UNIVERSITY OF DELHI

NETAJI SUBHAS INSTITUTE OF TECHNOLOGY

CHOICE BASED CREDIT SYSTEM

SCHEME OF COURSES
FOR

M. TECH.
(Biochemical Engineering)

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1 This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

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PREAMBLE

I. INTRODUCTION

Higher education is very important for the growth and development of any country. It is a living organ and requires continuous changes to ensure the quality of education. National Knowledge Commission and University Grants Commission have recommended many academic reforms to address the challenges of today's networked globalized world. People are coming together with the help of new technologies which is resulting towards new aspirations, expectations, collaborations and associations. The concept of "work in isolation" may not be relevant and significant anymore. The UGC guidelines on adoption of Choice Based Credit System may be an important step to revamp the processes, systems and methodologies of Higher Educational Institutions (HEIs). The teacher centric mode be changed to learner centric mode. Class room teaching and learning be made effective; relevant and interesting. Concepts and theories be explained with examples, experimentation and related applications.

A culture of discussions, arguments, interpretations, counter-interpretations, re-interpretations, opposing interpretations must be established. Research should not only be confined to redefinition, extension and incremental change. Innovation & creativity should become an epicentre for all research initiatives. The most important capital is the human capital and thus the ultimate objective is to develop good human beings with utmost integrity & professionalism for this new world.

The Choice Based Credit System supports the grading system which is considered to be better than conventional marks system. It is followed in many reputed institutions in India and abroad. The uniform grading system facilitates student mobility across the institutions within and across the countries and also enable potential employers to assess the performance of the students. The Choice Based Credit System makes the curriculum interdisciplinary and bridge the gap between professional and liberal education.

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

The Bio chemical 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.

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- Attain careers as practicing biochemical engineers in fields such as pharmaceuticals, microelectronics, chemicals, polymers/advanced materials, food processing, energy, biotechnology, or environmental engineering;
- Attain advanced studies in disciplines such as Biochemical Engineering, Environmental Engineering, Medicine, Law, or Business;
- Assume professional leadership roles.
- Foster a personalized, supportive environment for all students by taking advantage of the unique combination of a small college atmosphere in a major research university;
- Enrich the undergraduate experience through cultural diversity and international opportunities or experiential learning;
- Provide a solid foundation and understanding of the fundamental principles of mathematics, science, and engineering;
- Provide students with experience in learning and applying tools (e.g., computer skills) to solve theoretical and open-ended Biochemical Engineering problems;
- Provide students with opportunities to participate in multidisciplinary teams and to develop and practice written and oral communication skills, both within the team and to a broader audience;
- Provide students with opportunities to design and conduct Biochemical Engineering experiments and to design systems, components, and chemical processes to meet specific needs and constraints;
- Provide a contemporary grounding in professional responsibility, including ethics, the global and societal impact of engineering decisions, and the need for lifelong learning.

II. CHOICE BASED CREDIT SYSTEM

The Indian Higher Education Institutions have been moving from the conventional annual system to semester system. Currently many of the institutions have already introduced the choice based credit system. The semester system accelerates the teaching-learning process and enables vertical and horizontal mobility in learning. The credit based semester system provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching. The choice based credit system provides a 'cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an

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interdisciplinary approach to learning. It is desirable that the HEIs move to CBCS and implement the grading system.

A. Types of Courses

Courses are the subjects that comprise the M.Tech. programme.

1. A course may be designed to comprise lectures, tutorials, laboratory work, field work, outreach activities, project work, vocational training, viva, seminars, term papers, assignments, presentations, self-study etc. or a combination of some of these components.

2. The learning objectives and learning outcomes of each course will be defined before the start of a semester.

3. Courses are of two kinds: Core and Elective.

i. **Core Course (CC)**: This is a course which is to be compulsorily studied by a student as a core requirement to complete the requirement of M.Tech in Biochemical Engineering.

ii. **Elective Course**: An elective course is a course which can be chosen from a pool of subjects. It's intended to support the discipline of study by providing an expanded scope, enabling exposure to another discipline/domain and nurturing a student's proficiency/skill. An elective may be of following types:

a) **Discipline Centric Elective (ED)**: It is an elective course that adds proficiency to the students in the discipline.

b) **Open Elective (EO):** It is an elective course taken from other engineering disciplines that broadens the perspective of an Engineering student.

4. Each course contributes certain credits to the programme. A course can be offered either as a full course (4 credits) or as a half course (2 credits). A full course is conducted with 3 hours of lectures and either 1 hour of tutorial or 2 hours of practical work per week. A half course is conducted with 2 hours of lectures.

5. A student of Postgraduate programme has to accumulate about 40% credits from the Core Courses and the remaining credits from the Elective Courses to become eligible for the award of degree/ diploma/ certificate programme.

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6. A course (full/half) may also be designed without lectures or tutorials. However, such courses may comprise Field work, Outreach activities, Project work, Vocational Training, Seminars, Self-study etc. or a combination of some of these.
7. A Project work/Dissertation is considered as a special course involving application of the knowledge gained during the course of study in exploring, analyzing and solving complex problems in real life applications. A candidate completes such a course on his own with an advisory support by a teacher/faculty member.

B. Examination and Assessment

The following system will be implemented in awarding grades and CGPA under the CBCS system.

1. **Letter Grades and Grade Points:** A 10-pointgradingsystem shall be used with the letter grades as given in Table 1 below:

Table1: Grades and Grade Points

Letter Grade	Grade point
O (Outstanding)	10
A+ (Excellent)	9
A (Very Good)	8
B+ (Good)	7
B (Above average)	6
C (Average)	5
P (Pass)	4
F (Fail)	0
Ab (absent)	0

2. **Fail grade:** A student obtaining Grade F shall be considered failed and will be required to reappear in the examination. If the student does not want to reappear in an elective subject (that is ED, EO but not CC courses) then he/she can re-register afresh for a new elective subject.
3. **Non-credit course:** For non credit courses, 'Satisfactory' or "Unsatisfactory' shall be indicated instead of the letter grade and this will not be counted for the

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computation of SGPA/CGPA. However, a student must get satisfactory to get the degree.

4. **Fairness in Assessment:** The CBCS promotes continuous evaluation system where end semester examinations weightage should not be more than 60%. The Departments should design their own methods for continuous evaluation. They have the flexibility and freedom in designing the examination and evaluation methods that best fits the curriculum, syllabi & teaching, learning methods. In this regard, the checks and balances be implemented which would enable the Departments to carry out the process of assessment and examination effectively and fairly.
5. **Computation of SGPA and CGPA:** The following procedure shall be used to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA):
   i. The SGPA is the ratio of sum of the product of the number of credits and the grade points scored in all the courses of a semester, to the sum of the number of credits of all the courses taken by a student,that is:

$$SGPA(S_i) = \frac{\sum C_j \times G_j}{\sum C_j}$$

   Where S_i is the i^{th} semester, C_j is the number of credits of the j^{th} course of that semester and G_j is the grade point scored by the student in the j^{th} course.

   ii. The CGPA is also calculated in the same manner taking in to account all the courses taken by a student over all the semesters of a programme, that is:

$$CGPA = \frac{\sum C_i \times SGPA(S_i)}{\sum C_i}$$

   Where SPGA ($S_{i)}$ is the SGPA of the i_{th} semester and C_i is the total number of credits in that semester.

   iii. The SGPA and CGPA shall be rounded ff to 2 decimal points and reported in the transcripts.

   iv. CGPA shall be converted into percentage of marks, if required, by multiplying CGPA with 10.

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III. PROGRAMME STRUCTURE

1. The M.Tech. Biochemical Engineering programme spans 4 semesters, normally completed in 2 years.
2. The courses offered in each semester are given in the **Semester-wise Course Allocation.**
3. The discipline centric subjects under CC and ED categories are listed for each discipline separately.
4. A course may have pre-requisite courses that are given in the **Semester-wise Course Allocation**. A student can opt for an elective only if he/she has fulfilled its pre-requisites.
5. A student has to register for all electives before the start of a semester.

IV. COURSE CODIFICATION

The codes for various Postgraduate Programme are as follows:

i. Department of Electronics and Communication Engineering:
   1. Signal Processing-ECSP
   2. Embedded System and VLSI-ECES

ii. Department of Computer Engineering:
   1. Information System-COIS

iii. Department of Instrumentation and Control Engineering:
   1. Process Control-ICPC
   2. Industrial Electronics-ICIE
   3. Mechatronics-ICMT

iv. Department of Biotechnology:
   1. Biochemical Engineering –BTBC
   2. Bioinformatics-BTBF

v. Manufacturing processes and Automation Engineering:
   1. CAD CAM-MACD
   2. Manufacturing process and Automation Engineering.- MAMP
   3. Production Engineering-MAPE
   4. Engineering Management-MAEM
   5. Nanotechnology-MANT

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The codes for Departmental core subjects and Domain-specific Electives are specific to each Discipline. The first two characters are derived from last two letters from Departmental codes listed above.

For I[st] semester, the codes are:

BCC01	CC
BCC02	CC
BCD**	Elective
BCD**	Elective
BCD**	Elective
EO***	Open Elective

For II[nd] semester, the codes are:

BCC03	CC
BCC04	CC
BCD**	Elective
BCD**	Elective
BCD**	Elective
EO***	Open Elective

For III[rd] semester, the codes are:

BCD**	Elective
BCD**	Elective
BCD**	Elective
BCC05	Seminar
BCC06	Major Project

For IV[th] semester, the codes are:

BCC07	Dissertation

*Code as specified in the table 3-4 of discipline centric electives.

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V. EVALUATION SCHEME

The courses are evaluated on the basis of continuous assessments, mid-semester exams and end-semester exams. The weightage of each of these modes of evaluation for the different types of courses are as follows.

Type of Course	CA	Mid Semester Exam (Theory)	End-semester Exam (Theory)	Continuous Assessment (Lab)	End-semester Exam (Lab)
CC/ED/EO Theory with Tutorial	25	25	50	Nil	Nil
CC/ED/EO Theory with Practical	15	15	40	15	15
Major Project and Dissertation	Nil	Nil	Nil	40	60
Online Self Learning Course	50	Nil	50	Nil	Nil

VI. EVALUATION AND REVIEW COMMITTEE

The Committee of Courses and Studies in each department shall appoint one or more Evaluation-cum-Review Committees (ERC), each committee dealing with one course or a group of courses. This ERC consists of all faculty members who are likely to teach such courses in the group. Normally Head of the department shall be ERC Chairman.

The ERC has the following functions-

(i) To recommend appointment of paper setters/examiners of various examinations at the start of each semester.

(ii) To prepare quizzes, assignments, test papers etc. for Continuous Assessment (CA), Mid-Semester examination (MS) and End Semester (ES) examination and to evaluate them. Normally, each concerned faculty member, who is also a member of ERC, will do this job for his/her class. However, in exceptional circumstances any part of the work may be entrusted to some other member of the ERC.

(iii) To consider the individual representation of students about evaluation and take remedial action if needed. After scrutinizing, ERC may alter the grades awarded upward/downward. The decision of the ERC shall be final.

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(iv) To moderate assignments, quizzes etc. for courses given by each of the concerned faculty members for his/her class with a view to maintain uniformity of standards.

(v) To review and moderate the MS and ES results of each course with a view to maintain uniformity of standards.

(vi) To lay guidelines for teaching a course.

VII. ATTENDANCE, PROMOTION AND DETENTION RULES

1. A student should normally attend all the classes. However, a student will be allowed to appear in the examination if he/ she has put in a minimum of 75% attendance separately in each course for which he / she has registered. A relaxation up to a maximum of 25% may be given on the production of satisfactory evidence that (a) the student was busy in authorized activities, (b) the student was ill.
2. A student should submit the evidence to the fact 1(a) and / or 1(b) above within seven working days of resuming the studies. Certificates submitted later will not be considered.
3. No relaxation in attendance beyond 25% is permitted in any case.
4. A student may re-register for a course if he/ she want to avoid a decrement in the grades.
5. There shall be no supplementary examinations. A student who has failed in a course will have to re-register for the course in a subsequent year.
6. If the student does not want to reappear in an elective course (that is, ED, EO, but not CC courses) then he/she can re-register afresh for a new elective course

VIII. DECLARATION OF RESULTS

1. The Mtech (BCE) programme consists of 82 credits. A student will be awarded the degree if he/she has earned all 82 credits.
2. CGPA will be calculated on the basis of the best 78 credits earned by the student.
3. The candidate seeking re-evaluation of a course shall apply for the same on a prescribed pro-forma along with the evaluation fee prescribed by the University from time to time only for the End Semester Examination within seven days from the date of declaration of result.
4. The Institution/University may cancel the registration of all the courses in a given semester if
   i. The student has not cleared the dues to the institution/hostel.
   ii. A punishment is awarded leading to cancellation of the student's registration.

IX. CURRICULUM MODIFICATION

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The curriculum will be updated regularly within a period of 5 to 10 years since last revision to keep pace with the advancements in the field of Biochemical Engineering.

X. CENTRAL ADVISORY COMMITTEE

There shall be a Central Advisory Committee consisting of the following—

a) Dean, Faculty of Technology, Chairman
b) Dean PGS
c) Head of Institution
d) Heads of Departments running M.Tech Courses

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PROGRAM OUTCOMES

a) Each student will have the ability to apply knowledge of mathematics, science and engineering fundamentals.

b) Each student will have the ability to design and conduct experiments, and to analyze and interpret experimental results.

c) Each student will have the ability to design systems, components, or processes to meet specified objectives within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability in Biochemical Engineering.

d) Each student will have the ability to work as a member of multidisciplinary teams, and have an understanding of team leadership.

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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	
BCC01	CC	Bioprocess Principles and Technology	3	0	2	4	15	15	40	15	15	100
BCC02	CC	Enzyme Technology and Applications	3	0	2	4	15	15	40	15	15	100
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	1	0	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
EO***	EO	Open Elective	3	1	0	4	-	-	-	-	-	100
		TOTAL	$			24						

#. The LTP allocation evaluation scheme and Pre-requisites 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.

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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	
BCC03	CC	Bioprocess Analysis and Reactor Design	3	0	2	4	15	15	40	15	15	100
BCC04	CC	Microbial Biochemistry	3	0	2	4	15	15	40	15	15	100
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	1	0	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
EO***	EO	Open Elective	3	1	0	4	-	-	-	-	-	100
		TOTAL	$			24						

#. The LTP allocation evaluation scheme and Pre-requisites 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.

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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	
BCC05	CC	Seminar	0	0	4	2	-	-	-	40	60	100
BCC06	CC	Major Project	0	0	-	6				40	60	100
BCD**	ED	Elective#	3	0	2	4	15	15	40	15	15	100
BCD**	ED	Elective#	3	0	2	4	30	20	50	-	-	100
BCD**	ED	Elective#	-	-	-	4	50	-	50	-	-	100
		TOTAL	$			20						

#. The LTP allocation evaluation scheme and Pre-requisites 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.

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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	
BCC07	CC	Dissertation	0	0	-	14	-	-	-	40	60	100
		TOTAL	-	-	-	14						

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

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	
BCC01	CC	Bioprocess Principles and Technology	3	0	2	4	15	15	40	15	15	100
BCC02	CC	Enzyme Technology and Applications	3	0	2	4	15	15	40	15	15	100
EO***	EO	Open Elective	-	-	-	4	-	-	-	-	-	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	
BCC03	CC	Bioprocess Analysis and Reactor Design	3	0	2	4	15	15	40	15	15	100
BCC04	CC	Microbial Biochemistry	3	0	2	4	15	15	40	15	15	100
EO***	EO	Open Elective	-	-	-	4	-	-	-	-	-	100
		TOTAL	$			12						
$. The actual weekly load will depend upon the electives chosen by the student.												

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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	
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	1	0	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
		TOTAL	$			12						

#. The LTP allocation evaluation scheme and Pre-requisites 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	
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	1	0	4	-	-	-	-	-	100
BCD**	ED	Elective #	3	0	2	4	-	-	-	-	-	100
		TOTAL	$			12						

#. The LTP allocation evaluation scheme and Pre-requisites 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.

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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	
BCC06	CC	Major Project	0	0	-	6	-	-	-	40	60	100
BCD**	ED	Elective#	3	0	2	4	-	-	-	-	-	100
BCD**	ED	Elective#	3	1	0	4	-	-	-	-	-	100
		TOTAL	$			14						

#. The LTP allocation evaluation scheme and Pre-requisites 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	
BCC05	Seminar	0	0	4	2	50	-	50	-	-	100
BCC07	Dissertation	0	0	-	14	-	-	-	40	60	100
BCD**	Elective#	-	-	-	4	50	-	50	-	-	100
	TOTAL	-	-	-	20						

The LTP allocation evaluation scheme and Pre-requisites 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.

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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				
BCD**							
BCD01	Introduction to Biochemical Engineering [1]		None				
BCD02	Thermodynamics of Biological System		None				
BCD03	Concepts in Modern Biology[2]		None				
BCD04	Food Science and Engineering		None				
BCD05	Environmental Biotechnology		None				
BCD06	Biomass processing & Bioenergy		None				
BCD07	Transport phenomena in biological systems		BCE-501/ BCE-503 (Intro to B. E.)				
BCD08	Advance Genetic Engineering		BCE-501/ BCE-503 (Intro to B. E.)				
BCD09	Advance Biochemical Engineering		BCE-501/ BCE-503 (Intro to B. E.)				
BCD10	Animal and Plant Cell Technology		BCE-501, BCE-502				
BCD11	Modeling and Simulation in Biochemical Engineering		BCE-508, BCE-502				
BCD12	Biological Waste Treatment		BCE-505 (Env. BT)				
BCD13	Advance Separation Process		BCE-501, BCE-507				
BCD14	Bioprocess Plant Design		BCE-501, BCE-507				

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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**				
BCD**							
BCD31	Applied Biostatistics		None				
BCD32	Entrepreneurship, IPR and Biosafety		None				
BCD33	Computational Biology		None				
BCD34	Computational Fluid Dynamics		BCE-502				
BCD35	Metabolic Regulations and Engineering		BCE-501/ BCE-503 (Intro to B. E.)				

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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**		**Pre-Requisites**				
EO***							
EO001	Technical Communication		None				
EO002	Disaster Management		None				
EO003	Basics of Finance Management		None				
EO004	Basics of Human Resources Management		None				
EO005	Project Management		None				
EO006	Basics of Corporate Law		None				
EO007	Biological computing		None				
EO008	Basic of social science		None				
EO009	Entrepreneurship		None				
EO010	Social work		None				
EO011	IP and Patenting		None				
EO012	Supply Chain Management-Planning and logistics		None				
EO013	Organization Development		None				
EO014	Industrial Organisation and Managerial Economics		None				
EO015	Global Strategy and Technology		None				
EO016	Engineering System Analysis and Design		None				
EO017	Biology for Engineers		None				
EO018	Energy, Environment and Society		None				
EO019	Public Policy and Governance		None				

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

M. TECH. (BIOCHEMICAL ENGINEERING)

SYLLABUS FOR CORE COURSES

Course No	Title of the Course	Course Structure	Pre-Requisite
BCC01	**BIOPROCESS PRINCIPLES AND TECHNOLOGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

After completion of the course the students will acquire:

1. an understanding of fundamental concepts and principles of bioprocess systems
2. knowledge of industrially important microbes, their isolation, improvement and preservation
3. concepts in design and optimization of medium for industrial applications in bioprocesses
4. knowledge of design and operation of bioprocesses
5. an understanding of the real industrial scale production of various valued bioproducts.

COURSE CONTENT

Bioprocess calculations: Basic concepts. Fundamentals of material and energy balance for processes with/without chemical reaction. Simultaneous mass and energy balance in flow and without flow conditions.

Microbiological Aspects: 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

Microbial nutrition: 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

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

Industrial Bioprocess: Process technology for production of primary metabolites, such as baker's yeast, ethanol, citric acid, amino acids, polysaccharides and plastics. Microbial

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production of industrial enzymes- glucose isomerase, cellulase, amylase, protease etc, Production of secondary metabolites- penicillins and cephalosporins

PRACTICALS

1. Material and energy balance calculations in bioprocesses
2. Isolation and preservation techniques of microorganisms
3. Strategic enhancement in biomass and bioproduct 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

SUGGESTED READINGS

1. Vogel HC, Todaro CL, Todaro CC, Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment; Noyes Publications
2. Stanbury PF, Whitaker A, Principles of Fermentation Technology; Pergamon Press.
3. Jackson AT, Process Engineering in Biotechnology; Prentice Hall.

Course No	Title of the Course	Course Structure	Pre-Requisite
BCC02	**ENZYME TECHNOLOGY AND APPLICATIONS**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. Analyze the structure of enzymes with reference to its influence on classification, function and solubility
2. Understand basic principles and methodologies of enzyme technology in order to manipulate a given strain for the desired function
3. Construct enzyme reactors for mobilized and immobilised enzymes along with the skills to carry out enzyme kinetics

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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

COURSE CONTENT

Introduction: 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)

Pre-Steady–State and Multi-Substrate Enzyme Kinetics: 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: Mechanism for two substrates reactions, compulsory order, random order reactions and Ping-Pong mechanism. 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: Factors Affecting Enzyme Activity: Temperature and pH effects, thermal deactivation of enzymes. pH dependence: Ionization of Acids and Bases. Active Site Studies: The identification of binding sites and catalytic sites, Trapping the enzyme substrate complex, The use of Substrate analogues, Enzyme modification by chemical procedures affecting amino acids side chains, the enzyme modification by treatment with proteases and site-directed mutagenesis.

Enzyme Immobilization: Enzyme Immobilization & Kinetics of Immobilization: Immobilization of Biocatalysts an Introduction, 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.

Applied and Industrial Enzyme Technology: Bioreactors for soluble and immobilized enzymes, Mass transfer and catalysis in immobilized enzyme reactors, Enzyme based biosensors; Enzyme catalyzed processes with cofactor regeneration; Enzymatic reactions in

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micro-aqueous medium and nonconventional media. Case studies involving enzyme application in industrial bioprocess: Industrial process using enzymes for production of drugs, fine biochemicals and chiral intermediates etc

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

SUGGESTED READINGS

1. Blanch HW, Clark DS, Biochemical Engineering; Marcel Decker
2. Doran PM, Bioprocess Engineering Principles; Elsevier
3. Trnveer S, Inamdar A, Biochemical Engineering Principles and functions; PHI Learning Private limited
4. Wiseman A, Handbook of Enzyme Biotechnology; Ellis Horwood
5. Moser A, Bioprocess technology, kinetics and reactors; Springer Verlag
6. Schugerl K, Bellgart KH, Bioreaction Engineering, Modeling and control; Springer Verlag
7. Rao DG, Introduction to Biochemical Engineering; Tata McGraw Hill
8. Bailey JE, Ollis DF, Biochemical Engineering fundamentals; Tata McGraw Hill
9. Palmer T, Enzymes, Biochemistry, Biotechnology Clinical Chemistry; Horwood

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
BCC03	**BIOPROCESS ANALYSIS AND REACTOR DESIGN**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

1. Analyze the bioreactor principles and to compare the various types of reactors with reference to its influence on classification and function
2. Understand bioprocess engineering of biochemical reaction engineering in order to manipulate a continuous sytem for the desired 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

COURSE CONTENT

Reaction kinetics: 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.

Single reactor system: 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.

Multiple reactor system: 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

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different types in series.

Multiple reactions: 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.

Control Systems: 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.

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SUGGESTED READINGS

1. Levenspile O, Chemical Reaction Engineering; Wiley
2. Walas SM, Reaction Kinetics for Chemical Engineers;Tata McGraw Hill
3. Fogler SH, Elements of Chemical Reaction Engineering; Prentice Hall
4. Rajaram J, Kuriacose JC, Kinetics and Mechanics of Chemical Transformations; Macmillam India Ltd
5. Bailey JE, Ollis DF, Biochemical Engineering fundamentals; Tata McGraw Hill
6. Schergeri K, Bioreacation Engineering; Wiley
7. Ghosh TK, Bioprocess computations in Biotechnology; Ellis Horwood
10. Doran PM, Bioprocess Engineering Principles; Elsevier

Course No	Title of the Course	Course Structure	Pre-Requisite
BCC04	**MICROBIAL BIOCHEMISTRY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

After the completion of the course the student will acquire:

1. An understanding of the cellular structure, function and diversity of microbes present on earth
2. The knowledge of nutrients required by microbial cells and will be able to design and prepare media for microbial culture
3. An understanding of the microbial metabolism which can be harnessed for enhanced production of microbial metabolites
4. The knowledge of specialized pathways in microbial metabolism that are harnessed for biochemical processing and bioenergy production
5. An understanding of the genetic basis of microbial diversity and evolution which can be manipulated for strain improvement

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.

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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.

SUGGESTED READINGS

1. Madigan MT, Martinko JM, Brock Biology of Microorganisms; Pearson
2. Stryer L, Biochemistry; Freeman
3. Gottschalk G, Bacterial Metabolism; Springer-Verlag

Course No	Title of the Course	Course Structure	Pre-Requisite
BCC05	SEMINAR	0L- 0T- 4P	None

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCC06	MAJOR PROJECT	-	None

Course No	Title of the Course	Course Structure	Pre-Requisite
BCC07	DISSERTATION	-	None

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M. TECH. (BIOCHEMICAL ENGINEERING)

SYLLABUS FOR DISCIPLINE CENTRIC ELECTIVES

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD01	**INTRODUCTION TO BIOCHEMICAL ENGINEERING**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. To become familiar with biochemical engineering fundamentals and applications
2. To learn the microbial growth and kinetics of microbial processes
3. To learn fundamentals of upstream and downstream processing for bioprocess operations
4. To understand the basic principles of fluid flow and solid handling in bioreactors
5. To learn about the various modes of bioreactor operations

COURSE CONTENT

Introduction: Definition and scope of biochemical engineering. Unit operations in biochemical processes, Metabolic stoichiometry and bioenergetics, Mass and energy balance in microbial processes

Microbial growth: Microbial growth, substrate utilization and product formation. Preparation and sterilization of medium for fermentation, concept of yield, metabolic heat

Fermentation: Modes of bioreactor operation: batch, continuous and fed batch, Mixing and aeration, operation, measurement of parameters and control of bioreactors

Bioseparation technologies: solid liquid separation and other DSP steps

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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

SUGGESTED READINGS

1. Veith WF, Biochemical Engineering – Kinetics, Mass Transport, Reactors and Gene Expression; John Wiley and Sons Inc
2. Aiba S, Humphrey AE, Millis NF, Biochemical Engineering; University of Tokyo Press.
3. Shuler ML, Kargi F, Bioprocess Engineering Basic Concepts; Prentice Hall.
4. Coulson JM, Richardson JM, Chemical Engineering; Butterworth Heinemann.
5. Bailey JE, Ollis DF, Biochemical Engineering fundamentals; Tata McGraw Hill
6. Schergeri K, Bioreacation Engineering; Wiley
7. Doran PM, Bioprocess Engineering Principles; Elsevier

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD02	**Thermodynamics of Biological System**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. Be able to understand the basic knowledge of Thermodynamics
2. To know about Biological systems as open, non-equilibrium systems
3. To understand about chemical potential of biological system
4. To understand the Colligative properties with respect to biological fluid
5. To know about Physical chemistry of biological system

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COURSE CONTENT

Thermodynamics – 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.

Biological systems as open, non-equilibrium systems : failure of classical and thermodynamics in describing biological processes, Standard free energy changes and equilibrium constants, direction and rate.

Chemical potential : 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.

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

Physical chemistry of biological system : 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.

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SUGGESTED READINGS

1. Dill KA, Bromberg S, Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology; Garland Science
2. Haynie DT, Biological Thermodynamics; Cambridge University Press
3. Hammes. GG, Thermodynamics and Kinetics for the Biological Sciences; Wiley-Interscience
4. Lehninger AL, Bioenergetics; W.A.Benjamin

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD03	**CONCEPTS IN MODERN BIOLOGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

1. General understanding of organization in biological systems
2. Conceptual knowledge of functioning in biological systems
3. Clarity about relevance of Biology to engineering graduates
4. Understanding human body or any other suitable organism as a study-model for engineering students
5. Understanding electrical, chemical and magnetic forces, and communication networks in biosystem

COURSE CONTENT

Introduction to Macromolecules : 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

Molecular genetics: Genes; Basics of DNA replication, transcription, translation, Genome organization; Mutations; Genetechnology

Cell biology and energetics: Cell structure; Membranes; Function of cell organelles; Energetics; ATP and glycolysis; Respiration; Photosynthesis

Reproduction, Heredity, Evolution: Reproduction and Heredity; Cell division: mitosis, meiosis, gamete formation, pollination; Mendalian genetics; Evolution; Gene variation

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(Hardy-Weinberg principle); Darwin's theory of evolution
Organizational & Functional Diversity in living world: Viruses, bacteria, protists, fungi; Physiology aspects of Plants & Animals; Regulatory systems (nervous, endocrine, immune systems); Ecology; Populations and communities; Biosphere; Conservation

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 Bioproduct formation

SUGGESTED READINGS

1. Roberts M, Reiss MJ, Mongerg, Advanced Biology; Nelson Thornes
2. Ratledge C, Kristianse B, Basic Biotechnology; Cambridge University Press
3. Brown TA, Genetics: A molecular Approach; Stanley Thornes Publishers

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD31	**APPLIED BIOSTATISTICS**	**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 biochemical engineering
3. Must be able to compute a mean, variance, and standard deviation for the data obtained during experimentation
4. To learn the basic concept of ANOVA and its application in data analysis.
5. Student shall become able to design the experiments and expression of result outcomes in form of tables, graphs etc.

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COURSE CONTENT

Basics of probability and statistics, Description of Data and Theoretical Distributions, Normal distribution, Sample and population, Z distribution/confidence interval, sample size, Tests of significance – t test, F test (The Analysis of Variance (ANOVA) table and the F-test), 2 test/Odds ratio, Nonparametric tests, Other tests, Design of experiment- introduction, screening designs, Data analysis, Higher order experimental designs, Regression analysis and coefficient, data reduction, principal component analysis.

SUGGESTED READINGS

1. Jagota A, Data Analysis and Classification for Bioinformatics; Bioinformatics By The Bay Press.
2. Hoel PG, Port SC, Stone CJ, Introduction to Statistical Theory; Houghton Mifflin College.
3. Grant GR, Ewens WJ, Statistical Methods in Bioinformatics: An Introduction; Springer Verlag.
4. Gumbel EJ, Statistics of Extremes; Columbia University Press.

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD32	**ENTREPRENEURSHIP, IPR AND BIOSAFETY**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

1. To understand the concept of Intellectual property
2. Have a knowledge on patent database system worldwide
3. To understand the principle of patent system
4. To know the process of filing patent
5. Have knowledge on different safety rules required for entrepreneurship.

COURSE CONTENT

Introduction to Intellectual Property:

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

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Studies; Introduction to History of GATT, WTO, WIPO and TRIPS

Concept of 'prior art':

Invention in context of "prior art"; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, EPO, India etc.); Analysis and report formation

Basics of Patents:

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

Patent filing and Infringement:

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, case studies and examples

Safety rules:

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.

SUGGESTED READINGS

1. Shippe KC, A short course in international intellectual property rights; World Trade Pr
2. Erbisch FM, Maredia KM, Intellectual Property Rights In Agricultural Biotechnology; CABI Publishing
3. Carvalho NP, The TRIPS Regime of Patent Rights; Kluwer Law International
4. Knigh HJ, Patent Strategy for Researchers and Research Managers; Wiley

Course No	Title of the Course	Course Structure	Pre-Requisite

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BCD33	COMPUTATIONAL BIOLOGY	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

1. To learn the fundamentals of computational biology
2. To understand how networks, algorithms, and models are employed in biological system
3. To learn to apply computational methods to solve problems in modern molecular biology
4. Understand the flow of genetic information in populations and the relationship between genetics and evolutionary theory
5. Understand the functioning of organisms, at the molecular, cellular, organ, and organism levels

COURSE CONTENT

Introduction: 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.

Phylogenetics: 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.

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

Machine Learning, Systems Biology And Other Advanced Topics : 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.

Perl for Bioinformatics: 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

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SUGGESTED READINGS

1. Gusfield D, Algorithms on Strings Trees and Sequences; Cambridge University Press
2. Mount DW, Bioinformatics: Sequence and Genome Analysis; Cold Spring Harbor Laboratory Press
3. Lesk AM, Introduction to Bioinformatics; Oxford University Press
4. Tisdall, James, Beginning PERL for Bioinformatics; O'Reilley Publications
5. Leach AR, Molecular Modeling Principles and Applications; Prentice Hall
6. Baldi P, Brunak S, Bioinformatics: The Machine Learning Approach; East West Press

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD04	**FOOD SCIENCE AND ENGINEERING**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

COURSE CONTENT

Introduction: Structure and composition of fruit and vegetables: Definition, cellular components, chemical composition and nutritional value

Physiology and biochemistry of fruit and vegetables: 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.

Preservation of foods by low temperatures: Chilling temperatures: Consideration relating to storage of foods at chilling temperatures, Applications and procedures, Controlled and Modified atmosphere storage of foods, Post storage handling of foods.

Preservation of foods by high temperatures: Basic concepts. 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:

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Conventional canning process, batch and continuous retards. Aseptic processing

Thermal and Mechanical Properties of Foods: Specific heat. thermal conductivity, thermal diffusivity and glass transition temp and its relation with water activity. Electrical Conductivity and Dielectric Properties of Foods: Optical Properties of foods Relationship between stress compression and deformation of foods, hydrodynamics and aerodynamics properties of foods

Food safety and Hygiene: HACCP Systems: General standards for contaminants and toxins in foods, General principles for the use of food additives in foods, Analysis of pesticide residues

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 Calorimter.
10. To characterize the type of fluids using viscometer.

SUGGESTED READINGS

1. Mottershead B, Food Technology; Lesley Woods
2. Robinson J, Food Technology; Nelson Thornes
3. Lal G, Siddappa GS, Tondan GL, Preservation of Fruits and Vegetables; Alibris
4. Jacobs MB, The chemical analysis of foods and food products; The chemical analysis of foods and food products, by Morris B. Jacobs
5. Jay M, Modern Food Microbiology; Springer

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCD05	ENVIRONMENTAL BIOTECHNOLOGY	3L- 0T- 2P	None

COURSE OUTCOMES (CO)

1) Students will learn about environmental systems and pollutants along with the existing and emerging technologies that are important in the area of environment biotechnology.
2) Students will understand the importance of microbial diversity and technologies for environmental sustainability and processes.
3) To understand principles of waste water technologies and analyze case studies of the area to conceptualize a research program with an aim to solve the existing global environmental problems.
4) To critically analyze relevant journal articles and investigate industrial applications of the concepts of biotechnology for effluent treatment.
5) Students should learn as to how they can manipulate, enhance or retard biological processes for bioremediation of natural sources and xenobiotic degradation.

COURSE CONTENT

Environmental Systems and Pollutants: 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

Air Pollution: 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

Water and Waste Water Treatment: 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

Soil pollution and solid waste management: Generation, processing, and disposal of

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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.

Pollution prevention: 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

SUGGESTED READINGS

1. Young MM, Comprehensive Biotechnology; Pergamon Press.
2. De AK, Environmental Chemistry; Wiley Eastern Ltd.
3. Allsopp D, Seal KJ, Introduction to Biodeterioration; ELBS/Edward Arnold.
4. Metcalf, Eddy, Tchobanoglous G,Waste Water Engineering - Treatment, Disposal and Reuse; Tata McGraw Hill.

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCD06	**BIOMASS PROCESSING AND BIOENERGY**	**3L- 0T- 2P**	**None**

COURSE OUTCOMES (CO)

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

COURSE CONTENT

Bioenergy Feedstocks: Biomass types, characterization and chemistry, Terrestrial *vs* aquatic biomass, bioenergy feedstock cultivation and harvesting,
Bioconversion Technologies: Direct Combustion and gasification, Biodiesel/bio-oils, gaseous biofuel (biohydrogen and biogas), microbial fuel cell, biorefinery approach, theory of anaerobic digestion; problems associated with biomass conversion,
Fuel Biotechnology: Biofuels, bioenergy commercialization and case studies, life cycle assessments, recent advances in bioenergy research
Algal Biofuel: Harvesting, drying, biomass pretreatment (physical, chemical and biological) and bioenergy production

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

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SUGGESTED READINGS

1. Hakeem KR, Jawaid M, Rashid U, Biomass and Bioenergy: Processing and Properties; Springer
2. Ravindranath, Nijavalli H, Oakley DH, Biomass, energy and environment: a developing country perspective from India; Oxford University Press
3. Khanal, Kumar S, Surampalli RY, Zhang TC, Lamsal BP, Tyagi RD, Kao CM, Bioenergy and biofuel from biowastes and biomass; American Society of Civil Engineers (ASCE)
4. Pandey, Ashok, Handbook of plant-based biofuels; CRC Press
5. Gouveia L, Microalgae as a Feedstock for Biofuels; Springer Berlin Heidelberg

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD07	**TRANSPORT PHENOMENA IN BIOLOGICAL SYSTEMS**	**3L- 0T- 2P**	**BCE-501/ BCE-503 (Intro to B. E.)**

COURSE OUTCOMES (CO)

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

1. Analyze the application of transport phenomena with reference to its influence on system reliability and stress dealing nature.
2. Understand basic principles of process engineering in order to manipulate a given property (state and path funcution) for the desired function
3. Development of conserved equations for single or multiple reactor unit
4. Apply the principles of tranport processing 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

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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

SUGGESTED READINGS

1. Arthur TJ, Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems; John Wiley and Sons
2. Doran PM, Bioprocess Engineering Principles; Academic Press
3. Blanch HW, Douglas SC, Biochemical Engineering; CRC Press
4. Shuler ML, Kargi F, Bioprocess Engineering: Basic Concepts; Prentice-Hall of India Pvt Ltd

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCD08	**ADVANCE GENETIC ENGINEERING**	**3L- 0T- 2P**	**BCE-501/ BCE-503 (Intro to B. E.)**

COURSE OUTCOMES (CO)

After the completion of course the students will:

1. Have strong foundations in the basic concepts of recombinant DNA technology. The students will have a Technical know-how on versatile techniques used in recombinant DNA technology.
2. Explain the events involved in generating recombinant DNA molecules, to include cDNA generation, expression vectors and the choice of host cell.
3. Learn how manipulation of nucleic acids alters functions of proteins and subsequent cellular processes.
4. Be able to explain how the polymerase chain reaction can be used to amplify DNA segments, and how it may be used to analyze DNA.
5. Be able to review cases wherein genetic engineering and site directed mutagenesis have been used for manipulation and improvement of genetic traits

COURSE CONTENT

Concepts in genetic engineering: Tools and techniques, Properties and applications of DNA Modifying Enzymes: Host controlled restriction modification system (Nomenclature, Type I-IV restriction endonucleases, Isoschizomers); DNA Methyltransferases; DNA polymerases; Special case of thermo-stable DNA polymerases in context to PCR (History, concept, enzymology, applications); Reverse transcriptases

Cloning Vectors: Plasmids; Lambda based vectors and derivatives (Insertion vectors, replacement vectors, cosmids, phasmids, phagemids, in-vitro packaging, selection schemes); high-cloning capacity vectors: single stranded DNA vectors (M13, fd, f1); YACs, BACs, PACs, BIBACs, Plant Transformation vectors Ti, Ri plasmids, Binary, Conjugate, selection schemes), Protein Expression Vectors (expression systems for high level protein expression in E.coli and yeast, transcriptional efficiency, inducible promoters, translational efficiency, translational initiation, elongation, codon usage), protein extraction and purification (protein purification tags, histidine and GST tags, IMAC)

Introduction to Cloning: Isolation of gene for cloning, Generalized cloning schemes, host genotypes specificities and applications, strategies for selection and screening (Introduction to marker and reporter genes, positive and negative selection, insertion inactivation, α complementation). Introduction of cloned genes into the host cells: Transformation, transduction, Particle gun, electroporation, liposome mediated, cultivation etc. Virus mediated gene transfer, Transposable elements, RNA viruses, viroids.

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Analysis and expression of cloned gene in host cells: Restriction enzyme analysis, Southern blotting, Northern blotting, In-situ hybridization DNA sequencing. RFLP, PCR, RAPD, DNA finger printing, Lipase chain reaction, Ribozymes, DNA probes, antisense RNA, Expression of clonal genes.

Genomic DNA libraries: Procedures for Partial, Representative, Enriched, DNA libraries in context to medium and high-capacity cloning vectors cDNA libraries (Self-priming methods, replacement synthesis, Okayama and Berg strategy, use of Adapters/Linkers and methylation for directional cloning.

Applications: Site-directed mutagenesis, PCR based methods for site-directed mutagenesis (Single primer methods viz. Mis-incorporation of mismatched oligos, Over-lap extension), whole plasmid single round PCR), mis-repair of mutant oligonucleotides, selection of mutant (dut/ung *E. coli* strains for SDM through uracil replacement), 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.

SUGGESTED READINGS

1. Old, Primrose, Principles of Gene Manipulation; Wiley-Blackwell
2. Lewin B, Genes VIII; Oxford.
3. Singer M, Berg P, Genes and Genomes; Wiley
4. Brown TA, Genome-3; Garland Science

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCD34	COMPUTATIONAL FLUID DYNAMICS	3L- 1T- 0P	BCE-502

COURSE OUTCOMES (CO)

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

1. Analyze the application of computational fluid dynamics with reference to its influence on system reliability and stress dealing nature.
2. Understand basic principles of computational fluid dynamics in order to manipulate a given property (state and path funcution) for the desired function
3. Development of model using numerical methods
4. Apply the principles of computational fluid dynamics 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

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

SUGGESTED READINGS

1. Ferziger JH, Peric M, Computational Methods for Fluid Dynamics; Springer
2. Hirsch C, Numerical Computation of Internal and External Flows; John Wiley & Sons
3. Patankar SV, Numerical Heat Transfer and Fluid Flow, Hemisphere
4. Versteeg HK, Malalsekera W, An Introduction to Computational Fluid Dynamics: The Finite Volume Method; Longman Scientific & Technical
5. Anderson JD, Computational Fluid Dynamics: The Basics with Applications; McGraw-Hill Inc.

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCD35	**METABOLIC REGULATION AND ENGINEERING**	**3L- 1T- 0P**	BCE-501/ BCE-503 (Intro to B. E.)

COURSE OUTCOMES (CO)

1. To understand the microbial metabolic pathway and their analysis
2. To get familiar with the regulation of metabolic pathways and its application in bioprocess engineering
3. To apply the principles of metabolic engineering for overproduce the desired products
4. To apply the genetic engineering techniques in metabolic regulation and engineering
5. To learn the application of metabolic engineering for real industrial scale processes

COURSE CONTENT

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

Metabolic Regulation: 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;

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

Case Studies: Case studies on metabolic engineering.

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SUGGESTED READINGS

1. Vogel HC, Todaro CL, Todaro CC, Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment; Noyes Publications
2. Stanbury PF, Whitaker A, Principles of Fermentation Technology; Pergamon Press
3. Jackson AT, Process Engineering in Biotechnology; Prentice Hall
4. Stephanopoulos GN, Metabolic Engineering: Principles and Methodologies; Academic Press / Elsevier
5. Lee SY, Papoutsakis ET, Metabolic Engineering; Marcel Dekker
6. Nielsen J, Villadsen J, Bioreaction Engineering Principles; Springer
7. Christiana DS, The Metabolic Pathway Engineering Handbook Fundamentals; CRC Press Taylor & Francis Group

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD09	**ADVANCED BIOCHEMICAL ENGINEERING**	**3L- 0T- 2P**	**BCE-501/ BCE-503 (Intro to B. E.)**

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 understand and apply the growth kinetics and reaction engineering principles in production fermentative bioproducts
4. To learn the concept of mixed cultures and their application in bioremediation and biochemical engineering
5. To be able to apply the knowledge of gained through theory and laboratory practices in the real industrial scale fermentation processes

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COURSE CONTENT

Microbial growth kinetics: Kinetics of cell growth; Mathematical models for substrate uptake and product formation; Plasmid stability in recombinant cell cultures; growth kinetics with plasmid instability,
Sterilization Equipments: design of equipments for media and air sterilization; microbial cell cultivation strategies;
Bioreactor Engineering: Novel bioreactor designs; Developments in aeration & agitation in bioractors; immobilized whole cell and immobilized enzyme reactors; physiology of immobilised cells, RTD and mixing in bioreactors; special bioreactors for plant and mammalian cells, integrated systems of bioreaction and bioseparation; biosensors in bioprocesses,
Mixed culture: multiple interacting microbial cultures, Dynamics of mixed cultures; case studies utilizing mixed cultures,
Scale up: concept of scale-up and scale down of bioreactors and other ancillary equipments

PRACTICALS

1. Microbial growth and product formation kinetics;
2. Effects of inhibitor on microbial growth
3. Bioconversion in batch, fedbatch 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.

SUGGESTED READINGS

1. Veith WF, Biochemical Engineering – Kinetics, Mass Transport, Reactors and Gene Expression; John Wiley and Sons Inc
2. Jackson AT, Process Engineering in Biotechnology; Prentice Hall
3. Aiba, Humphrey AE, Millis NF, Biochemical Engineering; University of Tokyo Press
4. Doble M, Gummadi SN, Biochemical Engineering Pirnciples,; Prentice Hall
5. Shuler ML, Kargi F, Bioprocess Engineering Basic Concepts; Prentice Hall.
6. Coulson JM, Richardson JM, Chemical Engineering; Butterworth Heinemann.
7. Bailey JE, Ollis DF, Biochemical Engineering fundamentals; Tata McGraw Hill
8. Doran PM, Bioprocess Engineering Principles; Elsevier

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCD10	**Animal and Plant Cell Technology**	**3L- 0T- 2P**	**BCE-501, BCE-502**

COURSE OUTCOMES (CO)

1. Students will learn tools and techniques used for culturing mammalian and plant cells, tissues and organs.
2. Students will learn the tools and 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 understand the application of transgenic technology for production of improved animals/plants for production of important metabolities to be used in healthcare and medicine
4. Students will learn the potential of animal and plant 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 and plant biotechnology

COURSE CONTENT

Introduction and Basic Techniques: Historical developments and scope, Design of cell culture laboratory, Equipments required for cell culture, Nutritional Requirement and media, Chemical, physical and metabolic functions of different constituents of culture medium, Plant growth regulators, Serum and supplements, Aseptic techniques

Culture Techniques: Methods of plant cell cultivation, Cell suspension culture, Organ Culture, Haploid culture and Protoplast culture, kinetics of callus/cell growth, nutrient optimization, Development of primary adherent/suspension culture, Sub-culturing for establishment and maintenance of cell lines, Growth studies, population doubling time, Cryopreservation and recovery of cell lines,

Characterization of cell lines: Identification/Authentication of cell line, sterility testing, chromosomal stability of cell line, Transfection efficiency for genetic manipulation and production of industrially important metabolites

Bioreactors: Perfusion bioreactors, hollow fiber bioreactor, operational strategies and integrated approach; Micro and macro carrier culture Biological and technological barriers: hydrodynamic shear and its quantification, mixing and impeller design aspects, Immobilized plant cell and cell retention reactors, Hairy root cultures and their cultivation, Comparison of reactor performances,

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Application of Animal and Plant cell technology: Hybridoma technology, Genetic engineering in animal cell culture, Scale-up and large scale operation, Stem cell culture, Biotransformation using plant tissue culture, Secondary metabolite from plant cell technology, Genetic engineering for production of oral vaccines, nutraceuticals and pharmaceuticals**,** molecular farming, Biofortification Case studies

PRACTICALS

1. Primary Cell culture in static phase (T-flask)
2. Growth studies, Role of serum, FBS and Temperature
3. Monolayer culture
4. Transfection of mammalian cell lines
5. Karyotype preparation
6. Stem Cell Culture
7. Immunocytochemistry
8. Development of callus and suspension cultures of plant cells
9. Growth kinetics of Callus
10. Production of secondary metabolites in bioreactors using suspension cultures
11. Production of secondary metabolites using immobilized cells
12. Development of hairy root cultures

SUGGESTED READINGS

1. Spier RE, Griffiths JB, Animal Cell Biotechnology; Academic press.
2. Masters JRW, Animal cell culture - A Practical approach; Oxford.
3. Clynes M, Animal Cell Culture Techniques; Springer Verlag.
4. Butler M, Dawson M, Cell culture LabFAx; Bios scientific Publications Ltd.
5. Freshny RI, Culture of Animal Cells; Wiley-Leiss.
6. Caldentey KMO, Barz WH, Willis HL, Plant Biotechnology and Transgenic Plants; Marcel Dekker.
7. Hammond J, McGarvy P, Yusibov V, Plant Biotechnology; Springer Verlag.
8. Bhojwani SS, Razdan MK, Plant Tissue Culture : Theory and Practice; Elsevier Health Sciences
9. Chrispeels MJ, Sadava DE, Chrispeels MJ, Plants, Genes and Crop Biotechnology; Jones and Bartlett Publications.

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Course No	Title of the Course	Course Structure	Pre-Requisite
BCD11	**MODELING, SIMULATION AND CONTROL ENGINEERING**	**3L- 0T- 2P**	**BCE-508, BCE-502**

COURSE OUTCOMES (CO)

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

1. Analyze the process simulation and to compare the simulation results with reference to its influence on classification and function
2. Understand basic principles modeling and control engineering in order to manipulate a given condition for the desired function
3. Construct models and simulate them with the skills to carry out evaluation of the convntional models
4. Apply the principles of control 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

COURSE CONTENT

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

Mathematical Modeling: 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

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

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

Matlab and Simulink: Application in Bioprocess Systems: 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.

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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

SUGGESTED READINGS

1. Luben WL, Process Modeling Simulation and Control for Chemical Engineers; McGrawHill
2. Franks RGE, Mathematical Modeling in Chemical Engineering; John Wiley and Sons
3. Biquette WB, Process Dynamics- Modeling analysis with simulation; Prentice Hall
4. Palm WJ, Introduction to Matlab 7 for Engineers; McGraw Hill
5. Beers KJ, Numerical Methods for Chemical Engineering Applications in MATLAB®; Cambridge University press
6. http://www.mathworks.com

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD12	**BIOLOGICAL WASTE TREATMENT**	**3L- 0T- 2P**	**BCE-505 (Env. BT)**

COURSE OUTCOMES (CO)

1. Understand the difference and spectrum of biological waste than other waste materials
2. Understand the aspects and principles of Solid waste management
3. Understand the aspects and principles of Hazardous waste management
4. Understand the aspects and principles of waste water management
5. Understand different national as well as International rules and regulation related to waste management.

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

COURSE CONTENT

Introduction: 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

Solid Waste Engineering: Design of Transfer and Transport Facilities, Landfilling, Types and objectives of material recovery systems.

Hazardous Waste Engineering: 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

Wastewater Management: Measurement of Wastewater, Constituents, 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, digestor design, high rate digestion, heat transfer in digestor. Operation and design features of trickling filters, Upflow Anaerobic Sludge Blanket Reactor (UASB) and Rotating Biological Contractor (RBC), New developments, fixed film reactors, Nitrification-denitrification, Phosphorous removal. Treatment and disposal of waste of the industries e.g. distilling and brewing, antibiotics and sugar etc.

Regulations: 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

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

SUGGESTED READINGS

1. Kreith F, Handbook of Solid Waste Management; McGraw-Hill Education
2. Theisen GH, Eliassen R,Solid Wastes Engineering Principles Technologies; Mcgraw-Hill Book Company
3. Theodore L, Reynolds JP, Introduction to Hazardous Incineration; Wiley
4. Wong J, Nolan GL, Design of Remediation Systems; Lewis Publishers Inc
5. Berlin RE, Stanton CC, Radioactive Waste Management; John Wiley & Sons

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD13	**ADVANCED SEPARATION PROCESS**	**3L- 0T- 2P**	**BCE-501, BCE-507**

COURSE OUTCOMES (CO)

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

1. Analyze the application of advances separation process with reference to its influence on system reliability and stress dealing nature.
2. Understand basic principles of process engineering in order to manipulate a given property (state and path funcution) for the desired function
3. Fibractation of distillation clumns and process purge unit
4. Apply the principles of advanced separation 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

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

COURSE CONTENT

UNIT I: Distillation, Raoult's law, ideal solutions, x-y and H-x-y diagrams, flash vaporization and condensation, Differential distillation, steam distillation, Binary distillation: McCabe-Thicle and Ponchon-Savarit Method, Totalreflux, minimum and optimum reflux ratios

UNIT II: Design of distillation column with open steam, multiple feeds, side streams and partial condensers, Approximate and plate to plate calculations for multicomponent distillation, Liquid-liquid extraction, Extraction equipment Design

UNIT III: Equilibrium diagram, Choice of solvent, Single stage and multistage counter current extraction with/without reflux, Continuous contact extractors, Leaching equipment and equilibrium, Single stage and multistage cross current and counter-current leaching,

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

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

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

SUGGESTED READINGS

1. Geankoplis CJ, Transport Processes and separation process principles; Prentice Hall of India Pvt. Ltd
2. McCabe WL, Smith, Unit Operation of Chemical Engineering; McGraw- Hill International edition.
3. Vogal HC, Todaro CL, Fermentation and Biochemical Engineering Hand book. Principles Process design and equipment; Noyes Publication

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
BCD14	**BIOPROCESS PLANT DESIGN**	**3L- 0T- 2P**	**BCE-501, BCE-507**

COURSE OUTCOMES (CO)

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

1. Analyze the structure of bioprocess plant design with reference to its influence on classification, function and solubility
2. Understand basic principles and methodologies of plant equipments and anciallary in order to manipulate a functional plant design
3. Construct process equipments for various bioporocess operations along with the skills to carry out process dynamics and control
4. Apply the principles of process economics 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

COURSE CONTENT

Introduction: General design information; Mass and energy balance; Flow sheeting; Piping and instrumentation
Materials of construction for bioprocess plants; Mechanical design of process equipment; Vessels for biotechnology applications; Design of fermenters
Design considerations for maintaining sterility of process streams: processing equipment; Selection and specification of equipment for handling fluids and solids;
Selection: 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;
Utilities: For biotechnology production plants; Process economics; Bioprocess validation; Safety considerations; Case studies.

PRACTICALS

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

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

SUGGESTED READINGS

1. Ludwig EE, Applied Process Design for Chemical and Petrochemical Plants; Butterworth-Heinemann.
2. Sinnott RK, Coulson JM, Richardsons JF, Chemical Engineering; Butterworth-Heinemann.
3. Perry RH, Green DW, Chemical Engineers Handbook; McGraw-Hill.
4. Meyers FE, Stephens MP, Manufacturing Facilities Design and Material Handling; Prentice Hall.
5. Peters M, Timmerhaus K, Plant Design and Economics for Chemical Engineers; McGraw-Hill.
6. Bausbacher E, Hunt R, Process Plant Layout and Piping Design; Prentice Hall

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

M. TECH. (BIOCHEMICAL ENGINEERING)

SYLLABUS FOR OPEN ELECTIVES

Course No	Title of the Course	Course Structure	Pre-Requisite
EO001	**Technical Communication (TC)**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

1. The course will improve writing and documentation skills of students with emphasis on the importance of effective communication with focus on choice of words, formation of proper sentence structures and writing styles.
2. This will enhance the students capability to prepare technical documents and correspondence.
3. The course will equip the student with good communications skills for placements, preparing SOPs and CVs.
4. The course will sensitize the students towards research ethics, copyright and plagiarism.

COURSE CONTENT

- Definition of communication, meaning, importance & process of communication, objectives, types, C's of communication, barriers to communication
- human & non -human communication, distinctive features of human languages
- Business correspondence-definition, meaning and importance of business communication, business letters- purchase, enquiry, quotation, order, followup, acceptance-refusal
- Emphasis on (i) paragraph writing, its kinds, coherence & cohesion
  (ii)writing a paragraph/thesis: selection of topic and its development
  (iii) writing reports, manuals, notices, memos, agendas, minutes
  (iv)Interviews, speeches, presentations,
- Research ethics, methodologies, copyright, plagiarism

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

SUGGESTED READINGS

1. Hewing M, Advanced English Grammar; Cambridge University Press
2. Raman M, Sharma S, Sharma S, Technical Communication: Principles and Practices; Oxford University Press

Course No	Title of the Course	Course Structure	Pre-Requisite
EO002	**Disaster Management**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

1. Demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
2. Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
3. Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
   Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in.

COURSE CONTENT

Unit -I: Introduction

Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Repercussions Of Disasters And Hazards: Economic Damage, Loss Of Human And Animal Life, Destruction Of Ecosystem.

Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

Unit -II: Disaster Prone Areas In India

Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

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Unit -III: Disaster Preparedness And Management

Preparedness: Monitoring Of Phenomena Triggering A Disaster Or Hazard; Evaluation Of Risk: Application Of Remote Sensing, Data From Meteorological And Other Agencies, Media Reports: Governmental And Community Preparedness.

Unit -IV: Risk Assessment

Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global And National Disaster Risk Situation. Techniques Of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation In Risk Assessment. Strategies for Survival.

Unit -V: Disaster Mitigation

Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of Disaster Mitigation In India.

SUGGESTED READINGS

1. Nishith R, Singh AK, Disaster Management in India:Perspectives, issues and strategies; New Royal book Company
2. Pardeep S, Disaster Mitigation Experiences And Reflections; Prentice Hall Of India
3. Goel SL, Disaster AdminastrationAnd Management Text And Case Studies; Deep &Deep Publication Pvt. Ltd.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO003	**Basics of Financial Management**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

1. The course's objective is to provide a theoretical framework for considering corporate finance problems and issues and to apply these concepts in practice.
2. In this course, you will enhance your knowledge and understanding of financial management.
3. You will learn how managers should organize their financial transactions effectively and with integrity and how to give everybody the ability and confidence to tackle common financial problems in practice.
4. It will also provide adequate preparation for future finance classes.

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

COURSE CONTENT

Unit I

Nature, scope and objectives of financial management, Time value of money, Risk and return (including Capital Asset Pricing Model).

Unit II

Long term investment decisions: The Capital Budgeting Process, Cash Flow Estimation, Payback Period Method, Accounting Rate of Return, Net Present Value (NPV), Net Terminal Value, Internal Rate of Return (IRR), Profitability Index.

Unit III

Financing Decisions: Sources of long-term financing, Estimation of components of cost of capital, Methods for calculating Cost of Equity, Cost of Retained Earnings, Cost of Debt and Cost of Preference Capital, Weighted Average Cost of Capital (WACC). Capital Structure-Theories of Capital Structure (Net Income, Net Operating Income, MM Hypothesis, Traditional Approach). Operating and Financial leverage. Determinants of capital structure

Unit IV

Dividend Decisions: Theories for Relevance and irrelevance of dividend decision for corporate valuation-Walter's Model, Gordon's Model, MM Approach, Cash and stock dividends. Dividend policies in practice.

Unit V

Working Capital Decisions: Concepts of Working Capital, Operating & Cash Cycles, sources of short term finance, working capital estimation, cash management, receivables management, inventory management.

SUGGESTED READINGS

1. Khan MY, Jain PK, Financial Management: Text and Problems; Tata McGraw Hill.
2. Srivastava R, Mishra A, Financial Management; Oxford University Press
3. Chandra P, Financial Management-Theory and Practice; Tata McGraw Hill
4. Horne V, James C, Wachowicz J, Fundamentals of Financial Management; Pearson Education.

This M. Tech. Course has been passed in Standing Committee on Academic Matters, University of Delhi, held on June 3, 2016.

SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO004	**Basics of Human Resource Management**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

This course is designed to provide students with an understanding of human resource management (HRM) functions within organizations, including an appreciation of the roles of both HRM specialists and line managers in designing and implementing effective HRM policies and practices.

COURSE CONTENT

Unit - I

Evolution and growth of human resource management (with special reference to scientific management and Human relations approaches).Role of HR in strategic management.Nature.objectives, scope, and functions of HR management.

Unit - II

Challenges of HR (the changing profile of the workforce - knowledge workers, employment opportunities in BPOs, IT and service industries, Flexi options), Workforce diversity (causes, paradox, resolution of diversity by management).

Unit III

HRD; Human resource management as a profession.Concepts of line-staff in the structure of human resource department and the role of human resource manager.

Unit - IV

Manpower planning -objectives, elements, advantages, process. Job design - (simplification, rotation, enlargement, enrichment and approaches}.Job analysis.Job evaluation.

Unit - V

Recruitment (factors affecting, sources, policy, evaluation). Selection(procedure, tests, interviews). Placement and Induction.

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

SUGGESTED READINGS

1. Aswathappa K, Human Resource and Personnel Management; Tata McGraw-Hill
2. Chhabra TN, Human Resource Management, DhanpatRai and Co.
3. Mirza SS, Human Resource Management; Tata Mc-GrawHill
4. Chadha NK, Human Resource Management-issues, case studies, experiential exercises; Sri SaiPrintographers

Course No	Title of the Course	Course Structure	Pre-Requisite
EO005	**Project Management**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

In this comprehensive course, student will learn the fundamentals of project management: how to initiate, plan, and execute a project that meets objectives and satisfies stakeholders. This course provides a step-by-step guide to planning and executing a project and to develop a manageable project schedule.

COURSE CONTENT

Unit-I

Objectives of Project Planning, monitoring and control of investment projects. Relevance of social cost benefit analysis, identification of investment opportunities. Pre-feasibility studies.

Unit-II

Project Preparation: Technical feasibility, estimation of costs, demand analysis and commercial viability, risk analysis, collaboration arrangements; financial planning; Estimation of fund requirements, sources of funds.Loan syndication for the projects.Tax considerations in project preparation and the legal aspects.

Unit-III

Project appraisal: Business criterion of growth, liquidity and profitability, social cost benefit analysis in public and private sectors, investment criterion and choice of techniques. Estimation of shadow prices and social discount rate.

Unit-IV

Project review/control-Evaluation of project.PERT/CPM.resource handling/leveling.

Unit-V

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Cost and Time Management issues in Project planning and management , success criteria and success factors, risk management.

SUGGESTED READINGS

1. Ravindran R, Operations Research and Management Science Handbook; CRC Press
2. Kerzner H, Applied Project Management: Best Practices on Implementation; John Wiley & Sons
3. Goodpasture JC, Quantitative Methods in Project Management; J Ross Publishing
4. Meredith JR, Mantel Jr SJ, Project Management: A Managerial Approach; John Wiley

Course No	Title of the Course	Course Structure	Pre-Requisite
EO006	**Basics of Corporate Law**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

The objective of this Course is to provide in-depth knowledge of the Corporate laws and process related to integrate these aspects of management studies in decision making within an organization; analyze and interpret management information; make decisions based on the information available; communicate information effectively; understand and apply the theoretical aspects of accounting methods used for collecting, recording and reporting financial information; explain and appraise the taxation laws which govern corporations and individuals.

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

COURSE CONTENT

Unit I: Introduction : Administration of Company Law, characteristics of a company; common seal; lifting of corporate veil; types of companies including private and public company, government company, foreign company, one person company, small company, associate company, dormant company, producer company; association not for profit; illegal association; formation of company, promoters and their legal position, pre incorporation contract and provisional contracts; on-line registration of a company.

Unit II: Documents: Memorandum of association and its alteration, articles of association and its alteration, doctrine of constructive notice and indoor management, prospectus, shelf prospectus and red herring prospectus, misstatement in a prospectus; GDR; book building; issue, allotment and forfeiture of shares, calls on shares; public offer and private placement; issue of sweat capital; employee stock options; issue of bonus shares; transmission of shares, buyback and provisions regarding buyback; share certificate; D-Mat system; membership of a company.

Unit III: Management and Meetings: Classification of directors, additional, alternate and adhoc director; women directors, independent director, small shareholders' director; director identity number (DIN); appointment, who can appoint a director, disqualifications, removal of directors; legal position, powers and duties; key managerial personnel, managing director, manager; meetings of shareholders and board; types of meeting, convening and conduct of meetings, requisites of a valid meeting; postal ballot, meeting through video conferencing, e-voting; committees of board of directors – audit committee, nomination and remuneration committee, stakeholders relationship committee, corporate social responsibility committee; prohibition of insider trading.

SUGGESTED READINGS

1. Hicks, Andrew, Goo SH, Cases and Material on Company Law; Oxford University Press
2. Gowar LCB, Principles of Modern Company Law; Stevens & Sons
3. Majumdar AK, Kapoor GK, Company Law and Practice; Taxmann
4. Hanningan, Brenda, Company Law; Oxford University Press
5. Sharma JP, An Easy Approach to Corporate Laws; Ane Books Pvt. Ltd
6. Ramaiya, A Guide to Companies Act; LexisNexis Buttersworthwadhwa
7. Kannal S, Sowrirajan VS, Company Law Procedure; Taxman's Allied Services (P) Ltd.

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO007	**BIOLOGICAL COMPUTING**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

1. To understand computing in context of biological systems
2. To understand computing languages needed to solve biological problems
3. To acquire computational skills for analysis of biological processes through grid computing
4. To gain knowledge of different biological databases and their usage
5. To gain innovative insight into DNA computing

COURSE CONTENT

Introduction, Orientation and UNIX,
Python: Introduction to Variables and Control flow, Python II - Parsing In and Output,
Python III - Scripting and Functions, Python IV- Number Crunching and Plotting,
Grid computing, Biogrid, R basics and Visualization, Unix for fast text processing, SQL Database
Biological databases, R for speed, R for fun, Local BLAST, Unit Testing and Code Correctness
DNA computing,

SUGGESTED READINGS

1. Bolouri H, Paton R, Computations in cells & tissues; Springer
2. Haubold T, Bernhard, Wiehe, Introduction to Computational Biology: An Evolutionary Approach; Springer

Course No	Title of the Course	Course Structure	Pre-Requisite
EO008	**Basics of Social Science**	**L-T-P: 3-1-0**	**None**

COURSE OUTCOMES (CO)

Sociology is a major category of academic disciplines, concerned with society and the relationships among individuals within a society. It in turn has many branches, each of which is considered a "social science".

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

COURSE CONTENT

Unit 1.

The Development of Sociology in the 19th Century

Unit 2. **Sociology as Science:**

a. Science, scientific method and critique.
b. Major theoretical strands of research methodology.
c. Positivism and its critique.
d. Fact value and objectivity.
e. Non- positivist methodologies.

Unit 3. **Religion and Society:**

a. Sociological theories of religion.
b. Types of religious practices: animism, monism, pluralism, sects, cults.
c. Religion in modern society: religion and science, secularization, religious revivalism, fundamentalism.

Unit 4. **Politics and Society:**

a. Sociological theories of power.
b. Power elite, bureaucracy, pressure groups, and political parties.
c. Nation, state, citizenship, democracy, civil society, ideology.
d. Protest, agitation, social movements, collective action, revolution.

Unit 5. **Sociological Thinkers:**

a. Kar l Marx- Historical materialism, mode of production, alienation, class struggle.
b. Emile Durkheim- Division of labour, social fact, suicide, religion and society.
c. Max Weber- Social action, ideal types, authority, bureaucracy, protestant ethic and the spirit of capitalism.
d. Talcolt Parsons- Social system, pattern variables.
e. Robert K. Merton- Latent and manifest functions, conformity and deviance, reference groups.
f. Mead - Self and identity.

SUGGESTED READINGS

1. Beteille, Andre, Sociology: Essays in Approach and Method; Oxford University Press
2. Giddens, Anthony, Sociology; Polity Press
3. Weber M, The Methodology of the Social Sciences; Free Press.
4. Durkheim E, The Rules of Sociological Method; Macmillan

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO009	ENTREPRENEURSHIP	L-T-P: 3-1-0	None

COURSE OUTCOMES (CO)

This Course Aims at Instituting Entrepreneurial skills in the students by giving an overview of who the entrepreneurs are and what competences are needed to become an entrepreneur.

COURSE CONTENT

Unit I-Introduction:
Concept and Definitions, Entrepreneur v/s Intrapreneur; Role of entrepreneurship in economic development; Entrepreneurship process; Factors impacting emergence of entrepreneurship; Managerial versus entrepreneurial Decision Making; Entrepreneur v/s Investors; Entrepreneurial attributes and characteristics; Entrepreneurs versus inventors; Entrepreneurial Culture; Women Entrepreneurs; Social Entrepreneurship; Classification and Types of Entrepreneurs; EDP Programmes; Entrepreneurial Training; Traits/Qualities of an Entrepreneurs.

Unit II- Creating Entrepreneurial Venture:
Generating Business idea- Sources of Innovation, methods of generating ideas, Creativity and Entrepreneurship; Challenges in managing innovation; Business planning process; Drawing business plan; Business plan failures; Entrepreneurial leadership- components of entrepreneurial leadership; Entrepreneurial Challenges; Legal issues – forming business entity, considerations and Criteria, requirements for formation of a Private/Public Limited Company, Intellectual Property Protection- Patents Trademarks and Copyrights – importance for startups, Legal Acts Governing Business in India.

Unit III-Functional plans:
Marketing plan– for the new venture, environmental analysis, steps in preparing marketing plan, marketing mix, contingency planning; Organizational plan – designing organization structure and Systems; Financial plan – pro forma income statements, pro forma cash budget, funds Flow and Cash flow statements; Pro forma balance sheet; Break Even Analysis; Ratio Analysis.

Unit IV- Entrepreneurial Finance:
Debt or equity financing, Sources of Finance- Commercial banks, private placements, venture capital, financial institutions supporting entrepreneurs; Lease Financing; Funding opportunities for Startups in India.

Unit V- Enterprise Management:
Managing growth and sustenance- growth norms; Factors for growth; Time management, Negotiations, Joint ventures, Mergers & acquisitions.

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

SUGGESTED READINGS

1. Kumar A, Entrepreneurship: Creating and Leading an Entrepreneurial Organization; Pearson
2. Hishrich, Peters, Entrepreneurship: Starting, Developing and Managing a New Enterprise; Irwin
3. Taneja, Entrepreneurship; Galgotia Publishers
4. Barringer, Brace R, Duane R, Entrepreneurship; Pearson Prentice Hall
5. Hisrich, Robert D, Peters M, Shephered D, Entrepreneurship; Tata McGraw Hill
6. Lall, Madhurima, Sahai S, Entrepreneurship; Excel Books
7. Charantimath, Poornima, Entrepreneurship Development and Small Business Enterprises; Pearson Education

Course No	Title of the Course	Course Structure	Pre-Requisite
EO010	Social work	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

In this course students will learn about various methods of social work, about community organization, social welfare administration, Problems pertaining to Marriage, Family and caste

COURSE CONTENT

Unit 1.Social work

Philosophy and Methods. Social work: Meaning, Objectives, Scope, Assumptions & Values; History of Social work in U.K. U.S.A.and India, philosophy of Social Work. Democratic (Equality, Justice Liberty & Fraternity) and Humanitarian (Human Rights) Matrix.Social works as a profession.

Unit 2. Methods of Social work

Meaning, Scope Principles, Processes (Psychosocial study, Assessments, treatment-goal formulation and techniques), Evaluation, Follow-up and Rehabilitation. Social Groups work: Meaning,Objective, Principles, Skills, Processes (Study, Diagnosis, treatment and evaluation), Programme, Planningand Development, Role of Social group worker, Leadership Development.

Unit 3 Community organization

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Meaning, Objective, Principles, Approaches, Roles of Community Organization Worker.

Unit 4 Social Welfare Administration

Meaning Scope, Auspices-Private and Public, Principles, Basic Administrative Processes and Practice decision making communication, planning.organisation, budgeting and finacial control, reporting. Social work Research: Meaning objectives, types, scope, scientific method, Selection and formulation of the problem Research Design Sampling, Sources and Methods of Data Collection, Processing of Data, analysing and interpretation, Report writing. Social Action: Meaning,Scope, approaches (Sarvodays, Antyodaya etc.) and Strategies.

Unit 5 Work in India Problem pertaining to Marriage, Family and caste

Dowry- child Marriage, Divorce, Families with working couples, Disorganised Families, Families with Emigrant Heads of the Households, Gender Inequality, Authoritarian Family structure, Major Changes in Caste systems and problem of casteism. Problems Pertaining of Weaker Sections. Problems of Children, Women Aged. Handicapped and Backward Classes (SCs, STs, and other Backward Classes). **Problems of Deviance:** Truancy Vagrancy and Juvenile Delinquency, Crime, White Colla Crime, Organized Crime,Collective Violence, Terrorism, Prostitution and Sex Related Crimes. Social Vices: Alcohilism. Drug Addiction, Beggary, Corruption and communalism. **Problems of Social Structure :** Poverty, Unemployment, Bonded Labour, Child Labour. **Fields of Soclal work India :** Child Development, Development of Youth, Women's Empowerment, Welfare of aged, Welfare of Physically. Mentally and Social Handicapped, Welfare of backward Classes (Scs, STs and Other Backward Classes) Rural Development Urban Community Development, Medical And Psychiatric Social work, Industrial Social work, Social Security offender Reforms.

SUGGESTED READINGS

1. Bedi R, Social Work: An Introductory Text Book; Deep and Deep Publications
2. Bhattacharya S, Social Work: An Integrated Approach; Regal Publications
3. Dhawan N, Social work perspective Philosophy and Methods; Bharat Book Centre
4. Gautam PR, Social Work: Methods Practices And Perspectives; Centrum Press

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO011	**EO011: IP and Patenting**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

The objective of this Course is to provide in-depth knowledge of the laws and process related to Trademarks, Copyrights and other forms of IPs with focus on Patents, the Indian and International Patent filing procedure, drafting patent application and conducting prior art searches. Students will be exposed to the technical, management and legal aspects of IP and Patents.

COURSE CONTENT

UNIT I: Introduction: Historical and philosophical background of patents and other intellectual property, Patent System: the Constitution, Congress, Patent Office (PTO), and courts; Analyzing and understanding judicial opinions

UNITII: Comparative overview of patents, copyrights, trade secrets, and trademarks: Legal fundamentals of patent protection for useful inventions**,** Design and plant patents, Legal fundamentals of copyright protection, Similarity and access, Expression vs. ideas and information, merger, Fair use of copyrighted works (e.g., for classroom use), Contributory copyright infringement, Critical differences between patent and copyright protection, Copyright infringement distinguished from plagiarism, Legal fundamentals of trade-secret protection, Legal fundamentals of trademark protection

UNIT III: Requirements and limitations of patentability: New and useful: (A) The legal requirement of novelty (B) First to invent vs. first inventor to file, The legal requirement of non-obviousness.

UNIT IV: The process of applying for a patent ("patent prosecution"): Anatomy of a patent application, Adequate disclosure, The art of drafting patent claims, Patent searching: (A) Purposes and techniques, Actions for patent infringement, Interpretation of claims, Doctrine of equivalents, Product testing as a possibly infringing use, Doctrine of exhaustion

SUGGESTED READINGS

1. Rines, Robert H, Create or Perish: The Case for Inventions and Patents; Acropolis

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO012	**Supply Chain Management and Logistics**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

Supply chain management consist of all parties (including manufacturer, marketer, suppliers, transporters, warehouses, retailers and even customers) directly or indirectly involved in fulfillment of a customer. The main objective is to acquaint the students with the concepts and tools of supply chain management and logistics as relevant for a business firm.

COURSE CONTENT

Unit I

Introduction: Concept of supply chain management (SCM) and trade logistics; Scope of logistics; Logistic activities – an Overview; Contribution of logistics at macro and micro levels; SCM and trade logistics; Business view of SCM; Concept, span and process of integrated SCM; Demand management – methods of forecasting; Supply chain metrics (KPIs), performance measurement and continuous improvement; Product development Process and SCM; Strategic role of purchasing in the supply chain and total customer satisfaction; Types of purchases; Purchasing cycle.

Unit II

Managing Relationship: Role of Relationship marketing in SCM; Managing relationships with suppliers and customers; Captive buyers and suppliers; Strategic partnerships; Supplier-retailer collaboration and alliances.

Unit III

Focus Areas of Logistics and Supply Chain management: Transportation-Importance of effective transportation system; Service choices and their characteristics; inter-modal services; Transport cost characteristics and rate fixation; In-company management vs. out-sourcing; World sea borne trade; International shipping- characteristics and structure; Liner and tramp operations; Liner freighting; Chartering-Types, principles and practices; Development in sea transportation-Unitization, containerisation, inter and multimodal transport; CFC and ICD. Air transport: Set up for air transport and freight rates; Carriage of Goods by sea -Role and types of cargo intermediaries. Warehousing and inventory management: Reasons for warehousing; Warehousing evaluation and requirements; Warehousing location strategies; Inventory management principles and approaches; Inventory categories -EOQ, LT, ICC

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Unit IV

IT Enabling Logistics and Supply Chain: Technology in logistics – EDI, bar Coding, RFID etc., data warehousing, electronic payment transfers; Business management systems; TRADITIONAL ERP, SPECIAL ERP, MR, DRP, PDM, EIP, CPFR, WMS, TMS; Re-engineering the supply chain- Future directions.

Unit V

Trends and Challenges in logistics and supply chain management: Third party logistic outsourcing –challenges and future directions.

SUGGESTED READINGS

1. Christopher M, Logistics and Supply Chain Management; Prentice Hall.
2. Handfield, Nicholas Jr, Introduction to Supply Chain Management; Prentice Hall
3. Coyle JJ, Langley CCJ, Gibs BJ, Logistics approach to Supply Chain Management; Cengage Learning.

Course No	Title of the Course	Course Structure	Pre-Requisite
EO013	ORGANISATION DEVELOPMENT	3L- 1T- 0P	None

COURSE OUTCOMES (CO)

Organisation Development is a growing field of Human Resource Management. It has its foundations in a number of behavioural and social sciences .

COURSE CONTENT

Organtzattonal Systems and Human Behaviour - Developing a basic knowledge of how organizattons and groups furnction as systems; introducing and discussing various theoretical approaches and issues.

Interpersonal and Consulting Skills - Increasing effectiveness as a change agent by providing a variety of opportunities in order to increase self-awareness, practise alternative ways ofapproaching personal and interpersonal problem-solving and develop basic consulting and interviewing skills.

Introduction to Organization Development - Introducing some basic theories, models and methods in the field of organizationdevelopment, especially those relating to the role of

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consultant and strategies forchange.
Intervention and Change in Organizations - Consolidating and further developing consulting skills and strategies
Action Research Project - Carrying out a change activity in an organization, while also researching the effects and lor the process. This provides participants with an opporfunity to consolidate andde,monstrate skills and knowledge gained in other units of the course

SUGGESTED READINGS

1. Koutsoyiannis A, Modern Microeconomics; ELBS.
2. Kakkar DN, Managerial Economics for Engineering; Vikas Publishing House Pvt Limited
3. Dwivedi DN, Managerial Economics; Vikas Publishing House Pvt Limited
4. Maheshwari, Managerial Economics; PHI
5. Ruddardutt, Sundharam KPM, Indian economy;

Course No	Title of the Course	Course Structure	Pre-Requisite
EO014	**Industrial organisation and managerial economics**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

This course help students in understanding the basics of management and Industrial organization

COURSE CONTENT

Unit I: Principles of management, General idea, various functions, scope of engineering. Organisation structure, Types, merits and demerits.
Unit II: Plant location and layout, Factors effecting location, types of layout. Production planning and control, Sequence of planning and control of production. Scheduling , routing, despatching., Methods Study, Methods analysis, time study methods of rating.
Unit III: General idea of personnel management, Industrial psychology, job evaluation and monitoring. Business decision making and forward planning. Demand and demand forcasting of production analysis- prices and pricing decision-profit and capital, management. Analysis of inter-industry relation, macro-economics and business.

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

SUGGESTED READINGS

1. Koutsoyiannis A, Modern Microeconomics; ELBS.
2. Kakkar DN, Managerial Economics for Engineering; Vikas Publishing House Pvt Limited
3. Dwivedi DN, Managerial Economics; Vikas Publishing House Pvt Limited
4. Maheshwari, Managerial Economics; PHI
5. Ruddardutt, Sundharam KPM, Indian economy;

Course No	Title of the Course	Course Structure	Pre-Requisite
EO015	**Global Strategies and Technology**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

This subject focuses on the specifics of strategy and organization of the multinational company, and provides a framework for formulating successful and adaptive strategies in an increasingly complex world economy.

COURSE CONTENT

Globalization of industries, the continuing role of country factors in competition, organization of multinational enterprises, and building global networks, Analysis of competitive situations from the general management point of view, including fit between key environmental forces and the firm's resources, and changes in these over time. Formulating and implementing strategy based on that analysis. Developing and leveraging a firm's core competencies to gain long-term sustainable advantage.

SUGGESTED READINGS

1. Peng MW, Global strategy; Cengage Learning
2. Ghemawat P, Redefining Global Strategy: Crossing Borders in a World Where Differences Still Matter; Harvard Business Review Press
3. Kluyver CA, Fundamentals of Global Strategy; Business Expert Press

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO016	**Engineering System analysis and Design**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

The students will learn about system definitions and role of system analyst. They will learn about system modeling and design. They will be exposed to System Implementation and Maintenance issues.

COURSE CONTENT

Unit 1

System definition and concepts: Characteristics and types of system, Manual and automated systems

Real-life Business sub-systems: Production, Marketing, Personal, Material, finance Systems models types of models: Systems environment and boundaries, Real time and distributed systems, Basic principles of successful systems

Unit 2

Systems analyst: Role and need of systems analyst, Qualifications and responsibilities, Systems Analyst, agent of change.

Various phases of systems development life cycle: Analysis, Design, Development, Implementation, Maintenance

Unit3

Systems Design and modeling:Process modeling, Logical and physical design, Design representation, Systems flowcharts and structured charts, Data flow diagrams, Common diagramming conventions and guidelines using DFD and ERD diagrams. Data Modeling and systems analysis, designing the internals: Program and Process design, Designing Distributed Systems

Unit 4

User Interfaces – Relational Analysis – Database design – program design– structure chart – HIPO – SSADM – Alternate Life cycles – Prototypes.

Unit 5

System Implementation and Maintenance:Planning considerations, Conversion methods, producers and controls, System acceptance Criteria, System evaluation and performance, Testing and validation, Systems qualify Control and assurance, Maintenance activities and issues.

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

SUGGESTED READINGS

1. Haryszkiewycz, Introduction to Systems Analysis and Design; PHI
2. Senn JA, Analysis and Design of Information Systems; McGraw Hill

Course No	Title of the Course	Course Structure	Pre-Requisite
EO017	**BIOLOGY FOR ENGINEERS**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

1. General understanding of organization in biological systems
2. Conceptual knowledge of functioning in biological systems
3. Clarity about relevance of Biology to engineering graduates
4. Understanding human body or any other suitable organism as a study-model for engineering students.
5. Understanding electrical, chemical and magnetic forces, and communication networks in biosystem.

COURSE CONTENT

The Biological system – An Introduction; Biomolecules & self assemblies; Molecular recognition; Bioenergetics; Communication network in biosystem; Mechanics in biology; Storage, preservation and propagation of biological information; Biomaterials in engineering applications; Organisms as factories for biomaterials; Engineering organisms for novel applications

SUGGESTED READINGS

1. Johnson T, Biology for Engineers; CRC Press
2. Small M, Dynamics of Biological system; CRC Press
3. Ottesen T, Olufsen MS, Larsen JK, Applied Mathematical Models and Human Physiology; Society for Industrial and Applied Mathematics,

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO018	**Energy, Environment and Society**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

1. To be able to assess the energy resources available worldwide
2. To understand the negative impact of conventional energy resource utilization on ecosystem
3. To learn about various types of pollutions and their control strategies
4. To understand renewable energy resources and their socio-economic impact

COURSE CONTENT

Introduction to Environment, Energy and its impact on society
Universe, Environment and Ecosystem: Origin of earth, atmosphere, Origin of Life, Ecosystem, Biotic and abiotic components, Ecological pyramids, Food chain, Food web, Habitat and Niche, Major ecosystems, Atmosphere, Biodiversity
Pollution: Air Pollution, Water Pollution, Soil Pollution, Noise Pollution
Energy: Different sources of Energy, Renewable sources of energy, Non renewable energy, Bioenergy, Bioethanol and Biodiesel
Biofertilizers, Biopesticides and Biopolymers
Environmental Ethics and Morals

SUGGESTED READINGS

1. Kishore VVN, Renewable Energy Engineering and Technology, Principles and Practice; The Energy and Resources Institute (TERI)
2. Tiwari GN, Ghosal MK, Narosa, Fundamentals of Renewable Energy Sources; Alpha Science International
3. Mital KM, Biogas Systems: Principles and Applications; New Age International
4. Nijaguna BT, Biogas Technology; New Age International
5. Goswami Y, Kreith F, Kreider JF, Principles of Solar Engineering; Taylor & Francis
6. Rezaiyan J, Cheremisinoff NP, Gasification Technologies, A Primer for Engineers and Scientists; Taylor and Francis

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SCHEME OF COURSES – M.TECH. (Biochemical Engineering)

Course No	Title of the Course	Course Structure	Pre-Requisite
EO019	**Public Policy and Governance**	**3L- 1T- 0P**	**None**

COURSE OUTCOMES (CO)

Students will be introduced to Public Policy and Administrative governance. They will also learn about Administrative Governance.

COURSE CONTENT

Unit 1 Introduction to Public Policy and Administrative Governance: Introduction to public policy, econometrics for policy research, policy analysis, economics for public decision making.
Unit 2 Public Bureaucracy in Theory and Practice: Benefit cost analysis, public budgeting, revenue and expenditures, managing and leading public service organisations.
Unit 3 Administrative Governance: The Challenge of Policy Implementation, public and non-profit programme evaluation.
Unit 4 Non-state Actors in Policy-making and Administrative Governance: governance in twenty-first century, Social Diversity and the Question of "Difference" in Policy-making and administrative Governance

SUGGESTED READINGS

1. Shields J, Evans BM, Shrinking the State: Globalization and Public administration "reform"; Fernwood
2. Radin B, Beyond Machiavelli: Policy Analysis Reaches Midlife; Georgetown University Press
3. Baumgartner FR, Berry JM, Hojnacki M, Kimball DC, Lobbying and Policy Change: Who Wins, Who Loses, and Why; University of Chicago Press
4. Conlan T, Posner P, Beam D, Pathways of Power: The dynamics of National Policymaking; Georgetown University press

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