UNIVERSITY OF CALICUT

M.Tech DEGREE COURSE

IN

INDUSTRIAL BIOTECHNOLOGY

(DEPARTMENT OF BIOTECHNOLOGY ENGINEERING)

Proposed Curricula, Scheme of Examinations & Syllabi

(With effect from 2013 admissions)

(PROPOSED)

SCHEME OF EXAMINATIONS

SEMESTER I

Course Code	Subject	Hours/Week			Internal Marks	Sem End Marks	Total	Credits
		L	T	P				
IBT10 101	Optimization Techniques & Numerical Methods	3	1	0	100	100	200	4
IBT10 102	Molecular Biology &Immuno-technology	3	1	0	100	100	200	4
IBT10 103	Advanced Bioinformatics	3	1	0	100	100	200	4
IBT10 104	Fermentation & Enzyme Engineering	3	1	0	100	100	200	4
IBT10 105	Elective I	3	1	0	100	100	200	4
IBT10 106(P)	Immunology & Molecular Biology	0	0	2	100	0	100	2
IBT10 107(P)	Seminar	0	0	2	100	0	100	2
	TOTAL	15	5	4	700	500	1200	24

ELECTIVE I

IBT 10 105(A) Clinical Biotechnology
IBT 10 105(B) Biopharmaceutical& Pharmaceutical Technology
IBT 10 105(C) Biopolymer Technology
IBT 10 105(D) Protein Engineering

SEMESTER II

Course Code	Subject	Hours/Week			Internal Marks	Sem End Marks	Total	Credits
		L	T	P				
IBT10 201	Advanced Bioprocess I	3	1	0	100	100	200	4
IBT10 202	Analytical Techniques & Research Methodology	3	1	0	100	100	200	4
IBT10 203	Transport phenomena in Bioprocess system	3	1	0	100	100	200	4
IBT10 204	Elective II	3	1	0	100	100	200	4
IBT10 205	Elective III	3	1	0	100	100	200	4
IBT10 206(P)	Bioprocess & Fermentation Technology	0	0	2	100	0	100	2
IBT10 207(P)	Seminar	0	0	2	100	0	100	2
	TOTAL	15	5	4	700	500	1200	24

Elective II

IBT 10 204 (A) Animal& Plant Cell Culture
IBT 10 204 (B) Food Processing Technology
IBT 10 204 (C) Metabolic Engineering
IBT 10 204 (D) Bioprocess Modeling& Simulation

Elective III

IBT 10 205 (A) Molecular Diagnostics
IBT 10 205 (B) Bioreactor Design
IBT 10 205 (C) Genomics& Proteomics
IBT 10 205 (D) Bio-fuel Engineering

SEMESTER III

Course Code	Subject	Hours/Week			Internal Marks		Sem End Marks	Total	Credits
		L	T	P					
IBT10 301	Elective IV	3	1	0	100		100	200	4
IBT10 302	Elective V	3	1	0	100		100	200	4
IBT10 303(P)	Industrial Training	0	0	0	50		0	50	1
IBT10 304(P)	Master Research Project (Phase I)	0	0	22	Guide	EC*	0	300	6
					150	150			
	TOTAL	6	2	22	550		200	750	15

NB: The student has to undertake the departmental work assigned by HOD
*EC – Evaluation Committee

Elective IV

IBT 10 301 (A) Advanced Bio separation Techniques
IBT 10 301 (B) IPR for a Global Bio-economy
IBT 10 301 (C) Molecular Modeling & Drug Discovery
IBT 10 301 (D) Fundamentals of synthetic biology

Elective V

IBT 10 302 (A) Tissue Engineering & Biomaterials
IBT 10 302 (B) Nano-biotechnology
IBT 10 302 (C) Management, Entrepreneurship & Bio-business
IBT 10 302 (D) Structural Biology

SEMESTER IV

Course Code	Subject	Hours/Week			Internal Marks		Sem End Marks		Total	Credits
IBT10 401(P)		L	T	P	Guide	EC*	External Guide	Viva-Voce		
	Master Research Project (Phase II)	0	0	30	150	150	150	150		
	TOTAL	0	0	30	300		300		600	12

NB: The student has to undertake the departmental work assigned by HOD

FIRST SEMESTER

IBT 10 101 OPTIMIZATION TECHNIQUES AND NUMERICAL METHODS

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits: 4

Objectives:

- To analyze and apply mathematical techniques in Biotech industries

Module I: Linear Programming (15 hrs)

Introduction, Formulation and solution by graphical method, Feasible, Basic and basic feasible solution, optimal solution, simplex method, Artificial variables, Degeneracy, duality in LP problems, duality theorems, Applications of duality.

Module II: Transportation and Assignment Problems (13 hrs)

Introduction, transportation problems, finding a basic feasible solution, testing for optimality, Assignment problems.

Module III: Interpolation (13 hrs)

Introduction, Newton's forward interpolation formula for equal intervals, Gregory- Newton backward interpolation formula, error in polynomials, Newton's forward and backward interpolation formulae.

Module IV: Central Difference Interpolation (12 hrs)

Gauss' forward and backward interpolation formulae, Stirling's formulae, Bessel's formulae, Laplace- Everett formulae.

References:

1. Optimization methods in Operations research and Systems analysis, Mital K.V. and Mohan C., New Age Publications, 1996.
2. Fundamentals of Operations research, Ackoff and Sasieni, M.W., Wiley, 1968.
   Foundations of Optimization Lecture Notes in Economics and Mathematical systems, Bazeraa M.S. and Shetty C.M., Springer Verlag, 1976.
3. Operations Research, Verma A.P., Kataria and sons, 2001.
   Introduction to Numerical Analysis (Second Edition), Hildebrand F.B., Dover Publications,1987.
4. Applied Numerical Analysis, Gerlad, Curtis F. and Wheatley, Patrick O., Pearson Education, 2002.
5. Numerical methods, Kandasamy P., Thilagavathy K., Gunavathy K., S. Chand & Co.,2003

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 102 MOLECULAR BIOLOGY AND IMMUNOTECHNOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Aims for preparing the students for a career in applied research in molecular biology & immunology in therapeutic and technological innovations*

Module I (12 hrs)

Organization of Nucleic Acids & Gene Expression: Different forms of DNA and RNA, Organization of DNA in Prokaryotic and Eukaryotic Chromosomes. DNA Replication in Prokaryotes and Eukaryotes, Telomeric Replication in Eukaryotes, Replication of Viral DNA – brief overview. Transcription, translation, posts translational Moduleifications. Regulation of gene expression- The Operon Concept – Promoter, Operator, Terminator, Attenuator, Inducer, Repressor, Effect of cAMP Complex; *lac* operon.DNA Repair, Mutagenesis and Mutations

Module II (14 hrs)

Recombinant DNA Technology & Applications: Introduction to cloning, Method of creating recombinant DNA molecules, Cloning Vectors, Expression Vectors. Enzymes in Genetic Engineering**,** Nucleic Acid Hybridization and DNA Libraries**:**

The hybridization reaction, Production and Labeling of Gene Probes, Southern Blotting, Northern Blotting, in situ hybridization, Construction of Genomic and cDNA libraries. Molecular Analysis and Amplification Methods. Applications of Recombinant DNA Technology- Diagnostic Tools: SNPs, VNTRs, Drugs and Therapies: Therapeutic proteins from Transgenic plants and animals, Gene Therapy

Combating Disease: Recombinant vaccines – DNA Vaccines;

Plant Breeding: Herbicide-resistance, Virus-resistance, Insect and pest-resistance, Stress tolerance. DNA fingerprinting, Directed mutagenesis, Antisense Technology.

Module III (14 hrs)

Biology of complement systems - structure and function of MHC class I and II molecules - antigen recognition and presentation - humoral and Cell mediated immune responses - hypersensitivity reaction - immune suppression and immune tolerance - auto immune disorders. Antigen - isolation, purification and characterization of various antigens and haptens - antibodies - production, purification and quantification of immunoglobulin; antigen - antibody reaction; hybridoma and monoclonal antibody production; immuno-diagnosis and applications - human monoclonal antibodies; catalytic antibodies - complement fixation - assessment of immune complexes in tissues.

Module IV (13 hrs)

Purification of mononuclear cells from peripheral blood - isolation and characterization of T cells subsets; B cells and macrophages; fluorescent activated cell sorter - mitogen and antigen induced lympho-proliferation assay - cell mediated lympholysis - mixed lymphocyte reaction - assessment of delayed hypersensitivity reactions - macrophage cultures - assay of macrophage activation - isolation of dendritic cells - In situ and In vivo characterization of cells from tissues - generation of T cell clones - HLA typing. Biology and assay of cytokines - Vaccine technology including DNA vaccines - identification of T and B epitopes for vaccine development – immune-diagnosis of Infectious diseases - immuno screening of recombinant library.

References:

1. David Friefelder, *Molecular Biology (2e)*, Jones and Bartlett Publishers Inc, 1987.
2. Primrose S.B and R. W. Old, *Principles of gene manipulation - An introduction to genetic engineering (Vol. 2),* Blackwell Scientific Publications, 1980.
3. Benjamin Lewin, *Genes VIII* ,Prentice Hall , 2004.
4. Walker J.M and R.Rapley, *Molecular Biology and Biotechnology,* Indian Reprint by Panima Publishing Corporation, 2000.
5. Sambrook J et al, *Molecular Cloning (Vol I, II and III),* Cold Spring Harbor Laboratory (CSHL) Press, 1989.
6. Berger S.L. and A.R Kimmel, *Methods in Enzymology (Vol.152),* Academic Press, 1987.

7. Immunology, Richard A. Goldsby, Thomas J. Kindt. Barbara, A. Osborne, Janis Kuby 5th Edition, 2003. W. H. Freeman & Company.
8. Immunology, L.M. Roitt, J. Brestoff and D.K. Male, 1996.
9. Immuno-biology, Janeway CA and Paul Travers 1994.
10. Immunological techniques, D.M. Weir, 1992

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 103 ADVANCED BIOINFORMATICS

Teaching Scheme: 3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Provide critical tools for managing the immense volume of biological data and increase the efficiency of drug discovery and development*.

Module I (14 hrs)

Scope of Bioinformatics, Applications in various fields, Types of Databases- Relational & Object oriented, Biological Databases - Types of databases – Primary and Secondary biological databases. Primary databases, secondary databases, genotype databases, molecular structure databases and genome databases. Hidden Markov Models: Forward and Backward algorithm, Viterbi algorithm, Applications: Modeling Protein sequence families, multiple alignments. Nucleotide databases, Protein databases, specialized databases, Disease databases, information retrieval from biological databases

Module II (13 hrs)

Programming skills in Bioinformatics, PERL: Introduction and basics of PERL, variables, numbers, operators, loops, Arrays, Hashes, Control structures, File handling, strings manipulations, regular expressions. Sequence analysis and alignment, Evolutionary analysis. Metabolomics

Module III (13 hrs)

Sequence alignment basics, Scoring matrices, comparative genomics, Motif representation: consensus, regular expressions; PSSMs; phylogenetic analysis-steps in phylogenetic analysis, Sequence annotation: principles of genome annotation- annotation tools & resources.

Role of Bioinformatics in drug design, Introduction to few bioinformatics soft wares- BLAST, CLUSTAL-W, PHYLIP, RASMOL, HEX, Primer3, Chemsketch.

Module IV (13 hrs)

Virtual screening and compound ranking/scoring. Receptor-ligand interactions analysis, Fragment-based design, *de novo* design (LUDI), Pharmacophore generation (Catalyst), Scaffold hopping, 3D database screening, Simulations, molecular mechanics/dynamics (CHARMm). Explicit/implicit solvation Models, Transmembrane protein Modeling, Homology Modeling, Antibody Modeling, Electrostatics calculations, protein ionization and pK prediction, Protein Modeling (MODELER®) and analysis, protein engineering. Protein-protein docking and refinement, Sequence analysis, sequence alignment, phylogenetic analysis, X-Ray (CNX), structure refinement and analysis.

References:

1. Bioinformatics, David.W.Mount
2. Essential Bioinformatics, Jin Xiong
3. Bioinformatics, Andreas D. Baxevanis
4. Perl for Bioinformatics, James Tisdall

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 104 FERMENTATION AND ENZYME ENGINEERING

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits :4

Objectives:

- *Aims at transformation and industrialization of industrial enzyme,*
- *New technical innovation of fermentation engineering,*
- *High expression and mass preparation of proteins*.

Module I (13 hrs)

Fermentation & processing: Introduction to fermentation technology: Upstream and downstream processing of biomolecules. Isolation, Preservation and Improvement of Industrial Micro-Organisms; Medium requirements for fermentation process; Criteria for good medium; Sterilization - batch and continuous heat sterilization of liquid media, filter sterilization of liquid media and Air. Design of sterilization equipment

Module II (15 Hrs)

Kinetics of substrate utilization, product formation and biomass production: Phases of cell growth in batch cultures - transient growth kinetics, Simple unstructured kinetic Models for microbial growth, Growth of filamentous organisms; Environmental conditions affecting growth kinetics, substrate and product inhibition on cell growth and product formation; structured kinetic Models, segregated kinetic Models of growth. Production of primary and secondary metabolites. The production of some commercially important Organic acids, amino acids and alcohols, study of production processes for various classes of low molecular weight secondary metabolites: Antibiotics, quinones, aromatics, Vitamins and Steroid.

Module III (10hrs)

Principles of enzyme catalysis: Proteins as enzymes; Classification of Enzymes; Mechanism of Enzyme Action; Determination of elementary step rate kinetics, patterns of substrate concentration dependence, Modulation and regulation of enzyme activity .

Module IV (15 Hrs)

Industrial application of enzymes :Immobilized enzymes - principles & techniques of immobilization - commercial production of enzymes; amylases, proteases, cellulose, artificial enzymes, industrial applications, fermentation, enzymes Modification, site directed mutagenesis; immobilized enzyme in industrial processes. Structure and function of coenzyme - reactions involving TPP, pyrodoxal phosphate, nicotinamide, flavin nucleotide, coenzyme A and biotin. Industrial utilization of enzymes, food, detergents, energy, waste treatment, pharmaceuticals and medicine.

References:

1. Cruger.W and A.Cruger, *A Textbook of Industrial Microbiology* (*2e)*, Sinauer Associates, Sunderland,US, 2004.
2. Stryer.L, *Biochemistry (4e)*, Freeman, 2002.
3. Michael Shuler and FikretKargi, *Bioprocess Engineering: Basic Concepts (2e)*, Prentice Hall, Englewood Cliffs, NJ, 2002.
4. Bailey .J.E and D. F. Ollis, *Biochemical Engineering Fundamentals (2e)*, Mc-Graw Hill, Inc., 1986.
5. Pauline M Doran, *Bioprocess engineering principles (1e)*, Academic Press, 1995.
6. Biological chemistry, H.R Mahier& E. Cordes 1986.
7. Enzymes, Dizon& Webb.
8. Principles of Biochemistry, AL. Lehninger, D.L. Nelson and M. M. Cox. 1993. Worth Publishers, New York

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 105(A) CLINICAL BIOTECHNOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *To understand the design of Clinical trails and research*
- *To know about some of the important biological , their use and applications in the pharma sector*

Module I (14 hrs)

Introduction: Introduction to Clinical study and design of clinical studies. Epidemiological research and treatment studies: Double-blind and Single-blind Randomized controlled trial, Non-blind trial, Nonrandomized trial-quasi-experiment. Observational studies: Cohort study-Prospective cohort and Retrospective cohort. Time series study, Case-control study and Nested case-control study. Community survey and Ecological study. Seasonal studies: Conduction of studies in seasonal indications such as Allergies and Influenza.

Module II (15 hrs)

Statistical Analysis and Interpretation: Background and purpose, trial design consideration, Parallel group design, cross over design, factorial design. Introduction to Statistical Application Software (SAS), procedures and clinical data management.

Drug Design and Synthesis: Synthesis of compounds in accordance with the molecular structure and biological activity concept: Analgesics, neuromuscular blocking agents, anti-fertility drugs and bactericidal & bacteriostatic agents (sulphonamides, mercury compounds and antiseptics).

Study of Therapeutic Proteins and Related Case Studies: Organ function test**,** Blood and Blood products: Clotting factors, anticoagulants, Thrombolytic Agents, Tissue plasminogen activator and streptokinase. Safety guidelines in Blood Transfusion. Therapeutic Proteins: Antibodies, Enzymes, Hormones, Growth factors (Erythropoietin), Vaccines (HIV and Cancer), Interferon and Interleukins.

Module III (12 Hrs)

Cancer Biology and Therapy: Introduction to cancer biology and Modes of treatment: radiotherapy, chemotherapy, surgery, Biological therapy, immunotherapy and gene therapy.

Clinical Toxicology: Basic concept in toxicology. Types and mechanism of toxin action-Epoxidation & drug toxicity, N-oxidation & drug toxicity and sulphur xenobiotics. Hepatotoxicity and Nephrotoxicity. Biotransformation of toxins, inactivation and removal from the body. Blood bags, storage of blood

Module IV (12 Hrs)

Clinical Research Governance and Ethics: Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. Good Clinical Practices (GCP) and International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.

References:

1. Pharmaceutical Biotechnology, Second Edition by Michael J. Groves
2. Medical Biotechnology by JuditPongracz, Mary Keen (2009)
3. Medical Biotechnology by FirdosAlam Khan (2012)
4. Leon Lachmanetal, *Theory and practice of Industrial Pharmacy,* Lea arid Febiger.
5. Richard B. Silverman, *The Organic Chemistry of Drug Design and Drug Action, Elsevier, Publications.*
6. Rang Dale Riter, Pharmacology, Churchill Livingstone

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 105(B) BIOPHARMACEUTICAL & PHARMACEUTICAL TECHNOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits: 4

Objectives:

- *Prepare individuals for employment in pharmaceutical manufacturing and related industries*

Module I (10 hrs)

Pharmaceuticals, biologics and biopharmaceuticals: Introduction to pharmaceutical products, Biopharmaceuticals and pharmaceutical biotechnology, Biopharmaceuticals: current status and future, Pharmaco-Kinetics- absorption of drugs, distribution of drugs, protein binding of drugs, Basic Issues in the Manufacture of Macromolecules, Traditional pharmaceuticals of biological origin-animal origin, plant origin, microbial origin.

Module II (10 hrs)

Pharmacokinetics: Biotransformation of drugs, Preclinical Pharmacokinetics, Compartment Modeling- one compartment open Model, two compartment open Model, multi compartment Model, non linear kinetics, bioavailability and bioequivalence, excretion of drugs, pharmacokinetics – effects of food and fasting.

Module III (14 hrs)

The drug development and manufacturing process: Drug discovery, Patenting- Patent types, The patent application, Patenting in biotechnology, Pre-clinical trials, Clinical trials, The role and remit of regulatory authorities-The Food and Drug Administration, The investigational new drug application, The new drug application, European regulations, Guides to good manufacturing practice, Formulation and Delivery Issues of Therapeutic Proteins, Biotechnology-Derived Drug Products: Formulation Development, Stability Testing, Filling, and Packaging.

Module IV (19 hrs)

Pharmaceutical dosage forms: Dosage Forms and Basic Preparations, Excipients for Pharmaceutical Dosage Forms, Compressed tablets, wet granulation, dry granulation or slugging, direct compression, tablet formulation, coating, capsules, sustained action dosage form, parental, oral liquids, ointments, recombinant blood products and therapeutic enzymes, hormones of therapeutic interest Pharmaceutical products, Analysis and Control: laxatives – analgesics – non steroidal contraceptives – external antiseptics – antacids and other, antibiotics – biological – hormones – vitamins - preservation, analytical methods and test for various drugs and pharmaceuticals, packaging techniques – quality control. Drug Safety Evaluation: Strategy and Phasing for Drug Safety Evaluation in the Discovery and Development of Pharmaceuticals, Regulation of Human Pharmaceutical Safety, Acute Toxicity Testing in Drug Safety Evaluation, Special Concerns for the Preclinical Evaluation of Biotechnology Products, Immunotoxicology in Pharmaceutical Development, The Application of In Vitro Techniques in Drug Safety Assessment, Pharmaceutical Quality Assurance.

References:

1. Heinrich Klefenz ,*Industrial pharmaceutical biotechnology*, John Wiley sons, 2002.
2. Susanna Wu-Pong, Yongyut Rojanasakul, and Joseph Robinson, *Biopharmaceutical drug and design and development*, Humana Press, 2007.
3. Gary Walsh, *Biopharmaceuticals: Biochemistry and Biotechnology (2e)*, John Wiley & Sons, 2003.
4. Herbert A Kirst, Wu-KuangYeh; Milton J, *Enzyme Technologies for pharmaceutical and biotechnological applications*, WILEY-VCH Verlag, 2003.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 105(C) BIOPOLYMER TECHNOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits: 4

Objectives:

- *Altering the molecular structure of polysaccharides by enzymatic and chemical means*
- *Help in offering solutions towards technology development for biodegradable polymers*

Module I (10 hrs)

Introduction: Biopolymers – The current scenario, different biopolymers – produced from various renewable resources, characteristics, merits and demerits over conventional polymers

Module II (16 hrs)

Biopolymer Technology and Applications: Biopolymers and Artificial Biopolymers in Biomedical Applications, an Overview, Novel Synthesis of Biopolymers and Their Medical Applications, Composite Films Based on Poly (Vinyl alcohol) and Lignocellulosic Fibres: Preparation and Characterizations, Composite Materials Based on Gelatin and Fillers from Renewable Resources: Thermal and Mechanical Properties, Properties of PHAs and Their Correlation to Fermentation Conditions

Module III (14 hrs)

Biosynthesis and Modifications: Synthesis and Modification of different Biopolymers like xanthum gum, PHA, PHB etc. Polymers for storing biological molecules (blood bags)

Bio-surfactants: Source, characteristics and properties of Bio-surfactants; Production of Bio-surfactants via the fermentation and biotransformation routes; Production of Bio-surfactants with immobilized cells; Integrated bioprocess for continuous production of Bio-surfactants including downstream processing; Applications of Bio-surfactants – Food Industry, Environmental Control.

Module IV (13 hrs)

Material Testing and Analytical Methods:

An Overview of Available Testing Methods, Comparison of Test Systems for the Examination of the Fermentability of Biodegradable Materials, Structure-Biodegradability Relationship of biopolymers **Case studies:** Optimization of production and purification of Xanthum gum and other biopolymers like PHA, PHB

References :

1. EmoChiellini ,EmoChiellini and Helena Gil**,** *Biorelated Polymers: Sustainable Polymer Science and Technology*, Springer 2001.
2. Johnson .R.M, L.Y. Mwaikambo and N. Tucker, *Biopolymers***,** Rapra Technology, 2003.
3. NaimKosaric*(Ed)*. *Biosurfactants.*Marcell Dekker Inc, 1993.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 105(D) PROTEIN ENGINEERING

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Learn structure and function of proteins of particular importance, the student will know the production of recombinant insulin & in general how to engineer protein to be used as therapeutics*

Module I (14 hrs)

The protein makeup: Amino acids and their molecular properties, Chemical reactivity in relation to post-translational Modification and peptide synthesis. Covalent, Ionic, Hydrogen, Coordinate, hydrophobic and Vander vals interactions in protein organization. Interaction and elucidation of protein structure with electromagnetic radiation. Peptide mapping, peptide sequencing, significance of Ramachandran's plot, High-throughput protein sequencing setup Secondary structure: Alpha, beta and loop structures and methods to determine. Super-secondary structure: Alpha-turn-alpha, beta-turn-beta (hairpin), beta-sheets, alpha-beta-alpha, topology diagrams, up and down & TIM barrel structures nucleotide binding folds, prediction of substrate binding sites. Tertiary structure: Domains, folding, denaturation and renaturation, overview of methods to determine 3D structures, Quaternary structure: Modular nature, formation of complexes.

Module II (14 hrs)

Structure function relationship: DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, Trp repressor, Eukaryotic transcription factors, Zn fingers, helix-turn helix motifs in homeodomain, Leucine zippers, Membrane proteins: General characteristics, Transmembrane segments, prediction, bacteriorhodopsin and Photosynthetic reaction center, Immunoglobulins: IgG Light chain and heavy chain architecture, abzymes and Enzymes: Serine proteases, understanding catalytic design by engineering trypsin, chymotrypsin and elastase, substrate-assisted catalysis other commercial applications.

Module III (13 Hrs)

Design and construction of novel proteins and enzymes, Conformation of proteins in general and enzymes in particular, Effect of amino acids on structure of proteins, Energy status of a protein molecule, Structure function relations of enzymes, Physical methods such as x-ray crystallography for determination of protein structure, Site directed mutagenesis for specific protein function, Basic concepts for design of a new protein/enzyme molecule, Specific examples of enzyme engineering.

Module IV (12 Hrs)

Protein phosphorylation – immunoglobulins - Nucleotide binding proteins – enzyme serine proteases - ribonuclease – lyzozymeProtein data base analysis – methods to alter primary structure of proteins – Examples of engineered proteins – de novo protein design. Therapeutics - cellular and molecular therapeutics, Interferons, insulin, monoclonal antibodies in therapy.

References:

1. Voet D. and Voet G., "Biochemistry", Third Edn. John Wiley and Sons, 2001
2. Branden C. and Tooze J., "Introduction to Protein Structured, Second Edition", Garland Publishing, NY, USA, 1999
3. Creighton T.E. Proteins, Freeman WH, Second Edition, 1993
4. Moody P.C.E. and Wilkinson A.J. "Protein Engineering", IRL Press, Oxford, UK, 1990.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 : 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 106 (P) IMMUNOLOGY AND MOLECULAR BIOLOGY

Teaching Scheme: 3 Hours practical per week **Credits: 2**

Objectives:

- *To provide hands on training towards the application of molecular techniques and products of industrial importance*

1. Isolation ,estimation and electrophoresis of DNA from organisms
2. Isolation of plasmid and quantification
3. Isolation of RNA and quantification
4. Restriction digestion
5. purification of DNA from gel and Ligation
6. Competent cell preparation and Transformation
7. Conjugation in E.coli
    - Phage infection in E.coli
8. Induction of Lac operon.
9. Protein Isolation and estimation from microbes
10. Separation of lymphocytes from blood and staining of blood cells
11. Antigen antibody interaction-Haemagglutination, Immunodiffusion, Immunoelectrophorosis
12. Immunoprecipitation
13. Enzyme linked Immunosorbant Assay(ELISA)
14. Isolation of Immunoglobulins and quantification
15. Western blotting

References:

1. Practical immunology-Frank C Hayand Olwyn M R Westwood Blackwell science
2. Manual of immunological methods- Pauline brousseau

Internal Continuous Assessment *(Maximum Marks-100)*

Regularity - 30 marks

Record - 20 marks

Tests, Viva - 50 marks

IBT 10 107(P) SEMINAR

Hours per week: 2 hours practical **Credits:** 2

Objectives

- *To assess the debating and language capability of the student to present a technical topic. Also to impart training to a student to face audience and present his/her ideas and thus creating self esteem and courage that are essential for an engineer.*

Individual students are required to choose a topic of their interest from Bio-process design/design related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of the seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal Continuous Assessment *(Maximum Marks-100)*

Presentation +Discussion	: 60
Relevance + Literature	: 10
Report	: 20
Participation	: 10
Total marks	: 100

SECOND SEMESTER

IBT 10 201 ADVANCED BIOPROCESS: MODEL DEVELOPMENT, PARAMETER ESTIMATION AND STABILTY ANALYSIS

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits: 4

Objectives:

- *Develop knowledge and appreciation of the conceptual and factual bases for bioprocess design and operation*

Module 1 (14 hrs)

Aspects of Modeling in bioprocess industries: Basic classifications, fundamental features of Models: Knowledge-based and data based Models, unstructured and structured Models, compartmental Models, metabolic network Models, fuzzy logic, hybrid Models

Uses and limitations of mathematical Models : Illustrations of algebraic equations, ordinary differential equations, difference equations partial differential equations, integral equations and integro-differential equations. Importance of probability and Stochasticity in biological processes. Introduction to chaos

Module 2 (13 hrs)

Characteristics of a dynamical system: State-space representations: state variables and parameters, input and output vectors, state evolution. Linear and non-linear systems. Popular examples like Monad Model, Lotka-Volterra systems

Numerical methods for solving a linear system: General form of a linear system , Concepts of numerical techniques : Newton's method, Euler Integration, Runge-Kutta Integration, MATLAB integration routines**.** Linearization of non-linear Models and its interpretation: basic concepts

Module 3 (14 hrs)

Development of mathematical Models: Material and energy balances - Design parameters and tuning parameters - developing equations for process rates from first principles

Concepts in optimization for parameter estimation: Objective function, convex problems, parameter search space - local and global optimums, stationary points, Hessian matrix, Necessary and sufficient conditions for optimality, constraints, Lagrange multipliers

Design of experiments for parameter estimation - Accuracy of parameter estimates: sensitivity analysis. Concepts in parameter identifiability

Module 4 (12 hrs)

Analysis of mathematical Models: Concepts of stability in one dimensional systems - Equilibria, convergence, eigenvalues, attractors and basin of attraction, bistability, phase portraits, bifurcation

Concepts of stability in multidimensional systems - Equilibrium points, limit cycles, eigenvalues of the Jacobian matrix.

References

1. Wayne Bequette.B, Process dynamics Modeling and analysis and simulation,. Prentice Hall Inc, 2004.
2. John H. Seinfeld and Leon Lapidus., Mathematical Methods in Chemical Engg., (Vol. 3), Process Modeling, Estimations and Identification. Prentice Hall, 1974.
3. Volesky.B and J. Votruba., Modeling and Optimization of Fermentation Process (Process Simulation and Modeling). Elsevier Science and Technology, 1992.
4. Dynamic Moduleels in Biology By Stephen P. Ellner, John Guckenheimer
5. Katok, A. B. and B. Hasselblatt (1999). Introduction to the Modern Theory of Dynamical Systems. Cambridge, Cambridge University Press
6. Izhikevich E.M. (2007) Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting. The MIT Press, Cambridge, MA

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 202: ANALYTICAL TECHNIQUES AND RESEARCH METHODOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits: 4

Objectives:

- *Integrate the theory and practice for analyzing and quantitating biomolecules obtained from various sources*
- *How to design a study, collect data for research projects, strategically conceptualize and analyze them and documentation*

Module I (14 hrs)

Development and application of Modern analytical instrumentation. Chromatography: HPLC (including ELSD, CAD and DLS detectors), UPLC, GC, HPTLC, Ion chromatography and 2D techniques etc.

Mass spectrometry: Fragmentation patterns for molecular analysis. Derivatisation techniques. Sample introduction features for large molecules. Recent developments in applications to proteomics and metabolomics (SELDI, MALDI, Q-TOF, Triple Quad and Ion trap mass analyzers).

Module II (16 hrs)

Immunoassay: radioimmunoassay(RIA);enzyme-multiplied immunoassay technique (EMIT);fluorescence polarization immunoassay(FPIA);closed enzyme donor immunoassay (CEDIA);kinetic interaction of micro-particles in solution (KIMS);enzyme-linked immunosorbent assay (ELISA).

Hybrid techniques: Gas chromatography with Fourier transforms infra red spectroscopic detection(GC-FTIR), gas chromatography with mass spectrometric detection(GC-MS), liquid chromatography with mass spectrometric detection(LC-MS and LC-MS/MS),and inductively

coupled plasma with mass spectrometric detection(ICP-MS). Applications to proteomics, metabolomics, Impurity identification and profiling.

Electrophoresis: PAGE, SDS-PAGE, Zone electrophoresis, Capillary electrophoresis, 2-Dtechniques, laserablation, Qualitative and quantitative analysis using image analyzers. Particle size analysis and EM. Application of IR and NMR spectroscopy, X-raydiffraction and differential scanning calorimetry, Microcalorimetry in bio products. Advanced analytical techniques like automated electrophoresis and lab on chip.

Module III (13 hrs)

Mechanics of Research Methodology

Basic concepts: Types of research, Significance of research, Research framework, Case study method, Experimental method, Sources of data, Data collection using questionnaire, Interviewing, and experimentation.

Research formulation: Components, selection and formulation of a research problem, Objectives of formulation, and Criteria of a good research problem.

Research hypothesis: Criterion for hypothesis construction, Nature of hypothesis, Need for having a working hypothesis, Characteristics and Types of hypothesis, Procedure for hypothesis testing.

Sampling Methods: Introduction to various sampling methods and their applications.

Data Analysis: Sources of data, Collection of data, Measurement and scaling technique, and Different techniques of Data analysis.

Module IV (10 Hrs)

Thesis Writing and Journal Publication

Writing thesis, Writing journal and conference papers, IEEE and Harvard styles of referencing, Effective Presentation, Copyrights, and avoiding plagiarism.

References:

1. Practical Biochemistry – Wilson and Walker.
2. Handbook of analytical separations, vol. 4, byIan Wilson,2003
3. Encyclopedia of spectroscopy and spectrometry, vol. 1-3,2000
4. Methods ofbiochemicalAnalysis,Vol.35,ClarenceSuelter,1991
5. MethodsofbiochemicalAnalysis,Vol.36,ClarenceSuelter,1992
6. Dr. Ranjit Kumar, *Research Methodology: A Step-by-Step Guide for Beginners*, SAGE, 2005.
7. Geoffrey R. Marczyk, David DeMatteo& David Festinger, *Essentials of Research Design and Methodology,* John Wiley & Sons, 2004.
8. John W. Creswel , *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches,* SAGE, 2004
9. Suresh C. Sinha and Anil K. Dhiman, *Research Methodology (2 Vols-Set),* Vedam Books, 2006.
10. C. R. Kothari, *Research Methodology: Methods and Techniques,* New Age International Publisher, 2008.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 203 TRANSPORT PHENOMENA IN BIOPROCESS SYSTEM

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits: 4

Objectives:

- *To understand the balance between momentum, energy and mass in bioprocess systems*

Module I (14 hrs)

Introduction to Transport Phenomena – momentum, heat and mass transfer in bioprocessing

Review of basic concepts – Conservation of Mass, Conservation of Energy, Momentum Balance – Momentum Balance in a Circular Pipe, Flow Velocity Profile

Fermentation Broth Rheology – Viscosity, Rheological Properties of Fermentation Broths, Factors affecting broth viscosity

Mixing in a Bioreactor – Flow regimes with and without baffles, various types of impellers and mixing equipment. Power Requirements for Mixing, Ungassed Newtonian Fluids, Gassed Fluids

Module II (13 hrs)

Review of basic concepts – Various Modes of heat transfer, viz., conduction convection and radiation. Design Equations for Heat Transfer Systems – Energy Balance, Calculation of Heat-Transfer Coefficients.

Application of heat transfer in bioprocessing, Heat Management in Bioreactors, Relationship between heat transfer, cell concentration and stirring conditions

Module III (13 hrs)

Review of basic concepts – Diffusivity, theory of diffusion, analogy between mass, heat and momentum transfer, role of diffusion in bioprocessing. Definition of binary mass transfer coefficients, transfer coefficients at high mass transfer rates- boundary layer theory, penetration theory. Convective mass transfer – Liquid-solid mass transfer, liquid-liquid mass transfer, gas liquid mass transfer.

Module IV (13 hrs)

Oxygen transport to microbial cultures – Gas liquid mass transfer fundamentals, oxygen requirement of microbial cultures. Oxygen requirements of microbial cultures oxygen mass transfer fundamentals oxygen transfer and oxygen demand. Oxygen transfer by aeration and agitation. Determination of oxygen mass transfer coefficient by various methods including dynamic gassing out and oxygen balance methods.

. **References:**

1. Arthur T. Johnson, *Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied to Biological Systems*, John Wiley and Sons, 1998.
2. Pauline M. Doran, *Bioprocess Engineering Principles*, Academic Press, 1995.
3. Blanch H.W and Douglas S. C, *Biochemical Engineering*, CRC Press, 1997.
4. Michael L Shuler and Fikret Kargi, *Bioprocess Engineering: Basic Concepts*, Prentice-Hall of India Pvt Ltd, 2008.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 204(A) ANIMAL & PLANT CELL CULTURE

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *An introduction to plant and animal cell tissue culture techniques, nucleic acid transfections and industrial applications of cell culture.*

Module I (16 hrs)

Fundamentals of plant tissue culture, plant regeneration: organogenesis. Somatic embryogenesis; somaclonal variation, its genetic basis and application in crop improvement. Cell/callus line selection for resistance to herbicide, stress and diseases. Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and "synthetic seeds"; haploid production: advantages and methods. Protoplast technology: isolation, culture and plant regeneration, protoplast fusion, identification and characterization of somatic hybrids, applications of protoplast technology. Specific gene transfer: indirect and direct methods, current status and limitations. Automation in plant tissue culture. Field techniques for propagation of regenerated plants

Module II (10 hrs)

Explant selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2; Callus and cell suspension culture; Induction and growth parameters; Chromosomal variability in callus culture. Plant regeneration from embryo, meristem and callus culture. Androgenesis: Anther and pollen culture; Isolation and culture of protoplasts. Vectors in plant biotechnology

Module III (13 hrs)

Introduction, importance, history of animal cell culture development, different tissue culture techniques including primary and secondary culture, continuous cell lines, suspension culture, organ culture etc. Different type of cell culture media, growth supplements, serum free media balanced salt solution, other cell culture reagents, culture of different tissues and its application. Behavior of cells in culture conditions, division, their growth pattern, metabolism of estimation of cell number,

Module IV (14 hrs)

Development of cell lines, characterization and maintenance of cell lines, stem cells, cryopreservation, common cell culture contaminants. Animal tissue and Organ culture- Plasma clot method, Raft method, Agar-gel method, Grid method, etc. Cyclic exposure to Medium and Gas phase, Advantages, limitations and applications, artificial skin. Products and their Applications, Transgenics and Prospectives, Principles of *invitro* fertilization

References:

1. Dodds J .H. PlantGenetic Engineering, Cambridge University Press.
2. Mantal S.H., Mathews J.A.Mickee R.A. *Principles of Plant Biotechnology An Introduction to Genetic Engineering in plants,* Blackwell Scientific Publications
3. Bernur R. Pastrnek. J.J. , Molecular Biology, Principles and Applications in recombinant DNA, Panima Publishing Cooperation, New Delhi
4. Freshney RI. 2005. *Culture of Animal Cells*. Wiley Liss.
5. Portner R. 2007. *Animal Cell Biotechnology*. Humana Press

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 204(B) FOOD PROCESSING TECHNOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week

Credits: 4

Objectives:

- *Understand the basics of manufacturing of food products of consistent quality and nutritional value at affordable cost*
- *Develop skilled and competent manpower for food processing industries*

Module I (13 hrs)

Food as a Source of Nutrients: sources and function of lipids, carbohydrates, proteins and minerals. Effect of processing on food proteins, Food additives. Significance of microorganisms in foods: primary sources of microbes in food. Chemical & Microbial Kinetics in Food Products, Nutrient preservation.

Module II (14 hrs)

Diffusivity and Mechanism of Mass Transfer: Definitions of Concentrations, Mass fluxes, Fick's Law of Diffusion. Food packaging materials Introduction to Units Operations in Food Processing Industry: Cleaning, Grading, Decorticating, Disintegrating, trimming, peeling, and cutting balancing, pulping, size reduction, separation. Drying and Evaporation, Forming, Heat exchanging, mixing, distillation, extraction, filtration and centrifugation, Material Handling, Pumping and Packaging.

Module III (13 hrs)

Hydrothermal treatment of grains, Parboiling and milling of paddy, Wheat and its quality characteristics for milling into flour, Dry and wet milling of corn, Modern methods of milling of pulses. Factors affecting milling of pulses, Engineering Properties of Food Materials: Mechanical, Physical &Rheological properties. Food Spoilage & Control: Factors causing food spoilage – Temperature, Moisture, Enzymes, Micro-organisms, Control measures, Forms of water in foods, Sorption of water, Water activity.

Module IV (13 hrs)

Radiation sensitivity of micro-organisms, Effect of ionizing radiation on nutrients Food storage requirements and methods. Microbial spoilage and methods of control of fruits and vegetables. Pasteurization of milk and defects in milk and milk products. Microbiology of Canned Foods, Causes of spoilage, Food Preservation by use of Low Temperature, High temperature and Drying

References:

1. Food Chemistry by L H Meyor (CBS Publisher, Delhi)
2. Modern Food Microbiology, James M. Jay, CBS Publishers & Distributors, Delhi.
3. Food Microbiology, W C Frazier and D C Westhoff, McGraw Hill Book Company, NY.
4. Post harvest technology of Cereals, Pulses and Oilseeds by Chakravarti A. Oxford Publishing.
5. Cereal Technology by Potter NN. AVI Publication.
6. Unit Operations of Agricultural Processing, K.M.Sahay&K.K.Singh, VikasPublishing House.
7. Engineering of Dairy & Food Products, A.W.Farral.
8. Food Engineering Fundamentals, J.Clair Batty, Steven L Folkman, John Wiley& Sons.
9. Fundamentals of Food Process Engineering, Romeo Toledo, Van Nostrand Reinhold, New York.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 204(C) METABOLIC ENGINEERING

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *To understand and utilize cellular pathways for chemical transformation, energy transduction, and supramolecular assembly*
- *Purposeful alteration and manipulation of metabolic pathways for industrial applications.*

Module I (10 hrs)

Prokaryotic and Eukaryotic cell structures; pure culture techniques- isolation, cultivation, enumeration and preservation of microbes; staining techniques- simple and differential staining. Nutritional requirements and nutritional grouping of microorganisms; Different media (simple, complex and defined) - Growth curve; Axenic culture, Synchronous culture, Continuous culture; Different; Effects of physical and chemical factors on microbial growth. Microbial genetics- recombination - transformation, transduction, conjugation, regulation of gene expression.

Module II (10 hrs)

Bioenergetics, Metabolism of Carbohydrates, Proteins, Amino acids, Lipids and Nucleic acids- their biosynthesis and degradation; Integration of carbohydrate and fatty acid metabolism. Mechanism of oxidative phosphorylation and its inhibitors, and photophosphorylation, urea cycle, hormonal regulation of mammalian metabolism. Heterocylic compounds and secondary metabolites - prostaglandins, leukotrienes, thromboxanes, interferons and interleukins, antibodies, alkaloids, plant and animal pigments

Module III (16 hrs)

Metabolic engineering in practice: Concept of directed cellular energy utilization –analytical and synthetic elements of metabolic engineering – targets of metabolic engineering. Strategies for redirecting branched and linear pathways: (Alteration of feed back regulation; limiting accumulation of end product feed back resistant mutants, alteration of permeability).

Metabolic Flux Analysis: Concept and utility of MFA – Theory – case studies – over determined systems – experimental determination of MFA by isotope labeling – applications of MFA: Case studies- concept & fundamentals of metabolic control analysis

Module IV (17 hrs)

Application of pathway manipulations: Strategies for overproduction of primary metabolites. Strategies for overproduction of secondary metabolites (precursor effects, prophophaseidiophase relationship, enzyme induction, feed back regulation.)

Bioconversions: (ME concepts applied in process decisions for enhanced bioconversion).

Examples of pathway manipulations: Enhancement of product yield (alcohol, amino acids) – extension of substrate ranges (lignocelluloses utilization) – extension of product spectrum (antibiotic, biopolymers) - improvement of cellular properties (alteration of metabolism, enhanced efficiency and yield, genetic stability).

References:

1. Microbiology, L.M. Prescott, J.P. Harley and D.A. Klein, 7/e, 2007. McGraw Hill, Boston.
2. Fundamental Principles of Bacteriology, A.J. Salle, 1999. Tata McGraw - Hill Publishing Company Limited, New Delhi.
3. Microbial Ecology. Fundamentals and Applications, R. M. Atlas and R. Bartha, 2000.
4. Microbiology, M.J. Pelzer Jr., E.C.S. Chan and N.R. Kreig, 1993. McGraw Hill Inc., New York.
5. Biochemistry, 4th edition, L.Stryer., 1999. W.H, Freeman & company, New York.
6. Principles of Biochemistry, AL. Lehninger, D.L. Nelson and M. M. Cox., 1993. Worth Publishers, New York.
7. Biochemistry 4th edition, G. Zubay, 1998. McMillan Publishing Co. New York.
8. G Stephanopoulos et al; *Metabolic Engineering principles & Methodologies*
9. T. Scheper R Faurie, J. Thommel*Advance in Biochemical engineering Biotechnology: Microbila production of L – Aminoacid*

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 204(D) BIO PROCESS MODELLING AND SIMULATION

Teaching Scheme: 3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *To give student an understanding of Process Modeling and Simulation*

Module I (13 hrs)

Perspective on Modeling of physical, chemical and biological phenomena, uses and limitations of mathematical Models in Bioprocess Models- Basic classifications, fundamental features of Models. Several examples involving algebraic equations, ordinary differential equations, difference equations partial differential equations, integral equations and integro-differential equations.

Module II (13 hrs)

Elements of probability theory, stochastic Models parameter estimation Model forms for parameter estimation. Parameter estimation using moments, design of experiments for parameter estimation. Accuracy of parameter estimates. Design of experiments for Model discrimination - Regression and interpolation.

Module III (13 hrs)

Mathematical Models for mixing vessel- mixing with reaction - reversible reaction- steam jacketed vessel-isothermal constant and variable hold up CSTR in series- Boiling of single component liquid-open and closed vessel - continuous flow boiling. Multi-component boiling system - batch distillation-condensation.

Module IV (14 hrs)

Review of numerical techniques for the solution of bioprocess Models. Non linear systems analysis Phase – Plane analysis in classical bioreactor Models,

Introduction to population balance Modeling in bioprocess engineering – The solution of population balance equations. Budding of yeast population – Modeling of cells with dynamic morphology – Modeling for biological populations with correlation between life spans of siblings. Modeling of Industrial sterilization processes

References:

1. John H. Seinfeld and Leon Lapidus., *Mathematical Methods in Chemical Engg., (Vol. 3), Process Modeling, Estimations and Identification*. Prentice Hall, 1974.
2. Luyben W.L., *Process Modelling, Simulation and Control for Chemical Engineers*, McGraw Hill International Edition
3. Ramakrishna. D, *Population Balances.* Academic Press, 2000
4. Biquette W.B., *Process Dynamics - Modeling Analysis and Simulation*, Prentice Hall
5. Volesky.B and J. Votruba., *Modeling and Optimization of Fermentation Process (Process Simulation and Modeling)*. Elsevier Science and Technology, 1992.
6. Biquette W.B., *Process Dynamics - Modeling Analysis and Simulation*, Prentice Hall of India

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 205(A) MOLECULAR DIAGNOSTICS

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Understanding the molecular basis of diseases and techniques involved in diagnosis of diseases.*

Module I (14 hrs)

Host pathogen interactions in disease process, Significance of disease pathology and clinical spectrum; Clinical diagnosis of diseases- Introduction, importance and historical perspective of development of molecular diagnostic technology, ,Cancer biomarkers ,concept of development of group specific and strain specific nucleic acid based diagnostics, basis for selection of gene/nucleotide sequence of pathogenic organism to target for detection.

Module II (14 hrs)

Molecular techniques for analysis of Biochemical, Immune, Genetic Neurological and inherited disorders. Application of restriction endonuclease analysis for identification of pathogens, principle of development of pathogen specific DNA probes, Southern and Northern hybridization. Antibody based diagnosis; Monoclonal antibodies as diagnostic reagents; Production of monoclonal antibodies with potential for diagnosis; Diagnosis of bacterial, viral and parasitic diseases by using ELISA and Western blot.

Module III (12 hrs)

DNA sequencing and diagnosis , Theoretical background of development of PCR and Real time PCR and its variations, application of PCR for diagnosis of infectious diseases of animals and poultry, nucleic acid sequence based diagnostics. Array based techniques in diagnosis; single nucleotide polymorphism and disease association; Two dimensional gene scanning.

Module IV (13 hrs)

Bioinformatics tools for molecular diagnosis. Advancements in diagnostic technology including DNA array technology, biosensors and nanotechnology. OIE guidelines in development of diagnostics. Protein Micro array; Present methods for diagnosis of Specific diseases like Tuberculosis, Malaria and AIDS; Ethics in Molecular Diagnosis

References:

1. Elles R &Mountford R. 2004. *Molecular Diagnosis of Geneti Disease*. Humana Press.
2. Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics* Horizon Bioscience.
3. Andrew Read and Dian Donnai, *New clinical Genetics*, Scion Publishing Ltd, Oxfordshire, UK, 2007.
4. James W Goding, *Monoclonal antibodies: Principles and Practice*, 3rd Edition, Academic Press, 1996.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 205(B) BIOREACTOR DESIGN

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Learn the basic and advanced principles of a designing a reactor for industrial applications*

Module I (12 hrs)

Introduction and Review of Bio-reaction engineering concepts, Mass transfer effects in heterogeneous reaction , Continuous stirred tank and plug flow reactor performance equations. Modeling of non-ideal behavior in bio reactors- problem and solution. Tanks in series Model. Dispersion Models with chemical reaction. Applications to design of continuous sterilizers – problems and solution.

Module II (14 hrs)

Continuous Stirred Tank Bioreactor : performance equation for M-M kinetics, substrate inhibition kinetics and product inhibition kinetics, chemostat with cell cultures –steady state cell and substrate concentrations and productivity as a function of dilution rate, CSTR with immobilized enzymes, operation of CSTR in a constant feed rate policy

Fed–batch reactor: Applications of fed reactor, Fed batch operation of mixed reactor, material balance on cell and substrate

Recycle system: Chemostat with recycle, Biological waste water treatment, Feed forward control of the activated sludge process

Module III (14 hrs)

The Transient Behavior of Bioreactors: Stability analysis, Stability of the chemostat, Stability of chemostat with substrate inhibition, Operating diagram, Transient responses of the chemostat, control of the chemostat,

Design of a fermenter: Basic function of a fermenter for microbial or animal cell culture, basic bioreactor design criteria, overview of bioreactor types-stirred tank bioreactor, bubble column bioreactor, air-lift reactor, propeller loop reactor, jet loop reactor, schematic overview of a

fermenter with control system, operating issues that affect reactor design, aeration and oxygen mass transfer in bioreactor system, design of chemostat

Instrumentation and control: Methods of measuring process variables, measurement and control of dissolved oxygen, pH measurements

Module IV (13 hrs)

Introduction to structured and unstructured Models for bioprocess systems. Structured compartment Model – Williams and Ramakrishna Model ,single cell Model, metabolic Model, Genetically structured Model, Model simulation using MATLAB, Simulink.

References:

1. Chemical Reaction Engineering - Octave Levenspiel
2. Elements of Chemical Reaction Engineering - H. Scott Fogle
3. Bioprocess Engineering Principles - Pauline M.Doran
4. Bioprocess Engineering Basic Concepts - Michael L. Shuler, FikretKargi
5. Biochemical Engineering Fundamentals - James E. Bailey, David F. Ollis

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 205(C) GENOMICS & PROTEOMICS

Teaching Scheme

3 Hours lecture and 1 hour tutorials per weeks **Credits: 4**

Objectives:

- *Understanding structural, functional and comparative genomics its application for health applications and drug discovery*

Module I (13 hrs)

Goals of the Human Genome Project, cloning vectors, concept of maps, physical maps, shotgun libraries, DNA polymorphism, nucleotides, DNA sequences. Sequence databases: Gene Bank, EMBL Nucleotide sequence databank, DNA Data Bank of Japan (DDBJ), database formats. Recombinant DNA technology, restriction enzymes, resource for restriction enzyme (REBASE), similarity search. Polymerase chain reaction, primer selection for PCR, BLASTn, application of Bio Edit.

Module II (13 hrs)

Genome information and special features, coding sequences (CDS), un-translated regions (UTR's), cDNA library, expressed sequence tags (EST). Approach to gene identification; masking repetitive DNA, database search, codon-bias detection, detecting functional sites in the DNA. Internet resources for gene identification, detection of functional sites, gene expression. Introduction, Basic steps for gene expression, concept of microarrays; spotted arrays, oligonucleotide arrays, designing the experiment, Two-color microarray experiments

Module III (13 hrs)

Protein sequence information, composition and properties, physic chemical properties based on sequence, sequence comparison, Primary databases, Secondary databases. Pair-wise sequence alignment, gaps, gap-penalties, scoring matrices, PAM250,BLOSUM62, local and global sequence alignment, multiple sequence alignment, useful programs, ClustalW, BLASTp

Module IV (14 hrs)

Proteomics classification; Tools and techniques in proteomics; 2-D gelelectrophoresis, gel filtration, PAGE, isoelectric focusing, affinity chromatography, HPLC, ICAT, fixing and spot visualization, Mass spectroscopy for protein analysis, MALDI-TOF, Electrospray ionization (EST), Tandem mass spectroscopy (MS/MS)analysis; tryptic digestion and peptide fingerprinting (PMF), Protein Micro array inprotein expression, profiling and diagnostics, drug target discovery. Database searching, 3-dimensional structure determination by X-ray and NMR. Phylogenetic analysis

References:

1. Bioinformatics; Methods and applications; Genomics, Proteomics and Drug Discovery; (Rastogi, S. C. and Mendiratta and Rastogi, P)
2. Bioinformatics; A practical guide to the analysis of genes and proteins.; Edited by, Andreas D. Baxevanis and Francis Oulelette
3. Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.
4. Primrose SB &Twyman RM. 2007. *Principles of Genome Analysis and Genomics*. Blackwell.
5. Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II. Wiley-CVH.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 205(D) BIOFUEL ENGINEERING

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *To understand the concepts, systems, and technology now being used to produce biofuels on both an industrial and small scale*

Module I (13 hrs)

Introduction: Description of Biofuels; Energy Use & Efficiency; Biofuel Production; Alternative Energies; Biochemical Pathways Review for Organoheterotrophic, Lithotrophic& Phototrophic Metabolism; Importance of COD; Biofuel Feedstocks: Starch, Sugar, Lignocellulosic, Agro & Industrial by-products.

Production of Biohydrogen: Enzymes involved in H2 Production; Photobiological H2 Production: Biophotolysis and Photofermentation; H2 Production by Fermentation: Biochemical Pathway, Batch Fermentation, Factors affecting H2 production, Carbon sources, Process and Culture Parameters; Detection and Quantification of H2

Module II (14 hrs)

Production of Bioethanol: Process Technology for Bioethanol production using Sugar; Starch and Lignocellulosic Feedstocks: Selection of micro-organisms and feedstock; Associated Unit Operations; Determination of Bioethanol yield; Recovery of Bioethanol; Recent Advances; Process Integration

Production of Biodiesel: Chemical, Thermodynamic & Reaction Kinetic Aspects of Biodiesel Production: Transesterification and Supercritical Esterification, Saponification and Hydrolysis, Acid & Base Catalysis; Sources of Oils; Methods of Biodiesel Production – General procedure and Large scale production; Quality Control Aspects.

Module III (13 hrs)

Microbial Fuel Cells: Biochemical Basis; Fuel Cell Design: Anode & Cathode Compartment, Microbial Cultures, Redox Mediators, Exchange Membrane, Power Density; MFC Performance Methods: Substrate & Biomass Measurements, Basic Power Calculations, MFC Performance: Power Density, Single-Chamber vs Two-Chamber Designs, Wastewater Treatment Effectiveness; Future Directions

Module IV (14 hrs)

Microbial Modeling of Biofuel Production: Microbial Growth Moduleels: Unstructured, Single Limiting Nutrient Models, Inhibition Models, Models for Multiple Limiting Substrates, Yield Parameters; Kinetic Rate Expressions; Bioreactor Operation and Design for Biofuel Production: Batch, CSTR, CSTR with Cell Recycle, Fed-Batch Systems, Plug Flow Systems; Modeling of Glucose Utilization and Hydrogen Production; Batch and CSTR Fermentations and Simulations

References:

1. Caye M. Drapcho, N.P. Nhuan and T. H. Walker, *Biofuels Engineering Process Technology* , McGraw Hill Publishers, New York, 2008.
2. Jonathan R.M, *Biofuels – Methods and Protocols (Methods in Molecular Biology Series),* Humana Press, New York, 2009.
3. Lisbeth Olsson (Ed.), *Biofuels (Advances in Biochemical Engineering/Biotechnology Series,* Springer-Verlag Publishers, Berlin, 2007

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 206(P) BIOPROCESS & FERMENTATION TECHNOLOGY

Teaching Scheme

3 Hours practical per week **Credits: 2**

Objectives:

- *To understand and apply the basic and advanced concepts of fermentation and bioprocess in industry*

1. Isolation of industrially important microbes (Bacteria, Actinomycetes &Fungi) from environment
2. Identification and Culture preservation of industrially important microbes
   a. Staining techniques (Gram staining &Fungal staining)
   b. Glycerol stock preparation
3. Production of extracellular enzyme by liquid fermentation and Quantification of enzyme activity and specific activity
4. Kinetics study of enzymes
5. Techniques of enzyme immobilization
6. Production of metabolites by solid state fermentation
7. Strain improvement by non recombinant methods-Physical mutation and chemical mutation
8. Experimental design for improvement of fermentation by Plackett-Burman method
9. Study of Rheology of fermentation broth
10. Determination of volumetric mass transfer coefficient by sodium sulphite oxidation method.
11. Down stream processing
    a. Cell rupture
    b. Precipitation
    c. Dialysis
    d. Chromatography
    e. Molecular weight determination by SDS PAGE

References:

1. Practical Fermentation Technology- Brian McNeil, Linda M.Harvey- John Wiley & Sons, Ltd
2. Enzyme Technology Martin F. Chaplin , Christopher Bucke

Internal Continuous Assessment *(Maximum Marks-100):*

Regularity - 30 marks
Record - 20 marks
Tests, Viva - 50 marks

IBT 10 207 (P) SEMINAR

Teaching scheme: 2 hours per week **Credits:** 2

Objectives

- *To assess the debating capability of the student to present a technical topic.Also to impart training to a student to face audience and present his ideas and thus creating in him / herself esteem and courage that are essential for an engineer.*

- All students are required to choose a topic of their interest from Bio-Process Design/Design related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

- **Internal continuous assessment: 100 marks**

  Evaluation shall be based on the following pattern:

Report	=	50 marks
Concept/knowledge in the topic	=	20 marks
Presentation	=	30 marks
Total marks	=	100 marks

THIRD SEMESTER

IBT 10 301(A) ADVANCED BIOSEPARATION TECHNIQUES

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Understand the principles and theory of Chromatography, mechanism of interaction and its applications in separation and analysis biomolecules such as proteins, peptides and small molecules of therapeutic importance.*

Module I (14 hrs)

Role of Downstream Processing in Biotechnology: Role and importance of downstream processing in biotechnological processes. Problems and requirements of bio-product-purification. Economics and downstream processing in Biotechnology. Cost cutting strategies, characteristics of biological mixtures, process design criteria for various classes of bio-products (high volume-low value products and low volume- high value products), physicochemical basis of bio-separation processes. Primary Separation and Recovery Processes**:** Cell disruption methods for intracellular products, removal of insolubles, biomass (and particulate debris) separation techniques; flocculation and sedimentation, centrifugation and filtration methods

Module II (12 hrs)

Precipitation & Extraction methods: Precipitation with salts, organic solvents &polymers. Batch extractions, staged extractions-cross current, co current, counter current extractions. Differential extractions, fractional extractions with a stationary phase, fractional extractions with two moving phases. Reverse micelle extraction, supercritical fluid extraction, in-situ product removal/integrated bioprocessing.

Module III (14 hrs)

Membrane-based separations (micro- & ultra-filtration): Theory; design & configuration of membrane separation equipment; applications; reverse osmosis, dialysis, electro dialysis, Iso-electric focusing. Adsorption isotherms, industrial adsorbents, adsorption equipments for batch and continuous operations (co current and counter current), adsorption in fixed beds.

Module IV (13 hrs)

Chromatography: Principles of chromatographic separation – gel filtration, reversed phase, hydrophobic interaction, ion-exchange, expanded bed adsorption, bio affinity and IMAC, supercritical fluid chromatography.

Case studies: Preparation of commercial enzymes: Continuous isolation of enzyme prolyl-t RNA synthetase from mung bean, Intracellular foreign proteins from recombinant *E.coli and* extracellular enzyme (protease) recovery; Purification of biosurfactants from fermentation broths.

References:

1. Belter P.A, Cussler E and Wei Shan Hu, *Bioseparation – Downstream Processing for Biotechnology*, Wiley Interscience, 1988.
2. Asenjo and Juan A. Asenjo, *Separation Processes in Biotechnology,* CRC Press, 1990.
3. Wankat P.C, *Rate Controlled Separation,* Kluwer Publishers, 1990.
4. Wang D.I.C, Cooney C.L, Demain A.L, Dunnil.P, Humphery A.E. and Lilly M.D. *Fermentation and Enzyme Technology*, John Wiley and Sons, 1979.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 301(B) IPR FOR A GLOBAL BIO-ECONOMY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *An understanding of IPR and Patent Systems in India. Development of a global standardization of patenting and the emerging of economies based on IPR.*

Module I (13 hrs)

Introduction to Patent and other IPRs, Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications. Patent protection Patentability requirements-inventive-step, industrial applicability and disclosure requirements,

Module II (14 hrs)

Biotechnological Invention by documentation and Search, Drafting of Patent in field of Biotechnology, Patent filing in India and in abroad, Successful research and commercialization of biotechnological inventions. Precautions while patenting disclosure/non-disclosure, Patent infringement- meaning, scope, litigation. Diamond VS Chakrabarty Case. Orphan Drugs and diseases, The 90/10 research gap, Effect of TRIPS on drug prices in the developing world.

Module III (13 hrs)

The International Debate on Traditional Knowledge as Prior Art in the Patent System', Bioprospecting & Biopiracy, Biopiracy case studies (Case studies of Neem /Turmeric/Arogya pacha of KaniTribals in Kerala/Rosy Periwinkle of Madagascar)-Traditional Knowledge Digital Library- Need and Development.. CBD as a treaty for protecting Traditional Knowledge.

Module IV (13 hrs)

TRIPS- Does it favour Global transfer of Biotechnology? CBD and the need of CBD for global developing countries. Regime shifting between TRIPS and Other agreements in Global lawmaking.' Industry Strategies for Intellectual Property and Trade: The Quest for TRIPS and Post-TRIPS Strategies'

Agriculture and food security: Intellectual property rights and the trade in seeds; Genetic Use Restriction Technologies- Terminator and Traitor technology. UPOV Treaty- disadvantages for India, Indian PPVFR Act 2001.Criteria for Plant variety (Novelty, Distinct, Unique, Stable)

References:

1. Kankanala. C., Genetic Patent Law & Strategy, 1stEdition,
2. BAREACT, Indian Patent Act 1970, Acts & Rules
3. Laurence Liang, *'Beyond Representation. The Figure of the Pirate'.* Available at:http://www.altlawforum.org/PUBLICATIONS/Beyond%20Representation.doc
4. Vandana Shiva, *Bioprospecting as Sophisticated Biopiracy* (2007) *Signs* 32(2): 307-313.
5. Convention on Biological Diversity, at: http://www.biodiv.org/convention/articles.asp
6. UNEP/CBD/WG-ABS/2/3, 2003, *`The Role of Intellectual Property Rights in Access and Benefit-Sharing Arrangements'* at: http://www.biodiv.org/doc/meetings/abs/abswg-02/official/abswg-02-03-en.pdf
7. Carlos Correa, *Traditional Knowledge and Intellectual Property: Issues and Options Surrounding Protection of Traditional Knowledge* (2001), available at: http://www.geneva.quno.info/pdf/tkmono1.pdf
8. Cori Hayden, *When Nature Goes Public. The Making and Unmaking of Bioprospecting in Mexico* (Princeton: Princeton University Press, 2003.
9. Drahos 'Negotiating Intellectual Property Rights. Between Coercion and Dialogue' in Drahos&Mayne (eds), *Global Intellectual Property Rights* (2002) 161-182.
10. Graham Dutfield, *Intellectual Property Rights and the Life Science Industries. A Twentieth-Century History* (2003), chapter 8.
11. Glen Burgos & Dan Kevles, Plants as Intellectual Property: American Practice, law, and policy in World Context (1992) 7 *Osiris* 74-104.
12. Michael Blakeney, 'Stimulating Agricultural Innovation', in Maskus& Reichmann, *International Public Goods and Transfer of Technology Under a Globalized Intellectual Property Regime*, chapter 14.
13. BiswajitDhar, Sui generis systems for plant variety protection, available at:http://www.geneva.quno.info/pdf/sgcol1.pdf
14. Prabuddha Ganguli *Intellectual Property Rights-Unleashing the Knowledge Economy*. Tata McGraw Hill Publishing Company Limited, New Delhi.
15. Beier, F.K, Crespi, R.S and Straus, T. *Biotechnology and Patent protection* –Oxford and IBH Publishing Co. New Delhi.
16. SassonA, *Biotechnologies and Development*, UNESCO Publications.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 301(C) MOLECULAR MODELLING & DRUG DISCOVERY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *To understand the various molecular Modeling structures. To understand the basic principles underlying drug design*

Module I (14 hrs)

Modeling basics. Generation of 3D Coordinates Crystal data, Fragment libraries, and conversion of 2D Structural data into 3D Form, Force fields, and Geometry optimization, Energy minimizing Procedures, use of Charges, Solvent effects and Quantum Mechanical methods. Conformational analysis. Computational tools for Molecular Modeling, conformational analysis using - Systematic Search Procedures, Monte carlo and molecular dynamics methods. Determining features of proteins (Interaction potential, Molecular Electrostatic Potential, molecular interaction fields, properties on molecular surface and Pharmacophore identification. 3DQSAR Methods.

Module II (13 hrs)

Introduction, force field, quantum chemistry, Schrödinger equation, potential energy functions, energy minimization, local and global minima, saddle point, grid search, various approximations; LCAO, HF, semi-empirical calculations; single point calculations, full-geometry optimization methods, ZDO, MNDO, CNDO, NDDO, AM1,PM3, RM1, conformational search, Z-matrix, docking, molecular Modeling packages.

Module III (13 hrs)

Comparative protein modeling: Modeling by Homology the alignment, construction of frame Work, selecting variable regions, side chain placement and refinement, validation of protein Models – Ramchandran plot, threading and ab initio modeling. Analog based drug design: Introduction to QSAR, lead Module linear and nonlinear Modeled equations, biological activities, physicochemical parameter and molecular descriptions, molecular Modeling in drug discovery.

Module IV (13 hrs)

Introduction, drug discovery area, pharmaco genetics and pharmacogenomics applications, SNPs, parameters in drug discovery identification of drug target molecules, drug design and its approaches, computer-aided drug designing methods; computer aided molecular design (CAMD), Quantum CAChe and project leader, ligand design methods, docking programs; De novo design

References:

1. Principles and applications of Modeling by Leach
2. Molecular Modeling by the Hans Peter Heltie & GerdFalkens, VCH.
3. Chemical Applications of Molecular Modeling Jonathan Goodman.
4. Computational Chemistry by Guy H, Grant &W Graham Richards, Oxford University.
5. Bioinformatics; Methods and applications; Genomics, Proteomics and Drug Discovery; (Rastogi, S. C. and Mendiratta and Rastogi, P.
6. Bioinformatics; A practical guide to the analysis of genes and proteins.; Edited by, Andreas D. Baxevanis and Francis Oulelette

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 301(D) FUNDEMENTALS OF SYNTHETIC BIOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Design and construction of new biological functions and systems not found in nature.*

Module I (12 hrs)

Introduction to Biotechnology and Synthetic Biology- History, Goals, Applications, and Methods Overview**,** Risks of engineered systems, Synthetic Biology Standards, ethics of the field

Module II (14 hrs)

The Central Dogma of Biology.DNA Structure & Modification Processes. PCR Technology, DNA Sequencing & Synthesis Technology. Different application areas of engineered bacteria

Synthetic Biology: Design Paradigm (Parts, Devices, Systems).Cloning. Cloning vs. Bio-Brick Assembly Process. Fundamental Engineering Concepts in Application to Synthetic Biology.

Module III (14 hrs)

The importance of network structure in cellular networks .Review of continuous and stochastic Models of cellular networks. The interplay between structure and dynamics. Bifurcation analysis and evolutionary design approaches in synthetic biology. Standards and ontologies (SBML, CellML, PoBoL, CAD in synthetic biology).

Module IV (13 hrs)

Control systems in metabolism. Control systems in protein networks. Robustness and small signal analysis of cellular pathways. Advanced structural analysis including elementary Models, FBA and MFA. Metabolic engineering strategies. Protein networks, control and dynamical analysis. Protein network engineering.

References:

1. Synthetic biology-Industrial and environmental applications by Markus Schmidt
2. System biology and synthetic biology by Pengcheng Fu & svenpanke.
3. The emergence of life- from chemical origins to synthetic biology By Pier Luigi Luisi

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 302(A) TISSUE ENGINEERING & BIOMATERIALS

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *To understand the basics to synthesize materials that can stimulate beneficial biological responses from the body and use them for tissue repair*

Module I (13 hrs)

Structure of solids. Review of basic concepts. Biomaterials, definition, classification. Polymers, metals, alloys, ceramics and composites, physical, chemical and mechanical aspects of bulk and surface properties of metallic ,polymer and ceramic biomaterials (in vivo and in vitro) Corrosion studies. Structure property relation. Characterization of biomaterials. Bulk analysis-XRD, FTIR, SEM, TGA etc. Surface analysis-XPS, SIMS, AES, STM etc

Module II (14 hrs)

Tissue environment of the implanted biomaterial: unit cell processes Survey of clinical cases of biomaterials-tissue interactions, Tissue structures and unit cell processes, Integrins and adhesion proteins

Unit cell processes comprising the healing response, Unit cell processes underlying tissue engineering, Structure and function of naturally occurring ECMs and its regeneration

Module III (14 hrs)

Cell-surface interactions: Analysis of surfaces of biomaterials and protein adsorption, Phenotype changes following adhesion on biomaterials, Structural determinants of biologically active materials, Methodology for cell-surface interactions, Cell-scaffold interactions during regeneration, Non-cooperative cell-surface interactions, From randomness to co-operativity. Scaffold and transplant- Engineering biomaterials, Degradable materials, porosity, mechanical strength, 3-D architecture and cell incorporation.

Module IV (12 hrs)

***In vivo* and clinical case studies**: Blood and tissue compatibility of biomaterials and their in vitro and in vivo assessment. Tissue response to implants; biocompatibility, Epithelialization (epidermal regeneration) and endothelialization of vascular prostheses, *In vivo* synthesis of skin, In *vivo* synthesis of peripheral nerve, Rules for synthesis of tissues and organs, Joints and dental tissues: prosthetic replacement, Implants for bone regeneration, Regeneration of soft musculoskeletal tissues, Biomaterial applications in the heart and other organs. Ethical, FDA and regulatory issues

References:

1. Ratner, Hoffman, Schoen *Biomaterial science- an introduction to materials in medicine*Academic press
2. Bernhard Palsson, Sangeeta Bhatia ,*Tissue Engineering*, Pearson Prentice Hall, 2003
3. Robert. P.Lanza, Robert Langer & William L. Chick, *Principles of tissue engineering*, Academic press,1997
4. Park .J.B. *Biomaterials- science and engineering*, Plenum press
5. Sharma C.P., Szycher.M*Blood compatible materials and devices* Technomic publishing company
6. R. M. Johnson, R. M. Mwaikambo, Tucker Biopolymers Rapra technology.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 302(B) NANOBIOTECHNOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Provide basic knowledge in the interface between chemistry, physics and biology on the nano structural level with a focus on biotechnological usage*

Module I (14 hrs)

The Science of Nano - What is Nanobiotechnology, Cellular nanostructures, self-assembly of colloidal nanostructures of biological relevance, bioactive nanoparticles (respiratory surfactants, magnetic nanoparticles), Introduction to Nanostructures : Carbon Nanotubes (CNT), Fullerenes (C60, C300) Nano Peapods, Quantum Dots and Semiconductor Nanoparticles Metal-based Nanostructures (Iron Oxide Nanoparticles), Nanowires Polymer-based Nanostructures (Dendrimers), Gold Nanostructures: (Nanorods, Nanocages, Nanoshells)

Module II (13 hrs)

Protein-based Nanostructures: Nanomotors: Bacterial (*E.coli*) and Mammalian (Myosin family). Nanobiosensors: Science of Self-assembly - From Natural to Artificial Structures. Nanoparticles in Biological Labeling and Cellular Imaging: Science of Nanoparticles Functionalization

Module III (13 hrs)

Nanotechnology & Microfluidics: Nano Printing of DNA, RNA, and Proteins Biochips Applications in Nano Scale Detection, Lab-on-a-chip Devices (LOC), Medical Applications of Nanobiotechnology: Nanoparticles' Cytotoxicity.

Module IV (13 hrs)

Nanoparticles: Synthesis and Applications. Applications of Nanostructures in Drug: Discovery, Delivery, and Controlled Release. Nanostructures in Cancer Research: Examples of Nanostructures in Research and Therapy. Nanotechnology for Tissue Engineering: Applications

in Regenerative Therapy. Nanotechnology in Tissue Engineering, Microemulsions and Drug Delivery in Nanotechnology

References:

1. GeroDecher, Joseph B. Schlenoff, *Multilayer Thin Films*, Wiley-VCH Verlag GmbH & Co. KGaA, 2003
2. David S. Goodsell, *Bionanotechnology : Lessons from Nature*, Wiley-Liss , 2004.
3. Kenneth J. Klabunde , *Nanoscale Materials in Chemistry* , John Wiley & Sons, Inc., 2004
4. *Nanobiotechnology: Concepts, Applications and Perspectives* by Christof M. Niemeyer and Chad A. Mirkin Wiley-VCH; 1 edition, 2004

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 302(C): MANAGEMENT ENTREPRENEURSHIP & BIO-BUSINESS

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Impart technical knowledge and develop managerial skills for managing Bio - Technology business*
- *To promote entrepreneurship amongst students to venture in Bio - Technology business*

Module I (12 hrs)

Management: Introduction: Meaning nature and characteristics of Management, scope and functional areas of management, Management and administration, roles of management, levels of management. Development of Management Thought: Early management approaches and Modern management approaches. Functions of Management**:** Planning and Forecasting, Organizing, Directing and Controlling.

Module II (13 hrs)

Managing Engineering Design and Development: Product and Technology Life Cycles, Nature of Research and development, Research Strategy and organization, selecting R & D Projects, Protection of Ideas. Creativity, Nature of Engineering Design, Systems Engineering / New Product Development, Control System in Design, Product Liability and Safety, Designing for Reliability, other "abilities" in Design.

Managing Production Operations**:** Assuring product quality, Productivity, Work measurement, Maintenance and Facilities (Plant) engineering and other manufacturing functions.

Module III (15 hrs)

Entrepreneur: Meaning of an Entrepreneur, Role of entrepreneurs in Economic Development, Entrepreneurship in India, Entrepreneurship Barriers. Role of Micro Small & Medium Enterprises (MSME) in Economic Development, Impact of Liberalization, Privatization and Globalization on MSME, Effect of WTO/GATT. Different Schemes; TECSOK, KIADB, KSSIDC, KSIMC, DIC-Single Window Agency, MSME, NSIC, SIDBI, KSFC.

Preparation of Project: Meaning of Project, Project Identification, Project Selection, Project Report –Contents, Formulation and Project Appraisal. Identification of Business Opportunities: Market Feasibility studies, Technical Feasibility Studies; Financial Feasibility Studies and Social Feasibility studies.

Module IV (14 hrs)

Technologies and Bio-Safety: Principles of business management and concept of Bio-business, Fundamentals and constituents of Biotech for bio-business, SWOT analysis of Indian Bio-business.

Commercialization: Analysis of factor influencing international competitiveness in biotechnology, type of firms commercializing biotechnology, financing, tax incentives, issues and policies. Bioscience enterprises- raw bio-commodities, hybridization, tissue culture, bio-fermentation, bio-fertilizers.

Project Cost and Market Potential: Total product cost, capital investment and profitability, manufacturing cost estimation, capital investment estimation, Risk capital and working capital, manufacturing cost estimation for an intracellular protein, using cost analysis for R & D decision making.

References:

1. R.A. Baron, S.A. Shane; Entrepreneurship, Thomson, 2004, ISBN 0-324-27356
2. Small Business Management: Entrepreneurship and Beyond, Timothy S Hatten

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 302(D): STRUCTURAL BIOLOGY

Teaching Scheme

3 Hours lecture and 1 hour tutorials per week **Credits: 4**

Objectives:

- *Study protein and nucleic acid structure and function, focusing on energetic forces that guide folding, and computer Modeling to predict structures*

Module I (13 hrs)

Nucleic acid structures, RNA folding, RNA loops, conformational study, various ribose ring conformations, ribose-ring puckering, protein-protein interactions, protein ligand interactions, DNA-binding proteins, RNA-binding proteins, Ramachandran plot, ,3-dimensional structures of membrane proteins, importance of 310 helix and loops, biophysical aspects of proteins and nucleic acids.

Module II (14 hrs)

Over expression of recombinant protein, Construction of an over expression system : Cloning the gene encoding the target protein in cloning vector, Over expression of the protein as a recombinant protein using expression vector in appropriate host cells. *In vivo* expression system:*Escherichia coli*, yeast (*S. cerevisiae*, *P. pastries* etc.), insect cells. *In vitro* expression system-cell-free system. Protein purification: Sonication, Chromatography, Affinity chromatography, Gel filtration, Hydrophobic interaction chromatography, Ion exchange chromatography, Confirmation of the purity of the protein,

Module III (13 hrs)

Crystallization: Crystallization techniques: Sitting drop vapor diffusion, Hanging drop vapor diffusion, Micro batch under oil, Dialysis. Data collection - X-ray diffraction data. Phase determination and calculation of electron density, Modeling and Structure Refinement,

Module IV (13 hrs)

Protein Structure Prediction; Homology Modeling, prediction of protein structure from sequences, functional sites, Protein folding problem, protein folding classes, protein identification and characterization; AACompIdent, TagIdent, PepIdent and MultiIdent; PROSEARCH, PepSea, Pep MAPPER, Find Pept, Predicting trans-membrane helices, Primary structure analysis and prediction, Secondary structure analysis and prediction, motifs, profiles, patterns and fingerprints search. Methods of sequence based protein prediction.

References:

1. Introduction to Protein Architecture, by A.M.Leak
2. Introduction to Protein Structure, by Banden and Tooze.
3. Tinoco, Ignacio, Jr., Sauer, Kenneth, Wang, James C., & Puglisi, Joseph D. (2001) Physical Chemistry: Principles and Applications in Biological Sciences, 4th ed. Prentice Hall, ISBN: 0-13-095943-X
4. vanHolde, Kensal E., Johnson, W. Curtis, & Ho, PuiShing (1998) Principles of Physical Biochemistry. Prentice Hall. ISBN 0-13-720459-0
5. Cantor, Charles, and Schimmel, Paul (1980) Biophysical Chemistry, Vols. I-III, W. H. Freeman and company, San Francisco

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be a minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern

Answer any 5 questions by choosing at least one question from each Module.

Module I	Module II	Module III	Module IV
Question 1 20 marks Question 2 : 20 marks	Question 3 : 20marks Question 4: 20marks	Question 5 : 20marks Question 6: 20marks	Question 7 : 20marks Question 8: 20marks

IBT 10 303 (P) INDUSTRIAL TRAINING

Teaching scheme: 1 hour per week **Credits:** 1

The students have to undergo an industrial training of minimum two weeks in a Biotechnology related industry during the semester break after second semester and complete within 15 calendar days from the start of third semester. The students have to submit a report of the training undergone and present the contents of the report before the evaluation committee constituted by the department. An internal evaluation will be conducted for examining the quality and authenticity of contents of the report and award the marks at the end of the semester.

Internal continuous assessment: Marks: 50

IBT 10 304 (P) MASTERS RESEARCH PROJECT PHASE – I

Teaching scheme: 22 hours per week **Credits:** 6

Objective:

- *To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.*

The project work can be a purely research based / industry based project which contains and applies the basic and advanced principles of biotechnology as well as chemical engineering. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If it is found essential, they may be permitted to continue their project outside the parent institute subject to the conditions in clause 10 of M.Tech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the Masters research project phase-I during the third semester and the same is continued in the 4th semester (Phase-II). Phase-I consists of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

Internal Continuous assessment:

First Review:

Guide	50 marks
Evaluation Committee	50 marks

Second review:

Guide	100 marks
Evaluation Committee	100 marks

Total **300 marks**

FOURTH SEMESTER

IBT 10 401(P) MASTERS RESEARCH PROJECT PHASE – II

Teaching scheme: 30 hours per week **Credits:** 12

Objectives:

- *To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.*

Masters Research project phase-II is a continuation of project phase-I started in the third semester. Before the end of the fourth semester, there will be two reviews, one at middle of the fourth semester and other towards the end. In the first review, progress of the project work done is to be assessed. In the second review, the complete assessment (quality, quantum and authenticity) of the Thesis is to be evaluated. Both the reviews should be conducted by guide and Evaluation committee. This would be a pre qualifying exercise for the students for getting approval for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

Internal Continuous assessment:

First review:

Guide	50 marks
Evaluation committee	50 marks

Second review:

Guide	100 marks
Evaluation committee	100 marks

End semester Examination:	**300 marks**
External Guide	150 marks
Viva-voce	150 marks