NMAM INSTITUTE OF TECHNOLOGY, NITTE  
DEPARTMENT OF BIOTECHNOLOGY ENGINEERING  
SCHEME OF TEACHING AND EXAMINATION FOR  
M.TECH. (Full Time) INDUSTRIAL BIOTECHNOLOGY  
AUTONOMOUS SCHEME: 2015-16 – Approved by BOS on 6th June 2015

I Semester  
23 Credits

<table>
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Elective – I

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<td>Bioprocess Modeling &amp; Automation</td>
<td>Biopharmaceuticals</td>
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<tr>
<td>15IBT112</td>
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II Semester  
27 Credits

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<td>15IBT212</td>
<td>Cancer Biology</td>
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<td>15IBT213</td>
<td>Biofuels Engineering</td>
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<td>15IBT222</td>
<td>Metabolic Engineering</td>
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<td>15IBT223</td>
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<tr>
<td>15IBT302</td>
<td>Seminar on Current Topics in Industrial Biotechnology</td>
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<td>15IBT303</td>
<td>Project – Phase I</td>
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| Total       | 300 | 100 | 400 | 20 |

### IV Semester

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| Total       | 100 | 300 | 400 | 30 |

Total Credits: I to IV semester = 100

**Note:**

- 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 Phase 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 carry out 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. At the end of III semester, student should present progress report in the form of seminar and report.
- Project Phase II: Student shall continue with project phase I. He/she should submit the final project report and present a seminar to the project evaluation committee. 400 Marks for project is distributed between internal and external examiner equally (200 for external and 200 for internal).
- 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 is mandatory.
- The Project Report Valuation and Viva-Voce will be conducted by a committee consisting of the following:
  - Head of the Department (Chairman, BoE)
  - Guide(s)
  - One external examiner
I SEMESTER M. TECH. INDUSTRIAL BIOTECHNOLOGY
NUMERICAL METHODS & BIOSTATISTICS

Subject Code : 15IBT101 Credits : 04
No. of Lecture Hrs./ Week : 04 CIE Marks : 50
Total No. of Lecture Hrs. : 50 SEE Marks : 50

Course Objectives: To learn numerical methods and statistical techniques to evaluate biological and bioprocess data. To understand the needs of statistical analysis in experimental design and analysis. To apply statistical methods for design of experiments and interpret the results. To apply statistical techniques to microarray analysis and genome mapping.

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

- Demonstrate methods for data representation using statistical tools.
- Apply statistical tools to biological problems and experimental designs.
- Understand the importance of statistics in solving biological problems.
- Perform ANOVA for biological data.
- Design and formulate statistical designs for experimentation.
- Evaluate and interpret the statistical analysis of biological data.
- Apply statistical techniques to genome mapping and interpret the outcomes.

MODULE 1: 10 Hours
Introduction to statistics and study design: Introduction to statistics, data, variables, types of data, tabular, graphical and pictorial representation of data. Significance of statistics to biological problems, experimental studies; randomized controlled studies, historically controlled studies, crossover, factorial design, cluster design, randomized; complete, block, stratified design, biases, analysis and interpretation.

MODULE 2: 10 Hours
Descriptive statistics and Observational study design: Types of variables, measure of spread, logarithmic transformations, multivariate data. Basics of study design, cohort studies, case-control studies, outcomes, odd ratio and relative risks.

Principles of statistical inference: Parameter estimation, hypothesis testing. Statistical inference on categorical variables; categorical data, binomial distribution, normal distribution, sample size estimation.

MODULE 3: 10 Hours
Comparison of means: Test statistics; t-test, F distribution, independent and dependent sample comparison, Wilcoxon Signed Rank Test, Wilcoxon-Mann-Whitney Test, ANOVA.

Correlation and simple linear regression: Introduction, Karl Pearson correlation coefficient, Spearman Rank correlation coefficient, simple linear regression, regression model fit, inferences from the regression model, ANOVA tables for regression.

MODULE 4: 10 Hours
Design and analysis of experiments: Random block design, multiple sources of variation, correlated data and random effects regression, model fitting. Completely randomized design, stratified design. Biological study designs. Optimization strategies with case studies.

MODULE 5: 10 Hours
Statistics in microarray, genome mapping and bioinformatics: Types of microarray, objectives of the study, experimental designs for micro array studies, microarray analysis, interpretation, validation and microarray informatics. Genome mapping, discrete sequence matching, programs for mapping sequences with case studies.

TEXT / REFERENCE BOOKS:

FERMENTATION TECHNOLOGY - I

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

MODULE 1  CELL CULTIVATION AND GROWTH KINETICS  10 Hours

MODULE 2  INOCULUM DEVELOPMENT AND MEDIA PREPARATION  10 Hours
Media components and optimization (PB, RSM techniques), types of media, Strain preservation , inoculum preparation, Development of inocula for industrial fermentation/ seed fermenter.

MODULE 3  STERILIZATION  10 Hours
Sterilization: death kinetics, del factor, batch and continuous; insitu and ex-situ sterilization, Sterilization of medium, air, filters, fermenter. Numericals.

MODULE 4  FERMENTATION PROCESS  10 Hours

MODULE 5  CONTROL OF INDUSTRIAL FERMENTATION  10 Hours
Requirements for control, sensors, controllers, design of fermenter control specification, control of incubation, advanced incubation control.

TEXT BOOKS:

REFERENCE BOOKS:

ADVANCED MOLECULAR BIOLOGY

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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:

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

MODULE 1  MOLECULAR RESEARCH PROCEDURES AND WORKING WITH NUCLEIC ACIDS  10 Hours
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).

MODULE 2  GENE EXPRESSION IN PROKARYOTES AND EUKARYOTES AND MANIPULATION OF GENE EXPRESSION  10 Hours
Eukaryotes: some considerations in choice of cell lines, endogenous selectable markers and dominant selectable markers, stepwise amplification of transgene, plasmid vectors for transfection, major expression systems used in animal cells.

MODULE 3  rDNA TECHNOLOGY  10 Hours
Early thoughts and experiments in cloning, first step towards cloning frogs and toads, nuclear totipotency,
Prokaryotic vectors: Bacterial plasmids, viral vectors: cosmids, plasmids, 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 cerevisiae; 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.

MODULE 4  GENE EXPRESSION DIRECTED MUTAGENESIS AND PROTEIN ENGINEERING  10 Hours
Oligonucleotide directed mutagenesis with M13 DNA, PCR amplified oligonucleotide directed mutagenesis, degenerate oligonucleotide primers, random mutagenesis and site
directed mutagenesis. Adding disulphide bonds, changing asparagine to other amino acids, reducing number of free sulphhydryl 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.

MODULE 5 rDNA TECHNOLOGY FOR PRODUCTION OF THERAPEUTICS

10 Hours

Recombinant interferon. Subunit vaccines: against herpes simplex virus, foot and mouth disease, peptide vaccines. Live recombinant vaccines: Vaccinia virus recombinants, BCG vaccines, poliovirus chimera.

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\text{H} and V\text{L} and generation of cDNA, PCR amplification of cDNA for antibody V\text{H} and V\text{L}. Linking of V\text{H} and V\text{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.

TEXT BOOKS:

REFERENCE BOOKS:

BIOPROCESS ENGINEERING

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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:
- Demonstrate the concepts of fluid flow, mass transfer, mixing and filtration for industrial application.
- Identify rheological behavior and diffusion phenomena of fermentation broth.
• Apply mass transfer concepts to design aeration and agitation of fermentation process.
• Demonstrate knowledge of filtration and mixing process in industrial operation.
• Develop control strategies for bioprocess operations.

**MODULE 1 INTRODUCTION**

**MODULE 2 FLUID FLOW AND MIXING**
Fluid statics: Pressure at a point and measurement, osmotic pressure. Viscosity and its measurements: Newton’s laws of viscosity, Newtonian and non Newtonian fluids (NF & NNF). Rheology of fermentation broth.

**MODULE 3 MASS TRANSFER**
Aeration: Oxygen uptake in cell culture, Gassed fluid, \( K_L a \) and its measurement, oxygen supply and demand, sparger, aeration number, power requirement, bubble shear.

**MODULE 4 UNIT OPERATIONS**

**MODULE 5 BIOPROCESS CONTROL**
Concept of bioprocess control, Elements of feedback controller, types of controller action, advanced control strategies, controller tuning, online and offline measurements (P,T, pH, agitator speed, off gas analysis).

**TEXT BOOKS:**

**REFERENCE BOOKS:**
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:

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

MODULE 1  PRINCIPLES OF MODELING  
Concept of modeling and simulation, general aspects of modeling, dependent and independent variables, classification of models. Material and energy balance equations, constitutive equations, general strategy of modeling, Solution strategies and simulation. Measurements, errors and accuracy. Modeling of simple systems.

MODULE 2  LINEAR AND NON LINEAR EQUATIONS  
Elemental balances and degrees of reduction, extractor, absorber. Models of enzyme kinetics (Michaelis-Menten), growth kinetics (Monod) and product formation kinetics. Receptor-ligand dynamics, RT-PCR modeling. Numerical solutions to linear and nonlinear algebraic equations.

MODULE 3  ORDINARY DIFFERENTIAL EQUATIONS  
Models of predator-prey, commensalism and mutualism, Structured kinetic models, pharmacokinetic models. Bioreactors modeling (MFR and PFR with linear and nonlinear kinetics), models of heat transfer and mass transfer in bioreactor. Numerical solutions to ODEs.

MODULE 4  PARTIAL DIFFERENTIAL EQUATIONS & STOCHASTIC MODELING  
Kinetics of immobilized system with internal mass transfer, diffusion across biological membranes, fluid flow in physiological vessel (blood flow), numerical solutions to PDEs. Principles of stochastic modeling, age distribution of microbial cells, budding of yeast cells.

MODULE 5  MODEL SIMULATION  
MATLAB: Basic commands, plotting tools, matrices and operation, flow control, solving linear, nonlinear equations, ODEs, PDE toolbox, SIMULINK. Use of MATLAB to solve problems formulated in Unit 1 to Unit 4.
TEXT / REFERENCE BOOKS

INSTRUMENTAL METHODS OF ANALYSIS

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

MODULE 1 INTRODUCTION 10 Hours
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.
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.

**MODULE 2 ABSORPTION & EMISSION SPECTROSCOPY** 10 Hours

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.

**MODULE 3 RESONANCE & SCATTERING SPECTROSCOPY** 10 Hours

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.

**MODULE 4 CHROMATOGRAPHIC TECHNIQUES** 10 Hour


**MODULE 5 ELECTROPHORETIC TECHNIQUES** 10 Hours


**TEXT / REFERENCE BOOKS:**

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 biopharma sector.

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

- Demonstrate fundamental principles of drug development methods.
- Understand operations and practices followed in biopharma industry.
- Describe various procedures involved in drug development and pharma operations.
- Explain production of various pharma products of microbial and animal origin.
- Describe mechanism and functioning of biopharmaceutical products.
- Apply methods of recombinant DNA technology to production of biopharmaceuticals.
- Identify and demonstrate methods of quality assurance and validation procedures in biopharma sector.

MODULE 1 DRUG DEVELOPMENT
10 Hours

MODULE 2 PHARMACEUTICAL OPERATIONS & PRACTICE
10 Hours
Principles and equipment for: Extraction, drying, evaporation, distillation, centrifugation, filtration, comminution, particle sizing, powder handling, granulation, pelletization, coatings Pharmacopoeias, Formulations and Legislations – Pharmaceutical Calculations

MODULE 3 MICROBIAL & ANIMAL PRODUCTS
10 Hours

MODULE 4 PHARMACEUTICALS
10 Hours
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

MODULE 5 VALIDATION TECHNIQUES
10 Hours
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**


**BIOREACTION ENGINEERING**

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**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:

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

**MOULE 1  BIOLOGICAL KINETICS**

Enzyme nomenclature and enzyme classification, energy potentials of enzyme (Stern layers). Types of reaction, elementary and non elementary reaction, molecularity and order of reaction, The enzyme-substrate complex and enzyme action, simple enzyme kinetics with one and two substrate. Derivation of Michaelis-Menten kinetics, Briggs-Haldane approach, Monod equation. Double Michaelis–Menten kinetics, allosteric kinetics, effect of

**MOULE 2  ENZYME REACTION IN HOMOGENEOUS SYSTEMS  10 Hour**

**MOULE 3  ENZYME REACTION IN HETEROGENEOUS SYSTEMS  10 Hour**

**MOULE 4  INDUSTRIAL ENZYMES & APPLICATIONS  10 Hour**

**MOULE 5  ENZYME PURIFICATION  10 Hour**

**TEXT BOOKS:**

**REFERENCE BOOKS:**
FERMENTATION TECHNOLOGY & MOLECULAR BIOLOGY LAB

Subject Code : 15IBT105  Credits : 02
No. of Practical Hrs./ Week : 03  CIE Marks : 50
Total No. of Practical Hrs. : 36  SEE Marks : 50

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

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

- Prepare and develop inoculum for industrial fermentation.
- Design medium for optimal fermentation and reduce lag period.
- Design and Perform experiments on plant tissue culture.
- Design and Perform molecular biology experiments.

EXPERIMENTS

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.
8. Restriction Digestion and Restriction Mapping Technique.
9. PCR Technique and the Use of Gel-Doc System.
10. Salt Extraction and Estimation of High Quality Genomic DNA obtained from Plant Source.
11. Small-Scale Extraction and Estimation of RNA obtained from Plant Source.
12. Western blotting technique.
Course Objectives: To learn methods involved food processing; To understand and apply drying method in food processing operations; To study the food conversion methods and describe equipments required; To apply method of cooling for food processing and preservation; To analyze and investigate properties of food, quality of food and design various food processing operations through experiments.

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

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

MODULE 1 FOOD PROCESSING METHODS 10 Hours
Scope and importance of food processing; Properties of food- Physical, thermal, mechanical, sensory. Raw material preparation- Cleaning, sorting, grading, peeling.

MODULE 2 DRYING 10 Hours
Moisture content- definition, methods of determination- direct and indirect methods. Equilibrium moisture content- Hysteresis effect- Psychrometry- properties of air, water-vapour mixer, problems in psychrometry. Drying-mechanisms-constant rate period and falling rate period- methods and equipment used- factors affecting rate of drying.

MODULE 3 FOOD CONVERSION OPERATION 10 Hours
Size reduction- Fibrous foods, dry foods and liquid foods- Theory and equipments- membrane separation- filtration- equipment and application.

MODULE 4 FOOD PRESERVATION BY COOLING 10 Hours
Refrigeration, Freezing-Theory, freezing time calculation, methods of freezing, freezing equipments, freeze drying, freeze concentration, thawing, effect of low temperature on food. Water activity, methods to control water activity.

MODULE 5 FOOD ADULTARTION & LAWS 10 Hours
Intentional and unintentional: Preservatives, antioxidants, sweeteners, flavours, colours, vitamins, stabilizers; Indirect additives: organic residues, inorganic residues and contaminants. FSSAI, Essential Commodities Act, BIS, Codex Alimentarius, PRP, GAP, GRAS, SSOP, HACCP.
TEXT BOOKS

REFERENCE BOOKS

FERMENTATION TECHNOLOGY II

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

MODULE 1 OVERVIEW OF DOWNSTREAM OPERATIONS 10 Hours
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.

**MODULE 2  REMOVAL OF INSOLUBLES**  
10 Hours  
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

**MODULE 3  ISOLATION**  
10 Hours  
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.

**MODULE 4  PRODUCT PURIFICATION**  
10 Hours  
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.

**MODULE 5  POLISHING**  
10 Hours  

**Case studies:** Ethanol, Vinegar, Beer, Wine, Antibiotics.

**TEXT / REFERENCE BOOKS:**

**REFERENCE BOOKS:**
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:

- Explain processes involved in doing research work.
- Identify research problem, formulate and design solution methodologies.
- Apply statistical methods to evaluate and interpret research output.
- Apply knowledge of softwares for data interpretation and data presentation.
- Demonstrate the importance of intellectual properties and research ethics.
- Describe process of Patent application.
- Write a research article or paper without plagiarism.

MODULE 1: 10 Hours

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.


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.

MODULE 2: 10 Hours

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.).

MODULE 3: 10 Hours

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.

**MODULE 4:**

**Biosafety:** Introduction & historical background; Primary Containment for Biohazards; Biosafety Levels for Microbes, Plants & Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs: RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication. Roles of Institutional Biosafety Committees.

**MODULE 5:**

**Patent laws:** History, broad account & latest amendments (if any) of the provisions of Indian Patent Act 1970 & recent amendments, GATT & TRIPS Agreement, Hague Agreement, WIPO Treaties, Budapest Treaty, PCT.

**TEXT/REFERENCE BOOKS:**


**Important Links for Resource Material:**

1. http://www.w3.org/IPR/
3. http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
4. www.patentoffice.nic.in
5. www.iprlawindia.org/
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:

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

MODULE 1 BIOREACTOR AND ITS OPERATION 10 Hours
Purpose and importance, basic requirements for operation; classification – SLF, SSF, animal, plant, sterilization, immobilized, seed reactor. Operational modes of bioreactor: batch, semi-batch/fed-batch, continuous. Bioreactors: Fermenter, packed bed reactor, airlift reactor, hollow fibre reactor, reactor for plant cells and mammalian cell culture, SSF reactor.

MODULE 2 BIOCHEMICAL ASPECTS OF BIOREACTOR DESIGN 10 Hours

MODULE 3 NONIDEALITY IN BIOREACTOR 10 Hours

MODULE 4 DESIGN ASPECTS OF A BIOREACTOR 10 Hours
Mechanical design aspects of a fermenter (Tower, Packed bed, Air lift only): L/D ratio, Effect of rheology on fermenter operation, agitation requirement (shaft/other means, calculations), aeration requirement (nozzle design). Mixing pattern in fermenter, back mixing in tower fermenter, heat requirements in fermenter. Aseptic measures and sterilization requirements.

MODULE 5 COMPUTATIONAL ANALYSIS OF BIOREACTOR DYNAMICS AND SCALE UP 10 Hours
Computational fluid dynamics (CFD) analysis of bioreactor – basic concepts, meshing methods, application to bioreactor dynamics analysis (mixing pattern, aeration pattern). Use of supervisory control and data Acquisition (SCADA) for fermenter control. Neural networks and stability analysis of bioreactor.
Bioreactor Scale up: Strategies and methods – Similarity criteria, Hubbard method, method of Wang et al., Ettiler’s method. Dimensionless numbers and scale up. Scale up based on aeration and power requirement (Aeration and power number).

TEXT BOOKS:

REFERENCE BOOKS:

NANOMATERIALS AND NANOTOOLS

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

**MODULE 1 INTRODUCTION**

10 Hours
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).

**MODULE 2 NANOMATERIAL AND NANO TOOLS**

10 Hours
MODULE 3  NANOTECHNOLOGY FOR DRUG DISCOVERY & DRUG DELIVERY  
10 Hours
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.

MODULE 4  MICROFLUIDICS  
10 Hours
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.

MODULE 5  APPLICATIONS AND RISK ASSESSMENT  
10 Hours

TEXT / REFERENCE BOOKS:
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:

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

MODULE 1  FUNDAMENTALS OF CANCER  
10 Hours
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.

MODULE 2  PROCESS OF CARCINOGENESIS  
10 Hours
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.

MODULE 3  MOLECULAR ASPECT OF CANCER  
10 Hours
Epigenetic regulation of transcription, Evidence for role for epigenetics in carcinogenesis: histone modification and cancer, methylation and cancer, Telomerases and Telomeres 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.

**MODULE 4 TUMOR SUPPRESSOR GENES**

10 Hours

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).

**MODULE 5 THERAPIES FOR CANCER**

10 Hours

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, other 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 caspasases, 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), strategies 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:**

BIOFUELS ENGINEERING

Subject Code : 15IBT213  Credits : 04
No. of Lecture Hrs./ Week : 04  CIE Marks : 50
Total No. of Lecture Hrs. : 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:
- Demonstrate the importance of biofuels.
- Describe technologies for biofuel production.
- Identify feedstocks for biofuel production.
- Apply analytical procedures for purity analysis of biofuels.
- Know the application of national and international standards of biofuels quality.
- Understand and apply concepts of fuel cells for energy production using microbial fuel cells.

MODULE 1 INTRODUCTION  
10 Hours
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.

MODULE 2 PRODUCTION OF BIODIESEL  
10 Hours

MODULE 3 PRODUCTION OF BIOETHANOL  
10 Hours
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.

**MODULE 4 PRODUCTION OF BIOHYDROGEN**  
10 Hours

Enzymes involved in H₂ Production; photobiological H₂ production: Biophotolysis and photofermentation; H₂ production by fermentation: Biochemical pathway, batch Fermentation, factors affecting H₂ production, carbon sources, process and culture parameters; detection and quantification of H₂. Reactors for biohydrogen production. Advances in biohydrogen production technology.

**MODULE 5 MICROBIAL FUEL CELLS**  
10 Hours

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:**

**REFERENCE BOOKS:**

**INDUSTRIAL WASTE WATER TREATMENT**

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

**Course Outcomes:**

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

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

MODULE 1 WATER AND WASTE WATER ENGINEERING AN OVERVIEW 10 Hours
Constituents of waste water, physical chemical and biological parameters of waste water, sampling methods, waste water effluent standards, sewage disposal methods.

MODULE 2 PRIMARY AND SECONDARY TREATMENT OF WASTE WATER 10 Hours
Screens, oil traps, grit chambers, coagulation, clariflocculation, oxidation ponds and lagoons, Attached growth biological treatment : Activated sludge process and its modifications, trickling filter, biological nitrification and denitrification, anaerobic process, sludge disposal.

MODULE 3 ADVANCED WASTE WATER TREATMENT 10 Hours

MODULE 4 WASTE WATER RECLAMATION AND REUSE 10 Hours
Waste water reuse application, need for water reuse, public health and environmental issues in water reuse, introduction to risk assessment for water reuse, different reuse options: Agriculture and landscape irrigation, industrial reuse, ground water recharge, non-potable uses with case studies.

MODULE 5 ISSUES RELATED TO TREATMENT PLANT PERFORMANCE 10 Hours
Need for upgrading treatment plant performance, treatment process reliability and selection of design values, odour management, introduction to automatic process control, energy efficiency, upgrading waste water treatment plant performance by process optimization, important design consideration for new waste water treatment plants: Liquid stream, solid processing, odour control.

TEXT BOOKS:

REFERENCE BOOKS:
QUALITY, SAFETY & PROJECT MANAGEMENT

Subject Code : 15IBT221
No. of Lecture Hrs./ Week : 04
Total No. of Lecture Hrs. : 50

Credits : 04
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. To learn concepts of project management and apply them to process industry.

Course Outcomes:
At the end of this course, student will be able to:
- Demonstrate importance of GMP and GLP in process industry.
- Demonstrate safety measures and guidelines to implement GMP and GLP in industry.
- Demonstrate fundamental concepts of project management.
- Apply GMP and GLP protocols to process industry.
- Design and apply GMP and GLP protocols to laboratories, field studies, in-vitro studies.
- Apply principles of project management to pharmaceutical industry.

MODULE 1  PRINCIPLES OF QUALITY CONTROL
10 Hours
Regulation, standards and guidelines of GMP & GLP, basic terminology and validation overview, validation master plan, scope, documentation format, elements of qualification, numbering system, risk-based assessment, revalidation and its applications. Quality benchmarking, details of international standards (ISO, GMP, GLP, TGM, VAN and ISI), its need and fact sheet evaluation. Role of quality audit and quality circle in quality assurance; measurement of quality, information and decision making or utilization of data. Quality operations, its inspection and test used for it. Human resource and training for quality.

MODULE 2  GMP (Good manufacture practice)
10 Hours

MODULE 3  GLP (Good Laboratory Practices)
10 Hours
Good Laboratory Practices: principles; commodities; apparatus; reagents and materials; pest control; cryogenic safety - general precautions; storage; test systems; standard protocols; quality assurance; Laboratory signage - biosafety level; treatment and disposal – sharps, cultures, stock & lab ware; Biotoxin and pathological waste – fixed tissues & bedding; storage and retention of records.

Implementation of GLP: Implementation as a Project, stepwise implementation of GLP requirements. Quality assurance and GLP compliance of laboratory suppliers with GLP.
Principles, The application of the GLP Principles to field studies, The role and responsibilities of the study director in GLP Studies, The application of the principles of GLP to in-vitro studies, Establishment and control of archives that operate in compliance with the principles of GLP.

MODULE 4  SAFETY AND REGULATIONS  10 Hours
The GM-food debate and biosafety assessment procedures for biotech foods & related products, including transgenic food crops, case studies of relevance. Environmental aspects of biotech applications. Use of genetically modified organisms and their release in environment. Biosafety assessment procedures in India and abroad. International dimensions in biosafety: bioterrorism and convention on biological weapons. Biosafety regulations and national and international guidelines with regard to rDNA technology, transgenic science. Experimental protocol approvals, levels of containment.

MODULE 5  PROJECT MANAGEMENT  10 Hours
Project management – definitions – overview – project plan – management principles applied to project management – project management life cycles and uncertainty

TEXT / REFERENCE BOOKS:

METABOLIC ENGINEERING
Subject Code : 15IBT222  Credits : 04
No. of Lecture Hrs./ Week : 04  CIE Marks : 50
Total No. of Lecture Hrs. : 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:

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

MODULE 1  INTRODUCTION TO EXAMPLES OF PATHWAY MANIPULATION

QUALITATIVE TREATMENT  10 Hours

MODULE 2  MATERIAL BALANCES AND DATA CONSISTENCY  10 Hours
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®

MODULE 3  METABOLIC FLUX ANALYSIS  10 Hours
Theory, overdetermined systems, underdetermined systems- linear programming, sensitivity analysis, methods for the experimental determination of metabolic fluxes by isotope labeling, applications of metabolic flux analysis.

MODULE 4  METABOLIC CONTROL ANALYSIS  10 Hours
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

MODULE 5  ANALYSIS OF METABOLIC NETWORKS  10 Hours
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
**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:

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

**MODULE 1 ENTREPRENEURSHIP-ENTERPRISE**  
10 Hours


**MODULE 2 OPPORTUNITY SCOUTING AND IDEA GENERATION**  
10 Hours

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.

**MODULE 3 MANAGEMENT ROLES AND FUNCTIONS IN A SMALL BUSINESS**  
10 Hours


**MODULE 4 PRINCIPLES OF DOUBLE-ENTRY BOOK-KEEPING**  
10 Hours

risk/venture capital, fixed capital, working capital and a basic awareness of financial services such as leasing and factoring.

**MODULE 5  ISSUES IN SMALL BUSINESS MARKETING.  10 Hours**
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**

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**PETROLEUM BIOTECHNOLOGY**

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

**MODULE 1 BIOREFINARIES** 10 Hours
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.

**MODULE 2 BIOPROCESSING OF METHANE AND AROMATIC COMPOUNDS** 10 Hours
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.

**MODULE 3 BIOCORROSION** 10 Hours
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.

**MODULE 4 BIOEMULSIFIERS** 10 Hours
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.

**MODULE 5 BIOREMEDIATION** 10 Hours

**TEXT / REFERENCE BOOKS:**

FOOD PROCESSING & DOWNSTREAM OPERATIONS LAB

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

Course Outcomes:
At the end of this course, student will be able to:
• Demonstrate analytical procedures to determine quality of food products.
• Explain the principles involved in food processing operations through experiments.
• Perform downstream operations involved in purification of fermented products.
• To design downstream operation strategies for obtaining final finished product from fermentation broth.

EXPERIMENTS
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 b, 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.
8. Production of citric acid using Aspergillus niger.
10. Microbial production of protein and enrichment using aqueous two-phase extraction.
11. Production of exopolysaccharides using bacteria.
12. Intracellular lipid production from cellulosic sources using red yeast or green alga.