1.1.3. Number of courses having focus on employability/ entrepreneurship/ skill development during the year.
Year of offering: 2021-22
Batch- 2020-24 (3rd semester)

Program: Biotechnology		
Course Title: Numerical Methods and Differential Equations		**Course Code: 20EMAB205**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Interpolation techniques

Finite differences, Forward, Backward and central difference Operators. Newton Gregory forward and backward interpolation formulae. Stirling's formula for central difference. Newton's divided difference formula for unequal intervals.

08 Hours

2. Numerical Solution of Partial Differential Equations

Introduction, Classification of PDE, Parabolic, Elliptic and Hyperbolic Partial differential equations, Introduction to finite difference approximations to derivatives, finite difference solution of parabolic PDE, explicit and implicit methods, finite difference method to Elliptic PDE-initial –boundary vale problems, Hyperbolic PDE-explicit method. Engineering problems: Temperature distribution in a heated plate, steady-state heat flow and vibration of a stretched string.

12 Hours

Unit II

3. Matrices and System of linear equations

Introduction to system of linear equations, Elementary row transformations, Rank of a matrix, Consistency of system of linear equations, solution of system by (i) Direct methods-Gauss elimination, Gauss Jordon method (ii) Iterative method - Gauss-Seidel method. Eigen values and Eigenvectors of a matrix. Largest Eigen value and the corresponding Eigenvector by power method. Engineering problems. **08 Hours**

4. Introduction to Statistics

Introduction, Scope of biostatistics, Variables, Measurement scales, Ordered array, Graphical representation of data: Bar Chart, Line chart, histogram, frequency curve, Ogive curves. Descriptive statistics: Measure of central tendency (arithmetic mean, median, mode, quartiles); Measures of dispersion (Quartile deviation, Standard deviation, coefficient of variation), Measure of skewness (Pearson and Bowley's) **12 Hours**

Unit III

5. Introduction to Laplace transform and Solution of Differential Equations

Definition, transforms of elementary functions- transforms of derivatives and integrals-Properties. Periodic functions, Unit step functions and Unit impulse functions. Inverse Transforms- properties-Convolution Theorem. Applications to differential equations

10 Hours

Text Books:

1. Numerical methods for Engineers, Chapra S C and Canale R P, 5ed, TATA McGraw-Hill, 2007
2. Advanced Engineering Methods, Kreyszig E. 8Ed, John Wiley & sons, 2003.
3. Applied Statistics and Probability for Engineers, Douglas Montgomery, George Runger, 6Ed, John Wiley, 2014

Reference Books:

1. Introduction to Probability and Statistics: Principles and Applications for Engineering and Computing, J.Susan Milton, Jesse C Arnold, , 4, TATA Mc-Graw Hill Edition, 2007
2. Fundamentals of Mathematical Statistics, Gupta S.C and Kapoor V.K, 11Ed, Sultan Chand & Sons, New Delhi, 2002
3. Higher Engineering Mathematics, Grewal B S, 38ed, Khanna Publication, New Delhi, 2001.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Microbiology		**Course Code: 15EBTC201**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Introduction

The scope of Microbiology, Historical Foundations, Taxonomy and classification of microorganisms, Bergey's Manual of Systematic Bacteriology, prokaryotic and eukaryotic cells, Eubacteria and Archaebacteria, study of different types of microorganisms: bacteria, yeasts, viruses, fungi, protozoa (structure, classification, modes of reproduction & growth). Microbes and human society: Microbial applications in agriculture, veterinary, healthcare, industry and environment.

05 hours

2. Functional anatomy of Prokaryotic and Eukaryotic cells:

Size, shape and arrangement of bacterial cells, structures external to cell wall, cell wall and structures internal to cell wall including endospores. Structure and functions of eukaryotic cell. Genome structure in prokaryotic and Eukaryotic cells, Genotype & Phenotype, Genetic transfer and recombination (Transformation, Conjugation & Transduction), Genes and evolution.

07 hours

3. Microscopic Examination

Bright-field Microscopy, Dark-field Microscopy, Phase-contrast Microscopy, Fluorescence Microscopy and Electron Microscopy. Preparation of specimen for light and electron microscopy. Advances in Scanned Probe Microscopy, Scanning Tunneling Microscopy, Atomic Force Microscopy. **04 hours**

4. Microbial Growth

The requirements for growth (Physical & Chemical requirements), Culture media & their classification, Effect of different factors on growth, Growth of bacterial culture: bacterial division, generation time, phases of growth. Fundamentals of microbial growth Kinetics.Chemostat & Turbidostat, Measurement of growth: Direct and Indirect methods.

04 hours

Unit II

5. Microbial Techniques

Pure culture techniques (streak plate, spread plate, pour plate), Staining techniques (simple and differential staining techniques), Enumeration techniques (Direct Microscopic Count, plating techniques, membrane filtration, Electronic enumeration, etc). Characterization: Phenotypic and Biochemical characterization. 16S rRNA gene homology.

10 hours

6. Microbial Metabolism

Catabolic and Anabolic reactions, Energy production, Carbohydrate catabolism: Glycolysis, Alternatives to Glycolysis, Cellular respiration, Energy production by aerobic process, Energy production by anaerobic process, Energy production by photosynthesis, Mechanism of ATP synthesis. Lipid and Protein catabolism, Photosynthesis: Light dependent and light independent reactions. Metabolic diversity among microorganisms: autotrophs and heterotrophs. Metabolic pathways of energy use: Polysaccharide biosynthesis, lipid biosynthesis, amino acid and protein biosynthesis. The integration of metabolism. Utilization of Energy and Biosynthesis: Utilization of energy for biosynthetic and non-biosynthetic processes.

10 hours

Unit III

7. Control & Preservation of Microorganisms

Control of microorganisms by physical methods (heat, filtration, radiation). Microbial death kinetics, Thermal death point, Thermal death time, Decimal reduction time. Control of microorganisms by chemical methods (phenols, alcohols, halogens, dyes, detergents, heavy metals, etc), Common preservation techniques for microbes.

05 hours

8. Applied and Industrial Microbiology

Food Microbiology, role of microorganisms in food production, Industrial Microbiology: Introduction to Fermenter & fermentation processes, Media for industrial application, Industrial Products: amino acids, vitamins, enzymes, pharmaceuticals, organic acids (discussion of case study), r-DNA technology & therapeutic products from microbes. Biosynthetic pathways and Introduction to Metabolic Engineering.

05 hours

Text Books:

1 Chan & Pelzar, Microbiology, Publisher: Tata McGraw Hill 5th Edition 2008.
2 Tortora, Microbiology: An Introduction, Publisher: Pearson Education, 8th Edition, 2004

Reference Books:

1. Stanier Ingraham & Wheeler, General Microbiology, Pub: Mac Millan 5th edition. 2007.
2. Heritage, Introductory Microbiology Pub: Cambridge, 1st edition, 2007

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions

I	3 Questions to be set of 20 Marks Each	1, 2, 3,4	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Biochemistry		**Course Code: 15EBTC202**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Biochemical Foundation & Carbohydrates

Types of chemical reactions, Solution chemistry. pH (Henderson-hesselbatch equation) Buffers and their Biological importance, carbohydrates- chemical structure and properties classification- Monosaccharide's, Disaccharides, Sugar derivatives, deoxy sugars, amino sugars, and sugar acids, phosphorylated sugars, structure and properties of polysaccharides, Homopolysaccharides, Heteropolysaccharides - Peptidoglycan, Glycosaminoglycans, Glycoconjugates, Glycobiology . Biological importance of carbohydrates. **07 Hours**

2. Lipids

Definition and classification of lipid – simple, compound and derived lipids. Structure, classification and properties of fatty acids, Essential and non-essential fatty acid with physiological importance. Structure and physiogical functions of phospholipids, Sphingolipids, cerebrosides and gangliosides. Steroids- Structure and functions of cholesterol,. Eicosanoids, lipoproteins and terpenes. Vitamins-classifications and functions **05 Hours**

3. Amino acids and Proteins

Definition, Classification and properties of amino acids, reactions, rare amino acids, essential and nonessential amino acids with physiological importance. Peptides - Definition of peptide bond, Biologically important peptides. Proteins – Classification- primary, secondary- Alpha helix, Beta sheets, tertiary and quaternary proteins-hemoglobin. Ramachandran plot, polypeptide sequencing- Edman degradation, Chemical synthesis of Peptides. **05Hours**

4. Nucleic acids

Structure and properties of purines, pyrimidines, nucleosides and nucleotides. Nucleic acids- Structure of DNA, RNA -Types, **03 Hours**

Unit II

5. Carbohydrate metabolism

Glycolysis-aerobic and in anaerobic pathway, Energy yield of glycolysis Regulation of glycolysis-metabolic and hormonal. Fates of pyruvate. Glycogen - synthesis and degradation. Regulation of glycogen metabolism. Gluconeogenesis, Pentose phosphate pathway. Significance of pentose phosphate pathway and regulation. Production of Acetyl-CoA, Reactions of Citric acid cycle, Anaplerotic reactions, regulation of citric acid cycle. Glyoxylate cycle, Electron transport chain, ATP synthesis, shuttle systems and Oxidative phosphorylation. Cyclic and Non-cyclic Photophosphorylation and Calvin Cycle (C3) in plants Disorders of carbohydrate metabolism. Production of microbial polysaccharides; industrial and Medical application of exopolysaccharides.

10 Hours

6. Metabolism of Amino acids

General reactions of amino acid metabolism, urea cycle, amino acid biosynthesis-aspartate and glutamate family and degradation of aromatic amino acid - phenylalanine and tyrosine, metabolic disorders of amino acid metabolism, biosynthesis of plant substances and neurotransmitters, Environmental and Industrial Significance of Amino acid metabolism.

05 Hours

7. Metabolism of Fatty acids

Fatty acid oxidation, biosynthesis of fatty acids, Ketone bodies, phospholipids and spingolipids cholesterol biosynthesis, Regulation, metabolic disorders of lipid metabolism. Environmental and Industrial Significance of lipid metabolism **05 Hours**

Unit III

8. Metabolism of Nucleic acids

Biosynthesis and degradation of purines and pyrimidines, salvage pathway, uric acid production, regulation, metabolic disorders of nucleic acid metabolism. **05 Hours**

9. Biological Membranes And Transport Mechanism

Composition and functions of biological membranes (fluid mosaic model) – Proteins, Carbohydrates, Glycoprotein and glycolipids, Membrane transport - Passive transport and Active transport. Mechanism of Na+ and K+, glucose and amino acid transport. Role of transport in signal transduction processes. **05 Hours**

Text Books

1. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry, Sixth Edition, W.H. Freeman, 2012.
2. Jeremy M. Berg, John L. Tymoczko, Lubert Stryer. , Biochemistry, 7th revised International edition, Palgrave MacMillan, 2011.

Reference Books

1. Donald Voet and Judith G. Voet. , Biochemistry, 4th edition, Wiley; , 2010
2. Geoffrey L. Zubay, Principles of Biochemistry , Edition: 4th, William C Brown Pub, 1999.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3,4	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	5,6,7	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	8,9	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Calculations		**Course Code: 15EBTF201**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1.Units and dimensions

Introduction to Fundamental and derived Units. FPS, MKS, CGS and SI system. Conversion from one system to another system with examples.

04 Hours

2.Basics of chemical calculation

Introduction, concept of mole, Atomic mass and molar mass, composition of mixtures of solids, liquids and gaseous. Ideal gas law, Amagats law and Dalton's law. Varification of Vol %=Mol %. Physical properties of solution, normality, morality and molality. Solving problems for normality, morality and molality. **08 Hours**

3.Material balances without chemical reaction

General material balance equation, simplification for steady state without chemical reaction. Material balances of unsteady-state operation. Problems on mixing of streams, Distillation, Drying, Absorption, evaporation, Filtration, Extraction & Crystallization.

08 Hours

Unit II

4.Material balances with chemical reaction

Introduction, Concept of limiting, excess reactant and inerts. Conversion, yield and selectivity. Fuels and combustion-Definition of ultimate and proximate analysis of coal, air fuel ratio calculation. Problems.

10 Hours

5.Energy Balance

General steady state energy balance Equation.Thermopysics-Enthalpy, Heat capacities of solids, liquids and gases. Heat capacities of mixture, Thermo chemistry-Heat of combustion, formation and reaction. Effect of temperature on heat of reaction. Definition and significances of NCV and GCV and problems.

10 Hours

Unit III

6a .Stoichiometry of microbial growth and product formation kinetics

Introduction and definition of various yield coeffiISAnts. Elemental balances and Degree of reduction. Problems.

05 Hours

6b .Stoichiometry of microbial growth and product formation kinetics

Introduction and Basic cell kinetic models, Strutured,unstructured and mixed growth kinetic models

05 Hours

Text Books

1. B.I Bhatt and S.M.Vora, Stoichiometry,Tata McGraw Hill publications,4th edn,2007.
2. David Himmelblau, Basic principles and calculation in chemical engineering, Pearson Education Limited,6th edn,2005

Reference Books

1) Hougen, Watson and Rigatz, Chemical Process principles Pati-I , CBS Publishers & Distributors,2nd edn,2004.
2) J E Bailey and D F Ollis, Biochemical engineering Fundamentals, Mc Grew Hill Publication,2nd edn,1986.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3,	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	6a,6b	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Unit Operations-I		**Course Code:17EBTF201**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 3 hours/week**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:40	**Examination Duration:3 hrs**	

Unit I

1. Basics of mass transfer

Introduction to Mass Transfer, Classification of mass transfer operations, Diffusion, Fick's law of diffusion, Vapour Liquid Equilibrium (Txy & xy plots),Raoult's law, Relative volatility and its importance. Prediction of VLE data for binary mixture (Ideal system).

05 Hours

2. Distillation

Types of distillation: simple/Batch distillation, Multi stage tray tower distillation, Packed column distillation & steam distillation. Determination of theoretical stages in multistage tray tower distillation column: Construction of equilibrium curve, Equations for operating lines of rectifying section & stripping section, Equation for feed line (q-line).Concept of Reflux ratio, Types of Refluxes: Total reflux, Minimum reflux & Optimum reflux. Conceptual numerical Problems on determination of number of theoretical stages.

10 Hours

Unit II

3. Drying & Crystillation:

Importance of Drying, Terminologies and definitions, Drying rate curves under constant drying conditions, Drying Equipments: Tray dryer, Freeze dryer/Lyophilizer,spray dryer etc.*Crystallization:*Concept of Crystlallation, Principle and Applications

05 Hours

4. Extraction

Introduction, Liquid-Liquid & Solid-Liquid Extraction Principles, selection of solvents. Batch and Continuous Extraction.Extraction Processes:Aqueous two phase Extraction, Super critical Fluid extraction.

04 Hours

5. Adsorption

Concept of Adsorption, Types of Adsorption, Adsorption Isotherms, Applications of Adsorption in Chromatography. **03 Hours**

6. Heat transfer

Heat transfer: Introduction, Modes of heat transfer: conduction, convection and radiation. Conduction: Fourior's law of heat conduction, Thermal conductivity. Steady state heat conduction through unilayer and multilayer plain wall, Unilayer & multilayer Cylindrical pipe. Conceptual problems.

04 Hours

Unit III

7. Convective heat transfer & Heat transfer equipment's

Forced and natural convection, individual and overall heat transfer coeffiISAnt, Correlation for h and U for the flow in circular tubes and annulus. Calculation of h (film heat transfer coeffiISAnt) based on dimensionless number, Concept of Log Mean Temperature Difference (LMTD). Typical heat transfer equipments: Double pipe heat exchanger, Shell and tube heat exchanger. (Line diagram and operation).

05 Hours

8. Condensation & Boiling

Condensation: Drop wise & Film wise condensation. Boiling: Phenomenon, different regimes of Boiling (descriptive only). Insulation, Critical thickness of Insulation.

05 Hours

Text Books

1. McCabe W. L. and Smith J. C, Unit operations of chemical engineering, 7th, McGraw-Hill, 2005
2. C. J. Geankoplis, Transport Processes and unit operations, 4th, Prentice Hall of India, 2004

Reference Books

1. George Granger Brown, Unit Operations, 1st , CBS Publishers &Distributors, 2004
2. Alan S Foust, Principles of Unit operations, 2nd, John Wiley & Sons, 1980

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Microbiology Lab		**Course Code: 15EBTP201**
L-T-P: 0-0-1	**Credits:1.0**	**Contact Hours: 2Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 03 Hours**	

List of Experiments:

1. Laboratory safety precautions, material safety guidelines, cleaning & storage practices, culture disposal practices.
2. Study of Laboratory equipments: Microscope, Autoclave, Laminar Air Flow Bench, Hot Air Oven, Bacteriological Incubator and Freeze Drier. SOP and Calibration.
3. Media preparation: Nutrient broth/Agar, Mac-Conkey's medium and Potato-Dextrose broth/Agar.
4. Micrometry: Bacterial Cell measurement
5. Pure culture techniques: Streak plate Method, Spread plate Method, Pour plate Method.
6. Isolation and enumeration of microorganisms from environmental sources. (Open-ended experiment)
7. Simple and Differential Staining Techniques (Gram staining technique).
8. Hanging drop technique for motility and Endospore staining.
9. Study of bacterial growth curve (difference between non spore former and spore former) Sterilization by Filtration and antibiotic susceptibility testing.

Text Books/Reference Books:

1. Microbiology: A Lab Manual Seventh Edition by Cappuccino J G and Sherman N 2012 Pearson education Inc, 2012 (ISBN 978-81-317-1437-9).
2. Laboratory experiments in Microbiology, Ninth Edition by Ted R. Johnson and Christine Case. Pearson Education (ISBN 978-0-321-56028-5)
3. Techniques in Microbiology: A Student Handbook by John M. Lammert. Pearson Education (ISBN 978-0-13-224011-6)

Program: Biotechnology		
Course Title: Biochemistry Lab		**Course Code: 15EBTP202**
L-T-P: 0-0-1	**Credits:1.0**	**Contact Hours: 02 Hours/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks:100**

Teaching Hours: 24	Examination Duration: 03 Hours	

List of Experiments

1. Biochemical Measurements: Molarity, Normality, Molality, Moles, weight/volume measurements, percent solution, concentration Units. pH measurements and Buffer preparation, SOP's, Instrument calibrations.
2. Qualitative analysis of carbohydrates and Lipids
3. Qualitative analysis of amino acids and proteins.
4. Estimation of Reducing sugar by Folin – Wu method.
5. Estimation of Reducing sugar by Nelson –Somogyi/DNS method.
6. Estimation of Amino acids by ninhydrin method.
7. Estimation of Proteins by Lowry's method.
8. Estimation of Inorganic Phosphate by Fiske-Subbarao method.
9. Estimation of Urea by DAMO method
10. Estimation of DNA by Diphenylamine method.
11. Estimation of RNA by Orcinol method.

Text Books/ Reference Books

1. David Plummer An introduction to Practical biochemistry.Third edition,McGraw-Hill,1987.
2. Sadasivam S and Manickam A.,Biochemical methods.Second edition,New Age International,2005.

Program: Biotechnology		
Course Title: Unit Operations-I Lab		Course Code: 17EBTP201
L-T-P : 0-0-1	Credits: 1.0	Contact Hours: 02 Hours/Week
ISA Marks: 80	ESA Marks: 20	Total Marks: 100

Teaching Hours: 24	Examination Duration: 03Hours	

List of Experiments:

1. Diffusivity measurements
2. Drying characteristics.
3. Liquid Extraction
4. Convective mass transfer
5. Simple distillation
6. Steam distillation
7. Heat transfer in packed bed
8. Vertical condenser
9. Adsorption studies
10. Leaching

Text books/ Reference books

1. McCabe W. L. and Smith J. C, Unit operations of chemical engineering, 7th, McGraw-Hill, 2005
2. C. J. Geankoplis, Transport Processes and unit operations, 4th, Prentice Hall of India, 2004

1.1.3. Number of courses having focus on employability/ entrepreneurship/ skill development during the year.

Year of offering: 2021-22

Batch- 2020-24 (4th semester)

IV Semester

Program: Biotechnology		
Course Title: Biostatistics		**Course Code: 20EMAB210**
L-T-P: 3-1-0	**Credits: 4.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Bivariate Distribution Fitting of curves

Introduction to biostatistics, Review of Central tendency and Dispersion, Correlation, linear regression, Curve fitting (Nonlinear and Exponential curves) **05 Hours**

2. Probability

Definition of probability, addition rule, conditional probability, multiplication rule, Baye's rule, sensitivity, specificity, predictive value positive and negative, Probability in Genetics: Punnett square, Hardy - Weinberg law, Wahlund's Principle **05 Hours**

3. Probability distributions

Discrete probability distributions - Binomial, Poisson, Continuous Probability Distribution – Normal, Exponential, Gamma distribution **05 Hours**

Unit II

4. Sampling and Statistical Inference

Introduction, Sampling, Sampling distribution, sample size determination, Confidence intervals, Tests of hypothesis, p-value, t-test for single mean, difference of mean (with equal variance and unequal variance), paired t-test, Chi Square test for goodness of fit and independence of attributes, analysis of variance (one-way and two-way classifications). Case studies of statistical designs of biological experiments (RCBD, RBD)

08 Hours

5. Design of Experiments-1

Introduction, OFAT, 2^2 and 2^3 factorial experiments: Data table, Graphical representation, Main and interaction effects, ANOVA Table **07 Hours**

Unit III

6. Design of Experiments -2

Fractional factorial design, Placket-Burman design, Response Surface Methods-Central Composite Design

05 Hours

7. Population Growth Models

Introduction, Discrete time and continuous growth, Density Independent growth model: Geometric and Exponential growth model, Density dependent growth: Logistic growth model **05 Hours**

Text Books:

1. Applied Statistics and Probability for Engineers,Douglas Montgomery, George Runger, 6Ed, John Wiley, 2014
2. Introduction to Probability and Statistics: Principles and Applications for Engineering and Computing,J.Susan Milton, Jesse C Arnold, , 4, TATA Mc-Graw Hill Edition, 2007
3.Mathematical Models in Biology and Medicine, Kapoor J.N, EWP New Delhi, 2000

Reference Books:

1. Fundamentals of Mathematical Statistics, Gupta S.C and Kapoor V.K, 11Ed, Sultan Chand & Sons, New Delhi, 2002

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4, 5	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Immunology		**Course Code: 15EBTC203**
L-T-P: 3-0-0	**Credits: 03**	**Contact Hours:**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 hours**	

Unit I

1. Immune system

History and Scope of Immunology and Immune system, Classification of Immune system, Types of Immune responses, Molecules ,Cells and Organs of Immune system and Anatomy of immune response.

06 hours

2. Humoral Immunity

Overview of Humoral immunity, B- Lymphocytes – Development and their activation, Antibody response, Structure and functions of Immunoglobulins, Classes and sub-classes of immunoglobulins, genetic control of antibody production, Monoclonal and Polyclonal antibodies, Production of Monoclonal antibodies and quality screening processes in large scale monoclonal antibody production

05 hours

3. Cell Mediated Immunity

Overview of cell mediated immunity and its significance, T-Lymphocytes – Development, Types and their activation, Major Histocompatibility (MHC) Complex, Antigen Presenting Cells (APC) and antigen processing and presentation, Mechanism of Phagocytosis- Oxygen dependent and Oxygen independent.

04 hours

Unit II

4. Regulation of Immune Response and Immune tolerance

Immune response – Nature and necessity of its regulation, Complement System- Types, activation and types and their biological applications, Cytokines – types and their role in immune response, Immune Tolerance and their types, Hypersensitivity reactions – Types and Treatments. **Food allergy,** Case study on mechanism of immunity booster.

05 hours

5. Immunological disorders

Auto immune disorders – Features, important types and Experimental models of auto immune diseases ImmunodefiISAncy Disorders – Types and features.

04 hours

6. Transplantation immunology

Transplantation antigens – Types and functions, Types of Transplantations, Immunological basis of Graft rejection , and their disease association**,** Role of HLA in graft rejection, Tumor specific antigens, Tissue typing, Immune suppression and immune suppressive drugs.

06 hours

Unit III

7. Molecular Immunology

Vaccines – Types and their development, Production of Recombinant DNA vaccines, Application of PCR technology to produce antibodies, Immune Therapy with genetically engineered antibodies, Catalytic antibodies, immunotherapeutic applications of hematopoietic stem cells, Purification and preparation of antigens in vaccine development and Immunoinformatics.

06 hours

8. Immunodiagnosis

Immunization and Antiserum, Antigen-Antibody interactions – Precipitation reactions and Agglutination reactions Immuno-electrophoresis and Immunoflurescence assay, Principle and applications of ELISA and RIA and Western blotting analysis.

04 hours

Text Books

1. Janis. Kuby, Immunology, V, WH Freeman and Company, 2003
2. Pandian and Senthil Kumar, Immunology and Immunotechnology , Panima Publishing Corporation, 2007

Reference Books

1. P.M. Ladyard, Immunology , Bios SISAntific Publishers Ltd , 2000
2. Roitt I, Essential Immunology, Blackwell sISAntific Publications.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4, 5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Enzyme Technology		**Course Code: 17EBTC201**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Introduction to enzymes

History, nomenclature, classification of enzymes, sources of enzymes, properties of enzyme, Types of specificities, mechanism of enzyme action-Lock and Key model and Induced fit model, Enzyme catalysis -Acid base catalysis, covalent catalysis, metal ion catalysis, Proximity and orientation effects. Mechanism of coenzymes (NAD/NADP,FAD/$FADH_2$,PLP, Coenzyme A, TPP, Biotin) **07 Hours**

2. Purification of enzymes

Objectives and strategies in enzyme purification, choice of source-plant, animal and microbial, purification of intracellular and extracellular enzymes (Comprehensive flow sheet for enzyme purification),methods of homogenization, methods of separation-Enzyme fractionation by precipitation (using Temperature, salt, solvent, pH, etc.), liquid-liquid extraction, ionic exchange, gel chromatography, affinity chromatography and other special purification methods., Methods of characterization of enzymes; Analysis of yield, purity and activity of enzymes. Molecular weight determination-SDS-PAGE, MALDI-TOF **08 Hours**

3. Enzymatic techniques

Enzyme assay, Enzyme and isoenzyme measurement methods with examples(fixed incubation and kinetic methods) Methods for investigating the kinetics of Enzyme catalyzed reactions-Initial velocity studies, rapid-reaction techniques, Standardization and optimization methods, stability and activity of enzymes **05 Hours**

Unit II

4. Enzyme Kinetics and Enzyme Inhibitions.

Kinetics of single substrate reactions; Derivation of Michaelis -Menten equation, turnover number; K_{cat} value, determination of Km and Vmax, Line Weaver Burk plot, Eadie Hofstee plot, Hanes woolf plot, Importance of Km & Vmax; Enzyme inhibitions- reversible, competitive, uncompetitive and non-competitive inhibitions and kinetics, allosteric and irreversible inhibition. Substrate inhibitions, Multi-substrate reactions-ordered mechanisms, random mechanisms, Ping-pong mechanism. Allosteric enzymes and regulation - The Monad - Changeux - Wyman model (MCW) and The Koshland - Nemethy - Filmer (KNF) model, Feedback regulation and covalent regulation.

07 Hours

5. Enzymes Of Medical Importance

Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG Co A reductase inhibitors, pseudocholinesterase, 5'-nucleotidase (5NT), glucose-6-phosphate dehydrogenase (GPD), CKisoforms, immunoreactive trypsinogen (IRT) and chymotrypsin; amylase isoenzymes.Importance of enzymes in diagnostics, Enzyme pattern in diseases like Myocardial infarctions, (SGOT, SGPT & LDH). Isoenzymes (CK, LD, ALP). Enzymes in immunoassay techniques, Therapeutic enzymes. **07 Hours**

6. Enzyme Immobilization

Techniques of enzyme immobilization, adsorption - matrix entrapment- encapsulation- cross-linking - covalent binding - examples; whole cell immobilization and their application, kinetics of immobilized enzymes, effect of solute, partition & diffusion on the kinetics of immobilized enzymes, uses of immobilized enzymes, Design of Immobilized Enzyme Reactors- Stirred tank reactors(STR), Continuous Flow Stirred Tank Reactors (CSTR), Packed- bed reactors (PBR), Fluidized-bed Reactors (FBR); Membrane reactor **06 Hours**

Unit III

7. Industrial Applications of enzymes:

Enzymes used in detergents, use of proteases in food, leather and wool industries, uses of lactase in dairy industry, methods involved in production of glucose and maltose syrup from starch (using starch hydrolyzing enzymes),Glucose from cellulose, glucose oxidase and catalase in food industry, **05 Hours**

8. Enzyme transformation and Enzyme Biosensors

The design and construction of novel enzymes- Enzyme Engineering and site directed mutagenesis, Designer enzymes, synzymes, Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes) Elements of biosensors, Design of enzyme electrodes and their applications as biosensors in industry, health care and environment.

05Hours

Text Books

1. David L. Nelson, Michael M. Cox, Lehninger Principles of Biochemistry. , 6, W.H. Freeman, 2012
2. Trevor Palmer, 2. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, 1, East-West Press Pvt. Ltd, 2004

References

1. Laurence A. Moran, Raymond S. Ochs, J. David Rawn, and K. Gray Scrimgeour. , Principles of biochemistry., 3, Prentice Hall, 2002
2. Faber, Biotransformation in Organic Chemistry , 4, Springer, 2000
   Aehle W, Enzymes in industry- production and applications, 3, Wiley-VCH, 2007
3. Nicholas .C. Price and Lewis Stevens, Fundamentals of Enzymology , 3, Oxford University Press , 1991

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Cell and Molecular Biology		**Course Code:15EBTC205**
L-T-P: 4-0-0	**Credits: 04**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Cell Biology and Biotechnology

Organization of Prokaryotic and Eukaryotic cells. Structure and functions of membranes, nucleus, endoplasmic reticulum, Golgi complex, mitochondria, chloroplast and vacuoles. Cell division, Cell Cycle regulation and Cancer. Applications of cell biology and its principles in Genetic Engineering and Microbial, Plant & Animal Biotechnology

05 Hours

2. Molecular Biology and Nucleic Acids

Development and scope of Molecular Biology, Central Dogma of Molecular Biology and its updated view, Classical experiments and Nucleic acids as genetic material, Overview of Genome: Viral genome, bacterial genome, Mitochondrial genome, Eukaryotic genome. Organization of Prokaryotic and Eukaryotic genome/Chromosomes. Typical Gene structure in Prokaryotes and Eukaryotes. Structure and forms of nucleic acids, factors determine the structure of DNA. Denaturation and melting curves. Overview of Isolation, Purification, Estimation and Storage of Nucleic acids.

10 Hours

3. Replication of DNA

An overview and Basic rules for DNA Replication, Enzymes and proteins of DNA Replication, DNA Replication is Semi conservative, Origin of DNA Replication, Replicon and Replication fork, Unidirectional and Bidirectional replication of DNA, Mechanism of DNA replication in prokaryotes and in Eukaryotes.

05 Hours

Unit II

4. Transcription

General features of Transcription process, Types of RNA molecules, Prokaryotic and eukaryotic RNA polymerases, Promoter structure and Mechanism of transcription in prokaryotes and eukaryotes, Post transcriptional modifications of mRNA, tRNA and rRNA, Transcription inhibitors

05 Hours

5. Translation

Features of Genetic code and Wobble hypothesis, Overview of protein synthesis, Components required for protein synthesis, Mechanism of protein synthesis in prokaryotes and eukaryotes, Post-translational modifications and Protein targeting, Inhibitors in translation

04 Hours

6. Regulation of Gene Expression in Prokaryotes and Eukaryotes.

Regulation of gene activity, Gene regulation in Prokaryotes: Constitutive, Inducible and repressible gene expression systems, Operon model for gene expression regulation in prokaryotes, Positive and Negative regulation of – Lac Operon – Regulation, Catabolic repression and Gratuitous inducers etc, Trp Operon and Gal Operon. Gene regulation in Eukaryotes, Regulation of Gene expression at Genome level, Transcriptional level –Acetylation of Histones, Chromatin remodeling, DNA Methylation, DNA elements, Transcription factors, Insulators, Regulatory proteins and Hormones. Gene regulation at Post transcriptional level – Splicing, RNA interference, Transport of mRNA and by regulating mRNA stability.

07 Hours

7. Mutations and DNA Repair

Mutation – Source of genetic variability, basic features of Mutation process, Molecular basis of Mutation, Conditional lethal mutations as a powerful tool for genetic studies and Ames test of Mutagenecity testing. DNA damage and different types of DNA repair systems and Human diseases.

04 Hours

Unit III

8. Polymerase Chain Reaction

Principle of polymerase chain reaction (PCR) - Components of PCR reaction and optimization of PCR. Primer design and types of PCR– Inverse PCR, Hot-start PCR, Loop mediated PCR -, Reverse transcription PCR and Real time PCR. Chemistry of primer synthesis.

05 Hours

9. Analysis of Gene Expression

Analyzing Transcription – Northern Blots, RNase protection assay, Reverse Transcription (RT) PCR and Primer extension assay. Transcriptome Analysis – Differential screening and Array based methods. Promoter activity study – Reporter genes and Run-On assays. Translational Analysis – Western Blots and 2-D Analysis.

05 Hours

Text Books

1. Cell and Molecular Biology – S C Rastogi, New Age International Publishers, New Delhi (1996).
2. Fundamentals of Molecular Biology Ane's Student Edition. - Veer Bala Rastogi, Ane Books India, New Delhi (2008)

Reference Books

1. Instant Notes in Molecular Biology – P.C. Turner, Viva Series Publishing, New Delhi
2. Essentials of Molecular Biology – V Malathi, Dorling Kindersley (India) Pvt Ltd, New Delhi (2013).

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6,7	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	8,9	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Unit Operations-II		**Course Code:17EBTF202**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours:40**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:40	**Examination Duration:3 hours**	

Unit I

1. Basic concepts

Fluid definition, Properties of biological fluids, Classification of biological fluids, Types of fluid flow, Reynolds number, pressure measurement devices: manometers, Bourdon gauge, bellow gauge, capsule gauge, Hydrostatic equilibrium, Newton's law of viscosity.

04 hours

2. Fluid dynamics

Basic equations of fluid flow: Mass balance, Continuity equation, Bernoulli's equation, Laminar Flow through Circular pipe, Velocity and shear stress distribution, Boundary layer, Boundary layer separation, minor loss and major loss.

05 hours

3. Flow past immersed bodies

Drag, lift, Drag coefficient, Kozney- Carman equation, Ergun's Equation. Motion of particles through fluids, Settling, Types of settling, Stoke's law, Newton's law, Criteria for settling regime, Numerical problems.

06 hours

Unit II

4. Transportation and metering of liquids

Pipe and tube, joints and fittings, valves—Diaphragm/pneumatic valve, pinch valve, ball valve, plug valve. Pumps: peristaltic pumps, sinusoidal pumps, single use diaphragm pumps. Characteristic curves of a pump, Measurement of fluid flow rates, venturimeter, rotameter, pitot tube, vortex-shedding meter, turbine meter, magnetic meters, ultrasonic meters, thermal meters. Numerical problems.

08 hours

5. Mechanical separations

Filtration, Filter media, Filter aids, factors affecting rate of filtration, specific cake resistance, media resistance. Types of filters, Membrane processes—ultra filtration and microfiltration, Filtration equipment: rotary drum filter, leaf filter. Sedimentation, Kynch theory of sedimentation, Thickener, Numerical problems.

07 hours

Unit III

6. Mixing and agitation of liquids

Mixing and Agitation, Flow patterns in agitated tanks, Mechanism of mixing, Estimation of mixing time, Types of Impellers & propellers, Standard turbine design, Numerical problems.

05 hours

7. Dimensional Analysis and similitude

Units and dimensions, Dimensionless number, Rayleigh and Buckingham π theorem. Model and prototype. Similitude. Problems on Rayleigh and Buckingham π theorem.

05 hours

Text Books

1. Unit operations of chemical engineering by McCabe W. L., Smith J. C, and Peter Harriott, 7th edition, McGraw-Hill, 2005.
2. Transport Processes and Separation Process Principles by C. J. Geankoplis, 4th edition, Prentice Hall of India, 2004.

Reference Books

1. Fluid Mechanics by John F. Douglas, Janusz M. Gasiorek, John A. Swaffield, 4th edition, Pearson Education limited 2007.
2. Principles of Unit operations by Alan S Foust, 2nd edition, John Wiley & Sons, 2005.
3. Engineering Fluid Mechanics by K. L. Kumar, 7th edition, Eurasia Publishing house (P) Ltd, 2007.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Enzyme Technology Lab		**Course Code: 15EBTP204**
L-T-P: 0-0-1	**Credits:1.0**	**Contact Hours: 02 Hours/week**
ISA Marks:80	**ESA Marks: 20**	**Total Marks:100**
Teaching Hours: 24	**Examination Duration: 03 Hours**	

List of Experiments

1. Biochemical Measurements: Molarity, Normality, Molality, Moles, weight/volume measurements, percent solution, concentration Units. pH measurements and Buffer preparation, SOP's, Instrument calibrations.
2. Determination of activity of amylase enzyme
3. Estimation of protein content of amylase and specific activity
4. Effect of temperature on enzyme activity
5. Effect of pH on enzyme activity
6. Effect of substrate concentration on enzyme activity
7. Effect of enzyme concentration on enzyme activity
8. Effect of inhibitor on enzyme activity
9. Enzyme immobilization and kinetics of immobilized enzyme
10. Molecular weight determination by SDS PAGE
11. Staining the gel using CBB and silver staining

Text Books/ Reference Books

1. Introduction to Practical biochemistry – David Plummer, McGraw-Hill Publishing Co,3rd edition,pp:332.
2. Biochemical methods- Sadasivam and Manickam(1996), New Age International Publishers, 2nd edition, pp256.
3. Experimental Biochemistry – A Student Companion by Beedu Shashidhar Rao and Vijay Deshpande.(2005) I.K International Pvt. Ltd,New Delhi. pp301

Program: Biotechnology		
Course Title: Cell and Molecular Biology Lab		**Course Code: 15EBTP205**
L-T-P: 0-0-1	**Credits: 1.0**	**Contact Hours: 02 Hours/Week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 03 Hours**	

List of Experiments

1. Basic Calculations and Solutions preparation skills and Good Lab Practices(GLPs)for the Molecular biology lab
2. Study **SOPs** of Cell and Molecular Biology laboratory equipments – Table top cooling Centrifuge, UV – Visible Spectrophotometer, PCR machine and Gel Documentation system.
3. Staining and microscopic observation of plant/animal cellsand chromosomes
4. Study of Mitosis and Meiosis Cell Divisions
5. Isolation of genomic DNA from Bacteria/ Plant/ Animal cells
6. UV Spectrophotometric analysis of DNA and RNA
7. Calculation of Tm value of isolated DNA sample
8. Agarose gel electrophoresis and gel elution method.
9. Isolation and agarose gel electrophoresis estimation of Plasmid DNA
10. Extraction of Total RNA from different biological sources

Text Books /Reference Books

1. Cell and Molecular Biology – A Lab Manual K V Chaitanya PHI Learning Private Limited Delhi – 110092, 2013.
2. Molecular Cloning Volumes I, II and III – Sambrook J *et al* (2000) Cold Spring Harbour Laboratory Press, 2000

Program: Biotechnology		
Course Title: Unit Operations-II Lab		**Course Code:17EBTP202**
L-T-P: 0-0-1	**Credits: 1**	**Contact Hours: 02 Hours/Week**
ISA Marks:80	**ESA Marks:20**	**Total Marks:100**
Teaching Hours:	**Examination Duration:3 hours**	

List of Experiments:

1. Pressure drop correlations through packed bed.
2. Studies on sedimentation.
3. Studies on agitation and mixing
4. Constant pressure filtration using leaf filter
5. Pressure drop correlations through circular pipes
6. Study of fluid flow patterns
7. Terminal settling velocity
8. Studies on Bernoulli's equation
9. Studies on flowmeter

Text Books/Reference Books

1. Unit operations of chemical engineering by McCabe W. L., Smith J. C, and Peter Harriott, 7th edition, McGraw-Hill, 2005.
2. Transport Processes and Separation Process Principles by C. J. Geankoplis, 4th edition, Prentice Hall of India, 2004.

1.1.3. Number of courses having focus on employability/ entrepreneurship/ skill development during the year.
Year of offering: 2021-22
Batch- 2019-23 (5th semester)

Program: Biotechnology		
Course Title: Genetic Engineering and Applications		**Course Code: 15EBTC301**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Basics of Recombinant DNA technology

Development and Scope of Recombinant DNA Technology and Genetic Engineering. Emergence and commercialization of Molecular Biotechnology. Ethical, Social, Economical and Political issues related to Gene modification and Genetic Engineering. Gene Cloning: Introduction and Steps involved in gene cloning. Subcloning and its applications. Vectors in GE - biology, features, types, cloning & expression vectors

06 Hours

2. Enzymes in Genetic Engineering

DNA modifying enzymes and necessity of DNA modification in gene cloning. Enzymes used for DNA modification. Restriction Endonucleases, classification & mode of action, Role and applications of different DNA modifying enzymes in gene cloning process - DNA Polymerases, Reverse Transcriptase, RNA Polymerase, Alkaline Phosphatases, Polynucleotide Kinase and DNA Ligases etc.

05 Hours

3. Molecular Cloning Strategies and Genetic Transformation

Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Quantification on and storage of nucleic acids, Construction of cDNA library , Construction of Genomic library ,Screening and preservation of DNA libraries. DNA Cloning – Methods and applications. Genetic Transformation of prokaryotes and DNA Transfection in Eukaryotic hosts. Biological and Non-biological methods of gene transfer in hosts. Chloroplast transformation.

09 Hours

Unit II

4. Selection, Screening and Analysis of Recombinants

Introduction to screening and analysis of recombinants. Genetic selection and screening methods - Selectable Marker genes, Reporter genes. Screening using Nucleic acid hybridization methods - Preparation of probes for hybridization experiments and different blotting techniques. Screening by PCR based methods. Screening by Immunological methods and Analysis of cloned genes.

07 Hours

5. Production of Proteins from Cloned Genes

Introduction to recombinant gene expression, scope and applications of recombinant gene expression. Special vectors for expression of foreign genes in E coli. General problems with the production of recombinant protein in E coli. Production of recombinant proteins by Eukaryotic cells. **07 Hours**

6. Directed Mutagenesis and Protein Engineering

Oligonucleotide – Directed Mutagenesis with M13 DNA, Plasmid DNA, PCR Amplification etc. Protein Engineering – Meaning and Scope, Protein Engineering for adding disulphide bonds, increasing enzymatic activity, decreasing protease sensitivity, modifying protein specificity, Increasing enzyme stability and specificity etc.

06 Hours

Unit III

7. Genetic Engineering and Microbial Biotechnology

Genetic manipulation of Microorganisms – Introduction and scope. Applications of Recombinant Microorganism – Production of recombinant therapeutic proteins, Production of Antibiotics, Combating Human diseases, Microbial pesticides, EffiISAnt utilization of Carbohydrates and Bioremediation or Environmental cleanup.

05 Hours

8. Plant and Animal Transgenic Technology and Applications

Applications of Transgenic Plant Technology – Development of Insect resistant plants, Herbicide resistant plants, Pathogens resistant plants, and Abiotic stress tolerant plants. Plants as Bioreactors for large scale production. Applications of Animal cloning and Transgenic technology - Cloning in Domestic animals. Applications of Transgenic Animals - as research models, and as bioreactors for large scale production of substances for Human welfare.

05 Hours

Text Books

1. Genetic Engineering by Smitha Rastogi and Neelam Pathak, Oxford University Press, USA (2009)
2. Molecular Biotechnology – Principles and applications of Recombinant DNA by Bernard r Glick and Jack J Pasternak, ASM Press, American SoISAty for Microbiology, Washington DC 2003

Reference Books

1. Gene Cloning and DNA Analysis by T A Brown. Wiley-Blackwell (2010)
2. An Introduction to Genetic Engineering – Third Edn By Desmond S T Nicholl, Cambridge University Press, Singapore 2008.

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioinformatics		**Course Code: 19EBTC301**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit - I

1.Database

Introduction, meaning of databases, types of databases, Primary Database: NCBI, Genbank, DDBJ, EMBL. File formats, Secondary Database: PROSITE, PIR, UNIPROT, BLOCKS, Pfam, specialized databases: metabolic pathway database, Structure Database: PDB, MMBD, CATH, SCOP, Ligand Database, Enzyme database, human disease database, microbial and viral genome database, structure visualization tools.

7 Hours

2.Pairwise Sequence Alignment

Meaning and significance of Sequence alignment, Pairwise sequence alignment, Global alignment, Local Alignment, overview of methods, Methods & Algorithms-dot matrix, dynamic programming, substitution matrices, gap penalties, FASTA, BLAST, PSI-BLAST & PHI-BLAST.

8 Hours

3.Multiple Sequence Alignment

Meaning of Multiple Sequence Alignment, Global Multiple Sequence Alignment: Progressive Alignment methods, Iterative methods, Local Multiple sequence Alignment, Significance of Multiple Sequence Alignment, Multiple Sequence Alignment editors. Motifs and Patterns analysis

5 Hours

Unit - II

4.Molecular Phylogenetics

Meaning of phylogenetic analysis, Meaning & significance of evolutionary trees, Rooted and unrooted trees, Elements of phylogenetic Models, Phylogenetic Data Analysis, Distance based methods: Neighbor Joining (NJ) method, Fitch-Margoliash (FM) method, Minimum Evolution (ME) method, Character based methods: Maximum parsimony, Maximum Likelihood; Tree Evaluation methods, Phylogenetic Softwares

7 Hours

5.Gene Prediction

Prokaryote and Eukaryote gene prediction, Prokaryote and Eukaryote promoter site prediction Gene Prediction tools, Genomic database, Next Generation Sequencing.

5 Hours

6.Protein Prediction

Protein structures: Secondary Structure: Alpha helix, beta Sheets, phi & psi angles, Ramachandran plots. Protein Secondary Structure Prediction, Tertiary Structure Predictions:

Homology modeling, Protein analysis software: Physicochemical parameters, binding site, sub-cellular location, protein stability, patterns

. **8 Hours**

Unit - III

7.In-silico Drug Designing-I

Introduction to traditional drug designing, Introduction in-silico drug designing approach, Methodology for in-silico drug designing: Structure based and Fragment based drug designing, Steps in drug designing: Target identification, target validation, lead identification and validation, different tools used for drug designing, molecular Modeling

5 Hours

8.In-silico Drug Designing-II

Identification of ligands, Lipinski's rule, Virtual Screening, Process of Docking, Quantitative structure-activity relationship (QSAR), Physical and Chemical basis of receptor ligand interactions, ADMET property analysis. **5 Hours**

Text Books

1. Andreas D. Baxevanis, B. F. Francis Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd, Wiley-Inte, 2005
2. David Mount, Bioinformatics: Sequence and Genome Analysis , 2nd, Cold Sprin, 2004

Reference Books

1. P. Rastogi, N. Mendiritta, S. C. Rastogi, Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery, 4th, Prentice-H, 2013.
2. Anand Solomon K, Molecular Modelling and Drug Design , 1st, MJP Publis, 2015
3. Richard Durbin, Sean R. Eddy, Anders Krogh, Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids, 1st, Cambridge , 1998

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology	
Course Title: Reaction Engineering	Course Code: 15EBTC303

L-T-P: 4-0-0	Credits: 4	Contact Hours: 50
ISA Marks: 50	ESA Marks:100	Total Marks: 100
Teaching Hours: 50	Examination Duration: 3 hrs	

UNIT-I

1: **Introduction**

Introduction to homogeneous and heterogeneous reaction in ideal reactors. Elementary and elementary reactions kinetics of homogeneous and heterogeneous reaction system.

06 Hours

2: **Interpretation of Batch Reactor data**

Introduction to analysis of experimental reactor data, evaluation of rate equation, integral and differential analysis of kinetic data's, constant volume system and variable volume System. Total pressure technique of analyzing the kinetic data of gaseous reaction system.

08 Hours

3. **Introduction to Bioreactor Design.**

General discussion on basics bioreactor design. General material balance equation for various conditions. Ideal reactors for a single reaction. Design equations for homogeneous system: batch, stirred tank and tubular flow reactor, size comparison of reactor systems.

08 Hours

UNIT-II

4 Design for Multiple Reactions

Introduction, general design approach to multiple reactions. Quantitative and qualitative analysis of product distribution. Effect of temperature and pressure on single reaction. General graphical procedure, optimum temperature progression. Factors affecting choice of reactors: optimum yield, conversion, selectivity and reactivity.

08 Hours

5 Non-Ideal Reactors

Non-ideal reactors, residence time distribution studies, Stimulus Response Technique, pulse and step input response of reactors, RTD's for CSTR and PFR, Relationship between C, E and F-curve. Kinetic models for non Ideal reaction system, Axial Dispersion Model

04 hours

6 Microbial kinetics:

Introduction to microbial kinetics, Yield coefficient, Simple kinetic models for microbial growth, transient growth kinetics Factors affecting the kinetics of Monod model; Growth of Filamentous Organisms. kinetic Models for product formation and substrate degradation

08 Hours

UNIT-III

7 Heterogeneous Reactor System:

Heterogeneous reactions in Bioprocessing. The rate equation for surface for kinetics, Pore diffusion kinetics with combined with surface kinetics. Porous catalyst particle Performance equation for reactor containing Porous catalyst particles. External and internal mass transfer effects.

04 Hours

8 Reactor Engineering

Bioreactor configurations: Bubble column, airlift reactor, packed bed, fluidized bed, trickle bed,

04 Hours

Text Books

1) Chemical Reaction Engineering by Octave and Levenspiel., John Wiley, 3rd Edition, 2006.
2) Elements of Chemical Reaction Engineering by Fogler, H.S., Prentice Hall, 1986.

Reference Books

1) Bioprocess Engineering Principles by Pouline M Doran Academic Press , 2003
2) Biochemical Engineering Fundamentals By Bailey and Ollies McGraw Hill 2nd Edition
3) Chemical Reactor Analysis and Design by Forment G F and Bischoff K B. John wiley,1976
4) Chemical engineering By J.F Richardson and J.M Coulson Volume 6

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Biological Thermodynamics		**Course Code:15EBTC304**
L-T-P: 3-0-0	**Credits: 3**	**Contact Hours:40**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:40	**Examination Duration:3 hours**	

Unit I

1. Basic concepts

System, Surrounding, State and Properties, Intensive and extensive properties, State and path functions, Heat reservoir, Hess Law, energy and biological world, energy flow transformation, energy conversions, energy, nutritional requirements of living systems, Flow of electrons in organism, energy flow in metabolic process, division of labor in cells, Numerical problems

06 hours

2. Basic laws of thermodynamics

Zeroth law, First law of Thermodynamics, cyclic process, non-flow process, flow Process, internal energy, Heat capacity, second law of thermodynamics, Concept of entropy, Calculation of entropy changes, Third law of thermodynamics. Numerical problems.

09 hours

Unit II

3. PVT behavior

P-V-T Behavior of pure fluid, Processes involving ideal gases, Equation of state for real gases: Vander Waals equation, Redlich-Kwong equation, Peng-Robinson equation, Virial equation. Compressibility charts: Principle of corresponding states, Numerical problems.

07 hours

4. Thermodynamic properties of Biological fluids

Classification of thermodynamic properties, Work function, Gibbs free energy, Gibbs-Helmholtz equation, ATP Synthesis in cell and Protein Folding, Metabolic reactions in cells. Entropy - heat capacity relationships, Relationships between C_p and C_v,, Activity of molecule, Chemical potential, Oxidation-Reduction reaction, Cell Membrane Transportation & Protein Extraction, Osmosis, Nernst equation in membrane transportation, Numerical problems.

08 hours

Unit III

5. Statistical Thermodynamics

Boltzmann distribution & partition function, Protein folding and helix-coil transition, Binding equilibria, Oxygen biding to myoglobin & Hemoglobin.

04 hours

6. Reaction Equilibria

Reaction Stoichiometry, Effect of temperature on standard heat of reaction. energy coupling reactions, activation energy, Criteria of chemical reaction equilibrium, Relationship between Equilibrium constant and standard free energy change, Effect of temperature, pH and pressure on equilibrium constants and other factors affecting equilibrium conversion, Numerical problems**.**

06 hours

Text Books

1. Biological Thermodynamics by Donald T. Haynie, 2nd edition, Cambridge University Press,2008
2. Introduction to chemical engineering thermodynamics by J.M.Smith, H. C. VanNess, M.M. Abbott, 7th edition, Tata McGraw-Hill, NewDelhi, 2005.

Reference Books

1. Thermodynamics. An engineering approach, by Yunus A. Cengel, Michael A. Boles, 8th edition, McGraw- Hill, 2014.
2. Chemical Engineering Thermodynamics by Y.V.C. Rao. 2nd edition, Universities Press, 1997.
3. Chemical and Process Thermodynamics by B.G.Kyle. 3rd edition, Prentice Hall of India Private limited,2015.

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Research Methodology		**Course Code:15EBTC305**
L-T-P: 3-0-0	**Credits: 03**	**Contact Hours: 40**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 hours**	

Unit I

1. Introduction to Research and Research Methodology

Introduction, Objectives and scope of research, Research methods and Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical Concept of Translatory research.

04 Hours

2. Research Philosophy and Formulation of Research Problem

Concept of Research Philosophy- (Ontology, Logic, Method and Epistemeology) Formulation of Research Problem- Necessity of defining the research problem and framing the problem statement.

03 Hours

3. Sources and Review of Literature

Introduction and need for Literature Review., Search Procedures and Gap analysis. Sources of Literature - Research articles, review articles, Research communications, Book chapters. Bibliometrics- Citation index, Impact factor, author h-index and i10-index, awareness on predatory journals and its identification, grants and funding agencies for biotechnology research

08 Hours

Unit II

4. Sampling & Data Collection

Explain sampling and its significance. Describe different methods of sampling. **03 Hours**

5. Statistical Analysis of Data

Measures of Central Tendency, Measures of Dispersion and variance, Correlation and Regression Development of hypothesis and testing : Chi- square test, Student's t-test, ANOVA

07 Hours

6. Design of Experiments

Introduction and significance of DOE, Types - Factorial Design, Plackett Burman Design, Central Composite Design, Response Surface Methodology, Design of matrix and analysis, Contour plots and response surface plots, QBD principles, Introduction to Artificial Intelligence and its application in biotechnology

05 Hours

Unit III

7. Environment, Ethics and IPR in Research

Impacts of Research on Environment, - Ethical issues, ethical committees, Research Generated Intellectual Property Rights- Copy-right & royalty, Patent law, Trade mark, Trade secret, Geographical Indicator, Industrial Design. Concept of Plagiarism

05 Hours

8. Research Communication

Written Communication- Introduction, Structure and components of scientific reports – Bibliography, referencing and footnotes. Oral Presentation – Developing and delivering presentation **05 Hours**

Text Books

1.C.R. Kothari and Guarav Garg, Research Methodology, III Edition, New Age International Publisher, New Delhi, 2014

2. N. Gurumani, Research Methodology for Biological SISAnces, I Edition, MJP Publishers, Chennai, 2007

Reference Books

1. Design and Analysis of Experiments by Montgomery D. C. John Wiley Publishers

2. An Introduction to Research Methodology by Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K. RBSA Publishers

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Lab Title: Mini project		**Lab Code:15EBTW301**
L-T-P: 0-0-3	**Credits: 03**	**Contact Hours: 9 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 9 hrs/week	**Examination Duration: 03 hours**	

Guidelines:

- Mini project to be carried out in a group of maximum 4 students.
- Every student needs to maintain laboratory work book which should contain the details of all the work carried out in the laboratory.
- Entries to be done in log books for instrument usage.
- Timely report submission to the coordinator.
- Requisitions for chemicals and glassware's to be provided in advance for the project work

Review committee:

- Review committee is formed by the project coordinator taking into consideration that review committee consists of faculty experts from all domains. Review committee consists of the guide of the respective project group also.

Reviews:

- Continuous internal evaluation will be done by the respective guides/review committee as per the rubrics.
- Total of 3 reviews per semester will be carried out to evaluate the progress of the project.
- During review-1 students have to submit a report duly signed by guide.
- Final evaluation will be done by examiners during semester end examination as per the ESA evaluation scheme.

Phases of mini project:

Sl. No	Phases	Reviewed	Activities
1	Review-1	By Review committee	Need analysis, Detail Review of literature, Objectives, Overall plan of work.
2	Review-2	By Project Guide	Development of protocols, Standardization and screening. Design of experiments, Conduct of experiments, Initial experimental data.
3	Review-3	By Review committee	Final experimentation, Data interpretation and analysis, Conclusion.

Program: Biotechnology		
Course Title: Genetic Engineering & Immunotechnology Lab		**Course Code: 15EBTP301**
L-T-P: 0-0-1	**Credits:1.0**	**Contact Hours: 2Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 03 Hours**	

List of Experiments:

1. Preparation of Competent *E coli* cells (**Structured Inquiry**)
2. Ligation of DNA fragment with vector and Transformation (Demonstration)
3. Restriction digestion analysis of plasmid DNA (Structured Inquiry)
4. Introduction to PCR –Programming, and amplification of DNA (Exercise)
5. Screening of Transformants by Colony PCR (Demonstration)
6. TA Cloning method for cloning of PCR product. (**Structured Inquiry**)
7. Demonstration of Southern blotting (Demonstration)
8. Agglutination techniques – Heam agglutination techniques and Bacterial agglutination techniques (Exercise)
9. Radial diffusion and Rocket Immunoelectrophoresis (Exercise)

   Dot-ELISA(Enzyme Linked Immuno Sorbent Assay) (Exercise)

Text Books/Reference Books

1.Principles of Gene Manipulations- Introduction to Genetic Engineering, by R.W. Old and S.D. Primrose(2007), Blackwell SISAntific Publications.

2. Molecular Cloning- By T.Maniatis, E.F. Fritsch and J. Sambrook, Cold spring Harbour (2009)

Program: Biotechnology		
Course Title: Bioinformatics Lab		**Course Code: 15EBTP302**
L-T-P: 0-0-1	**Credits:1.0**	**Contact Hours: 2Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 03 Hours**	

List of Experiments:

1. Searching bibliographic database for relevant information and retrieve from nucleic acid and Protein sequence database
2. PDB: Protein Data Bank and structure visualization
3. Searching sequence database using BLAST algorithm & Pair wise alignment of the sequences
4. Multiple Sequence Alignment & Phylogenetic Analysis: CLUSTALW/Phylogeny
5. Gene structure Prediction
6. Protein Secondary Structure Prediction
7. Protein Tertiary Structure Prediction
8. Protein Sequence analysis: Physicochemical parameters, binding site, sub-cellular location, protein stability, patterns and conserve domain.
9. Identification of ligands/Virtual Screening
10. Molecular Docking and interaction analysis
11. Define gene structure and design primers specific to the identified gene of microorganisms and draw restriction digestion map for sequence identified

Text Books/Reference Books

1. Andreas D. Baxevanis, B. F. Francis Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, 3rd, Wiley-Inte, 2005
2. David Mount, Bioinformatics: Sequence and Genome Analysis , 2nd, Cold Sprin, 2004

1.1.3. Number of courses having focus on employability/ entrepreneurship/ skill development during the year.

Year of offering: 2021-22
Batch- 2019-23 (6th semester)

Program: Biotechnology		
Course Title: Bioprocess Engineering		**Course Code:15EBTC306**
L-T-P: 4-0-0	**Credits: 4**	**Contact Hours: 4 hours/week**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:50	**Examination Duration:3 hrs**	

Unit - 1

1.Media and Inoculum development for industrial fermentations

Bioprocess development: An interdisciplinary challenge, Biotechnology & Bioprocess Engineering, steps in bioprocess development, Media ingredients, medium formulation, oxygen requirements, antifoams, medium optimization, Ingredients for mammalian cell culture and plant cell culture.Introduction, Criteria for transfer of inoculum, development of inocula for bacterial processes, yeast processes and mycelial processes. Inoculum development for plant Fermenter.

8 Hours

2.Sterilization

Media sterilization, Design of sterilization process: Batch Process (Dell factor, holding time, and thermal death kinetics), continuous sterilization process; sterilization of fermenter and other ancillaries. Scale up of sterilization, filter sterilization of air and media.

5 Hours

3.Design of bioreactors

Basic objective of fermenter design, aseptic operation & containment regulation, achievement and maintenance of aseptic conditions, body construction, agitator and sparger design, baffles, stirrer glands and bearings. Animal cell bioreactors.

7 Hours

Unit - II

4.Scale Up of Bioreactor

Scale up of bioreactors: Introduction, Scale-Up methods: Geometric and Dynamic Similarity, Criteria for scale-up: Constant power consumption/volume, constant KLa, constant mixing time, constant tip speed, Regime analysis: Time constant for transport phenomena, time constant for conversion. Scale down approach. **5 Hours**

5.Heat Transfer

Heat transfer in Bioprocess: Design equation for heat transfer process, Energy balance, Logarithmic and arithmetic mean temperature difference, Calculation for heat transfer coeffiISAnt, applications of design equations, Relationship in between heat transfer, cell

concentrations and stirring conditions, Numerical based examples on above. **4 Hours**

6.Mass Transfer

Mass transfer in Bioprocess: Role of diffusion in bioprocessing, Different equations in mass transfer (liquid-solid, liquid-liquid and gas-liquid) , Oxygen uptake in cell culture: Factors affecting cellular oxygen demand, Oxygen transfer from gas bubble to cells, Oxygen transfer in fermenter, measuring dissolved oxygen concentrations, Measurement of KLa: Oxygen balance method, Gassing out techniques (static method of Gassing out and dynamic method of Gassing out) Sulphite oxidation, Factors affecting KLa, Oxygen transfer in large vessels, Numerical based examples on above.

5 Hours

7.Fermenter fluid rheology

Fermentation broth: Viscosity, Viscosity measurement, Rheological properties of fermentation broths, Factors affecting broth viscosity , Mixing in Fermenters: Mechanism of mixing, Assessing mixing effectiveness, estimation of mixing time, Power requirement for mixing: Ungassed Newtonian fluids,ungassed non-Newtonian fluids, Gassed fluids, Calculation of power requirements,Scaleupof mixing systems, Improving mixing in Fermenters, Effect of rheological properties on mixing, Role of shear in stirred fementers: Interaction between cells and turbulent eddies,Bubble shear, operating conditions for shear damage. Numericals

6 Hours

Unit - III

8.Bioreactor kinetics

Batch reactor kinetics, CSTR kinetics, Fedbatch kinetics and plug flow kinetics, Numericals

5 Hours

9.Solid State fermentation:

Introduction, SSF v/s SMF, Types of SSF reactors, Microbial growth kinetics in SSF, Heat & Mass Transfer in SSF

5 Hours

Text Books

1. Pauline M. Doran, Bioprocess Engineering Principles, 2, Academic Press, 2003
2. Stanbury & Whittaker, Principles of Fermentation Technology, 2, Pergamum Press, 2000

Reference Books

1. Michael L. Shuler & Fikret Kargi, Bioprocess Engineering, 2, Prentice Hall, 2001
2.Bailey, James E.; Ollis, David F., Biochemical Engineering Fundamentals, McGraw-Hill Education, 1986

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2, 3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6,7	Solve Any 2 out of 3

III	2 Questions to be set of 20 Marks Each	8,9	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Control and Automation		**Course Code:19EBTC302**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 4 hours/week**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:50	**Examination Duration:3 hrs**	

Unit I

1 Instrumentation & Process Dynamics: Introduction to Measurement of important physicochemical and biochemical parameters in bioprocess. Methods of on line and off line estimation of biomass, substrates and products. Brief introduction to typical automatic control system and its components. Open loop and closed loop control systems.

05 Hours

2 First & Second Order Systems: Mathematical representation of physical systems. Transfer function representation of linear first order systems, Examples: mercury in glass thermometer & Liquid level system. Mathematical forms of standard Input function/Forcing Functions such as Step input, Impulse Input, Linearly increasing Input and Sinusoidal Input. Response of first order system for step input, Features of step response, Response of linearly increasing input. Conceptual numerical. First Order Systems in Series: Interacting and Non-Interacting systems & their Transfer function representation. Second Order Systems: Transfer function representation of Second order systems, Example: Pneumatic Control Valve.

10 Hours

Unit II

3 Controller and Final Control Elements: Different types of controllers-P (Special case of P-controller i.e ON-OFF controller), PI, PD, PID controllers. Derivation of Transfer Functions of different types of controllers. Final control element: The role of Final control Element in control system. Example: Pneumatic Control Valve: Working of Pneumatic control valve, Types of Pneumatic Control Valves i.e. Air to close & air to open.

10 Hours

4 Block Diagram Reduction: Block diagram representation of control systems, Block diagram reduction in case of Servo and Regulatory control systems. Reduction of block diagrams for single input & Single output systems (SISO) & Multiple Input & Multiple Output Systems (MIMO), Problems on block diagram reduction.

05 Hours

5 Block Diagram Reduction (MIMO systems): Analysis of Multiple Input Multiple Output Systems**:** Introduction to Multiple Input & Multiple Output Systems (MIMO), Examples of MIMO systems.Analysis of MIMO systems considering only one Input at a time while other Inputs are Suppressed. Considering only one output at a time while other outputs are Suppressed. Problems on block diagram reduction considering MIMO systems.

10 hours

Unit III

6 Transient response of different controllers for Servo & Regulatory control Problems: Transient response of P, PI, PD & PID controllers for servo and regulatory problems. The

determination of offset in all cases. **05 Hours** **7 Analysis of Stability:** Concept of stability, stability criterion. Routh test for stability. Theorems of Routh Array test, Conceptual numerical on Routh test for stability. **05 hours**
Text Books 1. Process System analysis and control by Donald R Coughnowr, 2nd Edn.Mc Graw Hill,1991 2. Chemical Process Control by George Stephanopoulos, Prentice Hall of India, 1999
Reference Books 1. Process Control-Peter Harriott, Tata McGraw-Hill Publishing Company Limited, 2004.

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
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III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bio Analytical Techniques		**Course Code: 19EBTE301**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Introduction to Bio-analysis

Introduction to instrumentation, Functional elements of an instrumentation system, static and dynamic characteristics, calibration of instrumental methods, Types of errors, Methods of expressing precision and accuracy, Confidence limits, Uncertainties in Instrumental measurements – Sensitivity and detection, preparation & storage of solutions, usage of laboratory glasswares, statistical analysis of experimental data, Electrodes and Biochemical preparation.

05 Hours

2. Spectroscopy

General principles–Radiation, energy and atomic structure- types of spectra and their biochemical usefulness basic laws of light absorption. Electromagnetic radiation & Spectrum, Beer – Lambert's Law and apparent deviations; UV – VIS Spectrophotometer

05 Hours

3. Advanced Spectroscopy

Spectroflourimetry, Atomic absorption spectroscopy, IR spectroscopy, FTIR, Nuclear Magnetic Resonance, Mass spectroscopy, ORD, CD, X-ray diffraction.

05 Hours

Unit II

4. Chromatographic techniques

Analytical techniques for biomolecules purification, Paper chromatography, thin layer chromatography, Column chromatography, Gas chromatography, Ion-exchange chromatography, molecular exclusion chromatography, affinity chromatography, High performance liquid chromatography & UPLC- Principles, Methods, Instrumentation, Detectors, Analysis of data.

09 Hours

5. Electrophoretic techniques

Theory & application of polyacrylamide & Agarose gel electrophoresis for protein & nucleic acids, capillary electrophoresis, pulsed field gel electrophoresis, Iso-electric focusing, 2D-gel electrophoresis and Immunoelectrophoresis

06 Hours

Unit III

6. Centrifugation techniques

Basic principles of sedimentation, centrifuges and their uses, preparative ultracentrifuges, density gradient ,analytical ultra centrifuges, applications

06 Hours

7. Advanced Instrumental methods

LC-MS, GC-MS, HPTLC, SEM, Atomic Force Microscopy, transmission electron microscopy (TEM)

04 Hours

Text Books

1. Wilson K & Walker J., Principles and Techniques of Practical Biochemistry, 5th edition, Cambridge Univ. Press., 2000.
2. Rodney Boyer, Modern Experimental Biochemistry, 3rd edition, Pearson Education, 2002
3. Chatwal and Anand, Spectroscopy, Himalaya Publishing house-New Delhi, 2016

Reference Books

1. Willard H. W. & Meritt L. L, Instrumental methods for chemical analysis, 7th edition. CBS Publishers & Distributors, 2004
2. Chatwal and Anand, Instrumental methods for chemical analysis, Himalaya Publishing house, 2012

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Plant Design and Economics		**Course Code: 18EBTE301**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Introduction to Process Design Development

Design project procedure, design information from the literature and other sources of information, flow diagrams, preliminary design, and comparison of different processes, Equipment design and specialization, factors affecting the investment. **06Hours**

2. General Design Considerations

Marketability of the product, availability of technology, Health and safety hazards, raw materials, human resources, loss prevention Environmental protection and utilities, site characteristics, plant location, plant layout, plant operation and control, utilities, structural design, storage, materials handling, materials and fabrication Selection, optimum design and design strategy. Waste disposal, physical treatment, chemical treatment and biological treatment, govt. regulations and other legal restrictions, community factors. Safety and hazard control measures.

10 Hours

Unit II

3. Cost Analysis and Manufacturing Cost

Cost Analysis: Factors involved in project cost estimation. Cash flow diagrams for the industrial operation, Cumulative cash position, factors affecting the Investment and production cost, Different methods employed for the estimation of the capital investment. Estimation of equipment cost by sixth tenth rule, Cost index. Marshall and swift installed – equipment indexes, Engineers News-Record construction index, Nelson –Farrar refinery construction index. and Chemical Engineering plant cost index Manufacturing Costs: Direct Production costs, indirect cost and fixed charges (including depreciation, taxes, insurance, rental costs etc.)

10 Hours

4. Bioprocess Economics:

Economic analysis for the production of following Products.(Historical Perspective, Fermentation Technology, Recovery of product and process economics of following products)

- High volume, low value products. (Citric acid, Ethanol and Amino acids etc)
- Medium volume, medium value products.(Antibiotics, Crude Enzymes and Vitamins etc)
- Low volume, high value products. (MAb, purified Enzymes and Therapeutic proteins etc)

06 Hours

Unit III

5. Profitability Analysis and Optimization Technique

i) Importance of profitability analysis in investment decision making. Different Methods for calculating the profitability. Minimum Acceptable Rate of return. Methods that Do not consider Time value of money. **04 Hours**

ii) General procedure to find the optimum conditions, factors affecting the optimization, comparison of analytical and graphical methods. Linear programming, Simultaneous Equations and dynamic programming **04 Hours**

Text Books:

1. Peters and Timmerhaus, Plant Design and Economics for Chemical Engineers, McGraw Hill 5th edition, 2004.
2 Chemical Engineering plant design, Frank C Vilbrandt and Charles E Dryden , McGraw Hill 4th edition, 1959

Reference Books:

1. Rudd and Watson, Strategy of Process Engineering, Wiley, 1987.
2. Backhurst, J.R And Harker, J. H - Process Plant Design, Heieman Educational Books, (1973).
3. Biochemical Engineering Fundamentals, James E Baily David F Oillis. McGraw-Hill 2nd International Edition

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Insilco Modeling and Drug Design		**Course Code: 15EBTE302**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Insilico Drug Design

Generation of rational Approaches in Drug Design Molecular modeling: The second generation, Conception frame and methodology of molecular modeling, Importance of the " Bioactive Confirmation", Molecular Mimicry and Structural Similarities, Molecular Mimicry, Structural similarities and Superimposition Techniques, Rational Drug design and Chemical Intuition

08 Hours

2. Molecular Modeling :

Constructing and Initial Model, Refining the Model, Manipulating the Model, Visualization. Structure generation or Retrivel, structure visualization, Confirmation generation, Deriving Bioactive Confirmations Molecule Superposition and Alignment Deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Molecular Interactions: Docking Calculation of Molecular Properties, Energy Calculations (no derivation), Example of Small Molecular Modeling Work, **08 Hours**

Unit II

3. Computer Assisted New LEAD Design.

Introduction, Basic Concepts, Molecular Recognition by Receptor and Ligand Design, Active Confirmation, Approaches to Discover New Functions, Approaches to the Cases with known and unknown receptor structure **03 Hours**

4. Docking Methods

Program GREEN Grid: Three-Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Method, Three Dimensional Database Search Approaches, Automated Structure Construction Methods with known Three Dimensional Structure of the Receptor, Structure construction in the case of Unknown Receptor Structure. Scope and Limitation Points for Consideration in Structure Methods, Handling of X Ray Structure of Protein, Future Perspectives, Types of programs available for molecular modeling scope and limitations-interpretation of results **11 Hours**

Unit III

5. Computer Assisted Drug Discovery-Part-I.

The Drug Development Process, Introduction, The Discovery and Development Process, New Lead Discovery Strategies, Composition of Drug Discovery Teams, The Practice of Computer-Assisted Drug Discovery (CADD),

05 Hours

6. Computer Assisted Drug Discovery-Part-II.

Current Practice of CADD in the Pharmaceutical Industry, Management Structure of CADD Groups, Contributions and Achievements of CADD Groups, Limitations of CADD Support, Inherent Limitations of CADD Support, State of Current Computational Models, Software and Hardware Constraints.

05 Hours

Text Books:

1. Moody P.C.E. and A.J.Wilkinson Protein Engineering,IRL Press Oxford 1990.
2. The molecular modeling perspective in drug design by N Claude Cohen,1996,Academic Press

Reference Books:

1. M.Michael Gromiha, Protein Bioinformatics- From Sequence to Function. Academic press 2010
2. Branden C.and Tooze R.Introcuction of Protein structure, Garland 1993

Scheme for End semester assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
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III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Modeling and Simulation		**Course Code: 18EBTE401**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1.Introduction to modeling:

Introduction, Mathematical Modeling of Bioprocess Engineering System, General Aspects of the Modeling Approach, General Modeling Procedure: Fundamentals uses of mathematical model, scope of coverage, principles of formulation; Fundamental Laws of Modeling: continuity equation, energy equation with examples **05 Hours**

2.Fundamental Laws of Modeling:

Equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics; Lumped and distributor parameters with examples **05 Hours**

3. Mathematical models of Biochemical Engineering Systems:

Modeling of Batch reactors, modeling of CSTR, Numericals. Plug flow reactor, Fluidized bed reactor, Reactors used in effluent treatments, packed bed reactor. **05 Hours**

Unit II

4. Use of MATLAB in Process Simulation:

Basics-Data analysis-curve fittings, Numerical integration, Euler and fourth order RungeKutta method, Input and Output in MATLAB. Solving problems using MATLAB by numerical integration, Euler and fourth order Runge Kutta methods. Simulation of CSTR and Batch Reactor, Simulation of Plug flow reactor. **10 Hours**

4.Introduction to Process Design:

Steps involved in process design, Process flow diagram structure and hierarchical approach, importance of Material and Energy balance, selection of unit operations,

05 Hours

Unit III

5.Introduction to process simulation software

Bioprocess design with example: Process Description, Specifying Process Sections, Specifying Equipment Sharing, Initialization of Reaction Operations, Process Analysis, Cost Analysis and Economic Evaluation, Environmental Impact.

05 Hours

6. Use of Super Pro in Process Simulation:

Components and mixtures, Physical and Chemical properties of components, material and energy balance simulation, adding unit operation, scheduling the unit process, process cost estimation, sizing of the unit operation.Case study: Monoclonal antibody production, Enzyme production

	05 Hours
Text Books: 1.Luyben W.L., Process Modeling Simulation and Control for Chemical Engineers., McGraw Hill, 1988. 2. Pauline M. Doran, “Bioprocess Engineering Calculation”, Blackwell Scientific Publications.	
Reference Books: 1. Kenneth J. Beers. “Numerical Methods for Chemical Engineering Applications in MATLAB®”, Massachusetts Institute of Technology, Cambridge University press 2007 edition. 2. Bailey and Ollis, “Biochemical Engineering Fundamentals”, 2 nd ed.,McGraw Hill, 1986.	

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Lab Title: Minor project		**Lab Code:15EBTW302**
L-T-P: 0-0-6	**Credits: 06**	**Contact Hours: 18 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 18 hrs/week	**Examination Duration: 03 hours**	

Guidelines:

- Minor project to be carried out in a group of maximum 4 students.
- Every student needs to maintain laboratory work book which should contain the details of all the work carried out in the laboratory.
- Entries to be done in log books for instrument usage.
- Timely report submission to the coordinator.
- Requisitions for chemicals and glassware's to be provided in advance for the project work

Review committee:

- Review committee is formed by the project coordinator taking into consideration that review committee consists of faculty experts from all domains. Review committee consists of the guide of the respective project group also.

Reviews:

- Continuous internal evaluation will be done by the respective guides/review committee as per the rubrics.
- Total of 3 reviews per semester will be carried out to evaluate the progress of the project.
- During review-1 students have to submit a report duly signed by guide.
- Final evaluation will be done by examiners during End semester assessment as per the ESA evaluation scheme.

Phases of minor project:

Sl. No	**Phases**	**Reviewed**	**Activities**
1	Review-1	By Review committee	Need analysis, Detail Review of literature, Objectives, Overall plan of work.
2	Review-2	By Project Guide	Development of protocols, Standardization and screening. Design of experiments, Conduct of experiments, Initial experimental data.
3	Review-3	By Review committee	Final experimentation, Data interpretation and analysis, Conclusion.

Program: Biotechnology		
Course Title: Bioprocess Engineering Lab		**Course Code: 15EBTP303**
L-T-P: 0-0-1.5	**Credits:1.5**	**Contact Hours: 3Hrs/week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 36	**Examination Duration: 03 Hours**	

List of Experiments:

1. Study of Lab fermenter with respect to design and process control parameter
2. Comparison of Batch and fed batch growth kinetics.
3. Determination of thermal death kinetics of microorganism
4. Determination of kinetic parameters of microorganism using batch mode.
5. Kinetics of product formation & substrate degradation
6. Design an experiment to determine mixing time and power requirement of fermenter
7. Determination of K_{La}
8. Solid state fermentation
9. Design an experiment to study the effect of mass transfer on microbial growth.
10. Introduction to bioprocess modeling and simulation software: SuperPro.
11. Building model for batch reactor using SuperPro

Text Books/Reference Books

1. Pauline M. Doran, Bioprocess Engineering Principles, 2, Academic Press, 2003
2. Stanbury & Whittaker, Principles of Fermentation Technology, 2, Pergamum Press, 2000

Program: Biotechnology		
Course Title: Bioprocess Control & Reaction Engineering Lab		**Course Code: 19EBTP301**
L-T-P: 0-0-1.5	**Credits: 1.5**	**Contact Hours: 02 Hours/Week**
ISA Marks:80	**ESA Marks:20**	**Total Marks:100**
Teaching Hours:24 Hours	**Examination Duration:3 hours**	

List of Experiments:

1. Study of characteristics of Transducers (such as Resistance Temperature Detector (RTD) sensor, Thermister, Thermocouple).
2. Determination of Time constant of given first order system (such as mercury in glass thermometer, bimetallic thermometer, RTD sensor using step response).
3. Response of first order system for step & Impulse inputs.
4. Response of first order systems arranged in Non-interacting mode for standard inputs (like step input, Impulse Input).
5. Response of first order systems arranged in Interacting mode for standard inputs (like step input, Impulse Input).
6. Transient response of change in set point/load variable on different control systems (such as Temperature, Pressure and Flow control systems) using different controllers (such as P-controller, PI-Controller, ON-Off controller etc).
7. Linearization of Non Linear Systems (such as control Valve).
8. Analyze the characteristics of different types of reactors (PFR & MFR)
9. Determination of Vessel dispersion number
10. Determination of rate constant for first order reaction.

Text Books/Reference Books

1. Process System analysis and control by Donald R Coughnowr, 2nd Edn.Mc Graw Hill,1991
2. Chemical Process Control by George Stephanopoulos, Prentice Hall of India, 1999

1.1.3. Number of courses having focus on employability/ entrepreneurship/ skill development during the year.
Year of offering: 2021-22
Batch- 2018-22 (7th semester)

Program: Biotechnology		
Course Title: Downstream Processing Technology		**Course Code: 19EBTC401**
L-T-P: 4-0-0	**Credits: 4.0**	**Contact Hours: 04 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 50	**Examination Duration: 03 Hours**	

Unit I

1. Introduction

Role and importance of downstream processing in biotechnological processes. Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Steps involved, case studies, costing of product and numericals

09 Hours

2. Primary Separation Techniques

Cell disruption methods for intracellular products, Removal of insolubles, Biomass (and particulate debris) heat and photosensitive materials (considering lyophilization) separation techniques; Flocculation and Sedimentation, Centrifugation and methods of centrifugation, filtration methods and types of filter media, numericals.

11 Hours

Unit II

3. Membrane separation processes

Membrane – based separations theory; Design and configuration of membrane separation equipment; Concentration polarization and fouling – causes, consequences and control techniques; Applications: Reverse osmosis, Dialysis, Ultra filtration, Micro filtration, Numerical of membrane separation process, Case Studies.

12 Hours

4. Enrichment operations

Precipitation methods with salts, organic solvents, and polymers, Extraction methods for separations. Reversed micellar extraction and Aqueous two-phase extraction, Supercritical extraction; In situ product removal / integrated bio-processing, numericals.

08 Hours

Unit III

5. Product recovery-I

Introduction to chromatography (Van Deemter equation), reversed phase chromatography, Hydrophobic Interaction Chromatography, Ion Exchange Chromatography, numericals.

05 Hours

6. Product recovery-II

Gel Filtration Chromatography, Affinity Chromatography, Polishing Operations: Crystallization, Drying**,** Delivery of biotechnological product to the end user

05 Hours

Text Books:

1. B. Sivasankar, Bioseparations: Principles and Techniques , Eastern Economy Edit, Prentice-H, 2005

2. P.A. Belter E.L. Cussler, W.S. Hu, Bioseparations: downstream processing for biotechnology, John-Wiley, New York, 1988

Reference Books:

1. BIOTOL, Product Recovery in Bioprocess Technology, VCH, 1990
2. Shuler and Kargi , Bioprocess Engineering , Prentice Hall, 1992
3. Asenjo J. and Dekker M, Separation Processes in Biotechnology , 1993 CRC Press

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioprocess Equipment Design		**Course Code: 15EBTC402**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit – I

1. Notation and terminologies

Pipe Joints: Flanged pipe joint, Hydraulic pipe joint, Gland & stuffing box expansion joint, Union joint, Socket & spigot Joint. Welded joints: Butt, Fillet, lap welded joint. Vessel openings: Manholes, nozzles, drains, sight Glasses. Pipe design: Basic notation and terminologies, Schedule 10 and 40. Introduction to design.

04 Hours

2. Materials of Construction

Material properties: Mechanical & types of Corrosion; Materials used: Stainless steel and their alloys, properties of different metals used in stainless steel, Selection criteria, Different Standards (Indian steel codes, American Society for Mechanical Engineers-Bioprocess Engineer (ASME BPE) standard, AISI (American Iron & Steel Institute) standard), different Stainless steel grade: 304, 316.

08 Hours

Unit – II

3. Design of Bioreactor

Fermenter: Steps involved in the design: Volume of Reactor, H/D ratio, impeller design, baffle design, shaft design, Thickness of the shell, thickness of the top & bottom Cover, thickness of jacket, heat transfer area of jacket, Power number**,** Power required to drive the Impeller.

09 Hours

4. Design of shell and tube Heat exchanger

Heat exchangers: Steps involved in the design, Energy balance, LMTD, Tubing characteristics, Tube side heat transfer coefficient, baffle spacing, shell side heat transfer coefficient, Fouling, Overall heat transfer coefficient, Tube side & shell side Pressure drop calculations.

09 Hours

Unit – III

5. Equipment qualification & Validation

Design qualification, FAT (factory acceptance test), Site acceptance test, Commissioning, Installation Qualification, Operational qualification, Performance qualification, Equipment validation.

05 Hours

6.Bioreactor Accessories

Sterilization by filters, Design criteria for filters, filter housing, Filter Integrity test: Diffusive air flow test, Bubble point test, Pressure drop test, Water intrusion test; Valves: Diaphragm valve, Pneumatic valve, pinch valve, Non-return safety Valve; Aseptic seals in fermenter (Gasket, Lip seal, O rings).

05 Hours

Text Books:

1. Chemical Engineering Design by R K Sinnott, vol-6, 4th edition, Butterworth-Heinemann, 2005.
2. Process Equipment Design by M. V. Joshi & V. V. Mahajani, 3rd edition, Macmillan India Ltd, 1996.

Reference Books:

1. Fermentation & Biochemical engineering handbook by H. C. Vogel & C. L. Todaro, 2nd edition, Standard publishers distributors.
2. Introduction to chemical equipment design by B. C. Bhattacharyya, 1st edition, CBS Publishers & distributors, 1985

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Industrial Biotechnology		**Course Code: 20EBTE401**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1 Introduction

History of fermentation products, Range of fermentation process: Traditional approach: biomass, enzymes, metabolites and biotransformation; Modern fermentation process: rDNA products, animal cell culture: therapeutic proteins, monoclonal antibodies; application of system biology approach; generalized representation of typical fermentation process.

05Hours

2. Isolation and improvement of industrial microorganisms

Isolation methods: Primary screening and secondary screening; Improvement of industrial microorganism: selection of induced mutants for primary and secondary metabolites, isolation of revertant mutants, use of rDNA systems, and improvement by other properties.

05Hours

3. Fermentation products

Beverages(beer), Ethanol, Aminoacids, enzymes(lipase/protease), penicillin, therapeutic proteins, monoclonal antibodies and vaccines.

05Hours

Unit II

4 Bioreactor configuration-I

CSTR with recycle, CSTR in series, Airlift reactor, Fluidized bed bioreactor, bubble column bioreactor, packed bed bioreactor, tickle bed bioreactor, deep jet bioreactor, rotating disc bioreactor.

05Hours

5. Bioreactor configuration-II

Animal cell bioreactors:- Homogeneous reactor: Solid and macro porous micro carriers bioreactor; Heterogeneous reactor: Hallow fiber bioreactor, Packed glass bed bioreactor, fluidized bed bioreactor, cell encapsulation; Disposable bioreactor: Wave bioreactor and stirred bag bioreactor, Perfusion system- single use reactor and Open raise ponds, photo bioreactor.

05Hours

6. Advance downstream processing

Process integration in product recovery, large scale refolding of therapeutic proteins, advanced membrane technology, Chromatography: column quantification and validation, AKTA purifier, reversed micellar technique for bio separation Single use technology in purification.

05Hours

Unit III

7. Fermentation monitoring and control:

On-line and off-line monitoring instruments, Bioprocess modeling for control, Estimation technique: Traditional method, linear black-box model and non-linear model; control strategies for fermentation, real time data analysis: Raman spectroscopy.

05 Hours

8. Fermentation data analysis:

Introduction, classification of fermentation measurement and quantities, calculation of metabolites, estimation of unmeasured variables, calculation of integral and averaged variable, physiological variable and pattern recognition technique, SIMCA software.

05Hours

Text Books:

1. L.E.Casida,JR ,Industrial Microbiology, New Age International (P) Ltd Publication.
2. Prescot and Dun, Industrial Microbiology, McGraw-Hill Book Company, Inc. New York

Reference Books:

1. D.Lanch,Drew,Wang, Comprehensive Biotechnology-Volume 3,Elsevier Publication.
2. George T. Austin, Nicholas Basta; Shreves Chemical Process Industries Handbook; McGraw Hill Professional, 1998

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7a,7b	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Food Processing Technology		**Course Code: 15EBTE402**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Fundamentals of Food Processing Technology

Basic concepts about properties of foods: liquid, solid and gases; Introduction to food processing: scope and significance; Principles of food processing and preservation

04 Hours

2. Microbial Food Spoilage

Food as substrate for microorganisms, Primary sources of micro organisms in foods, Microbes induced biochemical changes in foods, Microbiological Examination of foods , Food poisoning, and types. , A brief account of various organisms related with food poisoning- *E. coli, Clostridium, Bacillus, Staphylococcus and Vibrio*

.

07 Hours

3. Food biotechnology and Applications

Enzymes, organic acids, antibiotics, baker's yeast, single cell protein and Mushrooms. Biocolours, Concept of fermented foods and beverages, Probiotics, Prebiotics & Symbiotics, Genetically Modified Foods

04 Hours

Unit II

4. Unit Operations in Food Processing

Introduction, Food Engineering operations- raw material preparation, cleaning, sorting, grading and peeling. Food conversion operations- size reduction, emulsification, filtration, membrane separation, centrifugation and extraction. Pulsed Electric Field processing, High-Pressure Processing,

04 Hours

5. Thermal Processing of Foods

Heat processing using steam or water, Blanching, Pasteurization, Heat Sterilization, Evaporation, Distillation, Extrusion and Canning. dielectric heating, ohmic and infrared heating. Dehydration, Intermediate Moisture Foods, Baking and Roasting, Heat processing using hot oils- Frying.

06 Hours

6. Non-Thermal Processing of Foods

Chilling, Freezing, Freeze-drying, Vacuum Concentration, Processing by chemical methods- sugar, salt, curing, smoking, acid and chemicals. Irradiation of foods. Controlled and Modified–Atmosphere Packaging. Concept of hurdle technology.

05 Hours

Unit III

7. Food Product Development

Concept and need of new product development, testing and sensory evaluation,Development of product formulation and development,, Role of food ingredients in human health Packaging and shelf life of food products. Concept of Functional Foods and Nutraceuticals.

05 Hours

8. Food laws, Labeling and Regulatory Bodies

Food Laws- General Standards and Regulations as per FSSAI, . Regulatory bodies governing food laws. Certification and labeling of foods. Concept of HACCP and AGMARK

05 Hours

Text Books:

1. P.J.Fellows, Food Processing Technology. Principles and Practices, Second Edition, Woodland Publishing Ltd,Cambridge,England,2002
2. Avantina Sharma, Text Book of Food Science and Technology, International Book Distributing Co, Lucknow, UP, 2006

Reference Books:

1. Ramaswamy H & Marcotte M. Food Processing: Principles and Applications. Taylor & Francis. 2006

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Plant and Animal Biotechnology		**Course Code: 15EBTE403**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Introduction to plant tissue culture

Introduction and scope of plant tissue culture. Historical events in the development of plant tissue culture method. Practical applications and recent advances. Laboratory organization, Cell culture media and its components. Aseptic manipulation in plant tissue culture laboratory. . Ethical and Social issues related to development and release of transgenic plants with case studies – Bt Cotton.

05 Hours

2. Methods and Techniques in Plant tissue Culture.

Callus and suspension culture, Micropropagation, Protoplast culture & Somatic Hybridization, Anther & Ovary Culture, Somatic Embryogenesis, Embryo & Endosperm culture, Somaclonal variation Germplasm storage by cryopreservation – pretreatment for cryopreservation, freezing, thawing, plant growth and regeneration and applications. **04 Hours**

3. Introduction to animal cell and tissue culture

History and Scope of Animal cell and Tissue culture, Advantages and Disadvantages of Cell culture, laboratory facilities for tissue culture. Culture media for cells and tissues. Laboratory layout, Essential equipments and Consumable items, Aseptic Techniques- elements of aseptic environment and culturing vessels Types of tissue culture – Primary cultures and Cell lines maintenance of cell line cultures

06Hours

Unit II

4.Culture characterization and culture maintenance

Need for characterization, Parameters of Characterization, Cell Morphology, Confocal microscopy, DNA content analysis, Enzyme activity and Antigenic markers. Contamination in cell culture – sources, monitoring and eradication of contamination Cryopreservation and transportation. **04 Hours**

5. Animal Cell culture Scale up and Automation

Introduction to scale up and automation. Scale up in suspension culture: Continuous culture, Scale & complexities, Mixing & Aeration. Scale up in Monolayer culture: Multi surface propagators, Roller culture, Microcarriers, and Perfused Monolayer culture. Process control and Automation: Robotic cell culture and High throughput screening. **05 Hours**

6. Animal cell culture and Biopharmaceuticals production

Mammalian cells as desired expression systems for protein biopharmaceuticals, Construction and selection of high-producing cell lines, Medium development for mammalian cell culture, and Process development for mammalian cell culture. Single use disposable animal cell culture technologies for biopharmaceutical manufacturing. **06 Hours**

Unit III

7. Plant Cell culture and Secondary Metabolite production

Introduction, Selection of high yield cells and Mass cultivation of plant cells: Free cell suspension culture, Immobilized plant cell culture, and Two phase system culture. Elicitor induced accumulation of products. Biotransformation using plant cell cultures, Genetic modification and factors limiting large scale production of useful compounds.

05 Hours

8. Animal cell culture applications and Tissue engineering

Hybridoma Technology and Animal cell culture applications in Monoclonal antibodies production. Products of Animal tissue culture – Erythropoietin, Tissue Plasminogen Activator & Factor VIII etc. Tissue Engineering – Introduction, Cell types, Extracellular matrix and Tissue engineering concepts. Artificial skin development by tissue engineering and its applications.

05 Hours

Text Books:

1. Introduction to Plant tissue culture Second edition. M K Razdan Oxford & IBH Publishing Co Pvt Ltd, New Delhi. 2003
2. Animal Cell Culture – Concept and Application by Sheelendra M Bhatt, Narosa Publishing House, New Delhi ISBN: 978-81-7319-926-4

Reference Books:

1. Introduction to Plant Cell, Tissue and Organ culture Sunil D Purohit PHI Learning Private Ltd, New Delhi 2013. ISBN – 978-81-203-4677-2
2. Culture of Animal Cells - A Manual of Basic Technique by R. Ian Freshney A John Wiley & Sons, Inc., Publication New York (2000)

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Biopharmaceuticals		**Course Code: 15EBTE404**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Introduction:

Introduction to pharmaceutical industry, API and pharmaceutical products, Formulation Industry, Introduction to dosage forms, Biopharmaceuticals & Biotechnology, Biopharmaceuticals: Current status & future prospects. Drug discovery & development process, Sources of Biopharmaceuticals, Dosage forms and routes of drug administration.

06 Hours

2. Pharmacokinetic and Pharmacodynamics of Peptide & Protein Drugs:

Introduction to pharmacokinetics and pharmacodynamics, drug as agonist & antagonist, Pharmacokinetics of protein therapeutics, ADME study for small molecules & protein therapeutics, optimization of pharmacokinetic profile, Pharmacodynamics of protein therapeutics, PK/PD Models.

10 Hours

Unit II

3. The Drug Manufacturing Process:

Pharmacopeias, good manufacturing practices (GMP), good laboratory practices (GLP), manufacturing facilities, clean rooms, water plant & grades of water, production of final product & formulation, analysis of final product (Qualitative & Quantitative), documentation: SOP, specifications & records, batch manufacturing records (BMR), batch packaging records (BPR).

08 Hours

4. Therapeutic Agents:

The cytokines (Interleukins & Interferons), haemopoetic growth factors (erythropoietin), hormones of therapeutic interest (insulin & glucagon), preservation and clinical use of blood products, therapeutic enzymes, monoclonal & polyclonal antibodies, vaccines and vaccine technology (with appropriate case studies).

08 Hours

Unit III

5. Quality in Pharmaceutical Industry:

Quality Assurance & Quality Control, validation & qualification studies, aseptic fill-process validation, cleaning validation, Validation Master Plan, Qualification: IQ, OQ and PQ. Calibration of analytical instruments.

04 Hours

6. Regulatory issues and Drug product approval

Drug approval process (NDA & ANDA), Regulatory framework: Quality, Safety & Efficacy, Biosimilars and follow-on biologics, FDA & its Organizational structure, European regulations, Drug Registration in Japan, World harmonization of drug approvals (The ICH). **04 Hours**
Text Books: 1. Biopharmaceuticals: Biochemistry & Biotechnology. Author: Gary Walsh. Second Edition, 2011. Pub: John Wiley & Sons. 2. Pharmaceutical Biotechnology: Fundamentals and Applications. Ed: Daan J.A. Crommelin et al. Third Edition. Publisher: Informa Healthcare.
Reference Books: 1. Molecular Biotechnology: Principles & Applications of r-DNA. Author: Bernard Glick & Jack Pasternak. 2002. Pub: Panima Books. 2. Manual of Industrial Microbiology & Biotechnology by Arnold L. Demain. 1999 Pub: ASM Press. 3. Biopharmaceuticals: An Industrial perspective. Authors: Gary Walsh & Brendan Murphy. 2009. Pub: Spring Books.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Genomics and Proteomics		**Course Code: 15EBTE405**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Introductory Genomics

Genomics- Introduction, History and Scope and types, Structure of prokaryotic and eukaryotic genome, Mitochondrial and Chloroplast genome, C- value of genome. Genomics Approaches – traditional and updated, Genome mapping as an approach of genomics and recent approaches of genomics.

04 Hours

2. Genome Analysis and markers

Genome analysis and markers – Introduction, necessity and tools of genome analysis and markers. Genome Sequencing **-** Whole genome Shot gun, Hierarchial Shotgun, High-throughput sequencing, Chromosome walking, Chromosome jumping, Next Generation Sequencing. Molecular Markers: Concept of Markers, different types of markers and their general applications. Brief introduction to nature and applications of RFLP, RAPD, AFLP, SNP, Micro satellites, Minisatellites, Short Sequence Repeats, VNTR, EST, STS, Marker Assisted Selection

07 Hours

3. Genomics- Recent Advancements and Applications

Microarray analysis, Genomic libraries, Gene-disease associations. Genomics Applications: Nutrigenomics, Toxicogenomics, Pharmacogenomics, Metagenomics, Medical applications, Human Genome Project. Model Organisms for Genomics studies- Yeast and Drosophila

04 Hours

Unit II

4. Introductory Proteomics

Proteomics- Introduction, History, Scope and Types. Protein – Sequence, Structure and function relationship. Different approaches for proteomics studies and their applications.

04 Hours

5. Proteome separation and Purification

Proteome extraction and purification. Separation of Proteins- ion-exchange, size exclusion and affinity chromatography techniques,1-D by Isoelectric focusing, 2-D by SDS-PAGE. Protein Identification- Edman degradation, Mass Spectrometry, MALDI-TOF, Electrospray ionization, Peptide mass fingerprinting.

08 Hours

6. Proteomics- Recent Advancements and Applications

Applications of proteome analysis to drug; Protein-protein interaction Protein engineering: Protein chips. Clinical and biomedical application of proteomics.

03 Hours

Unit III

7. Bioinformatics tools in Genomics

Raw genome sequences, Major Genomic Databases, Genome Annotation, similarity search, Genome sequence alignment tools.

05 Hours

8. Bioinformatics tools in Proteomics

Proteome Databases, Proteome Annotation, Protein characterization and function, Families, patterns, domains and profiles.

05 Hours

Text Books:

1. Bioinformatics- Methods and Applications. Genomics, Proteomics and Drug Discovery. S.C. Rastogi, N. Mendiratta and P. Rastogi. PHI Learning Private Limited, delhi.
2. GENES IX Benjamn Lewin Oxford University and Cell Press 2010

Reference Books:

1. Introduction to Genomics- Arthur Lesk. Oxford University & Cell Press
2. Principles of Proteomics by R M Twyman BIOS Scientific Publishers 2004

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Environmental Biotechnology		**Course Code: 18EBTE404**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Introduction

Issues and scope of Environmental Biotechnology, Environment and Biotechnology, Areas of applications for Biotechnology. Microbes and Environment, Genetically modified organisms and Legislation. **03 Hours**

2. Waste Water Treatment

Sources of water pollution, Waste water characteristics: Physical, Chemical and Biological characteristics. Chemical Oxygen Demond (COD) and Biochemical Oxygen Demond (BOD). Introduction to physical and chemical waste water treatment methods. Biological wastewater treatment methods: Aerobic suspended growth treatment processes (Activated Sludge Process, aerared lagoons etc), Aerobic attached growth treatment processes (Trickling Filter, Rotating Biological contactors), Anaerobic suspended growth treatment processes- contact digestors, packed column reactors, UASB. **12 Hours**

Unit II

3. Solid waste Management

Basic aspects, Generation of solid wastes, general composition of Municipal solid waste, On site handling, storage and processing, Collection of solid wastes. Solid waste processing techniques and equipments. Recovery of biological conversion products from solid waste such as composting, sanitary landfilling, recycling, vermicomposting, incineration. Solid waste management for energy recovery-Biogas production, processing of lignocellulosic waste biomass for ethanol production

10 Hours

4. Bioremediation

Uses of bacteria for bioremediation, bioremediation of aromatic and aliphatic hydrocarbons, PCB dechlorination, immobilization techniques for bioremediation, biosorption & bioaccumulation, genetic engineering of microbes for bioremediation. Phytoremediation-plants capable of assimilating heavy metals **05 Hours**

Unit III

5.Bioleaching

Bioleaching using microbes, role of Thiobacilli, direct & indirect bioleaching, copper extraction by leaching, dump leaching **05 Hours**

6. Environmental Impact Assessment

Introduction, Scope and history of EIA, Need of Environmental Impact assessment. Stakeholder and public involvement, Identification and quantification of environmental effects and Environmental Impact statement (EIS) **05 Hours**

Text Books:

1. Metcalf and Eddy, Wastewater Engineering, International Edition, McGraw-Hill, 1991
2. George Tchobanoglous, Hilary Theisen and Rolf Eliassen, Solid Wastes, McGraw Hill Kogakusha

Reference Books:

1. Colin Ratledge, Basic Biotechnology , Cambridge Pub, 2001
2. Indu Shekhar Thakur, Environmental Biotechnology, IK Pub, 2006
3. Pradipta Kumar Mohapatra, Environmental Biotechnology, IK Pub, 2006

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Quality Assurance & Regulations		**Course Code: 18EBTE403**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Introduction

Introduction to Quality and Quality Regulation, Validation and Regulatory Affairs in Bio (Pharmaceutical) Manufacturing: An Introduction to FDA Operations & Industry Compliance Regulations, The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP), Good Manufacturing Practice (GMP) & Good Laboratory Practice (GLP).

06 Hours

2. Quality and Quality Management

Terms Relating to Quality Management System, Quality Policy, Quality Objectives, Quality Planning, Quality Control, Quality Assurance, Quality Improvement, Continual Improvement, Effectiveness, Efficiency; Relating to Process and Product, Quality Characteristics; Terms Relating to Conformity, Non-Conformity, Defect, Preventive Action, Corrective Action, Rework, Repair, Scrap, Concession, Deviation Permit, Release; Terms Relating to Documentation.

10 Hours

Unit II

3. Process Validation

Definition and concept of validation, An introduction to process validation, Validation and Qualification, IQ, OQ and PQ. A Review of Prospective, Concurrent, Retrospective Validation Calibration and performance evaluation. Validation of Water & Thermal Systems, including HVAC Facilities & Cleaning Validation. Validation septic Processes, Computer software validation in pharmaceuticals (CSV).

10 Hours

4. Analytical Method Validation

FDA and ICH guidelines. Analytical method validation, Specificity, Linearity, Accuracy, Precision, Limits of detection (LOD) and quantification (LOQ), Minimum detectable amount (MDA), Sample stability and method robustness, System suitability, Statistical process control for HPLC, Troubleshooting out-of-control systems, Case studies, Validation of Analytical Methods.

06 Hours

Unit III

5. Quality Standards

Introduction, ISO 9000 Series of Standards, Management Responsibility, Quality System, Contract Review, Design Control, Document and Data Control, Control of Quality Records, Internal Quality Audits, Training, Servicing, Environmental Management System.

04 Hours

6. Implementation and Regulation

Role of QC and QA in Bio/Pharmaceutical organization, Quality System, Contract Review, Design Control, Document and Data Control, Product Identification and Traceability, Process Control, Control of Quality Records, Internal Quality Audits, Training.

04 Hours

Text Books:

1. Pharmaceutical Process Validation by Robert Nash and Alfred Wachter, Marcel Dekker. Publisher: Marcel Dekker Inc. 2011.
2. Good Manufacturing Practices for Pharmaceuticals: A Plan for Total Quality Control From Manufacturer to Consumer, Sidney J. Willig, Publisher: Marcel Dekker Inc. 2005.

Reference Books:

1. Validation of Pharmaceutical Processes: Sterile Products, Frederick J. Carlton (Ed.) and James Agalloco (Ed.), Marcel Dekker, 2008.
2. Validation Standard Operating Procedures: A Step by Step Guide for Achieving Compliance in the Pharmaceutical, Medical Device, and Biotech Industries, Syed Imtiaz Haider, Saint Lucie Press, 2004.

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I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bioethics, Safety & IPR		**Course Code:20EBTE403**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1. Perceptions about Biotechnology: Biotechnology and social responsibility, Positive & negative perceptions of Biotechnology, Public acceptance issues, surveys, areas of public concern for Biotechnology. Socio, ethical, economic and legal aspects of Biotechnology. Public education & Biotechnology. **05Hours**

2. Bioethics: Legality, morality, and ethics, Principles of bioethics: autonomy, human rights, beneficence, justice, equity, etc. Expanding scope of ethics from Biomedical practice to Biotechnology, ethical conflicts in Biotechnology. **05 Hours**

3. Biosafety concept and issues : Rational vs. subjective perception of risks and benefits, Hazards of BT , relationship between risk and hazard, Ethical implications of biotechnology products and techniques, **05 Hours**

Unit II

4. National and International Regulations: Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI) **10Hours**

5. Biosafety & Management: Laboratory associated Biosafety practices, assessment of biohazard, Biosafety levels,. Risk analysis and assessment, Containment levels-physical, biological containments,. Good manufacturing practice and Good lab practices (GMP and GLP). **05 Hours**

Unit III

6. Intellectual Property rights: Introduction to history of GATT, WTO, WIPO and TRIPS; Introduction to IPR, Types of IP: Patents, Trademarks, Copyright, Design & Related Rights. Plant variety protection, Traditional knowledge, breeders rights, Geographical indications, Biodiversity and farmers rights. Patenting in biotechnology, case studies. **05 Hours**

7. Food, Agri and Pharma Sector: The GM-food debate and biosafety assessment procedures for biotech foods including transgenic food crops, case studies- Golden Rice and Flav Savr Tomatto. Biosafety assessment of pharmaceutical products such as drugs/vaccines etc. Biosafety issues in Clinical Trials. **05 Hours**

Text Books

1.Bioethics & Biosafety- Sateesh MK, I.K.International Publishing House

2.Intellectual Property rights on Biotechnology – Singh K, BCIL, New Delhi.
3.Biotechnology: Expanding Horizons - B D Singh, Kalayani Publishers, 2010

Reference Books:

1. Bioethics & Biosafety – R. Rallapalli & Gita Bali, APH publication, 2007
2. Safety considerations for Biotechnology-Paris, OECD publications

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Vaccine Technology		**Course Code: 21EBTE401**
L-T-P: 3-0-0	**Credits: 03**	**Contact Hours: 03 Hours/Week**
CIE Marks: 50	**SEE Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1 History of Vaccine Discovery and Development

Variolation and Vaccination in Late Imperial era, early methods of vaccination, Edward Jenner's Role in the Introduction of Smallpox Vaccine, Eradication of small pox. Fight against polio,Historical background of vaccination, vaccine preventable infectious diseases, Over view of bacterial and viral vaccines and their importance to public health. Epidemiology and pathophysiology of vaccine preventable diseases with special emphasis on Diphtheria, and Tetanus.

07 Hours

2. Role of vaccines in epidemiology and public health system.

Active and passive immunization, General immunization practices, Strategies for improving vaccination levels. Timing and Spacing of Vaccines.. Adverse Reactions Following Vaccination.Contraindications and Precautions to Vaccination. Role of B and T cells, primary and secondary immune response, Immunological memory, Booster doses, Factors influencing the magnitude of vaccine performance, adjuvants. Immune correlates in vaccine development.

08 Hours

Unit II

3. Vaccine design, development and types:

Subunit vaccine component - antigen, delivery system. Structure-based Vaccine design - tools and techniques. Characters of effective vaccines: Vaccines, Live, killed, attenuated, sub unit vaccines, conjugated vaccines. Vaccine technology- Role and properties of adjuvants, recombinant DNA and protein based vaccines, plant-based vaccines, reverse vaccinology; Peptide vaccines, conjugate vaccines, Edible vaccines.

06 Hours

4. Vaccine manufacturing and Quality Control.

Commercial scale vaccine manufacturing: Upstream (use of cell lines, human diploid) and downstream (chromatography) of active substances. Vaccine formulation (liquid and lyophilization). Use of additives/adjuvants/stabilizers. Vaccine safety and efficacy of vaccines (in vitro and in vivo). cGMP implementation in the production of safe vaccines. Case study of vaccine manufacturing: HBV and polio vaccine **09 Hours**

Unit III

5. Policies, ethical considerations and Regulatory affairs of vaccines.

Regulation and testing of vaccines, Regulation of vaccines in developing countries, Role and

functioning of National Regulatory Authorities (ICMR) and WHO.Different stages of review and regulation of vaccines (investigational new drug application, biologics license application, post-licensure). Evolution of vaccine regulations overtime and the current status of NRAs functionality globally. Brief on Indian regulatory system.

05 Hours

6. Recent advancements in vaccinology:

Concepts of reverse vaccinology, case study of Reverse Vaccinology. Novel vaccine delivery systems. Tools & servers for computational Vaccine design-from Genome to Vaccine. Antigenicity modification, epitope replacement, germline targeting. Antigenically variable infectious agents and their vaccines. **05 Hours**

Text Books

1. IAP Textbook of Vaccines by Nitin K Shah, Rohit Agrawal, Vipin M Vashishtha, TU Sukumaran
2. Vaccines. 6th Edition, Stanley Plotkin Walter Orenstein Paul Offit.

Reference Books

1. Vaccine Development and Manufacturing. Emily P. Wen (Editor), Ronald Ellis (Editor), Narahari S. Pujar (Editor).
2. Vaccines & Vaccine Technologies. Jose Ronnie Vasconcelos

Scheme for End semester examination (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3, 4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5, 6	Solve Any 1 out of 2

Program: Biotechnology		
Lab Title: Senior Design Project		**Lab Code:20EBTW401**
L-T-P: 0-0-6	**Credits: 06**	**Contact Hours: 18 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 18 hrs/week	**Examination Duration: 03 hours**	

Guidelines:

- Senior Design Project to be carried out in a group of maximum 4 students.
- Every student needs to maintain laboratory work book which should contain the details of all the work carried out in the laboratory.
- Entries to be done in log books for instrument usage.
- Timely report submission to the coordinator.
- Requisitions for chemicals and glassware's to be provided in advance for the project work

Review committee:

- Review committee is formed by the project coordinator taking into consideration that review committee consists of faculty experts from all domains. Review committee consists of the guide of the respective project group also.

Reviews:

- Continuous internal evaluation will be done by the respective guides/review committee as per the rubrics.
- Total of 4 reviews per semester will be carried out to evaluate the progress of the project.
- During each review, team has to present the project work carried out (Viva-voce or PPT).
- Final evaluation will be done by external examiners during End semester assessment as per the evaluation scheme.

Phases of senior design project:

Sl. No	Phases	Reviewed	Activities
1	Review-1	By Review committee	Need analysis, Detail Review of literature, Objectives, Overall plan of work.
2	Review-2	By Project Guide	Development of protocols, Standardization and screening.
3	Review-3	By Project Guide	Design of experiments, conduct of experiments, Initial experimental data.
4	Review-4	By Review committee	Final experimentation, Data interpretation and analysis, Conclusion.

Program: Biotechnology		
Course Title: Downstream Processing Technology Lab		**Course Code: 15EBTP401**
L-T-P: 0-0-1	**Credits: 1.0**	**Contact Hours: 02 Hours/Week**
ISA Marks: 80	**ESA Marks: 20**	**Total Marks: 100**
Teaching Hours: 24	**Examination Duration: 03 Hours**	

List of Experiments

1. Cell disruption technique: Sonication.
2. Solid-liquid separation method: Filtration.
3. Solid-liquid separation methods: Centrifugation.
4. Product enrichment operations: Two – phase aqueous extraction.
5. Isoelectric precipitation of proteins
6. Membrane Separation methods: Tangential Flow Filtration
7. Chromatography techniques: Gel exclusion chromatography
8. Chromatography techniques: Ion exchange chromatography
9. Determination of protein molecular weight: SDS-PAGE
10. Estimation of metabolite using high performance liquid chromatography

Text Books/ Reference Books:

1. Bioseparations: Principle & Technique; Shiv Shankar B.; PHI LEARNING PRIVATE LIMITED;2009
2. Bioseparations: Downstream Processing for Biotechnology; Paul A. Belter E. L. Cussler Wei-Shou Hu; WILEY INDIA PVT. LTD.-NEW DELHI; 2011
3. Separation Processes in Biotechnology; Juan A. Asenjo; CRC Press (28 June 1990).
4. Protein Purification : Principles and Practice; Robert K Scopes;Springer; 2010 December

1.1.3. Number of courses having focus on employability/ entrepreneurship/ skill development during the year.

Year of offering: 2021-22
Batch- 2018-22 (8th semester)

Program: Biotechnology		
Course Title: Biological Data Analysis		**Course Code: 18EBTE402**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 03 Hours/Week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1.Introduction to Basic statistics:

Strategy of Experimentation, History of the Design of Experiments, Basic Principles of DOE: Randomization, Replication, Blocking, Multi-factor Designs, Confounding; Steps for Planning, Conducting and Analyzing an Experiment, Typical applications of Experimental design, Basic Principles, Guidelines for Designing, Concepts of random variable, probability, density function,cumulative distribution function. Concept of confidence level. Statistical Distributions: Normal, Log Normal &Weibull distributions. Hypothesis testing, Probability plots.

04 Hours

2. Screening Design:

Introduction, Terminology: factors, levels, interactions, treatment combination, Orthogonal array, PB design, analysis of PD design, Numericals. **05 Hours**

3.Full Factorial Design:

Basic Definitions and Principles, The Advantage of Factorials, The Two-Factor Factorial Design, Statistical Analysis of the Fixed Effects Model, Model Adequacy Checking, Estimating the Model Parameters, Concept of the General Factorial Design, 2^k Factorial Design, The 2^2Design, The 2^3 Design, The General 2^k Design. **07 Hours**

Unit II

4. Response surface methods:

Introduction, Central composite design, Box Behnken design, importance of counter and surface plots. **05 Hours**

5. R Programming Basics:

Overview of R programming, Environment setup with R Studio, R Commands, Variables and Data Types, Control Structures, Vectors, Factors, Functions, Matrices, Arrays and Lists. **06 Hours**

6. Interfacing:

Interfacing R to other languages, Parallel R, Basic Statistics: Linear Model, Generalized Linear models, Non-linear models, Time Series, Autocorrelation and Clustering. **05 Hours**

Unit III

7. Introduction to Bioconductor for Sequence Data:

Sequencing Resources, Ranges Infrastructure, DNA /amino acid sequence from FASTA files, Reads from FASTQ files, Aligned Reads from BAM files, Called Variants from VCF files, Genome Annotations from BED, WIG, GTF files. **04 Hours**

8. Biological Data Analysis:

Preparing count matrices, The DESeq, DataSet, sample information, and formula design, exploratory analysis and visualization, Differential expression analysis, Plotting results, Annotating and exporting results **04 Hours**

Text Books:

1. R for Everyone: Advanced Analytics and Graphics: b y Jared P. Lander Addison Wesley Data & Analytics Series, 2013.

2. Design and analysis of experiments" by D.C. Montgomery, 7th edition John Wiley and sons, NewYork

Reference Books:

1. A Little Book of R for Bioinformatics: by Avril Coghlan, Release 0.1

2. Das. M.M. and Giri N.C. : - Design and Analysis of Experiments

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2,3	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	4,5,6	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	7,8	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Bio-business & Entrepreneurship		**Course Code: 20EBTE402**
L-T-P: 3-0-0	**Credits: 3.0**	**Contact Hours: 3 hours/week**
ISA Marks:50	**ESA Marks:50**	**Total Marks:100**
Teaching Hours:40	**Examination Duration:3 hrs**	

Unit-I

1. Entrepreneurship

Concept of Entrepreneurship - Development of Entrepreneurship; Stages in entrepreneurial process; Role of entrepreneurs in Economic Development; Characteristics of successful Entrepreneur, Classification of Entrepreneurs, Myths of Entrepreneurship, Entrepreneurial Development models, Entrepreneurial development cycle, Problems faced by Entrepreneurs. Entrepreneurship in India: Small scale industries: Definition; Characteristics; Need and rationale. Objectives; Scope; Introduction to bio-business, from the Indian context, SWOT analysis of bio-business.

10 hours

2. Social Responsibilities of Business

Meaning of Social Responsibility, Social Responsibilities of Business towards Different Groups, Social Audit, Business Ethics and Corporate Governance Institutional Support for Business Enterprises: Introduction, Policies & Schemes of Central Level Institutions, State Level Institutions.

05 hours

Unit-II

3. Entrepreneurship opportunity in biotechnology

Business opportunity, Essential requirement, marketing strategies, schemes, challenges and scope-with case studies on entrepreneurship opportunities in different domains of Biotechnology (Agri biotechnology, industrial Biotechnology, food biotechnology, Biopharma, Nutraceuticals. etc).

05 hours

4. Project management, technology management and startup schemes

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.

10 hours

Unit-III

5. Startup Schemes

Building Biotech business challenges in Indian context-biotech partners (BIRAC, DBT, Incubation centers. Etc.), operational biotech parks in India. Indian Company act for Bio business-schemes and subsidies. Patent expiry and Entrepreneurship opportunity, Principles of Technology leasing, licensing and transfer, Business incubation support schemes, Successful startups-case study.

05 hours

6. Funding Opportunities

Startup schemes in Indian government Sources of Funding for startups. Crowd funding, Self-funding, Venture Capitalists, Angel Investment. Banking support for startup business. Types of companies: Sole proprietorship company, Partnership company, Private Limited, Limited company etc.

05 hours

Text Books:

1. Principles of Management – P. C.Tripathi, P.N. Reddy – Tata McGraw Hill,
2. Entrepreneurship Development - S.S.Khanka - S.Chand & Co.
3. Project Management by Sahni, Ane Books.

Reference books

1. Management Fundamentals - Concepts, Application, Skill Development - Robers Lusier - Thomson
2. Project Management for Business & Technology, Nicholas, PHI.

Scheme for End Semester Assessment (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1,2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	5,6	Solve Any 1 out of 2

Program: Biotechnology		
Course Title: Genomic Data Analysis		**Course Code: 21EBTE402**
L-T-P: 3-0-0	**Credits: 03**	**Contact Hours: 03 Hours/Week**
CIE Marks: 50	**SEE Marks: 50**	**Total Marks: 100**
Teaching Hours: 40	**Examination Duration: 03 Hours**	

Unit I

1.Introduction to Genomics and Data science:

Genomics- Introduction, Structure of prokaryotic and eukaryotic genome, Central dogma, Genome analysis– Introduction, necessity and tools of genome analysis Genome Sequencing methods, Next Generation Sequencing, Introduction to Data Science: Data, Information, Data science, Data science process, Data analytics process, exploratory data analysis, data types and plotting. **5 Hours.**

2. Python for genomic data science:Part I

Introduction, Installation, Jupyter note book, types and sequence, python numbers and strings, variables, handling numerical data, python objects, data structure.

10 Hours

Unit II

3. Python for genomic data science:Part II

Ifs and loops, python functions, library, communication with outside, modules and package**.**

5 Hours

4. Genomic analysis: Algorithms

Introduction, DNA as string, manipulation of DNA, Dynamic programming: Local and Global alignment, BLAST algorithm, DNA assembly. **5 Hours**

5. Biopython

Introduction, working with sequence, sequence objects, sequence alignment, reading genomic sequence files**.** **5 Hours**

Unit III

6. Introduction to Galaxy software

Introduction, galaxy platform, working with genomic data, creation of work flow, annotation, sharing and publishing of genomic data, Genome and RNA sequence analysis. **5 Hours**

7. Introduction to Bioconductor for Sequence Data

Sequencing Resources, Ranges Infrastructure, DNA /amino acid sequence from FASTA files, Reads from FASTQ files, Aligned Reads from BAM files, Called Variants from VCF files, Genome Annotations from BED, WIG, GTF files. **5 Hours**

Text Books

1. Bioinformatics with Python Cookbook, Second Edition: Tiago Antao, Ingram short title; 2nd edition (1 January 2018), ISBN-13 : 978-1789344691.
2. R Bioinformatics Cookbook, Dan MacLean, Packt Publishing Limited (11 October 2019), ISBN-13 : 978-1789950694.
3. Hahne F, Huber W, Gentleman R, Falcon S. Bioconductor Case Studies. Springer Publishing Company, 2008. Mathur SK.

Reference Books

1. Lee JK. Statistical Bioinformatics: A Guide for Life and Biomedical Science Researchers. Hoboken, N.J.: WileyBlackwell, 2010.
2. Statistical Bioinformatics with R. Academic Press, 2010.
3. Genome Data Analysis, Ju Han Kim,2019, Springer Singapore

Scheme for End semester examination (ESA)

UNIT	8 Questions to be set of 20 Marks Each	Chapter numbers	Instructions
I	3 Questions to be set of 20 Marks Each	1, 2	Solve Any 2 out of 3
II	3 Questions to be set of 20 Marks Each	3,4,5	Solve Any 2 out of 3
III	2 Questions to be set of 20 Marks Each	6,7	Solve Any 1 out of 2

Program: Biotechnology		
Lab Title: Capstone Project		**Lab Code:20EBTW402**
L-T-P: 0-0-11	**Credits: 11**	**Contact Hours: 33 hrs/week**
ISA Marks: 50	**ESA Marks: 50**	**Total Marks: 100**
Teaching Hours: 33 hrs/week	**Examination Duration: 03 hours**	

Guidelines:

- Capstone Project to be carried out in a group of maximum 4 students.
- Every student needs to maintain laboratory work book which should contain the details of all the work carried out in the laboratory.
- Entries to be done in log books for instrument usage.
- Timely report submission to the coordinator.
- Requisitions for chemicals and glassware's to be provided in advance for the project work

Review committee:

- Review committee is formed by the project coordinator taking into consideration that review committee consists of faculty experts from all domains. Review committee consists of the guide of the respective project group also.

Reviews:

- Continuous internal evaluation will be done by the respective guides/review committee as per the rubrics.
- Total of 4 reviews per semester will be carried out to evaluate the progress of the project.
- During each review, team has to present the project work carried out (Viva-voce or PPT).
- Final evaluation will be done by external examiners during End semester assessment as per the evaluation scheme.

Phases of Capstone project:

Sl. No	Phases	Reviewed	Activities
1	Review-1	By Review committee	Need analysis, Detail Review of literature, Objectives, Overall plan of work.
2	Review-2	By Project Guide	Development of protocols, Standardization and screening.
3	Review-3	By Project Guide	Design of experiments, conduct of experiments, Initial experimental data.
4	Review-4	By Review committee	Final experimentation, Data interpretation and analysis, Conclusion.