Course No.	Course Name	L-T-P - Credits	Year of Introduction
MA201	LINEAR ALGEBRA AND COMPLEX ANALYSIS	3-1-0-4	2016

Prerequisite : Nil

Course Objectives

COURSE OBJECTIVES

- To equip the students with methods of solving a general system of linear equations.
- To familiarize them with the concept of Eigen values and diagonalization of a matrix which have many applications in Engineering.
- To understand the basic theory of functions of a complex variable and conformal Transformations**.**

Syllabus

Analyticity of complex functions-Complex differentiation-Conformal mappings-Complex integration-System of linear equations-Eigen value problem

Expected outcome .

At the end of the course students will be able to
(i) solve any given system of linear equations
(ii) find the Eigen values of a matrix and how to diagonalize a matrix
(iii) identify analytic functions and Harmonic functions.
(iv)evaluate real definite Integrals as application of Residue Theorem
(v) identify conformal mappings(vi) find regions that are mapped under certain Transformations

Text Book:

Erwin Kreyszig: Advanced Engineering Mathematics, 10th ed. Wiley

References:

1.Dennis g Zill&Patric D Shanahan-A first Course in Complex Analysis with Applications-Jones&Bartlet Publishers
2.B. S. Grewal. Higher Engineering Mathematics, Khanna Publishers, New Delhi.
3.Lipschutz, Linear Algebra,3e **(** Schaums **Series)**McGraw Hill Education India 2005
4.Complex variables introduction and applications-second edition-Mark.J.Owitz-Cambridge Publication

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	Complex differentiation Text 1[13.3,13.4] Limit, continuity and derivative of complex functions	3	
	Analytic Functions	2	
	Cauchy–Riemann Equation(Proof of sufficient condition of analyticity & C R Equations in polar form not required)-Laplace's Equation	2	
	Harmonic functions, Harmonic Conjugate	2	15%
II	Conformal mapping: Text 1[17.1-17.4] Geometry of Analytic functions Conformal Mapping,	1	
	Mapping $w = z^2$ conformality of $w = e^z$.	2	15%

	The mapping $w = z + \frac{1}{z}$ Properties of $w = \frac{1}{z}$ Circles and straight lines, extended complex plane, fixed points Special linear fractional Transformations, Cross Ratio, Cross Ratio property-Mapping of disks and half planes Conformal mapping by $w = \sin z$ & $w = \cos z$ (Assignment: Application of analytic functions in Engineering)	1 3 3	
FIRST INTERNAL EXAMINATION			
III	Complex Integration. Text 1[14.1-14.4] [15.4&16.1] Definition Complex Line Integrals, First Evaluation Method, Second Evaluation Method Cauchy's Integral Theorem(without proof), Independence of path(without proof), Cauchy's Integral Theorem for Multiply Connected Domains (without proof) Cauchy's Integral Formula- Derivatives of Analytic Functions(without proof)Application of derivative of Analytical Functions Taylor and Maclaurin series(without proof), Power series as Taylor series, Practical methods(without proof) Laurent's series (without proof)	2 2 2 2 2	15%
IV	Residue Integration Text 1 [16.2-16.4] Singularities, Zeros, Poles, Essential singularity, Zeros of analytic functions Residue Integration Method, Formulas for Residues, Several singularities inside the contour Residue Theorem. Evaluation of Real Integrals (i) Integrals of rational functions of $\sin\theta$ and $\cos\theta$ (ii)Integrals of the type $\int_{-\infty}^{\infty} f(x)dx$ (Type I, Integrals from 0 to ∞) (Assignment : Application of Complex integration in Engineering)	2 4 3	15%
SECOND INTERNAL EXAMINATION			
V	Linear system of Equations Text 1(7.3-7.5) Linear systems of Equations, Coefficient Matrix, Augmented Matrix Gauss Elimination and back substitution, Elementary row operations, Row equivalent systems, Gauss elimination-Three possible cases, Row Echelon form and Information from it.	1 5	20%

	Linear independence-rank of a matrix Vector Space-Dimension-basis-vector space$\mathbf{R^3}$ Solution of linear systems, Fundamental theorem of non-homogeneous linear systems(Without proof)-Homogeneous linear systems (Theory only	2 1	
VI	Matrix Eigen value Problem Text 1.(8.1,8.3 &8.4) Determination of Eigen values and Eigen vectors-Eigen space Symmetric, Skew Symmetric and Orthogonal matrices –simple properties (without proof) Basis of Eigen vectors- Similar matrices Diagonalization of a matrix-Quadratic forms- Principal axis theorem(without proof) (Assignment-Some applications of Eigen values(8.2))	3 2 4	20%
END SEMESTER EXAM			

QUESTION PAPER PATTERN:

Maximum Marks : 100 Exam Duration: 3 hours

The question paper will consist of 3 parts.

Part A will have 3 questions of 15 marks each uniformly covering modules I and II. Each question may have two sub questions.

Part B will have 3 questions of 15 marks each uniformly covering modules III and IV. Each question may have two sub questions.

Part C will have 3 questions of 20 marks each uniformly covering modules V and VI. Each question may have three sub questions.

Any two questions from each part have to be answered.

Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT201	**Fluid Flow and Particle Technology**	**3-1-0-4**	**2016**

Course Objectives

This course serves as a basis for two fundamental unit operations namely, fluid flow and particle technology, which find limitless applications in bioprocess engineering. The subject is offered with reasonable emphasis on the applications of fluid flow, in the backdrop of existing basic theory.

Syllabus

Properties and nature of fluids, fluid flow characteristics, flow trough pipe, transportation and metering of fluids, flow past immersed bodies, Particle technology, describing the size of a single and populations of particles, particle size analysis, particle size reduction, solid-solid and solid-liquid separations, storage and transport of solids.

Expected outcome

Upon successful completion of this course, the students should be able to

- Apply fluid properties to analyze and solve fluid mechanics problems.
- Apply key concepts of fluid flow, to any specific domain of bioprocessing.
- Understand the principles of flow measurement and transportation of fluids.
- Understand and apply the basic methods of characterization of particles and bulk solids
- Analyze solid-solid and solid-liquid separation processes

Reference Books

1. McCabe W. L., J. C. Smith and P. Harriott, *Unit Operations of Chemical Engineering*, 6/e, McGraw Hill, 2000.
2. Martin J. Rhodes, *Introduction to Particle Technology*, 2/e, John Wiley & Sons, 2008.
3. Coulson J. M and J. F Richardson, *Chemical Engineering: Fluid flow, Heat transfer and Mass transfer (Vol - I)*, 5/e, Butterworth-Heinemann, 1999.
4. Coulson J. M and J. F Richardson, *Chemical Engineering: Particle technology and Separation processes (Vol - II)*, 5/e, Butterworth-Heinemann, 1999.
5. Perry R. H. and D.W. Green, Eds., *Perry's Chemical Engineer's Handbook*, 7/e, McGraw Hill, 1997.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Properties and nature of fluids** - Ideal fluid, Real fluid, Density, Specific weight, Specific Volume, Capillarity and Surface Tension, Viscosity, Vapour pressure, Absolute and Gauge Pressures. Fluid Statics - Forces on fluids and hydrostatic equilibrium, Measurement of Pressure using different types of manometers. Forces on submerged bodies - Buoyancy, Stability of floating and submerged bodies.	8	15%

II	**Introduction to fluid flow**- Flow of incompressible fluids- Classification of flow - Steady and unsteady state flow, uniform and non-uniform flow, Stream line, Streak line, Path line, Stream tube, Velocity Potential - Laminar and Turbulent flow - Reynold's Experiment. Equations of Change for isothermal systems - Equation of Continuity, Equation of Motion - Navier Stoke's Equation and Euler equation (derivations not required). Newtonian and non- Newtonian fluids - Momentum flux and Newton's Law of Viscosity. Flow in boundary layers - Boundary layer separation and Wake formation.	8	15%
	FIRST INTERNAL EXAM		
III	**Flow through pipe** - Bernoulli Equation, Correction factors in Bernoulli Equation, Pump work – Numerical problems, Shear stress and Velocity distribution in circular channel. Hagen-Poiseuille Equation, Laminar flow of non-Newtonian fluids, Velocity distribution for turbulent flow, The friction factor chart, Fanning Equation- Numerical problems.	8	15%
IV	**Transportation and Metering of Fluids** - Pipes and tubes, Pipe joints, Valves – Materials of construction, Pumps- Reciprocating and Centrifugal pumps, Characteristics of centrifugal pumps - Priming, Cavitation, NPSH, Water hammer, Loss of head and power in centrifugal pumps, Characteristic curves. Flow measurement - Orifice meter, Venturi meter, Rotameter, Pitot tube, Weirs and notches, velocity meters	8	15%
	SECOND INTERNAL EXAM		
V	**Flow past immersed bodies**- Drag coefficient - Flow through packed bed - Kozney Carman equation, Blake Plummer equation and Ergun equation. Motion of Particles through fluids - Motion from gravitational and Centrifugal fields - Terminal Settling velocity, Stoke's law- Intermediate law - Newton's law – Hindered Settling. Fluidization - Advantages and disadvantages, Applications, Minimum Fluidization velocity, Pressure drop-flow rate diagrams. Types of fluidization.	12	20%
VI	**Particle technology** – Describing the size of a single particle- Shape factor, mean diameter, Description of populations of particles, Particle size analysis-methods of particle size measurement-Sieving, microscopy, sedimentation, permeametry, electrozone sensing, laser diffraction, ICI sedimentation, Photosedimentation, Elutriation, common methods of displaying size distribution-Arithmetic and Log-normal distributions. Particle size reduction – particle fracture mechanisms, models for predicting energy requirements and particle size distribution, types of size reduction equipments,	12	20%

	factors affecting choice of equipments. Particle size enlargement - interparticle forces, granulation, equipments for granulation. Solid-liquid separation-Filtration and centrifugation, Sedimentation and Decantation, flocculation, Solid-solid separation - screening, air classification (theory only). Storage and transportation of bulk solids - Different methods and types of conveyors.		
END SEMESTER EXAMINATION			

EVALUATION SCHEME

- **INTERNAL EVALUATION:**
  Two internal tests each of 20 marks and of one hour duration.
  Two assignments each of 10 marks
- **EXTERNAL EVALUATION:**
  Maximum Marks : 100 Exam Duration: 3 hours

QUESTION PAPER PATTERN:

The question paper consists of Part A, Part B and Part C.

Part A consists of 8 compulsory questions, one question each from module 1 to 4 and two questions each from Modules 5 to 6, (8×3=24 marks).

Part B is of 40 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (8×5=40 marks).

Part C is of 36 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (6×6=36 marks)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT203	**Concepts in Biochemical Engineering**	**4-0-0-4**	**2016**

Course Objectives

This course introduces students to contemporary Chemical engineering principles associated with biological processing in order to develop a conceptual understanding of industrial bioprocessing.

Syllabus

Introduction to Biological concepts, structure and functions of various types of cells, cell polymeric chemicals and their building blocks, biochemical aspects of cell growth and product synthesis, enzymes as biological catalysts, bioreactors and modes of bioreactor operation, monitoring bioprocesses.

Expected outcome

On successful completion of this course, students should be able to:

- Appreciate the use of microorganisms and enzymes in biological processing.
- Know different types of metabolites and how they are formed.
- Understand the principles behind batch, fed batch and continuous systems.
- Understand different types of bioreactors and their working.
- Understand common bioprocess parameters and monitor them.

Reference Books

1. James E Bailey, David F Ollis, *Biochemical Engineering Fundamentals*, 2/e, McGraw-Hill Chemical Engineering Series, 1986.
2. Michael L Shuler, Fikret Kargi, *Bioprocess Engineering Basic Concepts*, Second Edition, Prentice Hall International PTR, 2002.
3. Pauline M Doran, *Bioprocess Engineering Principles*, Academic Press, 1995.
4. D G Rao, *Introduction to Biochemical Engineering*, Tata McGraw-Hill Education, 2005.
5. Mukesh Doble, Sathyanarayanan N Gummadi, *Biochemical Engineering*, PHI Learning Pvt. Ltd., 2007.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
I	**Biological concepts** - Microbial world, important cell types, animal and plant cells, structure of cells, cell fractionation, cycles of life, Cell polymeric chemicals, their structure and their functions, repetitive and non-repetitive biological polymers, hybrid biochemicals such as cell envelopes, antibody and other glycoproteins, the hierarchy of cellular organisation.	8	15%
II	**Cell growth and product synthesis** - Nutritional requirements, metabolism and bioenergetics, batch growth, growth patterns and kinetics in batch culture, effect of environmental conditions on cell growth and product	10	15%

	synthesis, Carbon catabolism - EMP pathway and other biochemical reaction networks, Respiration - TCA Cycle, Respiratory chain, Photosynthesis-light harvesting, End products of metabolism, Substrate and product inhibition on cell growth and product formation, Maintenance, Patterns of substrate flow in cells synthesising products.		
FIRST INTERNAL EXAM			
III	**Enzymes as biocatalysts** – similarities and differences between enzyme biocatalysts and chemical catalysts, Nomenclature and classification of enzymes. Chemical nature and properties of enzymes. Theory of enzyme action, Co-factors and co-enzymes. Substrate activation and inhibition, enzyme deactivation, Simple enzyme kinetics, Applications of enzymes in industrial, pharmaceutical and analytical sectors with examples, advantages and disadvantages of enzyme-based production processes. Enzyme immobilisation.	10	15%
IV	**Bioprocessing basics** - intracellular and extracellular products, growth associated and non-growth associated products, yield coefficient and maintenance coefficient, Bioprocessing using animal and plant cells, Modes of bioreactor operation - batch bioreactor, simple batch data analysis, Disadvantages of batch bioreactor, Continuous bioreactor, advantages of continuous bioreactor, Fed-batch, continuous with cell recycle, perfusion culture, Photobioreactors, applications.	10	15%
SECOND INTERNAL EXAM			
V	**Bioreactors** - Basic functions of a bioreactor, Bioreactors vs chemical reactors, Basic bioreactor configurations, keys to bioreactor selection, Component parts of a fermenter and their functions, Basic design aspects of a stirred tank fermenter, Aerobic fermentation processes, Oxygen demand in fermentations, factors affecting oxygen demand, Oxygen supply, Balance between oxygen demand and supply, role of aeration and mixing in oxygen transfer, mechanism of mixing, radial and axial flow impellers, flow patterns in an unbaffled stirred tank, flow patterns for radial flow and axial flow impellers in baffled stirred tanks, impeller selection.	10	20%
VI	**Bioprocesses monitoring** - common bioprocess parameters monitored or controlled, measurement of inlet gas flow rates, agitation rates, temperature, pH/redox, dissolved O_2 and CO_2, reactor head space pressure, measurement of cell mass and common metabolites, metabolic state variables of the cells, respiratory quotient, on-line and off-line measurements, ion-specific sensors, biosensors - Enzyme and Microbial Electrodes.	10	20%
END SEMESTER EXAMINATION			

EVALUATION SCHEME

- **INTERNAL EVALUATION:**
  Two internal tests each of 20 marks and of one hour duration.
  Two assignments each of 10 marks
- **EXTERNAL EVALUATION:**
  Maximum Marks : 100 Exam Duration: 3 hours

QUESTION PAPER PATTERN:

The question paper consists of Part A, Part B and Part C.

Part A consists of 8 compulsory questions, one question each from module 1 to 4 and two questions each from Modules 5 to 6, (8×3=24 marks).

Part B is of 40 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (8×5=40 marks).

Part C is of 36 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (6×6=36 marks)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT205	**Bioprocess Calculations**	**3-1-0-4**	**2016**

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.

Syllabus

Fundamentals of Material Balances – Material Balances with chemical reactions – Material Balances without chemical reactions – Material and energy balances for sterilization, industrial fermentation, downstream processing and waste treatment processes - Fundamentals of Energy Balances – Stoichiometry of cell growth and product formation – thermodynamics of microbial growth and product formation

Expected Outcomes

Upon successful completion of this course, the students should be able to

- Solve basic calculations in bioprocess engineering.
- Carry out material and energy balances for various unit operations.
- Calculate percentage yield, selectivity, and extent of reaction.
- Formulate growth medium based on stoichiometry and elemental balances.
- Calculate heat of reaction for microbial growth and product formation.

Reference Books

1. K.V. Narayanan, B. Lakshmikutty, *Stoichiometry and Process Calculations*, Prentice Hall of India, 2006.
2. David M. Himmelblau, James B. Riggs, *Basic Principles and Calculations in Chemical Engineering*, Prentice Hall, 2012.
3. B.I. Bhatt, S.M. Vora, *Stoichiometry*, Fourth edition, Tata McGraw Hill, 2004.
4. P.M. Doran, *Bioprocess Engineering Principles,* 2/e, Elsevier- Academic Press, 2013.
5. R.M. Felder, R. W. Rousseau, *Elementary Principles of Chemical Processes*, 3/e, John Wiley and Sons, 2000.

Course Plan

Module	Contents	Hours	Sem. Exam Marks
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.	7	15%
II	**Material balances without chemical reactions:** Material balances for unit operations like evaporation, crystallization, drying, leaching, adsorption, extraction,	8	15%

	absorption and distillation. Bypass, recycle and purging operations – simple numerical examples.		
FIRST INTERNAL EXAM			
III	**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. Recycle and purge involving chemical reactions – Simple Numerical examples	10	15%
IV	**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. Energy balance in cyclic processes, energy balance for flow and non- flow processes- simple numerical examples.	7	15%
SECOND INTERNAL EXAM			
V	Material and energy balances for sterilization, industrial fermentation, downstream processing and waste treatment processes - simple numerical examples and case studies.	10	20%
VI	**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 - simple numerical examples.	10	20%
END SEMESTER EXAM			

EVALUATION SCHEME

- **INTERNAL EVALUATION:**
  Two internal tests each of 20 marks and of one hour duration.
  Two assignments each of 10 marks
- **EXTERNAL EVALUATION:**
  Maximum Marks : 100 Exam Duration: 3 hours

QUESTION PAPER PATTERN:

The question paper consists of Part A, Part B and Part C.

Part A consists of 8 compulsory questions, one question each from module 1 to 4 and two questions each from Modules 5 to 6, (8×3=24 marks).

Part B is of 40 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (8×5=40 marks).

Part C is of 36 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (6×6=36 marks)

Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT207	**Microbiology**	**3-0-0-3**	**2016**

Course Objectives

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

Syllabus

Historical aspects and the landmark discoveries of microbiology; microscopy and staining techniques. Eukaryotic and prokaryotic cell structure and function; microbial taxonomy; classification systems, Microbial nutrition and cultivation, Microbial growth and control of microorganisms. Microbial interactions and ecology; microorganisms in different environments- aquatic and soil. Application of microbiology.

Expected outcome

Upon successful completion of this course, the students should be able to

- Identify and characterize the major groups of microorganisms.
- Understand basic techniques for visualization, cultivation and identification of a variety of microorganisms.
- Distinguish among viral, prokaryotic and eukaryotic structure, organization, metabolism and environmental needs.
- Relate the role of microbial interactions with ecology and applications.

Reference Books

1. Prescott, Harley and Klein, *Microbiology*, McGraw Hill International Edition, 2008.
2. Pelczar M. J., E. C. E. Chan and N. R. Krieg, *Microbiology*, Tata McGraw Hill, 1993.
3. Ingraham J. L. and C. A. lngraham, *Introduction to Micro Biology A Case History Approach*, 3/e, Thomson Publications, 2003.
4. Brock, *Biology of Microorganism*, Prentice Hall, International Inc, 2005.
5. Schlegel H. G., *General Microbiology*, Cambridge University Press, 1993.

Course Plan			
Module	Contents	Hours	Sem. Exam Marks
I	**Historical perspectives:** 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 biotransformation. **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.	8	15%

II	**Study of microbial structure** **Eukaryotic and prokaryotic cell structure and function:** size, shape and arrangement, cell membranes, cell organelles, cell walls, component 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, archaea and their broad classification; Eukaryotic microbes: Yeasts, molds and protozoa; viruses and their classification, viroids and prions.	7	15%
FIRST INTERNAL EXAM			
III	**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.	8	15%
IV	**Microbial Growth**: Definition of growth; growth curve; mathematical expression of exponential growth phase; measurement of growth and growth yields; synchronous growth; effect of environmental factors on growth, growth in natural environments. **Control of microorganisms**: Basic terminology- sterilization, disinfection, sanitization, antisepsis. 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.	8	15%
SECOND INTERNAL EXAM			
V	**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	9	20%

	soil, role of microorganisms in organic matter decomposition.		
VI	**Application of microbiology**: Food microbiology- 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. Industrial microbiology- Microorganisms as biofertilizers and biopesticides, commercially important microorganisms for industrial fermentation.	5	20%
END SEMESTER EXAMINATION			

EVALUATION SCHEME

- **INTERNAL EVALUATION:**
  Two internal tests each of 20 marks and of one hour duration.
  Two assignments each of 10 marks
- **EXTERNAL EVALUATION:**
  Maximum Marks : 100 Exam Duration: 3 hours

QUESTION PAPER PATTERN:

The question paper consists of Part A, Part B and Part C.

Part A consists of 8 compulsory questions, one question each from module 1 to 4 and two questions each from Modules 5 to 6, (8×3=24 marks).

Part B is of 40 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (8×5=40 marks).

Part C is of 36 marks (question selection: at least one question from each module and not more than two question from any module). The student has to answer one question from each module, (6×6=36 marks)

Course Number	Course Name	L-T-P	Credits	Year of introduction
HS200	**Business Economics**	**3-0-0**	**3**	**2016**

Course Objectives

- To familiarize the prospective engineers with elementary Principles of Economics and Managerial Economics;.
- To acquaint the students with tools and techniques that are useful in their profession in Managerial Decision Making which will enhance their employability;
- To gain understanding of some Macroeconomic concepts to improve their ability to understand the business climate;
- To prepare and understand balance sheet at an elementary level.

Syllabus

Nature of economics. Demand and Supply Analysis, demand curve, supply curve and equilibrium price determination. Production economics, economies of Scale, optimal quantity determination, Production and Cost functions, the law of Diminishing Marginal Productivity, Costs, Break-Even Analysis Chart Preparation and Cost-Volume-Profit Analysis. Market Structure and Price-Output Decisions under various competition situations and Collusion/Cartel formations in the real life situation. Monetary theory, functions of RBI and NI. Computation and some aspects of macro economics. Capital Budgeting decisions, forecasting techniques and elementary Balance Sheet..

Expected Outcome

A student who has undergone this course

- *would be able to make investment decisions based on capital budgeting methods in alignment with microeconomic and macroeconomic theories.*
- *would be able to analyse the profitability of the firm, economy of operation, determination of price under various market situations with good grasp on the effect of trade cycles in business.*
- *would gain knowledge on Monetary theory, measures by RBI in controlling interest rate and emerging concepts like Bit Coin.*
- *would gain knowledge of elementary accounting concepts used for preparing balance sheet and interpretation of balance sheet*

Course Plan			
Unit	**Topics**	**Hours Allotted**	**Percentage Marks**
I	**Nature of Economics** Definitions of Economics and their limitations, Economic Problems (2 Hrs.), Economic Systems, meaning of Business or Managerial Economics (2 Hrs.)and its role and relevance in managerial decision making in an industrial setting (2 Hrs).	6	15%
II	**Demand and Supply Analysis** Demand Curve, Demand function (2 Hrs.), Elasticity of demand and its estimation (2 Hrs.), Supply curve, equilibrium price and price mechanism (2 Hrs).	6	15%
FIRST INTERNAL EXAM			
III	**Production Economics** Economies of Scale and Diseconomies of Scale (1 Hr.), Production and Cost Functions. Factors of Production (2 Hrs.), Law of Diminishing marginal Productivity. Construction and analysis of Break Even Charts (3 Hrs.)	6	15%
IV	**Market Structure and Price-Output Decisions** Price and output determination under Perfect Competition, Monopoly and Monopolistic Competition (3 Hrs.). Collusion and Cartel, Nash Equilibrium (3 Hrs.).	6	15%
SECOND INTERNAL EXAM			
V	**Money, National Income and Taxation** Money, Emerging Bit Coin concept, Quantity Theory of Money, Interest Rate Management (2 Hrs), Open Market Operations by RBI, Selective Credit Controls, SLR, CRR (2 Hrs), Definition & Measurement of National Income, methods, sectors of economy (3 Hrs), inflation, deflation, trade cycles- Value-Added Tax (2 Hrs).	9	20%
VI	**Investment Decisions and Balance Sheet Analysis** Capital Budgeting, Investment Analysis – NPV, IRR, Profitability Index, ARR, Payback Period (3 Hrs), Depreciation, Time value of money. Business Forecasting– Elementary techniques (2 Hrs). Balance sheet preparation principles and interpretation (4 Hrs)	9	20%
END SEMESTER EXAM			

Text Book

Yogesh, Maheswari, *Management Economics* , PHI learning, NewDelhi, 2012

References

1. Dornbusch, Fischer and Startz, Macroeconomics, McGraw Hill, 11th edition, 2010.
2. Khan M Y, Indian Financial System, Tata McGraw Hill, 7th edition, 2011.
3. Samuelson, Managerial Economics, 6th edition, Wiley
4. Snyder C and Nicholson W, Fundamentals of Microeconomics, Cengage Learning (India), 2010.
5. Truett, Managerial Economics: Analysis, Problems, Cases, 8th Edition, Wiley Welch, Economics: Theory and Practice 7th Edition, Wiley

Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT231	**Microbiology Laboratory**	**0-0-3-1**	**2016**

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. It includes preparing stained smears, culturing microorganisms, conducting immunology experiments, performing tests to identify bacteria and fungi, and studying microbial growth control methods.

Syllabus

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 e.g.: Isolation of bacteria capable of degrading PAH from oil contaminated earth.
6. Isolation and characterization of bacteria from leaf tissues, leaf rot etc.
7. Differential and selective media
8. Testing of microbial capacity to produce biologically active substances
9. Taxonomic classification of isolated microbes
10. Long and short term storage of microbes (bacteria and fungi)
11. Isolation of fungal and plant protoplasts
12. Principles of microscopy, phase contrast and fluorescent microscopy
13. Haemocytometer
14. Staining: Gram, Giemsa , Trypan blue
15. Microbiological examination of water.
16. **Biochemical tests:** IMVIC test, Catalase test, Coagulase test, Gelatinase test, Oxidase test and other related tests.

Expected outcome

Upon successful completion of this course, students should be able to

- Carry out routine and specialized microbiological tests applicable to biotechnology.
- Identify plant, animal and bacterial cells and their components.
- Prepare suitable medium for growth of bacteria.
- Isolate and characterize bacteria.
- Measure growth of bacteria.
- Carry out biochemical tests to identify microorganism.
- Demonstrate competency in microbiological laboratory safety.

Reference Books

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.

END SEMESTER EXAMINATION

EVALUATION SCHEME

Practicals are internally evaluated by continuous assessment as per the following criteria.

Practical records /Outputs - 60 marks

Regular class Viva - 10 marks

Final written test/quiz - 30 marks

Course Code	Course Name	L-T-P-Credits	Year of Introduction
BT233	**Fluid Flow and Particle Technology Laboratory**	**0-0-3-1**	**2016**

Course Objectives

This course aims to introduce the students to practice experiments studied in fluid flow and particle technology theory paper. Industrial applicability of various techniques of fluid flow operations in process engineering shall be explicated with significant emphasis on individual hands on experimentation.

Syllabus

1. Study of measurement of pressure
2. Study on factors influencing viscosity of process fluids
3. Reynold's Experiment
4. Determination of drag coefficient and verification of Stoke's law.
5. Estimation of pressure drop for flow through packed bed.
6. Determination of venture coefficient/ orifice coefficient.
7. Particle size analysis by Sieve analysis.
8. Sub sieve particle size analysis using Beaker decantation.
9. Sub sieve particle size analysis using Pipette Analysis.
10. Studies on flocculation- Analysis of orthokinetic and perikinetic aggregation.
11. Batch settling test to determine area of a continuous thickener.
12. Use of viscometers for measurement of viscosity of process fluids.
13. Estimation of various parameters for agitation of liquids.
14. Estimation of pressure drop for flow through fluidized bed.
15. Calibration of Rotameter for liquid flows.
16. Determination of velocity profile using Pitot tube.

Expected outcome

Upon successful completion of this course, the students should be able to

- Study the effect of factors influencing viscosity of process fluids.
- Determination of drag coefficient and verification of Stoke's law.
- Analyse particle size by sieving, beaker decantation and pipette analysis.
- Carry out batch settling test to determine area of a continuous thickener.
- Estimation of pressure drop for flow through packed bed and fluidized bed.
- Calibrate rotameter for liquid flows.

Reference Books

1. McCabe W. L., J. C. Smith and P. Harriott, *Unit Operations of Chemical Engineering*, 6/e, McGraw Hill, 2000.
2. Martin J. Rhodes, *Introduction to Particle Technology*, 2/e, John Wiley & Sons, 2008.
3. Coulson J. M and J. F Richardson, *Chemical Engineering: Fluid flow, Heat transfer and Mass transfer (Vol - I)*, 5/e, Butterworth-Heinemann, 1999.
4. Coulson J. M and J. F Richardson, *Chemical Engineering: Particle technology and Separation processes (Vol - II)*, 5/e, Butterworth-Heinemann, 1999.
5. Perry R. H. and D.W. Green, Eds., *Perry's Chemical Engineer's Handbook*, 7/e, McGraw Hill, 1997.

END SEMESTER EXAMINATION

EVALUATION SCHEME

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