BMS COLLEGE OF ENGINEERING, BENGALURU

VISION	MISSION
PROMOTING PROSPERITY OF MANKIND BY AUGMENTING HUMAN RESOURCE CAPITAL THROUGH QUALITY TECHNICAL EDUCATION & TRAINING	ACCOMPLISH EXCELLENCE IN THE FIELD OF TECHNICAL EDUCATION THROUGH EDUCATION, RESEARCH AND SERVICE NEEDS OF SOCIETY

DEPARTMENT OF BIOTECHNOLOGY

Established in 2002, the department of Biotechnology, BMSCE, aims to impart quality education with distinctive proficiency of merging Engineering principles with biological systems. The department offers Undergraduate program with an intake of 40.

DEPARTMENT VISION

To be a Centre of excellence in the field of biotechnology equipped to create graduates who endeavor for the welfare of mankind.

DEPARTMENT MISSION

1. To impart quality education for lifelong professional growth and opportunity in a wide range of Careers.
2. To create awareness towards socio-ethical implications of potentials of biotechnology.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

PEO1: Graduates will be successful professionals in Biotechnology and allied fields with proficiency of working in a multidisciplinary team.

PEO2: Graduates will pursue higher education with synergistic combination of the skills of biologists & engineers.

PEO3: Graduates will inculcate ethical and social values for the well-being of mankind and environment.

PROGRAM OUTCOMES (POs)

PO 1	Graduates will **apply knowledge of Mathematics, Science and Engineering concepts** to solve problems pertinent to Biotechnology.
PO 2	Graduates will be able to **identify problems related to biotechnology, analyze and derive valid conclusions** with fundamental knowledge in biology, Engineering and computation.
PO 3	Graduates will be able to **design solution to problems by applying suitable components and processes** within the safety constraints for environmental & societal needs.
PO 4	Graduates will be able to **design, conduct experiments, analyze and interpret data** for **investigating problems** in BT and allied fields.
PO 5	Graduates will be able to **select and apply appropriate tools and techniques** in biological manipulation, Process engineering and data interpretation.
PO 6	Graduates will be able to **apply reasoning to assess societal, health, safety and legal issues** and understand **his responsibilities in biotechnological engineering practices.**
PO 7	Graduates will be able to **understand the potentials, and impact of biotechnological solutions** on environment and societal context and **need for sustainable solution**.
PO 8	Graduates will have understanding of regulatory **norms and ethics** in BT product/processes development.
PO 9	Graduates will be able **to work individually and as a team** in a multidisciplinary environment.
PO 10	Graduates will possess **oral and written communication** skills.
PO 11	Graduates will **demonstrate knowledge of engineering and management principles**.
PO 12	Graduates will have **contemporary knowledge in BT** and will have the ability to engage in **lifelong learning**.

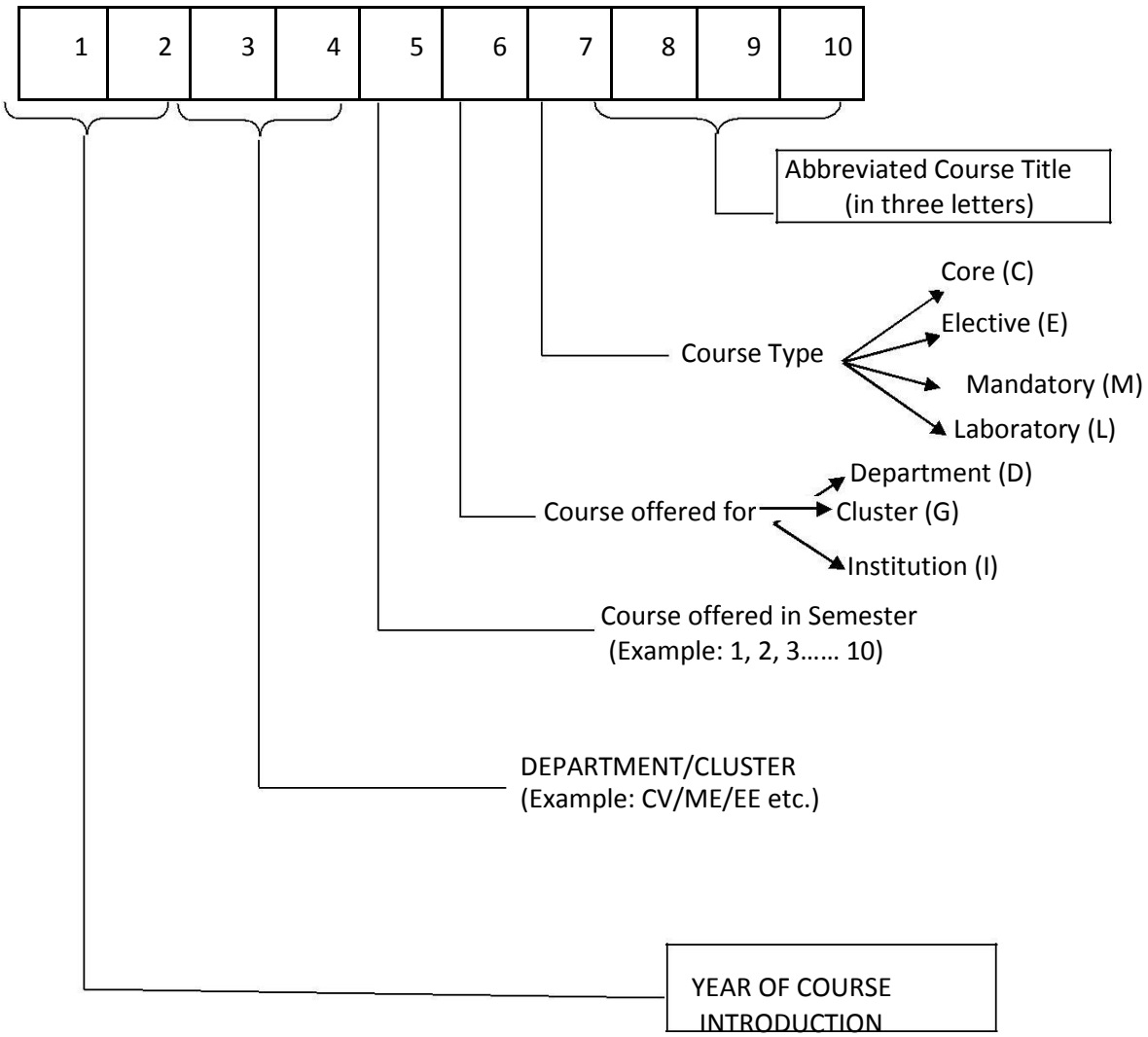
PROGRAM SPECIFIC OBJECTIVES (PSOs)

PSO1: Apply knowledge of basic sciences and biotechnological techniques to manipulate living organisms.
PSO2: Design, optimize, analyze and scale up a bioprocess to develop value added products.
PSO3: Generate, analyze and interpret Biological data using Insilco approaches.

NOTATIONS

AY	Academic Year
AAT	Alternative Assessment Tools
BOE	Board of Examiners
BOS	Board of Studies
CBCS	Choice Based Credit System
CGPA	Cumulative Grade Point Averages
CIE	Continuous Internal Evaluation
CO	Course Outcomes
DC	Departmental Core
GC	Group Core
HSS	Humanity and Social Science courses
IC	Institutional Core
IE	Institutional Elective
IL	Institutional Lab
LTPS	Lecture-Tutorial-Practical-Selfstudy
NFTE	Not Fit for Technical Education
PCC	Professional Core Courses
PEO	Programme Educational Objective
PO	Programme Outcomes
PEC	Professional Elective Courses
SEE	Semester End Examination
SGPA	Semester Grade Point Average
ST	Studio

NOMENCLATURE FOR THE COURSE CODE



Example:

- Code for Engineering Mathematics-II Course in 2st Semester is
  1 4 M A 2 I C M A T
- Code for Material Science and Metallurgy Course in 3rd Semester is
  1 5 M E 3 D C M S M
- Code for Concrete Technology Course in 4th Semester is
  1 5 C V 4 D C C O N

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SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL **Program: BE** **Semester: III**

Course Code										Course Title	Credit Hours/Week					Contact Hrs/wk	Marks		
											L	T	P	S	Credit Total		CIE	SEE	Total
1	5	B	T	3	D	C	B	B	M	Basics of Biomolecules	2	1	0	0	3	4	50	50	100
1	5	B	T	3	D	C	C	M	B	Cell & Molecular Biology	3	0	1	2	6	5	50	50	100
1	5	B	T	3	D	C	M	B	G	Microbiology	2	0	1	2	5	4	50	50	100
1	5	B	T	3	D	C	P	E	T	Process Engg Thermodynamics	3	1	0	0	4	5	50	50	100
1	5	B	T	3	D	C	U	O	1	Unit operations-1	2	1	0	0	3	4	50	50	100
1	5	M	A	3	G	C	A	P	M	Applied Mathematics	3	1	0	0	4	5	50	50	100
Total															**25**	**27**	**300**	**300**	**600**

L-Lecture Hours/week; **T**-Tutorial Lecture Hours/week; **P-**Practical Lecture Hours/week; **S-**Self study

CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration).

SCHEME OF INSTRUCTION

Department/Cluster: BIOTECHNOLOGY/CHEMICAL **Program: BE** **Semester: IV**

Course Code	Course Title	Credit Hours/Week					Contact Hrs/wk	Marks		
		L	T	P	S	Total		CIE	SEE	Total
15BTT4DCBAB	Biochemistry & Bioenergetics	2	1	1	0	4	6	50	50	100
15BTT4DCUO2	Unit Operations-2	3	0	1	2	6	5	50	50	100
15MA4DCBSP	Engg Maths-IV (Biostatistics and probability)	3	1	0	0	4	5	50	50	100
15BTT4DCEBT	Environmental Biotechnology	3	0	0	0	3	3	50	50	100
15BTT4DCBCA	Basics of Computer applications	2	0	1	2	5	4	50	50	100
15BTT4DCPPC	Process principles and calculations	2	1	0	0	3	4	50	50	100
Total						**25**	**27**	**300**	**300**	**600**

L-Lecture Hours/week; **T**-Tutorial Lecture Hours/week; **P**-Practical Lecture Hours/week, **S**-Self Study.

CIE-Continuous Internal Evaluation; **SEE**-Semester End Examination (of 3 Hours duration)

COURSE TITLE	BASICS OF BIOMOLECULES										Credits	3			
COURSE CODE	1	5	B	T	3	D	C	B	B	M	L-T-P-S	2	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of chemistry, Mathematics and Basics of Biology.

COURSE DESCRIPTION: This course describes the structures of important biological molecules along with the basic concepts of organic and solution chemistry.

COURSE OBJECTIVES: This course is a foundation course needed to understand the concepts of Metabolic Engineering, Enzyme Technology, Structural Biology, Molecular Biology, Genetic Engineering and Bioinformatics.

UNIT - 1

BASIC CONCEPTS [6L+3T]

Types of reaction mechanisms, structure and properties of water, pH and buffers. Non-covalent interactions- hydrogen bonds, van der Waals forces, electrostatic and hydrophobic interactions. Stereochemistry-importance of stereochemistry, geometric and optical isomerism, configuration and conformation, chirality, relation between chirality and optical activity, representation of chiral structure by Fischer formulas, absolute and relative configuration, D & L and R and S nomenclature.

UNIT - 2

STRUCTURE OF CARBOHYDRATES [5L+3T]

Carbohydrates-Introduction, sources, classification into mono, oligo and polysaccharides, Classification of monosaccharides based on number of carbon atoms and functional groups, Isomerism of carbohydrates, Fischer and Haworth formula, pyranose and furanose structures, anomers and epimers, chair and boat conformations, structure and function of simple sugars-mono and disaccharides, homo and hetero polysaccharides, sugar derivatives, glycoproteins.

UNIT - 3

STRUCTURE OF LIPIDS [3L+2T]

Lipids- Introduction, sources, nomenclature, classification, properties and functions, Derived lipids- phospholipids, glycolipids, waxes, Steroids- structure and biological role .

UNIT - 4

STRUCTURE OF AMINO ACIDS AND PROTEINS [7L+3T]

Introduction, classification, optical isomerism, chemical properties, acid-base properties polyionic nature, zwitter ions, pK_a and pI, peptide bond formation and properties, biologically important peptides (oxytocin, vasopressin, bradykinin and glutathione), classification of proteins, levels of protein structure, determination of primary structure (sequencing strategies), conformational analysis and forces that determine proteins structures, geometries, potential energy calculations, phi, psi and omega angles, Ramachandran or steric contour diagram, potential energy calculations, allowed chi angles of side chains in proteins, hydrogen bonding, disulphide bonds, salt bridges, hydrophobic interactions, alpha helices, beta sheets, helix to coil transition, general features and thermodynamic aspects of protein folding and folding kinetics, protein-ligand interactions, Scatchard plot, co-operative interactions, allosteric effects, Hill constant, Relationship between the primary, secondary and tertiary structure of proteins, fibrous proteins (structure of collagen and keratin), Quaternary structures with Hemoglobin as an example.

UNIT - 5

STRUCTURE OF NUCLEIC ACIDS [5L+2T]

General characteristics of nucleic acid structure, geometries, glycosidic bond, rotational isomers, ribose puckering, stabilizing ordered forms (A, B and Z forms), base pairing, base stacking, tertiary structure of nucleic acids, intra-molecular interactions in the double helix, thermodynamics of melting of DNA, interaction with small ions, tertiary structure of nucleic acids, Supercoiling, linking number, protein–DNA/RNA interactions.

Bibliography

TEXT BOOKS:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, W.H. Freeman and company (5th Ed.)
2. Biochemistry by Voet and Voet, Wiley New York

REFERENCE BOOKS:

1. Principles of Biochemistry by Lubert Stryer Freeman (Int. Ed.)
2. Principles of Nucleic Acid Structure by Sanger, Springer Verlag
3. Principles of Protein Structure by G Schulz and R H Schrimer, Springer Verlag

e-books:

1. https://archive.org/details/LehningersPrinciples of Biochemistry5e
2. http://www.tok.ro/toksite/downloads/Bioinformatika/Konyvek/biokemia,%20sejtbiologia%20%20konyvek/Stryer%20Biochemistry.pdf

MOOCs:

1. https://www.mooc-list.com/initiative/saylororg?static=true
2. https://www.mooc-list.com/course/principles-biochemistry-edx?static=true
3. http://nptel.ac.in/courses/102105034/

COURSE OUTCOMES (COs):

CO 1	Identify the different reaction types and mechanisms involved in bio-organic reactions.
CO 2	Solve problems based on the concepts of solution chemistry and illustrate the different structural configurations of organic molecules
CO 3	Explain the physiochemical properties and structural confirmations of biomolecules
CO 4	Comprehend the importance of biomolecules in biological systems

ASSESSMENT: Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	CELL AND MOLECULAR BIOLOGY										Credits	6			
COURSE CODE	1	5	B	T	3	D	C	C	M	B	L-T-P-S	3	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of Basic biology.

COURSE DESCRIPTION: The Cell biology component of the course is designed to impart knowledge on the structural and functional details of the cell. It deals with chemical nature, structural organization, and function of various organelles of different types of the cells and the nature of genetic material & inheritance patterns of living organism. The Molecular biology component of the course focuses on the molecular aspects of the cell and its molecular components especially DNA, RNA and protein. It deals with all cellular processes involving the genetic material and its output, viz., replication, transcription, translation, DNA repair and Recombination as well as their regulation.

COURSE OBJECTIVES: The objective of the course is to make graduates understand the concepts of cell and molecular process and provide a background appropriate for applying the knowledge in applied biotechnology such as genetic engineering, genomics, Bioinformatics, Pharmaceutical Biotechnology, diagnostics, and therapeutics.

PART A : THEORY

UNIT - 1

THE CELL [10 HOURS]

i) Membrane systems, Organelle and their functions: Cell membrane, Nucleus, chromosomes and their packing, Mitochondria, chloroplast, peroxisomes, lysosome, vacuole, Golgi bodies, Endoplasmic reticulum, ribosomes

ii) Cytoskeletal elements and cellular transport: Microfilaments, intermediate filaments, microtubules, Cytoskeletal dynamics, extracellular and intracellular transport

iii) Cell division and its regulation: cell cycle, mitosis, meiosis and their regulation.

iv) Cell signaling: information flow at systems-level, cell signaling pathways and networks.

UNIT - 2

GENES AND INHERITANCE [06 HOURS]

i) Genes and genomes : PK and EK genes , genomes and their organization

ii) Inheritance: Mendelian and Non-Mendelian inheritance, Multiple alleles, Sex determination, linkage and crossing over, chromosomal disorders, Bacterial conjugation.

UNIT - 3

MOLECULAR MECHANISMS OF CELL-I [07 HOURS]

i) Replication: Proof of concept, PK and EK DNA replication and their models

ii) Transcription: PK and EK transcription, post transcriptional modifications, inhibitors of transcription

UNIT – 4

MOLECULAR MECHANISMS OF CELL-II [10 HOURS]

i) Translation: Concepts of genetic code, PK and EK translation, post translational modifications, inhibitors of Translation.

ii) Cell sorting ,translocation and transport

iii) Regulation of transcription and translation: Control at global and gene level, Operons and Positive verses negative regulation.

UNIT – 5

REGULATION AND REPAIR [06 HOURS]

Mutations, Recombination & repair: DNA damage, classification of mutations, mutagens, DNA repair, transposons, Recombination.

PART B: CELL & MOLECULAR BIOLOGY LAB (2 hrs/week)

1. Study of mitosis from onion root tips
2. Study of meiosis from onion flower buds.
3. Chloroplast isolation.
4. Isolation and fusion of protoplast.

5. Differential staining of blood cells.
6. Isolation of genomic DNA from bacteria/ plant/ animal cells.
7. Isolation of plasmid DNA .
8. Agarose gel electrophoresis for size determination.
9. Polytene chromosome from Drosophila.
10. Pedigree analysis.

REFERENCES

TEXT BOOKS:

1. Molecular Biology of the Cell, Bruce Alberts Garland Science Pub.
2. Genetics by Monroe W Strickberger Macmillan pub.
3. Cell and Molecular Biology by Gerald Karp, John Wiley & Sons.
4. Genes VIII/IX/X by Lewin

REFERENCE BOOKS:

1. Cell and Molecular Biology by Lodish, Freeman pub.
2. Cell Biology by J W Kimball, Addison-Welsey Pub.
3. Molecular Cell Biology by Darnell and Baltimore.

e- books:

1. Molecular Biology of the Cell, Bruce Alberts Garland Science Pub.
   http://bit.ly/MolBioCell5thPDFFree
2. Molecular Biology by David Freifelder
   https://openlibrary.org/authors/OL773152A/David_Freifelder

MOOCs:

1. http://www.nptel.ac.in/courses/102103012/
2. https://www.mooc-list.com/tags/biotechnology
3. http://ocw.mit.edu/courses/biology/

COURSE OUTCOMES (COs):

CO 1	Describe structure and function of cell and organelles.
CO 2	Understand the concepts of inheritance and apply to solve related problems.
CO 3	Explain mechanism of DNA replication, transcription and translation.
CO 4	Comprehend mechanisms of gene regulation as well as DNA damage, repair and recombination processes**.**
CO 5	Demonstrate ability to conduct experiment, interpret and analyze data related to cell and its processes.
CO 6	Identify problems related to cell and its molecular processes, formulate solution and derive valid conclusions

ASSESSMENT:

Continuous Internal Evaluation (CIE): Includes mid-term tests, weekly/fortnightly class tests, homework, assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): A written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce). Both CIE and SEE is given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	MICROBIOLOGY										Credits	5			
COURSE CODE	1	5	B	T	3	D	C	M	B	G	L-T-P-S	2	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Basics of biology, Biology for Engineers.

COURSE DESCRIPTION: The tiny microbes play essential role in each and everyone's life. This course will enable students to understand the diverse nature of microbial world. Also focusses on morphological and functional properties of Bacteria, Fungi, and Viruses. Uses laboratory experiments that stress aseptic techniques and that develop skills necessary to handle microbes, including the characterization of unknown microbes.

COURSE OBJECTIVES: To enable the students to

- understand the working principle of various types of microscopes
- Select an appropriate microscopic technique for identification of microorganisms.
- Gain knowledge in biology of microbial organisms, microbial metabolic pathways, and their industrial applications.
- develop ability to isolate and characterize and produce a desired a product from microorganism
- Develop ability to control microbes in engineering practices.

PART A : THEORY

UNIT - 1

INTRODUCTION [5 HOURS]

History of Microbiology, The Scope of Microbiology, Microbial diversity And Taxonomy (Numerical, Phylogenetic and Molecular approaches), Types of Microorganisms.

MICROSCOPY: Bright-Field Microscopy, Dark-Field Microscopy, Phase-Contrast Microscopy, Fluorescence Microscopy, Electron Microscopy.

UNIT - 2

MICROBIAL NUTRITION AND GROWTH [6 HOURS]

The morphology and ultra-structure of Bacteria, Culturing of Bacteria, Nutritional requirements, Culture Media and types, Bacterial Growth, Factors affecting growth, Measurement of growth, pure culture and cultural characteristics.

UNIT - 3

STUDY OF MICROORGANISMS [5 HOURS]

Genetic recombination in bacteria, reproduction & morphology and classification of fungi. Viruses of Bacteria: general characteristics, morphology and structure, the classification and nomenclature of bacteriophages, replication of bacterial viruses, Lysogeny.

Microbial Metabolism-overview of Metabolic pathways (Glycolysis, HMP, ED pathway, alcohol and acid fermentation-homo & heterolactic, mixed acid), Primary and secondary Metabolites-brief mention with examples and applications**.**

UNIT - 4

CONTROL OF MICROORGANISMS [5 HOURS]

Physical methods (heat, filtration, radiation), Chemical methods (Phenol & Phenolic compounds, Alcohols, Halogens, Dyes, Detergents, Aldehydes, Heavy metals, etc), Antibiotics and other chemotherapeutic agents.

UNIT - 5

APPLIED MICROBIOLOGY [5 HOURS]

Microbes in Agriculture: Recycling of Nutrients, Biofertilizers, Biopesticides, Aquatic Microbiology, Microbes in Food industry: As food contaminants, Food processing, Microbes as food (Yeast and SCP).

PART B: MICROBIOLOGY LAB (2 hrs/week)

1. Laboratory rules, General instruments (Microscope, Autoclave, Hot air oven, Incubator, LAF) and other requirements in Microbiology laboratory.
2. Media preparation, plugging and sterilization. (NA/NB, PDA/PDB, MRBA, EMB agar, Blood agar, Mac Conkey agar).
3. Pure culture techniques (serial dilution, pour plate, spread plate and streak plate methods).
4. Isolation and characterization of Microbes from soil, Water and Air.
5. Examination of microorganisms from hand, nail, tooth scrapings and rotten fruits and vegetables.

6. Enumeration of microbes (Bacteria and Fungi) by DMC, SPC and Turbidometry.
7. Examination of living microbes by TWM technique, Hanging drop technique (Bacteria and Protozoa).
8. Staining techniques: Simple staining, Gram staining and endospore staining for Bacteria and Lacto phenol cotton blue staining for fungi.
9. Biochemical Tests (Starch hydrolysis, Gelatin liquefaction, MPN, Catalase and IMViC tests).
10. Measurement of growth and factors influencing growth of microbes (Determination by dry weight, effect of TDT and TDP, size determination by Micrometry).
11. Antibiotic susceptibility testing of bacteria.
12. Alcoholic and mixed acid fermentation.

Bibliography

TEXT BOOKS:

1. General Microbiology, Michael j Pelczar, Chan and Krieg, Tata McGraw Hill Pub
2. Industrial Microbiology, Prescott and Dunn, CBSPub. (4th Ed.)

REFERENCE BOOKS:

1. General Microbiology, Stanier, John Ingraham and Mark Wheelis, Mac- Millan Pub.
2. Microbiology an Introduction, Tortora, Funke and Case. Pearson education.
3. Experiments in Microbiology, Plant pathology and Biotechnology,, K.R.Aneja(4th ed.)

e- books:

1. http://www.austincc.edu/rohde/noteref.htm

2. http://www.freebookcentre.net/medical_books_download/Medical-Microbiology.html

3. http://books.pakchem.net/microbiology-books.html

MOOCs:

1. https://www.mooc-list.com

2. https://www.mysliderule.com/topic/microbiology

Online courses: http://www.onlinecollegecourses.com

COURSE OUTCOMES (COs):

CO 1	**a)** Ability to describe principle of various types of microscopes and demonstrate their effective use **b)** Ability to Select an appropriate microscopic technique for identification microbes.
CO 2	**a)** Understand the structure and biology of microbial organisms. **b)** Describe the various metabolic pathways and industrial applications of microbial organisms **c)** Ability to measure microbial growth using suitable technique.
CO 3	Conduct experiments, and draw inferences for isolation, characterization and produce a desired a product using microorganism.
CO 4	Conduct sterilization techniques for control measures in Biotechnological engineering practices

ASSESSMENT: Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce). Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	PROCESS ENGINEERING THERMODYNAMICS										Credits	4			
COURSE CODE	1	5	B	T	3	D	C	P	E	T	L-T-P-S	3	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of Engineering Physics, Chemistry and Mathematics.

COURSE DESCRIPTION: This course includes basic thermodynamic principles and related conceptual engineering problems. This course presents basic definition and development of laws of thermodynamics. The course also focusses on PVT behavior of pure fluids and properties of fluids. It will also have description of basic concepts of vapor/liquid equilibrium, chemical equilibrium, phase equilibria, bioenergetics and heterogeneous reaction equilibria.

COURSE OBJECTIVES: The objective of the course is to prepare the students to understand and apply the various concepts in thermodynamics in biochemical engineering processes.

UNIT - 1

BASIC CONCEPTS AND LAWS OF THERMODYNAMICS [8L+3T]

System, Surroundings & Processes, Open & Closed systems, State properties, Intensive & Extensive Properties, State & Path functions, Equilibrium state & Phase Rule, Zeroth Law of Thermodynamics, Reversible & Irreversible processes, First Law of Thermodynamics, Heat Capacity, Heat reservoirs & Heat Engines, Second Law of thermodynamics, Concept of entropy, Carnot Principle, Calculation of entropy changes, Clausius inequality, Entropy & irreversibility, Third law of Thermodynamics.

UNIT - 2

PVT BEHAVIOUR AND COMPRESSIBILITY CHARTS [8L+2T]

PVT Behaviour of pure fluids, Equations of state & Ideal gas law, Processes involving ideal gas law: Constant volume, Constant pressure, Constant temperature, Adiabatic & Polytrophic processes, Equations of state for real gases: Vander Waals equation, Redlich-Kwong equation, Peng-Robinson equation, Virial equation, Principles of corresponding states, Generalized compressibility charts, Heat effects accompanying chemical reactions, Standard heat of reaction, formation, combustion, Hess's law of constant heat summation, Effect of temperature on heat of reaction.

UNIT – 3

PROPERTIES OF PURE FLUIDS AND PROPERTIES OF SOLUTIONS [8L+3T]

Work function, Gibbs free energy, Relationships among thermodynamic properties: Exact differential equations, Fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy & heat capacity relations, Modified equations for internal energy (U) & enthalpy (H), Effect of temperature on U, H & entropy (S), relationships between Cp and Cv, Gibbs-Helmholtz equation, Fugacity, fugacity coefficient, effect of temperature & pressure on fugacity, Determination of fugacity of pure gases, Fugacities of solids and liquids, Activity: Effect of temperature and pressure on activity, Partial molar properties, chemical potential, fugacity in solutions, Henry's law and dilute solutions, Activity in solutions, activity coefficients, Gibbs-Duhem equation, Property changes of mixing, Excess properties.

UNIT - 4

PHASE EQUILIBRIA [7L+3T]

Criteria of phase equilibria, Criterion of stability, Duhem's theorem, Vapour-Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, VLE at low pressures, VLE at high pressures, Consistency test for VLE data, Calculation of activity coefficients using Gibbs- Duhem equation, Liquid-Liquid equilibrium.

UNIT - 5

BIOCHEMICAL ENERGETICS [8L+2T]

Reaction stoichiometry, Criteria of biochemical reaction equilibrium, Equilibrium constant & standard free energy change, Effect of temperature, Pressure on equilibrium constants & Other factors affecting equilibrium conversion, Liquid phase reactions, Heterogeneous bioreaction equilibria, Phase rule for reacting systems. Stochiometric and energetic analysis of cell growth and product formation-elemental balances, degree of reduction concepts-available –electron balance, yield coefficients, oxygen consumption and heat evolution in aerobic cultures, thermodynamics efficiency of growth.

Bibliography

TEXT BOOKS:

1. Introduction to Chemical Engineering Thermodynamics by Smith J. M., Van Ness H. C. McGraw Hill (6th Ed.), 2003.

2. A Textbook of Chemical Engineering Thermodynamics by Narayanan K. V., Ed 1. PHI publishers (1st Ed.), 2001.

REFERENCE BOOKS:

1. Biochemical Calculations by Segel I. H., John Wiley & Sons Inc. (2nd Ed.), 1976.
2. Chemical Engineering Thermodynamics by Rao Y. V. C., New Age International.
3. Engineering Thermodynamics by Jones J. B., Hawkins. , John Wiley & Sons Inc.

e-books:

1.Engineering thermodynamics by P K Nag.
2.Engineering thermodynamics by Tarik Al Shemmeri.

MOOCs:

1.www. nptel. ac. in -biotechnology-thermodynamics
2.www.ocw.mit.edu-thermodynamics and kinetics.

COURSE OUTCOMES (COs):

CO 1	Identify the various types of systems, processes and to solve engineering problems using laws of thermodynamics.
CO 2	**a)** Comprehend the P-V-T behaviour of pure fluids and solve related problems **b)** Understand heat effects in chemical reactions and solve related problems.
CO 3	Solve problems related to properties of pure fluids and solutions.
CO 4	Apply the concept of phase equilibria, reaction equilibria and energetics in the Biochemical engineering problems.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	UNIT OPERATIONS-1										Credits	3			
COURSE CODE	1	5	B	T	3	D	C	U	O	1	L-T-P-S	2	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of Engineering Physics and Mathematics

COURSE DESCRIPTION: This course provides students with the fundamental knowledge of momentum transfer and mechanical operations. This course gives the basic knowledge of fluid-flow phenomena, Kinematics of flow, Phenomena of flow past immersed bodies, and various aspects of transportation of fluids and metering of fluids. Basic concepts of dimensional analysis also included in this course. This course also emphasizes on different types of mechanical operations used in biochemical industries.

COURSE OBJECTIVES: The course objective is to make students capable of identifying the various types of fluids, their flow characteristics and their applications. This course will also enable students to understand the principle behind various mechanical operations like size reduction, filtration, sedimentation and mixing in upstream and downstream processes. This course will also train students to formulate, analyse and solve engineering problems involving fluid mechanics and mechanical operations.

UNIT - 1

DIMENSIONAL ANALYSIS [2L+1T]

Units and Dimensions: Fundamental and derived units, Conversion. Dimensionless groups and constants. Dimensional analysis: Rayleigh's method, Buckingham's π method.

UNIT - 2

FLUID FLOW PHENOMENA [5L+2T]

Fluid definition and Classification (Newtonian and Non-Newtonian), Newton's law of viscosity, Pressure measurement using manometers, Hydrostatic equilibrium, Types of flow-laminar & turbulent, Flow in Boundary Layers, Reynolds experiment.

UNIT - 3

FLOW OF INCOMPRESSIBLE FLUIDS [6L+3T]

Fluid flow – Continuity and Bernoulli equations, Flow through circular and non-circular conduits- Hagen Poiseuille equation, Pressure drop through packed bed - Ergun's equations.

UNIT - 4

FLOW MEASUREMENTS [4L+4T]

Flow measurements - Orifice meter, Venturimeter, Rota meter, Performance & Characteristics of Pumps - Centrifugal & Reciprocating pumps, Energy calculations, Fans, Compressors and Blowers.

UNIT- 5

MECHANICAL OPERATIONS [9L+3T]

Size reduction – Laws governing size reduction and equipment, Sieve analysis – Types, Screen effectiveness & capacity, Sedimentation & Settling - Batch & Continuous Sedimentation, Stoke's law, Terminal settling velocity. Kynch theory and Thickener design. Mixing – Types of mixers, power number, power consumption in mixing operation, Filtration - constant rate and constant pressure filtration, Filtration equipments, Cyclone separators and classifiers. Fluidization -Characteristics of fluidized systems, flow through packed beds, Conveyors - Slurry transport, Pneumatic conveyors, Mechanical conveyors, and elevators (Screw conveyor, Belt conveyor, Bucket elevator, continuous flow conveyor elevators), storage of solids.

Bibliography

TEXT BOOKS:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill.
2. Introduction to chemical Engineering by Badger and Banchero. McGraw Hill.

REFERENCE BOOKS:

1. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann (5^{th} Ed.).
2. Principles of Unit Operations by Foust A.S. Et al, John Wiley & Sons Inc (2^{nd} Ed.).
3. Transfer Processes & Unit Operations by Geankoplis C.J., PHI Publishers (3^{rd} Ed.)

e-books:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill. (http://www.ualberta.ca/~seyedsha/Ebooks/Unit%20Operations%20Of%20Chemical%20Engineering,%205th%20Ed,%20McCabe%20And%20Smith.pdf)
2. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann (http://traininghrd.nigc.ir/files/files/chemist%20book%20cd2/chemical%20eng/RICHARDSON,%20J.%20F.%20(2002)2/Coulson_Richardsons_Chemical_Engineering_Volume_2.pdf)

MOOCs:

1.https://www.edx.org/course/basics-transport-phenomena-delftx-tp101x#!

2.http://www.nptel.ac.in/syllabus/102106027/

COURSE OUTCOMES (COs):

CO 1	Identify the various types of fluids, their characteristics and applications.
CO 2	Analyse the fluid flow under various regimes, select suitable transport and metering mechanism.
CO 3	Comprehend the concepts of size reduction, filtration, sedimentation and mixing in upstream and downstream processes.
CO 4	Formulate, analyse and solve engineering problems involving fluid mechanics and mechanical operations.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

Course Title	Applied Mathematics	Course Code	15MA3GCAPM
Credits	04	L – T – P- S	3 – 1 – 0 - 0
Contact hours	48 hours (36L+12T)		

COURSE PREREQUISITES: Concepts of Trigonometry, Trigonometric formulas. Concepts of: differentiation, partial differentiation and integration. Solution to ordinary differential equations.

COURSE OBJECTIVES: The purpose of the course is to make the students well conversant with Fourier- Series, Fourier Transforms, formulate physical problems in terms of Partial Differential Equations, find insight into the physical behaviour of systems from mathematical solution and develop computational skills using efficient numerical methods for problems in science and engineering.

COURSE DESCRIPTION: The course is an introduction to matrices, Fourier series and Fourier Transforms techniques. Modelling of physical problems involving the heat and wave equation and solve the partial differential equations using analytical techniques such as the method of separation of variables and Fourier transform. The course also offers an exposure to an optimisation technique involving functionals. Emphasis being given to solve engineering oriented problems.

UNIT-1

MATRICES **[9 hours]**

Introduction: Elementary row transformations, Echelon form of a matrix, rank of a matrix by elementary row transformations. Consistency of a system of linear equations and solution. Solution of a system of non-homogenous equations: Gauss elimination method, LU decomposition method, Gauss-Seidel method. Eigenvalues and eigenvectors of matrices. Reduction of a matrix to diagonal form. **(7L+2T)**

Suggested Reading: Inverse of a matrix by Gauss-Jordan method. Largest eigenvalue and corresponding eigenvector using Rayleigh power method.

UNIT-2

NUMERICAL METHODS **[10 hours]**

Solution of algebraic and transcendental equations: Newton-Raphson method. Finite Differences and interpolation: Forward differences, backward differences. Newton-Gregory forward interpolation formula, Newton-Gregory backward interpolation formula, Lagrange's

interpolation formula, Lagrange's inverse interpolation. Numerical integration: Simpson's 1/3rd, 3/8th rule, Weddle's rule. Numerical solution of ordinary differential equations: Runge-Kutta method of fourth order. **(8L+2T)**

Suggested Reading: Euler's modified method and Milne's method to solve ordinary differential equations. Solution of simultaneous differential equations by Runge-Kutta method of fourth order.

UNIT-3

FOURIER SERIES AND FOURIER TRANSFORMS [13 hours]

Introduction: Periodic function, Dirichlet's condition, and statement of Fourier Theorem. Fourier series of periodic function of period 2*l*, Fourier series of functions having points of discontinuity.

Applications: Fourier series of typical waveforms -saw toothed waveform, triangular waveform, square waveform, half-wave rectifier, full wave rectifier and modified saw tooth waveform. Practical harmonic analysis.

Fourier Transforms: Concept of finite Fourier Transform, Infinite Fourier Transform**:** Fourier Sine and Cosine transforms and properties. Inverse Transforms. (**9L+4T)**

Suggested Reading: half range Fourier series, Convolution theorem, Parseval's identities for Fourier transform and Physical Significance of Parseval's identities.

UNIT-4

PARTIAL DIFFERENTIAL EQUATIONS [9 hours]

Formation of Partial differential equations-elimination of arbitrary constants, elimination of arbitrary functions. Equations of first order- The linear equation $P\,p + Q\,q = R$ **(**Lagrange's partial differential equation). Applications: One-dimensional heat equation and wave equation (without proof), various possible solutions of these by the method of separation of variables. **(7L +2T)**

Suggested Reading**:** Direct integration method. Method of separation of variables. D'Alembert's solution of wave equation. Solution of boundary value problems using Fourier Transform method.

UNIT- 5

CALCULUS OF VARIATIONS **[7 hours]**

Variation of a functional, Euler's equation, variational problems.

Applications: Geodesics on a plane, hanging cable problem, Geodesics of a right circular cylinder. Brachistochrone problem.

Isoperimetric problems. **(5L +2T)**

Suggested Reading: Geodesics of a right circular cone, minimal surface of revolution.

MATHEMATICS LAB

- Solution of system of algebraic equations using Gauss Seidel method
- LU decomposition of matrices.
- Eigenvalues and eigenvectors of matrices.
- Largest, smallest eigenvalue and the corresponding eigenvectors of a matrix.
- Diagonalisation of matrices

Bibliography

Text Books

(1)Higher Engineering Mathematics, B.S. Grewal, 43rd edition, 2014, Khanna Publishers.

(2)Advanced Engineering Mathematics, Dennis G. Zill and Cullen, 4th edition, 2011, Jones and Bartlett India Pvt. Ltd.

Reference Books

(1) Advanced Engineering Mathematics, Erwin Kreyszig, 10th edition Vol.1 and Vol.2, 2014, Wiley-India.

(2) Higher Engineering Mathematics, B.V. Ramana, 7th reprint, 2009, Tata Mc. Graw Hill.

(3)Numerical methods for Scientific and Engineering Computation, M. K. Jain, S.R. K Iyengar, R. K. Jain, 6th edition, 2010, New Age International (P) Limited Publishers.

E books and online course materials

(1) Engineering Mathematics, K. A. Stroud, Dexter J. Booth, Industrial Press, 2001 http://books.google.co.in/books/about/Engineering_Mathematics.html?id=FZncL-xB8dEC&redir_esc=y.

(2) Advanced Engineering Mathematics, P. V. O'Neil, 5th Indian reprint, 2009, Cengage learning India Pvt. Ltd.

(3)http://ocw.mit.edu/courses/mathematics/ (online course material)

Online Courses and Video Lectures:

(1)http://nptel.ac.in/courses.php?disciplineId=111

(2)https://www.khanacademy.org/

(3)https://www.class-central.com/subject/math (MOOCS**)**

On completion of the course the student will have the ability to:

Course Code	COURSE OUTCOME (CO**)**	**PO**	**Bloom's level**
15MA3GCAPM	CO-1: Compute solution of a system of algebraic equations, algebraic and transcendental equations, and ordinary differential equations numerically.	2, 3	3
	CO-2: Demonstrate an understanding of Fourier series and Fourier transforms techniques.	2, 3, 4	4
	CO-3: Formulate boundary value problems involving one dimensional heat and wave equation.	2, 3, 4	4
	CO-4: Solve partial differential equations with appropriate boundary conditions using analytical techniques.	2, 3, 4	4
	CO-5: Use calculus of variations to find the extremal of a functional.	2, 3	3

Program Outcome:

1. Graduates will apply knowledge of Mathematics, Science and Engineering concepts to solve problems pertinent to Chemical and Biotechnology.
2. Graduates will be able to identify problems related to chemical engineering and biotechnology, analyse and derive valid conclusions with fundamental knowledge in chemistry, biology, Engineering and computation.
3. Graduates will be able to design, conduct experiments, analyse and interpret data for Investigating problems in chemical engineering, biotechnology and allied fields.

Assessment:

- Each unit consists of one full question.
- Each full question consists of three or four subdivisions.
- Five full questions to be answered.
- To set one question from Units 1, 2, 5 and two questions from Unit 3 and Unit 4

Questions for CIE and SEE will be designed to evaluate the various educational components (Blooms taxonomy) such as:

- Remembering and understanding the course contents (weightage: 40%)
- Applying the knowledge acquired from the course (weightage: 35%)
- Analyzing various engineering problems (weightage: 15%)
- Understanding of various system models (weightage: 5%)

COURSE TITLE	BIOCHEMISTRY & BIOENERGETICS										Credits	4			
COURSE CODE	1	5	B	T	4	D	C	B	A	B	L-T-P-S	2	1	1	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Know edge of organic chemistry, Basics of Biomolecules and Cell Biology and Genetics.

COURSE DESCRIPTION: This course describes the major metabolic pathways and their bioenergetics.

COURSE OBJECTIVES: This course is a foundation course needed to understand the concepts of Metabolic Engineering, Enzyme Technology, Structural Biology and Bioinformatics.

PART A: THEORY+ TUTORIAL

UNIT - 1

PRINCIPLES OF BIOENERGETICS [4L+3T]

Energy concepts: Different forms of energy, Energy conservation/transduction, Energy flow cycle, Energy batteries, High energy compounds, Structure and properties of ATP, Thermodynamic concepts, Free energy change and equilibrium constant, Coupling reactions, Free energy and oxidation–reduction potential, Bioenergetic interconversions and thermodynamic constraints on their stoichiometrics, Simple problems.

UNIT - 2

CARBOHYDRATE METABOLISM [6L+3T]

Introduction, Glycolysis: pathway, regulation and bioenergetics, Gluconeogenesis: pathway regulation and bioenergetics, Glycogen metabolism: degradation, synthesis, regulation and bioenergetics, Hexose interconversions, TCA cycle: pathway, regulation and bioenergetics, Amphibolic and Anaplerotic reactions, HMP pathway, Glyoxylate pathway, Structure and functions of electron carriers of ETC, Respiration and ATP formation in mitochondria, Electron transport chain, Oxidative phosphorylation, Energetics of Electron transport chain, Ion-electrochemical potential difference calculations, Malate-Aspartate shuttle system.

UNIT - 3

PHOTOSYNTHESIS [5L+2T]

Introduction, Bacterial photosynthesis, Chloroplast/thylakoid structure, Photosynthetic apparatus, Photosynthetic reaction centre, Hill reaction, Light reaction, Cyclic and non-cyclic photophosphorylation, CO_2 assimilation reaction, $C_4$and CAM pathways, Photorespiration.

UNIT - 4

LIPID METABOLISM [6L+2T]

Digestion, mobilization and transport of fats, Oxidation of saturated fatty acid & its Energetics, Formation of ketone bodies and their oxidation, Biosynthesis of fatty acid: fatty acid synthase complex, biosynthesis of palmitate and its energetics, Biosynthesis of phospholipids and their Energetics, Biosynthesis of cholesterol and its regulation.

UNIT - 5

NITROGEN METABOLISM [5L+3T]

Overview of amino acid catabolism in mammals: transamination (mechanism of transamination involving PLP to be included), oxidative deamination, Nitrogen excretion, Urea cycle and its energetics, Biosynthesis of amino acids of oxaloacetate family.

Biosynthesis of nucleotides: de novo purine nucleotide synthesis (AMP and GMP), de novo pyrimidine nucleotide synthesis (UTP, CTP and dTTP), Regulation of biosynthesis of purine and pyrimidine nucleotides, Recycling of purine and pyrimidine nucleotides by salvage pathway, Catabolism of purine and pyrimidine nucleotides.

Bibliography

TEXT BOOKS:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, W.H. Freeman and company (5th Ed.)
2. Principles of Biochemistry by Lubert Stryer (Freeman Int. Edition)

REFERENCE BOOKS:

1. Biochemistry by Voet and Voet, Wiley New York
2. Biochemistry by Garett and Grisham, Thompson Learning
3. Bioenergetics by David.G.Nicolls and Styart J. Ferquson, Academic Press, Elsevier

e-books:

1. https://books.google.co.in/books/about/Bioenergetics.html?id=0_9EWX1fg8wC&redir_esc=y
2. https://archive.org/details/LehningersPrinciplesOfBiochemistry5e

MOOCs:

1. https://www.mooc-list.com/course/principles-biochemistry-edx?static=true
2. http://nptel.ac.in/syllabus/syllabus.php?subjectId=102101002

PART B: BIOCHEMISTRY LAB (2hrs/week)

1. Volume/weight measurements, Concentration units, pH measurements, Preparation of buffers.
2. Qualitative tests for carbohydrates and lipids.
3. Qualitative tests for amino acids and proteins.
4. Estimation of blood sugar by Folin-wu method.
5. Estimation of blood sugar by O-toluidine method.
6. Estimation of inorganic phosphate by Fiske-Subbarow method.
7. Estimation of amino acid by ninhydrin method.
8. Estimation of urea by diacetyl monooxime method.
9. Estimation of protein by Lowry method.
10. Estimation of cholesterol by Zak and Henly's method.
11. Determination of iodine value of lipids.
12. Determination of saponification value of lipids.
13. Estimation of blood sugar by Hegde and Johnson method.
14. Titration of amino acids by acids and bases.

REFERENCE BOOKS:

1. **Lab manual** by Faculty
2. **An introduction to Practical Biochemistry** by David T. Plummer, Tata Mc Graw Hill (3rd Ed.)
3. **Experimental Biochemistry** by Beedu Sashidhar Rao and Vijay Deshpande, I.K. International Pvt. Ltd.

COURSE OUTCOMES (COS):

CO 1	Understand the principles governing bioenergetics and the role of high energy compounds in living systems.
CO 2	Understand the concepts of thermodynamics of electron transfer and redox reactions in aerobes.
CO 3	Describe the steps involved in metabolic pathways in living systems and their homeostasis in health and disease
CO 4	Understand the mechanism of energy generation in living systems.
CO 5	Design, conduct experiments related to qualitative and quantitative analysis of biomolecules and interpret data.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): A written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce). Both CIE and SEE have equal (50:50) weightages. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	UNIT OPERATIONS-2										Credits	6			
COURSE CODE	1	5	B	T	4	D	C	U	O	2	L-T-P-S	3	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of Process Engineering Thermodynamics and Process Principles and Calculations.

COURSE DESCRIPTION: This course provides students with the fundamental knowledge of heat and mass transfer. The course also includes heat and mass transfer problems and description of phase diagrams and experimental equipment. Practical part includes experiments on mechanical operations, momentum transfer, heat transfer in heat exchangers and mass transfer operations.

COURSE OBJECTIVES: The course objective is to provide students with the fundamental knowledge needed to successfully practice the profession of biological engineering using the knowledge of heat and mass transfer. It trains students to design, test, and analyze systems and processes that involve transport phenomena. The course also enables students to formulate and solve heat and mass transfer problems and to use experimental equipment. It will also help students develop their ability to apply knowledge of mathematics, science and engineering to conduct experiments and interpret data. Students will learn to identify, formulate and solve engineering problems.

PART A: THEORY

UNIT – 1

CONDUCTIVE & CONVECTIVE HEAT TRANSFER [7 HOURS]

Modes of heat transfer, Conduction - Steady state heat conduction through unilayer and multilayer walls, critical thickness of insulation, Overall & Individual heat transfer co-efficient, LMTD, Forced & natural convection, Basic concepts in unsteady state heat conduction, Heat Transfer equipments - Double pipe heat exchanger, Shell and Tube heat exchanger.

UNIT - 2

CONDENSATION AND EVAPORATION [5 HOURS]

Condensation - Film wise & drop wise condensation, Evaporation principle, Evaporators - Horizontal tube evaporator and long tube vertical evaporator, Single and multiple effect evaporator, Enthalpy balances and Economy of evaporator.

UNIT - 3

BASICS OF MASS TRANSFER [7 HOURS]

Mass transfer Operations, Diffusion – Types, Steady state diffusion:- Fick's I law, equimolar counter current diffusion, Measurement of diffusivity, Mass transfer coefficients, Basic concepts in unsteady state diffusion, Fick's II law, Theories of mass transfer across phase boundaries – two film theory and penetration theory, Analogy between heat and mass transfer using dimensionless numbers.

UNIT - 4

MASS TRANSFER OPERATION – I [10 HOURS]

Distillation - Methods of distillation, Distillation of binary mixtures – Raoults law, McCabe Thiele method, Basic concepts in Extraction – Leaching operation - Principle, Mass transfer in leaching operations, Liquid-Liquid extraction - Principle, equilibrium calculations, ternary equilibrium diagram, Aqueous two phase separations.

UNIT – 5

MASS TRANSFER OPERATION – II [10 HOURS]

Basic concepts in Adsorption - Nature of adsorbents, Adsorption Isotherms, Ion exchange, Drying - Principle of drying, drying rate curve, Crystallization – Principle, stages in crystallization and methods of super saturation.

Bibliography

TEXT BOOKS:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill.
2. Introduction to chemical Engineering by Badger and Banchero. McGraw Hill.

REFERENCE BOOKS:

1. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann (5th Ed.).
2. Principles of Unit Operations by Foust A.S. Et al, John Wiley & Sons Inc (2nd Ed.).
3. Transfer Processes & Unit Operations by Geankoplis C.J., PHI Publishers (3rd Ed.)
4. Biological and Bioenvironmental Systems Heat and Mass Transfer by Dutta A.K., Technology & Engineering (2002).

e-books:

1. Unit operations in Chemical Engineering by McCabe W.L. and Smith J.C. McGraw Hill. http://www.ualberta.ca/~seyedsha/Ebooks/Unit%20Operations%20Of%20Chemical%20Engineering,%205th%20Ed,%20McCabe%20And%20Smith.pdf

2. Chemical Engineering-Vols I&II by Coulson and Richardson, Butterworth-heinemann https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&cad=rja&uact=8&ved=0CEcQFjAH&url=https%3A%2F%2Fornithopter.googlecode.com%2Ffiles%2FCoulson__Richardsons_Chemical_.pdf&ei=p0iJVfLFE4XiuQTA6aTwDg&usg=AFQjCNFgBbve1dez_wkIdeYqMUfMKuuxCQ&bvm=bv.96339352,d.c2E

MOOCs:

1. https://www.edx.org/course/basics-transport-phenomena-delftx-tp101x#!
2. http://ocw.mit.edu/courses/chemical-engineering/10-302-transport-processes-fall-2004/index.htm
3. http://www.nptel.ac.in/syllabus/102106027/

PART B :UNIT OPERATIONS LABORATORY (2HRS/WEEK)

The experiments should cover any 12 of the following topics.

A) Momentum Transfer

1. Friction in circular pipes
2. Flow rate measurement using venturi / orifice meters (incompressible fluid)
3. Characteristics of centrifugal Pumps

B) Mechanical Operations

1. Batch sedimentation
2. Leaf filter
3. Screen effectiveness
4. Drop weight crusher

C) Heat Transfer

1. Unsteady State heat conduction

2. Vertical/Horizontal condenser
3. Heat transfer in Double Pipe Heat exchanger

D) Mass Transfer

1. Distillation – Simple (Differential) distillation
2. Packed column distillation
3. Diffusion of organic vapors in Air
4. Liquid-Liquid extraction

COURSE OUTCOMES (COs):

CO 1	Apply mathematical knowledge to formulate and analyze problems related to steady state heat conduction, convection and insulation.
CO 2	Understand the working principle and construction of heat exchangers and evaporators and solve related problems.
CO 3	Analyze diffusional processes and estimate flux and mass transfer coefficients in a diffusion process.
CO 4	Explain working principle of various separation processes and equipment required.
CO 5	Apply the concepts of mechanical operations, momentum transfer, heat transfer and mass transfer operations in lab experiments.
CO 6	Demonstrate the concepts of heat and mass transfer in bioprocess.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): a written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce). Both CIE and SEE have equal (50:50) weightages. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

Course Title	Biostatistics and Probability	Course Code	15MA4DCBSP
Credits	04	L – T – P- S	3 – 1 – 0 - 0
CIE	100 marks (50% weightage)	SEE	100 marks (50% weightage)

COURSE PREREQUISITES: Basic concepts of Statistics and Probability, addition theorem, conditional probability, Bayes' theorem, discrete random variable, Binomial distribution. Basic concepts of statistics. Matrices.

COURSE OBJECTIVES: Student will get acquainted with the procedure of collecting, designing, analysing and drawing inference about the data.

COURSE DESCRIPTION: The course offers an extensive study to small and large data using various statistical methods. Emphasis is on the application to biological models.

UNIT-1

STATISTICS & PROBABILITY DISTRIBUTIONS [11 hours]

Curve fitting: $y = a + bx$, $y = a + bx + cx^2$, $y = ab^x$, Correlation and regression.

Introduction, Discrete distribution: Poisson distribution- problems, Continuous distributions: Normal, Gamma distribution, problems. **(8L+3T)**

UNIT-2

MARKOV CHAIN AND GENETIC APPLICATION [8 hours]

Introduction, Probability vectors, stochastic matrices, fixed points, regular stochastic matrices. Markov chains, higher transition probabilities, stationary distribution of regular Markov chains and absorbing states.

Genetic Applications: Hardy - Weinberg law, Wahlund's Principle, Sib mating, Selfing.
(6L+2T)

UNIT-3

DESIGN OF EXPERIMENTS [9 hours]

Principles of experimental design – Randomisation, Replication, Local Control.

Randomised block design, Completely Randomised block design, Latin Square Design, Factorial Experiments –Problems. **(7L+2T)**

UNIT-4

STATISTICAL INFERENCE - I **[9 hours]**

Introduction, estimation – point, interval; procedure for testing of hypothesis, level of significance, construction of confidence interval.

[Large sample] Test of significance for single mean, difference between two means, single proportion, difference between two proportions, and difference of two Standard deviations. **(7L+2T)**

UNIT-5

STATISTICAL INFERENCE – II **[11 hours]**

[Small sample] Test of significance for single mean, difference between two means, paired t-test, ratio of variances (F- distribution), Chi -Square distribution-goodness of fit, independence of attributes. Analysis of variance (one-way and two-way classifications). Non parametric test – Wilcoxon Rank Sum test and Kruskal – Wallis One Way Analysis of Variance by Ranks. **(8L+3T)**

Bibliography

Text Books:

1. Fundamentals of Biostatistics, Khirfan A Khan, Atiya Khanum, 3rd edition, 2012, Ukaaz Publications.
2. P. S. S. Sundar Rao and J. Richard – An Introduction to Biostatistics, 4th edition, 2006, Prentice Hall of India.

Reference Books:

1. Wayne W. Daneil – Biostatistics: A foundation for Analysis in the Health sciences 10th edition, 2013, John Wiley & Sons.
2. Schaum's Outline of Probability and Statistics, 4th edition, 2013, Schaum's outlines
3. Biostatistics – P.N.Arora, P.K. Malhan, 2nd edition, 2013, Himalaya Publishing House.
4. Fundamentals of Biostatistics by Veer BalaRastogi- 2nd edition, 2009, Ane books Pvt. Ltd. India.

E books and online course materials

1. Statistics online computational resource wiki.stat.ucla.edu/socr/index.php/Probability_and_statistics_EBook
2. accessengineeringlibrary.com/.../schaums-outline-of-probability-and-statistics-fourth-edition.

3. Fundamentals of Statistics and Probability for Engineers, T.T. Soong, John Wiley and Sons Ltd.
4. fastebook.org/.../fundamentals-of-biostatistics-khan-and-khanum.html

Online Courses

1.http://ocw.mit.edu/courses/mathematics/18-05-introduction-to-probability-and-statistics-spring-2014/

2. http://nptel.ac.in/courses*/111105041/1* NPTEL >> Mathematics >> Probability and Statistics

3. https:// www.khanacademy.org/Math

4. https:// www.class-central.com/subject/math (MOOCS)

5. E-learning: www.vtu.ac.in

Course outcomes (Cos)

	CO
CO-1	Ability to estimate the correlation of two variables and prediction of one variable from the other.
CO-2	Apply the basic principles of probability and probability distributions to the problems in Bio-technology.
CO-3	Apply the concepts of Markov chain to the field of genetics.
CO-4	Demonstrate and understanding of sampling and its various techniques.
CO-5	Draw inferences about the characteristics of population from the samples based on the parametric and non-parametric tests.

Mapping Program Outcome:

1. Graduates will apply knowledge of Mathematics, Science and Engineering concepts to solve problems pertinent to Biotechnology.
2. Graduates will be able to identify problems related to biotechnology, analyze and derive valid conclusions with fundamental knowledge in biology, Engineering and computation.
3. Graduates will be able to design, conduct experiments, analyze and interpret data for investigating problems in biotechnology and allied fields.

Assessment:

- Each unit consists of one full question.
- Each full question consists of three or four subdivisions.
- Five full questions to be answered.
- To set one question from Units 2, 3, 4 and two questions from Unit 1 and Unit 5

Questions for CIE and SEE will be designed to evaluate the various educational components (Blooms taxonomy) such as:

- Remembering and understanding the course contents (weightage: 40%)
- Applying the knowledge acquired from the course (weightage: 35%)
- Analyzing various engineering problems (weightage: 15%)
- Understanding of various system models (weightage: 5%)

COURSE TITLE	ENVIRONMENTAL BIOTECHNOLOGY										Credits	3			
COURSE CODE	1	5	B	T	4	D	C	E	B	T	L-T-P-S	3	0	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Knowledge of chemistry, Mathematics, Basics of Biology,

COURSE DESCRIPTION: This course describes the major environmental issues and the various biotechnological applications that are currently being used for sustainability of environment.

COURSE OBJECTIVES: To enable the students to gain knowledge on the various environmental issues and the application of biotechnological concepts /principles for betterment (remediation) and sustainability of environment.

UNIT - 1

BIOACCUMULATION OF TOXICANTS [5 HOURS]

Introduction, characteristics of Xenobiotics, Relationship of Bioaccumulation with Chemical Structure, Ecophysiology of Bioaccumulation, Process of toxicants uptake-kinetic aspects, Factors affecting bioaccumulation, doses of toxicants, dose–effect relationships, quantal response & graded responses, application of dose-effect relationship. Measurement of bioaccumulation. Kinetic modelling of bioaccumulation.

UNIT - 2

BIODEGRADATION AND BIOREMEDIATION OF TOXICANTS [11 HOURS]

Biodegradation of organic pollutants (aerobic and anaerobic degradation of biopolymers, co-metabolic degradation of organo pollutants), biodegradation of pesticides: fate of pesticides in environment, microbial adaptations to pesticide contaminated soils, enzymes catalyzing pesticide degradation reactions. microbial transformations of pesticides(β oxidation, oxidative dealkylation, thioetheroxidation,decarboxylations,epioxidations,hydroxylations,ring cleavages, hydrolysis, nitro reactions.) microbial transformations of heavy metals (heavy metal toxicity, microbes

involved, metal –microbe interactions, transformations, genetic aspects of heavy metal resistance , applications) bioleaching and biomining :(Microbes in Bioleaching, Metal Recovery, Microbial recovery of phosphate, microbial extraction of petroleum, microbial production of fuels. Bioremediation using microbes, bioremediation processes & technologies, monitoring of the efficacy of bioremediation, Phytoremediation.

UNIT - 3

BIOTECHNOLOGICAL APPLICATIONS OF GREEN CHEMISTRY [9 HOURS]

Principles of green chemistry ,significance; biofuels : need for alternate energy source (types of non-renewable and renewable energy resources, impact of conventional fuels on environment,) sources, types– producer gas, biogas, biodiesel, biomethanol, power alcohol (bioethanol), merits and demerits .; biofertilizers and biopesticides (types , characteristics & advantages , genetic transformation) ;biopolymers & bioplastics (types, characteristics & advantages, applications); Alternative feedstocks /starting materials ;Alternative reagents or transformations .

UNIT- 4

BIOLOGICAL TREATMENT OF WASTE WATER [7 HOURS]

Introduction , waste water characteristics, (Physical,chemical,biological) Waste water treatment, unit operations, design and modeling of activated - sludge process, Microbial Process for wastewater treatment, BOD, COD, Secondary treatment,microbial removal of phosphorous and nitrogen; Nutrient removal by Biomass production. Industrial waste treatment opportunities for reverse osmosis and ultra filtration. Wastewater treatment of food processing industries like sugar factories, vegetable oil industries, potato processing industries, dairy industries, beverages industries and distilleries.

UNIT - 5

SOLID WASTES MANAGEMENT [7 HOURS]

Basic aspects, characteristics of solid wastes, general composition of urban solid wastes, Methods of solid waste treatment -aerobic & anaerobic, biogas generation, biotechnological processes involving solid Hazardous wastes: Biomedical, Dairy, Pulp, Textile, leather and pharmaceutical industry wastes, petroleum waste treatment.

Bibliography

TEXT BOOKS:

1. A textbook of Environmental Chemistry and Pollution Control: S.S Dara, S.Chand & Co.

2. Textbook of Environmental Biotechnology: Pradipta Kumar Mohapatra., IK International.

REFERENCE BOOKS:

1. Environmental Biotechnology: Foster C.F., John ware D.A., Ellis Horwood Limited, 1987.
2. Environmental Biotechnology: Indu Shekhar Thakur, IK Publishers, 2006.
3. Fuels from Waste: Larry Anderson and David A Tillman. Academic Press, 1977.
4. Bioprocess Technology- fundamentals and applications: S O Enfors &LHagstrom, RIT, Stockholm, 1992.

e-books:

1. ibrary.umac.mo/ebooks/b28045907.pdf
2. http://www.springer.com/in/book/9781588291660

MOOCs:

1. http://nptel.ac.in/syllabus/syllabus.php?subjectId=120108005

COURSE OUTCOMES (COS):

CO 1	Understand the fundamental mechanisms involved in the interaction of living and non-living systems with toxicants.
CO 2	Analyze applicability of phenomena such as bioremediation and bioaugmentation.
CO 3	Understand impact of renewability concept in present day scenario.
CO 4	Select design processes in treatment of waste water and solid wastes

ASSESSMENT: Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini- project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	BASICS OF COMPUTER APPLICATIONS										Credits	5			
COURSE CODE	1	5	B	T	4	D	C	B	C	A	L-T-P-S	2	0	1	2
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Basics of computer concepts, Molecular Biology

COURSE DESCRIPTION: This course imparts the knowledge about creating and accessing databases using SQL as well as HTML and XML documents and their scope in biotechnology field. Students will be able to write Perl scripts which are important in Bioinformatics and other biological science applications.

COURSE OBJECTIVES: The objective of the course is to make graduates comprehend the concepts like SQL, HTML, XML and Perl languages and prepare them to work individually and as a team in a multidisciplinary environment.

PART A: THEORY

UNIT - 1

BASICS OF DATABASES **[6 HOURS]**

DBMS: Database system-concepts and architecture. RDBMS: concepts, constraints, languages and design, Entity- Relationship model, Microsoft SQL server, introduction to SQL, basic commands, using SQL in MS Access, creating and modifying tables, joining tables, simple queries using SQL, inner join, outer joins, data sorting and filters.

UNIT - 2

INTERNET **[4 HOURS]**

Network architecture. Internet: internet addresses, Internet protocol suit - transport layer protocols, File transfer protocol, internet access and applications. HTTP, web services, WWW proxies, applications on the web.

UNIT - 3

HTML and XML **[4 HOURS]**

HTML : Fundamentals, Basic Tags, Elements, Attributes, Formatting, Phrase Tags, Images, Tables, Lists, Frames, Colours, Forms, Style sheets, HTML JavaScript.XML: Fundamentals, Namespaces, Syntax and applications.

UNIT - 4

INTRODUCTION TO PERL **[7 HOURS]**

An overview of Perl: Escape sequences, Numerical data types, strings in Perl, Operators, Perl statements: Introduction to statements, Types - Input/Output statements, conditional statements, looping, and jumping statements. Lists: Introduction to lists and accessing list values. Arrays : initilising array, adding elements to an array, accessing single and multiple elements from an array. Array manipulating functions (pop, push, shift, unshift, splice, sort). Hashes: Introduction to Hashes, creating a hash, working with hashes, adding, changing and accessing hash values. Regular expressions: Introduction to regular expressions, patterns, metacharacters, modifiers, grouping and alteration. Matching, substitution, translation and binding operators.

UNIT - 5

PERL FOR BIOINFORMATICS **[5 HOURS]**

Representing Sequence Data, Store a DNA Sequence, Concatenating DNA Fragments, Transcription, Translation, Perl Documentation, Calculating the Reverse Complement in Perl, Reading Proteins in Files, Searching for motifs.

Bibliography

TEXT BOOKS:

1. Microsoft SQL Server 2008 For Dummies, Mike Chapple, 2009, John Wiley & Sons Publisher
2. Fundamentals of Database systems, Ramez Elmarsi, and Shamkant B. Navathe, Durvasula V.L.N.Somayajulu and Shyam K.Gupta, Pearson Education.
3. Steven Holzner, XML: A Beginner's guide: Go Beyond the basics with Ajax, XHTML, XPath2.0, XSLT 2.0 and XQuery, McGraw Hill Professional, Ist Edition, 2008.
4. Beginning Perl for Bioinformatics, James Tisdall, Publisher: O'Reilly, First Edition October 2001
5. Perl cook book by O'Reilly & Associates, second edition, 2003.

REFERENCE BOOKS:

1. Learning Perl (III edition) by Tom Christiansen, Jon Orwant, Larry Wall, 2001.
2. SAMS teach SQL yourself in 10 minutes by Ben Forta, 3rd Edition
3. SQL Queries for more mortals: A hands on guide to data manipulation in SQL by Michael J. Hernandez and John L. Viescas (2000).
4. Internet:The complete reference by Margaret Levine young, Tata McGraw Hill, 1999.
5. A First course in database systems by Jeffrey D. Ullman and Jennifer D. Widon. (2nd Ed.)

e-books:

1. www.free-ebooks.net/ebook/Build-and-Design-a-Website-HTML-CSS
2. www.onlineprogrammingbooks.com/sql/
3. http://www.freebookcentre.net
4. http://www.getfreeebooks.com

MOOCs:

1. www.edx.org
2. www.w3schools.com
3. www.mooc-list.com

PART B: BASICS OF COMPUTER APPLICATIONS LAB: (2 hrs/week)

1. A Program to implement Data Definition language
2. A Program to implementation on DML, TCL and DRL
3. A Program to implement Nested Queries & Join Queries
4. A Program to implement Views
5. A Program to illustrate basic HTML tags
6. A Program to illustrate Table tag
7. A Program to illustrate Form tag
8. A Program to illustrate Hyper Link tag
9. A Program to illustrate ordered and unordered List tag
10. A Program to illustrate CSS (cascading style sheet)
11. A Program to illustrate img tag and Embedded Multimedia
12. Perl Program for Pattern Matching

COURSE OUTCOMES (COS):

CO 1	Apply the concept of SQL to create and access the databases and can develop a database
CO 2	Comprehend the concept of networks, internet, and web services.
CO 3	Apply the concept of HTML and XML to create a website.
CO 4	Describe the different datatypes of PERL and its functions and write the PERL scripts for various biological and allied applications.
CO 5	Apply the concepts of programming for emerging technologies

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): a written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce). Both CIE and SEE have equal (50:50) weightages. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

COURSE TITLE	PROCESS PRINCIPLES AND CALCULATIONS										Credits	3			
COURSE CODE	1	5	B	T	4	D	C	P	P	C	L-T-P-S	2	1	0	0
CIE	100 marks (50% weightage)										SEE	100 marks (50% weightage)			

COURSE PRE-REQUISITES: Engineering chemistry & mathematics, unit operations.

COURSE DESCRIPTION: This subject puts emphasis on the basic engineering principles of bioprocess. It also highlights the modern application of biotechnological process and the role of bio process engineer in biotechnological industry.

COURSE OBJECTIVES: To enable the students to formulate and solve problems related to

(1) Energy balances of chemical reactions (2) stoichiometric equations for microbial growth & product formation and (3) material balances in steady state unit operations

UNIT – 1

INTRODUCTION TO BIOPROCESS CALCULATIONS [3L+2T]

Concept of mole, Mole fraction. Compositions of mixtures of solids, liquids and gases.

UNIT - 2

HUMIDITY AND HUMIDITY CHART [5L+2T]

Vapour-Pressure concept, Saturation, Partial saturation, molal, absolute humidity concepts. Humidity chart

UNIT – 3

MATERIALS BALANCE WITHOUT REACTION [6L+3T]

General material balance equation for steady and unsteady state. Typical steady state material balances in distillation, absorption, extraction, crystallization, drying, mixing, evaporation, Humidification & dehumidification. Elementary treatment of material balances involving bypass, Recycle.

UNIT – 4

STEADY STATE MATERIAL BALANCE WITH REACTION [6L+3T]

Principles of Stoichiometry, Concept of limiting, excess reactants and inerts, fractional and percentage conversion, fractional yield and percentage yield, selectivity, Fuels: Proximate and Ultimate analysis of coal, Combustion Calculations.

UNIT - 5

ENERGY BALANCE [6L+3T]

General steady state energy balance equation, Heat capacity. Enthalpy, Std. Heat of formation, Std. Heat of reaction and Std. Heat of combustion, Heat of solution. Heat of mixing, ΔHc calculations, elevated temperatures, Stoichiometry of microbial growth & product formation, yield coefficient Concepts, Elemental material balance.

Bibliography

TEXT BOOKS:

1. Basic Principles and Calculations in Chemical Engineering by Himmelblau D. M. Ed 6. PHI Publishers (6^{th} Ed.), 1997.
2. BioProcess Engineering, Basic concepts by Shuler & Kargi, PHI Publishers (2^{nd} Ed.) 2002

REFERENCE BOOKS:

1. Chemical Process Principles Part – I by Hougen O. A., Waston K. M. and Ragatz R. A., Wiley, New York
2. Stoichiometry (SI Units) by Bhatt B. L. and Vora S. M. . Tata McGraw Hill (3^{rd} Ed.), 1996.

e- books:

1.Chemical process and principles by Olaf a. Hougen and Kenneth M. Watson

MOOCs:

https://www.mooc-list.com

COURSE OUTCOMES (COs):

CO 1	Apply the basic concepts of process calculations in biochemical engineering applications.
CO 2	Formulate and solve the material balances on steady state unit operations involving with & without reaction.
CO 3	Formulate and solve the energy balances of chemical reactions.
CO 4	Formulate and solve the stoichiometric equations for microbial growth & product formation.

ASSESSMENT:

Continuous Internal Evaluation (CIE): includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE): written examination for theory. Both CIE and SEE are given equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.