NUMERICAL METHODS & BIOSTATISTICS			
Subject Code	**16BBT11/16BBC11/16IBT11**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS 04

Course objectives : The course will enables the students
- To develop skills towards the design & analysis of statistical experiments
- Use appropriate numerical and statistical methods to analyze and interpret data
- Demonstrate effective use of these tools in problem solving and analysis

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
Introduction to statistics and study design: Introduction to statistics, data, variables, types of data, tabular, graphical and pictorial representation of data. Significance of statistics to biological problems, experimental studies; randomized controlled studies, historically controlled studies, cross over, factorial design, cluster design, randomized; complete, block, stratified design, biases, analysis and interpretation.	**1O**	**L1,L2,L3, L4**
MODULE –2		
Descriptive statistics and Observational study design: Types of variables, measure of spread, logarithmic transformations, multivariate data. Basics of study design, cohort studies, case-control studies, outcomes, odd ratio and relative risks. Principles of statistical inference: Parameter estimation, hypothesis testing. Statistical inference on categorical variables; categorical data, binomial distribution, normal distribution, sample size estimation	**10**	**L1, L2,L3,L4**
MODULE – 3		
Comparison of means: Test statistics; t-test, F distribution, independent and dependent sample comparison, Wilcoxon Signed Rank Test, Wilcoxon-Mann-Whitney Test, ANOVA. Correlation and simple linear regression: Introduction, Karl Pearson correlation coefficient, Spearman Rank correlation coefficient, simple linear regression, regression model fit, inferences from the regression model, ANOVA tables for regression. Multiple linear regression and linear models: Introduction, Multiple linear regression model, ANOVA table for multiple linear regression model, assessing model fit, polynomials and interactions. One-way and Two-way	**10**	**L2, L3,L4**

ANOVA tables, F-tests. Algorithm and implementation using numerical methods with case studies.		
MODULE – 4		
Design and analysis of experiments: Random block design, multiple sources of variation, correlated data and random effects regression, model fitting. Completely randomized design, stratified design. Biological study designs. Optimization strategies with case studies.	**10**	**L3, L4, L5**
MODULE – 5		
Statistics in microarray, genome mapping and bioinformatics: Types of microarray, objectives of the study, experimental designs for micro array studies, microarray analysis, interpretation, validation and microarray informatics. Genome mapping, discrete sequence matching, programs for mapping sequences with case studies.	**10**	**L3, L4, L5**

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

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

Graduate Attributes (as per NBA)

- Problem Analysis.
- Design / development of solutions.
- Modern Tool Usage

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. Alvin E. Lewis, Biostatistics, McGraw-Hill Professional Publishing, 2013.
2. J.D. Lee and T.D. Lee. Statistics and Numerical Methods in BASIC for Biologists, Van Nostrand Reinhold Company, 1982.
3. T.P. Chapman, Statistical Analysis of Gene Expression Microarray Data, CRC, 2003.

REFERENCE BOOKS

1. Wolfgang Boehm and Hartmut Prautzsch, Numerical Methods, CRC Press, 1993.
2. John F. Monahan. Numerical Methods of Statistics (Cambridge Series in Statistical and Probabilistic Mathematics), Cambridge University Press, 2011.
3. Joe D. Hoffman. Numerical Methods for Engineers and Scientists, CRC Press, 2nd Edition, 2001.
4. Warren J. Ewens Gregory Grant, Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology and Health), Springer, 2005

CONCEPTS IN BIOTECHNOLOGY			
Subject Code	**16BBT12/16BBC12**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS 04

Course objectives : The course will enables the student:

- Appreciate the Basic concepts and apply the knowledge to Biotechnological problems
- Use these skills towards the design & analysis of life science experiments
- Demonstrate effective use of these tools and techniques in solving problems relevant for society

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
Introduction to Biology; Macromolecules; Carbon chemistry; Proteins: Structure, folding, catalysis; Nucleic acids: DNA & RNA; storage and transfer of genetic information; Lipids: membranes, structure & function; Carbohydrate chemistry, energy storage, building blocks.	**10**	**L1, L2,L3**
MODULE –2		
Cell Structure: Eukaryotic and Prokaryotic cells, plant and animal cells, structure of nucleus, mitochondria, ribosomes, Golgi bodies, lysosomes, endoplasmic reticulum, chloroplast, vacuoles; Cell cycle and cell division: Different phases of cell cycle, cell division: Mitosis and meiosis. Mendelian law of inheritance: Monohybrid and dihybrid inheritance, law of segregation and independent assortment; Gene Interaction; Multiple alleles, supplementary and complementary genes, epistasis. Identification of genetic material: classical experiments; chromosome structure and organization, chemical composition of chromatin, structural organization of nucleosomes, heterochromatin, polytene and lamp-brush chromosomes, human chromosomes, chromosomal disorders.	**10**	**L1, L2,L3,L4**
MODULE – 3		
Scope and History of microbiology, Introduction to the structure and functions of microorganism: Bacteria, Viruses, Fungi and Protozoan's. Microscopy and microbial techniques: Study of microscopes; sterilization techniques: Heat, steam, Radiation, Filtration and chemical methods; Pure culture techniques: Serial Dilution, Streak, Spread, Pour Plate. Immune System, Innate and adaptive immunity, antigens and antibodies;	**10**	**L1, L2, L3, L4**

types of immune response, hypersensitivity. Humoral immunity: B-lymphocytes, Immunoglobulin classes, Major Histocompatibility Complex (MHC). Cell mediated immunity. Thymus derived lymphocytes (T-cells), Antigen presenting cells (APC); Immunity to infection, Cytokines.		
MODULE – 4		
Scope of agricultural biotechnology, Role of Micorbes in agriculture, Biopesticides, Bio fertilizers (Nitrogen fixing microbes), GM crops. Plant metabolic engineering and industrial products: Molecular farming for the production of industrial enzymes, biodegradable plastics, antibodies, edible vaccines. Metabolic engineering of plants for the production of fatty acids, industrial oils, flavonoids etc. Basic aspects of Food & Nutrition.	**10**	**L3, L4, L5, L6.**
MODULE – 5		
Industrially important Microorganisms, Preservation techniques, Different media for fermentation, basic structure of fermentor and different types. Types of fermentation processes (surface, submerged, and solid state) and their products (ethanol, citric acid, lactic acid, enzymes, antibiotics) Biological treatment of waste water, primary, secondary and tertiary treatments. Bio indicators, Bioremediation of xenobiotic compounds, Bioleaching of minerals from ores, Bio-sorption of toxic metals. Solid waste management. Biofuel production from agricultural wastes.	**10**	**L3, L4, L5, L6.**

Course outcomes: After completion of the course, students will be

- Demonstrate strong basics in principles of biotechnology.
- Demonstrate strong basics in biotechnology and numerical analysis,

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Societal and Environmental concern

Question Paper Pattern:

- The question paper will have ten questions
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) form each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. De Robertis EDP and De Robertis Jr. EMF, Cell and Molecular Biology, Wippincott Williams and Wiilkins publisher, 2001.
2. Strickburger M W, Principles of Genetics, 3rd edition, Prentice Hall Publication, India, 2011.

3. Prescott and Dunn, Industrial Microbiology, Macmillian, 1982.
4. Ashim K Chakravarthy, Immunology & Immunotechnology, Oxford University Press, 2006.

REFERENCE BOOKS

1. Gardner, Simmonns and Snustad, Principles of Genetics, 8th edition, 2005.
2. P S Verma, V R Agarwal, Cell Biology, Genetics, Evolution and Ecology, New Publisher Delhi, 2007.
3. K. Lindsey and M.G.K. Jones, Plant biotechnology in Agriculture, Prentice hall, New Jersey. 1989.
4. Munnecke DM, Johnson LM and others, Biodegradation and Detoxification of Environmental Pollutants CRC Press, 1982

PRINCIPLES OF BIOCHEMICAL ENGINEERING

Subject Code	**16BBT13/16BBC13**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS 04

Course objectives : The course will enable the students

- Analyze chemical and biochemical systems, their principles using thermodynamic fundamentals.
- Perform feasibility studies on chemical engineering processes along with fluid flow system.
- Acquire knowledge for heat and mass transfer systems employed in industrial processes.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
Energy and Material Balances: Material Balance: Law conservation of mass, Material balance with and without reactions. Energy Balance: Law of conversation of energy, Energy balance with and without chemical reactions. Introduction to Momentum Transfer: Types of fluids: Newtonian and Non Newtonian fluids. Measurement of viscosity, Laminar and Turbulent flow, eddy viscosity, flow of a fluid past a solid surface (Cells and immobilized systems), motion of particles in fluid(centrifugation & sedimentation), flow of fluid	**10**	**L1, L2, L3**

through granular bed (packed column), fluidization and bubble column.		
MODULE –2		
Concepts of Heat and Mass Transfer: Heat Transfer: Thermal conductivity and mechanism of energy transport, design principles of heat exchangers, measurement of heat transfer coefficient, principles, construction and application of evaporators and dryers. Mass transfer: Diffusion and its types, measurement of diffusivities, theoretical estimation of diffusitivities, interfacial diffusion (Mass transfer), convective mass transfer, measurement of mass transfer coefficient, Mass transfer process (Principle, construction and application of Distillation, adsorption, extraction and crystallization).	**10**	**L1, L2, L3**
MODULE – 3		
Thermodynamics and Bioenergetics Thermodynamics: First and Second law of thermodynamics, application of first and second law in Biomolecular structure, PVT behaviour, PVT diagram of pure fluids, thermodynamics models used in process industries (Peng-Robinson model, EOS, NRTL,SRK etc). Properties of solution, phase equilibrium. Chemical potential and activity of molecules, statistical thermodynamics, Bioenergetics: Energetic of metabolic pathways, energy coupling, thermodynamic efficiency of growth and yield co-efficients.	**10**	**L1, L2, L3**
MODULE – 4		
Reaction Engineering: Kinetics of enzyme catalyzed reactions, kinetics of microbial growth, substrate utilization and product formation. Batch and continuous reactors, energy and mass balance in biological reactions. Heterogeneous reaction: Shell balance (Immobilized system), effect of mass transfer on reaction, Thiele modulus, solid liquid mass transfer correlations, minimizing mass transfer effects.	**10**	**L1, L2, L3, L4**
MODULE – 5		

Drying &RTD in reactors: Drying; moisture content and its types, wet and dry moisture contents, drying curve, drying equipments, RTD curves-its interpretation, RTD for CSTR and PFR calculations.	**10**	**L1, L2, L3, L4**

Course outcomes:

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

- Derive and calculate thermodynamic relations using energy equations.
- Analyze the kinetics related to enzyme catalyzed reactions

Graduate Attributes (as per NBA)

- Problem analysis
- Design / Development of solutions

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. Bhatt B. I and S.M. Vora Stoichiometry Tata McGraw Hill, 4th Edition, 2004.
2. McCAbe RL & J.C Smith "Unit operations of Chemical Engineering" McGraw Hill International Editions, 2001.
3. Mass Transfer Operations by Robert E. Treybal. McGraw-Hill Education.
4. Introduction to Chemical Engineering thermodynamics by Smith & Vanness, MGH.

REFERENCE BOOKS

- O. Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley, 1999.
- Bailey J.E. and Ollis D.F. Biochemical Engineering Fundamentals 2nd Edition, McGraw- Hill Book CO., Singapore, (1986).
- Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, PHI, 2002.
- Pauline Doran, Bioprocess Engineering Principles,1st Edition, Academic Press, 1995.

BIOMOLECULES AND MOLECULAR BIOLOGY			
Subject Code	**16BBT14**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS 04

Course objectives : The course will enable the students

- To portray the properties and metabolism associated with biomolecules
- To enlighten on transcription, translation, and regulation of gene expression in prokaryotes and eukaryotes

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
Introduction to Macromolecules**:** Biomolecules; Nucleic acids: storage and transfer of genetic information; Carbohydrates: energy transactions and structural blocks Proteins: structure, folding and catalysis; Lipids: membranes and energy transactions; Nucleic Acids: Structure of DNA, Alternative forms of DNA - A, B, Z and triplex DNA. Melting Curve of DNA double helix, Hyperchromoic effect and factors responsible for DNA double helical structure, Structure of RNA and Structural aspects of mRNA, tRNA and rRNA. Composition and primary structure of proteins; Conformational analysis and forces that determine protein structures and geometries; potential energy calculations, phi, psi, omega angles, Ramachandran or steric contour diagram, chi angles of side chains in proteins; hydrogen bonding; disulphide bonds; hydrophobic interactions; alpha helices; beta sheets; helix to coil transition, general features and thermodynamic aspects of protein folding and folding kinetics, protein-ligand interactions.	**10**	**L1, L2, L3**
MODULE –2		
Replication, Repair and Recombination**:** Mode of DNA Replication, basic Requirements for DNA Synthesis, Steps involved in DNA synthesis, Origin of replication in Prokaryotes and Eukaryotes. Replication initiation, elongation and termination in prokaryotes and eukaryotes; Repliosome and Replication Fork, Enzymes and accessory proteins; Fidelity; Replication of single stranded circular DNA – Mitochondrial and Chloroplast DNA.	**10**	**L1, L2, L3**

DNA damage and DNA repair, DNA repair mechanisms - Photoreactivation; Nucleotide excision repair; Mismatch correction; Post replication repair and SOS repair; Recombination: Homologous and non-homologous; Site specific recombination.		
MODULE – 3		
Basic features of RNA synthesis and Steps involved in Transcription, Prokaryotic & Eukaryotic RNA Polymerases, Prokaryotic Transcription and regulation; Transcription unit, Promoters and Transcription process, Initiation; Attenuation; Termination: Rho-dependent and independent; Antitermination. Transcriptional control in lambda phage; Eukaryotic transcription and regulation; RNA polymerase structure and assembly; RNA polymerase I, II, III; Eukaryotic promoters and enhancers; General Transcription factors; TATA box binding protein (TBP) and TBP associated factors (TAF); Activators and repressors; Transcript processing; Processing of tRNA and rRNA.	**10**	**L1, L2, L3**
MODULE – 4		
Gene regulation and Operon concept, Constitutive, Inducible and Repressible systems; Operators and Regulatory elements; Positive and negative regulation of operon; lac, trp, ara, his, and gal operons and their regulation; Transcriptional and post-transcriptional gene silencing. Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing and polyadenylation; Splicing; RNA editing; Nuclear export of mRNA; mRNA stability; Catalytic RNA. ; Chi sequences in prokaryotes; Gene targeting; Gene disruption; FLP/FRT and Cre/ Lox recombination.	**10**	**L1, L2, L3**
MODULE – 5		
Translation and Protein targeting; Requirements for protein biosynthesis, Steps involved in protein biosynthesis, Ribosomes; Composition and assembly; Genetic code; Evolution of Triplet concept, Properties of genetic code. tRNA and its role in translation; Wobble hypothesis; Mechanism of initiation, elongation and termination; Co- and post-translational modifications; Genetic codon variation in mitochondria; Transport of proteins and molecular chaperones; Protein stability; Protein turnover and degradation.	**10**	**L1, L2, L3, L4**
Course outcomes: At the end of the course the graduates should be able to: • Develop a profound foundation in fundamental of biochemical concepts. • Explain the expression, regulation, manipulation, of genes and genetic manipulation techniques in the living cells at transcriptional and post transcriptional level.		

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / Development of Solutions
- Modern Tool Usage
- Individual and Team Work

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. Benjamin Lewin, Gene IX, 9th Edition, Jones and Barlett Publishers, 2007.
2. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; Molecular Biology of the Gene, 6th Edition, Benjamin Cummings Publishing Company Inc, 2007.

REFERENCE BOOKS

1. Charles R. Cantor, Paul R. Schimmel, Biophysical Chemistry. W.H.Freeman, 1980.
2. G P Jeyanthi, Molecular Biology, MJP Publishers Chennai 2009.
3. Veer balRastogi, Fundamentals of Molecular biology,Ane's Publication New Delhi 2011 .
4. John Kurian , The Molecules of Life , Garland Science , 2012

ENZYME TECHNOLOGY (ELECTIVE)			
Subject Code	**16BBT151**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS 03			

Course objectives :

- Conceptualize for product separation techniques from biological source and their utility in various industries.
- Principles and techniques involved in kinetics and immobilization of enzymes.

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
Introduction, current and potential uses of enzyme technology. Enzymes as biocatalysts: advantages and	**08**	**L1, L2,L3**

disadvantages over chemical catalysts and characteristics. Extraction and Purification of Enzymes: Extraction of enzymes: Extraction of soluble enzymes and membrane-bound enzymes, nature of extraction medium and conditions of extraction. Purification of enzymes: preliminary and secondary purification procedures, degree of purification and criteria of purity of enzymes. Determination of molecular mass of enzymes.		
MODULE –2		
Enzymatic Techniques: Principles of enzymatic analysis. End-point and kinetic methods, immunoassays, spectrophotometric, electrochemical and radiochemical. Test strips methods, automation in enzymatic analysis: fixed time, fixed and continuous concentration. Handling of enzymes and coenzymes. Applications of enzymes in medicine and diagnostic kits; therapeutic enzymes.	**08**	**L1, L2,L3,L4**
MODULE – 3		
Industrial Applications of Enzyme Technology: Textile industry, detergents, pulp and paper, leather, wood, animal feed, food and dairy industry - amylases, proteases, lipases, pectinases. Immobilization of Enzymes: Introduction, immobilization techniques and carriers. Immobilization techniques for soluble and insoluble (bound) enzymes. Immobilization of cells and organelles. Activity and kinetics of immobilized enzymes.	**08**	**L3,L4**
MODULE – 4		
Immobilized Enzyme Reactors: Types of bioreactors: Batch stirred tank, plug-flow tubular, continuous stirred tank, fixed (packed) bed, fluidized bed and membrane. Applications Of Immobilized Enzymes: Enzyme sensors for clinical analysis, therapeutic medicine (intracorporeal and extracorporeal applications). Production of high-fructose corn syrup, L-aspartic acid, L- alanine and acrylamide. Environmental applications. Economic aspects of immobilized enzymes, microorganisms, mammalian cells and plant cells. Safety aspects.	**08**	**L1, L2, L3, L4**
MODULE – 5		
Enzyme Engineering: Glucose isomerase, subtilisin, redesigned lactate dehydrogenase. Synthetic enzymes-peroxidase. Catalytic antibodies.	**08**	**L3, L4, L5**
Course outcomes: • After completion of the course, students are able to utilize the principles of enzyme purification and the product in various industries.		
Graduate Attributes (as per NBA) • The question paper will have ten questions • Each full question consists of 16 marks. • There will be 2 full questions (with a maximum of four sub questions) form each module. • Each full question will have sub questions covering all the topics under a module.		

- The students will have to answer 5 full questions, selecting one full question from each module.

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. Klaus Buchholz, Volker Kasche and Uwe Theo Bornscheuer. Biocatalisys and Enzyme Technology. 1st edn. Wiley-VCH, 2005.
2. Wolfgang Aehle. Enzymes in industry-production and applications. 3rd edn. Wiley-VCH, 2007.
3. Chaplin M.F. and C. Bucke. Enzyme Technology. CUP. Cambridge. 1990.

REFERENCE BOOKS

1. Price N. C. and L Stevens. Fundaments of Enzymology: 3rd edn. Oxford University Press. 2003.
2. Trovor Palmer. Enzyme- Biochemistry, Biotechnology, Clinical chemistry. East West Press Pvt Ltd. 2004.
3. Bommanius A.S. and R. Riebel. Biocatalysis. Wiley-VCH. 2004.
4. Octave Levenspiel. Chemical Reaction Engineering. 3rd Edition. John Wiley and Sons. 1999.

ANALYTICAL TECHNIQUES (ELECTIVE)			
Subject Code	**16BBT152**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**08**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03

Course objectives : The course will enables the students:

- To develop technical skills of all basic biochemical and biophysical techniques.
- To use appropriate analytical methods and to critically review the experimental observations.
- To inculcate the ability to design & conduct case-specific experiments, and analyze the results.

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		

BRIEF REVIEW OF ELECTROMAGNETIC SPECTRUM AND ABSORPTION OF RADIATIONS: Theory of spectroscopy, absorption by organic molecules, choice of solvent and solvent effects, modern instrumentation – design and working principle. Applications of UV-Visible spectroscopy (qualitative and quantitative analysis). Principles of vibrational spectroscopy, frequency and factors influencing vibrational frequency, instrumentation and sampling techniques, interpretation of spectra, applications in biology. FT-IR-theory and applications, Attenuated Total Reflectance (ATR). Raman Spectroscopy, theory, instrumentation, and applications to biology. Discussions with Case studies.	**08**	**L1, L2,L3**
MODULE –2		
FUNDAMENTAL PRINCIPLES OF NMR: Instrumentation, solvents, chemical shift, and factors affecting chemical shift, spin-spin coupling, coupling constant, and factors influencing the value of coupling constant, spin-spin decoupling, proton exchange reactions, FT-NMR, 2D -NMR, NMDR, NOE, NOESY, COSY and applications in Pharmacy, interpretation of spectra, C13 NMRIntroduction, Natural abundance, C13 NMR Spectra and its structural applications. Discussions with Case studies.	**08**	**L2,L3,L4, L5**
MODULE – 3		
BASIC PRINCIPLES AND INSTRUMENTATION OF ION FORMATION AND TYPES: Fragmentation processes and fragmentation pattern, Chemical ionization mass spectroscopy (CIMS), Field Ionization Mass Spectrometry (FIMS), Fast Atom Bombardment MS (FAB MS), Matrix Assisted laser desorption / ionization MS (MALDI-MS), GC-MS. LC-MS. MS-MS. Discussions with Case studies.	**08**	**L2, L3,L4, L5**
MODULE – 4		
INTRODUCTION TO X-RAY: Generation of X-rays, X-ray diffraction, Bragg's law, X-ray powder diffraction, interpretation of diffraction patterns and applications. Single crystal diffractions of biolomolecules. Fibre diffraction. Neutron diffraction. XAFS. ORD Principle, Plain curves, curves with cotton effect, octant rule and its applications with example, circular dichroism and its relation to ORD. Discussions with Case studies.	**08**	**L2, L3, L4, L5**
MODULE – 5		

CHROMATOGRAFIC TECHNIQUES: Classification of chromatographic methods based on mechanism of separation: paper chromatography, thin layer chromatography, ion exchange chromatography, column chromatography and affinity chromatography – techni ques and applications. Gas Chromatography : Theory and principle, column operation, instrumentation, derivatisation methods and applications. HPLC, LC-MS and applications in HPTLC. Discussions with Case studies.	**08**	**L2, L3, L4, L5**

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

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

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Modern Tool Usage • Life-long Learning

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. Fundamentals of Bioanalytical Techniques and Instrumentation, Sabari Goshal & A K Shrivastava, PHI, 2009.
2. Donglas A. Skoog, James, J. Leary, Principles of Instrumental Analysis by, 4th Edition. 1992.
3. George T. Tsao, Philip M. Boyer Chromatography, Springer-Verlag, 1993
4. James W. Munson, Pharmaceutical Analysis – Moder n Methods, Taylor & Francis, 2001

REFERENCE BOOKS

1. A. H. Beckett & J. B. Stenlake, Practical Pharmaceutical Chemistry, 4th Edition, 1988.
2. B. K. Sharma, Instrumental Methods of Chemical Analysis, Goel Publishing House Meeru 9th Edition, 2000.
3. Saroj Dua & Neera Garg, Biochemical Methods of Analysis, Alpha Science, 2010.
4. Robert. M. Silverstein, Spectrometric identification of Organic Compounds, 7th Edition, 1981.

IMMUNOTECHNOLOGY (ELECTIVE)			
Subject Code	**16BBT153**	**IA Marks**	**20**
Number of Lecture Hours/Week	**03**	**Exam Marks**	**80**
Total Number of Lecture Hours	**40**	**Exam Hours**	**03**

CREDITS – 03

Course objectives: The course will enables the students

- To describe the basic principles, concepts of Immunology and understand the organs, cells, molecules as well as pathways involved in the induction and regulation of innate & adaptive immunity
- To gain an understanding on the characteristics of antigens, antibodies, humoral, cell mediated immune responses and their regulatory responses
- Integrate information on the role of the immune system in complement system, hypersensitivity, transplantation, immuno-disorders, Tumors and the requirements for developing new safe and effective therapeutics
- Demonstrate a comprehensive understanding of the theory behind the immuno-techniques used in the research project, diagnosis and show a critical awareness of how these techniques can be applied to biological problems

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE – 1		
THE IMMUNE SYSTEM: Introduction: Phylogeny of Immune system, Immunity, Clonal nature of immune response. Organisation and structure of lymphoid organs and cells. Nature and Biology of antigens and antibodies classes, subclasses and determinants.	**08**	**L1, L2,L3**
MODULE –2		
LYMPHOCYTE MEDIATED IMMUNITY B-lymphocytes and their activation; Genetic control of antibody production, production of monoclonal and polyclonal antibodies. MHC Complex, antigen presenting cells (APC), mechanisms of T cell activation, Cell mediated cytotoxicity: mechanism of T cell and NK cell mediated lysis, antibody dependent cell mediated cytotoxicity and macrophage mediated cytotoxicity Antigen processing and presentation.	**08**	**L1, L2,L3,L4**
MODULE – 3		

IMMUNE REGULATION AND THERAPY Complement activation**,** cytokines, Hypersensitivity, Autoimmunity, Immuno-deficiency, production of recombinant-DNA vaccines. Catalytic antibodies, application of PCR technology to produce humanized antibodies, immunotherapy with genetically engineered antibodies,	**08**	**L2, L3,L4**
MODULE – 4		
TRANSPLANTATION IMMUNOLOGY Immunological basis of graft, types of transplantation, mechanism of graft rejection, role of HLA in graft rejection, tissue typing, immuno-suppression and immunosuppressive drugs, immuno-tolerance, tumor specific antigens, mechanism of AIDS	**08**	**L3, L4, L5**
MODULE – 5		
IMMUNODIAGNOSIS Antigen antibody interaction – Precipitation reactions, Agglutination reactions, Blood typing, A, B, ABO & Rh, principles and applications of ELISA, Radio Immuno Assay (RIA), western blot analysis, immuno-electrophoresis, surface Plasmon resonance (SPR)based immunoassay, immuno-fluorescence, chemiluminescence assay, FACS.	**08**	**L3, L4, L5**

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

- Gain an in-depth knowledge in the basic principles, concepts of immunology wrt the cells, molecules and pathways involved in the induction and regulation of innate and adaptive immunity
- Recognize and distinguish the immunity exhibited by humoral and cell mediated immune responses against an antigen
- Dissect, compare and infer the diversified roles of immune system, recognize the disorders of the immune system and the requirements for developing new, safe and effective therapeutics
- Acquire proficient skills and an insight into the importance, principles, limitations of immunological, pathological testing techniques including therapies in clinical practice and communicate results of research project effectively with the scientific community

Graduate Attributes (as per NBA):

• Problem Analysis
• Design / development of solutions.
• Societal and Environmental concern
• Lifelong Learning

Question paper pattern:

• The question paper will have ten questions.
• Each full question consists of 16 marks.
• There will be 2 full questions (with a maximum of four sub questions) from each module.
• Each full question will have sub questions covering all the topics under a module.

• The students will have to answer 5 full questions, selecting one full question from each module.
Text Books 1. Sharon J.,"Basic Immunology" Williams and Wilkins. (1998). 2. Roitt I., Brostoff, J and Male, D., "Immunology", Mosby Publ. (2002). 3. Kuby J., "Immunology", W.H. Freeman & Co. (2006).
Reference Books 1. Janeway C. and Travers P., "Immunobiology", Garland Publ. (2001). 2. Abbas A., Litchman A. H., and Pober J., "Cellular and Molecular Immunology" W B Saunders & Co.(2000)

GENETIC ENGINEERING TECHNIQUES (ELECTIVE)			
Subject Code	**16BBT154**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**08**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS 03			
Course objectives : The course will enables the students: • To impart theoretical knowledge of the Molecular Biology and Genetic Engineering. • To develop technical skills including the ability to design & conduct experiments • To use appropriate analytical methods to critically review the experimental observations and results			
MODULES		**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1			
DNA REPLICATION: Comparative account on initiation, elongation and termination in prokaryotes and eukaryotes DNA Repair: Mismatch correction, Mechanisms in thymine-dimer repair: Photoreactivation, Nucleotide excision repair, SOS repair DNA Recombination: Homologous and non-homologous recombination; Holliday Model; Site specific recombination: General mechanism, Examples: SSR in Bacteriabacteriophage, FLP/FRT and Cre/Lox recombination. Transcription: Prokaryotic & Eukaryotic Mechanisms; Significance of Promoters, Enhancers, Silencers, Transcription factors, Activators and repressors; Post transcriptional modifications; Transcription inhibitors		**08**	**L1, L2,L3**

MODULE –2		
GENETIC CODE AND ITS PROPERTIES: Wobble hypothesis. Translation: Role of Ribosomes & tRNA; Mechanism of translation: Activation of amino acids, initiation complex formation, elongation of polypeptide, termination and release of polypepetide; Post-translational modifications; Transport of proteins and molecular chaperones. Transcriptional regulation in Prokaryotes: General mechanism of positive and negative control; Operon concept: lac, trp, and gal operons; Transcriptional control in Eukaryotes: Chromatin remodeling: Acetylation and deacetylation of histone proteins; Regulatory proteins: DNA binding transactivators, coactivators; Homeotic gene and their role in gene regulation.	**08**	**L1, L2,L3,L4**
MODULE – 3		
Plasmids, Phage Vectors, Phagemids, Cosmids, YACs and BACs; Cloning & Expression vectors. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering: Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction: General mechanism and applications; Variants of PCR; In vitro mutagenesis.	**08**	**L2, L3,L4**
MODULE – 4		
Microprojectile bombardment; Agrobacterium transformation, Ti plasmid: structure and functions, Ti plasmid based vectors, mechanism of T- DNA transfer; Chloroplast transformation; Transgenic science in plant improvement: resistance to biotic and abiotic stresses, biopharming – plant s as bioreactors. Introduction of DNA into mammalian cells; Animal vectors and Transfection techniques; Transgenic science for improvement of animals and livestock, animal as bioreactors for recombinant proteins. Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Genetic manipulation of microbes for the production of insulin, growth hormones.	**08**	**L3, L4, L5**
MODULE – 5		
Introduction of DNA into mammalian cells; Animal vectors and Transfection techniques; Transgenic science for improvement of animals and livestock, animal as bioreactors for recombinant proteins. Gene transfer techniques into microbial cells: transformation, electroporation, lipofection, calcium phosphate mediated; Genetic manipulation of microbes for the production of insulin, growth hormones.	**08**	**L3, L4, L5**

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

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

Graduate Attributes (as per NBA)

- Problem Analysis.
- Design / development of solutions.
- Life-long Learning

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter. Molecular Biology of the Cell, 4th edition, New York: Garland Science; 2002.
2. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell. Molecular Cell Biology, 4th edition, New York: W. H. Freeman; 2000.
3. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001

REFERENCE BOOKS

1. Brown TA, Genomes, 3rd edition. Garland Science 2006.
2. T. A. Brown. Gene Cloning: An Introduction, Stanley Thornes Publishers Limited, 1995.
3. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001

CHEMICAL ENGINEERING AND MOLECULAR BIOLOGY LAB

Subject Code	**16BBTL16**	**IA Marks**	**20**
No. of Lab Hrs./ Week :	**03**	**Exam Marks**	**80**
		Exam Hours	**03**

CREDITS 02

Course objectives :

To provide hands on training with procedures for real time problems in chemical engineering and to teach molecular biology technique.

Sl.NO	Experiment	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
1	Calculation minimum settling velocity of cells.	**L3**
2	Calculation of fluidizing velocity of immobilized enzyme system.	**L4**
3	Rate of drying.	**L3**
4	Extraction of antibiotics from different organic solvent and studying its efficiency of extraction.	**L3**
5	Study of adsorption of proteins on matrix by different isotherms.	**L3**
6	Study of mass transfer effect on reaction of immobilized enzymes.	**L4**
7	Isolation of genomic DNA from Bacteria/ Plant/ Animal cells and its quantification.	**L3**
8	Study of Denaturation and Renaturation of DNA and Calculation of Tm value of DNA.	**L4**
9	Isolation of total RNA from *E.coli.*	**L3**
10	Preparation of Competent *E coli* cells and Transformation.	**L3**
11	Isolation of Plasmid DNA and its purification.	**L3**
12	Restriction analysis and agarose electrophoresis of DNA.	**L3**

Course outcomes:

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

- Perform experiments related to methods in chemical engineering and basic molecular biology techniques.

Graduate Attributes (as per NBA)

- Problem analysis
- Design / Development of solutions
- Modern tool usage
- Communication
- Life-long learning

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

TEXT/REFERENCE BOOKS

1. Hans Peter Schmauder (Editor). Methods in Biotechnology Published by Taylor & Francis. 2004.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Keith Wilson and John Walker, Pricniples and Techniques of Biochemistry and Molecular Biology, 2000.

II SEMESTER

INDUSTRIAL BIOTECHNOLOGY			
Subject Code	**16BBT21**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**
CREDITS 04			

Course objectives : This course will enable students

- To understand the details of microbial techniques for growth, cultivation and characterization of microorganisms with industrial importance.
- To appreciate the recent developments in the area of medical microbiology, environmental microbiology, industrial microbiology, etc.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
INTRODUCTION: The era of the discovery of Microbes, Pasteur and fermentation, The discovery of Antibiotics, Production strains, screening techniques, Growth of Industrial Fermentations, Screening techniques, Strain Development, Preservation of Micro organisms and Preparation of Inoculum.	**10**	**L1,L2,L3**
MODULE –2		
MICROBIAL TRANSFORMATION AND PRODUCTION MEDIA: Characteristics of an Ideal Production Media, Raw materials for production, Screening for production Media, Principles of Sterilization, Sterilization equipment, Sterilization of production Media, Sterilization of Air.	**10**	**L1,L2,L3**
MODULE – 3		
PRINCIPAL TYPES OF FERMENTOR IN INDUSTRIES: Introduction to Fermentors, Factors involved in fermentor Design, Fermentor configurations, Principal operating characteristics of fermentors, Computer control of Fermentation process, Computer application in fermentation technology, Justification and Planning.	**10**	**L1,L2,L3**
MODULE – 4		

MICROBIOLOGICAL ASSAY: Introduction and History of Assay, Microbiological assay of: Vitamins and Amino Acids, Antibiotics, Trace elements. Advantages and Disadvantages of Microbiological Assay, Automation of Microbiological Assay.	**10**	**L1,L2,L3,L4**
MODULE – 5		
INDUSTRIAL APPLICATIONS OF MICROBES: Pharmaceutical sector, Food and Enzymes Industries. Fermented foods. Sewage and Sewage disposal, Objectives of Sewage treatment, Collection of Sewage, Sewage treatment Methods.	**10**	**L2,L3,L5**

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

- Understand the techniques used for the isolation, growth, identification, disinfection and sterilization of microorganisms used in the Industries.
- Define the role of microorganisms towards environmental protection, industrial applications.
- Out-line industrial fermentation processes leading to the production of antibiotics, organic acids, enzymes, vitamins and therapeutic products.

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Societal and Environmental concern
- Life-long Learning

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. Microbiology by Michael J Pelczar Jr Chan ECS, Noel R Krieg, Tata McGraw Hill Publishing co ltd.
2. Microbiology by Prescott, Harley, Klein, McGraw Hill.
3. Industrial Microbiology by Samuel C Prescott, Cecil G Dunn, Agro bios (India)
4. Palynology and its applications By Shripad N.Agashe, Oxfor and IBH publishing Pvt. Ltd.
5. Biotechnological Applications of Microbes by Edite-Ajit Verma, IK Intl. Pub House.
6. Alcamos Fundamentals of Microbiology by Jeffery C Pommerville, Jones and Bartlett Publishers.
7. Microbiology, an Introduction, Gerard J. Tortora, Berdell R. Funke, Christine L. Case, 2012. Pearson
8. Principles of Microbiology: Ronald M Atlas, 1995.McGraw-Hill Inc., US (addition)
9. Microbiology: Principles and Explorations, Jacquelyn G. Black, 8thEdition, John Wiley & Sons,2012.

REFERENCE BOOKS

1. The Air Spora: A manual for catching and identifying airborne biological particles. Maureen E. Lacey and Jonathan S. West. Springer.
2. Soil Microbiology by NS Subba Rao, Oxford and IBH.
3. Palynology and its applications By Shripad N.Agashe, Oxfor and IBH publishing Pvt. Ltd.
4. Text Book of Microbiology by Anantahnarayan and Jayaram Panicker, Universities Press.

ADVANCED BIOINFORMATICS			
Subject Code	**16BBT22**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**
CREDITS 04			

Course objectives :

- To have knowledge of molecular and genetic engineering principle to design and predict the structure of novel compounds.
- To know the principle of drug design and its applications in proteomics and genomics. Explore logical and critical thinking ability to solve biological problems with the help of BioPerl and other bioinformatic techniques

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
Basic Concepts of Molecular Biology: Proteins, Nucleic Acids: DNA, RNA. Molecular Genetics: Genes and Genetic code, Transcription, Translation and Protein synthesis, Chromosomes Genome: Maps and Sequences, Sequencing Techniques, Human Genome project, Sequence Databases.	**10**	**L1,L2,L3**
MODULE –2		
Biological Databases: Types of databases – Primary and Secondary biological databases. Primary databases, secondary databases, genotype databases, molecular structure databases and genome databases. Hidden Markov Models: Forward and Backward algorithm, Viterbi algorithm, Applications: Modelling Protein sequence families, multiple alignments.	**10**	**L2, L3, L4**
MODULE – 3		

Protein Modeling and Insilico Drug Design: Protein structure, signal peptides, transmembrane proteins, analysis of protein structures. Protein modeling, modeling protein structures using High Throughput methods. Insilico drug design, Virtual Library design, vHTS and Scaffold Hopping, Predictive Science (Biological Activity, ADMET). Structure based Drug Design (SBDD), Lead Optimization, Structural Mining: Protein Ligand work analysis. Study of drug-interactions, Docking.	**10**	**L1, L2, L3**
MODULE – 4		
Perl and Bioinformatics: Basics of PERL, Intermediate and Advanced, Biological databases, Sequence analysis and alignment, Evolutionary analysis. Metabolomics. Working with Discovery Studio (Molecular Modeling): 2D and 3D visualization, 2D and 3D molecular descriptors, Quantum mechanics / molecular, mechanics. SAR analysis, 2D and 3D QSAR. Bayesian statistics, neural networks, recursive partitioning, GFA, etc. Library analysis and Library design. Predictive ADME and toxicology (TOPKAT®), Conformation generation and Analysis. Structure-based and structure-guided design, docking, scoring. Virtual screening and compound ranking/scoring.	**10**	**L4,L5, L6**
MODULE – 5		
Receptor-ligand interactions analysis, Fragment-based design, de novo design (LUDI), Pharmacophore generation (Catalyst), Scaffold hopping, 3D database screening, Simulations, molecular mechanics/dynamics (CHARMm). Explicit/implicit solvation models, Transmembrane protein modeling, Homology modeling, Antibody modeling, Electrostatics calculations, protein ionization and pK prediction, Protein modeling (MODELER®) and analysis, protein engineering. Protein-protein docking and refi nement, Sequence analysis, sequence alignment, phylogenetic analysis, • X-Ray (CNX), structure refi nement and analysis	**10**	**LI, L2,L3,L4,L5**
Course outcomes: After completion of the course, students are able to explain the overview of bioinformatics and biological databases, use the knowledge of docking to know the 3D structure of receptor; its scope and limitation.		
Graduate Attributes (as per NBA) • Problem Analysis • Design / development of solutions. • Life-long Learning		
Question Paper Pattern: • The question paper will have ten questions. • Each full question consists of 16 marks • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module.		

The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. David W. Mount. "Sequence and Genome Analysis", Bioinformatics CSHL Press, 2nd Ed., 2004.
2. Baxevanis and F. B. F. Ouellette. "Bioinformatics: a practical, guide to the analysis of genes and proteins", JohnWiley, 2nd Ed., 2001.
3. Jonathan Pevsner. "Bioinformatics and Functional Genomics", Wiley-Liss, 1st Ed., 2003.

REFERENCE BOOKS

1. Setubal Joao and meidanis Joao, Introduction to Computational Molecular Biology, Publisher: PWS Publishing; 1st edition, 1997.
2. R. Durbin, S. Eddy, A. Krogh and G. Mitchison, Biological Sequence Analysis, Cambridge. Cambridge University Press, 1998.
3. Paul M. Selzer, Richard J. Marhöfer, Andreas Rohwer, Applied bioinformatics: an introduction, Berlin Springer 2008.

AGRICULTURAL BIOTECHNOLOGY

Subject Code	**16BBT23**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS 04

Course objectives : The course will enable the students

- To understand the significance of sustainable development Agricultural biotechnology
- To comprehend the importance of various technologies to protect economical crops
- To appreciate the importance of Genetically modified plants and their management

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
INTRODUCTION TO AGRICULTURAL BIOTECHNOLOGY: Introduction, history and scope of agriculture in India. Staple food, fiber, fuel and fruit crops of India and abroad, Agro-climatic zones and cropping pattern of India. Conventional crop improvement programs- Introduction, Selection and Hybridization, Mutation, Haploidy and Polyploidy Breeding. Modern agriculture biotechnology for food security and national economy.Green-revolution.	**10**	**L1, L2,L3**

MODULE –2		
APPLICATIONS OF PLANT TRANSFORMATION TECHNOLOGY: Productivity and performance disease resistance, genes and gene constructs used for viral resistance by coat protein mediated production, bacterial resistance by lysozyme gene and fungal resistance by chitinase and beta glucanase genes. Agrobacterium mediated tranformation. Crop improvement to resist adverse soil conditions. Salinity tolerance, drought resistance. Herbicide resistance in commercially important plants. Insecticide resistance through BT-gene. Integrated pest management. current status of BT crops in the world. Effect of transgenic crops on environment	**10**	**L3,L4, L5**
MODULE – 3		
INTRODUCTION TO PLANT CELL CULTURE: Explant selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2; Callus and cell suspension culture; plant regeneration: organogenesis. Somatic embryogenesis; somaclonal variation, its genetic basis and application in crop improvement. Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and "synthetic seeds"; haploid production: advantages and methods. Protoplast technology.	**10**	**L3,L4, L5, L6**
MODULE – 4		
Antisense RNA technology (ACC synthase gene and polygalacturonase) Delay of softening and ripening of fleshy fruits by antisense RNA for ACC synthase gene in tomato, banana. Use of antisense RNA technology for extending shelf life of fruits and flowers. Protection of cereals, millets and pulses following harvest using biotechnology. Biotechnology for fortification of agricultural products- Golden rice, transgenic sweet potatoes. Importance of biofertlilizers in agriculture. (Rhizobium azatobacter, Mycorrhiza, Frankia and Blue green algae) current practices and production of biofertilizers	**10**	**L3, L4, L5, L6**
MODULE – 5		
AN OVERVIEW OF LEGAL AND SOCIO-ECONOMIC IMPACT OF BIOTECHNOLOGY: Biotechnology & hunger. Ethical issues associated with labeling and consumption of GM foods. Public perception of GM technology. Biosafety management. Cartagena protocol on biosafety. Ethical implication of BT products, public education, Biosafety regulations, experimental protocol approvals, guidelines for research, environmental aspects of BT applications	**10**	**L3, L4, L5,**
Course outcomes: After studying this course, students will be able to: • Demonstrate strong basics in principles of Agricultural Biotechnology • Appreciate the ability to use biotechnology for sustainable development.		

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Life-long Learning • Societal and Environmental Concern

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. Singh BD (2003) Biotechnology- Expanding Horizons. Kalyani Publishers, Rajindernagar, Ludhiana.
2. Bhojwani SS and Razdan MK (1996) Plant Tissue Culture: Theory and Practice, a revised edition. Panima Publishing Corporation, New Delhi.

REFERENCE BOOKS

1. Lindsey, K and Jones. (1990) Plant biotechnology in Agriculture. Prentice Hall, USA.
2. Rajashekaran K, Jacks TJ and Finley JW (2002) Crop Biotechnology. American Chemical Society, Washington, DC

ENVIRONMENTAL BIOTECHNOLOGY			
Subject Code	**16BBT24**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**
CREDITS 04			

Course objectives : The course will enable the students

- To understand the significance of sustainable development and protection of ecosystem.
- To comprehend the importance of various treatment technologies to clean up the environment

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		

INTRODUCTION TO ENVIRONMENT: Concerns pertaining to Ecological damage, Environmental Pollution Types - Water, Soil, Air, Noise and Thermal pollutions, their sources and ecological effects of pollutants on living and non-living systems.. Acid rain: sources and solutions. Significance of GHGs and carbon footprint; Biodegradation, of xenobiotic compounds, organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. Microbial desulfurization of coal. Environmental implications of Acid mine drainage and its remediation; Role of Biotechnology in providing solutions to environmental problems	**10**	**L1,L2,L3**
MODULE –2		
BOD, COD and TOC – Estimation and correlation; Definition of Waste; Physical, Chemical and Biological characteristics of Industrial waste. Nitrification and Denitrification and their kinetics; Wastewater treatment systems. Waste Management in different industries (food processing, leather tanning, pharmaceutical, textile) Solid waste management: landfills, composting, earthworm treatment, recycling and processing of organic residues, Sources and dispersion of atmospheric pollutants and dispersion models. Control methods for air pollutants, noxious pollutants and odor control; Design of air pollution control equipments; Photochemical reactions.	**10**	**L2,L3,L4, L6**
MODULE – 3		
WASTE TREATMENT METHODS: Types (Suspended and Attached growth processes), Aerobic and Anaerobic treatment of wastes; Other biological treatment process, Anaerobic digestion – Stoichiometry & Kinetic relationships, design consideration, Process modeling and control, Biological nutrient removal, Biological treatments with Case studies; Bioremediation types and biorestoration of contaminated lands. Handling of hazardous wastes from bioprocess industries and related case studies.	**10**	**L2, L3,L4, L5, L6**
MODULE – 4		
ENVIRONMENTAL SENSING TECHNIQUES: Characterization of water contaminants and their measurement, Spectroscopic techniques, AAS, NAA, GCMS, HPLC, Electro analytical techniques, Environmental sensing techniques. Discussions with Case studies.	**10**	**L2, L3, L4**
MODULE – 5		

ENVIRONMENTAL POLICIES AND REGULATIONS: Waste minimization and its plan; Conservation of water and energy, Fugitive loss, Programs of municipal pollution control, Risk evaluation and decision analysis. Sustainable development, Environmental Management Systems, ISO and ISO 14000 series: Introduction, Areas covered in the series of standards, Necessity of ISO certification, Environmental Auditing; Other tools for environmental management, Environmental Impact assessment(EIA) and its future and scope. Objectives, Elements of EIA, Baseline studies Methodologies of EIA , , Types of impacts, Prediction of impacts and its methodology, Uncertainties in EIA, Status of EIAs in India. EIA at various industries	**10**	**L2, L3, L4**

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

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

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Societal and Environmental concern.
- Life-long Learning

Question Paper Pattern: The question paper will have ten questions.

- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. Pradipta Kumar Mohapatra, Textbook of Environmental Biotechnology, I K International, 2007
2. Buckingham and Evans, Hazardous Waste Management, LaGrega, 2 nd Edition, McGraw Hill International Edition, 2001.
3. Noel De Nevers Air Pollution Control Engineering, 2 nd Edition, McGraw Hill International Edition, 2000

REFERENCE BOOKS

1. Bailey & Ollis, Biochemical Engineering Fundamentals, 2 nd Edition, McGraw Hill International Edition, 1986
2. Standard Methods for the Examination of Water and Waste Water, 22ndEdition , AmericanPublic Health Association, American Water Works Association & Water Environment Federation, 2012.
3. Environmental Management, N K Uberoi, 2 nd Edition, Excel Books publication, 2007
4. Environmental Impact Assessment, Canter, 2 nd Edition, McGraw Hill International Edition,1996

FOOD BIOTECHNOLOGY
(ELECTIVE)

Subject Code	**16BBT251**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03

Course objectives :

- Understand the components of food and principles of food spoilage and techniques for food preservation.
- Know the application of biotechnology for food preservation and food production with improved nutritional benefits.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
Basic Constitutes of Food: Basic constituents of food, colloidal systems in food, molecular stability of colloidal systems, types of food starches, soluble fibers: pectin's, mucilage & gums, protein rich foods, oils in foods. Food Microbiology: Microbial growth pattern, types of microorganisms associated with food: mold, yeast and bacteria. Contaminants of food stuff, milk and meat during handling and processing. Mechanism of food spoilage. Biochemical changes caused by microorganism. Determination of various types of food products. Food borne intoxicants and mycotoxins.	**08**	**L1, L2**
MODULE –2		
Food Preservation Technology: Food preservation by high and ultra high temperatures- canning, drying. Food dehydration: Equipments for food dehydration: fixed tray dehydration, cabinet drying, tunnel drying. Freeze dehydration, controlled atmosphere, storage, Food preservation by irradiation treatment. Preservation by freezing and refrigeration. Frozen foods. Thermal properties of frozen foods. Food freezing equipments: Air blast freezers, plate freezers and immersion freezers. Preservation by Chemicals and Bacteriocins.	**08**	**L1, L2, L3**
MODULE – 3		

Introduction to plant cell culture. Explant selection, sterilization and inoculation; Various media. Food Production Technology: Importance of food industry, specific objectives of food processing, impact of food processing on food constituents. Production of single cell protein, Tailoring of milk proteins and milk fats, Production of fermented food products: yoghurt, pro-biotic cheese.Nutritional value, labeling of constituents: Soya foods, organic foods, dietary foods, nutritional food supplements, Use of plant cell culture for the production of food additives (Vanillin, Capsaicin),microbial transformations, regulatory and social aspects of BT. Food packaging, edible films, Marketing of food and promotional strategies.	**08**	**L1, L2, L3,L4**
MODULE – 4		
Biotechnology for Improved Processing: Role of biotechnology in food industry, maintenance of nutritional quality, Enzymes in bakery and cereal products, utilization of hydrolases and lipases enzymes. Applications of immobilized enzymes in food industry, enzymes for enhanced flavor and aroma compounds, enzymes in fat and oil industries. Genetically modified plants for high nutritional food.	**08**	**L1, L2, L3, L4**
MODULE – 5		
Food Quality Assurance and Control:Importance and functions of quality assurance and control. Methods of quality, concept of rheology, assessment of food materials- fruits, vegetables, cereals, dairy products, meat and processed food products. Microbiological safety of food products, chemical safety of food products, contaminants by heavy metal, fungal toxins and pesticide residue. Food regulations, grades and standards, USFDA/ ISO 9000 Series. Food adulterations and safety, sensors and instrumental analysis in quality control food laws and standards.	**08**	**L1, L2, L3, L4,L5**
Course outcomes: At the end of the course the graduates should be able to: • Enlighten with comprehensive knowledge of biotechnological applications to food industry.		
Graduate Attributes (as per NBA) • Problem Analysis • Design / Development of Solutions • Professional Ethics • Life-long Learning • Communication Efficiency • Societal and Environmental Concern • Innovation and Entrepreneurship		

Question Paper Pattern:

- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. James M, Jay. Food Biotechnology CBS Publishers , 2nd edition, 2005.
2. Kalidasshetty Food Biotechnology, CRC Press. 1st ed. 2005
3. T.Britze, R.K Robinson., Advanced Dairy Science and Technology. Wiley- Blackwell publisher. 1st edition. 2008

REFERENCE BOOKS

1. H. Elmer, L James, Marath and Steele. Applied dairy microbiology, CRC press, 2nd edition, 2005.
2. R. Paul Singh., "Introduction to Food Engineering", Academic Press, 3rd Ed., 2004.
3. P. Fellows, "Food Processing Technology: Principles and practice". Woodhead Publishing Ltd., Cambrideg, 2nd Ed., 2005.

CLINICAL BIOTECHNOLOGY (ELECTIVE)

Subject Code	**16BBT252**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03

Course objectives :

- To understand and emphasis on the various domain of clinical trials and drug metabolism
- To evaluate the intensity and integrity of various diseases and implications of various governing agencies

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
Introduction:Introduction to Clinical study and design of clinical studies. Epidemiological research and treatment studies: Double-blind andSingle-blind Randomized controlled trial, Non-blind trial, Nonrandomized trial-quasi-experiment. Observational studies: Cohort study-Prospective cohort and Retrospective cohort.Time series study, Case-control study andNested case-control study. Community survey and Ecological study. Seasonal studies: Conduction of studies in seasonal indications such as Allergies and Influenza.	**08**	**L1, L2**

MODULE –2		
Statistical Analysis and Interpretation:Background and purpose, trial design consideration, Parallel group design, cross over design, factorial design. Introduction to Statistical Application Software (SAS), procedures and clinical data management.	**08**	**L1, L2, L3**
MODULE – 3		
Drug Design and Synthesis:Synthesis of compounds in accordance with the molecular structure and biological activity concept: Analgesics, neuromuscular blocking agents, anti-fertility drugs and bactericidal & bacteriostatic agents (sulphonamides, mercury compounds and antiseptics). Study of Therapeutic Proteins and Related Case Studies.Blood and Blood products: Clotting factors, anticoagulants, Thrombolytic Agents, Tissue plasminogen activator and streptokinase. Safety guidelines in Blood Transfusion. Therapeutic Proteins: Antibodies, Enzymes, Hormones, Growth factors (Erythropoietin), Vaccines (HIV and Cancer), Interferon and Interleukins.	**08**	**L1, L2, L3**
MODULE – 4		
Cancer Biology and Therapy:Introduction to cancer biology and modes of treatment: radiotherapy, chemotherapy, surgery, Biological therapy, immunotherapy and gene therapy. Clinical Toxicology: Basic concept in toxicology. Types and mechanism of toxin action- Epoxidation & drug toxicity, N-oxidation & drug toxicity and sulphur xenobiotics. Hepatotoxicity and Nephrotoxicity. Biotransformation of toxins, inactivation and removal from the body.	**08**	**L1, L2, L3**
MODULE – 5		
Clinical Research Governance and Ethics: Overview on regulatory affairs for pharmaceuticals, neutraceuticals and medical devices. Good Clinical Practices (GCP) And International quality standard and related guidelines (ICH-E6). Risk assessment and trial monitoring. Legal and ethical issues on biotechnology, medical research and related clinical practice.	**08**	**L1, L2, L3, L4**
Course outcomes: At the end of the course the graduates should be able to: • differentiate between drug toxicity and drug concentration along with the mechanism of various interactions of health sectors.		
Graduate Attributes (as per NBA) • Problem Analysis • Design / Development of Solutions • Modern Tool Usage		

- Professional Ethics
- Life-long Learning
- Communication Efficiency
- Societal and Environmental Concern
- Individual and Team Work
- Innovation and Entrepreneurship

Question Paper Pattern:

- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. Designing clinical research by Stephen B. Hulley, 3rd Edition, 2007
2. Principles and practice of clinical research by John I. Gallin, Frederick P. Ognibene, 2nd Edition, 2006.
3. Conducting GCP- Compliant Clinical Research: A Practical Guide by Wendy Bohaychuk, Graham, Ball University Edition John Wiley & Sons Ltd, New York, 2009.

REFERENCE BOOKS

1. Pharmaceutical Perspectives of Cancer Therapeutics by Ram I. Mahato, Yi Lu University Edition, Springer Dordrecht Heidelberg London, 2001.
2. Design and analysis of clinical trials: concepts and methodologies by Shein-Chung Chow, Jen-pei Liu, 2nd Edition, John Wiley & Sons Ltd, New York, 2004
3. New drug development: design, methodology, and analysis by J. Rick Turner University Edition John Wiley & Sons Ltd, New York. 2004

PHARMACEUTICAL BIOTECHNOLOGY (ELECTIVE)			
Subject Code	**16BBT253**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS 03			

Course objectives : The course will enable the students

- To understand the significance of Pharmaceutical biotechnology towards sustainable development
- To comprehend the importance of various technologies and practices in pharmaceutical industries

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY**

		(RBT) LEVEL
MODULE – 1		
Introduction: Introduction to pharmaceutical biotechnology, pharmacokinetic concepts, current research trends, new advances and approved biologicals for pharmaceutical use and manufacturing principles. Quality assurance and control; Concept of GMP, GLP.	**08**	**L1, L2,L3**
MODULE –2		
THERAPEUTICS BASED ON BIOTECHNOLOGY: Hematopoietic growth factor and coagulation factors, interferons and cytokines; Preparation and standardization of hormones-thyroid, insulin and growth hormones; Enzymes-Enzymatic therapy and monographs; antibiotics and their derivatives-penicillin, streptomycin, tetracycline, cephalosporins, macrolides, peptide antibiotics (any two); vaccines BCG, DPT, Poliomyelitis, Typhus, toxoids-diptheria and tetanus; antitoxins-diptheria and gas-gangrene(any two); others-whole human blood, dried human plasma, gamma globulins, clinical dextran and absorbable haemostats, uses, and storage.	**08**	**L3,L4, L5**
MODULE – 3		
BIOTRANSFORMATION: Introduction, methods used in biotransformation, steroid transformation, contraceptives, L- Dopa, chemical reactions and mechanisms (hydroxylation, aromatization, synthetic routes, epoxidation and others), production and application of monoclonal antibodies.	**08**	**L3, L4, L5**
MODULE – 4		
NUTRACEUTICALS: Antioxidants, flavanoids, carotenoids, cholesterol lowering chemicals, nutritional importance and their functions, deficiency diseases, nutritional status evaluation. Drug delivery systems: Introduction to drug delivery systems and methods, overview of barriers, calculation of drug metabolism and, pharmacodynamics.	**08**	**L3, L4, L5**
MODULE – 5		
RECOMBINANT PROTEINS AND PROTEOMICS IN DRUG DEVELOPMENT: Role of proteomics in drug development Application of recombinant proteins in pharmaceutical industry, health care and future prospects.	**08**	**L3, L4, L5**

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

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

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Societal and Environmental concern
- Life-long Learning

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module

TEXT BOOKS

1. Walsh G (2003). Biopharmaceuticals: Biochemistry and Biotechnology, Second Edition. John Wiley & Sons Ltd.
2. Pharmaceutical Biotechnology:Fundamentals and Applications, Editors: Crommelin, Daan J. A., Sindelar, Robert D., Meibohm, Bernd (Eds.) 2013
3. Modern Biopharmaceuticals: Recent Success Stories by Jorg Knablein 2013, Wiley-Blackwell
4. Modern Biopharmaceuticals: Design, Development and Optimization, 4 Volumes Set 2005 by Jorg Knablein2013, Wiley-Blackwell
5. Pharmaceutical biotechnology by Ashutoskar
6. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Second Edition 2012 by Oliver Kayser, Heribert Warzecha wiely publishing house

REFERENCE BOOKS

1. Manfred E. Wolff Burger's Medicinal Chemistry and Drug Discovery (5th edition) Wiley & Sons, Inc. 2000.
2. Binghe wang, Teruna siahaan, Richard soltero Drug delivery: principles and applications John wiley & sons, 2005
3. Michael D. Coleman Human Drug Metabolism: An Introduction John Wiley & Sons, 2005
4. Ala F. Nassar, Paul F. Hollenberg, and JoAnn Scatina Drug metabolism handbook concepts and applications John wiley & sons 2009.

SYSTEMS BIOLOGY (ELECTIVE)			
Subject Code	**16BBT254**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03		
Course objectives : The course will enables the students • To, appreciate the concepts underlying in various tools in systems biology. • To comprehend the essentials of design of systems biology • Prepare them to leverage their knowledge connectivity in biological sciences		
MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
INTRODUCTION TO SYSTEMS BIOLOGY: Scope, Applications. Concepts, implementation and application. Databases for Systems Biology, Mass Spectrometry and systems Biology. Bioinformatics databases supporting systems biology approaches	**08**	**L1, L2, L3**
MODULE –2		
NETWORK MODELS AND APPLICATIONS: Natural Language Processing and Ontology enhanced Biomedical data mining, text mining. Integrated Imaging Informatics - ntegrin, centroid, cell culture. Standard platforms and applications - metabolic control analysis, glycolysis, metabolic network, Michaelis-Menten kinetics, and flux balance analysis. Signal Transduction - phosphorylation, Jak-Stat pathway, MAP kinase. Biological Processes - mitochondria, cyclin, Cdc2. Modeling of Gene Expression - lactose, lac operon, tRNA. Analysis of Gene Expression Data - support vector machines, cDNA microarray. Evolution and Self organization - hypercycle, quasispecies model, self-replication. Reconstruction of metabolic network from Geme Information	**08**	**L3, L4, L5, L6**
MODULE – 3		
INTEGRATED REGULATORY AND METABOLIC MODELS: Phosphorylation, Gene expression, and Metabolites. Estimation Modeling and Simulation - Circadian rhythms, Petri net, mRNA. Deterministic - Circadian rhythms, mRNA, Circadian oscillations. Multi scale representations of Cells and Emerging Phenotypes - Gene Regulatory Networks, attractor, and Boolean functions. Mathematical models and Optimization methods for De Novo Protein design. Global Gene expression assays. Mapping Genotype - Phenotype relationship in cellular networks	**08**	**L3, L4, L5**
MODULE – 4		
MULTISCALE REPRESENTATIONS OF CELLS AND EMERGING PHENOTYPES: Multistability and Multicellurarity, Spatio-Temporal systems biology, Interactomics, Cytomics – from cell state to predictive medicine.	**08**	**L3, L4, L5**
MODULE – 5		

MODELING TOOLS: SBML, MathML CellML, Petri Nets and Boinformatics tools with case studies and discussions.	**08**	**L2, L3, L4, L5**

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

- Demonstrate strong basics in principles of systems biology.
- Tackle live problems in various spheres of biological sciences

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Modern Tool Usage

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. Computational Systems Biology by Andres Kriete, Roland Eils. Academic Press, 2006.
2. Systems Biology by Andrzej K. Konopka, CRC, 2006.
3. Systems biology in practice: concepts, implementation and application by Edda Klipp, WileyVCH, 2005.
4. Systems Biology by Isidore Rigoutsos, G. Stephanopoulos, Published by Oxford University Press US, 2006.
5. Theoretical Models in Biology by Glenn Rowe, Oxford University Press – Publisher, 2004.

REFERENCE BOOKS

1. Transactions on Computational Systems Biology I by Corrado Priami, Springer – Publisher, 2009.
2. Systems Biology by Fred C. Boogerd, H.V. Westerhoff, Elsevier – Publisher, 2007.
3. Sangdun Choi. Introduction to Systems Biology, Humana Press.2007.
4. Michael G. Katze.Systems Biology. Springer, 2013.
5. Konopka A.K. Systems Biology: Principles, Methods, and Concepts. CRC Press, Tailor & Francis.2007.
6. Robert A. Meyers. Systems Biology, Wiley Blackwell. 2012.

INDUSTRIAL BIOTECHNOLOGY LAB			
Subject Code	**16BBTL26**	**IA Marks**	**20**
No. of Lab Hrs./ Week	**03**	**Exam Marks**	**80**
		Exam Hours	**03**

Course objectives :

- To understand the details of microbial techniques for growth, cultivation and characterization of microorganisms with industrial importance.

Sl.NO	Experiment	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
1	Media preparation, Preparation of plates and tubes.	L5,L4
2	Pure culture techniques (Streak, pour and spread - plates)	L2,L3,L4
3	Growth curve studies.	L1,L2,L3,L4,L5
4	Antibiotic sensitivity tests.	L2,L4,L5,L6
5	Characterization of bacteria by Biochemical Tests: IMViC, Starch hydrolysis, carbohydrate fermentation, Catalase, Urease, hydrogen sulphide, Nitrate reduction.	L2,L3,L5
6	Media optimization by Plackett Burman Design, Response Surface Methodology	L2,L3,L4
7	Tray Drier	L2,L3,L4
8	Salting in and Salting out	L1,L2,L3,L4,L5,L6
9	Batch operation and optimization of a bioreactor	L1,L2,L3,L4,L5
10	Fed batch operation of a bioreactor	L1,L2,L3,L4
11	Product recovery by filteration	L1,L2,L3,L4,L5
12	Product purification by chromatography	L1,L2,L3,L4,L5

Course outcomes:

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

- Prepare the media and use for the cultivation of the microorganisms.
- Perform laboratory experiments for the isolation, identification and characterization of microorganisms.
- Carry-out experiments for the enumeration, staining and control

Graduate Attributes (as per NBA)

- Problem analysis
- Design / Development of solutions
- Modern tool usage
- Communication
- Life-long learning

Conduct of Practical Examination:

1. All laboratory experiments are to be included for practical examination.
2. Students are allowed to pick one experiment from the lot.
3. Strictly follow the instructions as printed on the cover page of answer script for breakup of marks.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

TEXT/REFERENCE BOOKS

1. Lab Math by Dany Spencer Adams, IK Intl. Pub house.
2. Lab Ref by Jaine Roskams& Linda Rodgers IK Intl.Pub house.
3. Case-Microbiology: An Introduction by Gerard J. Tortora, Berdell R. Funke, Christine L. 11thEdition- Pearson publications.

4. Laboratory Manual Of Microbiology And Biotechnology by Aneja K.R. Medtec, 2014

SEMESTER III

16BBT31- 16BBT34 INTERNSHIP / PROJECT WORK

(PROJECT I PHASE EVALUATION)

IV SEMESTER

RESEARCH METHODOLOGY, BIOSAFETY& IPR			
Subject Code	**16BBT41/16BBC41/16BI41/16IB41**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS 04

Course objectives : The course will enable the students:

- To understand and apply different methodologies of scientific research
- To appreciate the Basic concepts of IPR
- To apply the principles of biosafety guidelines in biotech practices

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
CONCEPT OF RESEARCH: Types & classification, steps involved. Identification of the research question, hypotheses, and justification for the topic Literature Collection: Review of literature, review process and bibliography, research/discriminative reading, consulting source material, Research Objectives and hypothesis, Research Design : detailed discussion of the conceptualization and operationalization of variables. Research method and materials, Research action. Data collection and analysis plan: data gathering – thorough description of methods of data gathering and sources.; Analytical techniques – detailed discussion of data gathering and analytical methods, including explanation of their suitability of these techniques compared with others and any possible problems arising from the methods selected; application and execution of analytical techniques and interpretations of findings. Format for manuscript writing, documentation, organization of reference material, bibliography, end note etc to be discussed with case studies. Research budget and resources.	**10**	**L1, L2,L3**
MODULE –2		
INTRODUCTION TO INTELLECTUAL PROPERTY: Types of IP: Patents, Trademarks, Copyright & Related Rights, Issues related to plagiarism in research, copyright laws, acknowledging the sources etc to be discussed with case studies. Basics of Patents and Concept of Prior Art; Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of "prior art";	**10**	**L2,L3,L4**

Patent databases; Searching Internatio nal Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTScope(WIPO), IPO, etc.)		
MODULE – 3		
Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies. Patent filing procedures; National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting – d isclosure/non-disclosure; Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement- meaning, scope, litigation, case studies.	**10**	**L3,L4**
MODULE – 4		
BIOSAFETY: Introduction & historical background; Primary Containment for Biohazards; Biosafety Levels for Microbes, Plants & Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs: RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication. Roles of Institutional Biosafety Committees	**10**	**L2, L3, L4**
MODULE – 5		
History, broad account & latest amendments (if any) of the provisions of :- Indian Patent Act 1970 & recent amendments, GATT & TRIPS Agreement, Madrid Agreement, Hague Agreement, WIPO Treaties, Budapest Treaty, PCT.	**10**	**L2, L3, L4, L5**

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

- Demonstrate strong basics in principles of Research methodology, IPR and biosafety issues

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Professional Ethics

Question Paper Pattern: The question paper will have ten questions.

- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. C R Kothari Research Methodology, New Age International (P) Ltd. 2008 .
2. Wayne Goddard, Stuart Melville Research Methodology: An Introduction: Juta and Company Ltd, 2004
3. P. Hambleton, J. Melling, T. T. Salusbury Biosafety in industrial biotechnology – Springer
4. M. K. Sateesh. Bioethics and Biosafety By IK International 2008

REFERENCE BOOKS

1. D K Bhattacharyya, Research Methodology By Excel Publisher Publishing Co. Pvt. Ltd., 2007
2. Kankanala C., Genetic Patent Law & Strategy 1st Edition, Manupatra Information Solution Pvt. 2007
3. BAREACT Indian Patent Acts & Rules, Universal Law 1970

METABOLIC ENGINEERING

(ELECTIVE)

Subject Code	16BBT421	IA Marks	20
Number of Lecture Hrs./Week	03	Exam Marks	80
Total number of lecture hours	40	Exam Hours	03

CREDITS-03

Course objectives : The course will enables the students

• To, appreciate the concepts underlying in various tools in cell metabolic engineering technology

• To comprehend the essentials of metabolic pathways and analyze them

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
INTRODUCTION AND METABOLIC REGULATION: Introduction: Importance of metabolic engineering and its multidisciplinary nature. An overview of Cellular Metabolism, Transport Processes, Passive Transport, Facilitated Diffusion, Active Transport, Fueling Reactions, Fermentative Pathways, Glycolysis, TCA Cycle and Oxidative Phosphorylation, Anaplerotic	**08**	**L1, L2, L3**

Pathways, Catabolism of Fats, Organic Acids, and Amino Acids, Biosynthetic Reaction, Biosynthesis of Amino Acids, Biosynthesis of Nucleic Acids, Fatty Acids.		
MODULE –2		
METABOLIC FLUX AND APPLICATIONS OF METABOLIC FLUX ANALYSIS: Metabolic flux analysis and its application, Methods for experimental determination of metabolic flux by isotope dilution method. Production of Glutamic Acid and regulation by Bacteria, Calculation of Theoretical Yields, Metabolic Flux Analysis of Lysine Biosynthetic Network in C. glutamicum, Metabolic Flux Analysis of Specific Deletion Mutants of C. glutamicum, Metabolic Fluxes in Mammalian Cell Cultures, Determination of Intracellular Fluxes, Application of Flux Analysis to the Design of Cell Culture Media.	**08**	**L2, L3, L4**
MODULE – 3		
REGULATION OF METABOLIC PATHWAYS: Regulation of Enzymatic Activity, Overview of Enzyme Kinetics, Simple Reversible Inhibition Systems, Irreversible Inhibition, Allosteric Enzymes: Cooperativity, Regulation of Enzyme Concentration, Control of Transcription Initiation, Control of Translation, Global Control: Regulation at the Whole Cell Level, Regulation of Metabolic Networks, Branch Point Classification, Coupled Reactions and the Role of Global Currency Metabolites.	**08**	**L2, L3, L4**
MODULE – 4		
METABOLIC ENGINEERING IN PRACTICE: Enhancement of Product Yield and Productivity, Ethanol, Amino Acids, Solvents, Extension of Substrate Range, Metabolic Engineering of Pentose Metabolism for Ethanol Production, Cellulose-Hemicellulose Depolymerization, Lactose and Whey Utilization, Sucrose Utilization, Starch Degrading Microorganisms, Extension of Product Spectrum and Novel Products, Antibiotics, Polyketides, Vitamins, Biopolymers, Biological Pigments, Hydrogen, Pentoses: Xylitol, Improvement of Cellular Properties, Prevention of	**08**	**L3, L4**

Overflow Metabolism, Alteration of Substrate Uptake, Maintenance of Genetic Stability.		
MODULE – 5		
BIOSYNTHESIS OF METABOLITES AND BIOCONVERSIONS: Primary metabolites: Alteration of feedback regulation, limiting of accumulation of end products, resistant mutants. Secondary metabolites: Precursor effects, prophage, idiophase relationship, enzyme induction, feedback repression, catabolic repression, important groups of secondary metabolic enzymes, phosphotransferase, ligases oxido reductases, oxygenases, carboxylases.Advantages of bioconversions, specificity, yields. Factors important to bioconversions, regulation of enzyme synthesis, permeability co metabolism, conversion of insoluble substrates.	**08**	**L4, L5**

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

• Demonstrate strong basics in metabolic engineering

• Develop and design different metabolic pathways to understand the cell regulatory events

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Modern Tool Usage

Question Paper Pattern: The question paper will have ten questions.

• Each full question consists of 16 marks.

• There will be 2 full questions (with a maximum of four sub questions) from each module.

• Each full question will have sub questions covering all the topics under a module.

• The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. Metabolic Engineering – Principles and Methodologies by Gregory N. Stephanopoulos, Aristos A. Aristidou, Jens Nielsen. 1998
2. Control of metabolic process by A.C. Bowden and M.L. Cardens, Plenum Publisher. 1991
3. Principle of Fermentation Technology by P.F. Stanbury and A. Whitkar, Pergammon press. 1984.
4. Metabolism of Agrochemicals in Plants by Terry Roberts, Willey Int., 1988

REFERENCE BOOKS

5. Bioprocess engineering basic concepts by M.L. Shuler and Kargi. 1992
6. Fermentation and enzyme Technology by Wang D I C Cooney C I Demain, A L John Willey, 1991
7. Scale-up Methods in Chemical Engineering by Johnson and Thring. 2006

QC, QA & Validation (ELECTIVE)			
Subject Code	**16BBT422/16BBC422**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS 03			

Course objectives : The course will enable the students

- Appreciate the Basic concepts of Quality Control and Validation techniques for Biotechnology product development.
- To understand and apply the different QC and QA methodologies.

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
QUALITY CONTROL AND ASSURANCE TECHNIQUE: Introduction, Basis concepts of Quality:- Developing quality culture. Quality Assurance General Concepts: Definition of quality assurance concept and components of Q. A., Concept of Quality control, Quality control of Biological products: International Biological standards, safety testing of pharmaceutical Quality control of antibiotics. International, Japanese, British and Indian pharmacopeias. Current GMP in manufacturing, processing, packaging of drugs. GMP for finished products.	**10 Hours**	**L1, L2,L3**
MODULE –2		
GOOD LABORATORY PRACTICE: Current GLP in manufacturing, responsibilities. General provision, organization and personnel, building and facilities, equipment, control of components and drug product, laboratory and control of records and reports, Non-clinical testing, Controls on animal house, Application of Computers in Quality control Laboratory	**10 Hours**	**L2,L3,L4**
MODULE – 3		

MANUFACTURING OPERATIONS AND CONTROL: Revised schedule M, sanitation of manufacturing premises, Mix –ups and cross contamination, processing of intermediates and Bulk product, Packaging operations, I.P.Q.C., Release of finished products process deviations, Drug product inspection, expiration dating, Document and formats, Specification, Master production and control record, Batch production and control record Significance of SOPs and record, change control, Drug Master file	**10 Hours**	**L2, L3,L4**
MODULE – 4		
INTRODUCTION TO PHARMACEUTICAL VALIDATION: Definition, Manufacturing Process Model, Government regulation, scope of Validation, Advantage of Validation, Organizations for Validation, Validation Master plan, URS, D.Q., IQ, OQ & P.Q. of facilities. , General principles of analytical method validation, Validation of HPLC , Dissolution test apparatus Process Validation : Prospective, concurrent, retrospective & revalidation, Process validation of formulations. Validation of Pharmaceutical Water System & pure steam, Validation of HAVC system, Validation of Compressed air, Cleaning of Equipment, Cleaning of Facilities,Vendor Certification	**10 Hours**	**L3, L4**
MODULE – 5		
DRUG REGULATORY AFFAIRS: Harmonization of regulatory requirements including ICH activity. Regulatory requirements of different regions applicable to pharmaceutical developments, manufacturing, quality control on finished products, extended release products, biopharmaceutical and bioequivalence assessment and good clinical practices and Comparison with regulation in India. Filing of INDA, NDA and ANDA for approval and registration.	**10 Hours**	**L3, L4, L5**

Course outcomes:

After studying this course, students will be able to:

• Demonstrate strong basics in principles of QA and QC

• Demonstrate the ability to use validation techniques and tools for product development.

Graduate Attributes (as per NBA)

- Knowledge on QC ,QA and validation
- Problem Analysis
- Design / development of solutions
- Professional Ethics Question

Question Paper Pattern:

The question paper will have ten questions.

- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question

from each module.

TEXT BOOKS

4. Pharmaceutical Quality Assurance, MA Potdar, Nirali Prakashan, Pune.
5. Validation of Pharmaceutical process, F. J. Carleton and J. Agalloco, Marcel Dekker Inc.
6. Pharmaceutical Process Validation, Second Ed., Ira R. Ferry & Robert Nash., Marcel Dekker Inc.
7. Quality Planning & Analysis by J. M. Juran and F. M. Gryna, Tata Mcgraw Hill, India.
8. Improving Quality through Planned experimentation by Moen, Tata Mcgraw Hill.

REFERENCE BOOKS

8. Good Manufacturing Practices for Pharmaceutical; A Plan for total Quality Control, 4 th Ed, Sidney willing.
9. Quality Assurance Guide by Organization of Pharmaceutical producers of India.
10. Pharmaceutical Process Validation; By F. R., Berory and Robert A. Nash.
11. Impurities Evaluation of Pharmaceutical; Satinder Ahiya Marcel Decker.

INDUSTRIAL ECONOMICS
(ELECTIVE)

Subject Code	**16BBT423/16BBC423**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03

Course objectives : The course will enable the students

- Appreciate the Basic concepts of industrial economics
- To understand and apply the different strategies

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
CONCEPT AND ORGANIZATION OF A FIRM: ownership, control and objectives of the firm; Growth of the firm – Size and growth of a firm, growth and profitability, constraints on growth; Recent trends in Indian industrial growth; Progress and Problems of some major industries in India-Special emphasis on Biotech industries	**08**	**L1, L2,L3**
MODULE –2		

REGIONAL INDUSTRIAL GROWTH AND PRODUCTIVITY: Regional industrial growth in India; Industrial economic concentration and remedial measures; Development of Cottage and small scale industries concept and measurement; Indian situation. Theories of industrial locations – Weber and Sargent theories, Factors affecting location.	**08**	**L2,L3,L4**
MODULE – 3		
INDUSTRIAL FINANCE : Sources of short term and long term finance; Industrial Financial Institutions: Role and functioning in India; Corporate securities; Ownership and creditor-ship securities concentration; Economies of Scale; Market structure and profitability; Market structure and innovation; Product pricing – theories and evidence	**08**	**L3,L4**
MODULE – 4		
METHODS OF PROJECT EVALUATION: Ranking of Projects – NPV and IRR; Social cost-benefit Analysis; Theories and empirical evidence on Mergers and Acquisitions (M & A's) and diversification. Structure of Industrial labor; Employment dimensions of Indian Industry, Industrial legislation	**08**	**L3, L4, L5**
MODULE – 5		
INDUSTRIAL RELATIONS AND POLICY IN INDIA: Worker's participation in management and Collective Bargaining; Exit policy and social security; Second National Commission on labor. Classification of industries and role of public and private sectors. Competition Act, 2002, MNCs and transfer of technology. Industrial legislation – Industrial Disputes Act and Factories Act	**08**	**L2, L3, L4**
Course outcomes: After studying this course, students will be able to: • Demonstrate strong basics in principles of industrial economics • Demonstrate the ability to manage industrial projects		
Graduate Attributes (as per NBA) • Problem Analysis • Design / development of solutions. • Professional Ethics • Life-long Learning		
Question Paper Pattern: The question paper will have ten questions. • Each full question consists of 16 marks. • There will be 2 full questions (with a maximum of four sub questions) from each module. • Each full question will have sub questions covering all the topics under a module. • The students will have to answer 5 full questions, selecting one full question from each module.		

TEXT BOOKS

1. Ahluwalia, I.J. (1985), Industrial Growth in India, Oxford University Press, New Delhi.
2. Barthwal, R.R. (1985), Industrial Economics, Wiley Eastern Ltd. New Delhi.
3. Cherunilam, F. (1994), Industrial Economics: Indian Perspective (3rd Edition), Himalaya Publishing House, Mumbai.
4. Desai, B. (1999), Industrial Economy in India (3rd Edition), Himalaya Publishing House, Mumbai. Divine, P.J. and R.M. Jones et. al. (1976),
5. An Introduction to Industrial Economics, George Allen and Unwin Ltd., London.
6. Government of India, Economic Survey (Annual). 7. Hay, D. and D.J. Moris (1979), Industrial Economics: Theory and Evidence, Oxford University Press, New Delhi.
7. Kuchhal, S.C. (1980), Industrial Economy of India (5th Edition), Chaitanya Publishing House, Allahbad

REFERENCE BOOKS

1. Harndeen, J.B. (1975), The Economics of Corporate Economy, Dunellen Publishers, New York.
2. Kemien, M.T. and N.L. Schwartz (1982), Market Structure and Innovation, Cambridge University Press, Cambridge.
3. Bagchi, A. and M. Banerjee (Eds.) (1979), Change and Choice in Indian Industry, Bagchi Publications, Calcutta.
4. Kelkar, V.L. and V.V. Bhnoji Rao (Eds.) (1996), India Development Policy Imperatives, Tata McGraw Hill, New Delhi.
5. Brahmananda, P.R. and V.R. Panchmukhi (Eds.) (1987), The Development Process of the Indian Economy, Himalaya Publishing, Bombay.
6. Chakravarty, S. (1987), Development Planning: The Indian Experience, Oxford University Press, New Delhi.

ENTREPRENEUR DEVELOPMENT (ELECTIVE)			
Subject Code	**16BBT424/16BBC424**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03		
Course objectives : The course will enables the students • Appreciate the Basic concepts of entrepreneur development • Apply the proof-of-concepts to Large scale and Entrepreneurship opportunities		
MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
ENTREPRENEURSHIP-ENTERPRISE: Conceptual issues. Entrepreneurship vs. Management. Roles and functions of Entrepreneur in relation to the enterprise and in relation to the economy. Entrepreneurship is an interactive process between the individual and the environment. Small business as seedbed of Entrepreneurship. Entrepreneur competencies, Entrepreneur motivation, performance and rewards.	**08**	**L2,L3,L4**
MODULE –2		
OPPORTUNITY SCOUTING AND IDEA GENERATION: Role of creativity and innovation and business research. Sources of business ideas. Entrepreneur opportunities in contemporary business environment, for example opportunities in net-work marketing, franchising, business process outsourcing in the early 21 century. The process of setting up a small business: Preliminary screening and aspects of the detailed study of the feasibility of the business idea and financing/non-financing support agencies to familiarize themselves with the policies/programs and procedures and the available schemes.Preparation of Project Report and Report on Experiential Learning of successful and unsuccessful entrepreneurs	**08**	**L2,L3,L4**
MODULE – 3		
MANAGEMENT ROLES AND FUNCTIONS IN A SMALL BUSINESS: Designing and re-designing business process, location, layout, operations planning and control. Basic awareness on the issues impinging on quality, productivity and environment. Managing business growth. The pros and cons of alternative growth options: internal expansion, acquisitions and mergers, integration and diversification. Crisis in business growth.	**08**	**L2, L3,L4**
MODULE – 4		
PRINCIPLES OF DOUBLE-ENTRY BOOK-KEEPING: Journal entries, cash-book, pass book, and Bank Reconciliation Statement, ledger accounts, trail balance and preparation of final accounts: Trading and Profit and Loss Account; Balance-sheet. Brief introduction to Single-Entry system of record keeping.	**08**	**L2, L3, L4**

Sources of risk/venture capital, fixed capital, working capital and a basic awareness of financial services such as leasing and factoring.		
MODULE – 5		
ISSUES IN SMALL BUSINESS MARKETING: The concept and application of product life cycle, advertising and publicity, sales and distribution management. The idea of consortium marketing, competitive bidding/tender marketing, negotiating with principal customers. The contemporary perspectives on Infrastructure Development, Product and Procurement Reservation, Marketing Assistance, Subsidies and other Fiscal and Monetary Incentives. National state level and grass-root level financial and non-financial institutions in support of small business development.	**08**	**L3, L4, L5**

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

- Demonstrate strong basics in entrepreneurship
- Demonstrate the ability to manage industrial projects and develop products

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / development of solutions.
- Innovation and Entrepreneurship

Question Paper Pattern:

- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

TEXT BOOKS

1. Brandt, Steven C., "The 10 Commandments for Building a Growth Company", 1. Macmillan Business Books, Delhi, 3rd Ed., 1977.
2. Bhide, Amar V., "The Origin and Evolution of New Business", Oxford University Press, New York, 2000.
3. Dollinger M.J., "Entrepreneurship strategies and Resources", Pearson Education, New Delhi, 3rd Ed., 2006.
4. Desai, Vasant Dr., "Management of small scale enterprises", Himalaya Publishing House, 2004.
5. Taneja, Gupta, "Entrepreneur Development New Venture Creation", Galgotia Publishing Company, 2nd Ed., 2001

REFERENCE BOOKS

1. Patel, V.G., “The Seven Business Crises and How to Beat Them”, TMH, 1995.
2. SIDBI Report on Small Scale Industries Sector [latest edition]
3. Verma, J.C.., and Gurpal Singh, “Small Business and Industry-A Handbook for Entrepreneurs”, Sage, New Delhi, 2002.
4. Manohar, “Entrepreneurship & Management”, Wiley India, 2012