NETAJI SUBHAS UNIVERSITY OF TECHNOLOGY

CHOICE BASED CREDIT SYSTEM

SCHEME OF COURSES FOR

M. TECH.
(Biochemical Engineering)

DEPARTMENT OF BIOCHEMICAL ENGINEERING

Program Educational Objectives (PEO) of the programme are as follows:

The Biochemical engineering Program are equipped with problem solving, teamwork, and communication skills that will serve them throughout their careers consistent with the following Educational Objectives Research programs in Biochemical Engineering and related areas.

- To attain careers as practicing biochemical engineers in fields such as pharmaceuticals, microelectronics, chemicals, polymers/advanced materials, food processing, energy, biotechnology, or environmental engineering;
- To provide students with opportunities to participate in multidisciplinary teams in order to develop and practice communication skills, both within the team and to a broader audience;
- To provide students with opportunities to design and conduct Biochemical Engineering experiments in order to design systems, components, and chemical processes to meet specific needs and constraints;
- To provide a contemporary grounding in professional responsibility, including ethics, the global and societal impact of engineering decisions, and the need for lifelong learning.

PROGRAM OUTCOMES

1. Acquire in-depth knowledge of specific discipline or professional area, 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.

2. Analyse complex engineering problems critically, apply independent judgement for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

4. Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.

5. Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

6. Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after considerisation of economical and financial factors.

8. Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

Program Specific Outcomes (PSOs)

a) Students will acquire in-depth knowledge of the concepts of biochemical engineering to evaluate and critically analyze complex problems in order to create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, for production of valuable bioproducts.
b) Student will acquire the ability to design systems, components, or bioprocesses in Biochemical Engineering to meet specified objectives within realistic constraints such as environmental, social, political, health and safety, manufacturability, and sustainability in Biochemical Engineering.
c) Student will acquire the ability to effectively communicate his research and ideas, individually and as a member of multidisciplinary teams in form of effective reports and research papers in global, economic, environmental, and societal context.
d) Students will be able to engage in independent and life-long learning in the broadest context of technological change while they develop an understanding of the concerns related to intellectual property rights, biosafety and bioethics.

e)

SEMESTER-WISE COURSE ALLOCATION
FULL TIME

M.TECH. BIOCHEMICAL ENGINEERING (Full Time) SEMESTER I

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCC01	CC	Biochemical Engineering-I	3	0	2	4	15	15	40	15	15	100
BTBCC02	CC	Enzyme Technology	3	0	2	4	15	15	40	15	15	100
BTBCD**	ED	Elective[#]	3	0	2	4	-	-	-	-	-	100
BTBCD**	ED	Elective[#]	3	0	2	4	-	-	-	-	-	100
FCMG**	FC	Research Methodology and IPR	3	1	0	4	25	25	50	-	-	100
		TOTAL	$			20						

#. The LTP allocation evaluation scheme and Prerequisites for electives are given in Tables 3-4

The course code will depend upon student's choice of elective.

$. The actual weekly load will depend upon the electives chosen by the student.

M.TECH. BIOCHEMICAL ENGINEERING (Full Time) SEMESTER II

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCC03	CC	Bioprocess Analysis and Reactor Design	3	0	2	4	15	15	40	15	15	100
BTBCC04	CC	Biochemical Engineering-II	3	0	2	4	15	15	40	15	15	100
BTBCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BTBCD**	ED	Elective#	3	1	0	4	-	-	-	-	-	100
BTBCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
FE****	FE	Foundation Elective (Audit Course)	3	1	0	-	25	25	50	-	-	100
		TOTAL	$			20						

#. The LTP allocation evaluation scheme and Prerequisites for electives are given in Tables 3-4
The course code will depend upon student's choice of elective.
$. The actual weekly load will depend upon the electives chosen by the student.

M.TECH. BIOCHEMICAL ENGINEERING (Full Time) SEMESTER III

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCC05	CC	Dissertation Phase I	-	-	-	10	-	-	-	40	60	100
BTBCD**	**D	Elective#	3	0	2	4	-	-	-	-	-	100
EO****	EO	Open Elective	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			18						

#. The LTP allocation evaluation scheme and Prerequisites for electives are given in Tables 3-4
The course code will depend upon student's choice of elective.
$. The actual weekly load will depend upon the electives chosen by the student.

M.TECH. Biochemical Engineering (Full Time) SEMESTER IV

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCC06	CC	Dissertation Phase II	-	-	-	16	-	-	-	40	60	100
		TOTAL	-	-	-	16						

SEMESTER-WISE COURSE ALLOCATION
PART-TIME

M.TECH. BIOCHEMICAL ENGINEERING (Part Time) SEMESTER I

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCC01	CC	Biochemical Engineering-I	3	0	2	4	15	15	40	15	15	100
BTBCC02	CC	Enzyme Technology	3	0	2	4	15	15	40	15	15	100
FC****	FC	Research Methodology and IPR	3	1	0	4	25	25	50	-	-	100
		TOTAL	$			12						
$. The actual weekly load will depend upon the electives chosen by the student.												

M.TECH. BIOCHEMICAL ENGINEERING (Part Time) SEMESTER II

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCC03	CC	Bioprocess Analysis and Reactor Design	3	0	2	4	15	15	40	15	15	100
BTBCC04	CC	Biochemical Engineering-II	3	0	2	4	15	15	40	15	15	100
FE****	FE	Foundation Elective (Audit Course)	-	-	-	-	25	25	50	-	-	100
		TOTAL	$			08						
$. The actual weekly load will depend upon the electives chosen by the student.												

M.TECH. BIOCHEMICAL ENGINEERING (Part Time) SEMESTER III

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BTBCD**	ED	Elective#	3	1	0	4	-	-	-	-	-	100
BTBCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
		TOTAL	$			12						

#. The LTP allocation evaluation scheme and Prerequisites for electives are given in Tables 3-4
The course code will depend upon student's choice of elective.
$. The actual weekly load will depend upon the electives chosen by the student.

M.TECH. BIOCHEMICAL ENGINEERING (Part Time) SEMESTER IV

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BTBCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
EO****	EO	Open Elective	3	1	0	4	-	-	-	-	-	100
		TOTAL	$			12						

#. The LTP allocation evaluation scheme and Prerequisites for electives are given in Tables 3-4
The course code will depend upon student's choice of elective.
$. The actual weekly load will depend upon the electives chosen by the student.

M.TECH. BIOCHEMICAL ENGINEERING (Part Time) SEMESTER V

CODE	TYPE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
							Theory			Practical		Total
							CA	MS	ES	Int	Ext	
BTBCC06	CC	Dissertation Phase I	0	0	-	10	-	-	-	40	60	100
BTBCD**	ED	Elective[#]	3	0	2	4	-	-	-	-	-	100
		TOTAL	$			14						

#. The LTP allocation evaluation scheme and Prerequisites for electives are given in Tables 3-4
The course code will depend upon student's choice of elective.
$. The actual weekly load will depend upon the electives chosen by the student.

M.TECH. BIOCHEMICAL ENGINEERING (Part Time) SEMESTER VI

CODE	COURSE OF STUDY	L	T	P	C	EVALUATION SCHEME Percentage (Weightage)					
						Theory			Practical		Total
						CA	MS	ES	Int	Ext	
BTBCC07	Dissertation Phase II	0	0	-	18	-	-	-	40	60	100
	TOTAL	-	-	-	18						

The LTP allocation evaluation scheme and Prerequisites for electives are given in Tables 3-4
The course code will depend upon student's choice of elective.
$. The actual weekly load will depend upon the electives chosen by the student.

Foundation elective Course will be online course i.e. Edx, Coursera, NPTEL etc.

TABLE 3A: LIST OF DISCIPLINE CENTRIC ELECTIVES WITH PRACTICAL							
LTP Allocation			**Evaluation Scheme**				
L	**T**	**P**	**CA**	**MS**	**ES**	**CA**	**ES**
3	**0**	**2**	**15**	**15**	**40**	**15**	**15**
CODE	**COURSE OF STUDY**		**PREREQUISITE**				
First Semester Electives							
BTBCD01	Fermentation Technology		None				
BTBCD02	Thermodynamics of Biological System		None				
BTBCD03	Concepts in Modern Biology		None				
BTBCD04	Environmental Biotechnology		None				
Second Semester Electives							
BTBCD05	Biomass processing & Bioenergy		None				
BTBCD06	Transport phenomena in biological systems		None				
BTBCD07	Genetic Engineering		BTBCD 03				
BTBCD08	Microbial Physiology		BTBCD 03				
BTBCD09	Downstream Processes in Industrial Biotechnology		None				
BTBCD10	Modeling and Simulation in Biochemical Engineering		BTBCD 31				
BTBCD11	Bioprocess Plant Design		BTBCC01, BTBCC04				
BTBCD12	Animal Cell Technology		None				
Third Semester Electives							
BTBCD13	Biological Waste Treatment		BTBCD04				
BTBCD14	Food Science and Engineering		None				
BTBCD15	Plant Biotechnology		None				

TABLE 3B: LIST OF DISCIPLINE CENTRIC ELECTIVES WITH TUTORIAL							
LTP Allocation			**Evaluation Scheme**				
L	**T**	**P**	**CA**	**MS**	**ES**	**CA**	**ES**
3	**1**	**0**	**25**	**25**	**50**	**-**	**-**
CODE	**COURSE OF STUDY**		**PREREQUISITE**				
First Semester Electives							
BTBCD31	Probability and Biostatistical Methods		None				
BTBCD32	Entrepreneurship, IPR and Biosafety		None				
Second Semester Electives							
BTBCD33	Computational Biology		None				
BTBCD34	Computational Fluid Dynamics		BTBCC 01				
Third Semester Electives							
BTBCD35	Metabolic Regulations and Engineering		BTBCD 01				

LIST OF FOUNDATION ELECTIVES		
FE**		
FE01	English for Research Paper Writing	None
FE02	Disaster Management	None
FE03	Sanskrit for Technical Knowledge	None
FE04	Value Education	None
FE05	Constitution of India	None
FE06	Pedagogy Studies	None
FE07	Stress Management by Yoga	None
FE08	Personality Development through Life Enlightenment Skills.	None

TABLE 4: LIST OF OPEN ELECTIVES							
LTP Allocation			**Evaluation Scheme**				
L	**T**	**P**	**CA**	**MS**	**ES**	**Int**	**Ext**
3	**1**	**0**	**25**	**25**	**50**	**-**	**-**
Code	**Name of Elective**		**Prerequisites**				
EO001	Business Analytics		None				
EO002	Industrial Safety		None				
EO003	Operations Research		None				
EO004	Cost Management of Engineering Projects		None				
EO005	Composite Materials		None				
EO006	Waste to Energy		None				

M. TECH. (BIOCHEMICAL ENGINEERING)

SYLLABUS FOR CORE COURSES

Course No	Title of the Course	Course Structure	Prerequisite
BTBCC01	**BIOCHEMICAL ENGINEERING-I**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO):

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

1. To become familiar with biochemical engineering fundamentals and to understand the requirements for microbial growth in culture.
2. To apply the knowledge of microbial growth and product formation kinetics for optimum growth and utilization of substrate.
3. To analyze the requirements of the production process and be able to design a system for efficient growth and product formation.
4. To compare and evaluate bioreactor performance for production of different kind of metabolites.
5. To be able to write research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	3	3	-	1	-	-	2	2	2
CO 2	3	3	3	3	3	-	1	-	1	1	1	3
CO 3	3	3	3	3	3	2	2	2	3	2	2	2
CO 4	3	3	3	3	3	-	2	2	1	-	-	1
CO 5	1	1	1	3	2	3	3	2	3	3	3	2

COURSE CONTENT

Unit I: Definition and scope of biochemical engineering. Metabolic stoichiometry and bioenergetics,

Unit II: Steady state Mass and energy balance in microbial processes. Unsteady state material and energy balance

Unit III: Preparation and sterilization of medium for fermentation,

Unit IV: Microbial Growth Kinetics, Microbial growth, substrate utilization and product formation, concept of yield, metabolic heat,

Unit V: Modes of bioreactor operation: batch, continuous and fed batch, Mixing and aeration, operation, measurement of parameters and control of bioreactors, Scale up

PRACTICALS

1. Preparation and sterilization of media for fermentation
2. Study of microbial growth curve under batch cultivation
3. Estimation of growth kinetics parameter for bacterial/yeast culture under stationary and shake flask conditions
4. Demonstration of bench top lab scale fermenter
5. Determination of volumetric oxygen transfer coefficient in fermenter
6. Solid state fermentation for industrial enzyme production/citric acid
7. Immobilization of microbial cells

BOOKS/REFERENCE

1. Biochemical Engineering – Kinetics, Mass Transport, Reactors and Gene Expression by W.F. Veith. Publisher: John Wiley and Sons Inc.
2. Biochemical Engineering by S. Aiba, A.E. Humphrey and N.F. Millis. Publisher: University of Tokyo Press.
3. Biochemical Engineering Fundamentals by J.E. Baily and D.F. Ollis. Publisher: McGraw Hill.
4. Bioprocess Engineering Basic Concepts by M.L. Shuler and F. Kargi. Publisher: Prentice Hall.
5. Bioprocess Enginneering Principles by P. Doran. Publisher: Academic Press.
6. Bioreaction Engineering Principles by J. Nielson and J. Villadsen Publisher: Plenum Press.
7. Chemical Engineering by J.M. Coulson, and J.F. Richardson. Publisher: Butterworth Heinemann.
8. Fermentation and Biochemical Engineering Handbook: Principles, Process

Course No	Title of the Course	Course Structure	Prerequisite
BTBCC02	**ENZYME TECHNOLOGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. Understand basic principles and methodologies of enzyme technology in order to manipulate a given strain for the desired function.
2. Analyze the structure of enzymes with reference to its influence on classification, function and solubility.
3. Construct enzyme reactors for mobilized and immobilized enzymes along with the skills to carry out enzyme kinetics.
4. Apply the principles of enzyme engineering techniques to conceptulaize and deliver solutions pertaining to industrial, environmental and social problems.
5. Write a simple research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1	2	2	-	-	1	3	3	1	1
CO 2	3	3	1	2	2	-	-	1	2	3	3	2
CO 3	2	3	3	-	2	2	2	2	2	3	3	3
CO 4	3	3	2	2	3	2	3	3	3	3	3	3
CO 5	1	2	3	3	3	3	3	3	1	3	3	3

COURSE CONTENT

UNIT I: Introduction to enzymes, Classification, Sources, Mechanism of enzyme action. Strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes , Enzymes of biological importance, application of enzymes: Functional group interconversion using enzymes, Retrosynthetic biocatalysis, Chemoenzymatic synthesis of natural products; sources of enzymes, enzymes from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes)

UNIT II: Pre-Steady–State Kinetics: Rapid mixing, Stopped flow and Relaxation techniques, Determination of the number of active sites of enzyme and determination of rate constants. Enzyme kinetics at limiting conditions: Dilute substrates, solid substrates and enzyme activity at interfaces. Kinetics of Multi-Substrate Reactions, Kinetics of biphasic liquid systems, stabilization of biphasic aqueous-organic systems and equilibrium in biphasic aqueous-organic systems, Factors Affecting Enzyme Activity, Active Site Studies:

UNIT III: Enzyme Immobilization, Carriers and methods of immobilization Electrostatic effect, Effect of charged and uncharged support, Effect of external and internal mass transfer, Effect of

Intra-particle diffusion with uncharged supports, Simultaneous external and internal mass transfer resistances and partitioning effects. Dam Kohler number and effectiveness factor.

UNIT IV: Bioreactors for soluble and immobilized enzymes, Mass transfer and catalysis in immobilized enzyme reactors, Enzyme based biosensors; Enzymatic reactions in micro-aqueous medium and nonconventional media.

UNIT V: Case studies involving enzyme application in industrial bioprocess: Industrial process using enzymes for production of drugs, fine biochemicals and chiral intermediates etc. Molecular design for alteration of enzyme functional properties, Enzyme catalyzed processes with cofactor regeneration

PRACTICALS

1. Production and purification of industrial enzymes
2. Studies on Enzyme kinetics
3. Effects of process conditions on enzyme activity
4. Kinetics of Enzyme inhibition
5. Enzyme immobilization techniques
6. Characterization of Immobilized enzymes and their applications.

BOOKS/REFERENCE

1. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker (1987)
2. Pauline M. Doran: Bioprocess Engineering Principles, Elsevier Publications.
3. Biochemical Engineering Principles and functions by Syed Trnveer Ahmed Inamdar, PHI Learning Private limited.
4. Wiseman, A: Handbook of Enzyme Biotechnology, 3rd Edition, Ellis Horwood Publication (1999)
5. Moser, A; Bioprocess technology, kinetics and reactors; Springer Verlag, (1988)
6. Schugerl K: Bellgart K H (Eds); Bioreaction Engineering, Modeling and control; Springer Verlag, Berlin (2000)
7. Introduction to Biochemical Engineering by D G Rao. Tata, McGraw Hill, New Delhi.
8. Bailey JE, Ollis DF; Biochemical Engineering fundamentals (1986)
9. Blanch HW and Clark DS: Biochemical Engineering Marcel Decker. (1987)
10. Enzymes, Biochemistry , Biotechnology Clinical Chemistry: Trevor Palmer (2001)

Course No	Title of the Course	Course Structure	Prerequisite
BTBCC03	**BIOPROCESS ANALYSIS AND REACTOR DESIGN**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. Understand bioprocess engineering of biochemical reaction engineering in order to manipulate a continuous sytem for the desired function.
2. Analyze the bioreactor principles and to compare the various types of reactors with reference to its influence on classification and function.
3. Construct bioreactor for natural and modified products along with the skills to carry out evaluation of the biosimulator.
4. Apply the principles of engineering techniques to conceptulaize and deliver solutions pertaining to industrial, environmental and social problems.
5. Write a simple research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	1	2	2	-	1	1	3	-	1	1
CO 2	3	3	2	2	2	2	-	1	2	-	2	2
CO 3	3	3	3	-	2	2	2	2	2	3	3	3
CO 4	3	3	1	2	3	3	3	3	3	3	3	3
CO 5	2	1	2	3	3	3	3	3	1	3	3	3

COURSE CONTENT

UNIT I: Reaction thermodynamics, order and molecularity of reaction, homogeneous and heterogeneous reactions, elementary and non elementary reactions, reaction yield, reaction rate, calculation of reaction rates from experimental data, general reaction kinetics for biological system, production kinetics in cell culture, kinetics of substrate uptake in cell culture, growth kinetics with plasmid instability, kinetics of bisubstrate enzyme reactions, kinetics of enzyme deactivation.

UNIT II: Constant volume and variable reactors, batch operation of a well mixed enzyme and cell culture reactor, fed batch operation of a well mixed enzyme and cell culture reactor, continuous operation of well mixed enzyme and cell culture reactor, continuous operation of plug flow enzyme and cell culture reactor, autocatalytic reactions, recycle reactors-plug flow reactor and continuous stirred tank reactor, comparison between major modes of reactor operation.

UNIT III: Continuous stirred tank reactors of equal size in series, continuous stirred tank reactors of unequal size in series, finding conversion in given system, determining the best system for a given conversion, plug flow reactors in series and parallel, reactors of different types in series.

UNIT IV: Simple reactions ,stepwise reactions, parallel reactions ,series reactions, maximising r

in batch reactor , plug flow reactor and continuous stirred tank reactor, reactor choice for series reactions and series parallel reactions, reversible reactions; Design for multiple reactions: Reactions in parallel- qualitative discussion about product distribution, quantitative treatment of product distribution and reactor size, selectivity. Reactions in series-quantitative discussion about product distribution in plug flow and batch reactor; Deviations from ideal reactors: Concept of non ideality, reasons of non ideality, RTD studies, f curve, c curve, e curve, diagnosis of ills of flow reactors, modeling of non ideal behaviour-dispersion model, tanks in series model.

UNIT V: Introduction to Process control systems, Use of Laplace & Inverse Laplace Transformation in study of Process Dynamics & Control . Dynamic Modeling of a Process, Dynamic behavior of First order system, First order systems in series & second & higher order systems for various kind of inputs, Linearization of nonlinear systems, Transportation & Transfer Lag. Classification of control systems, Regulator & Servo control, Feed Forward & Feed backward control, Negative & Positive Feed back Control, Variables & Physical Elements of a Control system, Modes of control action, Controllers & Final control Elements, Reduction of Block & Signal Flow Diagrams, Closed loop transfer function

PRACTICALS

1. Study of first order reaction.
2. Inversion of sucrose.
3. Study of pseudo first order reaction-Acid catalyzed hydrolysis of methyl acetate
4. Study of a second order reaction-Saponification of ethyl acetate.
5. Determination of Arrhenius parameters for amylase or invertase.
6. Study of homogeneous catalytic reaction, decomposition of hydrogen peroxide, Acid catalyzed ester hydrolysis.
7. Batch fermentation of sucrose using invertase.
8. Study of PFR.
9. Study of CSTR and CSTR combination in first order reactions.
10. Study of F & C curves in CSTR.
11. Study of F & C curves in helical coil reactor.
12. Study of PFR & CSTR combination in second order reaction.

BOOKS/REFERENCE

1. Chemical Reaction Engineering: Levenspile O
2. Chemical Engineering Kinetics: Smith J.
3. S.M. Walas, “Reaction Kinetics for Chemical Engineers”, McGraw Hill, New York.
4. Elements of Chemical Reaction Engineering: H.Scott, Fogler.
5. J. Rajaram and J.C. Kuriacose, “Kinetics and Mechanics of Chemical Transformations “Macmillam India Ltd., 1993.
6. Basic Biotechnology, edited by Colin Ratledge and Bjorn Kristiansen, Cambridge University Press 2003.
7. Biochemical Engineering Fundamentals, Bailey, and Ollis, McGraw Hill Book Co.1986.
8. Bioreacation Engineering, K. Schergeri, Vols 1 & 2, John Wiley. 1985.
9. Bioprocess computations in Biotechnology, T.K. Ghosh, Ellis Horwood Publications, 1988.

10. Advanced Biochemical Engg., ‘ Henry R. Bugay Georgs Belforj, John Wiley & Sons.
11. Process Biotechnology Fundamentals, S.N. Mukhopadhaya, Viva Books Pvt. Ltd., 2001’
12. Bioprocess Engineering Principles by Pauline Doran

Course No	Title of the Course	Course Structure	Prerequisite
BTBCC04	**BIOCHEMICAL ENGINEERING-II**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. To identify, recognize, and appreciate engineering contributions in bioprocesses.
2. To become able to apply basic biology, biochemistry and genetic engineering principles in fermentation process.
3. To be able to analyze growth kinetics and reaction engineering principles in production of fermentative bio products.
4. To create mixed culture system for their application in bioremediation and biochemical engineering.
5. To be able to evaluate real industrial scale fermentation processes and construct a more efficient industrial bioprocess.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	2	3	-	1	2	2	1	2	2
CO 2	3	3	3	2	3	-	-	2	2	-	-	2
CO 3	2	2	2	1	3	3	3	3	3	3	3	3
CO 4	2	2	2	2	2	3	3	3	3	3	3	3
CO 5	2	3	3	3	3	2	3	3	1	1	3	3

COURSE CONTENT

UNIT I: Classification of fluids, fluids in motion, role of viscosity & momentum transfer in fluids, non-Newtonian fluids, viscosity measurement, factors affecting broth viscosity, Mixing equipment, flow patterns, power requirements for mixing in ungassed Newtonian & non-Newtonian fluids & in gassed fluids, scale-up of mixing systems.

UNIT II: Heat- transfer equipment, mechanisms of heat transfer, heat transfer between fluids, Design equations for heat-transfer, calculation of heat transfer coefficients, relation between heat transfer, cell concentration & stirring conditions.

UNIT III: molecular diffusion, film theory, convective mass transfer, oxygen uptake in cell cultures, oxygen transfer in fermenters, measuring dissolved oxygen concentrations, measurement of k_La.

UNIT IV: cell growth kinetics, growth kinetics with plasmid instability, production kinetics in cell culture, kinetics of substrate uptake in cell culture, effect of culture conditions on cell kinetics, determining cell kinetic parameters from batch data, effect of maintenance on yields, kinetics of cell death.

UNIT V: heterogeneous reactions in bioprocessing, Internal mass transfer & reaction, the Thiele modulus & effectiveness factor, external mass transfer, liquid- solid mass transfer, minimizing mass transfer effects.

PRACTICALS

1. Microbial growth and product formation kinetics;
2. Effects of inhibitor on microbial growth
3. Bioconversion in batch, fed batch and continuous bioreactors
4. Oxygen transfer studies in fermentation
5. Mixing and agitation in fermenter
6. Residence Time Distribution (RTD) studies
7. Mass transfer in immobilized cell/enzyme reactors.

BOOKS/REFERENCE

1. Biochemical Engineering – Kinetics, Mass Transport, Reactors and Gene Expression by W.F. Veith. Publisher: John Wiley and Sons Inc.
2. Process Engineering in Biotechnology by A.T. Jackson. Publisher: Prentice Hall.
3. Biochemical Engineering by S. Aiba, A.E. Humphrey and N.F. Millis. Publisher: University of Tokyo Press.
4. Biochemical Engineering Pirnciples, M. Doble and S. N. Gummadi, Publisher: Prentice Hall (2007)
5. Biochemical Engineering Fundamentals by J.E. Baily and D.F. Ollis. Publisher: McGraw Hill.
6. Bioprocess Engineering Basic Concepts by M.L. Shuler and F. Kargi. Publisher: Prentice Hall.
7. Bioprocess Enginneering Principles by P. Doran. Publisher: Academic Press.
8. Bioreaction Engineering Principles by J. Nielson and J. Villadsen Publisher: Plenum Press.
9. Chemical Engineering by J.M. Coulson, and J.F. Richardson. Publisher: Butterworth Heinemann.

Course No	Title of the Course	Course Structure	Prerequisite
FC001	**Research Methodology and IPR**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. To understand research methods and processes.
2. To analyze research problem and prepare the plan for investigations.
3. To apply various quantitative techniques for data analysis.
4. To be able to communicate and present research findings.
5. To understand IPR and related aspects.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	2	2	3	-	1	2	2	-	-	1
CO 2	1	3	3	2	3	3	2	1	2	-	3	3
CO 3	3	1	2	3	3	-	1	-	1	-	2	-
CO 4	-	-	-	1	2	2	3	-	1	-	2	-
CO 5	3	2	1	-	1	-	3	3	3	3	3	3

COURSE CONTENT

Unit-I: Introduction, Concepts of research, Meaning and objectives of research, Research process, Types of research, Research problem identification, Research proposal- contents, Funding agencies, Ethical aspects and Plagiarism detection tools.

Unit-II: Research design process, Need and types of research design, Literature survey, Use of internet and advanced search techniques, Various reputed publishers and their databases, Identification of research gaps, Measurement and scaling techniques, Data collection-types and method, Processing and analysis of data, Design and analysis of experiment.

Unit-III: Quantitative techniques, Sampling fundamentals, Type of hypothesis, Introduction and applications of Binomial, normal and Poisson distributions, Statistical tests: Chi-squared test, t-test, f-test etc., Multivariate analysis, Introduction to various statistical analysis software.

Unit-IV: Computer applications in research, Pre-writing considerations, Principles of thesis and report writing, Formats for thesis, report and research papers, Documentation and presentation tools-introduction to LATEX and MS office.

Unit-V: Nature of Intellectual Property: Patents, Designs, Trade and Copyright, Process of Patenting and Development: technological research, innovation, patenting, development, New developments in IPR: National and international scenarios.

BOOKS/REFERENCE

1. Stuart Melville and Wayne Goddard, "Research Methodology: An Introduction for Science & Engineering Students", Juta and Company Ltd.
2. Dr. C. R. Kothari, "Research Methodology: Methods and Techniques", New Age International Publisher.
3. Wadehra B.L., "Law Relating to Patents, Trademarks, Copyright Designs and Geographical Indicators", Universal Law Publishing.

4. Ranjit Kumar, “Research Methodology: A Step by Step Guide for Beginners”, 2nd Edition, SAGE Publications Ltd.
5. G.C. Ramamurthy, “Research Methodology”, Dream Tech Press, New Delhi.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCC05	**DISSERTATION PHASE I**	**-**	**None**

Course No	Title of the Course	Course Structure	Prerequisite
BTBCC06	**DISSERTATION PHASE II**	**-**	**None**

M. TECH. (BIOCHEMICAL ENGINEERING)

SYLLABUS FOR DISCIPLINE CENTRIC ELECTIVES

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD01	**FERMENTATION TECHNOLOGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. Learn and understand the fundamental concepts and principles of isolation of microbial strains of interest.
2. Apply the knowledge of industrially important microbes for their isolation, strain improvement and preservation.
3. Analyze and compare nutritional requirement in order to design and optimize medium for industrial applications in bioprocesses.
4. To be able to evaluate the efficiency of solid state and submerged fermentation and develop processes for overproduction of biological metabolites.
5. To carry out literature review, write technical reports and be able to design optimal industrial scale production processes.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	3	3	-	2	1	-	3	3	2
CO 2	3	3	3	3	3	-	2	1	2	2	2	3
CO 3	3	3	3	3	3	2	2	2	3	2	2	2
CO 4	3	3	3	3	3	-	2	2	-	-	1	3
CO 5	2	3	3	3	3	3	2	2	2	2	2	3

COURSE CONTENT

UNIT I: Isolation, preservation and screening of industrially important microorganisms, Quality improvement of microorganism: isolation of mutants, recombinant microorganisms: preparation, selection and screening, inoculum development for fermentation

UNIT II: Nutritional requirements for growth and product formation. Medium design and optimization with statistical analysis (ANOVA), Placket-Burman and Central Composite Design technique, Pre-treatment of industrial raw materials

UNIT III: Various types of Fermentation, submerged fermentation, solid state fermentation, solid surface fermentation, aerobic and anaerobic fermentation, overview of biosynthetic mechanisms.

UNIT IV: Unit Operations, Downstream processes for separation and purification of industrially produced bio products

UNIT V: Process technology for production of primary metabolites, such as baker's yeast, ethanol, citric acid, amino acids and plastics. Microbial production of industrial enzymes-glucose isomerase, cellulase, amylase, protease etc, Production of secondary metabolites-penicillins and cephalosporins, Process technology for recombinant products.

PRACTICALS

1. Material and energy balance calculations in bioprocesses
2. Isolation and preservation techniques of microorganisms
3. Strategic enhancement in biomass and bio product from microorganism cultures
4. Media design and optimization
5. Screening of mutants and genetically engineered microbes
6. Submerge and solid state fermentation for enzymes and organic acids production
7. Biomass production techniques

BOOKS/REFERENCE

1. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation/ Noyes Publications.
2. Principles of Fermentation Technology by P.F. Stanbury and A. Whitaker. Publisher: Pergamon Press.
3. Process Engineering in Biotechnology by A.T. Jackson. Publisher: Prentice Hall.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD02	**Thermodynamics of Biological System**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. Be able to understand the basic knowledge of Thermodynamics.
2. To analyze biological systems as open, non-equilibrium systems.
3. To be able to apply the chemical potential of biological system for industrial production.
4. To evaluate the Colligative properties with respect to biological fluid.
5. To create suitable environment for effective interaction between ligands and macromolecules.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	3	2	3	-	-	1	-	-	-	1
CO 2	2	3	2	2	3	2	2	1	-	-	-	1
CO 3	1	2	1	3	3	3	3	3	3	-	3	3
CO 4	1	3	3	3	3	1	3	3	1	1	3	3
CO 5	2	2	2	2	2	3	2	2	2	2	2	2

COURSE CONTENT

UNIT I: Concepts of system, properties, equilibrium, zeroth law, heat and work, first law of thermodynamics, non flow and steady flow energy equations, second law of thermodynamics, reversibility, entropy, properties of ideal gases, various thermodynamic processes. Properties of air, water, vapour mixtures, introduction to psychometry.

UNIT II: failure of classical and thermodynamics in describing biological processes, Standard free energy changes and equilibrium constants, direction and rate.

UNIT III: Visualization of the potential, Steady velocity and steady flow; Fick's law and diffusion. Local Equilibria and Steady State: Energy vs. Power; Transducers in biological states, Constitutive equations, Dynamic efficiency and (Onsager nonequilibrium thermodynamics), Prigogine's principle, Spontaneous coupling and entropy production.

UNIT IV: Properties of solution, concept of osmotic pressure, Vant hoff Law, Raoult's law, Boiling Point Elevation and Freezing Point Depression.

UNIT V: Ligand binding to macromolecules, Hydrodynamics of macromolecules, Application of magnetic resonance in Biology

PRACTICALS

1. The comparison of thermal conductivity of different metals
2. Determination of the calorific value using flow calorimeter
3. Determination of the calorific value using Throttle calorimeter

4. Ethanol , Acetic Acid Ethyl equilibrium determination
5. Calculate Coefficient of Performance of Vapor compression refrigeration system for Reversed Carnot, Ideal and Actual cycles.
6. Explain the working and estimate the heat transfer rates in a forced draft-cooling tower.
7. Examine the thermal properties of rubber
8. Determine if the temperature of a liquid affects its viscosity
9. Experimentally Determine the Absolute Zero
10. Draw and analyze Temperature profiles of a premixed LPG flame.

BOOKS/REFERENCE

1. Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology by Dill, Ken A., and Sarina Bromberg.
2. Biological Thermodynamics by D.T. Haynie.
3. Biophysical Chemistry by C.R. Cantor and P.R. Schimmel.
4. Physical Chemistry: Principles and Applications in Biological Sciences by I. Tinoco, K. Sauer and J.C. Wang.
5. Physical Chemistry for the Chemical and Biological Sciences by R.Chang.
6. Physical Chemistry by R.J. Silbey and R.A. Alberty.
7. Principles of Physical Chemistry, with Applications in the Biological Sciences by D. Freifelder.
8. Thermodynamics and Kinetics for the Biological Sciences by G.G. Hammes.
9. Bioenergetics by A.L. Lehninger.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD03	**CONCEPTS IN MODERN BIOLOGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. Students will learn different levels of organization in biological systems.
2. Students will be able to utilize the information of biological systems to understand its functioning.
3. Students will be able to integrate any apply the knowledge to manipulate biological systems for human welfare.
4. Understanding human body or any other suitable organism as a study-model for engineering students.
5. Bringing in the knowledge of electrical, chemical and magnetic forces, and communication networks in biological systems to solve practical problems.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	3	2	3	-	-	1	1	-	1	1
CO 2	3	2	3	2	3	2	2	2	2	1	2	2
CO 3	1	2	1	3	3	3	3	3	3	-	3	3
CO 4	3	2	3	2	3	-	1	1	1	-	-	1
CO 5	3	3	3	3	3	2	2	3	2	2	2	3

COURSE CONTENT

UNIT I: Introduction to Biology; Macromolecules; Carbon chemistry; Proteins: Structure, folding, catalysis; Nucleic acids: storage and transfer of genetic information; Lipids: membranes, energy storage; Carbohydrates: energy storage, building blocks

UNIT II: Viruses, bacteria, protists, fungi; Physiology aspects of Plants & Animals; Regulatory systems (nervous, endocrine, immune systems); Ecology; Populations and communities; Biosphere; Conservation

UNIT III: Cell structure; Membranes; Function of cell organelles; Energetics; ATP and glycolysis; Respiration; Photosynthesis

UNIT IV: Reproduction and Heredity; Cell division: mitosis, meiosis, gamete formation, pollination; Mendalian genetics; Evolution; Gene variation (Hardy-Weinberg principle); Darwin's theory of evolution

UNIT V: Genes; Basics of DNA replication, transcription, translation, Genome organization; Mutations; Gene technology

PRACTICALS

1. Quantitative determination of Protein
2. Quantitative determination of Fat
3. Quantitative determination of Carbohydrate
4. Isolation of DNA from bacteria
5. Quantitative analysis of DNA
6. Microscopy and cell morphology
7. Cell Division.
8. ATP production by photosynthesis
9. Experiments on Bio product formation

BOOKS/REFERENCE

1. Advanced Biology By Michael Roberts, Michael Jonathan Reiss, Grace Monger
2. Ecology: A Textbook By Hermann Remmer
3. Basic Biotechnology edited by Colin Ratledge, Bjorn Kristianse
4. Genetics: A molecular Approach By: T. A. Brow

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD04	**ENVIRONMENTAL BIOTECHNOLOGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. Learn about environmental systems and pollutants along with the existing and emerging technologies that are important in the area of environment biotechnology.
2. Understand the importance of microbial diversity and technologies for environmental sustainability and processes.
3. Analyze relevant journal articles and investigate industrial applications of the concepts of biotechnology for effluent treatment.
4. Evaluate the principles of wastewater technologies and analyze case studies of the area to conceptualize a research program with an aim to solve the existing global environmental problems.
5. Manipulate, enhance or retard biological processes for bioremediation of natural sources and xenobiotic degradation.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	-	2	2	2	-	2	2
CO 2	3	3	3	3	3	-	2	2	2	2	2	-
CO 3	3	3	3	-	3	3	3	3	2	-	3	3
CO 4	2	3	3	3	3	1	3	3	-	-	3	3
CO 5	2	3	3	3	3	1	3	3	2	1	3	3

COURSE CONTENT

UNIT I: Physical and chemical aspects of natural environmental processes, Metals and nonmetals, carcinogens, radioactive materials, and pathogens/pathogenic sample. Industrial, Municipal and agricultural waste, Handling, processing, and disposal of various hazardous and toxic materials, diversity and role of microorganisms in diverse and complex environments, Use and management of microbes for the benefit of ecosystems and society

UNIT II: Dynamic nature of air quality, Ambient and industrial conditions, Principals and practices of air quality management, Air Quality Management, Air treatment technologies, Contaminant movement in air matrices, and data analysis

UNIT III: Water resources, drinking water standards, water quality characteristics, water pollutants, Sampling and laboratory instrument procedures, An overview of the geology, properties, flow, and pollution of ground water systems, sewage and potable water treatment plants, Unit operations, physical, chemical and biological used in waste water treatment, Design of an Effluent treatment plant, Reactors for waste water treatment

UNIT IV: Generation, processing, and disposal of municipal, industrial, and agricultural waste

materials, technical concepts of solid waste management, Design and operation of landfills, waste-to-energy systems, composting facilities, recycling facilities, and other emerging waste management technologies.

UNIT V: Principles of pollution prevention and environmentally conscious products, processes and manufacturing systems, Post-use product disposal, life cycle analysis, Pollution prevention economics, Overview of major environmental laws such as the Clean Air and Clean Water Acts, Regulatory issues

PRACTICALS

1. Estimation of D. O., B. O. D. and C.O. D. in a given waste water sample
2. To estimate the hardness of water sample
3. To estimate total, dissolved and suspended solid in waste water
4. To test acidity and alkalinity of waste water
5. To understand the effect of heavy metal/pesticide on behavioural characteristic of fish
6. To calculate LD50, IC50 and IC10 values
7. To evaluate the effect of pollutant/water pollution using comparative proteomics
8. Genotoxicity assays against selected pollutants: Comet Assay and Micronucleus Test

BOOKS/REFERENCE

1. Comprehensive Biotechnology by M. Moo-Young. Publisher: Pergamon Press.
2. Environmental Chemistry A.K. De. Publisher: Wiley Eastern Ltd.
3. Introduction to Biodeterioration by D. Allsopp and K.J. Seal. Publisher: ELBS/Edward Arnold.
4. Waste Water Engineering – Treatment, Disposal and Reuse by Metcalf, Eddy and G. Tchobanoglous. Publisher: Tata McGraw Hill.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD31	**Probability and Biostatistical Methods**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

1. Student shall learn the fundamentals of statistics.
2. Get familiar with role and application of statistics in Bioinformatics.
3. Must be able to compute a mean, variance, and standard deviation for the data obtained during experimentation.
4. To evaluate concept of Probability and its application in data analysis.
5. Student shall become able to design and create the experiments and expression of result outcomes in form of tables, graphs etc.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	-	3	-	1	1	2	2	1	2
CO 2	2	2	2	3	3	3	3	3	3	-	2	2
CO 3	1	2	2	2	2	1	2	2	1	1	2	2
CO 4	1	3	3	3	3	-	3	3	1	1	3	3
CO 5	1	1	1	-	1	2	2	3	3	3	3	3

COURSE CONTENT

Unit I: Descriptive Statistics & Probability: Measure of central tendency and dispersion, Axiomatic concepts; Conditional probability. Multiplication rule of probability. Baye's rule.

Unit II: Random variable and expectation: Random variable and distribution function. Mathematical expectation. Statistical parameters. Chebyshev's inequality.

Unit III: Probability distributions: Binomial, Multinomial, Poisson and Exponential distribution.

Unit IV: Correlation, regression and sampling distributions: Method of least square and curve fitting, Probable error, Regression, Statistics and sampling distributions, Tests of significance

Unit V: Exact sampling distributions and small sample test: The Chi-square distribution. Student's t-distribution. Snedecor's F-distribution

SUGGESTED READINGS:

1. Principles of Biostatistics by Pagano, M. and Gaureau, K. 7th ed., Publisher: Thomson Learning, (2007).
2. Probability and Statistics for Engineers and Scientists by Ross, S.M. 3rd ed. Publisher: Academic Press, (2005).
3. Probability and Statistics for Engineers and Scientists by Walpole, R.E., Myers, R.H., Myers, S.L., Ye, K. Publisher: Prentice Hall, Inc. (2002)
4. Statistical Method for Engineering and Sciences by Taneja, H.C. Publisher: IK International, (2009).

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD32	**ENTREPRENEURSHIP, IPR AND BIOSAFETY**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

1. To learn and understand the concept of Intellectual property.
2. Have a knowledge on patent database system worldwide.
3. To be able to analyze the requirements of patent system for different countries.
4. To know the process of filing patent and be able to evaluate the shortcomings in patent application to be filed.
5. Have knowledge on different safety rules required for entrepreneurship.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	-	3	-	1	1	2	3	1	-
CO 2	2	2	2	3	3	3	3	3	3	3	2	-
CO 3	1	2	2	2	2	-	2	2	1	3	1	2
CO 4	1	1	1	3	3	3	3	1	1	3	2	2
CO 5	3	3	3	1	3	1	1	1	1	3	1	-

COURSE CONTENT

UNIT I: Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of New GMOs; International framework for the protection of IP, IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies; Introduction to History of GATT, WTO, WIPO and TRIPS

UNIT II: Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation Types of patents; Indian Patent Act 1970; Recent Amendments; Filing of a patent application; Precautions before patenting-disclosure/non-disclosure; WIPO Treaties; Budapest Treaty; PCT and Implications; Role of a Country Patent Office; Procedure for filing a PCT application

UNIT III: Patent application- forms and guidelines, fee structure, time frames; Types of patent applications: provisional and complete specifications; PCT and convention patent applications; International patenting-requirement, procedures and costs; Financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US Patenting by research students, lecturers and scientists-University/organizational rules in India and abroad, credit sharing by workers, financial incentives Patent infringement- meaning, scope, litigation

UNIT IV: Case studies related to IPR issues in Biotechnology, issues related to patenting of

microbiological inventions, recombinant product and processes, genetic modification tools etc.

UNIT V: Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; 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.

BOOKS/REFERENCE

1. A short course in international intellectual property rights By Karla C. Shippe
2. Intellectual Property Rights In Agricultural Biotechnology By F.H. Erbisch, K.M. Maredia
3. The TRIPS Regime of Patent Rights By Nuno Pires de Carvalho
4. Patent Strategy for Researchers and Research Managers By H. Jackson Knigh

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD05	**BIOMASS PROCESSING AND BIOENERGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. To become familiar with the energy requirements and energy system for rural sectors.
2. Understand the biomass feedstock and their biochemical composition.
3. Apply the guidelines for bioenergy use and audits.
4. Analyze the biotechnological application in bioenergy generation.
5. Evaluate the various available bioenergy option and biofuel routes.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	2	3	-	1	-	2	2	2	2
CO 2	2	2	2	2	2	1	2	-	-	-	1	1
CO 3	2	2	2	1	3	3	3	-	3	3	3	3
CO 4	2	3	3	3	3	-	3	2	2	2	3	3
CO 5	1	3	3	3	3	1	3	3	1	-	3	3

COURSE CONTENT

UNIT I: Biomass types, characterization and chemistry, Terrestrial *vs* aquatic biomass, bioenergy feedstock cultivation and harvesting,

UNIT II: Thermochemical processing of biomass: Pelletization, Direct Combustion and gasification, microbial fuel cell, biorefinery approach, problems associated with biomass conversion,

UNIT III: Liquid and Gaseous biofuels: Biofuels, Biodiesel/bio-oils, Ethanol, gaseous biofuel (biohydrogen and biogas), microbial fuel cell, biorefinery approach,

UNIT IV: Harvesting, drying, biomass pretreatment (physical, chemical and biological) and bioenergy production

UNIT V: bioenergy commercialization and case studies, life cycle assessments, recent advances in bioenergy research, Recent developments in Biofuel technologies.

PRACTICALS

1. Biomass characterization: elemental and biochemical composition
2. Biomass processing: physical, chemical and biological treatment
3. Bioethanol production form agro-residues
4. Anaerobic digestion of waste and biomass
5. Algal biomass production and processing for biofuel
6. Microbial fuel cells

BOOKS/REFERENCE

1. Biomass and Bioenergy: Processing and Properties. Khalid Rehman Hakeem, Mohammad Jawaid, Umer Rashid, Springer , 2014
2. Biomass, energy and environment: a developing country perspective from India. Ravindranath, Nijavalli H., and David Oakley Hall, Oxford University Press, 1995.
3. Bioenergy and biofuel from biowastes and biomass. Khanal, Samir Kumar, Rao Y. Surampalli, Tian C. Zhang, Buddhi P. Lamsal, R. D. Tyagi, and C. M. Kao. American Society of Civil Engineers (ASCE), 2010.
4. Pandey, Ashok, ed. Handbook of plant-based biofuels. CRC Press, 2008.
5. Microalgae as a Feedstock for Biofuels. Gouveia, Luisa. Springer Berlin Heidelberg, 2011.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD06	**TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. Understand basic principles of process engineering in order to manipulate a given property (state and path funcution) for the desired function.
2. Apply the principles of tranport processing techniques to conceptulaize and deliver solutions pertaining to industrial, environmental and social problems.
3. Analyze the application of transport phenomena with reference to its influence on system reliability and stress dealing nature.
4. Development of conserved equations for single or multiple reactor unit.
5. Write a simple research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

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CO 1	3	3	3	2	3	-	2	2	2	2	2	2
CO 2	2	2	2	2	2	1	2	1	-	-	1	1
CO 3	2	2	2	1	3	3	3	3	3	3	3	3
CO 4	3	3	3	-	3	-	2	1	1	-	-	1
CO 5	2	1	2	3	3	3	3	3	1	3	3	3

COURSE CONTENT

UNIT I: Development of mass, momentum and energy balance equations. Equation of change for isothermal systems. Velocity distribution in flow systems. Interphase transport. Microscopic and macroscopic balances.

UNIT II: Multi-component systems and their transport characteristics. Energy transport in non-isothermal systems. Energy transport by radiation.

UNIT III: Shell balance for momentum transfer. Velocity profiles. Residence time distribution Measurement techniques. RTD for single phase flow in tubes, coils, packed beds, stirred vessels.

UNIT IV: Multiphase flow. Stratified and dispersed flows. Interaction between phases Measurement techniques. Modelling and correlations of RTD in different contractors; Trickle beds, packed beds, bubble columns, spray columns, plate columns, fluidized beds etc.

UNIT V: Prediction of Pressure drop; Friction factor, drag coefficient, single phase flow, multiphase flow. Lockhart Martinelli approach. Drift flow concept, Rheology.

PRACTICALS

1. Viscosity of Newtonian Liquids
2. Thermal Conductivity of Solids
3. Velocity Profiles in Steady Turbulent Flow
4. Temperature Profiles in Solid Rods
5. Concentration Profiles in a Stagnant Film
6. Friction Factors for Flow in Circular Tubes
7. Heat-transfer Coefficients in Circular Tubes
8. Efflux Time for a Tank with Exit Pipe
9. Heating Liquids in Tank Storage

BOOKS/REFERENCE

1. Transport Phenomena, R. Byron Bird (Author), Warren E. Stewart (Author), Edwin N. Lightfoot (Author), 2nd edition, 2014.
2. Arthur T. Johnson, Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems, John Wiley and Sons, 1998.
3. Pauline M. Doran, Bioprocess Engineering Principles, Academic Press, 1995.
4. Blanch H.W and Douglas S. C, Biochemical Engineering, CRC Press, 1997.
5. Michael L Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, Prentice-Hall of India Pvt Ltd, 2008.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD07	**GENETIC ENGINEERING**	**3L- 0T- 2P**	**BTBCD 03**

COURSE OUTCOMES (CO)

After the completion of course the students will:

1. To learn the basic concepts of recombinant DNA technology and technical know-how of versatile techniques in recombinant DNA technology.
2. To understand the events involved in generating recombinant DNA molecules.
3. To be able to apply the understanding for manipulating nucleic acids in order to alter protein functions and cellular processes.
4. To be able to design expression systems for production of recombinant products.
5. To analyze and evaluate the cases wherein genetic engineering have been used for manipulation and improvement of genetic traits.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	2	3	-	2	2	2	2	2	2
CO 2	2	2	2	2	2	-	2	1	1	-	-	1
CO 3	2	2	2	1	3	3	3	3	3	3	3	3
CO 4	2	2	2	2	2	3	3	3	3	3	3	3
CO 5	-	3	3	3	3	-	3	3	1	-	3	3

COURSE CONTENT

Unit I: Tools and techniques, Properties and applications of DNA Modifying Enzymes: Host controlled restriction modification system; DNA Methyltransferases; DNA polymerases; Special case of thermo-stable DNA polymerases in context to PCR; Reverse transcriptases

Unit II: Plasmids; Lambda based vectors and derivatives, Protein Expression Vectors (expression systems for high level protein expression in E.coli and yeast, transcriptional efficiency, inducible promoters, translational efficiency, codon usage), protein extraction and purification (protein purification tags, histidine and GST tags, IMAC)

Unit III: Isolation of gene for cloning, Generalized cloning schemes, host genotypes specificities and applications, strategies for selection and screening, Transformation, transduction, Particle gun, electroporation, liposome mediated, cultivation etc. Virus mediated gene transfer, Transposable elements, RNA viruses, viroids.

Unit IV: Restriction enzyme analysis, Southern blotting, Northern blotting, In-situ hybridization DNA sequencing. RFLP, PCR, RAPD, DNA finger printing, Ribozymes, DNA probes, antisense RNA, Expression of clonal genes.

Unit V: Site-directed mutagenesis, PCR based methods for site-directed mutagenesis, mis-repair of mutant oligonucleotides, selection of mutant, Ligase chain reaction, In-silico analysis, manipulation and annotation of DNA sequences for experimental design and efficient management of cloning experiments.

PRACTICALS

1. Isolation of Plasmid
2. Cloning of GOI in plasmid vector.
3. Preparation and Transformation of Competent Cells
4. Gene expression in *E.coli*
5. Optimization of cloned-gene expression.
6. Reporter Gene assay (Gus/CAT/b-GAL).
7. Purification of the expressed product.
8. Analysis of gene product.
9. Construction of restriction map of plasmid DNA.
10. PCR amplification.

BOOKS/REFERENCE

1. From Principles of Gene Manipulation by Old & Primrose.
2. Genes VIII by Benjamini Lewin, Oxford.
3. Genes and Genomes by M.Singer & P.Berg.
4. Genome-3, T.A. Brown.
5. Genetic Engineering, Sandhy Mitra

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD08	**MICROBIAL PHYSIOLOGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. understanding of the cellular structure, function and diversity of microbes present on earth.
2. apply the knowledge of nutrients required by microbial cells and will be able to design and prepare media for microbial culture.
3. analyze microbial biodiversity that can be selected and harnessed for enhanced production of microbial metabolites.
4. evaluate specialized pathways in microbial metabolism that are harnessed for biochemical processing and bioenergy production.
5. carry out genetic manipulation of microorganism to create improved strains for bio-production of important metabolites.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	1	1	2	-	2	1	-	3	2	-
CO 2	3	3	3	3	3	-	2	-	2	2	2	3
CO 3	3	3	3	3	3	1	2	-	2	2	2	3
CO 4	3	3	3	3	3	2	2	3	2	2	2	3
CO 5	3	3	3	3	3	2	2	3	2	2	2	3

COURSE CONTENT

UNIT I: Cell Structure (Special emphasis on Cell Wall & Membrane) and Microbial Diversity Structural differences between different microbial cell types and cellular organelles; Biochemical/Microscopic/ Molecular methods used to differentiate between archae, eubacteria and eukaryotes; Cell wall of prokaryotes; Outer membrane of Gram –ve bacteria and control of its synthesis; Potential targets for drug design.

UNIT II: Biomolecules and Principles of Microbial Nutrition Importance of non-covalent interactions in biological systems; Non-informational and Informational Macromolecules and their organization; Microbial nutrition; Different types of culture medium; C/N/P balance and making of culture medium.

UNIT III: Bioenergetics and Catabolic Pathways Oxidation-reduction reactions; Electron carriers and cellular metabolism; High-energy compounds and their role in microbial fermentations; Enzymes as catalysts; Cellular metabolites and interconnectivity in biochemical pathways; Respiration and Electron Transport.

UNIT IV: Metabolic diversity, Energy from oxidation of inorganic electron donors; Iron oxidation; Methanotrophy and methylotrophy; Nitrate and Sulfate reduction; Acetogenesis; Methanogenesis; Fermentation-energetics and redox constraints; Anaerobic respiration; Chlorophylls and other pigments involved in microbial photosynthesis; Anoxygenic and

oxygenic photosynthesis; Autotrophic CO_2 Fixation: Calvin cycle, Reverse Citric Acid cycle, Hydroxypropionate cycle.

UNIT V Microbial Genetics and Genomics Mutations and their chemical basis; Mutagens and their use in Biotechnology; Modes of recombination; Comparative prokaryotic genomics

PRACTICALS

1. Sterilization, disinfection, safety in microbiological laboratory.
2. Preparation of media for growth of various microorganisms.
3. Identification and culturing of various microorganisms.
4. Staining and enumeration of microorganisms.
5. Growth curve, measure of bacterial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen.
6. Assay of antibiotics production and demonstration of antibiotic resistance.
7. Isolation and screening of industrially important microorganisms.
8. Determination of thermal death point and thermal death time of microorganisms.

BOOKS/REFERENCE

1. M.T. Madigan and J.M. Martinko, Brock Biology of Microorganisms, 11th Edition, Pearson Prentice-Hall, 2006.
2. L. Stryer, Biochemistry, 4th Edition, Freeman, 2002.
3. G. Gottschalk, Bacterial Metabolism, 2nd Edition, Springer-Verlag, New-York, Berlin. 1986.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD09	**Downstream Processing**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. Understand basic principles of process engineering in order to manipulate a given property (state and path funcution) for the desired function.
2. Apply the principles of advanced separation techniques to conceptulaize and deliver solutions pertaining to industrial, environmental and social problems.
3. Analyze the application of advances separation process with reference to its influence on system reliability and stress dealing nature.
4. Fabrication of distillation columns and process purge unit.
5. Write a simple research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	-	2	1	2	-	3	3
CO 2	2	3	3	3	3	3	3	3	3	3	3	3
CO 3	2	2	2	-	2	-	-	1	2	-	2	2
CO 4	2	2	2	-	3	3	3	3	3	3	3	3
CO 5	2	3	3	3	3	-	3	3	3	3	3	3

COURSE CONTENT

UNIT I: Multistage separation processes: Distillation and liquid-liquid extraction, Graphical and Computational design methods.

UNIT II: Adsorption: adsorption equilibria, adsorption column sizing.

UNIT III: Mechanical design of Multistage separation processes.

UNIT IV: Membrane separation processes, Pressure swing adsorption, Foam separation, Separation by thermal diffusion, Electrophoresis, Crystallization.

UNIT V: High resolution methods for purification of bio products.

PRACTICALS

1. Reverse Osmosis
2. Adsorption in batch reactors
3. Solvent Extraction (Liquid-liquid extraction)
4. Verification of Fick's law of diffusion of adsorbate molecules
5. Vacuum Evaporation
6. Leaf Filter

BOOKS/REFERENCE

1. Transport Processes and separation process principles. Christie John Geankoplis, Prentice Hall of India Pvt. Ltd. New Delhi.
2. Unit Operation of Chemical Engineering. Warren L. McCabe smith, McGraw- Hill International edition.
3. Fermentation and Biochemical Engineering Hand book. Principles Process design and equipment, Henry C. Vogal, Celeste L. Todaro, Noyes Publication- Westwood, new Jersey U.S.A.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD10	**MODELING AND SIMULATION IN BIOCHEMICAL ENGINEERING**	**3L- 0T- 2P**	**BTBCD31**

COURSE OUTCOMES (CO)

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

1. Understand basic principles modeling and control engineering in order to manipulate a given condition for the desired function.
2. Apply the principles of control engineering techniques to conceptulaize and deliver solutions pertaining to industrial, environmental and social problems.
3. Analyze the process simulation and to compare the simulation results with reference to its influence on classification and function.
4. Construct models and simulate them with the skills to carry out evaluation of the convntional models.
5. Write a simple research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	-	2	2	2	-	3	3
CO 2	2	3	3	3	3	3	3	3	3	-	3	3
CO 3	2	2	2	-	2	1	2	2	2	-	2	1
CO 4	2	2	2	-	3	3	3	3	3	3	3	3
CO 5	2	3	3	3	3	-	3	3	3	3	3	3

COURSE CONTENT

UNIT I: 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.

UNIT II: Mathematical models for Biochemical engineering systems - continuous flow tanks-enclosed enclosed vessel-mixing vessel - mixing vessel mixing with reaction - reversible reaction. Steam jacketed vessel - boiling of single component liquid-open and closed vessel-continuous boiling system – batch distillation

UNIT III: Introduction to SuperPro Designer for Material and Energy Balance with and without reaction.

UNIT IV: Basics-Data analysis-curve fittings, Numerical integration, Euler and fourth order RungeKutta method, Input and Output in MATLAB.

UNIT V: Solving problems using MATLAB by numerical integration, Euler and fourth order Runge Kutta methods. Simulation - Simulation of gravity flow tank – Simulation of CSTR in

series- Simulation of non isothermal CSTR Simulation of batch reactor using MATLAB, SIMULINK for dynamic systems.

PRACTICALS

1. Material Balance without Reaction using superpro designer
2. Material Balance with Reaction using superpro designer
3. Energy Balance using superpro designer
4. Solving Linear equations using MATLAB
5. Solving polynomial equations using MATLAB
6. Optimization Techniques using MATLAB
7. Parameter Estimation in kinetics using MATLAB
8. Modeling of Batch, Fed Batch and Continuous using Berkeley Madonna software
9. Simulation of Batch Reactor by SIMULINK
10. Simulation of Continuous Reactor by SIMULINK

BOOKS/REFERENCE

1. Luben W.L. "Process Modeling 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.
5. Kenneth J. Beers. "Numerical Methods for Chemical Engineering Applications in MATLAB®", Massachusetts Institute of Technology, Cambridge University press 2007 edition
6. http://www.mathworks.com

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD11	**BIOPROCESS PLANT DESIGN**	**3L- 0T- 2P**	**BTBCC01**

COURSE OUTCOMES (CO)

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

1. Understand basic principles and methodologies of plant equipments and anciallary in order to manipulate a functional plant design.
2. Apply the principles of process economics to conceptulaize and deliver solutions pertaining to industrial, environmental and social problems.
3. Analyze the structure of bioprocess plant design with reference to its influence on classification, function and solubility.
4. Construct process equipments for various bioporocess operations along with the skills to carry out process dynamics and control.
5. Write a simple research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	-	2	2	2	-	3	3
CO 2	2	3	3	3	3	3	3	3	3	3	3	3
CO 3	2	1	2	2	2	-	2	2	2	-	-	2
CO 4	2	2	2	-	3	3	3	3	3	3	3	3
CO 5	1	2	3	3	3	-	3	3	3	3	3	3

COURSE CONTENT

UNIT I: General design information; Mass and energy balance; Flow sheeting; Piping and instrumentation

UNIT II: Mechanical design of process equipment; Vessels for biotechnology applications; Design of fermenters

UNIT III: processing equipment; Selection and specification of equipment for handling fluids and solids;

UNIT IV: specification and design of heat and mass transfer equipment used in bioprocess industries; Design of facilities for cleaning of process equipment used in biochemical industries;

UNIT V: For biotechnology production plants; Process economics; Bioprocess validation; Safety considerations; Environmental assessment of industrial bioprocesses; Basic concepts in automation, Case studies.

PRACTICALS

Design of the complete process plant for an identified product or service.

BOOKS/REFERENCE

1. Applied Process Design for Chemical and Petrochemical Plants by E.E. Ludwig. Publisher: Butterworth-Heinemann.
2. Chemical Engineering by R.K. Sinnott, J.M. Coulson and J.F. Richardsons. Publisher: Butterworth-Heinemann.
3. Chemical Engineers Handbook by R.H. Perry and D.W. Green. Publisher: McGraw-Hill.
4. Manufacturing Facilities Design and Material Handling by F.E. Meyers and M.P. Stephens. Publisher: Prentice Hall.
5. Plant Design and Economics for Chemical Engineers by M. Peters and K. Timmerhaus. Publisher: McGraw-Hill.
6. Process Plant Layout and Piping Design by E. Bausbacher and R. Hunt. Publisher: Prentice Hall PTR.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD33	**COMPUTATIONAL BIOLOGY**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

1. To know the database, resources and tools of computational biology.
2. To understand how networks, algorithms, and models are employed in biological systems.
3. To learn to apply computational methods to solve problems in modern molecular biology.
4. To learn, apply computational tools for understanding the flow of genetic information and be able to analyze the results.
5. To learn to apply and evaluate different computational tools for understanding the functioning of organisms.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	1	1	1	3	2	1	2
CO 2	3	3	2	3	3	1	2	1	2	-	1	2
CO 3	2	2	2	3	3	-	-	3	1	-	-	2
CO 4	3	3	3	3	3	-	-	3	1	-	1	1
CO 5	2	3	3	3	3	1	1	3	1	-	1	-

COURSE CONTENT

UNIT I: Molecular sequences, Genome sequencing: pipeline and data, Next generation sequencing data, Biological databases: Protein and Nucleotide databases, Sequence Alignment, Dynamic Programming for computing edit distance and string similarity, Local and Global Alignment, Needleman Wunsch Algorithm, Smith Waterman Algorithm, BLAST family of programs, FASTA algorithm, Functional Annotation, Progressive and Iterative Methods for Multiple sequence alignment, Applications.

UNIT II: Introduction to Phylogenetics, Distance and Character based methods for phylogenetic tree construction: UPGMA, Neighbour joining, Ultrametric and Min ultrametric trees, Parsimonous trees, Additive trees, Bootstrapping.

UNIT III: Protein Structure Basics, Visualization, Prediction of Secondary Structure and Tertiary Structure, Homology Modeling, Structural Genomics, Molecular Docking principles and applications, Molecular dynamics simulations.

UNIT IV: Machine learning techniques: Artificial Neural Networks and Hidden Markov Models: Applications in Protein Secondary Structure Prediction and Gene Finding, Introduction to Systems Biology and its applications in whole cell modeling, Microarrays and Clustering techniques for microarray data analysis, informatics in Genomics and Proteomics, DNA computing.

UNIT V: Variables, Data types, control flow constructs, Pattern Matching, String manipulation, arrays, lists and hashes, File handling, Programs to handle biological data and parse output files

for interpretation.

BOOKS/REFERENCE

1. Dan Gusfield. Algorithms on Strings Trees and Sequences, Cambridge University Press.
2. David W. Mount Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, Second Edition, 2004.
3. Arthur M. Lesk, Introduction to Bioinformatics by Oxford University Press, 2008.
4. Tisdall, James, Beginning PERL for Bioinformatics, O'Reilley Publications, 2001.
5. Andrew R. Leach, Molecular Modeling Principles and Applications, Second Edition, Prentice Hall.
6. Baldi, P., Brunak, S. Bioinformatics: The Machine Learning Approach, 2nd ed., East West Press, 2003

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD34	**COMPUTATIONAL FLUID DYNAMICS**	**3L- 1T- 0P**	**BTBCC 01**

COURSE OUTCOMES (CO)

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

1. Understand basic principles of computational fluid dynamics in order to manipulate a given property (state and path funcution) for the desired function.
2. Apply the principles of computational fluid dynamics to conceptulaize and deliver solutions pertaining to industrial, environmental and social problems.
3. Analyze the application of computational fluid dynamics with reference to its influence on system reliability and stress dealing nature.
4. Development of model using numerical methods.
5. Write a simple research proposal, business plan, and market analysis on the current and updated modern tools and technologies for a biotechnology invention and sustainable development.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	2	3	-	2	2	2	2	2	2
CO 2	2	2	2	2	2	-	2	-	-	1	-	1
CO 3	2	2	2	-	3	3	3	3	3	3	3	3
CO 4	2	2	2	2	2	3	3	3	3	3	3	3
CO 5	1	3	3	3	3	1	3	3	1	-	3	3

COURSE CONTENT

UNIT I: Basic equations of fluid dynamics, Physical Classification of fluid dynamics problems,

UNIT II: Well posed problems. Initial value methods, Finite Difference Methods, Integration method, Theta Metod, Finite element method (Galerkin and Collocation). Panel method for compressible subsonic and supersonic flow.

UNIT III: Governing Equations**,** Conservation Equations, Direct Numerical Simulation, Large-Eddy-Simulation, Time-Averaged Equations for Turbulent Flow

UNIT IV: Reynolds Stress Equations, Turbulence Modeling, The Role of Walls

UNIT V: Wall Functions, Renormalization Group k- Models, Low-Reynolds-Number k-Models, Finite Volume Method, SIMPLE Algorithm, Advanced Discretization Methods and Numerical Schemes Solution Procedure: Differencing Scheme, Numerical Diffusion,Relaxation Factors, Convergence

BOOKS/REFERENCE

1. Ferziger J.H. & Peric M. (1999) Computational Methods for Fluid Dynamics, Springer, Berlin, Germany.
2. Hirsch C. (1988) Numerical Computation of Internal and External Flows, John Wiley &

Sons, New York, USA.
3. Patankar S.V. (1980) Numerical Heat Transfer and Fluid Flow, Hemisphere, Washington D.C., USA.
4. Versteeg H.K. & Malalsekera W. (1995) An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Longman Scientific & Technical, Harlow, Essex, UK.
5. Anderson J.D. (1995) Computational Fluid Dynamics: The Basics with Applications, McGraw-Hill, Inc.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD12	**Animal Cell Technology**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. Students will learn tools and techniques used for culturing mammalian cells, tissues and organs.
2. Students will be able to apply techniques for characterization of cell lines including authentication and stability of cell lines as well as long term maintenance and storage of cell lines.
3. Students will analyze the requirements of transgenic technology for production of improved animals for production of important metabolites to be used in healthcare and medicine.
4. Students will be able to evaluate the potential of animal cells as biofactories and stem cells for studying developmental biology along with the reactors used for cultivation and production.
5. Students will understand the financial, social, ethical and IPR issues related to Animal biotechnology.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	-	3	1	1	-	1	1
CO 2	2	2	2	3	3	1	3	3	3	-	3	3
CO 3	2	3	3	3	3	-	3	3	3	3	3	3
CO 4	1	3	3	3	3	-	3	3	1	-	3	3
CO 5	3	1	-	-	3	3	2	3	3	3	3	3

COURSE CONTENT

Unit I: Introduction to Animal Biotechnology and Historical perspectives, Requirements of Animal tissue Culture: Laboratory design, equipments used for Animal tissue culture, nutrient media, Natural and artificial media, Serum and other supplements, Sterilization methods

Unit II: Development of primary culture, Primary and secondary cell culture, Establishment of cell lines, Transformed cell lines, Characterization of cell lines: Authentication of cell lines, Identification of cell type, Stability of cell lines and application of established cell lines, Organ culture technique, Immobilized cell cultures, Germplasm Conservation, Bioreactors for animal cell cultivation

Unit III: Stem Cell Culture: Principle, development, characterization and application of stem cell cultures, Nuclear Transfer and iPSC's, In vitro fertilization and embryo transfer, somatic cell hybridization, hybridoma technology, Applications of Animal cell culture for production of important metabolites.

Unit IV: Vectors, gene transfer methods – microinjection, virus mediated and other methods of gene transfer, targeted gene transfer, molecular characterization of transforments Transgenic animals with new traits, transgenic animals as bioreactors for producing pharmaceutically important compounds and therapeutic etc. Bioethical issues related to animal biotechnology

Unit V: Current topics in cell culture research, case studies

PRACTICALS

1. To prepare and sterilize L-15 media for animal cell culture (Incomplete culture medium)
2. To prepare heat inactivated serum for preparation of complete cell culture medium
3. To count viable cells using haemocytometer.
4. Development of Primary cell culture
5. To carry out trypsinization of adherent monolayer and subculture cells from primary culture.
6. To carry out cryopreservation of cells from secondary cell culture
7. To demonstrate role of serum in cell culture
8. To culture and subculture suspension cell lines
9. To observe cytotoxicity in cells using MTT assay
10. Mycoplasma testing in cell culture

BOOKS/REFERENCE

1. Animal Cell Biotechnology: R.E. Spier and J.B Griffiths (1988), Academic press.
2. Animal cell culture – A Practical approach by J.R.W. Masters. Publisher : Oxford.
3. Animal Cell Culture Techniques by M. Clynes. Publisher : Springer Verlag.
4. Cell culture LabFAx by M. Butler and M. Dawson. Publisher: Bios scientific Publications Ltd.
5. Cell Growth and Division – A Practical approach by R.Basega. Publisher: IRL Press.
6. Culture of Animal Cells by R.I. Freshney. Publishers : Wiley-Leiss.
7. Living resources for Biotechnology, Animal cells: A Doyle,R.Hay and B.E. Kirsop (1990), Cambridge University Press, Cambridge.
8. Animal Biotechnology: Murray Moo-Young (1989), Permagon Press, Oxford.
9. Ranga, M. M Animal Biotechnology.
10. Srivastava, A.K.-Animal Biotechnology.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD13	**BIOLOGICAL WASTE TREATMENT**	**3L- 0T- 2P**	**BTBCD04**

COURSE OUTCOMES (CO)

1. Understand the difference and spectrum of biological waste than other waste materials.
2. Apply the aspects and principles of Solid waste management.
3. Analyze the aspects and principles of Hazardous waste management.
4. To evaluate different wastewater management strategies.
5. To be able to design and create waste management strategies for effective biological waste treatment.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	2	2	2	2	2	-	2	1	-	-	1	1
CO 2	2	2	2	-	3	3	3	3	3	3	3	3
CO 3	2	3	3	3	3	-	3	2	2	2	3	3
CO 4	1	3	3	3	3	-	3	3	-	-	3	3
CO 5	2	2	2	2	2	3	3	3	3	3	3	3

COURSE CONTENT

UNIT I: Waste Definition, Types of biological waste, Source and characteristics of waste, physical and chemical methods of waste treatment, Effects, Management Options and Future of waste treatment methods

UNIT II: Design of Transfer and Transport Facilities, Landfilling, Types and objectives of material recovery systems.

UNIT III: Principles and Design of Waste Minimization Facilities, Principles and Design of Hazardous Waste Landfills, Principles and Design of Hazardous Waste Storage Facilities, Principles and Design of Radioactive Waste Treatment/Site Remediation

UNIT IV: Measurement of Wastewater, Bioprocess kinetics applied to waste treatment. Theory of activated sludge process, design, operation and control, BOD reduction and biomass relationship, modifications, stabilization ponds, operational and design aspects. Anaerobic treatment systems. Sludge digestion theory, digester design, high rate digestion, heat transfer in digester. Operation and design features of trickling filters, Upflow Anaerobic Sludge Blanket Reactor (UASB) and Rotating Biological Contractor (RBC), Dynamics of mixed microbial culture, fixed film reactors, Nitrification-denitrification, Phosphorous removal. Treatment and disposal of waste of the industries e.g. distilling and brewing, antibiotics etc.

UNIT V: Management of Regulated Medical Waste practice worldwide, Law of waste management in India and international (USA, EU), The Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008, Bio-Medical Waste (Management and Handling) Rules, 1998.

PRACTICALS

1. Handling and Sterilization of waste material.
2. Characterization of municipal solid waste (Total solid, Moisture, pH , Ash)
3. Microbiology of Air, water and soil
4. Animal Carcass Disposal Procedures
5. Estimation of COD of waste water
6. Estimation of BOD of waste water
7. Estimation of heavy metals in municipal solid waste
8. Coliform MPN Test
9. Water Quality Monitoring

BOOKS/REFERENCE

1. Handbook of Solid Waste Management, Kreith, F. (Editor in Chief),
2. Solid Wastes Engineering Principles Technologies, G., Theisen, H., and Eliassen, R.
3. Introduction to Hazardous Incineration, Theodore, L., Reynolds, J. P.
4. Standard Handbook of Hazardous Waste Treatment and Disposal, Freeman, H. M.
5. Hazardous Waste Management, Wentz, C. A.
6. Waste Minimization Through Process Design. Rossiter, A. P. (Editor)
7. Wong, J., Nolan, G. L., Design of Remediation Systems, Lewis Publishers, Inc. (1997).
8. Berlin, R. E., Stanton, C. C., Radioactive Waste Management, John Wiley & Sons (1989).

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD14	**FOOD SCIENCE AND ENGINEERING**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. To learn about different Structure and composition of fruit and vegetables.
2. To understand the Physiology and biochemistry of fruit and vegetables.
3. To compare and analyze different strategies of preservation of food.
4. To evaluate different Thermal and Mechanical Properties of Foods.
5. To understand the rules and regulations related to Food safety and Hygiene.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	1	-	1	-	1	2	-	-
CO 2	3	3	3	3	1	-	1	-	1	2	1	-
CO 3	1	3	3	3	3	1	3	1	1	-	3	3
CO 4	1	3	3	3	3	1	3	3	2	2	3	3
CO 5	3	1	1	-	3	-	3	3	3	1	3	-

COURSE CONTENT

UNIT I: Structure and composition of fruit and vegetables: Definition, cellular components, chemical composition and nutritional value Post harvest handling, physiological development; growth, maturation and senescence, fruit ripening, physiology of respiration, effect and role of ethylene, biochemistry of respiration; aerobic and anaerobic metabolism, chemical changes during maturation.

UNIT II: Engineering properties of natural and processed food, Rheology and Texture analysis, heat and mass transfer in food processing.

UNIT III: Thermal processing of foods: Lethality requirement and assessing the adequacy of a thermal process, Blanching: functions, disadvantages and ways of minimizing them, Pasteurization: Batch and continuous. Commercial sterilization of foods: Conventional canning process, batch and continuous retards. Aseptic processing

UNIT IV: Non Thermal Processesing of foods: cold storage, high pressure preservation, Radiation based methods etc.

UNIT V: HACCP Systems: General standards for contaminants and toxins in foods, General principles for the use of food additives in foods, Analysis of pesticide residues. Food safety and regulatory methods: Indian Scenario

PRACTICALS

1. Determination of moisture content of foods by oven drying and distillation methods.
2. Determination of Total and Acid insoluble ash content in foods.
3. Determination of Crude fat content by solvent extraction methods in foods.

4. Determination of crude Protein foods by Kjeldhal methods.
5. Determination of reducing and total sugar content in foods.
6. Determination of crude fiber content in foods.
7. Determination of specific vitamin content of food such as ascorbic acid, Carotenes etc.
8. Determination of specific added food Preservatives in foods.
9. To determine nutritive value of food material by use of Bomb Calorimeter.
10. To characterize the type of fluids using viscometer.

BOOKS/REFERENCE

1. Food Product Development by Chicago: Arlington
2. Guidelines for Sensory Analysis in Food Product Development and Quality Control By David H. Lyon, Mariko A. Francombe, Terry A. Hasde
3. Food Technology By Barbara Mottershead, Lesley Woods
4. Food Technology By Jill Robinson
5. Preservation of Fruits and Vegetables G.Lal, G.S.Siddappa & G.L.Tondan
6. Hand book of analysis and quality control for fruit and vegetable products, by S. Ranganna,
7. The chemical analysis of foods and food products, by Morris B. Jacobs
8. Modern Food Microbiology by James M. Jay

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD15	Plant Biotechnology	3L- 0T- 2P	None

COURSE OUTCOMES (CO)

1. Students will learn tools and techniques used for culturing plant cells, tissues and organs.
2. Students will understand the application and advantages of tissue culture technique over classical breeding and would be able to apply the same for crop improvement
3. Students will analyze the requirements of transgenic technology for crop improvement and production of important metabolites to be used in healthcare and medicine.
4. Students will be able to evaluate the potential of plant cells as biofactories along with the reactors used for cultivation and production.
5. Students will understand the financial, social, ethical and IPR issues related to Animal biotechnology.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	3	3	-	3	1	1	-	1	1
CO 2	2	2	2	3	3	1	3	3	3	-	3	3
CO 3	2	3	3	3	3	-	3	3	3	3	3	3
CO 4	1	3	3	3	3	-	3	3	1	-	3	3
CO 5	3	1	-	-	3	3	2	3	3	3	3	3

COURSE CONTENT

Unit I: Introduction to Plant Biotechnology and Historical perspectives, Laboratory design, equipments used for plant tissue culture, nutrient media, Plant Growth regulators, Aseptic environment, Media sterilization,

Unit II: Culture technique and its applications: Isolation of single cells, Plating technique, Callus culture, Clonal Propogation, Shoot bud differentiation and somatic embryogenesis, Somaclonal and Gametoclonal Variation, Wide hybridization, Production and application of Haploids, Protoplast culture and its application, Production of pathogen free plants, Plant secondary metabolites, Germplasm conservation.

Unit III: Genetic engineering in plants: Transformation vectors, Gene transfer using Agrobacterium and viral vectors, Selectable and screenable markers for selection of transformants, Agroinfection, Physical methods of gene transfer, removal of selectable markers from transgenic plants. Chloroplast engineering and transplastomic plants, Gene targeting in plants

Unit IV: Transgenic plants: Transgenic crops with new traits – herbicide tolerance, insect and disease resistance, resistance against abiotic stress – heat, drought, salinity, heavy metals etc. Molecular farming: edible vaccines, antibodies and therapeutics, bioethics of plant genetic

engineering

Unit V: Current topics in plant biotechnology, case studies such as Hydroponics, aeroponics

PRACTICALS

1. To learn Good Cell Culture Practice and aseptic techniques for Plant tissue culture
2. To prepare MS medium and its sterilization
3. To carry out surface sterilization of explants material and check its sterility.
4. To carry out micropropagation using plant leaf explants
5. To demonstrate *in vitro* organogenesis in plants
6. To initiate Callus propagation using meristem tissue.
7. To demonstrate indirect organogenesis in plants
8. To establish suspension cell culture
9. To carry out anther culture for haploid production (androgenesis).
10. To carry out somatic embryogenesis using carrot explant
11. To carry out protoplast isolation and culture.
12. To prepare artificial seeds

BOOKS/REFERENCE

1. Plant Biotechnology and Transgenic Plants by K.M.O. Caldentey, W.H. Barz and H.L. Willis. Publisher: Marcel Dekker.
2. Plant Biotechnology by J. Hammond, P. McGarvy and V. Yusibov. Publisher: Springer Verlag.
3. Plant Biotechnology in Agriculture (Biotechnology Series) by K. Lindsey and M.G.K. Jones. Publisher: Prentice Hall.
4. Plant Cell and Tissue culture for the Production of Food Ingredients by T-J Fu, G. Singh and W.R. Curtis. Publisher: Kluwer Academic/ Plenum Press.
5. Plant Cell Tissue and Organ Culture by O.L. Gamborg and G.C. Phillips. Publishers: Narosa Publications.
6. Plant Tissue Culture: Theory and Practice by S.S. Bhojwani and M.K. Razdan. Publisher: Elsevier Health Sciences.
7. Plants, Genes and Crop Biotechnology by M.J. Chrispeels, D.E. Sadava and M.J. Chrispeels. Publisher: Jones and Bartlett Publications.
8. Practical Application of Plant Molecular Biology by R.J. Henry. Publisher: Chapman and Hall.

Course No	Title of the Course	Course Structure	Prerequisite
BTBCD35	**METABOLIC REGULATION AND ENGINEERING**	**3L- 1T- 0P**	**BTBCD 01**

COURSE OUTCOMES (CO)

1. Learn the application of metabolic engineering for real industrial scale processes.
2. Understand the microbial metabolic pathways and their analysis.
3. Apply the principles of metabolic engineering for overproduce the desired products.
4. Analyze regulation of metabolic pathways and its application in bioprocess engineering.
5. Evaluate the genetic engineering techniques in metabolic regulation and engineering.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	3	2	3	-	2	2	2	2	2	2
CO 2	2	2	2	2	2	1	2	1	-	-	1	1
CO 3	2	2	2	-	3	3	3	3	3	3	3	3
CO 4	2	3	3	3	3	-	3	1	2	2	3	3
CO 5	1	3	3	3	3	-	3	3	1	-	3	3

COURSE CONTENT

UNIT I: Metabolic pathway synthesis of small molecules; key crossroads and branch points in metabolic pathways

UNIT II: Regulation of the synthesis of enzymes, control of metabolic pathway by regulatory enzymes, Control of enzyme activity-proteolysis, covalent modification and ligand binding; Control of protein synthesis by induction and repression; Regulation of a few major metabolic pathways relevant to bioprocesses industries;

UNIT III: Metabolic pathway synthesis. Metabolic control theory and metabolic flux analysis, and their applications;

UNIT IV: Application of gene cloning in redirecting cellular metabolism for over-production of a desired metabolites; Strategies to overcome regulatory mechanisms for hyper production of primary and secondary metabolites such as enzymes, amino acids, alcohols, anti-oxidants, organic acids and antibiotics.

UNIT V: Case studies on metabolic engineering.

BOOKS/REFERENCE

1. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation/ Noyes Publications.
2. Principles of Fermentation Technology by P.F. Stanbury and A. Whitaker. Publisher: Pergamon Press.
3. Process Engineering in Biotechnology by A.T. Jackson. Publisher: Prentice Hall.
4. Stephanopoulos, G.N. "Metabolic Engineering: Principles and Methodologies".

Academic Press / Elsevier, 1998.
5. Lee, S.Y. and Papoutsakis, E.T. “Metabolic Engineering”. Marcel Dekker, 1998.
6. Nielsen, J. and Villadsen, J. “Bioreaction Engineering Principles”. Springer, 2007.
7. Christiana D. Smolke, “ The Metabolic Pathway Engineering Handbook Fundamentals”, CRC Press Taylor & Francis Group, 2010.

M. TECH. (BIOCHEMICAL ENGINEERING)

SYLLABUS FOR OPEN ELECTIVES

Course No	Title of the Course	Course Structure	Prerequisite
EO001	Business Analytics	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

1. Understand the role of business analytics within an organization.
2. Analyze data using statistical and data mining techniques and understand relationships between the underlying business processes of an organization.
3. To gain an understanding of how managers use business analytics to formulate and solve business problems and to support managerial decision making.
4. To become familiar with processes needed to develop, report, and analyze business data.
5. Use decision-making tools/Operations research techniques.
6. Mange business process using analytical and management tools.
7. Analyze and solve problems from different industries such as manufacturing, service, retail, software, banking and finance, sports, pharmaceutical, aerospace etc.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	-	-	-	3	-	3	-	-	-	-
CO 2	3	3	3	3	3	-	-	2	1	-	1	2
CO 3	3	2	3	3	-	3	2	-	-	-	3	-
CO 4	3	2	1	-	3	-	-	-	-	3	-	-
CO 5	-	-	3	3	3	-	-	-	3	-	3	-
CO 6	3	3	3	3	3	-	-	-	-	-	-	-
CO 7	-	3	3	-	3	-	3	-	-	3	-	3

COURSE CONTENT

Unit1:

Business analytics: Overview of Business analytics, Scope of Business analytics, Business Analytics Process, Relationship of Business Analytics Process and organisation, competitive advantages of Business Analytics.

Statistical Tools: Statistical Notation, Descriptive Statistical methods, Review of probability distribution and data modelling, sampling and estimation methods overview.

Unit 2:

Trendiness and Regression Analysis: Modelling Relationships and Trends in Data, simple Linear Regression.

Important Resources, Business Analytics Personnel, Data and models for Business analytics, problem solving, Visualizing and Exploring Data, Business Analytics Technology.

Unit 3:

Organization Structures of Business analytics, Team management, Management Issues, Designing Information Policy, Outsourcing, Ensuring Data Quality, Measuring contribution of Business analytics, Managing Changes.

Descriptive Analytics, predictive analytics, predicative Modelling, Predictive analytics analysis, Data Mining, Data Mining Methodologies, Prescriptive analytics and its step in the business analytics Process, Prescriptive Modelling, nonlinear Optimization.

Unit 4:

Forecasting Techniques: Qualitative and Judgmental Forecasting, Statistical Forecasting Models, Forecasting Models for Stationary Time Series, Forecasting Models for Time Series with a Linear Trend, Forecasting Time Series with Seasonality, Regression Forecasting with Casual Variables, Selecting Appropriate Forecasting Models. Monte Carlo Simulation and Risk Analysis: Monte Carle Simulation Using Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model. Analytic Solver Platform, New-Product Development Model, Newsvendor Model, Overbooking Model, Cash Budget Model.

Unit 5:

Decision Analysis: Formulating Decision Problems, Decision Strategies with the without Outcome Probabilities, Decision Trees, The Value of Information, Utility and Decision Making.

Unit 6:

Recent Trends in: Embedded and collaborative business intelligence, Visual data recovery, Data Storytelling and Data journalism.

BOOKS/REFERENCE

Business analytics Principles, Concepts, and Applications by Marc J. Schniederjans, Dara G. Schniederjans, Christopher M. Starkey, Pearson FT Press.

Business Analytics by James Evans, persons Education.

Course No	Title of the Course	Course Structure	Prerequisite
EO002	Industrial Safety	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

1.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1												
CO 2												
CO 3												
CO 4												
CO 5												

COURSE CONTENT

Unit-I: Industrial safety: Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

Unit-II: Fundamentals of maintenance engineering: Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

Unit-III: Wear and Corrosion and their prevention: Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

Unit-IV: Fault tracing: Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

Unit-V: Periodic and preventive maintenance: Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv.

Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

BOOKS/REFERENCE

1. Maintenance Engineering Handbook, Higgins & Morrow, Da Information Services.
2. Maintenance Engineering, H. P. Garg, S. Chand and Company.
3. Pump-hydraulic Compressors, Audels, Mcgrew Hill Publication.
4. Foundation Engineering Handbook, Winterkorn, Hans, Chapman & Hall London.

Course No	Title of the Course	Course Structure	Prerequisite
EO003	Operations Research	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

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

1. Students should able to apply the dynamic programming to solve problems of discreet and continuous variables.
2. Students should able to apply the concept of non-linear programming
3. Students should able to carry out sensitivity analysis
4. Student should able to model the real world problem and simulate it.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	3	2	3	-	-	-	-	-	-	-
CO 2	3	2	3	2	3	-	-	-	3	-	-	-
CO 3	3	2	3	2	3	-	-	-	2	-	-	-
CO 4	3	3	3	3	3	1	2	3	1	1	2	-

COURSE CONTENT

Unit 1:
Optimization Techniques, Model Formulation, models, General L.R Formulation, Simplex Techniques, Sensitivity Analysis, Inventory Control Models

Unit 2
Formulation of a LPP - Graphical solution revised simplex method - duality theory - dual simplex method - sensitivity analysis - parametric programming

Unit 3:
Nonlinear programming problem - Kuhn-Tucker conditions min cost flow problem - max flow problem - CPM/PERT

Unit 4
Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models - Geometric Programming.

Unit 5
Competitive Models,Single and Multi-channel Problems, Sequencing Models, Dynamic Programming, Flow in Networks, Elementary Graph Theory, Game Theory Simulation

BOOKS/REFERENCE

1. H.A. Taha, Operations Research, An Introduction, PHI, 2008
2. H.M. Wagner, Principles of Operations Research, PHI, Delhi, 1982.
3. J.C. Pant, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Hitler Libermann Operations Research: McGraw Hill Pub. 2009
5. Pannerselvam, Operations Research: Prentice Hall of India 2010
6. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010

Course No	Title of the Course	Course Structure	Prerequisite
EO004	Cost Management of Engineering Projects	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

1.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1												
CO 2												
CO 3												
CO 4												
CO 5												

COURSE CONTENT

Unit I: Introduction and Overview of the Strategic Cost Management Process Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost. Objectives of a Costing System; Inventory valuation; Creation of a Database for operational control; Provision of data for Decision-Making.

Unit II: Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities. Detailed Engineering activities. Pre project execution main clearances and documents

Unit III: Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram.

Unit IV: Project commissioning: mechanical and process Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis.

Unit V: Pricing strategies: Pareto Analysis. Target costing, Life Cycle Costing. Costing of service sector. Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Total Quality Management and Theory of constraints. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing. Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, Learning Curve Theory.

BOOKS/REFERENCE

1. Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi
2. Charles T. Horngren and George Foster, Advanced Management Accounting
3. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting
4. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher
5. N.D. Vohra, Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd.

Course No	Title of the Course	Course Structure	Prerequisite
EO005	Composite Materials	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

1.

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1												
CO 2												
CO 3												
CO 4												
CO 5												

COURSE CONTENT

UNIT–I: INTRODUCTION: Definition – Classification and characteristics of Composite materials. Advantages and application of composites. Functional requirements of reinforcement and matrix. Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT – II: REINFORCEMENTS: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers. Properties and applications of whiskers, particle reinforcements. Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures. Isostrain and Isostress conditions.

UNIT – III: Manufacturing of Metal Matrix Composites: Casting – Solid State diffusion technique, Cladding – Hot isostatic pressing. Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving. Properties and applications.

UNIT–IV: Manufacturing of Polymer Matrix Composites: Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding. Properties and applications.

UNIT – V: Strength: Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount

BOOKS/REFERENCE

1. Material Science and Technology – Vol 13 – Composites by R.W.Cahn – VCH, West Germany.
2. Materials Science and Engineering, An introduction. WD Callister, Jr., Adapted by R. Balasubramaniam, John Wiley & Sons, NY, Indian edition, 2007.

3. Hand Book of Composite Materials-ed-Lubin.
4. Composite Materials – K.K.Chawla.
5. Composite Materials Science and Applications – Deborah D.L. Chung.
6. Composite Materials Design and Applications – Danial Gay, Suong V. Hoa, and Stephen W. Tasi.

Course No	Title of the Course	Course Structure	Prerequisite
EO006	Waste to Energy	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

Mapping of PO's with CO's

PO→ / CO↓	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1												
CO 2												
CO 3												
CO 4												
CO 5												

COURSE CONTENT

Unit-I: Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

Unit-II: Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

Unit-III: Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

Unit-IV: Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

Unit-V: Biogas: Properties of biogas(Calorific value and composition), Biogas plant technology and status, Bio energy system, Design and constructional features, Biomass resources and their classification, Biomass conversion processes, Thermo chemical conversion, Direct combustion, biomass gasification, pyrolysis and liquefaction, biochemical conversion, anaerobic digestion, Types of biogas Plants, Applications, Alcohol production from biomass, Bio diesel production, Urban waste to energy conversion, Biomass energy programme in India

BOOKS/REFERENCE

1. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.
2. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.