

BE(Biotechnology) – I SEMESTER

THEORY

CODE	TITLE	UNIT
HU 1101	Technical English	1.0
PH 1101	Physics- I	1.0
CH 1201	Engineering Chemistry	1.0
MA 1005	Introduction to Engg. Mathematics	1.0
BT 1001	Fundamentals of Biology	1.0
ME 1101	Engineering Mechanics	1.0

SESSIONAL

CODE	TITLE	UNIT
ME 1004	Engineering Graphics	1.0
CP 1102	Unix & C Programming	1.0
PH 1102/		
CH 1202	Physics Lab./ Chemistry Lab.	0.5
PE 1102	Work Shop Practice- I	0.5
GA 1002	NCC/ NSS/ PT & Games/ Creative Arts	0.5

BE(Biotechnology) – II SEMESTER

MA 1101	Mathematics- I	1.0
EE 2101	Basic Electrical Engineering	1.0
CP 2101	Data Structure in C++	1.0
CH 2103	Environmental Science	1.0
PH 2103	Physics- II	1.0
CH 2106	Advance Organic Chemistry	1.0

CH 1202/	Chemistry Lab./	
PH 1102	Physics Lab.	0.5
ME 2104/	Engineering Mechanics Lab./	
EE 3102	Basic Electrical Engineering Lab.	0.5
CP 2102	Data Structure Lab.	0.5
PE 2102	Workshop Practice- II	0.5
GA 2002	NCC/ NSS/ PT & Games/ Creative Arts	0.5

BE(Biotechnology) – III SEMESTER

EC 3101	Basic Electronics	1.0
MA 3003	Statistics for Biologists	1.0
BT 3001	Chemical Engineering I	1.0
BT 3103	Thermodynamics of Chemical & Biological Systems	1.0
BT 3005	Cell Biology	1.0
BT 3007	Biomolecules	1.0

EC 3102	Basic Electronics Lab.	0.5
EE3102	Electrical Engineering Lab	0.5
CH 3002	Organic Chemistry Lab	0.5
BT 3006	Cell Biology Lab.	0.5
GA 3002	NCC/NSS/PT & Games/Creative Arts	0.5

BE(Biotechnology) – IV SEMESTER

BT 4011	Molecular Biology	1.0
BT 4003	Microbiology	1.0
BT 4005	Chemical Engineering II	1.0
BT 4013	Bioenergetics and Metabolism	1.0
BT 4015	process Measurement and Control	1.0
BT 4010	Modern Methods of Analysis	1.0

BT 4012	Molecular Biology Lab	0.5
BT 4004	Microbiology Lab	0.5
BT 4006	Chemical Engineering I Lab	0.5
BT 4014	Biochemistry Lab	0.5
GA 4001	NCC/NSS/PT&Games/Creative Arts	0.5

BE(Biotechnology) – V SEMESTER

BT 5001	Chemical Engineering III	1.0
BT 5011	Genetic Eng. And rDNA Technology	1.0
BT 5013	Immunology	1.0
BT 5007	Bioprocess Engineering	1.0
BT 5009	Reaction Engineering	1.0
BT 5010	Microbial Interactions	1.0

BT 5002	Chemical Engineering Lab. II	0.5
BT 5012	Genetic Eng. And rDNA Tech. Lab	0.5
BT 5014	Immunology Lab.	0.5
BT 5008	Bioprocess Engineering Lab.	0.5

BE(Biotechnology) – VI SEMESTER

BT 6001	Bioseparation Engineering	1.0
BT 6011	Enzyme Technology	1.0
BT 6013	Introduction to Bioinformatics	1.0
BT 6007	Food Science and Technology	1.0
MB 6001	Principles of Management	1.0
BT 6009	Bioreactor and Bioprocess Design	1.0

BT 6002	Bioseparation Engineering Lab	0.5
BT 6012	Enzyme Technology Lab.	0.5
BT 6014	Bioinformatics Lab	0.5
BT 6010	Dept. Project I	0.5

BE(Biotechnology) – VII SEMESTER

BT 7001	Biological Waste Management	1.0	BT 7006	Plant Cell Technology Lab	0.5
BT 7005	Plant Cell Technology	1.0	BT 7008	Environmental Biotechnology Lab.	0.5
BT 7007	Process Biotechnology	1.0	BT 7020	Bioprocessing Lab.	0.5
PE 7124	Engineering Economy	1.0	BT 7010	Dept. Project II	0.5

ELLECTIVE I

(Any one from following)

BT 7012	Agriculture Biotechnology	1.0
BT 7013	Bioresources & Biodiversity	1.0
MMI 1101	Human Anatomy & Physiology for Biomedical Engineers	1.0
MMI 3103	Introduction to Clinical Instrumentation	1.0

ELLECTIVE II

(Any one from following)

BT 7015	Biomaterials	1.0
BT 7017	Nano Biotechnology	1.0
MMI 3101	Biomedical Imaging Devices & Concept	1.0

BE(Biotechnology) – VIII SEMESTER

BT 8005	Protein Engineering	1.0	BT 8006	Protein Engineering Lab	0.5
BT 8007	Bioenergy	1.0	BT 8009	Colloquim	0.5
BT 8008	Functional Genomics	1.0	BT 8010	Project	1.0
BT 8016	Mineral Biotechnology	1.0			

ELLECTIVE III

(Any one from following)

BT 8011	Marine Biotechnology. & Aquaculture	1.0
BT 8012	Pharmaceutical Biotechnology	1.0
BT 8013	Biotechnology Management	1.0
MMI 2107	Fiber Optics & LASER in Medicine	1.0

ELLECTIVE IV

(Any one from following)

BT 8015	Legal and Social Issues in Biotechnology	1.0
BT 8017	Bioremediation	1.0
BT 8018	Animal & Stem Cell Technology	1.0

FIRST SEMESTER

HU 1101

TECHNICAL ENGLISH

1.0

MODULE – I

Single word substitution, Idioms and phrases, Pairs of words, Common errors, Précis, Comprehension, Expansion.

MODULE – II

Official Correspondence - Memorandum, Notice, Agenda, Minutes, Circular letter, applying for a job, Resume, Demo-official letter.

MODULE – III

Business Correspondence-Types, sales letters; Social Correspondence- Invitation to speak, Congratulations; etc.

MODULE – IV

Report writing; general and technical report, Definition, Types, structure.

MODULE – V

Technical proposals, Definitions, types and format.

MODULE – VI

Research papers and articles.

MODULE – VII

Mechanics of manuscript preparation. Phonetics (Symbols and Transcription) Daniels jones, Dictionary of pronunciations.

BOOKS FOR REFERENCE:

1. Blickle, Margaret D., and K.W.Houp.
2. Reports for Science and Industry, Henry Holt & Co. N.Y.
3. Duddy, E.A. & M.J. Freeman Written Communication in Business, Amercian book Co. N.Y.
4. Berry, Thomas Elliot, The most Common Mistakes in English Usage; Tata McGraw Hill.
5. Stevensin, B.W., J.R. Spicer and E.C. Ames, English in Business and Engineering. Prentice Hall, Eaglewood
6. Cliffs, N.J.
7. Raul, Asha, Effective Business Communication, Prentice Hall of India.
8. Singh B. Business Correspondence including Bank letters.
9. Singh B. Theory and Practice of Business Correspondence, HPJ Kapoor Publications.
10. Report Writing and Business Correspondence Mohan and Sharma, Tata McGraw Hill Publications, India.
11. Best, W.D. The Students companion, Rupa & Co. Publications.

MODULE – I

Waves and Oscillations: (SS* : Wave motion: longitudinal and transverse waves, plane waves, phase velocity). Wave packets and group velocity, wave equation, superposition of waves (RHK-Ch-18), equation of motion of simple harmonic oscillator and solutions, damped harmonic motion and forced oscillations(RHK 17.2-17.4,17.7,17.8)

[6]

MODULE – II

Fields: Vector and scalar fields, physical and mathematical concepts of gradient, divergence and curl (Cartesian coordinates only), Gauss's theorem and Stokes' theorem (Statements only, SAD-Ch.3).

[5]

MODULE – III

Electromagnetic Theory: Gauss's law in integral and differential form, electric potential and relation with E(SAD 4.5-4.8),(SS*- capacitance(SAD-6.5) and electrostatic energy density (SAD 4.10)), dielectrics, three electric vectors, dielectric susceptibility boundary conditions on E and D(SAD 5.5-5.7, 5.9).

[5]

Ampere's law in integral and differential form, applications.(SAD 7.1-7.4), Hall effect (RHK-32.4), three magnetic vectors (SAD 7.5), magnetic permeability and susceptibility, boundary conditions on B and H (SAD 8.5-8.7).

[5]

Faraday's law in integral and differential form(SAD 9.2-9.3), (SS - Inductance, magnetic energy density (SAD 8.8, 8.9)), continuity equation for charge (SAD 5.8), displacement current (SAD 9.4), Maxwell's equations in free space (SAD 9.5), electromagnetic wave equation for plane waves in dielectric medium and free space, relation between \vec{E} , \vec{B} and \vec{k} , Poynting vector (SAD 10.3-10.7).

[5]

MODULE – IV

Plasma Physics: Plasma state, types of plasma, applications of plasma(FFC-Ch-1,2)

[4]

MODULE – V**Physical Optics:**

Interference: Two-Beam Interference(AG 12.1-12.6), interference in thin films and wedge-shaped layers(AG 13.8-13.9), reflection and anti-reflection coatings(AG 13.2-13.4), applications of interferometry: Newton's rings(AG 13.10), Michelson's Interferometer (AG 13.11)

[5]

Diffraction: Fraunhofer diffraction by single slit(AG 16.1-16.3) , double slit and grating (AG 16.6-16.8), limit of resolution, Rayleigh criterion(AG 16.5), Fresnel diffraction(Qualitative, AG 17.1-17.3)

[5]

Polarization : (SS- Polarization of light, Malus's law, polarization by reflection, Brewster's law, Double refraction) Analysis of linearly and circularly polarized light(RHK 44.1-44.5), Fresnel's equations and their applications (AG 21.1-21.2)

[5]

Text Books:

1. Mathew N.O. Sadiku (**SAD**), Elements of Electromagnetics, Oxford University Press(2001)
2. A.Ghatak(**AG**), Optics, 3rd Edition, Tata Mcgraw Hill, 2005
3. Resnick, Halliday and Krane(**RHK**), Physics- Part-I & II, 5th Edition, John Wiley (2002)
4. F.F.Chen(**FFC**), Introduction to Plasma Physics, 2nd Edition, Plenum Press, 1994

References:

1. W.H.Hayt and J.A.Buck, Engineering Electromagnetics, Tata McGraw Hill (2006)
2. M.R.Srinivasan, Physics for Engineers, New Age International, 1996
3. S.N.Sen, Introduction to Plasma Physics, Pragati Prakasan, Meerut -1, India

MODULE – I

Chemical Bonding: Trends in periodic properties (ionization energy, electron affinity, electro negativity), VBT, VSEPR theory, MOT for diatomic molecules and polyatomic molecules, coordination complexes & ligands, CFT, colour and magnetism of coordination complexes, spectrochemical series

MODULE – II

Kinetics and catalysis: kinetics of chain reactions, parallel reactions, side reactions, fast reactions in solutions, flash photolysis, kinetics of catalytic action (acid base catalysis, biological catalysis), application of catalyst in industrially important processes (Haber's processes, Ostwald process, Bergius process)

MODULE – III

Thermo-chemistry and Fuels: Hess's law, entropy, enthalpy and combustion calculations, characterization and application of fossil fuels, solid fuel (carbonization & gassification), liquid fuels (refining, reforming, petrol & diesel, knocking characteristics, octane and cetane number) and gaseous fuels (water gas, producer gas, coal gas and biogas), lubricants and its properties

MODULE – IV

Electrochemistry and corrosion sciences: Redox process cell, potential and free energy, galvanic cells, electrolysis and Nernst's equation, Fuel cells, and its applications, chemical and electrochemical corrosion, general methods of corrosion prevention (with brief introduction to chemistry of paints, varnishes and enamel)

MODULE – V

Fundamentals of spectroscopic techniques: Basic principles of vibrational, rotational and Mossbauer spectroscopy

MODULE – VI & VII

Macromolecules: Classification, Addition and Condensation polymers, molecular weight of polymers (M_n , M_w , M_v), glass transition temperature (T_g), structure property relationship in polymers (chemical, electrical, optical and mechanical), examples and use of inorganic polymers, synthesis of some commercially important polymers and their use (Nylon 6, Nylon 6, 6, PE, PET, PS)

MODULE – VI & VII

An introduction to computational chemistry

Text Book:

1. Applied chemistry A text book for engineers and technologists, H. D. Gesser, Plenum publishers.
2. Inorganic chemistry: J. D. Lee.
3. Engineering chemistry: Sashi Chawla

Reference:.

1. Fundamentals of molecular spectroscopy: C. N. Banwell, TMH publication
2. Computational chemistry: E. Lewars, Kluwer publication
3. Physical chemistry: P. W. Atkins

Algebra:**Complex numbers:**

Definition Fundamentals operations with complex numbers modules, amplitude, conjugate of a complex number, Graphical representation of complex numbers, Demoivre's theorem, Roots of complex numbers.

Arithmetic Geometric and Harmonic progressions. Binomial theorem, Exponential and Logarithm series

Determinant and Matrices:

Determinants and their properties, Cramer's rule type of matrices, Addition Multiplication. Transpose, Adjoint and Inverse of a matrix Solution of linear system of equations by matrix inversion method.

10L

Trigonometry:

Circular functions, trigonometric functions and equations, sides of a triangle and T-ratios, Inverse trigonometric functions.

5L

Co-ordinate Geometry (Two dimensional):

Cartesian & Polar Co-ordinates. Distance between two points, Area of a triangle, Equation of a straight line. Angle between two lines. Distance of a point from a straight line. Equations of circle, parabola, ellipse, and Hyperbola.

10L

Vector Algebra:

Notation, Types, Addition and Subtraction of vectors, Linearly dependent & independent vectors, Scalar and vector product of two vectors.

2L

Differential Calculus:

Function, Limits and continuity, Differential coefficients, Differentiation of Algebraic, Inverse and Transcendental function, Differentiation by substitution, Differentiation of Implicit functions, Logarithmic differentiation, Differentiation of parametric equations, Geometrical meaning of the derivative Equation of tangent and normal lines to a curve. Rate measure and approximations.

10L

Integral Calculus:

Integration as the inverse process of differentiation Integration by the methods of substitution, by parts and by partial fractions, The definite integrals and their simple applications to areas.

8L

Suggested Books:

1. Senior Secondary School Mathematics, By R.S. Aggarwal, Bharti Bhawan Publications.
2. Mathematics, by R.D. Sharma, Dhanpat Rai Publications.
3. A text Book of Algebra & Co-ordinate Geometry, By K.C. Sinha, Students Friends publications..

MODULE – I

Nature of living things: Definition of life, Miller's experiment, theories and evidences of origin of life, levels of biological organization, classification of living world, difference between prokaryotes and eukaryotes.

MODULE – II

Molecular organization of cell: Difference between animal and plant cell, salient features of intracellular organelles, cell division and cell cycle.

MODULE – III

Evolutionary processes: Lamarckism, Darwinism, role of mutations and isolating mechanisms, adaptive radiation.

MODULE – IV

Fundamentals of genetics: Mendelian principles, pleiotropy, epistasis, linkage and crossing over.

MODULE – V

Animal physiology: Hormones and their mode of action, types of asexual and sexual reproduction, stages of embryogenesis.

MODULE – VI

Biology of plants: Morphology and anatomy of root, stem and leaves, reproduction in flowering plants.

MODULE – VII

Plant physiology : Water relations (absorption, adsorption, imbibition, guttation, transpiration, diffusion and osmosis), plant growth regulators (auxins, cytokinins, gibberellins, abscisic acid and ethylene).

Books Recommended:

1. Purves et al, Life: The Science of Biology
2. R. Dulbecco, The Design of Life.

Equivalent Force System and Equilibrium: Principles of statics, laws of mechanics, freebody diagram, coplanar, non-coplanar and spatial force system and conditions of equilibrium, vector representation and analysis of forces and moments, Varignon's theorem.

Structural Mechanics: Analysis of simple plane truss by method of sections and methods of joints, analysis of frames and parabolic cables, cantilever and simply supported beams with concentrated, distributed and moment loads, shear force and bending moment diagrams, concept of stress and strain.

Interfacial Friction: Friction and impending motion, static, kinetic and rolling friction, application to inclined planes, wedges, screws jacks and belts.

Kinematics and Kinetics of Particle and Rigid Bodies: Conceptual framework and vector representation of displacement, velocity, acceleration, linear and angular momentum, rectilinear and curvilinear motion in two dimensions, centroidal and non-centroidal rotation, general plane motion, Newton's laws of motion, D'Alembert's principle, equilibrium of dynamic forces.

Work and Energy: Translation and rotation of rigid body about a fixed axis, conservation of energy, energy and work equations in translation and rotational motion, virtual work.

Impulse and Momentum: Impulse force and momentum, conservation of momentum, coefficient of restitution, momentum equation. Vibrating Systems: Inertia, features of a vibrating system, free vibration, systems with single degree of freedom.

Books Recommended:

1. Kumar, Engineering Mechanics
2. Shames, Engineering Mechanics

Analytical Trigonometry:

De-Moivre's Theorem and its applications. Expansion of $\sin x$ and $\cos x$ in powers of x . Complex arguments. Separation into real and imaginary parts Gregory's Result. Expansions. Summation of trigonometric Series. Hyperbolic functions.

(8L)

Differential Calculus:

Successive Differentiation. Leibnitz's Theorem. Rolle's Theorem. Lagrange's and Cauchy's Mean value Theorem. Generalised Mean value Theorem. Taylor's and Maclaurin's infinite series. Cartesian and polar subtangent and Subnormal. Pedal equations. Orthogonal intersection of curves. Curvature and radius of Curvature in case of Cartesian parametric, polar, pedal and tangential polar forms. Centre of curvature and evolute. Indeterminate forms L Hospital's Rule. Concavity, convexity and points of inflexion. Asymptotes (cartesian Co-ordinates only).

Functions of two variables. Partial derivatives. Euler's Theorem on Homogeneous functions. Its generalisation and extension. Total differential and derivatives. Errors and Approximations. Taylor's series in case of two variables. Maxima and Minima of two variables. Lagrange's method of Undertermined multipliers in case of two and three variables. Jacobians. Envelope of curves. Tangent planes and Normal lines.

(22L)

Integral Calculus:

Reduction Formula. Beta and gamma functions. Area, length, volume and surface area without the use of multiple integrals.

(9L)

Infinite series:

Convergency and Divergency of infinite series. Tests for Convergence. Comparison Test, p series test, Cauchy's root test. D' Alembert's ratio test, Razabe's Test, Gauss's Test, Logarithmic and Higher logarithmic ratio test (No proof). Leibnitz's Rule for alternating series test.

(6L)

Book Reference:

1. Calculus for Technical Students : Part I & Part II, By Pran Nath., Tara Publications, Varanasi.
2. Engg. Mathematics by H.K. Dass, S. Chand & Co. Ltd.
3. Advanced Engg. Mathematics, E. Kreyzig, Wiley Eastern Ltd., N. Delhi.

EE 2101	BASIC ELECTRICAL ENGINEERING	1.0
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MODULE – I

Introduction: Importance of Electrical Engineering in day-to-day life. Electrical elements and their classification. KCL and KVL equations. Loop current and Node voltage method. D.C. Circuits: Steady state analysis with independent and dependent sources; Series and Parallel circuits; Star-Delta conversion. D.C. Circuit Theorems: Superposition theorem; Thevenin's & Norton's theorem; Maximum Power Transfer theorem. (12)

MODULE – II

A.C. Single-phase Series Circuits: Common signals and their waveforms. RMS and Average value. Form factor & Peak factor of sinusoidal waveform. Impedance of Series and parallel circuits. Phasor diagram. Power. Power factor. Power triangle. (5)

MODULE – III

A.C. Single-phase Parallel Circuits: Admittance method, Phasor diagram. Power. Power factor. Power triangle. (5)

MODULE – IV

Resonance and Q-factor, A.C. Circuit Theorems: Superposition theorem; Thevenin's & Norton's theorem; Maximum Power Transfer theorem. (7)

MODULE – V

Three Phase Circuits: Line and Phase relation for Star and Delta connection. Power relations. Analysis of balanced and unbalanced 3 phase circuits. (7)

MODULE – VI

Magnetic Circuits: Introduction. Series-parallel magnetic circuits. Analysis of Linear and Non-linear magnetic circuits. Energy storage. A.C. excitation. Eddy currents and Hysteresis losses. (5)

MODULE – VII

Coupled Circuits (Dot rule)

Basic Indicating Instruments: Moving coil and moving iron type instruments. (4)

Books Recommended:

1. Nagrath and Grabel, Basic Electrical Engineering
2. Fitzerald and Higinbotham, Basic Electrical Engineering

MODULE – I & II

Introduction to C++ and algorithm analysis: C++ classes, C++ details, Using matrices, Mathematical background for algorithm analysis, model and what to analyze, Running Time calculations.

MODULE – III

Lists, Stacks and Queues: Abstract Data Types, The list ADT, The Stack ADT, The Queue ADT

MODULE – IV

Trees: Preliminaries, Binary Trees, The Search Tree ADT – Binary Search Trees, AVL Trees, Splay Trees, Tree Traversals, B-Trees.

MODULE – V

Hashing and Priority Queues: Model and Simple implementations, Binary Heap, Applications of Priority Queues, d-Heaps, Leftist and Skew Heaps.

MODULE – VI

Sorting: Preliminaries, Insertion sort, A Lower Bound for Simple Sorting Algorithms, Shell sort, Heap sort, Merge sort, and Quick sort.

MODULE – VII

Graph Algorithms: Definitions, Topological Sort, Shortest Path Algorithms, Network Flow Problems and Minimum Spanning Tree.

Text Books:

1. Mark A. Weiss – Data Structures & Algorithm Analysis in C++, 2nd Edition, Pearson Education, New Delhi – 2002.

Reference:

1. Gregory L. Heilean – Data Structures Algorithms, and Object Programming, Tata McGraw Hill, New Delhi – 2002.
2. Adam Drozdek – Data Structures and Algorithms in C++, Thomson Learning (Vikas Publishing House) New Delhi – 2001.
3. John R. Hubbard – Data Structures with C++, Tata McGraw Hill, New Delhi, 2004

MODULE– I

Environmental Awareness: Multidisciplinary nature of environmental Science, Definition, scope , importance and need for public awareness

(2)

MODULE– II

Ecology and Environment: concept of an ecosystem ,structure and function of an ecosystem, producer ,consumer and decomposer, energy and nutrient flow biogeochemical cycles, food chain ,food web, ecological pyramid

(3)

MODULE– III

Environmental Pollution : Segments of environment, sources, pathways and fate of environmental pollutants, causes of environmental pollution , physical ,chemical and biological transformation of pollutants , population explosion, environment and human health, human rights, value education ,women and child welfare

(5)

MODULE– IV

Air Pollution: various segments of atmosphere and their significance,classification of air pollutants, toxic effects, sampling and analysis, stationary and mobile emission, sources and their control, photochemical smog ,sulphurous smog, green house effect, global warming, ozone depletion, Air (prevention and control of pollution) Act

(10)

MODULE– V

Water Pollution: Water resources ,sources of water pollution ,various pollutants, their toxic effect, potability of water , municipal water supply , disinfection, characteristics of waste water, primary and secondary waste water treatment, BOD and COD measurement and their significance ,rain water harvesting ,water shed management,Water (pollution and control) Act.

(12)

MODULE– VI

Natural Resources and Biodiversity: Renewable and non renewable resources, Forest resource, consequences of deforestation, floods and draughts, equitable use of resources for sustainable development, Dams benefits and problems, Biodiversity: ecosystem diversity , threats to biodiversity, conservation of biodiversity.

(4)

MODULE– VII

A brief introduction to Noise Pollution, Soil Pollution, Solid Waste Management.

(4)

Books Recommended:

1. Sharma and Kaur, Environmental Pollution
2. De, Environment Chemistry

MODULE – I**Special Theory Of Relativity**

Postulates, Galilean transformations, Lorentz transformations, length contraction, time dilation, velocity addition, mass change and Einstein's mass energy relation. (AB: 1.1,1.2,1.4,1.7,1.8,1.9, and Appendix to chapter-1

[6]

MODULE – II**Quantum Mechanics:**

Planck's theory of black-body radiation (AB: 2.2, 9.5, 9.6), Compton effect (AB: 2.7), wave particle duality, De Broglie waves, Davisson and Germer's experiment (AB: 2.4, 3.1, 3.2, 3.3, 3.4, 3.5), uncertainty principle (AB: 3.7, 3.8, 3.9), physical interpretation of wave function and its normalization (AB: 3.2), expectation value (AB: 5.4).

[8]

Schrodinger equation in one dimension (AB: 5.2), solutions of time-independent Schrodinger equation for free particle (AB: 3.6, 5.5, 5.6), particle in an infinite square well, potential barrier and tunneling (AB: 5.7, 5.8), hydrogen atom (qualitative) (HRW: 40-8).

[8]

MODULE – III**Statistical Physics And Thermodynamics:**

Elementary ideas, comparison of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics (AB: 9.1, 9.2, 9.3, 9.4).

[4]

Zeroth law, first law, second law, entropy, heat transfer, steady state one-dimensional heat conduction [(HRW: 19-2, 19-9, 21-3, 19-11), (SS: 14.2, 14.7)].

[6]

MODULE – IV**Lasers And Applications:**

Emission of light by atoms, spontaneous and stimulated emission (AB: 4.9, and AG: 23.1), Einstein's A and B coefficients, laser: population-inversion (AG: 23.4), properties of laser radiation, Ruby & He-Ne lasers, applications of lasers (AB: 4.9) and AG: 23.1), elementary ideas of holography (AG: 18.1) and fiber optics (AG: 24.1-24.3).

[8]

MODULE – IV**Nuclear Physics:**

Nuclear forces, binding energy, liquid drop model (AB: 11.1-11.6), fission, nuclear reactors, fusion, energy processes in stars, controlled thermonuclear reactions (AB: 12.9-12.12).

[5]

Text Books:

1. Arthur Beiser, Concepts of Modern Physics, 5th edition, Tata McGraw Hill, 1997.
2. Ajoy Ghatak, Optics, 2nd edition, Tata McGraw Hill, 1997.

Reference Books:

1. Jasprit Singh, Modern Physics for Engineers, John Wiley & Sons, 1999.
2. Kenneth Krane, Modern Physics, 2nd edition, John Wiley & Sons, 1998.
3. Wehr, Richards and Adair, Physics of the Atom, 4th edition, Addison Wesley.

Structure, bonding and reactivity. Energy of activation and transition state. Stereochemistry and stereospecific reactions: Conjugation and resonance. Aromaticity, carbonium ions, carbanions, free radicals and carbenes. Aliphatic and aromatic nucleophilic substitutions, Aliphatic and aromatic electrophilic substitutions, Addition and elimination reactions, Rearrangements, Oxidations and reductions. Heterocyclic compounds: Chain polymerization, Concept of functionality and step polymerization, Interfacial condensation and phase transfer catalysis, Group transfer polymerization, Olefin metathesis, Insertion reaction. Determination of organic structure by elemental analysis and spectroscopy, Ultraviolet spectroscopy, Infra-red spectroscopy, Mass spectrometry, Nuclear magnetic resonance spectroscopy, Electron spin resonance spectroscopy.

Books Recommended:

1. Morison and Boyd, Organic Chemistry
2. Finar, Organic Chemistry.

MODULE – I

Introduction: Importance of Electrical Engineering in day-to-day life. Electrical elements and their classification. KCL and KVL equations. Loop current and Node voltage method. D.C. Circuits: Steady state analysis with independent and dependent sources; Series and Parallel circuits; Star-Delta conversion. D.C. Circuit Theorems: Superposition theorem; Thevenin's & Norton's theorem; Maximum Power Transfer theorem.

(12)

MODULE – II

A.C. Single-phase Series Circuits: Common signals and their waveforms. RMS and Average value. Form factor & Peak factor of sinusoidal waveform. Impedance of Series circuits. Phasor diagram. Power. Power factor. Power triangle.

(5)

MODULE – III

A.C. Single-phase Parallel Circuits: Admittance method, Phasor diagram. Power. Power factor. Power triangle.

(5)

MODULE – IV

Resonance and Q-factor, A.C. Circuit Theorems: Superposition theorem; Thevenin's & Norton's theorem; Maximum Power Transfer theorem.

(7)

MODULE – V

Three Phase Circuits: Line and Phase relation for Star and Delta connection. Power relations. Analysis of balanced and unbalanced 3 phase circuits.

(7)

MODULE – VI

Magnetic Circuits: Introduction. Series-parallel magnetic circuits. Analysis of Linear and Non-linear magnetic circuits. Energy storage. A.C. excitation. Eddy currents and Hysteresis losses.

(5)

MODULE – VII

Coupled Circuits (Dot rule), Self and mutual inductances, Coefficient of coupling.

Basic Indicating Instruments: Moving coil and moving iron type instruments.

(4)

Text Books:

1. Basic Electrical Engineering, Fitzgerald, Hinginbotham
2. Basic Electrical Engineering I.J. Nagrath and D.P. Kothari, 2nd Edition, TMH, Delhi.

Reference Books:

1. Electric circuits- Schaum Series
2. Electrical Engineering- Del Toro.
3. Basic Electrical Engineering- Mittle.

Population and samples, Types of variables, Plotting the data, Probability, Random samples, Binomials, Poisson and normal distributions, Chi-squared tests: goodness-of-fit tests and contingency tables, Sampling distributions, Standard error, Confidence intervals for means, Significance tests on means, Students t distribution, Analysis of variance, Fisher's F distribution, Simple linear regression, Correlation coefficient, Non parametric tests.

Books Recommended:

1. Godfrey, Roebuck and Sherlock, Concise statistics
2. Mahajan, Method of Biostatistics

Introduction to chemical engineering calculations- Units and dimensions, mole units, basis of calculations, the chemical equation and stoichiometry, dimensional analysis.

Material balance fundamentals, conversion and yield, material balance problems that do not involve chemical reactions.

Material balance problems that involve chemical reactions, recycle, bypass and purge calculations.

Ideal Gas Law, real gas relationship, vapor pressure, saturation and equilibria.

Vapor-liquid equilibria, partial saturation and humidity, condensation and vaporization.

Energy balance concepts and units, enthalpy changes, general energy balance that do not involve reactions.

Energy balance that involves chemical reactions, Heat of solution and mixing, Humidity charts and their use.

Books Recommended:

1. Himmelblau, Basic Principles and Calculations in Chemical Engineering.
2. Hougen, O.A. and Watson, K.M. Chemical Process Principles (Part I)

Introduction: Concept of Continuum. Macroscopic approach, Thermodynamics system control volume intensive and extensive properties, Thermodynamic equilibrium, State of system, state diagram, path and process, Zeroth law Thermodynamics, concept of temperature, Heat and work. Thermodynamic properties of pure substances in solid, Liquid and vapour phases, Equations of state, Thermodynamic property table and charts. First law of Thermodynamics: Energy and its forms, Enthalpy, specific heats, Compressibilities and expansion coefficient, First law applied to control volumes (Open System) – Steady & Unsteady flow analysis, Typical applications. Second Law Of Thermodynamics: Second Law, Kelvin-Planck and Clausius statement. Corollaries of Second Law – Reversible and irreversible processes, Thermodynamic (absolute) temperature scale. Entropy: Inequality of Clausius and concept of Entropy. Entropy change of a system and Control Volume. Principle of increase of Entropy, available and Unavailable Energy. Ideal Gases: Definition, Specific Heats, Entropy change for Flow and Non-Flow processes. Cycles: Simple Vapour power cycles – Carnot, Rankine. Air-Standard Cycles – Joule, Otto, Diesel Cycles. Vapour compression refrigeration cycle.

Gibbs – Duhem equation, phase rule, single component phase equilibria. Thermodynamics of solutions. Ideal and non-ideal solutions. Estimation and determination of activity coefficients. Regular solution theory. Fugacity and properties of mixture. Chemical reaction equilibria. Homogeneous and heterogeneous reaction systems. Thermodynamic analysis of biochemical reactions. Classical and non-equilibrium thermodynamics of biochemical reactions.

Books Recommended:

1. P.K. Nag, Thermodynamics
2. Wylen, Fundamentals of classical thermodynamics.
3. Denbigh, Principles of chemical equilibria
4. Dodge, Chemical engineering thermodynamics
5. Stephanopoulos et al, Metabolic engineering, Principles and Methodologies.

Introduction To The Cell: Evolution of cell, prokaryotic and eukaryotic cell, unicellular and multicellular organisms.

Cell Organelles: Cell wall, cell membranes, cytosol, mitochondria, chloroplast, nucleus, ribosome, liposomes, golgi body, endoplasmic reticulum, motility organelles, flagella, pilli, cilia

Molecular Genetics: Cell division, mechanism of cell division, mechanism of cell development, formation of tissues.

Cell Signaling: General principles of cell signaling, Signaling via G-Protein linked cell-surface Receptors, Signaling via Enzyme-linked cell-surface Receptors, target cell adaptation

Cell Kinetics: Concept of free energy, laws of thermodynamics, entropy, Gibbs free energy

Chromosomes: Chromosomal DNA and its packaging, The global structure of chromosomes, chromosome replication

Reaching Cell: Fractionation of subcellular organelles, Microscopy(SEM, TEM, Confocal microscopy, Phase contrast microscopy, Fluorescent microscopy), micrometry, Nephelometry, hemacytometer, flow cytometry

Books Recommended

1. Alberts et al, Molecular Biology of the Cell
2. Lodish et al, Molecular Cell Biology
3. DeRobertis, Cell Biology
4. Harper, The Cell

Introduction: Composition of living matter, major classes of biomolecules in cell, chemical evolution of biomolecules. Physical properties and hydrogen bonding of H₂O, hydrophobic interaction, Vander Waal's interactions, ionic interactions, ionisation of water, Henderson-Hassel Balch equation, pH scale, idea about buffer.

Nucleic acids: Generalised structural plan of nucleic acids (DNA,RNA), Nucleotides, Nucleosides, Features of DNA double helix, phosphodiester bonds, hypochromic effect, different types of DNA, Denaturation.

Proteins: Structure and properties of 20 amino acids, Zwitterion nature of amino acids in aqueous solution, Abbreviation and classification of 20 amino acids, titration curve of glycine, peptide bond formation, definition of N-terminal and C-terminal amino acids, basic understanding of primary, secondary, tertiary, quaternary structure of proteins, Ramachandran plot, elementary idea of protein denaturation and loss of biological activity.

Enzymes: IUB enzyme classification (overview), Lock and key model and induced fit model apoenzyme, holoenzyme, Mechanism of enzyme action by lowering activation energy, concept of active site, Michaelis Menten equation, Effect of temperature, pH and substrate concentration on enzyme action, enzyme turnover number Specific activity, factors contributing catalytic efficiency of enzymes, Enzyme inhibition – reversible and irreversible inhibitors, competitive, non-competitive uncompetitive inhibition (brief idea).

Carbohydrates: Definition, empirical formula, classification into mono, oligo, & polysaccharides, Optical isomerism, mutarotation, structure of biologically important carbohydrates (D-glucose, D-galactose, D-mannose, D-ribose, D-2 deoxyribose), formation of D-maltose, D-sucrose, D-lactose, Polysaccharides such as starch, glycogen, cellulose, mucopolysaccharides.

Lipids: Definition, general formula of fatty acids, properties of fatty acids, general structure and function of major lipid sub-classes: triacylglycerol, phosphoglycerides, sphingolipids, waxes, sterols, Suitability of triglycerides as storage lipids.

Vitamins & Minerals: Different types of vitamins – water soluble and fat soluble, role of vitamins as coenzyme precursors and enzyme prosthetic group (general treatment), details of coenzyme function of NAD, & pyridoxal phosphate. Role of inorganic elements like Iron, Copper, Zinc, Manganese, Cobalt, & Selenium.

Books Recommended:

1. Albert Lehninger, Principles of Biochemistry
2. Lehninger, Nelson, Cox, Principles of Biochemistry
3. Cohn and Stumpf, Outlines of Biochemistry
4. Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Biochemistry
5. R.K. Murray, D.K. Granner et al., Harper's Biochemistry
6. Voet & Voet, Biochemistry

DNA structure: DNA as genetic material, structure of DNA, DNA replication, repetitive DNA, kinetics of DNA renaturation.

Chromosome biology: Ultrastructure of Chromosomes, Structure of centromere and telomere, Molecular organization of chromosomes, genetic recombination.

Genetic organization: Discovery and salient features of genetic code, overlapping genes, organellar genetic code, colinearity of genes and protein, organelle and extranuclear inheritance.

Regulation of gene activity: Central dogma, difference in genetic organization of prokaryote and eukaryote, *lac* operon, *trp* operon, regulation of bacteriophage λ life cycle, nucleic acid binding motifs in regulatory proteins.

Mutation: General properties and types of mutation, DNA damage and repair, reverse and suppressor mutations, duplications, deletions, inversions and translocations, polyploidy, transposable elements, inborn errors of metabolism.

RNA: RNA synthesis, RNA processing and RNA editing.

Protein: Protein synthesis, Posttranslational modifications.

Books Recommended:

1. Alberts et al, Molecular Biology of the Cell
2. Lodish et al, Molecular Cell Biology.

Introduction: Microbes and man, History of Microbiology, Methods in Microbiology- Microscopy, Methods of sterilization; culture media, Pure culture methods, Staining of Bacteria, Micrometry, culturing cells and spores, Classification of microorganisms into different groups: Bacteria, Viruses, Fungi, Actinomycetes, Outline of classification of bacteria and fungi

Structure of Microorganisms and Microbial Metabolism: Fine structure of bacteria, Archaeobacteria, Mycoplasmas, Mycobacteria, Myxobacteria, Rickettsiae and chlamydiae, structure and classification of Viruses (Bacteriophage, Oncogenic viruses), Growth of Microorganisms, Cell cycles, Population growth, Batch culture, Continuous culture, Synchronous growth, Fed-batch culture.

Microbial Genetics: Control of transcription, Mutation in microorganisms, Recombination in prokaryotes, Genetic Engineering, Modern application of Genetic Engineering, Transposable genetic elements.

Environmental Microbiology: Distribution of Microbes in Air and water, Allergic disorders by air microflora, air sampling, Microbial components of water, Water treatment, Bacteriological analysis of water. Microbiology of Extreme environments (Methanogens, Halobacteria, Thermoacidophiles), Thermophilic eubacteria, Microbiology of sewage

Agricultural Microbiology and Microbial Biotechnology:

Microbial Biodeterioration of agricultural products, Mycotoxins, control of microbes and safe storage of agricultural products, RH value, Aw values. Microbes in metal recovery, microbes in paper industries, Microbes as a source in vitamin production. Industrially important micro-organisms, secondary metabolites from micro-organisms.

Food Microbiology: Microbiology of foods, Types of microbes associated with food spoilage, food Preservation methods, Microbiology of Milk and dairy products, Microbiological examination of milk, Food Poisoning, Important Fermented foods, Single cell Protein.

Medical Microbiology: Diseases caused bacteria, virus, fungi, and protozoans; Fungal diseases (Mycoses), Immunity and types of Immunity, Vaccines, Anti microbial agents, Antibiotics and disinfectants, Classification of antibiotics (Broad spectrum and narrow spectrum), National Immunization Programme,

Books Recommended

1. Pelczar, Chan and Krieg, Microbiology
2. Stanier et al, General Microbiology.

Basic Equations of Fluid Flow: Fluid-Flow Phenomena, Newtonian and non-Newtonian fluids, Turbulence and its nature, Reynolds number and transition from laminar to turbulent flow, flow in boundary layers, boundary layer formation in straight tubes, continuity equation, Bernoulli equation with and without fluid friction, pump work in Bernoulli equation, angular momentum equation.

Flow of Incompressible Fluids: Fluid flow in pipes, friction factor, laminar flow in pipes, Hagen-Poiseuille equation, turbulent flow in pipes and closed channels, effect of roughness, friction factor charts, Reynolds numbers and friction factor relationship, friction losses from sudden expansion and contraction of cross section, flow of liquids in thin layers.

Flow of Compressible Fluids: Processes of compressible flow, Flow through variable-area conduits, adiabatic frictional flow, isothermal frictional flow, flow past immersed bodies, drag coefficients, stagnation point and stagnation pressure, motion of particles through fluids, hindered settling, fluidization, minimum fluidization velocity, types of fluidization.

Transportation and Metering of Fluids: pipe fittings and valves, positive displacement pumps, centrifugal pumps, head losses in centrifugal pump, blower and compressor, flow measuring devices such as venturimeter, orifice meter, pitot tube and rotameter.

Heat transfer by conduction in solids: Fourier's Law, thermal conductivity, Steady state conduction, compound resistance in series, heat flow through a cylinder, one dimensional unsteady state heat conduction.

Heat transfer by convection: Thermal boundary layer, Heat transfer by forced convection in laminar and in turbulent flows, heat transfer by natural convection in laminar flow, heat transfer from condensing vapors, filmwise and dropwise condensation.

Radiation heat transfer: Fundamental facts concerning radiation, emission of radiation, black body radiation, absorption of radiation by opaque solids, Kirchhoff's Law, radiation between surfaces, view factors, combined heat transfer by conduction-convection and radiation.

Books Recommended:

1. McCabe, Smith and Harriot, Unit Operation of Chemical Engineering
2. Fox and McDonald, Introduction to fluid mechanics
3. Hollman, Heat transfer, 8th Ed.
4. Foust, Wenzel, Clump, Maus and Andersen, Principles of Unit Operations.
5. Geankoplis, Transport processes and unit operations

Introduction: First and second law of thermodynamics, standard free energy, reasons for high standard free energy of hydrolysis of ATP, Electron transport, oxidative phosphorylation, chemiosmotic model, prevention of oxidative phosphorylation by uncoupling agents and ionophores. Metabolism – anabolism / catabolism, differences between catabolic & anabolic pathways.

Anaerobic Carbohydrate Metabolism: Individual reactions of glycolysis, entry of galactose & fructose in glycolysis, utilization of sucrose and lactose, alcoholic fermentation, reduction of Pyruvate to lactate, glycogenolysis, biosynthesis of starch & sucrose, gluconeogenesis, regulation of glycolysis.

Citric acid cycle: Oxidation of Pyruvate to Acetyl CoA, individual reactions of TCA cycle, energetics of the cycle, Anaplerotic reactions, regulation of TCA

Lipid Metabolism: Individual reactions of beta oxidation pathway, omega oxidation, oxidation of unsaturated fatty acids and odd chain fatty acids, formation of ketone bodies, biosynthesis of fatty acids, role of serum lipoproteins (LDL & HDL) in the development of coronary heart disease..

Nitrogen Metabolism: Transamination, deamination reactions, transport of ammonia from peripheral tissues to liver by glutamine, excretion of nitrogen (Ammonotelic, Ureotelic, & Uricotelic), Urea cycle (preliminary account), Metabolism of purines & pyrimidines (preliminary account), biosynthesis of non-essential amino acids, Amino acids as precursors of biological amines like dopamine, non epinephrine, epinephrine, GABA, & Histamine.

Transport across cell membrane: Passive transport (transport of chloride and bicarbonate across erythrocyte membrane, glucose transport), Active transport (Primary & secondary), Na⁺ and K⁺ pump, glucose transport in intestinal epithelial cells, symport, antiport, and uniport (examples), ion channels (voltage gated and ligand gated) brief idea .

Enzymes Immobilization: Definition, methods of immobilisation -covalent coupling to supports (brief), physical adsorption, entrapment, chemical aggregation, microencapsulation, immobilisation through carbohydrate chains. Effect of pH, temperature, chemical denaturants on immobilised enzymes. Applications of immobilised enzymes (brief)-in medicine, industry, analysis, basic research.

Books Recommended:

1. Albert Lehninger, Principles of Biochemistry
2. Lehninger, Nelson, Cox, Principles of Biochemistry
3. Cohn and Stumpf, Outlines of Biochemistry
4. Lubert Stryer, Jeremy M. Berg, John L. Tymoczko, Biochemistry
5. M. Treven, Immobilized Enzymes
6. R.K. Murray, D.K. Granner et al., Harper's Biochemistry
7. Voet & Voet, Biochemistry

The general control system, transfer functions, process characteristics.

Concept of feed back and feed forward control system, process measurements- temperature, pressure, flow, level, physical properties - density, viscosity, pH, power, rotational speed.

Final control element, control valves and their characteristics, the controller, proportional integral, proportional integral derivatives controller, pneumatic and hydraulic controller. Servomotor technology in control.

Control system dynamics: transfer function of first order, second order systems. Response of control loop components to forcing functions. Transfer function of feedback control system. Tests for unstable system.

Advanced control systems: multivariable control problem, ratio control, cascade control, computed variable control, feed forward control, override control, adaptive control.

Application of computer control, on line computer control, servomotor technology in control, brief idea about application of dynamic matrix control, predictive control, Fuzzy logic control.

Control of heat exchanger, distillation column, bioreactor control system analysis.

Books Recommended:

1. Coughanouer and Koppel, Process System analysis and Control
2. Perry's Chemical Engineers Handbook.

Centrifugation Techniques: Introduction, basic principle of sedimentation, basic idea of types of centrifuges, density gradient centrifugation, preparative centrifugation, analysis of subcellular fractions, & applications of analytical centrifugation.

Chromatographic Techniques – I: (a) Introduction to chromatography; General principles, column chromatography – columns, stationary phases. Packing of columns, application of sample, column development, fraction collection and analysis). Partition and adsorption chromatography (brief idea). (b) Affinity Chromatography; Principle, materials – matrix, selection of attachment of ligands, practical procedures, specific and non-specific elution, applications. (c) Ion Exchange Chromatography: Principle, types of exchangers, materials, choice of exchangers and buffers and applications. (d) Gel Filtration: Principle, idea of distribution coefficient, exclusion limit, fractionation range, bed volume, void volume, elution volume, chemical properties of gel and applications.

Chromatographic Techniques – II: (a) Gas Chromatography: Principle of GC system, solid support, capillary column, stationary phase, preparation and application of sample, separation conditions, detection systems and applications. (b) HPLC: Principle, components of HPLC system, column, column packing, chromatographic solvents, pumping systems, detectors systems, and its applications.

Electrophoresis: (a) General principle, factors affecting electrophoresis – voltage, current, resistance, buffer – composition, concentration, pH. (b) Gel electrophoresis; Types of gels (starch, agarose, polyacrylamide), Idea of electrophoresis unit, preparation of gel, sample application, running the samples, SDS-PAGE - Principle, apparatus and methods, gradient gels, Two dimensional gels, isoelectric focusing.

Spectroscopy – I: (a) Spectroscopic Techniques; Introduction, Energy levels and transition of electrons, Types of spectra, Beers Lamberts law, molar and extinction coefficient, limitations of Beers Lamberts law. (b) Visible and UV Spectrophotometry; Principles, Instrumentation and applications. (c) Spectrofluorimetry; Principle, stoke's shift, quantum efficiency, instrumentation, & applications

Spectroscopy – II: (a) Atomic and Flame spectrophotometry; Principles, Instrumentation & applications for flame emission / atomic absorption spectrophotometry and their comparative study. (b) Mass spectrometry; Principles, Instrumentation and applications

Thermal Analysis: Differential scanning calorimetry and differential analysis - Instrumentation, Thermogravimetry, Methodology of Thermogravimetry, differential scanning calorimetry and differential thermal analysis.

Books Recommended:

1. K. Wilson & K.H. Goulding, A biologist's guide to Principles and Techniques of Practical Biochemistry.
2. Willard and Merrit, Instrumental Methods and Analysis
3. Ewing GW Instrumental Methods of Chemical analysis.

FIFTH SEMESTER

BT 5001

CHEMICAL ENGINEERING III

1.0

Phase diagram, temperature concentration diagram, enthalpy concentration diagram, Ideal solution, Rault's Law, relative volatility, azeotropes. Differential distillation, flash vaporization, vacuum and steam distillation

Multistage contact operations, characteristics of multistage towers, McCabe Theile Method, reflex, maximum, minimum and optimum reflex, tray efficiency, determination of height and column diameter.

Ternary liquid equilibria, triangular graphical representation, concept of theoretical or ideal stages and multistage continuous operation.

Leaching, solid-liquid equilibrium, equipments used in solid-liquid extraction. Single and multiple contact. Overall stage efficiency, graphical determination of number of stages.

Description of adsorption and absorption processes and their applications, types of adsorption, nature of adsorbents adsorption equilibria.

Properties and handling of particulate solids, size reduction, screening and particle size distribution.

Drag force and terminal settling velocity, principles of filtration, centrifuges.

Books Recommended:

1. McCabe, Smith and Harriot, Unit Operations of Chemical Engineering
2. Foust et al, Principles of Unit Operations.
3. Treybal, R.E. Mass Transfer Operations
4. Badger and Banchero. Introduction to Chemical Engineering.

Overview of Recombinant DNA Technology: Basics Of Recombinant DNA Technology: safety guidelines of recombinant DNA research.

Gene Regulation: Genetic elements that control gene expression in prokaryotes and eukaryotes, Role of genes within cells.

Polymerase Chain Reaction: Thermostable DNA Polymerases, PCR technique, Inverse PCR, Nested PCR, RACE PCR, RealTime PCR, Site directed mutagenesis,

Methods In Genetic Engineering: Restriction and modifying enzymes, Restriction mapping, Southern blot, Northern blot, Western blot, SAGE.

Creation Of Recombinant Molecules: Characteristics of plasmid and other cloning vectors, artificial chromosomes, prokaryotic and eukaryotic expression vectors, Recombinant Protein purification by IMAC method.

Libraries: Genomic, cDNA, EST, Cot-based, Screening of libraries with DNA probes and with antisera. Large insert genomic libraries and physical mapping Strategies and approaches to genome sequencing

Applications Of Recombinant DNA Technology: Transgenic plants and animals, DNA vaccine, Gene therapy, PCR based diagnosis.

Books Recommended:

1. Old and Primorose- Gene Manipulation
2. Alberts et al, Molecular Biology of the Cell
3. Watson, Recombinant DNA.

Introduction and history. The immune system, innate and acquired immune system, components of immune system, role of humoral and cell-mediated immunity.

Antibodies, the genetic basis of antibody diversity, structure-function, immunoglobulin classes. Polyclonal and Monoclonal antibodies, Catalytic antibodies.

Structure and properties of antigens, biological aspects of antibody-antigen interaction.

Identification and measurement of antibodies and antigens, Radial Immuno diffusion, Ouchterlony Double diffusion, Immuno electrophoresis, Radio Immunoassay, ELISA, Western blot, Immunofluorescence. Agglutination and complement

Hypersensitivity, Type I, Type II, Type III, Type IV

Major histocompatibility complex, Development of DNA vaccine
Immunological disorders

Books recommended

1. Roitt, Essential Immunology
2. Jareway et al, Immunology, the immune system in health and disease

Cell growth and bio-product formation kinetics: Quantification of cell growth, growth patterns and kinetics in batch culture, environmental factors affecting growth kinetics, heat generation by microbial growth, unstructured non segregated model, models for transient behavior, kinetics of product formation.

Mass balance and yield concepts: Yield and maintenance coefficients, calculation based on elemental balances, degree of reduction, theoretical predictions of yield coefficients.

Enzyme kinetics: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, models for more complex enzyme kinetics, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems, brief introduction to large scale enzyme production.

Media and air sterilization: introduction and the kinetics of death, batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters.

Agitation and aeration: types of impellers and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (k_La), measurement of k_La , power requirement for agitation in gaseous and non gaseous systems.

Operating considerations for bioreactors: Choosing the cultivation methods, Batch, fed-batch and continuous bioreactors:

Scale up, operation and control of bioreactors: Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and control.

Books Recommended:

1. Lee, Biochemical Engineering
2. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
3. Aiba and Humphary. Biochemical Engineering
4. Doran, Bioprocess Engineering Principles
5. Bailey and Ollis, Biochemical Engineering Fundamentals

Kinetics of homogeneous reactions: classification of reactions, reaction rate, speed of reaction, rate equation, concentration-dependent term of rate equation, rate constant, order and molecularity, representation of elementary and nonelementary reactions, kinetic models for nonelementary reactions, temperature-dependent term of a rate equation, activation energy and temperature dependency.

Kinetic analysis of batch reactor data: Integral and differential methods for analyzing kinetic data, interpretation of constant volume batch reactor, data for zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, auto catalytic reaction.

Kinetic interpretation of batch reactor data for single reactions: interpretation of variable volume batch reaction data for zero, first and second order reactions, Ideal batch reactor, steady state CSTR and plug flow reactors and their use for kinetic interpretation.

Design for single reaction: size comparison of single reactors, plug flow reaction in series and/or parallel, equal and different size of mixed reactor in series, finding the best system for given conversion, recycle reactor, Design of multiple reactions in batch, CSTR and PFR,

Energy balance equations: equations for batch, CSTR and PFR and their application to the design of reactors, concepts of non-ideality, residence time distribution of fluids in vessels, models for non-ideal flow.

Reaction catalyzed by solids: introduction to heterogeneous reactions, rate equation for surface kinetics, pore diffusion resistance combined with surface kinetics, porous catalyst particles, performance equations for reactors containing porous catalyst particles, experimental methods for finding rates, advantages and disadvantages of packed bed and fluidized bed catalytic reactors.

Biochemical reaction systems: enzyme fermentation, Michaelish-Menten kinetics, inhibition by foreign substances, kinetics of competitive and noncompetitive inhibitions, microbial fermentation, batch fermentor and mixed flow fermentor, kinetic expressions of fermentation.

Books Recommended:

1. Levenspiel, O. Chemical Reaction Engineering Ed.3, John Wiley & Sons (Asia)
2. Smith, Chemical Engineering Kinetics.
3. Fogler, Elements of Chemical Reaction Engineering

Microbiology of soils: history of soil microbiology, soil & its properties, soil microorganisms, factors influencing soil microbial population, ecology of soil microorganisms.

Microbial Interactions in soil: Parasitism, Commensalism, Symbiosis and related microbial interactions, Rhizosphere and Rhizoplane, Bioinoculants.

Biological control of plant diseases, Role of Signal transduction cascades in pathogenesis, Role of Avr (Avirulent) & Vr (Virulent) genes, Recent advances in plant diseases control with special reference to plant microbe interactions.

Aquatic microbiology: microbiology of sewage, aquatic microorganisms & their interactions, Role of relative humidity (RH) & water availability (Aw) in Microbial interactions

Food Microbiology: Microbial contamination of food & food products (Milk products, Cereals, Meat, Fish) Microbiological examination of food.

Microbial flora of healthy human host, host – microbe interactions, natural resistance and nonspecific defense mechanisms. Microbial agents of disease

Epidemiological details of infectious diseases with special reference to host-microbe interactions (Cholera, typhoid, Q-Fever, AIDS, Hepatitis, Otomycosis)

Books Recommended:

1. Pelczar, Chan and Krieg, Microbiology
2. Stanier et al, General Microbiology
3. Rangaswamy et. al. Agriculture Microbiology
4. Gary Stacey, & Noel T. Keen Plant-Microbe interactions
5. Effect of Mineral-Organic-Microorganism Interactions on Soil by J. Berthelin, P. M. Huang, J. M. Bollag, F. Andreux (Plenum Publishing Corporation)

Separation of insoluble products: sedimentation, filtration, centrifugation, coagulation and flocculation.

Cell Disruption: Mechanical methods, Non-mechanical methods.

Separation of soluble products: Liquid-liquid extraction, aqueous two-phase extraction, precipitation, adsorption.

Dialysis, electro-dialysis, ultra-filtration and micro-filtration, cross-flow ultra-filtration and micro-filtration.

Chromatography: Adsorption chromatography, Ion- exchange chromatography, gel-filtration chromatography, affinity chromatography, high pressure liquid chromatography, hydrophobic chromatography.

Chromatography scale-up.

Crystallization and drying.

Books Recommended:

1. M.R. Ladisch, Bioseparations Engineering, Wiley Interscience 2001
2. Kennedy and Cabral, Recovery processes for biological materials.
3. Heinemann, Product Recovery in Bioprocess Technology, Butterworth Publication.

Discovery, classifications and nomenclature of enzymes. Enzyme isolation. Enzyme assay, Intracellular localization of enzymes. Isozymes, Multienzyme complex, and multifunctional enzymes.

Enzyme kinetics and kinetics of enzyme inhibition. Competitive, non-competitive and uncompetitive inhibition of enzymes. Double reciprocal plots. Effect of PH, temperature, substrate and enzyme and inhibitors concentration on enzyme kinetics. Phenomena of allosterism and allosteric kinetics.

Enzyme memory and pnenomical enzymes. Mechanism and action of chymotrypsin, glyceraldehyde, 3- phosphate dehydrogenase, lysozyme, carboxypeptidase, ribonuclease, aldolase and ribozyme.

Molecular structure and function of enzymes. Physico-chemical characterization of enzymes. Folding and active site formation in enzymes. Stability of enzymes: Enzyme stabilization by selection and genetic engineering, protein engineering, reaction environment rebuilding.

Techniques used in the purification of the enzymes. Criteria of enzyme homogeneity, Techniques used for determination of native and sub-unit molecular weight of enzymes.

Bio-separations in enzymology: solid-liquid separation (filtration, centrifugation, membrane, flocculation), extraction, concentration (reverse osmosis, ultrafiltration), drying, instrumentation (GC/HPLC).

Enzyme immobilization, production and application of free and immobilized enzymes in food and feed, detergent, textiles, pulp and paper, pharmaceuticals, diagnostics.

Books Recommended:

1. Godfrey and West, Industrial enzymology
2. Dordick, Biocatalyst for industry.
3. Bommarius, A.S. et al., Biocatalysis: Fundamentals and Application- Wiley Publication
4. Hans Bisswanger, Enzyme Kinetics- Wiley Publication
5. Methods in Enzymology- A series.

History of Bioinformatics; Biological information resources and retrieval system; Knowledge Discovery and data mining; data characteristics and presentation.

Molecular databases (Sequence and structural); database searching (keyword and sequence homology searching using BLAST and FASTA); sequence alignment (pair wise and multiple);

Computational Methods: Gene identification methods; data mining (Genome databases) and phylogenetic analysis; Predictive methods using nucleic acids and protein sequences.

Bioinformatics Software; Molecular structure drawing tool (Chemdraw); VMD/Rasmol/Insight-II; Clustal X1.8; OLIGO; Molecular modeling/ Docking(CAChe);

Gene identification methods; Genomics and Human genome project; Strategy of genome sequencing;);

Biological Data bases and their management; Introduction to SQL (Sequence Query Language)

Concept on data base in Protein and nucleic acids, Various programmes for sequence comparison and analysis,

Genome projects (human, Rice), Molecular modeling and structure function relationship, Proteomics, Molecular Dynamics. Current trends and future prospects of bioinformatics

Books Recommended:

1. Gibas C, Jambeck P; Developing Bioinformatics Computer Skills.
2. Baxevanis AD, Ouellette BFF (eds): Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins
3. Higgins D, Taylor W (eds): Bioinformatics: Sequence, Structure and Databanks.

An introduction to the chemical, physical and biochemical properties of foods; food proteins, lipids, carbohydrates, nucleic acids, vitamins, minerals, pigments.

Food enzymes, main classes and factors affecting their activity. Food rheology, application of rheology in food system. Food texture studies.

Introduction to food preservation and food processing; heating, chilling, freezing, dehydration; use of salt, sugar, acid, chemical preservatives, modified atmospheres in food preservation; water relations and chemical and microbial stability of foods.

Fermentations: selection of cultures, bacterial cultures, Yeast cultures, leavening

Beverages, Brewing of beer, wine and distilled liquors

Fermented Vegetables, fermented dairy products, oriental fermented foods.

Books Recommended:

1. G.F. Stewart, Introduction to Food Science and Technology
2. R.P. Singh and D.R. Heldman, Introduction to Food Engineering, Academic Press.

Concepts of Managements: Definition, nature and scopes, overall view of Management, Relation with other social sciences and industry.

Evolution Of Management Thought: Classical theory of management, Bureaucracy – Introduced by Max Webber, Scientific Management – F.W. Taylor and his followers,

Process Management-Introduced B.H. Fayol and others, NCO classical theory of management, Human Relations-b.E. May and Roethlisberger, Behavioural Science approach – By Mc Gregor Maslow and others, Modern Management theories Peter Drucker.

Management Functions: Planning, Organization, Staffing, Directing and controlling. Executive Functions Production, Marketing, Finance,

Personnel. Planning : Concept, Nature, Importance, Objectives, Policies, Procedure, Strategies, and Method of Decision Making.

Organizations : Definition, Theories of Organization, Forms of Organization, Formal and Informal Organization, Type of Formal Organizations, Departmentation, Line and Staff Relationship, Span of Decentralization, Committees. Staffing: Selection, Recruitment, Training,

Development and Welfare. Directing : Leadership and Supervision, Motivation and Communication. Controlling : The elements, Process and style of Control, Techniques of Control. Social Responsibility of Business.

Books Recommended:

1. Koontz et al, Essentials of Management
2. Drucker, The Practice of management.

Design considerations for designing bioreactors: oxygen transfer, heat transfer, rheology, mixing.

Analysis of ideal bioreactors: Fed-Batch reactors, Enzyme catalyzed reactions in CSTRs, CSTR reactors with Recycle and Wall growth, Ideal Plug- Flow Tubular reactor.

Reactors with non-ideal mixing: Mixing time in agitated tanks, Residence time distributions, Models for non-ideal reactors.

Scale up and scale down concepts,

Mechanical fittings in a bioreactor: vessel, agitation system materials, welds, finish, valves, piping and valves for biotechnology, special requirements of utilities and cleaning of production plants.

Instrumentation and control of bioprocesses: Physical and chemical sensors for the medium and gases., online sensors for cell properties, off-line analytical methods; Biosensors.

Calculation for designing a bioreactor.

Books Recommended:

1. Coulson, Richardson, Sinnott, An introduction to chemical engineering design, Pergamon Press.
2. Lydersen, D'Elia, Nelson, Bioprocess engineering: Systems and equipment.
3. Bailey and Ollis, Biochemical Engineering Fundamentals.

Physical, chemical and biological characteristics of waste water, BOD, COD

Primary Treatment: Screening, Grit Chamber, removal of oil and grease.

Aerobic processes of secondary treatment– activated sludge, lagoons, stabilization ponds, suspended growth, nitrification, trickling filters, rotating biological contactors, anoxic suspended growth and fixed film denitrification,

Anaerobic processes of treatment – biological concepts, suspended growth and fixed film processes and reactor configuration, Sequential batch reactor for combined processes (aerobic and anaerobic)

Tertiary Treatment :Effluent disposal and reuse.

Solid waste management,

Designing aspects of Wastewater treatment plant

Books Recommended:

1. Metcalf and Eddy Inc., Waste water engineering
2. N.P. Cheremisinof, Biotechnology of waste water treatment.

***In Vitro* culture:** Applications: benefits and limitations, Culture media components, role of plant growth regulators, sterilization techniques, aseptic manipulation techniques.

Callus Culture and Cyto-Differentiation: Organogenesis and Embryogenesis, Clonal/Micro Propagation, Somaclonal Variation, Artificial Seeds.

Overcoming Barriers using Tissue Culture: Pre- and Post-Fertilization barriers, Production and Use of Haploids.

Suspension Cell Cultures: Cell Cycle Synchronization, Mutation Selection, Production of Secondary Metabolites and other Plant-Derived Chemicals, Bioreactors, Bio-transformation, Long-term storage of cultures.

Protoplast Culture: Isolation, Purification and Plating; Regeneration, Protoplast Fusion, Somatic Hybrids and Cytoplasmic Hybrids.

Plant Cell Transformation: Vectors and Techniques Used.

Transgenic Plants: Genetically Modified Crops, Resistance against Biotic and Abiotic Stresses, Molecular Farming.

Books Recommended:

1. Dixon and Gonzales, Plant cell culture – a practical approach.
2. Razdan, An introduction to plant tissue culture.

Overview of a few bioprocesses in terms of raw material, microorganism, enzyme, metabolic pathway, bioprocess, and uses. Product/processes to be considered for such analysis to include organic solvents, enzymes, organic acids, amino acids, antibiotics, vaccines, cell culture products.

Commercial production of tissue cultured plants- Technology transfer, equipment and procedures, quarantine, pathological indexing, packaging, cost analysis, marketing

Books Recommended:

1. Atkinson and Mavituna, Biochemical Engineering and Biotechnology Handbook.
2. Glazer and Nikaido, Microbial Biotechnology.
3. Shuler and Kargi Bioprocess Engineering: Basic concepts Prentice Hall PTR

Cost terminology and break – even analysis: Fixed costs and variable cost, sunk cost and opportunity cost. Accounting principles, Journal and ledger entries, balance sheet, profit and loss statement, ratio analysis. Cost structure and methods for allocating overhead costs. Standard costs. Time value of money operations and equivalence. Single sum and series of cash flow, uniform and gradient series multiple compounding periods in a year, continuous compounding. Bonds and installment financing. Comparison of alternative. Bases of comparison : Present worth amount, annual equivalent amount, future with amount. Rate of return, pay out period. Defining mutually exclusive alternatives, decision criteria for selection of alternatives. Comparison of alternatives with unequal service life. Replacement analysis : Reasons for replacement. Evaluation of replacement involving sunk costs. Patterns of maintenance cost and economic life of an asset. Replacement where future challengers are unknown. Depreciation and Income Tax considerations – Methods of depreciation and their comparison. Tax concepts. After Tax cash flow. Effect of depreciation method. Decision models under uncertainty; the Laplace principle, Maximin and Minimax principle, Maximax and Minimin principle. Introduction to sequential decision and decision trees. Decisions under risk.

Books Recommended:

1. Thusen, Engineering Economy
2. Degrama, Engineering Economy.

Molecular Markers: Comparison of different types of markers: - RFLP, RAPD, AFLP, AP-PCR, STS, EST, SNP, DNA Microarray; Construction of Molecular Maps

Genome Sequencing in Plants and Functional Genomics.

Transplastomic Plants: Engineering and Transformation of Chloroplast Genome.

Genetic Improvement of Plants using different *In vitro* culture Techniques. Development of crops adaptable to environmental stresses, diseases and pests.

Transgenic plants: Molecular Farming: Plants As factories for biopharmaceuticals, Transgenic value added speciality crops, Use of antisense RNA and other technologies.

Biofertilizers, Biopesticides, Bioinsecticides

Soil Reclamation: Phytoremediation

Books Recommended:

1. A. Mizrahi, Biotechnology in agriculture
2. S. Natesh, Biotechnology in agriculture

Biodiversity, biomass resources, agro and forests residue utilization, biomass conversion technologies, biogas. Flora and fauna in the world in general and in India in particular. Medicinal plants and herbs in eastern India, utilization of herbs for the society, ancient technologies for use of bioresources.

Major ecosystems and their flora and Fauna; Nomenclature and classification of organisms; Co-evolution, symbiosis and interaction among organisms; Causes of depletion of biodiversity and Conservation strategies; Analysis of biodiversity; On farm, *ex situ*, *in situ* and gene bank conservation; Geological and human activities endangering biodiversity; Domestication and utilization of biodiversity; Bioprospecting biodiversity for food, feed, health care and other products; Ethnobiology, IPRs and patenting; Organic farming and sustainable use of natural and bioresources; Organic standards and certification of organic produce and products; Global initiatives on future prospects..

Books Recommended:

1. Atkinson and Mavituna, Biochemical engineering and biotechnology Handbook.

ELLECTIVE I

MMI 1101 HUMAN ANATOMY & PHYSIOLOGY FOR BIOMEDICAL ENGINEERS 1.0

Syllabus as per Biomedical Instrumentation Course.

ELLECTIVE I

MMI 3103 INTRODUCTION TO CLINICAL INSTRUMENTATION 1.0
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Syllabus as per Biomedical Instrumentation Course.

ELLECTIVE II

BT 7015	BIOMATERIALS	1.0
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Functional requirements of biomaterials and tissue replacement, synthetic biomaterials: metals, polymers, ceramics, gels, hybrids, biocompatibility and wound healing, biomechanical and tirbological issues, material selection for orthopedic, dental, cardiovascular and soft tissue reconstruction biomaterials.

Books Recommended:

2. Park and Lakes, Biomaterials an introduction.

ELLECTIVE II

BT 7017	NANO BIOTECHNOLOGY	1.0
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Introduction to Nanobiotechnology, biological problems; Nanocrystals in Biological Detection; Microfluidic Meets Nano: Potential for Nanobiotechnology; Protein based nanocyrstals; Microbial nanoparticle production; DNA based nanostructures and Gold nanoparticle conjugates; Luminescent quantum dots for biological imaging; Emerging Nanotechnologies: nano labels, biosensors, medicine.

Books Recommended:

1. Niemeyer and Mirkin ed. Nanobiotechnology: concepts, applications & perspectives,
2. Jain, KK. Nanobiotechnology in molecular diagnostics: current techniques and applications

ELLECTIVE II

MMI 3101	BIOMEDICAL IMAGING DEVICES & CONCEPT	1.0
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Syllabus as per Biomedical Instrumentation Course.

Protein - general introduction, forces that determine protein structure and physicochemical properties. Mechanisms of protein folding, molten globule structure, characterization of folding pathways.

Determination of protein structure by various spectroscopic techniques. Background and basic principles, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, NMR, X-ray crystallography, MALLS.

Thermal properties of proteins and application of DSC. Protein denaturation, aggregation and gelation. Flow properties of proteins and sensory properties of proteinaceous foods.

Protein functionality. Protein raw materials- cereals, legume, oil seeds and pseudo cereals. Muscle protein, Milk protein, Egg protein.

Protein modification as result of technological processes: thermal, enzymatic, physical, pressure, solvents, interactions.

Nutritive role of food proteins.

Books Recommended:

1. Carl, Branden and Tooze, John. Introduction to Protein Structure, Garland Publishing (Taylor and Francis Group). New York.
2. Yada, R. Y.; Jackman, R. L.; Smith, J. L. Protein Structure-Function Relationships Blakie Academic and Professional: London
3. Clark, R. J. H and Hester, R. E. Spectroscopy of Biological Systems, John Wiley and Sons, New York
4. Nakai, S. and Modler, H. W. Food Proteins: Properties and Characterization, VCH Publishers, New York.

Detailed syllabus will be notified later.

Genomic evolution: The world of RNA, ribozyme, Genetics to genomics to functional genomics.

Forward genetics (Phenotype to gene structure) and Reverse genetics (Gene structure to phenotype)

Whole Genome Sequencing: Strategies used, DNA sequence analysis and data handling, Database mining for candidate gene discovery, Model dicot plant: *Arabidopsis* and Model monocot/crop plant: Rice

Post-Transcriptional Gene silencing: RNA interference, antisense RNA, siRNA, MiRNA,

Gene expression: DNA Microarrays, SAGE, Real Time PCR

Proteomics: Sample Preparation, 2-D Electrophoresis, Image Acquisition 2-D Analysis Protein Picking Protein Arraying Protein Digestion MALDI Preparation Data Integration

Metabolomics: The Third Piece of the omics puzzle, Resources for identification of metabolomes, Metabolome Annotation and Characterization with Mass Spectrometry.

Economical beneficiation of low rank coal through biological processing, biological conversion of coal to organic chemicals, role of microorganisms in metal extraction, metal recovery, environmental control and mine site remediation.

Books Recommended:

1. S.K. Kawatra, Mineral Biotechnology.

Products and processes from the seas, understanding and conserving the seas, mass culturing of phyto and zooplankton, environmental and economic aspects of aqua culture.

Tissue culture of lower plants, algae, lichens and bryophytes, in vitro variation existing in cell populations or induced by culture conditions, Economic importance of marine biomass, Diseases of marine fauna (WSSV).

Books Recommended:

1. Review papers from scientific journals, books and internet.

Genomics and its impact on medicine. Molecular medicine: rational drug design, gene testing, gene therapy, pharmacogenomics. Principles of monoclonal antibodies, monoclonal antibodies in disease detection and treatment, oncogenes, tumor suppressor genes, growth factors, cancer. Genetic diseases and DNA based diagnosis of genetic diseases. Development of genetically engineered pharmaceuticals.

Drug Design, novel drug delivery systems, improved formulation

Books Recommended:

1. Maulik and Patel, Molecular Biotechnology – Therapeutic applications and strategies.
2. Zito, Pharmaceutical Biotechnology.

ELLECTIVE III

BT 8013	BIOTECHNOLOGY MANAGEMENT	1.0
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Detailed syllabus will be notified later.

ELLECTIVE III

MMI 2107	FIBER OPTICS & LASER IN MEDICINE	1.0
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Syllabus as per Biomedical Instrumentation Course.

Process validation, regulation of biotechnology, intellectual property rights and patenting of products and processes, ethical issues, society and public perception towards biotechnology, release of genetically modified organisms.

International and Indian Scenario, WTO Evolution of patenting system, Biosafety regulation and practices in genetic engineering research, Designing of manufacturing area, GMP, FAO requirements.

Books Recommended:

1. F.B. Rudolph, Biotechnology : Science engineering and ethical challenges for 21st century.
2. P. Grubb, Patents for chemicals, pharmaceuticals and biotechnology.

Introduction, Environmental site assessments, microbial ecology of contaminated sites, Predictive models for efficacy of bioremediation, rates and dynamics of bioremediation, Microorganisms involved in the biodegradation of organic compounds, heavy metals, bioconversion and removal of metals and radionuclides, adaptation: dynamics of genes, enzyme activities and populations, phytoremediation processes, plants involved and their mechanisms in bioremediation, protein engineering for improved biodegradation of recalcitrant pollutants.

Books Recommended:

1. Wild, Varfolomeyev and Scozzafava. Perspective in Bioremediation: Technologies for Environmental Improvement
2. Singh and Ward Applied Bioremediation and phytoremediation Springer

Basics of Cell and Tissue Culture: Laboratory requirements for tissue culture, substrates for cultures, culture media for animal cell cultures, culture procedures and principles, freeze storing of cells and transport of cultures.

Characteristics of Cells in Culture: Contact inhibition, anchorage independence/dependence, cell-cell communication, cell senescence.

Cell Culture Lines: Definition, development and maintenance, cloning of cell lines, cell synchronization viral sensitivity of cell lines, cell line preservation and characterization, stem cell lines.

General Tissue Culture Techniques: Types of tissue cultures, methods of disaggregating primary cultures, primary tissue explantation technique.

Organ Culture: Methods, behavior of organ explants and utility of organ culture, whole embryo culture.

Methods in Cell Culture: Micro carrier cultures, cell immobilization, animal cell bioreactor, large scale cell cultures for biotechnology, somatic cell fusion, flow cytometry, transfection.

Applications of Animal Cell Culture: Use in gene therapy, cloning from short-term cultured cells, cloning from long-term cultured cells, Cloning for production of transgenic animals, cloning for conservation.

Books Recommended:

1. Freshney, Animal cell culture – a practical approach
2. N. Jenkins, Animal Cell Biotechnology: methods and protocols.