VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM
CHOICE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016-2017
M.TECH. IN BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING

I Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment		I.A.	Exam		
16BBT11/16BBC11/16IBT11	NUMERICAL METHODS AND BIOSTATISTICS	4	-	3	20	80	100	4
16BBT12/16BBC12	CONCEPTS IN BIOTECHNOLOGY	4	--	3	20	80	100	4
16BBC13/16BBT13	PRINCIPLES OF BIOCHEMICAL ENGINEERING	4	--	3	20	80	100	4
16BBC14	MOLECULAR BIOLOGY AND GENETIC ENGINEEIRING	4	--	3	20	80	100	4
16BBC15X	ELECTIVE - 1	3	--	3	20	80	100	3
16BBC16	BIOTECHNOLOGY AND BIOCHEMICAL ENGINEERING LAB	--	3	3	20	80	100	2
16BBC17	SEMINAR	--	3	--	100	--	100	1
Total		**19**	**6**	**18**	**220**	**480**	**700**	**22**

ELECTIVE – 1	
16BBC151	ANALYTICAL TECHNIQUES
16BBC152	COMPUTATIONAL BIOLOGY
16BBC153	BIOPROCESS CONTROL & INSTRUMENTATION
16BBC154	METABOLIC ENGINEERING

BOARD OF STUDIES IN BIOTECHNOLOGY. VTU, BELGAUM, KARNATAKA.

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II Semester **CREDIT BASED**

Subject Code	Name of the Subject	Teaching hours/week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work / Assignment/ Tutorials		I.A.	Exam		
16BBC21	FERMENTATION TECHNOLOGY	4	--	3	20	80	100	4
16BBC22	BIOREACTOR PLANT DESIGN	4	--	3	20	80	100	4
16BBC23	BIOSEPARATION AND PRODUCT RECOVERY	4	--	3	20	80	100	4
16BBC24	PLANT AND ANIMAL BIOTECHNOLOGY	4	--	3	20	80	100	4
16BBC25X	ELECTIVE – 2	3	--	3	20	80	100	3
16BBC26	FERMENTATION TECHNOLOGY AND BIOSEPARATION LAB	--	**3**	3	20	80	100	2
16BBC27	SEMINAR	--	3	--	100	--	100	1
	Total	**19**	**6**	**18**	**220**	**480**	**700**	**22**

ELECTIVE – 2	
16BBC251	CELL CULTURE TECHNIQUES
16BBC252	ENVIRONMENTAL BIOTECHNOLOGY
16BBC25	BIOPROCESS OPTIMIZATION, MODELING & SIMULATIONS

BOARD OF STUDIES IN BIOTECHNOLOGY. VTU, BELGAUM, KARNATAKA.

3	
16BBC254	NANOBIOTECHNOLOGY

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III Semester: **CREDIT BASED**

Course Code	Subject	No. of Hrs./Week		Duration of the Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Practical / Field Work		I.A.	Exam		
16BBC31	SEMINAR/PRESENTATION ON INTERNSHIP (8 WEEKS FROM THE COMMENCEMENT OF 3RD SEMESTER)	-	-	-	25		25	20
16BBC32	REPORT ON INTERNSHIP	-	-	-	25		25	
16BBC33	EVALUATION AND VIVA ON INTERNSHIP				50	50	100	
16BBC34	EVALUATION OF PROJECT PHASE: I	-	-	-	50		50	1
	Total	**-**	**-**	**-**	**150**		**200**	**21**

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IV Semester **CREDIT BASED**

Subject Code	Subject	No. of Hrs./Week		Duration of Exam in Hours	Marks for		Total Marks	CREDITS
		Lecture	Field Work / Assignment		I.A.	Exam		
16BBT41/16BBC41/16BI41/16IBT41	RESEARCH METHODOLOGY, BIOSAFETY AND IPR	4	--	3	20	80	100	4
16BBC42X	ELECTIVE – 3	3	--	3	20	80	100	3
16BBC43	EVALUATION OF PROJECT PHASE-II	-	-	-	50	-	50	3
16BBC44	EVALUATION OF PROJECT WORK AND VIVA-VOCE.	–	-	3	-	100+100	200	10
Total		**7**	**-**	**09**	**90**	**360**	**450**	**20**
Grand Total (I to IV Sem.) : 2050 Marks; 85 Credits								

ELECTIVE – 3	
16BBC421	PROJECT MANAGEMENT
16BBC422/16BBT422	QC, QA & VALIDATION
16BBC423/16BBT423	INDUSTRIAL ECONOMICS
16BBC424/16BBT424	ENTREPRENEUR DEVELOPMENT

BOARD OF STUDIES IN BIOTECHNOLOGY. VTU, BELGAUM, KARNATAKA.

NUMERICAL METHODS & BIOSTATISTICS
(CORE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	16BBT11/16BBC11/16IBT11	IA Marks	20
Number of Lecture Hours/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.	**10 Hours**	**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 Hours**	**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,	**10 Hours**	**L2, L3,L4**

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 ANOVA tables, T-tests; F-tests. Algorithm and implementation using numerical methods with case studies.		
MODULE -4		
DESIGN AND ANALYSIS OF EXPERIMENTS: Random block design, multiple sources of variation, correlated data and random effects regression, model fitting. Completely randomized design, stratified design. Biological study designs. Optimization strategies with case studies.	**10 Hours**	**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, Tools, software and programs for mapping sequences with case studies.	**10 Hours**	**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
(CORE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	16BBT12/16BBC12	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: The course will enables the students

- 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 Hours**	**L1, L2,L3**
MODULE -2		
CELL STRUCTURES AND ITS FUNCTIONS: Eukaryotic and Prokaryotic cells, plant and animal cells, structure of nucleus, mitochondria, ribosomes, Golgi bodies, lysosomes, endoplasmic reticulum, chloroplast, vacuoles; Cell cycle and cell division: Different phases of cell cycle, cell division: Mitosis and meiosis. Mendelian law of inheritance: Monohybrid and dihybrid inheritance, law of segregation and independent assortment; Gene Interaction; Multiple alleles, supplementary and complementary genes, epistasis. Identification of genetic material: classical experiments; chromosome structure and organization, chemical composition of	**10 Hours**	**L1, L2,L3,L4**

chromatin, structural organization of nucleosomes, heterochromatin, polytene and lamp-brush chromosomes, human chromosomes, chromosomal disorders.		
MODULE -3		
SCOPE OF MICROBIOLOGYAND IMMUNOLOGY: Introduction to the structure and functions of microorganism: Bacteria, Viruses, Fungi and Protozoan's. Microscopy and microbial techniques: Study of microscopes; sterilization techniques: Heat, steam, Radiation, Filtration and chemical methods; Pure culture techniques: Serial Dilution, Streak, Spread, Pour Plate. Immune System, Innate and adaptive immunity, antigens and antibodies; types of immune response, hypersensitivity. Humoral immunity: B-lymphocytes, Immunoglobulin classes, Major Histocompatibility Complex (MHC). Cell mediated immunity. Thymus derived lymphocytes (T-cells), Antigen presenting cells (APC); Immunity to infection, Cytokines.	**10 Hours**	**L1, L2, L3, L4**
MODULE -4		
SCOPE OF AGRICULTURAL BIOTECHNOLOGY: Role of Microbes 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. Discussion of case studies for addressing health and malnutrition, via agri BT.	**10 Hours**	**L3, L4, L5, L6.**
MODULE -5		
INDUSTRIALLY IMPORTANT MICROORGANISMS AND PRESERVATION TECHNIQUES: Different media for fermentation, basic structure of fermenter and different types. Types of fermentation processes (surface, submerged, and solid state) and their products (ethanol, citric acid, lactic acid, enzymes, antibiotics) Biological treatment of waste water, primary, secondary and tertiary treatments. Bio indicators, Bioremediation of xenobiotic compounds, Bioleaching of minerals from ores, Bio-sorption of toxic metals. Solid waste management. Biofuel production from agricultural wastes. Case studies and solutions for current issues of waste management.	**10 Hours**	**L3, L4, L5, L6.**
Course outcomes: After studying this course, students will be able to: • 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) 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. 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
(CORE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	16BBT13/16BBC13	IA Marks	20
Number of Lecture Hours/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, appreciate the concepts underlying in various Chemical engineering streams like Unit operations, Fluid Mechanics, Thermodynamics, Heat transfer etc
- To comprehend the essentials of design of Bioreactors / fermenters
- prepare them to leverage their knowledge of biological molecules / products, scale up operations and productions.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		

HISTORICAL DEVELOPMENT OF BIOPROCESS TECHNOLOGY: An overview of traditional and modern applications of biotechnological processes, Roles and responsibilities of a Chemical engineer in bioprocess industry, Steps in bioprocess development. Biology of the cell, classification, construction and cell nutrients. Industrial enzymes -, Nomenclature and Classification of enzymes, structure and functions of enzymes with relevant case studies.	**10 Hours**	**L1, L2,L3**
MODULE -2		
EQIPMENTS: Mixing-Power requirement (Calculation of power no), Ungassed and gassed fluids, factors affecting the broth viscosity, Mixing equipments (Banbury mixers, Muller Mixers), Size Reduction (laws of size reduction, Mechanical efficiency and crushing efficiency Concept of Sphericity, Volume surface Mean Diameter, Arithmetic Mean Diameter, Mass mean diameter, Volume Mean Diameter and Proof for sphericity is unity for regular object) Crushing equipments (Jaw crusher, Garyatory crusher, Shredders, Ball mill) Filtration (constant pressure and constant rate filtration explanations with only the equations.	**10 Hours**	**L2, L3, L4, L5**
MODULE -3		
INDUSTRIALLY IMPORTANT FILTRATION EQUIPMENTS AND ACCESSORIES: (Rotary filters, Plate and frame filters and Leaf filters) Settling and its type (free and Hindred settling: equation for newtons, Intermediate Stokes regimes and Criteria for selection of the equation) Problems, Size Enlargement operations. Flow pattern in agitated vessel, Role of shear in fermentation broth, bubble shear, rheological behavior of fermentation broth, 3-D Continuity equation, Pressure drop in flow through packed bed and Fluidized bed (Kozeny,Carman, Blake Plummer Equations), Flow of compressible fluids, Time to empty the liquid from a tank (Rectangle Tank and Hemispherical Tank), problems, Problems on calculation of resultant velocity and resultant acceleration of fluid on space ordinates (x,y,z). Numerical Problems.	**10 Hours**	**L2, L3, L4, L5**
MODULE -4		
BASICS OF THERMODYNAMICS: Procedure for Energy balance and Energy balance for cell culture, Concept of Internal energy, Enthalpy-calculations procedure (Enthalpy and internal energy changes calculations using first law of Thermodynamics), calculations of Entropy changes (Entropy changes for constant Temperature, Constant volume, constant pressure and work lost due to entropy) Differential equations of Entropy, Problems on entropy and Its calculations, Gibbs Free energy and other free energies of systems, Effect of temperature and Pressure on the Gibbs free energy and Helmoltz free energy. Discussion of case studies.	**10 Hours**	**L2, L3, L4**
MODULE -5		
INTRODUCTION TO HEAT TRANSFER:	**10 Hours**	**L3, L4, L5,**

over view of Industrial Heat Exchangers (Construction and working principle of DPHE, STHE, Helical coil heat exchangers along with the heat transfer equations) and Concept of LMTD, Boiling Condensation, Nucleate and film boiling (Regimes of pool boiling) Regenerators and Recupretors. Transient growth kinetics, measurement of microbial population by turbidometry and studying the effect of temperature, pH, carbon and nitrogen Batch, fed batch and continuous cultures. Discussion of design strategies and case studies.		**L6**

Course outcomes:

After studying this course, students will be able to:

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

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. Paulin and M Doran Bioprocess engineering and principles 2nd Edition, Wiley, 2006
2. R.M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, J. Wiley, New York, 2000.
3. D.M.Himmelblau, Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall of India. New Delhi, 1996

Reference Books:

1. SC Arrora And Domkundar Process Heat Transfer 3rd edition, Wiley, 2006.
2. Engineering Thermodynamics by K.V. Narayan 3rd edition 2010
3. R.K. Bansal Fluid Mechanics 3rd edition 2010.
4. Bird et al., Transport Phenomena, 2nd Edition, Wiley, 2006

MOLECULAR BIOLOGY AND GENETIC ENGINEERING
(CORE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	16BBC14	IA Marks	20
Number of Lecture Hours/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 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 Bacteria-bacteriophage, FLP/FRT and Cre/Lox recombination. Transcription: Prokaryotic & Eukaryotic Mechanisms; Significance of Promoters, Enhancers, Silencers, Transcription factors, Activators and repressors; Post transcriptional modifications; Transcription inhibitors	**10 Hours**	**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,	**10 Hours**	**L1, L2,L3,L4**

coactivators; Homeotic gene and their role in gene regulation.		
MODULE -3		
VECTORS: Plasmids, Phage Vectors, Phagemids, Cosmids, YACs and BACs; Cloning & Expression vectors. Enzymes in genetic engineering: Restriction Enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase, Polynucleotide kinase, Alkaline phosphatase. Methods in construction of recombinant vectors: Linkers, Adaptors, Homopolymeric tailing. Techniques in Genetic Engineering: Construction of libraries: Genomic and cDNA libraries. Hybridization techniques: Northern and Southern hybridizations. Polymerase Chain Reaction**:** General mechanism and applications; Variants of PCR; *In vitro* mutagenesis.	**10 Hours**	**L2, L3,L4**
MODULE -4		
GENE TRANSFER TECHNIQUES INTO PLANTS: 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.	**10 Hours**	**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.	**10 Hours**	**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

ELECTIVES I

ANALYTICAL TECHNIQUES

(ELECTIVE SUBJECT)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	16BBC151	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 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 Hours**	**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 NMR-Introduction, Natural abundance, C13 NMR Spectra and its structural applications. Discussions with Case studies.	**08 Hours**	**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 Hours**	**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 Hours**	**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 Hours**	**L2, L3, 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.

COMPUTATIONAL BIOLOGY
(ELECTIVE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	16BBC152	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 appreciate the concepts underlying in various tools in computational biology
- To comprehend the essentials of design of biological experiments via *in silico* tools

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT)

		Level
MODULE -1		
Sequence databases Formats, querying and retrieval, Nucleic acid & Protein sequence databases, Genome Databases, NCBI, EBI, TIGR, SANGER ; Various file formats for bio-molecular sequences: Similarity matrices; Pair-wise alignment; BLAST; Statistical significance of alignment; Sequence assembly; multiple sequence alignment; Tools and techniques. Phylogenetics: distance based and character based approaches. Discussions with Case studies.	**08 Hours**	**L1, L2,L3**
MODULE -2		
SEQUENCE PATTERNS AND PROFILES: Basic concept and definition of sequence patterns, motifs and profiles, various types of pattern representations viz. consensus, regular expression (Prosite-type) and sequence profiles; trees Motif representation: consensus, regular expressions; PSSMs; Markov models; Regulatory sequence identification using Meme; Gene finding: composition based finding, sequence motif-based finding. Profile-based database searches using PSI-BLAST, analysis and interpretation of profile-based searches. Discussions with Case studies.	**08 Hours**	**L2, L3, L4**
MODULE -3		
DATABASES: PDB, NDB, Chemical Structure database. Pubchem, Gene Expression database: GEO, SAGE, InterPro, Prosite, Pfam, ProDom, Gene Ontology Structure classification database: CATH, SCOP, FSSP, Protein-Protein interaction databases. Representation of molecular structures (DNA, mRNA, protein), secondary structures, domains and motifs; Protein structure classification, evolution; structural quality assessment; structure comparison and alignment; Visualization software (Pymol, Rasmol etc.); 3-D structure comparison and concepts, CE, VAST and DALI, concept of coordinate transformation, RMSD, Z-score for structural comparison. Discussions with Case studies.	**08 Hours**	**L3, L4, L5**
MODULE -4		
STRUCTURE PREDICTION: Chou Fasman, GOR methods; analysis of results and measuring the accuracy of predictions. Prediction of membrane helices, solvent accessibility; RNA structure prediction; Mfold; Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology/comparative modelling, fold recognition, threading approaches, and *ab initio* structure prediction methods. Force fields, backbone conformer generation by Monte Carloapproaches, side-chain packing; Energy minimization; Structure analysis and validation**:** Pdbsum, Whatcheck, Procheck, Verify3D and ProsaII; Rosetta; Discussions with Case studies.	**08 Hours**	**L3, L4, L5**
MODULE -5		
COMPUTATIONAL BIOLOGY IN DRUG DESIGN:	**08 Hours**	**L2, L3, L5,**

Target identification, validation and Identification and Analysis of Binding sites; virtual screening, lead optimization. Ligand based drug design: QSARs and QSPRs, In silico prediction ADMET properties for Drug Molecules. Pharmacophore identification. Protein-ligand docking; Rigid and Semi Flexible Molecular Docking. Studying Protein-Protein interactions via computational biology tools. Computational Biology applications for proteomics, Comparative genomics**,** Transcriptomics, Microarray technology, expression profiles data analysis; SAGE; MS Data analysis, Probabilistic Models of Evolution, Protein arrays; Metabolomics, Gene Mapping, SNP analysis, Systems Biology. Discussions with case studies.		**L6**

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of computational biology
- Connect between tools, databases and biological 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. David W. Mount. Sequence and Genome Analysis, CSHL Press, 2nd Edition, 2004.
2. Baxevanis and F. B. F. Ouellette, Bioinformatics: a practical, guide to the analysis of genes and proteins, 2nd Edition, JohnWiley, 2001.
3. Jonathan Pevsner, Bioinformatics and Functional Genomics, Wiley-Liss, 1st Edition, 2003.
4. Philip E. Bourne & Helge Weissig Tsai, Structural Bioinformatics, Wiley, 2003.

Reference Books:

Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids, Durbin et al Cambridge University Press. 2007.

5. Thomas E. Creighton Proteins: structures and molecular properties, New York Freeman, 1992
6. Johann Gasteiger and Thomas Engel Chemoinformatics Wiley, 2003
7. Tsai, C Stan, Biomacromolecules Introduction to Structure, function and Informatics, Wiley& Sons, 2007Robert A. Meyers. Systems Biology Wiley Blackwell. 2012.

BIOPROCESS CONTROL AND INSTRUMENTATION

(ELECTIVE SUBJECT)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Subject Code	16BBC153	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 enable the students

- To, appreciate the concepts underlying in various tools in bioprocess control
- To comprehend the essentials of design of bioprocess control and instrumentation

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		
AIMS AND OBJECTIVES OF CONTROL SYSTEMS: Closed loop control and open loop control systems-Examples, Elements of control system, process variables, process parameters, Representation of control systems in terms of block diagrams and its explanation, Laplace transforms. Z transforms.	**08 Hours**	**L1, L2,L3**
MODULE -2		
FUNDAMENTALS OF STATIC AND DYNAMIC CHARACTERISTICS: Indicators and recorders. Pressure measurement- Bourdon, diaphragm and bellow type gages. Vacuum measurements. Temperature measurement- Bimetal and resistance thermometers, thermocouples and pyrometers, Flow measurement, Level measurement devices, pH and DO analyzers, on-line and off-line analysis of biomass estimation	**08 Hours**	**L2,L3,L4**
MODULE -3		
INTRODUCTION TO CONTROLLER: Mode of action of controllers and the Transfer function, Response of the controller to Step, Pulse, Linear changes to error signals, qualities of good controller, proportional Band. Transmitters, Measurements systems. Measurement of process variables, Actuators, Positioners, Control valves, Valve body, valve Plug, Variable Displacement pumps, and constant output pumps, PLC. Sequential control, Logic and security systems.	**08 Hours**	**L2, L3,L4**
MODULE -4		

Block diagram Deduction, Analysis of typical control system-Closed loop analysis -Servo and Regulatory problems for First and second order systems, Closed and loop transfer functions, P-controller for set point change, off-set,P-controller for load change, Pi controller with set point change. Stability. Process identification, Root locus, Routh Array, Bode and Nyquist diagrams. Stability margins. Robustness, Steady state errors. Frequency domain response	**08 Hours**	**L3, L4, L5**
MODULE -5		
Elements of tuning and closed loop dynamics Industrial controllers. Design methodology. Control specifications. PID tuning. Rule and model based tunning. Autotunners. Common control loops. Process design and operability. Control structures. Cascade. Feed forward. Ratio. Examples. Interactive systems. Multivariable processes. RGA. Decoupling control. Design, scale up and optimization of various equipment and biosystems used for biotechnological process industries (equipment used in upstream, downstream and fermentation processes).	**08 Hours**	**L3, L4, L5**

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of Bioprocess controls and automation techniques
- Design and develop various control systems in bioreactors

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. Smith & CorrIpio, Principles and practice of automatic process control. John Wiley, 1985.
2. LuybenW.L., Luyben M.L., Essentials of process control, Mc Graw-Hill, 1997
3. Ogunnake B.A., Ray W.H., Process dynamics, modeling and control, Oxford University Press, 1994

REFERENCE BOOKS

1. Luyben, Process modeling, simulation and control for chemical engineers. McGraw Hill, 1990.
2. McMillan, Tuning and Control loop performance. ISA 1990.
3. D E Seborg, T F Edger, Process dynamics and control, John Wiley, 1999

METABOLIC ENGINEERING
(ELECTIVE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – I

Subject Code	16BBC154	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, 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 Pathways, Catabolism of Fats, Organic Acids, and Amino Acids, Biosynthetic Reaction, Biosynthesis of Amino Acids, Biosynthesis of Nucleic Acids, Fatty Acids.	**08 Hours**	**L1, L2, L3**
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 Hours**	**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 Hours**	**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 Overflow Metabolism, Alteration of Substrate Uptake, Maintenance of Genetic Stability.	**08 Hours**	**L3, L4**
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 Hours**	**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 eventsl		
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

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

BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – I

Laboratory Code	16BBC16	IA Marks	20
Number of Lecture Hours/Week	01Hr Tutorial (Instructions) + 02 Hours Laboratory	Exam Marks	80
		Exam Hours	03

CREDITS – 02

Course objectives:

This laboratory course would enable the students

- To gain practical knowledge of the basic biotechnology and Biochemical engineering
- Use appropriate analytical methods to critically review the experimental observations and results

Laboratory Experiments:	**Revised Bloom's Taxonomy (RBT) Level**
1. Preparation of buffers and biochemical reagents.	**L2, L4, L5**
2. Estimation of proteins by Lowry's and Bradford methods	**L2, L3, L4**
3. Methods in genomic DNA/plasmid Isolation, Quantification of nucleic acids by agarose electrophoresis/spectrophotometric methods	**L2, L3, L4**
4. Quantification of nucleic acids by agarose gelectrophoresis/spectrophotometric methods	**L5, L6**
5. Amplification of DNA by PCR.	
6. Isolation and screening of microbes for Enzymes/Organic acids/secondary metabolites(antibiotics)/nitrogen fixing	**L5, L6**
7. Cell differentiation by gram staining	**L2, L3, L4**
8. Isolation of Enzymes/organic acids (from suitable sources)	**L2, L5, L6**

9. Perform bioassays like, Enzyme activity, specific activity, Antibiogram	**L3, L4**
10. Enzyme Kinetic Parameters: Km, Vmax and Kcat ter	**L2, L3, L4**
11. Optimization of biotic and abiotic parameters for enzyme production in batch fermentation	**L5, L6**
12. Batch growth kinetics of microbes	**L5, L6**

Course outcomes:

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

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

Graduate Attributes (as per NBA)

- Problem Analysis.
- Design/Development of solutions.
- Professional Ethics
- Individual and Team Work

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.

Reference Book:

1. Sandhya Mitra, Genetic Engineering : Principles and Practice, 2007
2. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
3. Hans Bisswanger Practical Enzymology, Wiley-Blackwell, 2013
4. T. A. Brown. Gene Cloning: An Introduction, Stanley Thornes Publishers Limited, 1995
5. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
6. Keith Wilson and John Walker, Pricniples and Techniques of Biochemistry and Molecular Biology, 2000.

II SEMESTER

FERMENTATION TECHNOLOGY (CORE SUBJECT) [As per Choice Based Credit System (CBCS) scheme] SEMESTER –II			
Subject Code	16BBC21	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture	50	Exam Hours	03

BOARD OF STUDIES IN BIOTECHNOLOGY. VTU, BELGAUM, KARNATAKA.

Hours			

CREDITS – 04

Course objectives: The course will enable the students

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

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		
HISTORY OF DEVELOPMENT OF FERMENTATION INDUSTRY: The range of fermentation process, Microbial biomass, enzymes, metabolites, recombinant products, Transformation process, the component parts of Fermentor. Types of industrial bioprocesses; submerged, surface, solid state fermentations: aerobic, anaerobic and light based processes. The differences between laboratory, pilot, and manufacturing scale bioreactor experiments, Green biologics of fermentation technology, types of Reactor and reactor design, process economics. Discussions with case studies	**10 Hours**	**L2,L3, L5, L6**
MODULE -2		
SCREENING OF IMPORTANT METABOLITES FROM MICROBIAL SOURCES: Primary and secondary screening of industrially important microbes, Screening methods, General Techniques in improvement of industrial strains, Isolation of auxotrophic mutants, resistant mutants, revertant mutants, Selection by induced mutants producing improved yields of secondary metabolites. Preservation and storage at reduced temperature; Agar slopes, liquid nitrogen, dehydrated form, dried culture and lyophilisation. Quality control of preservation of stock cultures.	**10 Hours**	**L2, L3, L4, L5**
MODULE -3		
INTRODUCTION TO CULTURE MEDIUM AND FORMULATION: Energy sources, Carbon & Nitrogen sources, Minerals, Growth factors, Buffers, Precursors and regulators, Oxygen and antifoam ingredients, Medium optimization. Substrates for solid state fermentation, Evaluation methods for complex Substrates differences based on product use. .	**10 Hours**	**L2, L3, L4**
MODULE -4		
STERILIZATION PROCESS AND INOCULUM DEVELOPMENT Medium sterilization, Design for Batch sterilization process, Calculation of del factors and holding time. Design of continuous sterilization process, Sterilization of Fermenters, Feeds & liquid	**10 Hours**	**L3, L4**

wastes, Filter sterilization of media. Discussions with case studies Development of Inoculum, criteria for transfer, development of inoculum in yeast, bacterial and mycelial processes, aseptic inoculation of plant fermenters. Inoculum development methods.		
MODULE -5		
LABORATORY TO LARGE SCALE FERMENTATION PROCESSES: Batch, Continuous culture, Synchronous, non-synchronous growth kinetics, Feedback systems, comparison of Batch and Continuous culture in industrial processes and investigative tools. Fed batch culture, Applications of Fed back cultures Techniques and trends in Fermentation technology for the production of recombinant vaccines, therapeutic proteins, antibiotics and diagnostics. Discussions with case studies. Treatment and disposal procedure for industrial effluents.	**10 Hours**	**L3, L4, L5, L6**

Course outcomes:

After studying this course, students will be able to:

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

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. Stanbury& Whitaker, Principles of Fermentation Technology, Second Edition, BH publications, 1995

2. W. Crueger and A. Crueger, Biotechnology – Text book of Industrial Microbiology, Sinauer Publishers,1990

3. S O Enfors & L Hagstrom, Bioprocess Technology - Fundamentals and Applications, RIT, Stockholm, 1992

REFERENCES BOOKS:

1. Casida, Industrial Microbiology, Wiley, 1986. A. N. Glazer and H. Nikaids, Microbial Biotechnology, 2007
2. T.D. Brock, Biotechnology : A Text Book of Industrial Microbiology, Smaeur Associates, 1990
3. Moo-Young, M., Bull, A. T., Dalton, H. Comprehensive Biotechnology, Pergamon Press. 1987.

BIOREACTOR PLANT DESIGN
(CORE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER –II

Subject Code	16BBC22	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: The course will enable the students

- Appreciate the Basic concepts and apply the knowledge of Bioreactor plant design
- Use these skills towards the design & analysis fermentors
- Demonstrate effective use of these tools and techniques in solving problems relevant for industry
- Gain knowledge on design Bioreactors using CAED

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		
INTRODUCTION TO BIOPROCESS: Objectives, Material and energy balance involved, Energy based calculation involved in bioprocess technology(Upstream and Downstream process Both steady state and Unsteady state), Process Flow diagrams development, validation (introduction, structure and resources for validation) of systems and processes including SIP and CIP, cGMP guidelines. Seed culture and inoculum development, culture cell banks, Operational models of reactors (Batch, continuous, Fed Batch, repetitive batch, recycle and continuous cultivation), Novel bioreactors (Stirred tank, Air lift & Loop reactors, fluidized bed reactor, Packed bed and Hollow fiber membrane bioreactors, immobilized Bioreactor), Bioreactors for waste treatment processes; SSF bioreactors, Selection of bioprocess equipment (upstream and downstream), heat transfer and mass transfer equipment's.	**10 Hours**	**L1, L2,L3**
MODULE -2		
BASIC DESIGN AND CONSTRUCTION OF FERMENTERS AND ITS AUXILIARIES: Material of construction, Vessels for Bioprocess (Vessel geometry and vessel design), bearing assemblies, Motor drives, Aseptic seals, Flow measuring and control devices, Agitator and Sparger Design, piping, valves, Pressure relief system, Conveyor and elevator, sensors and instrumentation, control system and stability of control system**.**	**10 Hours**	**L2,L3,L4**

MODULE -3		
REACTOR CONFIGURATION: Facility design aspects and Utility supply aspects, Equipment cleaning aspects, Design considerations for maintaining sterility of process streams and process equipment, Materials of construction for bioprocess plants.Medium requirements and formulation for fermentation processes (examples of simple and complex media), design and usage of commercial media for industrial fermentations, Batch and continuous heat sterilization of liquid media, Filter sterilization of liquids, Air sterilization-Techniques involved, sterility test and integrity test, Inoculation process, sampling process, cell harvesting, Cooling of fermenter system, water system for bioprocess industry (production of triple distilled water), Primary packing and secondary packing, waste disposable technology, environmental aspects.	**10 Hours**	**L4, L5, L6**
MODULE -4		
Mass transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes, Oxygen uptake rates and determination of oxygen transfer coefficients (k_La), role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems. Numerical using Reynold's, Prandtl's, Chil ton & Colburn analogies. Scale up and scale down, effect of scale up on oxygenation issues, mixing, sterilization, pH, temperature, nutrient availability and supply; Bioreactor scale up based on constant power consumption per volume, mixing time, impeller tip speed(Shear), mass transfer coefficients. Scale up of downstream processes: Adsorption; (LUB method); Extractors (geometry based c rules); Filtration (cross flow Chromatography constant resolution etc. Centrifugation (equivalent times etc.). Scale-down related aspects.	**10 Hours**	**L3, L4, L5**
MODULE -5		
CONCEPTS OF CAED: Detailed process and mechanical design of the following equipments via CAED – Agitated and jacketed vessels, fermenter vessels, shell and tube heat exchanger and double pipe heat exchanger. Types of joints (welded), pipe and pipe fittings.	**10 Hours**	**L5, L6**
Course outcomes: After studying this course, students will be able to: • Demonstrate strong basics in principles of fermentation technology • Demonstrate skills in applying the concepts towards design of bioreactors and fermenters via CAED,		
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. Bailey and Ollis, Biochemical Engineering Fundamentals, Prentice Hall, 1992
2. Atkinson, B. & Maviuna, F. Biochemical Engg. and Biotechnology Handbook, Mc-Graw hill (2nd Edition), 1993)
3. W.R.Vieth et al., Design and Analysis of Immobilised Enzyme Flow Reactors. 1993.
4. M. L. Schuler & F. Kargi, Basic concepts Bioprocess Engineering - by Entice Hall 1992

REFERENCES BOOKS:

1. Pauline M. Doran, Bioprocess Engineering Principles, Academic Press 1995.
2. H. C. Vogel & C. L. Todaro, Fermentation & Biochemical Engineering Hand Book (1983), Principles, Process Design and Equipment.
3. Butterworth-Heiemann, A compendium of Good Practices in Biotechnology, BIOTOL Series, 1993.

BIOSEPARATIONS AND PRODUCT RECOVERY
(CORE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER –II

Subject Code	16BBC23	IA Marks	20
Number of Lecture Hours/Week	04	Exam Marks	80
Total Number of Lecture Hours	50	Exam Hours	03

CREDITS – 04

Course objectives: The course will enable the students

- Appreciate the basic concepts and apply the knowledge for separations of biomolecules
- Use these skills towards the isolation of fermented products and product recovery
- Demonstrate effective use of these tools and techniques in solving problems relevant for industry

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		
INTRODUCTION TO DOWNSTREAM PROCESSES Role and importance of downstream processing in biotechnological processes. Problems and requirements of bio product purification. Economics of downstream processing in biotechnology; cost cutting strategies, characteristics of biological mixtures, process design criteria for various classes of by-products (high volume, low valve products and low volume, high valve products). Discussion of case studies.	**10 Hours**	**L1, L2,L3**

MODULE -2		
PRIMARY SEPARATION AND RECOVERY PROCESS: Cell disruption methods for intracellular products, removal of insoluble (particulate debris), centrifugation and filtration methods. Membrane based separations (dialysis, micro and ultra-filtration, reverse osmosis), theory design and configuration of membrane separation equipment application. Enrichment operations; precipitation methods (with salts, organic solvents and polymer extractive separations aqueous two phase extraction). Discussion of case studies.	**10 Hours**	**L3, L4, L5**
MODULE -3		
ELECTROPHORETIC TECHNIQUES; Theory of Electrophoresis; Classification; Applications : Moving boundary electrophoresis, Zone Electrophoresis, Gel Electrophoresis, Continuous Gel Electrophoresis, Disc gel Electrophoresis, Agarose Gel Electrophoresis, Cellulose Acetate, Starch Gel and page (Polyacrylamide gel electrophoresis) and SDS - Polyacrylamide, High voltage electrophoresis, Isoelectric focusing, Immunoelectrophoresis. Capillary electrophoresis. PFGE. Discussion of case studies.	**10 Hours**	**L2, L3,L4, L5**
MODULE -4		
INTRODUCTION TO MOLECULAR INERACTION AND CHROMATOGRAPHY: Adsorption and absorption, Kinds of adsorption interactions. Adsorption characteristics, molecular orientation, adsorption isotherms: quantitative Relationships; adsorption from solutions, and the importance of Adsorption phenomena. Principle and classification of chromatography, important terms of chromatography, Partition chromatography - Single dimensional (Both Ascending and Descending) and two dimensional chromatography; Paper chromatography, Thin layer chromatography, Adsorption Chromatography. Discussion of case studies.	**10 Hours**	**L2, L3, L4, L5**
MODULE -5		
ADVANCED PURIFICATION TECHNIQUES: Ion Exchange Chromatography, Gel Filtration Chromatography, Affinity Chromatography. Principle of HPLC, theory and calculations, Instrumentation both analytical and preparative, Types of Columns, Detectors; Sampling Methods; Applications of HPLC, LCMS, GCMS. FPLC, HPTLC. Drying techniques, Crystallization, lyophilisation, Pervaporation, super liquid extraction, foam based separations, in situ product removal, Single step purification, Super critical extraction, online membrane separation, Discussion of case studies	**10 Hours**	**L2, L3, L4, L5**
Course outcomes: After studying this course, students will be able to: • Demonstrate strong basics in principles of separation techniques, purification of fermented products and towards isolation of desired molecule • Design and develop various techniques with respect to product recovery		
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. Belter P.A., Cussler E. and Wei Shan Hu. Bioseparation – Downstream Processing *for Biotechnology* Wiley Interscience. 1988.
2. Asenjo, Juan A. Asenjo Separation Processes in Biotechnology. CRC Press. 1990
3. Biotol. Product Recovery in Bioprocess Technology – (BIOTOL Series). Butterworth-Heinemann College. 1992.
4. Ganapathy Subramanian, Bioseparations and Bioprocessing, Wiley, 2007

REFERENCE BOOKS

5. Wang D.I.C., Cooney C.L., Demain A.L., Dunnil.P., Humphery A.E. and Lilly M.D. Fermentation and Enzyme Technology John Wiley and Sons. 1979.
6. Engelbert Buxbaum, Biophysical chemistry of proteins, Spinger, 2011
7. David Freifelder Physical Biochemistry W H Freeman, 1982

PLANT AND ANIMAL BIOTECHNOLOGY
(CORE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject Code	16BBC24	IA Marks	20
Number of Lecture Hours/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, appreciate the concepts underlying in various Chemical engineering streams like Unit operations, Fluid Mechanics, Thermodynamics, Heat transfer etc
- To comprehend the essentials of design of Bioreactors / fermenters
- To leverage their knowledge of biological molecules / products for scale up operations and productions.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		

INTRODUCTION TO PLANT TISSUE CULTURE: Tissue culture media (composition and preparation) Sterlization methods; Culture media and growth regulators; Various types of culture and single cell isolation techniques; callus, suspension, Totipotency; Organogenesis, somatic embryogenesis. Embyo culture. Androgenesis and gynogenesis. Endosperm culture. Protoplast culture, selection of cybrids and asymmetric hybrids. Cryopreservation.	**10 Hours**	**L1, L2,L3**
MODULE -2		
INTRODUCTION TO PLANT GENETIC ENGINEERING: Gene isolation – General strategies for cloning genes from plants. Types of plant vectors; Ti and Ri-plasmids: structure and functions, Ti plasmid based vectors, advantages. Gene transfer techniques in plants; Vector mediated (*Agrobacterium* and Virus mediated gene transfer), Direct gene transfer (Physical and Chemical methods). Screening and selection of transformants – Marker g enes (Reporter genes and selectable markers). Molecular markers and Marker-Assisted selection- Non-PCR based approaches (RFLP) and PCR based techniques- RAPD, AFLP, SSRs, STS.	**10 Hours**	**L3,L4**
MODULE -3		
TRANSGENICS: for long shelf life of fruits , Stress Resistance, Herbicide resistance - phosphoinothricin, glyphosate, atrazine; Insect resistance, Transgenics for increased nutritional quality (Golden Rice), male sterile lines- barstar and barnase systems, Molecular farming for the production of lipids, fatty acids, biodegradable polymers, industrial enzymes, antibodies and edible vaccines.	**10 Hours**	**L3, L4, L5**
MODULE -4		
BIOLOGY OF CULTURED CELLS: Animal Cell culture media- Physiochemical properties, Balanced salt solutions, complete media, Serum containing and Serum- free media. Primary culture- Types, Primary explants and method of tissue disaggregation, Chick embryo cell culture, Mouse embryo cell culture, Human biopsy materials. Subculture and Propagation of cell cultures. Quantitation and Cytotoxicity assays - hemocytometer, Electronic counting, Dye exclusion and inclusion tests, clonogenic assay, Metabolic assays, MTT based assay. Cell lines – Properties of finite and continuous cell lines, characterization, authentication, routine maintenance and preservation of cell lines. Contamination - Detection and Prevention of contaminants. Scale-up of animal cell cultures- Scale-up in suspension and monolayer. Immortalization of cell lines.	**10 Hours**	**L2, L3, L4**
MODULE -5		
Invitro fertilization and embryo culture., Embryo preservation, Artificial insemination, preparation of foster mother, embryo transfer, Cloning - concept of nuclear transfer, nuclear reprogramming and creation of Dolly; Stem cells - embryonic and adult stem cells, plasticity and concept of regenerative medicine; Genetherapy (ex vivo and in vivo), Tansgenic animals: Methods of transgenesis and applications (biopharming, disease	**10 Hours**	**L3, L4, L5**

models, functional knockouts), Application of animal cell culture - Vaccine production, monoclonal antibody production, specialized cell types, Concepts of tissue engineering , outlines of human genome project, human disease genes, Molecular techniques for rapid diagnosis of genetic diseases, applications.		

Course outcomes:

After studying this course, students will be able to:

- Demonstrate strong basics in principles of Plants and animal biotechnology
- foundation to tackle live problems in various spheres of biological sciences

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. R.A. Dixon & Gonzales Plant Cell Culture: A Practical Approach, IRL Press. 1994.
2. Murray Moo-Young, Animal Biotechnology, Pergamon Press, 1989
3. S.S. Bhojwani and M K Razdan, Plant Tissue Culture: Applications and Limitations, Elsevier, Amsterdam. 1996
4. William G Hopkins, Plant Biotechnology, Infobase Publishing, 2007.

Reference Books:

1. R Ian Freshney, Culture of Animal Cells, Wiley-Liss Publications, 2011
2. HS Chawla, Biotechnology in Crop Improvement, Intl Book Distributing Company. 1998
3. Butler M, Animal Cell Technology: Principles and Practices, Oxford Press. 2005
4. R.E. Spier and J.B. Griffiths, Animal Cell biotechnology, Academic press. 1992.

ELECTIVES-II

CELL CULTURE TECHNQIUES (ELECTIVE SUBJECT) [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	16BBC251	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, appreciate the concepts underlying in various tools in cell culture technology • To comprehend the essentials of design of reactor for cell culture biology		
Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
MODULE -1		
INTRODUCTION TO PLANT CELL AND TISSUE CULTURE: Definition and technologies; Design of typical plant tissue culture laboratory and its management. Sterilization methods and principles; Plant tissue culture (PTC): Media composition, phytohormones and their selective usage, Concept of Cellular Totipotency. Callus & suspension cultures. Plant propagation: Regeneration through meristem and callus cultures; Somatic embryogenesis: production, preservation and use of somatic embryos as propagules; Artificial Seeds and Automation of Somatic Embryo Production. Embryo culture; Haploid plant production; Protoplast culture; Somatic hybridization; Induction & utilization of somatic variants; Cryopreservation: Storage of germplasm.	**08 Hours**	**L1, L2, L3**
MODULE -2		
PLANT TISSUE CULTURE AND BIOSYNTHESIS OF SECONDARY PRODUCTS: Principles and the technology, pharmaceutical, pigments, other natural products and beverage production; Kinetics, scale up and Characterization: optimization of physiochemical parameters. Plant secondary metabolites manipulation of different pathways (Metabolic engineering), genetic stability of production. Large scale production of secondary metabolites: Different types of reactors and their design; Biotransformation: Principle and applications; Commercialization of tissue culture technology: Concept of commercialization.	**08 Hours**	**L2, L3, L4**
MODULE -3		
ANIMAL CELL CULTURE TECHNIQUES, LABORATORY DESIGN & EQUIPMENTS: Sterilization of different materials used in animal cell culture; Aseptic concepts; Maintenance of sterility; Cell culture vessels. Media and reagents: Types of cell culture media; Ingredients of media; Physiochemical properties of the culture media; Balance salt solutions; Natural and artificial media, Serum and its importance, Serum free media, chemically defined media, Protein free media; Preparation and sterilization of cell culture media, serum and other reagents.	**08 Hours**	**L3, L4, L5**
MODULE -4		
PRIMARY CULTURE TECHNIQUES AND CELL LINES: selection, isolation and preparation of tissue (mouse and chick embryo isolation); isolation of cells by tissue disaggregation; enzymatic &	**08 Hours**	**L3, L4, L5, L6**

mechanical methods. Viability tests and Quantitation. Criteria for Sub culture. Secondary culture. Characterization and maintenance of cell lines. Continuous cell lines, Organotypic culture, preservation of cell lines. Common cell culture contaminants. Biology of cultured cells. Stem cells; Types, identification, culture and applications. Scale up studies. Concepts of tissue engineering and case studies.		
MODULE -5		
MICROBIAL CELL CULTURE TECHNIQUES: Sterilization, media preparation and Culture maintenance. Isolation of pure-colonies. Bacterial titre estimation. Growth kinetics. Culture characterization. Auxotroph culture isolation. Biochemical characterization. Antibiotic sensitivity. Bacterial recombination, Replica plating technique, Preservation methods. Screening and isolation of microorganisms, Primary and secondary screening, Metabolic screening, Enrichment and specific screening for the desired product. Strain improvement for the selected organism: strategies of strain improvement for primary, secondary metabolites with relevant examples. Use of UV/Chemicals, recombinant DNA technology, protoplast fusion techniques for strain improvement of primary and secondary metabolites. Selection of improved Strain/Cell line.	**08 Hours**	**L2, L3, L5**
Course outcomes: After studying this course, students will be able to: • Demonstrate strong basics in principles of cell culture techniques • Design and develop different bioreactors for cell culture		
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. Bhojwani SS. Plant Tissue Culture:. Theory and Practice. Elsevier. 1983 2. Chawla H S. Introduction to Plant Biotechnology:. (2nd edn).Science Publishers Inc. 2002 3. Roberta H. Smith Plant Tissue Culture: Second Edition: Academic Press. 2000 4. Freshney I., Culture of Animal Cells : 5th Edition, Wiley-Liss. 2005.		
REFERENCE BOOKS 1. John R. W. Masters. Animal Cell Culture:. A Practical Approach. 5th edn. Oxford University Press. 2000 2. M M Ranga. Animal Biotechnology: 3rd Edition. Agrobios (India) 2007. 3. M. Prescott Microbiology. Lansing. WCB/McGraw-Hill. 1999. 4. Stanbury P.F., and Whitaker A Principles of Fermentation Technology, Pergamon Press,		

. 1984.

ENVIRONMENTAL BIOTECHNOLOGY (ELECTIVE SUBJECT) [As per Choice Based Credit System (CBCS) scheme] SEMESTER – II			
Subject Code	16BBC252	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 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.	**08 Hours**	**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.	**08 Hours**	**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.	**08 Hours**	**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.	**08 Hours**	**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	**08 Hours**	**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, 2nd Edition, McGraw Hill International Edition, 2001.
3. Noel De Nevers Air Pollution Control Engineering, 2nd Edition, McGraw Hill International Edition, 2000

Metcalf Eddy, Wastewater Engineering Treatment and Reuse, 4th Edition, Tata McGraw Hill, 2003

REFERENCE BOOKS

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

BIOPROCESS OPTIMIZATION, MODELING AND SIMULATIONS

(ELECTIVE SUBJECT)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Subject Code	16BBC253	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 enable the students

- To, appreciate the concepts underlying in various tools in modeling and simulations
- To comprehend the essentials of design of bioprocess optimization
- Prepare them to leverage the knowledge towards modern biological processes.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT)

		Level
MODULE -1		
SCOPE AND HIERARCHY OF OPTIMIZATION: Examples of applications of optimization, the essential features, procedure of optimization problems, obstacles to optimization. Classification of models, fitting functions to empirical data, the method of least squares, factorial experimental designs, fitting a model to data subject to constraints, Continuity of functions, unimodal versus Multimodel functions. Convex and Concave functions, Convex region, Necessary and sufficient conditions for an extremism of an unconstrained function one-dimensional search quadratic approximation.	**08 Hours**	**L1, L2,L3**
MODULE -2		
NUMERICAL METHODS: Function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods of uni-dimensional search, region elimination methods, polynomial approximation methods, multivariable optimization: Direct methods, random search, grid search, uni-variate search, simplex method, conjugate search directions, Powell's method, indirect methods- first order, gradient method, conjugate method, indirect method- second order: Newton's method forcing the Hessain matrix to be positive definite, movement in the search direction, termination, summary of Newton's method.	**08 Hours**	**L2,L3,L4**
MODULE -3		
OPTIMIZATION OF UNIT OPERATIONS: Recovery of waste heat, STHE and DPHE (Pinch technology), optimal design of stages in distillation column. Optimal pipe diameter, optimal residence time for maximum yield in an ideal isothermal batch reactor, chemostat, optimization of thermal cracker using liner programming, Optimization of components in bioreactor- media, oxygen requirement, pH, temperature. L/D ratio, Flow rate optimization of fluids. Optimal speed of agitator, paddles.	**08 Hours**	**L3,L4, L5**
MODULE -4		
Solution of General form of dynamic models, dimensionless models. General form of linear systems of equations, nonlinear function. General state-space form. Solving homogeneous, linear ODEs with distinct and repeated Eigenvalues. Solving non-homogeneous equation, equation with time varying parameters. Introduction to systems and modelling - discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation. Discrete event simulation . Random number generation and their techniques - tests for random numbers Random variable generation	**08 Hours**	**L3, L4, L5**
MODULE -5		
Analysis of simulation data - Input modelling – ver ification and validation of simulation models – output analysis for a single model.	**08 Hours**	**L3, L4, L5**

Related to li near regression and generalization of linear regression technique. Stirred tank heaters: model equations, Isothermal continuous stirred tank chemical reactors, Biochemical reactors: model equations, linearization. Case studies		

Course outcomes:

After studying this course, students will be able to:

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

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. T.F.Edgar and Himmelblau DM. Optimization of chemical processes by Mc-Graw. Hill.2001.
2. William L. Luyben: Process Modelling, simulation and Control for Chemical engineers. McGraw-Hill publishing company 1973.
3. Coughanowr and Koppel: Process system analysis and control. McGraw-Hill publishing company. 2009

REFERENCE BOOKS

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

NANOBIOTECHNOLOGY
(ELECTIVE SUBJECT)
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – II

Subject Code	16BBC254	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 enable the students

- To comprehend the essentials of Nanotechnology and biotechnology
- To appreciate the concepts underlying the various techniques in Nanotechnology
- To prepare them leverage their knowledge towards product development

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		
INTRODUCTION TO NANOMATERIALS AND NANOBIOMATERIALS: History of Nanotechnology and Nanobiotechnology, scope and Applications. Structures and properties of Carbon based, metal based and bionanomaterails: Fullerenes, Bucky Ball, Nanotubes, Quantum Dots, Magnetic, Nano Shells,Dendrimers, Nanocarriers, Nanocrystals, Nanowires, Nanomembranes, hybrid biological/inorganic, protein & DNA based nanostructures. Introduction & overview of 1st, 2nd and 3rd generation biomaterials.	**08 Hours**	**L1, L2,L3**
MODULE -2		
CHARACTERIZATION OF NANOSTRUCTURES: UV-Visible spectroscopy, Electron Microscopy-Scanningelectron microscopy (SEM), Atomic Force microscopy (AFM), Transmission electron microscopy (TEM), Scanning Probe microscopy (SPM), Scanning tunnel microscopy (STM); Fourier Transform infrared spectroscopy (FTIR); X-ray spectroscopy.	**08 Hours**	**L2,L3,L4**
MODULE -3		
NANO SYNTHESIS AND FABRICATION: Introduction & overview of Nanofabrication: Bottom up-self assembly and Top down approaches using processes like Ball milling, Sol-gel Process, ChemicalVapour deposition (CVD). Plasma or flame spraying synthesis, Ion-Bean sculpting electrodeposition and various lithography techniques. Nanolithography and Soft lithography. Biosensors: types, applications and developments. Biosensor in modern medicine.	**08 Hours**	**L3,L4, L5, L6**
MODULE -4		

APPLICATION OF NANOBIOTECHNOLOGY: Medical Nanobiotechnology: Diagnostics: Imaging: Benefits and Applications. Nanotherpeutics: cancer treatment – Nanotechnology based chemotherapy (Smart Bomb), Pebbles, wound care products, Implantable materials for vascular interventions, Implantables materials for orthopaedics and dentistry. Active implantable devices and biomics. Nanosurgery. Pharmaceutical Nanobiotechnology: Drug delivery – Nanoparticles used as drug delivery systems, types of drug loading, drug release (sustained and targeted release mechanism), Biodegradable polymers. Application in the field of Nano Surgery and Tissue Engineering. Nano Safety Issues**:** Nanotoxicology: Toxicology health effects caused by Nanoparticles, Ethics,Challenges and Future.	**08 Hours**	**L3, L4, L5**
MODULE -5		
BIOMEMS AND NEMS: Micro & Nano-Electromechanical systems – Fabrication process – choice of materials – advantages and limits of various approaches, Applications, Thermal Radiations, Magnetic, Chemical and Mechanical Transducers – Sensing and Actuators.	**08 Hours**	**L3, L5**
Course outcomes: After studying this course, students will be able to: • Demonstrate strong basics in principles of Nanotechnology • Tackle live problems in Nanobiotechnology • Conceptualize the design and development aspects in the domains like NEMS/BIOMEMS		
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) 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. Nanotechnology in biology and Medicine by Tuan Vo-Dine, Tylor and Francis 2. Introduction to NanoScience and nanotechnology by Poole C P and Owens F J 3. Nanobiotechnology protocols by Rosenthal, Sandra J and Wright and David W. Human press. 4. Nanotechnology – Basic science and Emerging Technologies 2002, Chapman Hill		

REFERENCE BOOKS

1. Nanotechnology by Greggory Timp (Ed) Spring
2. Nanotechnology by M. Karkere IK international publication
3. Biological molecules in Nanotechnology by Stephen lee and Lynn M Savage
4. Nanotechnology-A gentle Introduction to Next big Idea, Mark Ratner and Daniel Ratner
5. Application of Nanotechnology in drug delivery 2014, by Ali Demir

FERMENTATION TECHNOLOGY & BIOSEPARATION LAB

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – II

Laboratory Code	16BBC26	IA Marks	20
Number of Lecture Hours/Week	01Hr Tutorial (Instructions) + 02 Hours Laboratory	Exam Marks	80
		Exam Hours	03

CREDITS – 02

Course objectives:

This laboratory course enables the students

- To gain practical knowledge of the Fermentation Technology and Biochemical engineering
- Use appropriate analytical methods to critically review the experimental observations and analyze the results

Laboratory Experiments:	**Revised Bloom's Taxonomy (RBT) Level**
1. Development of inoculum and biomass estimation(dry weight basis) in Shake flask studies	**L2, L4, L5**
2. Preparation of the fermenter	**L2, L3, L4**
3. Production and estimation of citric acid in both SSF and submerged fermentation	**L2, L3, L4**
4. Production of ethanol/enzymes in fermenter- Study of product formation kinetics and substrate utilization	**L5, L6**
5. Production ethanol/enzyme by immobilized microbes	
6. Purification of intracellular products through cell disruption techniques (homogenization /sonication)	**L2, L3, L4**
7. Separation of biomass/product through tangential flow filtration(TFF)	**L5, L6**
8. Product enrichment operation through two phase aqueous extraction	**L2, L3, L4**
9. Analysis of biomolecules through TLC/HPLC	**L5, L6**
10. Separation of Enzymes through gel and ion exchange chromatography	**L3, L4**
11. Molecular weight determination of protein by both native and SDS PAGE	**L2, L3, L4**
12. Characterization protein by western blotting	**L5, L6**

Course outcomes:

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

- Understand the basic principles of fermentor and its operations
- Optimize the parameters for production of ethanol and organic acids
- Appreciate various downstream processing techniques, purification steps and operations of associated instruments

Graduate Attributes (as per NBA)

- Problem Analysis.
- Design/Development of solutions.
- Modern tool usage.
- Individual and Team Work

Conduct of Practical Examination:

- All laboratory experiments are to be included for practical examination.
- Students are allowed to pick one experiment from the lot.
- 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.

Reference Books:

1. Casida, Industrial Microbiology, Wiley, 1986
2. Staunbery and Whitekar Principles of Fermentation Technology, BH Publishing, 1999
3. Keith Wilson and John Walker, Principles and Techniques of Practical biochemistry, Cambride University Press, 5th Edition, 2000
4. Bioprocess Technology- Fundamentals and Applications by S O Enfors & L Hagstrom (1992), RIT, Stockholm
5. Belter P.A., Cussler E. and Wei Shan Hu. 1Bioseparation – Downstream Processing *for Biotechnology* 1988.. Wiley Interscience.
6. Biotol. Product Recovery in Bioprocess Technology – (BIOTOL Series). 1992.

SEMESTER III

16BBC31- 16BBC34 INTERNSHIP / PROJECT WORK (PROJECT I PHASE EVALUATION)

SEMESTER IV

RESEARCH METHODOLOGY, BIOSAFETY& IPR **(CORE SUBJECT)** [As per Choice Based Credit System (CBCS) scheme] SEMESTER –IV			
Subject Code	16BBT41/16BBC41/16BI41/16IBT41	IA Marks	20
Number of Lecture Hours/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 ff

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 Hours**	**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"; Patent databases; Searching Internatio nal Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTScope(WIPO), IPO, etc.)	**10 Hours**	**L2,L3,L4**
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 Hours**	**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 Hours**	**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 Hours**	**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

IV SEM ELECTIVES

PROJECT MANAGEMENT

(ELECTIVE SUBJECT)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER –IV

Subject Code	16BBC421	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 enable the students

- To Appreciate the Basic concepts of Project management
- To understand and apply the different principles of project management methodologies.
- To learn the translation of Proof-of-concepts to product realization, and product life cycles, marketing, IPs, regulatory affairs etc

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
MODULE -1		

PROJECT PLANNING: scope – problem statement – project goals – objectives – success criteria –assumptions – risks – obstacles – approval process – projects and strategic planning. Project implementation – project resource requirements – types of resources – men –materials finance. Case studies.	**08 Hours**	**L1, L2,L3**
MODULE -2		
PROJECT MANAGEMENT : Introduction – Meaning – nature and characteristics of Management, Scope and functional areas of Management – Management as a Science, Art or Profession Management & Administration – Roles of Management, Levels of Management, Development of Management Thought – Early Management Approaches – Modern Management Approaches.	**08 Hours**	**L2, L3, L4**
MODULE -3		
PLANNING: Nature, importance and purpose of planning, process objectives – Types of plans (Meaning only) – Decision making – Importance of planning – steps in planning & planning premises – Hierarchy of plans.	**08 Hours**	**L2, L3, L4**
MODULE -4		
ORGANIZING AND STAFFING: Nature and purpose of organization - Principles of organization – Types of organization - Departmentation – Committees – Centralization Vs decentralization of authority and responsibility – Span of control – MBO and MBE (Meaning only) Nature and importance of Staffing – Process of Selection & Recruitment (in brief).	**08 Hours**	**L2, L3, L4**
MODULE -5		
DIRECTING & CONTROLLING: Meaning and nature of directing-Leadership styles, Motivation Theories, Communication – Meaning and importance – Coordination, meaning and importance and Techniques of Coordination. Meaning and steps in controlling – Essentials of a sound control system –Methods of establishing control.	**08 Hours**	**L3, L4, L5**
Course outcomes: After studying this course, students will be able to: • Demonstrate strong basics in principles and applications of Project Management		
Graduate Attributes (as per NBA): • Problem Analysis • Design / development of solutions. • Innovation and Entrepreneurship • Professional Ethics • 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. Beenet P Lientz, Kathyn, Project Management – for 2 1st Centrury- Academic Press, 1995
2. Martin Grossmann Entrepreneurship in Biotechnology: managing for growth from start-up to initial public offering. Verlag. Springer-2003
3. Holger Patzelt and Thomas Brenner. Handbook of Bioentrepreneurship By Springer 2008
4. Graham Dutfield, IPR, Trade and Biodiversity, Earthscan publications, 2000

REFERENCE BOOKS:

1. Damian Hine, John Kapeleris. Innovation and entrepreneurship in biotechnology, an international prospective. By Edward Elgar Publishing. 2006
2. P. S. Teng. Bioscience entrepreneurship in Asia: creating value with biology. By World scientific publishing. Co. Pte. Ltd. 2008
3. A.K. Singh. Entrepreneurship Development and Management by Firewall Media, 2006
4. Ramachandran, Entrepreneurship Development by. Tata McGraw-Hill Education, 2008

QC, QA AND VALIDATION

(ELECTIVE SUBJECT)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER –IV

Subject Code	16BBT422/16BBC422	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 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.	**08 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.	**08 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	**08 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**	**08 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.	**08 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 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. Pharmaceutical Quality Assurance, MA Potdar, Nirali Prakashan, Pune
2. Validation of Pharmaceutical process, F. J. Carleton and J. Agalloco, Marcel Dekker Inc.
3. Pharmaceutical Process Validation, Second Ed., Ira R. Ferry & Robert Nash., Marcel Dekk Inc.
4. Quality Planning & Analysis by J. M. Juran and F. M. Gryna, Tata Mcgraw Hill, India.
5. Improving Quality through Planned experimentation by Moen, Tata Mcgraw Hill.

Reference Books:

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

INDUSTRIAL ECONOMICS

(ELECTIVE SUBJECT)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER –IV

Subject Code	16BBT423/16BBC423	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 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 Hours**	**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 Hours**	**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 Hours**	**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 &	**08 Hours**	**L3, L4, L5**

A's) and diversification. Structure of Industrial labor; Employment dimensions of Indian Industry, Industrial legislation		
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 Hours**	**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
5. Divine, P.J. and R.M. Jones et. al. (1976), 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.
8. 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)

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER –IV

Subject Code	16BBT424/16BBC424	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

- 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 Hours**	**L1, L2,L3**
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.	**08 Hours**	**L2,L3,L4**

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		
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 Hours**	**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. Sources of risk/venture capital, fixed capital, working capital and a basic awareness of financial services such as leasing and factoring.	**08 Hours**	**L2, L3, L4**
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 Hours**	**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 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,
5. Taneja, Gupta, "Entrepreneur Development New Venture Creation", Galgotia Publ 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", New Delhi, 2002.

4. Manohar, "Entrepreneurship & Management", Wiley India, 2012.