UNIVERSITY OF KERALA

B. TECH. DEGREE COURSE

(2013 SCHEME)

SYLLABUS FOR

IV SEMESTER

BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING

SCHEME -2013

IV SEMESTER

BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING (B)

Course No	Name of subject	Credits	Weekly load, hours			C A Marks	Exam Duration Hrs	U E Max Marks	Total Marks
			L	T	D/ P				
13.401	Engineering Mathematics -III (BCHMNPSU)	4	3	1	-	50	3	100	150
13.402	Chemical & Biochemical Reaction Engineering (B)	4	3	1	-	50	3	100	150
13.403	Molecular Biology & Genetics (B)	3	2	1	-	50	3	100	150
13.404	Computer Programming in C++ (B)	4	3	1	-	50	3	100	150
13.405	Industrial Bioprocess Technology (B)	4	3	1	-	50	3	100	150
13.406	Bioprocess Engineering (B)	4	2	2	-	50	3	100	150
13.407	Instrumental Methods of Analysis Laboratory (B)	3	-	-	3	50	3	100	150
13.408	Fluid Solid Systems Laboratory (B)	3	-	-	3	50	3	100	150
	Total	**29**	**16**	**7**	**6**	**400**		**800**	**1200**

13.401 ENGINEERING MATHEMATICS – III (BCHMNPSU)

Teaching Scheme: 3(L) - 1(T) - 0(P) **Credits**: 4

Course Objective:

- *To introduce the basic notion in complex analysis such as Analytic Functions, Harmonic functions and their applications in fluid mechanics and differentiations and integration of complex functions, transformations and their applications in engineering fields.*
- *Numerical techniques for solving differential equations are also introduced as a part of this course.*

Module – I

Complex Differentiation: Limits, continuity and differentiation of complex functions. Analytic functions – Cauchy Riemann equations in Cartesian form (proof of necessary part only).Properties of analytic functions – harmonic functions. Milne Thomson method.

Conformal mapping: Conformality and properties of the transformations $w = \frac{1}{z}$, $w = z^2$, $w = z + \frac{1}{z}$, $w = \sin z$, $w = e^z$ - Bilinear transformations.

Module – II

Complex Integration: Line integral – Cauchy's integral theorem – Cauchy's integral formula – Taylor's and Laurent's series – zeros and singularities – residues and residue theorem.

Evaluation of real definite integrals – $\int_0^{2\pi} f(sinx, cosx)dx$, $\int_{-\infty}^{\infty} f(x)dx$ (with no poles on the real axis). (Proof of theorems not required).

Module – III

Numerical techniques-Solutions of algebraic and transcendental equations-Bisection method – Regula-falsi method – Newton - Raphson method. Solution of system of equations - Gauss elimination, Gauss- Siedel iteration. Interpolation – Newton's Forward and backward formulae - Lagrange's interpolation formula.

Module – IV

Numerical integration-Trapezoidal Rule- Simpson's one third rule.

Numerical solution of ODE –Taylor's series method - Euler's method - Modified Euler's method – Runge-Kutta method of order Four.

Numerical Solution of two-dimensional partial differential equation (Laplace equation)-using finite difference method (five point formula)

References:

1. Bali N. P. and M. Goyal, *Engineering Mathematics*, 7/e, Laxmi Publications, India, 2012.
2. Kreyszig E., *Advanced Engineering Mathematics*, 9/e, Wiley India, 2013.
3. Grewal B. S., *Higher Engineering Mathematics*, 13/e, Khanna Publications, 2012.
4. Koneru S. R., *Engineering Mathematics*, 2/e, Universities Press (India) Pvt. Ltd., 2012.
5. Sastry S. S., *Introductory Methods of Numerical Analysis*, 5/e, PHI Learning, 2012.
6. Babu Ram, *Numerical Methods*, 1/e, Pearson Education, 2010.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Five Short answer questions of 4 marks each. All questions are compulsory. There should be at least one question from each module and not more than two questions from any module.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course Outcome:

After successful completion of this course, the students will be able to use numerical methods to solve problems related to engineering fields. This course helps students to master the basic concepts of complex analysis which they can use later in their career.

13.402 CHEMICAL AND BIOCHEMICAL REACTION ENGINEERING (B)

Teaching Scheme: 3(L) - 1(T) - 0(P) **Credits**: 3

Course objectives:

This course offers a prefatory towards design of chemical and biochemical reaction systems, in the backdrop of the knowledge of existing fundamental theory of reaction kinetics. Applications of reaction engineering shall be presented using a variety of process engineering situations and case-studies, in the form of numerical exercises.

Module – I

Basic concepts of chemical kinetics: Classification of chemical reactions with examples. Rate equations, rate constant, temperature dependency- Arrhenius law, collision theory, transition state theory, comparisons and predictions - Concentration dependency-non-elementary homogeneous reactions- Active intermediates, pseudo steady state hypothesis (PSSH), searching for a mechanism, General considerations, hydrogen bromide reaction, polymerisation - steps in free radical polymerization, Other examples of non-elementary reactions.

Analysis of rate equations: Interpretation of batch reactor data: integral and differential method of rate analysis. Integral method; irreversible first order ,second order and third order type reactions, zero order reactions, reversible first and second order reactions, autocatalytic reactions. Variable volume batch reactor. Differential method of rate analysis, method of half lives, method of initial rates, least square analysis, linearisation of rate laws.

Evaluation of laboratory reactors,: Integral (fixed bed) reactor, stirred batch reactor, stirred contained solid reactor (SCSR), Differential reactors: Continuous stirred tank reactor (CSTR), Laminar flow reactor, stirred through transport reactor, recirculating transport reactor.

Module – II

Ideal reactors: concept of ideality, design equations for batch, tubular and stirred tank reactors. Space time and space velocity, steady state mixed flow, plug flow and laminar flow reactors. Multiple reactor systems, Plug flow reactor in series and parallel, equal sized mixed reactors in series, mixed flow reactors of different sizes in series, determination of the best system for a given conversion. Advantages and limitations of series combinations. Recycle reactors, optimum recycle ratio, plug flow and mixed flow reactors for an autocatalytic reaction. Reactor Scale-up.

Design for multiple reactions: Reactions in parallel, contacting patterns for reactions in parallel, quantitative treatment of product distribution and reactor size for reactions in parallel and series, kinetics of series parallel reaction.

Non isothermal reactor design - Temperature and pressure effects - single reactions: Heat of reaction from thermodynamics, heat of reaction and temperature, equilibrium constants from thermodynamics, equilibrium conversion, adiabatic temperature and equilibrium, general graphical design procedure, optimum temperature progression. (***Numerical problems are not expected***)

Heat effects: Adiabatic operations and nonadiabatic operations, Nonisothermal continuous flow, reactors at steady state, application to the CSTR, adiabatic tubular and batch reactor, steady state tubular reactor with heat exchange. Product distributions and temperature for multiple reactions.

Unsteady state operation: General design equations, unsteady operations of plug flow reactors, CSTR and batch reactors. (***Numerical problems are not expected***)

Module – III

Non-ideal Flow: Residence time distribution for chemical reactors: General characteristics - RTD functions. Measurement of the RTD - pulse input, step tracer input, integral relationships, mean residence time, other moments of the RTD, Normalized RTD function E(theta), Interval age distribution. RTD in ideal reactors: Batch and plug flow reactors, single CSTR RTD, Laminar flow reactor, PFR/CSTR series RTD. Reactor modelling with RTD - use of RTD to determine conversion. RTD models - segregation models, tanks in series model, the dispersion model. Conversion for the tanks-in-series model, fitting the dispersion model for small extents of dispersion and large extents of dispersion. Models for small deviations from plug flow and long tails. Mixing of fluids - self mixing of fluids - degree of segregation, early and late mixing of fluids.

Module – IV

Biochemical Reaction Engineering: Kinetics of microbial growth and product formation- Phases of growth in a microbial culture, Microbial growth kinetics- Monod Kinetics, Inhibition kinetics, Maintenance energy and endogeneous metabolism, Influence of pH, Temperature and other factors on microbial growth kinetics; Product formation- Classification schemes for microbial products, kinetics of product formation- Leudeking-Piret equation.

Modeling of microbial growth processes: Model structure and complexity- different perspectives for kinetic representations using models- prediction of specific growth rate using unstructured, un-segregated models- logistic equation- growth models for filamentous organisms- structured kinetic models- compartment models, metabolic models, cybernetic models. (***Qualitative study only***)

Modeling of reactor configurations for microbial growth processes: Kinetic analysis of Batch growth of micro-organisms, Kinetics of growth in continuous culture- Monod Chemostat model, cell productivity, optimal dilution rate, productivity ratio, wash out;

Stirred tank bioreactor with recycle of biomass, Continuous stirred tank fermenters in series, plug flow fermenters. Estimation of kinetic parameters- use of batch and continuous culture experiments. Bioreactor dynamics - stability analysis in bioreactors- nontrivial and wash out steady states.

Novel bioreactors: Packed bed bioreactors, Bubble-column bioreactors, Fluidized bed bioreactors, Trickle bed bioreactors, Airlift loop bioreactors, Photobioreactors,- Key issues in bioreactor design and operation - alternate bioreactor configurations. (***Qualitative study only***)

References

1. Levenspiel O., *Chemical reaction engineering,* 3/e, John Wiley and Sons, 2001.
2. Fogler H.S., *Elements of Chemical Reaction Engineering*, 4/e, Prentice Hall, 2006.
3. Coulson J.M. and J.F. Richardson, *Coulson and Richardson's Chemical Engineering Vol.3: Chemical and Biochemical Reactors and Process Control*, 3/e, Butterworth-Heinemann, 1991.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

***Note:** Part B questions should have at least 60 % numerical problems. There could be numerical problems in part A also.*

Course outcome:

Upon successful completion of this course, the students shall be sufficiently aware of the basic concepts in reaction kinetics and their applications in the process engineering context. They shall develop a flare for developing feasible designs for chemical and biochemical reaction systems in an engineer's perspective.

13.403 MOLECULAR BIOLOGY AND GENETICS (B)

Teaching Scheme: 2(L) - 1(T) - 0(P) **Credits**: 3

Course objectives:

This course shall serve as the crux of biotechnology, in its scientific standpoint. The students shall be able to assimilate even foundation courses on genetic engineering only in the backdrop of a deep insight of molecular biology and hence a flawless insight into the key aspects of the subject is imperative at the outset itself.

Module – I

Identification of the genetic material - classical experiments: Griffith's, Avery McLeod, Hershey Chase. Structure of

DNA: Detailed structure of DNA, different forms of DNA, denaturation and melting curves. Structure of RNA: mRNA, rRNA and tRNA primary, secondary, tertiary structures and functions. DNA Replication: Models of DNA replication- Experimental evidence for semi conservative; Mechanism of DNA replication in E.coli (bidirectional), Stages of replication, Mitochondrial (D-loop), Viral DNA (Rolling circle), Enzymes and protein factors involved in replication. Chromosomal replication of prokaryotes and eukaryotes.

Transcription:-Transcription apparatus, RNA polymerases and proteins involved in transcription, Stages of Transcription, transcription factors, upstream activation sequences, Consensus sequences. Exon intron concept. Difference between prokaryotic and eukaryotic transcription. Post transcriptional processing of RNA's- tRNA, rRNA, mRNA splicing, inhibitors of transcription.

Module – II

Translation: The genetic code and Wobble hypothesis and codon usage, Protein synthesis in prokaryotes and eukaryotes, protein factors involved in protein synthesis, post translational modifications, inhibitors of translation. Chromosome organization in eukaryotes, Interaction between DNA and DNA binding proteins, DNA binding domains and motifs: Helix loop helix, Zinc finger, homeodomain Leucine zippers and basic helix-loop helix.

Mutagenesis: Types of mutations, Mutagens- types and action, DNA repair: Photoreactivation, Excision repair, Recombination repair and SOS repair

Regulation of gene expression: Constitutive and induced enzymes in bacteria, enzymes repression, catabolic repression. Regulatory genes, structural genes and repressors. The operon model - lactose, histidine operon, arabinose and tryptophan operon.

Module – III

Transposons : Types ; retroposons – Viral and nonviral super family; LINES and SINES. Reverse transcription, retroviruses and retroviral genome.

Oncogenes: Characteristics of tumor cells, types, viruses as transforming agents (DNA and RNA virus), carcinogens, tumor suppressor genes

Genetic recombination in Bacteria: Conjugation, transduction and transformation.

Module – IV

Classical genetics: Mendelian Laws, monohybrid and dihybrid inheritance. Multiple alleles and blood group antigens, Sex chromosomes and sex linked inherited disorders; Linkage, crossing over and genetic mapping of chromosomes.

References:

1. Lewin B., *Genes V*, Oxford University Press, Oxford, New York, 1994.
2. Freifelder D., *Molecular Biology*, Jones and Bartlett Publishers Inc., 1987.
3. Goodenough U., *Genetics*, Holt Saunders International, 1985.
4. Gardner E. J., M. J. Simmons and D. P. Snustad, *Principles of Genetics*, Wiley, 1991.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.
20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course Outcome:

Upon successful completion of this course, the students shall have grasped the fundamentals of molecular genetics and cellular control systems, which shall aid them in learning advanced courses such as genetic engineering/ recombinant DNA technology with substantial ease.

13.404 COMPUTER PROGRAMMING IN C ++ (B)

Teaching Scheme: 3(L) - 1(T) - 0(P) **Credits**: 4

Course objectives:

The course envisages the student to learn the fundamentals of object-oriented programming through a study of the concepts of program specification, algorithm development, and coding. Students learn how to write programs in an object-oriented high-level programming language. They are expected to develop knowledge in the fundamentals of algorithms, flowcharts, problem solving, programming concepts, classes and methods, control structures, arrays, and strings.

Module – I

Problem solving Algorithm / pseudo code, flowchart, program development steps - C++ programming language –

Character set, tokens, data types, variables, operators, expressions, Input and Output, Selection statements – if, switch statements, Looping statements - for, while, do-while statements, Jump statements – break, continue, goto exit ()

Arrays - single and multi-dimensional arrays, initializing array elements, Character arrays, Unformatted console I/O functions, Unformatted Stream I/O functions, string functions.

Module – II

Functions – Arguments, returning function results, call by value, call by reference, functions calling functions, functions and arrays - Global variables, automatic, static and register variables, pointers and arrays ,recursive functions, function overloading.

Structures - functions and structures - Arrays of structures - structures within structures, Structures containing arrays.

Files - Input and Output, sequential and random access.

Module – III

Basic concepts of object oriented programming, advantages of object oriented programming, Implementation of object oriented programming concepts in C++, Definition of a class, members of a class, data members and member functions, Declaration of objects, array of objects, Constructors and Destructors, Inheritance. – Simple programs.

Module – IV

Searching – Linear and binary search methods, sorting – Bubble sort, selection sort, Insertion sort, Quick sort, merge sort.

Introduction to data structures, singly linked lists, doubly linked lists, circular list, representing stacks and queues in C++ using arrays and linked lists, infix to post fix conversion, postfix expression evaluation.

References:

1. Hubbard J. R., *Schaum's Outline of Programming with C++*, Tata McGraw Hill, 2004.
2. Lafore R., *Object-Oriented Programming in C++*, SAMS Publishing, 2001.
3. Kamthane A. M., *Object Oriented programming with ANSI and TURBO C++,* Pearson Education, 2006.
4. Balaguruswamy E., *Object Oriented programming with C++*, Tata McGraw Hill, 2013.
5. D'Orazio, T. B, *Programming in C++: Lessons and Applications*, McGraw-Hill, 2003.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.
20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

***Note:** 60 % of the questions in Part B should be to test the programming skills of the students. There could be small programs in Part A also.*

Course Outcome:

Upon successful completion of this course, the students shall become familiar with the basic problem solving skills using the high level language. They become conversant with the approaches to software problems in C++ and write small-scale C++ programs using the above skills. The students shall understand and use the basic programming constructs of C++ and manipulate various C++ data types, such as arrays, strings, and pointers. They acquire the knowledge to isolate and fix common errors in C++ programs and apply the principles of object-oriented concepts to solve engineering problems that require computation.

13.405 INDUSTRIAL BIOPROCESS TECHNOLOGY (B)

Teaching Scheme: 3(L) - 1(T) - 0(P) **Credits**: 4

Course Objectives:

The course shall cover all applied aspects of industrial microbiology, relevant to upstream and bioreaction stages of an integrated bioprocess. Knowledge acquired herein, shall enable the student to choose his/her domain of interest in industrial bioprocessing, in the course of his/her future endeavour.

Module – I

Introduction to fermentation processes: The range of fermentation processes- Microbial biomass, Microbial enzymes, Microbial metabolites, Recombinant products, Transformation processes, the chronological development of the fermentation industry, the component parts of a fermentation process.

Isolation, preservation and improvement of industrially important micro-organisms: Isolation methods - Enrichment liquid culture, Enrichment cultures using solidified media, Screening methods, preservation of industrially important micro-organisms - Storage at reduced temperature, Storage on agar slopes, Storage under liquid nitrogen, Storage in a dehydrated form - Dried cultures, Lyophilization, Quality control of preserved stock cultures, Improvement of industrial micro-organisms - selection of induced mutants, modification of permeability, Isolation of mutants – auxotrophic and revertant mutants, Use of recombinant systems for improvement of industrial micro-organisms - application of the parasexual cycle, protoplast fusion techniques, recombinant DNA techniques, production of heterologous proteins, use of recombinant DNA technology for the improvement of native microbial products. Improvement of industrial strains by modifying properties other than the yield of product- selection of stable strains, strains resistant to infection, non-foaming strains, strains which are resistant to components in the medium, morphologically favourable strains, strains which are tolerant of low oxygen tension, Elimination of undesirable products from a production strain, The development of strains producing new fermentation products.

Media for industrial fermentations: Typical media, Medium formulation- Water, Energy sources, Carbon sources- Factors influencing the choice of carbon source, Examples of commonly used carbon sources- Carbohydrates, Oils and fats, Hydrocarbons and their derivatives; Nitrogen sources- Examples of commonly used nitrogen sources, Factors influencing the choice of nitrogen source; Minerals; Chelators; Growth factors; Nutrient recycle; Buffers, The addition of precursors and metabolic regulators to media-Precursors, Inhibitors, Inducers. Oxygen requirements, Fast metabolism, Rheology, Antifoams, Medium optimization. Animal cell media- Serum, Serum-free media supplements, Protein-free media, Trace elements, Osmolality, pH. Non-nutritional media supplements.

Sterilization: Medium sterilization- batch and continuous sterilization processes- Sterilization of the fermenter, Sterilization of the feeds, Sterilization of liquid wastes, Filter sterilization, Filter sterilization of fermentation media, Filter sterilization of air, Sterilization of fermenter exhaust air.

Development of inocula for industrial fermentations: Criteria for the transfer of inoculums, The development of inocula for yeast, bacterial and mycelia processes- Sporulation on solidified media, Sporulation on solid media, Sporulation in submerged culture, use of the spore inocula, Inoculum development for vegetative fungi, effect of the inoculum on the morphology of filamentous organisms in submerged culture, aseptic inoculation of plant fermenters- Inoculation from a laboratory fermenter or a spore suspension vessel, Inoculation from a plant fermenter.

Module – II

Fermentation processes and fermenters: Aerobic and anaerobic fermentation processes, solid state and submerged fermentation. Types of bioreactors- classification based on feeding mechanism (Batch, continuous, semi- batch), Bioreactors for plant and animal cell cultures.

Immobilized biocatalysts: Enzymes and Cells, Advantages of immobilized biocatalysts in general, methods of immobilizing enzymes, methods for the immobilization of cells, Bioreactor Designs for usage in biocatalysis, Practical Application of Immobilized Biological Catalyst Systems.

Recovery and purification of fermentation products: A general overview of Downstream Processing operations like Cell disruption, Removal of microbial cells and other solid matter- Cell aggregation and flocculation, Foam separation, Filtration, Centrifugation; Product concentration- Precipitation, Liquid-liquid extraction, Two-phase aqueous extraction, Supercritical fluid extraction, adsorption, membrane separations. Product purification- Chromatography, Product polishing- Drying, Crystallization; Whole broth processing.

Effluent treatment: Strengths of fermentation effluents**,** Treatment and disposal of effluents**,** Treatment Processes- Physical treatment, Chemical treatment, Biological treatment- Aerobic processes- Trickling filters, Towers, Biologically aerated filters (BAFs), Rotating biological contactors (rotating disc contactors), Rotating drums, Fluidized-bed systems, Activated sludge processes, Anaerobic treatment- Anaerobic digestion, Anaerobic digesters, Anaerobic filters, Up-flow anaerobic sludge blankets (UASB), By-products- Distilleries, Breweries, Amino acid wastes, Fuel alcohol wastes.

Module – III

Production and purification of primary metabolites : Industrial processes for the manufacture with the important engineering problems involved in the manufacture of the following products with flow diagram, reactions and conditions: Organic acids - citric acid,

lactic acid itaconic acid and acetic acid and other commercially important organic acids; amino acids - glutamic acid, lysine, phenylalanine, aspartic acid and other commercially important amino acids; alcohols - ethanol, acetone and butanol.

Production of secondary metabolites: Industrial production processes for various classes of secondary metabolites: antibiotics: beta- lactams-penicillin and cephalosporin; amino-glycosides - streptomycin, kanamycin; macrolides- erythromycin, quinines, aromatics; commercially important vitamins and steroids.

Module – IV

Production of beverages such as Beer, wines and spirits, vinegar; Use of whole cells for food related purposes- Single Cell Protein (SCP), Yeast Production; Production of fermented foods**-** Bread making, Cheese, yoghurt and fermented milk products, Fermented Foods from Corn, Fermented Foods from Cassava, Fermented Vegetables – Sauerkraut, Cucumbers (pickling); Fermentations for the Production of the Stimulant Beverages- Tea, Coffee, and Cocoa fermentation, Fermented Foods Derived from Legumes and Oil Seeds, Food condiments made from fish.

Microbial production of industrial enzymes: Proteases, amylases, lipases and cellulases. Production of biofertilizers- manufacture, formulation and utilization, Biopesticides- Characteristics of biopesticides. Important biopesticides- Bt-toxin, Kasugamycin, Beauverin, Devine and Collego; Biopreservatives - Nisin; Biopolymers- Xanthan gum and PHB.

Environmental applications: Bioremediation- microbes in mining, ore leaching, oil recovery, waste water treatment, biodegradation of non cellulose and cellulosic wastes for environmental conservation.

Production modern biotechnology products: Production of recombinant proteins having therapeutic and diagnostic applications, production of vaccines. Production of monoclonal antibodies. Products of plant and animal cell culture.

References:

1. Stanbury P. F., A. Whitaker and S. J. Hall, *Principles of Fermentation Technology*, 2/e, Butterworth- Heinemann, 1995.
2. Casida Jr, L. E, *Industrial Microbiology*, New Age International (P) Ltd., 1996.
3. Cruger W. and A. Crueger, *Biotechnology: A Textbook of Industrial Microbiology*, Panima Publishing Corporation, 2004.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)
30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.
20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Course outcome:

Upon successful completion of this course, the students shall have acquired familiarity with the basic technology involved in industrial bioprocessing for production of a variety of products of commercial value. The basic steps involved in an integrated bioprocess should be familiarized in a qualitative standpoint.

13.406 BIOPROCESS ENGINEERING (B)

Teaching Scheme: 2(L) - 2(T) - 0(P) **Credits**: 4

Course Objectives:

This course presents industrial bioprocessing in its engineering perspective. The subject envisages at illuminating the role of a bioprocess engineer in an integrated bioprocess, in the backdrop of pertinent case studies and numerical exercises.

Module – I

Overview of bioprocess engineering: Engineering perspective of fermentation processes – role of bioprocess engineers- integrated bioprocessing- comparison of bioprocess engineering with biochemical engineering.

Medium engineering for cell cultivation and bioreaction: Technological concerns of medium design engineering in bioprocessing – design procedure for growth and production medium- Stoichiometric design approach- bioorganic reaction medium engineering- Novel media.

Design of sterilization equipment: Thermal death kinetics of cells and spores:- Survival curve- decimal reduction factor, Extinction probability- sterilization of culture medium- batch and continuous sterilization- Design of batch sterilization processes - Calculation of the Del factor during heating and cooling, Calculation of the holding time at constant temperature- Richards' rapid method for the design of sterilization cycles, The scale up of batch sterilization processes- Design of continuous sterilization processes based on tubular reactor concept- Filter sterilization- theory of depth filters, design of depth filters.

Module – II

Mass transfer in bioprocessing systems: Gas liquid mass transfer- volumetric oxygen transfer coefficient- correlations (Cooper correlation, Oldshue correlation, Yamamoto correlation, Yoshida correlation, Richards correlation) – oxygen transfer mechanism- assessment of KLa- chemical method, dynamic differential gassing out method, dynamic integral gassing out method, oxygen balance method, enzymatic method- merits and demerits of each method.

Immobilized cell systems: Potential advantages of cell immobilization, methods of active and passive immobilization- diffusional limitations in immobilized enzyme systems- bioreactor design considerations.

Scale up and scale down of bioprocess systems: Need for scale up and scale down- operating boundaries for aerated and agitated fermenters- scale up criteria for microbial cell processes- constant power input per unit volume, constant KLa, constant mixing quality,

constant momentum factor, constant impeller tip speed, constant mixing rate number-scale up example with flow chart- scale down procedure.

Module – III

Fermentation monitoring: Various physical, chemical and biological parameters measured or controlled in bioreactors-Physical and chemical sensors for fermentation medium and gases- online sensors for cell properties-offline analytical methods- measurement of medium properties and cell population composition- flow cytometry.

Analysis by Microfluidics: Basic principles of flow based analytical techniques, flow injection, sequential injection, Bead injection and Sequential injection chromatography-methods and applications.

Measurement analysis: Use of digital computers for data acquisition, interpretation and analysis- software systems- data smoothing and interpolation –Fault analysis- state and parameter estimation methods- use of observers or estimators.

Process control: Open loop and closed loop control - direct regulatory control, cascade control of metabolism- programmed control- application of artificial intelligence in bioprocess control - knowledge based expert systems, neural networks.

Bioprocess modeling and simulation: Structure of bioprocess models- concept of balance domain- model validation using MATLAB- objectives and benefits of bioprocess simulation-simulation tools such as SIMULINK, Biopro Designer, Biotechnology Design Simulator and Bioprocess Simulator.

Module – IV

Bioprocess considerations in using plant and animal cell cultures: Methods for cultivation of animal cells- requirements for culturing of animal cells-bioreactor design considerations-perfusion systems-products of animal cell cultures- importance of plant cell cultures-comparison of plant cell and microbes in culture-bioreactor considerations for suspension cultures, immobilized systems and organ cultures- products of plant cell cultures.

Bioprocess systems for genetically engineered organisms: Basic elements of genetic engineering, genomics and bioinformatics- guidelines for choosing host-vector systems-comparison of strategies-genetic instability in recombinant cell cultures- segregational loss, plasmid structural instability, host cell mutations, growth rate dominated instability-considerations in plasmid design to avoid process problems- simple mathematical model for prediction of genetic instability- regulatory constraints on genetic processes- outline of metabolic engineering and protein engineering with simple case studies.

Medical applications of bioprocess engineering: overview of tissue engineering-commercial tissue culture processes- gene therapy using viral vectors-use of bioreactors as artificial hybrid organs and for mass production of cells for transplantation.

References:

1) Doran P. M., *Bioprocess Engineering Principles,* Academic Press, 1995.
2) Bailey J. E. and D. F. Ollis, *Biochemical Engineering Fundamentals,* 2/e, McGraw Hill, 1986.
3) Shuler M. L., F. Kargi, *Bioprocess Engineering - Basic concepts*, 2/e, Prentice Hall of India, 2002.
4) Ratledge C. and B. Kristiansen, *Basic Biotechnology*, 2/e, Cambridge University Press, 2001.
5) Mukhopadhyay S. N., *Process Biotechnology Fundamentals*, 3/e, Viva Books, 2010.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

30% - Assignments (minimum 2) such as home work, problem solving, quiz, literature survey, seminar, term-project, software exercises, etc.

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

The question paper shall consist of 2 parts.

Part A (20 marks) - Ten Short answer questions of 2 marks each. All questions are compulsory. There should be three questions each from modules I and II, and two questions each from modules III and IV.

Part B (80 Marks) - Candidates have to answer one full question out of the two from each module. Each question carries 20 marks.

Note: Part B questions should have at least 60 % numerical problems. There could be numerical problems in part A also.

Course outcome:

Upon successful completion of this course, the students shall become aware of the applications of engineering principles to each stage of an industrial bioprocess. The concepts learned herein shall enable them in visualizing bioprocesses in a true engineering perspective.

13.407 INSTRUMENTAL METHODS OF ANALYSIS LAB (B)

Teaching Scheme: 0(L) - 0(T) - 3(P) **Credits**: 3

Course Objectives:

This course aims to familiarize students with the basic instrumental techniques necessary for analysis of bioprocess systems. The techniques shall be learned in a flawless manner such as to enable the students to identify and implement appropriate techniques for analytical applications in diverse bioprocess contexts.

List of Experiments:

1. Precision and validity of an experiment- Tutorial session.
2. Analysis and presentation of data (Tables, Graphs, Histogram, pi diagram) – Tutorial &Assignment.
3. Beer-Lamberts law – Tutorial & Experimental – U V-Vis Spectrophotometer.
    a. Change in absorbance with concentration of Potassium dichromate
    b. Absorption maxima – change in absorbance in Potassium dichromate with wavelength
    c. Concentration of two components in a binary mixture- Absorption of light byPotassium dichromate and potassium permanganate
    d. Change in absorbance of albumin and DNA solution with wavelength
    e. Determination of molar extinction coefficient of Aminoacids-Tyrosine, Tryptophan, Histidine.
    f. Kinetics of Enzyme activity- Amylase, Phenol oxidase, Carboxydase.
4. Flame photometry-Determination of Na & K
5. pH meter
    a. Measurement of pH.
    b. Titration curves for strong acids and strong bases.
    c. Titration curves for Aminoacids.
    d. Titration curves for weak acids.
    e. Titration curves for weak bases.
    f. Preparation of buffer solutions.
    g. Composition of buffer solutions as a function of pH.
6. Conductivity meter
    a. Measurement of conductivity
    b. Conductometric titrations
7. Viscometer – Measurement of viscosity of fluids

8. Refractometer – Measurement of refractive index
9. Polarimeter
    a. Inversion of cane sugar
    b. Measurement of optical activity.
    c. Determination of optical purity
10. Orsat analyser – Analysis of flue gases.
11. Densitometry and image analysis12.
12. Determination of molecular weight of macro molecules by
    a. Molecular Exclusion Chromatography.
    b. SDS PAGE
13. Ion sensitive electrode- Measurement of cyanide, chloride etc.
14. Oxygraph- Measurement of Gas volume. Principle design and applications of the following TGA & DSC15.
15. PCR analyzer
16. SEM
17. FTIR Spectroscopy – IR spectra of hydrocarbons, aminoacids, carbohydrates
18. Atomic Absorption Spectrometry – Measurement of trace elements
19. Mass Spectrometry
20. NMR
21. HPLC
22. X ray diffractometer

Note: *Any 10 experiments to be done depending on the availability of instruments. Visits to research institutions and industries for demonstration of the various analytical instruments may also be arranged.*

References:

Manuals of various instruments

Internal Continuous Assessment *(Maximum Marks-50)*

40% - Test
40% - Class work and Record
20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

80% - Procedure, conducting experiment, results, tabulation and inference
20% - Viva voce

Candidate shall submit the fair record for endorsement by the external examiner.

Course Outcome:

Upon successful completion of the course, the students should have learned the principles, applications and operation of various instruments, required for bioprocess analysis. This should enable them to identify and execute the most appropriate method of analysis for a given bioprocess situation, with substantial ease.

13.408 FLUID SOLID SYSTEMS LAB (B)

Teaching Scheme: 0(L) - 0(T) - 3(P) **Credits**: 3

Course Objectives:

This course aims to introduce the students to an engineering lab on momentum transfer operations in process engineering. The theoretical principles of momentum transfer learned beforehand, shall be translated to flawless practice. Industrial applicability of various techniques shall be explicated with significant emphasis on individual hands- on- experimentation.

List of Experiments:

1. Determination of size distribution of pellets in a cell suspension (photosedimentation/ beaker decantation/ use of Andreason's pipette/ ICI sedimentation columns/ mano-metric methods. Micromerograph)
2. Size analysis by microscopy, sieve analysis and Hydrometer method. (the sample used may be cassava powder/ powdered yeast)
3. Determination of porosity of particles (porosimeters)
4. Determination of surface area of particles (gas absorption measurements)
5. Batch settling test using yeast suspension to determine area of a continuous thickener.
6. Use of viscometers for measurement of viscosity of fermentation broths /process fluids.
7. Studies on factors influencing viscosity of process fluids.
8. Scale up of centrifuges- use of Gyrotesters.
9. Studies on flocculation- analysis of orthokinetic and perikinetic aggregation.
10. Scale up studies on mixing vessels.
11. Estimation of various parameters for agitation of liquids.
12. Calibration of flow meters for liquid flows
13. Reynold's experiment.
14. Determination of velocity profile using Pitot tube.
15. Flow through packed beds: Estimations of pressure drop.
16. Flow through fluidised beds: Estimations of pressure drop.
17. Fall of solid bodies and liquid drops through liquids: determination of drag coefficient and verification of Stoke's Law.
18. Characteristics of pumps.
19. Measurement of flow using notches and weirs
20. Measurement of pressure.
21. Friction losses in pipes and fittings
22. Measurement of flow using orifices and mouth pieces.

Internal Continuous Assessment *(Maximum Marks-50)*

40% - Test

40% - Class work and Record

20% - Regularity in the class

University Examination Pattern:

Examination duration: 3 hours *Maximum Total Marks: 100*

80% - Procedure, conducting experiment, results, tabulation and inference
20% - Viva voce

Candidate shall submit the fair record for endorsement by the external examiner.

Course Outcome:

Upon successful completion of this course, the students shall become familiar with the operation of basic techniques and equipments involved in momentum transfer operations involved in bioprocess systems. A hand- on experience with laboratory prototypes shall equip them adequately to subsequently adapt and apply their knowledge to the operation of such systems in the real-life bioprocess industry.