UNIVERSITY OF KERALA

B. TECH. DEGREE COURSE

(2013 SCHEME)

SYLLABUS FOR

III SEMESTER

BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING
### SCHEME -2013

#### III SEMESTER

**BIOTECHNOLOGY & BIOCHEMICAL ENGINEERING (B)**

<table>
<thead>
<tr>
<th>Course No</th>
<th>Name of subject</th>
<th>Credits</th>
<th>Weekly load, hours</th>
<th>C A Marks</th>
<th>Exam Duration Hrs</th>
<th>U E Max Marks</th>
<th>Total Marks</th>
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<tbody>
<tr>
<td>13.301</td>
<td>Engineering Mathematics-II (ABCEFHMNPRSTU)</td>
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<tr>
<td>13.302</td>
<td>Humanities (BEFMRSU)</td>
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<tr>
<td>13.303</td>
<td>Bioprocess Calculations (B)</td>
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<td>13.304</td>
<td>Microbial Biochemistry (B)</td>
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<td>13.305</td>
<td>Microbiology (B)</td>
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<td>13.306</td>
<td>Principles of Momentum Transfer (B)</td>
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<td>13.307</td>
<td>Biochemistry Laboratory (B)</td>
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<td>13.308</td>
<td>Microbiology Laboratory (B)</td>
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<td><strong>800</strong></td>
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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


Module – II


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


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:


**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.
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


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


PART-II- ACCOUNTANCY (1 Period per week)

Module – III


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

References


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
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


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:**


**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.


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, polynucleotides- 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 allosterery.

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,

References:


**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, 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.

**Module – III**

**Microbial interactions and ecology:** Types of microbial interactions- mutualism, protocoooperation, 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:


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:

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.
4. Protein estimation Biuret, Folin’s, Spectrophotometry and Bradford Assay.
5. Acid hydrolysis of Proteins and Estimation of Amino acids by Ninhydrin, OPA PTH.
7. Saponification of Fats.
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-niropheonol using absorption spectroscopy.
16. UV spectra of nucleic acids.
17. Chemical actinometry using potassium ferri oxalate.
18. Estimation of SO-4 by nephelometry.
20. Limits of detection using aluminum alizarin complex.
21. Chromatography analysis using TLC.
22. Chromatography analysis using column chromatography

References:

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.
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:

**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.*