ANNEXURE-II

**TBE-201: MATERIAL & ENERGY BALANCE**

| L | T | P | C |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

**Course objectives:** The objective of the course is to impart:

- The knowledge of principles of material and energy balances applied during unit operation in food processing
- The knowledge of designing and optimizing the process in food technology

**Course outcomes**

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Understand the basic of engineering principles for the calculation of material and energy balance | Understanding |
| CO2 | Apply material and component balance in unit operation of food processing | Apply |
| CO3 | Understand fluid flow required to perform material balance in mechanical and rheological operations of food materials | Understanding |
| CO4 | Apply energy balance for the calculation of thermal and freezing load in unit operation of food processing | Apply |
| CO5 | Understand material and energy balance simultaneously during analysis for multicomponent systems | Understanding |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | 1 | - | - | - | 1 | - | - | - | - | - | 1 | 2 | 2 |
| CO2 | 2 | 1 | 1 | 1 | - | 1 | 1 | - | - | - | - | 2 | 3 | 3 |
| CO3 | 2 | - | - | - | - | - | 1 | - | - | - | - | 1 | 1 | 1 |
| CO4 | 2 | 1 | - | - | - | 1 | 1 | - | - | - | - | 2 | 2 | 2 |

| CO5 | 2 | 1 | - | - | - | 1 | 1 | - | - | - | - | 2 | 2 | 2 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Average** | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 2 | 2 |

1: Slight (Low)          2: Moderate (Medium)          3: Substantial (High)
*If there is no correlation, put "-"*

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

- Review of basic Engineering mathematics
- Basics of unit and dimensions
- Fundamental of material and energy balance
- Stress-strain behavior in materials
- Fundamentals of fluid flow

**Course Outcome 2 (CO2)**

- Basics of material and component balance
- Material balance in unit operation
- Problems related to material balance in food processing

**Course Outcome 3 (CO3)**

- Fundamentals of fluid flow study in food processing
- Mass balance continuity equation
- Newtonian and Non-Newtonian Fluids power law equation
- Calculation of Energy losses and Pressure drops in flow systems

**Course Outcome 4 (CO4)**

- Energy balance in food operations
- Enthalpy Changes in Foods during Freezing
- Application of Humidity and psychrometric chart in food processing
- Properties of Saturated and Superheated Steam

**Course Outcome 5 (CO5)**

- Understanding simultaneous Material and Energy Balances
- Material and energy balance during analysis for multicomponent systems
- Unsteady State Material and Energy Balances

# Syllabus

### Module-I: Introduction to material & Energy Balance

Review of basic engineering mathematics; units and dimensions; material and energy balance. Principles of Fluid Flow - Introduction to stress strain behavior in materials; properties of fluid viscosity; capillary tube viscometer; power law equation for pseudo plastic; Newtonian and dilatant fluids; flow in pipes-friction, laminar and turbulent flow equations, considerations in pumping fluid.

### Module-II: Material Balance

Basic Principles: Law of Conservation of Mass, Process Flow Diagrams, System Boundaries, Total Mass Balance, Component Mass Balance, Material Balance Problems Involved in Dilution, Concentration, and Dehydration, Steady State, Volume Changes on Mixing, Batch versus Continuous processing, Blending of Food Ingredients, Total Mass and Component Balances, Use of Specified Constraints in Equations, Problems related to material balance in food processing.

### Module-III: Fluid-Flow Theory

Introduction, Fluid statics, fluid pressure, absolute pressures, gauge pressures, head, Fluid dynamics, Mass balance continuity equation; Energy balance; Potential energy; Kinetic energy; Pressure energy; Friction loss; Mechanical energy; Other effects; Bernouilli's equation flow from a nozzle; Viscosity shear forces viscous forces; Newtonian and Non-Newtonian Fluids power law equation; Streamline and turbulent flow; dimensionless ratios;        Reynolds number; Energy losses in flow; Friction in Pipes Fanning equation Hagen Poiseuille equation; Blasius equation; pipe roughness; Moody graph; Energy Losses in Bends and Fittings; Pressure Drop through Equipment; Equivalent Lengths of Pipe; Compressibility Effects for Gases; Calculation of Pressure Drops in Flow Systems

### Module-IV: Energy balance

General Principles, Energy Terms, Heat Content, Enthalpy, Specific Heat of Solids and Liquids, Enthalpy Changes in Foods during Freezing, Freezing Point Depression by Solutes, Sensible Heat of Water and Ice at Temperatures Below the Freezing Point, Total Enthalpy Change, Specific Heats of Gases and Vapours. Humidity and psychrometric chart, Energy balance calculations in humidification and adiabatic cooling. Steam table, Properties of Saturated and Superheated Steam

### Module-V: Analysis of Material and Energy Balance

Simultaneous Material and Energy Balances: Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems, Unsteady State Material and Energy Balances: Transient materials and energy balances involving with and without chemical reactions.

**Reference Books and Suggested Readings:**

| Title | Authors |
|---|---|
| Fundamentals of Food Process Engineering; 2nd ed, 2000, CBS Publishers | Toledo RT; |
| Fundamentals of Food Process Engineering | D.R.Heldman and R.P.Singh |
| Basic Principles and Calculations in Chemical Engineering | David Himmelblau; Printice Hall of India |
| Chemical process Principles, Material and Energy Balances, 2$^{nd}$ Edition, New Age International. | Hougen,O.A., Watson, K.M., and Ragatz, R.A. |

**TBE-203 FLUID FLOW & UNIT OPERATIONS**

| L | T | P | C |
|---|---|---|---|
| 3 | 1 | 2 | 5 |

**Course objectives: The objective of this course is to impart**

- Knowledge of various fluid properties and their measurement.
- Knowledge of different types flow and flow behavior during flow of fluid through pipes.
- Knowledge of varius losses occurs during fluid flow.

| CO1 | Understand the concept of viscosity and other fluid properties and their measurement. | Understanding |
|---|---|---|
| CO2 | Differentiate various types of fluid flows and understand the types of motion. | Understanding |
| CO3 | Understand and apply differential balance of fluid flow to solve the problems related to fluid flow. | applying |
| CO4 | Understand the concept of energy losses during fluid flow in a pipe. | Understanding |
| CO5 | Understand the principle involved in various unit operations. | Understanding |
| CO6 | Conduct various experiments to apply the concepts of fluid mechanics and unit operations. | Analyzing |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** |
| **CO1** | 2 | 1 | - | - | - | - | - | - | - | 1 | - | 1 | 1 | 1 |
| **CO2** | 2 | 1 | 1 | 1 | - | 1 | - | - | - | - | - | 1 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | - | 1 | 1 | - | - | 1 | - | 1 | 3 | 3 |
| **CO4** | 3 | 1 | 1 | 1 | - | 1 | 1 | - | - | - | - | 1 | 2 | 2 |
| **CO5** | 3 | 2 | 1 | 1 | - | - | - | - | - | - | - | 2 | 3 | 3 |
| **CO6** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 3 | 3 |
| **Average** | **3** | **1.5** | **1.4** | **1.5** | **1** | **1** | **1** | **1** | **3** | **1** | **1** | **1.33** | **2.33** | **2.33** |

1: Slight (Low)        2: Moderate (Medium)        3: Substantial (High)        *If there is no correlation, put "-"*

# Syllabus

**Module I: Introduction and properties of fluids**

Introduction to fluids, properties of fluids: viscosity, thermodynamic properties, compressibility, Surface tension and Capillarity, Vapour pressure and cavitation, Pressure and it's measurement; fluid pressure at a point, pressure variation in a fluid at rest, simple manometers and differential manometers, hydrostatic forces on submerged surfaces, buoyancy and floatation.

**Module II: Kinematics of fluid flow**

Introduction, methods of describing fluid flow, types of fluid flow; steady and unsteady; uniform and non-uniform, laminar and turbulent, rotational and irrotational, Rate of flow or discharge, continuity equation, velocity potential and flow net, types of motion and voricity.

**Module III: Dynamics of fluid flow**

Conservation laws, Euler's equation of motion, Bernoulli's equation, applications of Bernoulli's equation, viscous flow, Raleigh's method and Buckingham's π theorem, types of similarities, dimensional analysis, dimensionless numbers**. Flow Measurements and pumps**: Orifice and venturi meter, Pitot tube, Rotameter and other flow measuring instruments, Positive displacement and centrifugal pumps.

**Module IV: Flow through pipes, orifices and flow over dub-merged objects**

**Internal flow:** laminar and turbulent flow in pipes, general equation for head loss – Darcy- Weisbach and Fanning's equations, Moody's diagram, energy losses through pipe fittings, flow through network of pipes. **Boundary layer flows-**Introduction, Prandtl's boundary layer equation and Boundary layer separation. Flow around submerged bodies: Drag force, lift and drag coefficient, drag on flat plate circular cylinder and sphere.

**Module V: Unit operations**

Different types of screening equipment in industries, Screen efficiency, **Filtration:** Governing equations, constant pressure operation, constant flow operation, cycle time, types of filters. **Centrifuges and Cyclones**: Gravity settling, centrifugal separation, cyclone separations, separation efficiency, pressure

loss, **Size reduction -** Rittingers Law, Kicks law, Bondscrushing law, Work index, Problems, Classification of size reduction equipment : Crushers, Grinders, Ultra-fine grinders, Cutting machines, Problems.

**Module VI: Laboratory experiments**

Determine coefficient of discharge of an orifice meter, venturimeter, determine the friction factor for the pipes, verify the Bernoulli's Theorem, find critical Reynolds number for a Pipe flow, determine the meta-centric height of a floating body, determine the minor losses due to sudden enlargement, sudden contraction and bends.

**Reference Books and Suggested Readings:**

| Title | Authors |
|---|---|
| A textbook of fluid mechanics and hydraulic machines. Laxmi publications | Bansal, R. K. (2004) |
| Unit Operations of Chemical Engineering: McGraw Hill | McCabe and Smith |

## Course Title : MICROBIOLOGY

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-205 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**

The objective of this course is to enable the students to understand importance of microorganisms in Biochemical Engineering to acquaintance them with scope and basic techniques of microbiology.

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Understand difference between bacteria, yeast and molds on the basis of their morphology, physiology and microscopic enumeration. | Apply |
|---|---|---|
| CO2 | Understand growth curve, growth kinetics and continuous cultures. | Apply |
| CO3 | Hands on Isolation and maintenance of pure cultures and quantitative estimation of growth. | Apply |
| CO4 | Know various physical and chemical methods for control of microorganisms. Various infectious diseases and Vaccines. | Apply |
| CO5 | Understand occurrence of microorganisms in soil, water, air and food. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | | | | | | | 1 | | | | 1 | 3 | 3 |
| CO2 | 1 | 2 | 2 | 2 | | 2 | | | | | | 1 | 3 | 3 |
| CO3 | 1 | 2 | | 3 | | | 2 | | | | | 1 | 3 | 3 |
| CO4 | 3 | 2 | | | | | | 1 | | | | 1 | 3 | 3 |
| CO5 | 3 | 2 | 2 | 2 | | | | 1 | | | | 1 | 3 | 3 |
| Total | 2 | 2 | 2 | 2 | | 2 | | | 2 | | | 1 | 3 | 3 |

1: Slight (Low)  2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS
### UNIT-I
Microbiology and its scope, landmark discoveries relevant to field of microbiology, microscopy, classification, morphology and physiology of bacteria, yeast, molds, algae and virus. Microscopic observation of bacteria, yeast and mould, Phase contrast and electron microscopy Gram staining, counting of cells (both direct and indirect), growth curve, MPN.

### UNIT-II
Microbial growth kinetics, growth curve, diauxic growth factors influencing growth, continuous and synchronous culture, Microbial nutrition and reproduction.

**UNIT-III**
Pure culture techniques – microbial culture media, isolation, identification and maintenance of cultures, characteristics of pure culture, enumeration techniques.

**UNIT-IV**
Physical and chemical method of control of microorganisms,classification of infectious diseases caused by bacteria,viruses,fungi, immune response, antigen-antibody interaction. Pathogen-host interaction ,Vaccines.

**UNIT-V**
Microbial ecology, occourence of microorganism in soil . water, air, food and sewage , food spoilage, food borne infections and food poisoning.Antibiotics classification and their mode of action.

**Reference-**
1. " Microbiology '' by M.J. Pelezar , Jr. E.C.S. Chan and N.R. Krieg, 5th Ed., TMH Book Company.
2 " Foundation in Microbiology'', Kathleen Talaro & Arthur Talaro , W.C.B.Wm.C. Brown Publishers (1994)
3.Prescott's Microbiology By Joanne Willey and Linda Sherwood and Christopher J. Woolverton

## Course Title :  MICROBIOLOGY LAB

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional  Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-207 | 2 | 0 | 0 | 4 | - | 20 | 30 | 50 | 50 | 100 |

**Experiments:**

1.  Study of parts of compound microscope and its handling.

2.  Preparation of liquid culture media for bacterial growth

3.  Preparation of agar plate and agar slants.

4.  To isolate the micro-organism by streake plate method.

5.  To isolate the micro-organism by pour plate method.

6.  To isolate the micro-organism by spread plate technique.

7.  To isolate the micro-organism by serial dilution technique.

8.  To identify Gram positive and gram negative bacteria.

9.  Measurement of cells/spores by counting chamber ( haemocytometer procedure)

**TBE-202: HEAT TRANSFER OPERATIONS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course objectives:** The objective of the course is to impart:

- Basic understanding of the phenomena of heat transfer, to develop methodologies for solving a wide variety of practical application in food processing
- Useful information concerning the performance and design of particular heat transfer systems like heat exchanger and processes used in food processing operations.

**Course outcomes**

On the successful completion of the course, students will be able to

| | | |
|---|---|---|
| CO1 | Understand the basic of engineering principles of heat transfer and their significance in practical applications | Understanding |
| CO2 | Apply steady state heat conduction with heat generation like heat flow through slab, hollow sphere and cylinder with linear heat transfer, including uniform/non-uniform heat generation | Apply |
| CO3 | Understand unsteady state heat conduction and convection widely used in thermal processing of food materials | Understanding |
| CO4 | Apply mechanism of radiation heat transfer in systems used for advanced food processing operations including solar radiation | Apply |
| CO5 | Understand the concept of heat exchanger and application of different types of heat exchangers used in dairy and food processing industry | Understanding |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|-----|---|---|---|---|---|---|---|---|---|----|----|----|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** |
| **CO1** | 1 | 1 | - | - | - | 2 | - | - | - | - | - | 1 | 2 | 2 |
| **CO2** | 2 | 1 | 1 | 1 | - | 1 | 1 | - | - | - | - | 2 | 3 | 3 |
| **CO3** | 2 | - | - | - | - | - | 1 | - | - | - | - | 2 | 1 | 1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO4** | 2 | 1 | - | - | - | 2 | 1 | - | - | - | - | 2 | 2 | 2 |
| **CO5** | 2 | 2 | - | - | - | 1 | 1 | - | - | - | - | 2 | 1 | 2 |
| **Average** | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 3 | 1 | 1 | 2 | 2 | 2 |

1: Slight (Low)        2: Moderate (Medium)        3: Substantial (High)        *If there is no correlation, put "-"*

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

- Knowledge about basic heat transfer modes
- Basics of food properties measurements and errors
- Fundamental of conduction as heat transfer
- heat transfer through materials

**Course Outcome 2 (CO2)**

- concept of steady state heat conduction with heat generation
- temperature distribution with different boundary conditions
- Understanding extended surfaces (fins) of uniform area
- Effectiveness and efficiency of the fins used in food processing

**Course Outcome 3 (CO3)**

- Fundamentals of unsteady state heat conduction
- Concept of system with negligible internal resistance in various geometries
- Understanding convection heat transfer and film coefficient
- Calculation of Energy losses and Pressure drops in flow systems

**Course Outcome 4 (CO4)**

- Energy balance in food operations
- Enthalpy Changes in Foods during Freezing
- Application of Humidity and psychrometric chart in food processing
- Properties of Saturated and Superheated Steam

**Course Outcome 5 (CO5)**

- Understanding simultaneous Material and Energy Balances
- Material and energy balance during analysis for multicomponent systems
- Unsteady State Material and Energy Balances

# Syllabus

### Module-I: Introduction to Heat Transfer

Basic heat transfer processes, heat transfer coefficients, properties related to heat transfer, food properties measurements and errors; One-dimensional steady state conduction: Theory of heat conduction, Fourier's law and its derivation, Concept of electrical analogy and its application for thermal circuits, heat transfer through composite walls and insulated pipelines

### Module-II: Steady State Heat Conduction with Heat Generation & Dissipation

One-dimensional steady state heat conduction with heat generation: Heat flow through slab, hollow sphere and cylinder with linear heat transfer, uniform/non-uniform heat generation, development of equations of temperature distribution with different boundary conditions; Steady-state heat conduction with heat dissipation to environment: Introduction to extended surfaces (fins) of uniform area of cross-section and with Equation of temperature distribution with different boundary conditions; Effectiveness and efficiency of the fins

### Module-III: Unsteady State Heat Transfer and Convection

Introduction to unsteady state heat conduction: System with negligible internal resistance and in various geometries; Convection: Forced and free convection, use of dimensional analysis for correlating variables affecting convection heat transfer; Newton's Law of cooling, film coefficient, and correlation of dimensionless number, Combined free and forced convection; Dimensionless numbers: Concept of Nusselt number, Prandtl number, Reynolds number, Grashoff number, some important empirical relations used for determination of heat transfer coefficient; Heisler charts and calculations

### Module-IV: Heat Transfer by Radiation

Radiation: Heat radiation, emissivity, absorptivity, transmissivity, radiation through black and grey surfaces, determination of shape factors; Radiation: Stefan –Boltzmann law, emissivity, mechanism of radiation heat transfer in systems including solar radiation, collectors. Heat transfer analysis involving conduction, convection and radiation

### Module-V: Heat Exchanger & Application

Heat Exchangers: General discussion, fouling factors, jacketed kettles, LMTD, parallel and counter flow heat exchangers, Overall heat transfer coefficient, fouling factors, log mean temperature difference heat exchange mechanism in various types of heat exchangers, e.g. Tubular, extended surface and plate heat exchangers, effectiveness – NTU relationship; Application of different types of heat exchangers in dairy and food industry

**Reference Books and Suggested Readings:**

- Eduardo Cao. 2010. Heat Transfer in Process Engineering. The McGraw-Hill Companies, Inc., New York, USA.
- J.P. Holman. 2010. Heat Transfer, 10th Ed. McGraw-Hill Book Co., Boston, USA.
- Don W. Green and Robert H. Perry. 2008. Perry's Chemical Engineers' Handbook. McGraw-Hill Co., Inc., NY, USA.
- R. K. Rajput. 2008. Heat and Mass Transfer. S. Chand and Co., New Delhi
- John H. Lienhard IV and John H. Lienhard V. 2008. A Heat Transfer Textbook. Phlogiston Press, Cambrige, MA, USA.
- Warren L. McCabe, Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th Ed. McGraw-Hill, Inc., NY, USA.
- Christie John Geankoplis. 2003. Transport Processes and Separation Process Principles, 4th Ed. Prentice-Hall, NY, USA.
- J, M. Coulson, J. F. Richardson, J. R. Backhurst and J. H. Harker. 1999. Coulson & Richardson's Chemical Engineering, Vol. 1, Fluid Flow, Heat Transfer and Mass Transfer, 6th Ed. Butterworth–Heinemann, Oxford, UK.

**TBE 204: CHEMICAL ENGINEERING THERMODYNAMICS**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course objectives:**

- To understand the theory and applications of classical thermodynamics, thermodynamic properties, equations of state, methods used to describe and predict phase equilibria.

**Course outcomes**

On the successful completion of the course, students will be able to

| CO1 | Understand the basic of thermodynamics and the terminology associated with engineering thermodynamics. | Understanding |
|-----|----|----|
| CO2 | Understand the knowledge of contemporary issues related to chemical engineering thermodynamics | Understanding |
| CO3 | Understand and apply the knowledge of phase equilibria in two-component and multicomponent systems. | Understanding |
| CO4 | Understand the thermodynamic properties of substances in gas or liquid state of ideal and real mixture | Understanding |
| CO5 | Apply the knowledge of various thermodynamic cycles | Applying |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|-----|---|---|---|---|---|---|---|---|---|----|----|----|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 2 | 1 | 1 | - | - | 1 | 1 | - | - | - | - | 1 | 3 | 3 |
| CO2 | 3 | 2 | 1 | - | - | 1 | 1 | - | - | - | - | 2 | 2 | 2 |
| CO3 | 3 | 1 | - | - | - | 2 | 1 | - | - | - | - | 2 | 3 | 3 |
| CO4 | 2 | 1 | - | - | - | 2 | 1 | - | - | - | - | 2 | 3 | 3 |
| CO5 | 3 | 2 | 1 | 1 | - | 1 | 1 | - | - | - | - | 2 | 3 | 3 |
| CO6 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 3 | 3 |
| Average | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 3 | 3 |

1: Slight (Low)     2: Moderate (Medium)     3: Substantial (High)     ss     *If there is no correlation, put "-"*

# Syllabus

**Module 1**

Basic Concepts & First Law of Thermodynamics: Scope of thermodynamics, System & Surroundings, Properties -Force, Temperature & pressure, Equilibrium, Processes- Reversible & Irreversible, Work, Heat, Energy, Phase rule, Joule's Experiment, Internal energy, Enthalpy, Heat capacities, Application of first law to closed & open systems. Volumetric properties of pure fluids: PVT behavior of pure substances, Virial equation of state and its application, ideal gas and cubic equation of state, Generalized correlations for gases and liquids.

**Module 2**

Second Law of Thermodynamics: Heat engine and its efficiency, Heat pump, Refrigerator, COP, Second law of Thermodynamics, Kelvin–Planck statement & Clausius Statement, Carnot's cycle and Carnot theorems, Clausius inequality, Entropy balance for open systems, ideal work and lost work, Principle of entropy.

**Module 3**

Thermodynamic properties of pure substances in solid, liquid and vapor phases; P-vT behaviour of simple compressible substances, phase rule, thermodynamic property tables and charts, ideal and real gases, ideal gas equation of state and van der Waals equation of state; law of corresponding states, compressibility factor and generalized compressibility chart, T-ds relations, Helmholtz and Gibbs functions, Gibbs relations, Maxwell relations, Joule-Thomson coefficient, coefficient of volume expansion, adiabatic and isothermal compressibilities, Clapeyron and Clapeyron-Clausius equations.

**Module 4**

Dalton's and Amagat's laws, properties of ideal gas mixtures, air-water vapor mixtures and simple thermodynamic processes involving them; specific and relative humidities, dew point and wet bulb temperature, adiabatic saturation temperature, psychrometric chart.

**Module 5**

Carnot vapor cycle, ideal Rankine cycle, Rankine reheat cycle, air-standard Otto cycle, air-standard Diesel cycle, air-standard Brayton cycle, vapor-compression refrigeration cycle.

**Reference**

1. "Introduction to Chemical Engineering Thermodynamics" by J.M. Smith and H.C. Van Ness,
2. McGraw Hill International Ltd, 2005.
   "Chemical Engineering Thermodynamics" by Y.V.C. Rao, Universities Press (India) Ltd.

## Course Title: BIOCHEMISTRY

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-206 | 5 | 3 | 1 | 3 | 15 | 20 | 15 | 50 | 50 | 100 |

**Objective:- :** Biochemistry focuses on understanding the biochemical control of biological processes, particularly in the microbial cell, and the tools for investigating these mechanisms.

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Understand the polymeric biomolecules and their monomeric building blocks. | **Apply** |
|---|---|---|
| CO2 | Know the specificity of enzymes (biochemical catalysts), and the mechanism involved in enzyme action. | **Apply** |
| CO3 | Understand the metabolism of glucose, leads ultimately to the generation of large quantities of ATP. Describe the metabolism of fats and amino acids, and explain their role for energy generation. Describe the replication of DNA, and explain the transfer of genetic information | **Apply** |
| CO4 | Understand Concept of protein metabolism. | **Apply** |
| CO5 | Understand Concept of Nucleic acid biosynthesis | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | | | 2 | | 2 | 2 | | | | | 1 | 2 | 3 |
| CO2 | 1 | | | 2 | | 2 | 2 | | | | | 1 | 2 | 3 |
| CO3 | 1 | 3 | | 2 | | 2 | 2 | | | | | 1 | 2 | 3 |
| CO4 | 1 | 3 | | 2 | | 2 | 2 | | | | | 1 | 2 | 3 |
| CO5 | 1 | 3 | | 2 | | 2 | 2 | | | | | 1 | 2 | 3 |
| CO6 | 1 | 3 | | 2 | | 2 | 2 | | | | | 1 | 2 | 3 |
| Total | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |

1: Slight (Low)          2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## Syllabus

**Unit 1:** Introduction-aims and scope. Structure and function of biomolecules: carbohydrates, proteins, lipids, nucleic acids, vitamins and coenzymes.

**Unit 2:** Structure and function of enzymes, mechanism of enzymatic catalysis and enzyme kinetics.

**Unit 3:** Biological membranes and transport across them. Bioenergetics. Metabolic

pathways for breakdown of carbohydrates-glycolysis, pentose phosphate pathway, citric acid cycle, electron transport chain, Photophosphorylation. Lipid metabolism. Nucleic acid metabolism: mechanism and biosynthesis of DNA and RNA.

**Unit 4:** Protein metabolism; out lines of amino acid metabolism. Protein biosynthesis, inhibitors of protein synthesis.

**Unit 5:** Biochemistry Lab
1        Estimation of carbohydrates.
2.       Estimation of proteins.
3.       Estimation of nucleic acids:
4.       Separation of amino acids by paper chromatography.
5.       Thin layer Chromatography.
6.       Assay of enzyme activity and enzyme kinetics.

**References:**
1.       "Principles of Biochemistry", A.L. Lehninger, D.L. Neston, N.M. Cox, CBS
          Publishers & Distributors.
2.       "Biochemistry", Lubert Stryer, W.H. Freemen & Co. , New York.
3.       "General Biochemistry", J.H. Weil, New Age International (PLD).
4.       "An Introduction to Practical Biochemistry", David T. Plummer, Tata McGraHill
          Co. Ltd., New Delhi.

**TBE-301: MASS TRANSFER OPERATIONS**

| L | T | P | C |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

**Course objectives:** The objective of the course is to impart:

- Basic understanding of the phenomena of mass transfer, to develop methodologies for solving a wide variety of practical application in food processing

- Useful information concerning the principle and working of particular mass transfer unit operations like drying, evaporation used in food processing operations.

**Course outcomes**

On the successful completion of the course, students will be able to

| CO1 | Understand the basic of engineering principles of mass transfer and their significance in practical applications | Understanding |
|---|---|---|
| CO2 | Understand the concept of mass transfer coefficients and related dimensionless numbers | Understanding |
| CO3 | Understand principles of drying, equilibrium and free moisture widely used in handling and storage of food materials | Understanding |
| CO4 | Apply mechanism of evaporation in food processing operation by using different type of evaporators | Apply |
| CO5 | Apply the concept of absorption and crystallization used in different food processing operations | Understanding |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** |
| **CO1** | 1 | 1 | - | - | - | 1 | - | - | - | - | - | 1 | 2 | 2 |
| **CO2** | 2 | 2 | 2 | 1 | - | 1 | 1 | - | - | - | - | 2 | 3 | 3 |
| **CO3** | 2 | - | - | - | - | - | 2 | - | - | - | - | 1 | 1 | 1 |
| **CO4** | 2 | 1 | - | - | - | 2 | 1 | - | - | - | - | 2 | 2 | 2 |
| **CO5** | 2 | 2 | - | - | - | 2 | 2 | - | - | - | - | 2 | 1 | 2 |
| **Average** | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 2 | 2 | 2 |

1: Slight (Low)          2: Moderate (Medium)          3: Substantial (High)          *If there is no correlation, put "-"*

**Course Level Assessment Questions**

**Course Outcome 1 (CO1)**

- Knowledge about basic mass transfer operation
- Basics of molecular diffusion in fluids
- Fundamental of diffusion in mass transfer
- Diffusion coefficient measurement and prediction

**Course Outcome 2 (CO2)**

- concept of steady state heat conduction with heat generation
- temperature distribution with different boundary conditions
- Understanding extended surfaces (fins) of uniform area
- Effectiveness and efficiency of the fins used in food processing

**Course Outcome 3 (CO3)**

- Fundamentals of drying as mass transfer operation
- Concept of drying conditions including constant-rate and falling-rate
- Calculation of drying time under different drying conditions
- Principle and designing of different dryer

**Course Outcome 4 (CO4)**

- Fundamentals of evaporation as mass transfer operations
- Application of evaporation in food processing
- Principal and working of different evaporators
- Design of single and multiple effect evaporator

**Course Outcome 5 (CO5)**

- Understanding absorption for binary and multi component systems
- Material and energy balance during absorption and crystallization
- Principles of Crystallization and their application
- Types of Crystallizers used in practice

# Syllabus

**Module-I: Introduction to Mass Transfer**

Introduction to Mass transfer operation, Concentration, Mass & Molar Avg. Velocity, Mass & Molar Flux, N & J flux, Fick's law of diffusion, Steady state molecular diffusion in fluids under stagnant and laminar flow conditions, steady state diffusion: of A through non-diffusing B, equimolar counter diffusion. Effect of Temperature and Pressure on diffusivity; Diffusion coefficient measurement and prediction

**Module-II: Interphase Mass Transfer & M.T. Coefficients**

Concept of Equilibrium, Diffusion between two phases, Modes of Convective Mass transfer; Introduction to Mass transfer coefficients, Gas Phase & Liquid Phase M.T. coefficients, Local & Overall M.T. coefficients, Dimensionless Numbers in Mass transfer, Simultaneous Heat & Mass Transfer, Steady state co- current & counter-current processes

**Module-III: Drying**

Importance of drying in processes, principles of drying, equilibrium and free moisture, bound and unbound water, constant drying conditions, constant-rate, period, critical moisture content and falling-rate period, porous solids and flow by capillarity, calculation of drying time under constant drying conditions. Classification of dryers, solids handling in dryers, equipment for batch and continuous drying processes: working principle of tray driers, tower driers, rotary driers, spray driers. Concept of freeze drying

**Module-IV: Evaporation**

Introduction, single- and multiple- effect operation, long tube vertical evaporators, agitated-film evaporators, evaporator capacity, BPE and Duhring's rule, evaporator economy, enthalpy balances for single effect evaporator. Multiple effect evaporators, methods of feeding, capacity and economy of multiple effect evaporators, multiple effect calculations

**Module-V: Absorption & Crystallization**

Absorption - Equilibrium solubility of gases, Material balance for transfer of one component. Counter current multistage operations for binary and multi component systems. Continuous contactors, absorption with chemical reaction Concept of HTU and NTU; Industrial Absorbers; Sparged vessels (bubble columns), mechanically agitated vessels for a single phase and gas liquid contact; Principles of Crystallization, Super saturation, Nucleation, Crystal growth, Material & Energy Balance applied to Crystallizers, Types of Crystallizers used in practice.

**Reference Books and Suggested Readings:**

- Warren L. McCabe, Julian Smith, Peter Harriott. 2004. Unit Operations of Chemical Engineering, 7th Ed. McGraw-Hill, Inc., NY, USA.

- Christie John Geankoplis. 2003. Transport Processes and Separation Process Principles, 4th Ed. Prentice-Hall, NY, USA.
- J, M. Coulson, J. F. Richardson, J. R. Backhurst and J. H. Harker. 1999. Coulson & Richardson's Chemical Engineering, Vol. 1, Fluid Flow, Heat Transfer and Mass Transfer, 6th Ed. Butterworth–Heinemann, Oxford, UK.
- M. Necati Özişik. 2008. Heat Conduction, 2nd Ed. John Wiley & Sons, NY, USA.
- Robert E. Treybal. 2014. Mass Transfer Operations, 3rd Ed. McGraw-Hill Book Company, Auckland, USA.
- Earle RL. 2012. Unit Operations in Food Processing. Pergamon Press.

**TBE-303 CHEMICAL REACTION ENGINEERING**

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course objectives:**
- To apply knowledge from calculus, differential equations, thermodynamics, general chemistry, and material and energy balances to solve reactor design problems,
- To examine reaction rate data to determine rate laws, and to use them to design chemical reactors,
- To simulate several types of reactors in order to choose the most appropriate reactor for a given need,
- To design chemical reactors with associated cooling/heating equipment.

| CO1 | Able to develop an understanding of the basic concepts involved in using reaction rate equations and kinetic constant | Understand Apply |
|---|---|---|
| CO2 | Perform derivations of rate equations for non-elementary reactions both in homogenous and in heterogeneous reacting systems | Apply |
| CO3 | Able to understand the role of temperature and concentration in the rate equation | Understand |
| CO4 | Perform constant volume batch reactor calculations | Apply |
| CO5 | Develop calculations using the integral method and applying differential method of analysis using reactions with different orders | Understand Apply |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 2 | 3 | - | - | - | - | - | - | 1 | - | 1 | 1 | 1 |
| CO2 | 3 | 3 | 3 | 1 | - | 1 | - | - | - | 1 | - | 1 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 2 | - | 2 | - | - | - | 1 | - | 1 | 2 | 2 |
| CO4 | 3 | 3 | 1 | - | 2 | 1 | - | - | - | 1 | - | 1 | 2 | 2 |
| CO5 | 3 | 3 | 2 | 2 | 2 | 1 | - | - | 2 | 1 | - | 3 | 2 | 2 |
| Average | 3 | 2.8 | 2.4 | 1.6 | 2 | 1.2 | | | 2 | 1 | | 1.4 | 2 | 2 |

1: Slight (Low)    2: Moderate (Medium)    3: Substantial (High)    *If there is no correlation, put "-"*

## SYLLABUS

**Module- I**

Rate of Reaction, Elementary and non-elementary homogeneous reactions, Molecularity and order of reaction, Mechanism of reaction, temperature dependency from thermodynamics, collision and activated complex theories. Integral and differential methods for analyzing kinetic data, interpretation of constant volume reactor, zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, catalytic reaction, auto catalytic reaction, reversible reactions.

**Module-II**

Interpretation of variable volume batch reactions for zero, first and second order reactions, Space-time and state-velocity, design equation for ideal batch, steady-state continuous stirred tank, steady-state plug flow reactors for isothermal reaction.

**Module- III**

Design for single reactions, Size comparison of single reactors, Multiple reactor systems, plug flow/mixed flow reactors in series and parallel, reactors of different types in series, optimum reactor size, recycle reactor, autocatalytic reactions.

**Module -IV**

Introduction to multiple reactions, qualitative discussion about product distribution, quantitative treatment of product distribution and of reactor size, selectivity, the side entry reactor, irreversible first-order reactions in series, Quantitative treatment: plug flow or batch reactor, Quantitative treatment: mixed flow reactor, Successive irreversible reactions of different orders, reversible reactions, irreversible series-parallel reactions, the Denbigh reactions and their special cases, Heat of reaction from thermodynamics, equilibrium constants from thermodynamics, General graphical design procedure for non-isothermal reactors, Optimum temperature progression, Heat effects: Adiabatic operations and non-adiabatic operations, Exothermic reactions in mixed flow reactors.

**Module -V**

Residence time distribution of fluids in vessels, State of aggregation of the flowing systems, Earliness of mixing, Role of RTD, State of Aggregation and earliness of mixing in determining reactor behavior, E, F and C curves, Conversion in Non-ideal flow reactors.


**Reference Books:**

Levenspiel, O. (1998). Chemical reaction engineering book, 3rd edn,

## Year-III, Semester-V

## Course Title: Molecular Biology and Genetic Engineering

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-305 | 4 | 3 | 0 | 2 | 30 | 20 | - | 50 | 50 | 100 |

### Objective:-

- Students will understand concept of transcription, translation and its regulation.
- Students will understand about the concept of genes and heredity.
- Students will come to know about r-DNA technology and the concepts of gene expression and its control.
- Students will understand the concept of DNA sequencing and gene cloning.

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Analyze Molecular structure of genes and chromosomes apply concepts of molecular genetics to develop new techniques in various fields like medical, pharmaceuticals, food production etc. | **Apply** |
|---|---|---|
| CO2 | apply concepts of molecular genetics to develop new techniques in various fields like medical, pharmaceuticals etc.Understand the fundamentals of molecular biology and genetic engineering. | **Apply** |
| CO3 | Understand Regulation and clustering of genes. | **Apply** |
| CO4 | An exposure to recent developments in genetic engineering techniques, treatment of various diseases including cancer, diabetes and hereditary diseases. | **Apply** |
| CO5 | Case studies of GMO Production. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 1 | 2 | | 1 | | 2 | | | | | | 2 | 3 | 3 |
| CO2 | 1 | 2 | | 1 | | 2 | 2 | | | | | 2 | 3 | 3 |
| CO3 | 1 | 2 | 2 | 1 | | 2 | | | | | | 2 | 3 | 3 |
| CO4 | 1 | 2 | 2 | 1 | | 2 | 2 | | | | | 2 | 3 | 3 |
| CO5 | 1 | 2 | 2 | 1 | | 2 | | | | | | 2 | 3 | 3 |
| Total | 1 | 2 | 2 | 1 | | 2 | 2 | | | | | 2 | 3 | 3 |

1: Slight (Low)      2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

**Unit-I**

Development of Molecular Biology. Nucleic acids: forms, structure and functions. Gene:

Its concept, construction and inheritance. Inter and intra molecular non-covalent interaction in living system.

**Unit-II**

Replication of DNA. Transcription and its regulation. Genetic codes: their identification, characteristics and function. Repression and inhibition mechanism. Prokaryotic translation process.

**Unit-III**

Controlling of Prokaryotic Gene Expression: control circuit of operon. Construction and control of Lac operon and Tryptophan operon.

**Unit-IV**

r-DNA Technology: Principles, construction, properties of vectors. Restriction enzyme: properties, function and application. Techniques used in r-DNA Technology. Strategy of Gene cloning, expression of gene and selection of genetically modified cells.

**Unit-V**

Case studies for genetic modification in *E. coli* and yeast. Developement of GMO ,Restriction mapping, DNA sequencing and DNA/RNA Labelling.

**References :**

1. "Molecular Biology of the Gene", J.D. Watson, Melnopark, California.
2. "Lewin's GENES XII", Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones & Bartlett Learning (2017).
3. "Biochemistry", A.L. Lehninger, Worth Publication, New York.
4. " Recombinant DNA Technology", Dhillon J.R., John Wiley & Sons, New York.
5. "Genetics", P.K. Gupta, Rastogi Publication, Meerut.

## Year III, Semester-V

## Course Title: Bioprocess Engineering

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-307 | 5 | 3 | 0 | 4 | 15 | 20 | 15 | 50 | 50 | 100 |

**Objective:- :** To introduce the engineering principles of bioprocesses including microbial kinetics, sterilization principles and design considerations.

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Describe and analyze phenomena, problems in bioprocesses, apply engineering principles to address issues in bioprocesses. | **Apply** |
|---|---|---|
| CO2 | Identify limiting factors in a bioprocess and propose solutions to address biological and engineering problems. Analyze kinetics of cell growth or enzyme-catalyzed reactions. | **Apply** |
| CO3 | Analyse the environmental factors which affect cell growth and optimization process of cell growth | **Apply** |
| CO4 | Identify suitable sterilization process/module for media and air. Determination of the air requirement in a bioreactor system | **Apply** |
| CO5 | scale up the bioprocess for large scale production of biomolecules. | **Apply** |

| COs | | | | Pos | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 | | 1 | 2 |
| CO1 | 3 | | CO1 | 3 | | CO1 | 3 | | CO1 | 3 | | CO1 | 3 | |
| CO2 | 3 | 3 | CO2 | 3 | 3 | CO2 | 3 | 3 | CO2 | 3 | 3 | CO2 | 3 | 3 |
| CO3 | 3 | 3 | CO3 | 3 | 3 | CO3 | 3 | 3 | CO3 | 3 | 3 | CO3 | 3 | 3 |
| CO4 | 3 | 3 | CO4 | 3 | 3 | CO4 | 3 | 3 | CO4 | 3 | 3 | CO4 | 3 | 3 |
| CO5 | 3 | 3 | CO5 | 3 | 3 | CO5 | 3 | 3 | CO5 | 3 | 3 | CO5 | 3 | 3 |
| Total | 3 | 3 | Total | 3 | 3 | Total | 3 | 3 | Total | 3 | 3 | Total | 3 | 3 |

1: Slight (Low)     2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## Syllabus

Unit 1

Microbial growth patterns and kinetics; substrate utilization and product formation in batch and continuous reactors; Scale up of Bioreactors

Unit 2

Mass and energy balance in a typical bioconversion process and yield concepts etc.

Unit 3

Sterilization of media: principles, batch and continuous sterilization processes. Sterilization of air: principles, methods of air sterilization.

Unit 4
Aeration and agitation: Oxygen transfer in microbial systems, oxygen demands, mass transfer theories, measurements of volumetric oxygen transfer coefficient, rheology of fermentation fluids.

Unit 5:
Design and execution of simple laboratory scale experiments on the following topics:
1. Effect of physical and chemical environment on growth; selected biochemical tests.
2. Growth kinetic studies of yeast in a bench top lab fermenter under controlled conditions.
3. Studies on settling characteristics of various microbial cultures.
4. Study the solid state fermentation with suitable example.

**References:**

1.       "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book   Co., New York.
2.   "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
3.   Bioprocess Engineering – P.M. Doran
3.       "Biochemical Engineering", Shuichi Aiba, Arthur E. Humphrey, Nancy F. Millis; University       of Tokyo Press.
4..       "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.

## Course Title: Bioinformatics

### Evaluation Scheme:

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-309 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

### Unit-I

Definitions of informatics, chronological history Molecular Biology's Central dogma; Gene structure and information content, protein structure and function, Molecular Biology tools.

### Unit–II

Database concept, Biological Database; (Different types of data books spl. biochemical pathway databases). Sequence analysis, pairwise alignment and database searching. Multiple sequence alignments, Trees and profiles.

### Unit–III

Genomies and gene recognition; from sequencing genes to genomes sequence assembly, Annotation and analyzing whole genome sequences, functional genomics.

### Unit-IV

Predicting protein structure and function from sequences, Determine the structures of proteins, Predicting the structures of proteins, from 3D to 1D. Feature detection, in protein sequences, Secondary structure prediction, predicting 3D structures.

### Unit-V

Application and software tools for bioinformatics, challenges for bioinformatics, Industry drug design & DNA chip.

## Course Title: INSTRUMENTATION and PROCESS CONTROL

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-302 | 3 | 2 | 1 | 0 | 15 | 20 | 15 | 50 | 50 | 100 |

**Course Objectives**: The objectives of this course are to impart:

- To gain the knowledge of different process instruments widely used in food and chemical industries.

**Course Outcomes**: On the successful completion of the course the students will be able to:

| CO 1 | Understand the principles involved in measurements. Attain knowledge on different measurement methods employed in industrial processing and manufacturing. | Understand |
|---|---|---|
| CO 2 | Application of different pressure measurement devices in food and chemical industries. | Analysis & Create |
| CO 3 | Application of different temperature measurement devices in food and chemical industries. | Understand, Analysis & Create |
| CO 4 | Application of various level and flow measurement devices in food and chemical industries. | Analysis & Create |
| CO 5 | Measurement of viscosity, thermal conductivity, chromatography, moisture analyzers, etc. | Create & Analysis |

**CO-PO Mapping**

| CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO1 | 3 | 2 | 1 | 1 | - | - | 1 | - | - | - | - | 1 |
| CO2 | 3 | 1 | 1 | 1 | - | 3 | 3 | 3 | 1 | 1 | - | 1 |
| CO3 | 3 | 3 | 2 | 2 | 3 | - | - | - | 1 | - | - | 2 |
| CO4 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | - | - | - | - | 2 |
| CO5 | 3 | 3 | 2 | 2 | 3 | - | - | - | 1 | 1 | 3 | 2 |
| Avg. | 3 | 2 | 1.6 | 1.4 | 3.0 | 2.0 | 1.67 | 3.0 | 1.0 | 1.0 | 3.0 | 2 |

# Syllabus

**Module-I**

Characteristics of measurement system, classification, performance characteristics, dynamic calibration, errors, statistical error analysis, reliability and related topics

## Module-II

Temperature measurement, definitions and standards, techniques and classification-temperature measurement using change in physical properties, electrical type temperature sensors, radiation thermometry

## Module-III

Measurement of pressure: Manometers, Elastic pressure transducers, Measurement of Vacuum.

## Module-IV

Flow measurement; head types-area flow meters, mass flow meters, positive displacement type flow meters, electrical type flow meters and solid flow measurement. Level measurement; float types- hydrostatic types, thermal effect types, electrical methods and solid level measurement, density and viscosity measurement

## Module-V

Instruments for analysis, spectroscopic analysis by absorption, emission, mass, diffraction and color, gas analysis by thermal conductivity, chromatography, moisture analysis and liquid composition analysis, measurement of pH

**Reference Books and Suggested Readings:**

| Title | Author |
| --- | --- |
| Industrial Instrumentation and Control, Prentice Hall of India, 2016. | Singh, S. K. |
| Industrial Instrumentation, Wiley Eastern Ltd., New York, 1990. | Eckman, D.P. |
| Principles of industrial instrumentation, Tata McGraw Hill, 2008. | Patranabis |
| Instrumentation Measurement and Analysis, Tata McGraw Hill, 1978. | Nakra and Chaudhary |

## Year III, Semester-VI
## Course Title : DOWN STREAM PROCESSING

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-304 | 3 | 2 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**

Objective of this course is to enable the student to understand importance of Down Stream Processing in Industrial fermentation .

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Understand complex nature of fermentated broth and , complexities in isolation and purification of bioproducts | **Apply** |
|---|---|---|
| CO2 | Understand solid-liquid separation methods, cell disruption methods. | **Apply** |
| CO3 | Understand precipitation methods , aqueous two phase extraction , adsorption and membrane based separation. | **Apply** |
| CO4 | Understand principle, practice and applications of chromatographic techniques, Electrophoresis. | **Apply** |
| CO5 | Finishing operations – crystallization, drying and formulation | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | 2 | | | | | | 3 | 3 | 3 |
| CO2 | 3 | | | | | 2 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | 3 | 2 | | | 2 | | | | | | 3 | 3 | 3 |
| CO4 | 3 | 2 | 2 | 2 | | 2 | 2 | | | | | 3 | 3 | 3 |
| CO5 | 3 | 1 | 2 | | | 2 | | | | | | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | 2 | | 2 | 2 | | | | | 3 | 3 | 3 |

1: Slight (Low)    2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS
### UNIT-I
Characterization of bioproducts: flocculation and conditioning of broth.

### UNIT-II
Mechanical separation : Filtration, centrifugation ,Cell disruption

## UNIT-III
Membrane based separation, , Protein precipitation and its separation; Aqueous two phase extraction , Adsorption.

## UNIT-IV
Chromatographic separation based on size, charge, hydrophobic interaction, metal ion affinity. Electrophoresis.

## UNIT-V
Crystallization and drying.

## REFERENCES:-

**1.** "Biochemical Engineering Fundamentals '' by J.E. Bailey and D.F.Ollis, McGraw –Hill Book Co., New York.

2. " Basic Biotechnology '' , J. Bu'lock , B. Krishtiansen, Academic Press

3 " Comprehensive Biotechnology" ; Vol.2, Murray-Moo-Young , Pergamon Press, New York.

## Year III, Semester-VI

## Course Title: FERMENTATION TECHNOLOGY

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-306 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:- :** To introduce the students to the various concepts of fermentation and acquire experimental knowhow of microbial production of various industrial products such as alcohol, organic acids, enzymes, amino acids etc.

**Course Outcome:-** On successful completion of the course student will be able to -

| CO 1 | Understand the various concepts of fermentation, analyze the industrial aspect of the field of microbiology. | **Apply** |
|---|---|---|
| CO2 | Understand the industrial aspect of the field of microbiology and know the differences between aerobic and anaerobic fermentation. | **Apply** |
| CO3 | Understand to produce some industrially important liquid fermentation products e.g. ethanol, vinegar etc,produce some industrially important biomass based fermentation products e.g. baker's yeast etc. | **Apply** |
| CO4 | Understand solid and submerged fermentations. | **Apply** |
| CO5 | Understand distinguish primary and secondary metabolites analyze finished microbial products. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO2 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO4 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO5 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO6 | 3 | 2 | 2 | 3 | 1 | 3 | | | 3 | | | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | 3 | 1 | 3 | | | 3 | | | 3 | 3 | 3 |

1: Slight (Low)　　　2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

### UNIT-I

Alcoholic fermentation and related products. Glycerol fermentation. Malting and brewing: beer production, wine manufacturing and other distilled liquors.

### UNIT-II

Microbial production of organic acids and fermentation processes. Biomass as a fermentation product: Baker's yeast, Bioinsecticides, Biofertilizers. Amino acids: Lysine and glutamic acid.

### UNIT-III

Commercial enzymes: solid and submerged fermentation, recovery etc. Secondary metabolites such as antibiotics and vitamins.

### UNIT-IV

Microbial transformations, vaccines, recombinant therapeutic proteins.

**References:**

1. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc. New York.
2. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.
3. "Microbial Technology", Vol.II, H.J. Peppler and D. Perlman, Academic Press, New York.
4. Official methods of analysis of AOAC.
5. BIS booklets for various products.
6. "An Introduction to Practical Biochemistry", David T. Plummer, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

**Year III, Semester-VI**
**Course Title :   ENVIRONMENTAL BIOTECHNOLOGY**

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional  Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-308 | 3 | 3 | 0 | 0 | 15 | 20 | 15 | 50 | 50 | 100 |

**Objective:-**

The objective of this course is to enable the students to understand  necessity for treatment of waste water and various physical , chemical and biological methods of waste water treatment

**Course outcome:-**  On successful completion  of the course student will be able to –

| CO1 | Understand characteristics of waste water , classification of treatment methods and  bioprocess kinetics applied to waste treatment. | **Understand** |
|---|---|---|
| CO2 | Understand various aerobic methods  and their design aspects of waste water treatment. viz. ASP ponds and lagoons, TF,RBC. | **Apply** |
| CO3 | Understand theory of anaerobic digestion and digester design. | **Apply** |
| CO4 | Understand biological removal of nitrogen and phosphorous and other advanced treatment methods. Case studies. | **Apply** |
| CO5 | Understand methods to estimate DO, BOD , COD, solids and determination of other water pollutants, evaluation of treatment process performance. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO2 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO4 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO5 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO6 | 3 | 2 | 2 | 3 | 1 | 3 | | | 3 | | | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | 3 | 1 | 3 | | | 3 | | | 3 | 3 | 3 |

1: Slight (Low)        2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

**SYLLABUS**

**Unit-I**

Source and Characteristics of waste, Physical and chemical methods of waste treatment. Bioprocess Kinetics applied to waste treatment.

## Unit-II
Anaerobic treatment systems, UASB. Sludge digestion theory, digestor design, high rate digestion, heat transfer in digestor.

## Unit-III
Theory of activated sludge process design, operation and control, BOD reduction and biomass relationship , Sequential Batch Reactors, Membrane Bioreactors,  Modification, operational and design aspects.

## Unit-IV
Nitification- denitrification, Phosphorous removal. Treatment and disposal of sewage and waste of the industries e.g. distilling and brewing, antibiotics and sugar etc. Bioremediation.

1

## Unit-V
Experimental determination of various organic and inorganic pollutants-: DO, BOD, COD, solids-total , suspended, volatile and fixed. Evaluation of the effect of process, variables on the performance of ASP, and anaerobic digesters.

REFERENCE:
 1. " Waste water Engineering: Treatment, Disposal and Reuse", Metcalf & Eddy, Inc.; Tata McGraw-Hill Publishing Company Ltd., New Delhi.
 2. " Water supply and Pollution Control ", Warren Viessman Jr. and Mark J. Hammer; Harper& Row Publishers; New York.

**Year IV, Semester-VII**
**Course Title : Bioreaction Engineering**

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ES E | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-310 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**
The objective of this course is to enable the student to understand basic requirements for production of bioproducts , types of bioreactors .

**Course outcome:-** On successful completion of the course student will be able to –

| CO1 | Understand upstream processing in biotechnological processes. | **Apply** |
|---|---|---|
| CO2 | Understand control of process parameters in bioprocesses | **Apply** |
| CO3 | Understand operational problems encountered and their prevention and control, | **Apply** |
| CO4 | Understand about constructional and operational features of different types of bioreactors. | **Apply** |
| CO5 | Understand bioreactors used in treatment of waste water. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | | | | | | | 2 | 3 | 3 |
| CO2 | 3 | | | | | 2 | | | | | | 2 | 3 | 3 |
| CO3 | 3 | | | | | | | | | | | 2 | 3 | 3 |
| CO4 | 3 | | | | | | | | | | | 2 | 3 | 3 |
| CO5 | 3 | 2 | | | | 2 | 2 | | | | | 2 | 3 | 3 |
| Total | 3 | 2 | | | | 2 | 2 | | | | | 2 | 3 | 3 |

1: Slight (Low)          2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

**UNIT-I**
Bioreaction Kinetics, Food to microorganism ratio, Pure and Mixed culture kinetics

**UNIT_II**
Instrumentation and process control in biotechnological processes.

**UNIT-III**
 Aseptic operation, Mixing in bioreactors. Foam control in bioreactors. Computer application in bioreactor

**UNIT-IV**

Membrane bioreactors. Bioreactors with immobilized biocatalyst. Air lift bioreactors. Solid state bioreactors.

**UNIT-V**

Bioreactors in waste water treatment.

References:
1. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London,

## Course Title :   FERMENTATION TECHNOLOGY LAB

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-312 | 3 | 0 | 0 | 6 | - | 20 | 30 | 50 | 50 | 100 |

## Syllabus

Design and execution of simple laboratory scale experiments on the following topics:

1Analysis of molasses.

2.Preparation of Malt and determination of diastatic power

3.Determination of fermentation efficiency of yeast for batch production of ethanol.

4. Effect of substrate concentration on biomass yield for baker's yeast production and its characterization.

5. Fermentation efficiency for vinegar production.

6. Citric acid production by (a) solid state and (b) submerged fermentation.

7.Microbial production of enzymes by (a) solid state and (b) submerged fermentation.

8.Analysis of' finished products (rectified sprit, beer etc.).

## Year IV, Semester-VII
## Course Title :  ENZYME ENGINEERING & TECHNOLOGY

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PCC | TBE-401 | 3 | 2 | 0 | 2 | 15 | 20 | 15 | 50 | 50 | 100 |

**Objective:-**
The objective of this course is to enable the students to understand basics of enzyme kinetics and  production and industrial application of enzymes.

**Course outcome:-** On successful completion  of the course student will be able to –

| | | |
|---|---|---|
| CO1 | Understand importance of enzymes , their classification and nomenclature. | **Apply** |
| CO2 | Understand kinetics of single and multiple substrate, inhibition kinetics and activation. | **Apply** |
| CO3 | Understand immobilization kinetics and methods of whole cell immobilization and enzyme immobilization, enzyme reactors. | **Apply** |
| CO4 | Understand production technology of industrial enzymes. | **Apply** |
| CO5 | Understand enzyme assay methods, immobilization methods, purification methods,operational feature of enzyme reactors. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | 3 | | | | | | | 3 | 3 |
| CO2 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO4 | 3 | 2 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO5 | 3 | 3 | | | | 3 | | | | | | 3 | 3 | 3 |
| CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | | 3 | | | 3 | 3 | 3 |
| Total | 3 | 2.5 | 3 | 3 | 3 | 3 | 1 | | 3 | | | 3 | 3 | 3 |

1: Slight (Low)        2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

### Unit-I

 Introduction and scope of enzyme, mechanism of enzymatic catalysis, characterization of active sites and ligand binding sites.

**Unit-II**

Enzyme kinetics of single substrate reaction. Derivation of Michaelis- Menten equation, turover number, determination of Km and Vm (Lineweaver Burk Plot); Numerical related to enzyme kinetics, multiple-substrate reaction mechanism. Kinetics of inhibition and activation, King and Altma method, allosteric enzymes.

**Unit-III**

Immobilization of enzymes and cells. Methods of immobilization; Adsorption, Entrapment, Encapsulation, Covalent binding, Cross linking and their examples: Merits and demerits of different immobilization methods. Effect of micro and macro environmental parameters on the immobilized enzymes; External film and internal pore diffusion partitioning and electrostatic interaction. Performance of soluble and immobilized enzyme reactors, operational strategies, carrier life and cycle time.

**Unit-IV**

Production of selected industrial enzymes and their applications

**Unit-V**

Assay of enzyme activity and specific activity, kinetics analysis of an enzyme catalyzed reaction Immobilization of enzymes, Salt precipitation of and enzyme, immobilization of microbial cells, Comparative study of performance of soluble and immobilized enzyme reactors.

**Reference:**

1- Biochemical engineering fundamentals by J. E. Bailey and D.F. oils, Mcgraw Hill Books Co New York.
2- Immobilized enzymes by Trevan
3- Enzyme kinetics by Roberts
4- Enzyme engineering by Laidler
5- Enzyme technology by Chaplin and Bucke. Cambridge University Press

## Course Title: BIOREACTOR DESIGN

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-403 | 2 | 2 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-** To provide the basic principles of reactor design for bioprocesses.

**Course Outcome:-** On successful completion of the course student will be able to –

| CO1 | Understand comprehend the state of the arts in bioreactor technology and its broad range of applications,develop mathematical descriptions of reaction kinetics in cellular systems and their relationships with bioreactor design. | **Apply** |
|---|---|---|
| CO2 | Understand basic principles of mass and energy conservation to analyze bioreactor systems. Identify the major engineering parameters that characterizes the performance of bioreactors and techniques to measure and control these parameters. | **Apply** |
| CO3 | Understand complete bioreactor based on targets, constraints and physical properties. | **Apply** |
| CO4 | Understand suitable process instrumentation for monitoring and control of bioreactors. | **Apply** |
| CO5 | Understand the problem of selection of suitable bioreactor configuration. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | 1 | | | | | | | | | 2 | 3 | 3 |
| CO2 | 3 | 2 | 1 | | | | | | | | | 2 | 3 | 3 |
| CO3 | 3 | 2 | 1 | | | | | | | | | 2 | 3 | 3 |
| CO4 | 3 | 2 | 1 | 1 | 2 | 1 | | | | | | 2 | 3 | 3 |
| CO5 | 3 | 2 | | | | | | | | | | 2 | 3 | 3 |
| Total | 3 | 2 | 1 | 1 | 2 | 1 | | | | | | 2 | 3 | 3 |

1: Slight (Low)       2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

### UNIT-I

Design equations for batch, continuous and fed batch reactors. Non- ideal flow behaviour of Batch and continuous flow reactors.

### UNIT-II

Novel bioreactor configuration such as fluidized bed reactor, air-lift reactor, bubble column, membrane bioreactor etc.

## UNIT-III

Bioreactor operation measurement and control: Aseptic operations, measurement and control of process variables (pH, dissolved oxygen, viscosity, temperature, NADH), agitative power and foam control.

## UNIT-IV

On-line analysis, bioprocess control and computer coupled bioreactors. Bioprocess economics.

## References:

2. "Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London,

# Course Title: IPR and Biosafety Regulation

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-405 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

### Objective:-

- To introduce history and evolution of IPR- like patent, design and copy right, Indian patent act 1970 (amendment 2000), international convention in IPR, major changes in Indian patent system as post TRIPS effects (i) obtaining patent (ii) geographical indication.
- Student will understand various forms of IPR, Requirement of a patentable novelty, invention step and prior art and state of art, procedure.
- To understand the Rights/protection, infringement or violation, remedies against infringement – civil and criminal.
- Detailed information on patenting biological products, Biodiversity, Budapest treaty, Appropriate case studies

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Understand the importance of intellectual property rights. | **Apply** |
|---|---|---|
| CO2 | Understand the legal aspects of Rights/protection, infringement or violation, remedies against infringement – civil and criminal. | **Apply** |
| CO3 | Understand to file patent application and review it. | **Apply** |
| CO4 | Understand to work as patent review officer and consultant. | **Apply** |
| CO5 | | |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | 2 | | | | 3 | | | | | 3 | 3 | 3 |
| CO2 | 3 | 2 | 2 | | | 3 | 3 | | | | | 3 | 3 | 3 |
| CO3 | 3 | | 2 | | | 3 | 3 | | | | | 3 | 3 | 3 |
| CO4 | 3 | | 2 | | | 3 | 3 | | | | | 3 | 3 | 3 |
| CO5 | 3 | | 2 | | | 3 | 3 | | | | | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | | | 3 | 3 | | | | | 3 | 3 | 3 |

1: Slight (Low)      2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

### UNIT-I

Jurisprudential definition and concept of property, right, duties and their correlation. History and evolution of IPR- like patent, design and copy right etc.

**UNIT-II**

Indian patent act, international convention in IPR. TRIPS agreement; IPR issues in relation to biotech products/ processes; architecture of patent application.

**UNIT-III**

Detailed information on patenting biological products, biodiversity, Budapest treaty, appropriate case studies. Biosafety Principles - environment and health risk assessment; biosafety regulatory guidelines and controlling agencies.

**UNIT-IV**

 Environmental law for hazardous microorganisms and GMOs; Biotechnology Related Issues of Public Concern. Bioethics.

**UNIT-V**

 Regulatory issues concerning the global biotechnology & pharmaceutical industries, including Good Laboratory & Clinical Practice (GLP & GCP).

References:

1. "An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology", Padma Nambisan, Academic Press (2017).
2. "IPR, Biosafety and Bioethics", Shomini Parashar, Deepa Goel, Pearson India (2013).
3. "Intellectual property rights in the global economy",  Maskus, Keith E, Institute for International Economics, Washington(2000).
4. "Intellectual property rights in India", V. K. Ahuja, Lexis Nexis India (2009

# Course Title: FOOD BIOTECHNOLOGY

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ES E | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-407 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**

The objective of this course is to enable the students causes of food spoilage and its effects , various methods to prevent food spoilage and testing and quality control of food materials.

**Course outcome:-** On successful completion of the course student will be able to –

| CO1 | Understand about food spoiling microorganisms and microbial examination of food, | **Apply** |
|---|---|---|
| CO2 | Understand about food borne infections and food poisoning | **Understand** |
| CO3 | Understand principles and practice of food preservation by various methods | **Apply** |
| CO4 | Understand about good manufacturing practices, testing and quality control of food. | **Apply** |
| CO5 | Understand about Production of fermented foods and treatment and disposal of food waste | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | 3 | 3 | 2 | | 3 | 1 | | | | 1 | | 3 | 1 |
| CO2 | | | | | | 3 | | 3 | 3 | | | 2 | 1 | 3 |
| CO3 | | 3 | 3 | 2 | | | 1 | | | | 1 | | | |
| CO4 | | 3 | | 2 | | | | | 3 | | 1 | 2 | | |
| CO5 | 3 | | | | | | | | | 3 | | | | |
| Total | 3 | 3 | 3 | 2 | | 3 | 1 | 3 | 3 | 3 | 1 | 2 | 2 | 2 |

1: Slight (Low)          2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

**Unit 1. Introduction:**

Important genera of food borne microorganisms, factors affecting the growth and survival of microorganisms in food Direct examination, culture techniques, MPN count, dye reduction assay,

**Unit 2.** Microbiological examination of food:

Microbial spoilage of food, common food borne diseases, bacterial agents of food borne illness, non-bacterial agents of food borne illness.

### Unit 3. Food preservation:

Principles of food preservation, asepsis, anaerobic conditions, removal of microorganisms, low temperature, high temperature, radiation, drying, chemical preservatives and miscellaneous methods, canning.

### Unit 4. Cleaning

Cleaning and disinfection code for good manufacturing practices, microbial and chemical safety of food products, indicator organisms, ISO, hazard analysis and critical control points, sterility testing.

### Unit 5. Fermented foods:

Fermented milk, cheese, sauerkraut, fermented meat, beer, vinegar, fish products, products of baking, oriental foods. Role of enzymes in different food products (bakery, cheese, beverage production and cereal products) and industries, utilization of food waste for production of valuables.

### Text /Reference Books:
- Modern Food Microbiology by James M. J., CBS Publishers and Publishers.
- Food Microbiology by Freiser.
- Willis Biotechnology, Challenges for the flavour and food industries by Lidsay, Elsevier Applied Science.
- Food Biotechnology by Roger A., Gordan B., and John T.
- Basic Food Microbiology by George J. B., CBS Publishers and Distributors.

## Course Title: Plant Cell Biotechnology

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-409 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**
- To teach the students about tissue culture techniques.
- To familiarize the students with applied aspects of plant biotechnology.
- To make the students aware of transgenic plants.
- To understand the gene transfer methods.
- To teach the students about the production of secondary metabolites of plant origin.

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Understand about Plant cell and concept of totipotency. | Apply |
|---|---|---|
| CO2 | Exposure to various plant products of industrial importance. | Apply |
| CO3 | To optimize production of secondry metabolites from suspension culture and characterization of product. | Apply |
| CO4 | Formulate nutrient optimization for plant cell growth | Apply |
| CO5 | To work in industry producing transgenic plants. | |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 2 | | 2 | | | 2 | | | | | | 3 | 3 | 3 |
| CO2 | 2 | | 2 | | | 2 | | | | | | 3 | 3 | 3 |
| CO3 | 2 | | 2 | | | 2 | | | | | | 3 | 3 | 3 |
| CO4 | 2 | 2 | 2 | | | 2 | | | | | | 3 | 3 | 3 |
| CO5 | 2 | 2 | 2 | 1 | | 2 | | | | | | 3 | 3 | 3 |
| Total | 2 | 2 | 2 | 1 | | 2 | | | | | | 3 | 3 | 3 |

1: Slight (Low)        2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

**UNIT-I**

Special features and organization of plant cells; totipotency and regeneration of plants, examples of regeneration from leaves, roots, stem etc.

**UNIT-II**

Plant product of industrial importance, biochemistry of major metabolic pathways and

products, cells suspension culture development.

## UNIT-III

Large scale production of secondary metabolites from suspension cultures. Characterization, kinetics of growth and product formation. Initiation and maintenance of callus cultures,cell suspension- continous and batch cultures.

## UNIT-I V

Nutrient optimization, cells growth regulators, biological and technological barriers, mutation,Genome reorganization induced invitro, somaclonal variation and gametoclonal variations, meristem culture, embryo culture, micropropagation importance and applications.

## UNIT-V

Genetic engineering of plant cell, plant cells reactors and their performance. Immobilized plant cell reactor and novel design concepts.

## References:

1.  "Plant Tissue Culture and its Biotechnological Application", W. Barz, E. Reinhard and    M.H. Zenk (Eds.); Springer-Verlag, Berlin.

2.   "Plant Cell Biotechnology", H. Smith and Mantell (Eds); Cambridge University Press, Cambridge.

## Course Title: NOVEL BIOPRODUCTS

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-411 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**
**To acquaintance the students with production and application of novel bioproducts with emphasis on use of renewable resources.**

**Course outcome:-** On successful completion of the course student will be able to –

| CO1 | Understand production of biopreservatives, biopolymers, xanthan , gum etc. | **Apply** |
|---|---|---|
| CO2 | Understand microbial process for production of biopharmaceuticals, bioinsecticides etc. | **Understand** |
| CO3 | Understand technology for use of renewable resources for production of novel bioproducts. | **Apply** |
| CO4 | Understand production of liquid and gaseous biofuels, salient features of biofuel cells, biosensors and biomarkers with their application. | **Apply** |
| CO5 | Understand miscellaneous uses of microorganisms for example in steroid transformations, bioconversion of vegetable oils , bioleaching and MEOR. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | | | | | | | 3 | 3 | 3 |
| CO2 | 3 | 2 | 1 | | | 1 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | 2 | 1 | | | 1 | | | | | | 3 | 3 | 3 |
| CO4 | 3 | 2 | 1 | | | 1 | | | | | | 3 | 3 | 3 |
| CO5 | 3 | | 1 | | | | | | | | | 3 | 3 | 3 |
| Total | 3 | 2 | 1 | | | 1.25 | | | | | | 3 | 3 | 3 |

1: Slight (Low)      2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

Unit-I
Production and application of natural Biopreservatives ( Bacteriocin/ Nisin). And Biopolymers (Pullulan/Xanthan Gum and PHB) production and application.

Unit-II
Production and application of Biopharmaceuticals and biopesticides production by microorganisms.


Unit-III
Liquid and gaseous biofuels, biofuel cells and application, biosensors and biomarkers.

Unit-IV
Biotransformation, bioleaching, microbiology and enhanced oil recovery.

References:
1."Principle of Fermentation Technology", P.F. Stanbury and A. Whitaker; Pergamon Press.
2. "Basic Biotechnology", J. Bu'lock, B. Kristiansen, Academic Press.
3. "Biochemical Engineering Fundamentals" by J.E. Bailey and D.F. Ollis, McGraw-Hill Book Co., New York.
4. Bioprocess Engineering Basic Concepts. 2nd edition.. Michael L. Shuler and Fikret Kargi, Prentice Hall, Upper Saddle River, NJ.
5. Bioprocess Engineering Principles Pauline Doran, Academic Press, London,

## Course Title: PRINCIPLES OF BIOCHEMICAL ENGINEERING

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| OEC | OBE-433 | 3 | 3 | 0 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-** This course introduces the basic aspects of biochemical engineering and bioprocess technology and their commercial implications to the students from various disciplines.

**Course Outcome:-** On successful completion of the course student will be able to –

| CO1 | Understand comprehend the state of the arts in bioreactor technology and its broad range of applications, develop mathematical descriptions of reaction kinetics in cellular systems and their relationships with bioreactor design. | **Apply** |
|---|---|---|
| CO2 | Understand basic principles of mass and energy conservation to analyze bioreactor systems. Identify the major engineering parameters that characterize the performance of bioreactors and techniques to measure and control these parameters. | **Apply** |
| CO3 | Understand complete bioreactor based on targets, constraints and physical properties. | **Apply** |
| CO4 | Understand suitable process instrumentation for monitoring and control of bioreactors. | **Apply** |
| CO5 | Understand the problem of selection of suitable bioreactor configuration. | **Apply** |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | | | | | | | 3 | 3 | 3 |
| CO2 | 3 | 2 | 1 | | | 1 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | 2 | 1 | | | 1 | | | | | | 3 | 3 | 3 |
| CO4 | 3 | 2 | 1 | | | 1 | | | | | | 3 | 3 | 3 |
| CO5 | 3 | | 1 | | | | | | | | | 3 | 3 | 3 |
| Total | 3 | 2 | 1 | | | 1.25 | | | | | | 3 | 3 | 3 |

1: Slight (Low)        2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

### SYLLABUS

**UNIT-I**
Introduction: Development and prospects of biochemical engineering. Characteristics of living organisms, classification, morphology and physiology of microorganisms.

**UNIT-II**
Growth, reproduction and nutritional aspects of micro-organisms. Culture isolation, maintenance. Physical and chemical control of micro-organisms.

## UNIT-III

General requirements of the microbial processes. Batch fermentation, growth and product formation kinetics. Sterilization of media and air. Aeration and agitation. Down stream processing.

## UNIT-IV

Production of alcohol, glycerol, organic acids, baker's yeast, enzymes.

## UNIT-V

Antibiotics, biofertilizers,biopesticides. Concepts of biological waste treatments. New developments in biotechnology.

## References:

1. "Biochemical Engineering Fundamentals" by J. E. Bailey & D. F. Ollis (1987) 2nd Ed
McGraw Hill International Edition.
2."Bioprocess Engineering Principles" by P. M. Doran, (1995) Academic Press.
3. "Industrial Microbiology", S.C. Prescott and C.G. Dunn, McGraw-Hill Book Company, Inc.
New York.
4. "Industrial Microbiology", L.E. Casida Jr. Wiley Eastern Ltd.

# TBE-413: Industrial Training

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 4 | 2 |

The students offer summer internship of 6 to 8 weeks would be giving presentation on the work they performed or learned during training

**COURSE OBJECTIVES:** The objectives of this course is to enable the students

- To expose to industrial environment
- To acquaint with the various machines for the manufacturing of food products
- For testing of raw materials and finished products

**Course Outcome**

On the successful completion of the course, students will be able to:

| CO1 | Understand the plant layout, work culture and human relationship. | Understand |
|-----|---|---|
| CO2 | Apply the theoretical knowledge in understanding the working of various machines and manufacturing processes | Apply |
| CO3 | Understand the process sequence and optimization of process parameters. | Apply, Analyze |
| CO4 | To get exposure to various conventional and modern tools and equipment for testing of raw materials and finished products | Apply |
| CO5 | To analyze the research problem and devise methodology/ steps to solve it and development of products | Analyze, Create |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|-----|---|---|---|---|---|---|---|---|---|----|----|----|------|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** |
| **CO1** | 1 | 3 | 2 | - | - | 2 | 1 | 3 | 3 | 2 | 3 | 3 | 2 | 2 |
| **CO2** | 3 | 2 | 2 | 1 | 2 | 2 | - | 1 | 2 | - | 2 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 2 | 2 | 2 | 3 | 2 | 2 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | - | - | - | - | - | 1 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 2 | 3 | 3 | 2 | 2 |
| **Average** | 3 | 3 | 2 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 2 | 2 |

1: Slight (Low)　　2: Moderate (Medium)　　3: Substantial (High)　　*If there is no correlation, put "-"*

# TBE-415: Seminar

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 4 | 2 |

**COURSE OBJECTIVES:** The objectives of this course is to enable the students

- Study a topic of latest developments/innovative technology on their own and to prepare a dissertation report on this topic.
- Present a lecture on the topic on power point format.
- Improve the communication skill of the students.

**Course Outcome**

On the successful completion of the course, students will be able to:

| CO1 | Review, collect and study literature on a topic of interest | Understand |
|-----|-----|-----|
| CO2 | Apply the knowledge to prepare a report on this topic. | Apply |
| CO3 | Deliver a lecture on the topic on power point format and answer questions from audience, if any | Apply |
| CO4 | While being in the audience listen to the lectures delivered by other participants evaluate the same and comment on the same | Evaluate |
| CO5 | Analyze own shortcomings as well as that of other participants and improve upon the same | Analyze, Evaluate |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|-----|---|---|---|---|---|---|---|---|---|----|----|----|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** |
| **CO1** | 1 | 3 | 2 | 3 | 3 | 2 | 2 | - | 2 | - | 2 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 2 | 2 |
| **CO3** | 3 | - | - | - | 2 | 2 | 2 | - | 2 | 3 | 2 | 2 | 2 | 2 |
| **CO4** | 3 | - | - | - | - | 1 | 1 | 2 | 3 | 3 | 1 | 2 | 2 | 2 |
| **CO5** | 2 | - | 1 | 2 | 1 | 2 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 2 |
| **Average** | **3** | **3** | **2** | **2** | **2** | **2** | **2** | **2** | **2** | **3** | **2** | **2** | **2** | **2** |

1: Slight (Low)          2: Moderate (Medium)          3: Substantial (High)          *If there is no correlation, put "-"*

# TBE-417: PROJECT

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 8 | 4 |

**COURSE OBJECTIVES:** The objectives of this course is to enable the students

- To identify a food product that can be manufactured in India or a research problem and conduct experiment.
- To prepare a report for a project based on manufacturing of product/ development of technology
- To present a lecture on the topic on power point format.
- To improve the communication skill of the students.

**Course Outcome**

On the successful completion of the course, students will be able to:

| CO1 | Review, collect and study literature on a topic of interest | Understand |
|-----|------------------------------------------------------------|------------|
| CO2 | Apply the knowledge to prepare a report on the same | Apply |
| CO3 | Evaluate the collected literature and formulate a project | Apply, Evaluate |
| CO4 | Define a process/method for completion of the same | Apply |
| CO5 | Analyze sustainability of the technology | Analyze |

**CO-PO Mapping**

| COs | POs | | | | | | | | | | | | PSOs | |
|-----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | 3 | - | 2 | 1 | - | 1 | - | 2 | 3 | 2 | 2 |
| CO2 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | - | 2 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO4 | 3 | 2 | 2 | - | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO5 | 3 | 3 | 3 | - | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 3 | 2 | 2 |
| Average | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 2 |

1: Slight (Low)        2: Moderate (Medium)        3: Substantial (High)        *If there is no correlation, put "-"*

**TBE – 419 : EDUCATIONAL TOUR**

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 0 | 0 |

Students will be taken to the visit of industries/research organization, in their field of

specialization, during the vacation period

---

**OBJECTIVE: The objective of this course is t**o enable the students
- to visit industries/research organization in their field of biochemical engineering during the vacation period.
- to demonstrate a variety of product formation and manufacturing processes in industries specialization.
- to learn professional ethics.

---

**Course Outcome**

On the successful completion of the course, students will be able to

| CO1 | visit industries/research organization in their field of biochemical engineering. | Engineer and Society Life long Learner |
|---|---|---|
| CO2 | to demonstrate a variety of product formation and manufacturing processes in industries specialization. | Engineer and Society Individual & Team Work |
| CO3 | To learn professional ethics. | Ethics |
| CO4 | improve the communication skill of the students. | Communication |
| CO5 | Analyze environment and sustainability of related technology. | Analyze Environment & Sustainability |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | 3 | | | 1 | | | 3 | 3 | 3 |
| CO2 | 3 | 2 | | | | 2 | 2 | | 1 | | | 3 | 3 | 3 |
| CO3 | 3 | | | | | | | 3 | | | | 3 | 3 | 3 |
| CO4 | 3 | | | | | | | | | 3 | | 3 | 3 | 3 |
| CO5 | 3 | | | | | 2 | 3 | | 1 | | | 3 | 3 | 3 |
| Total | 3 | 2 | | | | 3.5 | 2.5 | 3 | 1 | 3 | | 3 | 3 | 3 |

1: Slight (Low)      2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

**Year IV, Semester-VIII**
## Course Title: Sustainable Bio-Energy Recourses

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-402 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:- :**To provide knowledge about various types of bio-energy, processing, production and utilization of various form of biomass; Also aware about the importance of bio-energy for clean environment and about the sustainability.

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Analyze the importance of various Bioenergy resources and their utilization. | Apply |
|---|---|---|
| CO2 | Utilize the concept of biogas production, gasohol and biodiesel. | Apply |
| CO3 | Solve the problems related to production process & technology based on bio-energy. | Apply |
| CO4 | Apply techniques for production of bio-energy from biomass at large scale | Apply |
| CO5 | Design and construct biological fuel cell. | Apply |

| COs | Pos | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | 3 | | | | | | 3 | 3 | 3 |
| CO2 | 3 | 3 | 3 | 2 | | 3 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | 3 | 3 | 2 | | 3 | | | | | | 3 | 3 | 3 |
| CO4 | 3 | 3 | 3 | 2 | 2 | 3 | | | 3 | | | 3 | 3 | 3 |
| CO5 | 3 | 3 | 3 | 2 | 2 | 3 | | | 3 | | | 3 | 3 | 3 |
| Total | 3 | 3 | 3 | 2 | 2 | 3 | 3 | | 3 | | | 3 | 3 | 3 |

1:Slight(Low)          2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

**Syllabus**

**Unit-I:**

Bioenergetics, Biomass Sources, Characteristics & Preparation: Biomass Sources and Classification. Chemical composition and properties of different biomass materials and bio-fuels – Sugar cane molasses and other sources for fermentation ethanol-Sources and processing of oils and fats for liquid fuels.

**Unit-II:**

Biogas, Technology: Feedstock for biogas production, Aqueous wastes containing biodegradable organic matter, animal residues. Microbial and biochemical aspects: Operating parameters for biogas production. Digesters for rural application.

**Unit-III:**

Bio-Ethanol and Bio-Diesel Technology: Production of Fuel Ethanol by Fermentation of Sugars. Gasohol as a Substitute for Leaded Petrol. Trans-Esterification of Oils to Produce Bio-Diesel.

**Unit-IV:**

Pyrolysis and Gasification of Biomass: Thermo-chemical conversion of ligno-cellulose biomass – Biomass processing for liquid fuel production - Pyrolysis of biomass-Pyrolysis regime, effect of particle size, temperature, and products obtained.

**Unit-V:**

Combustion of Biomass and Cogeneration Systems: Combustion of Woody Biomass: Theory, Calculations and Design of Equipments. Case Studies: Combustion of Rice Husk, Use of Bagasse for Cogeneration.

**References** :

1. "Introduction to Bioenergy", Vaughn C. Nelson and Kenneth L. Starcher, CRC Press (2016).
2. "Biofuels and Bioenergy", John Love and John A. Bryant", John Wiley & Sons Ltd. (2017).
3. "Bioenergy : Biomass to Biofuels", Anju Dahiya, Academic Press(2014).

## Course Title: Bioprocess Equipment Design

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-404 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**
- To introduce the basic design concepts for bioprocess equipments
- Students will know about the design of equipments to facilitate mixing and aeration
- Students will know how to control the temperature of the bioprocess system
- To teach the design of equipments used for downstream processing
- To provide the basic concept of scale up

**Course outcome:-** On successful completion of the course student will be able to –

| CO 1 | Students will be able to know the different materials, pipings and pumps used in bioprocessing . | Apply |
|---|---|---|
| CO2 | Student will be able to understand the design aspects of aerators and agitators | Apply |
| CO3 | Students will be able to conceptualize the application of heating and cooling system in bioprocessing | Apply |
| CO4 | Student will be able to know about the design of various purification techniques | Apply |
| CO5 | Students will gain knowledge about the scale up of bioprocesses | |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | 1 | 2 | | | | | 3 | 3 | 3 |
| CO2 | 3 | | | | | 1 | 2 | | | | | 3 | 3 | 3 |
| CO3 | 3 | | | | | 1 | 2 | | | | | 3 | 3 | 3 |
| CO4 | 3 | 2 | 1 | | | 1 | 2 | | | | | 3 | 3 | 3 |
| CO5 | 3 | | | | | 1 | 2 | | | | | 3 | 3 | 3 |
| Total | 3 | 2 | 1 | | | 1 | 2 | | | | | 3 | 3 | 3 |

1: Slight (Low)        2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

Unit 1
Selection of materials, pumps, piping, valves for bioprocess systems

Unit 2
Design of aeration system, design of agitation system, power requirements in gassed and ungassed bioreactors

Unit 3
Heating and cooling systems in bioprocess industries

Unit 4
Design of centrifuge, Design of filtration systems, Design of crystallizer, Design of dryers

Unit 5
 Scale-up: criteria, basic concepts and related problems.

References:

- Perry's handbook of Chemical Engineering
-  Bioprocess  Engineering Principles:  Pauline M. Doran ,Publisher Elsevier
- William M( Bill) Huitt, Bioprocessing piping and equipment design: a campanign guide for the ASME BPE standard-Wiley-ASME press series.
- Bioprocess Engineering : Systems Equipment and facilities : Bjorn K Lybersen

## Course Title: INSTRUMENTATION AND CONTROL IN BIOPROCESSES

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ESE | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-406 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**

The objective of this course is to enable the student to understand basic concepts of biosensors, components of biosensors and their application in industry, medical science and environmental studies.

**Course outcome:-** On successful completion of the course student will be able to –

| CO1 | Understand the basic principles of instrumentation and control | Apply |
|---|---|---|
| CO2 | Understand about various types of biological sensors and their applications. | Apply |
| CO3 | Understand about various types of transducers, their functioning and criteria for selection. | Apply |
| CO4 | Understand chemical, electrochemical and optical sensing mechanism and tools. | Apply |
| CO5 | Understand applications of Biosensors in industry, medical and environmental studies. Biochips and their application. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | | | | | | | 3 | 3 | 3 |
| CO2 | 2 | 2 | 2 | | | 2 | | | | | | 3 | 3 | 3 |
| CO3 | 3 | | | | | | | | | | | 3 | 3 | 3 |
| CO4 | 3 | | | | | 2 | | | | | | 3 | 3 | 3 |
| CO5 | 3 | 2 | | | | 2 | | | | | | 3 | 3 | 3 |
| Total | 3 | 2 | 2 | | | 2 | | | | | | 3 | 3 | 3 |

1: Slight (Low)    2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

## SYLLABUS

**Unit 1. Introduction**

Parameters required to be measured and controlled in bioprocesses: flow, DO, pH, $CO_2$, Temperature, level, foam etc. Introduction to instrumentation and control in bioprocesses. Use of PLC, HMI and SCADA in bioprocess control.

## Unit 2. Biosensors

Concepts and applications, Biosensing and biosensor technology.

## Unit 3. Transduction principles:

Classification of transducers, selection of transducers, Temperature transducers: thermo-resistive transducers, thermoelectric, chemical thermometry. Pressure transducer, photoelectric transducers, flow transducers.

## Unit 4. Analytical techniques:

Chemical sensing methods, optical sensing mechanisms and tools, eletrochemical sensing mechanisms and tools, mass spectroscopy.

## Unit5. Application

Applications of biosensor-based instruments to the bioprocess industry, application of biosensors to environmental samples, introduction to biochips and their application in modern sciences.

## Text /Reference books:

- Transducers for Biomedical Instruments by S.C. Cobbold, Prentice Hall.
- Principles of Medical Electronics & Biomedical Instrumentation by Rao and Guha, University Press, India.
- Coughnour and Koppel, " Process Systems Analysis and Control ", McGraw-Hill, New York, 1986.
- S. K. Singh, " Industrial Instrumentation and Control ", Tata McGraw-Hill, 2008.
- George Stephanopolous, " Chemical Process Control ", Prentice-Hall of India Pvt-Ltd., New Delhi, 1990.
- Nakra and Chaudhary, " Instrumentation Measurement and Analysis", Tata McGraw Hill, 1978.
- P. K. Sarkar, " Process Dynamics and Control", Prentice Hall India, 2014.
- D. N. Considine, "Process Instrumentation and Controls Handbook", Considine, McGraw Hill.

## Course Title: BIO-MATERIALS SCIENCE AND ENGINEERING

**Evaluation Scheme:**

| Course Type | Subject Code | Credits | Periods | | | Sessional Marks | | | | ES E | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | L | T | P | MSE | TA | Lab. | Total | | |
| PEC | TBE-408 | 4 | 3 | 1 | 0 | 30 | 20 | - | 50 | 50 | 100 |

**Objective:-**

The objective of this course is to enable the students with properties of Biomaterials , their characteristics, and applications.

**Course outcome:-** On successful completion of the course student will be able to –

| | | |
|---|---|---|
| CO1 | Understand about structure, property characteristics and testing of biomaterials. | Understand |
| CO2 | Understand compatibility of biomaterials with living bodies. | Understand |
| CO3 | Understand production technology of biomaterials such as biopolymers and other materials having specific use for example drug delivery. | Apply |
| CO4 | Understand about materials suitable for implants such as orthopedic and dental implants. | Apply |
| CO5 | Understand about materials suitable for soft tissue replacement for example implants for cardiovascular and ophthalmology and organs transplant. Legal Issues related to use of biomaterials. | Apply |

| COs | POs | | | | | | | | | | | | PSOs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | | | | | | | | | | | 2 | 3 | 3 |
| CO2 | 3 | | | | | 2 | | | | | | 2 | 3 | 3 |
| CO3 | 3 | | | | | | | | | | | 2 | 3 | 3 |
| CO4 | 3 | | | | | | | | | | | 2 | 3 | 3 |
| CO5 | 3 | 2 | | | | 2 | 2 | | | | | 2 | 3 | 3 |
| Total | 3 | 2 | | | | 2 | 2 | | | | | 2 | 3 | 3 |

1: Slight (Low)     2: Moderate (Medium) 3: Substantial (High) *If there is no correlation, put "-"*

**Syllabus**

**Unit 1. Introduction:**

Introduction and overview of biomaterials, structure and property relation in materials and characterization and testing of biomaterials.

**Unit 2. Interactions of materials:**

Interactions of materials with human body, bio-compatibility of materials, metals, alloys,

ceramics, polymers and composites as biomaterials.

## Unit 3. Biopolymers:

Biopolymers, natural materials, material for drug delivery: biodegradable polymers.

## Unit 4. Implants:

Materials for hard tissue replacement: orthopedic implants, dental implants.

## Unit 5.

Materials for soft tissue replacement: dermal and facial prosthesis, cardiovascular implants, ophthalmology, materials for artificial organs transplant and extracorporeal device. legal issues related to development of biomaterials.

## Text/Reference Books:

- Biomaterials: An Introduction by Park J.B. and Lakes R.S., Plenum Press, New York.
- Biomaterials, Medical Devices & Tissue Engineering: An Integrated Approach by Silver F.H., Chapman and Hall publication.
- Biomaterials by Bhat Sujata V., Narosa Publishing House.
- Biomaterials science: an introduction to materials in medicine by Buddy D. Ratner., Elsevier Academic Press.
- Biomaterials: A Tantalus Experience by Jozef A. Helsen., Yannis Missirlis Springer.
- Biomaterials by Temenoff Johnna S., Dorling Kindersley India Pvt Ltd.

# TBE-410: PROJECT

| L | T | P | C |
|---|---|---|---|
| 0 | 0 | 20 | 10 |

**COURSE OBJECTIVES:** The objectives of this course is to enable the students

- To articulate a clear research question or problem and formulate a hypothesis

- To identify and practice research ethics and responsible conduct in research

- To communicate confidently and constructively with fellow students and faculty as mentors explain their research to others in the field and to broader audiences through research presentation

**Course Outcome:** On the successful completion of the course, students will be able to:

| CO1 | Identify and utilize relevant previous work that supports their research | Understand |
|-----|--------------------------------------------------------------------------|------------|
| CO2 | Identify and apply appropriate methodologies to address the research question or creative objective | Apply |
| CO3 | Work collaboratively with other members, demonstrating effective communication and problem-solving skills | Apply |
| CO4 | Present the research work effectively in a conference | Apply |
| CO5 | Analyze the sustainability of related technology | Analyze |

## CO-PO Mapping

| COs | POs | | | | | | | | | | | | PSOs | |
|-----|-----|---|---|---|---|---|---|---|---|----|----|----|------|---|
|     | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 |
| CO1 | 3 | - | - | 3 | - | 2 | 1 | - | 1 | - | 2 | 3 | 2 | 2 |
| CO2 | 3 | 2 | 2 | 2 | 1 | 2 | 3 | - | 2 | 3 | 3 | 2 | 2 | 2 |
| CO3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO4 | 3 | 2 | 2 | - | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| CO5 | 3 | 3 | 3 | - | 1 | 2 | 3 | 3 | 2 | 1 | 2 | 3 | 2 | 2 |
| Average | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 2 | 2 |

1: Slight (Low)　　　2: Moderate (Medium)　　　3: Substantial (High)　　　*If there is no correlation, put "-"*