VISVESVARAYA TECHNOLOGICAL UNIVERSITY , BELGAVI
CHOISE BASED CREDIT SYSTEM (CBCS)
SCHEME OF TEACHING AND EXAMINATION 2016 -17

MTECH IN INDUSTRIAL BIOTECHNOLOGY

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/ Tutorials		I.A.	Exam		
16BBT11/16BBC11/16IBTT11	NUMERICAL METHODS & BIOSTATISTICS	4	-	3	20	80	100	4
16IBT12	FERMENTATION TECHNOLOGY - I	4	--	3	20	80	100	4
16IBT13	ADVANCED MOLECULAR BIOLOGY	4	--	3	20	80	100	4
16IBT14	BIOPROCESS ENGINEERING	4	--	3	20	80	100	4
16IBT15X	ELECTIVE - 1	3	--	3	20	80	100	3
16IBTL16	FERMENTATION TECHNOLOGY & MOLECULAR BIOLOGY LAB	--	**3**	3	20	80	100	2
16IBT17	SEMINAR	--	3	--	100	--	100	1
Total		**19**	**6**	**18**	**220**	**480**	**700**	**22**

ELECTIVE – 1	
16IBT151	INSTRUMENTAL METHODS OF ANALYSIS
16IBT152	BIOPROCESS MODELING & AUTOMATION
16IBT153	MICROBIAL BIOTECHNOLOGY
16IBT154	BIOREACTION ENGINEERING

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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		
16IBT21	FOOD PROCESS ENGINEERING	4	--	3	20	80	100	4
16IBT22	FERMENTATION TECHNOLOGY – II	4	--	3	20	80	100	4
16IBT23	QUALITY, SAFETY AND PROJECT MANAGEMENT	4	--	3	20	80	100	4
16IBT24	BIOREACTOR DESIGN AND ANALYSIS	4	--	3	20	80	100	4
16IBT25X	ELECTIVE-2	3	--	3	20	80	100	3
16IBTL26	FOOD PROCESSING & DOWNSTREAM OPERATIONS LAB	--	**3**	3	20	80	100	2
16IBT27	SEMINAR	--	3	--	100	--	100	1
	Total	**19**	**6**	**18**	**220**	**480**	**700**	**22**

ELECTIVE – 2	
16IBT251	INDUSTRIAL WASTE TREATMENT
16IBT252	NANO MATERIALS AND NANO TOOLS
16IBT253	CANCER BIOLOGY
16IBT254	STEM CELL BIOLOGY

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III Semester: INTERNSHIP **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		
16IBT31	Seminar/Presentation on Internship	-	-	-	25		25	20
16IBT32	Report on Internship.	-	-	-	25		25	
16IBT33	Evaluation and Viva on Internship				50	50	100	
16IBT34	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 / Tutorials		I.A.	Exam		
16BT41/16BC41/16BI41/16IBT41	RESEARCH METHODOLOGY, BIOSAFETY & IPR	4	--	3	20	80	100	4
16IBT42X	ELECTIVE-III	3	--	3	20	80	100	3
16IBT43	Evaluation of Project Phase-II	-	-	-	50	-	50	3
16IBT44	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	
16IBT421	ADVANCED BIOINFORMATICS
16IBT422	METABOLIC ENGINEERING
16IBT423	ENTREPRENEURSHIP DEVELOPMENT
16IBT424	PETROLEUM BIOTECHNOLOGY

NUMERICAL METHODS & BIOSTATISTICS			
Subject Code	**16BT11/16BC11/16IBT11**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS 04

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

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

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

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

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

Graduate Attributes (as per NBA)

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

Question Paper Pattern:

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

TEXT BOOKS

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

REFERENCE BOOKS

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

FERMENTATION TECHNOLOGY- I			
Subject Code	16IBT12	IA Marks	20
Number of Lecture Hrs./Week	04	Exam Marks	80
Total number of lecture hours	50	Exam Hours	03
CREDITS 04			

Course objectives:
To learn various cell culture methods, strain improvement and to design and develop medium for inoculum development;
To understand techniques of sterilization and to study the various aspects of fermenter for an industrial fermentation process;
To apply the knowledge of control system for control of industrial fermentation process.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
CELL CULTIVATION AND GROWTH KINETICS Cell culture (Bacteria, fungal, plant, animal), Microbial growth kinetics, logistic growth model, growth of filamentous organism Strain improvement of industrial micro organism. Measurement of cell mass. Cell immobilization. Numericals.	10	L1,L2,L3
MODULE –2		
INOCULUM DEVELOPMENT AND MEDIA PREPARATION Media components and optimization (PB, RSM techniques), types of media, Strain preservation, inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter.	10	L1,L2,L3
MODULE – 3		
STERILIZATION Sterilization: death kinetics, del factor, batch and continuous; insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Numericals.	10	L3,L4,L5
MODULE – 4		
FERMENTATION PROCESS Parts of fermenter: Body, Baffles, Sparger, valves, ports, Aeration: Oxygen requirement, Oxygen uptake in cell culture, Oxygen transfer in fermenter**,** gas hold up, K_La measurement, Measurement of dissolved	10	L3,L4,L5

oxygen concentrations, Estimating Oxygen Solubility, Measurement of K_La, factors effecting K_La in fermenter, Agitation: fluid rheology. Numericals.		
MODULE – 5		
CONTROL OF INDUSTRIAL FERMENTATION Requirements for control, sensors, controllers, design of fermenter control specification, control of incubation, advanced incubation control.	10	L2,L3,L5

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

- Demonstrate the methods of cell culture under various conditions, strain improvement methods
- Design and develop medium for cell cultivation for fermentation process
- Apply the knowledge of sterilization techniques
- Understand needs of various parts of fermenter and their operation
- Apply the knowledge of control theory for industrial fermentation control

Graduate Attributes (as per NBA)

Problem Analysis
Design / Development of Solutions
Project Management and Finance
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. Stanbury, Vitaker and Hall, "Principles of Fermentation Technology", Butterworth Heinemann, 2nd Ed., 1999.
2. El-Mansi (Ed.), "Fermentation Microbiology and Biotechnology", CRC Press, 3rd Ed., 2011.

REFERENCE BOOKS

1. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2nd Ed., 2012.
2. Badal C. Saha (Ed.), "Fermentation Biotechnology", CBS Publishers & Distributors Pvt. Lt 2004.
3. Brian McNeil and Linda Harvey (Ed), "Practical Fermentation Technology", Wiley, 2008.

ADVANCED MOLECULAR BIOLOGY			
Subject Code	16IBT13	IA Marks	20
Number of Lecture Hrs./Week	04	Exam Marks	80
Total number of lecture hours	50	Exam Hours	03
CREDITS 04			

Course objectives:
To learn and understand procedures in molecular biology research to work with nucleic acid processing;
To gain the knowledge of gene expression models of prokaryotic and eukaryotic system;
To apply the knowledge of molecular research in rDNA technology and in therapeutics;
To use fundamental experimental knowledge of molecular research procedures in understanding molecular biology concepts, detection and therapy.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
MOLECULAR RESEARCH PROCEDURES AND WORKING WITH NUCLEIC ACIDS Chemical synthesis of DNA[Glick], synthetic genes, isolation of DNA, RNA, handling and quantification of nucleic acids, labeling, nucleic acid hybridization. PCR: essential features, designing of primers, DNA polymerases of PCR, exotic PCR techniques (PCR using mRNA (RT-PCR), nested PCR, inverse PCR, RAPD, processing of PCR products, applications. Alternative amplification techniques, Production of gene probes: gene probe labeling, non radioactive DNA labeling, end labeling of DNA, labeling by primer extension, nick translation labeling. Nucleotide sequencing: Maxam Gilbert, Sanger method, direct PCR sequencing, cycle sequencing, automated flourosense DNA sequencing (primer walking).	10	L1,L2,L3
MODULE –2		
GENE EXPRESSION IN PROKARYOTES AND EUKARYOTES AND MANIPULATION OF GENE EXPRESSION: Prokaryotes; Prokaryotic gene expression and control of gene expression; isolation of functional promoters: Promoter selection with E. coli plasmid pBR316 and pK01. Gene expression from strong and regulatable promoters: Regulatable promoters, increasing protein	10	L1,L2,L3

production, large scale systems, expression in other microorganisms. Fusion proteins: cleavage of fusion proteins, uses of fusion proteins, expression of native protein, DNA integration into host chromosome. Eukaryotes: some considerations in choice of cell lines, endogenous selectable markers and dominant selectable markers, stepwise amplification of transgene, plasmid vectors for transfection, major expression systems used in animal cells.		
MODULE – 3		
rDNA TECHNOLOGY Early thoughts and experiments in cloning, first step towards cloning frogs and toads, nuclear totipotency, Prokaryotic vectors: Bacterial plasmids, viral vectors: cosmids, phasmids, M13 vectors, broad host range vectors. Eukaryotic vectors: Generalized eukaryotic expression vector, Yeast expression systems: *Saccharomyces cerevisiae* vectors, yeast selectable markers, direct expression in *Saccharomyces cerevisiae*, secretion of heterologous proteins by *Saccharomyces cerevisia;* Other yeast expression systems: Expression of hepatitis B virus surface antigen, expression of bovine lysozyme C2, cloning of large DNA fragments in BAC and YAC vectors; cultured insect cell expression system: Baculovirus transfer vector, Scaleup problem with Baculovirus system; Mammalian cell line expression system: Human Papova BK virus shuttle vector, Production of protein drug for clinical trials, viral vectors-adenovirus, retrovirus, pox virus and bacculovirus. Plant as bioreactors: biopharming and neutraceuticals (edible vaccines, Ab, polymer producers from plants). Live recombinant vaccines.	10	L2,L4,L5
MODULE – 4		
GENE EXPRESSION DIRECTED MUTAGENESIS AND PROTEIN ENGINEERING Oligonucleotide directed mutagenesis with M13 DNA, PCR amplified oligonucleotide directed mutagenesis, degenerate oligonucleotide primers, random mutagenesis and site directed mutagenesis. Adding disulphide bonds, changing aspargine to other amino acids, reducing number of free sulphahydril residues, increasing enzyme activity, modifying enzyme specificity, increasing protein stability. Applications: Point mutation- Interferons β16(betaseron/ betaferon), lispro insulin(humalog), novel vaccine adjutants,	10	L2,L4,L5

domain shuffling, linking domains, swapping protein domains, deleting domain , whole protein shuffling, fusion proteins.		
MODULE – 5		
rDNA TECHNOLOGY FOR PRODUCTION OF THERAPEUTICS Recombinant interferon. Subunit vaccines: against herpes simplex virus, foot and mouth disease, peptide vaccines. Live recombinant vaccines: Vaccinia virus recombinants, BCG vaccines, poliovirus chimaeras. Attenuated vaccines: Cholera, *Salmonella* as live bacterial vaccine. Vector vaccines: vaccines directed against virus and bacteria.Monoclonal antibodies: Isolation of immunoglobulin variable region genes and expression on the surface of bacteriophage- isolation of mRNA for V_H and V_L and generation of cDNA, PCR amplification of cDNA for antibody V_H and V_L. Linking of V_H and V_L to give scFv, Insertion of scFv into phagemid vector, expression of scFv on the surface of bacteriophage, screening phage display libraries of immunoglobulin genes, preparation of soluble scFv, screening supernatants containing soluble scFv, application of monoclonal antibodies in biomedical research, diagnosis and treatment of diseases.	10	L2,L3,L5

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

- Demonstrate working procedures and protocols in molecular research
- Understand gene expression models
- Apply molecular research concepts in rDNA technology and in therapeutics
- Analyze and know the requirements of vectors and protein expression
- Design recombinant vectors for therapeutic applications

Graduate Attributes (as per NBA)

Problem Analysis
Design / Development of Solutions
Modern Tool Usage
Professional Ethics
Life-long Learning
Societal and Environmental Concern

Question Paper Pattern:

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

TEXT BOOKS

1. Primrose, S. B and Twyman, R. M. "Principles of gene manipulation and genomics". Blackwell Publishing, 7th Ed, 2006.
2. Gerald Karp. "Cell and Molecular Biology". John Wiley, 6th Ed., 2009.

REFERENCE BOOKS

1. Walker, J. M. and Rapley, R. "Molecular Biology and Biotechnology". Panima Publishing Corporation, 4th Ed., 2003.
2. Glick, B. R and Pasternak, J. J. "Molecular Biotechnology-Principles and applications of Recombinant DNA". ASM Press, Washington DC, 1994.
3. Nicholl, D. S. T. "An introduction to Genetic Engineering". Cambridge University Press, 3rd Ed., 2008.
4. Nancy Craig et al. "Molecular Biology: Principles of Genome Function", Oxford University Press, 1st Ed., 2010.

BIOPROCESS ENGINEERING

Subject Code	16IBT14	IA Marks	20
Number of Lecture Hrs./Week	04	Exam Marks	80
Total number of lecture hours	50	Exam Hours	03

CREDITS 04

Course objectives:

To learn the fundamental concepts of bioprocess engineering;
To learn and understand fluid flow process, mixing process and mass transport;
To apply the concepts of fluid flow, mixing and filtration to industrial operations;
To understand and design measurement & control strategies for these operations.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
INTRODUCTION Introduction to bioprocess engineering, Balances: elemental balances, material balance (steady and unsteady) and heat balance, Energy balancing for bioreactors. Yield: The yield values for anaerobic & aerobic systems. Mass and energy yield coefficients, overall yield for microorganisms	10	L1,L2,L3
MODULE –2		

FLUID FLOW AND MIXING Fluid statics: Pressure at a point and measurement, osmotic pressure. Viscosity and its measurements: Newton's laws of viscosity, Newtonian and non Newtonian fluids (NF & NNF), Rheology of fermentation broth. Fluid Flow: types of fluid flow, laminar, turbulent flow. Bernoulli equation. Flow measuring devices: Variable head & area meters, wheel flow meter. Hydrodynamic boundary layer, boundary layer shear force.	10	L1,L2,L3,L4
MODULE – 3		
MASS TRANSFER Diffusion: Types of diffusion, Fick's law, Role of diffusion in bioprocessing, L-L, L-S and G-L mass transfer. Aeration: Oxygen uptake in cell culture, Gassed fluid, K_La and its measurement, oxygen supply and demand, sparger, aeration number, power requirement, bubble shear.	10	L1,L2,L4,L5
MODULE – 4		
UNIT OPERATIONS Filtration: Filter aids, filtration theory. Centrifugation: centrifugation theory. Mixing: Mechanisms of mixing. Flow pattern: radial and axial flow impeller, mixing theory, mixing time, effectiveness of mixing and power requirement.	10	L1,L2,L4,L5
MODULE – 5		
BIOPROCESS CONTROL Concept of bioprocess control, Elements of feedback controller, types of controller action, advanced control strategies, controller tuning, online and offline measurements (P,T, pH, agitator speed, off gas analysis).	10	L2,L3,L5
Course outcomes: At the end of this course, student will be able to: • Demonstrate the concepts of fluid flow, mass transfer, mixing and filtration for industrial application. • Identify rheological behavior and diffusion phenomena of fermentation broth. • Apply mass transfer concepts to design aeration and agitation of fermentation process. • Demonstrate knowledge of filtration and mixing process in industrial operation. • Develop control strategies for bioprocess operations.		
Graduate Attributes (as per NBA) Problem Analysis Design / Development of Solutions Conduct investigations of Complex Computing Problems 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. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2nd Ed., 2012.
2. Stanbury, Vitaker and Hall, "Principles of Fermentation Technology", Butterworth Heinemann, 2nd Ed., 1999.

REFERENCE BOOKS

1. Shuler and Kargi, "Bioprocess Engineering", PHI, 2nd Ed., 2001.
2. Brian McNeil and Linda Harvey (Ed), "Practical Fermentation Technology", Wiley, 2008.
3. David Himmelblau, "Basic principles and Calculations in Chemical Engineering", Prentice Hall. 6th Ed, 1996.
4. Donald R. Coughanowr, Lowell B. Koppel, "Process systems analysis and control", MGH, 2nd Ed., 1991.
5. Richardson and Coulson, "Chemical Engineering", Volume 1, Butterworth Heinemann, 6th Ed., 1999.

INSTRUMENTAL METHODS OF ANALYSIS

Subject Code	16IBT151	IA Marks	20
Number of Lecture Hrs./Week	03	Exam Marks	80
Total number of lecture hours	40	Exam Hours	03

CREDITS 03

Course objectives :

To learn fundamentals of analytical methods;
To understand various components of instrumentation system used in analysis;
To learn the concepts and applications of spectroscopic, chromatographic and electrophoretic techniques used for analysis of biomolecules;
To understand working principle and instrumentation system of spectroscopic, chromatographic and electrophoretic techniques

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

INTRODUCTION Introduction to analytical methods, types of analytical methods, selection of analytical method (accuracy, precision, sensitivity, selectivity, scale, time and cost).Measurement and error: Types of error, measurement of error and accuracy. Electromagnetic radiation: Properties of electromagnetic radiation, interaction of radiation with matter, Born – Oppenheimer approximation. Sources of radiation: Continuous sources of UV, visible and IR radiation (D2, Tungsten filament, Xenon arc lamps, Nernst glower, Globar sources). Components of an analytical instrument, signal amplifiers (Transistors, Operational Amplifiers), noise, signal to noise ratio, sources of noise, signal to noise improvement. Sampling: types of samples, sample preparation, sample size, sampling error, stock solutions, sample dilution. Calibration methods: reagent blank, one point calibration, linear calibration, standard addition method, internal and external standard.	08	L1,L2,L3
MODULE –2		
ABSORPTION & EMISSION SPECTROSCOPY Optical spectroscopy: Source, optical components, wavelength selector, sample holders, detectors. UV-Visible spectroscopy: Theory (Beer – Lambert's law), chromophores and their characteristic absorption, theory of UV absorption (electronic transition – n to pi*, pi to pi*, sigma to sigma*; Solvatochromism, Conjugated dienes – Woodward Fieser rules), instrumentation (single and double beam), qualitative and quantitative analysis, single and multiple component analysis, numericals. Infrared spectroscopy: Theory, instrumentation, qualitative analysis, FT-IR. Atomic absorption spectroscopy: Theory, instrumentation and applications. Fluorescence and Phosphorescence spectroscopy: Theory, instrumentation and applications.	08	L1,L2,L4,L5
MODULE – 3		
RESONANCE & SCATTERING SPECTROSCOPY Nuclear magnetic resonance spectrometry: Theory (Larmor Equation), environmental effects on pNMR, chemical shift, spin-spin splitting, applications of pNMR, data interpretation. Molecular mass spectrometry: Theory, methods of	08	L3,L4,L5

ionization (EI, ESI, Ion Spray, MALDI), mass analyzers (Magnetic sector, Quadrupole, TOF), MALDI-TOF in protein analysis and applications. Turbidimetry: Theory, instrumentation and applications. Introduction to ICP-MS, ICP-OES		
MODULE – 4		
CHROMATOGRAPHIC TECHNIQUES Introduction to chromatographic separations, classification. Basic principles and theory of chromatography (Plate theory, Rate theory – van Deemter equation), numericals. Gas chromatography and HPLC: principle, instrumentation, column, detector, mobile phase, sample preparation. Application of chromatographic techniques.	08	L1,L2,L3
MODULE – 5		
ELECTROPHORETIC TECHINQUES General principle, support media- Agarose gel, starch gel, agarose starch gel, polyacrylamide gel. Electrophoresis of protein: SDS-PAGE, native gels, gradient gels, isoelectric focusing gels, 2D polyacrylamide gel electrophoresis, cellulose acetate electrophoresis. Detection, estimation and recovery of proteins in gels. Electrophoresis of nucleic acids. Capillary electrophoresis: Zeta potential, Electro-endo-osmotic flow, Instrumentation, detectors, Applications.	08	L1,L2,L3,L4,L5

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

- Explain application of electromagnetic radiation in biomolecule analysis.
- Demonstrate fundamental concepts of analytical procedures like sampling, sample preparation, use of calibration of analytical methods, and Identify suitable technique.
- Explain the fundamental concepts and applications of spectroscopic, chromatographic and electrophoretic techniques.
- Understand working principle of instrumentation system of spectroscopy, chromatography and electrophoresis.
- Apply concepts of spectroscopic, chromatographic and electrophoretic techniques to analyse biomolecules qualitatively and quantitatively
-

Graduate Attributes (as per NBA)

-

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. Willard and Merit, "Instrumental Methods of Analysis", CSS Publishers, 1986.
2. Douglas A. Skoog, F. James Holler and Timothy A. Nieman, "Principles of Instrumental Analysis", Harcourt Brace College Publishers, 5th Ed., 1998.
3. R.M. Silverstein and W.P. Webster, **"**Spectrometric Identification of Organic Compounds"**,** Wiley & Sons, 7th Ed., 2005.
4. Chatwal & Anand, **"**Instrumental Methods of Chemical Analysis**"**, Himalaya Publishing House, 5th Ed., 2013.
5. K. Wilson and J. Walker, "Principles and Techniques of Practical Biochemistry", Cambridge University Press, 1994.
6. S. Ahuja & N. Jespersen, "Modern Instrumental Analysis", Elsevier, 2006
7. David Harvey, "Modern Analytical Chemistry", MGH, 1st Ed., 2000.
8. B. Sivasankar, "Instrumental Methods of Analysis", Oxford University Press, 2012.

BIOPROCESS MODELING AND AUTOMATION

Subject Code	16IBT152	IA Marks	20
Number of Lecture Hrs./Week	03	Exam Marks	80
Total number of lecture hours	40	Exam Hours	03

CREDITS 03

Course objectives :

To learn the concepts and need for process modeling and simulation.
To apply the concepts of modeling to linear and nonlinear bioprocesses.
To apply the modeling principles to systems generating ordinary and partial differential model equations.
To understand principle of stochastic modeling.
To use and apply software tools for simulation of model equations.

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

PRINCIPLES OF MODELING Concept of modeling and simulation, general aspects of modeling, dependent and independent variables, classification of models. Material and energy balance equations, constitutive equations, general strategy of modeling, Solution strategies and simulation. Measurements, errors and accuracy. Modeling of simple systems.	08	L1,L2,L3
MODULE –2		
LINEAR AND NON LINEAR EQUATIONS Elemental balances and degrees of reduction, extractor, absorber. Models of enzyme kinetics (Michaelis-Menten), growth kinetics (Monod) and product formation kinetics. Receptor-ligand dynamics, RT-PCR modeling. Numerical solutions to linear and nonlinear algebraic equations.	08	L1,L2 L3 L4
MODULE – 3		
ORDINARY DIFFERENTIAL EQUATIONS Models of predator-prey, commensalism and mutualism, Structured kinetic models, pharmacokinetic models. Bioreactors modeling (MFR and PFR with linear and nonlinear kinetics), models of heat transfer and mass transfer in bioreactor. Numerical solutions to ODEs.	08	L1,L2,L3
MODULE – 4		
PARTIAL DIFFERENTIAL EQUATIONS & STOCHASTIC MODELING Kinetics of immobilized system with internal mass transfer, diffusion across biological membranes, fluid flow in physiological vessel (blood flow), numerical solutions to PDEs. Principles of stochastic modeling, age distribution of microbial cells, budding of yeast cells.	08	L1,L3,L4,L5
MODULE – 5		
MODEL SIMULATION MATLAB: Basic commands, plotting tools, matrices and operation, flow control, solving linear, nonlinear equations, ODEs, PDE toolbox, SIMULINK. Use of MATLAB to solve problems formulated in Unit 1 to Unit 4	08	L1,L2,L3

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

- Understand the concepts and need for process modeling and simulation.
- Apply the concepts of modeling to linear and nonlinear bioprocesses.
- Apply the modeling principles to systems generating ordinary and partial differential model equations.
- Describe principle of stochastic modeling.

- Use and Apply software tools for simulation of model equations.

Graduate Attributes (as per NBA)
Computational knowledge
Problem Analysis
Design / Development of Solutions
Conduct investigations of Complex Computing Problems
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. I.J. Dunn, E. Heinzle, J. Ingham and J.E. Prenosil, "Biological Reaction Engineering", Wiley-VCH, 2nd Ed., 2003.
2. Stanley M. Dunn, Alkis Constantinides and Prabhas V. Moghe, "Numerical Methods in Biomedical Engineering", Academic Press, 2006.
3. W. Fred Ramirez, "Computational Methods in Process Simulation", Elsevier, 2nd Ed, 1998.

REFERENCE BOOKS

4. Ashim K. Datta, "Biological and Bioenvironmental Heat and Mass Transfer", Marcel Deccer Inc., 2002.
5. Jens Nielsen, John Villadsen and Gunnar Liden, "Bioreaction Engineering Principles", Plenum Publishers, 2nd Ed., 1994.
6. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2nd Ed., 2012.

MICROBIAL BIOTECHNOLOGY

Subject Code	16IBT153	IA Marks	20
Number of Lecture Hrs./Week	03	Exam Marks	80
Total number of lecture hours	40	Exam Hours	03

CREDITS 03

Course objectives :

- This course on microbial biotechnology has the major objective to learn the various aspects of industrial applications of microbiology. From the basics of microbiology the Course is oriented towards the industrially important product development. The topics cover most of the applications of microbiology like enzyme production, bioremediation, protein production, bioleaching.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY

		(RBT) LEVEL
MODULE – 1		
INTRODUCTION Study of Prokaryotes & Eukaryotes, Classification and Identification of Microorganisms: Phenotypic and Genotypic	08	L1,L2,L3
MODULE –2		
FUNGAL BIOTECHNOLOGY Classification and Identification of fungi, (Barnett manual reference). Industrial applications of fungi. Fungal diseases	08	L1L2L3
MODULE – 3		
MICROBIAL PROTEINS Introduction of DNA to Bacteria: By Transformation, Conjugation, Transduction and Injection of bacteriophage DNA, microbial enzymes: Strain selection and development, fermentation process and composition of the medium, large scale application of microbial enzymes	08	L1,L3,L4
MODULE – 4		
STRAIN IMPROVEMENT OF INDUSTRIAL MICROBES Mutation methods: chemical and physical, selection of induced mutants, isolation of auxotropic mutants, isolation of resistant mutants, protoplast fusion technique, recombinant DNA technique.	08	L2,L4,L5,L6
MODULE – 5		
STRAIN IMPROVEMENT OF INDUSTRIAL MICROBES Mutation methods: chemical and physical, selection of induced mutants, isolation of auxotropic mutants, isolation of resistant mutants, protoplast fusion technique, recombinant DNA technique.	08	L1,L2,L3,L4,L5
Course outcomes: At the end of this course student will be able to 1. Recall the identification of microbes based phenotypic and genotypic characteristics. 2. Explain the uses of fungal strains in industrial applications. 3. Apply the concepts of microbial technology to various fields of bioprocessing. 4. Appraise the production of microbial enzymes from using native and engineered strains.		
Graduate Attributes (as per NBA) Computational knowledge Problem Analysis Design / Development of Solutions Conduct investigations of Complex Computing Problems Modern Tool Usage 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. Paule Prave, Uwe Faust, Wolfgang Sitting and Dieter A Sukatsch, *Fundamentals of Biotechnology*, Wiley-Blackwell, 1987.
2. P.F. Stanbury and A. Whitaker, *Principles of Fermentation Technology*, Pergamon Press, 1984.
3. Alexander N. Glazer, Hiroshi Nikaido, *Microbial Biotechnology: Fundamentals of Applied Microbiology*, 2nd Ed., Cambridge University Press, 2007.

REFERENCE BOOKS

1. Bernard Davis & Renato Dulbecco, *Microbiology*, 4th Ed., Lippincott Company, Philadelphia, 1990.
2. SJ Prit, *Principle of Microbe & Cell Cultivation*, Blackwell Scientific Co, 1975.

BIOREACTION ENGINEERING

Subject Code	16IBT154	IA Marks	20
Number of Lecture Hrs./Week	03	Exam Marks	80
Total number of lecture hours	40	Exam Hours	03

Course objectives :

- To learn kinetics of enzymatic reactions and to understand enzyme substrate models of enzyme reactions;
- To analyse the effects of parameters affecting enzyme kinetics and to identify and formulate methods to evaluate enzyme kinetics in homogeneous and heterogeneous systems;
- To analyse mass transfer effects on enzyme kinetics and to know the technologies of production of industrial enzymes;
- To learn and understand methods of protein purification for applications at higher concentrations.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY

		(RBT) LEVEL
MODULE – 1		
BIOLOGICAL KINETICS Enzyme nomenclature and enzyme classification, energy potentials of enzyme (Stern layers). Types of reaction, elementary and non elementary reaction, molecularity and order of reaction, The enzyme-substrate complex and enzyme action, simple enzyme kinetics with one and two substrate. Derivation of Michaelis-Menten kinetics, Briggs-Haldane approach, Monod equation. Double Michaelis–Menten kinetics, allosteric kinetics, effect of temperature and Ph on enzyme kinetics. Substrate and product inhibition of growth. Substrate uptake kinetics. Interacting microorganisms	08	L1,L2,L3
MODULE –2		
ENZYME REACTION IN HOMOGENEOUS SYSTEMS Basic reaction theory, reaction thermodynamics, Reaction rate & kinetics: first, second and zero order reaction. Estimation of reaction rate: integral & differential method. Enzyme kinetics: Michaelis-Menten Kinetics Enzyme immobilization kinetics, enzyme deactivation kinetics, Mass transfer limitations. Enzyme inhibition kinetics (substrate, product, inhibitor), Competitive, Noncompetitive and Mixed Inhibition kinetics.	08	L1,L2,L3
MODULE – 3		
ENZYME REACTION IN HETEROGENEOUS SYSTEMS Catalyst immobilization, substrate concentration profile in an immobilized biocatalyst particle. Steady state shell balance. Zero, first order and M-M kinetics. Concentration profile in other geometry. Dimensionless parameters from diffusion reaction model. Effect of internal and external mass transfer. Effect of Mass-Transfer Resistance	08	L1,L3,L4
MODULE – 4		
INDUSTRIAL ENZYMES & APPLICATIONS Enzyme engineered for new reactions-novel catalyst for organic synthesis. Case studies: thermozymes cold adopted enzymes. Ribozymes, hybrid enzymes, diagnostic enzymes, therapeutic, inteins. enzymes of industrial importance (amylase, glucose isomerase, cellulose, lipase, protease, xylanase, invertase, peroxidases).	08	L2,L3,L4,L5
MODULE – 5		

ENZYME PURIFICATION Separation of insolubles: filtration, centrifugation. Extraction and purification of solubles: Ultra filtration, high performance tangential flow filtration, Liquid liquid extraction (ATPS). Recovery and purification of intracellular products: cell disruption, chromatographic techniques. Analytical assays of purity level of enzymes.	08	L3,L4,L5

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

- Explain enzyme substrate models and kinetics of enzyme reaction.
- Demonstrate effects of process parameters on enzyme reactions.
- Formulate evaluation methods for kinetic parameters for homogeneous and heterogeneous enzyme reactions.
- Analyse mass transfer effects involved in immobilized enzyme systems.
- Explain production of industrial enzymes.
- Describe protein enrichment or purification methods.

Graduate Attributes (as per NBA)

Computational knowledge
Problem Analysis
Design / Development of Solutions
Conduct investigations of Complex Computing Problems
Modern Tool Usage
Project Management and Finance
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. Pauline M. Doran, "Bioprocess Engineering Principles", Academic Press, 2nd Ed., 2012.
2. El-Mansi (Ed.), "Fermentation Microbiology and Biotechnology", CRC Press, 3rd Ed., 2011.

REFERENCE BOOKS

1. Ashok Pandey et al., "Enzyme Technology", Springer Publisher, 2006.
2. Nielsen et al., "Bioreaction Engineering Principles", Plenum Publishers, 2nd Ed., 2002.
3. Mohammed A. Desai (Ed.), "Downstream Processing of Proteins: Methods and Protocols", Humana Press, 2000.
4. Satinder Ahuja, "Handbook of Bioseparations", Vol 2, Academic Press, 1st Ed., 2000.
5. Devasena, T. "Enzymology", Oxford University Press, 2012.

Marangoni, "Enzyme kinetics: A modern approach", Wiley India 2012

FERMENTATION TECHNOLOGY & MOLECULAR BIOLOGY LAB

Subject Code	**16IBTL16**	**IA Marks**	**20**
No. of Lab Hrs./ Week :	**03**	**Exam Marks**	**80**
		Exam Hours	**03**

CREDITS 02

Course objectives :
To learn the methods involved in preparation of medium for microbial and plant cell culture.
To understand methods of medium design and reduction of lag phase.
To gain hands on experience in plant tissue culture and molecular biology techniques.

Sl.NO	Experiment	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
1	Preparation of inoculums and aseptic inoculum transfer into media.	**L3**
2	Preparation of medium for microbial culture, Media optimization using RSM.	**L4**
3	Study of growth kinetics using different carbon sources.	**L3**
4	Strategy to reduce lag phase. Case Inoculum media Production media a. Same composition Same composition b. Different Composition Different composition [Compare growth curve of case 1 & 2 using same microorganism] .	**L3**
5	Production of callus, preparation of media and suspension culture.	**L3**
6	Secondary metabolite production using suspension culture.	**L4**
7	Plasmid Isolation by Mini Prep Method.	**L3**
8	Restriction Digestion and Restriction Mapping Technique.	**L4**
9	PCR Technique and the Use of Gel-Doc System.	**L3**
10	Salt Extraction and Estimation of High Quality Genomic DNA obtained from Plant Source.	**L3**
11	Small-Scale Extraction and Estimation of RNA obtained from Plant Source.	**L3**
12	Western blotting technique.	**L3**

Course outcomes:
At the end of the course the graduates should be able to:
- Prepare and develop inoculum for industrial fermentation.
- Design medium for optimal fermentation and reduce lag period.
- Design and Perform experiments on plant tissue culture.
- Design and Perform molecular biology experiments.

Graduate Attributes (as per NBA)
Computational knowledge
Problem Analysis
Design / Development of Solutions

Societal and Environmental Concern Individual and Team Work Innovation and Entrepreneurship
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.

II SEMESTER

FOOD PROCESS ENGINEERING			
Subject Code	**16IBT21**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**
CREDITS: 04			

Course objectives :

- To learn methods involved food processing;
- To understand and apply drying method in food processing operations;
- To study the food conversion methods and describe equipments required;
- To apply method of cooling for food processing and preservation;
- To analyze and investigate properties of food, quality of food and design various food processing operations through experiments.

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
FOOD PROCESSING METHODS -Scope and importance of food processing; Properties of food- Physical, thermal, mechanical, sensory. Raw material preparation- Cleaning, sorting, grading, peeling. Processing methods: Heating- Blanching and Pasteurization. Freezing- Dehydration- canning- additives- fermentation- extrusion cooking- hydrostatic pressure cooking- dielectric heating- micro wave processing and aseptic processing – Infra red radiation processing- Concepts and equipment used.	10	L1, L2
MODULE –2		

DRYING-Moisture content- definition, methods of determination- direct and indirect methods. Equilibrium moisture content- Hysteresis effect- Psychrometry- properties of air, water- vapour mixer, problems in psychrometry. Drying- mechanisms-constant rate period and falling rate period- methods and equipment used- factors affecting rate of drying.	10	L3, L4
MODULE – 3		
FOOD CONVERSION OPERATION -Size reduction- Fibrous foods, dry foods and liquid foods- Theory and equipments- membrane separation- filtration- equipment and application	10	L3, L4, L5
MODULE – 4		
FOOD PRESERVATION BY COOLING- Refrigeration, Freezing-Theory, freezing time calculation, methods of freezing, freezing equipments, freeze drying, freeze concentration, thawing, effect of low temperature on food. Water activity, methods to control water activity	10	L4,L5
MODULE – 5		
FOOD ADULTARTION & LAWS- Intentional and unintentional: Preservatives, antioxidants, sweeteners, flavours, colours, vitamins, stabilizers; Indirect additives: organic residues, inorganic residues and contaminants. FSSAI, Essential Commodities Act, BIS, Codex Alimentarius, PRP, GAP, GRAS, SSOP, HACCP.	10	L2, L3

Course outcomes: After going through this course the student will be able to:

- Understand the need for food processing.
- Apply drying methods, heat transfer methods for food processing applications.
- Describe food conversion methods and equipments required.
- Analyse properties of food and their quality before and after processing steps.
- Design food processing operations.

Graduate Attributes (as per NBA)

- Problem Analysis
- Design / Development of Solutions
- Professional Ethics
- Life-long Learning
- Project Management and Finance
- Societal and Environmental Concern
- 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. R. Paul Singh., "Introduction to Food Engineering", Academic Press, 3rd Ed., 2004.
2. P. Fellows, "Food Processing Technology: Principles and practice". Woodhead Publishing Ltd., Cambrideg, 2nd Ed., 2005.

REFERENCE BOOKS

1. Dennis,R.H. , "Food Process Engineering". Academic Publishing and Press, King Saud University, 1981.
2. Rao, M.A. and Rizvi, and Ashim K. Datta "Engineering Properties of Foods", CRC Press, 2010.
3. Singh, R. Paul and D.R. Heldman, "Introduction to Food Engineering", Academic Press/ Elsevier, 4th Ed., 2009.
4. Gopala Rao, Chandra, "Essentials of Food Process Engineering", B.S. Publications, 2006.
5. Toledo, Romeo T., "Fundamentals of Food Process Engineering", Springer, 3rd Ed., 2007.
6. Smith, P.G., "Introduction to Food Process Engineering", Springer, 2004.
7. Berk, Zeki, "Food Process Engineering and Technology", Academic Press / Elsevier, 2009.

FERMENTATION TECHNOLOGY II

Subject Code	**16IBT22**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS: 04

Course objectives :

- To understand the importance of downstream operations in a fermentation industry and to obtain a purified marketable product.
- To apply the knowledge of purification techniques for removal of insoluble materials and for mass transfer operations in product isolation.
- To describe the method of chromatography in product purification and to apply the concept of crystallization to product enrichment.
- To apply the knowledge of downstream processing techniques to fermentation process and evaluate fermentation products by conducting experiments.

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

OVERVIEW OF DOWNSTREAM OPERATIONS- Role and importance of downstream processing in biotechnological processes. Problems and requirements of bioproduct purification. Process economy: Economics & Cost cutting strategies, process design criteria for various classes of bioproducts (high volume, low value products and low volume, high value products), Process overview: General account of downstream processing steps: removal of insoluble's, cell disruption, isolation, product purification and product formulation, Quality analysis: Analysis of product purity: Chromatography, electrophoresis and spectroscopy.	10	L1, L2
MODULE –2		
REMOVAL OF INSOLUBLES-Filtration: Bead or depth filters, plate and frame filter, pressure leaf filter, continuous rotary drum filters, filter media and filter aids. Microfiltration. Centrifugation: Flocculation and sedimentation, simple and ultra centrifugation, density gradient centrifugation, Cell types: Bacteria, fungal mycelia, plant cell and animal cell, cell disruption: Mechanical and non-mechanical disruption	10	L3, L4
MODULE – 3		
ISOLATION- Extraction: Liquid-liquid extraction, aqueous two-phase extraction, and supercritical fluid extraction, Adsorption: The chemistry of adsorption, batch adsorption, adsorption in continuous stirred tank, fixed bed, distillation, evaporation.	10	L1, L2, L3
MODULE – 4		
PRODUCT PURIFICATION- Chromatography: Adsorbent, yield and purity, discrete stage analysis, kinetics analysis. Precipitation: With non solvent, with salt, with temperature, large scale precipitations. Ultra filtration: Basic ideas, equipment. Electrophoresis.	10	L3,L4,L5
MODULE – 5		
POLISHING- Crystallization: Theory – nucleation, crystal growth; mixed product removal crystallizer with mixed suspension. Crystallization processes, Drying: drying curve, tray dryer, flash dryer, freeze drying – principle and process, freezing, primary and secondary drying, application. Downstream processing for the following products: Antibiotics, organic acids, vitamins, insulin. ancillary operations: Water quality, solvent recovery, waste disposal. **Case studies**: Ethanol, Vinegar, Beer, Wine, Antibiotics	10	L2, L3

Course outcomes: After going through this course the student will be able to:

- Demonstrate the importance of downstream operations in a fermentation industry.
- Apply the knowledge of purification techniques for removal of insoluble materials.
- Describe and apply the knowledge of mass transfer operations in fermentation product isolation.
- Describe the method of chromatography in product purification.
- Demonstrate and apply concept of crystallization to product enrichment.
- Apply and design experimental procedures to process fermentation products.

Graduate Attributes (as per NBA)

Computational knowledge
Problem Analysis
Design / Development of Solutions
Societal and Environmental Concern
Individual and Team Work
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. Paul A. Belter, "Bioseparations: Downstream processing for Biotechnology". Wiley Interscience, 1st Ed., 1988.
2. Roger Harrison et al., "Bioseparation Science and Engineering", Oxford Uni. Press, 2002

REFERENCE BOOKS

1. Jenkins R.O. (Ed.). "Product Recovery in Bioprocess Technology" - BIOTOL Series, Butterworth Heinemann, 1992.
2. Ghasem D. Nazafpour, "Biochemical Engineering and Biotechnology", Elsevier, 1st Ed., 2007.
3. N. Krishna Prasad, "Downstream Process Technology – A New Horizon in Biotechnology", 1st Ed., PHI, 2010.

QUALITY, SAFETY & PROJECT MANAGEMENT			
Subject Code	**16IBT23**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**
CREDITS: 04			

Course objectives :

- To understand the importance and principles of quality control in process industry.
- To describe good manufacturing practices and to apply GMP procedures for QC in pharmaceutical and process industries.
- To know the treatment and disposal methods in process industry.
- To apply GLP to laboratories, field studies, in-vitro studies and to apply safety measures and regulatory affairs in implementing GLP and GMP.
- To learn concepts of project management and apply them to process industry

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
PRINCIPLES OF QUALITY CONTROL- Regulation, standards and guidelines of GMP & GLP, basic terminology and validation overview, validation master plan, scope, documentation format, elements of qualification, numbering system, risk-based assessment, revalidation and its applications. Quality benchmarking, details of international standards (ISO, GMP, GLP, TGM, VAN and ISI), its need and fact sheet evaluation. Role of quality audit and quality circle in quality assurance; measurement of quality, information and decision ma king or utilization of data. Quality operations, its inspection and test used for it. Human resource and training for quality.	10	L1, L2
MODULE –2		
GMP (Good manufacture practice)- Basic components of GMP Facilities, design, materials, flow, environment control, prevention of cross contamination. Quality, concept of GMP, quality assurance & quality control. Legal requirements pertaining to GMP. Regulatory considerations in application of encapsulated cell therapies: GMP on cell-based therapies, FDA regulations of human tissues and products. Treatment of diabetes with encapsulated islets: Concepts of encapsulation, intravascular designs, biocompatibility and microcapsule composition.	10	L3, L4
MODULE – 3		
GLP (Good Laboratory Practices)- principles; commodities; apparatus; reagents and materials; pest control; cryogenic safety - general precautions; storage; test systems; standard protocols; quality assurance; Laboratory signage - biosafety level; treatment and disposal –sharps, cultures, stock & lab ware; Biotoxin and pathological waste – fixed tissues & bedding; storage and retention of records. **Implementation of GLP:** Implementation as a Project, stepwise implementation of GLP	10	L3, L4

requirements. Quality assurance and GLP compliance of laboratory suppliers with GLP Principles, The application of the GLP Principles to field studies, The role and responsibilities of the study director in GLP Studies, The application of the principles of GLP to in-vitro studies, Establishment and control of archives that operate in compliance with the principles of GL.		
MODULE – 4		
SAFETY AND REGULATIONS -The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance. Environmental aspects of biotech applications. Use of genetically modified organisms and their release in environment. Biosafety assessment procedures in India and abroad. International dimensions in biosafety: bioterrorism and convention on biological weapons. Biosafety regulations and national and international guidelines with regard to rDNA technology, transgenic science. Experimental protocol approvals, levels of containment	10	L3,L4
MODULE – 5		
PROJECT MANAGEMENT- 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. Project monitoring – evaluation – control – project network technique –planning for monitoring and evaluation – project audits – project management information system – project scheduling – PERT & CPM –project communication – post project reviews - Closing the project – types of project termination – strategic implications – project in trouble – termination strategies – evaluation of termination possibilities – termination procedures Project management – definitions – overview – project plan – management principles applied to project management – project management life cycles and uncertainty	10	L2, L3
Course outcomes: After going through this course the student will be able to: • Demonstrate importance of GMP and GLP in process industry. • Demonstrate safety measures and guidelines to implement GMP and GLP in industry. • Demonstrate fundamental concepts of project management. • Apply GMP and GLP protocols to process industry. • Design and apply GMP and GLP protocols to laboratories, field studies, in-vitro studies. • Apply principles of project management to pharmaceutical industry.		

Graduate Attributes (as per NBA)

Problem Analysis
Modern Tool Usage
Professional Ethics
Life-long Learning
Project Management and Finance
Societal and Environmental Concern
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 / REFERENCE BOOKS

1. Mindy J. Allport-Settle. "Current Good Manufacturing Practices: Pharmaceutical, Biologics, and Medical Device Regulations and Guidance Documents Concise Reference", CreateSpace, 2009.
2. Erik Kopp. "Pharmaceutical Good Manufacturing Practices / DRUG GMPs plus Electronic Records; Electronic Signatures Regulations", EK Publications, 1st Ed., 2010.

REFERENCE BOOKS

1. Carol DeSain. "Documentation Basics That Support Good Manufacturing Practices and Quality System Regulations" Tamarack Associates, LLC, 2004.
2. Graham Bunn, Joseph D. Nally. "Good Manufacturing Practices for Pharmaceuticals", Informa Healthcare, 6th Ed., 2006.

BIOREACTOR DESIGN AND ANALYSIS

Subject Code	**16IBT24**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**

CREDITS: 04

Course objectives :

- To understand and describe operation of different types of bioreactors used in fermentation and bioprocess industry.
- To learn the concepts of reaction engineering principles and apply them to bioreactors.
- To study and evaluate non-ideal behavior of bioreactors.
- To design bioreactor based on thumb rules.
- To apply the computational analysis methods for evaluating dynamics of bioreactor.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
BIOREACTOR AND ITS OPERATION- Purpose and importance, basic requirements for operation; classification – SLF, SSF, animal, plant, sterilization, immobilized, seed reactor. Operational modes of bioreactor: batch, semi-batch/fed-batch, continuous. Bioreactors: Fermenter, packed bed reactor, airlift reactor, hollow fibre reactor, reactor for plant cells and mammalian cell culture, SSF reactor	10	L1, L2, L3
MODULE –2		
BIOCHEMICAL ASPECTS OF BIOREACTOR DESIGN -Performance of batch reactor – with cell growth and product formation. Performance of continuous reactors – Chemostat, turbidostat, dilution rate and washout. Performance of PFR, and recycle bioreactor. Combination of bioreactor – multistage chemostat, multistage combinations. Performance of semi-batch or fed batch reactors. Performance of immobilized enzyme reactors.	10	L3, L4, L5
MODULE – 3		
NONIDEALITY IN BIOREACTOR - Zero, I and II order models. Prediction of conversion in non-ideal chemostat. Transient behavior in bioreactors. Stability analysis of bioreactors: Phase – plane analysis, bifurcation analysis	10	L3, L4
MODULE – 4		
DESIGN ASPECTS OF A BIOREACTOR - Mechanical design aspects of a fermenter (Tower, Packed bed, Air lift only): L/D ratio, Effect of rheology on fermenter operation, agitation requirement (shaft/other means, calculations), aeration requirement (nozzle design). Mixing pattern in fermenter, back mixing in tower fermenter, heat requirements in fermenter. Aseptic measures and sterilization requirements	10	L3,L4, L5
MODULE – 5		

COMPUTATIONAL ANALYSIS OF BIOREACTOR DYNAMICS AND SCALE UP - Computational fluid dynamics (CFD) analysis of bioreactor – basic concepts, meshing methods, application to bioreactor dynamics analysis (mixing pattern, aeration pattern). Use of supervisory control and data Acquisition (SCADA) for fermenter control. Neural networks and stability analysis of bioreactor. Bioreactor Scale up: Strategies and methods – Similarity criteria, Hubbard method, method of Wang et al., Ettler's method. Dimensionless numbers and scale up. Scale up based on aeration and power requirement (Aeration and power number)	10	L2, L3, L4

Course outcomes: After going through this course the student will be able to:

- Describe different types of bioreactors and their operation.
- Apply reaction engineering principles to bioreactors and evaluate their performance.
- Describe non-ideality in bioreactors and evaluate non-ideal parameters.
- Design bioreactor based on thumb rules for fermentation operation.
- Apply computational techniques for dynamic analysis of bioreactors.

Graduate Attributes (as per NBA)

Design / Development of Solutions
Project Management and Finance
Communication Efficiency
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. Tapobrata Panda, "Bioreactors – Analysis and Design", TMH, 2011.
2. Vogel and Todaro, "Fermentation and Biochemical Engineering Hand Book", 2nd Ed., Standard Publishers and Distributors, 2005.

REFERENCE BOOKS

1. Mukhopadhyay, "Process Biotechnology Fundamentals", Viva Books Pvt. Ltd., 2nd Ed., 2004.
2. Dunn et al., "Biological Reaction Engineering", Wiley-VCH, 2nd Ed., 2000.
3. Mukesh Doble et al., "Biotransformations and Bioprocesses", Marcel Decker Inc.2004.
4. Peppler and Periman, "Microbial Technology: Fermentation Technology" Vol 2, Academic Press/Elsevier, 2nd Ed., 2004.

INDUSTRIAL WASTE WATER TREATMENT

Subject Code	16IBT251	IA Marks	20
Number of Lecture Hrs./Week	03	Exam Marks	80
Total number of lecture hours	40	Exam Hours	03

CREDITS: 03

Course objectives :

- To learn about water quality, types of waste water and their characterization, sampling methods for analysis of parameters.
- To describe water quality standards and their impact and to explain primary and secondary treatment methods of waste water.
- To apply membrane filtration techniques and disinfection methods to purify waste water, and to understand importance of reclamation and reuse of waste water.
- Describe the methods of water reusage.
- To know various issues related to the performance of treatment plant and identify the problems associated with them and to combat them

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
WATER AND WASTE WATER ENGINEERING AN OVERVIEW -Water quality, Physical chemical and biological parameters of water, water quality standards, water quality indices. Waste water: Terminology, impact of regulation on waste water engineering, health and environmental concern in waste water management, waste water characteristics and treatment methods, current status and future trends, waste water reclamation and reuse, biosolids and residual management. Constituents of waste water, physical chemical and biological parameters of waste water, sampling methods, waste water effluent standards, sewage disposal methods	08	L1, L2, L3
MODULE –2		
PRIMARY AND SECONDARY TREATMENT OF WASTE WATER- Screens, oil traps, grit chambers, coagulation, clariflocculation, oxidation ponds and lagoons, Attached growth biological treatment : Activated sludge process and its modifications, trickling filter, biological nitrification and denitrification, anaerobic process, sludge disposal	08	L3, L4, L5
MODULE – 3		
ADVANCED WASTE WATER TREATMENT- Removal of dissolved organic, inorganic constituents and biological constituents, Filtration: modeling and backwashing for slow sand and rapid sand filters, adsorption principle and isotherms, gas stripping, ion	08	L3, L4

exchange, advanced oxidation process. Membrane filtration: RO, UF, MF, NF, electrodialysis. Disinfection: chlorine dioxide, chloramines, ozonation, UV radiation		
MODULE – 4		
WASTE WATER RECLAMATION AND REUSE- Waste water reuse application, need for water reuse, public health and environmental issues in water reuse, introduction to risk assessment for water reuse, different reuse options: Agriculture and landscape irrigation, industrial reuse, ground water recharge, non-potable uses with case studies.	08	L3,L4, L5
MODULE – 5		
ISSUES RELATED TO TREATMENT PLANT PERFORMANCE-Need for upgrading treatment plant performance, treatment process reliability and selection of design values, odour management, introduction to automatic process control, energy efficiency, upgrading waste water treatment plant performance by process optimization, important design consideration for new waste water treatment plants: Liquid stream, solid processing, odour control.	08	L3, L4

Course outcomes: After going through this course the student will be able to:

- Define water quality and explain methods to characterize water quality.
- Describe water quality standards and their impact.
- Explain primary and secondary treatment methods of waste water.
- Apply membrane filtration techniques, and disinfection methods to purify waste water.
- Analyze the importance of reclamation and reuse of waste water.
- Describe methods of water reusage.
- Identify various issues related to the performance of treatment plants and problems associated with them to combat them

Graduate Attributes (as per NBA)

Problem Analysis
Design / Development of Solutions
Life-long Learning
Project Management and Finance
Communication Efficiency
Societal and Environmental Concern
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. Weber, W.J., "Physicochemical process for water quality control", John Wiley and sons, New York, 1983.
2. Metcalf and Eddy, "Waste Water Engineering: Treatment and reuse", Tata McGraw. Hill Publication, New Delhi, 4th Ed., 2003.

REFERENCE BOOKS

1. Fair and Gayer. "Water and waste water Engineering" John Wiley & Sons, 3rd Ed., 2010.
2. C.A. Shastry, "Water treatment plants", Narosa Publishing House, Bombay, 1996.
3. Peavy, H.S., Rowe, D.R. and Tchobanoglous, G. "Environmental Engineering", MGH, NY, 1985.
4. Arundel, "Sewage and Industrial Effluent Treatment", Wiley India, 2012.

NANO MATERIALS AND NANO TOOLS			
Subject Code	**16IBT252**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS: 03			

Course objectives :

- To learn fundamental concepts of nanotechnology and nanomaterials in various dimensions and characterize them.
- Apply the concepts of nanotechnology for drug discovery and drug delivery applications.
- To describe use of nanomaterials in microfluidics and develop microfluidic cell culture devices.
- To design BioMeMs for use in medical and analytical field.
- To understand the risks, safety factors associated with nanomaterials

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
INTRODUCTION-Introduction to nanoscience, quantum mechanics, structure-property relationships in materials, Fabrication methods: Top down and bottom up approaches, Nanolithography(Dip pen, photo, X-ray, electron beam, nanosphere).	08	L1, L2, L3
MODULE –2		

NANOMATERIAL AND NANO TOOLS- Zero dimensional : Nano particle, 1-D: Nano wires, nano rods, 2-D: thin films, special nanomaterials: Buckyballs (Fullerenes), nanotubes, dendrimers, nanoshells, magnetic nanoparticle. Quantum dot (Nanocrystals), self-assembled monolayers, scanning probe microscopy (Scanning tunneling microscopy, atomic force microscopy). Characterization of nanomaterials: Physical, chemical and structural. applications of nanomaterial.	08	L3, L4, L5
MODULE – 3		
NANOTECHNOLOGY FOR DRUG DISCOVERY & DRUG DELIVERY-Drug discovery using nanocrystals and resonance light scattering (RLS), Nanosensors in drug discovery. Benefits of nanoimaging agents, controlled release of drugs, benefits of nano-drug delivery, nanomaterials and biocompatibility: BioMEMS and dendrimers, carbon nanotubes and fullerenes. Delivery of small molecules, proteins and nucleic acids: PAMAM dendrimers as nanoscale oral drug delivery systems, nanoemulsions for intravenous drug delivery, cancer vaccine delivery, nanotherapeutics, nanorobots, use of microneedles and nanoparticles for drug delivery.	08	L3, L4
MODULE – 4		
MICROFLUIDICS - Microflows (laminar flow), micro drops, Hagen-Pouiselle equation, micromixing, microvalves & micropumps, fabrication of soft materials, application of microfluidics: Lab on a chip(cellomics, immunoassay), Microparticle based assays, magnetic particle in biotechnology**.** Micro manipulations and separations using electric fields**.** On chip single cell cultivation system. Microfluidic cell culture device, micro machined bioreactor. Microchips for genomic and proteomic analysis.	08	L3,L4, L5
MODULE – 5		
APPLICATIONS AND RISK ASSESSMENT - Introduction to MEMS, biomems, design of bioMEMS, process steps for MEMS. Recent developments in BioMEMS and nanochips. DNA based BioMEMS, application of BioMems in diagnostics. Bioconjugated nanoparticles for biotechnology and bioanalysis, surgical application of MEMS. Drug delivery systems. Effects of nanoparticle exposure in humans, risks assessment, management, ethical aspects	08	L3, L4

Course outcomes: After going through this course the student will be able to:

- Describe and characterize nanomaterials and their properties.
- Apply concepts of nanotechnology in drug discovery and delivery systems.
- Apply nanotechnology concepts in designing microfluidic devices.
- Develop microfluidic devices for the microfluic cell culture systems.
- Design BioMeMs and demonstrate its application in various fileds.
- Understand the risks associated with nanomaterial applications

Graduate Attributes (as per NBA)

Computational knowledge
Problem Analysis
Design / Development of Solutions
Conduct investigations of Complex Computing Problems
Modern Tool Usage
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. Bharat Bhushan (Ed.). "Springer Handbook of Nanotechnology", Springer, 3rd Ed., 2010.
2. H.Brune, H.Ernst. "Nanotechnology: Assessment and Perspectives", Springer, 2006.
3. Tuan Vo-Dinh. "Nanotechnology in Biology and Medicine", CRC press, 2007.
4. Melgardt M. de Villiers et al. (Ed.). "Nanotechnology in Drug Delivery", Springer publications, 2009.
5. Jean Berthier, Pascal Silberzan."Microfluidics for Biotechnology", Artech House, 2nd Ed., 2009.

REFERENCE BOOKS

1. Guozhong Cao and Ying Wang (Ed.). "Nanostructure and Nanomaterial" (World Scientific Series in Nanoscience and Nanotechnology: Volume 2) Imperial College Press, 2nd Ed., 2004.
2. M.S. Ramachandra Rao, Shubra Singh. "Nanoscience and Nanotechnology: Fundamentals to Frontiers", Wiley India, 2012.

CANCER BIOLOGY

Subject Code	**16IBT253**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS: 03			

Course objectives :

- To understand fundamental concepts of cancer and its developmental stages.
- To describe origin of cancer and process of cancer progression.
- To study and analyse the genetic and epigenetic factors involved in carcinogenesis.
- To identify tumour suppressor genes and their characterization.
- To study the genes responsible for suppression of cancer and to explain therapeutic treatments of cancer.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
FUNDAMENTALS OF CANCER -Cancer cell characteristics, terminologies used in cancer cell biology, different forms of cancer, differences between benign and malignant tumor, different stages in development of cancer, Influential factors in human carcinogenesis, carcinogenic contaminants, dietary deficiencies, obesity, chronic alcohol consumption, hormones and cancer, tumor markers, detection using biochemical assays, molecular tools for early diagnosis of cancer**.**	08	L1, L2, L3
MODULE –2		
PROCESS OF CARCINOGENESIS - Environmental causes for carcinogenesis, chemical carcinogenesis, carcinogen metabolism, radiation and carcinogenesis, DNA and RNA tumor viruses, Cancer cell origin from single abnormal cell (clonal origin) and different cell types (polyclonal origin), change in cells DNA sequence and origin of cancer, Mutations that accelerate the development of cancer, Contribution of non-mutagenic agents, toxic and mitogenic agents and inflammation to tumorigenesis, Multi-step origin of cancer, Genetic instability and Chromosomal anomalies in cancer cells, tumor progression involving mutation, collaboration of two or more mutant genes Darwinian evolution and natural selection, Deranged control of cell differentiation during carcinogenesis, Enhanced mutability and drug resistance in cancer cells, defects in DNA repair mechanism leading to tumorigenesis	08	L1, L2, L3
MODULE – 3		
MOLECULAR ASPECT OF CANCER - Epigenetic regulation of transcription, Evidence for role for epigenetics in carcinogenesis: histone modification and cancer, methylation and cancer, Telomeres and Telomerases in cancer. Proto-	08	L3, L4

oncogenes and Oncogenes, Oncogenes that encode: growth factors or their receptors, cytoplasmic protein kinases, nuclear transcription factors, mechanism of oncogenic activation, product that affect apoptosis, promote tumor formation through secondary effect on other genes. Association of different oncogenes with immortalization and transformation. Angiogenesis is the key for cancer progression, involvement of blood vessels in metastasis, the angiogenic switch, angiogenic inducers, angiogenic inhibitors: antiangiogenic approach to combat cancer. Metastasis: Cell adhesion molecules-E-cadherins, integrins and proteases, epithelial-mesenchymal transition (EMT), intravasation and extravasation, metastatic colonization, metastatic tropism, metastasis suppressor gene		
MODULE – 4		
TUMOR SUPPRESSOR GENES -Definition of tumor suppressor genes, tumor suppressor genes and their functions, genetic status of tumor suppressor genes and oncogenes-Cell fusion experiments to prove the status of tumor suppressor genes and oncogenes. Hereditary predisposition to cancer due to mutant tumor suppressor gene, loss of heterozygosity. Loss of heterozygosity of retinoblastoma gene and its expression. The role of retinoblastoma gene in regulating cell cycle clock-cyclin dependent kinases (CDKs), CDK inhibitors, retinoblastoma proteins (pRb) and its role in cell cycle regulation, viral oncoproteins and blocking of pRb, perturbation in pRb function and tumorigenesis, the role of TGF□ in cell cycle, the role of p53 in normal cell, mutant p53 interference with normal p53 function, mutation in the p53 pathway and cancer, interaction of DNA viral protein products with RB and p53, Mdm2 and ARF role in p53 function, inactivation of p53 and inherited mutant allele of p53 in predisposition to cancer, inactivation of apoptotic machinery by cancer cells. Other tumor suppressor genes-Neurofibromatosis (NF1), Adenomatous Polyposis Coli (APC) and von-Hippel Lindau syndrome (VHL).	08	L1, L2, L3
MODULE – 5		
THERAPIES FOR CANCER-The role of molecular targets in cancer therapies, conventional therapies: chemotherapy of cancer, Therapy from plant derived materials, radiation therapy, Strategies that target DNA repair pathways, DNA methylation inhibitors, inhibitors of histone deacetylases, telomerase inhibitors. antiEGFR drugs, strategies	08	L3, L4, L5

against Raf, Imatinib, cyclin dependent kinase inhibitors, othe cell cycle kinase targets, inhibitors of mitotic spindle, strategies that aim to correct a p53 mutation, strategies that aim to activate endogenous p53, strategies that aim to suppress, endogenous p53. apoptotic drugs: Direct and indirect activation of caspases, regulation of the Bcl-2 family of proteins, targeting TRAIL and its receptors. Inhibitors of the Wnt pathway and Hh pathway, leukemia and differentiation therapies. Metalloproteinase inhibitors (MPIs), strategis for restoring metastasis suppressors, antiangiogenic therapy and vascular targeting. Immune therapy of cancer: nonspecific immune stimulation, vaccination against cancer: therapeutic vaccines, whole-cell vaccines, peptide vaccines, dendritic cell vaccines, vaccines for cancer prevention, adoptive immune therapy, passive therapy with anti-tumor antibodies, cytokine therapy, inhibition of inflammation, vaccine against cervical cancer, second-and third generation therapeutics, pharmacogenomics, nanomedicine in treatment of tumors.		

Course outcomes: After going through this course the student will be able to:

- Demonstrate fundamental concepts of cancer and its developmental stages.
- Describe origin of cancer and process of cancer proliferation.
- Analyse the genetic and epigenetic factors involved in carcinogenesis.
- Identify tumour suppressor genes and their characterization.
- Describe the genes responsible for suppression of cancer.
- Explain therapeutic treatments of cancer

Graduate Attributes (as per NBA)

Computational knowledge
Problem Analysis
Design / Development of Solutions
Conduct investigations of Complex Computing Problems
Modern Tool Usage
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. Robert A. Weinberg, “The Biology of Cancer”, Garland Science, New York, 2007.
2. Gerald Karp, “Cell and Molecular Biology”, John Wiley and Sons Inc. New York, 1996.
3. Benjamin Lewin, “Genes VIII”, Pearson Prentice Hall, 2004.
4. Bruce Alberts and other, “Molecular Biology of the Cell”, Garland Publishing, 3rd Ed., 1994.

5. Lauren Picorino, "Molecular Biology of Cancer: Mechanism, Targets and Therapeutics", Oxford University Press, 2012.
6. Graham L. Patrick. "An introduction to Medical Chemistry", Oxford University Press, New York 1995

REFERENCE BOOKS

1. Lodish & David Baltimore, "Molecular Cell Biology", Scientific American Pub. 2003.
2. Hansh D., Sammes, P. G., Toylor, J. B. "Comprehensive Medicinal Chemistry", Pergamon press, Oxford, 1990.
3. "Wilson and Gisvold's Text book of organic medicinal and pharmaceutical chemistry", Lippincott-Raven Pub. 10th Ed. 1998

STEM CELL BIOLOGY			
Subject Code	**16IBT254**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS: 03			

Course objectives :

- broad out line of different types of stem cells and their origin,
- differentiation of stem cells into different types of tissues, the process of transdifferentiation
- application of stem cells in curing certain diseases.

MODULES	**TEACHING HOURS**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
MODULE – 1		
INTRODUCTION -Definition of stem cells, Unique properties of stem cells, Embryonic stem cells (ES cells), Growing of ES cells in laboratory, markers of ES cells, differentiation of ES cells. Adult stem cells (AS cells), Characteristics and locations of AS cells, Potential use of AS cells, As cell plasticity, Similarities and differences between embryonic and adult stem cells, Definition of progenitor and stem cells, Multipotent adult progenitor cells (MAPC), Amniotic fluid derived pluripotent cells, Isolation, characterization and differentiation potential of amniotic fluid derived cells, Stem cells and progenitor cells from cord blood, characteristics and cryopreservation of stem and progenitor cells from cord blood, cardiac stem cells (CSC), distribution of CSC in the heart.	08	L1, L2

TRANSDIFFERENTIATION: Definition and process of transdifferentiation, Transdifferentiation of: liver to pancreas, pancreas to liver, bone marrow to other cell types, prerequisites for transdifferentiation, transdifferentiation of non-islet cells to islet cells-pancreatic acinar cells, bone marrow cells to islet cells, engineering other non cells to produce insulin		
MODULE –2		
ORGAN SPECIFIC STEM CELLS -Human epider stem cells in adult brain, glial characterization of neural stem cells, adult neurogenesis in vivo. Mesenchymal stem cells (MSCs): skeletal muscle stem cells-phenotype, in bone marrow vasculature, adipose tissue derived stem cells-cell population, composition and characterization, multipotentiality, adipogenesis, osteogenesis and chondrogenesis. Stem cells in the adult kidney- stem cell therapy for renal failure, Liver stem cells, pancreatic stem cells-progenitor cells during early embryogenesis of pancreas and in adult pancreas. Adult progenitor cells as potential treatment for diabetes-defining □ cells, stem cells and progenitor cells	08	L1, L2, L3
MODULE – 3		
HAEMATOPOIETIC STEM CELLS (HSCs)- Sources of HSCs, isolation HSCs based on function and biological response, isolation of HSCs based on cell surface antigen expression, separation of human HSCs, Ex-vivo expansion of haematopoietic progenitor cells (HPCs), clinical trials with HPCs, Ex-vivo expansion of HSCs, circulating HSCs transplantation, nomenclature of haematopoietic colonies and lineages, colony forming units. Haematopoietic stem cells transplantation (HCT) for solid tumors-HCT as allogenic immunotherapy, allogenic immunotherapy for solid tumors; non-myeloblastic HCT for renal cell carcinoma (RCC), for other solid tumors and for melanoma, Immunoreconstitution of HCT: autologous and allogenic, HCTs for treating autoimmune diseases	08	L2,L3, L4
MODULE – 4		
APPLICATION OF STEM CELLS I - Neurological diseases: sources of stem cells for brain cell repair, isolation and manipulation of stem cells for cell replacement in CNS, inductive signals in the adult CNS environment, strategies to promote the intrinsic neurogenic potential of the adult CNS Restoration of vision: retinal neurogenesis,	08	L2, L3

neurogenesis in the central visual targets, regeneration of optic tectum Repair of myocardial damage by: non resident primitive cells and resident primitive cells, myocardial regeneration in humans. Regeneration of epidermis from adult keratinocyte stem cells: characteristics of keratinocyte stem cells, keratinocyte cultivation, transplantation of keratinocyte stem cells, regeneration of epidermis		
MODULE – 5		
APPLICATION OF STEM CELLS II- Orthopedic application of stem cells: bone, cartilage, meniscus, ligaments and tendons, spine. Stem cells in tissue engineering and gene therapy: Current approaches to tissue engineering, tissue engineering by mesenchymal stem cells (MSCs), ex-vivo delivery of stem cells, reconstruction of-skeleton, bone, cartilage, teeth, skeletal and cardiac muscle. Ex-vivo reconstruction: cells and scaffolds, Recruitment and mobilization of distant cells Stem cell gene therapy: gene addition, gene editing	08	L3, L4

Course outcomes: After going through this course the student will be able to:

1. Explain various types of stem cells in the human body and explain their trans-differentiation and application.
2. Make use of stem cells for tissue repair, regeneration and restoration.
3. Appraise the use of stem cells in tissue engineering and gene therapy.
4. Elaborate on different conditions required for maintenance of different types of stem cells.

Graduate Attributes (as per NBA)

Problem Analysis
Design / Development of Solutions
Modern Tool Usage
Professional Ethics
Life-long Learning
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. Robert Lanza Ed. *Handbook of Stem Cells*-Vol. 2, *Adult and fetal stem cells*, Elsevier Acad. Press, 2004.
2. *Stem cell information*, The National Institute of Health, Bethesda, MD USA- Resource for stem cell research, 2008.
3. Bruce Alberts *et al*., *Molecular Biology of the Cell,* 5th Ed., Garland Sci., 2007.

REFERENCE BOOKS

1. Darnell, Lodish & Baltimore, *Molecular Cell Biology*, 4th Ed., WH Freeman, 2000.
2. Bernard R. Glick and Jack J. Pasternak, *Molecular Biotechnology-Principles and Applications of Recombinant DNA*, 4th Ed., ASM Press, Washington DC, 2010.
3. Scott Gilbert, *Developmental Biology*, 10th Ed., Sinauer Associates Inc., 2013.

FOOD PROCESSING & DOWNSTREAM OPERATIONS LAB			
Subject Code	**16IBTL26**	**IA Marks**	**20**
No. of Lab Hrs./ Week :	**3**	**Exam Marks**	**80**
		Exam Hours	**3**

Course objectives :

- To learn and demonstrate experiments for the analysis food products and its constituents.
- To understand concepts of food processing and its principles.
- To gain hands on experience in downstream operation of fermented products.
- To be able to design downstream processing strategies.

Sl.NO	**Experiment**	**REVISED BLOOM'S TAXONOMY (RBT) LEVEL**
1	Analysis of quality of food products: a. Determination of total soluble solids b. Determination of titratable acidity and pH of fruit juice c. Determination of ash and acid insoluble ash	**L2, L3**
2	Determination of processed food content (any three) d. salt content in processed products. e. fat content f. gluten content g. crude fiber in foods h. ascorbic acid.	**L2, L3, L4**
3	Quality analysis of milk and water	**L3, L4**
4	Determination of b, Z and F value in thermal processing	**L3, L4**
5	Experiments on determination of drying rate of given food materials	**L3, L4**
6	Experiments on determination of physical properties of foods	**L4, L5**
7	Experiments on determination of heat transfer coefficient of parallel flow heat exchanger.	**L3, L4**
8	Production of citric acid using *Aspergillus niger*	**L4, L5**
9	Ethanol production from oil cake using Baker's yeast.	**L3, L4, L5**
10	Microbial production of protein and enrichment using aqueous two-phase extraction	**L3, L4, L5**
11	Production of exopolysaccharides using bacteria.	**L3, L4, L5**

12	Intracellular lipid production from cellulosic sources using red yeast or green alga	**L3, L4, L5**

Course outcomes:

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

- Demonstrate analytical procedures to determine quality of food products.
- Explain the principles involved in food processing operations through experiments.
- Perform downstream operations involved in purification of fermented products.
- To design downstream operation strategies for obtaining final finished product from fermentation broth.

Graduate Attributes (as per NBA)

Problem Analysis
Design / Development of Solutions
Professional Ethics
Life-long Learning
Project Management and Finance
Societal and Environmental Concern
Individual and Team Work
Innovation and Entrepreneurship

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.

SEMESTER III

16IBT31- 16IBT34 INTERNSHIP / PROJECT WORK (PROJECT I PHASE EVALUATION)

IV SEMESTER

RESEARCH METHODOLOGY, BIOSAFETY& IPR			
Subject Code	**16BT41/16BC41/16BI41/16IBT41**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**04**	**Exam Marks**	**80**
Total number of lecture hours	**50**	**Exam Hours**	**03**
CREDITS 04			

Course objectives : The course will enable the students:

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

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

MODULE – 4		
BIOSAFETY: Introduction & historical background; Primary Containment for Biohazards; Biosafety Levels for Microbes, Plants & Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs: RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication. Roles of Institutional Biosafety Committees	**10**	**L2, L3, L4**
MODULE – 5		
History, broad account & latest amendments (if any) of the provisions of :- Indian Patent Act 1970 & recent amendments, GATT & TRIPS Agreement, Madrid Agreement, Hague Agreement, WIPO Treaties, Budapest Treaty, PCT.	**10**	**L2, L3, L4, L5**

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

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

Graduate Attributes (as per NBA)

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

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

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

TEXT BOOKS

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

REFERENCE BOOKS

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

ADVANCED BIOINFORMATICS			
Subject Code	**16IBT421**	**IA Marks**	**20**

Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03

Course objectives : The course will enables the students
•To learn fundamentals of bioinformatics tools.
To describe tools for sequence alignment and apply for phylogenetic analysis.
To describe tools for pattern analysis and apply for analysis of motifs and profiles.
To describe tools for prediction of protein folding and their applications.
To describe tools for tertiary structure prediction and methods of validation.
To apply tools of bioinformatics for molecular cloning, primer design, drug design, proteomics, transcriptomics & metabolomics

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
SEQUENCE-ALIGNMENT: 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; Clustal; Phylogenetics: distance based approaches, maximum parsimony. **PATTERN ANALYSIS IN SEQUENCES:** 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.	**08**	**L1, L2**
MODULE –2		
FOLD PREDICTION MEHODS- 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.); Experimental determination of structures (X-ray	**08**	**L2, L3**

crystallography, NMR); Secondary structure prediction; prediction of membrane helices, solvent accessibility; homology modelling, fold recognition methods; RNA structure prediction; Mfold.		
MODULE – 3		
STRUCTURE PREDICTION AND VALIDATION -Tertiary Structure prediction: 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 modeling, fold recognition, threading approaches, and ab initio structure prediction methods. Force fields backbone conformer generation by Monte Carlo approaches, side-chain packing; Energy minimization; a brief introduction to molecular dynamics Macro-molecular force fields, solvation, long-range forces Geometry optimization algorithms: Steepest descent, conjugate gradient, Various simulation techniques, Molecular mechanics, conformational searches, Molecular Dynamics. **Structure analysis and validation:** Pdbsum, Whatcheck, Procheck, Verify3D and ProsaII; Rosetta; Critical assessment of Structure prediction (CASP) Structures of oligomeric proteins and study of interaction interfaces.	**08**	**L2, L3, L4**
MODULE – 4		
APPLICATIONS - Role of Bioinformatics in Molecular Cloning, Primer Design, Drug design, Proteomics, Transcriptomics & Metabolomics. Cloning & Primer Design: Restriction mapping, Web based tools (MAP, REBASE); Primer design – need for tools, Primer design programs and software Structure-based drug design: Identification and Analysis of Binding sites and virtual screening Ligand based drug design: Structure Activity Relationship QSARs and QSPRs, QSAR Methodology, In silico prediction ADMET properties for Drug Molecules. Computer-aided drug design (pharmacophore identification); Protein-Protein interactions. Principles of docking and ligand design. Protein-ligand docking; Vaccine Design Techniques	**10**	**L3, L4**
MODULE – 5		
APPLICATIONS- Chemoinformatics. Comparative Genomics, Genomes of Viral, Archeal, Bacterial, Eukaryotic genomes with special reference to model organisms (Yeast, Drosophila, C. elegans, Rat, Mouse, Human, plants such as Arabidopsis thaliana, Rice, etc.)	**08**	**L3, L4, L5**

System-wide analyses: Transcriptomics: Microarray technology, expression profiles, data analysis; SAGE; MPSS, Clustering, Probabilistic Models of Evolution, Proteomics: 2D gel electrophoresis; Mass Spectrometry; Protein arrays; Metabolomics: Metabolic networks in motion: ^{13}C-based flux analysis; Gene Mapping, SNP analysis, Machine learning, Molecular Network Analysis, Probabilistic framework for modelling and inference, Systems Biology.		

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

- Describe tools for sequence alignment and apply for phylogenetic analysis.
- Describe tools for pattern analysis and apply for analysis of motifs and profiles.
- Describe tools for prediction of protein folding and their application.
- Demonstrate tools used for tertiary structure prediction and their validation methods.
- Apply tools of bioinformatics for molecular cloning, primer design, drug design, proteomics, transcriptomics & metabolomics

Graduate Attributes (as per NBA)

Computational knowledge
Problem Analysis
Design / Development of Solutions
Conduct investigations of Complex Computing Problems
Modern Tool Usage
Life-long Learning
Project Management and Finance
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. David W. Mount. “Sequence and Genome Analysis”, Bioinformatics CSHL Press, 2nd Ed., 2004.
2. Baxevanis and F. B. F. Ouellette. “Bioinformatics: a practical, guide to the analysis of genes and proteins”, JohnWiley, 2nd Ed., 2001.
3. Jonathan Pevsner. “Bioinformatics and Functional Genomics”, Wiley-Liss, 1st Ed., 2003.
4. Philip E. Bourne & Helge Weissig Tsai. “Structural Bioinformatics”, Wiley, 2003.
5. C. Branden and J. Tooze. “Introduction to Protein Structure”, Garland Publishing, 2nd Ed., 1999.

REFERENCE BOOKS

1. Durbin *et al*. “Biological Sequence Analysis: Probabilistic models of protein and Nucleic acids”, Cambridge University Press, 2007.
2. Johann Gasteiger and Thomas Engel “Chemoinformatics” Wiley-VCH, 2003.
3. Sheen, David. “Physical Biochemistry”, Wiley & Sons, 2000.
4. Ramakrishnan and Gehrke. “Database Management System”. MGH, 3rd Ed., 2002

METABOLIC ENGINEERING			
Subject Code	**16IBT422**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**
CREDITS 03			

Course objectives : The course will enables the students

- To understand fundamental concepts of metabolic pathways and manipulation strategies.
- To learn and describe material balancing through stoichiometry and analysis.
- To describe linear programming methods to metabolic flux analysis.
- To explain experimental methods to determine flux.
- To learn fundamentals of metabolic flux control and evaluate parametric coefficients.
- To describe methods to build metabolic networks.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
INTRODUCTION TO EXAMPLES OF PATHWAY MANIPULATION - QUALITATIVE TREATMENT -Enhancement of Product Yield and Productivity, Extension of substrate Range, Extension of Product spectrum and Novel products, Improvement of Cellular properties, Xenobiotic degradation.	**08**	**L1,L2**
MODULE –2		
MATERIAL BALANCES AND DATA CONSISTENCY -Comprehensive models of cellular reactions; stoichiometry of cellular reactions, reaction rates, dynamic mass balances, yield coefficients and linear rate equations, analysis of over determined systems- identification of gross measurement errors. Introduction to MATLAB®	**08**	**L1, L2,L3**
MODULE – 3		
METABOLIC FLUX ANALYSIS- Theory, overdetermined systems, underdetermined systems-linear programming, sensitivity analysis, methods for the experimental determination of metabolic fluxes by isotope labeling, applications of metabolic flux analysis.	**08**	**L2,L3,L4**
MODULE – 4		
METABOLIC CONTROL ANALYSIS - Fundamentals of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients, MCA of	**08**	**L3,L4**

linear pathways, branched pathways, theory of large deviations.		
MODULE – 5		
ANALYSIS OF METABOLIC NETWORKS - Control of flux distribution at a single branch point, Grouping of reactions, case studies, extension of control analysis to intermetabolite, optimization of flux amplifications, consistency tests and experimental validation.	**10**	**L1, L2,L3**

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

- Demonstrate fundamental concepts of metabolic pathways and manipulation strategies.
- Apply material balancing methods to evaluate metabolic flux.
- Describe linear programming methods and apply it to metabolic flux analysis.
- Explain experimental methods to determine flux.
- Demonstrate fundamentals of metabolic flux control and Evaluate parametric coefficients.
- Describe methods to build metabolic networks.

Graduate Attributes (as per NBA)

Problem Analysis
Design / Development of Solutions
Life-long Learning
Societal and Environmental Concern

Question Paper Pattern:

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

TEXT BOOKS

1. Stephanopoulos, G.N. “Metabolic Engineering: Principles and Methodologies”. Academic Press / Elsevier, 1998.
2. Lee, S.Y. and Papoutsakis, E.T. “Metabolic Engineering”. Marcel Dekker, 1998.
3. Nielsen, J. and Villadsen, J. “Bioreaction Engineering Principles”. Springer, 2007.
4. Voit, E.O. “Computational Analysis of Biochemical Systems : A Practical Guide for Biochemists and Molecular Biologists”. Cambridge University Press, 2000.
5. Scheper, T. “Metabolic Engineering” Vol 73 (Advances in Biochemical Engineering Biotechnology) Springer, 2001.

REFERENCE BOOKS

1. Rhodes, P.M. and P.F. Stanbury “Applied Microbial Physiology: Practical Approach”. IRL Press, 1997.
2. Caldwell, D.R. “Microbial Physiology & Metabolism”. Wm. C. Brown, 1995.
3. Rehm, H.J. and G. Reed, “Biotechnology : Products of Primary Metabolism” Vol.6 and “Biotechnology : Products of Secondary Metabolism” Vol.7, VCH / Wiley, 1997.

ENTREPRENEURSHIP DEVELOPMENT			
Subject Code	**16IBT423**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03

Course objectives : The course will enables the students

- To demonstrate the knowledge and understanding of the engineering and management principles in bioprocess industry.
- To explain types of entrepreneurship, and motivating factors.
- To identify business opportunities and financing agencies.
- To understand need and essentials of report writing for financial assistance.
- To learn and understand role of management and its functions in a business.
- To learn record maintenance methods and preparation of balance sheets.
- To know the strategies of marketing and its impact on business

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**	**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. The process of setting up a small business: Preliminary screening and aspects of the detailed study of the feasibility of the business idea and financing/non-financing support agencies to familiarize themselves with the policies/programs and procedures and the available schemes.Preparation of Project Report and Report on Experiential Learning of successful and unsuccessful entrepreneurs.	**08**	**L1 L2 L3 L4**

MODULE – 3		
MANAGEMENT ROLES AND FUNCTIONS IN A SMALL BUSINESS -Designing and re-designing business process, location, layout, operations planning and control. Basic awareness on the issues impinging on quality, productivity and environment. Managing business growth. The pros and cons of alternative growth options: internal expansion, acquisitions and mergers, integration and diversification. Crisis in business growth.	**08**	**L1 L3 L4 L5**
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**	**L1 L2 L4 L5**
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**	**L1 L2 L3**

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

Demonstrate the knowledge and understanding of the engineering and management principles in bioprocess industry.

- Explain types of entrepreneurship, and motivating factors.
- Identify business opportunities and financing agencies.
- Demonstrate the need and essentials of report writing for financial assistance.
- Understand role of management and its functions in a business.
- Apply techniques of record maintenance methods and preparation of balance sheets.
- Understand the strategies of marketing and its impact on business

Graduate Attributes (as per NBA)

Design / Development of Solutions
Professional Ethics
Life-long Learning
Project Management and Finance
Communication Efficiency
Societal and Environmental Concern
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", Macmillan Business Books, Delhi, 3rd Ed., 1977.
2. Bhide, Amar V., "The Origin and Evolution of New Business", Oxford University Press, New York, 2000.
3. Dollinger M.J., "Entrepreneurship strategies and Resources", Pearson Education, New Delhi, 3rd Ed., 2006.
4. Desai, Vasant Dr., "Management of small scale enterprises", Himalaya Publishing House, 2004.
5. Taneja, Gupta, "Entrepreneur Development New Venture Creation", Galgotia Publishing Company, 2nd Ed., 2001.
6. Shiba Charan Panda, "Entrepreneurship Development", New Delhi, Anmol Publications, 1996.

REFERENCE BOOKS

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

PETROLEUM BIOTECHNOLOGY

Subject Code	**16IBT424**	**IA Marks**	**20**
Number of Lecture Hrs./Week	**03**	**Exam Marks**	**80**
Total number of lecture hours	**40**	**Exam Hours**	**03**

CREDITS 03

Course objectives : The course will enables the students

- To understand concepts of bio-refineries and use of biomolecules in bio-refineries.
- To describe the processing of methane and aromatic compounds using biocatalysts.
- To learn concept of bio-corrosion and describe bio-corrosion of various metals and their prevention.
- To understand emulsification and describe methods of emulsification by biological components.
- To apply principle of bio-emulsification in sewage treatment.
- To learn methods of bioremediation and apply them to remediation of oil spills and in petroleum industry waste water treatment.

MODULES	TEACHING HOURS	REVISED BLOOM'S TAXONOMY (RBT) LEVEL
MODULE – 1		
BIOREFINARIES- Petroleum biotechnology as an integrated approach, microbial diversity in oil reservoirs and DNA fingerprinting, Potential use of biocatalyst in oil refineries, extremophiles and oil refineries – a new application. Bio-desulfurization – enzymatic treatments; Bio-denitrogenation of petroleum; Enzymatic transformation of asphaltenes.	**10**	**L1, L2**
MODULE –2		
BIOPROCESSING OF METHANE AND AROMATIC COMPOUNDS -Bioprocessing of crude oils and distillates in oil-water system, aromatic bioprocessing biocatalysts and its genetic engineering. Aromatic bioprocessing of BioARC (Biological Aromatic Ring Cleavage). Biological distribution and classification of methane monooxygenases, soluble methane monooxygenase, Methane monooxygenase in biocatalysts and Biomimetics	**08**	**L1 L2 L3**
MODULE – 3		
BIOCORROSION- Bio-corrosion of steel, aluminum alloy in fuel/water system; aerobic corrosion of iron; microbial inhibition of corrosion, electrochemical interpretation of bio-corrosion; prevention, control and monitoring of bio-corrosion; Molecular tools in bio-corrosion – DNA hybridization technique	**08**	**L1 L2 L3**
MODULE – 4		
BIOEMULSIFIERS- Low molecular weight bio-surfactants; Bio-emulsifiers – Protein Polysaccharide interactions, emulsan paradigm, microbial sources, engineering of novel emulsans; Polymeric bio-emulsifiers – Alasan, Liposan, Biodispersan, Production techniques of bio-emulsifiers. Application – Bio-emulsification, cleaning and sludge recovery, viscosity reduction and oil transportation.	**08**	**L1 L2 L3 L4**
MODULE – 5		
BIOREMEDIATION- Phytoremediation: mechanisms and pilot studies, and mathematical modeling. Bioremediation of Marine Oil spills: Anthropogenic input of oil into ocean, Physical fate of spilled oil, eventual fate of spilled oil, spill response – at sea, on shore. Biotreatment of water pollutants from the Petroleum	**08**	**L1,L2,L3,L4**

industry: Anaerobic biodegradation and biotransformation, Biotransformation of S- and N-bearing inorganic compounds, Oxygenated fuel additives (MTBE biodegradation).		

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

- Understand concept of bio-refineries and their applications.
- Describe processing of methane and aromatic compounds using biocatalysts.
- Demonstrate biological corrosion and methods to combat them.
- Describe emulsification methods used for industrial application using biological materials.
- Apply bio-emulsification method to sewage water treatment process.
- Describe bioremediation process and apply it to petroleum industry waste water treatment.

Graduate Attributes (as per NBA)

Problem Analysis
Design / Development of Solutions
Project Management and Finance
Societal and Environmental Concern
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. Duhalt and Ramirez (Ed.), "Petroleum Biotechnology: Developments and Perspectives", Elsevier 2004.
2. Videla, Wilkes and Silva, "Manual of Biocorrosion", CRC Press, 1st Ed., 1997.
3. Stevens, Sequiera and Tiller, "Microbial Corrosion – 1", Springer, 1988

REFERENCE BOOKS

1. James Speight and Karuna Arjoon, "Bioremediation of Petroleum and Petroleum products", Wiley-Scrivener, 1st Ed., 2012.
2. Robert E. Hinchee, Jeffrey A. Kittel, H. James Reisinger, "Applied Bioremediation of Petroleum Hydrocarbons", Vol 3, Battelle Press, 1995.