UNIVERSITY OF KERALA

B. TECH. DEGREE COURSE

(2013 SCHEME)

SYLLABUS FOR

III SEMESTER

BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING

SCHEME -2013

III 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				
13.301	Engineering Mathematics-II (ABCEFHMNPRSTU)	4	3	1	-	50	3	100	150
13.302	Humanities (BEFMRSU)	3	3	-	-	50	3	100	150
13.303	Bioprocess Calculations (B)	5	3	2	-	50	3	100	150
13.304	Microbial Biochemistry (B)	4	3	1	-	50	3	100	150
13.305	Microbiology (B)	4	3	1	-	50	3	100	150
13.306	Principles of Momentum Transfer (B)	5	3	2	-	50	3	100	150
13.307	Biochemistry Laboratory (B)	2	-	-	2	50	3	100	150
13.308	Microbiology Laboratory (B)	2	-	-	2	50	3	100	150
	Total	**29**	**18**	**7**	**4**	**400**		**800**	**1200**

13.301 ENGINEERING MATHEMATICS - II (ABCEFHMNPRSTU)

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

Course Objective:

This course provides students a basic understanding of vector calculus, Fourier series and Fourier transforms which are very useful in many engineering fields. Partial differential equations and its applications are also introduced as a part of this course.

Module – I

Vector differentiation and integration: Scalar and vector functions-differentiation of vector functions-velocity and acceleration - scalar and vector fields - vector differential operator-Gradient-Physical interpretation of gradient - directional derivative – divergence - curl - identities involving ∇ (no proof) - irrotational and solenoidal fields - scalar potential.

Vector integration: Line, surface and volume integrals. Green's theorem in plane. Stoke's theorem and Gauss divergence theorem (no proof).

Module – II

Fourier series: Fourier series of periodic functions. Dirichlet's condition for convergence. Odd and even functions. Half range expansions.

Fourier Transforms: Fourier integral theorem (no proof) –Complex form of Fourier integrals-Fourier integral representation of a function- Fourier transforms – Fourier sine and cosine transforms, inverse Fourier transforms, properties.

Module – III

Partial differential equations: Formation of PDE. Solution by direct integration. Solution of Langrage's Linear equation. Nonlinear equations - Charpit method. Homogeneous PDE with constant coefficients.

Module – IV

Applications of Partial differential equations: Solution by separation of variables. One dimensional Wave and Heat equations (Derivation and solutions by separation of variables). Steady state condition in one dimensional heat equation. Boundary Value problems in one dimensional Wave and Heat Equations.

References:

1. Kreyszig E., *Advanced Engineering Mathematics*, 9/e, Wiley India, 2013.
2. Grewal B. S., *Higher Engineering Mathematics*, 13/e, Khanna Publications, 2012.

3. Ramana B. V., *Higher Engineering Mathematics*, Tata McGraw Hill, 2007.
4. Greenberg M. D., *Advanced Engineering Mathematics*, 2/e, Pearson, 1998.
5. Bali N. P. and M. Goyal, *Engineering Mathematics*, 7/e, Laxmi Publications, India, 2012.
6. Koneru S. R., *Engineering Mathematics*, 2/e, Universities Press (India) Pvt. Ltd., 2012.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

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

20% - Regularity in the class

University Examination Pattern:

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

The question paper shall consist of 2 parts.

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

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

Course Outcome:

At the end of the course, the students will have the basic concepts of vector analysis, Fourier series, Fourier transforms and Partial differential equations which they can use later to solve problems related to engineering fields.

13. 302 HUMANITIES (BEFMRSU)

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

Course objectives:

- *To explore the way in which economic forces operate in the Indian Economy.*
- *The subject will cover analysis of sectors, dimensions of growth, investment, inflation and the role of government will also be examined.*
- *The principle aim of this subject is to provide students with some basic techniques of economic analysis to understand the economic processes with particular reference to India.*
- *To give basic concepts of book keeping and accounting*

PART I ECONOMICS (2 periods per week)

Module – I

Definition of Economics –Central Economic Problems – Choice of techniques –Production possibility curve – Opportunity Cost-Micro & Macro Economics

Meaning of Demand – Utility-Marginal Utility and Law of Diminishing Marginal Utility-Law of demand - Determinants of Demand – Changes in Demand – Market Demand—Demand, forecasting-Meaning of supply-Law of Supply- Changes in Supply-- Market Price Determination – Implications of Government Price Fixation

Production function – Law of Variable proportion – Returns to scale – Iso-quants and Isocost line- Least cost combination of inputs – Cost concepts – Private cost and Social Cost -

Short run and Long run cost- cost curves – Revenue – Marginal, Average and Total Revenue-Break even Analysis

Module – II

National Income concepts - GNP – GDP – NNP– Per Capita Income – Measurement of National Income-Output method- Income method and Expenditure method -Sectoral Contribution to GDP– Money-Static and Dynamic Functions of Money-Inflation – causes of inflation – measures to control inflation – Demand Pull inflation – cost push inflation – Effects of Inflation – Deflation.

Global Economic Crisis India's Economic crisis in 1991 – New economic policy – Liberalization – Privatization and Globalization-Multinational Corporations and their impacts on the Indian Economy- Foreign Direct Investment (FDI) Performance of India-Issues and Concerns. Industrial sector in India – Role of Industrialization -Industrial Policy Resolutions-Industry wise analysis – Electronics – Chemical – Automobile – Information Technology.

Environment and Development – Basic Issues – Sustainable Development- Environmental Accounting – Growth versus Environment – The Global Environmental Issues- Poverty- Magnitude of Poverty in India- -Poverty and Environment

PART-II- ACCOUNTANCY (1 Period per week)

Module – III

Book-Keeping and Accountancy- Elements of Double Entry- Book –Keeping-rules for journalizing-Ledger accounts-Cash book- Banking transactions- Trial Balance- Method of Balancing accounts-the journal proper(simple problems).

Final accounts: Preparation of trading and profit and loss Account- Balance sheet (with simple problems) - Introduction to accounting packages (Description only).

References

1. Dewett K. K., *Modern Economic Theory,* S Chand and Co. Ltd., New Delhi, 2002.
2. Todaro M., *Economic Development*, Addison Wesley Longman Ltd., 1994.
3. Sharma M. K., *Business Environment in India,* Commonwealth Publishers, 2011.
4. Mithani D. M., *Money, Banking, International Trade and Public Finance*, Himalaya Publishing House, New Delhi, 2012.
5. Dutt R. and K.P.M. Sundaran*, Indian Economy,* S. Chand and Co. Ltd., New Delhi, 2002.
6. Varian H. R., *Intermediate Micro Economics,* W W Norton & Co. Inc., 2011
7. Koutsoyiannis A., *Modern Micro-economics,* MacMillan, 2003.
8. Batliboi J. R., *Double Entry Book-Keeping,* Standard Accountancy Publ. Ltd., Bombay, 1989.
9. Chandrasekharan Nair K.G., *A Systematic approach to Accounting*, Chand Books, Trivandrum, 2010.

Internal Continuous Assessment *(Maximum Marks-50)*

50% - Tests (minimum 2)

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

20% - Regularity in the class

University Examination Pattern:

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

The question paper shall consist of 2 parts. Part I and Part II to be answered in separate answer books.

Part I Economics *(70 marks) – Part I shall consist of 2 parts.*

Part A (20 Marks) - Two short answer questions of 10 marks each, covering entire syllabus. All questions are compulsory. (10x2=20marks)

Part B (50 marks) - Candidates have to answer one full question out of the two from Part I (Module I and Module II). Each question carries 25 marks.

Part II Accountancy *(30 marks)*

Candidates have to answer two full questions out of the three from Part II (Module III). Each question carries 15 marks.

Course outcome:

- *The students will be acquainted with its basic concepts, terminology, principles and assumptions of Economics.*
- *It will help students for optimum or best use of resources of the country*
- *It helps students to use the understanding of Economics of daily life*
- *The students will get acquainted with the basics of book keeping and accounting*

13.303 BIOPROCESS CALCULATIONS (B)

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

Course objectives:

This course is aimed at preparing students for making analysis of chemical and biochemical processes through calculations and also to develop in them a systematic approach towards solution of problems involved in the design, development and analysis of process engineering systems.

Module – I

Fundamentals of material balances: Law of conservation of mass, types of material balance problems - total and component balances, steady and unsteady state processes, batch and continuous processes. Concept of tie element, basis for calculations, independent material balance equations and degrees of freedom, steps for solving material balance problems – simple numerical examples.

Material balances without chemical reactions: Material balances for unit operations like evaporation, crystallization, drying, leaching, adsorption, extraction, absorption and distillation. Bypass, recycle and purging operations – simple numerical examples.

Module – II

Material balances with chemical reactions: Definition of terms like limiting reactant, excess reactant, percentage yield and selectivity, extent of reaction- simple numerical examples. Combustion of solid, liquid and gaseous fuels, heating value of fuels, proximate and ultimate analysis of coal, Orsat analysis. Material balance problems for combustion, oxidation, chlorination, nitration, hydrogenation and related processes. Recycle and purge involving chemical reactions – simple numerical examples.

Fundamentals of energy balances: Law of conservation of energy, components of energy balance equations- Heat and work, kinetic energy, potential energy and flow energy, internal energy and enthalpy. Heat capacities- mean heat capacity, heat capacity of gas mixtures. Prediction of heat capacity of solids and liquids, enthalpy change of phase changes- estimation of heat of fusion and vaporization. Steam tables, heat of mixing, enthalpy- composition diagrams. Energy balance in cyclic processes, energy balance for flow and non- flow processes- simple numerical examples.

Module – III

Material and energy balances for sterilization, industrial fermentation, downstream processing and waste treatment processes- simple numerical examples and case studies.

Module – IV

Stoichiometry of cell growth and product formation: Overall growth stoichiometry- medium formulation and yield factors, elemental material balances for growth, electron

balances, product formation stoichiometry, theoretical oxygen demand and maximum possible yield – simple numerical examples.

Thermodynamics of microbial growth and product formation: Heat of reaction with and without oxygen as principal electron acceptor, metabolic energy stoichiometry- heat generation and yield factor estimates, photosynthesis stoichiometry, energy balance equations for cell cultures- simple numerical examples.

References:

1. Felder R. M. and R. W. Rousseau, *Elementary Principles of Chemical Processes*, 3/e, John Wiley and Sons, 2000.
2. Narayanan K. V. and B. Lakshmikutty, *Stoichiometry and Process Calculations*, Prentice Hall of India, 2006.
3. Bhatt B. I. and S. M. Vora, *Stoichiometry*, 4/e, Tata McGraw Hill, 2004.
4. Doran P. M., *Bioprocess Engineering Principles*, 2/e, Elsevier- Academic Press, 2013.
5. Bailey J. M. and D. F. Ollis, *Biochemical Engineering Fundamentals*, 2/e, McGraw Hill, 1986.

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 70 % numerical problems. There could be numerical problems in part A also.

Course Outcome:

Upon successful completion of this course, the students shall acquire a basic understanding of the basic calculations in process engineering, which shall facilitate them in performing a detailed analysis of process engineering systems for application in various industrial situations.

13.304 MICROBIAL BIOCHEMISTRY (B)

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

Course Objectives:

This course is aimed at providing an insight into the biochemical foundations of Biotechnology, with emphasis on microbial systems. The course shall be offered in a sufficiently advanced perspective, in the backdrop of the existing knowledge of basic Biochemistry, acquired from the elementary course on basic Biochemical engineering and Biotechnology offered in the first year.

Module – I

General features of the cell, organelles and macromolecular assemblies; Biochemistry of water. Review of acid/base chemistry; importance of buffers in cellular homeostasis and mechanism of pH regulation; Henderson – Hasselbalch equation.

Biomolecules: Role of carbohydrates, proteins, lipids and nucleic acids in cellular functions. Chemical Properties and reactions of carbohydrates, proteins, lipids and nucleic acids.

Module – II

Biomolecules structure and function: Carbohydrates- simple sugars and polysaccharides, complex polymers and glycoproteins; fatty acids structure and chemistry, complex lipids, cholesterol, steroids; amino acids- protein building blocks, structure, nomenclature, ploynucleotides- DNA, RNA and their primary and secondary , tertiary structure, chemical synthesis, replication of DNA.

Enzymes: Concepts of ligand- enzyme binding interactions, classification, reaction rates, activation energy; inhibition and allostery.

Module – III

Overview of metabolism: cellular energy requirement for vital functions, energy conversions, photosynthesis and ATP, food chain, vitamins and co- factors; techniques used in the study of metabolism.

Mechanism involved in DNA replication and transcription, RNA processing, translational events in protein synthesis; Glycolysis and TCA cycle- glycolysis reactions, TCA cycle and glyoxalate cycle, mitochondrial shuttles. Electron transport chain, chemiosmotic coupling, mitochondrial metabolism, Photosynthesis.

Module – IV

Glyconeogenesis- Urea cycle, amino acid degradative pathways; biosynthetic pathways of amino acids in microorganisms. Fatty acid metabolism- β oxidation pathway, ketone bodies,

biosynthesis of fatty acids. Control of metabolism- biosynthetic and catabolic perspectives. Control of level of glucose in blood, hormonal integration of metabolism, signal transduction cascades – an introduction to regulatory mechanisms, genetic disorders of metabolism.

References:

1. Lehninger A. L., D. L. Nelson and M. M. Cox, *Principles of Biochemistry*, Palgrave MacMillan, 2002.
2. Stryer L., J. M. Berg and J. L. Tymoczko, *Biochemistry*, 5/e, W.H. Freeman and Co., 2002.
3. Zubay G., *Biochemistry*, 4/e, McGraw Hill Publishers, 1999.

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 the course, the students shall be fully aware of the biochemistry of microbial systems. This knowledge shall enable them in understanding key aspects of microbial metabolism, which is essential to the design and development of microbe - based bioprocess systems, particularly fermentation processes.

13.305 MICROBIOLOGY (B)

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

Course Objectives:

This course is a pre-requisite for gaining a fundamental understanding of microbe-based bioprocess systems. This course shall equip the students in applying their knowledge of microorganisms to a variety of bioprocess situations, in all realms of human endeavour.

Module – I

Historical Perspective: Discovery of microbial world; Landmark discoveries relevant to the field of microbiology; controversy over spontaneous generation- Scope and relevance of microbiology. Role of microorganisms in transformation of organic matter and in the causation of diseases.

Study of microbial structure:

Microscopic techniques: light microscopy, dark field microscopy, phase contrast microscopy, fluorescence microscopy, SEM, TEM, newer techniques: confocal microscopy, scanning probe microscopy.

Staining techniques: cell staining-simple staining, gram staining, and acid fast staining; staining of specific structures.

Eukaryotic and prokaryotic cell structure and function: size, shape and arrangement, cell membranes, cell organelles, cell walls, components external to cell walls. Microbial chemotaxis, mechanisms of solute transport across cell membranes.

Microbial taxonomy: Evolution and diversity of microorganisms, taxonomic ranks, classification systems, assessment of microbial phylogeny. Bacteria, archea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification, viroids and prions.

Microbial nutrition and cultivation: Nutrition of microorganisms; nutritional classes of microbes, Macro and micronutrients, sources and physiological functions of nutrients. Growth factors and their functions in metabolism.

Cultivation of microorganisms: Culture media- synthetic, complex media, solidifying agents, types of media - selective, differential and enrichment media, pure culture methods - spread plate, pour plate and streak plate, special techniques for cultivation of anaerobes.

Module – II

Microbial Growth: Definition of growth; growth curve; mathematical expression of exponential growth phase; measurement of growth and growth yields; synchronous growth;

continuous culture; effect of environmental factors on growth, growth in natural environments.

Microbial Metabolism: An overview of metabolism; glycolysis; Pentose-phosphate pathway; Entner-Doudoroff pathway; Glyoxalate pathway; The citric acid cycle; Fermentation; Aerobic and anaerobic respiration; Chemolithotrophy; Photosynthesis; Calvin cycle; Biosynthetic pathway for fatty acids synthesis; Common regulatory mechanisms in synthesis of amino acids; Regulation of major metabolic pathways.

Control of microorganisms: Basic terminology- sterilization, disinfection, sanitization, antiscepsis. Patterns of microbial death, physical methods for microbial control- heat, low temperature, filtration and radiation. Use of chemical agents, evaluation of effectiveness of antimicrobial agents.

Module – III

Microbial interactions and ecology: Types of microbial interactions- mutualism, protocooperation, commensalisms, predation, parasitism, amensalism, competition, symbiosis. Biogeochemical cycles:- cycles of nitrogen, carbon, sulphur and manganese.

Microorganisms in aquatic environments: microbial community in marine and fresh water environments, microbiological analysis of water purity-sanitary tests for coliforms (presumptive test, confirmed test, competed test), MPN test, defined substrate test, IMVIC test. Quality standards for drinking water.

Soil microbiology: Soil as a habitat for microorganisms, physico-chemical properties of soil, microbial community in soil, role of microorganisms in organic matter decomposition.

Module – IV

Microbial Diseases and Host Pathogen Interaction: Normal microbiota; Classification of infectious diseases; Reservoirs of infection; Nosocomial infection; Emerging infectious diseases; Mechanism of microbial pathogenicity; Nonspecific defense of host; Antigens and antibodies; Humoral and cell mediated immunity; Vaccines; Immune deficiency; Human diseases caused by viruses, bacteria and pathogenic fungi.

Chemotherapy/Antibiotics: General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.

Microbiology of food: Role of microorganisms in food spoilage and contamination, food preservation methods - physical and chemical methods, food borne diseases and intoxications, examples of fermented food products.

Microorganisms as biofertilizers and biopesticides, commercially important microorganisms for industrial fermentations.

References:

1. Pelczar M. J., E. C. E. Chan and N. R. Krieg, *Microbiology*, Tata McGraw Hill, 1993.
2. Ingraham J. L. and C. A. lingraham, *Introduction to Micro Biology A Case History Approach,* 3/e, Thomson Publications, 2003.
3. Brock, *Biology of Microorganism*, Prentice Hall, International Inc, 2005.
4. Schlegel H. G., *General Microbiology*, Cambridge University Press, 1993.

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 gain a detailed insight into the implications of microorganisms in various domains. Knowledge acquired herein shall find limitless applications in design and development of systems involved in the upstream and bioreaction stages of integrated industrial bioprocesses.

13.306 PRINCIPLES OF MOMENTUM TRANSFER (B)

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

Course Objectives:

This course shall serve as a prefatory for two fundamental unit operations namely, fluid flow and mechanical operations, which find limitless applications in process engineering. The subject shall be offered with reasonable emphasis on the applications of momentum transfer, in the backdrop of existing basic theory.

Module – I

Introduction: Concept of Continuum- Definition of fluid, ideal fluid , real fluid ; Fluid properties-density - specific weight - specific volume, specific gravity, viscosity, kinematic viscosity; measurement of viscosity; compressibility, surface tension, capillarity, absolute and gauge pressures.

Fluid Statics: Pascal's Law, Basic equation of fluid statics, hydrostatic law, hydrostatic equilibrium, barometric equation, Continuous gravity decanter - Centrifugal decanter - measurement of pressure using barometer, manometer – simple and differential, mechanical gauges; Pressure at a point in compressible fluid, Temperature at any point in compressible fluid, temperature lapse rate. Buoyancy and floatation- Centre of buoyancy, Metacentre, Metacentric height, Stability of floating and submerged bodies.

Introduction to fluid flow: Flow field, classification of flow- steady and unsteady flow, uniform and non uniform flow, one two and three dimensional flow, rotational and irrotational flow, adiabatic flow, streamline, streak line, path line, stream tube, stream function velocity potential; Potential flow. Rheology of fluids - Shear rate and shear stresses, Newtonian and non-Newtonian fluids, Time dependent flow, momentum flux, Reynolds's experiment, turbulent flow, turbulence, nature of turbulence.

Equations of change for isothermal systems: Equation of continuity, equations of motion - Navier-Stokes equation, Euler's equation , Bernoulli equation, kinetic energy correction factors - correction in Bernoulli equation for fluid friction, Friction head loss for changes in velocity, direction and due to pipe fittings.

Shear stress and velocity distribution in circular channel- The friction factor - Hagen-Poiseuille equation, Frictional loss in non circular conduits- Hydraulic radius and equivalent diameter.

Shell momentum balance for falling film, laminar flow of non-Newtonian fluids – Velocity distribution for turbulent flow. The friction factor chart.

Flow in boundary layers, wake formation, boundary layer thickness and boundary layer conditions in laminar flow- Blasius solution, boundary layer thickness and boundary layer conditions in transition and turbulent flow.

Module – II

Transportation fluids: Pipes and pipe standards, tubings, Pipe joints - flanges - expansion joints, valves-pressure relieving devices- safety and relief valves, accessories for safety relieving valves – materials of construction. (***Qualitative study only***)

Pumps - Reciprocating pumps, centrifugal pumps, centrifugal pump theory - selection of centrifugal pumps - various types, head Vs. flow rate - characteristics of centrifugal pumps, priming - cavitation, NPSH - Water hammer -calculations involving pump characteristics – loss of head and power in centrifugal pumps – Pumps in series and parallel- materials of construction of pumps-design of pipeline systems.

Metering of fluids: The displacement and current meters - variable area meter, orifice meter, venturimeter, flow nozzles, rotameter, wiers and notches - Pitot tubes – velocity meters - anemometers, turbine flow meter, current meters, hot wire anemometer, laser doppler anemometry, flow visualization. (***Qualitative study only***)

Module – III

Flow past immersed bodies: Drag coefficient - Flow through packed bed - Ergun equation - Kozeny-Carman equation - Blake Plummer equation - Design of packed beds - Motion of particles through fluids - Motion from gravitational and centrifugal fields - Terminal settling velocity - Approximate equation - Stoke's law - Intermediate law - Newton's law – Hindered settling.

Fluidization: The phenomenon of fluidization - Liquid-like behaviour of fluidized beds - Comparison with other contacting methods - Advantages and disadvantages of fluidized beds for industrial applications - fluidization quality. Pressure drop - vacuum - flow rate diagrams, minimum fluidizing velocity, effect of pressure and temperature on fluidized bed behaviour. The expanded bed - Flow patterns in fluidized beds - Design of fluidized beds.

Agitation and mixing of liquids: Agitation equipments - Impellers, propellers, paddles, turbines, flow patterns in agitated vessels, standard turbine design, circulation, velocities and power consumption in agitated vessels - Flow number – velocity gradient and velocity patterns, power correlations, dimensionless groups, blending and mixing, mixer selection, scale-up of agitator design.

Module – IV

Particle technology: Particle size analysis - mean diameter, shape factors, derived diameter. Sieving - cumulative and differential method of size analyses. Subseive size analysis-microscopic counting, Pipette analysis, hydrometer analysis, Photo sedimentation - sedimentation balance, sedimentation and decantation - ICI sedimentation - Elutriation, Laser beam Particle size analysis, online particle analysis.

A brief overview of mechanical operations: An overall familiarity of operations like Size reduction (Comminution), Screening, Classification, Filtration, Centrifugation, Mineral beneficiation operations - Sorting, Dense media separations, Jigging, Tabling, Floatation,

magnetic Separations and high voltage separations; Gas cleaning methods- Bag filters, Cyclone separation, Electrostatic separation, Scrubbing; Storage and transportation of solids, liquid and gases.

References:

1) McCabe W. L., J. C. Smith and P. Harriott, *Unit Operations of Chemical Engineering*, 6/e, McGraw Hill, 2000.
2) Badger W. L. and J. T. Banchero, *Introduction to Chemical Engineering*, Tata McGraw Hill, 2001.
3) Allen T., Particle *Size Measurement*, Chapman and Hall, 1977.
4) Foust A. S., L. A. Wenzel, C. W. Clump, L. Maus and L.B. Andersen, *Principles of Unit Operations*, 2/e, John Wiley and Sons, 1980.
5) Gaudin A. M., *Principles Mineral Dressing*, McGraw Hill, 1980.
6) Coulson J. M and J. F Richardson, *Chemical Engineering: Fluid flow, Heat transfer and Mass transfer (Vol – I)*, 5/e, Butterworth-Heinemann, 1999.
7) Coulson J. M and J. F Richardson, *Chemical Engineering: Particle technology and Separation processes (Vol – II),* 5/e, Butterworth-Heinemann, 1999.
8) Perry R. H. and D.W. Green, Eds., *Perry's Chemical Engineer's Handbook*, 7/e, McGraw Hill, 1997.

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 70 % numerical problems. There could be numerical problems in part A also.

Course outcome:

Upon successful completion of this course, the students shall be able to appreciate the applications of momentum transfer in the process engineering context. They should be able to apply the key concepts learned herein, to any specific domain of bioprocessing, where it finds relevant application.

13.307 BIOCHEMISTRY LAB (B)

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

Course Objectives:

This course is aimed at introducing the students to the basic Biochemistry lab, where they shall translate their theoretical knowledge of Biochemistry into practice. The students are expected to acquire basic skills on various basic biochemical techniques in a flawless manner, to ensure productive application of the same in any future endeavor.

Introduction:

Units, Volume/Weight measurements, concentrations units, pH. measurements. Preparation of buffers, Sensitivity, Specificity, Precision and Accuracy.

List of Experiments:

1. Qualitative tests for Carbohydrates. Estimation of Reducing sugars by the Benedict's method.
2. Qualitative tests for Amino Acids.
3. Quantitative method for Amino Acids, Ninhydrin method.
4. Protein estimation Biuret, Folin's, Spectrophotometry and Bradford Assay.
5. Acid hydrolysis of Proteins and Estimation of Amino acids by Ninhydrin, OPA PTH.
6. Extraction of lipids.
7. Saponification of Fats.
8. Phospholipids: Ashing and estimation of phosphate.
9. Estimation of cholesterol.
10. Estimation of Nucleic Acids, Precipitation by sodium sulphate, Test for ribose and deoxyribose
11. Enzyme assays: Phosphatase from potato, Amylase from sweet potato, Trypsin digestion of proteins.
12. Precision and validity in an experiment using absorption spectroscopy.
13. Validating Lambert-Beer's law using KMnO4
14. Finding the molar absorbtivity and stoichiometry of the Fe (1, 10 phenanthroline) 3 using absorption spectrometry.
15. Finding the pKa of 4-nirophenol using absorption spectroscopy.
16. UV spectra of nucleic acids.
17. Chemical actinometry using potassium ferri oxolate.
18. Estimation of SO-4 by nephelometry.

19. Estimation of AL3+ by flourimetry.
20. Limits of detection using aluminum alizarin complex.
21. Chromatography analysis using TLC.
22. Chromatography analysis using column chromatography

References:

1. Boyer R. F., *Modern Experimental Biochemistry*, Pearson education, India, 2004.
2. Ninfa A. J. and D. P. Ballou, *Fundamental Laboratory Approaches for Biochemistry and Biotechnology*, Fitzgerald Science Press Inc, USA, 1998.
3. Wilson K. and J. Walker, *Principles and Techniques of Practical Biochemistry*, Cambridge University Press, 2000.

Internal Continuous Assessment *(Maximum Marks-50)*

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

University Examination Pattern:

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

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

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

Course Outcome:

Upon successful completion of this course, the students shall have mastered the most fundamental biochemical analysis procedures, which are essential to their understanding of the Biotechnology in its true scientific perspective.

13.308 MICROBIOLOGY LAB (B)

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

Course Objectives:

This course is aimed at introducing the students to the basic Microbiology lab, where they shall translate their existing theoretical knowledge of Microbiology into practice. Basic skills on techniques for microbial isolation, quantitation and characterization, are imperative to designing and developing any microbe- based bioprocess system. The techniques shall hence be learned in a flawless manner, with skilled faculty, specialized in microbiology, being insisted for delivery of this course.

List of Experiments:

1. Introduction to principles of sterile technique and cell propagation.
2. Preparation of media and media components.
3. Identification of plant, animal and bacterial cells and their components.
4. Measurement of growth - Wet weight and dry weight measurements, extinction method of monitoring cell growth.
5. Selection and isolation of bacteria eg: Isolation of bacteria capable of degrading PAH from oil contaminated earth.
6. Isolation and characterization of bacteria from leaf tissues, leaf rot etc.
7. Testing of microbial capacity to produce biologically active substances
8. Taxonomic classification of isolated microbes
9. Long and short term storage of microbes (bacteria and fungi)
10. Isolation of fungal and plant protoplasts
11. Principles of microscopy, phase contrast and fluroscent microscopy
12. Staining: Gram, Giemsa , Trypan blue
13. Microbiological examination of water.
14. **Biochemical tests:** IMVIC test, Catalase test, Coagulase test, Gelatinase test, Oxidase test and other related tests.

References:

1. Alfred Brown, *Benson's Microbiological Applications: Laboratory Manual in General Microbiology,* McGraw Hill Publications, 2004.
2. Gunasekharan P, *Laboratory manual in Microbiology*, New Age International Publishers, 2007.
3. Cappuccino J. G. and N. Sherman, A *Laboratory Manual*, 4/e, Addison and Wesley, 1999.

Internal Continuous Assessment *(Maximum Marks-50)*

40% - Test

40% - Class work and Record

20% - Regularity in the class

University Examination Pattern:

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

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

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

Course Outcome:

Upon successful completion of this course, the students shall have acquired requisite skills on various microbiological procedures, which shall aid them in understanding microbial systems and processes. They should be able to apply this knowledge in a variety of bioprocess situations, particularly in the industrial arena.