T. E. Biotechnology

TERM – I

Subject Code No.	Subject	Teaching Scheme			Examination Scheme				**Total marks**
		Theory	Practical	TW/ Drawing	Paper	Practical	Oral	TW	
316281	Biochemistry II	4	2		100	50			150
309342	Mass Transfer I	4	2		100	50		25	175
316282	Bioseparations	3	4		100		50	25	175
316283	Industrial Microbiology	4			100				100
307351	Industrial Organization and Management	3	2		100			50	150
		18	10		500	100	50	100	**750**

TERM – II

Subject Code No.	Subject	Teaching Scheme			Examination Scheme				**Total marks**
		Theory	Practical	TW/ Drawing	Paper	Practical	Oral	TW	
309347	Chemical Reaction Engineering I	4	4		100			50	150
316284	Immunology	4	2		100		50		150
316285	Instrumentation and Process Control	3	2		100		50		150
309350	Mass Transfer II	4	2		100			50	150
316286	Computational Techniques and Process Modeling	3			100				100
316287	Seminar		2					50	50
		18	12		500		100	150	**750**

University of Pune
T. E. Sem (I)
316281: Biochemistry II

Teaching Scheme:	**Exam Scheme:**
Theory: 4 hr/week	**Paper: 100 Marks**
Practical: 2 hr/week	**Practical: 50 Marks**

UNIT 1 **[9 Hrs]**

Enzymes
Structural aspects, isozymes and multienzymes complexes, cofactors, activation, catalytic mechanisms with reference to specific examples. Enzyme kinetics; Michalies-Menten Equation, inhibition, competitive/non-competitive/un-competitive, allostersric and feedback inhibition. Enzymatic activity of molecules other than proteins.

UNIT 2 **[9 Hrs]**

Coezymes
Coenzyme I -Coenzyme A, Thiamine diphosphate, pyridine nucleotides, flavins and lipoic acid Coenzyme II Biotin and pyridoxal phosphate

UNIT 3 **[9 Hrs]**

Receptors and ligand binding, agonist, antagonist with case examples. NF-kappa b, PPAR, cannabinoid receptors, GPCR

UNIT 4 **[9 Hrs]**

Biochemical structures
Proteins, nucleic acids, lipids: secondary structure, tertiary structure, Ramchandran Plot, structure-function correlations, anatomy of biological macromolecules.

UNIT 5 **[9 Hrs]**

Basic physiology, homeostasis. Hormones, endocrine and exocrine systems. P-450 drug metabolizing enzymes and metabolism of drugs. Lysosomes and degradation of proteins. Muscle contraction, nerve conduction, action potential, signaling pathways, signal transduction, Nerve conduction, compartmentalization, membrane channels and pumps (Na/k pumps, other such examples)

UNIT 6 **[9 Hrs]**

Clinical Biochemistry, application of biochemistry in monitoring systemic diseases. vitamins. assimilation, macronutrients and micronutrients, vitamins and trace elements, chemistry and

metabolism. Nutritional Biochemistry, Its application in food technology (yogurt,cheese,wine etc.)

Practical:

1. Water: analysis and methods of preparation
   Conductivity
2. Isolation of complex polysaccharides using solvent extraction
3. Isolation of proteins by Salting in and out
4. Separation of proteins by SDS PAGE
5. To carry out purification of enzyme from liver or sprouts or microbial source such as Proteases, or Amylases, or lipases etc and calculate specific activity
6. Quantitative assays for enzymes using enzyme substrate reactions
7. To study enzyme kinetics and calculate K_m and V_{max}
8. To study effect of enzyme inhibitors and calculate K_i

Text Books

1. Lubert stryen Biochemistry, Freeman WH & Company, New York,
2. Conn and Stumph, Outlines of Biochemistry

Reference Books

1. JH Weil, General Biochemistry, New Ages International (P) Ltd. 1997.
2. David T. Plummer, An Introduction to practical biochemistry, Tata McGraw Publishing Company Ltd.
3. I.A.L. Lehninger, DL Netson, MM Cox Principles of Biochemistry, CBS Publishers and Distributors.

T. E. (Sem. I)

309342: Mass Transfer I

Teaching Scheme:	**Exam Scheme:**
Theory: 4 hr/week	**Paper: 100 Marks**
Practical: 2 hr/week	**Practical: 50 Marks**
	Term Work: 25 Marks

UNIT 1 **[9 Hrs]**

Introduction

General principles of Mass Transfer, classification of Mass Transfer Operations, choice of separation method, methods of conducting mass transfer operations, design principles.

Diffusion Mass Transfer Molecular Diffusion in gases and liquids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, diffusion in solids, unsteady state mass transfer.

UNIT 2 **[9 Hrs]**

Mass transfer Coefficients in laminar flow and turbulent flow, theories of Mass transfer, mass, heat and momentum transfer analogies. Inter-phase mass transfer, equilibrium in mass transfer, the two resistance theory, continuous cocurrent, countercurrent and crosscurrent processes, cascades.

UNIT 3 **[9 Hrs]**

Gas Absorption

Mechanism of gas absorption, equilibrium in gas absorption, application of mass transfer theories to absorption, absorption in wetted wall columns, values of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower.

Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, absorption with chemical reaction.

UNIT 4 **[9 Hrs]**

Humidification and Dehumidification

Principles, vapour-liquid equilibria, enthalpy of pure substances, basic definition of all humidification terms, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, equipment like cooling towers, tray towers, spray chambers, spray ponds, cooling tower design – HTU, NTU concept, calculation of height of cooling tower.

UNIT 5 **[9 Hrs]**

Equipment for gas liquid operation

Gas dispersal equipment – bubble columns, mechanically agitated vessels, tray towers.

Liquid dispersal equipment – Venturi scrubbers, wetted wall columns, spray towers, packed columns

UNIT 6 **[8 Hrs]**

Drying

Principles, equilibrium in drying, type of moisture binding, mechanism of batch drying, continuous drying, time required for drying, mechanism of moisture movement in solid, design principles of tray dryer, rotary dryer, drum dryer, spray dryer, fluidized bed and spouted bed dryer, pneumatic dryer and vacuum dryer.

Textbooks

1. Mass Transfer Operations – Treybal R.E., McGraw Hill
2. Unit Operations of Chemical Engineering, McCabe W.L. and Smith J.C. , McGraw Hill

Reference Books

1. Chemical Engineering, Vol I & II – Coulson J.M. and |Richardson J.F., McGraw Hill
2. Principles of Unit Operations in Chemical Engineering, Foust A.S.
3. Design of Equilibrium Stage Processes - Smith B.D.

Practical

1. Tray Dryer – To calculate rate of Drying
2. Rotary Dryer – To study the Characteristics of Rotary Dryer
3. Spray Dryer – To study the design and Operating Principles of Spray Dryer
4. Fluidized Bed Dryer – To study the characteristics of Fluidized bed Dryer
5. Liquid Diffusion – To calculate the Diffusion Coefficient for a liquid –liquid system
6. Winkelmann's method – To find the diffusion Coefficient of vapour in still air
7. Enhancement Factor – To find the enhancement factor for absorption with and without chemical reaction
8. Mass transfer Coefficient – To determine the Mass Transfer Coefficient for Absorption in a Packed Tower
9. Cooling Tower– To study the characteristics
10. Humidifier and Dehumidifier – To study the Characteristics
11. Interphase Mass Transfer Coefficient – To calculate the individual and overall Mass Transfer Coefficient
12. Wetted Wall Column – To find the mass transfer coefficient in a wetted wall Column

Note On Term Work:

- Minimum number of experiments – 8
- Minimum number of assignments – 2 (out of remaining experiments)
- Besides experimental work, evaluation of term work should be done through periodic tests
- Record of assessment of practical should be maintained on continuous basis

T. E. (Sem. I)
316282: Bioseparations

Teaching scheme:	**Exam scheme:**
Lectures: 3 Hrs / week	**Paper: 100 Marks**
Practicals: 4 Hrs / week	**Oral: 50 Marks**
	TermWork: 25Marks

UNIT 1 **[8 Hrs]**

Mechanical and enzymatic methods of cell disruption, importance of cell disruption in product release, homogenization, ultrasonication, extraction, absorption, adsorption.

UNIT 2 **[8 Hrs]**

Chromatographic methods, paper chromatography, thin layer chromatography, gas chromatography, GLC, HPLC, affinity chromatography, ion exchange chromatography, reverse phase chromatography

UNIT 3 **[8 Hrs]**

Basic separation techniques: sedimentation, centrifugation, ultracentrifugation, gradient centrifugation, filtration, micro/ultra filtration, use of membranes (semi permeable) in purification, reverse osmosis

UNIT 4 **[8 Hrs]**

Importance of separation techniques in biotechnology, its scope from research to industry, chemical, physical and biochemical aspects of separation and isolation, purification of biomolecules. Behavior of biomolecules in body fluids, milieu.

UNIT 5 **[8 Hrs]**

Leaching, crystallization, lyophilzation, drying. Chemistry of extraction, selection of solvent, use of solvent extraction in antibiotic separation, affinity extraction/ chromatography.

UNIT 6 **[8 Hrs]**

Industrial applications with examples. Separation of bioconversion products/ secondary metabolites e.g. Steroids and antibiotics.

Practical

1. Separation using dialysis, ultrafiltration (amicon filters)
2. Separation using centrifuge:
   Blood components

DNA/RNA
3. Separations using chromatography
4. Oligo DT cellulose –RNA separation
   Ion exchange chromatography (DEAE cellulose)
   Sepharose/ Sephadex column
5. Antibiotics- solvent extraction
6. Other extractable biomolecules
7. Extracellular protease/amylase
8. Industrial visit and a report on it

Textbooks

1. Bioseparation: Downstream processing for Biotechnology, Belter, P.A. and Cussler, E.L., Hu, W.S. Wiley, New York.
2. Biosepration Engineering: Principles, practice and economics, Wiley, Interscience

Reference Books

1. Unit Operation of Chemical Engineering, McCabe, W.L., Smith, J.C. and Harritt, P., McGraw Hill.
2. Separation Process Principles. Seader, J.D, and Henley, E.J. Wiley.

T. E. Sem (I)
316283: Industrial Microbiology

Teaching Scheme: **Exam Scheme:**
Theory: 4 hr/week **Paper: 100 Marks**

UNIT 1 **[8 Hrs]**

Economic activities of microorganisms
Introduction, microbial products, Screening and strain improvement: isolation, preservation and improvement of industrially important micro-organisms; Media for industrial fermentations; Sterilization; Inoculum preparation, Pilot plant, Scale up,

UNIT 2 **[8 Hrs]**

Production of alcohol, glycerol and beer. Mechanism of alcohol and glycerol fermentation. Production of wine and other alcoholic beverages.

UNIT 3 **[8 Hrs]**

Microbial production of organic acids viz. Citric, gluconic, fumeric itaconic, gibberellic and kojic acids. Activities of lactic acid bacteria and industrial production of lactic acid. Activities of acetic acid bacteria and production of vinegar

UNIT 4 **[8 Hrs]**

Production and isolation of antibacterial antibiotics like penicillin, streptomycin, chloromycetin, tetracyclines, semisynthetic penicillins. Antifungal antibiotics.
Production of dextrans. Amino acid fermentation. Metabolic controls in industrial fermentation. Saccharifying agents-methods of production and uses. Microbial production of vitamins B2 and B12.

UNIT 5 **[8 Hrs]**

Production, isolation and use of microbial enzymes, immobilized enzymes and their applications. Production of glucose and fructose and starch by enzymatic methods.
Single Cell proteins (SCPs). Production of fungal, algal protein and recent advances. Microbiological transformations, metal recovery

UNIT 6 **[8 Hrs]**

Fermentation economics: Market potential, capital expenditure, fermentation and product recovery costs, yields, product recovery, product purity, fermentation efficiency, case example such as ethanol economics

Text books

1. Industrial microbiology: Casida Newage Publication 2001
2. Industrial microbiology: Prescott and Dunn CBS publications 4th Edition, 1999
3. Principles of Fermentation Technology, Second Edition, Stanbury, Whitaker, S. Hall, Elsevier publication

Reference Books

1. Enzymes: Trevor, Horwood, 2001
2. Comprehensive Biotechnology Vol. 1- 4: M.Y. Young (Eds.), Pergamon Press.
3. Biotechnology: A Text Book of Industrial Microbiology: T.D. Brock, Smaeur Associates, 1990.

T. E. (Sem. I)
307351: Industrial Organization and Management

Teaching scheme: **Exam scheme:**
Lectures: 3 Hrs / week **Paper: 100 Marks**
Practical: 2 hrs/week **Term work: 50 marks**

UNIT 1 **[9 Hrs]**

Management Science
Management, its growth, concepts of administration and management of organization.
Definition of management, functions, authority and responsibility. Unity of command and direction Decision making in management by objectives.
Business Organization
Different forms of organization, their formation and working, Different organization structure- line organization, functional organization, line and staff organization.

UNIT 2 **[9 Hrs]**

Personnel Management
Manpower planning, sources of recruitment, selection and training of staff. Job evaluation, merit rating, performance appraisal, wage administration and system, of wage payment, incentive, motivations, industrial fatigue, Trade unions – industrial relations.

UNIT 3 **[9 Hrs]**

Purchase and stores management
Concepts of quotation, tenders and comparative statement, inspection and quality control, Inventory, carrying cost and fixed cost of inventory, examples of cost of Inventory, Stores management, functions of storekeeper, methods of inventory : LIFO, FIFO.

UNIT 4 **[9 Hrs]**

Marketing management
Concepts of selling, marketing, definition of marketing, market research and of pricing, penetration, pricing, skimming pricing, distribution of product, advertising and promotion.

UNIT 5 **[9 Hrs]**

Export and import management
Concepts of international trade, duties, antidumping duty, cost involved in exporting a product, pricing of export product. Government aids for export promotion, export houses, export promotion counsel, MODVAT, patent and patent rights.
Quality Management
TQM, quality circles, ISO systems.

UNIT 6 **[9 Hrs]**

Management Laws

Concepts of contract act, offer, and acceptance, types of contracts, Void contract, concept pf guarantee and warranty. Introduction of MRTP and FERA.

Work study

Work Measurement, motion and time study flow process chart, flow diagram, sio chart, string chart, therbligs.

Text Books

1. Management for Business and Industry-C.S. George Jr.
2. Principles of management- Knoots and O.Donnell.

Reference Books

1. Business Organization and management- M.C. Shulka

T. E. (Sem. II)

309347: Chemical Reaction Engineering I

Teaching Scheme:

Theory :4 hrs/ week **Exam Scheme**

Practical: 4 hr/week **Paper: 100 Marks**

Term Work: 50 Marks

UNIT 1 **[9Hrs]**

Kinetics of Homogeneous Reactions

Defining a rate equation and its representation, single and multiple reactions, elementary and non elementary reactions, molecularity and order of reactions, kinetic models for non-elementary reactions, searching mechanism, rate controlling step.

UNIT 2 **[9 Hrs]**

Analysis and interpretation of Batch Reactor data

Constant volume batch reactor, integral and differential methods of analysis, variable volume batch reactor, integral and differential methods of analysis.

UNIT 3 **[9 Hrs]**

Reactor Design

Introduction, conversion of mass in reactors, performance equation for ideal stirred tank reactor, tubular flow reactor, batch reactor, space time and space velocity.

Isothermal Reactors for single Reactions

Batch reactor, mixed versus plug flow reactors and second order reactions, graphical comparison, multiple reactor system, plug flow reactors in series & / or in parallel, equal size mixed reactors in series, reactors of different types in series, reactors of different types in series, recycle reaction (flow, batch), auto-catalytic reaction, non- steady flow semi-batch reactors.

UNIT 4 **[9 Hrs]**

Multiple reactions

Parallel and series reactions, performance of various ideal reactors, qualitative and quantitative discussion for multiple reactions, instantaneous and overall fractional yield.

UNIT 5 **[9 Hrs]**

Temperature and pressure effects

Temperature dependency from Arrhenius law, thermodynamics, collision theory, transition state theory, comparison of theories, rate of reactions predicted by theories, single reactions: heat of reaction from thermodynamics, equilibrium constants from thermodynamics, graphical design procedure, heat effects, adiabatic operations, non adiabatic operations.

UNIT 6 **[9 Hrs]**

Deviations from Ideal Reactor

Self mixing of a single fluid & two miscible units. Residence time distribution, F,C,E, curve and relation between them. Models for non-ideal reactions, dispersion model, tanks in series model segregated flow model.

Practical:

Minimum of ten experiments should be performed. Suggested list is as below

1. Study of first order reaction.
2. Inversion of sucrose
3. Study of pseudo first order reaction. Acid catalysed hydrolysis of methyl acetate
4. Study of a second order reaction – Saponification of ethyl acetate.
5. Determination of Arrhenius parameters
6. Study of homogeneous catalytic reaction, decomposition of hydrogen peroxide, acid catalysed ester hydrolysis.
7. Batch fermentation of sucrose using invertase
8. Study of PFR
9. Study of CSTR
10. Study of CSTR combination in first order reactions
11. Study of F & C curves in CSTR
12. Study of F & C curves in Helical coil reactor
13. Study of PFR & CSTR combination in second order reaction

Textbooks

1. Chemical Reaction Engineering: Levenspile O.
2. Elements of Chemical Reaction Engineering: H. Scott, Fogler.

Reference Books

1. Chemical Engineering Kinetics: Smith J.,

T. E. Sem (II)
316284: Immunology

Teaching Scheme: **Exam Scheme:**
Theory: 4 hr/week **Paper: 100 Marks**
Practical: 2 hr/week **Oral: 50 Marks**

UNIT 1 **[9 Hrs]**

Overview of immune system, innate and adaptive immunity, Physiological barriers against infection, phagocytosis, inflammation, humoral immunity, Cells and organs of immune system,

UNIT 2 **[9 Hrs]**

Antigens, Structure and function of antibody, Activation of B cells, theories of antibody production- clonal selection theory, organization and expression of Ig genes, generation of antibody diversity, antigen antibody interactions- principles and applications, cross reactivity, precipitation, agglutination, RIA, ELISA, Western blotting

UNIT 3 **[9 Hrs]**

Cell mediated immunity, Major Histocompatibility Complex (MHC), graft rejection, GVH, antigen processing and presentation, T cells

UNIT 4 **[9 Hrs]**

Immune effector mechanisms, cytokines, complement system, cell mediated effector responses, cytotoxic T cells, Natural killer cells, ADCC, hypersentitive reactions- allergen, reaginic antibody, Type I-IV reactions

UNIT 5 **[9 Hrs]**

Vaccines, active and passive immunization, attenuated vaccines, role of adjuvants, anti-sera, immunoglobulins, toxoids, recombinant vaccines, subunit vaccines, DNA vaccines

UNIT 6 **[9 Hrs]**

Immune system in diseases, autoimmunity, cancer and immune system, TB, Immunodeficiency, AIDS

Practical

1. Quantitation detection of immunoglbulin using precipitation reaction

2. Haem-agglutination
3. Determination of antibody titer by Radial Immuno Diffusion (RID)
4. Ouchterlony Immunodiffusion for detection of antigen/ antibody-Titration
5. ELISA
6. Western Blotting

Text Books

1. Kuby- Immunology (4th Edition) by R. A. Goldsby, T.J. Kindt, B.A. Osborne.

Reference Books

1. Essentials of Immunology (6th Edition): Ivan Riot- Blakswell Scientific Publications, Oxford, 1988
2. Fundamentals of Immunology: Paul W.E. (Eds.) Raven Press, New York, 1988.
3. Antibodies A laboratory Manual: Harlow and David Lane (1988), Cold spring harbor laboratory.

T. E. Sem (II)
316285: Instrumentation and Process Control

Teaching Scheme: **Exam Scheme:**
Theory: 3 hr/week **Paper: 100 Marks**
Practical: 2 hr/week **Oral: 50 Marks**

UNIT 1 **[8 Hrs]**

Introduction to process control
Need for their measurement and control pressure measurement by mechanical and electrical transducers. Low pressure measurement by McLeod Gage and Pirani gage. Temperature measurement by bi-metal thermometers, resistance thermometer thermistors, thermocouples. Radiation and optial pyrometers. Flow measurement by Hot – Wire ammometer and magnetic flow meters. Visualization by shadow-graph and interferometer. Liquid feel measurement in open vessels and in pressure vessels. Thermal conductivity measurement of solids, liquids and gases. Measurement of diffusivity in gases.

UNIT 2 **[8 Hrs]**

Process Dynamics
Introduction
Tools of dynamic analysis, Laplace transform and its properties, characteristics of ideal forcing functions (step, ramp, pulse, impulse, frequency)\
Process Modeling and Analysis
Reasons of modeling, formulating process models, input-out models, state-space model, transfer function model, prediction of quantitative behavior of dynamic response of system, block diagram, frequency response analysis, linearization of non-linear systems (for single variable systems only)
Dynamic behavior of first order and pure integrator (capacitive) systems
Model, transfer function, dynamic response for standard forcing functions, physical examples such as thermometer, liquid tank, CSTR etc.

Dynamic behavior of second order systems
Model, transfer function, types, dynamic behavior, physical examples such as manometer, interacting and non-interacting tank systems.
Dynamic behavior of systems having unusual dynamics
Dynamics of transportation lag, lead-lag, numerator dynamics, inverse response systems, transient response analysis using MATLAB.

UNIT 3 **[8 Hrs]**

Single loop feedback control system

Concept of feedback control, block diagram, closed loop transfer function for servo and regulatory operation, selecting controlled and manipulating elements, control performance measures, notion of stability, Routh's stability criteria.
Classical feedback controller: Basic control actions (ON-OFF, P, PI, PD, PID)- open and closed loop response, advantages and limitations of each control action, process control hardwares (measuring instruments, transmitters, transmission lines, actuators, final control elements), types of controllers- pneumatic, hydraulic, electronic, computer based (DDC), Microcomputer based (PLC, DCS), Supervisory control (SCADA).,introduction to neural and fuzzy control

UNIT 4 **[8 Hrs]**

Stability Analysis and Design of Feedback Control Systems
Concept, root locus analysis and stability criterion, root locus design, root locus plots using MATLAB, frequency response analysis and stability criterion (Bode and Nyquist plots using MATLAB), controller tuning (Ziegler Nichols and Cohen-Coon methods).

UNIT 5 **[8 Hrs]**

Enhancement of single loop PID feedback controllers
Analysis and design of cascade, feed forward, selective, ratio, over ride and slit range control strategies.

UNIT 6 **[8 Hrs]**

Industrial applications
Speed control, Temperature control, Control of gas supply, Control of pH, Control of dissolved oxygen, Antifoam control;
Additional sensors
Redox, Air flow, Weight, Pressure, On-line measurement of biomass
The adaptive control approach, Expert control system and fuzzy logic, neural networks

Practical

1. Dynamic Response of I^{st} order system.
2. Dynamic Response of II^{nd} order system.
3. Characteristics of On-Off Controller.
4. Characteristics of P, PI, PD, PID Controller.
5 Frequency Response Analysis and design
6. Root locus analysis
7. MATLAB exercise of Control System
8. MATLAB exercise
9. Study of Computer Aided control System.
10. Cascade Control.

Text Books

1. Coughanowr, “Process System analysis and control” Mc-Graw Hill.
2. Principles of Fermentation Technology – Stanbury P.F. and Whitaker A

Reference books

1. Nise, “Control System Engineering”,
2. Marlin, T, 1995. Process control : Designing processes and control systems for dynamic performance, McGraw-Hill
3. P. Harriot, “Process Control”
4. Fermentation Microbiology and Biotechnology – El-Mansi E.M.T. and Bryce C.F.A.

T. E. (Sem. II)
309350: Mass Transfer -II

Teaching Scheme: **Exam Scheme:**
Lecture: 4 hr/ week **Paper: 100 Marks**
Practical: 2 hr/week **Term Work: 50 Marks**

UNIT 1 **[9 Hrs]**

Distillation
Vapour – liquid equilibria for ideal and non-ideal systems, relative volatility, ideal solutions, azeotropes, positive and negative deviations from ideality, multi component system, methods of distillation - differential , flash, azeotropic, extractive, low pressure, steam distillation, batch rectification.
Continuous rectification for binary system, multistage (tray) towers, Lewis Sorrel, McCabe Thiele, and Ponchon Savarit methods for multistage operations, tray efficiencies, concept of reflux, mnimum reflux ratio, optimumreflux, total reflux, Fenske's equation, reboilers, use of open steam, rectification of azeotropic mixtures.
Partial and total Condensers, cold reflux, Fenske-Underwood equation, packed towers for distillation, NTU, HTU, HETP concept and calculations, concept of multicomponent distillation, distillation column internals.

UNIT 2 **[9 Hrs]**

Novel Techniques
Membrane separation techniques- Ultra filtration. Nanofiltration, reverse osmosis, Rate based processes such as diffusion coefficient based inert gas generation from air by carbon molecular sieves.

UNIT 3 **[9 Hrs]**

Liquid-Liquid Extraction
Ternary liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, x – y co – ordinates and solvent free basis.
Continuous countercurrent extraction with reflux, total reflux, stage efficiency, continuous contact extraction in packed towers, HTU and NTU concept, types of extractors – stage type and differential type.

UNIT 4 **[9 Hrs]**

Adsorption and Ion Exchange
Adsorption – Basic Principle and Equilibria in adsorption. Single gases and vapors – Adsorption of liquids. Types of adsorption – Physical and Chemical Adsorption Isotherms- Langmuir and Freundlich. Introduction to pressure Swing Adsorption (PSA), and Temperature Swing Adsorption (TSA).

Equipments: Continuous Contact: steady state –moving bed Adsorbers. Ion Exchange-Principles of Ion Exchange, Techniques and applications, Equilibria and rate of ion exchange, equipments.

UNIT 5 [9 Hrs]

Solid – Liquid Extraction (Leaching)
Leaching equipment – continuous counter current leaching, ideal stage equilibrium, operating time, constant and variable underflow, number of ideal stages, stage efficiencies. Calculation of single stage and multistage leaching processes.

UNIT 6 [9 Hrs]

Crystallization
Principle rate of crystal growth, population balance and size distribution, calacultion of yield, enthalpy balances, equipment.

Practical
Any eight practical to be conducted out of the following:

1. Simple Distillation
2. Total Reflux
3. Steam Distillation
4. Equilibrium Diagram for Liquid – Liquid Extraction
5. Characterization of Spray Extraction Column
6. York Schibel Column
7. Distillation using Sieve Plate, Bubble Cap Column
8. Batch/ Continuous Leaching
9. Process of Crystallization and its Characteristics
10. Batch Crystallization
11. Ion Exchange

Term work will be based on the conduct of above practical.

Text Books

1. Treybal R.E. “Mass Transfer Operation”
2. Richardson J. F. and Coulson J.M. “ Chemical Engineering”, Vol. I , II
3. Smith B.D., “ Design of Equilibrium Stage Process”.

Reference Books

1. Foust A.S., “ Principles of Unit Operations”
2. Henley E. J. and Seader H.K. “Stage wise Process Design” , McGraw Hill
3. McCabe and Smith, “ Unit Operations in Chemical Engineering”
4. King C. J. “ Separation Processes”, McGraw Hill

T. E. Sem (II)
316286: Computational Techniques and Process Modeling

Teaching Scheme: **Exam. Scheme:**
Lectures: 3 hrs/week **Theory: 100 Marks**

UNIT 1 **[8 Hrs]**

Systems of linear equation using eigen values and eigen vector, multiple ODE, Sylvester formulae, Gauss Siedel method.

UNIT 2 **[10 Hrs]**

Statistical Data Analysis
Least square method, curve fitting and Regression (linear and polynomial).
Numerical Analysis
Newton Raphson Method, Euler's and modified Euler's method, 2^{nd} and 4^{th} order Runge Kutta Method, Trapezoidal rule, Simpson's 1/3 rule and Simpson's 3/8 rule.

UNIT 3 **[8 Hrs]**

Numerical Analysis
Finite difference method (finite element volumes)

UNIT 4 **[10 Hrs]**

Introduction to Modeling
Introduction, definition of Modeling and simulation, different types of models, application of mathematical modeling, scope of coverage.

(3 Lectures)
Fundamental laws
Continuity equation, energy equation, equation of motion, transport equation, equation of state, phase and chemical equilibrium, chemical kinetics.
Heat Transfer and Other Equipments

Heat exchangers, evaporators, agitated vessels, pressure change equipments, mixing process, fluid – solid operations

UNIT 5 **[8 Hrs]**

Mass Transfer Equipments

Flash distillation, differential distillation, continuous binary distillation in tray and packed column, vaporizers, single phase and multiphase separation, multi-component separation, drying equipments, adsorption, absorbers and strippers.

UNIT 6 **[8 Hrs]**

Model of unlimited growth, modeling a continuous culture, substrate limited growth in chemostat, theory of fed-batch culture control with application for baker's yeast production, modeling of ethanol fermentation in a batch large scale bioreactor, modeling of suspended growth reactors, activated sludge systems and attached growth reactors, agitated and sparged bioreactor, tower-aerobic and anaerobic.

Text Books

1. Numerical method for Engineers with software and programming application By - Steven C Chopra and Reynolds P Canale
2. Bailey, J. and Ollis, D. (1986), Biochemical engineering Fundamentals (2^{nd} edition) McGraw Hill Kogakusha ltd. Tokyo.

Reference Books

1. Dunn, I.J., et al., (1992) Biological engineering Principles, Applications and Simulation, VCH, Weinheim.

316287: Seminar

Teaching Scheme: **Exam Scheme:**
Practical: 2 hr/week **Term Work: 50 Marks**

The mini project may be a review of literature of specific phenomena/new process. Working model to demonstrate the principal, alternatively a small experimentation to investigate bioprocess engineering data/unit process/ unit operation.
Based on this study focused report should be submitted.