B. E. SYLLABUS

BIOTECHNOLOGY

III & IV SEMESTER

With

Scheme of Teaching

& Examination

DEPARTMENT: BIOTECHNOLOGY ENGINEERING

1	Dr. C. VamanRao	M.Sc., Ph.D.	Prof. & Head
2	Dr. Ujwal P.	M.Sc., Ph.D.	Professor
3	Dr. Vidya S.M.	M.Sc., Ph.D.	Professor
4	Dr. Shyama Prasad S.	M.Sc., Ph.D.	Assoc. Prof.
5	Dr. D.M. Chetan	M.Sc., Ph.D.	Assoc. Prof.
6	Dr. Anil Kumar H.S.	M.Sc., Ph.D.	Assoc. Prof.
7	Dr. Bharath B.R.	M.Sc., Ph.D.	Asst. Prof. Gd III
8	Mr. VenkateshKamath H.	M.Tech., (Ph.D.)	Asst. Prof. Gd II
9	Mr. Vinayaka B. Shet	M.Tech., (Ph.D.)	Asst. Prof. Gd II
10	Mr. Sandesh K.	M.Tech., (Ph.D.)	Asst. Prof. Gd II
11	Ms. SnehaNayak	M.Tech., (Ph.D.)	Asst. Prof. Gd I
12	Ms. Louella C. Goveas	M.Tech., (Ph.D.)	Asst. Prof. Gd I
13	Ms. Harshitha M. Jathanna	M.Tech., (Ph.D.)	Asst. Prof. Gd I

DEPARTMENT OF BIOTECHNOLOGY ENGINEERING

Vision :

To accomplish excellence in Biotechnology research and creating manpower for the benefit of society and human kind with an emphasis on present and future global needs.

Mission :

To empower the students of Department of Biotechnology Engineering in to

1. Competent professionals to undertake projects by providing academic training and technical achievements,
2. A successful professionals in research, academia and industry,
3. An engineer for effective utilization of natural resources in biotechnology related industries.

Program Educational Objectives (PEOs):

The program educational objectives are set in line with Institutional and Departmental mission statements. The program educational objectives of B.E. Biotechnology are to produce professionals who later take the role of engineering professionals and researchers with following qualities:

PEO1. Apply fundamental knowledge of mathematics, principles of physics and chemistry, and biological sciences for the engineering applications.

PEO2. Demonstrate the application of biotechnological processes and engineering principles through designing of industrial biochemical processes that are of societal and industrial importance.

PEO3. Exhibit skills of handling microbial processes, biochemical analysis by making use of state of the art instruments.

PEO4. Exhibit strong, independent learning, analytical and problem solving skills with special emphasis on design, communication, and an ability to work in teams.

PEO5. To have successful career as engineering professional or a researcher through life-long learning in the field of biotechnology.

Graduate Attributes (GA):

The Graduate Attributes are the knowledge skills and attitudes which the students have at the time of graduation. These attributes are generic and are common to all engineering programs. These Graduate Attributes are identified by National Board of Accreditation.

GA-1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

GA-2. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

GA-3. Design/Development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

GA-4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

GA-5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

GA-6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

GA-7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

GA-8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

GA-9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

GA-10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

GA-11. Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

GA-12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Outcomes (POs):

In addition to PEOs, the B.E. Biotechnology program established a set of Program Outcomes (POs), expected to be met by every graduating student from the program at the time of graduation. Program outcomes listed below embrace the required outcomes as listed in Graduate Attributes (GAs) of National Board of Accreditation (NBA), India.

The graduates of B.E. Biotechnology will have ability to:

PO a. Apply knowledge of mathematics, physics, chemistry and biological science and engineering to analyze bioprocesses and related systems.

PO b. Identify and formulate and solve bioprocess engineering problems.

PO c. Design bioprocess systems involving unit operations, reacting systems, reactors and product purification systems.

PO d. Design and conduct experiments, as well as to analyze and interpret data.

PO e. An ability to function on multidisciplinary teams.

PO f. Understand professional and ethical responsibility.

PO g. Communicate effectively, work independently, and practice leadership and teamwork.
PO h. Use the techniques, skills, and modern engineering tools necessary for engineering practice.
PO i. Design system, components or processes to meet realistic needs of society, environment, health and safety, and sustainability.
PO j. Recognize the need for, and an ability to engage in life-long learning.
PO k. Acquire knowledge of contemporary issues.

Program Specific Outcomes (PSOs):

Program Specific Outcomes for B.E. programme in Biotechnology set by Faculty in Biotechnology Engineering are as follows:
PSO 1. Demonstrate proficiency in basic science and foundation engineering courses.
PSO 2. Demonstrate a working knowledge of advanced biological sciences.
PSO 3. Demonstrate competence in application of engineering principles to biological systems.

The following tables provide mapping of statements and outcomes.

Table 1: Mapping of Mission statements with Program Educational Objectives

Mission Statement	PEO1	PEO2	PEO3	PEO4	PEO5
Institution*: To develop NMAM Institute of Technology, Nitte as a Center of Excellence by imparting Quality Education to generate Competent, Skilled, and Humane Manpower to face emerging Scientific, Technological, Managerial and Social Challenges with Credibility, Integrity, Ethics and Social Concern.*	**M**	**H**	**M**	**H**	**H**
Department*: To empower the students of Department of Biotechnology Engineering in to* *1. Competent professionals to undertake projects by providing academic training and technical achievements.*	**M**	**H**	**H**	**H**	**M**
2. A successful professionals in research, academia and industry	**H**	**H**	**M**	**H**	**M**
3. An engineer for effective utilization of natural resources in biotechnology related industries.	**M**	**H**	**H**	**M**	**M**

* L = Low, M= Moderate, H= High

Table 2: Mapping of Program Outcomes with Program Educational Objectives (PO/PSO vs PEO)

PO/PSO / PEO	PO-a	PO-b	PO-c	PO-d	PO-e	PO-f	PO-g	PO-h	PO-i	PO-j	PO-k	PSO-1	PSO-2	PSO-3
PEO1	**H**	**M**	**L**	**L**					**L**			**L**	**M**	**M**
PEO2		**M**	**H**	**H**	**L**		**M**	**L**	**H**			**H**	**H**	**H**
PEO3	**M**	**M**		**H**		**M**	**L**	**H**		**M**	**L**	**M**	**M**	**L**
PEO4		**H**	**H**	**H**	**M**	**L**	**M**		**H**		**L**	**H**	**L**	**M**
PEO5	**L**	**L**		**M**		**M**	**L**	**M**		**H**	**H**	**M**	**H**	**M**

Table 3: Mapping of program outcomes with Graduate Attributes (PO/PSO vs PO)

PO/PSO / GA	PO-a	PO-b	PO-c	PO-d	PO-e	PO-f	PO-g	PO-h	PO-i	PO-j	PO-k	PSO-1	PSO-2	PSO-3
GA1	**H**											**H**	**H**	**H**
GA2		**H**									**M**	**H**	**H**	**H**
GA3			**H**									**M**		**H**
GA4				**H**	**M**							**H**	**M**	**M**
GA5					**M**			**M**				**M**	**H**	
GA6									**H**				**M**	**M**
GA7								**H**	**H**		**M**		**M**	**M**
GA8						**H**						**H**	**H**	**H**
GA9					**H**		**H**					**L**	**M**	**M**
GA10							**H**		**M**			**M**	**M**	
GA11												**H**		
GA12										**H**	**M**	**L**	**H**	**L**

CURRICULAR COMPONENTS

Degree Requirements for B. E. in Biotechnology

Category of courses	Category code	Credits offered	Min. credits to earn
Basic Science Core	BSC	28	28
Engineering Science Core	ESC	27	27
Humanities & Social Sciences Core	HSC	5	5
Professional Core Courses	PCC	106	106
Professional Elective Courses	PEC	21	21
Open Elective Courses	OEC	3	3
Programme Major Project	PMP	12	12
Add on courses/Audit Courses	AOC	0	0 (Optional for student)
Mandatory Learning Courses	MLC	0	Student should secure PP grade to graduate
Total		200	200

DEPARTMENT OF BIOTECHNOLOGY ENGINEERING
SCHEME OF TEACHING AND EXAMINATION

III Semester **31 Hours/week**

Sl.No.	Code	Course Title	Theory/Tuto. /Prac./ Self study	Total Hrs./Week	CIE	SEE	Credits
1	15BT301	Numerical Methods	4+0+0+0	4	50	50	4
2	15BT302	Unit Operations	4+0+0+S	4	50	50	4
3	15BT303	Biochemistry	4+0+0+0	4	50	50	4
4	15BT304	Microbiology	4+0+0+0	4	50	50	4
5	15BT305	Bioprocess Calculations	3+2+0+0	5	50	50	4
6	15BT306	Unit operations Lab	0+0+3+0	3	50	50	2
7	15BT307	Biochemistry Lab	0+0+3+0	3	50	50	2
8	15HU311	Enhancing Self Competence (ESC)	2+0+0+0	2	50	50	2
		TOTAL	**31**	**31**	**400**	**400**	**26**

DEPARTMENT OF BIOTECHNOLOGY ENGINEERING
SCHEME OF TEACHING AND EXAMINATION

IV Semester **30 Hours/week**

Sl. No.	Code	Course Title	Theory/Tuto. /Prac./ Self study	Total Hrs. /Week	CIE	SEE	Credits
1	15BT401	Biostatistics	4+0+0+0	4	50	50	4
2	15BT402	Heat & Mass Transfer	3+2+0+0	5	50	50	4
3	15BT403	Thermodynamics	2+2+0+0	4	50	50	3
4	15BT404	Structural Biology	4+0+0+0	4	50	50	4
5	15BT405	Molecular Biology & Genetics	4+0+0+S	4	50	50	4
6	15BT406	Cell and Developmental Biology	3+0+0+0	3	50	50	3
7	15BT407	Heat & Mass Transfer Lab	0+0+3+0	3	50	50	2
8	15BT408	Microbiology Lab	0+0+3+0	3	50	50	2
TOTAL			**30**	**30**	**400**	**400**	**26**

NUMERICAL METHODS

Sub Code	**: 15BT301**	**Credits**	**: 04**
Hrs/Week	**: 4+0+0+0**	**Total Hours**	**: 52**

Prerequisites: Differential Equations, Partial Differential Equations, and Calculus
Corequisites: Nil

Course Learning Objectives:

The objective of this course is

1. To differentiate or integrate functions which are represented by tabular values;
2. To apply numerical methods for solving engineering problems where the analytical solutions for some functions are not possible;
3. To solve ordinary and partial differential equations by numerical methods.

UNIT – I

FINITE DIFFERENCES AND INTERPOLATION

Finite differences: forward, backward and central difference operators, Newton-Gregory forward and backward interpolation formulae, Lagrange's interpolation formula, Lagrange's Inverse interpolation formula. Newton's divided difference interpolation formula, Central differences-Stirling's and Bessel's interpolation formulae(Without- proof).**11 Hours**

UNIT – II

NUMERICAL DIFFERENTIATION AND INTEGRATION

Numerical differentiation using Newton's forward & backward difference interpolation formulae.

NUMERICAL INTEGRATION

General quadrature formula, Trapezoidal rule, Simpson's one third rule, Simpson's three eigth rule, Weddle's rule, errors **12 Hours**

UNIT – III

SOLUTION OF SYSTEMS OF EQUATIONS

Numerical solution of algebraic and transcendental equations: Bisection Method, Ordinary iteration method, Regula– Falsi Method and Newton–Raphson Method. Numerical solution of simultaneous linear equations by LU-decomposition method, non-linear equations by Newton-Raphson method.**10 Hours**

UNIT – IV

NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS

Numerical solution of first order ordinary differential equations: Taylor's series Method, Picard's method, Euler's method, Modified Euler's Method, 4th order R-K Method. Adam's Bashforth predictor –corrector and Milne's Predictor - Corrector Methods. **9 Hours**

UNIT – V

NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS

Finite difference expressions for first and second order derivatives (ordinary and partial).Classification of second order partial differential equations.Numerical solutions of Laplace and Poisson equations by standard five point formulae and heat and wave equations by explicit method. **10 Hours**

Course Outcomes:

At the end of this course, the student will be able to

1. Develop various finite difference schemes and interpolation techniques for bioprocess problems.
2. Examine and Apply numerical differentiation and integration techniques to solve bioprocess engineering problems having no analytical solutions.
3. Select suitable numerical methods to Solve simultaneous linear and non-linear algebraic equations.
4. Identify and Make use of suitable numerical technique to solve ordinary differential equations.
5. Identify and Make use of suitable numerical technique to solve partial differential equations.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	H							L				H		L
CO2	H	H						L				H		M
CO3	H	M						L				H		M
CO4	H	M						L				H		L
CO5	H	M						L				H		L

PO = Programme Outcome; CO = Course Outcome; PSO = Programme Specific Outcome
Mapping codes: L = Low, M= Mid, H= High

TEXT BOOKS:

1. Grewal, B. S. *Higher Engineering Mathematics*, 36th Ed., Khanna Publishers, New Delhi, 2002.
2. Sastry, S. S. *Introductory methods of Numerical Analysis*, 2nd Ed., Prentice Hall, 1990.

REFERENCE BOOK:

1. Jain, M. K. Iyengar, S. R. K. and Jain, R. K. *Numerical methods for Scientific and Engineering computations*, 5th Ed., New Age International, 2007.

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UNIT OPERATIONS

Sub Code : 15BT302 **Credits : 04**
Hrs/Week : 4+0+0+S* **Total Hours : 52**

*** Self Study to be exercised under the supervision of course instructor and to be restricted to not more than 10% of the total teaching hours.**

***Prerequisites*:**Engineering Physics
***Corequisites*:** Nil

Course Learning Objectives:

The objective of this course is

1. To study various aspects of fluid flow and mechanical operations;
2. To understand dynamics of fluid flow and its role in bioprocesses;
3. To learn mechanisms of various fluid metering and pumping systems;
4. To learn concepts and equipments for solid-liquid handling and processing.

UNIT- I

FLUID STATICS & FUNDAMENTALS OF FLUID DYNAMICS

Units and Dimensions: Fundamental & derived variables.

Fluid statics: definition, classification. Newton's law of viscosity, Newtonian and non-Newtonian fluids. Types of fluid motion– related equations. Fluid statics: Pressure and its measurement using manometers. Hydrostatic equilibrium, barometric equation.

Fluid Dynamics: Equation of motion,energy balance equation, continuity equation, Euler's equation, Bernoulli's equation. **9 Hours**

UNIT- II

FLUID DYNAMICS: Drag, lift, drag coefficient. Energy loss in circular and non-circular pipes, flow of viscous and turbulent fluid through pipe: Hagen Poiseuille and Darcy-Weisbach equation. Energy loss in pipes due to sudden expansion, contraction and pipe fittings; energy loss in packed bed: Kozney-Karmen equation, Ergun's equation. Introduction to Two phase flow (G – L System), boundary layer theory, boundary layer separation, wake formation. Introduction to unsteady state flow.Dimensionless numbers, dimensional analysis by Rayleigh's method and Buckingham's pi method. **12 Hours**

UNIT – III

FLUID PUMPING AND METERING: Pipe and pipe fittings; fluid pumping: energy calculations, centrifugal pump, positive displacement pump, fans, blowers, compressors. Valves: types and applications. Metering of fluids: Orifice meter, venturi meter, rota meter, notches and weirs, load cells, wheel flow meter, magnetic flow meter. Construction and working of: Plunger pump, peristaltic pump, piston pump, metering pumps. **10 Hours**

UNIT – IV

SOLID-LIQUID SEPARATION TECHNIQUES

Filtration: Batch and continuous filtration; constant volume and constant Pressure filtration; filtration equipments (plate & frame, leaf), types of filters, filter aids.

Settling: Types of settling-sedimentation and centrifugation, Stoke's law, Newton's law, Terminal settling velocity.Kynch theory and Thickener design.
Centrifugal Separation:Basic theory of centrifugation, centrifugal pressure, flocculation and sedimentation, simple and ultra centrifugation, density gradient centrifugation, sedimentation in a centrifugal field. **10 Hours**

UNIT – V

MIXING AND SOLID HANDLING TECHNIQUES

Mixing: Principle, types of agitators (impellers used for cell culture), flow pattern. Dimensionless numbers and dimensional analysis in mixing, Power number calculation and aeration. Rate and time of mixing.
Size reduction: Laws of size reduction, equipments of size reduction; particle size analysis, screen effectiveness.
Fluidization: Characteristics of fluidized systems, solid-liquid system, gas-solid-liquid system, applications.
Conveyors: Slurry transport, pneumatic conveyors, mechanical conveyors, and elevators (screw conveyor, belt conveyor, bucket elevator, continuous flow conveyor elevators).

11 Hours

Course Outcomes:

At the end of this course, the student will be able to

1. Relate and apply principles of fluid statics for bioprocess operations.
2. Explain the relevance of single and multiphase fluid dynamics principle to bioprocess operations.
3. Illustrate, compare and contrast the various fluid metering and pumping devices.
4. Classify and describe various solid-liquid separation techniques.
5. List various solid handling techniques and utilize the concepts of mixing in industrial applications.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	L	M										L		H
CO2	L	M												M
CO3	L	M		M										H
CO4			L	M							M			H
CO5			L	M				L			M			H

TEXT BOOKS:

1. Backhurst, J. R., Harker, J. H., Richardson, J. F., Coulson, J. M., Chhabra, R. P. *Coulson & Richardson's Chemical Engineering*, Volume 1, 6th Ed., Butterworth Heinemann, 1999.
2. Harker, J. H., Backhurst, J. R. *Coulson & Richardson's Chemical Engineering*, Vol 2, 5th Ed., Butterworth Heinemann, 2002.

3. Buddhi, N. Hewakandamby, *A first course in Fluid Mechanics for Engineers*, www.bookboon.com (free ebook publishers), UK, 2012.

REFERENCE BOOKS:

1. McCabe, W. L., Smith, J. C. and Harriott, P. *Unit Operations of Chemical Engineering*, 7th Ed., MGH, 2010.
2. Geonkoplis, C. J. *Transport Processes and Separation Process Principles (Includes Unit Operations)*, 4th Ed., Prentice Hall, 2004.
3. Bansal, R. K. *A Textbook of Fluid Mechanics and Hydraulic Machines*, 9th Ed., Laxmi Publications, 2010.
4. Darby, R. *Chemical Engineering Fluid Mechanics*, 2nd Ed., CRC Press, 2001.
5. Walas, S. M. *Chemical Process Equipment: Selection and Design*, Butterworth Heinemann, 1988.
6. Johnson, A. T. *Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied* to Biological Systems, 1st Ed., Wiley-Interscience, 1998.

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BIOCHEMISTRY

Sub Code : 15BT303 **Credits:04**
Hrs/Week : 4+0+0+0 **Total Hours: 52**

***Prerequisites*:** Chemistry
***Corequisites*:**Biochemistry Lab

Course Learning Objectives:

The objective of this course is

1. To understand the physiological processes of living organisms in terms of molecular structure and reactivity.
2. To gain the knowledge of basic processes taking place in the biological systems and the pathological conditions related to biochemical defects.
3. To understand biological processes coordinated via complex molecular interactions involving molecules like proteins, carbohydrates and nucleic acids.
4. To understand the metabolic pathways and appreciate theintegration of individual pathways in multi-cellular processes.

UNIT -I

BIOMOLECULLES I

Introduction to Biochemistry; Nature and scope of biochemistry, biochemical evolution.Chemistry of sugars; stereo and optical isomerism, monosaccharides, disaccharides and polysaccharides; structure, occurrence and biological importance.Lipids; structure and properties of fatty acids, biological properties of lipids. **10 Hours**

UNIT – II

BIOMOLECULES II

Proteins – structure and properties of amino acids, peptides, structure of proteins; Primary, secondary, tertiary and quaternary. Nucleic acids –Nitrogen bases and nucleotides; purine and pyrimidines.Structure and molecular models of DNA and RNA.

10 Hours

UNIT – III

METABOLISM OF CARBOHYDRATES AND LIPIDS

Introduction to metabolism, glycolysis, gluconeogenesis, pentose phosphate pathway.TCA cycle – amphibolic pathway.Biosynthesis of polysaccharides – starch and glycogen.Blood glucose and its regulation.Oxidation of fatty acid – beta oxidation.Biosynthesis of cholesterol, phospholipids and glycolipids, metabolism of xenobiotics.**11 Hours**

UNIT – IV

METABOLISM OF PROTEINS AND NUCLEIC ACIDS: Formation of urea, protein degradation, protein targeting, protein folding. Biosynthesis of purines and pyrimidines, biodegradation of purines and pyrimidines.Interconnection pathways of metabolism.Metabolic regulation.**11 Hours**

UNIT – V

CLINICAL BIOCHEMISTRY: Collection and disposal of clinical samples. Plasma proteins, clinical significance of immunoglobulins, serum lipid profile, liver function test, renal function test. Gastric function test, normal and abnormal constituents of urine - hormones. Automation in clinical biochemistry, liquid biopsy.**10 Hours**

Course Outcomes:

At the end of the course, the student will be able to

1. Discuss about carbohydrates and lipids as biomolecules.
2. Explain amino acids, proteins and nucleic acids as biomolecules.
3. Summarize metabolic pathways of carbohydrates, lipids and compare and appraise their interactions.
4. Construct metabolic pathways of proteins and nucleic acids and explain their interactions.
5. Justify the application of biochemical principles to clinical investigation and therapies.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	L			L						L		L	H	
CO2	L		M	L				L					H	
CO3			L								L		M	
CO4			L						M	H	M		M	
CO5	M	L							H	L	L		M	

TEXT BOOKS:

1. Nelson, D. L. & Cox, M. M. Lehninger, A. L. *Lehninger's Principles of Biochemistry*, 4th Ed., W.H. Freeman, 2004.
2. Rastogi, S. C. *Biochemistry*, 2nd Ed., Tata McGraw Hill, 2003

REFERENCE BOOKS:

1. Chatterjea, M. N. and RShinde, R. *Text book of MedicalBiochemistry*, 8th Ed., Jaypee Brothers Publications, 2012.
1. Murray, R.K., *Harper's Illustrated Biochemistry*, 27th Ed., MGH, 2003.
2. Stryer, L. *Biochemistry*, 5th Ed., W.H. Freeman and Company, 2002.
3. Basten, G. *Introduction to clinical Biochemistry*,VentusPusblishing Aps, 2010.

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MICROBIOLOGY

Sub Code : 15BT304 **Credits:04**
Hrs/Week : 4+0+0+0 **Total Hours: 52**

***Prerequisites*:** Nil
***Corequisites*:** Nil

Course Learning Objectives:

The objective of this course is
1. To learn fundamental aspects of microbes, and their cultivation.
2. To learn microbial growth and metabolism.
3. To learn microbiological applications in medical, soil, agriculture and industry.

UNIT-I

INTRODUCTION

The scope of microbiology.Discovery of microbial world.Microbial diversity and taxonomy.Important contributors in microbiology.Prokaryotic and eukaryotic cell structure and functions.

The morphology and fine structure of bacteria-Size, shape, flagella, pili, capsules, sheaths, the cell wall, membranous inclusions, spores and cysts. General characteristics of viruses, types of viruses-RNA and DNA viruses. Fungi - Characteristics of fungi, classification and reproduction of fungi. Protozoans-Characteristics of protozoans, classification of disease causing protozoans.

Microbiological techniques: Sterilization methods – Physical methods (dry heat, moist heat, filtration and cold sterilization), Chemical methods-specific chemical antimicrobial agents: soaps and detergents, phenols, acids and alkalis, heavy metals and halogens. Staining techniques – Simple and differential staining. Microscopy - Simple, SEM, TEM.

12 Hours

UNIT – II

MICROBIAL NUTRITION, GROWTH & METABOLISM:

The principles of microbial nutrition.Ingredients of culture media.Types of media - (solid and liquid), natural, selective, differential and enrichment media.Microbial growth - definition of growth, growth curve of bacteria, calculation of doubling time (numerical). Factors

influencing microbial growth, measurement of growth-cell mass, cell number. Biochemical tests for identification of bacteria (As dealt in Bergey's manual). Methods of isolating pure culture: streak plate, pour plate method. Maintenance and preservation of culture: periodic transfer to fresh culture, overlaying with mineral oil, freeze drying.
Metabolic pathways and bioenergetics: Aerobic, anaerobic and anoxic growths, production of secondary metabolites, formation of toxic materials from microbes. **12 Hours**

UNIT – III

MEDICAL MICROBIOLOGY: Host-microbe Interactions: The process of infection-Pathogenicity, virulence and infection, Microbial adherence, penetration of epithelial cell layers, events in infection following penetration, Microbial virulence factors. Aetiology, clinical features, laboratory diagnosis and control of: Bacterial – Tuberculosis, Leprosy, Typhoid, Syphilis; Viral – AIDS, H1N1, Ebola, Poliomyelitis, Rabies, Zika, Chikungunya and Dengue;Serotyping. Fungal – Candidiacies, Dermatomycoses; Protozoans – Amoebiasis, Malaria.

10 Hours

UNIT-IV

SOIL AND AGRICULTURAL MICROBIOLOGY:
Soil microorganisms, ecological adaptation of soil microbes.Microbial interactions/associations, biogeochemical role of soil microorganisms (C, N, P, S cycles).
Plant-microbe interactions: Microbial diseases of crops. Plant disease management.Bioinsecticide -*Bacillus thuringiensis*, *Sphaeriotilusspp*, *Papilloma spp* and *Baculoviruses spp*. Biofertilizers – Nitrogen fixing microorganisms. Phosphate solubilizing microbes.
10 Hours

UNIT-V

APPLIED MICROBIOLOGY: Production of industrial enzymes, lactic acid, vinegar, citric acid, amino acids; Production of antibiotics, production of biopolymers (PHB, PLA), single cell protein. Role of suspended and attached microbes in waste water treatment, microbial films, microbial surfactants; microbial mining. **8 Hours**

Course Outcomes:
At the end of the course, the student will be able to
1. Identify the differences between pro and eukaryotes, ultra-structure of bacteria and list various principles, methods involved in microbial techniques.
2. Describe the concepts of microbial growth and metabolism.
3. Appraise and elaborate on the knowledge of microbes of medical significance.
4. Outline the soil-microbe interactions.
5. Illustrate the industrial significance of microbes.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	L	M								M		L	H	
CO2		H								L			M	H

CO3									H				H	
CO4		L							M				L	
CO5		M								L				M

TEXT BOOKS:

1. Stanier, R. Y. *General Microbiology*, Macmillan Press Ltd, 2003.
2. Willey, J., Sherwood, L., woolverton, C. J. *Prescott &HarleyMicrobiology*, 7th Ed. McGraw Hill, 2011.
3. Black, J. G. *Microbiology-Principles and Explorations,* 7th Ed., John Wiley and Sons Inc., 2008.
4. Pommerville, J. C. *Alcamo's fundamentals of microbiology,* 10th Ed. Jones and Bar, 2014

REFERENCE BOOKS:

1. Pelczar, M. J., Chan, E. C. S., Krieg, N. R. *Microbiology*, TMH, 2011
2. Talaro, K. P. Foundations in Microbiology, 6th Ed. McGraw Hill, 2014.
3. Bergey, D. H. *Bergeys Manual of Systematic Bacteriooogy*, vol 1 to 5, Springer, 2012.

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BIOPROCESS CALCULATIONS

Sub Code : 15BT305 **Credits: 04**
Hrs/Week : 3+2+0+0 **Total Hours:39+26***

***Prerequisites*:**Engg. Physics and Chemistry

***Corequisites*:** Nil

Course Learning Objectives:

The objective of this course is

1. To understand basic units and quantities and their inter-conversion.
2. To understand basic calculations of energy balance and mass balance of biochemical processes.
3. To learn balancing processes with and without reactions.
4. To learn material and energy balancing for unsteady processes and flowsheet preparation.

**Hours/week = Lecture Hours + Tutorial Hours*

UNIT- I

INTRODUCTION

Fundamental and derived quantities, systems of units and their inter conversion: FPS, CGS, MKS, and SI. Concept of mole and molecule; composition of mixtures: solids, liquids and gases; weight – mole – volume percentage calculations; Concentration: g/L, normality, molality, molarity and ppm; Buffer system: pH, pKa, Henderson-Hasselbalch equation, chemical equation and stoichiometry;Composition of ideal gases and mixtures.

8+5 Hours

UNIT – II

STEADY STATE MATERIAL BALANCE WITHOUT REACTION

General material balance equation, bypass and recycle. Material balances in distillation (with and without reflux), liquid-liquid extraction and leaching, crystallization, mixing, evaporation processes, filtration.Drying: material balance, Psychrometry (DBT,WBT, H, %RH), humidity chart and its application in drying. Material balance for multistage operations.

8+6 Hours

UNIT – III

STEADY STATE MATERIAL BALANCE WITH REACTION

Principles of stoichiometry: Limiting and excess reactants, fractional and percentage conversion, yield, selectivity. Combustion analysis of Fuels: Orsat analysis, ultimate and proximate analysis, excess air and air-fuel ratio calculations. Stoichiometry of microbial growth and product formation, elemental balance and degrees of reduction.**7+7 Hours**

UNIT- IV

ENERGY BALANCE

General energy balance equation.

Thermo-physics: Heat capacity and mean heat capacity. Estimation of heat capacity, prediction of heat capacity for solids and liquids.

Thermo-chemistry: Enthalpy, Standard heat of formation, Standard heat of reaction and Standard heat of combustion, Hess's law, calculation of change in enthalpy of reaction at elevated temperature. Calorific value (HCV & NCV). Heat balance: Fermenter, heat exchanger, condenser. **8+5 Hours**

UNIT – V

UNSTEADY STATE MATERIAL BALANCE AND FLOWSHEETING

Unsteady state material balance: CSTR, cell growth and product formation in batch cultures, batch distillation, sewage dilution.

Unsteady state energy balance: solvent heating tank system, pre-heating culture medium.Solution strategies to solve differential equations and boundary conditions (qualitative discussion).

Flow sheets: Block flowsheets, process flowsheets, mechanical flowsheets (P&ID), utilityflowsheets. **8+3 Hours**

Course Outcomes:

At the end of the course, the student will be able to

1. Understand the fundamental concepts of process calculations, unit conversions and apply them to express the composition of mixtures.
2. Solve steady state material balance for various unit operations to evaluate the composition and mass rates.

3. Apply steady state mass balance for various bioprocesses involving reactions and evaluate the product composition and yield.
4. Formulate energy balance equations for steady state unit operations and unit processes and demonstrate the applications of thermo-physics and thermo-chemistry.
5. Analyze the unsteady processes to develop balance equations and elaborate the methods of process flow sheet and its significance.

Mapping ofPOs& COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	L	H	M						L	M		L		H
CO2		H	H						L					H
CO3		H	H						M					H
CO4		H	M						M					H
CO5		M	H						L					M

TEXT BOOKS:

1. Doran, P. M. *Bioprocess Engineering Principles*, 2nd Ed., Academic Press, 2012.
2. Himmelblau, D. *Basic principles and Calculations in Chemical Engineering*, 8th Ed, Prentice Hall, 2012.

REFERENCE BOOKS:

1. Felder, R.M. and Rousseau, R.W., *Elementary Principles of Chemical Process*, 3rd Ed., John Wiley & Sons, 2005.
2. Hougen, O. A., Watson, K. M. and Ragatz, R. A. *Chemical Process Principles, Part – I: Material and Energy Balances*, CBS Publishers, 2004.
3. Shuler, M. L. and Kargi, F. *Bioprocess Engineering*, 2nd Ed., Prentice Hall, 2001.

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UNIT OPERATIONS LAB

Sub Code : 15BT306 **Credits:02**
Hrs/Week :0+0+3+0 **Total Hours:39**

***Prerequisites*:** Nil

***Corequisites*:** Unit Operations

Course Learning Objectives:

The objective of this course is

1. To understand basic fluid flow operations and mechanical separation processes through experiments.

EXPERIMENTS

1. Flow meters: a. Venturi meter b. Orifice meter

c. V-Notch d. Rotameter

2. Flow characteristics of open orifice
3. Characteristics of Pump:
   a. Centrifugal Pump b. Reciprocating Pump
4. Pressure drop calculations
   a. Packed bed b. Fluidized bed
5. Leaf Filter
6. Plate and Frame filter press
7. Batch sedimentation
8. Power calculation in Mixing
9. Sieve Analysis
10. Two phase flow studies

Course Outcomes:

At the end of the course, the student will be able to

1. Demonstrate the concepts of fluid flow operations, metering, and pumping.
2. Choose and apply the concepts of filtration process and sedimentation process.
3. Adapt the principles of sieve analysis for particle size determination.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1		M	M	H			L			L				H
CO2		M	H	H			L			L				M
CO3		L	M	H			L			L				M

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BIOCHEMISTRY LAB

Sub Code : 15BT307 **Credits : 02**

Hrs/Week : 0+0+3+0 **Total Hours: 39**

***Prerequisites*:** Nil

***Corequisites*:** Biochemistry

Course Learning Objectives:

The objective of this course is

1. To learn the basic techniques and tests to identify biomolecules
2. To learn the properties associated with these biomolecules.

EXPERIMENTS

1. Preparation of buffers of constant strength using strong acid-strong base and weak acid-weak base.
2. Titration of amino acids with acids & bases and determination of pKa.

3. Qualitative tests for carbohydrate and lipids.
4. Qualitative tests for amino acids and proteins.
5. Estimation of blood sugar by Folin-Wu method.
6. Estimation of blood sugar by O-toluidine method.
7. Estimation of proteins by Bradford method.
8. Estimation of inorganic phosphate by Fiske-Subbarao method.
9. Estimation of triglyceride by phospho vanillin method
10. Determination of Saponification value of lipids.
11. Determination of Iodine value of lipid.
12. Determination of acetyl value of a lipid.

Course Outcomes:

At the end of the course, the student will be able to

1. Explainthe principles and chemical preparations required for biochemical analysis.
2. Apply methods of analysis to carbohydrates, proteins and lipids in biological samples.
3. Choose and apply suitable estimation techniques in biochemical analysis.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	J	k	PSO		
												1	2	3
CO1		M		M			L			L		L	M	
CO2		M		H			L			L			H	
CO3		M		H			L			L			H	

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ENHANCING SELF COMPETENCE

Sub Code : 15HU311 **Credits : 02**
Hrs/Week : 2+0+0+0 **Total Hours : 26**

Course Learning Objectives:

This Course will enable students to

- Introspect and learn more about oneself,
- Learn social behaviour and etiquette,
- Develop positive attitude and values in life,
- Learn to be effective in communication and interactive skills; and
- To educate on writing and presentation skills and also to educate onself on legal and ethical aspects.

UNIT – I

Self Awareness and Emotional Quotient

4 Hours

UNIT - II

Grooming and Etiquette:
Personal grooming, hygiene, dressing for different occasions, making small talk, showing respect to women, eye contact, being appreciative, dos and don'ts in a conversation; Time Management.

4 Hours

UNIT - III

Attitude Development:
Building self worth, confidence, developing empathy; Goal Setting; Motivation.

5 Hours

UNIT – IV

Interactive Behavior:
Inculcate active listening, verbal non verbal communication, interview skills, group discussions, dealing with people in an organization, handling feed back and criticism.

7 Hours

UNIT – V

Writing and Presentation:
How to write formal and informal e mails, how to frame requests, accept or reject proposals, greetings, salutations, ending. Plagiarism, Presentation Skills.

6 Hours

Course Outcomes:

At the end of the course the student will be able to:

- He or she is aware of his or her strengths and weaknesses and is able to handle emotions.
- Ensuring a refined behavior.
- Ensure a student who is an asset to the society.
- A person who is well adjusted and a good communicator.
- Will be able to present to a group, on a one to one basis and create an impact.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1							L			M				
CO2							M			M				
CO3							L			L				
CO4					L		H			M				
CO5					M		L			M				

REFERENCE BOOKS :

1. "Communicating at work – Principles and Practices for Business and the Professions" - Ronald B Adler & Jeanne Marquardt Elmhorst; McGraw-Hill College; Sixth Edition.
2. "Organizational Behaviour", - Stephen P Robbins; Prentice Hall, India.
3. "Organizational Behaviour", - Fred Luthans; McGraw Hill International Edition.

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BIOSTATISTICS

Sub Code : 15BT401 **Credits : 04**
Hrs/Week : 4+0+0+0 **Total Hours:52**

***Prerequisites*:**Set Theory

***Corequisites*:** Nil

Course Learning Objectives:

The objective of this course is

1. To understand various probabilistic models for situations involving chance effect.
2. To learn and understand some probability distributions both discrete and continuous and its applications in biological systems.
3. To learn and apply ANOVA to problems of biological nature.

UNIT-I

AVERAGES AND DISPERSION

Data collection, presentation of data, diagrams and graphs, measures of central tendency, measures of dispersion, coefficient of variation. **10 Hours**

UNIT - II

PROBABILITY

Finite sample space, conditional probability, Baye's theorem(Over view).Onedimensional random variable, mean and variance. Curve fitting(linear, non-linear and exponential). Correlation and regression. **10 Hours**

UNIT–III

PROBABILITY-DISTRIBUTIONS

Discrete probability distributions: Binomial, Poisson, geometric. Continuous probability distributions: normal, exponential, gamma, Chi square and uniform distributions. Moment generating function, Central limit theorem (without proof). **10 Hours**

UNIT-IV

ESTIMATION & TESTING OF HYPOTHESIS

Confidence interval-large and small samples.Tests of significance—large and small sample, z-test, t-test, F-test, chi-square tests. **10 Hours**

UNIT–V

SAMPLING AND DESIGN OF EXPERIMENTS

Sampling- random sampling, experimental designs,Analysis of variance- one way and two-way classifications. **12 Hours**

Course Outcomes:

At the end of the course, the student will be able to

1. Collect and present biological data in graphical forms and calculate the measures of central tendency and dispersion.
2. Recall the concepts of probability, Use them for biological data and Perform correlation/regression analysis.
3. Apply the concepts of discrete and continuous probability distribution functions to biological data.
4. Choose a suitable hypothesis testing procedure and evaluate the outcomes.
5. Develop simple statistical experiments, collect data and perform statistical analysis of variance.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	H			M						L		M		L
CO2	M			M						L		M		L
CO3	M			L								M		
CO4	M	L		M						L		M		L
CO5	M			H				M		L		M		L

TEXT BOOKS

1. Pandey, M. *Biostatistics basic and advanced*, M. V. Lear Publishers, 2014
2. Rastogi, V. B. *Fundamentals of Biostatistics*, 2nd Ed., Ane Books Pvt. Ltd, 2011.
3. Khan, I. A. and Khanum, A. *Fundamentals of Biostatistics*, Ukaaz publications, 2004.

REFERENCE BOOKS

1. Kapoor, J. N. and Saxena, H. C. *Mathematical statistics*, 20th Ed., S. Chand and Company Pvt. Ltd., 2011.
2. Gupta, S. C. &Kapoor, V. K. *Fundamentals of Mathematical Statistics*, 11th Ed., S.Chand and Company Pvt. Ltd., 2014.
3. Rao, P.S.S.S and Richard, J. *Introduction to Biostatistics & Research Methods*, 5th Ed., PHI, 2012.

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HEAT & MASS TRANSFER

Sub Code : 15BT402 **Credits: 04**
Hrs/Week : 3+2+0+0 **Total Hours: 39+26***
***Prerequisites*:** Fundamentals of Physics
***Corequisites*:** Nil

Course Learning Objectives:
The objective of this course is
1. To learn the basics of heat transfer, mass transfer and the related equations.
2. To understand the importance, principle and mass transfer in bioprocess systems and industrial applications.
3. To learn heat transfer and mass transfer equipments used in bioprocess industry.
4. To learn simultaneous heat and mass transfer processes.

** Hours/week = Lecture Hours + Tutorial Hours*

UNIT- I

HEAT TRANSFER

Modes of heat transfer; Conduction :– Fourier's law, Steady state heat conduction in slab and cylinders, minimum thickness of insulation, steady state heat conduction with internal heat generation (slab, solid cylinder, solid sphere). Unsteady state heat conduction, Boundary conditions and Biot number. convection:– governing equation, convective HTC, overall HTC, natural and forced convection. dimensional analysis for heat transfer, Heat transfer with phase change. Radiation: - governing equations, laws of black body radiation.

8+5 Hours*

UNIT- II

HEAT TRANSFER EQUIPMENTS

Heat exchanger equipments – Double pipe, Shell & Tube, finned type, plate type heat exchangers, LMTD, NTU concept. Numericals on heat exchangers and pressure drop. Evaporators: Calendria type, single and multiple effect evaporator, Feed forward & feed backward. Enthalpy balances and Economy of evaporator. **8+5 Hours**

UNIT- III

MASS TRANSFER

Mass transfer flux, steady state diffusion:- Fick's I law, equimolar counter current diffusion, diffusion with second stationary component, role of diffusion in bioprocess, boundary conditions. Numericals on rate of diffusion.Diffusivity of gases, liquids and their measurement. Quantitative relationship for mass transfer: Volumetric mass transfer coefficient (k_La and k_Ga for Gas-liquid system). Mass transfer in bioreactors: Oxygen transfer in submerged fermentors, oxygen uptake rate and determination of oxygen transfer coefficients (k_La). Unsteady state diffusion; Fick's II law. Theories of mass transfer across phase boundaries – two film theory and penetration theory, convective and diffusive mass transfer Biot number. Analogy between heat and mass transfer.**8+5 Hours**

UNIT -IV

MASS TRANSFER OPERATIONS

Adsorption: Nature of adsorbents, adsorption isotherms, single and multi stage adsorption. Co-current and counter current operation. Fixed bed adsorbers, breakthrough curve, Numericals.

Extraction: Principle, equilibrium calculations, ternary equilibrium diagram, single and multistage cross current and counter current operations, equipments (Spray tower, Rotating Disc Contactor), Numericals. **7+6 Hours**

UNIT – V

SIMULTANEOUS HEAT AND MASS TRANSFER

Distillation: Principle, VLE, types of distillation: simple distillation, steam distillation, azeotropic distillation, extractive distillation. Governing equations: Rayleigh's equation, HETP, no. of theoretical stages (McCabe - Thiele method), sieve plate and packed bed distillation, hydrodynamics in distillation column, Numericals on McCabe - Thiele and Rayleigh's method.

Drying: Principle of drying, heat transfer in dryer, mass transfer in dryers, drying rate curve, drying equipments – Tray dryer, Numericals on drying time.**8+5 Hours**

Course Outcomes:

At the end of the course, the student will be able to

1. Understand and describe various modes of heat transfer and their associated equations.
2. Describe the components of heat transfer equipments and design them.
3. Illustrate the concepts and equations of mass transfer operations.
4. Utilize the mass transfer concepts for application in adsorption and extraction processes.
5. Analyze the effects of heat and mass transfer in industrial applications like drying and distillation.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	L	M	M						L					M
CO2		L	H						M					H
CO3		M	M						L					M
CO4		M	M						M	L				H
CO5		M	H						L	L				H

TEXT BOOKS:

1. Treybal, R.E., *Mass transfer operations*, 3rd Ed., MGH, 2012.
2. Datta, A. K. *Biological and Bioenvironmental Heat and Mass Transfer*, 1st Ed., CRC Press, 2002.

REFERENCE BOOKS:

1. Foust A.S. et al., *Principles of Unit Operations*, 2nd Ed., John Wiley & Sons, 2011.
2. Kern D.W., *Process Heat transfer*, McGraw Hill, 2013.

3. McCabe, W. L., Smith, J. C. and Harriott, P. *Unit Operations of Chemical Engineering*, 7th Ed., McGraw Hill, 2005.
4. Geankoplis, C.J.,*Transport Processes and Separation Process Principles (Includes Unit Operations*), 4th Ed., PHI, 2004.
5. Coulson J.M. and Richardson J.F., *Chemical Engineering*, Vol. I, Butterworth Heinemann, 1995.
6. Coulson J.M. and Richardson J.F., *Chemical Engineering*, Vol. II, 5th Ed., Butterworth Heinemann, 2002.
7. Johnson, A. T. *Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied* to Biological Systems, 1st Ed., Wiley-Interscience, 1998.
8. Doran, P. M. *Bioprocess Engineering Priciples*, Elseveir, Academic Press, 2008.

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THERMODYNAMICS

Sub Code : 15BT403 **Credits: 04**
Hrs/Week : 2+2+0+0 **Total Hours:26+26***

***Prerequisites*:**Partial differential equations, Fundamentals of Physics, Biochemistry

***Corequisites*:** Nil

Course Learning Objectives:

The objective of this course is

1. To learn fundamental laws of thermodynamics.
2. To know its application to simple biological systems.
3. To understand properties of pure fluids and property changes in fluid mixtures.
4. To apply the concepts to phase and reaction equilibria.

***** *Hours/week = Lecture Hours + Tutorial Hours*

UNIT- I

LAWS OF THERMODYNAMICS

System and surrounding, closed and open system, state and properties, intensive and extensive properties, state and path functions, equilibrium state, heat reservoir and heat engines, reversible and irreversible process. Laws of thermodynamics: Statements, concept of entropy. Equations of state: Ideal gas equation, van der Waal's equation and Virial equation. Principle of corresponding states and generalized compressibility chart.

6+2 Hours*

UNIT -II

APPLICATION OF LAWS

First law for cyclic, static and flow processes; heat capacity. P-V-T behavior of pure fluids, phase rule for non reacting systems, processes involving Ideal gas law: polytropic process, isochoric, isothermal, isobaric, adiabatic processes. Carnot cycle & principles, calculation of entropy changes, entropy and irreversibility.**4+5 Hours**

UNIT – III

THERMODYNAMICS OF PURE FLUIDS AND SOLUTIONS

Thermodynamic properties, work function, Gibbs free energy, relationships among thermodynamic properties: Fundamental property relations, Maxwell's equation, Clausius-Clapeyron equation, Antoine's equation, Gibbs – Helmholtz equation. Concept of fugacity, fugacity coefficient, activity and activity coefficient - for pure components and mixtures. Partial molar properties, chemical potential, Lewis Randall rule, Raoult's law, Henry's law, Gibbs-Duhem equations. **5+8 Hours**

UNIT – IV

PHASE EQUILIBRIA

Criteria of phase equilibrium, Gibbs phase rule, phase equilibrium in single and multi-component systems. Binary VLE for ideal solutions: X-Y, T-X-Y, P-X-Y diagrams, relative volatility, Liquid – liquid equilibrium diagrams: binary and ternary (Type I) system.

5+3 Hours

UNIT – V

BIOCHEMICAL EQUILIBRIA

Reaction stoichiometry, criteria of bio-chemical reaction equilibrium, equilibrium constant and standard free energy change, calculation of equilibrium concentrations.Effect of temperature on equilibrium constant, other factors affecting equilibrium conversion. Phase rule for reacting systems, liquid phase reactions, heterogeneousbioreactionequilibria. Coupled reactions and free energy change, Oxidation/Reduction reactions, Thermodynamics of oxygen binding to hemoglobin tetramer.Donnan membrane equilibrium.

6+8 Hours

Course Outcomes:

At the end of the course, the student will be able to

1. Define and recall the fundamentals of thermodynamics and of laws of thermodynamics.
2. Make use of the laws of thermodynamics to different systems and processes
3. Utilize thermodynamics concepts to explain the properties of pure fluids and their mixtures.
4. Apply the concepts of thermodynamic to phase equilibrium.
5. Appraise and adapt biochemical reaction equilibrium to biological systems.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	L	L												L
CO2		M	L						L				L	M
CO3		M	L						L					M
CO4		M	L							L				M
CO5		M	L						L	L			M	M

TEXT BOOKS:

1. Smith, J. M. and Vanness, H. C., Abott. M. *Introduction to Chemical Engineering Thermodynamics*, 7th Ed., McGraw Hill, 2005.
2. Donald, T. H. *Biological Thermodynamics*, 2nd Ed., Cambridge University Press, 2008.

REFERENCE BOOKS:

1. Narayanan, K.V. *A Textbook of Chemical Engineering Thermodynamics*, 2nd Ed., PHI, 2013.
2. Rao, Y. V. C. *Chemical Engineering Thermodynamics*, Universities Press Ltd, 2011.
3. Spalding, D. B. and Cole, E. H. *Engineering Thermodynamics*, 3rd Ed., English Language Book Society, London, 1985.
4. Alberty, R. A. *Thermodynamics of Biochemical Reactions*, 1st Ed., Wiley Interscience, 2003.
5. Johnson, A. T. *Biological Process Engineering: An Analogical Approach to Fluid Flow, Heat Transfer, and Mass Transfer Applied* to Biological Systems, 1st Ed., Wiley-Interscience, 1998
6. Segel, I.H., *Biochemical Calculations*, 2nd Ed., John Wiley & Sons, 2014.

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STRUCTURAL BIOLOGY

Sub Code : 15BT404 **Credits: 04**
Hrs/Week : 4+0+0+0 **Total Hours: 52**

Prerequisites: Biochemistry
Corequisites: Genetics & Molecular Biology

Course Learning Objectives:

The objective of this course is
1. To learn biological macromolecules and complexes of macromolecules.
2. To understand conformation, shape, structure, conformational changes, dynamics and interaction of biomolecules.
3. To convey the major principles and concepts of structural biology.

UNIT- I

PROTEIN STRUCTURES

Composition and primary structures of proteins, Conformational analysis and forces that determine protein structures, geometries, potential energy calculations, phi, psi, omega angles, Ramachandran or steric contour diagram, allowed chi angles of side chains in proteins, hydrogen bonding, disulphide bonds, hydrophobic interactions, alpha helices, beta sheets, helix to coil transition, general features and thermodynamic aspects of protein folding, folding kinetics, protein-ligand interactions, Scatchard plot, cooperative interactions, allosteric effects, Hill constant; Relationship between the primary, secondary, and tertiary structure of proteins, relevance of instrumental techniques (XRD, CD). Fibrous proteins (structure of collagen and keratin). Quaternary structures - dimers, homo & hetero dimers,

trimers, tetramers; Protein folds, structural families and classes, multifunctional domains (qualitative examples).

12 Hours

UNIT – II

STRUCTURE OF NUCLEIC ACIDS

Geometries of nucleic acid structures (A, T, G, C, U), glycosidic bond, rotational isomers. Stabilizing ordered forms of DNA (A, B and Z), base pairing types, base stacking, tertiary structure of DNA and preferred torsion angles, Intra-molecular interactions, Thermodynamics of melting of the DNA double helix, kinetics of unwinding of the DNA double helix, (instrumental method) Interaction with small ions. Ribose puckering and Tertiary structure of tRNA. **11 Hours**

UNIT– III

STRUCTURE OF BIOMEMBRANES

Structure and conformational properties of cell membranes, Singer and Nicholson model, integral proteins in membranes, permeability, properties, passive transport and active transport, facilitated transport, energy requirement. conformational variations during ion transport, mechanism of Na^+ / K^+, glucose and amino acid transport, monitoring membrane potentials, and molecular reception (qualitative). Clinical relevance to membrane transporters.

10 Hours

UNIT -IV

GLYCOBIOLOGY

Introduction, glyco-conjugates: proteinglycans, glycoproteins and glycolipids. Sugars used as information carriers – sugar code. Conformation and dynamics of oligosaccharides in solution.Introduction to glycomics. **9 Hours**

UNIT –V

BIOMOLECULAR INTERACTIONS

Association of macromolecules, supramolecular interactions, protein-protein interactions, protein-nucleic acid interactions, specific and non-specific DNA-protein complexes, lipid/membrane-protein interactions, introduction to molecular dynamics and its implication to biological function. **10 Hours**

Course Outcomes:

At the end of the course, the student will be able to

1. Understand and describe structural complexities of protein.
2. Understand and outline structural complexities of nucleic acids.
3. Illustrate the role of membrane proteins and their structural conformations.
4. Explain glycol conjugates and their role as information carrier.
5. Analyze and explain the importance of interaction between macromolecules for cellular functioning.

Mapping of POs & COs:

PO CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1		L							L				M	
CO2		M							L				M	
CO3		L							L	L			M	
CO4		L							L	L			L	
CO5		M							L	L	L		M	

TEXT BOOKS:

1. Cantor, R. and Schimmel, P.R, *Biophysical Chemistry* Volume 1,2&3,. 1st Ed., WH Freeman & Co. 2004.
2. Freifelder, D. *Physical Biochemistry: Applications to Biochemistry & Molecular Biology*, 2nd Ed., WH Freeman and Co., 1999.

REFERENCE BOOKS:

1. Branden, C. and Tooze, J. *Introduction to Protein Structure*,2nd Ed., Garland Sci., 1999.
2. Schulz, G. and Schrimer, R. H. *Principles of protein structure*, 1st Ed., Springer Verlag, 2009.
3. Saenger, W. *Principles of Nucleic Acid Structure*, Springer Verlag, 1984.
4. Lesk, A. M. *Introduction to Protein Science: Architecture, Function & Genomics*, 2nd Ed., Oxford Uni. Press, 2010.
5. Varki, A. et al., *Essentials of Glycobiology*, 2nd Ed., Coldspring Harbor Lab. Press, NY, 2008.

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MOLECULAR BIOLOGY &GENETICS

Sub Code : 15BT405 Credits: 04

Hrs/Week : 4+0+0+S* Total Hours:52

*** Self Study to be exercised under the supervision of course instructor and to be restricted to not more than 10% of the total teaching hours.**

***Prerequisites*:**Biochemistry

***Corequisites*:** Structural Biology

Course Learning Objectives:

The objective of this course is

1. To learn molecular aspects of information flow in cellular system.
2. To learn the various aspects of information flow like replication, transcription and translation.
3. To learn the structures, mechanism of information flow and its regulation.
4. To learn Mendelian laws of gene inheritance and gene interactions.
5. To understand the importance and role of chromosomes in inheritance.

UNIT- I

INTRODUCTION

Information flow in biological systems- the central dogma. Identification of genetic material, classical experiments- Hershey & Chase, Avery, McLeod etc., Chromosome, classification of chromosomes, centrosome, telomere, chemical composition of chromatin, structural organization of nucleosomes, heterochromatin. Chromosomes as the carriers of genetic information.Polytene and lamp - brush chromosomes, human chromosomes - karyotyping. DNA denaturation and renaturation, complexity of viral and bacterial genome, complexity of eukaryotic genome, Highly repeated DNA sequences: satellite DNA, minisatellite DNA, microsatellite DNA. Moderately repeated DNA sequences: repeated DNA sequence-with coding function, without coding function.Non repeated DNA sequences. **8 Hours**

REPLICATION

Replication of DNA, structure and function of DNA polymerases of prokaryotes and eukaryotes, models of replications in prokaryotes and eukaryotes. Mechanism of DNA replication, DNA damage and repair. RNA-dependent synthesis of RNA and DNA: Reverse transcription (reverse transcriptase), telomerase as specialized reverse transcriptase, RNA-dependent RNA polymerase (RNA replicase) **5 Hours**

UNIT – II

TRANSCRIPTION

Bacterial RNA polymerase, its structure and function, sigma factor cycle, eukaryotic RNA polymerases.Mechanism of transcription in prokaryotes and eukaryotes.Transcription factors, posttranscriptional processing, Genetic codon and its usage. **6 Hours**

TRANSLATION

Mechanism of translation, activation of amino acids, initiation, elongation and termination of protein synthesis.Differences between prokaryotic and eukaryotic protein synthesis, inhibitors of transcription and translation. Post translational modification. **6 Hours**

UNIT – III

REGULATION OF GENE EXPRESSION IN PROKAROTES AND EUKARYOTES

Gene regulation, Operon model, gal, lac, trp; positive versus negative regulation of gene expression, regulation of eukaryotic gene expression, transcriptional control. **8 Hours**

GENETIC RECOMBINATION

Genetic recombination in bacteria and viruses, site specific recombination, role of recombination and transposons. **3Hours**

UNIT- IV

MENDELIAN LAWS & GENE INTERACTIONS

Mendelian Laws of inheritance, monohybrid and dihybrid inheritance, law of segregation & independent assortment, Gene interactions: intermediate inheritance and co-dominance, Supplementary and Complementary genes - Comb patterns in fowls, Flower colour in sweet pea, Epistasis - Inhibitory and feather colour gene in fowls, deaf mutism in humans, recessive epistasis, dominant epistasis, duplicate recessive and dominant epistasis. Multiple alleles:

blood group antigens, Rh factor, coat colour in rabbits, Drosophila eye colour. Simple problems on the above topics. **8 Hours**

UNIT – V

SEX CHROMOSOMES AND INHERITED DISEASES, LINKAGE AND CROSSING OVER

Sex determination in plants and animals- haplodiploidy, XX – X0, XX-XY, ZZ – ZW, types.Sex Chromosomal disorders, inbreeding & genetic anomalies. Sex linked and X – linked inheritance, Examples of sex linked inheritance, X-linked inheritance-colour blindness, hemophilia. Sex influenced and Sex limited inheritance. Linkage, crossing over, chromosomal maps, gene mapping in bacteria and higher organisms.**8 Hours**

SELF STUDY: Students will learn problems related to genetics from real world and pedigree analysis.

Course Outcomes:

At the end of the course, the student will be able to

1. Relate and translate the concept of central dogma, various types of chromosomes and gene organization.
2. Explain the importance of DNA in information coding, and role of DNA in replication (heredity), transcription and translation.
3. Appraise the concept of gene regulation and expression, genetic recombination in eukaryotes and prokaryotes.
4. Interpret and apply Mendelian and non-Mendelian inheritance and gene interactions.
5. Describe the role of sex chromosomes in inheritance of disorders and gene mapping.

Mapping of POs& COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1		L								L			L	
CO2		L								L			L	
CO3		M							L	L			H	
CO4		M							L	L			M	
CO5		M								L	L		M	

TEXT BOOKS:

1. Alberts, B. et al., *Molecular Biology of the Cell*, 5th Ed., Garland Sci., 2007.
2. Freifelder, D. *Essentials of Molecular Biology*, 2nd Ed., Narosa Book Distributors Pvt. Ltd., 2008.
3. Gardener, J. *Principles of genetics*, 8th Ed., Wiley India Pvt Ltd, 2012.
4. Winchester, A. M. *Genetics*, 3rd Ed. 1966.

REFERENCE BOOKS:

1. Watson, J. D et al., *Molecular Biology of the Gene*,7th Ed., Pearson Education, 2013.

2. Lodish, H., Baltimore, D. & Darnell, J. *Molecular Cell Biology*, 4th Ed., WH Freeman, 2000.
3. Karp, G. *Cell and Molecular Biology-Concepts and Experiments*, 6th Ed., John Wiley & Sons Inc., 2010
4. Ringo, J. *Fundamental Genetics*, Cambridge University Press, 2004.
5. Sambamurthy, A. V. S. S. *Genetics*, 1st Ed., Narosa Publishing House, 2004.
6. Tamarin, R. H. *Principles of Genetics*, 5th Ed., TMH, 2004.
7. Strickberger M.W. *Genetics*, 3rd Ed., Pearson Education, 2003.

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CELL AND DEVELOPMENTAL BIOLOGY

Sub Code : 15BT406 **Credits:03**
Hrs/Week : 3+0+0+0 **Total Hours:39**

***Prerequisites*:**Nil

***Corequisites*:** Nil

Course Learning Objectives:

The objective of this course is
1. To understandthe cellular systems, its properties and functions.
2. To learn the developmental aspects of an embryo.

UNIT–I

CELL STRUCTURE AND FUNCTION

Cell Theory; Comparison between plant and animal cells- cell types; Cell wall; Plasma membrane; Cytoskeleton; Protoplasm; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, Ribosome; Centriole; Nucleus; Chemical components of a cell; Catalysis and use of energy by cells. Cell division: mitosis & meiosis, cell cycle and apoptosis, molecules that control cell cycle. **7 Hours**

UNIT – II

CYTOSKELETONAND CELL JUNCTIONS

Introduction to Cytoskeleton, Nature of Cytoskeleton, Microtubules, Actin filaments and Intermediate filaments, Celia and Centrioles.Introduction to Cell Junctions.Types of cell junctions, cell-cell adhesion, Integrins, mammalian extra-cellular matrix.

7 Hours

UNIT – III

CELL COMMUNICATION

Introduction, General principles of cell communication, Signaling molecules and cell receptors. Signal trasnsduction pathways Signaling through G-Protein linked receptor, Signaling through Enzyme linked receptor Intracellular signaling: computer based “Neural Networks”. **9 Hours**

UNIT – IV

BASIC CONCEPTS OF DEVELOPMENT

Cell fate and commitment, Mosaic and regulative development, Maintenance of differentiation, Pattern formation and compartments, Morphogenesis.

Fertilization: Structure of gametes and its recognition, Gamete fusion and prevention of polyspermy, activation of egg and fusion of genetic material.

Cleavage: Radial holoblastic cleavage, Spiral holoblastic cleavage, Rotational holoblastic cleavage, Meroblastic cleavage.

Gastrulation: in Sea urchin, Amphibia, birds, mammals, embryonic stem cells.

Cell fate and commitment, Mosaic and regulative development, Maintenance of differentiation, Pattern formation and compartments, Morphogenesis.Position effect.

9 Hours

UNIT – V

LATER EMBRYONIC DEVELOPMENT

Fate of the ectoderm – neural induction and the epidermis, Patterning the anteroposteriorneuraxis, Patterning the dorsoventralneuraxis, Neural tube, Neural crest, Mesoderm and endoderm – Mesoderm induction and patterning, Somitogenesis and patterning, Somite differentiation, Mammalian organ development (ex:Heart and Kidney), Endoderm development. Metamorphosis, Regeneration and Aging. **7 Hours**

Course Outcomes:

At the end of the course the student will be able to

1. Distinguish cellular diversity and order within each generation.
2. Understand cellular component in biological system.
3. Explain concepts of cellular communication.
4. Describe basic developmental processes.
5. Elaborate on later embryonic developmental process.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1	M								L				L	
CO2	M								L				L	
CO3	M								L				L	
CO4	M								L	L			L	
CO5	M								L	L			L	

TEXT BOOKS

1. Scott F. Gilbert, *Developmental Biology*, 5th Ed., Sinauer Associates, Inc. 1997.
2. Rastogi, S. C. *Cell Biology*, 3rd Ed., New Age International, 2005.

REFERENCE BOOKS

1. Lodish, H., Baltimore, D. & Darnell, J. , *Molecular Cell Biology*, 4th Ed., W.H. Freeman, 2000.
2. Alberts, B. et al., *Molecular Biology of the Cell*, 5th Ed., Garland Sci., 2007.
3. Cooper, G. M. &Hausmann, R. E. *The Cell: A Molecular Approach*, 6th Ed., Sinauer Associates Inc., 2013.
4. Karp, G. *Cell and Molecular Biology-Concepts and Experiments*, 6th Ed., John Wiley & Sons Inc., 2010.
5. Markert and Ursprung, *Developmental Genetics*, Prentice Hall, 1972.

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HEAT & MASS TRANSFER LAB

Sub Code : 15BT407 **Credits:02**
Hrs/Week : 0+0+3+0 **Total Hours:39**
***Prerequisites*:**Nil
***Corequisites*:** Heat & Mass Transfer

Course Learning Objectives:

The objective of this course is
1. To learn and understand various heat and mass transfer concepts and operations through experimental techniques.

EXPERIMENTS
1. Measurement of thermal conductivity of a liquid
2. Effectiveness of counter flow DPHE
3. Heat transfer in packed bed
4. Humidity measurement using psychrometry
5. Solubility of inorganic salt
6. Diffusivity measurement
7. Binodal curve for Ternary system
8. Ternary liquid-liquid equilibrium
9. Liquid – liquid extraction: Single stage and multi stage (cross current)
10. Single stage batch adsorption
11. Batch distillation
12. Packed bed distillation

Course Outcomes:

At the end of the course, the student will be able to
1. Make use of experiments to understand concepts of heat transfer operations and apply them to biochemical operations.
2. Choose experiments to understand concepts of mass transfer operations and apply them to biochemical operations.
3. Perform experiments to learn and apply concepts of simultaneous heat and mass transfer operations.

Mapping of POs & COs:

PO / CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1		L		H			L			L				M
CO2		M		H			L			L				M
CO3		L		H			L			L				M

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MICROBIOLOGY LAB

Sub Code : 15BT408 **Credits:02**
Hrs/Week : 0+0+3+0 **Total Hours:39**

***Prerequisites*:** Microbiology
Corequisites: Nil

Course Learning Objectives:

The objective of this course is
1. To learn the basic techniques of microbiology.
2. To learn the various biochemical tests to identify microbes.
3. To learn various methods to analyse microbes present in biological samples.

EXPERIMENTS
1. Aseptic techniques, Media preparation, transportation media.
2. Pure culture techniques: serial dilution, pour plate, spread plate and streak plate, CFU.
3. Preservation Techniques: Cryopreservation, glycerol, soil stock.
4. Stains and staining techniques: simple staining-positive and negative, endospore staining, motility test.
5. Stains and staining techniques: Gram staining technique
6. Biochemical tests for the identification of bacteria: fermentation of carbohydrates
7. Biochemical tests for the identification of bacteria: oxidase test, IMVIC test
8. Microbial analysis of food products
9. Microbial analysis of water (MPN).
10. Antimicrobial activity (MIC).

Course Outcomes:

At the end of the course the student will be able to
1. Demonstrate the importance of preparations required for performing microbiological experiments and perform microbial culture techniques.
2. Choose a suitable test for identification of microbes.
3. Adapt an analytical method for analysis of food and water for microbial contamination.

Mapping of POs & COs:

PO CO	a	b	c	d	e	f	g	h	i	j	k	PSO		
												1	2	3
CO1		L		H			L			M			M	
CO2		M		H			L			M			M	
CO3		M		H			L			M			M	

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