NMAM INSTITUTE OF TECHNOLOGY, NITTE, KARKALA

DEPARTMENT OF BIOTECHNOLOGY ENGINEERING

SCHEME OF EXAMINATION & SYLLABUS

M.TECH. (FULL TIME) IN

INDUSTRIAL BIOTECHNOLOGY

(AUTONOMOUS SCHEME)

2017-18

NMAM Institute of Technology, Nitte

Vision: Pursuing Excellence, Empowering people, Partnering in Community Development.

Mission: To develop NMAM Institute of Technology, Nitte, as Center of Excellence by imparting Quality Education to generate Competent, Skilled and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.

Core Values: Ethics, Team work, Honesty, Loyalty, Professional & Personal integrity.

Department of Biotechnology Engineering

Vision: To accomplish excellence in Biotechnology research and creating manpower for the benefit of society and human kind with an emphasis on present and future global needs.

Mission: To empower the students of Department of Biotechnology Engineering in to

1. Competent professionals to undertake projects by providing academic training and technical achievements,
2. A successful professional in research, academia and industry,
3. An engineer for effective utilization of natural resources in biotechnology related industries.

Programme Educational Objectives

The program educational objectives are set in line with Institutional and Departmental mission statements. The programme educational objectives of M.Tech. Industrial Biotechnology programme are to produce professionals who later take the role of engineering professionals and researchers with following qualities:

PEO-1. Inculcate a sound knowledge and technical skills in the area of biotechnology to face the modern challenges in biotechnological industry.

PEO-2. Utilize their technical skills in reputed laboratories, non-profit organizations, bioprocess industry, or in pursuit of doctoral studies to face the emerging challenges with credibility and integrity.

PEO-3. Articulate technical and ethical solutions to societal and industrial problems through their imparted technical knowledge and skills.

Programme Outcomes

M.Tech. in Industrial Biotechnology program established a set of Programme Outcomes (POs), expected to be met by every student graduating from the programme. Programme outcomes listed below embrace the required outcomes as listed in National Board of Accreditation (NBA), India guidelines. The graduates of M.Tech. in Industrial Biotechnology will have the ability to:

PO-1. Carry out research / investigation and development work to solve practical problems associated with society and industrial applications independently.

PO-2. Write and present a substantial technical report/document.

PO-3. Demonstrate a degree of mastery over interdisciplinary fields related to Industrial Biotechnology.

PO-4. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge with respect to sustainable development.

Table : Mapping of Mission statements with Program Educational Objectives

Mission Statement	PEO1	PEO2	PEO3
Institution*: To develop NMAM Institute of Technology, Nitte as a Center of Excellence by imparting Quality Education to generate Competent, Skilled, and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.*	**M**	**H**	**H**

** L = Low, M= Moderate, H= High*

Table : Mapping of Mission statements with Program Educational Objectives

Mission Statement	PEO1	PEO2	PEO3
Department*: To empower the students of Department of Biotechnology Engineering in to* *1. Competent professionals to undertake projects by providing academic training and technical achievements.*	**H**	**M**	**M**
2. A successful professionals in research, academia and industry	**M**	**H**	**M**
3. An engineer for effective utilization of natural resources in biotechnology related industries.	**L**	**M**	**H**

** L = Low, M= Moderate, H= High*

Table: Mapping of Program Outcomes with Program Educational Objectives

PEO	PO			
	PO-1	PO-2	PO-3	PO-4
PEO-1	**H**	**L**	**H**	**M**
PEO-2	**M**	**M**	**M**	**M**
PEO-3	**H**	**L**	**M**	**H**

** L = Low, M= Moderate, H= High*

NMAM INSTITUTE OF TECHNOLOGY, NITTE
DEPARTMENT OF BIOTECHNOLOGY ENGINEERING
SCHEME OF TEACHING & EXAMINATION FOR

M.TECH. (Full Time) INDUSTRIAL BIOTECHNOLOGY
(AUTONOMOUS SCHEME)

Revised & Approved by PG-BOS-BT on 20th May 2017

I Semester **25 Credits**

Course Code	Course Title	Hrs / week	Duration of Sem. End Exam in Hrs	Marks		Credits
		L/T/P/S		CIE	SEE	
17IBT101	Applied Statistics & Design of Experiments	4/0/2/0	03	50	50	5
17IBT102	Fermentation Technology-I	4/0/2/0	03	50	50	5
17IBT103	Advanced Molecular Biology	4/0/2/0	03	50	50	5
17IBT11X	Elective – I	4/0/0/0	03	50	50	4
17IBT12Y	Elective – II	4/0/0/0	03	50	50	4
17IBT104	Research Experience through Practice – I	0/0/4/0	-	100		2
Total		**30**		**350**	**250**	**25**

Elective – I		Elective – II	
17IBT111	Bioprocess Engineering	17IBT121	Biopharmaceuticals
17IBT112	Bioprocess Modeling & Automation	17IBT122	Instrumental Methods of Analysis
17IBT113	Bioreaction Engineering	17IBT123	Metabolic Engineering

Audit Courses:

S. N.	Audit Course Code	Audit Course Title	Contact Hrs / wk	Eligible Programme	Offering Department
1	17AP009	Quality and Safety Management	02	M.Tech. IBT	BT
2	17AP010	Project Management	02	M.Tech. IBT	BT

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Revised & Approved by PG-BOS-BT on 20th May 2017

II Semester **25 Credits**

Course Code	Course Title	Hrs / week	Duration of Sem. End Exam in Hrs	Marks		Credits
		L/T/P/S		CIE	SEE	
17IBT201	Food Process Engineering	4/0/2/0	03	50	50	5
17IBT202	Fermentation Technology II	4/0/2/0	03	50	50	5
17IBT203	Research Methodology, Biosafety & IPR	4/0/2/0	03	50	50	5
17IBT204	Elective III	4/0/0/0	03	50	50	4
17IBT21X	Elective IV	4/0/0/0	03	50	50	4
17IBT204	Research Experience through Practice – II	0/0/4/0	-	100	-	2
Total		**30**		**350**	**250**	**25**

Elective – III		Elective – IV	
17IBT211	Nano Materials and Nano tools	17IBT221	Bioreactor Design and Analysis
17IBT212	Cancer Biology	17IBT222	Entrepreneurship
17IBT213	Biofuels Engineering	17IBT223	Petroleum Biotechnology

Audit Courses:

S. N.	Audit Course Code	Audit Course Title	Contact Hrs / wk	Eligible Programme	Offering Department
1	17AP009	Quality and Safety Management	02	M.Tech. IBT	BT
2	17AP010	Project Management	02	M.Tech. IBT	BT

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III Semester **20 Credits**

Course Code	Course Title	Duration	Marks		Credits
		Practical / Field Work / Assignment	CIE	SEE	
17IBT301	Industrial Training / Mini Project	Full time: 8 weeks	Report: 50 Presentation: 50	-	8
17IBT302	Seminar on Current Topics in Industrial Biotechnology	-	Report: 50 Presentation: 50	-	2
17IBT303	Project: Part- I	Full time: 10 weeks	Report: 100 Presentation: 100	-	10
Total			**400**	**-**	**20**

IV Semester **30 Credits**

Course Code	Course Title	Duration	Marks		Credits
		Practical / Field Work / Assignment	CIE	SEE	
17IBT401	Project: Part - II	Full time: 30 weeks	**200** [PPE*-I – 100 PPE-II – 100]	200	30
Total			**200**	**200**	**30**

** PPE – Project Progress Evaluation*

Note:

- Theory SEE question paper will contain 2 questions from each unit. Student must answer one full question from each unit.
- Industrial Training / Mini Project: Student must complete 8 weeks of full time training in Industry. Alternatively student can perform a mini project in the Institute or in a recognized Research Institute for 8 weeks duration. In both cases student must present a detailed report and a seminar.
- Seminar: Student must choose a topic on current trends in Industrial Biotechnology and prepare a report. He/she must present a power point presentation in open seminar.
- Project Part I: After the 8 weeks of Industrial training/mini project student must engage in full time project work. Student in consultation with the guide(s) shall carryout literature survey / visit to Industries to finalize the topic of dissertation. Project work can be done at Industry or at the Institute on a full time basis for 10 weeks period. At the end of III semester student should present progress report in the form of seminar and report.
- Project Part II: Student shall continue with project part I. He/she should submit the final project report and present a seminar to the project evaluation committee.
- Project Phase I and Phase II together should not be less than 8 months duration.
- Publication of research work carried out in National / International conference or peer reviewed National / International Journal can be given a weighatge during assessment of project – part II.
- The Project Report Evaluation and Viva-Voce will be conducted by a committee consisting of the following: Head of the Department (Chairman, BoE), PG – Dept. Coordinator, Guide(s), One external examiner

DETAILED COURSE CONTENTS

I SEMESTER M. TECH. INDUSTRIAL BIOTECHNOLOGY

APPLIED STATISTICS & DESIGN OF EXPERIMENTS

Subject Code:	**17IBT101**	L-T-P-S:	**4-0-2-0**	Credits:	**05**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**02**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**20**
CIE Marks:	**50**			SEE Marks:	**50**

Course Learning Objectives:

- To learn statistical techniques for processing & evaluating biological data.
- To represent the processed data and perform regression analysis.
- To apply statistical tools & techniques for experimental design and interpret the results.

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

CO-1. Use descriptive statistical measures and probability distribution to process the experimental data and interpret the outcomes.
CO-2. Apply hypothesis testing principles to biological data and interpret them.
CO-3. Represent the raw & processed data in graphical form and formulate regression models.
CO-4. Design and evaluate experimental data using RCBD, Latin square designs and full factorial designs.
CO-5. Adapt and construct suitable experimental design for screening & optimizing the process parameters.
CO-6. Gain Practical exposure to use software tools and perform statistical analysis.
CO-7. Design the experiments using software tool, perform statistical analysis and interpret the outcomes.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M	H		L
CO2	M		L	
CO3		M	L	
CO4	L		M	
CO5	L		M	L
CO6	M	M		L
CO7	L		M	

UNIT 1: DESCRIPTIVE STATISTICS & PROBABILITY DISTRIBUTION 10 Hrs

Concept and necessity of statistics in scientific studies; Data and variables, types; nature of biological data and uncertainities. Descriptive and inferential statistics.

Measures of central tendency – mean, median, mode (raw data only); Measures of spread – variance, standard deviation, standard error, quartiles, Numericals.

Probability distributions: Binomial, Poisson, Normal distribution, sample size estimation, Confidence interval estimation, data diagnostics & normalization, statistical quality control charts (mean chart & range chart), Numericals.

UNIT 2: HYPOTHESIS TESTING 10 Hrs

Hypothesis testing: Hypothesis building, critical significance level, test statistic (parametric and non-parametric tests), criteria of hypothesis rejection / acceptance, type 1 & type 2 errors (α error and β error), sample size.

Tests of difference - One sample (Student's t test), two independent samples (t test, Wilcoxon signed rank test), two related samples (paired t test, Mann-Whitney U test or Wilcoxon sum rank test), More than 2 samples (F test, Tukey's test, Dunnet's test). Tests of relationship: Correlation coefficient (Pearson's & Spearman correlation), Numericals.

UNIT 3: DATA REPRESENTATION & REGRESSION ANALYSIS 10 Hrs

Representation of data – tabular, pictorial, graphical; Graphical representation of data – scatter plot, line plots, bar chart (simple, clustered, stacked, with SD/error bar), stem & leaf plot, box plot, 2D contour plot, 3D plot (mesh), Numericals.

Linear & quadratic models, regression coefficients, estimation using least squares method. Statistical analysis – R^2, critical value for regression coefficient, ANOVA – 1 way & 2 way, Lack of fit analysis, Numericals.

UNIT 4: DESIGN OF EXPERIMENTS – BLOCKED DESIGNS, FACTORIAL DESIGNS **10 Hrs**

Experimental designs, Randomization and Blocking, Completely Randomized Block design (RCBD), Latin Square design. Factorial Designs: Factors, levels, coded and decoded levels, full factorial design (2^2, 2^3), statistical analysis, Numericals.

UNIT 5: DESIGN OF EXPERIMENTS – SCREENING DESIGNS, OPTIMIZATION **10 Hrs**

Screening designs: Fractional factorial design - General 2^{k-p} design, Plackett-Burman design, confounding and aliasing, resolution of design, main effects, interaction effects, screening criteria, Numericals.

Optimization: Response surface methodology, Linear model (method of steepest ascent), Second order models (CCD, CCRD, Taguchi design); generation of experimental design; response variables; model terms: linear, quadratic & interaction terms; ANOVA table, data diagnostics & outlier analysis, contour & surface plots, optimization criteria, D-optimal design, Numericals.

PRACTICALS

1. Use of spreadsheet (MS Excel), Design Expert and Minitab for data analysis (1 hr)
2. Calculation of descriptive statistics using spreadsheet and online tool (2 hr)
3. Hypothesis testing by using spreadsheet, online tool and Minitab (2 hr)
4. Plotting Graphs – MS Excel, Minitab/Design Expert (2 hr)
5. DoE – Full Factorial: Design Expert (2 hr)
6. DoE – Plackett Burman Design, Method of Steepest ascent: Design Expert (3 hr)
7. DoE – CCRD: Design Expert (3 hr)
8. DoE – Box Behnken Design: Design Expert (2 hr)
9. DoE – Taguchi Design: Design Expert (3 hr)

TEXT BOOKS:

1. Dawn Hawkins, "**Biomeasurement**", 3rd Ed., Oxford University Press India, 2014.
2. Douglas C. Montgomery, "**Introduction to Statistical Quality Control - A Modern Introduction**", 7th Ed., John Wiley & Sons Inc., 2012.

REFERENCE BOOKS:

1. M. Longnecker and R.L. Ott, "**An Introduction to Statistical Methods and Data Analysis**", 7th Ed., Cengage Publishing, 2015.
2. Daryl S. Paulson, "**Biostatistics and Microbiology: A Survival Manual**", Springer-Verlag New York, 2009.
3. B. Rosner, "**Fundamentals of Biostatistics**", 5th Ed., Duxbury Thomson Learning, 2000.
4. M. Cavazzuti, "**Optimization Methods- From Theory to Design Scientific and Technological Aspects in Mechanics**", 1st Ed., Springer Verlag Berlin, 2013.
5. K. Balaji, A.V.S. Raghavaiah and K.N. Jayaveera, "**Biostatistics**", IK International, 2012.
6. Manju Pandey, "**Biostatistics - Basic and Advanced**", M.V. Learning., 2015.

ONLINE RESOURCES:

1. Dawn Hawkins, Biomeasurement, 3rd Ed, Student e-Resources. [http://global.oup.com/uk/orc/biosciences/maths/hawkins3e/]
2. NIST/SEMATECH e-Handbook of Statistical Methods [http://www.itl.nist.gov/div898/handbook/index.htm]
3. G. Cumming, F. Fidler, D.L. Vaux, Error bars in experimental biology, The Journal of Cell Biology, Apr 2007, 177 (1), pp7-11; DOI: 10.1083/jcb.200611141 [http://jcb.rupress.org/content/177/1/7.full]

4. GraphPad – Online statistics tool [https://www.graphpad.com/quickcalcs/]
5. Penn State Eberly College of Science – online statistics course [https://onlinecourses.science.psu.edu/stat503/]

FERMENTATION TECHNOLOGY - I

Subject Code:	**17IBT102**	L-T-P-S:	**4-0-2-0**	Credits:	**05**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**02**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**20**
CIE Marks:	**50**			SEE Marks:	**50**

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.

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

CO-1. Demonstrate the methods of cell culture under various conditions, strain improvement methods
CO-2. Design and develop medium for cell cultivation for fermentation process
CO-3. Apply the knowledge of sterilization techniques
CO-4. Understand needs of various parts of fermenter and their operation
CO-5. Apply the knowledge of control theory for industrial fermentation control
CO-6. Demonstrate the experimental techniques associated with aseptic processes, media preparation and related upstream processes.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	H		L	M
CO2	H		L	
CO3	H			
CO4	H		M	
CO5			M	
CO6	H		M	H

UNIT 1 CELL CULTIVATION AND GROWTH KINETICS 10 Hrs

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.

UNIT 2 INOCULUM DEVELOPMENT AND MEDIA PREPARATION 10 Hrs

Media components and optimization (PB, RSM techniques), types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter.

UNIT 3 STERILIZATION 10 Hrs

Sterilization: death kinetics, del factor, batch and continuous; insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Numericals.

UNIT 4 FERMENTATION PROCESS 10 Hrs

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 oxygen concentrations, Estimating Oxygen Solubility, Measurement of K_La, factors effecting K_La in fermenter, Agitation: fluid rheology. Numericals.

UNIT 5 CONTROL OF INDUSTRIAL FERMENTATION 10 Hrs

Requirements for control, sensors, controllers, design of fermenter control specification, control of incubation, advanced incubation control.

PRACTICALS

1. Preparation of inoculums and aseptic inoculum transfer into media.
2. Preparation of medium for microbial culture, Media optimization using RSM.
3. Study of growth kinetics using different carbon sources.
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]

5. Production of callus, preparation of media and suspension culture.
6. Secondary metabolite production using suspension culture.

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. Ltd., 2004.
3. Brian McNeil and Linda Harvey (Ed), "**Practical Fermentation Technology**", Wiley, 2008.

ADVANCED MOLECULAR BIOLOGY

Subject Code: **17IBT103**	L-T-P-S: **4-0-2-0**	Credits:	**05**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**02**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**20**
CIE Marks: **50**		SEE Marks:	**50**

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.

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

CO-1. Demonstrate working procedures and protocols in molecular research

CO-2. Understand gene expression models

CO-3. Apply molecular research concepts in rDNA technology and in therapeutics

CO-4. Analyze and know the requirements of vectors and protein expression

CO-5. Design recombinant vectors for therapeutic applications

CO-6. Demonstrate the experimental protocols involved in molecular analysis of nucleic acids.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	L	H		
CO2	H			
CO3	H			
CO4				H
CO5			H	
CO6	M		L	M

UNIT 1 MOLECULAR RESEARCH PROCEDURES AND WORKING WITH NUCLEIC ACIDS 10 Hrs

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).

UNIT 2 GENE EXPRESSION IN PROKARYOTES AND EUKARYOTES AND MANIPULATION OF GENE EXPRESSION 10 Hrs

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 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.

UNIT 3 rDNA TECHNOLOGY 10 Hrs

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.

UNIT 4 GENE EXPRESSION DIRECTED MUTAGENESIS AND PROTEIN ENGINEERING 10 Hrs

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, domain shuffling, linking domains, swapping protein domains, deleting domain , whole protein shuffling, fusion proteins.

UNIT 5 rDNA TECHNOLOGY FOR PRODUCTION OF THERAPEUTICS 10 Hrs

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.

EXPERIMENTS

1. Plasmid Isolation by Mini Prep Method.
2. Restriction Digestion and Restriction Mapping Technique.
3. PCR Technique and the Use of Gel-Doc System.
4. Salt Extraction and Estimation of High Quality Genomic DNA obtained from Plant Source.
5. Small-Scale Extraction and Estimation of RNA obtained from Plant Source.
6. Western blotting technique.

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.

ADVANCED BIOPROCESS ENGINEERING

Subject Code:	**17IBT111**	L-T-P-S:	**4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**00**
CIE Marks:	**50**			SEE Marks:	**50**

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.

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

CO-1. Demonstrate the concepts of fluid flow, mass transfer, mixing and filtration for industrial application.

CO-2. Identify rheological behavior and diffusion phenomena of fermentation broth.

CO-3. Apply mass transfer concepts to design aeration and agitation of fermentation process.

CO-4. Demonstrate knowledge of filtration and mixing process in industrial operation.

CO-5. Develop control strategies for bioprocess operations.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	H		L	
CO2	L		M	L
CO3	M			
CO4	M			
CO5	L		M	

UNIT 1 INTRODUCTION 10 Hrs

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.

UNIT 2 FLUID FLOW AND MIXING 10 Hrs

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.

UNIT 3 MASS TRANSFER 10 Hrs

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.

UNIT 4 UNIT OPERATIONS 10 Hrs

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.

UNIT 5 BIOPROCESS CONTROL 10 Hrs

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).

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.

BIOPROCESS MODELING AND AUTOMATION

Subject Code: **17IBT112**	L-T-P-S: **4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

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.

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

CO-1. Understand the concepts and need for process modeling and simulation.
CO-2. Apply the concepts of modeling to linear and nonlinear bioprocesses.
CO-3. Apply the modeling principles to systems generating ordinary and partial differential model equations.
CO-4. Describe principle of stochastic modeling.
CO-5. Use and Apply software tools for simulation of model equations.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	L		L	
CO2	H		L	
CO3	H		M	
CO4	L		M	
CO5	L		M	

UNIT 1 PRINCIPLES OF MODELING 10 Hrs

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.

UNIT 2 LINEAR AND NON LINEAR EQUATIONS 10 Hrs

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.

UNIT 3 ORDINARY DIFFERENTIAL EQUATIONS 10 Hrs

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.

UNIT 4 PARTIAL DIFFERENTIAL EQUATIONS & STOCHASTIC MODELING **10 Hrs**

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.

UNIT 5 MODEL SIMULATION **10 Hrs**

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.

TEXT / REFERENCE 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.
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.

ADVANCED BIOREACTION ENGINEERING

Subject Code: **17IBT113**	L-T-P-S: **4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

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.

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

CO-1. Explain enzyme substrate models and kinetics of enzyme reaction.

CO-2. Demonstrate effects of process parameters on enzyme reactions and formulate evaluation methods for kinetic parameters for homogeneous.

CO-3. Analyze heterogeneous enzyme reactions and associated kinetics.

CO-4. Explain production of industrial enzymes and discuss their applications.

CO-5. Describe protein enrichment or purification methods.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	L			L
CO2	M			L
CO3	H		M	L
CO4	M		M	L
CO5	M		M	L

UNIT 1 BIOLOGICAL KINETICS 10 Hour

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.

UNIT 2 ENZYME REACTION IN HOMOGENEOUS SYSTEMS 10 Hour

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.

UNIT 3 ENZYME REACTION IN HETEROGENEOUS SYSTEMS 10 Hour

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.

UNIT 4 INDUSTRIAL ENZYMES & APPLICATIONS 10 Hour

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).

UNIT 5 ENZYME PURIFICATION 10 Hour

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.

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

BIOPHARMACEUTICALS

Subject Code: **17IBT121**	L-T-P-S: **4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

Course Objectives: To understand fundamental principles of drug development methods and to describe various procedures involved in drug development and pharma operations. To learn operations and practices followed in biopharma industry. To learn about and describe the various pharma products of microbial and animal origin. To understand the mechanism and functioning of biopharmaceutical products. To apply methods of recombinant DNA technology for the production of biopharmaceuticals. To learn methods of quality assurance and validation procedures in biopharama sector.

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

CO-1. Demonstrate fundamental principles of drug development methods.
CO-2. Understand and describe operations and practices followed in drug development and pharma operations in pharma industry.
CO-3. Explain production of various biopharma products of microbial and animal origin and their mechanism of functioning.
CO-4. Apply methods of recombinant DNA technology to production of biopharmaceuticals.
CO-5. Identify and demonstrate methods of quality assurance and validation procedures in biopharama sector.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M		L	L
CO2	L		L	
CO3	M		M	
CO4	L		M	L
CO5		M		M

UNIT 1 DRUG DEVELOPMENT **10 Hrs**

Medicinal plants as source for new drug development – Screening techniques for natural products – Lead optimization – Structure-activity studies through computer-aided modeling – parallel synthesis and combinatorial libraries – rapid screening of combinatorial libraries.

UNIT 2 PHARMACEUTICAL OPERATIONS & PRACTICE **10 Hrs**

Principles and equipment for: Extraction, drying, evaporation, distillation, centrifugation, filtration, comminution, particle sizing, powder handling, granulation, pelletization, coatings Pharmacopoieas, Formulations and Legislations – Pharmaceutical Calculations

UNIT 3 MICROBIAL & ANIMAL PRODUCTS **10 Hrs**

Vaccines and sera: Bacterial vaccines, Viral vaccines – antibiotics: penicillins, cephalosporins, chloramphenicol, tetracyclines, erythromycin, novobiocin, fusidic acid, vancomycin, rifampcin, polypeptide antibiotics, carbohydrate antibiotics – Bacteriocins - blood products and plasma substitutes: plasma, serum and plasma fractions, fractionation of plasma, coagulation factors, human immunoglobulin, albumin preparations, plasma substitutes – disinfection: disinfectants, mode of action, factors influencing disinfectant action – sterilization: sterilization processes, preparation of sterile medicaments

UNIT 4 PHARMACEUTICALS **10 Hrs**

Recombinant DNA products: Human insulin, interferon, somatostatin, somatotropin, streptokinase – recombinant bioconversions of bioactive molecules: production of 7-aminocephalosporanic acid from cephalosporin, chemoenzymatic production of Epivir™ - Pharmacogenomics – Genetic polymorphisms in: drug metabolism, drug transport, drug targets

UNIT 5 VALIDATION TECHNIQUES **10 Hrs**

Validation Techniques for pharmaceutical industries Pilot Plant Scale-Up Techniques Analytical methods and tests for various drugs and Packaging techniques – Glass containers, plastic

containers, film wrapper, bottle seals. Quality assurance and control. Quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements; Common pitfalls in clinical trial management.

TEXT / REFERENCE BOOKS

1. E.A. Rawlins (Ed.), "**Bentley's Textbook of Pharmaceutics**", Bailliere Tindall, UK, 8th Ed., 1992.
2. Leon Shargel, Susanna Wu-Pong, Andrew B.C. Yu, "**Applied Biopharmaceutics & Pharmacokinetics**", Fifth edition, McGraw Hill, 5th Ed., 2005.
3. Proceedings of the Workshop on "**Developments in Drugs & Pharmaceutical Technology**", Organized by NAM S&T Centre, Ed: J.N. Mishra, Daya Publishing House, 2004.
4. A.R. Gennaro (Ed.) "**Remington: The Science & Practice of Pharmacy**", Volumes I & II, Indian Edition, Lippincott Williams & Wilkins, 2004.
5. Gray Walsh & B. Murphy, "**Biopharmaceuticals and industrial prospective**", Kluwer publishers 1999.
6. Gray Walsh, "**Biopharmaceuticals**", Wiley John & Sons, Inc. 2003.
7. Camille G. Wermuth, "**The practice of Medicinal chemistry**", Academic Press, 2003.
8. Dann, J.A, Crommelin & Robert D., Sindelar, "**Pharmaceutical Biotechnology**", Taylor & Francis, 2002.
9. Nallari, P. and Rao, V. V. "**Medical Biotechnology**", Oxford University Press, 2010.

INSTRUMENTAL METHODS OF ANALYSIS

Subject Code:	**17IBT122**	L-T-P-S:	**4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**00**
CIE Marks:	**50**			SEE Marks:	**50**

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.

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

CO-1. Explain application of electromagnetic radiation in biomolecule analysis and Demonstrate fundamental concepts of analytical procedures and Identify suitable technique of molecular analysis.

CO-2. Explain the fundamental concepts and applications of absorption and emission spectroscopic techniques.

CO-3. Explain the fundamental concepts and applications of resonance and scattering spectroscopic techniques.

CO-4. Understand working principle of instrumentation system of chromatography and apply them for biomolecular analysis.

CO-5. Apply concepts of electrophoresis to separation of biomolecules.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M	L	L	H
CO2	L		H	
CO3	M		M	
CO4	M		M	
CO5	M		M	

UNIT 1 INTRODUCTION **10 Hrs**

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.

UNIT 2 ABSORPTION & EMISSION SPECTROSCOPY 10 Hrs

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.

UNIT 3 RESONANCE & SCATTERING SPECTROSCOPY 10 Hrs

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 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.

UNIT 4 CHROMATOGRAPHIC TECHNIQUES 10 Hour

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.

UNIT 5 ELECTROPHORETIC TECHINQUES 10 Hrs

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.

TEXT / REFERENCE 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.

METABOLIC ENGINEERING

Subject Code: **17IBT123**	L-T-P-S: **4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

Course Objectives: 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.

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

CO-1. Demonstrate fundamental concepts of metabolic pathways and manipulation strategies.
CO-2. Apply material balancing methods to evaluate metabolic flux.
CO-3. Describe linear programming methods and apply it to metabolic flux analysis and explain experimental methods to determine flux.
CO-4. Demonstrate fundamentals of metabolic flux control and evaluate parametric coefficients.
CO-5. Describe methods to build metabolic networks.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	L			L
CO2	M		M	
CO3	L		M	
CO4	M		L	
CO5			M	M

UNIT 1 INTRODUCTION TO EXAMPLES OF PATHWAY MANIPULATION - QUALITATIVE TREATMENT 10 Hrs

Enhancement of Product Yield and Productivity, Extension of substrate Range, Extension of Product spectrum and Novel products, Improvement of Cellular properties, Xenobiotic degradation.

UNIT 2 MATERIAL BALANCES AND DATA CONSISTENCY 10 Hrs

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®

UNIT 3 METABOLIC FLUX ANALYSIS 10 Hrs

Theory, over-determined systems, underdetermined systems- linear programming, sensitivity analysis, methods for the experimental determination of metabolic fluxes by isotope labeling, applications of metabolic flux analysis.

UNIT 4 METABOLIC CONTROL ANALYSIS 10 Hrs

Fundamentals of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients, MCA of linear pathways, branched pathways, theory of large deviations

UNIT 5 ANALYSIS OF METABOLIC NETWORKS 10 Hrs

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.

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

RESEARCH EXPERIENCE THROUGH PRACTICE – I

Subject Code:	**17IBT104**	L-T-P-S:	**0-0-4-0**	Credits:	**02**
No. of Lecture Hrs./ Wk:	**00**			No. of Practical Hrs/Week:	**04**
Total No. of Lecture Hrs.:	**00**			Total No. of Practical Hrs.:	**40**
CIE Marks:	**100**			SEE Marks:	**00**

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

CO-1. Identify the current trends in industrial biotechnology and review the literature reports.

CO-2. Communicate verbally and present their reviews and observations to their peers.

CO-3. Write a detailed report giving the accounts of their reviews and opinion.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M			L
CO2		H		L
CO3	L	H		L

FOOD PROCESS ENGINEERING

Subject Code:	**17IBT201**	L-T-P-S:	**4-0-2-0**	Credits:	**05**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**02**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**20**
CIE Marks:	**50**			SEE Marks:	**50**

Course Objectives:

- To identify the scope and importance of food processing.
- To study the food conversion methods and food properties that are of major interest in food processing operations.
- To understand and apply drying, freezing, thermal, and pressure based methods in food processing operations.
- To learn the significance of food additives and relevant food laws and codes.

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

CO-1. Illustrate the need for food processing, relate the food properties necessary in food processing and inspect the necessity of pre-processing operations.

CO-2. Utilize drying & freezing operations for processing of food and assess the time requirements for these operations.

CO-3. Demonstrate and Choose suitable thermal and pressure based food processing method.

CO-4. Identify the influence of novel methods & packaging technology in food processing.

CO-5. Classify the food additives, Know their intended use and Recall related food laws& codes.

CO-6. Perform experiments to determine the quality of solid and liquid food products and estimate the properties involved in the thermo-physical processing of food.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M		L	
CO2			M	H
CO3	L		M	H
CO4			M	H
CO5	L		M	H
CO6	M	L	L	

UNIT 1 FOOD PRE-PROCESSING & CONVERSION METHODS 10 Hrs

Scope and importance of food processing in India and abroad, hurdles faced by food processing industry, Govt. of India initiatives (Food laws & standards, FDI, Food park, Make in India).

Properties of food- Physical, thermal, mechanical, sensory (Numericals). Raw material preparation- cleaning, sorting, grading, peeling. Classification and types of food processing operations (thermal, non-thermal, radiation).

Food conversion operations: Size reduction- stress-strain curve, laws of size reduction (Numericals), Equipments – fibrous foods, dry foods, liquid foods; Filtration - theory: constant pressure filtration (Numericals), vacuum filters; Membrane separation- theory, types and selection, reverse osmosis, Ultrafiltration, membrane separation UNITs (Numericals).

UNIT 2 DRYING & FREEZING OPERATIONS 10 Hrs

Drying operations: Moisture content- definition, methods of determination- direct and indirect methods. Equilibrium moisture content, hysteresis effect; Psychrometry: properties of air, water-vapour mixer (Numericals). Drying mechanisms: constant rate period and falling rate period, drying time calculation (Numericals), methods and equipment used, factors affecting rate of drying, effect of drying on food.

Freezing operations: Freezing theory, estimation of freezing time (Planck's method, Numericals), methods of freezing, refrigeration system/cycle, freezing equipments, freeze drying, effect of low temperature on food.

UNIT 3 FOOD PROCESSING BY HEAT & PRESSURE 10 Hrs

Blanching: methods, equipments and effect on food.

Pasteurization: Concept, evaluation of D, Z, and F for thermal pasteurization (Numericals), pasteurization of packaged and unpackaged food (equipments), effect on food.

Canning, Hydrostatic pressure cooking, Ultra high temperature processing (principle, equipments, effect on food quality).

UNIT 4 OTHER FOOD PROCESSING METHODS & PACKAGING 10 Hrs

Fermentation: types of food fermentation (Lactic acid, ethanolic), examples, effect on food.

Extrusion cooking: Principle, Extrusion systems, examples.

Dielectric heating/micro wave processing, Infra red radiation processing (Concepts and equipments).

Food Packaging: Functions, material, transport properties, packaging atmosphere, shelf life, innovations in packaging technology, Tetrapak.

UNIT 5 FOOD ADDITIVES & LAWS 10 Hrs

Intentional and unintentional additives: E numbers and labeling, Preservatives, antioxidants, sweeteners, flavors, colors, vitamins, stabilizers; Indirect additives: organic residues, inorganic residues and contaminants.

Food laws: Prevention of Food Adulteration Act-1954, Food Safety and Standards Act-2006, FSSAI; Codex Alimentarius: PRP, HACCP-7 Principles, steps, GAP, GRAS.

PRACTICALS

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
2. Determination of processed food content (any three)
    a. salt content in processed products.
    b. fat content
    c. gluten content
    d. crude fiber in foods
    e. ascorbic acid.
3. Quality analysis of milk and water
4. Determination of D, Z and F value in thermal processing.
5. Experiments on determination of drying rate of given food materials
6. Experiments on determination of physical properties of foods.

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., Cambridge, 2nd Ed., 2005.

REFERENCE BOOKS

1. Rao, M.A. and Rizvi, and Ashim K. Datta "**Engineering Properties of Foods**", CRC Press, 2010.
2. Gopala Rao, Chandra, "**Essentials of Food Process Engineering**", B.S. Publications, 2006.
3. Toledo, Romeo T., "**Fundamentals of Food Process Engineering**", Springer, 3rd Ed., 2007.
4. Berk, Zeki, "**Food Process Engineering and Technology**", Academic Press / Elsevier, 2009.
5. Earle R.L. and Earle M.D., "**Unit Operations in Food Processing**", NZIFST Inc., 1983 [http://www.nzifst.org.nz/unitoperations/index.htm] (web edition, e-Book).

FERMENTATION TECHNOLOGY II

Subject Code: **17IBT202**	L-T-P-S: **4-0-2-0**	Credits:	**05**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**02**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**20**
CIE Marks: **50**		SEE Marks:	**50**

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.

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

CO-1. Demonstrate the importance of downstream operations in a fermentation industry.
CO-2. Apply the knowledge of purification techniques for removal of insoluble materials.
CO-3. Describe and apply the knowledge of mass transfer operations in fermentation product isolation.
CO-4. Describe the method of chromatography in product purification.
CO-5. Apply concept of crystallization to product enrichment.
CO-6. Gain the skills and techniques to develop downstream process scheme for product purification.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	H		L	H
CO2	M		L	L
CO3	M		L	L
CO4	M		L	L
CO5	M		L	L
CO6	H	L	M	M

UNIT 1 OVERVIEW OF DOWNSTREAM OPERATIONS 10 Hrs

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.

UNIT 2 REMOVAL OF INSOLUBLES 10 Hrs

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

UNIT 3 ISOLATION 10 Hrs

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.

UNIT 4 PRODUCT PURIFICATION 10 Hrs

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.

UNIT 5 POLISHING 10 Hrs

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.

PRACTICALS

1. Production of citric acid using *Aspergillus niger*.
2. Ethanol production from oil cake using Baker's yeast.
3. Microbial production of protein and enrichment using aqueous two-phase extraction.
4. Production of exopolysaccharides using bacteria.
5. Intracellular lipid production from cellulosic sources using red yeast or green alga.

TEXT / REFERENCE 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.

RESEARCH METHODOLOGY, BIOSAFETY & IPR

Subject Code: **17IBT203**	L-T-P-S: **4-0-2-0**	Credits:	**05**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**02**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**20**
CIE Marks: **50**		SEE Marks:	**50**

Course Objectives: To learn fundamental concepts of doing research and to understand processes involved in performing a research work, and to write a research article or paper using ones own words. To describe and apply statistical techniques to research output and analyze them. To evaluate the research output and present them in the form of report and to be ethically true. To learn the application of softwares in the interpretation of results and data presentation. To understand the importance of intellectual property and methods to safeguard.

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

CO-1. Explain processes involved in doing research work and scientific writing.
CO-2. Know the components and laws involved in IPR.
CO-3. Demonstrate the importance of intellectual properties in research and details of patent filing process.
CO-4. Assess and apply the biosafety measures to the bioprocess operations.
CO-5. Describe the patent laws in Indian and International context.
CO-6. Discuss the success and failures stories of intellectual property rights.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	L	H		M
CO2		L	L	
CO3		M	L	L
CO4	L			M
CO5			L	
CO6		L	M	

UNIT 1: **10 Hrs**

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 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.

Scientific writing: Organization and writing of a research papers, short communications, review articles, technical and survey reports, dissertations and books. Organization of reference material, bibliography, Endnote to be discussed with case studies. Research budget and resources.

UNIT 2: **10 Hrs**

Introduction to Intellectual Property Rights: Types of IPR: 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 International Databases; Country-wise patent searches (USPTO, EPO, PATENTScope, WIPO, IPO, etc.). Concept of Project to Product.

UNIT 3: **10 Hrs**

IPR in Research: 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 – disclosure/non-disclosure; Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement- meaning, scope, litigation, case studies.

UNIT 4: 10 Hrs

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.

UNIT 5: 10 Hrs

Patent laws: 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.

PRACTICALS

Case studies on IPR – Success and failure cases

TEXT/REFERENCE BOOKS:

1. C R Kothari, "**Research Methodology**", New Age International (P) Ltd. 2008.
2. Kumar. "**Research Methodology**", Pearson Education India, 2005.
3. Wayne Goddard, Stuart Melville. "**Research Methodology: An Introduction**", Juta and Company Ltd, 2004.
4. Y.K.Singh. "**Research methodology: techniques and trends**", APH Publishing, 2007.
5. Kashi Ram Sharma. "**Research Methodology**", National publishing house, 2002.
6. D.K. Bhattacharya. "**Research Methodology**", Excel Publisher Publishing Co. Pvt. Ltd., 2007.
7. BARE ACT. "**Indian Patent Act 1970 Acts & Rules**", Universal Law.
8. Kankanala C. "**Genetic Patent Law & Strategy**", 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007.
9. P. Hambleton, J. Melling, T. T. Salusbury. "**Biosafety in Industrial Biotechnology**", Springer, 1994.
10. "**Laboratory biosafety manual**", World Health Organization, 3rd Ed., 2004.
11. Rajmohan Joshi. "**Biosafety and Bioethics**", Isha Books publisher, 2006.
12. M. K. Sateesh. "**Bioethics and Biosafety**", IK International, 2008.

ONLINE RESOURCES:

1. http://www.w3.org/IPR/
2. http://www.wipo.int/portal/index.html.en
3. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
4. www.patentoffice.nic.in
5. www.iprlawindia.org/
6. http://www.cbd.int/biosafety/background.html

7. http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm
8. http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section

NANOMATERIALS AND NANOTOOLS

Subject Code:	**17IBT211**	L-T-P-S:	**4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**00**
CIE Marks:	**50**			SEE Marks:	**50**

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.

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

CO-1. Understand the fundamental concepts of nanomaterials.

CO-2. Describe and characterize nanomaterials and their properties.

CO-3. Apply concepts of nanotechnology in drug discovery and delivery systems.

CO-4. Apply nanotechnology concepts in designing microfluidic devices.

CO-5. Demonstrate its application and risks associated with nanomaterial applications in various fields.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M		H	
CO2	L		M	M
CO3	L			L
CO4	L			L
CO5	L	L		L

UNIT 1 INTRODUCTION 10 Hrs

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).

UNIT 2 NANOMATERIAL AND NANO TOOLS 10 Hrs

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.

UNIT 3 NANOTECHNOLOGY FOR DRUG DISCOVERY & DRUG DELIVERY 10 Hrs

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.

UNIT 4 MICROFLUIDICS 10 Hrs

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.

UNIT 5 APPLICATIONS AND RISK ASSESSMENT 10 Hrs

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.

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

CANCER BIOLOGY

Subject Code: **17IBT212**	L-T-P-S: **4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

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.

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

CO-1. Demonstrate fundamental concepts of cancer and its developmental stages.
CO-2. Describe origin of cancer and process of cancer proliferation.
CO-3. Analyze the genetic and epigenetic factors involved in carcinogenesis.
CO-4. Identify tumour suppressor genes and their characterization.
CO-5. Describe the genes responsible for suppression of cancer and explain therapeutic treatments of cancer.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	H			
CO2		M		
CO3	H			
CO4	L			
CO5	M			H

UNIT 1 FUNDAMENTALS OF CANCER 10 Hrs

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.

UNIT 2 PROCESS OF CARCINOGENESIS 10 Hrs

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.

UNIT 3 MOLECULAR ASPECT OF CANCER 10 Hrs

Epigenetic regulation of transcription, Evidence for role for epigenetics in carcinogenesis: histone modification and cancer, methylation and cancer, Telomeres and Telomerases in cancer. Proto-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.

UNIT 4 TUMOR SUPPRESSOR GENES 10 Hrs

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 TGFβ 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).

UNIT 5 THERAPIES FOR CANCER 10 Hrs

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 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.

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

BIOFUELS ENGINEERING

Subject Code: **17IBT213**	L-T-P-S: **4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

Course Objectives: To understand importance of biofuels. To describe various feedstocks for production of biodiesel and to describe methods of production of biofuels like biodiesel, bioethanol, biohydrogen. To know standard procedures for analysis of purity of these biofuels and to learn national and international standards applicable for utilization of biofuels. To describe methods of hydrogen production using microbes. To understand and apply concepts of fuel cells for energy production using microbial fuel cells.

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

CO-1. Outline the various biofuel technologies and their importance to society.

CO-2. Describe technologies for biodiesel production.

CO-3. Discuss the technologies and feedstock used for bioethanol used.

CO-4. Understand the biohydrogen production techniques.

CO-5. Understand and apply concepts of fuel cells for energy production using microbial fuel cells.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	H		L	M
CO2	L		M	
CO3	L		M	
CO4	L		M	
CO5	L		M	

UNIT 1 INTRODUCTION 10 Hrs

Description of biofuels; energy use & efficiency; biofuel production – I and II generation biofuels; alternative energies; biochemical pathways review for organoheterotrophic, lithotrophic & phototrophic metabolism; importance of COD; biofuel feedstocks: biomass, starch, sugar, lignocellulosic, agro & industrial by-products. Biomass production for fuel – algal cultures, yeasts (lipid and carbohydrate). Fuel production through biomass incineration.

UNIT 2 PRODUCTION OF BIODIESEL 10 Hrs

Chemical, thermodynamic & reaction kinetic aspects of biodiesel production: Esterification and transesterification. Free fatty acids; saponification; single step and two step biodiesel production. Catalysts for biodiesel production – homogeneous (alkali/acidic) and heterogeneous. Sources of oils – edible and non edible; General procedure of biodiesel production and purification. Production technologies: Conventional method, microwave, ultrasonic, supercritical fluid, Lipase mediated process. Quality control aspects: GC analysis of biodiesel, fuel property measurements, ASTM (D-6751) and Indian standards (IS15607). Usage: B100 and B20 and advantages.

UNIT 3 PRODUCTION OF BIOETHANOL 10 Hrs

Process technology for bioethanol production using sugar; starch and lignocellulosic Feedstocks; byproducts of biodiesel industry as feedstock; selection of micro-organisms and feedstock – ethanol tolerance; associated unit operations; determination of bioethanol yield; recovery of bioethanol; process integration. Advances in bioethanol production.

UNIT 4 PRODUCTION OF BIOHYDROGEN 10 Hrs

Enzymes involved in H_2 Production; photobiological H_2 production: Biophotolysis and photofermentation; H_2 production by fermentation: Biochemical pathway, batch Fermentation, factors affecting H_2 production, carbon sources, process and culture parameters; detection and quantification of H_2. Reactors for biohydrogen production. Advances in biohydrogen production technology.

UNIT 5 MICROBIAL FUEL CELLS 10 Hrs

Biochemical Basis; fuel cell design: anode & cathode compartment, microbial cultures, redox mediators, exchange membrane, power density; MFC performance methods: substrate & biomass measurements, basic power calculations, MFC performance: power density, single-chamber vs two-chamber designs, effectiveness in wastewater treatment; advances in MFC.

TEXT BOOKS:

1. Caye M. Drapcho, N.P. Nhuan and T. H. Walker, "**Biofuels Engineering Process Technology**", Mc Graw Hill Publishers, New York, 2008.

2. Jonathan R.M, "**Biofuels – Methods and Protocols**" (Methods in Molecular Biology Series), Humana Press, New York, 2009.

REFERENCE BOOKS:

1. Lisbeth Olsson (Ed.), "**Biofuels**" (Advances in Biochemical Engineering/Biotechnology Series), Springer-Verlag Publishers, Berlin, 2007.
2. Glazer and Nikaido, "**Microbial Biotechnology – Fundamentals of Applied Microbiology**", Cambridge University Press, 2 Ed., 2007.

BIOREACTOR DESIGN AND ANALYSIS

Subject Code: **17IBT221**	L-T-P-S: **4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk: **04**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **50**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

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.

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

CO-1. Illustrate different types of bioreactors and their operation.
CO-2. Apply reaction engineering principles to bioreactors and evaluate their performance.
CO-3. Identify non-ideal behaviour in bioreactors and inspect the transient behavior of bioreactor.
CO-4. Design bioreactor based on thumb rules for fermentation operation.
CO-5. Make use of computational techniques for dynamic analysis of bioreactors and utilize the scale up rules.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M	L		
CO2	M		H	
CO3	L		L	
CO4	M	L	H	
CO5	M	L	M	

UNIT 1 BIOREACTOR AND ITS OPERATION 10 Hrs

Purpose and importance of bioreactor, Operational modes of bioreactor: batch, semi-batch/fed-batch, continuous. Major components of bioreactor and its purpose, Aseptic measures and sterilization requirements, classification of Bioreactor – SLF, SSF, animal and plant cell culture. Classification of bioreactors for environmental control and management. Bioreactors: Fermenter, Fixed bed bioreactor, airlift reactor, hollow fibre reactor, seed reactor.

UNIT 2 BIOCHEMICAL ASPECTS OF BIOREACTOR DESIGN 10 Hrs

Performance of batch reactor for Michealis-Menten equation and monod equation. Performance of continuous reactors – Chemostat, turbidostat, dilution rate and washout. Performance of PFR, and recycle bioreactor. Combination of bioreactor – multistage chemostat in series, multistage combinations. Performance of semi-batch or fed batch reactors. Performance of immobilized enzyme reactors.

UNIT 3 NON IDEALITY AND TRANSIENT BEHAVIOR OF BIOREACTORS 10 Hrs

Non ideality in bioreactor: causes and measurements, exit age distribution, Estimation of conversion in non-ideal PFR and CFSTBR. Models of non-ideality: micro & macro mixing,

dispersion model, Tank-in –series model, Cholette-cloutier model.
Stability analysis, Stability analysis of fed batch and chemostat, Stability of chemostat with substrate inhibition, Operating diagram, Transient response of the chemostat, control of chemostat, Turbidostat operation, Nutristat operation.

UNIT 4 DESIGN ASPECTS OF A BIOREACTOR 10 Hrs

Material of construction for bioreactor, corrosion, protective coating, Linings for bioreactors. Design of bioreactor vessel: shell thickness, design of jacket, agitation requirement (shaft/other means, calculations), Effect of rheology on fermenter operation, aeration requirement (nozzle design). Design of support system for bioreactor.

UNIT 5 COMPUTATIONAL ANALYSIS OF BIOREACTOR DYNAMICS AND SCALE UP 10 Hrs

Computational fluid dynamics (CFD) analysis of bioreactor – basic concepts, meshing methods, application to bioreactor dynamics analysis (mixing pattern, aeration pattern). (Theoretical concepts only) Use of supervisory control and data Acquisition (SCADA) for fermenter control. Neural networks and stability analysis of bioreactor (Theoretical concepts only).
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).

TEXT BOOKS:

1. Tapobrata Panda, "**Bioreactors – Analysis and Design**", TMH, 2011.
2. Blanch and Clark, "**Biochemical Engineering"**, 2nd Ed., Marcel Dekker Inc. 2012.

REFERENCE BOOKS:

1. Vogel and Todaro, "**Fermentation and Biochemical Engineering Hand Book**", 2nd Ed., Standard Publishers and Distributors, 2005.
2. M.V. Joshi, V.V. Mahajan, **Process Equipment Design**, 3rd Ed., Macmillan India, 1994.
3. Mukhopadhyay, "**Process Biotechnology Fundamentals**", Viva Books Pvt. Ltd., 2nd Ed., 2004.
4. Dunn et al., "**Biological Reaction Engineering**", Wiley-VCH, 2nd Ed., 2000.
5. Mukesh Doble et al., "**Biotransformations and Bioprocesses**", Marcel Decker Inc.2004.
6. Peppler and Periman, "**Microbial Technology: Fermentation Technology**" Vol 2, Academic Press/Elsevier, 2nd Ed., 2004.

ENTREPRENEURSHIP

Subject Code:	**17IBT222**	L-T-P-S:	**4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**00**
CIE Marks:	**50**			SEE Marks:	**50**

Course Objectives: 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.

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

CO-1. Demonstrate the knowledge and understanding of the engineering and management principles in bioprocess industry.

CO-2. Identify business opportunities and financing agencies and demonstrate the need and essentials of report writing for financial assistance.

CO-3. Understand role of management and its functions in a business.

CO-4. Apply techniques of record maintenance methods and preparation of balance sheets.

CO-5. Understand the strategies of marketing and its impact on business.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	L	L		
CO2		H	L	
CO3			M	
CO4		H		
CO5			L	L

UNIT 1 ENTREPRENEURSHIP-ENTERPRISE 10 Hrs

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.

UNIT 2 OPPORTUNITY SCOUTING AND IDEA GENERATION 10 Hrs

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.

UNIT 3 MANAGEMENT ROLES AND FUNCTIONS IN A SMALL BUSINESS 10 Hrs

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.

UNIT 4 PRINCIPLES OF DOUBLE-ENTRY BOOK-KEEPING 10 Hrs

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.

UNIT 5 ISSUES IN SMALL BUSINESS MARKETING. 10 Hrs

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.

TEXT / REFERENCE 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.
7. Patel, V.G., "**The Seven Business Crises and How to Beat Them**", TMH, 1995.
8. SIDBI Report on Small Scale Industries Sector [latest edition]
9. Verma, J.C.., and Gurpal Singh, "**Small Business and Industry-A Handbook for Entrepreneurs**", Sage, New Delhi, 2002.
10. Manohar, "**Entrepreneurship & Management**", Wiley India, 2012.
11. Schaper, "**Entrepreneurship & Small Business**", Wiley India, 2012.
12. Trehan, "**Entrepreneurship**", Wiley India, 2012.

PETROLEUM BIOTECHNOLOGY

Subject Code:	**17IBT223**	L-T-P-S:	**4-0-0-0**	Credits:	**04**
No. of Lecture Hrs./ Wk:	**04**			No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.:	**50**			Total No. of Practical Hrs.:	**00**
CIE Marks:	**50**			SEE Marks:	**50**

Course Objectives: 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.

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

CO-1. Understand concept of bio-refineries and their applications.
CO-2. Describe processing of methane and aromatic compounds using biocatalysts.
CO-3. Demonstrate biological corrosion and methods to combat them.
CO-4. Describe emulsification methods used for industrial application and sewage water treatment process using biological materials.
CO-5. Describe bioremediation process and apply it to petroleum industry waste water treatment.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M			M
CO2	L			M
CO3	M			M
CO4	M		M	M
CO5	M		H	M

UNIT 1 BIOREFINARIES 10 Hrs

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.

UNIT 2 BIOPROCESSING OF METHANE AND AROMATIC COMPOUNDS 10 Hrs

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.

UNIT 3 BIOCORROSION 10 Hrs

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.

UNIT 4 BIOEMULSIFIERS 10 Hrs

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.

UNIT 5 BIOREMEDIATION 10 Hrs

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

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

RESEARCH EXPERIENCE THROUGH PRACTICE – II

Subject Code:	**17IBT204**	L-T-P-S:	**0-0-4-0**	Credits:	**02**
No. of Lecture Hrs./ Wk:	**00**			No. of Practical Hrs/Week:	**04**
Total No. of Lecture Hrs.:	**00**			Total No. of Practical Hrs.:	**40**
CIE Marks:	**100**			SEE Marks:	**00**

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

CO-1. Identify the current trends in industrial biotechnology and review the literature reports.

CO-2. Communicate verbally and present their reviews and observations to their peers.

CO-3. Write a detailed report giving the accounts of their reviews and opinion.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	M			L
CO2		H		L
CO3	L	H		L

AUDIT COURSES

QUALITY AND SAFETY MANAGEMENT

Subject Code:	**17AP009**	L-T-P-S:	**2-0-0-0**	Credits:	**00**
No. of Lecture Hrs./ Wk:	**2**			No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.:	**25**			Total No. of Practical Hrs.:	**00**
CIE Marks:	**50**			SEE Marks:	**50**

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.

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

CO-1. Understand the concept of quality systems and compliance in the regulated industry and the role of quality assurance.

CO-2. Demonstrate importance of GMP and GLP in industry.

CO-3. Demonstrate safety measures and guidelines to implement GMP and GLP in industry.

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1	L	L		
CO2	L	L		
CO3	M	M		L

UNIT 1 PRINCIPLES OF QUALITY CONTROL 05 Hrs

Basic terminology and validation,validation master plan, scope, documentation format, elements of qualification, numbering system, revalidation and its applications, Role of quality audit and quality circle in quality assurance; measurement of quality, information, quality operations, Human resource and training for quality.

UNIT 2 GMP (Good manufacture practice) 05 Hrs

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.

UNIT 3 GLP (Good Laboratory Practices) 05 Hrs

Good Laboratory Practices, principles, commodities, apparatus, reagents and materials, pest control, cryogenic safety, general precautions, storage, test systems, standard protocols, quality assurance, Laboratory signage, treatment and disposal –sharps, cultures, stock & lab ware, storage and retention of records.

UNIT 4 SAFETY AND REGULATIONS 05 Hrs

Environmental aspects of biotech applications, Biosafety assessment procedures in India and abroad, International dimensions in biosafety, bioterrorism and convention on biological weapons.

UNIT 5 CASE STUDIES 05 Hrs

Transgenic food crops examples, GMO and their release in environment.

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

PROJECT MANAGEMENT

Subject Code: **17AP010**	L-T-P-S: **2-0-0-0**	Credits:	**00**
No. of Lecture Hrs./ Wk: **2**		No. of Practical Hrs/Week:	**00**
Total No. of Lecture Hrs.: **25**		Total No. of Practical Hrs.:	**00**
CIE Marks: **50**		SEE Marks:	**50**

Course Objectives: To understand the importance of project implementation and its resources. Students will also be able to understand the work breakdown and structural role in completion of projects with their leadership.

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

CO-1. Manage the selection and initiation of individual projects and portfolios of projects in the enterprise

CO-2. Apply project management practices to the launch of new programs, initiatives, products, and services.

CO-3. Demonstrate effective organizational leadership and change skills for managing projects, project teams

CO – PO Mapping

	PO			
CO	1	2	3	4
CO1		M		L
CO2		L		L
CO3		M		L

UNIT 1 INTRODUCTION 05 Hrs

Definitions, overview of projects, Project life cycle, application of principles to project management.

UNIT 2 PROJECT PLANNING 05 Hrs

Project planning, scope, problem statement, project goals, objectives, success criteria, assumptions, risks, obstacles, Approval process, projects and strategic planning

UNIT 3 PROJECT RESOURCES 05 Hrs

Project implementation, project resource requirements, types of resources, men, materials, finance. Project monitoring, evaluation, control, planning for monitoring and evaluation, project audits.

UNIT 4 PROJECT NETWORK 05 Hrs

Project description, work breakdown structure, basic scheduling with network, PERT & CPM, project communication, rules for drawing and representation, goals.

UNIT 5 ROLE OF HUMAN FACTORS 05 Hrs

Dealing with people, team building and leadership in projects, commitment, work culture, motivation, coordination, attitude, innovation.

TEXT / REFERENCE BOOKS:

John M. Nicholas & Herman Steyn. "**Project Management for Business, Engineering and Technology – Principles and Practice**" Elsevier, 2008.