ANNAMALAI UNIVERSITY

(Accredited With 'A' Grade by NAAC)

Faculty of Engineering and Technology
Department of Chemical Engineering

M.Tech., Industrial Bio Technology
(Choice Based Credit System)

HAND BOOK
REGULATIONS AND SYLLABUS
2019 - 2020
(onwards)

ANNAMALAI UNIVERSITY
FACULTY OF ENGINEERING AND TECHNOLOGY
M.E. / M. Tech (Two-Year Full Time& Three-year Part Time) DEGREE

PROGRAMME *(CBCS)*

REGULATIONS -2019

1. Conditions for Admission

Candidates for admission to the first year of the four-semester **M.E / M.Tech Degree programme in Engineering** shall be required to have passed B.E / B.Tech degree of Annamalai University or any other authority accepted by the syndicate of this University as equivalent thereto. They shall satisfy the conditions regarding qualifying marks and physical fitness as may be prescribed by the Syndicate of the AnnamalaiUniversity from time to time. The admission for M.E Part Time programme is restricted to those working or residing within a radius of **90 km** from Annamalainagar. The application should be sent through their employers.

2. Branches of Study in M.E / M.Tech

The Branch and Eligibility criteria of programmes are given in Annexure I

3. Courses of study

The courses of study along with the respective syllabi and the scheme of Examinations for each of the M.E / M. Tech programmes offered by the different Departments of study in the Faculty of Engineering and Technology are given separately.

4. Choice Based Credit System (CBCS)

The curriculum includes three components namely Program Core, Program Electives and Open Electives, Mandatory Learning Courses and Audit Courses in addition to Thesis. Each semester curriculum shall normally have a blend of theory and practical courses.

5. Assignment of Credits for Courses

Each course is normally assigned one credit per hour of lecture / tutorial per week and 0.5 credit for one hour of laboratory or project or industrial training or seminar per week. The total credits for the programme will be **68**.

6. Duration of the programme

A student of M.E / M.Tech programme is normally expected to complete in four semesters for full-time / six semesters for part-time but in any case not more than four years for full-time / six years for part-time from the date of admission.

7. Registration for courses

A newly admitted student will automatically be registered for all the courses prescribed for the first semester, without any option. Every other student shall submit a completed registration form indicating the list of courses intended to be credited during the next semester. This registration will be done a week before the last working day of the current semester. Late registration with the approval of the Dean on the recommendation of the Head of the Department along with a late fee will be done up to the last working day. Registration for the Thesis Phase - I and Phase-II shall be done at the appropriate semesters.

8. Electives

8.1 Program Electives

The student has to select two electives in first semester, another two electives in the second semester and one more in the third semester from the list of Program Electives.

8.2 Open Electives

The student has to select two electives in third semester from the list of Open Electives offered by the Department and / or other departments in the Faculty of Engineering and Technology.

8.3 MOOC (SWAYAM) Courses

Further, the student can be permitted to earn credits by studying the Massive Open Online Courses offered through the SWAYAM Portal of UGC with the approval of the Head of the Department concerned. These courses will be considered as equivalent to open elective courses. Thus the credit earned through MOOC courses can be transferred and considered for awarding Degree to the student concerned.

8.4 Value added courses (Inter Faculty Electives)

Of the two open elective courses, a student must study one value added course that is offered by other Faculties in our University either in second or third semester of the M.E programme.

9. Industrial Project

A student may be allowed to take up the one program elective and two open elective courses of third semester (Full Time program) in the first and second semester, to enable him/her to carry out Project Phase-I and Phase-II in an industry during the entire second year of study. The condition is that the student must register those courses in the first semester itself. Such students should meet the teachers offering those elective courses themselves for clarifications. No specific slots will be allotted in the time table for such courses.

10. Assessment

10.1 Theory Courses

The break-up of continuous assessment and examination marks for theory courses is as follows:

First assessment (Mid-Semester Test-I)	:	10 marks
Second assessment (Mid-Semester Test-II)	:	10 marks
Third Assessment	:	5 marks
End Semester Examination	:	75 marks

10.2 Practical Courses

The break-up of continuous assessment and examination marks for Practical courses is as follows:

First assessment (Test-I)	:	15 marks
Second assessment (Test-II)	:	15 marks
Maintenance of record book	:	10 marks
End Semester Examination	:	60 marks

10.3 Thesis work

The thesis Phase I will be assessed for 40 marks by a committee consisting of the Head of the Department, the guide and a minimum of two members nominated by the Head of the Department. The Head of the Department will be the chairman. The number of reviews must be a minimum of three per semester. 60 marks are allotted for the thesis work and viva voce examination at the end of the third semester. The same procedure will be adopted for thesis Phase II in the fourth semester.

10.4 Seminar / Industrial Training

The continuous assessment marks for the seminar / industrial training will be 40 and to be assessed by a seminar committee consisting of the Seminar Coordinator and a minimum of two members nominated by the Head of the Department. The continuous assessment marks will be awarded at the end of the seminar session. 60 marks are allotted for the seminar / industrial training and viva voce examination conducted based on the seminar / industrial training report at the end of the semester.

11. Student Counselors (Mentors)

To help the students in planning their course of study and for general advice on the academic programme, the Head of the Department will attach a certain number of students to a member of the faculty who shall function as student counselor (mentor) for those students throughout their period of study. Such student

counselors shall advise the students in selecting open elective courses from, give preliminary approval for the courses to be taken by the students during each semester, and obtain the final approval of the Head of the Department monitor their progress in SWAYAM courses / open elective courses.

12. Class Committee

For each of the semesters of M.E / M.Tech programmes, separate class committees will be constituted by the respective Head of the Departments. The composition of the class committees from first to fourth semesters for Full time and first to sixth semesters for Part-time will be as follows:

- Teachers of the individual courses.
- A Thesis coordinator (for Thesis Phase I and II) shall be appointed by the Head of the Department from among the Thesis supervisors.
- A thesis review committee chairman shall be appointed by the Head of the Department
- One Professor or Associate Professor, preferably not teaching the concerned class, appointed as Chairman by the Head of the Department.
- The Head of the Department may opt to be a member or the Chairman.
- All counselors of the class and the Head of the Department (if not already a member) or any staff member nominated by the Head of the Department may opt to be special invitees.

The class committee shall meet three times during the semester. The first meeting will be held within two weeks from the date of class commencement in which the type of assessment like test, assignment etc. for the third assessment and the dates of completion of the assessments will be decided.

The second meeting will be held within a week after the completion of the first assessment to review the performance and for follow-up action.

The third meeting will be held after all the assessments but before the University semester examinations are completed for all the courses, and at least one week before the commencement of the examinations. During this meeting the assessment on a maximum of 25 marks for theory courses / 40 marks for practical courses, for Industrial Training and for Thesis work (Phase-I and Phase-II) will be finalized for every student and tabulated and submitted to the Head of the Department for approval and transmission to the Controller of Examinations.

13. Temporary Break Of Study

A student can take a one-time temporary break of study covering the current semester and / or the next semester with the approval of the Dean on the recommendation of the Head of the Department, not later than seven days after the completion of the mid-semester test. However, the student must complete the entire programme within the maximum period of **four years for Full time / six years for Part time.**

14. Substitute Assessments

A student who has missed, for genuine reasons accepted by the Head of the Department, one or more of the assessments of a course other than the end of semester examination may take a substitute assessment for any one of the missed assessments. The substitute assessment must be completed before the date of the third meeting of the respective class committees.

A student who wishes to have a substitute assessment for a missed assessment must apply to the Head of the Department within a week from the date of the missed assessment.

15. Attendance Requirements

The students with 75% attendance and above are permitted to appear for the University examinations. However, the Vice Chancellor may give a rebate / concession not exceeding 10% in attendance for exceptional cases only on Medical Grounds.

A student who withdraws from or does not meet the minimum attendance requirement in a semester must re-register and repeat the same semester in the subsequent academic years.

16. Passing and declaration of Examination Results

All assessments of all the courses on an absolute marks basis will be considered and passed by the respective results passing boards in accordance with the rules of the University. Thereafter, the controller of examinations shall convert the marks for each course to the corresponding letter grade as follows, compute the grade point average (GPA) and cumulative grade point average (CGPA) and prepare the mark sheets.

90 to 100 marks	Grade 'S'
80 to 89 marks	Grade 'A'
70 to 79 marks	Grade 'B'
60 to 69 marks	Grade 'C'
55 to 59 marks	Grade 'D'
50 to 54 marks	Grade 'E'
Less than 50 marks	Grade 'RA'
Withdrawn from the Examination	Grade 'W'

A student who obtains less than 30 / 24 marks out of 75 / 60 in the theory / practical examinations respectively or is absent for the examination will be awarded grade RA.

A student who earns a grade of S, A, B, C, D or E for a course is declared to have successfully completed that course and earned the credits for that course. Such a course cannot be repeated by the student.

A student who obtains letter grade RA / W in the mark sheet must reappear for the examination of the courses.

The following grade points are associated with each letter grade for calculating the grade point average and cumulative grade point average.

S - 10; A - 9; B - 8; C - 7; D - 6; E - 5; RA - 0

Courses with grade RA / W are not considered for calculation of grade point average or cumulative grade point average.

A student can apply for re-totaling of one or more of his examination answer papers within a week from the date of issue of mark sheet to the student on payment of the prescribed fee per paper. The application must be made to the Controller of Examinations with the recommendation of the Head of the Department.

After the results are declared, mark sheets will be issued to the students. The mark sheet will contain the list of courses registered during the semester, the grades scored and the grade point average for the semester.

GPA is the sum of the products of the number of credits of a course with the grade point scored in that course, taken over all the courses for the semester, divided by the sum of the number of credits for all courses taken in that semester.

CGPA is similarly calculated considering all the courses taken from the time of admission.

17. Awarding Degree

After successful completion of the programme, the degree will be awarded with the following classifications based on CGPA.

For First Class with Distinction the student must earn a minimum of 68 credits within four semesters for full-time / six semesters for Part time from the time of admission, pass all the courses in the first attempt and obtain a CGPA of 8.25 or above.

For First Class, the student must earn a minimum of 68 credits within two years and six months for full-time / three years and six months for Part time from the time of admission and obtain a CGPA of 6.75 or above.

For Second class, the student must earn a minimum of 68 credits within four years for full-time / six years for Part time from the time of admission.

18. Ranking of Candidates

The candidates who are eligible to get the M.E /M.Tech degree in First Class with Distinction will be ranked on the basis of CGPA for all the courses of study from I to IV semester for M.E / M.Tech full-time / I to VI semester for M.E / M.Tech part-time.

The candidates passing with First Class and without failing in any subject from the time of admission will be ranked next to those with distinction on the basis of CGPA for all the courses of study from I to IV semester for full-time / I to VI semester for M.E / M.Tech part-time.

19. Transitory Regulations

If a candidate studying under the old regulations M.E. / M.Tech could not attend any of the courses in his/her courses, shall be permitted to attend equal number of courses, under the new regulation and will be examined on those subjects. The choice of courses will be decided by the concerned Head of the department. However he/she will be permitted to submit the thesis as per the old regulations. The results of such candidates will be passed as per old regulations.

The University shall have powers to revise or change or amend the regulations, the scheme of examinations, the courses of study and the syllabi from time to time.

ANNEXURE 1

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.TechProgramme
1	**Chemical Engineering**	i.	Chemical Engineering	B.E. / B.Tech – Chemical Engg, Petroleum Engg, Petrochemical Technology
		ii.	Food Processing Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Biochemical Engg, Agricultural Engg.
		iii.	Industrial Bio Technology	B.E. / B.Tech - Chemical Engg, Food Technology, Biotechnology, Leather Technology
		iv.	Industrial Safety Engineering	B.E. / B.Tech – Any Branch of Engineering
2	**Civil Engineering**	i.	Environmental Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Industrial Engg, Chemical Engg, BioChemicalEngg, Biotechnology, Industrial Biotechnology, Chemical and Environmental Engg.
		ii.	Environmental Engineering & Management	
		iii.	Water Resources Engineering & Management	B.E. / B.Tech – Civil Engg, Civil & Structural Engg, Environmental Engg, Mechanical Engg, Agricutural and irrigation Engg, Geo informatics, Energy and Environmental Engg.
3	**Civil & Structural Engineering**	i.	Structural Engineering	B.E. / B.Tech – Civil Engg, Civil & Structural Engg.
		ii.	Construction Engg. and Management	
		iii.	Geotechnical Engineering	
		iv.	Disaster Management &Engg.	
4	**Computer Science & Engineering**	i.	Computer Science & Engineering	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
5	**Electrical Engineering**	i.	Embedded Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Information technology, Electronics and communication Engg, Computer Science and Engg
		ii.	Smart Energy Systems	B.E. / B.Tech – Electrical and Electronics Engg, Control and Instrumentation Engg, Electronics and communication Engg,
		iii.	Power System	
6	**Electronics & Communication Engineering**	i.	Communication Systems	B.E. / B.Tech -Electronics and Communication Engg, Electronics Engg.

S.No.	Department		Programme (Full Time & Part time)	Eligible B.E./B.TechProgramme
7	**Electronics & Instrumentation Engineering**	i.	Process Control & Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electornics Engg, Control and

				Instrumentation Engg, Instrumentation Engg, , Electronics and Communication Engg,
		ii.	Rehabilitative Instrumentation	B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and Electornics Engg, Electronics and Communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics.
		iii	Micro Electronics and MEMS	B.E. / B.Tech – B.E. / B.Tech – Electronics and Instrumentation Engg, Electrical and ElectornicsEngg, Electronics and communication Engg, Control and Instrumentation Engg, Instrumentation Engg, Bio Medical Engg, Mechatronics, Telecommunication Engg
8	**Information Technology**	i	Information Technology	B.E. / B.Tech - Computer Science and Engineering, Information Technology, Electronics and Communication Engg, Software Engineering
9	**Mechanical Engineering**	iv.	Thermal Power	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical Engg (Manufacturing).
		v.	Energy Engineering & Management	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Mechanical (Manufacturing) Engg, Chemical Engg
10	**Manufacturing Engineering**	i.	Manufacturing Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Mechatronics Engg and Industrial Engg.
		ii.	Welding Engineering	
		iii.	Nano Materials and Surface Engineering	B.E. / B.Tech – Mechanical Engg, Automobile Engg, Manufacturing Engg, Production Engg, Marine Materials science Engg, Metallurgy Engg, Chemical Engg

DEPARTMENT OF CHEMICAL ENGINEERING

M.Tech INDUSTRIAL BIOTECHNOLOGY

VISION

Our vision is to be a leading Chemical Engineering Department in the Nation, to create and develop technocrats, entrepreneurs and business leaders

MISSION

The department fosters chemical engineering as a profession that interfaces engineering and all aspects of basic sciences to disseminate knowledge in order to prepare the students to be successful leaders and practitioners and to meet the present and future needs of the society by highest degree of standards and ethics.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs) :

I. To provide students with solid fundamentals and strong foundation in statistical, scientific and engineering subjects required to create and innovate in the field of biotechnology.

II. To train students with good scientific and technical knowledge so as to comprehend, analyze, design, and create novel products and solutions for developing novel therapeutics and enzymes.

III. To prepare students to excel and succeed in Biotechnology research or industry through the latest state-of-art post graduate education.

IV. This course enables the student to develop good communication and leadership skills, respect for authority, loyalty, necessity of bioethics, social responsibility, awareness of the environment and the life-long learning needed for a successful scientific and professional career.

PROGRAM OUTCOMES (POs):

On successful completion of the Masters in Biotechnology graduates will be able to

1. Acquire in depth knowledge of Biological science and Bioengineering for gaining ability to develop and evaluate new ideas

2. Demonstrate Scientific and technological skills to design and perform research through modern techniques for the development of high throughput process and products.

3. Analyze Biotechnological problems and formulate intellectual and innovative vistas for research and development

4. Provide potential solutions for solving technological problems in various domains of Biotechnology considering the societal, public health, cultural environmental factors.

5. Examine the outcomes of Biotechnological issues critically and gain knowledge for composing suitable corrective measures.

6. Create and apply modern engineering tools for the prediction and modeling of complex bioengineering activities

7. Posses self management and team work skills towards collaborative, multidisciplinary scientific endeavors in order to achieve common goals

8. Develop entrepreneurial and managerial skills for the implementation of multidisciplinary projects

9. Demonstrate adherence to accepted standards of professional bioethics and social responsibilities

10. Posses the attitude necessary for lifelong and acquire communication skills relevant to professional positions

11. Acquire knowledge in advanced fermentation techniques catering to fulfill the need of the society.

12. Develop skills in genetic engineering, enzyme engineering and bioprocess engineering to meet out the needs of biotechnology industries.

Program Educational Objectives	Program Outcomes											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
I	✓	✓	✓	✓	✓	✓						
II	✓	✓	✓	✓		✓						
III	✓	✓	✓	✓	✓			✓	✓	✓		
IV			✓	✓			✓	✓	✓	✓		

FACULTY OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF CHEMICAL ENGINEERING

Program: M.Tech

CURRICULUM – 2019

SEMESTER I									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
CHBTPC11	**PC**	Enzyme Technology and Fermentation Technology	3	-	-	25	75	100	3
CHBTPC 12	**PC**	Bioinformatics and Applications	3	-	-	25	75	100	3
CHBTPE13	**PE**	Program Elective-I	3	-	-	25	75	100	3
CHBTPE14	**PE**	Program Elective-II	3	-	-	25	75	100	3
CHBTMC15	**MC**	Research Methodology and IPR	2	-	-	25	75	100	2
CHBTCP16	**CP**	Preparative and analytical techniques in biotechnology laboratory	-	-	3	40	60	100	2
CHBTCP17	**CP**	Immuno technology and Advanced genetic engineering laboratory	-	-	3	40	60	100	2
CHBTAC18	**AC**	Audit Course-I	2	-	-	-	-	-	0
							Total		**18**

SEMESTER II									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
CHBTPC21	**PC**	Bioprocess Engineering	3	-	-	25	75	100	3
CHBTPC22	**PC**	Bioseparation Technology	3	-	-	25	75	100	3
CHBTPE23	**PE**	Program Elective-III	3	-	-	25	75	100	3
CHBTPE24	**PE**	Program Elective-IV	3	-	-	25	75	100	3
CHBTCP25	**CP**	Bioprocess and downstream processing laboratory	-	-	3	40	60	100	2
CHBTOE26	**OE**	Open Elective (Inter Faculty)	3	-	1	25	75	100	3
CHBTTS27	**TS**	Industrial Training and Seminar / Mini project		Tr 2	S 2	40	60	100	2
CHBTAC28	**AC**	Audit Course-II	2	-	-	-	-	-	0
							Total		**19**

SEMESTER III									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
CHBTPE31	**PE**	Program Elective-V	3	-	-	25	75	100	3
CHBTOE32	**OE**	Open Elective (inter faculty)	3	-	-	25	75	100	3
CHBTPV33	**PV-I**	Project work & Viva-voce Phase-I	-	Pr 16	S 4	40	60	100	10
							Total		**16**

SEMESTER IV									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
CHBTPV41	**PV-II**	Project work & Viva-voce Phase-II	-	Pr 24	S 6	40	60	100	15
							Total		**15**

DEPARTMENT OF CHEMICAL ENGINEERING

Program: M.Tech (PART TIME) **Specialization: Industrial Biotechnology**

CURRICULUM – 2019

SEMESTER I										
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.Tech Full Time**
CHBTPC11	**PC**	Enzyme Technology and Fermentation Technology	3	-	-	25	75	100	3	CHBTPC11
CHBTPC 12	**PC**	Bioinformatics and Applications	3	-	-	25	75	100	3	CHBTPC 12
CHBTMC13	**MC**	Research Methodology and IPR	2	-	-	25	75	100	2	CHBTMC15
CHBTCP14	**CP**	Preparative and analytical techniques in biotechnology laboratory	-	-	3	40	60	100	2	CHBTCP16
							Total		**10**	
SEMESTER II										
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.Tech Full Time**
CHBTPC21	**PC**	Bioprocess Engineering	3	-	-	25	75	100	3	CHBTPC21
CHBTPC22	**PC**	Bioseparation Technology	3	-	-	25	75	100	3	CHBTPC22
CHBTOE23	**OE**	Open Elective (Inter Faculty)	3	-	-	40	60	100	3	CHBTOE26
CHBTCP24	**CP**	Bioprocess and downstream processing laboratory	-	-	3	40	60	100	2	CHBTCP25
Total									**11**	
SEMESTER III										
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.Tech Full Time**
CHBTPE31	**PE**	Program Elective-I	3	-	-	25	75	100	3	CHBTPE13
CHBTPE32	**PE**	Program Elective-II	3	-	-	25	75	100	3	CHBTPE14
CHBTCP33	**CP**	Immuno technology and Advanced genetic engineering laboratory	-	-	3	40	60	100	2	CHBTCP17
							Total		**8**	

SEMESTER IV										
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.Tech Full Time**
CHBTPE41	**PE**	Program Elective-III	3	-	-	25	75	100	3	CHBTPE23
CHBTPE42	**PE**	Program Elective-IV	3	-	-	25	75	100	3	CHBTPE24
CHBTTS43	**TS**	Industrial Training and Seminar / Mini project		Tr 2	S 2	40	60	100	2	CHBTTS27
						Total			**8**	

SEMESTER V										
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.E. Full Time**
CHBTPE51	**PE**	Program Elective-V	3	-	-	25	75	100	3	CHBTPE31
CHBTOE52	**OE**	Open Elective (inter faculty)	3	-	-	25	75	100	3	CHBTOE32
CHBTPV53	**PV-I**	Project work & Viva-Voce Phase-I	-	Pr 16	S 4	40	60	100	10	CHBTPV33
						Total			**16**	

SEMESTER VI										
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**	**Equivalent Course Code in M.E. Full Time**
CHBTPV61	**PV-II**	Project work & Viva-voce Phase-II	-	Pr 24	S 6	40	60	100	15	CHBTPV41
						Total			**15**	

LIST OF PROGRAM ELECTIVES

1. Immunotechnology
2. Metabolic Process and Engineering
3. Computer Aided Learning of Structure and Functions of proteins
4. Advanced Genetic Engineering
5. Animal Biotechnology
6. Phytochemistry
7. Advanced Genomics and Proteomics
8. Bioreactor Design and Analysis
9. Nanobiotechnolgy
10. Biofuels and BioRefinery Engineering
11. Bioprocess Modelling and Simulation
12. Cancer Biology
13. Analytical Techniques in Biotechnology
14. Biothermodynamics
15. Plant Biotechnology

Audit Course-I & II

1. English for Research Paper Writing
2. Disaster Management
3. Sanskrit for Technical Knowledge
4. Value Education
5. Constitution of India
6. Pedagogy Studies
7. Stress Management by Yoga
8. Personality Development through Life Enlightenment Skills.

List of Open Electives

1. Biotechnology in Food Processing
2. Computational Fluid Dynamics
3. Environmental Biotechnology
4. Technology Management

CHBTPC11	ENZYME TECHNOLOGY AND FERMENTATION TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

Enable the students

- To learn enzyme reactions and its characteristics along with the production and purification process
- To give the student a basic knowledge concerning biotransformation reactions with the usage of enzymes
- To understand the production process of Primary and Secondary metabolites

FUNDAMENTALS OFFERMENTATION

Overview of fermentation – Microbial biomass – Microbial Enzymes – Microbial Metabolites – Types of fermentation – Media for industrial fermentations — Medium sterilization-– Development of inoculum for industrial fermentation -Medium optimization – Oxygen requirements of industrial fermentation – Mass transfer in fermentation – Determination of K_La values – Factors affecting K_La values in fermentation.

INDUSTRIAL FERMENTATION PROCESSES

Aerobic and anaerobic fermentations –Batch culture, continuous culture, fed batch culture – Comparison of batch and continuous culture – Submerged and solid state fermentation for the production of enzymes – Immobilization of enzymes and techniques for enzyme immobilization – Biocatalysis in organic media using enzymes – Biotransformation with crude enzymes and whole cells.

PRODUCTION OF ENZYMES AND METABOLITES

Production of Proteases, Cellulas, Lipase, Amylase, Glucose isomerase, Pectinase, Peroxidase Production of primary metabolites– organic acids (Citric acid, Lactic acid), amino acids (Glutamic acid, Lysine),alcohols (ethanol, butanol). Production of secondary metabolites – aminoacids (Glutamic acid, Lysine), antibiotics (Penicillin, streptomycin), Vitamins (Vitamin B12, Riboflavin)

ENZYME KINETICS

Overview of enzyme and its action – Time course of enzymatic reactions – Effects of substrateconcentration on velocity – Rapid equilibrium model of enzyme kinetics – Steady state model of enzyme kinetics – Significance of *kcat* and *Km* – Experimental Measurement of *kcat* and *Km* – Linear transformations of enzyme kinetic data – Bi Bi reaction mechanisms – Modes of reversibleinhibition- Allosteric regulation of enzymes.

APPLICATIONS OF ENZYMES

Enzymes in organic synthesis – Enzymes as biosensors – Enzymes for food, pharmaceutical, tannery, textile, paper and pulp industries – Enzyme for environmental applications- Enzymes for analytical and diagnostic applications – Enzymes for molecular biology research.

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3.Mansi, E.M.T.EL., Bryce, C.F.A., Dahhou, B., Sanchez, S., Demain, A.L. and Allman, A.R., "Fermentation Microbiology and Biotechnology", 3rd Edition, 2012, Taylor and Francis.
4.McNeil, B., Harvey, L., "Practical Fermentation Technology", 2008, John Wiley & Sons.
5.Palmer, T., Bonner, P., "Enzymes Biochemistry, Biotechnology, Clinical chemistry", 2nd Edition, 2011, Wood Head Publishing.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Acquire knowledge on enzyme and enzyme reactions that will be the key step in to proceed towards various concepts in biotechnology.
2. Understand the theoretical and practical aspects of kinetics will provide the importance and utility of enzyme kinetics towards research.
3. Know the process of immobilization in food, pharmaceutical and chemical industries and will provide simple and easy method of implementation.
4. Get ideas on Processing, Production and Purification of enzymes and metabolites at an industrial scale will be helpful to work technologically.
5. Acquire knowledge on applications of enzymes in food, pharma industries and effluent treatments.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓										
CO2												
CO3					✓					✓		
CO4					✓	✓		✓				
CO5												✓

CHBTPC12	**BIOINFORMATICS AND APPLICATIONS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To improve the programming skills of the student in the field of Biological research.
- To know the recent evolution in biological databank usage
- To apply the knowledge of computer tools in biotechnology

LINUX OS AND PERL

File system – Listing Directories – Working with files – Text processing – Shell programmes – Programming in PERL: Name conventions – Variables – Operators – Functions – Control structures – File input and output

BIOLOGICAL SEQUENCES AND DATABANKS

Introduction to Biological sequences and methods of sequencing, Biological databases: Primary,Secondary and Composite databanks - Scoring matrices: PAM, BLOSUM - Data lifecycle

SEQUENCE ANALYSIS

Pairwise Sequence alignment: Dynamic Programming Algorithms, Needleman-Wunch Algorithm, Smith-Waterman Algorithm, FASTA, BLAST – Multiple sequence alignment: Progressive methods, Iterative methods, Applications – Motif representation- PSSM - Gene finding-Artificial Neural Network – Hidden Markov Model

DATA ANALYSIS AND VISUALIZATION

Analysis of gene expression – Analysis of protein expression – Analysis of mutations in cancer – High-throughput image analysis – High volume scatter plots – Heat maps-visualizing distances – Plotting along genomic coordinates. Introduction to Phylogenetic analysis

STRUTURAL ANALYSIS

Protein structure visualization and prediction: Pymol, Rasmol, *ab initio* folding, Threading,Homology modelling - RNA structure prediction, Mfold - Molecular dynamics: Rosetta - protein-ligand docking – QSAR-Protein-protein interaction

REFERENCES

1. Baldi, P. and Brunak, S., "Bioinformatics: The Machine Learning Approach" 2nd Edition, 2001, MIT Press.
2. Gentleman, R., "Bioinformatics and Computational Biology Solutions using R and Bioconductor", 2005, Springer Science and Business media Inc.,.
3. Lesk, A. K., "Introduction to Bioinformatics", 4th Edition, , 2013, Oxford University Press
4. Liebler, "Introduction to Proteomics", 2002, Humana Press.
5. Mount, D.W., "Bioinformatics Sequence and Genome Analysis" 2nd Edition, 2004, Cold Spring Harbor Laboratory Press.
6. Rastogi, S.C., "Bioinformatics Concepts, Skills & Applications", 2nd Edition, 2009, CBS Publishers.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Develop bioinformatics tools with programming skills.
2. Apply computational based solutions for biological perspectives.
3. Acquire knowledge on sequencing techniques
4. Gain knowledge in computer based tools in Bioinformatics
5. Develop skills on structural analysis of proteins and data analysis of gene

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓		✓	✓			✓			
CO2		✓	✓		✓	✓						
CO3	✓	✓	✓			✓						
CO4		✓	✓			✓						
CO5	✓	✓				✓						✓

CHCEMC15	**RESEARCH METHODOLOGY AND IPR**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**2**

COURSE OBJECTIVES

Enable the students

- To improve the basic knowledge and concepts in the field of research.
- To understand the importance patent right
- To know the importance of intellectual property rights

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Effective literature studies approaches, analysis Plagiarism, Research ethics,.

Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCES:

1. Stuart Melville and Wayne Goddard, “Research methodology: an introduction for science & engineering students”
2. Wayne Goddard and Stuart Melville, “Research Methodology: An Introduction”

3. Ranjit Kumar, “Research Methodology: A Step by Step Guide for beginners” 2nd Edition
4. Halbert, “Resisting Intellectual Property”, 2007, Taylor & Francis Ltd.
5. Mayall , “Industrial Design”, 1992, McGraw Hill.
6. Niebel , “Product Design”, 1974, McGraw Hill.
7. Asimov , “Introduction to Design”, 1962, Prentice Hall.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, “ Intellectual Property in New Technological Age”, 2016.
9. T. Ramappa, “Intellectual Property Rights Under WTO”, 2008, S. Chand.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Understand that today’s world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.
5. Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.
6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			✓	✓	✓				✓			
CO2	✓	✓	✓	✓								
CO3		✓	✓				✓					
CO4		✓	✓		✓		✓					
CO5		✓	✓		✓				✓			

CHBTCP16	**PREPARATIVE AND ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**2**

COURSE OBJECTIVES

Enable the students

- To learn and understand the principles behind the qualitative and quantitative estimation of bio molecules and laboratory analysis of the same in the body fluids
- To have a practical hands on experience on Absorption Spectroscopic methods and to validate spectrometric and microscopic techniques
- To acquire experience in the purification by performing chromatography

EXPERIMENTS

1. Estimation of amino acids by Ninhydrin method
2. Estimation of total sugars by Phenol sulphuric acid method
3. Estimations of carbohydrates – reducing vs non-reducing, polymeric vs oligomeric, hexose vspentose.
4. Estimation of protein concentration using Lowrys' and Bradford method
5. DNA determination by UV-visible spectrophotometer – hyperchromic effect.
6. Separation of amino acids and lipids by TLC.
7. Enzyme kinetics: Determination of Km, Vmax and Kcat, Kcat/ Km.
8. Restriction enzyme – Enrichment and unit calculation.
9. Ion-exchange chromatography – Purification of IgG and Albumin.
10. Gel filtration – Size based separation of proteins.
11. Affinity chromatography – IMAC purification of His-tagged recombinant protein.
12. Extraction and characterization of photochemical using UV-visible spectrophotometer.
13. Separation of compounds using Column chromatography.

REFERENCES

1. Pingoud, A., Urbanke, C., Hoggett, J. and Jeltsch, A., "Biochemical Methods: A Concise Guidefor Students and Researchers", 2002, Wiley-VCH.
2. Segel, I.H., "Biochemical Calculations: How to Solve Mathematical Problems in General Biochemistry", 2nd Edition, 2004, John Wiley & Sons.
3. Wilson, K. and Walker, J., "Principles and Techniques of Biochemistry and Molecular Biology",7th Edition, 2010, Cambridge University Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Quantify Bio molecules using spectroscopy methods
2. Purify enzymes and metabolites using Chromatography techniques
3. Solve problems related Enzyme involved reactions and kinetics
4. Design processes for the recovery and subsequent purification of target biological products.
5. Learn about the analytical techniques in estimation of bio molecules

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓		✓				✓			
CO2		✓	✓								✓	✓
CO3		✓	✓	✓							✓	✓
CO4				✓		✓						
CO5			✓	✓								✓

CHBTCP17	**IMMUNOTECHNOLOGY LABORATORY ADVANCED AND GENETIC ENGINEERING**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**2**

COURSE OBJECTIVES

Enable the students

- To give practical exposure in the clinical diagnosis.
- To give laboratory training in different immunotechnological techniques.
- Provide hands-on experience in performing basic recombinant DNA techniques.
- To understand the principle behind each techniques and applications of each methodology in applied biological research.

IMMUNOTECHNOLOGY

1. Collection of serum, storage and purification of total IgG (salt precipitation).
2. Evaluation of Antibody titre by direct ELISA
3. Evaluation of Antigen by Sandwich ELISA
4. Characterization of antigens by native and SDS-PAGE
5. Characterization of antigens by Western blot analysis – Wet and semidry transfer
6. Conjugation of Immunoglobulin's (Streptavidin, colloidal gold)
7. Methods for prototype development of Immunodiagnostics (ICT card)
8. Blood smear identification of leucocytes by Giemsa stain
9. Separation of mononuclear cells by Ficoll-Hypaque
10. Separation of spleenocytes and proliferation against mitogens

GENETIC ENGINEERING

1. Isolation of DNA
2. Electroporation to Yeast
3. Isolation of RNA
4. cDNA synthesis
5. Primer designing
6. Real-time PCR
7. Plasmid isolation and confirming recombinant by PCR and RE digestion.
8. Western blot with ECL detection
9. Site directed mutagenesis
10. Southern blot (Non-radioactive)

Required Equipments:

Microscopes, restainer (mouse, rat, rabbit), purification columns, microplate reader, UV spectrometer, PAGE apparatus, Western blot apparatus (dry/semi-dry/wet), centrifuge, Haemocytometer, required strains & consumables

Microscopes, PCR, purification columns, microplate reader, UV spectrometer, PAGE apparatus, Western blot apparatus (dry/semi-dry/wet), Southern blot apparatus, centrifuge, Haemocytometer, required stains, chemicals, enzymes & consumables

REFERENCES

1. Edward A. Greenfield, Antibodies: A Laboratory Manual, 2nd Edition, 2014, Cold Spring Harbor Laboratory Press.

2. Current protocols in immunology / editorial board John E. Coligan.*et al*,. 2003, New York : Wiley Interscience.
3. Frank C. Hay and Olwyn M.R. Westwood, Practical Immunology 4th edition, 2002, Blackwell Science Ltd.,.
4. Sambrook, J. and Russsel, D.W., "Molecular cloning – A laboratory manual", Third edition, 2001, Cold Spring Harbor Laboratory Press, New York, USA.

COURSE OUTCOMES

At the end of this course, students will be able to

1.Know on immunological /clinical tests.
2.Understand the main principles, methods for preparation and cloning of DNA in various organisms.
3.Express clearly about the gene amplification and methods for analysis of DNA, such as hybridization, restriction analysis and gene expressions.
4.Know clearly about the gene amplification and methods for analysis of DNA, such as hybridization, restriction analysis and gene expressions.
5.Use genetic and biotechnological techniques to manipulate genetic materials and develops new and improved living organisms.

Mapping with Program outcomes												
Cos	**PO1**	**PO 2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			✓	✓	✓				✓			
CO2	✓	✓	✓	✓	✓							✓
CO3						✓					✓	✓
CO4						✓			✓		✓	✓
CO5					✓	✓			✓		✓	✓

CHBTPC21	**BIOPROCESS ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To impart knowledge on design and operation of fermentation processes with all its prerequisites.
- To endow the students with the basics of microbial kinetics, metabolic stoichiometry and energetics.
- To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

METABOLIC STOICHIOMETRY AND ENERGETICS

Outline of Stoichiometry and energetics – Growth yields, Growth yields based on total energy and ATP generation – Conservation of mass principles - Carbon and oxygen balances, ATP generation during growth – Relationship between substrate consumption, growth, respiration and noncellular products – Growth energetics of aerobic and anaerobic process – Case studies on

mass and energy balance for Embden–Meyerhoff–Parnas pathway, continuous ethanol fermentation, penicillin production.

MICROBIAL GROWTH, KINETICS, MAINTENANCE AND PRODUCT

Establishment of growth kinetic equations for batch, fed batch and continuous culture – Basic unstructured kinetic models of growth and product substrate utilization – Negative biokinetic rates– Multisubstrate kinetics – Mixed population kinetics - Kinetic models for microbial product formation - Kinetic model equations for inhibition by substrates and products.

STRUCTURED MODELS

Structured models for growth and product formation – Compartmental and metabolic models – Mechanistic models - Product formation kinetics – Gaden's and Deindoerfer's classifications – Chemically and genetically structured models – Kinetics models of heterogenous bioprocesses – Biofilm kinetics, Unstructured models of pellet growth – Considerations for the production of r-DNA products.

MASS TRANSFER IN BIOLOGICAL SYSTEMS

Interphase Gas-Liquid mass transfer – General oxygen balances for Gas-Liquid transfer – Models for oxygen transfer in large scale bioreactors – Case studies for large scale bioreactors – Model for oxygen gradients in a bubble column bioreactor, air lift bioreactor – Model for a multiple impeller fermenter – Gas-liquid mass transfer of components other than oxygen.

DIFFUSION AND BIOLOGICAL REACTION IN IMMOBILIZED BIOCATALYST

External mass transfer – Internal diffusion and reaction within biocatalysts – Derivation of finite difference model for diffusion – Reaction systems – Dimensionless parameters from diffusion – Reaction models – Effectiveness factor concept – Case study for diffusion with biological reaction – Estimation of oxygen diffusion effects in a biofilm.

REFERENCES

1. Blakebrough, N., T. K. Ghose, and A. Fiechter, Eds. "Advances in biochemical engineering" volume 3, 2013, Springer-Verlag.
2. Dunn, I.J., Heinzle, E., Ingham, J. and Prenosil, J.E., "Biological Reaction Engineering: Dynamic Modelling Fundamentals with simulation examples", 3rd Revised Edition, 2016, WILEY-VCH publications.
3. Moser, Anton., "Bioprocess technology: kinetics and reactors", 2012, Springer Science & Business Media.
4. Najafpour, G.D., "Biochemical Engineering & Biotechnology", 2 nd Edition,2015, Elsevier.
5. Truskey, G.A., Yuan, F. and Katz, D.F., "Transport Phenomena in Biological Systems", 2007, Pearson, Prentice Hall.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Apply engineering principles to systems containing biological catalysts to meet the needs of the society.
2. Interpret the kinetics of living cells and to develop a strategy to solve the issues emerging during fermentation processes.

3. Gain knowledge on modeling of biological systems
4. Apply the knowledge of mass transfer in biological systems
5. Acquire knowledge about effective factor of immobilized biological systems

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓				✓				
CO2	✓	✓	✓								✓	
CO3	✓	✓	✓			✓						
CO4			✓	✓		✓	✓					✓
CO5			✓									✓

CHBTPC22	**BIOSEPARATION TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To understand the methods to obtain pure proteins, enzymes and in general about product development R & D
- To have depth knowledge and hands on experience on Downstream processes to commercial therapeutically important proteins.
- To gain knowledge on membrane separation of bio molecules

DOWNSTREAM PROCESSING IN BIOTECHNOLOGY

Role and importance of downstream processing in biotechnological processes – Problems and requirements of bio product purification – Economics of downstream processing in Biotechnology, cost-cutting strategies – Separation characteristics of proteins and enzymes – size, stability, properties – Flocculation and conditioning of broth – Process design criteria for various classes of bio products (high volume, low value products and low volume, high value products) – Upstream production methods affect downstream purification strategies.

PHYSICO-CHEMICAL BASIS OF BIO-SEPARATION PROCESSES

Cell disruption methods for intracellular products – Physical, chemical, mechanical – Removal ofinsoluble, biomass and particulate debris separation techniques – Filtration at constant pressure and at constant rate – Empirical equations for batch and continuous filtration – Types of filtration - Centrifugal and cross – flow filtration – Types of filtration equipments – Centrifugation – Basic principles, design characteristics – Types of ccentrifuges and applications – Sedimentation.

MEMBRANE SEPARATIONS AND ENRICHMENT OPERATIONS

Theory, Design consideration and configuration of membrane separation processes – Reverse osmosis, microfiltration, ultra filtration, dialysis and pervaporation – Structure and characteristics of membranes – Membrane modules – Enrichment Operations – Extraction– equipment for extraction– Aqueous two-phase extraction process – Evaporators – Types of

evaporators – Adsorption isotherms and techniques – Protein precipitation – Methods of precipitation.

MECHANISM AND MODES OF CHROMATOGRAPHIC SEPARATION

Chromatography – Classification of chromatographic techniques – General description of column chromatography – Chromatographic terms and parameters – Practice of chromatography – Partition, normal-phase, displacement, reversed-phase, size exclusion, ion exchange, hydrophobic, affinity chromatography – Scale-up of chromatography – Process considerations in Preparative liquid chromatography and HPLC .

FINISHING OPERATIONS AND FORMULATIONS

Drying – Mechanism, methods and applications, Types of dryers – Tray, spray, rotary, belt, disc – Crystallization – Nucleation , growth – Types of crystallizers – Tank, scrapped surface, Oslo, Circulating-magma evaporator – Freeze drying – Principle, process, applications – Case studies- Citric acid, Penicillin , Cephalosporin, Recombinant Streptokinase, Interferon.

REFERENCES

1. Belter, P.A., Gussler, E.L. and Hu, W.S., "Bioseparation: Downstream Processing for Biotechnology", 2011, John Wiley and Sons.
2. Forciniti, D., "Industrial Bioseparation: Principles & Practice", 2008, Blackwell.
3. Ghosh, R., "Principles of Bioseparations Engineering", 2006, World Scientific Publishers.
4. Ladisch, M.R., "Bioseparations Engineering: Principles, Practice, and Economics", 2001, John Wiley & Sons.
5.Roger, H., "Bioseparations Science and Engineering", 2006, Oxford University Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Acquire knowledge about bio products and purifications strategies.
2. Apply advanced downstream processing methods for product recovery.
3. Know about the components of downstream equipment and shall be used in the effective design of separation system for successful operations.
4. Enhance problem solving techniques required in multi-factorial manufacturing environment in a structured and logical fashion.
5. Gain knowledge about finishing operation and formulation of bioproducts

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓		✓				✓		✓	✓
CO2	✓	✓	✓								✓	✓
CO3				✓		✓					✓	✓
CO4			✓	✓		✓	✓					✓
CO5		✓	✓								✓	✓

CHBCP25	BIOPROCESS AND DOWNSTREAM PROCESSING LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

Enable the students

- To learn about mass transfer in bio reactors and sterilization kinetics.
- To provide hands on training in Downstream processing through simple experimentations in the laboratory.
- To understand the nature of the end product, its concentration, stability and degree of purification required for targeted biological products.
- To gain knowledge about analogy when solving problems typical for the bio industry or for research.

1. Enzyme immobilization studies – Gel entrapment, adsorption and cross linking immobilisation.
2. Batch cultivation – *E.coli* – growth rate, substrate utilization kinetics, product analysis after induction, metabolite analysis by HPLC.
3. Fed batch cultivation - *E.coli* - growth rate, substrate utilization kinetics, product analysis after induction, metabolite analysis by HPLC.
4. Continuous cultivation – x - D construction, kinetic parameter evaluation, gas analysis, carbon balancing.
5. Optimization techniques – PlackettBurman, Response surface methodology.
6. Bioreactor studies: Sterilization kinetics, k_La determination, residence time distribution.
7. Cell separation methods-Centrifugation and microfiltration
8. Cell disruption methods- ultrasonicator, homogeniser.
9. Aqueous two phase extraction of biologicals.
10. Protein precipitation by salting –out method (ammonium sulphate).
11. Protein purification method- Column chromatography.
12. Product polishing- dryers, crystallizers.

Required Equipments:

Centrifuge, Column for purification, Ultrasonicator, Homogeniser, Microfiltration capsule, Hot air oven, Incubator, Laminar air flow chamber, HPLC, required chemicals & stains.

REFERENCES

1. J.C. Janson – Protein Purification – Principles, High Resolution Methods and Applications, 3rd Edition, 2011, Wiley.
2. Pauline Doran, Bioprocess Engineering Calculation, Blackwell Scientific Publications.
3. Shuler and Kargi, "Bioprocess Engineering ", 3rd Edition, 2017, Prentice Hall.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Gain ability to investigate, design and conduct experiments, analyze and interpret data, and apply the laboratory skills to solve complex bioprocess engineering problems.
2. Know about fermentation strategies in biochemical product production

3. Acquire knowledge for the separation of whole cells and other insoluble ingredients from the culture broth.
4. Learn the basic principles and techniques of chromatography to purify the biological products and formulate the products for different end uses.
5. Understand about the purification and polishing methods of biological products

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1		✓	✓	✓	✓							✓
CO2	✓	✓	✓								✓	
CO3			✓			✓					✓	
CO4	✓	✓	✓	✓							✓	✓
CO5		✓				✓		✓			✓	

CHBTTS27	**INDUSTRIAL TRAINING AND SEMINAR/MINI PROJECT**	**L**	**T**	**S**	**C**
		0	**2**	**2**	**2**

COURSE OBJECTIVES

- To train the students in the field work related to biotechnology and to have a practical knowledge in carrying out work.
- To train and develop skills in solving problems during execution of certain works related to biotechnology

The students individually undergo a training program in reputed concerns in the field of biotechnology during the summer vacation (at the end of second semester for full-time/ IV semester for part time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training they had, within ten days from the commencement of third semester for full time/fifth semester for part time. The student will be evaluated by a team of staff members nominated by head of the department through a vivavoce examination

COURSE OUTCOME

1. The student can face the challenges and practice with confidence
2. The student will be benefitted by the training with managing the situation arises during the execution of work related to biochemical process industries.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1										✓	✓	
CO2	✓							✓			✓	

CHBTPV33	Project Work Viva Voce Phase – I	L	P	S	C
		0	16	4	10

CHBTPV41	Project Work Viva Voce Phase – II	L	P	S	C
		0	24	6	15

Dissertation Phase – I and Phase – II
Teaching Scheme Lab work: 20 and 30 hrs/week for phase I and II respectively

COURSE OBJECTIVES

- Ability to synthesize knowledge and skills previously gained and applied to an in-depth study and execution of new technical problem.
- Capable to select from different methodologies, methods and forms of analysis to produce a suitable research design, and justify their design.
- Ability to present the findings of their technical solution in a written report.
- Presenting the work in International/ National conference or reputed journals.

Syllabus Contents:
The dissertation / project topic should be selected / chosen to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the world of work and the world of study. The dissertation should have the following
• Relevance to social needs of society
• Relevance to value addition to existing facilities in the institute
• Relevance to industry need
• Problems of national importance
• Research and development in various domain

The student should complete the following:

• Literature survey
Problem Definition
• Motivation for study and Objectives
• Preliminary design / feasibility / modular approaches
• Implementation and Verification
• Report and presentation

The dissertation stage II is based on a report prepared by the students on dissertation allotted to them.
It may be based on:
• Experimental verification / Proof of concept.
• Design, fabrication, testing of Communication System.
• The viva-voce examination will be based on the above report and work.

Guidelines for Dissertation Phase – I and II

• As per the AICTE directives, the dissertation is a year long activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.

• The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator.

• After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include Springer/Science Direct. In case of Industry sponsored projects, the relevant application notes, papers, product catalogues should be referred and reported.

• Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase-wise work distribution, and submit the proposal within a month from the date of registration.

• Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, A record of continuous progress.

• Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q&A.
In case of unsatisfactory performance, committee may recommend repeating the phase-I work.

• During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.

• Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, A record of continuous progress.

• Phase – II evaluation: Guide along with appointed external examiner shall assess the progress/performance of the student based on report, presentation and Q & A.
In case of unsatisfactory performance, committee may recommend for extension or repeating the work.

COURSE OUTCOME

At the end of the course students will be

1. Able to develop better knowledge about bioprocess engineering, fermentation techniques and genetic engineering from literatures.
2. Benefitted by the implementation of computational tools to solve the problems arising in bioprocesses.
3. Acquiring knowledge to represent bioprocesses with suitable kinetic models.
4. Gaining knowledge to transform technology to commercial products by scaling up
5. Developing technical reporting and project preparation for entrepreneurship

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓					✓		✓	✓
CO2	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓
CO3		✓	✓	✓	✓	✓	✓	✓			✓	✓
CO4		✓	✓	✓		✓	✓	✓			✓	✓
CO5		✓	✓	✓		✓	✓	✓		✓		

PROGRAM ELECTIVES

CHBTPEXX	IMMUNOTECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

Enable the students

- To understand the structure, functions and integration of immune system.
- To explain the antigen-antibody interactions that offers defence mechanism
- To know various techniques of therapeutically significant monoclonal and engineered antibodies production

IMMUNE SYSTEM AND ITS RESPONSE

Cells of the immune system and their development – Primary and secondary lymphoid organs – Humoral immune response – Cell mediated immune responses – T lymphocyte and B lymphocyte Tolerance – Homeostasis in immune system – Complement.

ANTIGEN AND ANTIBODY

Production of antibodies – Polyclonal, monoclonal – Hybridoma technology – Antibody – Isolation and identification – Validation and their use – Agglutination and precipitation tests – Coomb's test – ELISA types – ELISPOT– Plaque forming cell assay, Epitope mapping, Antigen detection assay,

SDS-PAGE- immunoblotting and immunoprecipitation – Immunofluorescence and immunohistochemistry – Measurement of Ag-Ab interaction.

CELLULAR IMMUNOLOGICAL TECHNIQUES

PBMC separation from the blood – Ficoll-hypaque method – Identification of lymphocytes based on CD markers – FACS – Lymphoproliferation assay – Cr5I release assay – Macrophage cultures detection assays – Rosette assay – Cytokine bioassays: IL2, IFNγ, TNFα – Mixed lymphocyte reaction – HLA typing.

VACCINE TECHNOLOGY

Principles in vaccine development – Adjuvant, Immunization (Active and Passive immunization) – Vaccine validation – Protein based vaccines – DNA vaccines – Plant based vaccines – Edible

vaccine – Recombinant antigens as vaccines – Multivalent subunit vaccine – Reverse vaccinology – New Types of Replicating vaccines.

IMMUNOTHERAPEUTICS

Engineered antibodies – Catalytic antibodies, idiotypic antibodies, plantibodies – Combinatorial libraries for antibody isolation. Cancer immunotherapy and Immunosuprressive therapy – Cytokine therapy – Immunoglobulin therapy: Replacement and immunomodulators – Gene transfer techniques for immunological diseases.

REFERENCES

1. Emily P. Wen, Ronald Ellis and Narahari S. Pujar, "Vaccine Development and Manufacturing" 2014, 1st Edition, Wiley,
2. Gerd-RudigerBurmester, Antonio Pezzutto and Jurgen Wirth, "Color Atlas of Immunology", 2003, 1st Edition, Thieme Medical Publishers,
3. Judith A. Owen, Jenni Punt and Sharon Stranford, "Kuby Immunology", 7th Edition, 2013, W.H. Freeman and Company.
4. Peter J. Delves, Seamus J. Martin, Dennis R. Burton and Ivan M. Roitt, "Roitt's Essential Immunology", 2011, 12th Edition, Wiley-Blackwell Publication.
5. Robert R. Rich, Thomas A Fleisher, William T. Shearer, Harry Schroeder, Anthony J. Frew and Cornelia M. Weyand, "Clinical Immunology-Principles and Practice", 2013, 4th Edition, Elsevier.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Aware the immune system structure and functions, immunity to various pathogens
2. Know about concepts evolved in antibody and antigens
3. Acquire knowledge about vaccine development processes
4. Produce the therapeutic and diagnostic molecules
5. Aware of tumour, allergy and hypersensivity reactions

Mapping with Program outcomes											
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓				✓			✓
CO2	✓	✓	✓	✓	✓	✓						✓
CO3		✓	✓	✓								✓
CO4		✓	✓	✓								✓
CO5		✓	✓	✓	✓							✓

CHBTPEXX	**METABOLIC PROCESS AND ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To understand metabolic networks in single cells and at the individual organ level

- To understand the use of organisms to produce valuable substances on an industrial scale
- To minimize the cost of production in effective manner

CELLULAR METABOLISM

Transport Processes – Fueling reactions – Glycolysis, fermentative pathways – TCA cycle and oxidative phosphorylation, anaplerotic pathways –Catabolism of fats, organic acids, and aminoacids - Biosynthesis of aminoacids, nucleic acids, and fatty acids – Polymerization – Growth energetics.

REGULATION, MANIPULATION AND SYNTHESIS OF METABOLIC PATHWAY

Regulation of enzyme activity – Regulation of enzyme concentration – Regulation of metabolic networks – Regulation at the whole cell level – Metabolic pathway manipulations – Enhancement of Product yield and productivity – Extension of substrate range, product spectrum and novel products (Antibiotics, Polyketides, Vitamins) – Improvement of cellular properties – Metabolic pathway synthesis algorithm – Lysine biosynthesis.

ANALYSIS AND METHODS FOR THE METABOLIC FLUX

Metabolic flux map – Fluxes through the catabolic pathways in microbes– Metabolic flux analysis for determined, over-determined and under-determined systems –Sensitivity analysis – Direct flux determination from fractional label enrichment – Applications involving complete enumeration of metabolite isotopomers – Carbon metabolite balances.

APPLICATION OF METABOLIC FLUX ANALYSIS

Amino acid production – Biochemistry and regulation– Metabolic flux analysis of lysine biosynthetic network and specific deletion mutants – Metabolic fluxes in mammalian cell cultures – Intracellular fluxes, validation of flux estimates by ^{13}C labeling studies – Design of cell culture media.

ANALYSIS OF METABOLIC CONTROL AND INDUSTRIAL CASE STUDIES

Fundamental of Metabolic Control Analysis (MCA), MFA, and MPA and their application, relating system variables to enzyme kinetics, Multi-substrate enzyme kinetics, Metabolic engineering examples for bio-fuel, bio-plastic and green chemical synthesis and industrial case studies.

REFERENCES

1.Christiana D. Smolke, " The Metabolic Pathway Engineering Handbook Fundamentals", 2010, CRC Press Taylor & Francis Group.
2. Cortossa, S., Aon, M.A., Iglesias, A.A. and Lloyd.D., "An Introduction to Metabolic and Cellular Engineering", 2nd Edition, 2011, World Scientific Publishing Co.
3. Curran, C.P., "Metabolic Processes and Energy Transfers - An Anthology of Current Thought", 2006, The Rosen Publishing group, Inc.,.
4. Nielsen, J., Villadsen, J. and Liden, G., "Bioreaction Engineering Principles",3rd Edition, 2011, Springer.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Gain knowledge about various transport process in biological systems
2. Understand regulations related to enzymatic and microbial systems.
3. Familiar with metabolic flux analysis.
4. Acquire the concept of biochemistry regulations and culture media designing.
5. Know the various metabolic control analysis techniques and kinetic studies.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓		✓	✓	✓	✓					✓	✓
CO2	✓	✓	✓	✓		✓			✓			✓
CO3	✓	✓	✓			✓						✓
CO4	✓	✓	✓			✓			✓			
CO5	✓	✓	✓			✓	✓					

		L	T	P	C
CHBTPEXX	**COMPUTER AIDED LEARNING OF STRUCTURE AND FUNCTIONS OF PROTEINS**	**3**	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To identify the importance of protein bio molecules.
- To realize the structure-function relationships in proteins
- To utilize the computational methods in protein structures and functions

AMINO ACIDS AND 3D STRUCTURE

Amino acids – Acid-base properties – Stereo chemical representations – Chemical and Physical properties – Primary structure – Secondary structure and motifs – Tertiary structures and domains – Quaternary structures – Classifications – CATH, SCOP – Protein Data Base analysis.

FIBROUS AND MEMBRANE PROTEINS

Amino acid composition and organization of fibrous proteins – Keratins – Fibroin –Collagen – Molecular organization of membranes – Bacteriorhodopsin – Structure of the Bacterial reaction centre – Oxygenic photosynthesis – Membrane proteins based on transmembrane beta barrels – Structure of ATP synthetase.

FUNCTION AND CONTROL OF FUNCTION

Protein flexibility – Hydrogen exchange – Rotations of side chains – Enzyme Catalysis – Steady state kinetics – Transition state stabilization – Allostery – Multiple binding sites and interactions – Allosteric properties of Hemoglobin – Negative Cooperativity.

BIOSYNTHESIS AND DEGRADATION

Over view of protein biosynthesis - Post translational covalent modifications – Proteolytic processing – Alteration of the chain Termini– Glycosylation – Lipid attachment – Hydroxylation – Phosporylation – Disulphide bond formation protein folding and targeting– Chemical aging –

Factors determine the rate of degradation – Proteases – Lysosomes – Ubiquitin mediated pathway.

DETERMINATION AND PREDICTION OF 3D STRUCTURE

Experimental physical methods – X-Ray crystallography, NMR, Cryo-EM, Neutron diffraction – Vibrational spectroscopy – Raman spectroscopy – Computational methods – Homology modeling – Fold recognition and Threading.

REFERENCES

1. Bujnicki, J.M., "Prediction of Protein Structures, Functions, and Interactions", 2009, John Wiley & Sons Ltd.,.
2. Creighton. TE., "Proteins: Structures and Molecular Properties", 2nd Edition, 1993, W. H. Freeman and Company, New York,.
3. Petsko, G.A. and Ringe, D., "Protein Structure and Function", 2004.
4. Rastogi, S.C., "Bioinformatics Concepts, Skills & Applications", 2nd Edition, 2009, CBS publishers.
5. Whitford, D.,"Proteins: Structure and Function", 2005, John Wiley & Sons Ltd.,.

COURSE OUTCOMES

At the end of this course, students will be able to
1. Gain knowledge about amino acids and its metabolism.
2. Analyze the various interactions in protein makeup.
3. Familiar with different levels of protein structure.
4. Acquire the concept of biosynthesis and degradation of proteins.
5. Know the role of functional proteins in various field of study.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓	✓						
CO2	✓	✓	✓	✓	✓	✓						
CO3		✓	✓	✓		✓						
CO4		✓	✓			✓					✓	✓
CO5		✓		✓		✓		✓				✓

CHBTPEXX	**ADVANCED GENETIC ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students
- To understand the gene cloning methods and the tools and techniques involved in gene cloning and genome analysis and genomics.
- To know the heterologous expression of cloned genes in different hosts, production of recombinant proteins and PCR techniques.

- To understand the comparative of genomics and proteomics.

CLONING WITH SPECIALIST-PURPOSE VECTORS

M13 based vectors, production of RNA probes and interfering RNA - controllable promoters for maximal expression of cloned gene – λP_L, trc, T_7 and pBAD - factors affecting the expression of cloned genes - purification tags for purification of cloned gene product – vectors for solubilization of expressed proteins - gateway system of transferring DNA fragments to vectors

cDNA LIBRARY CONSTRUCTION

OligodT priming, self priming and its limitations. Full length cDNA cloning – CAPture method and Oligo capping. Screening strategies – Hybridization, PCR, Immunoscreening, South-western and North-Western. Functional cloning – Functional complementation and gain of function. Difference cloning: Differential screening, Subtracted DNA library, differential display by PCR.

MUTAGENESIS AND ALTERED PROTEIN SYNTHESIS

Random mutagenesis - Error-prone PCR, Rolling circle error-prone PCR, use of mutator strains, temporary mutator strains, Insertion mutagenesis, ethyl methanesulfonate, DNA Shuffling, signature tagged mutagenesis and transposon mutagenesis. Incorporation of unnatural amino acids into proteins – Phage and cell-surface display for selection of mutant peptides

GENOME ENGINEERING

DNA damage – sources and types - DNA double stranded break repair mechanisms - Engineered nucleases in genome engineering - meganucleases, ZFNs, TALEN and CRISPR-Cas system – Mechanisms and applications – Benefits of genome engineering – targeted gene mutation, creating chromosome rearrangement, studying gene function with stem cells, transgenic animals, endogenous gene labelling and targeted transgene addition – genome engineering -prospects and limitations.

GENETIC MANIPULATION OF CELLS AND ANIMALS

Overview - principle of gene transfer - methods of gene transfer to animal cell culture - selectable markers for animal cells - Isolation and manipulation of mammalian embryonic stem cells - Using gene transfer to study gene expression and function - creating disease models using gene transfer and gene targeting technology - potential of animal for modelling human disease

REFERENCES

1. Benjamin Lewin, “Gene IX”, 2011, Oxford University Press, Cambridge, U.K.
2. Brown, T.A., “Gene cloning and DNA analysis: An introduction”, 6th Edition, 2010, Wiley-Blackwell,
3. Glick, B.R. and Pasternak J.J., “Molecular Biotechnology: Principles and Applications of Recombinant DNA”, 3rd Edition, 2003, ASM Press.
4. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vol 1-3, 2001, CSHL.
5. Primrose, S.B., and Twyman., “Principles of Gene Manipulation and Genomics”, 7th Edition, 2006, Blackwell Science,
6. Winnacker, E.L., “Frome Genes to Clones: Introduction to Gene Technology”, 2006, Wiley-Blackwell.

7. Yamamoto, Takashi (Ed.). "Targeted Genome Editing Using Site-Specific Nucleases", 2015, Springer,Japan.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand the basics of genes and its functionalities.
2. Know the clone methods of commercially important genes.
3. Produce the commercially important recombinant proteins.
4. Mutagenesis of gene and genome sequencing techniques.
5. Apply the skills of microarrays, Analysis of Gene expression and proteomics, techniques in genetic manipulation.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓				✓		✓	✓
CO2	✓	✓	✓	✓				✓	✓		✓	
CO3			✓	✓				✓	✓			
CO4			✓	✓	✓						✓	
CO5			✓	✓								✓

CHBTPEXX	**ANIMAL BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To provide the fundamentals of animal cell culture, diseases and therapy
- To know the concepts of basic genetic engineering
- To gain knowledge about the micromanipulation and transgenic animals

CELL CULTURE

Culturing of cells– Primary and secondary cell lines – Genetics of cultured cells – Scaling up in suspension –Monolayer culture – Bio-reactors used for animal cell culture –Roller bottle culture– Bioreactor process control –Stirred animal cell culture –Air-lift fermentor, Chemostat/Turbidostat– Cell lines and their applications.

GENE CLONING VECTORS AND IMMUNOLOGY

Viral disease in animals–Animal viral vectors –Vector design–SV40, adeno virus, retrovirus, vaccinia virus, herpes virus, adeno associated virus and baculo virus– Immune response – Lymphocyts, immune system – Baculo virus expression vectors–Vaccines and their applications in animal infections –High technology vaccines – Hybridomatechnology.and production of monoclonal antibodies.

STEM CELL AND CLONING

Characteristics of ES cells –Types of stem Cells – ES cell research–*In vitro* derivation of gametes –Maintenance of stem cells in culture and applications – Somatic cell nuclear transfer – Gene expression of pluripotent cells –Cellular reprogramming –Induced pluripotency– Cloning techniques in animals and therapeutic cloning.

GENE THERAPY

Prospects and problems – Single gene – Gene mapping – Hematopoietic cells for cellular gene therapy of animal disease –Knockout mice and mice model for human genetic disorder –Baculo virus in biocontrol– Enzymes technology – Somatic manipulation of DNA – Nucleic acid hybridization and probes in diagnosis– Preparation of probes, evaluation and applications.

METHODS OF TRANSGENESIS AND APPLICATIONS

Rumen manipulation– Probiotics embryo transfer technology – *Invitro* fertilization, transgenesis– Methods of transferring genes into animal oocytes, eggs, embryos and specific tissues by physical, chemical and biological methods–Biopharming– Transgenic animal technology, application to production and therapeutics (mice, sheep, cattle) – Artificial insemination and embryo transfer – Transgenic growth hormone genes.

REFERENCES

1. Freshney R.I. Cultures of Animal cells: A manual of Basic Techniques and specializedapplications, 6th Edn, 2010, John Wiley and Sons.
2. Glick, B.R. and Pasternack, J.J. and Pattern ,C. Molecular Biotechnology, 4th Edition, 2003, ASM Press.
3. Lewin, B. Genes VIII , 2004, Pearson Prentice Hall.
4. Portner, R, Animal Cell Biotechnology, Methods and Protocol, 2nd Edn, 2000, Humana Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand the animal cell culture, animal diseases and its diagnosis.
2. Gain the knowledge for therapy of animal infections.
3. Know the concepts of micromanipulation technology and transgenic animal technology.
4. Acquire knowledge about the gene manipulation.
5. Use the knowledge gained in this section to apply in the field of clinical research.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓				✓							
CO2				✓	✓							
CO3				✓								✓
CO4				✓								✓
CO5						✓		✓				

CHBTPEXX	**PHYTOCHEMISTRY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSEOBJECTIVES

Enable the students

- To give the details of plant derived value added compounds and its functions
- To know about the pharma drugs using plant sources
- To provide knowledge on biotech based production of agro medicines

HERBAL DRUGS

Phytochemicals and their classification–Phytochemical screening –Physiochemical tests — Macroscopic and microscopic techniques –Traditional plant and Herbal remedies — Herbal drugs WHO guidelines–Standardization of Herbal Drugs Derivatives with Special Reference to Brazilian Regulations

PHYTOCOMPOUNDS

Plant extract used to Bacterial, Fungal and Parasitic infection – Biological and Toxicology Properties of plant extract –Anti-MRSA and Anti-VRE activities of Phytoalexins and Phytoncides– Anti microbial and targeted screening of Plant extract – Plant derived compound against drug resistant microorganisms –Antioxidant and antitumor Plant metabolites (fruits and vegetables)– Bioactive compounds as food

PHYTOMEDICINE AND PHYTOPHARMACEUTICALS

Medicinal Plants for Development of Phytomedicine and Use in Primary Health Care– Immunostimulants and adaptogen from Plants –Polyphenols for Atherosclerosis and Ischemic Heart disease –Cancer Chemopreventive agents –Lipidoxidation nitrogen Radicals– Phytochemicals in oilseeds – Flavonoids in Cardiovascular disease – Bioengineering and Breeding approaches in improving phytochemical content of plants.

SEPARATION TECHNIQUES AND STRUCTURE ELUCIDATION

Thin layer chromatography– HPTLC– Column chromatography – GC-MS – LC-MS –HPLC – Partition chromatography – Gas chromatography – FT-IR – UV- NMR (1D&2D) – X-ray diffraction – QSAR and Molecular Modeling

SECONDARY METABOLITES PRODUCTION

Secondary metabolite production through cell culture system–Hairy root induction–Methods of gene transfer–Chemical methods– PEG – dextran–Physical method– Electroporation– Microinjection–Lipofection delivery for herbal therapeutics–Quality Control –Germplasm improvement

REFERENCES

1. Ahamed, I., Aqil, F. and Owais, M.,"ModernPhytomedicine",Turning medicinal Plants into drugs. 2006, WILEY VCH, Verlag GmbH & Co, KGaA, Weinheim.
2. Arnason, J.T., Arnason, J.E. and Arnason, J.T.,"Phytochemistry of Medicinal Plants", 1995, Kluwer Academic Publishers,.
3. Bidlack, W.R., Omaye, S.T., Meskin, M.S.andTopham, D.K.W.," Phytochemicals as Bioactive Agents", 1St Edition, 2000, CRC Press.
4. Meskin, M.S., Bidlack, W.R., Davies, A.J. and Omaye, S.T., "Phytochemicals in Nutrition and

Health", 2002, CRC Press.
5. Rasooli, I, "Bioactive compounds in Phytomedicine" , 1st Edition, 2011, Intech Open access Publishers.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand the fundamentals of phytochemicals and its functions.
2. Use the knowledge for the development of therapeutic products.
3. Learn the separation techniques of herbal agromedicines and its analysis.
4. Gain the knowledge about the plant tissue culture based secondary metabolites.
5. Use of the gained knowledge for improvement in quality of products.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓				✓			
CO2		✓	✓	✓	✓				✓			✓
CO3			✓	✓			✓					✓
CO4		✓	✓									✓
CO5			✓			✓		✓	✓			

CHBTPEXX	**ADVANCED GENOMICS AND PROTEOMICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To understand the gene cloning methods, tools and techniques involved in genome analysis and genomics.
- To explain the heterologous expression of cloned genes in different hosts, production of recombinant proteins and PCR techniques.
- To identify the importance of protein bio molecules and the structure-function relationships in proteins.
- To explain comparative genomics and proteomics.

GENE AND GENOME ANALYSIS

Gene prediction in prokaryotes and eukaryotes - Genome-wide association (GWA) analysis - Massively parallel Signature sequencing (MPSS), Whole genome Shotgun sequencing,Next Generation Sequencing (NGS) - Cytogenetic and physical mapping - GDB, NCBI, OMIM, NGI/MGD - Structural annotation - Functional annotation - Limitation of genomics

GENOME INFORMATICS

Functional genomics: Developmental biology and Differential gene expression, Microarray analysis- Epigenomics: Histone modification assays-ChIP-Chip and ChIP-Seq, DNA

Methylation assays-DNA hybridization technique - Metagenomics: *de novo*transcriptome assembly

GENOMIC DIVERSITY

Study systems: Cyanobacteria, Plasmodium, Yeast, Virus, *Arabidopsis thaliana*, *Homo sapiens*, Worm, Zebra fish - Comparative databases: COG, KEGG, MBGD, PEDANT, Organism Specific databases

PROTEOME INFORMATICS

2D Electrophoresis - Spot visualization and picking - Database for 2D gel - Tryptic digestion of protein - Peptide fingerprinting - Data analysis: Mass spectrometry; ion source (MALDI, spray sources); analyzer (ToF, quadrupole, quadrupole ion trap) and detectors - Ramachandran plot - Post-translational modifications of proteins, protein folding - Limitation of proteomics

APPLICATIONS OF GENOMICS AND PROTEOMICS

Genomicmedicine - Synthetic biology and bioengineering - Conservation genomics - Interaction proteomics - Protein networks - Expression proteomics – Biomarkers - Proteogenomics

REFERENCES

1. Campbell, A.M. and Heyer, L.J., "Discovering Genomics, Proteomics and Bioinformatics", 2nd Edition, 2007, Benjamin Cummings.
2. Dunham, I., "Genome Mapping and sequencing", 2003, Horizon Scientific.
3. Hartwell, L.H., Hood, L., Goldberg, M. L., Reynolds, A.E., Silver, L.M. and Veres, R.G., "Genetics from Genes to Genomes", 2004, McGraw Hill.
4. Primrose, S.B., and R.M. Twyman, "Principles of gene manipulation and Genomics", 2006, Blackwell Publishing, MA. USA.
5. Read, T.D., Nelson, K.E., Fraser, C.M., "Microbial Genomes", 2004, Humana Press, Inc., USA.
6. "The Arabidopsis Genome", Nature, Vol. 408, 2000.
7. "The Human Genome", Nature, Vol. 409, 2001.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Aware of how to clone commercially important genes and recombinant proteins.
2. Aware of gene and genome sequencing techniques.
3. Apply the skills of aware of microarrays, Analysis of Gene expression and proteomics, techniques in gene mapping.
4. Analyze the various interactions in protein makeup and different levels of protein structure.
5. Practice the latest application of protein science in their research.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓						✓			✓
CO2	✓	✓	✓		✓				✓			✓
CO3		✓	✓	✓					✓			✓
CO4	✓		✓			✓						✓
CO5		✓	✓								✓	✓

CHBTPEXX	**BIOREACTOR DESIGN AND ANALYSIS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To gain knowledge about design and scale-up of bioreactors.
- To develop bioengineering skills for the production of biochemical product using integrated biochemical process
- To acquire knowledge of instrumentation and control of bioreactors

BASIC BIOREACTOR CONCEPTS

Bioreactor Operation – Batch operation, semi-continuous and fed-batch operation, Continuous Operation – Chemostat, turbidostat – Microbiological reactors, enzyme reactors – Tank-type, Column-type biological reactors – Case studies – Continuous Fermentation with Biomass Recycle, Tanks-in-series, Tubular plug flow bioreactors.

AERATION AND AGITATION IN BIOPROCESS SYSTEMS

Mass transfer in agitated tanks – Effect of agitation on dissolved oxygen - Correlations with k_La in Newtonian and non Newtonian liquid – Power number, Power requirement for mixing in aeratedand non aerated tanks for Newtonian and non Newtonian liquids – Agitation rate studies - Mixing time in agitated reactor, residence time distribution – Shear damage, bubble damage, Methods of minimizing cell damage – Laminar and Turbulent flow in stirred tank bioreactors.

SELECTION AND DESIGN OF BIOPROCESS EQUIPMENT

Materials of construction for bioprocess plants – Design considerations for maintaining sterility of process streams processing equipments, selection, specification – Design of heat and mass transfer equipment used in bioprocess industries – Requirements, design and operation of bioreactor for microbial, plant cell and animal cell.

SCALEUP AND SCALEDOWN ISSUES

Effect of scale on oxygenation, mixing, sterilization, pH, temperature, inoculum development, nutrient availability and supply – Bioreactor scale-up based on constant power consumption per volume, mixing time, impeller tip speed (shear), mass transfer co-efficients – Scale up of downstream processes – Adsorption (LUB method), Chromatography (constant resolution etc.), Filtration (constant resistance etc.), Centrifugation (equivalent times etc.), Extractors (geometry based rules) – Scale–down related aspects.

BIOREACTOR INSTRUMENTATION AND CONTROL

Bioreactor controlling probes – Characteristics of bioreactor sensors - Methods of measuring process variables –Temperature – Flow measurement and control – Pressure measurement and control – Agitation – shaft power, rate of stirring – Detection and prevention of foam – Measurement of Microbial biomass – Measurement and control of Dissolved oxygen – Inlet and outlet gas analysis – pH measurement and control - Biosensors.

REFERENCES

1. Impre, J.F.M.V., Vanrolleghem, P.A. and Iserentant, D.M., "Advanced Instrumentation, Data Interpretation and Control of Biotechnological Processes", 2010, Kluwer Academic Publishers.
2. Mann, U., "Principles of Chemical Reactors Analysis & Design: New tools for Industrial chemical Reactor Operations", 2009, Willey–VCH.
3. Mansi, E.M.T.EL., Bryce, C.F.A., Demain, A.L. and Allman, A.R., "Fermentation Microbiologyand Biotechnology", 3 rd edition, 2012, Taylor and Francis.
4. Towler, G. and Sinnott, R., "Chemical Engineering Design: Principles, Practice, Economics of Plant and Process Design", 2 nd edition, 2012, Butterworth – Heinemann ltd., Elsevier.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Select appropriate bioreactor configurations and operation modes based upon the nature of bio products and cell lines and other process criteria.
2. Understanding the modeling and simulation of various bioprocesses
3. Identify problems and seek practical solutions for implementation of large scale production of bioproducts.
4. To identify the ways and means to reduce costs and enhance the quality of products.
5. To acquire knowledge about instrumentation facilities in bioreactors to control bioprocesses.

Mapping with Program outcomes											
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓				✓		✓	
CO2		✓	✓	✓		✓					✓	✓
CO3		✓	✓	✓	✓						✓	✓
CO4		✓	✓					✓				
CO5			✓			✓	✓				✓	✓

CHBTPEXX	**NANOBIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To learn about basis of nanomaterials
- To know the concepts of preparation methods and types of nanomaterilas

- To gain knowledge about applications of nanomaterials in genetic engineering

NANOSCALE PROCESSES AND NANOMATERIALS

Overview of nanoscale processes and characterization of nanomaterials – Physicochemical properties of nanomaterials – Concepts in nanotechnology – Natural nanomaterials –Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Polymeric nanoparticles, Buckyballs, Nanotubes) – Interaction between biomolecules and nanoparticle surface –Synthesis and assembly of nanoparticles and nanostructures using bio-derived templates.

STRUCTURAL AND FUNCTIONAL PRINCIPLES OF NANOBIOTECHNOLOGY

Biomolecular structure and stability – Protein folding – Self-assembly – Self-organization – Molecular recognition – Flexibility – Information-Driven nanoassembly – Energetics – Chemical transformation – Regulation – Biomaterials – Biomolecular motors – Traffic across membranes – Biomolecular sensing – Self-replication – Machine-phase nanobiotechnology.

PROTEIN-BASED NANOTECHNOLOGY

Overview of protein nanotechnology – Nanotechnology with S-Layer protein – Engineered nanopores – Bacteriorhodopsin and its potential – Protein assisted synthesis of metal nanoparticles – Synthesis of protein-based nanoparticles – Protein nanopaticle-hybrids – Covalent and non-covalent protein nanoparticle conjugates – Protein-carbon nanotube conjugates.

DNA-BASED NANOTECHNOLOGY

DNA-based nanostructures – Biomimetic fabrication of DNA based metallic nanowires and networks – Self assembling DNA structures – DNA-nanoparticle conjugates – DNA-carbon nanotube conjugates – DNA templated electronics – DNA nanostructures for mechanics and computing – DNA nanomachine.

NANOMEDICINE AND NANOSENSING

Promising nanobiotechnologies for applications in medicine – Role of nanotechnology in methods of treatment – Liposomes in nanomedicine – Therapeutic applications of nanomedicine – Nano-Sized carriers for drug delivery and drug carrier systems – Protein and peptide nanoparticles, DNA based nanoparticles, Lipid matrix nanoparticles for drug delivery – Design and development of bionanosensors using DNA, enzymes – Nanobiosensors for imaging and diagnosis.

REFERENCES

1. Gazit, E., and Mitraki, A., “Plenty of Room for Biology at the Bottom: An Introduction to Bionanotechnology”, 2013, Imperial College Press.
2. Goodsell, D.S., “Bionanotechnology”, 2004, John Wiley and Sons.
3. Jesus M. de la Fuente and Grazu, V., “Nanobiotechnology: Inorganic Nanoparticles Vs Organic Nanoparticles” ,2012, Elsevier.
4. Niemeyer, C.M. and Mirkin, C.A., “Nanobiotechnology: Concepts, Applications and Perspectives”, 2006, Wiley- VCH.
5. Shoseyov, O. and Levy I., “Nanobiotechnology: Bioinspired Devices and Materials of the

Future", 2008, Humana Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Familiarize about the science of nanomaterials
2. Demonstrate the preparation and characterization of nanomaterials
3. Understand the production of nanomaterials using biological molecules
4. Knowledge of nanomaterials in genetic engineering
5. Applications of nanomaterials in drug development.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓		✓		✓							
CO2	✓	✓	✓	✓							✓	
CO3	✓		✓	✓		✓	✓				✓	✓
CO4	✓	✓	✓			✓			✓			✓
CO5		✓	✓	✓			✓	✓	✓			✓

CHBTPEXX	**BIOFUELS AND BIOREFINERY ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To impart knowledge on Bioconversion of renewable lignocellulosic biomass to bio fuel and value added products
- To demonstrate a drive towards products benign to natural environment and increasing the importance of renewable materials
- To emphasise the development of Biomass an inexpensive feedstock considered sustainable and renewable to replace a wide diversity of fossil based products

INTRODUCTION

Cellulosic Biomass availability and its contents. Lignocellulose as a chemical resource. Physical and chemical pretreatment of lignocellulosic biomass. Cellulases and lignin degrading enzymes.

ETHANOL

Ethanol as transportation fuel and additive; bioethanol production from carbohydrates; engineering strains for ethanol production from variety of carbon sources to improved productivity.

BIODIESEL

Chemistry and Production Processes; Vegetable oils and chemically processed biofuels; Biodiesel composition and production processes; Biodiesel economics; Energetics of biodiesel production and effects on greenhouse gas emissions Issues of ecotoxicity and sustainability with expanding biodiesel production

OTHER BIOFUELS
Biodiesel from microalgae and microbes; biohydrogen production; biorefinery concepts

PLATFORM CHEMICALS
Case studies on production of C3 to C6 chemicals such as Hydroxy propionic acid, 1,3propanediol, propionic acid, succinic acid, glucaric acid, cis-cismuconic acid.

REFERENCES
1. Lee, Sunggyu; Shah, Y.T. "Biofuels and Bioenergy", 2013, CRC / Taylor & Francis.

2. Satinder Kaur Brar, Saurabh Jyoti Sarma, kannan Pakshirajan, Platform Chemical Biorefinery, I st Edition, 2016, Elsevier.

COURSE OUTCOMES
At the end of this course, students will be able to
1. Understand the fundamentals of biofuels.
2. Utilization of biomass as feedstock for sustainable and renewable energy generation.
3. Replace fossil fuel based products with Biodiesel derived from vegetable oils.
4. Know the concepts of production of third generation biofuels
5. Develop of biorefineries for economical production of biofuels

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓		✓	✓	✓							
CO2	✓	✓	✓	✓				✓			✓	
CO3	✓		✓	✓	✓						✓	
CO4	✓	✓	✓	✓							✓	✓
CO5	✓	✓	✓	✓		✓	✓	✓	✓			

CHBTPEXX	**BIOPROCESS MODELING AND SIMULATION**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES
Enable the students
- To understand the overall industrial bioprocess so as to help them to manipulate the process.
- To impart knowledge on design and operation of fermentation processes with all its prerequisites.
- Provide the students with the basics of bioreactor engineering.
- To develop bioengineering skills for the production of biochemical product using integrated biochemical processes.

CONCEPTS AND PRINCIPLES

Introduction to modelling – Systematic approach to model building – Material and energy balance– Classification of models – General form of dynamic models dimensionless models – General form of linear systems of equations nonlinear function – Conservation principles thermodynamic principles of process systems

MODELS

Structured kinetic models – Compartmental models (two and three) – Product formation Unstructured models – Genetically structured models – Stochastic model for thermal sterilization of the medium – Modelling for activated sludge process – Model for anaerobic digestion – Models for lactic fermentation and antibiotic production

MODELLING OF BIOREACTORS

Modelling of non-ideal behaviour in Bioreactors – Tanks-in-series and Dispersion models – Modelling of PFR and other first order processes – Analysis of packed bed and membrane bioreactors Recombinant Cell Culture Processes – Plasmid stability in recombinant Cell Culture limits to over-expression

MONITORING OF BIOPROCESSES

On-line data analysis for measurement of important physio-chemical and biochemical parameters– State and parameter estimation techniques for biochemical processes – Biochemical reactors-model equations – Steady-state function – Dynamic behaviour – Linearization – Phase plane analysis – Multiple steady state – Bifurcation behaviour

SOLUTION STRATEGIES

Solution strategies for lumped parameter models – Stiff differential equations – Solution methods for initial value and boundary value problems – Euler's method – R-K method – shooting method – Finite difference methods – Solving the problems using MATLAB/SCILAB – ISIM-Simulation of bioprocesses using models from literature sources

REFERENCES

1. Bailey, J.A. and Ollis, D. F., Fundamentals of Biochemical Engineering", 1986, McGraw Hill.
2. Bequette, B.W., "Process Control:Modeling, Design & Stimulating", 2003, Prentice Hall.
3. Boudreau, M.A. and McMillan, G.K.," New Directions in Bioprocess Modelling and Control", 2006, ISA.
4. Hangos, K.M. and Cameron, I.T., "Process Modelling and Simulation", 2001.
5. Heinzle, E., Biwer, A.P. and Cooney, C.A.L., "Development of Sustainable Bioprocess: Modeling", 2007, Wiley.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand the Knowledge about the fundamental models of bioprocesses.
2. Select appropriate bioreactor configurations and operation modes based upon the nature of bio products.
3. Apply modelling and simulation of bioprocesses to enhance the quality of products and systems.

4. Identify problems and seek practical solutions for large scale implementation of Biotechnology.
5. Acquire knowledge of various tools for modeling and simulation of bioprocesses.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓		✓	✓	✓						✓	
CO2	✓	✓	✓			✓					✓	
CO3		✓	✓	✓		✓		✓			✓	✓
CO4		✓	✓					✓	✓		✓	✓
CO5			✓		✓	✓		✓			✓	✓

CHBTPEXX	**CANCER BIOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To understand the Basic of biology of cancer
- To know the impact of antibodies against cancer in the human body leading to more effective treatments
- To understand the immunology based detection methods and imaging techniques
- To realize the cell based and cytokine based immunotherapy against cancer

PRINCIPLES OF CANCER BIOLOGY

Cancer: Definition, causes, properties, classification, clonal nature – Cell Cycle: Regulation of cell cycle, cell proliferation and apoptosis – Signal transduction pathways – Apoptosis: apoptotic pathways, signal molecules, effects on receptor, signal switches – Modulation of cell cycle in cancer – Mechanism of spread.

PRINCIPLES OF CARCINOGENESIS

Cancer risk factors – Theory of carcinogenesis – Chemical carcinogenesis – Physical carcinogenesis: x-ray radiation – mechanisms of radiation carcinogenesis – Stages of cancer: initiation, promotion, progression.

MOLECULAR BIOLOGY OF CANCER

Signal targets and cancer – Growth factors – Transformation – Activation of kinases – Oncogenes: c-Myc, Ras, Bcl-2 family – Mechanism of oncogene activation – Retroviruses and oncogenes – Detection of oncogenes – Oncogenes/proto oncogene activity – Tumor suppressor genes: Rb, p53, APC, BRCA paradigms – Telomerases.

CANCER METASTASIS

Clinical significances of invasion – Heterogeneity of metastatic phenotype – Metastatic cascade: basement membrane disruption, invasion – Recent approach to identify key factors controlling metastasis – Angiogenesis.

CANCER THERAPY

Therapy forms – Surgery, chemotherapy, radiation therapy - Detection of cancers – Prediction of aggressiveness of cancer – Advances in cancer detection – Tumor markers; New approaches of cancer therapy – mAbs, vaccines, gene therapy, stem cell therapy.

REFERENCES

1. Fialho, A. and Chakrabarty, A., "Emerging Cancer Therapy: Microbial Approaches and Biotechnological Tools" 1st Edition, 2010, Wiley.
2. Pelengaris, S. and Khan, M., "The Molecular Biology of Cancer", 2006, Blackwell Publishing.
3. Ruddon, R.W., "Cancer Biology", 2nd Edition, 2007, Oxford University Press.
4. Schulz, W.S., "Molecular Biology of Human Cancers – An Advanced Students Text Book", 2005, Springer,
5. Weinberg, R.A., "The Biology of Cancer", 2007, Taylor & Francis, Garland Science.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Know about carcinogenic materials leading to cancer.
2. Value the role of immune system against cancer.
3. Understand the cancer microenvironment and its influence on immune cells.
4. Gain knowledge of key factors controlling cancer therapy.
5. Acquire Knowledge about the applications of biology for cancer treatment.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓			✓	✓							✓
CO2	✓		✓	✓					✓			✓
CO3	✓		✓	✓	✓							✓
CO4	✓		✓	✓	✓				✓			✓
CO5	✓			✓			✓					✓

CHBTPXX	**ANALYTICAL TECHNIQUES IN BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To acquire knowledge on the different chromotographic methods for separation of biological products.
- To have a fundamental knowledge about the instrumentation of spectroscopic analysis
- To understand the methods to obtain pure proteins, enzymes and in general about product development R & D

PROTEIN CRYSTALLOGRAPHY

Biological macromolecules – Principle of protein crystallization – Method – Testing –

Cryotechniques – Influence of heterogeneity on crystallization – Progress in structural genomics –Micro crystallization – Utility of micro fluidics for crystallization.

PROTEIN AND PEPTIDE PURIFICATION

Chromatographic methods for protein and peptide purification – Multidimensional chromatography– High throughput screening of soluble recombinant proteins – Immunoprecipitation – Affinity chromatography for antibody purification – Role of reverse phase HPLC in proteomic research.

ELECTROPHORETIC TECHNIQUES

Strategies – Separation of proteins using 2D gel electrophoresis – Electrophoresis method for purifying proteins – *in situ* enzyme detection – Staining method – Separation of peptide mixture – Pulse field gel electrophoresis – Denaturing gradient gel electrophoresis.

MICROSCOPY

Microscopy with light and electrons – Electrons and their interaction with the specimen – Electron diffraction – Instrument, specimen preparation and application of TEM and SEM – Fluorescence microscopy – Laser confocal microscopy – Phase contrast – Video microscopy – Scanning probe microscopy.

SPECTROSCOPY

Methods for characterizing purified proteins – IR absorption process, IR spectrometer and sample preparation – Instrumentation and applications of UV, UV visible, Fluorescence – Over view of mass spectrometry, ionization methods, mass analysis, detection and quantitation – Circular dichroism (CD) spectroscopy – NMR – Fourier transform infrared spectroscopy (FTIR).

REFERENCES

1. Babine, R.E. and Abdel-Meguid, S.S., "Protein Crystallography in Drug Discovery", 2004, Willy-VCHVerlag GmbH& Co.
2. Bhowmik, G. and Bose, S., "Analytical Techniques in Biotechnology", 2011, Tata McGraw-Hill Publishers.
3. Chandler, D. and Roberso, R.W., "Bioimaging: Current Techniques in Light & Electron Microscopy", 2008, Jones and Bartlett publishers.
4. Pavia, D.L., Lampman, G.M., Kriz, G.S. and Vyvyan, J.R., "Introduction to Spectroscopy", 4thEdition, 2008, Brooks/Cole Cengage Learning.
5. Simpson, R.J., "Purifying Proteins for Proteomics", 2004, Cold Spring Harbor Lab Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Gain knowledge about fundamentals of biological molecules.
2. Acquire knowledge about the advanced microscopic techniques.
3. Understand the fundamentals of various spectroscopic methods.
4. Apply the skills of microscopy and spectroscopy techniques for biological products purification and separation.
5. Apply principles of various unit operations used in downstream processing

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓			✓	✓				✓		✓	✓
CO2		✓	✓	✓								
CO3		✓	✓									
CO4		✓	✓				✓	✓			✓	✓
CO5	✓		✓					✓			✓	✓

CHBTPEXX	**BIOTHERMODYNAMICS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To study about the fundamentals of thermodynamic systems.
- To learn about basic concepts of classical and statistical thermodynamics.
- To demonstrate the capability to analyze the energy conversion performance in a variety of modern applications in biological systems.

CONCEPTS AND LAWS OF THERMODYNAMICS

Basic concepts of thermodynamics – First Law of Thermodynamics – Second law of thermodynamics – Zeroth Law and Third Law of thermodynamics – Laws of thermodynamics and biology – Thermodynamics of equilibrium – Behavior of systems far from equilibrium – Dissipative structures in non-equilibrium systems – Thermodynamic features of small systems – Thermodynamics of macromolecular processes in cells – Thermodynamics of energy interactions in ecosystems – Conservation of energy.

ENERGY TRANSFORMATION AND BIOENERGETICS

Distribution of energy – Carbon, energy and life – Molecular level energy storage – Biothermodynamics of energy use by plant and animals – Methods for measuring the thermodynamic stability of membrane proteins – Protein folding – Modeling the native state ensemble of proteins using statistical thermodynamics – Energetic profiles of proteins derived from thermodynamics of the native state ensemble – Principle of components analysis of energetic profile space – Energetic profiles are conserved between homologus proteins.

GIBB'S FREE ENERGY AND ITS APPLICATIONS

Theory and derivation of Gibbs free energy – Free energy of reactions – Lipid membrane phase transitions – Thermodynamics of cellular metabolism – Sugar metabolism – Energy transport in ATP and NAD – Substrate recycling – Donnan Equilibrium – Enzyme-substrate interaction – Free energy of transfer of amino acids – Differences between heat engines and biological energy processes – Temperature regulation in organisms – Humidity and temperature effects on organisms – Non-equilibrium thermodynamics and life.

STASTICAL THERMODYNAMICS AND BINDING EQUILIBRIA

Diffusion – Boltzman distribution – Partition function – Analysis of thermodynamic data – Multi-state equlibria – Protein heat capacity functions – Cooperative transitions – Interaction free energy– Helix coil transition theory – Binding equlibria – Single site model – Multiple independent sites – Oxygen transport – Scatchard plots and Hill plots – Ligand binding in macromolecules.

REACTION KINETICS TO BIOLOGICAL SYSTEM

Free energy analysis of chemical reactions – Chemical coupling to drive reactions in biological systems – First order and second order reactions – Collision theory – Transition state theory – Free energy of activation – Arrhenius rate constant equation – Applications – Temperature and concentration effects on enzyme kinetics – Reaction mechanism of lysozyme – Kinetic identification of reaction intermediates – Sequential enzyme reactions in metabolism and analysis.

REFERENCES

1. Cengel, Y.A. and Boles, M.A., "Thermodynamics, an Engineering Approach", Sixth Edition, 2006, McGraw Hill.
2. Hammes, G.G., "Thermodynamics and Kinetics for the Biological Sciences for Biological System", 2000, Wiley.
3. Haynie, D.T., "Biological Thermodynamics", Second Edition, 2008, Cambridge University Press.
4. Johnson, M.L., Holt, J.M. and Ackers, G.K., "Bio thermodynamics", Part 1,2009, Academic Press.
5. Timasheff, S.N., "Protein Hydration, Thermodynamic Binding, and Preferential Hydration, Biochemistry", 2002.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand the fundamental thermodynamic properties of biological systems.
2. Acquire knowledge about the application of thermodynamics for energy conversion in biological systems.
3. Design, interpret and analyze the fundamental data for betterment of bioprocesses.
4. Understand the vapour liquid equilibrium for calculations of microbial growth and product formation.
5. Gain knowledge about various kinetic models using thermodynamic properties.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓	✓	✓	✓	✓						
CO2	✓	✓	✓	✓								
CO3			✓			✓		✓				
CO4	✓		✓								✓	
CO5			✓	✓		✓						✓

CHBTPEXX	PLANT BIOTECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

Enable the students

- To gain knowledge of plant cells and its functions
- To study the basics of genetic engineering methods in plant biology
- To develop knowledge on transgenic plants

PLANT TISSUE CULTURE

Concept of cellular totipotency– Cytodifferentiation– Organogenic differentiation – Nutritional requirements – Seed culture, embryo culture, Protoplast culture, Micropropagation, Cell suspension –*Invitro* production of haploids–Somaclonal variation –Germplasm storage and cryopreservation.

CHLOROPLAST AND MITOCHONDRIA

Structure, function –Light and dark reaction and genetic material –Rubisco synthesis and assembly, coordination, regulation and transport of proteins– Mitochondria: Genome – Cytoplasmic male sterility and import of proteins – Comparison and differences between mitochondrial and chloroplast genome –Chloroplast transformation

PLANT METABOLISM AND METABOLIC ENGINEERING

Nitrogen fixation – Nitrogenase activity – Nod genes, nif genes, bacteroids – Plant nodulins Production of secondary metabolites – Flavanoid synthesis and metabolic engineering.

GENE TRANSFER IN PLANTS

Transient and stable gene expression –Marker genes –Vector mediated gene transfer, *Agrobacterium* mediated DNA transformation–Tumor inducing principle, Ti plasmid – TDNAtransfer – Transformation techniques using *Agrobacterium*,importance in genetic engineering– Agrobacterium vectors – Viruses mediated gene transfer, status and expression of transferred genes.

TRANSGENICS IN CROP IMPROVEMENT

Resistance to biotic stresses and abiotic stresses – Herbicide resistance –Transgenics for quality –Transgenics plants as bioreactors – commercial transgenic crops and impact of recombinant DNA technology–Molecular Pharming – Therapeutic products –Transgene silencing and ethical issues.

REFERENCES

1. Adrian, Scott, Nigel W., Fowler, Mark R.Plant Biotechnology: The Genetic Manipulation of Plants by Slater 2nd Edition, 2008, Oxford University Press.
2. Chawla, H.S, Introduction to Plant Biotechnology, 2nd edition, 2007.
3. Gamburg ,O.L., and Philips G.C. Plant Tissue & Organ Culture: Fundamental Methods. 2005, NarosaPublishing House.
4. Grierson D. and Covey, S.N. Plant Molecular Biology, 2nd Edition, 1988, Blackie.
5. Heldt, Hans-Walter, Plant Biochemistry & Molecular Biology, 1stEdition 1997, Oxford University Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand the fundamentals of plant cells, structure and functions
2. Learn the nitrogen fixation mechanism and significance of viral vectors
3. Gain knowledge about the plant tissue culture and transgenic plants
4. Acquire knowledge in development of high yielding plant varieties using genetic engineering
5. Gain knowledge for the development of therapeutic products

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓		✓		✓							
CO2		✓	✓	✓	✓				✓	✓		
CO3	✓		✓									✓
CO4	✓	✓	✓	✓					✓		✓	✓
CO5	✓		✓	✓				✓				

OPEN ELECTIVE

CHBTOEXX	**BIOTECHNOLOGY IN FOOD PROCESSING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To know about the constituents and additives present in the food.
- To gain knowledge about the microorganisms, food spoilage diseases.
- To know different techniques used for the preservation of foods.

FOOD PROCESSING

Heat Processing using steam or water (Blanching, Pasteurization) – Heat sterilization (Evaporation and distillation) – Heat processing using hot air (Dehydration, baking and roasting)

– Heat processing using hot oils – Processing by the removal of heat (chilling , Freezing) – High pressure processing of foods – Pulsed electric field processing of liquids and beverages – Non-thermal processing by radiofrequency electric fields.

FOOD FERMENTATION

Fermentative production of foods – Single cell protein (yeast, mushroom) – Microorganisms responsible for production of fermented foods – Enzyme in bakery and cereal products – Enzymes in fat/oil industries – Protease in cheese making and beverage production – Production of Pectinases and Utilization in Food Processing – Food Flavour Production – Utilization of food waste for production of valuables.

FERMENTED FOODS

Overview of fermented foods – Bean-based – Grain-based – Vegetable-based – Fruit-based – Honey-based – Dairy-based – Fish-based – Meat-based – Tea-based – Advantages of fermented foods Health benefits of fermented foods – Nutritive value of fermented food – Biotechnological approaches to improve nutritional quality – Microbial changes in fermented food.

FOOD PRESERVATION TECHNIQUES

Spoilage of food - Microbiology of water, meat, milk, vegetables – Food poisoning – Cold preservation – Heat conservation – Ionizing radiation – High pressure – Electric field – Chemical food preservation – Combination of techniques for food preservation – Natural antioxidants – Antimicrobial enzymes – Edible coatings – Control of pH and water activity.

FOOD QUALITY AND CONTROL

Analysis of food – Major ingredients present in different product – Food additives, vitamins – Analysis of heavy metal, fungal toxins, pesticide and herbicide contamination in food – Microbial safety of food products – Chemical safety of food products – Good manufacturing practice

REFERENCES

1. Adams M., Adams M. R. and Robert Nout M. J., "Fermentation and food safety", 2001, Springer.
2. Da-Wen S., "Emerging Technologies for Food Processing", 2005, Academic Press.
3. Fellows, P.J., "Food Processing Technology: Principles and Practice", 3rd Edition, 2009, CRC Press.
4. Hutkins R. W., "Microbiology and Technology of Fermented Foods", IFT Press series, Volume of Institute of Food Technologists Series, 2006, Wiley-Blackwell.
5. Pometto A, Shetty K, Paliyath G and Levin R. E., "Food Biotechnology", 2nd Edition , 2005, CRC press,.
6. Zeuthen P. and Bogh-Sorensen, L., "Food Preservation Techniques", 1st Edition, 2003, CRC Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Understand the applications of heat transfer principles in food processing.
2. Gain knowledge of usage of microorganism in food processing.
3. Acquire knowledge of fermentation in food processing.
4. Understand the principles of different food preservations techniques.
5. Gain knowledge about quality control measures used in food processing industries.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	✓	✓				✓						✓
CO2	✓	✓	✓	✓	✓				✓			
CO3	✓	✓	✓	✓	✓				✓		✓	✓
CO4			✓	✓	✓							✓
CO5			✓	✓		✓	✓	✓				

CHBTOEXX	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Enable the students

- To develop skills of the students in the area of Chemical Engineering with emphasis in process calculations and fluid mechanics.
- To perform calculations pertaining to processes and operations.
- To apply fluid mechanics principles to applied problems

GOVERNING EQUATIONS

Fluid flow and its mathematical descriptions; conservation laws – Continuity equations – Momentum equation, energy equation – Navier-Stokes equations – Boundary conditions, Solutions of Governing Equations – Finite difference method, Finite element method, Finite Volume Method, Euler's Equations – Non-Newtonian Constitutive Equations – Curvilinear coordinates and Transformed equations – CFD as Research tool and Design tool – Validation Strategies.

NUMERICAL ANALYSIS

Solving System of Algebraic equations – Gauss Elimination, Gauss-Seidel – LU-Decomposition – Jacobi – Simpson Rule – Laplace solution – Euler's method – R-K method – Fourier analysis of first and second upwind.

COMPRESSIBLE FLOW COMPUTATION

Euler equations – Conservative and non-conservative from thermodynamics of compressible flow – Scalar conservations laws – Conservation – Weak solutions – Non-uniqueness – Entropy conditions – Godunov methods – Flux vector splitting Method – Reconstruction of dependent variables – Fluxes – Preconditioning of low speed Flows – Projection methods.

TURBULENT FLOW COMPUTATION

Physical Considerations – Survey of theory and models – Relation of High – Resolution Methods and Flow Physics – Large Eddy Simulation – Standard and Implicit – Numerical Analysis of Sub grid Models – ILES Analysis – Explicit Modeling – Implicit Modeling – Limiters – Energy Analysis – Computational Examples – Burgers' Turbulence – Convective Planetary Boundary Layer.

FINITE ELEMENT METHOD

Finite Element formulation – Errors, Solutions of Finite difference equations – Elliptic equations – Parabolic Equations – Hyperbolic Equations – Burger's Equations – Nonlinear Wave equation (Convection Equation) – Primitive Variable method for Incompressible viscous flows; Taylor-Galerkin Method and Pertov-Galerkin Method for Compressible Flows.

REFERENCES

1. Blazek, J., "Computational Fluid Dynamics: Principles and Applications", 2005, Elsevier Publications.
2. Cebeci, T., Shao, J.P., Kafyeke, F. and Laurendeau, E., "Computational Fluid Dynamics for Engineers", 2005, Springer - Horizons Publishing Inc.

3. Drikakis, D. and Rider, W.J., "High - Resolution Methods for Incompressible and Low-Speed Flows", 2005, Springer-Verlag Berlin Heidelberg.
4. Knight, D.D., "Elements of Numerical Methods for Compressible Flow", 2006, Cambridge University Press.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Gain knowledge about fundamentals of fluid flow.
2. Understand the application of numerical methods to solve fluid dynamic problems.
3. Acquire knowledge related to properties of fluid statics and dynamics.
4. Apply knowledge to study the models related to turbulent flow of fluids
5. Understand the concepts of finite element analysis methods and its applications in biological systems.

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1			✓									✓
CO2			✓			✓	✓					✓
CO3			✓			✓						
CO4			✓	✓		✓						
CO5			✓	✓		✓	✓					✓

CHBTOEXX	**ENVIRONMENTAL BIOTECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

Enable the students

- To understand the scientific and engineering principles of microbiological treatment technologies to clean up contaminated environments
- To replace conventional treatment methodologies by molecular biology and genetic engineering strategies
- To seek the way for the alternate sources of energy to avoid environmental issues

BIODEGRADATION AND BIOREMEDIATION

Aerobic and Anaerobic degradation of aliphatic and aromatic compounds – Biodegradation of herbicides and pesticides. Bioremediation technologies – Biostimulation, Bioaugmentation, Bioventing, biosparging and Phytoremediation – Bioleaching, bioprecipitation, bioaccumulation and biosorption of heavy metals.

MICROBIAL METABOLISM IN WASTE WATER TREATMENT

Decomposition of organic compounds in natural ecosystems – Co-metabolic degradation of organo-pollutants - Hydrolysis of biopolymers by aerobic and anaerobic microorganisms – Anaerobic degradation of carbohydrates, proteins, lipids – Nitrogen removal – Ammonification, nitrification, denitrification

BIOLOGICAL TREATMENT OF WASTE WATER

Physico-chemical characteristics of waste water – Overview of aerobic and anaerobic treatment processes – Process design of aerobic and anaerobic system – Activated sludge process – Trickling filter – Rotating biological contactors – Fluidized bed reactor – Up flow anaerobic sludge blanket reactor (UASB) – Membrane bioreactors – Algal photosynthesis in wastewater treatment.

BIOTECHNOLOGY FOR AIR POLLUTION AND WASTE MANAGEMENT

Air pollution control and treatment strategies – Biotechnology for treating air pollutants – Biofilters and Bioscrubbers – Biotechnology for the management of agricultural, plastic, dairy, paper and pulp, textile, leather, hospital and pharmaceutical industrial wastes.

BIOPRODUCTS FROM RENEWABLE SOURCES

Overview of renewable sources – Production of biocompost and vermicompost – Production of biofertilizers and biopesticides – Production of biomethane, bioethanol, biohydrogen, biodiesel – Production of bioplastics and biopolymers – Bioelectricity generation and value added products from renewable sources.

REFERENCES

1. Chakrabarty K.D., Omen G.S., Biotechnology And Biodegradation, Advances In Applied Biotechnology Series , Vol.1, 1989, Gulf Publications Co., London.
2. Evans, G.G. and Furlong, J., Environmental Biotechnology: Theory and Application, 2nd Edition, 2011, John Wiley & Sons.
3. Henze, M., Harremoes, P., Jansen, J.C. and Arvin, E., "Wastewater Treatment: Biological and Chemical Processes", 2nd Edition, 2013, Springer.
4. Jordening, H.J. and Winter, J., "Environmental Biotechnology: Concepts and Application", 2005, Wiley-VCH Verlag GmbH & Co.
5. Wong J.W-C., Tyagi R.D., and Pandey. A., "Current Developments in Biotechnology and Bioengineering Solid waste" 2016, Elsevier.
6. Zarook, S. and Ajay,S., Biotechnology for Odor and Air Pollution Control, 2005, Springer,

COURSE OUTCOMES

At the end of this course, students will be able to

1. Gain knowledge about the fundamentals of environmental Pollution and its problems.
2. Find the scientific solutions for the environmental protection.
3. Acquire knowledge about the applications of microbes in waste water treatment systems.
4. Design microbial based air pollution treatment facilities.
5. Understand the various methods for biological conversion of waste materials into useful products

Mapping with Program outcomes												
Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1				✓	✓				✓			
CO2		✓	✓	✓	✓			✓				
CO3	✓		✓	✓					✓			✓
CO4		✓	✓	✓	✓		✓	✓				✓
CO5	✓		✓	✓	✓				✓			✓

CHBTOEXX	**TECHNOLOGY MANAGEMENT**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVE:

Enable the students

- To understand the basic concepts of technology management
- To impart the knowledge of various aspects of Creativity, Innovation and New Product Development
- To understand the transfer of new technology to commercialization.

TECHNOLOGY MANAGEMENT

Concept and meaning of technology – Evolution and growth of technology – Role and significance of management of technology – Impact of technology on society and business – Process and product technology. Competitive advantages through new technologies: product development from scientific breakthrough to marketable product – Role of Government in Technology Development – Managing Intellectual Property.

TECHNOLOGICAL FORECASTING & ASSESSMENT

Intuitive – Extrapolation – Growth Curves – Technology Monitoring. Normative: Relevance Tree – Morphological Analysis – Mission Flow Diagram - Technology Choice –Technological Leadership and Followership – Technology Acquisition. Meaning of Innovation and creativity – Innovation management.

TECHNOLOGY STRATEGY

Strategy concept – Types – Key principles – Framework for formulating technology strategy - Technology forecasting: techniques and application – Technology diffusion and absorption: Rate of Diffusion – Innovation Time and Innovation Cost – Speed of Diffusion – Project management in adoption and implementation of new technologies.

TECHNOLOGY TRANSFER MANAGEMENT

Technology transfer process – Outsourcing strategic issues – Joint ventures – Technology sourcing. Integration of People and Technology – Organizational and Psychological Factors – Organizational Structure – Social Issues in Technology Management: Technological Change and Industrial Relations – Technology Assessment – Environmental Impact Analysis.

TECHNOLOGY TRANSFER AND ACQUISITION

Import regulations – Implications of "Uruguay Round" and WTO – Bargaining process – Transfer option – MOU. Adopting technology – Human interactions – Organizational redesign and re-engineering – Technology productivity. Technology Absorption and Innovation: present status in India – Need for new outlook – Absorption strategies for acquired technology – Creating new/improved technologies – Innovations – Technology Measurement – Technology Audit.

REFERENCES

1. Khalli,T., "Management of Technology", 2009, McGraw-Hill.
2. Narayanan,V.K., "Managing Technology and Innovation for Competitive Advantage" , 2007, Pearson Education.
3. Schilling, M.A., "Strategic Management of Technological Innovation", 2008, McGraw-Hill.
4. Thamhain, H.J., "Management of Technology: Managing Effectively in Technology-Intensive Organizations", 2nd Edition, 2005, Wiley.

COURSE OUTCOMES

At the end of this course, students will be able to

1. Gain knowledge on various issues related to Patents
2. Understand the innovative techniques to Quality enhancement
3. Develop new products from innovative ideas.
4. Acquire knowledge about various types of companies.
5. To know the importance of planning and evaluation.

Mapping with Program outcomes

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1							✓	✓	✓	✓		✓
CO2			✓	✓			✓	✓				✓
CO3		✓	✓	✓			✓	✓			✓	✓
CO4							✓	✓	✓		✓	✓
CO5				✓			✓	✓		✓		✓