# UNIVERSITY OF KERALA

## B. TECH. DEGREE COURSE

## (2013 SCHEME)

**SYLLABUS FOR**

**VI SEMESTER**

**BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING**

## SCHEME -2013

## VI 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 | | | | |
| 13.601 | Transport Phenomena in Bioprocesses (B) | 5 | 3 | 2 | - | 50 | 3 | 100 | 150 |
| 13.602 | Downstream Processing (B) | 4 | 2 | 2 | - | 50 | 3 | 100 | 150 |
| 13.603 | Biomaterials & Tissue Engineering (B) | 3 | 2 | 1 | - | 50 | 3 | 100 | 150 |
| 13.604 | Proteomics & Protein Engineering (B) | 3 | 2 | 1 | - | 50 | 3 | 100 | 150 |
| 13.605 | Numerical Methods for Process Engineers (B) | 4 | 2 | 2 | - | 50 | 3 | 100 | 150 |
| 13.606 | ELECTIVE I | 4 | 3 | 1 | - | 50 | 3 | 100 | 150 |
| 13.607 | Software Laboratory (B) | 3 | - | - | 3 | 50 | 3 | 100 | 150 |
| 13.608 | Heat & Mass Transfer Laboratory (B) | 3 | - | - | 3 | 50 | 3 | 100 | 150 |
| | **Total** | **29** | **14** | **9** | **6** | **400** | | **800** | **1200** |

**13.606 Elective I**

| | |
|---|---|
| 13.606.1 | Biopharmaceutical Technology (B) |
| 13.606.2 | Biosensors and Diagnostics (B) |
| 13.606.3 | Cancer Biology (B) |
| 13.606.4 | Immunology and Immunotechnology (B) |
| 13.606.5 | Energy Engineering (B) |
| 13.606.6 | Novel Analytical Methods in Biotechnology (B) |
| 13.606.7 | Metabolic Regulation and Engineering (B) |

## 13.601 TRANSPORT PHENOMENA IN BIOPROCESSES (B)

**Teaching Scheme:** 3(L) - 2(T) - 0(P) **Credits**: 5

**Course Objective:**

*This course is aimed at providing an insight into the basic science underlying various transport phenomena in process engineering. The principles underlying the transport of momentum, heat and mass shall be thoroughly explicated, with appropriate mention of their applications in process engineering systems.*

**Module – I**

**Viscosity and the mechanisms of momentum transfer:** Newton's law of viscosity, molecular momentum transport, generalization of Newton's law of viscosity, pressure and temperature dependence of viscosity of gases and liquids, prediction of viscosity of gases: Rigid sphere model and rigorous models, prediction of transport coefficients of liquids. Numerical problems.

Non- Newtonian fluids, different models for Non-Newtonian flow, theory of viscosity of gases and liquids, time dependant viscosity, viscosity measurement (cone-and-plate viscometer, coaxial cylinder rotary viscometer, impeller viscometer), Experimental viscometry:- Use of viscometers with biological reaction fluids, rheological properties of fermentation broth, factors affecting broth viscosity (cell concentration, cell morphology, osmotic pressure, product and substrate concentration), Bubbles and drops - bubble formation, break-up and coalescence; bubble rise velocities; interfacial area and hold-up in agitated and non-agitated systems; behaviour of bubbles in beverages; drop dispersion. Numerical problems.

**Module – II**

**Shell momentum balances and velocity distributions in laminar flow:** shell momentum balances and boundary conditions, flow of a falling film along a flat surface and on the surface of cylinders, flow of a Newtonian fluid in between two slits formed by two flat plates, flow through a circular tube, flow through annulus, and flow of two adjacent immiscible fluids. Flow of a Bingham fluid through a cylinder- Buckingham- Reiner Equation.

General transport equation for momentum, derivation of continuity equation, Analysis of equation of motion in rectangular coordinates (derivation not desired), Navier Stoke's equation and Euler equation with significance of each terms, transport equation in curvilinear coordinates (derivation not desired), application of transport equations to solve steady flow problems:- flow through a tube, tangential annular flow, rotating liquid, cone and plate viscometer.

Velocity distributions in turbulent flow: comparisons of laminar and turbulent flows, time-smoothed equations of change for incompressible fluids, and the time- smoothed velocity profile near a wall.

**Module – III**

**Energy Transport:** Thermal conductivity and the mechanism of energy transport- prediction of thermal conductivity of gases, effect of temperature and pressure on thermal conductivity of gases, relationship between thermal conductivity and viscosity of gases. Thermal conductivity of solids, relationship between thermal and electrical conductivity of solids, Numerical problems.

Shell energy balance:- Boundary conditions, application of shell balances to heat conduction problems with electric, nuclear and viscous heat sources, fixed bed flow reactor, cooling fins with insulated tip condition, heat transfer by free and forced convection.

Equations of energy in rectangular coordinates, energy equations in curvilinear coordinates (derivation not desired), application to steady state heat transfer problems:- tangential flow in annulus with viscous heat generation, free convection from vertical plate, flow of non-isothermal film and transpiration cooling.

**Module – IV**

**Diffusivity and the Mechanism of Mass Transport**: Definition of concentrations, velocities and mass fluxes, Fick's law of diffusion, kinetic theory of diffusion in gases at low density, theory of ordinary diffusion in liquids. Prediction of diffusivity of gases and liquids. Numerical problems.

Shell mass balances: Boundary conditions, diffusion through a stagnant gas film, diffusion with homogeneous and heterogeneous chemical reaction, diffusion into a falling liquid film (gas absorption), diffusion and chemical reaction inside a porous catalyst: the effectiveness factor.

Analogies between heat, mass and momentum transfer.

Derivation of equation of continuity for binary mixtures in rectangular coordinates, general study of equation of continuity in curvilinear coordinates (derivation not desired). Application to combined heat and mass transfer, thermal and pressure diffusion.

**References:**


1. Bird R B, Stewart W E and Lightfoot R N, *Transport Phenomena*, John Wiley and Sons.
2. John C Slattery, *Momentum, Energy and Mass Transfer in continua*, McGraw Hill, Co.
3. Bennet C U and Myers J E, Momentum, *Heat and Mass Transfer*, Tata McGraw Hill Publishing Co.
4. Robert S. Brodkey and Harry C Hersing, *Transport Phenomena a Unified Approach*, McGraw Hill.
5. Atkinson B and Mavituna F, *Biochemical Engineering and Biotechnology*, Handbook, Macmillan
6. Doran P, *Bioprocess Engineering Principles*, Academic Press

7. Blanch H.W and Clark D.S, *Biochemical Engineering*, Marcel Dekker
8. Scragg A.H, *Bioreactors in Biotechnology - A Practical Approach*, Ellis Horwood.
9. Bailey J. and Ollis D, *Biochemical Engineering Fundamentals*, McGraw Hill.

**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 Module- I and II and two questions each from module- 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:** The students are permitted to use the copy of the **tables of general equations of continuity, motion and energy in rectangular and curvilinear coordinates** inside the examination hall for the University examination.*

**Course Outcome:**

*The course shall enable the students in assimilating the scientific approach towards engineering problems involved in various transport processes. Successful completion of this course shall enable them to approach process engineering disciplines in an entirely new perspective, which is absolutely essential for future developments in this field.*

## 13.602 DOWNSTREAM PROCESSING (B)

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

**Course objectives:**

*This course aims at providing an overview of the various processes and operations involved in the recovery, concentration, purification and formulation of bioproducts of commercial interest. Emphasis shall be placed on the separation techniques for products produced through fermentation technology.*

**Module – I**

**Overview of bioseparations**: Broad classification of bioproducts, characteristics of fermentation broths, spectrum of bioseparations, need for downstream processing, criteria for choice of recovery processes, synthesis of bioseparation processes.

**Cell disruption**: Analysis of various physical, chemical, enzymatic and mechanical methods for release of intracellular products- kinetics of bead milling and high pressure homogenization- maintenance of activity of intracellular proteins during cell lysis.

**Flocculation**: Importance in downstream processing, electrical double layer concept, DLVO theory, mechanisms of charge dependent flocculation.

**Foam and bubble fractionation**: Principle and operation-applications

**Gravity sedimentation**: Mechanisms of sedimentation, Design of industrial equipments for gravity settling- thickeners, classifiers etc. – applications in downstream processing.

**Centrifugal bioseparations**: Theory of centrifugal settling- basic equations, Sedimentation coefficient, production centrifuges, centrifuge selection-RCF, scale up of centrifuges- sigma analysis, equivalent time- Isopycnic sedimentation, ultra centrifugation.

**Filtration**: Equipments for conventional filtration- filter media, pretreatment methods, general filtration theory- Darcy's law, compressible and incompressible filter cakes, filtration cycle, scale up and design of filtration systems laboratory filtration tests- batch pretreatment test, funnel filtration tests, filter leaf tests

**Module – II**

**Extractive bioseparations**: General principles, analysis of batch and staged extraction - analytical and graphical methods, differential and fractional extraction-scale up and design of extractors- reciprocating plate extraction columns, centrifugal extractors- aqueous two phase extraction, reversed micellar extraction and supercritical fluid extraction- theoretical principles, process, equipment and applications.

**Adsorption**: Adsorption equilibrium, adsorbent types, equipment operation- adsorption column dynamics- fixed bed and agitated bed adsorption, scale up of adsorption processes- LUB method, computer simulation method.

**Precipitation**: Factors influencing protein solubility, methods of precipitation, precipitate formation phenomena- orthokinetic and perikinetic aggregation- Smoluchowski's equation- precipitate ageing- Camp number- design of precipitation systems.

**Membrane separation processes**: Crossflow filtration – filter media- ultra filtration and microfiltration membranes, filter modules, modes of operation, concentration polarization and fouling- reverse osmosis, dialysis, electrodialysis, pervaporation, perstraction.

**Module – III**

**Chromatographic separations**: Classification of techniques, elution chromatography- retention theory, band broadening effects, separation efficiency, resolution, yield and purity, discrete stage analysis, kinetic analysis- Gas and liquid chromatography- Bonded phase chromatography, Ion exchange chromatography, gel permeation chromatography, affinity chromatography- supercritical fluid chromatography - Chiral chromatography- expanded bed chromatography- simulated countercurrent chromatography- process scale up.

**Electrokinetic separations**: Electrophoresis – Principles and techniques- immunoelectrophoresis, capillary zone electrophoresis - isoelectric focusing, isotachophoresis.

**Module – IV**

**Product crystallization**: Basic principles- nucleation and crystal growth- Mier's supersaturation theory- kinetics of crystallization-analysis of dilution batch crystallization- commercial crystallizers- process crystallization of proteins scale up and design of crystallizers- Recrystallization.

**Product drying**: Heat and mass transfer in drying- types of commercial dryers- vacuum dryers, freeze dryers, spray dryers- scale up and design of drying systems.

**Ancillary operations in bioseparations**: Water quality assessment, solvent recovery, waste disposal, biosafety.

**Economics of downstream processing**: Cost estimation, profitability analysis, analysis and evaluation of bioproduct manufacture by fermentation (with emphasis on product recovery steps) - case studies.

**Modern strategies**: Bioprocess integration, intensification, in situ bioproduct recovery, combined operations- whole broth processing, mass recycle.

**References**


1. Juan A. Asenjo (Ed), *Separation processes in biotechnology,* CRC.
2. Satinder Ahuja (Ed), *Handbook of Separations,* Academic Press.
3. Roger. H. Harrison et.al. *Bioseparations Science and Engineering,* Oxford University Press, 2004.
4. Paul. A. Belter, E.L.Cussler, Wei-Shou Hu *Bioseparations-Downstream processing for Biotechnology,* John Wiley and sons, 1988.
5. James.E.Bailey, David.F. Ollis *Biochemical engineering fundamentals,* McGraw Hill, 1986.
6. Syed Tanveer Ahmed Inamdar *Biochemical engineering- Principles and concepts*, Prentice Hall of India, 2007

1. Richardson J.F, Harker J.H, Backhurst J.R, *Coulson and Richardson's Chemical Engineering- Vol.2: Particle technology and separation processes,* Butterworth Heinemann, 2002.


**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, a student should become familiar with all relevant operations involved in bioseparations. He/she should be able to clearly distinguish bioseparations from conventional chemical/physical separations. The course should enable the students to select and sequence bioseparation processes involved in the manufacture of various bioproducts ranging from low value bulk commodity products like organic acids to high value products like therapeutic proteins.*

## 13.603 BIOMATERIALS AND TISSUE ENGINEERING (B)

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

**Course objectives:**

*The course is aimed at introducing students to the emerging areas of Biomaterials Science and Tissue Engineering, both of which are sub-components of a larger domain - Biomedical Engineering. The course is of introductory nature and shall focus on various biomaterials with respect to their applications in tissue engineering.*

**Module – I**

**Introduction**: Definition of biomaterials- Common biomaterials; Proteins, Carbohydrates and specialized polymers. Structure of Collagen and Fibroin- Production of these proteins by conventional cloning methods.

**Carbohydrates**: Modified carbohydrates acting as lubricants for biomedical applications; Polydextrose from bacteria; Carbohydrates modified from enzymes; artificial wood.

**Characterization of biomaterials**: definition, importance and application; Principles and general methods of compositional and structural characterization, techniques of X-ray, electron and neutron diffraction, EDAX, Thermal methods - DTA, TGA, DSC, DMA, temperature dependent rheology. Microscopy - optical, electron (TEM, SEM), Atomic force microscopy, optical profilometer and confocal laser scanning microscopy, Spectroscopy – UV-visible, fluorescence and phosphorescence IR, Raman and NMR spectroscopy, ESCA and Auger spectroscopy.

**Module – II**

**Biopolymers**: Synthesis from simple biological monomers- Dextrans; Rubber like materials produced by bacteria and fungi- Polyhydroxybutyrate (PHB), Polycaprolactone (PCL); Production of Biopol(copolymer of PHB and PHV); Biodegradable polymers.

**Industrial biopolymers**: Production of polyphenol resins. Evaluation of properties of biopolymers – Tensile strength (elasticity and breaking strength); Hydration, visco- elastic properties; viscosity.

**Bioceramics and Biocomposites:** Classification of bio-ceramic materials for medical applications. Alumina and zirconia in surgical implants, bioactive glasses and their clinical applications, phosphate glass ceramics. Dense and porous hydroxyl apatite calcium phosphate ceramics, coatings and resorbable ceramics. Carbon as an implant. CMC and PMC composites. Characterization of bio-ceramics. Types of composites and their advantages. Reinforcement: Glass, boron, carbon, organic and ceramic fibers, their structure, properties and processing. Matrix materials: Polymers, metal and ceramic matrices, their structure, properties and processing. Wettability and interface bonding ; Polymer matrix composites: Lamina, laminate composites.

Properties of Biocomposites- Mechanical properties, thermal properties and load transfer. Macromechanics: Elastic behavior, fracture behavior, fatigue behavior, creep behavior of composites. Tribological and electrical behavior of composites. Degradation of composites due to various environmental conditions, corrosion resistance of composites. Designing with composites; Biological application of composites.

**Module – III**

**Tissue engineering:** Introduction; structure and organization of tissues- Epithelial, connective; vascularity and angiogenesis, basic wound healing, cell migration, current scope of development and use in therapeutic and in-vitro testing. Aspects of Cell culture- Different cell types, progenitor cells and cell differentiations, different kind of matrix, cell-cell interaction; cell expansion, cell transfer, cell storage and cell characterization, cell culture bioreactors; Molecular biology aspects- Cell signalling molecules, growth factors, hormone and growth factor signalling, growth factor delivery in tissue engineering, cell attachment: differential cell adhesion, receptor-ligand binding, Cell surface markers.

**Module – IV**

Scaffold and transplant- Engineering biomaterials, Degradable materials, porosity, mechanical strength, 3-D architecture and cell incorporation. Engineering tissues for replacing bone, cartilage, tendons, ligaments, skin and liver. Basic transplant immunology, stems cells; Case studies and regulatory issues-cell transplantation for liver, musculoskeletal, cardiovascular, neural, visceral tissue engineering. Ethical, FDA and regulatory issues.

**References:**


1. Ratledge C and Kristiansen B, *Basic Biotechnol*, Cambridge University Press, 2nd Edition, 2001.
2. Doi Y, *Microbial Polyesters,* VCH Weinheim, 1990.
3. Sujata V. Bhat, *Biomaterial*, Springer, 2002.
4. Buddy D. Ratner, Fredrick J. Schoen, Allan S. Hoffman, Jack E. Lemons *Biomaterials Science: An Introduction to Materials in Medicine,* Academic Press, 2004.
5. Jonathan Black, *Biological Performance of materials,* Taylor and Francis, 2006.
6. Sharma C.P and Szycher M, *Blood compatible materials and devices,* Technomic Publishing Co. Ltd., 1991.
7. Piskin and A.S Hoffmann, *Polymeric Biomaterials,* Martinus Nijhoff Publishers, 1986.
8. Park J B, *Biomaterials - Science and Engineering,* Plenum Press, 1984.
9. Larry L. Hench and June Wilson, *An Introduction to Bioceramics,,* World Scientific Publishing Company; Edition 1993.
10. Sharon Brown , Ian Clarke, Paul Williams, *Biocera*mics; Trans Tech Publications, Ltd., 2002.
11. Kokubo T, *Bioceramics and their clinical applications,* CRC, 2008.

12. Joon Park; *Bioceramics: Properties, Characterization and Applications,* Springer, 2008.
13. Amar K. Mohanty Manjusri Misra Lawrence T. Drzal, *Natural Fibers, Biopolymer and Biocomposites,*CRC; 1st Edition, 2005.

**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 50 % numerical problems. There could be numerical problems in part A also.*

**Course Outcome:**

*Upon successful completion of this course, the students should be able to appreciate their role in the field of biomedical engineering. They should be able to develop an aptitude towards the field of tissue engineering, and should be able to make significant intellectual contributions to the medical field in their capacity as bioprocess engineers.*

## 13.604 PROTEOMICS AND PROTEIN ENGINEERING (B)

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

**Course objectives:**

*The course is intended at providing a deep insight into the areas of protein science, engineering and proteomics. A thorough knowledge of various techniques for studying the protein structure, proteome analysis and protein separation is absolutely invaluable for research in any applied area of Biosciences. Hence, the underlying theory of relevant techniques and technologies shall be presented with adequate emphasis on the latest developments in the field.*

### Module – I

**Introduction**: The proteome and the Genome, protein structure, functional protein families, need for proteomics, scope of proteomics, challenges of proteomics.

**Protein folding**: Hierarchical protein folding, Molecular chaperones, The HSP 70 chaperone system, Defective protein folding; Proteasomes, Prions, Polyketides and non-ribosomal peptides- Combinational manipulation of polyketides and non ribosomal peptides.

### Module – II

**Strategies for protein separation**: Two-dimensional polyacrylamide gel electrophoresis for proteome analysis, Brief history of 2-Dimensional Electrophoresis, 2-DE with pH gradients- sample preparation, solubilization, reduction- The first dimension: IEF with IPG, Equilibration between dimensions- The second dimension: SDS-PAGE- resolution and reproducibility of 2-Dimensional Electrophoresis, liquid chromatography in proteomics.

**Detection of proteins in polyacrylamide gels and on electroblot membranes**: Use of Organic dyes and silver stains, Reverse stains, Colloidal dispersion stains, organic fluorophore stains, metal chelate stains.

**Image analysis of two-dimensional gels**: Data acquisition, digital image procesing, Protein spot detection and quantitation, Gel matching, Data analysis, data presentation, protein data bases.

### Module – III

**Protein modification in proteomics**: Introduction, phosphoproteins; glycoproteins, Ubiquitin etc.

**Enhancing high-throughput proteome analysis**: Impact of stable isotope labeling: Sample preparation, twodimensional gel separation and analysis, Mass spectrometry: protein identification using MS data, Mass spectrometry: protein identification using MS/MS data.

**Protein chips and functional proteomics**: Introduction, different types of protein chips, detection and quantification of proteins bound to protein chips, emerging protein chip technologies.

**Applications of Proteome analysis**: Mining proteomes, protein expression profile, identification of protein-protein interactions and protein complexes, mapping proteins complexes. Recent advances in Proteomics.

**Module – IV**

**Directed mutagenesis and Protein engineering**: Directed mutagenesis procedures- Oligonucleotide directed and random mutagenesis, DNA shuffling; Protein engineering- basic principles, strategies and case studies: Addition of disulfide bonds- T4 Lysozyme, Xylanase, Human pancreatic Ribonuclease; changing asparagine to other amino acids, reducing the number of free sulphydryl residues, increasing enzyme activity, modifying metal cofactor requirements, decreasing protease sensitivity, modifying protein specificity- FokI endonuclease, Antibodies; increasing enzyme stability and specificity- altering multiple properties (Subtilisin, Peroxidase).

**References:**


1. Pennington S. R. and M. J. Dunn, Proteomics*: From Protein Sequence to Function,* Viva Books, 2001.
2. Daniel C. Liebler *Introduction to Proteomics,* Humana Press.
3. Twyman R. M, Principles *of Proteomic*s, BIOS Scientific Publishers, 2004.
4. Sahai S, *Genomics and Proteomics- functional and computational aspects,* Plenum publications, 1999.
5. Moody PCE and Wilkinson AJ, Protein *Engineering*, IRL press, Oxford, 1990.


**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:**

*The course shall provide sufficient theoretical background in the areas of protein engineering and proteomics, which shall enable the students to assimilate the practical aspects of the same to which they shall be exposed during their higher studies. With additional hands- on- training, any successful student shall be able to develop an interest for pursuing a research oriented career in these areas.*

## 13.605 NUMERICAL METHODS FOR PROCESS ENGINEERS (B)

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

**Course Objectives:**

*The course is intended to provide a foundation on various numerical techniques used for design and analysis of engineering systems. The course is of general nature and the applications of numerical methods in process engineering should be emphasized, with the aid of adequate case studies, examples and numerical problems.*

**Module – I**

High speed computations using digital computers. Computer arithmetic, Error analysis. Approximation of functions- Chebyshev polynomials Economized power series, Rational functions, Fourier series. Methods of fitting models to data. Empirical relations.

Numerical solution of nonlinear, transcendental and polynomial equations. Linear interpolation methods: Bisection method, Secant method, False position method, Birge-Vieta method, Newton Raphson method, Mullers method, Fixed point iteration method, Bairstow's method, QD algorithm, Chebyshev's method, Graeffe's root squaring method, Newton Raphson method for system of nonlinear equations.

Linear Algebraic Equations: Physical problems modeled with set of linear algebraic equations, Solution of sets of linear algebraic equations. Gauss elimination, Gauss- Jordan method, LU decomposition, Crout reduction, Triangular decomposition, Iterative methods, Jacobi method, Gauss- Seidel iteration, Relaxation method, Eigen value problems- Power method, Jacob's method, Given's method.

**Module – II**

Finite differences: Forward, backward and central differences. Properties and relations between finite difference operators, Property of difference of a polynomial, factorial polynomial and reciprocal factorial function. Difference equations. Interpolation with Equal Intervals: Gregory- Newton forward interpolation formulae, Central difference interpolation formulae, Gauss's forward and backward interpolation formulae, Stirling's interpolation, Bessel's interpolation, Laplace- Everet interpolation. Interpolation with Unequal Intervals: Lagrangian polynomials, Divided differences, Hermite interpolation, Piece-wise linear interpolation, Cubic splines, Bezier curves and B- splines.

Numerical Integration and Differentiation: Derivatives using Newton's forward and backward interpolation formulae. Use of Stirling's formula, Undetermined coefficients and Finite difference. Newton- Cotes Quadrature formula, Trapezoidal rule, Composite Trapezoidal rule, Simpson's rule, Boole's rule, Romberg integration. Gaussian Quadrature, Gauss- Legendre integration. Lobatto integration, Adaptive integration, Double integrals.

**Module – III**

Ordinary Differential Equations (ODE): Physical examples- The spring- mass problem, Initial value problem, Taylor- Series method, Euler's method, Modified Euler's method, Runge-Kutta method, Multi- step methods- Predictor- Corrector methods, Adams- Moulton method, Adams- Bashforth method.

**Module – IV**

Boundary Value Problems: Partial Differential Equations (PDE): Types of PDE, Physical examples: Temperature distribution in a rod, Temperature distribution in a slab, Solution methods: Shooting method, Alternating direction implicit method. Types of partial differential equations: Solution techniques for the Heat equation and the Wave equation in one and two dimensions- Numerical solution of Laplace equation.

**References:**


1. Curtis F. Gerald and Patrick O. Wheatley, *Applied Numerical Analysis,* Pearson Education Asia, Sixth Edition, 2002.
2. Veerarajan T. and Ramachandran T., *Numerical Methods with Programs in C,* Second edition, TMH, 2006.
3. Jain, M. K., S. R. K. Iyengar and Jain R. K., *Numerical Methods for Scientific and Engineering Computation,* New Age International Publishers, 2007.


**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 the course, students should be able to identify and apply the appropriate numerical techniques in various process engineering situations, to which they would be exposed in their future years. A sound knowledge of numerical techniques shall also be helpful in pursuing a research career in engineering.*

## 13.606.1 BIOPHARMACEUTICAL TECHNOLOGY (B) ( Elective I)

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

**Course Objectives:**

*The course is aimed at providing an exposure to various biopharmaceutical agents and their modes of action. Operations involved in development, manufacture and screening of drugs shall be presented in detail and latest developments in the field of biopharmaceutical technology shall be explicated.*

**Module – I**

Pharmaceuticals, biologicals and biopharmaceuticals**:** An overview Pharmaceutical and Biopharmaceutical biotechnology, current status and future prospects. Pharmaceuticals of animal origin, plant origin and of microbial origin.

The drug development process: Drug discovery, rational drug design. Delivery of biopharmaceuticals, Pre-clinical trials and clinical trials. The role of regulatory authorities.

Biopharmaceuticals: Description, pharmacology, formulation, pharmaceutical concern, clinical use recombinant vaccines, edible vaccines.

Drug manufacturing process: International pharmacopeia. Guide to good manufacturing practice. Manufacturing facility. Sources of pharmaceuticals, production of final product and analysis of final product.

Strategies in the search for new lead drugs/compounds: Improvement of existing drugs. Pros and cons of therapeutic copies. Systematic screening, including high throughput screening. Exploitation of biological information and planned research and rational approach.

**Module – II**

Natural products as pharmaceuticals and source of new lead structures: Design of effective natural products based approach to drug discovery. Examples of natural products or analogs as pharmaceuticals.

Combinatorial chemistry: Principles of combinatorial chemistry, synthetic methodology including solid phase synthesis. Compound purification and analytical tools in solid-phase synthesis.

Production and formulation of Biotech Compounds: Cultivation, production and purification, downstream processing, excipients, microbiological considerations, shelf life, doses, therapeutic response, routes of drug administration, delivery systems.

Proteins based drugs: Source, structure, folding, stability, analytical technique, purification, characterization, therapeutic protein, pharmacokinetic and pharmacodynamics of peptides

and proteins. Absorption, distribution, metabolism, elimination, protein binding. Protein engineering peptidomimetics.

Post productuction handling and delivery: Preparation, storage, handling, administration, Rationale and basic principles, physiologic and mechanistic approaches, approaches using devices, molecular approaches.

**Module – III**

Drug targets classification:DNA, RNA, post-translational processing enzymes, metabolic enzymes involved in nucleic acid synthesis, G-protein coupled receptors (monomeric transmembrane proteins), small molecule receptors, neuropeptide receptors, ion channels (monomeric multi-transmembrane)proteins, ligand-gated ion channels (Oligomeric transmembrane proteins), transporters (multi-transmembrane proteins); Drug Delivery and Drug targeting: Concepts of Bio availability, Process of drug absorption, Pharmacokinetic processes, Timing for optimal therapy, Drug delivery considerations for the new biotherapeutics, Parenteral delivery intravenous, intramuscular, interperitoneal. Oral delivery and systemic delivery through oral route-Structure and physiology of Gastro Intestinal tract, Impediments against oral availability, Advantages and disadvantages of oral drug delivery Drug targeting to CNS –Blood-Brain barrier, physiological and physiochemical factors for delivering to CNS ,current and new technologies in CNS delivery, Pulmonary drug delivery, Cell specific drug delivery, topical and intraocular drug delivery.

**Module – IV**

Oligonucleotides- Gene therapy in cancer treatment and in HIV infection, Antisense therapy, Ribozymes. Oligosaccharides- Oligosaccharide synthesis, Heparin, Glycoproteins, Polysaccharide bacterial vaccines, Approaches to carbohydrate-based cancer vaccines. Cardiovascular Drugs- Myocardial infarction agents, Endogenous vasoactive peptides, Hematopoietic agents. Anticoagulants, anthrombotics and hemostatics.

Chemotherapeutic Agents**:** Synthetic antibacterial agents, Anthelminitic agents, Antiamebic agents, Antiviral agents. Endocrine Drugs -Female sex hormones and analogs, Agents affecting the immune response.

Enzymes: Applications of enzyme in therapeutics, clinical analysis and pharma industry. Antibiotics: Antibacterial, antifungal antibiotics, screening of antibiotics procedures, inoculums and medium for commercial production of penicillin and cephalosporin, fermentation process, extraction and purification. Cancer immunotherapy.

**References:**


1. Gray Walsh and B. Murphy, *Biopharmaceuticals–An industrial prospective,* Kluwer Publishers, 1999.
2. Camille G. Wermuth, *The practice of Medicinal chemistry*. Academic Press, 2003.

3. Dann, J. A, Crommelin and Robert D, Sindelar, *Pharmaceutical Biotechnology*, Taylor and Francis, 2002.
4. Christine M. Bladon, *Pharmaceutical Chemistry*, John Wiley and SonsLtd., 2002.
5. Manfred E, Wolff. A *Burger's Medicinal Chemistry and Drug Discovery* John Wiley and Sons, 2000.
6. Grietje Molema and Dirk K. F. Meijer. *Drug Targeting Organ-Specific Strategies,* Wiley VCH, 2002.
7. Hillery A. M., Lloyd A. W. and J. Swarbrick, *Drug Delivery and Targeting,* Harwood Academic Publishers.
8. Templeton and Lasic, *Gene Therapy,* Marcel and Dekker, 2000.

**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:**

*The course shall provide a theoretical background in the quickly growing area of biopharmaceutical technology. The role of the bioprocess engineer in a biopharmaceutical industry shall become clear and successful students shall explore the possibility of choosing a career in the biopharmaceutical sector or opt for higher studies in biopharmaceutical technology.*

## 13.606.2 BIOSENSORS AND DIAGNOSTICS (B) ( Elective I)

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

**Course Objectives:**

*This course shall provide an overview of biosensors, along with their applications. The design aspects of various biosensor types shall be briefly discussed to facilitate development of novel biosensors for newer applications.*

**Module – I**

Introduction –Immobilization key to biosensor construction, Biosensors diversification. Biosensor instrumentation-

Transduction principles used in a biosensor, Biocomponent of the sensor. Biological sensing elements and transducer systems- their sensitivity specificity and linearity.

**Module – II**

Biosensor types: Design, construction and operation of major types of biosensors- Redoxmediated systems, FETs (Field Effect Transistors), Thermistors, Conductimeters, Piezoelectric crystals,Optoelectric biosensors. Flow injection analysis based biosensors, potentiometeric biosensors, fibre optics biosensors, Bioluminescence biosensors, Microbial biosensors, Affinity biosensors, amperometric biosensors, immunosensors.

**Module – III**

DNA Probes, organic acid probes, antigen-antibodies reaction, biochemical detection of organelles, receptors, sensors for pollution gases stability and reusability of sensors.

**Module – IV**

Applications of Biosensors: Biosensors for personal diabetes management, Noninvasive Biosensors in Clinical analysis and health care- Microfabricated Sensors and the Commercial Development of the I- stat Point-of-Care system- Surface Plasmon Resonance - Biosensors based on Evanescent Waves.

Applications in Veterinary, Agriculture and Food production, Environmental control and pollution monitoring. Biochips and their applications in modern sciences.

**References:**


1. Turner A. P. F, I. Karube and Wilson G.S, *Biosensors- Fundamentals and applications,* Oxford Univ. Press.
2. Thomas D. and J. M. Laval, *Enzyme Technology in concepts in Biotechnology*, Balasubramaniam et al, Univ.Press, 1996.

3. Yang V. C. and T. T. Ngo, *Biosensors and their Applications*, Academic/Plenum Publishers, 2000.
4. Ashok Mulchandani and Kim R Rogers, *Enzyme and Microbial bio sensors: Techniques and Protocols,* Humana Press Totowa, NJ, 1998.
5. Turner A. P. F. and G. S. Wilsons, *Biosensors: Fundamentals and Applications,* Oxford Science Publications, Oxford.

**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:**

*The course shall enable students to understand the latest developments in the field of biosensor development and application. With a basic understanding of biosensor design, they should be able to develop custom- designed biosensors for newer applications in due course.*

## 13.606.3 CANCER BIOLOGY (B) ( Elective I)

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

**Course Objectives:**

*Cancer biology is considered an advanced course in biological sciences, and deals with the basic principles underlying the development of cancers, their detection and therapy. An understanding of cell physiology is the crux to cancer biology and hence, the course shall be delivered with emphasis on the fundamentals of the subject.*

**Module – I**

Fundamentals of Cancer Biology: Regulation of Cell cycle, mutations that cause changes in signal molecules, effects on receptor, signal switches.

Tumor Suppression: Tumour suppressor genes, modulation of cell cycle in cancer. Different forms of cancers, Diet and cancer.

Principles of Carcinogenesis : Chemical Carcinogenesis, Metabolism of Carcinogenesis, Natural History of Carcinogenesis, Targets of Chemical Carcinogenesis. Principles of Physical Carcinogenesis, X - Ray radiation - mechanism of radiation Carcinogenesis.

**Module – II**

Molecular Cell Biology Of Cancer: Oncogenes, Identification of Oncogenes, Retroviruses and Oncogenes, detection of Oncogenes, Growth Factor and Growth Factor receptors that are Oncogenes, Oncogenes / Proto Oncogene activity. Growth factors related to transformations.

**Module – III**

Principles of Cancer Metastasis: Clinical significances of invasion, heterogeneity of metastatic phenotype, Metastatic cascade, Basement Membrane disruption, Three-step theory of Invasion, Proteinases and tumour cell invasion.

**Module – IV**

Detection of Cancer: Detection of Cancers, Prediction of aggressiveness of Cancer, Advances in Cancer detection. New Molecules for Cancer Therapy: Different forms of therapy, Chemotherapy, radiation Therapy and Immuno therapy: advantages and limitation.

**References:**


1. Maly B. W. J., *Virology a practical approach,* IRL Press, Oxford, 1987.
2. Dunmock N. J. and S. B. Primrose, *Introduction to Modern Virology,* Blackwel Scientific Publications, Oxford, 1988.

3. An Introduction to Cellular and Molecular Biology of Cancer, Oxford Medical Publications, 1991.
4. King R. J. B., *Cancer Biology*, Addision Wesley Longmann Ltd, U.K, 1996.
5. Ruddon R. W., *Cancer Biology*, Oxford University Press, Oxford, 1995.

**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:**

*The course shall provide a foundation to cancer biology, which shall develop an interest for pursuing an active research career in this field. Knowledge acquired herein could be taken to an advanced level, by pursuing higher studies in this area.*

## 13.606.4 IMMUNOLOGY AND IMMUNOTECHNOLOGY (B) ( Elective I)

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

**Course Objectives:**

*The course shall provide a basic understanding of the immune system and its role in combating diseases ranging from minor infections to the dreaded cancers. The tools and techniques used in immunology shall be explicated in detail, with emphasis on their applications.*

**Module – I**

Introduction to Immunology: Properties of immune response, Innate and acquired immunity, active and passive immunity.

Cells and Tissues of Immune System: Lymphocytes, Classes of lymphocytes, antigen presenting cells, NK Cells, Mast Cells, Dendritic Cell, Organs of the Immune System- Bone marrow, Thymus, Lymph node, Spleen, CALT, MALT.

**Module – II**

Molecular Immunology: - Molecular structure of antibodies, Classification, Isotypes. Synthesis, assembly and expression of immunoglobulin molecules, Nature of antigens, function and diversity, Generation of antibody diversity. Different characteristics of antigens, mitogens, Hapten, Immunogen, Adjuvants.

MHC: Discovery of MHC complex, Role of MHC, Structure of MHC molecule, Binding of peptides to MHC molecules, MHC restriction.

**Module – III**

Assessment of cell mediated immunity**:** Identification of Lymphocytes and their subsets in blood. T cell activation parameters, estimation of cytokines, macrophage activation, macrophage microbicidal assays, in-vitro experimentation applications of the above technology to understand the pathogenesis of infectious diseases**.**

Molecular basis of Immunology: Molecular basis of antibody diversity, polyclonal and monoclonal antibodies, complement system, antigen-antibody reaction.

Immunopathology: Preparation and storage of tissues, identification of various cell types and antigens in tissues, isolation and characterisation of cell types from inflammatory sites and infected tissues, functional studies on isolated cells, immunocytochemistry - immunofluoresecence, immunoenzymatic and immunoferritin techniques, immunoelectron microscopy.

Immune response and tolerance: Regulation of immune response, immuno tolerance; hyper sensitivity, autoimmunity; graft versus host reaction. Immuno-deficiency and immuno-proliferate diseases.

**Module – IV**

Antibodies and Immunodiagnosis: Monoclonal and polyclonal antibodies-their production and characterisation, Western blot analysis, Immuno electrophoresis, SDS-PAGE, purification and synthesis of antigens, ELISA-principle and applications, Radio Immuno Assay(RIA)-principles and applications, Non isotopic methods of detection of antigens - enhanced chemiluminescence assay.

Application of recombinant DNA technology for the study of the immune system, production of antidiotypic antibodies, catalytic antibodies, application of PCR technology to produce antibodies and other immuological reagents, immunotherapy with genetically engineered antibodies.

**References:**


1. Goldsby R. A., Kindt T.J and Osborne B.A, *Kuby Immunology* 4th Edition, WH Freeman, NY
2. Ivan Roitt, *Essentials of Immunology,* 6th Edition: Blakswell Scientific Publications, Oxford, 1988.
3. Paul W. E. (Eds.), *Fundamentals of Immunology*, Raven Press, New York, 1988.
4. Harlow and David Lane, Antibodies- *A laboratory Manual* Cold spring harbor laboratory.
5. Chakravarty A. K., *Immunology and Immunotechnology*, Oxford University Press, 2006.
6. Charles Janeway, *Immunobiology: The Immune System in Health and Disease,* Garland Science, 2005.
7. Richard Coico, Geoffrey Sunshine, *Immunology: A Short Course*, John Wiley and Sons, 2007.


**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:**

*The course shall enable successful students to consider taking up higher studies in the areas of immunology and immunotechnology, leading to a promising research career in the field. Entrepreneurship options for development of immunodiagnostic kits for several common diseases is also quite popular. Even the modest exposure to this field is hence likely to be of substantial benefit to students, and hence the subject may be learned, keeping these beneficial outcomes in mind.*

## 13.606.5 ENERGY ENGINEERING (B) ( Elective I)

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

**Course Objectives:**

*The course provides an exposure to one of most promising and proliferating interdisciplinary areas in engineering. An understanding of conventional and unconventional energy routes and methods for energy conservation in industrial and domestic settings is of utmost contemporary importance, considering the energy crisis our world is facing now.*

**Module – I**

Classification and sources of energy; problems relating demand and supply of various energy sources. Coal : origin and formation, composition and classification, resources and production, exploration and mining; analysis and testing storage and handling; coal carbonization, briquetting, coal hydrogenation.

Wood and wood products. Petroleum; origin, occurrence; Chemical composition. World reserve, production, refining operations, storage and conveying, testing and analysis different products from petroleum like naphtha, aviation gasoline, kerosene, diesel oil, gas oil, lubricating oil, asphalts etc., petroleum coke, oil shale and oil sand. Combusting methods; and systems, pulverised coal furnaces; cyclone furnaces, oil fired systems, gas fired systems, waste heat boilers.

**Module – II**

Nuclear energy: basic aspects of nuclear radiation, fission and fusion, process reactor systems; BW/PW/HW reactor; gas cooled reactors, fast breeder reactor; thermal design; problems of nuclear power generations and remedial measures.

Solar energy: Facts and scope; solar radiation; radiation measuring instruments; basic flat collector; solar heat pump and heat engine cooling and refrigeration; solar pond; conversion of solar energy into electrical energy; solar thermal power generation; hydroelectric energy; problems of hydro-electric energy and remedial measures. Thermal power plants, generation cycles, energy from ocean tidal wave, ocean thermal source; geothermal energy; wet steam and water, hot dry rocks, electricity from exothermal; sources; wind energy; tunnel mills and conversion cycles.

Post productuction handling and delivery: Preparation, storage, handling, administration, Rationale and basic principles, physiologic and mechanistic approaches, approaches using devices, molecular approaches.

**Module – III**

Hydroelectric energy; problems of hydro-electric energy and remedial measures. Thermal power plants, generation cycles, energy from ocean tidal wave, ocean thermal source; geothermal energy; wet steam and water, hot dry rocks, electricity from exothermal; sources; wind energy; tunnel mills and conversion cycles.

Biogas plant and its design: KVIC plants, process kinetics, digester design, sludge treatment, energy from wastes. Developments in energy routes.

**Module – IV**

Conversion of heat to power : thermoelectric converters; thermo-electric refrigerators magneto-hydrodynamics; fuel cells; conversion of chemical energy into electricity, fuel cell performance; energy accounting utility and process system optimization, energy audit, energy economics, reducing energy loss, co-generation, efficiency improvement; energy conversion in petrochemical industries, polymer industries, natural organic industries, fertilizer industries etc.

**References:**


1. Pandya S. B., *Conventional Energy Technology - Fuels and chemical Energy,* TMH, 1987.
2. Sharma S.P. and Chander Mohan, *Fuels and Combustion*, TMH, 1984.
3. Kash Kori C., *Energy Resources, Demand and Conservation with Special Reference to India,* TMH, 1975.
4. Twidell J.T and Weir T, *Renewable Energy Sources* ,Cambridge University Press.
5. Culp Jr., *Principles of Energy Conservation,* MGK, 1979.
6. Pryde P. R*., Non Conventional energy resources*, John Wiley, 1983.
7. Connolly T. J., *Foundation of nuclear engineering* John Wiley, 1978.
8. Gray T. J. and Gashos G.K., *Tidel Power*, Plenum Press, 1972.
9. Sarkar S., *Fuels and Combustion,* Orient Longman, 1974.
10. Duffie T. R. and W.A. Beckman, *Solar Energy Thermal Processes,* John Wiley, 1974.


**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:**

*The course shall provide an insight into various conventional and unconventional energy routes. Interested students should be able to choose a promising career in energy engineering upon completion of their post graduation in the relevant field. Development of novel energy generation methods is a focal area for research in all engineering disciplines, and hence successful students should be able to investigate and offer their own solutions to problems to save the world from the energy crisis, it is confronting right now.*

## 13.606.6 NOVEL ANALYTICAL METHODS IN BIOTECHNOLOGY (B) ( Elective I)

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

**Course Objectives:**

*This course is aimed at providing an overall picture of the principle and operation of various equipments and techniques used in analysis and separations in Biotechnology. The applications of each technique shall be focused in great detail, to facilitate the selection of the most appropriate method for specific situations which the students shall be exposed to in future.*

**Module – I**

Basic laboratory Instruments: Principle and working of pH meter, Laminar-air flow chambers, Centrifugation: Types of centrifuge machines, preparative and analytical centrifuges, differential centrifugation, sedimentation velocity, sedimentation equilibrium, density gradient methods and their applications; Dialysis, Ultra filtration, Seitz filter.
Microscopic identification of various microorganisms: Phase contrast Microscopy, confocal microscopy Fluorescent Microscopy, Electron Microscopy, Scanning Ion Conductance Microscopy, Video Micrography, Atomic force Microscopy. Flow Cytometry.

**Module – II**

**Electrophoresis:** General principle, factors affecting electrophoresis – voltage, current, resistance, buffer– composition, concentration, pH. Gel electrophoresis: Types of gels (starch, agarose, polyacrylamide), Idea of electrophoresis unit, preparation of gel, sample application, running the samples, SDS-PAGE - Principle, apparatus and methods, gradient gels, Two dimensional gels, isoelectric focusing.

**Module – III**

**Chromatographic Techniques–I:** Introduction to chromatography: General principles, column chromatography– columns, stationary phases. Packing of columns, application of sample, column development, fraction collection and analysis). Partition and adsorption chromatography (brief idea).

Affinity Chromatography; Principle, materials matrix, selection of attachment of ligands, practical procedures, specific and non-specific elution, applications. Ion Exchange Chromatography: Principle, types of exchangers, materials, choice of exchangers and buffers and applications. Gel Filtration chromatography: Principle, idea of distribution coefficient, exclusion limit, fractionation range, bed volume, void volume, elution volume, chemical properties of gel and applications.

**Chromatographic Techniques II:** Gas Chromatography: Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection systems and applications. HPLC: Principle, components of HPLC system, column, column packing, chromatographic solvents, pumping systems, detectors systems and its applications.

**Module – IV**

**Spectroscopy:** Spectroscopic Techniques; Introduction, Energy levels and transition of electrons, Types of spectra, Beers Lamberts law, molar and extinction coefficient, limitations of Beers Lamberts law. Visible and UV Spectrophotometry; Principles, Instrumentation and applications. Spectroflourimetry; Principle, Stoke's shift, quantum efficiency, instrumentation and applications.

**Spectroscopy:** Atomic and Flame spectrophotometry; Principles, Instrumentation and applications for flame emission / atomic absorption spectrophotometry and their comparative study. Mass spectrometry: Principles, Instrumentation and applications. Theory and applications of IR, NMR, Fluorescence, Atomic Absorption, Mass spectroscopy, CD, ORD, Mass, Raman Spectroscopy, ESR principles - instrumentation-applications, Beer-Lambert's law, Use of NMR in elucidation biosynthesis pathways.

Radioisotopic techniques: Use of radioisotopes in life sciences, radioactive labeling, principle and application of tracer techniques, detection and measurement of radioactivity using ionization chamber, proportional chamber, Geiger- Muller and Scintillation counters, autoradiography and its applications, Dosimetry, Immunoassay.

**Thermal Analysis:** Differential scanning calorimetry and differential analysis Instrumentation, Thermogravimetry, Methodology of Thermogravimetry, differential scanning calorimetry and differential thermal analysis.

**References:**


1. Wilson K. and K.H. Goulding, *A biologist's guide to Principles and Techniques of Practical Biochemistry.*
2. Willard and Merrit, *Instrumental Methods and Analysis*
3. Ewing G. W., Instrumental Methods of Chemical analysis.
4. Robert M. Silverstein *et al*., *Spectrometric identification of Organic Compounds,* 7th Edition, 1981.
5. Vogel, *Text Book of Quantitative Chemical Analysis,* 6th Edition, 2004.
6. John A. Adamovic, *Chromatographic Analysis of Pharmaceuticals,* 2nd Edition.
7. Raymond P. W. Scott, *Techniques and Practice of Chromatography,* Vol. 70.
8. Sethi P.D, Dilip Charegaonkar, *Chromatography,* 2nd Edition.
9. Niessen W. M. A., J. Van Der Greef, *Liquid Chromatography: Mass Spectrometry,* Vol. 58.
10. Kalsi.P.K, *Spectroscopy of Organic Compounds*.
11. Hanes, *Gel Electrophoresis of Proteins- A Practical Approach.*

12. Hamilton R. J. and Sewell P. A, *Introduction to High Performance Liquid Chromatography*
13. Gordon M. Message, *Practical aspects of Gas Chromatography and Mass Spectrometry,* John Wiley and Sons, New York. 1984
14. Chapman J. M. and G. Ayrey, *The Use of Radioactive Isotopes in The Life Sciences*, George Allen and Unwin Ltd., London.

**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:**

*The course shall be a prefatory for instrumental and non-instrumental analysis in Biotechnology. The students shall be able to appreciate the applications of various analytical techniques in different realms of Biotechnology and shall acquire the know how to select the most appropriate technique for a given application in the course of their research or industrial career , which they shall take up in future.*

## 13.606.7 METABOLIC REGULATION AND ENGINEERING (B) ( Elective I)

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

**Course Objectives:**

*This course is aimed at providing an overview of the applications of genetic level manipulation in redesigning metabolic pathways. With applications in medical, industrial and other applied areas of Biotechnology, metabolic engineering is an emerging subject with tremendous scope for a promising research career.*

**Module – I**

**Introduction:** Identification of metabolic regulation is a key point in metabolic engineering. Basic concepts of Metabolic Engineering – Overview of cellular metabolism – Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feedback regulation.

**Synthesis of Primary Metabolites:** Amino acid synthesis pathways and its regulation at enzyme level and whole cell level, Alteration of feedback regulation, Limiting accumulation of end products.

**Biosynthesis Of Secondary Metabolites:** Regulation of secondary metabolite pathways, precursor effects, prophase, idiophase relationship, Catabolite regulation by passing control of secondary metabolism, producers of secondary metabolites, applications of secondary metabolites.

**Module – II**

**Bioconversions:** Applications of Bioconversions, Factors affecting bioconversions, Specificity, Yields, Cometabolism, Product inhibition, mixed or sequential bioconversions, Conversion of insoluble substances.

**Regulation Of Enzyme Production:** Strain selection, Genetic improvement of strains, Gene dosage, metabolic pathway manipulations to improve fermentation, Feedback repression, Catabolite Repression, optimization and control of metabolic activities. The modification of existing - or the introduction of entirely new - metabolic pathways.

**Module – III**

**Metabolic Flux:** Integration of anabolism and catabolism, metabolic flux distribution analysis in bioprocess, material balance, kinetic types, equilibrium reaction. Experimental determination method of flux distribution, Metabolic flux analysis and its applications, Thermodynamics of cellular processes.

**Module – IV**

Metabolic Engineering with Bioinformatics: Metabolic pathway modeling, Analysis of metabolic control and the structure metabolic networks, Metabolic pathway synthesis algorithms, Applications Of Metabolic Engineering: Application in pharmaceuticals, chemical bioprocess, food technology, agriculture, environmental bioremediation and biomass conversion.

**References:**


1. Wang D. I. C., C. L. Cooney, A. L. Demain, P. Dunnil, A. E. Humphrey and M. D. Lilly, *Fermentation and Enzyme Technology,* John Wiley and Sons, 1980.
2. Stanbury P.F. and Whitaker A, *Principles of Fermentation Technology,* Pergamon Press, 1984.
3. Zubay G, *Biochemistry,* Macmillan Publishers, 1989.


**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 a grasp of the principles underlying metabolic engineering, with sufficient insight on its applications in various applied sectors of Biotechnology. This shall help them to plan ahead towards pursuing a research career in this field.*

## 13.607 SOFTWARE LAB (B)

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

**Course Objectives**:

*With ample career opportunities for engineering graduates in the software sector, this course is aimed at providing hands-on training on object oriented programming with C++, while at the same time, imparting a general idea about various other software packages for modeling, simulation and design applications in process Engineering.*

1. **C++ Programming exercises**

   Develop programs to implement the following numerical method solution of:

   1. Nonlinear and transcendental equations
   2. Linear Algebraic Equations, Set of equations
   3. Methods for interpolation and extrapolation
   4. Numerical Differentiation and Integration
   5. Solution of Ordinary Linear Differential Equations
   6. Boundary Value Problems Ordinary and Partial Differential Equations
   7. Fitting Models to data

2. **Learning and Use of MATLAB**

   Exercises in MATLAB application to Solution of Engineering problems, Systems Simulation, Optimization and Control.

3. **Software Packages**

   Steady State Simulation and Optimization of Flash Drums, Reactor/Bioreactor Models, Distillation Column models. Chemical/Bioprocess Plant Simulation and Design Using State –of –the art software packages like ASPEN PLUS, HYSIS, CHEMCAD, DESIGN II, Biopro Designer, Biotechnology Design Simulator and Bioprocess Simulator and other related packages applicable in process industries.

   Simulation studies of dynamics and control of reactors including bio reactors, Distillation Columns, Pressure driven Processes and Reactive Distillation Columns.

**References:**

**Veerarajan T and Ramachandran T**, *Numerical Methods with Programs in C,* Second edition, TMH, 2006.

**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*

*Questions based on the list of exercises prescribed.*

*Marks should be awarded as follows:*

*20% - Algorithm/Design*

*30% - Implementing / Conducting the work assigned*

*25% - Output/Results and inference*

*25% - Viva voce*

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

**Course Outcome**:

*Successful completion of this course shall equip students with requisite practical knowledge about object oriented programming, along with its applications in process engineering. The knowledge acquired herein could benefit the students to take up a career in the software sector or apply their software skills in diverse process engineering situations to achieve beneficial outcomes.*

## 13.608 HEAT AND MASS TRANSFER LABORATORY (B)

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

**Course Objectives:**

*This course is aimed at providing hands- on practical training on the operation of various heat and mass transfer equipments used in process industries. Experiments shall be performed with experimental prototypes and adequate care shall be exercised to correlate the results obtained therein with real life industrial situations. Further, visits to process industries may be arranged as part of this course, to facilitate a clear demarcation between the laboratory experimentation and the real-life industrial situation.*

**List of Experiments:**

**GROUP A Heat Transfer Operations**

1. Determination of thermal conductivity of solid
2. Determination of thermal conductivity of liquids
3. Determination of aporizati for surface heat transfer
4. Determination of heat transfer coefficient by natural convection
5. Determination of heat transfer coefficient by forced convection
6. Determination of heat transfer coefficient of fins by natural convection
7. Determination of heat transfer coefficient for fins by forced convection
8. Determination of heat transfer coefficient by film-type condensation
9. Determination of boiling heat transfer coefficient by conducting pool boiling experiment
10. Determination of overall heat transfer for parallel flow and counter flow in double pipe heat exchanger
11. To conduct test on heat pipe and compare the temperature distribution
12. Determination of heat transfer coefficient and effectiveness in shell and tube heat exchanger
13. Determination of overall heat transfer coefficient in an open pan evaporator
14. Heat Transfer in Composite walls- Determination of effective thermal conductivity and overall resistance.
15. Determination of radiation constant, emissivity, convective and radiation heat transfer coefficient.
16. Evaporation: Study of evaporation equipment – determination of steam economy in multiple effect evaporators.
17. Heat transfer in packed beds.
18. Heat transfer in aporizat beds

**GROUP B Mass Transfer Laboratory ()**

19. To plot the ternary phase diagram for any ternary liquid system (ex. Acetic-acid – water Toluene). To draw the tie line and to determine plait point for ternary system
20. To determine the diffusivity of liquid in gas ( ex. Acetone in air)
21. To study the drying characteristics of the given wet material by conducting a batch drying experiment and draw the drying curve.
22. To determine the Mass Transfer Coefficient for vaporization of naphthalene in air
23. To verify Rayleigh's Equation for Batch distillation
24. To find HETP and HTU for packed distillation column
25. Steam distillation (ex. To purify turpentine oil having high boiling point using steam distillation)- Determination of steam requirement and aporization efficiency, efficiency in steam distillation
26. VLE studies (To determine VLE data for methanol –water and to compare it with literature data)
27. To determine the mass transfer coefficient by carrying out liquid-liquid extraction in a packed column (acetic acid- toluene-water system can be used)
28. To study the process of crystallization in a batch crystallizer and to plot a graph between weight of crystals versus temp.
29. Leaching: simple leaching- experiment with the given solute-solvent-inert system and compare the actual recovery with the theoretical recovery for constant solvent to feed ratio and varying no. of stages.
30. Cross current leaching- continuous – determination of the overall stage efficiency of the continuous cross current leaching unit
31. Counter current leaching- counter current leaching experiment with the given solute-solvent-inert system by batch simulation of a counter current cascade.
32. Determine the values of constants **K** and **n** for adsorption of a solute on the given adsorbent at room temperature and verify Freundlich Equation.
33. Determination of the values of constants **K** and **n** for adsorption of a solute on the given adsorbent at room temperature and verification of Freundlich Equation.

***Note: At least 6 experiments each in Group A and Group B shall be performed.***

**References:**


1. **Shankar Srinivas**, *Mass Transfer Operations – A Lab Manual for Chemical Engineering* CEED, III Madras
2. **Trebal R. E.**, *Mass Transfer Operations*, McGraw Hill.
3. **Radhakrishnan K. B.**, *A Laboratory Manual for Heat Transfer Operations Lab,* Published by the Department of Chemical Engineering, TKM College of Engineering, Kollam.
4. **Jyothi S.N.,** *Laboratory Manual for Mass Transfer Operations Lab,* Published by the Department of Chemical Engineering, TKM College of Engineering, Kollam.

**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 certified fair record for endorsement by the external examiner.*

**Course Outcome:**

*Upon successful So of this course, the students should be able to understand the operation of various industrial equipments which work on heat and mass transfer principles. They should also be able to clearly correlate the results of various laboratory experiments with the respective outcomes in real life industrial scenario.*