Course Structure & Syllabus
B. Tech. Biochemical Engineering
(Batch: 2019 Onwards)

Department of Biochemistry & Biochemical Engineering
Sam Higginbottom University of Agriculture, Technology and Sciences

Course structure
Bachelor of Technology in Biochemical Engineering
(Batch: 2019 Onwards)

Semester I

Course Code	Course Title	L	T	P	Credits
BIOL-201	Elementary Biology (D)	2	0	0	2(2-0-0)
MAS-313	Elementary Mathematics (D)	3	1	0	4(3-1-0)
GPT-301	Moral & Value Education	3	0	0	3(3-0-0)
LNG-304	Professional Communication & Technical Writing	3	0	0	3(3-0-0)
ME-304	Workshop practice and Technology	2	0	4	4(2-0-2)
PHY 309	Applied Physics	3	0	0	3(3-0-0)
CHEM-311	Inorganic Chemistry	2	0	2	3(2-0-1)
CHEM-313	Organic Chemistry	2	0	2	3(2-0-1)
ENVS-415	Environmental Studies-I	2	0	0	2(2-0-0)
NSS- 318	National Service Scheme	0	0	2	1(0-0-1)
		Total			**28**

Semester II

Course Code	Course Title	L	T	P	Credits
ME-301	Engineering Graphics	0	0	4	2(0-0-2)
MCE 301	Cell Biology	2	0	2	3(2-0-1)
IM- 349	Introductory Microbiology	2	0	2	3(2-0-1)
BCBE 407	Introduction to Chemical Engineering	3	0	0	3(3-0-0)
MAS-408	Technical Mathematics-I	3	1	0	4(3-1-0)
ENVS-416	Environmental Studies-II	2	0	0	2(2-0-0)
CHEM-312	Physical Chemistry	2	0	2	3(2-0-1)
EE-302	Electrical Engineering	2	1	2	4(2-1-1)
CSIT-401	Computer and Languages	2	1	2	4(2-1-1)
NSS- 327	National Service Scheme	0	0	2	1(0-0-1)
		Total			**29**

Semester III

Course Code	Course Title	L	T	P	Credits
MCE-302	Molecular Biology	3	0	0	3(3-0-0)
CSIT 403	Information Technology	2	0	2	3(2-0-1)
BCBE-304	Biochemistry	2	0	2	3(2-0-1)
APFE-303	Principles of Food Engineering	2	0	2	3(2-0-1)
CHEM-330	Analytical Chemistry	2	0	2	3(2-0-1)
BCBE 408	Chemical Thermodynamics	3	0	0	3(3-0-0)
BCBE 411	Transport Phenomena	3	0	0	3(3-0-0)
MAS-488	Technical Mathematics II	3	1	0	4(3-1-0)
MAS-511	Statistical Methods	2	0	2	3(2-0-1)
NSS- 413	National Service Scheme	0	0	2	1(0-0-1)
		Total			**29**

	Semester IV				
Course Code	**Course Title**	**L**	**T**	**P**	**Credits**
ECE- 301	Basic Electronics	2	1	2	4(2-1-1)
ECE-404	Electronic Measurement and Instrumentation	3	1	2	5(3-1-1)
BCBE 412	Fluid Mechanics in Bioengineering	3	0	0	3(3-0-0)
BCBE 413	Heat Transfer operation	3	0	0	3(3-0-0)
BCBE 414	Mass and Energy Balance in Biochemical Engineering	2	1	0	3(2-1-0)
BCBE 415	Instrumentation and Analytical methods in Bioengineering	2	0	4	4(2-0-2)
BCBE 416	Immuno-technology	2	0	2	3(2-0-1)
NSS- 414	National Service Scheme	0	0	2	1(0-0-1)
		Total			**26**
BCBE 400	Training – I (credit will be awarded in 5th Semester)				-
	Semester V				
Course Code	**Course Title**	**L**	**T**	**P**	**Credits**
BCBE 417	Mass Transfer operation	3	0	0	3(3-0-0)
BCBE 418	Metabolic Regulation & Engineering	3	0	0	3(3-0-0)

CBBI-502	Concept of Bioinformatics	2	0	2	3(2-0-1)
BCBE 502	Industrial Biotechnology	2	0	2	3(2-0-1)
BCBE 503	Biochemical Engineering-I	2	0	4	4(2-0-2)
BCBE 504	Biopolymers	3	0	0	3(3-0-0)
BCBE 508	Protein Science and Engineering	3	0	0	3(3-0-0)
BCBE 509	Computational Methods for Biochemical Engineering	2	1	0	3(2-1-0)
BCBE 400	Training –I Evaluation	0	0	2	1(0-0-1)
NSS- 516	National Service Scheme	0	0	2	1(0-0-1)
		Total			**27**
	Semester VI				
Course Code	**Course Title**	**L**	**T**	**P**	**Credits**
MCE-501	Bio safety, Bioethics & IPR	3	0	0	3(3-0-0)
MCE-502	Recombinant DNA Technology	3	0	0	3(3-0-0)
BCBE 602	Fermentation Technology	2	0	2	3(2-0-1)
BCBE 604	Enzyme Technology	2	0	2	3(2-0-1)
BCBE 606	Biochemical Engineering -II	2	0	4	4(2-0-2)
BCBE 608	Bio-Waste Treatment	2	0	2	3(2-0-1)
MCE- 514	Tissue Engineering	3	0	0	3(3-0-0)
MCE- 503	Fundamentals of Nanobiotechnology	3	0	0	3(3-0-0)
BCBE 580	Seminar –I	0	0	2	1(0-0-1)
		Total			**26**
BCBE 500	Training –II (credit will be awarded in 7th Semester)				-

	Semester VII					
Course Code	**Course Title**		**L**	**T**	**P**	**Credits**
BAM 502	Marketing and Management of Biotechnology Products		3	0	0	3(3-0-0)
BAM-550	Entrepreneurship development & Industrial consultancy		0	0	2	2(0-0-1)
BCBE 609	Bio-separation Technology		2	0	4	4(2-0-2)
BCBE 611	Bioprocess Modeling & Simulation		2	1	0	3(2-1-0)
BCBE 612	Bioprocess Plant Design		2	1	0	3(2-1-0)
BCBE 613	Process Engineering		3	0	0	3(3-0-0)
BCBE 650	Mini Project		0	0	8	4(0-0-4)
BCBE 680	Seminar – II		0	0	2	1(0-0-1)
BCBE 500	Training –II Evaluation		0	0	2	1(0-0-1)
BCBE 600	Educational Tour & Field work					-
			Total			**24**
	Semester VIII					
Course Code	**Course Title**		**L**	**T**	**P**	**Credits**
BCE-699	Project work		0	0	24	12(0-0-12)
			Total			**12**
		Total Credits: 201				

Syllabus (Theory/Practical)

Semester I

BIOL-201 Elementary Biology 2 (2-0-0)

Unit I: Life: Living and non-living organisms. Origin of life: Oparin's abiotic theory. Evolution: Unicellularity, multicellularity, complex tissue system, Branches of Biology. Cell.

Unit II: Introduction to Botany: History of botany; Brief introduction of branches of botany; morphology, anatomy, taxonomy, physiology, palaeobotany. Introduction to lower botany: Algae, fungi, bacteria, virus, bryophytes, pteridophytes.

Unit III: Introduction to Zoology: Classification of animal kingdom; adaption of animals. Morphology of frog. Anatomy of frog: internal organs: different internal systems.

Unit IV: Scope and application of biology.

MAS-313 Elementary Mathematics-I 4 (3-1-0)

Unit I: Algebra: Theory of Quadratic equations, Partial fractions, Binomial theorem (for positive index), Exponential and Logarithmic series, Elementary concepts of Permutation and Combination.

Unit II: Trigonometry: Elementary concepts of Complex numbers, De-Movier's theorem and its application.

Unit III: Co-ordinate Geometry: Equation of standard curves and their identification.

Unit IV: Differential Calculus: Function, Limit, Continuity and Differentiability, Differentiation of standard functions, Method of Differentiation, Trangent and Noraml, Maxima and Minima.

Unit V: Integral Calculus: Indefinite integration of standard functions, Integration by substitution, by parts, by partial fraction.

Unit VI: Vector Analysis: Scalar and Vectors, sum and Difference of Vectors, Dot and Cross product. (Double, triple).

MVE-301 Moral and Value Education 3 (3-0-0)

Objectives

- To explicitly discuss that is implicitly communicated through Academic disciplines.
- To Inculcate Life affirming values based on 'Fear of God as the beginning of wisdom'.

Unit-I. Basics

- Integrating Heart-Head-Hand – Story of Sam Higginbottom.
- Contextual-Dialogical-Praxological' character of Value education.

- Different Values: Academic-Economic-Social-Material-Moral-Spiritual.

Unit-II. Biblical Foundation

Proverbs	Chapter 2-4.
Ten Commandments	Exodus 20: 1-17.
Two Commandments of Jesus	Mark 12: 29-31.
Sermon of Mount	Matthew Chapter 5-7.
Lord's Prayer	Matthew 6: 9-13; Luke 11: 1-4.
Parable of Good Samaritan	Luke 10: 29-37.
Parable of Two Brothers	Luke 15: 11-32.

Unit-III. Formation of Character

- Voice of Conscience
- Virtues .. Prudence-Justice-Courage-Discipline-Success-Faith-Hope-Love.
- Values of Life .. Marriage-No same sex marriage-Divorce-Abortion.
- Values of Belonging .. Family-Friends-Faith-Community-Nation-World.

Unit-IV. God-Human-Plants-Animals

- Stewardship of Creation.
- Biotechnological Advancement.
- Exploitation of Animals, Plants and Microorganisms.
- Environmental Hazards.

Unit-V. Our Constitution

- Fundamental Rights
- Directive Principles of State Policy.
- Fundamental Duties.
- Enlightened Citizenship: Ten Points of Dr. A.P.J.AbdulKalam.

Unit-VI. Interactive Sessions

- Sexual Harassment.
- Corruption.
- Substance Abuse.
- Violence.
- Communalism.
- Cyber crime.

LNG-304 Professional Communication and Technical Writing 3 (3-0-0)

Unit-I: Language

[a] Word enrichment (Antonyms, synonyms, homonyms, acronyms, homophones).

[b] Tenses.

[c] Concord.

[d] Modifiers.

[e] Preposition.

[f] Inflection.

[g] Determiners.

[h] Voice.

Unit-II:Communication

[a] Role of Body language in communication.

[b] Self introduction.

[c] Conversation in different situations.

[d] Use of specific expressions.

[e] Group Discussions.

[f] Role Plays.

[g] Interviews.

[h] To cater different types of audience.

Unit-III:Technical writing

[a] Resume.

[b] Curriculum vitae.

[c] Letters.

[d] Memos.

[e] Report.

[f] Proposals.

[g] Usage of graphics.

[h] Different administrative documents (Notices, Circulars, Memos, Agenda, Minutes).

Unit-IV:Speech

[a] Accent.

[b] Intonation.

[c] Different types of speeches.

[d] Delivering of different types of speeche

ME-304 Workshop Practice and Technology 4 (2-0-2)

Unit I: Introduction to Tools- Description, applications of tools used in different shops.

Carpentry- Classification of tools- marking and measuring- holding and supportingplanning- cutting- boring- striking- miscellaneous- etc.

Unit II: Fitting shop- Marking and measuring, holding, cutting tools etc.

Smithy- holding and supporting tools, cutting tools, striking tools.

Sheet metal: Welding: Properties of metals- Strength, elasticity, plasticity, Malleability, hardness, brittleness etc.

Unit III: Timber- Introduction- selection of timbers- seasoning of timbers- timber defects.

Unit IV: Brief introduction to joining process- Nuts and bolts- Screw- Screws- rivets and riveting- welding- electric arc-gas welding- TIG-MIG welding- threads.

Unit V: Extrusion- Classification- process geometry- Geometrical relationship- analysis of extrusion- stresses- load- power- maximum reduction possible- working and application of indirect extrusion- hydrostatic extrusion- defects in extruded parts.

Unit VI: Forging- Classification- strip and disc forging- Process geometry- geometrical relationship- geometrical relationship- Analysis of defects in forged products.

PHY-309 Applied Physics 3 (3-0-0)

Unit I: Optics: Interference: Coherent sources, conditions of interference, Fresnel's biprism experiment, interference in thin films, wedge shaped film, Newton's ring.

Unit II: Diffraction: Single slit and double slit diffraction, diffraction grating, Raleigh's criterion of limit resolution, resolving power of telescope and microscope.

Unit III: Polarization: Polarization of light, Brewster's law, Malus law, phenomenon of double refraction, geometry of calcite crystal, optic axis, principal section, ordinary and extraordinary rays, construction and working of Nicol prism. Plane, circularly and elliptically polarized light. There production and analysis. Retardation Plates, optical activity, specific rotation, polarimeters.

Unit IV: X-rays: Origin of X-rays, continuous and characteristic X-ray spectra, Mosley's law, absorption of X-rays, Diffraction of X-rays, Bragg's law, Bragg's spectrometer, practical applications of X-ray, X- ray Machine.

Unit V: Laser: Spontaneous and stimulated emission of radiation, Einstein's Coefficients. Components of laser. Type of laser and their working and application. Classes of laser equipments.

Unit VI: Electromagnetic Theory: Gauss's law, Poisson and Laplace equation, Maxwell's equations, Basic concepts of Electromagnetic waves and its solution in free space. Para, dia, ferro, antiferro and ferri magnetic materials. Hysteresis and magnetic circuits.

Reference books:

1. Fundamentals of Optics [Jetkins and White]
2. Perspectives of Modern Physics [Beiser]
3. Electrodynamics [David Griffith]
4. Laser – Theory and Applications [Thyagranjan / Ghatak]
5. Fundamentals of Physics [Resnick and Halliday]
6. Engineering Physics [Uma Mukherjee]
7. Text book of Engineering Physics [Navneet Gupta and Kumar]

CHEM-311 Inorganic Chemistry 3 (2-0-1)

- Nature of Covalent bond and shapes of molecules: Valence bond theory, pauleing slater theory, formation of hydrogen, fluorine, HF molecules, molecular orbital theory (MOT), LCAO (Liner combination of atomic orbital). Electronic configuration of Hetero nuclear diatomic molecules, VSEPR theory, Introduction of hybridization.
- Nuclear and Radiochemistry: Nuclear shell model, Mass defeat, packing fraction, Binding energy, Natural radioactive disintegration, concept of Half Life, Group displacement Law, Artificial radioactivity, Nuclear fusion and Nuclear fission reaction.
- Coordination Chemistry: Legends, coordination number complex ion, IUPAC rules for coordination compounds, Nomenclature chirality, Warner theory of coordination, pauling theory, crystal Eigand field theory.
- Organometallic Compounds: Types, Classification, Nature of carbon metals bond, preparation, Propeties
- Biochemical Significance of Inorganic metals: Introduction, Na, K, Cl, Fe, Zn, Co.
- Inorganic Polymers: Classification of inorganic polymers, preparation, Phosphate containing polymers. A general idea of Boranes, Carbides, Silicones, Carbonyles, Nitrosyles.

Practical: Semi microanalysis of inorganic salts and mixtures.

CHEM-313 Organic Chemistry 3 (2-0-1)

- Carbohydrates: Introduction, Classification, Monosaccharide stereochemistry, Fischer projection, Structure of D-glucose, Cyclic structure of D-glucose, Haworth projection, properties. Oligosaccharides- Structure of Sucrose. Polysaccharides- Structure of Starch, Cellulose and Glycogen.
- Aminoacids: Classification, Essential and Non-essential Amino acids, Optical activity, synthesis. Properties, Zwitter ion and Isoelectric Point.
- Proteins: Classification, Primary, Secondary and Tertiary structure. Properties, Colloidal nature, Denaturation, Test for Proteins.
- Fats and Oil: Composition of fats, Introduction, Nomenclature of fats, Physical and Chemical properties of fats, Rancidity, Analysis of fats chemical constants, Saponification, Specification Number, Iodine Number, Acid value, Reichert Miessl value, Polenski value.
- Alkaloids: Introduction, Classification, Determination of molecular structure of Alkaloids, Properties, Nicotine, Coniine.
- Terpenoids: Introduction, Classification. Structural features of Terpens or Isoprene Rule, Myrcene, Citral.
- Nucleic Acids: Chemistry of Nucleic acids, Structure and composition of purine and pyrimidines, Nucleosides, Nucleotides, general composition of DNA and RNA.

Practical:

- Identification of sugars and organic acids.
- Test for proteins and aminoacids.
- Test for fats, fatty acids, acids and saponification.
- Identification of phenol, acids, carbonyl compounds, hydrocarbons.

ENVS-415: Environmental Studies-I 2 (2-0-0)

Unit I: The multidisciplinary nature of environmental studies: Definition, scope and importance- need for public awareness- Ecosystems- Concept of an ecosystem- structure and function of an ecosystem- producers, consumers and decomposers- energy flow in the ecosystem- Ecological succession – Food chains, food webs and ecological pyramids – Introduction, types, characteristic features structure and function of following ecosystems- [(a) Forest ecosystem, (b) Grassland

ecosystem, (c) Desert ecosystem, (d) Aquatic ecosystem (ponds, streams, lakes, rivers, ocean, estuaries)].

Unit II: Social issues and the environment- from unsustainable to sustainable development urban problems related to energy- water conservation, rain water harvesting, water sheds management- resettlement and rehabilitation of people; its problems and concerns. Case studies.

Unit III: Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case studies, Wasteland reclamation. Consumerism and waste products.

Unit IV: Environmental protection act. Air (prevention and control of pollution) Act – Water (Prevention and control of pollution) Act– Wild life protection Act- Forest Conservation Act- Issues involved in enforcement of environmental legislation- public awareness.

SEMESTER – II

ME-301 Engineering Graphics-I 2 (0-0-2)

Unit I: Introduction: Graphics as a tool to communicate ideas, Engineering drawing instruments and its uses, Lettering and dimensioning, scales, layouts of drawing sheets, Construction of geometrical figures like pentagon and hexagon.

Unit II: Orthographic Projection: Principles of orthographic projection, Principal of auxiliary planes, First and third angle projections. Projection of points, Pictorial view. Projection of lines parallel to both the planes. Parallel to one and inclined to other, Inclined to both the planes, Application to practical problems. Projection of solid in simple position, Axis or slant edge inclined to one and parallel to other plane, Solids lying on a face or generator on a plane. Sectioning of solids lying in various positions. True shape of the section. Development of lateral surfaces, sheet metal drawing.

Unit III: Isometric Projection: Principles of isometric projection, Isometric projection using box and offset methods.

MCE 301 CELL BIOLOGY 3(2-0-1)

Unit I: An introduction to cell biology: History of cell biology. Development of cell theory.Modern cell biology.

Unit II: Diversity of cell size and shape: Structure of prokaryotic cells (bacteria, fungi, virus,cyanobacteria, mycoplasma etc.). General organization of eukaryotic cells, cell shape, cell size, cell volume and cell number.

Unit III: Organization of cell: Cell wall, plasma membrane, their structural organization andfunctions. Membrane bound cell organelles - nucleus, endoplasmic reticulum, golgi apparatus, mitochondria, chloroplast, lysosomes, peroxisomes and vacuoles. Non-membrane bound cell organelle- ribosome. Cytoskelton- microtubules, intermediate filaments and microfilaments.

Unit IV: Cell growth and division: Cell cycle, kinds of cell division, amitosis, mitosis, meiosis, comparison between mitosis and meiosis, crossing over, significance of cell division.

Practical:

- Microscopy- simple and compound microscope
- Preparation of stains.
- Grams staining.
- Study of cell division - different stages of mitosis
- Differential staining of blood cells.
- Hanging drop method for motility of bacteria.

IM-349 Introductory Microbiology 3 (2-0-1)

Unit I:Definition, Scope and History of Microbiology.

Unit II: Cellular organization of prokaryotic and eukaryotic cells.

Unit III: Difference between prokaryotic and eukaryotic cells.

Unit IV: General characteristics and nature of Bacteria, Mycoplasma, Rickettsiae, Chlamydiae,

Unit V: Actinomycetes, Protozoa, Fungi, Algae and Viruses.

Practical:

- Familiarity with equipment to be used in Microbiology Laboratory.
- Cleaning, washing and sterilization of glass wares.
- Observation of permanent slides to study the structural characteristics of common
- bacteria, fungi, algae and protozoa.

BCBE-407 Introduction to Chemical Engineering 3 (3-0-0)

Unit I: Chemical engineering principles applied to biological system, Principle of reactor design, Types of agitator

Unit II: Fluid mechanics: Rheology and mixing in fermentation broth. Flow pattern and power consumption.

Unit III: Fundamentals of heat transfer & its application Conduction, convection, radiation, heat exchangers

Unit IV: Fundamentals of mass and energy balance, concept of mass transfer coefficient Gas laws

Unit V: Fundamental of mass transfer: Molecular diffusion in fluids and solids.
Absorption: Equilibrium stage, Multistage and continuous contractors with application to gas absorption, calculation of NTU, HTU and number of stages. Psychometric chart and its application.

MAS-408 Technical Mathematics-I 4 (3-1-0)

Unit I: Introduction To Thermodynamics Terms (System, surrounding, boundaries etc.) open and closed loop systems, isolated systems, and thermodynamic variables, extensive and intensive properties.

Unit II: Thermodynamic process- lost thermal, adiabatic process, isobaric, isochoric, cyclic and irreversible processes.

Unit III: Classical thermodynamics and Bioenergetics: laws of thermodynamics, Solution thermodynamics, Phase equilibria, reaction equilibria, Ligand binding; Membrane potential; Energetics of metabolic pathways, oxidation and reduction reactions

Unit IV: laws of mass action, Gibbs functional change heat of reaction, fugacity + reactivity, construction, enthalpy of formation, laws for reaction systems.

Unit V: Air cycle, Otto cycle, work done in cycles, thermal efficiency. Refrigeration- Introduction to principles of vapors compression cycle.

ENVS-416 Environmental Studies-II 2 (2-0-0)

Unit I:Natural Resources: Renewable and non-renewable resources: Natural resources and associated problems.

(a) Forest resources: Use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people.

(b) Water resources: Use and over-utilization of surface and ground water, floods, drought conflicts over water, dams-benefits and problems.

(c) Mineral resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.

(d) Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies.

(e) Energy resources: Growing energy needs, renewable and nonrenewable energy sources, use of alternate energy sources, case studies.

(f) Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification

Unit II: Role of an individual in conservation of natural resources.- Equitable use of resources for sustainable lifestyles. Biodiversity and its conservation- Introduction- Definition: genetic, species and ecosystem diversity.

Unit III: Biogeographical classification of India- Value of biodiversity: consumptive use, productive use, social, ethical aesthetic and option values.

Unit IV: Biodiversity at global, national and local levels-India as mega-diversity nation-Hotspots of biodiversity- Threats to biodiversity: habitat loss, poaching of wildlife, man wildlife conflicts-Endangered and endemic species of India- Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

Unit V: Environmental Pollution- Definition-Causes, effects and control measures of: Air pollution-Water pollution- Soil pollution-Marine pollution- Noise pollution- Thermal pollution- Nuclear pollution. Solid waste management: Causes, effects and control measures of urban and industrial wastes. Role of an individual in prevention of pollution. Pollution case studies. Disaster management: floods, earthquake, cyclone and landslides.

CHEM-312 Physical Chemistry 3 (2-0-1)

Unit I: Ionic equilibrium: concepts of acids and their related strength, buffer solution and its pH, hydrolysis of salts, acids –base indicators oswalds and quinonoides theory, solubility product.

Unit II: Chemical kinetics: order and molecularity, differential rate laws and integrated rate laws equations for zero, 1st, 2nd and 3rd reactions (derivations included) significance of rate constant and its evaluation, time for definite fractional change of reaction, determination of order.

Unit III: Electro chemistry: reversible and irreversible cells, EMF of a cell and free energy, nernst equation, equilibrium constant, standard electrode potential, types of reversible electrodes, applications of EMF measurements, determination of solubility product, pH, dissociation constant of acids, hydrolics constant solubility, soluble salts.

Practical:

- Determination of rate constant and order of reaction for hydrolysis of ester by an acid.
- To study the kindtics of dissociation of Magnesium in dilute HCl.
- To determine the order of saponification of ethyl acetate with NaOH.
- Determination of density of liquid by density bottle.
- To find surface tension of the given liquid.
- To find the relation and absolute viscosity of given liquid.
- Determination of carbonates, bicarbonates and total alkalinity in water.

EE-302 Electrical Engineering 4 (2-1-1)

Unit I: Sinusoidal Steady State circuit Analysis: Voltage, Current, Sinusoidal and Phasor representation 1 Phase A.C. Circuit behavior of Resistance, Inductance and Capacitance and their combination, Impedance concept of power, power factor, series and parallel resonance, band width and quality factor.

Unit II: Network theory: Introduction to basic physical laws, Network theory, Theveinin's, Norton's, Maximum Power transfer theorems, Star- delta transformation, Circuit theory concepts: Mesh and nodal analysis.

Unit III: Three Phase supply: Star/ delta connections, line and phase voltage / current relations, three phase power and its measurement.

Unit IV: Measuring Instruments: Instruments for measurement of voltage, Current, power and energy: Construction, principle and application.

Unit V: Magnetic Circuit and Transformer: Magnetic circuit concept, Theory and working principle of single phase transformer.

Unit VI: Rotating Machines: Principles of energy conversion, Basic concepts of rotation machines, DC Machines, Different types and their Characteristics and application, Elementary idea of operation of synchronous and induction machines. Single phase induction and stepper motors, applications.

Practical:

- To verify Kirchhoff's Current Law and Kirchhoff's Voltage Law.
- Verification of Norton's Theorem.
- Verify Thevenin's Theorem and to calculate Thevenin's equivalent of given circuit.
- To verify the superposition theorem and to circulate current in any branch of a multisource using superposition theorem.

- To find the value of impedance and power factor of R-L-C series circuit.
- To find the value of impedance and power factor of R-L-C parallel circuit.
- To perform open circuit test and short circuit of a single phase transformer.

CSIT-401 Computer and Languages 4 (2-1-1)

Unit I:Introduction to Computers

Need and Role.

Definition, Characteristics and Applications.

Hardware : Basic block diagram and components.

Software : System and Application.

Unit II:Information Concepts

Data and its representation.

Introduction to Database.

Unit III:Operating System

Introduction, Functions.

Working with DOS, Windows and Linux.

Unit IV:Computer Networks and Internet

Introduction.

Types.

OSI reference model.

Internet: History, usage and applications.

Unit V:Computer Languages

Generations.

Translators (Assembler, Interpreter and compiler).

Unit VI:Programming Techniques

Programming constructs.

Algorithms and Flowcharts.

'C' Language

Introduction.

History.

Character set.

Expressions and Operators.

Input/Output Statements.

Control Statements.

Branching Statements (if, if-else, Nested if), switch.

Looping Statements (while, do-while, for).

'C' Language

Arrays.

Functions.

Introduction to pointers and structure.

Structured Programming and Software development.

Practical:

- Operating System

  Working with Dos commands

  Windows and its applications.

  Linux commands and Editors.

- 'C' Programming: Draw flow chart and write C program for the following:

i. To find the largest among three numbers.
ii. To check whether a given string is a palindrome or not.
iii. To find factorial of a given number by iteration.
iv. To find whether the given integer is: (i) a prime number; (ii) an Armstrong number.
v. To find sum of n terms of series:
vi. n – n*2/2! + n*3/3! - n*4/4! + ...
vii. To find sum and average of n integers using a linear array.
viii. To read n numbers from the keyboard and display these numbers
ix. in the reverse order their entry.
x. To sort a given list using either selection or bubble sort.
xi. To search a given number within a linear array.
xii. To perform Addition, Multiplication, Transpose of matrices.
xiii. To generate the fibbonacci series using a function.
xiv. To find factorial of a given number using a function.
xv. To interchange two values using: (i) Call by value; (ii) Call by reference.
xvi. Write a C program to display the mark sheet of a student using structure

SEMESTER – III

MCE 302 Molecular Biology 3(3-0-0)

Unit-I: Introduction: Development of molecular biology. Historical perspectives. Concepts in molecular biology.

Unit-II: Structure and properties of nucleic acids: Structure of nucleotides, DNA double helix, helical conformations and DNA topology. Types of DNA and RNA- A, B, Z forms of DNA, mRNA, tRNA, rRNA, hnRNA, snRNA. Physical and chemical properties of DNA.

Unit-III: DNA protein interaction: Molecular aspects of protein-nucleic acid binding. DNA binding motifs in proteins- Helix- turn - helix, Zinc finger motifs, Leucine zipper, HMG box, etc.

Unit-IV: Gene organization: Gene structure and architecture, gene clusters, split genes, overlapping genes, pseudogenes, operon, open reading frames, transposons, oncogenes. Range of genome size. C value and gene numbers. Reassociation kinetics, Repetitive DNA -satellite DNA.

CSIT-403 Information Technology 3 (2-0-1)

- **Information and Processing Concepts**: Definition of Information, Need of Information, Quality of Information, Value of Information, concept of Information, Entropy Category and Level of Information in Business Organization, Data Concepts and Data Processing, Data Representation.
- **Information Representation:** Information Contents, Introduction to Information Representation in Digital Media, Elementary Concepts in Information Perseverance. Data Compression – Huffman coding, LZW Coding. Text, Image Compression. Introduction to JPEG, MPEG, MHEG.
- **Database Concepts:** Definition of Database, Importance of Database, Overview of Database, Models, Schemas and Instances, DBMS architecture, Database languages, Relational Database. Database applications (MS ACCESS).
- **Programming Language Classification and Program Methodology:** Overview of Programming Languages, generations and programming techniques, Software Development Methodology, Life Cycles, Software Coding, Testing, Maintenance, Industry Standards. Introduction to ISO, SEI-CMM Standards for IT Industry.
- **Data Communications and Computer Networks:** Data Transmission, Need for Data Transmission over Distances, Types of Data Transmission, Media for Data Transmission. Computer Networks, Network Classification and Network Topologies.

- **Internet:** WWW, Gopher, FTP, Telnet, Web Browsers, Net Surfing, Search Engines, Email. Basic Concepts in E-Commerce, Electronic Payments, Digital Signatures, Network Security, Firewall.
- **Web Technologies:** introduction to HTML, DHTML, Java Script, ASP.
- **IT Industry Trends, Careers and Applications in India:** Scientific, Business, Educational and Entertainment applications. Industry Automation.Weather forecasting. Awareness of ongoing IT projects in India: NICNET ERNET. e-governance.

Practical:

- Working with MS ACCESS:
  i. Creating tables, relating tables, inserting, deleting and updating records of a table.
  ii. Designing User Interface screens.
  iii. Generating reports.
- Creation of web pages using HTML.
  i. Program to illustrate operation of tables.
  ii. Ordered and unordered lists.
  iii. Working with frames.
  iv. Hyperlinks.
- 3. Practicing with Web site designing tools like Microsoft FrontPage, Adobe's Dreamweaver.
- 4. Internet concepts: www, Internet surfing, live demo on websites, web Browser, file transfer Protocol.
- 5. Connecting remote machines using Telnet.
- 6. Working with search engines.

BCBE-304 Biochemistry 3(2-0-1)

Unit I: Introduction: Molecular basis of life, study of macro molecules, **Carbohydrates:** Their structure and biological functions, Monosaccharides disaccharides and polysaccharides Glycoproteins.

Unit II:Amino Acids and Proteins: Their structure and function, Types of amino acids, Fibrous proteins and globular proteins, Separation of proteins. **Fats and Lipids:** Their structure and biological functions, Types of lipids, triacylglycerol, Waxes, Phospholipids, Sphingolipids, Lipoproteins.

Unit III:Nucleic acid and Nucleotides: DNA, Structure of chromosomes and genes, Replication and transcription of DNA, RNA Protein synthesis and its regulation, Genetic recombination and

cloning. **Enzymes:** Properties and types, Kinetics of enzyme action, Enzyme inhibition, Allosteric enzymes, Assay of enzymes, Regulation of enzyme activity.

Unit IV: Bioenergetics and Metabolism: Metabolism, basic concepts and design, Glycolysis citric acid cycle oxidative phosphorylation pentose phosphate pathway and gluconeogenesis glycogen and disaccharide metabolism amino acid degradation and urea cycle. **Biological Membranes:** Characteristics of biological membranes components of membranes types of membranes fluid mosaic model membrane asymmetry.

Text /Reference Books

1. Biochemistry by Stryer L, W.H.Freeman and Company
2. Principles of Biochemistry by Lehninger, A; Butterworth Publishers, New York
3. Outlines of Biochemistry by Conn E E and Stump P K, John Wiley and Sons, New York
4. Proteins Biochemistry and Biotechnology by Walsh G, John Wiley and sons
5. Biochemistry by Rastogi, Tata Mc Graw Hill.

Practicals

i. Estimation of carbohydrates
ii. Estimation of protein by lowery method
iii. Extraction of lipids
iv. Separation of amino acids by paper chromatography
v. Preparation of different buffer solutions for biochemical experiments
vi. Separation by sugars by paper chromatography
vii. Thin layer chromatography
viii. Ultraviolet absorption of nucleic acids, amino acids and protein
ix. Determination of acid value, iodine value and specification value of fat
x. Experimental analysis of biochemical compounds by TLC
xi. Estimation of cholesterol.

APFE-303 Principles of Food Engineering 3(2-01)

- Units and dimensions, mass and energy balance, flow of fluids, heat transfer, modes of heat transfer, heat exchanger, kinetics of chemical reaction in foods, evaporation, dehydration, drying, refrigeration, physical separation process and extraction.

- **Practicals:** Application of psychometric chart in food engineering, measurements of pressure and fluid flow, study of heat exchangers, dryers, pulper , juicer, bottle washer, vacuum packaging, milling machines and equipments.

CHEM-330 Analytical Chemistry 3 (2-0-1)

- General principle of analytical chemistry: Volumetric analysis. Solutions, preparation of primary and secondary standard solutions, Neutralization (Acid- Base) Titration, Iodometry, Iodimetry, Permagnometry. Volumetric determination of calcium. Gravimetric analysis: principles and methodology. Estimation of calcium.
- Colorimetry: Principle Lamberts and Beer's law. Absorption law (Derivation required), methodology and applications.
- Thermometric analysis: Thermo gravimetric Analysis - types, Instrumentation, methodology and Application.
- Potentiometer titration: Electrode system, Ion selective electrodes, Ion selective membrane electrode, advantages of potentiometric titrations. Application of potentiometer titrations.
- Polarimetry and flourimetry: Instrumentation methodology and applications.
- Spectrophotometry: Principle, Instrumentation, methodology and Application.
- Spectroscopic techniques: Introduction of UV, IR and Mass Spectroscopy.

Practical:

i. Preparation of primary and secondary standard solution.
ii. Standardization of secondary standard solution.
iii. Preparation of and standardization of an acid solution.
iv. Preparation and standardization of solution of KMnO4.
v. Volumetric determination of Fe by KMnO4, K2CO2O7 solution.
vi. Determination of Ca volumetrically.

BCBE-408 Chemical Thermodynamics 3 (3-0-0)

Unit I: Introduction To Thermodynamics Terms (System, surrounding, boundaries etc.) open and closed loop systems, isolated systems, and thermodynamic variables, extensive and intensive properties.

Unit II: Thermodynamic process- lost thermal, adiabatic process, isobaric, isochoric, cyclic and irreversible processes.

Unit III: Classical thermodynamics and Bioenergetics: laws of thermodynamics, Solution thermodynamics, Phase equilibria, reaction equilibria, Ligand binding; Membrane potential; Energetics of metabolic pathways, oxidation and reduction reactions

Unit IV: laws of mass action, Gibbs functional change heat of reaction, fugacity + reactivity, construction, enthalpy of formation, laws for reaction systems.

Unit V: Air cycle, Otto cycle, work done in cycles, thermal efficiency. Refrigeration- Introduction to principles of vapors compression cycle.

Text Books

1. Introduction to Chemical Engineering Thermodynamics, Smith J.M , Van Ness H.C., Abbott M. M The McGraw Hill Companies, Inc., USA

2. Chemical and Engineering Thermodynamics, Sandler S.I. John Wiley and Sons, Inc., New York

Reference Books

1. Introductory Chemical Engineering Thermodynamics, Elliott J. R. and Lira C. T., Prentice Hall

2. Applied Thermodynamics for Engineering Technologists, Eastop T. D. and McConkey A., Addison Wesley Longman Ltd., England

BCBE- 411 Transport Phenomenon 3(3-0-0)

Unit I:Philosophy and fundamentals of three transport phenomena: Importance of transport phenomena; analogous nature of transfer process; basic concepts, conservation laws. Molecular transport of momentum, Heat and mass, laws of molecular transport, Newton's law of viscosity, Fourier law of heat conduction, and Fick's law of diffusion. Transport coefficients – viscosity, thermal conductivity and mass diffusivity.

Unit II:Shell momentum balances and velocity distributions in laminar flow: shell momentum balances and boundary conditions, flow of a falling film, flow through a circular tube, flow through annulus, flow of two adjacent immiscible fluids, creeping flow around a sphere.

Unit III:Shell energy balances and temperature distributions in solids and laminar flow: shell energy balances; boundary conditions, heat conduction with an electrical heat source, heat conduction with a nuclear heat source, heat conduction with a viscous heat source, heat conduction with a chemical heat source, heat conduction through composite walls, heat conduction in a cooling fin, forced convection, free convection.

Unit IV:Concentration distributions in solids and laminar flow: shell mass balances; boundary conditions, diffusion through a stagnant gas film, diffusion with a heterogeneous chemical

reaction, diffusion with a homogeneous chemical reaction, diffusion into a falling liquid film (gas absorption), diffusion into a falling liquid film (solid dissolution).

Unit V:The equations of change for isothermal systems: the equation of continuity, the equation of motion, the equation of mechanical energy, the equation of angular momentum, the equations of change in terms of the substantial derivative, use of the equations of change to solve flow problems. Velocity distributions in turbulent flow: comparisons of laminar and turbulent flows.

Text Books

1. Transport Phenomena, R.B. Bird, W.E. Stewart and E.W. Lighfoot; John Wiley

Reference Books

2. Fundamentals of Momentum Heat and Mass Transfer, J.R. Wilty, R.W. Wilson, and C.W. Wicks, John Wiley, New York

3. Transport Processes and Separation Process Principles, Christie J. Geankopolis, Prentice- Hall

MAS-488 Technical Mathematics-II 4 (3-1-0)

- Integral Calculus: Multiple integrals, Double, Triple integrals, their application in determining area and volume.
- Vector Calculus: Vector differentiation, Gradient, Divergent, Curl, their physical interpretation, Directional and Normal derivatives, Vector integration. Line surface and volume integrals, Green's theorems, Gauss theorem, Stoke's theorem.
- Fourier Series: Periodic function, Fourier series, Fourier coefficient and their determination (Euler formula).
- Partial differential equations: Partial differential equations of first order, Non linear partial differential equations, Linear homogeneous and non-linear homogeneous differential equations and applications.
- Series solution and special functions: Series solution of ordinary differential equations of second order, Bessel and Legendre functions and their properties.
- Laplace transformation: Laplace transform, Inverse Laplace transform and applications.

MAS-511 Statistical Methods 3 (2-0-1)

- Definition and Scope of Statistics: Source of Animal-Husbandry and Dairy Statistics.
- Method of condensation of data, frequency distribution.
- Measures of central-tendency, Measures of dispersion, Moments, skewness and kurtosis.

- Elementary notions of Probability, laws of addition and multiplication of probability.
- Theoretical frequency distributions.
- Binomial- frequency distributions and its applications.
- Poisson- frequency distributions and its applications.
- Normal- frequency distributions and its applications.
- Concept of Sampling. Simple Random Sampling (with and without replacement).
- Introduction to testing of Hypothesis and tests of significance. Z and t test for one and
- Two sample problems. Chi square test for independence of attributes and Goodness of fit.
- Simple correlation coefficient and its significance. Line of Regression and Rank- Correlation.

Practical:

i. Formation of frequency distribution and Graphical representation.
ii. Measures of central-tendency.
iii. Measures of dispersion.
iv. Applications of Z- test for one and two sample problems.
v. Applications of T-test for one and two sample problems.

SEMESTER – IV

BASIC ELECTRONICS

Course Code: (ECE-301) **Credits: 4 (2-1-2)**

- Energy Bands in Solids: Energy band theory of solids, Concept of forbidden gap, Insulators, Metals and Semiconductors.
- Transport Phenomenon in Semiconductors: Mobility and conductivity, electrons and holes in an intrinsic semiconductor, Donor and acceptor impurities, Fermi level, carrier densities in semiconductor, electrical properties of semiconductor, Hall Effect, Diffusion.
- Junction Diode: P-N junction, depletion layer, V-I characteristics, diode resistance, capacitance, switching time, diode application as a rectifier (half wave and full wave), diode circuits (clipper, clamper, voltage multipliers) Breakdown mechanism, Zener & Avalanche, breakdown characteristics, Zener diode and its applications.
- Bi-junction Transistor: Bipolar junction Transistor, CE, CB and CC configuration, characteristic curves (cut off, active and saturation region), Requirement of biasing, biasing types and biasing analysis, stability.

- Transistor as an Amplifier: Graphical analysis of CE amplifier, concept of voltage gain, current gain and power gain, h-parameter (low frequency), computation of Av, RI, Ro and approximate formulae.
- FET & UJT: Construction & characteristics of JFET -parameters of JFET -MOSFET –depletion ,enhancement modes-FET in CS,CD,CG Configurations-equivalent circuit of FET at low frequencies-FET model at high frequencies-FET Specifications. Construction, theory of operation & characteristics of UJT, PUT..
- Operational Amplifiers: Concepts of ideal op-amp, inverting, non-inverting and unity gain amplifiers, adders, difference amplifiers. , Integrators.
- Switching Theory & Logic Gates: Number systems, conversion of bases, Boolean algebra, Logic Gates, concept of universal gate, canonical forms, and minimization using K-map.
- Electronic Instruments: Multimeter, CRO and its Applications.

References:

1. Boylestad & Nashelsky/Electronic Devices & Circuits/ PHI
2. Morris Mano/Digital Computer Design/ PHI.
3. Milliman, J. Halkias/Integrated Electronics/TMH.
4. Malvino & Leach/Digital Principles & Application/
5. Sanjeev Gupta /Electronics devices & ckts./Dhanpat Rai sons

List of Experiments:

i. Study of lab equipments and components: CRO, Multimeter, Function Generator, Power supply-Active, Passive Components & Bread Board.

ii. P-N Junction Diode: Characteristics of PN Junction diode-Static and dynamic resistance measurement from graph.

iii. Applications of PN junction diode: Half & Full wave rectifier-Measurement of Vrms, Vdc, and ripple factor-use of filter-ripple reduction (RC Filter)-Clipper & Clamper

iv. Properties of junctions Zener diode characteristics. Heavy doping alters the reverse characteristics. Graphical measurement of forward and reverse resistance.

v. Application of Zener diode: Zener diode as voltage regulator. Measurement of percentage regulation by varying load resistor.

vi. Characteristic of BJT: BJT in CB and CE configuration-Graphical measurement of h parameters from input and output characteristics. Measurement of Av, AI, Ro and Ri of CE amplifier with potential divider biasing.

vii. Characteristic of FET: FET in common source configuration. Graphical measurement of its parameters gm, rd & m from input and output characteristics.

viii. Characteristic of silicon-controlled rectifier.

ix. To plot V-I Characteristics of DIAC.

x. To draw V-I characteristics of TRIAC for different values of Gate Currents.

ECE-404 Electronic Measurement and Instrumentation 5 (3-1-1)

- Precision and Accuracy: Errors in measurement application, AC and DC Bridges; and Q-meter.
- Measurement of Frequency, Phase, Time Interval: Cathode Ray Oscilloscopes- The block diagram, compensated attenuators, Horizontal and vertical amplifiers, Synchronization, Storage oscilloscope, Measurements using CROs- Voltage, Frequency, Period, Phase etc., Oscilloscope, probes, Specifications of typical CRO.
- Measurement of distortion, Measurement of Amplifier and Receiver characteristics.
- Measurement and Instrumentation of Non-electrical quantities: Active and passive transducers, Measurement of temperature, pressure, liquid level, humidity, flow and IC sensors.
- Instrumentation Interface bus: IEEE-483.
- Telemetry and Data Acquisition System.
- Advanced measuring Instruments: IP Display devices (CRT, LED, LCD), Block diagram and Application Recorders. Spectrum analyzer. Network analyzer, Storage Oscilloscope.
- Measurement of frequency and Time, Universal frequency counter and modes of measurement, Automatic time and Frequency Scaling, Digital Clock, Digital RF
- Frequency measurement, Phase meter, Energy meter.

Practical:

i. Study of Spectrum Analyzer.

ii. Study of CRO.

iii. Study of Q-meter.

iv. Measurement of temperature using RTD.

v. Measurement of temperature using Thermocouple.

vi. Measurement of Water Level.

vii. Measurement of Pressure.

viii. Instrumentation of Amplifier; Design for gain for verification of CMRR.

ix. Study of Network Analyzer.

x. Study of LVDT.

xi. Study of Strain Gauge.

xii. Study of Digital Storage Oscilloscope.

xiii. Study of Frequency Counters.

BCBC-412 Fluid Mechanics in Bioengineering 3(3-0-0)

Unit-1: Introduction & fundamental concept: Definition of stress, ideal fluid (Newtonian and non-Newtonian fluids). Properties of fluids. Fluid Statics: forces on fluid elements (body forces & surface forces) and Pressure measurement, concept of hydrostatic law.

Unit-II: Kinematics of flow- Introduction, methods of describing fluid motion, type of fluid flow, rate of flow or discharge, continuity equation.

Unit-III: Fluid dynamics - Equation of motions, Bernoulli's Equation and their applications. Analysis of inviscid, incompressible and irritation flow.

Unit-IV: Incompressible Flow in pipes - Laminar and turbulent flow in pipes, losses in pipe, losses in energy (or head) due to friction, Minor energy losses in pipes.

Unit-V: Packed bed: Flow through a packed bed of solids, pressure drop calculation, Fluidization, Minimum fluidization velocity.

Text Books

1. Unit Operations of Chemical Engineering, McCabe W.L, Smith J.C. and Harriott P, McGraw Hill International Edition, Singapore
2. Introduction to Fluid Mechanics, Fox and McDonald, John Wiley & Sons
3. Fluid Mechanics, Douglus J. F., Gasiorek J.M., Swaffield J.A., Addison-Wesley Longman

Reference Books

1. Introduction to Chemical Engineering, Badger W.L. and BancheroJ.T.,Tata McGraw Hill
2. Chemical Engineering, Vol .1, Coulson J.M. and Richardson J.F, Butterworth Heinemann, Oxford

BCBE-413 Heat Transfer 3(3-0-0)

Unit I: Conduction: Fourier's law, concept of resistance to heat transfer, critical insulation thickness, conduction with heat generation. Two-dimensional steady State Conduction: Analytical & Numerical Methods. Unsteady State unidirectional Heat Conduction.

Unit II: Convection: Film theory and concept of heat transfer coefficient. Heat transfer in laminar and turbulent flows.

Unit III: Heat Exchanger: sizing of shell & tube heat exchangers. Heat transfer in agitated vessels.

Unit IV: Boiling & Condensation: heat transfer to boiling liquids and from condensing vapours.

Unit V: Evaporation: Evaporator types, Single and multiple effect evaporators. Calculation of Surface area

Text Books

i. Heat Transfer, Holman J. P., McGraw Hill, New York.
ii. Process Heat Transfer, Kern D. Q., Tata Mc Graw Hill Edition.
iii. Unit Operations of Chemical Engineering, McCabe W.L., Smith J.C. and Harriott P. McGraw Hill International edition, Singapore.

Reference Books

i. Transport Processes and Unit Operations, Geankoplis C.J., Prentice Hall of India
ii. Fundamentals of Heat and Mass Transfer, Dewitt et al., John Willey & Sons
iii. Chemical Engineering Vol.1, Coulson J.M. and Richardson J.F. Butterworth Heinemann, Oxford
iv. Heat Transfer, Chapman A. J., Mac Millan, New York
v. Fundamentals of Momentum, Heat and Mass Transfer, Welty J.R., Wilson R.E., and Wicks C.E., John Wiley & Sons, Inc. New York

BCBE-414 Mass and Energy Balance in Biochemical Engineering 3(2-1-0)

Unit I: Introduction: Units and dimensions, Stoichiometry of chemical equations, Mole and weight fractions, Unit operations and unit processes with reference to material and energy balance calculations.

Unit II: Behaviour of Gas and Liquid Mixtures: Gas laws, Raoult's law, Henry's law, Duhring's plot, Saturation, Partial saturation, Relative saturation, Real gases, Bubble point and dew point temperatures.

Unit III: Material Balance Calculations: Law of conservation of mass, General material balance equation, Material balance calculations without chemical reactions, Material balance calculations with chemical reactions, Recycling, Bypass, Purge, Analysis of degrees of freedom.

Unit IV: Energy Balance Calculations: General energy balance equation, Internal energy, Enthalpy, Heat capacity of gases, liquids, and solids, Latent heats, Heats of formation, combustion, reaction and dissolution, Enthalpy-concentration chart, Fuel heating value, Theoretical flame temperature, Energy balance calculations in unit operations and systems with and without chemical reactions,

Humidity and psychrometric chart, Energy balance calculations in humidification and adiabatic cooling.

Text Books

i. Basic Principles of Calculations in Chemical Engineering, Himmelblau D.M., PrenticeHall

Reference Books

i. Stoichiometry, Bhatt V.I. and Vora S.M., Tata McGraw Hill
ii. Elementary Principles of Chemical Processes, Felder R.M. and Rousseau R. W., John Wiley & sons, Inc.
iii. Introduction to material and energy balances by Reklaitis G V, Wiley, New York
iv. Bioprocess Engineering Principles by P.M.Doran, Academic Press, Elsevier

BCBE-415 Instrumentation and Analytical methods in Bioengineering 4(2-0-2)

Unit I:Acid, Bases and Buffers: Ionization, Dissociation, Acidity, Basicity theories of Acid and Bases, Strength of Acids and Bases, Acid-Base Equilibrium in Aqueous and Non-aqueous media. pH, pH-dependent functions and structures off bio-molecules, Henderson –Hasselbach Equation, Use of Indicators, Buffers, Amino Acid titrations, Formal Titration. Numerical Problems based on above concepts

Unit II:Microscopy: Basic principles, instrumentation and application of Phase, ultraviolet and interference microscope and Fluorescence microscopy. Electron microscope – scanning emission microscopy, confocal microscopy

Unit III:Spectroscopic Techniques: Beer-Lamberts Law, Its verifications and Deviations, Concept of Absorptions, Transmission, Scattering, Phosphorescence, Fluorescence, Luminescence, Diffraction Spectra, Principle Instrumentation, working and application of – U V, Visible and IR Spectroscopy. Circular Dichroism (CD)-Principles, instrumentation and applications, Basics of IR and NMR, Basics of X-Ray diffraction Analysis, Mass Spectroscopy, Fourier transform infrared spectroscopy (**FTIR).**

Unit IV:Chromatography: Partition principle, partition coefficient, Nature of partition forces, detailed account of Paper, Thin layer & Column chromatography (Column efficiency and concept of plates). Gel filtration: - Concept of distribution coefficient, Types of gels & glass beads, Applications. Ion-Exchange chromatography: - Principle, Types of resins, Choice of buffers, Applications. b) Affinity chromatography: - Principle, Selection of ligand, Ligand attachment, Specific & non-specific elution, Applications. Elements of High Pressure Liquid

Chromatography & Gas Chromatography, Liquid chromatography–mass spectrometry (**LC-MS**), Gas chromatography mass spectrometry (**GC/MS**), High performance thin layer chromatography (**HPTLC**),

Unit V:Electrophoresis: Theory of Electrophoresis, Electrophoresis of Protein, PAGE, SDS-PAGE, Isoelectric Focusing of Protein Pulse Gel Electrophoresis and Western Blotting.2DGE, Agarose Electrophoresis of Nucleic Acid: Agarose gel of DNA, RNA, DNA sequencing gels, Southern blotting. **Biosensors:** Principle, Action Mechnism, Application and types.

BCBE-416 Immuno-technology 3 (2-0-1)

Unit I: Introduction to Immune system, The innate and adaptive immune defense and its components. Features of Antigen, Antigenic determinants, Structure and function of antibody, Antibody classes Basics of antigen and antibody interactions-affinity, avidity and specificity; Kinetics of immune responses. Immunodiagnostics.

Unit II: Technologies for production of antibodies, Production of Polyclonal and Monoclonal Antibodies- hybridoma Technology; Hapten-carrier system. Antibody engineering, Generation of antibody diversity.

Unit III: Immunological techniques: Cross reactivity, Precipitation and Agglutination reaction, Immuno-electrophoresis, RIA, ELISA, ELISPOT assay, Western blotting, Immunofluorescence and Flow cytometry. Cell Cytotoxicity; mixed lymphocyte reaction; In vivo cell tracking techniques.

Unit IV: Principle of Immunization- Active and Passive Immunization; Kinds of vaccines live, killed, attenuated, subunit vaccines, recombinant DNA vaccine, peptide vaccines, conjugate vaccines; Role and properties of adjuvants. Transplantation technology: Graft Acceptance and Rejection and its Mechanism, Tumor Immunology, Hypersensitivity.

Practical:

i. Detection of ABO blood groups.
ii. Blood film preparation and identification of cells
iii. Erythrocyte Sedimentation Rate (ESR).
iv. Packed Cell Volume (PCV).
v. Immunodiffusion
vi. Single Radial Immunodiffusion.
vii. Rocket immunoelectrophoroesis.
viii. Detection by viral fever by slide agglutination tests.

Recommended books:

i. Immunology and Immunotechnology 1st Edition by Ashim k. Chakravarty, Publisher: Oxford University Press, ISBN: 9780195676884.

ii. Immunotechnology Dr. Sneh Lata Arya, Published by Manglam Publications.

iii. A Textbook of Immunology & Immunotechnology by Annadurai B., Published by S. Chand & Company Ltd., ISBN 10: 8121928079.

iv. Immunotechnology by Gosling, J. P.& Reen, D. J., Published by Portland Press, ISBN 10: 1855780356.

v. Owen J. A., Punt J., Strandfold S.A, Jones P.P., Kuby-Immunology W.H. Freeman & Company (2013), 7 th ed.

SEMESTER – V

BCBE-417 Mass Transfer Operation 3(3-0-0)

Unit I: Diffusion: Molecular and turbulent diffusion, diffusion coefficient, Fick's Law of diffusion, Dependence of diffusion coefficient on temperature, pressure and composition; measurement and estimation of diffusivity. Diffusion in multi-component gas mixtures. Diffusion in Solids: Molecular, Knudsen & surface diffusion; Inter- phase mass transfer: Mass transfer coefficients, Diffusion between phases, Equilibrium solubility of gases in liquids, Mass transfer theories, Mass transfer in bioreactors.

Unit II: Distillation: Fundamentals principle of distillation, Henery's, Raoult's and Dalton's laws, xy and T-x-y diagrams, partial vaporization/condensation, Types of distillation, flash, differential and steam distillation. performance evaluation of distillation column including boiler and condenser. Industrial fractionation distillation process.

Unit III: Liquid-Liquid Extraction: General principle, Extraction processes and equipments, equilibrium diagram, choice of solvent, single and multistage co-current, countercurrent extraction. Operating modes of extraction: Batch and continuous. Aqueous polymer two phase extraction, Supercritical extraction.

Unit IV: Solid - Fluid Operations: Adsorption. Nature of adsorbents- silica gel, activated alumina, molecular sieves, activated carbon. Structure of adsorbents – surface area, pore size etc. Adsorption equilibria. Multi-component adsorption. Isotherms –Langmuir, BET, Gibb's. Potential theory. Design of fixed bed and moving bed adsorbtion.

Text Books

1. Mass-Transfer Operation, Robert E. Treybal, McGraw Hill

Reference Books

1. Unit Operations of Chemical Engineering, McCabe W.L., Smith J.C. and Harriott P. McGraw Hill International edition, Singapore
2. Principles of Unit Operations, Foust A.S. John Wiley & Sons, Singapore.
3. Introduction to Chemical Engineering, Badger W.L. and Banchero J.T., Tata McGraw Hill Edition.
4. Chemical Engineering, Vol. I, Coulson J.M. and Richardson J.F. Butterworth Heinemann,
5. Separation Processes, King C.J., Tata McGraw Hill
6. Transport Processes and Unit Operations, GeanKoplis, C.J. Prentice Hall
9. Separation of proteins and other biomolecules by various Chromatography techniques

BCBE- 418 Metabolic Regulation and Engineering 3(3-0-0)

Unit I: Regulatory mechanisms for control of enzyme synthesis - an overview; control of enzyme activity proteolysis, covalent modification and ligand binging: Metabolic control theory and metabolic flux analysis.

Unit II: Metabolic regulation of a few major metabolic pathways especially those relevant to bioprocess industries; Pathway engineering; Application of gene cloning in re-directing cellular metabolism for over-production of a few industrial products; Strategies to overcome regulatory mechanisms for over-production of several industrially important primary and secondary metabolites such as alcohols, organic acids, amino acids, enzymes and therapeutic compounds.

CBBI-502 Concept of Bioinformatics 3 (2-0-1)

- Bioinformatics and Internet: Internet Basics, FTP, www, connecting to Internet, Electronic mail, internet resources.
- Information Retrieval from Biological Databases: Integrated information Retrieval (Entrez System), Retrieving database entries.
- The NCBI data model: Introduction, Seq-id, Sequence, collection of sequence, annotation of sequence, Describing sequence.
- GenBank Sequence Database: Introduction to structure, Primary and secondary database, Format vs Content: Computer vs. Human, Databases, Genbank Flat file, GCG.

- Sequence Alignment And Database Searching: Introduction, Evolutionary Basis of Sequence Alignment, Optimal alignment method, Substitution Score and Gap Penalty, Statistical Significance of Alignment.
- Database similarity searching, FASTA, BLAST, Database searching Artifacts, Position Specific Scoring Matrices.
- Multiple Sequence Alignment: What is MSA, Structural or Evolutionary Alignment, how to align Sequences, Tools.
- Phylogenetic Analysis: Fundamental of Phylogenetic model, Tree interpretation- Paralogues and orthologues, Tree building and tree evaluation, Phylogenetic software.
- Predictive Method using Nucleotide Sequence: Introduction, Marking repetitive DNA, Database search, Codon bias detection, detecting functional site in DNA.
- Predictive Method using Protein Sequence: Protein identification based on composition, Physical properties based on sequence, Motif and pattern, Secondary structure and folding classes, specialized structure or features, Tertiary structures.
- Structure Database: Introduction to Structure, PDB, MMDB, Structure file format, visualizing structure information, Structure viewers, structure similarity searching, Advanced structure modeling.
- Comparative Genome Analysis: Introduction, application, genome analysis and annotation.

Practical:

i. Understanding Linux Operating System and Commands.
ii. Introduction to NCBI.
iii. Using Entrez to search Literature Databases.
iv. Retrieving DNA sequence from GenBank and analyzing various formats of the data stored.
v. Retrieving Protein sequence from GenPept (NCBI) and Expasy.
vi. Analyzing Protein Sequences.
vii. Analyzing DNA sequence.
viii. Sequence alignment using BLAST (Basic Local Alignment Search Tool).
ix. Sequence alignment using FASTA.
x. Multiple sequence alignment using ClustalW.
xi. Introduction to the structure database PDB.
xii. Visualization of the protein structure using VMD.
xiii. Secondary structure prediction using GOR algorithm.

BCBE 502 Industrial Biotechnology 3(2-0-1)

Unit I: Introduction to Industrial Biotechnology: Overview of fermentation; solid and submerged fermentation, culture techniques batch, fed-batch and continuous; strain improvement, media optimization and types of industrial fermenter. Primary and secondary metabolites.

Unit II: Microbes in agriculture and food industry: biofertilizers and biopesticides, SCP, microbial production of wine, beer and vinegar; biopreservatives (Nisin), cheese, biopolymers (xanthan gum, PHB etc), vitamins; Bioflavours and biopigments, microbial pigments in textile and food industry.

Unit III: Process technology for the production of cell biomass and primary metabolites- ethanol, acetone butanol, citric acid, dextran and amino acids.

Unit IV: Production of enzymes and specialty chemicals: Production of industrial enzymes such as proteases, amylases, lipases, cellulases, whole cell biocatalysis, Applications of bioconversion, transformation of steroids and sterols.

Unit V: Microbial production of pharmaceuticals and other bioproducts: Antibiotics, enzyme inhibitors and specialty chemicals; production of Vitamins, glutamic acid, L-Lysine. Biotransformation of non-steroidal compounds, antibiotics, environmental toxicants.

Unit VI: Bioenergy-fuel from biomass, production and economics of biofuels, biogas, bio-refineries, Microbial Enhanced Oil Recovery (MEOR).

Text books

1. Glazer AN, Nikaido H (2007): Microbial Biotechnology: Fundamentals of Applied Microbiology

2. Wulf Cruger and Anneliese Crueger (2003), Biotechnology: A Textbook of Industrial Microbiology, Panima Publishing Corporation.

3. Malden MA (2001): Industrial Microbiology: An introduction; Blackwell Science (2001)

Reference Books

1. H.W. Blanch, S. Drew, D.I.C.Wang and M. Moo-Young, Comprehensive Biotechnology: The Practice of Biotechnology: Current Commodity Products, Pergamon Press (1985).

2. C. Vogel and C.L. Tadaro, Fermentation and Biochemical Engineering Handbook: Principles, Process, Design and Equipment, Noyes Publications (1996).

3. P.F. Stansbury and A. Whitaker, Principles of Fermentation Technology: An Introduction to Current Concepts, Pergamon Press (1993).

List of Practical's:

i. Production and partial purification of Amylase.
ii. Production of Citric acid using *Aspergillus* species
iii. Screening and isolation of cellulase producing enzymes
iv. Determination of cellulolytic activity by DNS method
v. Screening microorganism for antibiotic production.
vi. Production and partial purification of Penicillin.

BCBE- 503 Biochemical Engineering- I 4(2-0-2)

Unit I: Introduction: Definition and scope of biochemical engineering. Unit operations in biochemical processes, Mass and energy balance in microbial processes, Metabolic stoichiometry and bioenergetics, Primary and secondary metabolites.

Unit II: Microbial Growth Kinetics: Phase of cell growth, Estimation of cell mass, Kinetics of cell growth in batch, continuous and fed batch system, Monod growth model and its various modifications; concept of limiting nutrient and effect of its concentration on cell growth; Study of growth inhibition kinetics, structured and unstructured kinetic rate models.

Unit III: Aeration and agitation: Transport phenomena in Bioprocess systems; gas liquid mass transfer in cellular systems. bubble aeration and mechanical agitation, calculation of power consumption, correlation between oxygen transfer coefficient and operating variables, estimation of KLa in fermentation process, factors affecting volumetric oxygen transfer, rheology of fermentation fluids.

Unit IV: Sterilization: General introduction, Methods of air sterilization, Thermal death kinetics of microorganisms. Batch, continuous sterilization, Sterilization of air.

Text Books

1. Biochemical Engineering Fundamentals by James E. Bailey& David F. Ollis, McGrew- Hill.
2. Bioprocess Engineering by Shuler & Kargi, Prentice Hall
3. Chemical Reaction Engineering, Levenspiel O., John Wiley& Sons (Asia), 3rd Ed., 2000
4. Encyclopedia of Chemical Engineering by Kirk & Othmer,
5. Aiba S, Humphrey A E and Millis N F, “Biochemical Engineering”, Academic Press (1973)
6. Bio reaction engg. Principles, John Villadsen, Jens Nielsens, Gunnar Liden, Springer

Reference Books

1. Chemical Engineering Kinetics, Smith J.M., McGraw Hill
2. Elements of Chemical Reaction Engineering, Scott Fogler H., Prentice Hall of India

BIOCHEMICAL ENGINEERING-I LAB

1. To prepare broth media for microbial growth.
2. To culture the microbial organisms in a shake flask using orbital shaker incubator.
3. To estimate the Microbial biomass produced through shake flask culturing.
4. To plot Microbial growth curve for shake flask culturing using turbidity method.
5. To Estimate the Monod Parameters for microbial growth kinetics
6. Estimation of cell maintenance coefficient and true growth yield by studying the mass and energy balance during cell growth.
7. To get familiarized with the lab scale fermenter (bench top fermenter)
8. Different agitator types; mixing time in a bioreactor; quantification of KLa in a fermentation process
9. Heat balance across a batch sterilization process.
10. Assembly and characterization of pH/DO electrodes

BCBE 504 Biopolymers 3 (3-0-0)

Unit I: Introduction to biopolymers, concept and history of biopolymers, Applications of biopolymers, Classes of biopolymers- naturaly extracted polymers and artificially synthesized, Basic structures and production mechanism of biopolymers..Current status of biopolymer industries.

Unit II: Mechanical and physico-chemical properties: elasticity, yield stress, ductility, toughness, strength, hardness, friction, lubricity; morphology and texture; electrical, optical, magnetic, thermal properties.

Unit III: Biological properties: Biocompatibility, Biodegradibility, and ecotoxicity. Characterization and Testing of Biomaterials: Bulk analysis methods applied to the study of Biomaterials (XRD, FTIR, DSC, TGA, etc.) Surface analysis methods applied to the study of biomaterials (SEM, TEM, AFM, etc.)

Unit IV: Production and processing of biopolymers. Exopolysachharides production and applications. Production and applications of microbial cellulose, alginate, chitosan, chitin, etc. Biocomposites and bioplastics: Starch and cellulose based plastics and polyesters (PLA, PHB), polyamides, Bio-Based Composites from biological wastes, bio-based polyethylene and genetically modified bioplastics. Nanotechnology in biocomposites.

Unit V: Applications of biopolymers and their composites in biomedical engineering: Biomaterials and medical implants, Ethical issues of biomaterials. Applications of biopolymers in pharmaceuticals and

medicine, agriculture and packaging, active and smart packaging; pollution control and bio-remediation.Applications of Biopolymers in Construction Engineering.

Recommended books:

1. Biopolymers: Structure, Performance and Applications by Ajay Kumar Mishra , Chaudhery Mustansar Hussain , Shivani Bhardwaj Mishra, Publisher: Nova Science Pub Inc, ISBN-10**:** 153611846X.
2. Biopolymers: Biology, Chemistry, Biotechnology, Applications General Aspects and Special Applications by A Steinbüchel, Publisher: Wiley VCH, ISBN-10: 978352730229.
3. Biopolymers: product and uses by Jan Cooper, Publisher: NY Research Press, ISBN: 9781632380661.

BCBE- 508 Protein Science and Engineering 3(3-0-0)

Unit I: Chemical, physical and molecular properties of Amino acids (Acid/Base properties Bifunctional monomers, Polarity, Classification Chirality and stereochemistry, Codes, Ways of representation, Essential, non-essential, non-standard and non-proteinogenic amino acids, Size, solubility, charge, pKa, dipolar nature, chemical reactions and configuration, conformational accessibilities), Bonds, Energies, Building Blocks of Proteins (Primary and secondary bond) interactions in protein structure.

Unit II: Primary, Secondary and, tertiary and quaternary structure, Ramachandran Plot, Motifs of protein structures and their packing, Schematic and topology diagrams, Protein folding and assembly, Protein folding pathways in prokaryotes and eukaryotes, Single and multiple folding pathways, Protein folding of single domain and multi-domain proteins, Structure of chaperones and role of chaperones in protein folding

Unit III: Structure-Function Relationship (Confirmation, Orientation, flexibility and movability) Protein Engineering and approaches: Engineering physical and biology properties of protein by chemical modification and Mutagenesis

Unit IV: Interaction with electromagnetic radiation (radio, micro, infrared, visible, ultraviolet,X-ray) and elucidation of protein structure with NMR and MALDI ToF, CD, FT Raman, FT-IR Sequencing Methods for proteins Modern advancement such as Tar Sequencing Strategies, DABITC/ PITC methods, solid phase mirosaequencing Fast atom Bombardment (FAB) mass spectra in protein sequencing.

BCBE- 509 Computational Methods for Biochemical Engineering 3(2-1-0)

Unit I: Mathematical formulation of the physical problem. Formulation of the differential Equation: Application of law of conservation of Mass, Momemtum and Energy.

Unit II: Mathematical formulation of finite difference equation. Finite difference methods in analysis of stage wise processes, numerical solution of partial differential equation.

Unit III: Probability theory: handling stochastic phenomena, groundwork for statistics. Vectors and matrices: applied to population dynamics, quantitative genetics and statistics.

Unit IV: Dynamical systems: techniques to analyse models of population growth, reaction kinetics, etc.

Books

1. Applied Mathematics in Chemical Engineering, Mickley, H.S., Sherwood, T.K., and Reed, C.E., McGraw Hill, N.Y.

2. Mathematical models in biology. L. Edelstein-Keshet McGraw-Hill Education, ISBN 0075549506.

3. Calculus for biology and medicine, C. Neuhauser. Prentice Hall, ISBN 0131234412.

4. Mathematical techniques by D. W. Jordan & P. Smith. Oxford University Press, ISBN 0199249725.

5. Dynamic models in biology by S. P. Ellner& J. Guckenheimer. Princeton University Press, ISBN-10: 0691125899.

SEMESTER – VI

MCE-501 Biosafety, Bioethics and IPR Issues 3 (3-0-0)

Unit I: The legal and socioeconomic impact of biotechnology, public education of the process of biotechnology involved in generating new forms of life for informed decision making, biosafety regulation and national and international guidelines, r-DNA guidelines, experimental protocol approvals, levels of containment, regulatory bodies in biotechnology, biosafety committee.

Unit II: Ethical issues, moral values on experimental animals, ethical implications of biotechnological products and techniques.

Unit III: Intellectual property rights, WTO, TRIPS, International conventions, patents and copy rights, patent claims, methods of applications of patents.

Unit IV: Legal implications, biodiversity and farmers right. Beneficial application and development of research focus to the need of the poor, identification of directions for yield effect in agriculture, aquaculture etc.

MCE-502 Recombinant DNA Technology 3 (3-0-0)

Unit I: Biology of cloning vectors: Plasmids, lambda bacteriophage, cosmids, M13bacteriophage, phagemid, Agrobacterium tumifaciens- binary and cointegration vector strategy.

Unit II: Enzymes used in genetic engineering: Exonucleases, endonucleases - S1 nuclease,restriction endonucleases; ligases, polymerases, reverse transcriptase, terminal deoxy nucleotidyl transferases, kinases, alkaline phosphatase.

Unit III: Principles of recombinant DNA technology: Construction of recombinant DNA, rDNA expression, genomic and complimentary DNA (cDNA) libraries, detecting expression of foreign genes.

Unit IV: Application of r-DNA technology: Medicine, industry, agriculture, live stockimprovement, environmental protection, etc.

BCBE-602 Fermentation Technology 3 (2-0-1)

Unit I: Introduction to fermentation technology: Interaction between chemical engineering, Microbiology and Biochemistry. History and development of fermentation industry: Introduction to submerged and solid state fermentation, Microbial culture selection for fermentation processes. Bioprocess economics. Bioproduct regulation. General fermentation economics.

Unit II: Microbial Growth Kinetics: Growth, substrate utilization and product formation. Raw material availability, quality, processes and pretreatment of raw materials. Applications of the nonconventional raw materials (cellulosic material and hydrocarbons).

Unit III: Different regulatory mechanisms involved in controlling the catabolic and anabolic processes of microbes. Induction, nutritional repression, carbon catabolite repression, crabtree effect, feedback inhibition and feedback repression.

Unit IV: Creation/procedures for developing mutants of the desired microbes with the stable capacity of producing desired metabolites. Isolation and preservation of different types of mutants induction resistant, feedback inhibition resistant. Concept for overproduction of metabolites.

Unit V: General Concepts of Scale up & Scale down in fermentation process, Criterion of scale up of various fermentors, Details of the process, parameters and materials -for the industrial manufacture of Antibiotics (β-lactum), Solvents(acetone) Amino acid (Lysine), Organic acids (Citric acid), Alcohols (Ethanol), Ind. Enzymes (Protease/Amylase) and Biopharmaceuticals (Insulin/Interferon etc.)-Microbial Transformations, Microbial leaching.

Text books and references:

1. Murray Moo -Young, Comprehensive Biotechnology, Vol. 1 & III-latest ed.
2. Microbes & Fermentation, A. Lel and Kotlers Richard J. Mickey, Oriffin Publication
3. Industrial Fermentations-Leland, N. Y. Chemical Publishers.
4. Prescott and Dunn's-Industrial Microbiology, 4 th, ed.
5. Biotechnology Series, Rehm, Reed & Weinheim, Verlag-Chemie.
6. Biochemical Engg., Aiba, Humphrey & Miller, Academic Press.
7. Fermentations & Enzyme technology, Wang & Humphrey, Wiley & Inter Science

Practicals:

1. Fermentative production of Penicillin Antibiotics using *Penicilium chrysogenum*.
2. Upstream and Downstream of bioprocess for the production of Citric acid by *Aspergillus niger*
3. Citric acid production by *Aspergillus niger* under submerged fermentation.
4. Microbial production of citric acid by solid state fermentation process.
5. Microbial production of enzymes by (a) solid state and (b) submerged fermentation.
6. Fermentative production of Ethanol using *Saccharomyces cerevisiae*.
7. Microbial production of Biosurfactant using suitable strain.
8. Microbial production of Biopolymer using suitable Strain.

BCBE 604 Enzyme Technology 3(2-0-1)

Unit I: Enzyme catalysis**:** Introduction of Enzyme: Brief history, nomenclature & classification, Coenzyme and Cofactors, Induced & Lock-Key hypothesis, Enzyme specificity and activity: Types of specificity, Identification of binding site & catalytic site, 3-D structure of active site, Kinetics of single and bi-substrate enzyme catalyzed reactions, Inhibition & its kinetics, factors affecting enzyme activity.

Unit II: Production and purification: Methods of production of enzyme, Extraction of enzyme of soluble and membrane bound enzymes, Nature of extraction medium, purification of enzyme, criteria of purity, determination of molecular weight of enzyme.

Unit III: Enzyme immobilization: Methods of immobilization of enzymes-physical & chemical techniques, Kinetics of immobilized enzyme, Effect of external mass transfer & intra-particle diffusion, limitation & applications of immobilized enzymes, Bioreactors using immobilized enzyme.

Unit IV: Applied enzyme catalysis: Applications of hydrolytic enzymes- hydrolytic, proteolytic, pectic enzymes, *etc*. Medical applications of enzymes, Enzyme mixtures for industrial applications, Medical and analytical applications of immobilized enzymes. Applications of enzyme in leather industry, detergent industry, dairy industry; Lignocellulose degrading enzymes.

Unit V: Enzyme Engineering: Introduction, aim, principle & steps of enzyme engineering; Prediction of enzyme structure, design and construction of novel enzymes, Bifunctional and polyfunctional enzyme, Enzyme in organic solvents.

Text Books:

1. Enzyme by Palmer (2001); Horwood publishing series.

2. Fundamental of Enzymology by Price and Stevens (2002): Oxford University Press.

Reference Books:

1. Enzyme technology by Helmut uhling (1998): John Wiley

2. A. L. Lehringer, d.L. Nelson, M.M Cox- "Principle of Biochemistry "by Werth publishers, 2000.

3. L. Stryer, J.M. Berge, J.L. Tymoezko-"Biochemistry" W.H. freeman & Co. 2002

4. Introduction to protein structure by B randen and Tooze (1998): Garland publishing group.

List of Experiments:

1. Production of Amylase through solid state fermentation by A. Niger.
2. Extraction and partial purification of enzymes by solvent or by (NH4)SO4 method
3. Study of enzyme kinetics by the use of Michaclis Menten equation.
4. Effect of temperature/pH/concentration on salivary amylase activity.
5. Production of catalase enzyme by microorganisms.
6. Production of lactase by yeast cell.
7. Various Techniques of enzyme immobilization.
8. Study of various enzyme reactors.
9. Studies on the kinetics of immobilized enzyme and immobilized cells

BCBE- 606 Biochemical Engineering –II 4(2-0-2)

Unit I: Design of bioreactors: Concept of ideal and non-ideal reactor, Design of Ideal reactors: Batch reactors, fed batch reactors, CSTR, PFR. Operating considerations in bioreactors for suspension and immobilized cultures, modifying batch and continuous reactors.

Unit II: Non-ideal reactors: Residence time distribution, Models for non ideal reactors: Dispersion model-plug flow with axial dispersion, tanks-n-series model. Unconventional bioreactors: Hollow fiber reactor, membrane reactor, perfusion reactor for animal and plant cell culture.

Unit III: Kinetics of mixed cultures: Major classes of interaction in mixed cultures, models describing mixed-culture interactions, reaction dynamics, industrial application of mixed cultures, case studies utilizing mixed cultures.

Unit IV: Scale up: Concepts, criteria for bioreactors scale up, Instrumentation and controls in bioreactors.

Books & References:

1. Biochemical Engineering Fundamentals by James E. Bailey& David F. Ollis, McGrew- Hill.
2. Bioprocess Engineering by Shuler & Kargi, Prentice Hall
3. Chemical Reaction Engineering, Levenspiel O., John Wiley& Sons (Asia), 3rd Ed., 2000
4. Encyclopedia of Chemical Engineering by Kirk & Othmer,
5. Aiba S, Humphrey A E and Millis N F, "Biochemical Engineering", Academic Press (1973)
6. Bio reaction engg. Principles, John Villadsen, Jens Nielsens, Gunnar Liden, Springer

Biochemical Engineering LAB

1. Estimation of cell mass; different phases of microbial growth.
2. Mass and energy balance in a typical bioconversion process.
3. Concept of limiting nutrient and its effect on cell growth; growth inhibition kinetics; product formation kinetics in a fermentation process.
4. To determine mixing time in a stirred tank reactor (STR).
5. Aerobic and anaerobic bioconversion process; power consumption in a fermentation process and its correlation with rheology of fermentation fluid.
6. Comparison between aerobic and anaerobic fermentation.
7. To determine Residence Time Distribution (RTD) for a CSTR.

BCBE 608 Bio-waste Treatment 3(2-0-1)

Unit I: Qualitative and Quantitative characteristics of waste, waste disposal norms and regulation, Principles of biological treatment, physical and chemical methods of waste treatment.

Unit II: Bioprocess kinetics applied to waste treatment. Operation and design features of trickling filters and rotating biological contractor (RBC).

Unit III: Theory of activated sludge process, design, operation and control, BOD reduction

and biomass relationship, modifications, stabilization ponds, operational and design aspects.

Unit IV: Anaerobic treatment systems. Sludge digestion theory, digester design, high rate digestion, heat transfer in digester.

Unit V: New developments, fixed film reactors, UASB. Nitrification - denitrification, Phosphorous removal. Treatment and disposal of waste of the industries e.g. distilling and brewing, antibiotics and sugar etc.

References:

1. "Waste Water Engineering: Treatment, Disposal and Reuse", Metcalf & Eddy, Inc.; Tata McGraw-Hill Publishing Company Ltd., New Delhi.
2. "Water supply and Pollution control", Warren Viessman Jr. and Mark J. Hammer; Harper & Row Publishers; New York.
3. "Environmental Engineering", Howard & Peavy, Donald R. Rawe and George Tehobanoglousd, Mcgraw- Hill International Editions.
4. "Waste Water Treatment", Rao & Dutta.

WASTE TREATMENT LAB

1. Estimation of dissolved oxygen in water sample.
2. Determination of Biochemical Oxygen Demand (BOD) in wastewater sample.
3. Determination of Chemical Oxygen Demand (COD) in wastewater sample.
4. Determination of Solids: Volatile, fixed and total.
5. Evaluation of the effect of process, variables on the performance of activated sludge process.
6. Evaluation of performance of anaerobic digestor.
7. Estimation of inorganic ions in water.
8. Biological conversion of wastes into useful products

MCE 514 Tissue Engineering 3(3-0-0)

Unit I: Introduction: Definitions, basic principles, clinical need of tissue engineering and regenerative medicine, structure-function relationships. Biomaterials: metals, ceramics, polymers (synthetic and natural). biodegradable materials, native matrix, advances in biomaterials and scaffold production, Challenges and future of tissue engineering

Unit II: Tissue culture basics: Embryogenesis, primary cells vs. cell lines, Development of cell lines, Characterization of different cell lines, maintenance of cell lines, finite vs non-finite cell lines, Cell culture media, sterile techniques, roller bottle techniques, Cell culture media: serum vs serum free

media, sorting techniques of mixed cells, enzymes, reactors and cryopreservation. Oxygen transport, angiogenesis, cell adhesion, signal transduction, cell growth and differentiation, and developmental processes.

Unit III: Skin tissue engineering. Introduction, Transplantation: current approach and limitations, ethical considerations, scar vs. regeneration, split skin graft, apligrafts, Cardiovascular tissue engineering, Liver tissue engineering, bioartificial liver (BAL) assist device, shear forces, self-assembled organoids, *In-vitro* models for disease studies, Stem cells: basic principles, embryonic stem cells vs adult stem cells, induced pluripotent stem cells, applications of embryonic stem cells and its future.

Unit IV: Examples and problems from gene therapy, cellular therapy, tissue engineering, and bioprocess design are used to illustrate fundamental bioengineering principals.

Reference Books

1. Robert Lanza, Robert Langer and Joseph P. Vacanti. Principles of Tissue Engineering. Academic Press.

2. Bernhard O. Palsson and Sangeeta N. Bhatia. Tissue Engineering. Prentice Hall.

3. Kal Sharma. Transport Phenomena in Biomedical Engineering: Artifical organ Design and Development and Tissue Engineering. McGraw Hill.

MCE-503 Fundamentals of Nanobiotechnology 3 (3-0-0)

Unit I: Introduction: Overview, history and background, importance of nanotechnology in modern science.

Unit II: Analyzing tools: Overview of modern microscopic tools like SEM, TEM, STM,AFM, Confocal Microscopy. Overview of types of Spectroscopies like UV-Vis, IR, Raman spectroscopy. X-Ray Crystallography.

Unit III: Nanomaterial Synthesis: Basic physics and chemistry of nanomaterials. Types of synthetic routes, Top-down and Bottom-up techniques.

Unit IV: Nanomaterial Applications: Application of nanomaterials in the field of electronics, composites, catalysis, ceramics. Uses in biosensors, drug delivery, gene therapy.

Unit V: Safety aspects: Nanoparticle related Health and safety issues, ethical, legal and social implications, environmental issues.

SEMESTER – VII

BAM-502 Marketing and Management of Biotechnology Products 3(3-0-0)

1. Concept of marketing
2. Customer Satisfaction and Buyer Behavior.
3. Marketing Mix
4. Analyzing Consumer Markets of Biotechnological products.
5. Pricing-strategies and methods of pricing of Biotechnological products.
6. Identifying Markets Segments and Selecting Target Markets for Biotechnological products.
7. Positioning the Market Offering Through the Product Life Cycle.
8. Distribution Channel.
9. Promotion of Biotechnological Products.

BAM 550 Entrepreneurship Development and Industrial Consultancy 2(0-0-2)

BCBE-609 Bio-Separation Technology 4(2-0-2)

Unit I: Basic Concepts Basic concepts of Bio-separation Technology; Separation characteristics of proteins and enzymes – size, stability, properties; purification methodologies; Characteristics of byproducts;

Unit II: Flocculation and conditioning of broth, overview of reaction processes involved Mechanical separation processes; Filtration at constant pressure and at constant rate; empirical equations for batch and continuous filtration, centrifugal and cross-flow filtration; Centrifugation: basic principles, design characteristics; ultracentrifuges:: principles and application; Crystallization and drying: principles and applications.

Unit III: Techniques involved in Separation Processes: Foam-fractionation; Solvent extraction of bio-processes, aqueous two-phase extraction, adsorption-desorption process; Salt precipitation; Chromatographic separation: Adsorption chromatography, Ion- exchange chromatography, gel filtration chromatography, affinity chromatography, high pressure liquid chromatography, hydrophobic chromatography; their preparation and uses, method of linkage, Electrophoresis SDS-PAGE (Polyacrylamide Gel), horizontal and vertical type, methods, and case studies.

Unit IV: Membrane based separation processes: Micro-filtration, Reverse osmosis, Ultra filtration and affinity ultra filtration, concentration polarization, rejection, flux expression, membrane modules, dead-ended and cross-flow mode, material balances and numerical problems, biological applications

Unit V: Industrial Applications: Industrial aspects of separation of biomolecules, Material balances, mathematical analysis and modeling, relative advantages and disadvantages of separation methods, Case studies.

Laboratory work: Extraction, partial purification of extracellular metabolites. Optimization of flocculating agent concentration, comparative analysis of cell disruption methods, Batch settling process, Estimation of filtration efficiency, protein precipitation by salting-out method, Batch drying, Qualitative and quantitative estimation of product. Separation of proteins by Gel filtration/ size exclusion chromatography. Aqueous two phase extraction.

Textbook:

1. M. R. Ladisch, Bioseparations Engineering, Wiley Interscience
2. Kennedy and Cabral, Recovery processes for biological materials.
3. Heinemann, Product Recovery in Bioprocess Technology, Butterworth Publication
4. Schuler &Kargi, Bio-process Engg. PHI

Reference books:

1. Bailey &Olis, Biochemical Engg. Fundamentals, McGraw-Hill, 1990
2. Mukhopadhyay, S. N. Process Biotechnology Fundamentals, Viva Books Pvt. Ltd.,
3. Muni Cheryan, Handbook of Ultrafilration
4. Perry, Chilton & Green, Chemical Engineers' Handbook, McGraw-Hill
5. Ho, W.S.W & K.K. Sirkar, Membrane Handbook, Van NostrandReinbold, N.Y.

BCBE- 611 Bioprocess Modeling and Simulation 3(2-1-0)

Unit I: Simulation: basics, discreet event simulation, conducting a simulation project, building a system model, model verification and validation, Simulation of batch pharmaceutical manufacturing systems

Unit II: Batch process simulation: concept, goals and capabilities. Software: SuperPro Designer, K-Tops, Aspen

Modeling: basic process operations with SuperPro Designer, chemical reactions, separation operations

Study of Structured Models: Analysis of various bioprocesses; Model simulation using MATLAB-SIMULINK and ISIM software packages.

Unit III: Fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics.

Unit IV: Examples of Mathematical Models: Modeling of gene regulation (Genetic switches), Modeling of signal transduction in prokaryotes and eukaryotes, Insilico microorganisms, metabolic flux analysis.

Unit V: Elementary mode analysis: Heat and Mass Transfer Equipment such as Heat exchangers, evaporators, flash distillation, differential distillation, continuous binary distillation in tray and packed column, vaporizers, single phase separation adsorption, absorbers and strippers, agitated vessels, mixing process. Reaction Equipment: Batch reactor, Semi batch reactor, Continuous stirred tank reactor, Plug flow reactor, Packed column reactor, Bioreactors, Reactors used in effluent treatments, Fluidized bed reactor.

Books Recommended

1. Harrell, C., Ghosh, B., Bowden, R., "Simulation Using Promodel", McGraw Hill Software: ProModel v.6.1 (incl. with the textbook) SuperPro Designer v. 6.0 or higher.

2. Luyben W L, "Process Modeling Simulation and Control for Chemical Engineers", international ed. McGraw Hill .

3. Rose L M, "The Application of Mathematical Modeling to Process Development and Design", First Ed. Applied Science Publisher Limited. London.

4. Bequette, "Process Dynamics- Modeling, Analysis and Simulation", PHI International.

5. Rase H F, "Chemical Reactor Design for Process Plants, Vol II: Case Studies and Design Data", John Wiley and Sons, New York

6. Denn M Morton, "Process Modeling",Longman Publisher

7. J.R. Leigh, Modeling and Control of fermentation Processes, Peter Peregrinus, London

BCBE- 612 Bioprocess Plant Design 3(2-1-0)

Unit I: General design principles, yield stress, *GMPs guidelines*, validation, safety in bioprocess plant. Stress analysis: static and dynamic loads, Elastic instability, combined stresses, theories of failure, Design considerations for maintaining sterility of process streams and process equipment, Design wall thickness, Design pressure, Design temperature, Design stress, corrosion allowance, design loads, minimum wall thickness, Pressure vessels: classification, design of vessels under internal and external pressure.

Unit II: Bioreactor Design *and Scale-up*: Ideal and non-ideal bioreactor. Criteria for bioreactors design, chemostat bioreactors, power requirements for Newtonian /non-newtonian broths and gassed fluids, Bioreactor scale-up based on constant power consumption per volume (P/V),

mixing time, shear, mass transfer coefficients, Effect of variables on bioreactor scale up: aeration and agitation, mixing, sterilization of media and bioreactor, inoculum development, nutrient availability, shear, pH, and Temperature.

Unit III: Bioprocess Economics: Control systems in bioreactors, process unit's symbology, stream numbering and drawings, basic control loop, instrumentation symbology, developing PFD for various bioprocesses, Process economics, Capital cost, operating cost estimation, profitability analysis, Case studies.

Textbooks

1. L. E. Brownell and E. H. Young- Process Equipment Design, Wiley India Pvt. Ltd. (2015)

2. M.V. Joshi and V.V. Mahajani- Process Equipment Design, MacMillan Company of India Ltd. (2009)

3. R. K. Sinnott- Chemical Engineering Series: An Introduction to Chemical Engineering Design (Vol. 6), Maxwell Macmillan Pergamon Publishing Corporation (2005)

Reference Books

1. K. Van't Riet and J. Tramper-Basic Bioreactor Design, Taylor & Francis Inc, New York, United States (1991)

2. Max Peters & Klans D Timmerhauss-Plant Design & Economics for Chemical Engineers", 4th Edition; Mc Graw Hill Book Co (1991)

3. Tapabrata Panda-Bioreactors Analysis and Design, Tata McGraw Hill Education Pvt. Ltd, (2011)

BCBE-613 Process Engineering 3(3-0-0)

Unit I: System and subsystem in chemical process engineering. System analysis. Economic degree of freedom - various algorithms.

Unit II: Economic design criteria. Terms involved in profitability analysis. Capital cost and manufacturing cost estimation methods.

Unit III: Strategy of scale-up and design of chemical processes; Role of pilot plant, process validation, salient features of patent literature.

Unit IV: Process evaluation and selection with special reference to eco-friendly technologies. Preparation of process specifications for typical equipment. Choice of batch v/s continuous process. Concept of dedicated and multiproduct plant facilities. Time cycle for batch processes.

Unit V: Development and evaluation of alternative flow sheets; efficient utilisation of energy; heat exchanger net-works. Preparation of process and instrumentation diagrams. Conceptual, project implementation- stage wise.

Books and References:

1. Strategy of Process Engineering, Rudd and Watson,. Wiley

2. Chemical Engineering Handbook, Perry, J.H., Mc GrawHill.

3. Plant Design and Economics for Chemical Engineers, Peters, M.S. and Timmerhaus, K.D, Mc Graw Hill.

BCBE 650 Mini Project 4(0-0-4)

To give a multifaceted assignment that serves as a culminating academic and intellectual experience for Students. To design and implement integrated approach to biological process using concepts of bioengineering and sciences. To plan the process for the designed product and analyze the prototype manufactured for improvement in design and function.

Each Students group led by a team leader will develop a design project involving formulation of problem, requirement, execution of the project and analysis. The Students will prepare a scientific report and powerpoint/ poster presentation. Depending on the type of project, design problem will be executed by simulation/modelling or developing a product.

SEMESTER VIII

BCBE 699 Project Work 12(0-0-12)

Each student shall be assigned a specific project. He/she shall select most appropriate process from various available alternatives and design the plant. A cost analysis, plant layout etc. may also form part of the total exercise. The final report will be examined by a panel.

BCBE 400 Training I 1(0-0-1)

BCBE 500 Training I 1(0-0-1)

The purpose of this training is to provide exposure to the working environment of various industries and research institution. During this period, the Students will get hands on training in the diverse areas of bioprocess engineering.

Scope of training: The Students will get an opportunity to know the ongoing R&D activities in different industries, institutes and universities. The Students will explore and gain experience in different branches of bioprocess viz agriculture, food, medicine and pharmaceutical. The Students will develop understanding of biosafety, bioethic, regulatory and compliances. Therefore, the summer training programme will help Students to identify the areas of their interest. Moreover, the Students will know how to write, analyze and compile data, and present the technical/scientific report.