SCHEME OF EXAMINATION

&

SYLLABUS FOR B.Tech

(Semester 1 to 8)

in

Biotechnology

AUGUST 2016 ONWARDS

(updated upto 2017)

UNIVERSITY SCHOOL OF BIOTECHNOLOGY

GGS INDRAPRASTHA UNIVERSITY

DWARKA, DELHI – 110078

FIRST SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
13	4	11	0	23	28

Code No.		L	T/P	Credits
THEORY PAPERS				
IT-105	Introduction to Computers	3	0	3
BA-131	Essential of Mathematics – I	3	1	4
BT-133	Foundation course in Biology	3	1	4
BA-135	Foundation course in Physico-Inorganic Chemistry – I	2	1	3
BA-137	Foundation course in Physics-I	2	1	3
PRACTICALS				
IT -155	Computer Lab	0	2	1
IT -157	Engineering Graphics - I Lab	0	2	1
BT-181	Foundation course in Biology - Lab	0	3	2
BA-183	Chemistry - I Lab	0	2	1
BA-185	Physics - I Lab	0	2	1
	TOTAL	**13**	**4/11**	**23**

SECOND SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
16	6	09	0	27	31

Code No.		L	T/P	Credits
THEORY PAPERS				
BT-116	Introduction to Biotechnology	3	1	4
IT -120	Electrical Science	3	1	4
BT-124	Techniques in Biotechnology	3	1	4
BA-132	Foundation Course in Physics - II	2	1	3
BA-136	Essential of Mathematics – II	3	1	4
BA-138	Foundation Course in Organic Chemistry – II	2	1	3
PRACTICALS				
BT-164	Techniques in Biotechnology - Lab	0	3	2
IT -166	Electrical Science – Lab	0	2	1
BA-184	Chemistry – II Lab	0	2	1
BA-186	Physics - II Lab	0	2	1
	TOTAL	**16**	**6/09**	**27**

THIRD SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
15	5	12	0	28	32

Code No.		L	T/P	Credits
THEORY PAPERS				
BT-201	Microbiology	3	1	4
BA-203	Bioenergetics – I	3	1	4
BT-205	Cell Biology	3	1	4
BT-209	Genetics	3	1	4
CT-211	Introduction to material and energy balances	3	1	4
PRACTICALS				
BT-251	Genetics-Lab	0	3	2
BA-253	Bioenergetics – I Lab	0	3	2
BT-255	Cell Biology – Lab	0	3	2
BT-257	Microbiology Lab	0	3	2
	TOTAL	**15**	**5/12**	**28**

FOURTH SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
15	5	12	0	28	32

Code No.		L	T/P	Credits
THEORY PAPERS				
BT-202	Immunology	3	1	4
BT-204	Molecular Biology	3	1	4
BT-206	Enzyme Technology	3	1	4
BA-208	Bioenergetics – II	3	1	4
CT-212	Fundamentals of Heat and Mass Transfer	3	1	4
PRACTICALS				
BT-254	Molecular Biology – Lab	0	3	2
BT-256	Enzyme Technology - Lab	0	3	2
BT-258	Immunology – Lab	0	3	2
BA-258	Bioenergetics - II Lab	0	3	2
	TOTAL	**15**	**5/12**	**28**

FIFTH SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
15	5	15	0	30	35

Code No.		L	T/P	Credits
THEORY PAPERS				
BT-305	Animal Biotechnology	3	1	4
BT-307	Recombinant DNA Technology	3	1	4
BT-309	Developmental and Stem Cell Biology	3	1	4
BT-311	Plant Biotechnology	3	1	4
BT-313	Unit Operations and Plant Design	3	1	4
PRACTICALS				
BT-355	Animal tissue Culture – Lab	0	3	2
BT-357	Recombinant DNA Technology – Lab	0	3	2
BT-359	Developmental and Stem Cell Biology Lab	0	3	2
BT-361	Plant Biotechnology I – Lab	0	3	2
CT-363	Chemical Engineering – Lab	0	3	2
	TOTAL	**15**	**5/15**	**30**

SIXTH SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
15	5	09	0	26	29

Code No.		L	T/P	Credits
THEORY PAPERS				
BT-314	Bioinformatics	3	1	4
BT-316	Statistical Methods in Biology and Experimental Design	3	1	4
BT-318	Downstream Processing	3	1	4
BT-320	Medical Biotechnology	3	1	4
BT-322	Bioprocess Engineering	3	1	4
PRACTICALS				
BT-352	Bioinformatics – Lab	0	3	2
BT-356	Plant Biotechnology II - Lab	0	3	2
BT-360	Bioprocess Engineering - Lab	0	3	2
	TOTAL	**15**	**5/9**	**26**

SEVENTH SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
15	5	6	0	26	26

Code No.		L	T/P	Credits
THEORY PAPERS				
BT-403	Environmental Biotechnology	3	1	4
BT-405	Protein Biotechnology	3	1	4
BT-407	Bioentrepreneurship and Management (NUES)	3	1	4
BT-409	Bioprocess Control Engineering	3	1	4
BT-411	Intellectual Property Rights, Biosafety and Bioethics in Biotechnology	3	1	4
PRACTICALS				
BT-451	Protein Biotechnology – Lab	0	3	2
BT-453	Environmental Biotechnology – Lab	0	3	2
BT-457	Industry visits / Case studies (NUES)	0		2
	TOTAL	**15**	**5/6**	**26**

EIGHTH SEMESTER EXAMINATION

L	T	P	S	Credits	Hours
0	0	20	0	20	

Code No.		L	T/P	Credits
PROJECT WORK / VIVA-VOCE:				
BT-450	Project Work	0	18	18
BT-452	Journal Club/Seminar	0	2	2
	TOTAL	**0**	**20**	**20**

Note:
Total no. of credits = 208 credits
Credits to be earned by students to qualify B. Tech degree = 200 Credits

FIRST SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BA-131 ESSENTIAL OF MATHEMATICS –I

1. Algebra of matrices, Row and Column operations, Inverse of matrix, Systems of linear equations- consistency and inconsistency, Cramer's rule, Rank of a matrix. **(4)**

2. Quadratic forms, Eigenvalues and eigenvectors of a matrix, Diagonalization of a matrix, Cayley-Hamilton theorem (without proof) **(5)**

3. Quadratic equations, De-Moivre's theorem and its applications **(4)**

4. Limits, Continuity and Differentiation **(5)**

5. Successive differentiation, Leibnitz's Theorem, Indeterminate forms **(4)**

6. Mean Value Theorems: Rolle's, Lagrange's, Taylor's and Maclaurin theorems and expansions and their applications **(6)**

7. Sequences and its convergence, Convergence and divergence of a series, Comparison test, Ratio test, Cauchy's n^{th} root test, Leibnitz's test (all tests without proof), Absolute and Conditional convergence**.** **(6)**

8. Partial derivatives, Chain rule, Differentiation of implicit functions, exact differentials. Maxima, Minima and Saddle points, Method of Lagrange multipliers. **(6)**

Text / Reference Books:

1. Advanced Calculus by D.V.Widder, *Prentice Hall, NY*
2. Calculus and Analytic Geometry by G.B. Thomas and R.L. Finney, 6^{th} edition, *Addision Wesley/Narosa*, 1985
3. Engineering Mathematics by K.A.Stroud, *Palgrave*
4. Advanced Engineering Mathematics by K.A.Stroud, *Industrial Press, Inc*., Newyork.
5. Advanced Engineering Mathematics by Alan Jeffrey, *Harcourt, Academic Press*.
6. Advanced Engineering Mathematics by Petter V.O'Neil, *Thomson*.
7. Differential Calculus by Shanti Narayan, *S. Chand & Co*.
8. A text book of Matrices by Shanti Narayan, *S. Chand & Co*.
9. Advanced Engineering Mathematics by E. Kreyszig 5^{th} Edition, *Wiley Eastern*, 1985.

FIRST SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-133 FOUNDATION COURSE IN BIOLOGY

1. **Introduction to Biology**: Historical aspects in the early study of biology, Approaches used for study of biology, Cell as the unit of life, Biology and everyday life. **(4)**

2. **Biological systems as structure-function relationships**: Biomolecules: Structure and function of macromolecules with emphasis on proteins, lipids, membranes, carbohydrates and nucleic acids. Cell membranes, cell organelles and their function with emphasis on Chloroplast photosynthetic unit, Calvin-Benson Cycle (C_3), Hatch Slack Pathway (C_4), Crassulacan Acid Metabolism (CAM), factors affecting photosynthesis.**(5)**

3. **Evolution and biodiversity of biological systems**: Concept of the origin of life on earth, major events in the history for study of life originating on earth, Darwin's theory of evolution; The evolution of populations; Concepts of species; Mechanism of speciation, Constructing the Phylogeny and approaches for the study of Phylogeny. **(5)**

4. **Foundations of plant morphology and Plant evolution**: Simple tissues (parenchyma, collenchyma, sclerenchyma); Complex tissue (xylem and phloem); primary body and growth (root, stem, leaf); Secondary growth. Evolution and development of flowering plants. Emerging model plants: mosses (early land plants), flowering plants (monocot and dicot model plants), Yeast. **(5)**

5. **Plant physiology**: Principles and processes such as Transpiration, nutrition, Plant movements (Tactic, Tropic, Nastic). Plant growth substances (Auxins, Cytokinins, Gibberellins, ABA, Ethylene), phytochrome and effect of light on plant development, vernalisation and flowering. **(5)**

6. **Economically Important Plants**: Classification systems, Important families (Fabaceae, Poaceae, Malvaceae, Cucurbitceae, Crucifereae, Leguminoseae), Cereals (wheat, rice maize), Beverages (tea, coffee, cocoa), Fibers (jute, linen, cotton), wood (pines, cedar, teak, sisham), rubber (para rubber), spices (turmeric, black pepper, cloves, coriander), medicinal plants (Ephedra, Taxus, Cinchona, Fox glove, Belladonna, Rauvolfia, Neem, Hemp.) **(5)**

7. **Diversity of life and its classification**: Kingdoms of Life –Prokaryotes, Eukaryotes, Archaea. Characteristics of each kingdom and representative examples, Eukaryotic and Prokaryotic pathogens, Host pathogen interactions, Classification of vertebrates and invertebrates up to class and their characteristics **(6)**

8. **The internal Animal Physiology**: Homeostasis, Transport across cell membranes, tissue systems and organ systems in vertebrates. **(5)**

Books/References:

1. Campbell, N.A. and Reece, J. B. Biology 10th edition, Pearson Benjamin Cummings, San Francisco.
2. Raven, P.H et al, Biology 10th edition Tata McGrawHill Publications, New Delhi.
3. Sadava D et al, Life: The Science of Biology 8th edition, W. H. Freeman and Company.

FIRST SEMESTER EXAMINATION

L	T	P	Credits	Hours
2	1	0	3	26

BA-135 FOUNDATION COURSE IN PHYSICO-INORGANIC CHEMISTRY - I

Chemical Bonding:

1. Ionic bond- energy changes, lattice energy Born Haber Cycle, Covalent bond-energy changes, Potential energy curve for H2 Molecule, characteristics of covalent compound. **(4)**

2. Co-ordinate bond - Werner's Theory, effective atomic numbers, isomerism in coordinate compounds. Hydrogen bonding. **(2)**

3. Concept of hybridisation and resonance, Valance Shell Electron Repulsion theory (VSEPR). Discussion of structures of H2O, NH3, SiF4. Molecular orbital theory, Linear combination of atomic orbitals (LCAO) method. Structure of simple homo nuclear diatomic molecule like H2, N2, O2, F2. **(4)**

Acids and Bases:

4. Basics of acidities and basicities, electrolytic dissociation, concept of strengths of acids and bases, ionization of water, concept of pH and its scale, Buffer solutions, Buffer solution of weak acid and its salt, calculation of pH of buffer solution, Henderson equation, acid-base indicators and theory of indicators. **(4)**

Catalysis:

5. Criteria for Catalysis-Homogeneous Catalysis, acid-base, Enzymatic catalysis, Catalysis by metal salts. **(2)**

6. Heterogeneous catalysis - concepts of promoters, inhibitors and poisoning, Physiosorption, Chemisorption, Surface area, industrially important process. **(2)**

Polymers:

7. Basic concepts & Terminology, such as monomers, Polymers, Functionality, Thermoplastics, Thermosets Linear, Branched, cross linked polymers etc. different definitions of molecular weight viz., Mw, Mn, Mv and then determinations. **(2)**

8. Industrial applications of polymers, Addition, condensation and Ionic polymerization's, solutions of polymers, good solvents, & bad solvent, solubility parameter, solutions viscosity and determination of intrinsic viscosity. **(2)**

Colloids

9. Collidal state, classification of colloidal solution, true solution, colloidal solution and suspensions, preparation of sol, Purification of colloidal solutions. **(2)**

10. General and optical properites, stability of colloids, coagulation of lyphobic sols, electrical properties of sols, kinetic properties of colloids:- Brownion movement, size of colloidal particle, emulsions, gels, colloidal electrolytes and applications of colloids. **(2)**

Text / Reference Books:

1. Concise Inorganic Chemistry, 5th Edition by J.D. Lee, *Blackwell Publishing* (1999).
2. Advance Chemistry by Philip Mathews, *Cambridge University* Press (1996).
3. Basic Inorganic Chemistry, 3rd Edition by F. A. Cotton, G. Wilkinson & P. L.Gaus, *Wiley*(1995).
4. Physical Chemistry, 6th Edition by P. W. Atkins, *W.H. Freeman & Company*; (November 1997).

FIRST SEMESTER EXAMINATION

L	T	P	Credits	Hours
2	1	0	3	30

BA-137 FOUNDATION COURSE IN PHYSICS - I

1. Interference By Division Of Wave front: Coherence and coherent sources, Interference by division of wave front. Young's double slit experiment, Fresnels' biprism. (3)

2. Interference By Division Of Amplitude: Interference by division of amplitude. Thin films, Newton's rings, Michelson's Interferrometer, Fabry Perot Interferometer (3)

3. Diffraction: Fresnel and Fraunhoffer types of diffraction. Fraunhofer diffraction: Single slit, double slit, circular aperture. Fresnel Diffraction, narrow slit. (3)

4. Diffraction–Applications: Fraunhofer diffraction: N-slit. Diffraction grating - avelength determination, resolving power and dispersive power. Resolving power of optical instruments – Rayleigh criterion. Fresnel Diffraction: zone plate. (3)

5. Polarization: Types of polarization, elliptically and circularly polarized light Brewster's law, Malu's law, Nicol prism, double refraction, quarter-wave and half-wave plates, optical activity, specific rotation, Laurent half-shade polarimeter. (3)

6. Introduction To Lasers: Introduction, Coherence, Einstein A and B coefficients, population inversion, Basic principle and operation of a laser. (3)

7. Lasers Types And Applications: Types of lasers, He-Ne laser, Ruby laser, semi-conductor laser and holography. (3)

8. Fibre Optics: Introduction to Optical fibre, Types of optical fibres and their characteristics, (Attenuation and Dispersion) step index and graded index fibres, principle of fibre optic communication- total internal reflection, Numerical aperture, Fibre optical communication network- its advantages. Fibre optic sensors (qualitative). (3)

9. Nature Of Light And Matter: Particle nature of radiation- The Photoelectric effect, Compton Effect. X-rays (continuous and characteristic), x-ray diffraction- Bragg's law. The origin of quantum theory- Planck's hypothesis, the wave nature of matter- wave-particle duality, matter waves (de Broglie hypothesis). (3)

10. Introduction to quantum mechanics: Basic postulates of quantum mechanics-the wave function - its physical interpretation, The Schrodinger equation. (3)

Text / Reference Books:

1. Modern Physics by A. Beiser, *Tata Mc Graw Hill Publishing Co*.
2. Optics by A.K. Ghatak, *Tata Mc Graw Hill Publishing Co.*
3. Introduction to Physical Optics by Jenkin & White, *Mc Graw Hill Publishing Co*

SECOND SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-116 INTRODUCTION TO BIOTECHNOLOGY

1. **Introduction to Biotechnology:** Definitions, Historical perspectives, Scope and importance, Commercial potential and interdisciplinary challenge. **(3)**

2. **Solutions and buffers:** Modes of expressing concentration of a solution, Making solutions, Concept of acids and bases, pH, Buffer system, Henderson-Hasselbach equation, Criteria for selection of buffers. **(3)**

3. **Recombinant DNA Technology:** Tools of rDNA Technology, Making recombinant DNA, Introduction of recombinant DNA into host cells, Introduction to selection and screening techniques for identification of recombinants, Principle, Steps and Applications of Polymerase Chain Reaction. **(5)**

4. **Protein Structure and Engineering:** Introduction to the world of Proteins, Amino acids as building blocks, Structure of proteins, Non-covalent interactions, 3-D Shape of Proteins, Structure Function relationship in Proteins, Introduction to Protein Designing and Proteomics. **(5)**

5. **Microbial Culture and Applications:** Microbial Culture Techniques, Measurement and Kinetics of Microbial Growth, Scale up of microbial process, Isolation of microbial products, Strain Isolation, Improvement and Preservation, Applications of microbial culture technology, Safety concerns in microbial technology. **(5)**

6. **Plant Cell Culture and Application:** Cell and Tissue culture techniques, Applications of Cell and Tissue culture, Gene transfer methods in plants, Transgenic plants with beneficial traits, Bioethics in plant genetic engineering. **(4)**

7. **Animal Cell Culture and Applications:** Animal Cell culture techniques, Finite and Continuous Cell lines, Characterization of cell lines, Scale-up of Animal Culture Process, Applications of animal cell culture, Bioethics in animal genetic engineering. **(4)**

8. **Biotechnology and Society:** Introduction to Patenting - Criterion for patents, Reading a patent, National and International Patent Laws, Ethical issues in agriculture and health care, Biotechnology in India and global trends; Product safety and marketing. **(4)**

9. **Introduction to Bioinformatics:** Introduction to databases, Primary and Secondary databases, Nucleic acid and Protein databases, Introduction to sequence alignment, Applications of bioinformatics. **(3)**

10. **Introduction to basic techniques in Biotechnology:** Beer-Lambert's Law, Spectrophotometer, Agarose Gel Electrophoresis , SDS-PAGE, Gel-Filtration Chromatography, Ion Exchange Chromatography, Affinity chromatography. **(4)**

Text / Reference Books:

1. Biotechnology, Smith, 2009, Cambridge Press.
2. Biotechnology, H.K.Das, 2010, Wiley Publishers.
3. Gene cloning and DNA Analysis. An introduction. T. A Brown, Blackwell Science.
4. Principles and Techniques of Biochemistry and Molecular Biology by Wilson & Walker, Cambridge Press, 2008.

SECOND SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	36

IT–120 ELECTRICAL SCIENCE

1. **Properties of Conductors and Insulators :** Basic laws of Electrical Engineering, Temperature Resistance Coefficients. **(5)**

2. **D. C. Circuits :** Network theorems and applications, Division of Current, Potentiometer, Circuit parameters, Energy and power, Superposition, Thevenin and Reciprocity theorems, Star Delta Formations. **(6)**

3. **Alternating Currents :** Peak, Average and RMS values for alternating currents, Power and Power factor , Resistance, Inductance and Capacitance, Resonance, Q Factor. **(5)**

4. **Measuring Instruments :** Electromagnetism, Moving Coli and Moving Iron, Instruments, Construction Instruments, Attraction and Repulsion type, Permanent Magnet and Eletrodynamics, Dynamometer type. **(5)**

5. **D. C. Generators & Motors :** Principle of operation of Generators & Motors, Speed Control of shunt motors, Flux control, Rheostatic control, voltage control, Speed control of series motors. **(5)**

6. **A. C. Generators & Motors :** Principle of operation, Revolving Magnetic field, Squirrel cage and phase wound rotor, Starting of Induction motors, Direct on line and Star Delta starters, Synchronous machines. **(5)**

7. **Transformers:** Construction, Regulation and efficiency calculations, Open and short circuit tests. **(5)**

Text / Reference Books:

1. Electrical Engineering Fundamentals by Vincent DEL TORO. HUGHES, Electrical Technology. *Englewood Cliffs, N.J., Prentice-Hall* [1972]

SECOND SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT–124 TECHNIQUES IN BIOTECHNOLOGY

1. **pH:** Concept of pH, Henderson Hasselbach equation, composition and preparation of some commonly used buffers, pH meters **(2)**

2. **Colorimetry and Spectroscopy:** Basic principles, nature of electromagnetic radiation, Beer-Lambert laws, colorimetric methods & instruments, principles of spectroscopy, types of spectra-absorbance, emission, fluorescence and action spectra, single and double beam spectrophotometers, densitometers, flame photometer, fluorimeters **(4)**

3. **Cell separation:** Flow cytometry, magnetic beads, elutriator. **(2)**

4. **Microscopy**: Basic principles, instrumentation, light and phase contrast, interference, polarization, inverted fluorescence, confocal & electron microscopes & their applications, Introduction to microtomy **(4)**

5. **Centrifugation:** Principle, types of centrifuges, rotors, differential and gradient ultracentrifugation-preparative & analytical. **(4)**

6. **Chromatography:** Principles, methodology and applications of chromatography using paper, thin layer, column (gel filtration, ion exchange, affinity), GC, HPCL, FPCL. **(5)**

7. **Electrophoresis**: Principles and types of electrophoresis and their applications for proteins, nucleic acids, including gradient gel and pulse-filed gel electrophoresis; gel matrices: polyacrylamide, agarose, etc. critical parameters for optimum separation and resolution, two dimensional electrophoresis (IEF). **(5)**

8. **Radioisotope Methods and Tracer Techniques in Biology:** Basic principles of radioactivity, properties & handling of radioisotopes in biology & medicine, radiation units, Geiger Muller & scintillation counters, autoradiography, radionucleide imaging, CT scan. **(4)**

9. **Immunochemical Techniques:** Production of antibodies, Immunoprecipitation, Immunoassays, Immunohistory and Immunocytochemistry **(4)**

10. **Biophysical Techniques:** X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectra, Magnetic Resonance Imaging (MRI), lasers in biology and medicine, Mass spectrometry. **(6)**

Text / Reference Books:

1. Introductory Practical Biochemistry by S. K. Sawhney & Randhir Singh; *Narosa Publishing house*, 2000.
2. Principles and Techniques of Biochemistry and Molecular Biology by K Wilson & J Walker, 6th Edition, Cambridge Press, 2008

SECOND SEMESTER EXAMINATION

L	T	P	Credits	Hours
2	1	0	3	28

BA-132 FOUNDATION COURSE IN PHYSICS – II

1. **Electricity and Magnetism- Basics:** Electric fields, Gauss' Law, its integral and differential form, applications. Lorentz force, fields due to moving charges, the magnetic field, Ampere's law, motion of a charged particle in an electric and magnetic field. **(3)**

2. **Electricity and Magnetism-applications: M**agnetic and electrostatic focusing, Hall effect, determination of e/m by cathode ray tube, positive rays, Electron microscope, Cyclotron and Betatron. **(4)**

3. **Classical and Quantum Statistics:** The Statistical distributions: Maxwell Boltzmann, the Black-body spectrum and failure of classical statistics to give the correct explanation, Bose-Einstein and Fermi-Dirac statistics, their comparisons, Fermions and Bosons. **(3)**

4. **Applications of classical and quantum statistics:** Applications of Maxwell-Boltzmann statistics - Molecular speed and energies in an ideal gas, the application of Bose-Einstein statistics to the Black-body radiation spectrum, Fermi-Dirac distribution to free electron theory, electron specific heats, Fermi energy and average energy - its significance. **(4)**

5. **Band theory of solids:** Origin of energy bands in solids, motion of electrons in a periodic potential- The Kronig-Penny model (qualitative). Brillouin zones, effective mass Metals. Semi-metals. Semi-conductors and insulators and their energy band structure. **(3)**

6. **Semiconductors and their applications:** Extrinsic and intrinsic semiconductors, doping - Fermi energy for doped and undoped semiconductors, the p-n junction (energy band diagrams with Fermi energy), the unbiased diode, forward and reverse biased diodes- its characteristics, tunnel diode, zener diode, photo-diode, LED, the photo-voltaic cell. **(4)**

7. **Superconductivity:** Introduction to superconductivity, the Meissner effect, Type I and II superconductors, the Josephson effect, flux quantization, Cooper pair, the BCS theory (qualitative) **(3)**

8. **Applications of superconductors:** Magnetic levitation, superconducting magnets, Josephson junctions and Squids. **(4)**

Text / Reference Books:

1. Modern Physics by Arthur Beiser, *Tata Mc Graw Hill Publishing Co*.
2. Introduction to Solid State Physics by Charles Kittel, *Wiley.*
3. Electronic Principles by Albert Paul Malvino, *Tata Mc Graw Hill Publishing Co.*

SECOND SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	42

BA-136 ESSENTIAL OF MATHEMATICS – II

1. Concavity and Convexity of curves, Asymptotes, Singular points, Curve tracing. **(6)**

2. Integration : Methods of Integration, Integration of algebraic, rational, trigonometric functions and irrational functions, Integration by parts, Substitution method, Definite integrals and its properties. **(6)**

3. Reduction formulae of trigonometric functions, Definition of improper integrals, Beta-Gamma functions and their properties. **(5)**

4. Formation of ordinary differential equation's (ODE), Definition of order and degree, Solutions of ODE's of first order: Method of separation of variables, Homogeneous and non-homogeneous equations, Exactness and integrating factors, Linear equations and Bernoulli's equations. **(5)**

5. Linear ODE's of nth order: Solutions of homogenous and non-homogenous equations, Operator method. Method of undetermined coefficients and variation of parameters. **(6)**

6. Power series method of solution of ODE, Legendre's Equation, Legendre's polynomials, Bessel's equation, Bessel's function of first kind. **(6)**

7. Introduction to probability theory, Definition of sample space, Event, Event space, Conditional probability. **(4)**

8. Additive and Multiplicative laws of probability, Baye's theorem, Application based on these results. **(4)**

Text / Reference Books:

1. Calculus and Analytic Geometry by G.B. Thomas and R.L. Finney, 6th edition, *Addison Wesley/Narosa,* 1985.
2. Differential Calculus by Shanti Narayan, *S. Chand & Co*.
3. Advanced Engineering Mathematics by E. Kreyszig, 5th Edition, *Wiley Eastern*, 1985.
4. Engineering Mathematics by K.A.Stroud, *Palgrave.*
5. Advanced Engineering Mathematics by K.A.Stroud, *Industrial Press, Inc*., Newyork.
6. Advanced Engineering Mathematics by Alan Jeffrey, *Harcourt Academic Press*.
7. Advanced Engineering Mathematics by Petter V.O'Neil, *Thomson*.
8. Advanced Calculus", Schaum's Outline Series, *Mc Graw Hill Ed*.
9. Advanced Calculus by D.V.Widder, *Prentice Hall*, NY
10. Differential Equations by S.L.Ross, *John Wiley*.
11. Differential Equations by N.M. Kapoor, *Pitamber Pub. Co*.
12. Probability, Schaum Outline Series, *Mc. Graw Hill*.

SECOND SEMESTER EXAMINATION

L	T	P	Credits	Hours
2	1	0	3	28

BA-138 FOUNDATION COURSE IN ORGANIC CHEMISTRY – II

1. **Electronic Displacements:** Inductive, mesomeric, field effect and resonance effect - resonance energy and its significance, (vertical and empirical resonance energy). Hyperconjugation: concept and consequences. **(2)**

2. **Reactive intermediates:** Generation, structure and general reactions of carbocations, carbanions, free radicals, carbenes (singlet and triplet) and benzyne. Wagner-Meerwein rearrangement, Electrophiles and nucleophiles, concepts of acids and bases. Arrhenius, Lowry-Bronsted and Lewis theory of acids and bases (HSAB), Carbon acids (active methyiene groups), super acids, Correlation of structure with acidity and basicity. Bonds weaker than covalent bond: Hydrogen bonding - nature, types, stability and effects, vander Waals forces. **(5)**

3. **IUPAC Nomenclature:** Systematic IUPAC nomenclature of different classes of compounds including aromatic, bicyclic, and spiro compounds and polyfunctional compounds. **(2)**

4. **Stereochemistry:** Classification of stereomers, diastereoiners, Separation of enantiomers. Absolute configuration (R and S), Projection formulae. Stereochemistry of compounds containing two asymmetric C-atoms. Elements of symmetry - centre, plane and axis of symmetry, Conformations: Conformations around a C-C bond in acyclic compounds, Structure of different cycloalkanes. Strain in acyclic and acyclic compounds. Cyclohexane conformations, Stereochemistry of disubstituted cyclohexanes. Geometrical isomerism- Concept, E and Z nomenclature, Stereoselective and specific Reactions. **(8)**

5. **pΠ - dΠ bonding** in organic compounds, ylids (S and P), Wittig reaction. **(2)**

6. **Tautomerism:** Cationotropy and anionotropy, Prototropic shifts in different systems, ring-chain tautomerism and valence tautomerism, Claisen rearrangement. **(2)**

7. **Alkanes:** Methods of preparation, Source-petroleum and coal in brief, Cracking and reforming. **(2)**

8. **Alkenes:** Methods of preparation. Reactions: Hydrogenation, hydroboration, oxidation, hydroxylation, addition- Markownikoff rule with explanation and peroxide effect. Dienes: types of dienes and their characteristic reactions, effect of conjugation on stability and reactivity, Diels-alder reaction in detail with its stereochemistry. Polymerisation of olefinic compounds, Use and mechanism of Ziegler-Natta catalysts. **(5)**

Text / Reference Books:

1. Modern Organic Chemistry by D. R. Boyed.
2. Organic Chemistry by I. L. Finar, Addison-Wesley Longman, Limited
3. Organic Chemistry by Roger Macomber. *University Science Books.*
4. Organic Chemistry Reaction Mechanism by Jerry March, *McGrawHill Companies*

THIRD SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-201 MICROBIOLOGY

1. **Microbes in Human Life:** Introduction of microorganisms, Brief history and scope of microbiology, Microbes & human welfare, Microbes & disease. **(2)**

2. **Functional Anatomy of Prokaryotic Cells:** Size, shape and arrangement of bacterial cells, Structure of the cell and cell wall, Preparation and staining of specimens for microscopy **(2)**

3. **Microbial Growth:** Nutritional requirements and nutritional categories, nutrients uptake by microbial cells, Culture media, Isolation of pure cultures, cultivation and preservation of cultures, Microbial growth Kinetcis **(4)**

4. **Control of microbial growth:** Physical and chemical methods of microbial control, Action of microbial control agents and evaluation of effectiveness of antimicrobial agents **(4)**

5. **Microbial physiology and metabolism:** Metabolic diversity and pathways of energy use, unique pathways of microbial fermentation and photosynthesis. **(4)**

6. **Microbial taxonomy:** Classification of microorganism, Methods of classification and identification of microorganisms, Assessing Microbial phylogeny, Bacterial diversity-archaebacteria, eubacteria, fungi, algae, protozoa and helminthes **(4)**

7. **A Survey of the Microbial World: General characteristics of** representative microorganisms of each group
   Archaebacteria - *halophiles, thermophiles and methanogens*
   Eubacteria: Gram -ve (Proteobacteria- *Chlamydia, Spirochaetes*), Nonproteobacteria (*E. coli, Psuedomonas*, *Rhizobium,*), Gram +ve bacteria (*Bacillus, Staphylococcus, Mycoplasma, Streptomyces*), Fungi (Yeast and Rhizopus), lichens
   Viruses (Viral structures, Cultivation and identification and viral multiplication), **(8)**

8. **Microbial interactions with humans:** Principles of disease and epidemiology, Microbial diseases and their control, Mechanism of microbial pathogenicity, history, spectrum and action of antibiotics and other antimicrobial drugs, **Superbugs and opportunistic infections, Biosecurity, Microbiome** **(6)**

9. **Applied and Industrial Microbiology:** Industrial fermentation, Primary and Secondary metabolites, Role of microorganisms in the production of probiotics, industrial chemicals and pharmaceuticals, biofilms, Microbes as alternative energy sources, bioremediation, and as industrial products. **(6)**

Text / Reference Books:

1. Microbiology: An Introduction by Tortora, Funke and Case. 7th Edition, 2001
2. Prescott, Harley and Klein's Microbiology by Willey MJ, Sherwood, LM & Woolverton C J 9th Ed. (2013)
3. Brock Biology of Microorganisms by Madigan MT, and Martinko JM, Bender KS,. 14th edition. Prentice Hall International Inc, 2014.

THIRD SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BA-203 BIOENERGETICS - I

1. **Biochemical Evolution:** Chemogeny, Biogeny, and Evolution of Chromosome Organization and Genetic Regulatory Mechanisms, Time factors in evolution, Evolution of Enzyme Systems. **(6)**

2. **Amino Acids, Peptides and Proteins:** Structure, Function, Methods of Characterization, Separation Techniques based on their structure and properties, Clinical Significance, Biosynthesis. **(6)**

3. **Carbohydrates:** Mono and Polysaccharide, Classification, Structure, Function, Separation and Characterization Techniques, Clinical significance, Biosynthesis. **(5)**

4. **Lipids:** Classification, Structure, Function, Separation and Characterization Techniques, Clinical Significance. **(6)**

5. **Nucleic Acids:** Nucleic Acids and Polynucleotides, Classification, Structure, Function, Separation and Characterization Techniques, Clinical Significance. **(5)**

6. **Vitamins and Micro and Macro Nutrients:** classification, Structure, Function, Separation and Characterization Techniques, Clinical Significance. **(5)**

7. **Biochemical Energetics:** Energy Yielding and Energy Requiring Reactions, Calculations of Equilibrium Concentrations, Oxidation-Reduction Reactions, Metabolism and ATP Yield. Photosynthetic Phosphorylation, Active Transport, Second Law of Thermodynamics, Enthalpy and Entropy, Activation Energy. **(7)**

Text / Reference Books:

1. Biochemistry by Lubert Stryer, W. H. Freeman & Company, NY, 4rd Edition, 1995.
2. Lehninger Principles of Biochemistry by Lehninger, Nelson and Cox, W. H. Freeman & Company, 4th Edition, 2004
3. Biochemistry by Zubey. Wm. C., Brown publishers 4th edition,1998.

THIRD SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT- 205 CELL BIOLOGY

1. **The Cell:** Cellular compartmentalization, Organeller architecture. (3)

2. **The Nucleus:** Chromosomal DNA and its Packaging, The Global Structure of Chromosomes. (4)

3. **Cytoskeleton:** The Nature of the Cytoskeleton, Intermediate Filaments, Microtubules, Cilia and Centrioles, Actin Filaments, Actin-binding Proteins, Muscle. (4)

4. **Cell Junctions, Cell Adhesion, and the Extracellular Matrix :** Cell Junctions, Cell-Cell Adhesion, The Extracellular Matrix of Animals, Extracellular Matrix Receptors on Animal Cells-the Integrins, The Plant Cell Wall (4)

5. **Membrane Structure, Transport of Molecules and Membrane Excitability:** The Lipid Bilayer, Membrane Proteins, Principles of Membrane Transport, Carrier Proteins and Active Membrane Transport, Ion channels and Electrical Properties of Membranes (5)

6. **Protein Sorting and Vesicular Trafficking in the Cell:** The Compartmentalization of Higher Cells, The Transport of Molecules into and out of the Nucleus, The Transport of Proteins into Mitochondria and Chloroplasts, Peroxisomes, The endoplasmic reticulum.**,** Transport from the ER through the Golgi Apparatus, Transport from the Trans Golgi Network to Lysosomes, Transport from the Plasma Membrane via Endosome: Endocytosis, The Molecular Mechanisms of Vesicular Transport and the Maintenance of Compartmental Diversity. (6)

7. **Cell Signaling:** General Principles of Cell Signaling, Signaling via G-Protein-linked Cell-Surface Receptors, Signaling via Enzyme-linked Cell-Surface Receptors, Kinase Receptors, Structural Features of Trans-membrane Receptors, Hormone Receptor Interaction, Two-component signaling, Second messengers. (6)

8. **Cell Cycle and Division:** The General Strategy of the cell Cycle, The Mechanics of Cell Division, The Early Embryonic Cell Cycle, Cell- Cycle control in Yeasts and Multicellular Animals. (4)

9. **Cancer:** Cancer as a Microevolutionary Process, Tumor cells, Proto-oncogenes and viral oncogenes, Tumor suppessor genes. (4)

Text / Reference Books:

1. Molecular Biology of Cell by Albert et.al. John Wiley & Sons
2. The Cell by Cooper. ASM Press
3. Cell and Molecular Biology by Karp. John Wiley & Sons
4. The World of the Cell, by Becker, Kleinsmith, and Hardin, 6th edition (2006), Pearson/Benjamin Cummings. ISBN 0-8053-4680-5

THIRD SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-209 GENETICS

1. **Introduction to Genetics:** Brief history of genetics, genes and environment, epigenetics, genetics and society, scope and significance of genetics. **(2)**

2. **Mendelian Analysis:** Mendel's laws of inheritance, multiple alleles, lethal alleles, pleioteorism, penetrance and expressivity, interaction of genes, quantitative Inheritance. **(5)**

3. **Chromosome Theory of Inheritance:** The chromosome theory of inheritance, sex chromosomes, sex determination, sex linkage **(4)**

4. **Linkage:** Discovery of linkage, basic eukaryotic chromosome mapping, three point testcross, interference and coincidence, recombinant frequencies from selfed dihybrids, linkage maps, X^2 test, linkage mapping in bacteria and viruses. **(6)**

5. **Mutations:** Morphological and biochemical mutations, mutagens, detection of mutations, one gene-one enzyme hypothesis, colinearity, mutations rates and frequencies, mutation breeding. **(6)**

6. **Fine Structure of Gene:** The modern concept of gene, promoter, terminator, fine structure of rII locus in T4 phage, split genes, overlapping genes. **(2)**

7. **The Extranuclear Genome:** Maternal inheritance, concept of extranuclear genome in higher plants and *Chlamydomonas*, overview of mitochondrial and chloroplast genome. **(4)**

8. **Structural and Numerical changes in Chromosomes:** Detection and inheritance of deficiencies, duplications, inversions, translocations, aneuploidy, haploidy and polyploidy. **(6)**

9. **Population Genetics:** Darwin's evolution, variation and its modulation, effect of sexual reproduction on variation, sources of variation. Hardy-Weinberg equilibrium **(3)**

10. **The Dynamic Genome:** Discovery of transposable elements in maize, transposable element in prokaryotes and eukaryotes. **(2)**

Text / Reference Books:

1. Introduction to Genetic Analysis by Griffiths, Wessler, Lewontin and Carroll, Freeman and Company, 10th Edition, 2012.
2. Genetics by P. K. Gupta, Rastogi Publications, Meerut, 4th Edition, 2011
3. Concepts of Genetics, Klug & Cummings, Prientice Hall.
4. Genetics: Analysis of Genes and Genomes by Hartl & Jones, Jones and Barlett, 6th Edition.

THIRD SEMESTER EXAMINATION

L	T	P	C	Hours
3	1	0	4	40

CT-211 Introduction to material and energy balances

1. **Introduction to engineering calculation**: Physical variables, dimensions and Units, Measurements convention, standard conditions and Ideal gases, physical and chemical property data **(4)**

2. **Stoichiometry:** Fundamental, example: Stoichiometry of amino acid synthesis, Incomplete reaction and yields . **(4)**

3. **Material balances (MB):** Thermodynamic preliminaries, System and process, state and equilibrium, procedure for MB calculations **(4)**

4. **Examples for basic MB**: Continuous Filtration, Batching mixing, MB with Recycle, By-pass and Purge Streams **(4)**

5. **Stoichiometry of growth and Product formation:** Growth stoichiometry and elemental balance, Electron balances, Biomass yield, product stoichiometry, Theoretical Oxygen demand **(8)**

6. **Energy balances (EB):** Basic energy concepts such as units, intensive and extensive properties, General energy balance equations, Enthalpy calculation procedures **(4)**

7. **Enthalpy change:**Enthalpy change in non-reactive processes, steam tables, procedure for EB calculations, Enthalpy change due to reaction **(4)**

8. **Example for basics EB:** Continuous water heater, cooling in down stream**(4)**

9. Heat of reaction for processes with biomass production, Energy balance equation for cell culture **(4)**

Text / Reference Books:

1. Principles of Chemical Engineering Processes: Material and Energy Balances, Second Edition by NayefGhasem, RedhouaneHenda
2. Advances in Chemical and Process Engineering: Volume 1 Material and Energy Balances for Engineers and Environmentalists By Colin Oloman
3. Bioprocess Engineering - Basic concepts by M. L. Schuler & F. Kargi, Entice Hall 1992.
4. Bioprocess Engineering Principles by Pauline M. Doran, Academic Press 1995.
5. Fermentation & Biochemical Engineering Hand Book (1983), Principles, Process Design and Equipment. HC Vogel, Noyes.

FOURTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-202 IMMUNOLOGY

1. **Introduction to Immunology:** Historical perspective, Properties of immune response, Innate and acquired immunity. **(4)**

2. **Cells & Tissues of Immune System:** Lymphocytes, Classes of lymphocytes, Antigen presenting cells, NK Cells, Mast Cells, Dendritic Cell, Organs of the Immune System, Bone marrow, Thymus, Lymph node, Spleen, CALT, MALT. **(4)**

3. **Molecular Immunology**: - Molecular structure of antibody, Classification, Isotypes, Immunoglobulin Super family, Synthesis assembly and expression of immunoglobulin molecules, Function and diversity, Generation of antibody diversity. **(4)**

4. **Antigens:** Nature of antigens, Different characteristics of antigens, Mitogens, Hapten, Immunogen, Adjuvants. **(4)**

5. **MHC**: Discovery of MHC complex, Role of MHC, Structure of MHC molecule, Binding of peptides to MHC molecules, MHC restriction. **(4)**

6. **Effecter Mechanism of Immune Response:** Cytokines, T- cell receptors, B-cell receptor, Cell mediated cytotoxic responses, complement system, Antigen processing and presentation. **(4)**

7. **Immunological Techniques**: - Antigen- antibody reactions, Immunodiffusion, Immunoelectrophoresis, ELISA, RIA, Immunoflourescence, Flow cytometry. **(4)**

8. **Immune system in health and disease:** Introduction to mechanisms underlying - Autoimmunity, Hypersensitivity, Tumor immunity, Tissue and organ transplant. **(5)**

9. **Production of Antibodies:** Production of polyclonal and monoclonal antibodies, and their applications, chimeric and humanized monoclonal antibodies. **(4)**

10. **Vaccines**: Active and passive immunization, Live and attenuated Vaccines, Subunit, Conjugate and DNA vaccines, Biosafety issues in immunology **(3)**

Text / Reference books:

1. Kuby Immunology By Owen, Punt, & Stranford, 7th, Seventh Edition, 2013, Macmillan press.
2. The Elements of Immunology by Fahim Halim Khan, Pearson Education, 2009.
3. Kuby- Immunology by R. A. Goldsby, T.J. Kindt, B.A. Osborne, 6th Edition 2006.
4. Essentials of Immunology: Ivan Riot- Blakswell Scientific Publications, Oxford, 6th Edition, 1988.
5. Fundamentals of Immunology: Paul W.E. (Eds.) Raven Press, New York, 1988.

FOURTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-204 MOLECULAR BIOLOGY

1. **Structure and properties of nucleic acids:** Models of DNA structure, RNA structure, Physical and Chemical properties of nucleic acids. (3)

2. **Prokaryotic and Eukaryotic Genomes:** Organization of genomes, Properties of Euchromatin and Heterochromatin Packaging of eukaryotic DNA into chromosomes, C-value paradox, Cot analysis, Repetitive DNA content of eukaryotic nuclear genome. (5)

3. **DNA Replication:** Features of organellar genomes and its replication, Models of nuclear DNA replication, Replication Enzymology and process: Initiation, Elongation and Termination of replication, Telomeres. (3)

4. **Transcription:** Components of transcriptional machinery, Transcription process: Promoter recognition, Initiation, Elongation and Termination of transcription. (3)

5. **RNA Processing**: Capping and Polyadenylation, RNA Splicing, Alternative and Trans Splicing, RNA Editing, rRNA and tRNA processing, mRNA stability and transport. (3)

6. **Translation: -** Genetic code, tRNA and aminoacyl synthetases, Ribosome, Translation process: Initiation, Elongation and termination of translation, Post translational modificati**on** (5)

7. **Regulation of gene expression: -** General aspects of regulation in prokaryotes & eukaryotes: The Operon model, Activators and Repressors, Transcriptional and Post-transcriptional gene regulation, Combinatorial regulation in eukaryotes. (5)

8. **Recombination and Repair:** Recombination overview, principle of Homologous recombination, Site-specific recombination, overview of DNA repair mechanisms: mismatch and excision repair. (4)

9. **Molecular evolution:** Phylogeny, Phylogenetic trees and its applications. (4)

10. **Epigenetics:** RNA interference process, Enzymatic machinery, Small RNA mediated gene regulation, DNA methylation, Enzymology and process, Gene silencing: transcriptional and post transcriptional gene silencing, History, process and applications. (5)

Text / Reference Books:

1. **Molecular Biology: Principles of Genome Function,** Nancy Craig et al., Oxford University Press, 2014.
2. **Molecular Biology of the Gene,** Watson et al., Pearson, 2014.
3. **Lewin's Gene XI,** Joycelyn E. Krebs et al., Jones and Bartlett, 2013.
4. **Genomes 3**, T. A. Brown, Garland Science, 2006.
5. **Essentials of Molecular Biology**, Malacinski and Freifelder, Jones and Bartlelt, 2005.

FOURTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-206 ENZYME TECHNOLOGY

1. **Introduction to Enzymes:** What are enzymes, Brief history of enzymes, Nomenclature and classification of enzymes, Properties of enzymes,Structure of enzymes, Active site of enzymes, Factors influencing enzyme activity, Enzyme assays. **(6)**

2. **Specificity and Mechanism of Enzymes Action**: Types of specificity, The Koshland "induced fit" hypothesis, Strain or transition – state stabilization hypothesis. Mechanism of catalysis, Mechanism of reaction catalyzed by enzyme without cofactors, Metal-activated enzyme and metalloenzyme, Coenzymes in enzyme catalyzed reactions. **(6)**

3. **Enzyme Kinetics**: Kinetics of enzyme-catalyzed reaction, Methods for investigating the kinetics of enzyme-catalyzed reactions, Interpretation of Km, Vmax, Turnover number and Kcat, Specific activity of enzymes, Enzyme units, Inhibition of enzyme activity, Regulation of enzyme activity. **(5)**

4. **Immobilization of Enzymes**: Concept, Methods of immobilization, Kinetics of immobilized enzymes, Effects of immobilization on enzymes, Use of immobilized enzymes, Bioreactors using immobilized enzyme. **(4)**

5. **Industrial Applications of Enzymes**: Industrial enzymes: Sales value of industrial enzymes, Traditional (non-recombinant) sources of industrial enzymes, The impact of genetic engineering on enzyme production, Engineered enzymes, Extremophiles: hyperthermophiles, Enzymes from hyperthermophiles, Enzymes from additional extremophiles, Enzymes in organic solvent. **(4)**

6. **Proteases and Carbohydrases:** Proteolytic enzymes: Carbohydrases, Lignocellulose degrading enzymes, Pectin and Pectic enzymes. **(6)**

7. **Other Industrial Enzymes:** Lipases, Penicillin acylase, Amino acylase and Amino acid production, Cyclodextrins and cyclodextrin glycosyl transferase, Enzymes in animal nutrition, Enzymes in molecular biology. Clinical applications of enzymes. **(5)**

8. **Enzyme Engineering**: Prediction of enzyme structure, Design and construction of novel enzymes. **(4)**

Text / Reference Books:

1. Enzymes: *Biochemistry,Biotechnology and Clinical Chemistry* by T. Palmer and P.L. Bonner : Woodhead publishing limited, 2007
2. Fundamentals of Enzymology by N.C.Price and L. Stevens: Oxford University Press, 2002.
3. Enzymes in Industry: Production and Applications by (Ed.) Wolfgang Aehle, WILEY-VCH Verlag GmbH & Co. KGaA., 2004.
4. Introduction to Proteins Structure by Branden and Tooze, Garland Publishing Group,1999
5. Proteins: *Biochemistry and Biotechnology* by Gary Walsh: John Wiley & Sons, Ltd, 2014.

FOURTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BA - 208 BIOENERGETICS – II

1. **Catabolism and the Generation of Chemical Energy:** Catabolism of carbohydrates, proteins, liquids and generation of chemical energy. **(6)**

2. **Metabolic Strategies:** General Principles of Intermediary Metabolism, Regulation of Pathways, Strategies for Pathway Analysis. **(5)**

3. **Glycolysis, Gluconeogenesis, and the Pentose Phosphate Pathway:** Glycolysis, Gluconeogenesis, Regulation of glycolysis and Gluconeogenesis, the pentose Phosphate Pathway. **(6)**

4. **The Tricarboxylic Acid Cycle:** Discovery of the TCA Cycle, Steps in the TCA Cycle, Stereochemical Aspects of TCA Cycle Reactions, ATP Stoichiometry of the TCA Cycle, Thermodynamics of the TCA Cycle, The Amphibolic Nature of the TCA Cycle, The Glyoxylate Cycle, Oxidation of other Substrates by the TCA Cycle, Regulation of TCA Cycle Activity. **(7)**

5. **Electron Transport and Oxidative Phosphorylation:** The Mitochondria Electron - Transport Chain, Oxidative Phosphorylation, Transport of Substrates, Pi, ADP and ATP into and out of Mitochondria, Electron Transport and ATP Synthesis in Bacteria. **(6)**

6. **Photosynthesis and other Processes Involving Light*:*** Photosynthesis, Other Biochemical Processes Involving Light. **(5)**

7. **Metabolism of Fatty Acids:** Fatty Acid Degradation, Biosynthesis of Saturated Fatty Acids, Regulation of Fatty Acid Metabolism. **(5)**

Text / Reference Books:

1. Biochemistry by Lubert Stryer, W. H. Freeman & Company, NY, 4rd Edition, 1995.
2. Lehninger Principles of Biochemistry by Lehninger, nelson and Cox, W. H. Freeman & Company, 4th Edition, 2004
3. Biochemistry by Zubey. Wm. C., Brown publishers 4th edition,1998.

FOURTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

CT-212 Fundamentals of Heat and Mass Transfer

1. **Heat transfer**
   Modes of heat transfer

2. **Heat transfer by conduction**
   Fourier's law, Three-dimensional conduction equation, Thermal conductivity, Steady-state conduction, unsteady-state conduction

3. **Heat transfer by convection**
   Coefficient of heat transfer, Natural convection, Forced convection, Jackets and coils of agitated vessels, Nonnewtonian Fluids, Liquid Metals

4. **Heat transfer with change of phase condensation**
   Condensation, Boiling (vaporization) of liquids

5. **Heat transfer by radiation**
   General references, Nomenclature for radiative transfer, Nature of thermal radiation,Radiative exchange between surfaces and solids, Emissivities of combustion products, Radiative exchange between gases or suspended matter and a boundary, combustion chamber heat transfer

6. **Fundamentals of mass transfer:**
   Introduction, Fick's First Law, Continuity and Flux Expressions, Diffusivity Estimation—Gases, Diffusivity Estimation—Liquids, Diffusion of Fluids in Porous Solids,

7. **Interphase Mass Transfer**
   Mass-Transfer Principles: Dilute Systems, Concentrated Systems, HTU (Height Equivalent to One Transfer Unit), NTU (Number of Transfer Units), Definitions of Mass-Transfer Coefficients k_G and k_L, Simplified Mass-Transfer Theories,Mass-Transfer Correlations, Effects of Total Pressure on k_G and k_L, Effects of Temperature on k_G and k_L, Effective Interfacial Mass-Transfer Area a, Volumetric Mass-Transfer Coefficients K_Ga and K_La
   Example of Mass Transfer in Biological Reactor

Text / Reference Books:

1. Heat Transfer, Holman J.P., McGraw Hill, New York, 8th Ed 1997.
2. Unit Operations of Chemical Engineering, McCabe W.L., Smith J.C. and Harriott P. McGraw Hill International edition, Singapore, 5th Ed., 1993.
3. Chemical Engineering, Vol. I and II, Coulson J.M. and Richardson J.F. Butterworth Heinemann, Oxford, 6th Ed., 1999.
4. transprt Processes and Unit Operations, Geankoplis C.J., Prentice Hall of India. 3rd, 1999.
5. Mass Transfer Operations, Treybal, R.E. Mc Graw Hill.

FIFTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-305 ANIMAL BIOTECHNOLOGY

1. **Introduction to Animal Tissue Culture:** Background, Advantages, Limitations, Application, Culture Environment, Cell Adhesion, Cell Proliferation, Differentiation. (4)

2. **Design, Layout and Equipment:** Planning, Construction, Layout, Essential Equipments, Aseptic Technique, Objectives, Elements, Sterile Handling, BioSafety, Risk Assessment, General Safety, Fire, Radiation, Biohazards. (5)

3. **Media:** Physicochemical Properties, Balanced Salt Solutions, Complete Media, Serum, Serum-Free Media, Disadvantages of Serum, Advantages of Serum-Free media. (5)

4. **Primary Culture:** Isolation of Tissue, Steps involved in primary cell culture, Cell Lines, Nomenclature, Subculture and Propagation, Immortalization of cell lines, Cell line designations, Routine maintenance, Introduction to cell culture reactors and scale-up (in suspension and in monolayer). (5)

5. **Characterization & Quantitation of Cell Line:** Need for characterization, Morphology, Chromosome Analysis, DNA Content, RNA and Protein, Enzyme Activity, Antigenic Markers, Transformation, Immortalization, Aberrant Growth Control, Tumorigenicity, Cell counting, DNA content, Protein, Rates of Synthesis, Cell Proliferation, Plating Efficiency, Labeling Index, Generation Time. (5)

6. **Contamination:** Source of contamination, Type of microbial contamination, Monitoring, Eradication of Contamination, Cross-Contamination (3)

7. **Cryopreservation:** Need of Cryopreservation, Preservation, Cell banks, Transporting cells (2)

8. **Cytotoxicity:** Introduction, In vitro limitations, Nature of assay, Viability assay, Survival assay, Microtitration assay, Transformation assay. (3)

9. **Transgenic Animals:** Methodology, Embryonic Stem Cell method, Microinjection method, Retroviral vector method, Applications of transgenic animals (4)

10. **Applied aspects of animal biotechnology:** Cloning and selection, In Vitro Fertilization and Embryo Transfer- Steps involved in IVF, Fertilization by means of micro insemination, PZD, ICSI, SUZI, MESA; Introduction to gene therapy: ex vivo versus in vivo gene therapy. Application of animal cell culture technology in drug testing, production of human and animal viral vaccines and pharmaceutical proteins. Bioethical concerns in animal biotechnology. (4)

Text / Reference Books:

1. Animal Cell Culture: A Practical Approach by R. Ian Freshney, Sixth edition, 2010, Wilwy-Blackwell publication
2. Animal Cell Culture by John R.W. Masters, Third Edition, 2000Oxford University Press
3. Molecular Biotechnology (Second Edition). S. B. Primrose, 1991. Blackwell Scientific Publications Ltd.
4. Animal Cell Biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press.

FIFTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-307 RECOMBINANT DNA TECHNOLOGY

1. **Enzymes used in RDT:** Restriction enzymes, DNA ligase, Phosphatase, DNA Kinase, Polymerases, Exonucleases, Reverse Transcriptase, Tools for genome editing. (5)

2. **Cloning Vectors:** Plasmids, Bacteriophages, Phagemids, Cosmids, Artificial chromosomes (BACs, YACs), Shuttle vectors, Virus based vectors. (4)

3. **Methods of gene transfer and selection:** Strategies for preparation of gene silencing and overexpression constructs. Methods of Transformation in prokaryotes and eukaryotes. Transformant selection strategies, Mode of action of antibiotics. (5)

4. **Preparation and application of molecular probes:** DNA probes, RNA probes, Radioactive labeling, Non-radioactive labeling, use of molecular probes, DNA barcoding. (3)

5. **Analysis and expression of cloned genes in host cells:** Restriction enzyme analysis, RFLP, Southern blotting, Northern blotting, Western blotting, South-Western, In-situ hybridization, Reporter genes, DNA Sequencing. (4)

6. **Overexpression of Recombinant Proteins:** Expression vectors, Factors affecting expression of cloned genes, Bacterial and eukaryotic hosts for protein expression, Optimization of heterologous protein expression, Fusion proteins. (5)

7. **Gene libraries** - cDNA synthesis, Construction of genomic and cDNA libraries, Linkers, Adaptors, Homopolymer tailing, Amplification of gene libraries, Screening of different libraries by colony and plaque hybridization, immunological screening (4)

8. **Polymerase Chain reaction (PCR):** Basic principles of PCR and use of different heat stable enzymes, Designing of primers, modifications, applications. (4)

9. **Modifying Genes:** Types of mutations, Chemical mutagens, Site-directed mutagenesis: methodology and implications, In vivo versus in vitro Mutagenesis (4)

10. Ethical, Legal and Social implications of rDNA technology products/organisms. (2)

Text / Reference Books:

1. Gene Cloning and DNA Analysis: An Introduction, T.A. Brown, Wiley-Blackwell, 2015.
2. Molecular Cloning: A Laboratory Manual, Green and Sambrook, Cold Spring Harbor Laboratory Press, 2012.
3. From Genes to Genomes: Concepts & Applications of DNA Technology by J.W. Dale & M.V. Schartz, Wiley-Blackwell, 2011.
4. . Molecular Biotechnology: Principles and Applications of Recombinant DNA, Glick and Pasternak, American Society for Microbiology, 2010.
5. Principles of Gene Manipulation and Genomics, Primrose and Twyman, 2006.

FIFTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-309 DEVELOPMENTAL AND STEM CELL BIOLOGY

1. History: Works of Pander, Rathke and Karl Ernst von Baer, Evolutionary embryology, cycle of life, approaches to studying embryology, Boveri, Mangold and Spemann's contribution and the concept of Morphogen Gradient. Concept of stem cells, Till and McCulloch experiments on Self Renewal, Haematopoiesis, Metcalf's experiments, Colony Stimulating Factors (CFU-S). (4)

2. Model organisms: Sea Urchin and Salamander as an early model system, Developmental Genetics and Cell –Cell communication using *Drosophila* and *C. elegans* as model system. Amphibians, Fishes and Birds as model organism to study Axis formation. (5)

3. Gastrulation: Emergence of ectoderm, endoderm and mesoderm and organogenesis, Paraxial and intermediary mesoderm, Lateral plate mesoderm and endoderm, Central nervous system and epidermis, Eye development in vertebrates, Neuronal crest cells and axonal specificity. (6)

4. Sex determination and gametogenesis in mammals. Post embryonic development– metamorphosis, regeneration and ageing. (5)

5. Molecular Imaging techniques to study stem cells, Lineage analysis, Stem cell self-renewal and differentiation pathways. (5)

6. Types of stem cells: Mesenchymal Stem cells and their differentiated Cells, Embryonic Stem Cells and their biogenesis and regulation, Epidermal stem cells (Liver stem cells, skin stem cells, Pancreatic stem cells), Induced pluripotent stem cells (iPSCs), neural crest derived stem cells, stem cells in animal model of regeneration. (5)

7. Recent advances and applications of stem cell research: Role of microenvironment in stem cell function, involvement of Epigenetics, Small RNAs, telomeres, and transcription factors in stemness of stem cells, genome editing of ES/iPS cells, use of iPSCs for understanding disease progression, bone marrow transplantation, skin transplantation, tissue engineering. (6)

8. Biosafety and bioethics related to stem cell sciences and clinical translation, Regulatory affairs involved (ISSCR guidelines). (4)

References:

1. Developmental Biology, Tenth Edition by Scott F. Gilbert.
2. Developmental Biology, Eleventh Edition by Scott F. Gilbert and Michael J. F. Barresi.
3. Human Embryology and Developmental Biology by Bruce M. Carlson.
4. Essentials of Stem cell biology, Third edition by Robert Lanza.
5. Molecular biology of the Cell, Sixth Edition by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts and Peter Walter.
6. www.stembook.org
7. Reading and viewing of classical papers and Nobel Prize lectures in the related area.

FIFTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-311 PLANT BIOTECHNOLOGY

1. **Introduction:** History of plant tissue culture, evolution of plant improvement methods, green revolution to genetic engineering approaches, comparison of conventional and advanced biotechnological methods. (4)

2. **Basics of Plant tissue culture**: Design of a plant tissue culture laboratory and additional facilities: Composition of commonly used culture media, selection criterion for different types of media and medium preparation, role of plant growth regulators and other adjuvants, diversity of disinfecting agents and sterilization protocols. (4)

3. **Concept of Cellular Totipotency and development of regeneration protocols:** cyto-differentiation, organogenic differentiation, Choice of explants, induction of Somatic embryos, artificial/synthetic seed technology, cryopreservation, clonal propagation, pathogen free plant production, implications in plant germplasm conservation,. (4)

4. **Potential of Variability induced *in vitro***: Somaclonal & gametoclonal variations, sources and reasons for their occurrence, their inheritance and detection in subsequent generations, screening and selection of desirable variations, application potential. (4)

5. **Cell and protoplast Suspension Culture:** Isolation of single cells/protoplasts, culture of single cells, suspension cultures-batch and continuous, structure and design of plant cell reactors, techniques of somatic hybridization and cybridization, use of somatic hybrids and cybrids in plant improvement efforts. (4)

6. **Haploid Production:** basic technique, factor affecting androgenesis, ontogeny of androgenic haploids, plant regeneration from pollen embryos, gynogenesis, haploid production through distant hybridization to raise homozygous diploids, applications and limitations. (4)

7. **Triploid Production:** endosperm culture, callusing/organogenesis, histology and cytology of cells, role as nurse tissue, potential applications such as seedless fruits and role in breeding programs. (4)

8. **Zygotic Embryo Culture:** culture requirements at various stages of development, role of the suspensor in embryo culture, microsurgical experiments, embryo and seed culture of parasitic angiosperms, morphogenic potential of the embryo callus, techniques of embryo rescue, in vitro pollination and fertilization efforts and their applications. (4)

9. **Transgenic plant production**: Need for their production, Nuclear genome transformation, organelle genome transformation, essential steps involved, examples of popular transgenic plants, ethical, commercial and marketing aspects of transgenic technology and its limitations.(4)

10. **Plants as biofactories**: Sustainable and renewable nature of source plants/explants, production of chemicals, pigments, flavonoids, perfumes, insecticides, anticancer agents and other useful compounds at industrial scale, strategies used to optimize their production and commercialization aspects. (4)

References:

1. Bhojwani, SS. (2005). Plant Tissue Culture: Theory And Practice, 5th Revised Edition, Elsevier.
2. Dodds, JH & Roberts, LW. (1995). Experiments in plant tissue culture. Cambridge University press, Cambridge.
3. Bhojwani, SS. (2003). Agrobiotechnology and Plant Tissue Culture. Oxford University Press.
4. Slater, S, Scott, NW & Fowler, MR. (2008). Plant Biotechnology: the genetic manipulation of plants, second edition, Oxford.

FIFTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-313 UNIT OPERATIONS AND PLANT DESIGN

1. **Introduction**
   Definitions and Principles (5)

2. **Fluid Mechanics**
   Fluid Statics and Its Applications, Fluid Flow Phenomena, Basic Equations of Fluid Flow, Incompressible Flow in Pipes and Channels, Flow of Compressible Fluids, Flow past Immersed Objects, Transportation and Metering of Fluids, Agitation and Mixing of Liquids. (5)

3. **Heat Transfer and Its Applications**
   Heat Transfer by Conduction, Principles of Heat Flow in Fluids, Heat Transfer to Fluids without Phase Change , Heat Transfer to Fluids with Phase Change, Radiation Heat Transfer, Heat-Exchange Equipment, Evaporation (5)

4. **Mass Transfer and Its Applications**
   Principles of Diffusion and Mass Transfer between Phases, Gas Absorption, Humidification Operations, Equilibrium-Stage Operations, Distillation, Introduction to Multicomponent Distillation, Leaching and Extraction, Drying of Solids, Fixed-Bed Separatons, Membrane Separation Processes, Crystallization (5)

5. **Operations Involving Particulate Solids** (5)
   Properties and Handling of Particulate Solids, Mechanical Separations

6. **Plant Design Introduction** (5)
   Plant Design, General Overall Design Considerations, Practical Considerations in Design, Engineering Ethics in Design

7. **Design Considerations** (5)
   Health and Safety Hazards, Loss Prevention, EnvironmentalProtection, Plant Location, Plant Layout, Plant Operation and Control, Patent Considerations

8. **Process Design Development** (5)
   Development of Design Database, Process Creation, Process Design, Process Flow Diagrams, Piping and Instrumentation Diagrams, Vessel and Piping Layout Isometrics, Equipment Design and Specifications, The Preliminary Design - A Specific Example

Suggested reading:

1. Unit Operations of Chemical Engineering Paperback – Jul 2014, by Warren McCabe (Author), Julian Smith (Author), Peter Harriott (Author)
2. Plant Design and Economics for Chemical Engineer by Max S. Peters

SIXTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-314 BIOINFORMATICS

1. **Biological algorithms**: Comparison with computer algorithms, string structures, Introduction to programming in computational biology through C/ Perl / Java. (2)

2. **Biological Databases:** Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, PDB, MMDB, Structure file formats, Visualizing structural information, Database of structure viewers , Collection of sequences, sequence annotation, sequence description. (5)

3. **Sequence Alignment and Database Searching**: Evolutionary basis of sequence alignment, Optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustal, Muscle, etc. Scoring matrices, Distance matrices. (5)

4. **Phylogenetic Analysis:** Alignment, tree building and tree evaluation, Comparison and application of UPGMA, NJ, MP, ML methods, Bootstrapping, Jackknife. Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, CBOL recommendations, BOLD. (5)

5. **Structural Biology:** 3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules. External coordinates and Internal Coordinates, Molecular Mechanics, Force fields etc. Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization ofprotein structure –like CATH,SCOP, FSSP (5)

6. **Classification and comparison of 3D structures:** DNA & RNA secondary and tertiary structures, t-RNA tertiary structure. Protien Secondary structure prediction: Algorithms viz. Chou Fasman, GOR methods, Tertiary Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology/comparative Modeling, fold recognition, threading approaches, and *ab initio* structure prediction methods. CASP. Computational design of Promoters, Proteins & Enzymes. (5)

7. **Application in drug design:** Chemical databases like NCI /PUBCHEM. Fundamentals of Receptor-ligand interactions. Structure-based drug design: Identification and Analysis of Binding sites and virtual screening. Ligand based drug design: Structure Activity Relationship – QSARs & Pharmacophore etc. In silico predictions of drug activity and ADMET. (5)

8. **Analysis of Microarray data:** Designing of oligo probes; Image processing and normalization; Microarray data variability (measurement ad quantification); Analysis of differentially expressed genes; Experimental designs. (5)

9. **Systems Biology:** System-level understanding of biological systems, use and integration of data from transcriptomics, proteomics and metabolomics; concepts in glycomics, interactomics and fluxomics. (3)

Text / Reference Books:

1. Bioinformatics: A practical guide to the analysis of genes and proteins A.D. Baxevanis and B.F.F. Ouellette (Eds). 2002 John Wiley and Sons.
2. Bioinformatics: Sequence and Genome Analysis by D.W. Mount, 2001, Cold Spring Harbor Laboratory Press.
3. Introduction to Bioinformatics Algorithms; Jones & Peuzner; Ane Books, India.
4. Microarray Bioinformatics; Dov Stekel; Cambridge University Press.
5. Web-resources and suggested reviews/ research papers.

SIXTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-316 STATISTICAL METHODS IN BIOLOGY AND EXPERIMENTAL DESIGN

1. **Introduction**: Types of biological data (ordinal scale, nominal scale, continuous and discrete data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling. **(5)**

2. **Descriptive Statistics:** Measures of Location, Properties of the Arithmetic Mean, median, mode, range, Properties of the Variance and Standard Deviation, Coefficient of Variation, Grouped Data, Graphic Methods, Obtaining Descriptive Statistics on the Computer, Case study. **(5)**

3. **Probability and Distribution:** Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, poisson distribution and normal distribution. **(4)**

4. **Correlation and Regression Analysis**: Correlation, Covariance, calculation of covariance and correlation, Correlation coefficient from ungrouped data Spearson's Rank Correlation Coefficient, scatter and dot diagram, General Concepts of regression, Fitting Regression Lines, regression coefficient, properties of Regression Coefficients. Standard error of estimate. **(6)**

6. **Statistical hypothesis testing:** Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making. **(4)**

7. **Tests of Significance:** Steps in testing statistical significance, selection and computation of test of significance and interpretation of results. Sampling distribution of mean and standard error, Large sample tests (test for an assumed mean and equality of two population means with known S.D.), z-test; Small sample tests (t-test for an assumed mean and equality of means of two populations when sample observations are independent); Parametric and Non parametric tests (Mann-Whitney test); paired and unpaired t-test, chi square test. **(8)**

8. **Experimental Designs:** Introduction to study designs: Longitudinal, cross-sectional, retrospective and prospective study, Principles of experimental designs, Randomized block, and Simple factorial designs, Analysis of variance (ANOVA) and its use in the analysis of RBD, introduction to meta-analysis and systematic reviews, ethics in statistics. **(8)**

Text / Reference Books:

1. Methods in Biostatistics for Medical Students and Research Workers (English), Jaype Brothers, 7th Edition, 2011
2. Statistical methods in biology by Norman T.J. Bailey, Cambridge University Press 3rd Edition, 1995.
3. Biostatistics by P. N. Arora and P. K. Malhan, Himalaya Publishing House, 2nd Edition, 2006.
4. Biostatistical analysis. Jerold Zar, Pearson Education, 4th Edition.
5. Biostatistics; A foundation for analysis in the Health Sciences, Wiley, 7th Edition.
6. ML Samuels, JA Witmer (2003) Statistics for the Life Sciences, 3rd edition. Prentice Hall.

SIXTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-318 DOWNSTREAM PROCESSING

1. **Screening and Design Purification strategies:** An overview, Establishment of a design space for biopharmaceutical process, High-throughput process development, Media selection in ion-exchange chromatography in a single microplate, high-throuput screening of dye- ligand for chromatography (5)

2. **Low-resolution protein purification methods:** Aqueous two phase partitioning systems, A platform for isolation of process related impurities from therapeutic proteins, Simultaneous purification refolding of protein by affinity precipitation and macro (Affinity ligand)-facilitated three-phase partitioning (MLFTPP), Co-expression and co-purification of antigen-antibody complexes in bacterial cytoplasm and periplasm, immunoglobulin purification by caprylic acid. (5)

3. Filtration, chromatography (comparison), rational of choosing between quality and cost of different products. (2)

4. **Protein Purification and characterization:** Introduction, initial recovery of proteins, removal of whole cells and cell debris, concentration and primary purification, protein inactivation and stabilization, protein characterization. (6)

5. **Large scale protein purification:** Some general principles, range and medical significance of impurities potentially present in protein based therapeutic products, labeling and packing of finished products. (3)

6. **Animal based products:** General DSP, Case studies of: monoclonal antibodies, Tissue plasminogen activator, insulin, erythropoietin. (4)

7. **Plant based products:** General DSP, Case studies of: shikonin., Protein extracts from Seed material and green tissues (3)

8. **Microbial based products:** General DSP, Case studies of: lipase, cellulose, amylase, horse radish peroxidase, subtilisin, ethanol, citric acid, xanthan gum (12)

References:

1. Nikolaos E. Labrou, Protein Downstream Processing: design, development and Application of high and low resolution methods in Molecular biology, Springer protocols, Humana Press, 2014.
2. Proteins: Biochemistry and biotechnology by Gary Walsh, Wiley Blackwell, Second Edition, 2002.

SIXTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-320 MEDICAL BIOTECHNOLOGY

1. **General Introduction and Overview:** Introduction to biotech products, emerging trends .**(1)**

2. **Specimen Collection & Processing: application:** Specimen collection (Blood, urine, spinal fluid, saliva synovial, fluid, Amniotic fluid), specimen processing, Preservation, transportation. **(2)**

3. **Criteria of Reliability and Quality Control:** Sensitivity, specificity, precision and accuracy, Receiver Operator Characteristics, Interpretation a test **(3)**

4. **Quality Management:** Fundamentals of total quality management, Element of QAP, External quality assessment and GLP, ISO guidelines. **(3)**

5. **General Function Tests:** Principle of diagnostic enzymology, Digestive enzyme, miscellaneous enzyme, Liver function test, Cardiac Function Test, Renal Function Test, Thyroid Function test, Reproductive endocrine function test. **(8)**

6. **Molecular and Immunodiagnostic tools for detection of genetic and infectious diseases:** Introduction, Antigen-Antibody Reactions, Antibody Production, molecular diagnosis of bacterial, viral and parasitic infections, PCR, RFLP, SSCP, Microarrays, FISH, In-situ hybridization. **(6)**

7. **Biomarkers and Drug Targets:** Basic concepts and novel advances, Antibody markers, CD Markers, FACS, HLA typing **(4)**

8. **Drug delivery and development of biopharmaceuticals**: Pulmonary drug delivery, Cell specific drug delivery**.** Brain-specific drug delivery. Nanomaterial in drug delivery, Liposomes. **(4)**

9. **Therapeutics:** Protein based Drugs, Hematopoietic Growth Factors, Interferons and Interleukins, Insulin, Growth Hormones, Recombinant Coagulation Factors and Thrombolytic Agents, Monoclonal Antibodies, Follicle-Stimulating Hormone, Oligonucleotides. (**8)**

10. **Regulatory and ethical norms of Medical Biotechnology. (1)**

Text / Reference Books:

1. Medical Biotechnology: Judith Pongrace ISBN-13: 978-0080451350.
2. Medical Biotechnology: Bernard R Glick ISBN-13: 978-1555817053.
3. Tietz Textbook of Clinical Chemistry, Carl A. Burtis, Edward R. Ashwood, Harcourt Brace & Company. Aisa Pvt. Ltd.
4. Essentials of Diagnostic Microbiology, Lisa Anne Shimeld.
5. Diagnostic Microbiology, Balley & Scott's.
6. Tietz Text book of Clinical Biochemistry, Burtis & Ashwood.
7. The Science of Laboratory Diagnosis, Crocker Burnett.

SIXTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-322 BIOPROCESS ENGINEERING

1. **Reaction Engineering:** Homogeneous reactions Basic reaction theory, calculation of reaction rates, general reaction kinetics for biological systems, yields in cell culture, cell growth kinetics, production kinetics, kinetics of cell death. Heterogeneous reactions: Concentration gradients and reaction rates in solid catalysts, internal mass transfer and reaction, the Thiele modulus and effectiveness factor, external mass transfer. (5)

2. **Process Initialization:** Types of sterilization, thermal death kinetics of microorganism. Heat sterilization of liquid medium in batch and continuous mode. Air sterilization. Inoculum development. Various types of Fermentation, submerged fermentation, aerobic and anaerobic fermentation. Overview of biosynthetic mechanisms. Metabolic stoichiometry. (5)

3. **Reactor Engineering:** Bioreactor configurations, practical considerations for bioreactor construction, monitoring and control of bioreactors, ideal reactor operations, batch operation of a mixed reactor. (5)

4. **Bioprocess Scale up:** Scale up with constant parameters like OTR, mixing, shear stress, flow regime, Reactor volume, etc. Scale-up methods by currently used rules-of-thumb viz. constant P/V, kLa, Various approaches to scale-up including regime analysis and scale-down. Analysis of alternate bioreactor configurations including cell-recycle, air-lift and immobilized-cell bioreactors, Problems on scale-up methods. (5)

5. **Commercial Products Processing :**Bulk organics (ethanol), Biomass (Bakers Yeast), Organic acids (Citric Acid), Amino Acids (L-Lysine), Microbial Transformations (Steroids), Antibiotics (Penicillin), Extra Cellular Polysaccharides (Xanthan Gum), Nucleotides (5-GMP), Vitamins (B_{12}), Pigments (Shikonin). (5)

6. **Process Technology:** production of cell biomass and some primary metabolites, e.g. ethanol, acetone-butanol, citric acid, dextran and amino acids. Microbial production of industrial enzymes-glucose isomerase, cellulase & lipases. (5)

7. **Bioconversions:** Applications of bioconversion, transformation of steroids and sterols. Transformation of non-steroidal compounds, antibiotics and pesticides. Bioenergy-fuel from biomass, production and economics of biofuels. (5)

8. **Biosafety & Biosecurity :** Biological Risk Assessment, Laboratory Biosafety Level 1 to 4, Animal Biosafety biosafety for research with recombinants, Biosecurity, development of biosecurity program, Containment for biohazards. (5)

Text / Reference Books:

1. Bioprocess Engineering - Basic concepts by M. L. Schuler, F. Kargi & M. DeLisa, 3rd Edition, Prentice Hall 2017.
2. Bioprocess Engineering Principles by Pauline M. Doran, 2nd Edition Academic Press 2012.
3. C. Ratledge & B. Kristiansen, "Basic Biotechnology" 3rd Edn. Cambridge University Press (2008).
4. Peter F. Stanbury, Stephen J. Hall & A. Whitaker, "Principles of Fermentation Technology", Â Elsevier India Pvt Ltd.(2007).

SEVENTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-403 ENVIRONMENTAL BIOTECHNOLOGY

1. **Introduction to environment** biotechnology: Issues and scope of environmental biotechnology, concept of ecology and ecosystem, environmental pollution (Water, soil and air). (5)

2. **Sewage and waste water treatment:** Anaerobic and aerobic treatment, conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic, and fermentative bacteria- technical process and conditions, emerging biotechnological processes in waste - water treatment. (4)

3. **Solid waste management:** landfills, composting, earthworm treatment, recycling and processing of organic residues, treatment of hazardous waste, biomedical waste management. (4)

4. **Biodegradation of xenobiotic compounds**: Organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. (4)

5. **Bioremediation and biorestoration:** Bioremediation strategies,in situ bioremediation, ex situ bioremediation, phytoremediation, reforestation through micropropagation, development of stress tolerant plants, use of mycorrhizae in reforestation, use of microbes for improving soil fertility, reforestation of soils contaminated with heavy metals. (4)

6. **Natural resource recovery:** Extraction of metals from ores; recovery of metals from solutions; microbes in petroleum extraction; microbial desulfurization of coal. (4)

7. **Environmental biotechnology in agriculture:** Biofertilizers and microbial inoculants, biopesticide, bioinsecticides, bioherbicides. (4)

8. **Biofuel**: Fossil fuels and emission from fossil fuels, green house gases, remediation from the emission from fossil fuels, biological energy sources, biogas, bioethanol, biohydrogen. (4)

9. **Environmental genetics**: Degradative plasmids, release of genetically engineered microbes in environment. (4)

10. Environmental laws and policies, safety and environmental ethics. (3)

Text / Reference Books:

1. Environmental biotechnology by Alan Scragg (2005);Oxford university press.
2. Text book of environmental biotechnology by P.K. Mohapatra: I.K. International
3. Research articles

SEVENTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-405 PROTEIN BIOTECHNOLOGY

1. Protein Structure: Introduction, overview of protein structure, higher-level structure protein post translational modification, protein stability and folding. (4)

2. Protein Sources: Introduction, microorganisms as sources of proteins, proteins from plants, animal tissue as protein source, direct chemical synthesis, conclusion (4)

3. Proteome analysis (3)

4. Protein engineering: case studies of engineering cytokines, antibodies. (3)

5. Therapeutic Proteins: Introduction, Blood products, Haemophilla A and B, Anticoagulants, Thrombolytic agents, Additional blood related products, vaccine technology, vaccines for AIDS. (6)

6. Therapeutic antibodies and enzymes: Introduction, antibodies for in vivo application therapeutic enzymes, single chain antibodies. (4)

7. Hormones and growth factors used therapeutically: Introduction, insulin, glucagon, gonadotrophins, growth hormone, erythropoietin, other growth factors, thyrotropin, corticotrophin, prolactin, peptide regulatory factors. (6)

8. Interferons, interleukins and additional regulatory factors: cytokine vs hormones, interferons, interleukins, tumour necrosis factors, colony-stimulating factors, cytosine toxicity. (3)

9. Catalytic industrial proteins: Cellulases and cellulosomes, glucose oxidase, chymosin, amylase. (3)

10. Non-catalytic industrial proteins: Introduction, functional properties of proteins, milk and milk proteins, animal and microbial proteins, sweet and taste modifying proteins. (4)

References:

1. Fersht, A.R.: Protein folding and stability: the pathway of folding of barnase.
2. Jamie B Spangler, Ignacio Moraga, Juan L. Mendoza and K. Christopher Garcia. Insights into Cytokine-Receptor interactions from cytokine engineering, *Annual review Immunology, 2015.*
3. Christopher J. Oldfield and A. Keith Dunker: Intrinsically disordered proteins and intrinsically disordered protein regions. Annual Review Biochemistry, 2014.
4. Patrick Chames, Marc Van Regenmortel, Etienne Weiss and Daniel Baty: Therapeutic Antibodies: Success, limitations and hopes for future.
5. Proteins: biochemistry and biotechnology by Gary Walsh, Wiley Blackwell, Second Edition.
6. Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding – Alan Fersht.

SEVENTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-407 BIOENTREPRENEURSHIP AND MANAGEMENT (NUES)

Objective: To provide elementary knowledge on the social studies of science, technology and economy, and build concepts associated with entrepreneurship, business, and economic and social development through biotechnology. The course also is also intended to impart certain basic communication skills related to scientific, technical and business writing. Through this course, the students develop a perspective on the importance of interdisciplinary influences in the success of biotechnology products and services in the market and build on them further or apply them in a business environment.

1. Historical and philosophical foundations of science, technology and society
2. Sociological and economic foundations of STI, development and changing values
3. Business economics, concepts, and principles
4. Enterprise and production management
5. Marketing management, methods and skills
6. Innovation in business: science, technology and beyond
7. Entrepreneurship, startup ecosystem
8. Communication for development vs. development communication
9. Business writing and communication: projects, promotions, tech transfer, etc.
10. Scientific and technical writing in academics
11. Ethics of communication in academics and business, norms and regulations
12. Case studies of success/failure in bioentrepreneurship and biotechnology business

Books/References:

Biobazar by Janet Hope, Harvard Univ Press
JD Bernal
Thomas Kuhn, Structure of Scientific revolutions
What is science, by Sundar Sarukkai, NBT

SEVENTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-409 BIOPROCESS CONTROL ENGINEERING

1. **The Control of a Chemical Process: Its Characteristics and Associated Problems.** (5)
Incentives for chemical Process control, Design Aspects of a Process Control System, Hardware for a process control system.

2. **Modeling the Dynamic and Static Behavior of Chemical Processes.** (5)
Development of a mathematical model, Modeling Considerations for control Purposes.

3. **Analysis of the Dynamic Behavior of Chemical Processes.** (5)
Computer Simulation and the linearization of nonlinear system, Laplace Transforms, Solution of Differential Equations using Laplace transforms, Transfer Functions and the input-Output Models, Dynamic Behavior of First order Systems, Dynamic Behavior of Second order systems, Dynamic behavior of Higher-order systems.

4. **Analysis and Design of Feedback Control Systems.** (5)
Introduction to Feed back control, Dynamic Behavior of Feedback-controlled Processes, Stability Analysis of Feed Back systems, Design of Feed Controllers, Frequency response analysis of linear Processes, Design of Feedback Control Systems using frequency response techniques.

5. **Analysis and Design of Advanced Control Systems.** (5)
Feed back control of systems with large dead time or Inverse response, Control system with Multiple Loops, Feed forward and ratio control, Adaptive and Inferential control systems.

6. **Design of Control Systems for Multivariable Processes.** (5)
Synthesis of Alternative control configurations for multiple-input, Multiple output Processes, Interaction and Decoupling of Control Loops, Design of control Systems for complete plants.

7. **Process Control Using Digital Computers** (5)
Digital Computer control Loops, From Discrete- Time Systems, Z-Transforms, Discrete-Time Repsonse of Dynamic systems, Designs of Digital Feed back controllers, Process Identification and Adaptive Control.

8. **Computer Aided Control.** (5)

Suggested readings:

1. Chemical Process Control: An Introduction to Theory and Practice by G. Stephanopoulos, Prentice Hall, New Delhi, 1984
2. Process Modeling Simulation and Control for Chemical Engineers, by W.L. Luyben.. 2nd ed., McGraw Hill, 1990.
3. Process Control: Modeling, Design and Simulation by B.W. Bequette, Prentice Hall, New Delhi, 2003. Process Dynamics and Control, John Wiley and Sons, 2nd ed., 2004. 2 3. 4.
4. Karim 'Chemical & Biochemical Process Control'.
5. Harriot 'Chemical Process Control'.

SEVENTH SEMESTER EXAMINATION

L	T	P	Credits	Hours
3	1	0	4	40

BT-411 INTELLECTUAL PROPERTY RIGHTS, BIOSAFETY AND BIOETHICS IN BIOTECHNOLOGY

Objective: To apprise the students of the various societal, governance and regulatory issues in biotechnology with special emphasis on ethics, safety and intellectual property rights. Through this course, the students develop a perspective on the importance of these aspects in the success of biotechnology products and services in the market. At the end of the course, they should be able to apply this perspective and the specific principles, laws, regulations etc., in academic and industrial settings for regulatory oversight and enforcement.

1. Biotechnology and Society, perceptions of the consumers, government, industry and civil society. **(3)**

2. Biotechnology and globalization, role of international economic and regulatory regimes. **(4)**

3. Bioethics: Codes of ethics in history, UN Declaration on bioethics and human rights, implications. **(4)**

4. Research and regulatory ethics: Responsible Conduct of Research, misconduct, Falsification, fabrication, plagiarism, conflict of interest, regulatory misconduct, implications for public trust in biotechnology. **(4)**

5. Biosafety: Concepts, biosafety in the laboratory, institution and outside, regulatory regime through institutional, state and national biosafety bodies, biosafety in rDNA work, hospitals, fields etc. **(4)**

6. International biosafety dimensions: Cartagena Protocol, biological warfare and bioterrorism. **(3)**

7. Food safety and environmental safety evaluation of genetically modified microbes, crops, animals. **(6)**

8. Intellectual Property Rights (patent, copyright, design, geographical indication, plant variety, trade secret, their scope and duration of protection, their international harmonisation and transition from national to WTO regime, PCT, TRIPS+, FTAs, current domestic and global scenario. **(3)**

9. Patents in biotechnology: Patentable subject matter, procedure of patenting, products and processes, novelty, non-obviousness, utility, enablement, disclosure. **(5)**

10. IPR in agriculture: Plant variety Protection, Plant Patents and Utility patents. **(2)**

11. Strategic aspects of patent filing locally and abroad, patent litigation. **(2)**

Books/References:

1. Encyclopedia of Bioethics
2. Biotechnology - A comprehensive treatise (Vol. 12). Legal economic and ethical dimensions VCH.
3. Thomas, J.A., Fuch, R.L. (2002). Biotechnology and Safety Assessment (3rd Ed). Academic Press.
4. Fleming, D.A., Hunt, D.L., (2000). Biological safety Principles and practices (3rd Ed). ASM Press.
5. The law and strategy of Biotechnological patents by Sibley. Butterworth publications
6. Recent reviews/articles and websites such as WIPO.