VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELAGAVI.

Scheme of Teaching and Examinations and Syllabus

M.Tech., BIOTECHNOLOGY & BIOCHEMICAL ENGG (BBC)

(Effective from Academic year 2020 - 21)

M.Tech., in BIOTECHNOLOGY AND BIOCHEMICAL ENGG(BBC)
Scheme of Teaching and Examinations – 2020 - 21
Choice Based Credit System (CBCS) and Outcome Based Education(OBE)

I SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours per Week			Examination				Credits
				Theory	Practical	Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	20BBC11	Numerical Methods &Biostatistics	03	--	02	03	40	60	100	4
2	PCC	20BBC12	Concepts in Biotechnology	03	--	02	03	40	60	100	4
3	PCC	20BBC13	Principles of Biochemical Engineering	03	--	02	03	40	60	100	4
4	PCC	20BBC14	Molecular Biology and Genetic Engineering Techniques	03	--	02	03	40	60	100	4
5	PCC	20BBC15	Bio-analytical Techniques	03	--	02	03	40	60	100	4
6	PCC	20BBCL16	Biotechnology and Biochemical EngineeringLaboratory	--	04	--	03	40	60	100	2
7	PCC	20RMI17	Research Methodology and IPR	01	--	02	03	40	60	100	2
			TOTAL	**17**	**04**	**12**	**21**	**280**	**420**	**700**	**24**

Note: PCC: Professional core.

Skill development activities:
Students and course instructor/s to involve either individually or in groups to interact together to enhance the learning and application skills.
The students should interact with industry (small, medium and large), understand their problems or foresee what can be undertaken for study in the form of research/ testing / projects, and for creative and innovative methods to solve the identified problem.
The students shall
(1) Gain confidence in modelling of systems and algorithms.
(2) Work on different software/s (tools) to Simulate, analyse and authenticate the output to interpret and conclude. Operate the simulated system under changed parameter conditions to study the system with respect to thermal study, transient and steady state operations, etc.
(3) Handle advanced instruments to enhance technical talent.
(4) Involve in case studies and field visits/ field work.
(5) Accustom with the use of standards/codes etc., to narrow the gap between academia and industry.
All activities should enhance student's abilities to employment and/or self-employment opportunities, management skills, Statistical analysis, fiscal expertise, etc.

Internship: All the students have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted for the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-

up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

Note: (i) Four credit courses are designed for 50 hours Teaching – Learning process.
(ii) Three credit courses are designed for 40 hours Teaching – Learning process.
(iii) Two credit courses are designed for 25 hours Teaching – Learning process.

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II SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Seminar	Skill Development Activities	Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	20BBC21	Fermentation Technology	03	--	02	03	40	60	100	4
2	PCC	20BBC22	Bioreactor Plant Design	03	--	02	03	40	60	100	4
3	PCC	20BBC23	Bio-separation and Product Recovery	03	--	02	03	40	60	100	4
4	PEC	20BBC24X	Professional elective 1	04	--	--	03	40	60	100	4
5	PEC	20BBC25X	Professional elective 2	04	--	--	03	40	60	100	4
6	PCC	20BBCL26	Fermentation Technology and Bio-separation	--	04	--	03	40	60	100	2
7	PCC	20BBC27	Technical Seminar	--	02	--	--	100	--	100	2
TOTAL				**17**	**06**	**06**	**18**	**340**	**360**	**700**	**24**

Note: PCC: Professional core, PEC: Professional Elective.

Professional Elective 1		Professional Elective 2	
Course Code under	**Course title**	**Course Code under**	**Course title**
20BBC241	Agricultural Biotechnology	20BBC251	Food Biotechnology
20BBC242	Animal Biotechnology	20BBC252	Pharmaceutical Biotechnology
20BBC243	Bioprocess Calculations	20BBC253	Bioprocess optimisation,Modelling & simulations
20BBC244	Genomics,Proteomics and Bioinformatics	20BBC254	Metabolic Engineering

Note:
1. Technical Seminar: CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a senior faculty of the department. Participation in the seminar by all postgraduate students of the programme shall be mandatory.
The CIE marks awarded for Technical Seminar shall be based on the evaluation of Seminar Report,

Presentation skill and performance in Question and Answer session in the ratio 50:25:25.

2. Internship: All the students shall have to undergo mandatory internship of 6 weeks during the vacation of I and II semesters and /or II and III semesters. A University examination shall be conducted during III semester and the prescribed internship credit shall be counted in the same semester. Internship shall be considered as a head of passing and shall be considered for the award of degree. Those, who do not take-up/complete the internship shall be declared as fail in internship course and have to complete the same during the subsequent University examination after satisfying the internship requirements.

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III SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week			Examination				Credits
				Theory	Practical/ Mini–Project/ Internship Skill Development activities		Duration in hours	CIE Marks	SEE Marks	Total Marks	
				L	P	SDA					
1	PCC	20BBC31	Biosafety, Bioethics and Regulatory affairs	03	--	02	03	40	60	100	4
2	PEC	20BBC32X	Professional elective 3	03	--	--	03	40	60	100	3
3	PEC	20BBC33X	Professional elective 4	03	--	--	03	40	60	100	3
4	Project	20BBC34	Project Work phase -1	--	02	--	--	100	--	100	2
5	PCC	20BBC35	Mini-Project	--	02	--	--	100	--	100	2
6	Internship	20BBCI36	Internship	(Completed during the intervening vacation of I and II semesters and /or II and III semesters.)			03	40	60	100	6
TOTAL				**09**	**04**	**02**	**12**	**360**	**240**	**600**	**20**

Note: PCC: Professional core, PEC: Professional Elective.

Professional elective 3		**Professional elective 4**	
Course Code under	**Course title**	**Course Code under**	**Course title**
20BBC321	Environmental Biotechnology	20BBC331	Bio-Business&Entrepreneurship Development
20BBC322	Biosensors Technologies	20BBC332	Bioenergy Management

20BBC323	Protein Engineering & Design	20BBC333	Biomaterials & Artificial Organs
20BBC324	Nano biotechnology	20BBC334	Vaccine Development

Note:

1. Project Work Phase-1: Students in consultation with the guide/co-guide if any, shall pursue literature survey and complete the preliminary requirements of selected Project work. Each student shall prepare relevant introductory project document, and present a seminar.

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide if any, and a senior faculty of the department. The CIE marks awarded for project work phase -1, shall be based on the evaluation of Project Report, Project Presentation skill and performance in Question and Answer session in the ratio 50:25:25.

SEE (University examination) shall be as per the University norms.

2. Internship: Those, who have not pursued /completed the internship shall be declared as fail in internship course and have to complete the same during subsequent University examinations after satisfying the internship requirements. Internship SEE (University examination) shall be as per the University norms.

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IV SEMESTER

Sl. No	Course	Course Code	Course Title	Teaching Hours /Week		Examination				Credits
				Theory	Practical/ Field work	Duration in hours	CIE Marks	SEE Marks Viva voce	Total Marks	
				L	P					
1	Project	20BBC41	Project work phase -2	--	04	03	40	60	100	20
			TOTAL	--	**04**	**03**	**40**	**60**	**100**	**20**

Note:

1. Project Work Phase-2:

CIE marks shall be awarded by a committee comprising of HoD as Chairman, Guide/co-guide, if any, and a Senior faculty of the department. The CIE marks awarded for project work phase -2, shall be based on the evaluation of Project Report subjected to plagiarism check, Project Presentation skill and performance in Question and Answer session in the ratio 50:25:25.

SEE shall be at the end of IV semester. Project work evaluation and Viva-Voce examination (SEE), after satisfying the plagiarism check, shall be as per the University norms.

NUMERICAL METHODS &BIOSTATISTICS

Course Code	**20BBC11**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION TO STATISTICS AND STUDY DESIGN:
Introduction to statistics, data, variables, types of data, tabular, graphical and pictorial representation of data. Significance of statistics to biological problems, experimental studies; Randomized controlled studies, historically controlled studies, cross over, factorial design, cluster design, randomized; complete, block, stratified design, biases, analysis and interpretation

Module-2

DESIGN:
Types of variables, measure of spread, logarithmic transformations, multivariate data. Basics of study design, cohort studies, case-control studies, outcomes, odd ratio and relative risks. Principles of statistical inference: Parameter estimation, hypothesis testing. Statistical inference on categorical variables; categorical data, binomial distribution, normal distribution, sample size estimation.

Module-3

COMPARISON OF MEANS:
Test statistics; t-test, F distribution, independent and dependent sample comparison, Wilcoxon Signed Rank Test, Wilcoxon-Mann-Whitney Test, ANOVA. Correlation and simple linear regression: Introduction, Karl Pearson correlation coefficient, Spearman Rank correlationCo-efficient, simple linear regression, regression model fit, inferences from the regression model, ANOVA tables for regression. Multiple linear regression and linear models: Introduction, Multiple linear regression model, ANOVA table for multiple linear regression model, assessing model fit, polynomials and interactions. One-way and Two way ANOVA tables, T-tests; F-tests. Algorithm and Implementation using numerical methods with case studies

Module-4

DESIGN AND ANALYSIS OF EXPERIMENTS:
Random block design, multiple sources of variation, correlated data and random effects regression, model fitting. Completely randomized design, stratified design. Biological study designs. Optimization strategies with case studies.

Module-5

STATISTICS IN MICROARRAY, GENOME MAPPING AND BIOINFORMATICS:
Types of microarray, objectives of the study, experimental designs for micro array studies, microarray analysis, interpretation, validation and microarray informatics. Genome mapping, discrete sequence matching

Course outcomes:
At the end of the course the student will be able to:

- Demonstrate strong basics in statistics and numerical analysis,
- foundation to tackle live problems in various spheres of bioscience and bioengineering
- Study and design various statistical problems

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Biostatistics	Alvin E. Lewis	McGraw-Hill Professional Publishing	**2013**
2	Statistics and Numerical Methods in BASIC for Biologists	D. Lee and T.D. Lee	Van Nostrand Reinhold Company	**1982**
Reference Books				
1	Numerical Methods	Wolfgang Boehm and HartmutPrautzsch	CRC Press	**1993**
2	Numerical Methods of Statistics	John F. Monahan	Cambridge University Press	**2011**
3	Numerical Methods for Engineers and	Joe D. Hoffman	CRC Press	**2001**
4	Statistical Methods in Bioinformatics: An Introduction	Warren J. Ewens Gregory Grant	Springer Science & Business Media	**2005**

CONCEPTS IN BIOTECHNOLOGY

Course Code	**20BBC12**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION TO BIOLOGY:
Macromolecules; Carbon chemistry; Proteins: Structure, folding, catalysis; Nucleic acids: DNA & RNA; storage and transfer of genetic information; Lipids: membranes, structure & function; Carbohydrate chemistry, energy storage, building blocks.

Module-2

CELL STRUCTURES AND ITS FUNCTIONS:
Eukaryotic and Prokaryotic cells, plant and animal cells, structure of nucleus, mitochondria, ribosomes, Golgi bodies, Lysosomes, endoplasmic reticulum, chloroplast, vacuoles; Cell cycle and cell division: Different phases of cell cycle, cell division: Mitosis and meiosis. Mendelian law of inheritance: Monohybrid and dihybrid inheritance, law of segregation and independent assortment; Gene Interaction; Multiple alleles, supplementary and complementary genes, epistasis. Identification of genetic material: classical experiments; chromosome structure and

organization, chemical composition of chromatin, structural organization of nucleosomes, heterochromatin, polytene and lamp-brush chromosomes, human chromosomes, chromosomal disorders.

Module-3

SCOPE OF MICROBIOLOGYAND IMMUNOLOGY:

Introduction to the structure and functions of microorganism: Bacteria, Viruses, Fungi and Protozoan's. Microscopy and microbial techniques: Study of microscopes; sterilization techniques: Heat, steam, Radiation, Filtration and chemical methods; Pure culture techniques: Serial Dilution, Streak, Spread, Pour Plate. Immune System, Innate and adaptive immunity, antigens and antibodies; types of immune response, hypersensitivity. Humoral immunity: B-lymphocytes, Immunoglobulin classes, Major Histocompatibility Complex (MHC). Cell mediated immunity. Thymus derived lymphocytes (T-cells), Antigen presenting cells (APC); Immunity to infection, Cytokines.

Module-4

SCOPE OF AGRICULTURAL BIOTECHNOLOGY:

Role of Microbes in agriculture, Bio-pesticides, Bio fertilizers (Nitrogen fixing microbes), GM crops. Plant metabolic engineering and industrial products: Molecular farming for the production of industrial enzymes, biodegradable plastics, antibodies, edible vaccines. Metabolic engineering of plants for the production of fatty acids, industrial oils, flavonoids etc. Basic aspects of Food & Nutrition. Discussion of case studies for addressing health and malnutrition, via Agriculture BT.

Module-5

INDUSTRIALLY IMPORTANT MICROORGANISMS AND PRESERVATION TECHNIQUES:

Different media for fermentation, basic structure of fermenter and different types. Types of fermentation processes (surface, submerged, and solid state) and their products (ethanol, citric acid, lactic acid, enzymes, antibiotics) Biological treatment of waste water, primary, secondary and tertiary treatments. Bio-indicators, bioremediation of xenobiotic compounds, Bioleaching of minerals from ores, Biosorption of toxic metals. Solid waste management. Biofuel production from agricultural wastes. Case studies and solutions for current issues of waste management.

Course outcomes:

At the end of the course the student will be able to:

- Demonstrate strong basics in principles of bioengineering
- Tackle live problems in various spheres of biochemical engineering
- Search for information from relevant data hand books, for the design and execution of experiments using bioreactors / fermenters)

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Bioprocess Engineering and	Paulin and M	Wiley	**2006**
2	Elementary Principles of	R.M. Felder and	J. Wiley	**2006**

Reference Books

1	Principles of Genetics	Gardner, Simmonns and Snustad	Wiley India Pvt. Limited,	**2005**
2	Cell Biology, Genetics, Evolution and Ecology	P S Verma, V R Agarwal	New Publisher Delhi	**2007**
3	Plant biotechnology in Agriculture	K. Lindsey and M.G.K. Jones	Prentice hall	**1989**

PRINCIPLES OF BIOCHEMICAL ENGINEERING

Course Code	**20BBC13**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

HISTORICAL DEVELOPMENT OF BIOPROCESS TECHNOLOGY:

An overview of traditional and modern applications of biotechnological processes, Roles and responsibilities of a Chemical engineer in bioprocess industry, Steps in bioprocess development. Biology of the cell, classification, construction and cell nutrients. Industrial enzymes -, Nomenclature and Classification of enzymes, structure and functions of enzymes with relevant case studies.

Module-2

EQIPMENTS: Mixing-Power requirement (Calculation of power no), Ungassed and gassed fluids, factors affecting the broth viscosity, Mixing equipments (Banbury mixers, Muller Mixers), Size Reduction(laws of size reduction, Mechanical efficiency and crushing efficiency Concept of Sphericity, Volume surface Mean Diameter, Arithmetic Mean Diameter, Mass mean diameter, Volume Mean Diameter and Proof for sphericity is unity for regular object) Crushing equipments (Jaw crusher, Garyatory crusher, Shredders, Ball mill) Filtration (constant pressure and constant rate filtration explanations with only the equations.

Module-3

INDUSTRIALLY IMPORTANT FILTRATION EQUIPMENTS AND ACCESSORIES: (Rotary filters, Plate and frame filters and Leaf filters) Settling and its type (free and hindered settling: equation for Newton's, Intermediate Stokes regimes and Criteria for selection of the equation) Problems, Size Enlargement operations. Flow pattern in agitated vessel, Role of shear in fermentation broth, bubble shear, rheological behavior of fermentation broth, 3-D Continuity equation, Pressure drop in flow through packed bed and Fluidized bed (Kozeny, Carman, Blake Plummer Equations), Flow of compressible fluids, Time to empty the liquid from a tank (Rectangle Tank and Hemispherical Tank), problems, Problems on calculation of resultant velocity and resultant acceleration of fluid on space ordinates (x, y, z). Numerical Problems.

Module – 4

BASICS OF THERMODYNAMICS:

Procedure for Energy balance and Energy balance for cell culture, Concept of Internal energy, Enthalpy-calculations procedure (Enthalpy and internal energy changes calculations using first law of Thermodynamics), calculations of Entropy changes (Entropy changes for constant

Temperature, Constant volume, constant pressure and work lost due to entropy) Differential equations of Entropy, Problems on entropy and Its calculations, Gibbs Free energy and other free energies of systems, Effect of temperature and Pressure on the Gibbs free energy and Helmholtz free energy. Discussion of case studies.

Module-5

INTRODUCTION TO HEAT TRANSFER:

Overview of Industrial Heat Exchangers (Construction and working principle of DPHE, STHE, Helical coil heat exchangers along with the heat transfer equations) and Concept of LMTD, Boiling Condensation, Nucleate and film boiling (Regimes of pool boiling) Regenerators and Recupretors. Transient growth kinetics, measurement of microbial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen Batch, fed batch and continuous cultures. Discussion of design strategies and case studies.

Course outcomes:

At the end of the course the student will be able to:

- Demonstrate strong basics in principles of bioengineering.
- Tackle live problems in various spheres of biochemical engineering.
- Search for information from relevant data hand books, for the design and execution of experiments using bioreactors / fermenters

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Bioprocess Engineering and principles2nd Edition	Paulin and M Doran	Wiley	2006
2	R.M. Felder and R.W. Rousseau	Elementary Principles of Chemical Processes, 3rd Edition	J. Wiley	2000
Reference Books				
1	SC Arrora and Domkundar	Process Heat Transfer 3rd edition	Wiley	2006
2	K.V. Narayan	Engineering Thermodynamics 3rd edition		2010
3	R.K. Bansal	Fluid Mechanics 3rd edition		2010

MOLECULAR BIOLOGY AND GENETIC ENGINEERING TECHNIQUES			
Course Code	**20BBC14**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

DNA REPLICATION:

Comparative account on initiation, elongation and termination in prokaryotes and eukaryotes DNA Repair: Mismatch correction, Mechanisms in thymine-dimer repair: Photo reactivation, Nucleotide excision repair, SOS repair DNA Recombination: Homologous and non-homologous recombination; Holliday Model; Site specific recombination: General mechanism, Examples: SSR in Bacteria bacteriophage, FLP/FRT and Cre/Lox recombination. Transcription: Prokaryotic & Eukaryotic Mechanisms; Significance of Promoters, Enhancers, Silencers, Transcription factors, Activators and repressors; Post transcriptional modifications; Transcription inhibitors

Module-2

GENETIC CODE AND ITS PROPERTIES:

Wobble hypothesis. Translation: Role of Ribosomes &tRNA; Mechanism of translation: Activation of amino acids, initiation complex formation, elongation of polypeptide, termination and release of polypeptide; Post-translational modifications; Transport of proteins and molecular chaperones. Transcriptional regulation in Prokaryotes: General mechanism of positive and negative control; Operon concept: lac, trp, and gal operons; Transcriptional control in Eukaryotes: Chromatin remodeling: Acetylation and deacetylation of histone proteins; Regulatory proteins: DNA binding transactivators, co-activators; Homeotic gene and their role in gene regulation.

Module-3

VECTORS:

Plasmids, Phage Vectors, Phagemids, Cosmids, YACs and BACs; Cloning & Expression vectors. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering: Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction**:** General mechanism and applications; Variants of PCR; *In vitro* mutagenesis.

Module-4

GENE TRANSFER TECHNIQUES INTO PLANTS:

Microprojectile bombardment; *Agrobacterium* transformation, Ti plasmid: structure and functions, Ti plasmid based vectors, mechanism of TDNA transfer; Chloroplast transformation; Transgenic science in plant improvement: resistance to biotic and abiotic stresses, bio pharming – plant s as bioreactors.

Module-5

Introduction of DNA into mammalian cells; Animal vectors and Transfection techniques; Transgenic science for improvement of animals and livestock, animal as bioreactors for recombinant proteins. Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Genetic manipulation of microbes for the production of insulin, growth hormones

Course outcomes:
After studying this course, students will be able to:

- Demonstrate strong basics in principles of Molecular biology and Genetic engineering
- Foundation to tackle live problems in various spheres of Genetic engineering

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher	Edition and year
1	Molecular Biology of the Cell, 4th edition	Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and PeterWalter	Garland Science	**2002**
2	Molecular Cell Biology, 4th edition	Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, andJames Darnell	W. H. Freeman	**2000**
Reference Books				
1	Genomes, 3rd edition	Brown TA	Garland Science	**2006**
2	Gene Cloning: An Introduction	Brown TA	Stanley Thornes Publishers Limited	**1995**
3	Molecular Cloning: A Laboratory Manual, Vols 1-3	J. Sambrook and D.W. Russel	CSHL	**2001**

BIOANALYTICAL TECHNIQUES			
Course Code	20BBC15	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

BRIEF REVIEW OF ELECTROMAGNETIC SPECTRUM AND ABSORPTION OF RADIATIONS:
Theory of spectroscopy, absorption by organic molecules, choice of solvent and solvent effects, modern instrumentation – design and working principle. Applications of UV-Visible spectroscopy (qualitative and quantitative analysis). Principles of vibrational spectroscopy, frequency and factors influencing vibrational frequency, instrumentation and sampling

techniques, interpretation of spectra, applications in biology. FT-IR-theory and applications, Attenuated Total Reflectance (ATR). Raman Spectroscopy, theory, instrumentation, and applications to biology. Discussions with Case studies.

Module-2

FUNDAMENTAL PRINCIPLES OF NMR:
Instrumentation, solvents, chemical shift, and factors affecting chemical shift, spin-spin coupling, coupling constant, and factors influencing the value of coupling constant, spin-spin decoupling, proton exchange reactions, FT-NMR, 2D -NMR, NMDR, NOE, NOESY, COSY and applications in Pharmacy, interpretation of spectra, C13 NMR Introduction, Natural abundance, C13 NMR Spectra and its structural applications. Discussions with Case studies.

Module-3

BASIC PRINCIPLES AND INSTRUMENTATION OF ION FORMATION AND TYPES: Fragmentation processes and fragmentation pattern, Chemical ionization mass spectroscopy (CIMS), Field Ionization Mass Spectrometry (FIMS), Fast Atom Bombardment MS (FAB MS), Matrix Assisted laser desorption / ionization MS (MALDI-MS), GC-MS. LC-MS. MS-MS. Discussions with Case studies

Module-4

INTRODUCTION TO X-RAY: Generation of X-rays, X-ray diffraction, Bragg's law, X-ray powder diffraction, interpretation of diffraction patterns and applications. Single crystal diffractions of biomolecules. Fibre diffraction. Neutron diffraction. XAFS. ORD Principle, Plain curves, curves with cotton effect, octant rule and its applications with example, circular dichroism and its relation to ORD. Discussions with Case studies

Module-5

CHROMATOGRAFIC TECHNIQUES:
Classification of chromatographic methods based on mechanism of separation: paper chromatography, thin layer chromatography, ion exchange chromatography, column chromatography and affinity chromatography – technical questions and applications. Gas Chromatography: Theory and principle, column operation, instrumentation, derivatisation methods and applications. HPLC, LC-MS and applications in HPTLC. Discussions with Case studies.

Course outcomes:
At the end of the course the student will be able to:

- Demonstrate strong basics in principles of Analytical techniques
- Tackle live problems in various spheres of biological sciences

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Fundamentals of Bioanalytical Techniques and Instrumentation	SabariGoshal& A K Srivastava	PHI	**2009**

2	Principles of Instrumental Analysis by, 4th Edition	Donglas A. Skoog, James, J. Leary	Saunders College Publishing, Philadelphia	**1992**
Reference Books				
1	Practical Pharmaceutical Chemistry, 4th Edition	A. H. Beckett & J. B. Stenlake	Academic Press	**1988**
2	Instrumental Methods of Chemical Analysis	B. K. Sharma	Goel Publishing House Meerut	**2000**
3	Biochemical Methods of Analysis	SarojDua&Neera Garg	Alpha Science	**2010**

BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING LABORATORY			
Course Code	**20BBCL16**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03

Sl. NO	**Experiments**
1	Preparation of buffers and biochemical reagents.
2	Estimation of proteins by Lowry's and Bradford methods
3	Methods in genomic DNA/plasmid Isolation, Quantification of nucleic acids by agarose electrophoresis/Spectrophotometric methods
4	Quantification of nucleic acids by agarose gel-electrophoresis/ Spectrophotometric methods
5	Amplification of DNA by PCR.
6	Isolation and screening of microbes for Enzymes/Organic acids/secondary metabolites(antibiotics)/nitrogen fixing
7	Cell differentiation by gram staining
8	Isolation of Enzymes/organic acids (from suitable sources)
9	Perform bioassays like, Enzyme activity, specific activity, Antibiogram
10	Enzyme Kinetic Parameters: Km, Vmax and Kcatter
11	Optimization of biotic and abiotic parameters for enzyme production in batch fermentation
12	Batch growth kinetics of microbes

Course outcomes:

At the end of the course the student will be able to:

- Understand the screening of microbes for metabolites;
- Isolate DNA plasmid and quantification of Nucleic acids;
- Perform bio assays like enzyme assay, antibiogram and kinetics of enzymes
- Analyze the products by shake flask culture

RESEARCH METHODOLOGY AND IPR			
Course Code	**20RMI17**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	1:0:2	SEE Marks	60
Credits	02	Exam Hours	03

Module-1

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India. **Defining the Research Problem:** Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, An Illustration.

Module-2

Reviewing the literature: Place of the literature review in research, Bringing clarity and focus to your research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, How to review the literature, searching the existing literature, reviewing the selected literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed. **Research Design:** Meaning of Research Design, Need for Research Design, Features of a Good Design,

Module-3

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.
Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.

Module-4

Testing of Hypotheses: Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. **Chi-square Test:** Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.

Module-5

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.
Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999,The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957,The Protection of Plant Varieties and Farmers' Rights Act, 2001,The Semi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules,

Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement, Covered under TRIPS Agreement, Features of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO.

Course outcomes:

At the end of the course the student will be able to:

- Discuss research methodology and the technique of defining a research problem
- Explain the functions of the literature review in research, carrying out a literature search, developing theoretical and conceptual frameworks and writing a review.
- Explain various research designs, sampling designs, measurement and scaling techniques and also different methods of data collections.
- Explain several parametric tests of hypotheses, Chi-square test, art of interpretation and writing research reports
- Discuss various forms of the intellectual property, its relevance and business impact in the changing global business environment and leading International Instruments concerning IPR.

Question paper pattern:

- The question paper will have ten questions.
- Each full question is for 20 marks.
- There will be 2full questions (with a maximum of four sub questions in one full question) from each module.
- Each full question with sub questions will cover the contents under a module.
- Students will have to answer 5 full questions, selecting one full question from each module.

Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Research Methodology: Methods and Techniques	C.R. Kothari	Gaurav Garg,New Age International,	**2018**
2	Research Methodology a step-by-step guide for beginners(For the topic Reviewing the literature under module 2)	RanjitKumar	SAGE Publications	**2011.**
3	Study Material (For the topic Intellectual Property under module 5), Professional Programme Intellectual Property Rights, Law and Practice	The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament	The Institute of Company Secretaries of India, Statutory Body Under an Act of Parliament	**2013**
Reference Books				
1	Research Methods: the concise knowledge base	Trochim	Atomic Dog Publishing	**2005**

2	Conducting Research Literature Reviews: From the Internet to Paper	Fink A	Sage Publications,	2009

***** END OF I SEMESTER *****

FERMENTATION TECHNOLOGY			
Course Code	**20BBC21**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

HISTORY OF DEVELOPMENT OF FERMENTATION INDUSTRY: The range of fermentation process, Microbial biomass, enzymes, metabolites, recombinant products, Transformation process, the component parts of Fermenter. Types of industrial bioprocesses; submerged, surface, solid state fermentations: aerobic, anaerobic and light based processes. The differences between laboratory, pilot, and manufacturing scale bioreactor experiments, Green biologics of fermentation technology, types of Reactor and reactor design, process economics. Discussions with case studies

Module-2

SCREENING OF IMPORTANT METABOLITES FROM MICROBIAL SOURCES: Primary and secondary screening of industrially important microbes, Screening methods, General Techniques in improvement of industrial strains, Isolation of auxotrophic mutants, resistant mutants, revertant mutants, Selection by induced mutants producing improved yields of secondary metabolites. Preservation and storage at reduced temperature; Agar slopes, liquid nitrogen, dehydrated form, dried culture and lyophilisation. Quality control of reservation of stock cultures

Module-3

INTRODUCTION TO CULTURE MEDIUM AND FORMULATION: Energy sources, Carbon & Nitrogen sources, Minerals, Growth factors, Buffers, Precursors and regulators, Oxygen and antifoam ingredients, Medium optimization. Substrates for solid state fermentation, Evaluation methods for complex Substrates differences based on product use.

Module-4

STERILIZATION PROCESS AND INOCULUM DEVELOPMENT

Medium sterilization, Design for Batch sterilization process, Calculation of del factors and holding time. Design of continuous sterilization process, Sterilization of Fermenters, Feeds & liquid wastes, Filter sterilization of media. Discussions with case studies Development of Inoculum, criteria for transfer, development of inoculum in yeast, bacterial and mycelial processes, aseptic inoculation of plant fermenters. Inoculum development methods.

Module-5

LABORATORY TO LARGE SCALE FERMENTATION PROCESSES: Batch, Continuous culture, Synchronous, nonsynchronous growth kinetics, Feedback systems, comparison of Batch and Continuous culture in industrial processes and investigative tools. Fed batch culture, Applications of Fed back cultures Techniques and trends in Fermentation technology for the production of recombinant vaccines, therapeutic proteins, antibiotics and diagnostics. Discussions with case studies. Treatment and disposal procedure for industrial effluents.

Course outcomes:
After studying this course, students will be able to:

- Demonstrate strong basics in principles of fermentation technology
- Demonstrate strong basics numerical analysis,
- Design and develop various fermentation processes

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Principles of Fermentation Technology	Stanbury& Whitaker	, Second Edition, BH publications	1995
2	Biotechnology Text book of Industrial Microbiology	W. Crueger and A. Crueger	Sinauer Publishers	1990
Reference Books				
1	Industrial Microbiology	Casida	Wiley	1986
2	Biotechnology : A Text Book of Industrial Microbiology	T.D. Brock	Smaeur Associates	1990
3	Comprehensive Biotechnology	Moo-Young, M., Bull, A. T., Dalton, H.	Pergamon Press	1987

BIOREACTOR PLANT DESIGN			
Course Code	**20BBC22**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION TO BIOPROCESS:
Objectives, Material and energy balance involved, Energy based calculation involved in bioprocess technology (Upstream and Downstream process Both steady state and Unsteady state), Process Flow diagrams development, validation (introduction, structure and resources for validation) of systems and processes including SIP and CIP, cGMP guidelines. Seed culture and inoculums development, culture cell banks, Operational models of reactors (Batch, continuous, Fed Batch, repetitive batch, recycle and continuous cultivation), Novel bioreactors Stirred tank, Air lift & Loop reactors, fluidized bed reactor, Packed bed and Hollow fiber membrane bioreactors, immobilized Bioreactor), Bioreactors for waste treatment processes; SSF bioreactors, Selection of bioprocess equipment (upstream and

downstream), heat transfer and mass transfer equipment's.

Module-2

BASIC DESIGN AND CONSTRUCTION OF FERMENTERS AND ITS AUXILIARIES:

Material of construction, Vessels for Bioprocess (Vessel geometry and vessel design), bearing assemblies, Motor drives, Aseptic seals, Flow measuring and control devices, Agitator and Sparger Design, piping, valves, Pressure relief system, Conveyor and elevator, sensors and instrumentation, control system and stability of control system**.**

Module-3

REACTOR CONFIGURATION:

Facility design aspects and Utility supply aspects, Equipment cleaning aspects, Design considerations for maintaining sterility of process streams and process equipment, Materials of construction for bioprocess plants. Medium requirements and formulation for fermentation processes (examples of simple and complex media), design and usage of commercial media for industrial fermentations, Batch and continuous heat sterilization of liquid media, Filter sterilization of liquids, Air sterilization-Techniques involved, sterility test and integrity test, Inoculation process, sampling process, cell harvesting, Cooling of fermenter system, water system for bioprocess industry (production of triple distilled water), Primary packing and secondary packing, waste disposable technology, environmental aspects.

Module-4

Mass transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes, Oxygen uptake rates and determination of oxygen transfer coefficients (kLa), role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems. Numerical using Reynold's, Prandtl's, Chilton & Colburn analogies. Scale up and scale down, effect of scale up on oxygenation issues, mixing, sterilization, pH, temperature, nutrient availability and supply; Bioreactor scale up based on constant power consumption per volume, mixing time, impeller tip speed(Shear), mass transfer coefficients. Scale up of downstream processes: Adsorption; (LUB method); Extractors (geometry based c rules); Filtration (cross flow Chromatography constant resolution etc. Centrifugation (equivalent times etc.). Scale-down related aspects.

Module-5

CONCEPTS OF CAED:

Detailed process and mechanical design of the following equipments via CAED – Agitated and jacketed vessels, fermenter vessels, shell and tube heat exchanger and double pipe heat exchanger. Types of joints (welded), pipe and pipe fittings.

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of fermentation technology
- Demonstrate skills in applying the concepts towards design of bioreactors and fermenters via CAED,

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook				
Sl No	**Title of the book**	**Name of the Author/s**	**Publisher Name**	**Edition and year**
1	Biochemical Engineering Fundamentals	Bailey and Ollis	Prentice Hall	**1992**
2	Biochemical Engg. and Biotechnology Handbook	Atkinson, B. &Maviuna, F	Mc-Graw hill (2nd Edition	**1993**
Reference Books				
1	Bioprocess Engineering Principles	Pauline M. Doran	Academic Press	1995
2	Fermentation & Biochemical Engineering Hand Book	H. C. Vogel & C. L. Todaro	William Andrew	1983
3	A compendium of Good Practices in Biotechnology	Butterworth-Heiemann	BIOTOL Series	1993

BIOSEPARATION AND PRODUCT RECOVERY			
Course Code	**20BBC23**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION TO DOWNSTREAM PROCESSES

Role and importance of downstream processing in biotechnological processes. Problems and requirements of bio product purification. Economics of downstream processing in biotechnology; cost cutting strategies, characteristics of biological mixtures, process design criteria for various classes of by-products (high volume, low valve products and low volume, high valve products). Discussion of case studies.

Module-2

PRIMARY SEPARATION AND RECOVERY PROCESS:

Cell disruption methods for intracellular products, removal of insoluble (particulate debris), centrifugation and filtration methods. Membrane based separations (dialysis, micro and ultra-filtration, reverse osmosis), theory design and configuration of membrane separation equipment application. Enrichment operations; precipitation methods (with salts, organic solvents and polymer extractive separations aqueous two phase extraction). Discussion of case studies.

Module-3

ELECTROPHORETIC TECHNIQUES;

Theory of Electrophoresis; Classification; Applications : Moving boundary electrophoresis, Zone Electrophoresis, Gel Electrophoresis, Continuous Gel Electrophoresis, Disc gel Electrophoresis, Agarose Gel Electrophoresis, Cellulose Acetate, Starch Gel and page (Polyacrylamide gel electrophoresis) and SDS - Polyacrylamide, High voltage electrophoresis, Isoelectric focusing, Immunoelectrophoresis. Capillary electrophoresis. PFGE. Discussion of case studies.

Module-4

INTRODUCTION TO MOLECULAR INERACTION AND CHROMATOGRAPHY:

Adsorption and absorption, Kinds of adsorption interactions. Adsorption characteristics, molecular orientation, adsorption isotherms: quantitative Relationships; adsorption from solutions, and the importance of Adsorption phenomena. Principle and classification of

chromatography, important terms of chromatography, Partition chromatography – Single dimensional (Both Ascending and Descending) and 2-D chromatography; Paper chromatography, Thin layer chromatography, Adsorption Chromatography. Discussion of case studies.

Module-5

ADVANCED PURIFICATION TECHNIQUES:

Ion Exchange Chromatography, Ge Filtration Chromatography, Affinity Chromatography. Principle of HPLC, theory and calculations, Instrumentation both analytical and preparative, Types of Columns, Detectors; Sampling Methods; Applications of HPLC, LCMS, GCMS. FPLC, HPTLC. Drying techniques, Crystallization, lyophilisation, Pervaporation, super liquid extraction, foam based separations, in situ product removal, Single step purification, Super critical extraction, online membrane separation, Discussion of case studies

Course outcomes:

- At the end of the course the student will be able to:
- Understand recovery and purification of biologically produced proteins and chemicals. Basic principles and engineering design of various separation processes including chromatography, electrophoresis, extraction, crystallization, and membrane separation.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Bioseparation Engineering	Endo, T.Nagamune, S. Katoh, T. Yonemoto	Japan Nikko	**1999**
2	Handbook on Bioseparation (separation science and technology)	Satinder Ahuja	Academic Press	**2000**

Reference Books

1	Product Recovery in Bioprocess Technology	BIOTOL	Butterworth-Heinemann,	**1992**
2	Downstream Processing and Bioseparation: Recovery and Purification of Biological Products	Jean-François Hamel, Jean B. Hunter,	American Chemical Society,	1990

AGRICULTURAL BIOTECHNOLOGY			
Course Code	**20BBC241**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION TO AGRICULTURAL BIOTECHNOLOGY: Introduction, history and scope ofagriculture in India. Staple food, fiber, fuel and fruitcrops of India and abroad, Agro-climatic zones andcropping pattern of India. Conventional cropimprovement programs- Introduction, Selection andHybridization, Mutation, Haploidy and PolyploidyBreeding. Modern agriculture biotechnology for foodsecurity and national economy. Green-revolution.

Module-2

APPLICATIONS OF PLANT TRANSFORMATION TECHNOLOGY:
Productivity and performance disease resistance, genes and gene constructs used for viralresistance by coat protein mediated production, bacterialresistance by lysozyme gene and fungal resistance bychitinase and beta glucanase genes. Agrobacteriummediated transformation. Crop improvement to resistadverse soil conditions. Salinity tolerance, droughtresistance. Herbicide resistance in commerciallyimportant plants. Insecticide resistance through BT-gene.Integrated pest management. current status of BT crops inthe world. Effect of transgenic crops on environment

Module-3

INTRODUCTION TO PLANT CELL CULTURE:
Explant selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2; Callus and cell suspension culture; plant regeneration: organogenesis. Somatic embryogenesis; somaclonal variation, its genetic basis and application in crop improvement. Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and "synthetic seeds"; haploid production: advantages and methods. Protoplast technology

Module-4

ANTISENSE RNA TECHNOLOGY(ACC synthase gene and polygalacturonase): Delay of softening and ripening of fleshy fruits by antisense RNA for ACC synthase gene in tomato, banana. Use of antisense RNA technology for extending shelf life of fruits and flowers Protection of cereals, millets and pulses following harvest using biotechnology. Biotechnology for fortification of agricultural products- Golden rice, transgenic sweet potatoes. Importance of biofertlilizers in agriculture. (Rhizobium azatobacter, Mycorrhiza, Frankia and Blue green algae) current practices and production of biofertilizers

Module-5

AN OVERVIEW OF LEGAL AND SOCIOECONOMICIMPACT OF BIOTECHNOLOGY:
Biotechnology & hunger. Ethical issues associated with labelling and consumption of GM foods. Public perception of GM technology. Biosafety management. Cartagena protocol on biosafety. Ethical implication of BT products, public education, Biosafety regulations, experimental protocol approvals, guidelines for research, environmental aspects of BT applications

Course outcomes:
At the end of the course the graduates should be able to

- Demonstrate strong basics in principles of Agricultural Biotechnology
- Appreciate the ability to use biotechnology for sustainable development

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl	Title of the book	Name of the	Publisher Name	Edition and
1	Biotechnology- Expanding Horizons	Singh BD	Kalyani Publishers	**2003**
2	Plant Tissue Culture: Theory and Practice, a revised edition	Bhojwani SS and Razdan MK	Panima Publishing Corporation	**1996**
Reference Books				
1	Plant biotechnology in Agriculture	Lindsey, K and Jones	Prentice Hall	**1990**
2	Crop Biotechnology	Rajashekaran K, Jacks TJ and Finley JW	American Chemical Society	**1990**

ANIMAL BIOTECHNOLOGY

Course Code	**20BBC242**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION TO ANIMAL CELL CULTURE

History and development of animal tissue culture. Equipment and materials, Principles of sterile techniques. Sources & types of tissues, balanced salt solutions Cell culture media - components of the medium, physical, chemical and metabolic functions of media. Role of serum and supplements, serum-free media, features and specifications of MEM, DMEM, RPMI and Ham's medium. Role of antibiotics in media. Measurement of cell viability and cytotoxicity. Dye exclusion and inclusion tests, colonigenic assay, macromolecular estimation, MTT based assay. Measuring parameters of growth – growth curves, PDT, Plating efficiency and factors influencing growth

Module-2

CELL LINES & ITS CULTURE

Primary culture, Establishment of Primary Culture, Development of cell lines, characterization of cell lines, maintenance and preservation of cell lines. Contamination -causes, detection and control, cell transformation – normal v/s. transformed cells, growth characteristics of transformed cells. Viral and chemical-mediated methods of cell immortalization, Scale-up of suspension cultures - Batch reactor, continuous culture, perfusion systems. Scale-up of monolayer cultures – roller bottles, Nunc cell factory, micro-carrier cultures, organotypic culture, matrices, factors affecting culture and perspectives

Module-3

INVITRO FERTILIZATION & CLONING

Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, in vitro fertilization, culture of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning basic concept, cloning from- embryonic cells and adult cells, cloning of different animals, ethical, social and moral issues related to cloning, *in situ* and *ex situ* preservation of germplasm, *in utero* testing of foetus for genetic defects, anti-fertility animal vaccines, gene knock out technology and animal models for human genetic disorders.

Module-4

MOLECULAR BREEDING

Introduction to different breeds of cattle, sheep, goats, pigs, canines and poultry, genetic characterization of livestock breeds, marker assisted breeding of livestock, introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection food/feed adulteration with animal protein,

Module-5

OTHER APPLICATIONS

Application of animal cell culture- Concepts of tissue engineering - skin, liver, kidney, Principles and species suitable for aquaculture (Indian major carps and prawns) Pearl culture - pearl producing mollusks, rearing of oysters, nucleation for pearl formation and harvesting of pearls, Probiotics and their significance in aquaculture.

Course outcomes:

After studying this course, students will be able to:

- Explain basic principles and techniques in genetic engineering. gene transfer technologies for animals and animal cell lines
- Gain Knowledge of the recent advances in animal breeding
- Explain the contribution 'functional genomics' is making and is likely to make in animal biotechnology now and in the future.
- Appraise the role of biotechnology in animal science for sustainable eco-system and human welfare.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

- The students will have to answer five full questions, selecting one full question from each

Textbook/ Textbooks				
Sl No	**Title of the book**	**Name of the**	**Publisher Name**	**Edition and**
1	Culture of animal cells, A manual of basic technique	R. Ian Freshney	Wiley-Liss, Inc	1994)
2	Animal Cell Biotechnology	Spier, RE and	JB Academic	**1990**
Reference Books				
1	Methods in Cell Biology	JP Mather and D Bames	Academic Press	**1998**
2	Fish & Fisheries of India	V. G. Jhingram	Central Publishing House	**1997**
3	Reproductive Techniques in Farm Animals	Gordon I	CABI	**2005**

BIOPROCESS CALCULATIONS			
Course Code	**20BBC243**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

UNITS AND DIMENSIONS: Fundamental and derived units, Conversion, Dimensional consistency of equations, Dimensionless groups and constants, conversions of equations. BASIC CHEMICAL CALCULATIONS: Concept of mole, mole fraction, Compositions of mixtures of solids, liquids and gases, Concept of Normality, Molarity, Molality, ppm, Ideal gas law calculations.

Module-2

Material balances calculation:In Distillation, Absorption, Extraction, Crystallization, Drying, Mixing and Evaporation Operations, Fuels – types of fuels, (solid, liquid and gaseous fuel), relevance to biofuels, characteristics of fuels, Ultimate and proximate analyses of fuels.

Module-3

MATERIAL BALANCE INVOLVING CHEMICAL REACTIONS: Material balances calculation involving bypass, recycle and operations. Generalized material balance equations, Principles of stoichiometry, Definitions of limiting and excess reactants, fractions and percentage conversion, yield and percentage yield, Selectivity, unit process – neutralization, oxidation, nitration, hydrolysis, and problems relating to these unit processes.

Module-4

ENERGY BALANCE: General steady state energy balance equation, Thermo physics, Thermo chemistry and laws, Heat capacity, Enthalpy, Heat of formation, Heat of reaction, Heat of combustion and Calorific values. Heat of solution, Heat of mixing, Heat of crystallization, determination of ΔHR at standard and elevated temperatures, Theoretical flame temperature and adiabatic flame temperature

Module-5

BIOPROCESS PRINCIPLES & STOICHIOMETRY OF BIOPROCES: Historical development of bioprocess technology; Bioprocess principles and operations, generalized process flow sheets. General material balance equation for steady state (for

manufacture of penicillin and ethanol) - outline of a bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses. Stoichiometry of microbial growth and

Course outcomes:

After studying this course, students will be able to:

- Explain replication, transcription and translation processes with underlying differences in prokaryotic and eukaryotic systems.
- Elaborate importance of genetic recombination with special reference to bacterial system.
- Outline DNA damage and repair mechanisms

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl	Title of the book	Name of the	Publisher Name	Edition and
1	Principles of Biochemistry	David L. Nelson	W.H. freeman and company	**2005**
2	Bioprocess Engineering	Pauline Doran	Academic	**2013**

Reference Books

1	Basic Principles and Calculations in Chemical Engineering	David Himmelblau	PHI	**2014**
2	Bioprocess Engineering	Shule and Kargi	Prentice Hall	**1992**
3	Chemical Process Calculations	R. Asokan	University Press	**2011**

GENOMICS,PROTEOMICS AND BIOINFORMATICS			
Course Code	20BBC244	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

GENOME ORGANIZATION AND GENE EXPRESSION Introduction, genetic elements that control gene expression, constitutive and inducible gene expression, correlation between mRNA and protein abundance, functional genomic analysis using forward genetics and reverse genetics. COMPARATIVE GENOMICS: Orthologs and paralogs, Comparative genomics of bacteria and horizontal gene transfer, Comparative genomics of mitochondrial genomes and eukaryotes, applications of comparative genomics.

Module-2

TRANSCRIPTOME ANALYSIS: mRNA as a subject of gene expression studies, traditional approaches for analysis of gene expression –transcriptional run off assays, RT-PCR, DNase protection assay, differential display PCR, Genome wide measurement of gene expression – SAGE, Massively Parallel Signature Sequencing, Microarrays, interpretation of RNA analyses, relationship of DNA and mRNA levels.

Module-3

PROTEOME ANALYSIS: Introduction, protein databases,2D gel electrophoresis, MALDI-TOF analysis, MASCOT analysis, Mass spectroscopy, peptide mass fingerprinting, peptide sequence analysis by tandem mass spectrometry, SELDI protein chip technology, proteomic analysis of post translational modifications experimental approaches for protein-protein interaction mapping, differential and quantitative proteomics

Module-4

Introduction, applications of genomics:in understanding basis of polygenic disorders, pharmacogenomics, Medical proteomics-biomarker discovery and its importance, Pharmaceutical proteomics-role of proteomics in drug development, applications of proteomics for the analysis of genetically modified plants

Module-5

Bioinformatics & Biological Databases: Introduction to Bioinformatics, Goals, Scope, Applications in biological science and medicine. Biological databases –Sequence, structure, Genome, Microarray, Metabolic pathway, motif, and domain databases. Mapping databases –genome wide maps. Chromosome specific human maps.SequenceAlignment: Introduction, Types of sequence alignments-Pairwise and Multiple sequence alignment, Alignment algorithms (Needleman &Wunch, Smith &Waterman and Progressive global alignment). Database Similarity Searching-Scoring matrices–BLOSSUM and PAM, Basic Local Alignment Search Tool (BLAST), and FASTA. Next Generation Sequencing –Alignment and Assembly. Molecular Phylogenetics: Introduction, Terminology, Forms of Tree Representation. Phylogenetic Tree Construction Methods -Distance-Based & Character-Based Methods and Phylogenetic Tree evaluation.

Course outcomes:

At the end of the course the student will be able to:

1. To understand and apply the techniques of genomics and proteomics to study gene and protein expression respectively. Understand the Architecture and Schema of online databases including structure of records in these databases.
2. To apply the techniques to study differential gene expression
3. To perform a correlation between gene expression and its corresponding protein profile.
4. Apply the principles of Bioinformatics and Programming to the problems related to process simulation and process engineering in Biological system

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks				
Sl No	**Title of the book**	**Name of the Author/s**	**Publisher Name**	**Edition and year**
1	Bioinformatics and Functional Genomics	Jonathan Pevsner	WileyBlackwell	2015
2	Introduction to Proteomics	Daniel CLiebler	Humana Press	**2002**
Reference Books				
1	Principles of Gene Manipulation and Genomics	Primrose S.B, Twayman .R.M	Blackwell publishing	2006
2	Principles of Proteomics	Twayman.R.M	Taylor and Francis	2004

FOOD BIOTECHNOLOGY			
Course Code	**20BBC251**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

BASIC CONSTITUTES OF FOOD: Basic constituents of food, colloidal systems in food, molecular stability of colloidal systems, types of food starches, soluble fibers: pectin's, mucilage & gums, protein rich foods, oils in foods. Food Microbiology: Microbial growth pattern, types of microorganisms associated with food: mold, yeast and bacteria. Contaminants of food stuff, milk and meat during handling and processing. Mechanism of food spoilage. Biochemical changes caused by microorganism. Determination of various types of food products. Food borne intoxicants and mycotoxins.

Module-2

FOOD PRESERVATION TECHNOLOGY: Food preservation by high and ultrahigh temperatures- canning, drying. Food dehydration: Equipments for food dehydration: fixed tray dehydration, cabinet drying, tunnel drying. Freeze dehydration, controlled atmosphere, storage, Food preservation by irradiation treatment. Preservation by freezing and refrigeration. Frozen foods. Thermal properties of frozen foods. Food freezing equipments: Air blast freezers, plate freezers and immersion freezers. Preservation by Chemicals and Bacteriocins.

Module-3

INTRODUCTION TO PLANT CELL CULTURE: Explant selection, sterilization and inoculation; Various media. Food Production Technology: Importance of food industry, specific objectives of food processing, impact of foodprocessing on food constituents. Production of single cell protein, Tailoring of milk proteins and milk fats, Production of fermented food products: yoghurt, probiotic cheese. Nutritional value, labelling of constituents: Soya foods, organic foods, dietary foods, nutritional
food supplements, Use of plant cell culture for the production of food additives (Vanillin, Capsaicin),microbial transformations, regulatory and social aspects of BT. Food packaging, edible films, Marketing of food and promotional strategies.

Module-4

BIOTECHNOLOGY FOR IMPROVED PROCESSING: Role of biotechnology in food industry, maintenance of nutritional quality, Enzymes in bakery and cereal products, utilization of hydrolases and lipases enzymes. Applications of immobilized enzymes in food industry, enzymes for enhanced flavor and aroma compounds, enzymes in fat and oil industries. Genetically modified plants for high nutritional food.

Module-5

FOOD QUALITY ASSURANCE AND CONTROL: Importance and functions of quality assurance and control. Methods of quality, concept of rheology, assessment of food materials- fruits, vegetables, cereals, dairy products, meat and processed food products. Microbiological safety of food products, chemical safety of food products, contaminants by heavy metal, fungal toxins and pesticide residue. Food regulations, grades and standards, USFDA/ ISO 9000 Series. Food adulterations and safety, sensors and instrumental analysis in quality control food laws andStandards.

Course outcomes: At the end of the course the graduates should be able to

- Apply knowledge of food engineering to design new process.
- Enlighten with comprehensive knowledge of biotechnological applications to foodindustry.
- Understand various areas of Food Safety & Quality Assurance

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Food Biotechnology	James M, Jay	CBS Publishers	2005
2	Food Biotechnology	Kalidas Shetty	CRC Press	**2005**
Reference Books				
1	Applied dairy microbiology	H. Elmer, L James, Marath and Steele	CRC press	2005
2	Introduction to Food Engineering	R. Paul Singh	Academic Press	2004
3	Food Processing Technology: Principles and practice	P. Fellows	WoodheadPublishing Ltd., Cambridge	2005

PHARMACEUTICAL BIOTECHNOLOGY			
Course Code	**20BBC252**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION: Introduction to pharmaceutical biotechnology, pharmacokinetic concepts, current research trends, new advances and approved biologicals for pharmaceutical use and manufacturing principles. Quality assurance and control; Concept of GMP, GLP.

Module-2

THERAPEUTICS BASED ON BIOTECHNOLOGY: Hematopoietic growth factor and coagulation factors,interferons and cytokines; Preparation andstandardization of hormones-thyroid, insulin and growthhormones; Enzymes-Enzymatic therapy and monographs;antibiotics and their derivatives-penicillin, streptomycin, tetracycline, cephalosporins, macrolides, peptide antibiotics (any two); vaccines BCG, DPT, Poliomyelitis, Typhus, toxoids-diptheria and tetanus; antitoxinsdiptheria and gas-gangrene(any two); others-whole human blood, dried human plasma, gamma globulins, clinical dextran and absorbable haemostats, uses, and storage.

Module-3

BIOTRANSFORMATION: Introduction, methods used in biotransformation, steroid transformation, contraceptives, L-Dopa, chemical reactions and mechanisms (hydroxylation, aromatization, synthetic routes, epoxidation and others), production and application of monoclonal antibodies.

Module-4

NUTRACEUTICALS: Antioxidants, flavanoids, carotenoids, cholesterol lowering chemicals, nutritional importance and their functions, deficiency diseases, nutritional status evaluation. Drug delivery systems: Introduction to drug delivery systems and methods, overview of barriers, calculation of drug metabolism and, pharmacodynamics.

Module-5

RECOMBINANT PROTEINS AND PROTEOMICS
IN DRUG DEVELOPMENT: Role of proteomics in drug development Application of recombinant proteins in pharmaceutical industry, health care and future prospects.

Course outcomes: At the end of the course the graduates should be able to

- Demonstrate strong basics in principles of Pharmaceutical Biotechnology
- Appreciate the ability to use biotechnology for sustainable development.
- Understand the Molecular mechanisms of drug action

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from

Textbook/ Textbooks

Sl No	Title of the book	Name of the	Publisher Name	Edition and

1	Biopharmaceuticals: Biochemistry and Biotechnology	Walsh G	John Wiley & Sons Ltd	**2003**
2	Pharmaceutical :Fundamentals and ApplicationsBiotechnology	Crommelin, Daan J. A., Sindelar, Robert D., Meibohm	Springer	**2013**
Reference Books				
1	Wolff Burger's Medicinal Chemistry and Drug Discovery	Manfred E	Wiley & Sons, Inc	**2000**
2	Binghewang, Terunasiahaan, Richard soltero	Drug delivery: principles and applications	applications John wiley& sons	**2005**
3	Drug Metabolism: An Introduction	Michael D. Coleman	John Wiley & Sons,	2005

BIOPROCESS OPTIMISATION, MODELLING &SIMULATIONS			
Course Code	**20BBC253**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

SCOPE AND HIERARCHY OF OPTIMIZATION:

Examples of applications of optimization, the essential features, procedure of optimization problems, obstacles to optimization. Classification of models, fitting functions to empirical data, the method of least squares, factorial experimental designs, fitting a model to data subject to constraints, Continuity of functions, unimodal versus Multi-model functions. Convex and Concave functions, Convex region, Necessary and sufficient conditions for an extremism of an unconstrained function one-dimensional search quadratic approximation.

Module-2

NUMERICAL METHODS:

Function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of uni-dimensional search, region elimination methods, polynomial approximation methods, multivariable optimization: Direct methods, random search, grid search, uni-variate search, simplex method, conjugate search directions, Powell's method, indirect methods- first order, gradient method, conjugate method, indirect method- second order: Newton's method forcing the Hessain matrix to be positive definite, movement in the search direction, termination, summary of Newton's method.

Module-3

OPTIMIZATION OF UNIT OPERATIONS:

Recovery of waste heat, STHE and DPHE (Pinch technology), optimal design of stages in distillation column. Optimal pipe diameter, optimal residence time for maximum yield in an ideal isothermal batch reactor, chemostat, optimization of thermal cracker using liner programming, Optimization of components in bioreactor- media, oxygen requirement, pH, temperature. L/D ratio, Flow rate optimization of fluids. Optimal speed of agitator, paddles.

Module-4

Solution of General form of dynamic models, dimensionless models. General form of linear systems of equations, nonlinear function. General state-space form. Solving homogeneous, linear ODEs with distinct and repeated Eigenvalues. Solving non-homogeneous equation, equation with time varying parameters. Introduction to systems and modelling – discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation. Discrete event simulation. Random number generation and their techniques - tests for random numbers Random variable generation

Module-5

Analysis of simulation data - Input modelling – verification and validation of simulation models – output analysis for a single model. Related to li near regression and generalization of linear regression technique. Stirred tank heaters: model equations, Isothermal continuous stirred tank chemical reactors, Biochemical reactors: model equations, linearization. Case studies

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of systems biology
- foundation to tackle live problems in various spheres of biological sciences connectivity between all major metabolic pathways

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Optimization of chemical processes	T.F.Edgar and Himmelblau DM	Mc-Graw. Hill.	**2001**
2	Process system analysis and control	Coughanowr and Koppel	McGraw-Hill publishing company	**2009**

REFERENCE BOOKS

1	Optimization for Engineering Design	Kalyan Moy Deb	PHI	2000
2	Applied mathematics in chemical engineering	Mickley, Sherwood and REED	McGraw-Hill publishing company	2006
3	Chemical process control: an introduction to theory and practice	George Stephanopoulos	Prentice-Hall of India Private Ltd.	1994

METABOLIC ENGINEERING

Course Code	**20BBC254**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	4:0:0	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

INTRODUCTION AND METABOLIC REGULATION:

Introduction: Importance of metabolic engineering and its multidisciplinary nature. An overview of Cellular Metabolism, Transport Processes, Passive Transport, Facilitated Diffusion, Active Transport, Fueling Reactions, Fermentative Pathways, Glycolysis, TCA Cycle and Oxidative Phosphorylation, Anaplerotic Pathways, Catabolism of Fats, Organic Acids, and Amino Acids, Biosynthetic Reaction, Biosynthesis of Amino Acids,

Biosynthesis of Nucleic Acids, Fatty Acids.

Module-2

METABOLIC FLUX AND APPLICATIONS OF METABOLIC FLUX ANALYSIS:

Metabolic flux analysis and its application, Methods for experimental determination of metabolic flux by isotope dilution method. Production of Glutamic Acid and regulation by Bacteria, Calculation of Theoretical Yields, Metabolic Flux Analysis of Lysine Biosynthetic Network in *C. glutamicum*, Metabolic Flux Analysis of Specific Deletion Mutants of *C. glutamicum*, Metabolic Fluxes in Mammalian Cell Cultures, Determination of Intracellular Fluxes, Application of Flux Analysis to the Design of Cell Culture Media.

Module-3

REGULATION OF METABOLIC PATHWAYS:

Regulation of Enzymatic Activity, Overview of Enzyme Kinetics, Simple Reversible Inhibition Systems, Irreversible Inhibition, Allosteric Enzymes: Cooperativity, Regulation of Enzyme Concentration, Control of Transcription Initiation, Control of Translation, Global Control: Regulation at the Whole Cell Level, Regulation of Metabolic Networks, Branch Point Classification, Coupled Reactions and the Role of Global Currency Metabolites.

Module-4

METABOLIC ENGINEERING IN PRACTICE:

Enhancement of Product Yield and Productivity, Ethanol, Amino Acids, Solvents, Extension of Substrate Range, Metabolic Engineering of Pentose Metabolism for Ethanol Production, Cellulose-Hemicellulose Depolymerization, Lactose and Whey Utilization, Sucrose Utilization, Starch Degrading Microorganisms, Extension of Product Spectrum and Novel Products, Antibiotics, Polyketides, Vitamins, Biopolymers, Biological Pigments, Hydrogen, Pentoses: Xylitol, Improvement of Cellular Properties, Prevention of Overflow Metabolism, Alteration of Substrate Uptake, Maintenance of Genetic Stability.

Module-5

BIOSYNTHESIS OF METABOLITES AND BIOCONVERSIONS:

Primary metabolites: Alteration of feedback regulation, limiting of accumulation of end products, resistant mutants. Secondary metabolites: Precursor effects, prophage, idiophase relationship, enzyme induction, feedback repression, catabolic repression, important groups of secondary metabolic enzymes, phosphotransferase, ligases oxidoreductases, oxygenases, carboxylases.Advantages of bioconversions, specificity, yields. Factors important to bioconversions, regulation of enzyme synthesis, permeability co metabolism, conversion of insoluble substrates.

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in metabolic engineering
- Develop and design different metabolic pathways to understand the cell regulatory events

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the book	Name of the	Publisher	Edition and
1	Metabolic Engineering Principles and Methodologies	Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen	Academic Press	**1998**
2	Control of metabolic process	A.C. Bowdenand M.L. Cardens	Plenum Publisher	**1991**
Reference Books				
1	Bioprocess engineering basic concepts	M.L. Shuler and Kargi	Pearson hall	1992
2	Fermentation and enzyme Technology	Wang D I C Cooney C I Demain	A L John Willey	1992
3	Scale-up Methods in Chemical Engineering	Johnson and Thring	Johnson and Thring	2006

FERMENTATION TECHNOLOGY& BIOSEPARATION LABORATORY			
Course Code	**20BBCL26**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	0:4:0	SEE Marks	60
Credits	02	Exam Hours	03

Sl.NO	**Experiments**
1	Development of inoculum and biomass estimation(dry weight basis) in Shake flask studies
2	Preparation of the fermenter
3	Production and estimation of citric acid in both SSF and submerged fermentation
4	Production of ethanol/enzymes in fermenter- Study of product formation kinetics and substrate utilization
5	Production ethanol/enzyme by immobilized microbes
6	Purification of intracellular products through cell disruption techniques (homogenization /sonication)
7	Separation of biomass/product through tangential flow filtration(TFF)

8	Product enrichment operation through two phase aqueous extraction
9	Analysis of biomolecules through TLC/HPLC
11	Separation of Enzymes through gel and ion exchange chromatography
12	Molecular weight determination of protein by both native and SDS PAGE
12	Characterisation protein by western blotting

Course outcomes:

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

- Understand the basic principles of fermenter and its operations
- Optimize the parameters for production of ethanol and organic acids

Appreciate various downstream processing techniques, purification steps and operations of associated instruments

TECHNICAL SEMINAR			
Course Code	**20BBC27**	CIE Marks	100
Number of contact Hours/week (L:P:SDA)	0:0:2	SEE Marks	--
Credits	02	Exam Hours	--

Marks distribution for CIE of the course 20BBC27 seminar:
Seminar Report: 30 marks
Presentation skill:50 marks
Question and Answer:20 marks

Course objectives:

The objective of the seminar is to inculcate self-learning, face audience confidently, enhance communication skill, involve in group discussion and present and exchange ideas.

Each student, under the guidance of a Faculty, is required to

- Choose, preferably through peer reviewed journals, a recent topic of his/her interest relevant to the Course of Specialization.
- Carryout literature survey, organize the Course topics in a systematic order.
- Prepare the report with own sentences.
- Type the matter to acquaint with the use of Micro-soft equation and drawing tools or any such facilities.
- Present the seminar topic orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

The CIE marks for the seminar shall be awarded (based on the relevance of the topic, presentation skill, participation in the question and answer session and quality of report) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculties from the department with the senior most acting as the Chairperson.

Marks distribution for CIE of the course 20BBC27 seminar:
Seminar Report: 30 marks
Presentation skill:50 marks
Question and Answer:20 marks

*** END OF II SEMESTER***

BIOSAFETY,BIOETHICS AND REGULATORY AFFAIRS			
Course Code	**20BBC31**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:2	SEE Marks	60
Credits	04	Exam Hours	03

Module-1

BIOTECHNOLOGY AND SOCIETY

Introduction to science, technology and society, issues of access-Case studies/experiences from developing and developed countries. Ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide. Public acceptance issues for biotechnology: Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries.

Module-2

LEGAL ISSUES & BIOETHICS

The legal, institutional and socioeconomic impacts of biotechnology; biotechnology and social responsibility, Public education to increase the awareness of bioethics with regard to generating new forms of life for informed decision making – with case studies. Principles of bioethics: Legality, morality and ethics, autonomy, human rights, beneficence, privacy, justice, equity etc. The expanding scope of ethics from biomedical practice to biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues.

Module-3

BIOSAFETY CONCEPTS

Ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management. Ethical implications of biotechnological products and techniques Laboratory associated infections and other hazards, assessment of biological hazards and levels of biosafety, prudent biosafety practices in the laboratory/ institution. Experimental protocol approvals, levels of containment.

Module-4

REGULATIONS

Biosafety assessment procedures in India and abroad. International dimensions in biosafety, bioterrorism and convention on biological weapons. Social and ethical implications of biological weapons. Biosafety regulations and national and international guidelines with regard to recombinant DNA technology. Guidelines for research in transgenic plants. Good manufacturing practice and Good lab practices (GMP and GLP). National and international regulations for food and pharma products.

Module-5

OTHER SECTORS:

The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance. Key to the environmentally responsible use of biotechnology. Environmental aspects of biotech applications. Use of genetically modified organisms and their release in environment. Discussions on recombinant organisms and transgenic crops, with case studies of relevance. Plant breeder's rights. Legal implications, Biodiversity and farmers rights.

Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Biosafety issues in Clinical Trials.

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of biosafety issues and good laboratory practices

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the book	Name of the	Publisher Name	Edition and
	Biotechnology and Safety Assessment	Thomas, J.A., Fuch, R.L	Academic Press	**2002**
	Biological safety Principles and practices	Fleming, D.A., Hunt, D.L	ASM Press.	**2000**
Reference Books				
1	Bioethics &Biosaftey	Sateesh MK	IK Publishers	**2008**
2	Biotechnologies and development	Sasson A	UNESCO Publications	**1988**
3	Biotechnologies in developing countries	Sasson A	UNESCO Publications	**1988**

ENVIRONMENTAL BIOTECHNOLOGY			
Course Code	**20BBC321**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

INTRODUCTION TO ENVIRONMENT:

Concerns pertaining to Ecological damage, Environmental Pollution Types - Water, Soil, Air, Noise and Thermal pollutions, their sources and ecological effects of pollutants on living and non-living systems.. Acid rain: sources and solutions. Significance of GHGs and carbon footprint; Biodegradation, of xenobiotic compounds, organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. Microbial desulfurization of coal. Environmental implications of Acid mine drainage and its remediation; Role of Biotechnology in providing solutions to environmental problems.

Module-2

BOD, COD and TOC – Estimation and correlation; Definition of Waste; Physical, Chemical and Biological characteristics of Industrial waste. Nitrification and Denitrification and their kinetics; Wastewater treatment systems. Waste Management in different industries (food processing, leather tanning, pharmaceutical, textile) Solid waste management: landfills, composting, earthworm treatment, recycling and processing of organic residues, Sources and dispersion of atmospheric pollutants and dispersion models. Control methods for air pollutants, noxious pollutants and odor control; Design of air pollution control equipments; Photochemical reactions.

Module-3

WASTE TREATMENT METHODS:

Types (Suspended and Attached growth processes), Aerobic and Anaerobic treatment of wastes; Other biological treatment process, Anaerobic digestion – Stoichiometry & Kinetic relationships, design consideration, Process modeling and control, Biological nutrient removal, Biological treatments with Case studies; Bioremediation types and biorestoration of contaminated lands. Handling of hazardous wastes from bioprocess industries and related case studies.

Module-4

ENVIRONMENTAL SENSING TECHNIQUES:

Characterization of water contaminants and their measurement Spectroscopic techniques, AAS, NAA, GCMS, HPLC, Electro analytical techniques, Environmental sensing techniques. Discussions with Case studies.

Module-5

ENVIRONMENTAL POLICIES AND REGULATIONS:

Waste minimization and its plan; Conservation of water and energy, Fugitive loss, Programs of municipal pollution control, Risk evaluation and decision analysis. Sustainable development, Environmental Management Systems, ISO and ISO 14000 series: Introduction, Areas covered in the series of standards, Necessity of ISO certification, Environmental Auditing; Other tools for environmental management, Environmental Impact assessment(EIA) and its future and scope. Objectives, Elements of EIA, Baseline studies Methodologies of EIA , Types of impacts, Prediction of impacts and its methodology, Uncertainties in EIA, Status of EIAs in India. EIA at various industries

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of environmental biotechnology for sustainable development and protection of our ecosystem.
- Apply the foundation principles and technologies to tackle live problems in various spheres of environmental sciences

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year

1	Textbook of Environmental Biotechnology	Pradipta Kumar Mohapatra	I K International	**2007**
2	Hazardous Waste Management	Buckingham and Evans	McGraw Hill International Edition	2001
Reference Books				
1	Biochemical Engineering Fundamentals	Bailey &Ollis	McGraw Hill International Edition	**1986**
2	Standard Methods for the Examination of Water and Waste Water	Laura Bridgewater	American Public Health Association	**2007**
3	Environmental Management	N K Uberoi	Excel Books publication	**2007**

BIOSENSOR TECHNOLOGIES(NSK)			
Course Code	**20BBC322**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

BIOSENSOR CHARACTERISTICS

Definition and components of biosensor, Basic measurement system, Measurement, Measureand, Errors in Measurements, Signal and Noise, Calibration, Method validation, Surface chemistry, Mass transport, Static characteristics- accuracy, precision, linearity, hysteresis, threshold; dynamic range, Dynamic Characteristics – response time, damping, calibration, standards and AC/DC bridges, Biocompatibility and surface fouling, sensor integration and systems fabrication.

Module-2

TRANSDUCERS

Various types of transducers; principles and applications - Calorimetric, Optical, Potentiometric / Amperometric, Conductometric / Resistometric, Piezoelectric, Semiconductor, Impedimetric, Chemiluminescence - based Biosensors, Quantum dots, Fluorescence, Raman Spectroscopy and Fluorescence Enhancement and DNA microarrays

Module-3

BIOCHEMICAL RECOGNITION

Chemical reactions: history of gravimetric and colorimetric reactions. Problems of specificity.Enzymes: biological catalysts, specificity, activity, storage/shelf life. Enzyme kinetics in solution and on a surface. Chemical equilibrium- forcing an unfavorable reaction. Cells: Signal transduction through chemoreception, membrane potential, cell metabolism, cytotoxicity, and transformed 'bioreporter' organisms. Antibodies: Immunochemistry, binding affinity and kinetics; hapten synthesis. Nucleic Acids (RNA and DNA): Basic biochemistry, hybridization; Amplification/self-replication; Secondary Structure and folding Aptamer (oligonucleotide) based recognition and molecularly imprinted polymers. Common assaying formats i) Labels: Radioisotopes, fluorophores, dyes, enzymes/substrates, liposomes, electroactive compounds. ii) ELISAs and nucleotide capture assays.

Module-4

MODERN INTEGRATED BIOSENSORS

Bioelectronic sensors (Fundamentals of microelectronics and CMOS based sensors) Biophotonic sensors (Fundamentals of photonic sensors, Resonant optical sensors, Plasmonic sensors) Biomechanical sensors (Principles of micro-electromechanical (MEM) resonators and sensors) Microfluidic devices for Lab-on-a-chip (Fabrication, Devices and techniques) Application of nanotechnology in bio sensing (Nanoparticles, Active nanochannels, Nanoelectronic, Nanophotonic and Nanomechanical sensors). Potential advantages & Developments towards a biomolecular computer, development of molecular arrays as memory stores; molecular wires and switches; mechanisms of unit assembly, Assembly of photonic biomolecular memory store; Information processing; commercial prospects for biomolecular computing systems
Chemometrics, Biosensor arrays; Electronic nose and electronic tongue

Module-5

APPLICATIONS

Biosensor applications in clinical chemistry, medicine and health care, biosensors for veterinary, agriculture and food, Low cost - biosensor for industrial processes for online monitoring; biosensors for environmental monitoring. Application of enzymes in analysis; design of enzyme electrodes and their application as biosensors in industry, healthcare, food and environment, Mobile/Point of Care biosensors

Course outcomes:

At the end of the course the student will be able to:

- Discuss the advantage and disadvantage of each type of element in biosensing element in relation to their use in biosensors.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Chemical Sensors and Bios ensors: Fundamentals and Applications	F.-G. Bănică	Wiley	**2012**
2	Advances in Biosensors	B.D. Malhotra, A.P.F.Turner	Elsevier JAI	**2003**
Reference Books				
1	Electronic Measurements and Instrumentation	P. Sharma	Umesh Publications	**2006**
2	Bioelectronics: From Theory to Applications	I.Willner, E.Katz	Wiley-VCH Verlag GmbH & C0	**2006**
3	Biosensors for environmental monitoring	Bilitewski, U.Turner	A.P.F. Harwood, Amsterdam	**2000**

PROTEIN ENGINEERING &DESIGN			
Course Code	**20BBC323**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Introduction to Protein Structure: The Building Blocks, Motifs of Protein Structure, Protein folding Molecular Recognition: Protein-protein interactions, Protein-DNA interactions, The Thermodynamics of Binding like thermal stability and specificity of Macromolecular Recognition, Transcription, translation, and post-translational modifications of proteins

Module-2

Concepts, principles and applications of various expression systems for protein and enzyme production. The principles and applications of the most current purification systems used in bioseparations.

Module-3

Protein design principles, Student design proposals, Protein engineering by directed evolution and rational design, Directed Evolution Strategy- Phage Display Systems, Cell Surface Display Systems, Cell Free Display System, Alternative Scaffolds, Combinatorial Enzyme Engineering, Protein Engineering using noncanonical amino acids

Module-4

Mutant selection and identifications, and establishment of mutant library for protein engineering, Enzyme and Biosensor engineering, Antibody engineering, Engineering of Therapeutic Proteins , In vitro synthetic enzymatic biosystems for bio-manufacturing of insulin, and other industrial enzymes

Protein Arrays/ Protein Chips and their application, 2D Gel Electrophoresis and its application Mass Spectrometry and Protein Identification, Proteomics Databases Proteomics Analysis Tools

Course outcomes:

At the end of the course the student will be able to:

Apprehend the concepts of protein engineering techniques and their applications

- Analyze the various types of protein structures and modifications
- Apply the knowledge of Protein engineering technology to produce novel proteins with pharmaceutical and industrial significance.
- Evaluate the biosafety, ethical and quality issues of various protein design technologies.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question fromeach module.

Textbook/ Textbooks				
Sl No	**Title of the book**	**Name of the Author/s**	**Publisher Name**	**Edition and year**
1	Strategies for the Design of Novel Proteins:Computer Methods in Protein Modeling	Jiri Novotny	Academic Press	**1996**
2	Protein Engineering and Design	Sheldon J. Park, Jennifer R. Cochran	Press	**2009**
Reference Books				
1	Phage Display Systems for Protein Engineering	A. Ernst and S. S. Sidhu	CRC	**2009**
2	Cell-Free Display Systems for Protein Engineering	P. A. Barendt and C. A. Sarkar	CRC	**2009**

NANOBIOTECHNOLOGY			
Course Code	**20BBC324**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

INTRODUCTION TO NANOMATERIALS AND NANOBIOMATERIALS:

History of Nanotechnology and Nanobiotechnology, scope and Applications. Structures and properties of Carbon based, metal based andbionanomaterails: Fullerenes, Bucky Ball, Nanotubes, Quantum Dots, Magnetic, Nano Shells,Dendrimers, Nanocarriers, Nanocrystals, Nanowires, Nanomembranes, hybrid biological/inorganic, protein & DNA based nanostructures. Introduction & overview of 1st, 2^{nd} and 3^{rd} generation biomaterials.

Module-2

CHARACTERIZATION OF NANOSTRUCTURES:

UV-Visible spectroscopy, Electron Microscopy-Scanning electron microscopy (SEM), Atomic Force microscopy (AFM), Transmission electron microscopy (TEM), Scanning Probe microscopy (SPM), Scanning tunnel microscopy (STM); Fourier Transform infrared spectroscopy (FTIR); X-ray spectroscopy

Module-3

NANO SYNTHESIS AND FABRICATION:

Introduction & overview of Nanofabrication: Bottom up-self-assembly and Top down approaches using processes like Ball milling, Sol-gel Process, Chemical Vapor deposition (CVD). Plasma or flame spraying synthesis, Ion-Bean sculpting electrodeposition and various lithography techniques. Nanolithography and Soft lithography. Biosensors: types, applications and developments. Biosensor in modern medicine.

Module-4

APPLICATION OF NANOBIOTECHNOLOGY:

Medical Nanobiotechnology: Diagnostics: Imaging: Benefits and Applications. Nanotherapeutics: cancer treatment – Nanotechnology based chemotherapy (Smart Bomb), Pebbles, wound care products, Implantable materials for vascular interventions, Implantables materials for orthopaedics and dentistry. Active implantable devices and

biomics. Nanosurgery. Pharmaceutical Nanobiotechnology: Drug delivery – Nanoparticles used as drug delivery systems, types of drug loading, drug release (sustained and targeted release mechanism), Biodegradable polymers. Application in the field of Nano Surgery and Tissue Engineering. Nano Safety Issues**:** Nanotoxicology: Toxicology health effects caused by Nanoparticles, EthicsChallenges and Future.

Module-5

BIOMEMS AND NEMS:

Micro & Nano-Electromechanical systems – Fabrication process – choice of materials – advantages and limits of various approaches, Applications, Thermal Radiations, Magnetic, Chemical and Mechanical Transducers – Sensing and Actuators.

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of Nanotechnology
- Tackle live problems in Nanobiotechnology
- Conceptualize the design and development aspects in the domains like NEMS/BIOMEMS

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Nanotechnology in biology and Medicine	Tuan Vo-Dine, Tylor and Francis	CRC	**2009**
2	Introduction to NanoScience and nanotechnology	Poole C P and Owens F J	Wiley	**2004**
Reference Books				
1	Nanotechnology	Greggory Timp	Springer	**1999**
2	Nanotechnology	Nanotechnology	IK international publication	**2008**
3	Biological Molecules in Nanotechnology	Stephen lee and Lynn M Savage	International Business Communications	**1998**

BIO BUSINESS & ENTERPRENEURSHIP DEVELOPMENT			
Course Code	**20BBC331**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

BIO ENTERPREUNERSHIP:

Introduction to bio-business, from the Indian context, SWOT analysis of bio-business Concept of Entrepreneurship - Evolution of Entrepreneurship, Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Entrepreneurship in India; Entrepreneurship - its barriers. Small scale industries: Definition; Characteristics; Need and rationale; Objectives; Scope; Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Global bio business and industry future trends.

Module-2

BUSINESS OPPORTUNITY IN AGRI BIOTECHNOLOGY:

Business opportunity, Essential requirement, marketing, strategies, schemes, challenges and scope-with case study on Plant cell and tissue culture technique, polyhouse culture. Herbal bulk drug production, Nutraceuticals, value added herbal products. Bioethanol production using Agri waste, Algal source. Integration of system biology for agricultural applications. Biosensor development in Agri management

Module-3

Business opportunity, Essential requirement, marketing strategies, schemes, challenges and scope-with case study- Pollution monitoring and Bioremediation for Industrial pollutants, Pesticides, Herbicides etc. Integrated compost production- microbe enriched compost. Biopesticide/insecticide production. Fermented products-probiotic and prebiotics. Stem cell production, stem cell bank, contract research. Production of monoclonal/polyclonal antibodies, Single cell protein and secondary metabolite production. Contact research in microbial genomics.

Module-4

PROJECT MANAGEMENT, INTELLECTUAL PROPERTY, TECHNOLOGY MANAGEMENT AND STARTUP SCHEMES:

Building Biotech business challenges in Indian context-biotech partners (BICEPS, BIRAC, DBT, Incubation centers. etc.), operational biotech parks in India. Indian Company act for Bio business-schemes and subsidies. Meaning of Project; Project Identification; Project Selection; Project Report; Need and Significance of Report; Contents; Formulation; Guidelines by Planning Commission for Project report; Network Analysis; Errors of Project Report; Project Appraisal. Identification of business opportunities: Market Feasibility Study; Technical Feasibility Study; Financial Feasibility Study & Social Feasibility Study. Patent expiry and Entrepreneurship opportunity, Principles of Technology leasing, licensing and transfer, Start-ups schemes in Indian government, Business incubation support schemes, Successful startups-case study

Module-5

REGULATORY AFFAIRS, BIOETHICS & BIO-SAFETY:
Regulatory affairs in Bio business-regulatory bodies and their regulations (ex. FDA, EU, DSIR, AYUSH, FSSAI etc.,) Public education of the process of biotechnology involved in generating new forms of life for informed decision-making. Ethical concerns of biotechnology research and innovation Interference with nature, fear of unknown, unequal distribution of risks.
Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards. biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management.

Course outcomes:
After studying this course, students will be able to:
- Demonstrate strong basics in entrepreneurship
- Demonstrate the ability to manage industrial projects and develop products

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.
- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	The 10 Commandments for Building a Growth Company	Brandt, Steven C	Macmillan Business Books	**1977**
2	Bhide, Amar V	The Origin and Evolution of New Business	Oxford University Press	**2000**
Reference Books				
1	Patel, V.G	The Seven Business Crises and How to Beat Them	TMH	**1995**
2	SIDBI Report on Small Scale Industries Sector [latest edition)			
3	Verma, J.C.., and Gurpal Singh	Verma, J.C.., and Gurpal Singh	Sage	2002

BIOENERGY MANAGEMENT			
Course Code	**20BBC332**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

BIOENERGY CONCEPTS- INTRODUCTION
Biopower, bioheat, Biofuels, advanced liquid fuels, drop-in fuels, Biobased products, Sustainability & Resilience, Bioenergy & Environment, Carbon Footprint, Emissions

of biomass to power generation applications, Emissions from biofuels,

Module-2

BIOMASS

Properties and types, proximate and ultimate analysis, calorific value, density, moisture content, energy content in biomass, chemical composition of biomass, Biomass logistics, Harvesting or collection, Densification, Transport, Storage.

Module-3

BIOMASS FEEDSTOCKS

Harvested Feedstock:

Feedstocks for first generation biofuels – Sugar crops, grains, oil seeds considered in terms of their potential for production; land use; competition with food and other industrial crops; energy inputs in production; and transport logistics.

Feedstocks for second generation Biofuels - Dedicated plantation, Forestry and agricultural residues, secondary biomass feedstocks (agricultural, industrial, commercial, and municipal organic wastes) considered in terms of their production, composition, purity, conversion potential and environmental impacts.

Feedstocks for third generation feedstocks - Micro and macro algae considered in terms of development of new biomass feedstocks and technical constrains. Biofuels from biomass conversion processes (solid: biochar; liquids: bioethanol and biodiesel; gaseous: biogas and syngas).

Residue Feedstocks: Agricultural waste, Forestry waste, Farm waste, Organic components of residential, commercial, institutional and industrial waste

Module-4

BIOMASS CONVERSION TECHNOLOGIES

Pretreatment of biomass (pelleting; chipping; biodrying etc.), Biorefineries& end productsBiochemical Conversion: Hydrolysis, enzyme & acid hydrolysis, Fermentation for bioethanol and Bio-butanol production, Anaerobic digestion for biogas/biomethane production, Trans-esterification for biodiesel productionThermochemical Conversion: Combustion, Gasification, Pyrolysis Types of reactors, chemical equilibrium and reaction kinetics.Management of solids / liquids / gaseous biomass process waste.Heat generation from biomass boilers and stoves (operation, sizing criteria).Power generation from biofuels: engines (ICE), turbines (steam, ORC, gas) and fuel cells.

Module-5

LIFE CYCLE ANALYSIS

Cradle-to-grave, field to wheels concepts; Goal and scope determination, defining LCA boundaries; Life Cycle Inventory, Life Cycle Assessment; Advanced low-carbon fuels from waste; Bio-electrochemical systems (e.g. microbial fuel cell) for bioenergy and chemical production.

Course outcomes:

At the end of the course the student will be able to:

- Integration of the biological and engineering principles of resource use and productivity in a quantitative manner in order to assess the effectiveness of agricultural and agroforestry biomass production systems
- Location of relevant information sources on biomass energy and to critically assess the quality of the data and the information source
- Production of clear and concise analyses of benefits and problems relating to the production and use of different forms of biomass energy

Question paper pattern:
The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Biorenewable Resources: Engineering New Products from Agriculture	Robert C. Brown	Wiley-Blackwell Publishing	**2003**
2	Anaerobic Biotechnology for Bioenergy Production: Principles and Applications.	Samir K. Khanal	Wiley-Blackwell Publishing 2008	**2008**
Reference Books				
1	Bioenergy : power, fuels and products	Jennifer A. De-Cesaro, Matthew H. Brown	Policy	2006
2	Introduction to Bioenergy	Vaughn C. Nelson and Kenneth L.	CRC	2017
3	Bioenergy: Biomass to Biofuels	AnjuDahiya	Academic press	2014

BIOMATERIALS AND ARTIFICIAL ORGANS			
Course Code	**20BBC333**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

STRUCTURE OF BIO-MATERIALS AND BIO-COMPATIBILITY

Definition and classification of bio-materials, mechanical properties, composite materials, Nanomaterials and nanocomposites, Tissue-biomaterial interactions, biomaterial characterization, medical devices, Testing of biomaterials: In-vitro, in-vivo pre-clinical tests, safety and biocompatibility evaluation

Module-2

METALS AND CERAMICS

Metallic implant materials, stainless steels, Co-based alloys, Ti-based alloys, ceramic implant materials, aluminum oxides, hydro-apatite, glass ceramics, carbons.

Module-3

SYNTHETIC AND BIOPOLYMERS

Polymerization, poly amides, Acrylic polymers, rubbers, high strength thermoplastics, Bio polymers: Collagen, Hyaluronic acid, chitosan and Elastin.

Module-4

ARTIFICIAL ORGANS

Artificial Heart, Prosthetic Cardiac Valves, Limb prosthesis, Externally powered limb prosthesis, Dental Implants, Artificial cornea, Artificial liver and pancreas, artificial skin.

Module-5

APPLICATIONS

Medical applications of biomaterials, Drug delivery, Bioinspired Materials and Biomimetics, Tissue engineering, Regenerative medicine, Stem cell biology, modern scaffold structures, advanced fabrication technologies including computer-aided tissue engineering and organ printing, global regulatory requirements, technology transfer and ethical issues

Course outcomes:

At the end of the course the student will be able to:

- Students should be able to0 understand the principles and features of polymeric materials,identifyand understand key structure-property-processing relationship of polymers
- Students should understand the roles of polymer design play in the biomedical applications.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbooks

Sl No	Title of the book	Name of the Author/s	Publisher Name	Edition and year
1	Fundamentals of Biomaterials	VasifHasirci, NesrinHasirci	Springer	**2018**
2	Biomaterials, Medical Devices, and Combination Products - Biocompatibility Testing	Shayne Cox Gad, Samantha Gad-McDonald	CRC Press	2015
Reference Books				
1	Joon B. Park, Roderic S. Lakes	Biomaterials – An Introduction	Springer	2010
2	Hench L. Larry and Jones J.	Biomaterials, Artificial organs and Tissue Engineering	Woodhead Publishing Limited,	2005
3	Marek J. Los, AndrzejHudecki, Emilia Wiechec	Marek J. Los, AndrzejHudecki, Emilia Wiechec	Associated Press	2018

VACCINE DEVELOPMENT			
Course Code	**20BBC334**	CIE Marks	40
Teaching Hours/Week (L:P:SDA)	3:0:0	SEE Marks	60
Credits	03	Exam Hours	03

Module-1

Immunopathology: Tolerance and Autoimmunity, Hypersensitive reactions, Primary and Secondary Immunodeficiency, Active and passive immunization, General immunization practices, , AIDS, Immune response to Infectious disease, Basic principles of vaccine development. Vaccination of immune-compromised hosts, Vaccination of human immunodeficiency virus- infected persons. Vaccines and its historical perspective.

Module-2

Traditional and modern methods of vaccine production, Egg and cell based vaccine development, Current and future scenario of Vaccines, Edible Vaccines, Reverse vaccinology, Immunoinformatics approach to identify T and B cell epitopes, Bacterial and Viral vaccine. Passive immunization; antibody, transfusion of immune competent cells, cell based vaccines. Immunomodulators (cytokines) Innovative methods of delivery of immunogens through liposomes, microspheres, ISCOMS.

Module-3

Vaccine Technology: Criteria for effective vaccine, Vaccines, Live, killed, attenuated, sub unit vaccines; Role and properties of adjuvants, recombinant DNA and protein based vaccines, Multivalent subunit vaccines, mini cell vaccines, conjugate vaccines plant-based vaccines, recombinant antigens as vaccines. Interferons, designing and screening for antivirals, mechanisms of action, antiviral libraries, antiretrovirals—mechanism of action and drug resistance. Comparative Genomics as a tool for vaccine design

Module-4

Licensed vaccines, Viral Vaccine (Poliovirus vaccine-inactivated & Live, Rabies vaccines Hepatitis A & B vaccines), Bacterial Vaccine (Anthrax vaccines, Cholera vaccines, Diphtheria toxoid), Parasitic vaccine (Malaria Vaccine). Vaccines against Hepatitis A, Malaria, Typhoid (in clinical trials). Conventional vaccines, antiidiotype vaccine, naked DNA vaccine. Recombinant Vaccines - Definition, recombinant vector vaccines, DNA vaccines. Vaccine potency testing.

Module-5

The vaccine industry, Vaccine manufacturing, Vaccine additives and manufacturing residuals, Regulation and testing of vaccines, Vaccine safety and Legal issues. Regulatory issues- Environmental concerns with the use of recombinant vaccines- Disease security and biosecurity principles and OIE guidelines Method of manufacture- in process control, batch control, test on final products. large scale manufacturing—QA/QC issues

Course outcomes:

At the end of the course the student will be able to:

Apprehend the concepts of immunization and vaccination

- Analyse the various types of vaccines
- Apply the knowledge of vaccine technology to cure various health ailments and intricacies.
- Evaluate the biosafety, ethical and quality issues of various vaccine technologies.

Question paper pattern:

The SEE question paper will be set for 100 marks and the marks scored will be proportionately reduced to 60.

- The question paper will have ten full questions carrying equal marks.
- Each full question is for 20 marks.
- There will be two full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub question covering all the topics under a module.
- The students will have to answer five full questions, selecting one full question from each module.

Textbook/ Textbooks

Sl No	Title of the	Name of the Author/s	Publisher	Edition and
1	Vaccines	Stanley A. Plotkin& Walter Orenstein & Paul A. Offit	Elsevier Publication	**2013**
2	Clinical Immunology	Brostoff J, Seaddin JK, Male D, Roitt IM	Gower Medical Publishing	**2002**

Reference Books

1	Essential Immunology	Roitt, I	Blackwell Scientific Publications	**2001**
2	New Vaccine Technologies	Ronald W. Ellis	Landes Bioscience	**2001**
3	Cheryl Barton	Advances in Vaccine Technology and Delivery	Espicom Business intelligence	**2009**

PROJECT WORK PHASE – 1			
Course Code	**20BBC34**	CIE Marks	100
Number of contact Hours/Week	2	SEE Marks	--
Credits	02	Exam Hours	--

Course objectives:

- Support independent learning.
- Guide to select and utilize adequate information from varied resources maintaining ethics.
- Guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- Develop interactive, communication, organisation, time management, and presentation skills.
- Impart flexibility and adaptability.
- Inspire independent and team working.
- Expand intellectual capacity, credibility, judgement, intuition.
- Adhere to punctuality, setting and meeting deadlines.
- Instil responsibilities to oneself and others.
- Train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Phase-1 Students in consultation with the guide/s shall carry out literature survey/ visit industries to finalize the topic of the Project. Subsequently, the students shall collect the material required for the selected project, prepare synopsis and narrate the methodology to carry out the project work.

Seminar: Each student, under the guidance of a Faculty, is required to

- Present the seminar on the selected project orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit two copies of the typed report with a list of references.

The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.

Course outcomes:

At the end of the course the student will be able to:

- Demonstrate a sound technical knowledge of their selected project topic.
- Undertake problem identification, formulation, and solution.
- Design engineering solutions to complex problems utilising a systems approach.
- Communicate with engineers and the community at large in written an oral forms.

Continuous Internal Evaluation

CIE marks for the project report (50 marks), seminar (30 marks) and question and answer (20 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

MINI PROJECT			
Course Code	**20BBC35**	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	02	Exam Hours/Batch	03

Course objectives:

- To support independent learning and innovative attitude.
- To guide to select and utilize adequate information from varied resources upholding ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Mini-Project: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as per the norms avoiding plagiarism.

Course outcomes:

At the end of the course the student will be able to:

- Present the mini-project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills.
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

CIE procedure for Mini - Project:

The CIE marks awarded for Mini - Project, shall be based on the evaluation of Mini - Project Report, Project Presentation skill and Question and Answer session in the ratio 50:25:25.The marks awarded for Mini - Project report shall be the same for all the batch mates.

Semester End Examination

SEE marks for the mini-project shall be awarded based on the evaluation of Mini-Project Report, Presentation skill and Question and Answer session in the ratio 50:25:25 by the examiners appointed by the University.

INTERNSHIP / PROFESSIONAL PRACTICE			
Course Code	**20BBCI36**	CIE Marks	40
Number of contact Hours/Week	2	SEE Marks	60
Credits	06	Exam Hours	03

Course objectives:

Internship/Professional practice provide students the opportunity of hands-on experience that include personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc. The objective are further,

To put theory into practice.

To expand thinking and broaden the knowledge and skills acquired through course work in the field.

To relate to, interact with, and learn from current professionals in the field.

To gain a greater understanding of the duties and responsibilities of a professional.

To understand and adhere to professional standards in the field.

To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.

To identify personal strengths and weaknesses.

To develop the initiative and motivation to be a self-starter and work independently

To develop the initiative and motivation to be a self-starter and work independently.

Internship/Professional practice: Students under the guidance of internal guide/s and external guide shall take part in all the activities regularly to acquire as much knowledge as possible without causing any inconvenience at the place of internship.

Seminar: Each student, is required to

- Present the seminar on the internship orally and/or through power point slides.
- Answer the queries and involve in debate/discussion.
- Submit the report duly certified by the external guide.
- The participants shall take part in discussion to foster friendly and stimulating environment in which the students are motivated to reach high standards and become self-confident.
- Students are motivated to reach high standards and become self-confident.

Course outcomes:

At the end of the course the student will be able to:

- Gain practical experience within industry in which the internship is done.
- Acquire knowledge of the industry in which the internship is done.
- Apply knowledge and skills learned to classroom work.
- Develop a greater understanding about career options while more clearly defining personal career goals.
- Experience the activities and functions of professionals.
- Develop and refine oral and written communication skills.
- Identify areas for future knowledge and skill development.
- Expand intellectual capacity, credibility, judgment, intuition.
- Acquire the knowledge of administration, marketing, finance and economics.
- Acquire the knowledge of administration, marketing, finance and economics.

Continuous Internal Evaluation

CIE marks for the Internship/Professional practice report (20 marks), seminar (10 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session by the student) by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as chairperson.

Semester End Examination
SEE marks for the internship report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University

PROJECT WORK PHASE -2			
Course Code	**20BBC41**	CIE Marks	40
Number of contact Hours/Week	4	SEE Marks	60
Credits	20	Exam Hours	03

Course objectives:

- To support independent learning.
- To guide to select and utilize adequate information from varied resources maintaining ethics.
- To guide to organize the work in the appropriate manner and present information (acknowledging the sources) clearly.
- To develop interactive, communication, organisation, time management, and presentation skills.
- To impart flexibility and adaptability.
- To inspire independent and team working.
- To expand intellectual capacity, credibility, judgement, intuition.
- To adhere to punctuality, setting and meeting deadlines.
- To instil responsibilities to oneself and others.
- To train students to present the topic of project work in a seminar without any fear, face audience confidently, enhance communication skill, involve in group discussion to present and exchange ideas.

Project Work Phase - II: Each student of the project batch shall involve in carrying out the project work jointly in constant consultation with internal guide, co-guide, and external guide and prepare the project report as perthenormsava per the norms avoiding plagiarism. the norms avoiding plagiarism.The norms avoiding plagiarism.

Course outcomes:
At the end of the course the student will be able to:

- Present the project and be able to defend it.
- Make links across different areas of knowledge and to generate, develop and evaluate ideas and information so as to apply these skills to the project task.
- Habituated to critical thinking and use problem solving skills
- Communicate effectively and to present ideas clearly and coherently in both the written and oral forms.
- Work in a team to achieve common goal.
- Learn on their own, reflect on their learning and take appropriate actions to improve it.

Continuous Internal Evaluation:

Project Report: 20 marks. The basis for awarding the marks shall be the involvement of the student in the project and in the preparation of project report. To be awarded by the internal guide in consultation with external guide if any.

Project Presentation: 10 marks.

The Project Presentation marks of the Project Work Phase -II shall be awarded by the committee constituted for the purpose by the Head of the Department. The committee shall consist of three faculty from the department with the senior most acting as the Chairperson.

Question and Answer: 10 marks.

The student shall be evaluated based on the ability in the Question and Answer session for 10 marks.

Semester End Examination

SEE marks for the project report (30 marks), seminar (20 marks) and question and answer session (10 marks) shall be awarded (based on the quality of report and presentation skill, participation in the question and answer session) by the examiners appointed by the University.