SCHEME OF EXAMINATION

&

COURSES OF STUDY

IN

M.Sc. PHYSICS

SCHOOL OF SCIENCE

H N B GARHWAL UNIVERSITY

(*A Central University*)

SRINAGAR GARHWAL -246174

(UTTARAKHAND)

M.Sc. (Physics) Semester I

Paper Code	Paper	Credits	Total Credits
SOP/FOS/PHY/C001	Classical Mechanics	3	18
SOP/FOS/PHY/C002	Mathematical Physics	3	
SOP/FOS/PHY/C003	Electrodynamics & Astrophysics	3	
SOP/FOS/PHY/C004	Electronics	3	
SOP/FOS/PHY/C005	Laboratory Course I (Practical –I)	3	
SOP/FOS/PHH/C006	Laboratory Course II (Practical –II)	3	
M.Sc. (Physics) Semester II			
Paper Code	**Paper**	**Credits**	**Total Credits**
SOP/FOS/PHY/C007	Atomic &, Molecular Physics	3	18
SOP/FOS/PHY/C008	Solid State Physics	3	
SOP/FOS/PHY/C009	Statistical Physics	3	
SOP/FOS/PHY/C010	Quantum Mechanics	3	
SOP/FOS/PHY/C011	Laboratory Course I (Practical –I)	3	
SOP/FOS/PHY/C012	Laboratory Course II (Practical –II)	3	
M.Sc. (Physics) Semester III			
Paper Code	**Paper**	**Credits**	**Total Credits**
SOP/FOS/PHY/C013	Advanced Quantum Mechanics	3	18
SOP/FOS/PHY/C014	Nuclear Physics	3	
SOP/FOS/PHY/C015	Laboratory Course I (General)	3	
SOP/FOS/PHY/E001	Condensed Matter Physics A	3	
SOP/FOS/PHY/E002	Electronics A	3	
SOP/FOS/PHY/E003	Laser Physics A	3	
SOP/FOS/PHY/E004	High Energy Physics A	3	
SOP/FOS/PHY/E005	Astrophysics A	3	
SOP/FOS/PHY/E006	Laboratory Course II (Circuit Design)	3	
M.Sc. (Physics) Semester IV			
Paper Code	**Paper**	**Credits**	**Total Credits**
SOP/FOS/PHY/C016	Computational Physics	3	18
SOP/FOS/PHY/C017	Particle Physics	3	
SOP/FOS/PHY/C018	Lab Course	3	
SOP/FOS/PHY/E007	Condensed Matter Physics B	3	
SOP/FOS/PHY/E008	Electronics B	3	
SOP/FOS/PHY/E009	Laser Physics B	3	
SOP/FOS/PHY/E010	High Energy Physics B	3	
SOP/FOS/PHY/E011	Astrophysics B	3	
SOP/FOS/PHY/E012	Project	3	

M. Sc. Semester I

SOP/FOS/PHY/C001: CLASSICAL MECHANICS

Unit I

Lagrangian formulation and Variational Principle: Mechanics of particles and system of particles, conversion law , constraints , degree of freedom, generalized coordinates **,** D'Alembert's principle, Lagrange's equations of motion from D'Alembert's principle, application of Lagrange's equation of motion to a particle and system of particles, conservation theorem, Hamilton's variational principle, Euler- Lagrange's differential equation

Unit II

Hamilton's formalism: Need of Hamilton's procedure , Legendre's transformation and Hamilton's equation of motion, physical significance of H cyclic coordinates, Hamilton's equation in cylindrical and spherical coordinates and applications, applications of Hamilton's equation of motion to a particle and system of particles

Unit III

Principle of least action (no proof): Canonical or contrast transformation, their advantages and examples, condition for a transformation to be canonical, infinitesimal contact transformation (ICT)

Poisson brackets : Definition and properties, Invariance with respect to Cnonical transformation, equation of motion in Poission's Bracket form, Jacobian's form.

Unit IV

Mechanics of Rigid Bodies and Theory of Small Oscillations: Coordinates of rigid body motion, Euler's angle, angular momentum of a rigid body moments and products of inertia, principle axis transformation, Euler's equation of motion of a rigid body, stable and unstable equilibriums. Lagrange's equation of motion for small oscillators, normal coordinates and normal mode frequency of vibrations, free vibration of linear triatomic molecules

Reference Books :N C Rama and P S Joag: Classical Mechanics (Tata Mc Graw Hil, 1991)

1. H Goldstein: Classical Mechanics (Addition Wesley, 1980)
2. A Sommerfield: Mechanics (Academic Press, 1952)
3. I Peiceivel and D Richards: Introduction to Dynamics (Cambridge University Press)

SOP/FOS/PHY/C002: MATHEMATICAL PHYSICS

Unit I

Differential Equations: Special equations of Mathematical Physics, Legendre and Associated Legendre equations.Hermite equation, Laguerre equation, Bessel's equation, Beta and Gamma functions. Fourier and Laplace Transforms, Laplace equation and its solution, Poission, Diffusion and Wave equations, Vibrating membrane.

Unit II

Group Theory: Definition, Classification of groups, subgroup, cyclic group, isomorphism and homomorphism, classes, vector spaces, representation theory of finite groups, Reducible and Ir-reducible representations, Schur's Lemmas and orthogonality theorem, Characters of representaions .

Unit III

Complex Variable: Function of complex variable, Analytic functions, Cauchy's integral theorem and Cauchy's integral formula , Taylor and Laurent's expressions, theorem of residues, Contour intergration.

Unit IV

Matrix and Tensors: Inverse and Trace of Matrix, Unitary Matrices, Orthogonality, Eigen values-Eigen vectors and Diagonalistaion of matrices, Coordinate transformation, Covarient and contravarient Tensors, addition, multiplication and contration of tensors, Associated tensors.

Reference Books :

1. G Arfken: Mathematical Methods for Physicist (Academic Press)
2. Pipes and Harvil: Mathematical Methods for Engineers and Physicist
3. C Harper: Introduction to Mathematical Physics (Prentice Hall of India)
4. A W Joshi: Element of Group Theory for Physicists (Wiley Eastern)

SOP/FOS/PHY/C003 : ELECTRODYNAMICS AND ASTROPHYSICS

Unit I

Maxwell's equations and Electromagnetic waves: Maxwell's equations and their physical significance. Equation of continuity and relaxation time, Vector and scalar potentials, Lorentz and Coulomb gauge,electromagnetic energy and Poynting's theorem, electromagnetic wave equations in free space, their plane wave solutions . Concept of Retarded potentials, Lienard Wiechert potentials, Multipole expansion of EM fields, Electric dipole radiations, field due to oscillating electric dipole, magnetic dipole radiations, electric quadrupole radiation

Unit II

Radiations from moving charges: Fields produced by moving charges, radiations from an accelerated charged particle at low velocities, radiations from a charged particles with co-linear velocity and acceleration, Radiations from an accelerated charged particle at low velocities in circular orbits-Larmor formula,Radiations from an accelerated charged particle at relativistic velocities in circular orbitsrelativistic generalization of Larmor Formula.

Unit III

The Solar System: Aspects of the sky: Concept of Celestial Coordinates and spherical astronomy. Astronomical telescopes. The early years of solar system, the solar system today. Study of Planets:Classification of the Planets, Orbits, Laws of planetary motion, Physical features, surface features, Internal Structure, Atmosphere, Satellites and Rings. Minor Bodies in Solar System: Asteroids, Meteors and Meteorites**:** Discovery of minor planets (Asteroids), their orbits and physical nature. Origin of the minor planets. Meteors and Meteorites. Observation of meteor showers and sporadic meteors. Orbits of sporadic meteoroids and meteor showers. Meteorites, its types and composition. Meteorite craters. Comets- Discovery and designation. Periodic comets. Physical nature. Spectra. Brightness variation. Gas production rates, dust and ion tails. Nature of dust particles and origin of comets.

Unit IV

Stellar System: Sun As A Star: History of Sun, Sun's interior, the photosphere, the solar atmosphere (chromosphere & corona). Salient features of sunspots, sun's rotation & solar magnetic field, explanation for observed features of sunspots. Distances of stars from the trigonometric. secular. and moving cluster parallaxes. Stellar motions. Magnitude scale and magnitude systems. Atmospheric extinction. Absolute magitudes and distance modulus. color index. The Hertzberg- Russell Diagram:The colour, Brightness or luminosity, the population of star. Elementary idea of Binary & Variable Stars. Nuclear fission, Nuclear fusion, condition for nuclear reaction in stars.Types of galaxies, Structure and features of the Milky Way Galaxy.

Reference Books:

1. D.J. Griffiths: Introduction to Electrodyanamics (Prentices Hall, 2002)
2. J.R. Reitz, F.J. Milford & R.W. Christy: Foundation of E.M. Theory
3. J.D.Jackson: Classical Electrodynamics (Wiley Eastern)
4. S.P. Puri: Classical Electrodynamics (Tata McGraw Hill, 1990)
5. J.B. Marion: Classical Electromagnetic Radiation
6. Landau and Lifshitz: The Classical theory of Fields (*Pergman Press*)
7. Panofsky and Philips: Electricity and Magnetism
8. R.N. Singh: Electromagnetic waves and fields (*Tata McGraw Hill*)
9. Jordan and Balman: Electromagnetic Waves and Radiation system

10. Marc L. Kutner: Astronomy: A Physical Perspecttive (Cambridge University Press)
11. Shu, F.H.: The Physical Universe An Introduction to Astronomy
12. Robert H. Baker : Astronomy
13. L Motz. & A.Duveen: The Essentials of Astronomy (Colombia University Press)
14. Willian K. Hartmann: Moons & Planets
15. I Morison: Introduction to Astronomy and Cosmology
16. A.W.Joshi & N.Rana: Our solar system
17. Jayant Naralikar: The Structure of Universe
18. K.D. Abhyankar : Astrophysics (Stars & Galaxies)
19. K.S.Krishnaswamy: Physics of Comets
20. McCusky: Introduction to Celestial Mechanics

SOP/FOS/PHY/C004 : ELECTRONICS

Unit I

Power amplifiers : Types of power amplifiers-series fed class A amplifier-series fed transformer coupled class B: push pull circuits-harmonic distortion in amplifiers-class C and D amplifiers-design considerations.

Unit II

Feedback in amplifiers: Feedback principle-effect of feedback on stability-nonlinear distortion input and output impedance-bandwidth-different types of feedback. Criteria for oscillation-phase shift,Wein bridge, crystal oscillator-frequency stability, astable, mono stable and bistable multivibrators, Schmitt trigger-bootstrap-sweep circuits.

Unit III

Operational amplifiers: Differential amplifier-ideal and real op—amp-input and out put impedance-frequency response-applications : amplifiers, mathematical operations, active filters, waveform generators-analog computations-comparators-S and H circuit-voltage regulator.

Unit IV

Optoelectronics: Optical fibres: graded index step index fibres-refractive index profiles-propagation of optical beams in fibres-mode characteristics and cut off conditions-losses in fibrwes-signal distortion group delay-material and wave guide dispersion.

Optical sources: Light emitting diodes-LED structure-internal quantum efficiency-injection laser diode-comparison of LED and ILD.

Optical detectors: PN junction photo diodes-PN photo detectors-avalanche photo diode-performance comparison.

Reference Books:

1. Millman & Halkias : Integrated Electronics (McGraw Hill)
2. Bolested: Electronic devices and circuit theory
3. Ryder : Electronics-fundamentals and applications(PHI)
4. Keiser : Optical fibre communications (McGraw Hill)
5. Agarwal : Nonlinear fibre optics(AP)

SOP/FOS/PHY/C005 : Laboratory Course –I

SOP/FOS/PHY/C006 : Laboratory Course -I

List of experiments : At least 10 experiments are to be performed

1. Study of LCR circuit
2. Transistorized LCR bridge
3. Study of UJT
4. Study of MOSFET
5. Study of NPN and PNP transistor characteristics
6. Study of DIAC
7. Study of TRIAC
8. Study of FET
9. R.C.coupled amplifier
10. T.C. coupled amplifier
11. Study of feedback amplifier
12. Study of Hartley oscillator
13. Study of Colpit oscillator
14. Study of Wien bridgev oscillator
15. Design and study of different network theorems

Seminar: Two seminars for each student are compulsory

Laboratry Course: Internal assessment through a written test

M.Sc. Semester II

SOP/FOS/PHC007: ATOMIC AND MOLECULAR PHYSICS

Atomic Spectroscopy: Fine structure of Hydrogen lines, alkali atom Spectra, penetrating and non penetrating orbits, electron spin orbit interaction, L-S and J-J coupling schemes, Hunde's rule Spectra of two valence electron atoms, (Helium, Magnesium), selection rules for atomic transitions, multielectron spectra, Central field approximation Hartrees self consistent field theory, Thomas Fermi statistical model, Pauli's exclusion principle and determination of ground state.

Zeeman Effect, Paschen Back Effect, Hyper fine structure, Stark effect, width of spectral lines, lamb shift.

Molecular Spectroscopy: Rotational spectra of diatomic molecules, non rigid rotator, vibrational spectra enharmonic oscillator explanation of rotational vibrational spectra in infrared, molecular dissociation and calculation of dissociation energy, Raman effect and intensity alternation of the rotational bands, Applications of infrared and Raman spectroscopy.

Born Openheimer approximation, Molecular orbital theory, Heitler-Loudon treatment of Hydrogen molecule ion and Hydrogen molecule, Electronic spectra of molecules, Fortrait Parabola, Deslandres table, vibrational structure of electronic bands, Intensities of electronic transitions, Franek Condon principle, Condon parabola.

Reference Books:

1. Atomic Spectra- H.E white Cambridge University Press, Newyork, 1935)
2. Principle of Atomic Spectra - Shore and Menzel
3. Spectra of Diatomic Molecules - G. Herzberg
4. C.B.Banewell: fundamentals of Molecular Spectroscopy
5. Molecular Spectroscopy – Arul Das.

SOP/FOS/PHY/C008 : SOLID STATE PHYSICS

Unit-I:

Crystal Structure: Periodic arrays of atoms, Primitive lattice cell, fundamental types of lattices, index system for lattice planes, Simple crystal structure, Atomic radii, coordination number, Cesium chloride structure, Hexagonal Close Packed Structure, Diamond Structure, cubic Zinc Sulphide structure, point group

Unit-2

Reciprocal lattice: diffraction waves by crystals,Braggs law,Scattered wave amplitude, Laue equations, Brillouin zones,reciprocal lattice to SC lattice, B C C lattice, F C C lattice, structure factor of B C C structure, F C C lattice, Atomic form factor

Unit -3

Crystal Binding and Elastic Constants: Ionic Crystal, Covalent Crystal, Metals, Hydrogen bonds, analysis of elastic springs, elastic compliance and stiffness constants, Elastic waves in cubic crystals, Experimental determination of elastic constants,

Unit-4:

Lattice Vibrations: Vibrations of crystals with monoatomic basis, First Brillouin zone, Group Velocity, Long wavelength limit, Two atoms per primitive basis, quantization of elastic waves, Phonons, Phonon momentum, Inelastic scattering of photons by phonons.\

Reference Books:

1. Introduction of Solid State Physics_ C Kittel
2. Solid State Physics_ N W Ashcroft & N David Mermin
3. Solid State Physics- Ajay Kumar Saxena
4. A J Dekker: Solid State Physics
5. Azaroff: Introduction to solids
6. Aschroft and Mermin: Solid State Physics
7. Peterson: Introduction to Solid State Physics
8. Verma and Srivastava: Crystallography for Solid State Physics

SOP/FOS/PHY/C009: STATISTICAL PHYSICS

Unit I

Basic Postulates- Phase space, relation between eigen states and phase space volume, Liouville's theorem, ensembles, microcanonical, canonical and grand canonical ensembles, Maxwell's Boltzmnn's distribution and Gibb's formulation for canonical and grand canonical ensembles, partition function, their thermodynamic properties, laws of thermodynamics.

Unit II

Application of classical distribution to the ideal gases: Degrees of freedom, translational motion, Helmholtz free energy, Gibb's free energy, entropy and thermodynamic properties, Gibb's paradox, Sakur-tetrode equation.

Imperfect gases: Difference between ideal and real gas, imperfect gases, Vander Waal's equation, virial coefficients, condensation of gases, general properties of liquids, Fermi theory, liquid Helium, phase rule.

Unit III

Quantum Statistics: Drawbacks of M B distribution, Bose-Einstein's and Fermi-Dirac distribution, symmetric and antisymmetric particles, partition functions, non degenerate, weakly degenerate and strongly degenerate cases, B.E. condensation, application to He, pressure-energy relationship, electronic specific heat of solids and paramagnetism.

Unit IV

Black Body Radiation: Planck's distribution, pressure and energy relationship of photons, black body radiation, Rayleigh Jean's formula, Wein's law, Wein's displacement formula, absorption and emission of radiation, Stefan's law, high temperature measurements.

Reference Books:

1. Glasstone: Theoretical Chemistry
2. E.S. Raj Gopal: Statistical Mechanics and Properties of Matter
3. Mayer And Mayer: Statistical Mechanics
4. Landau and Lifshitz: Statistical Physics
5. Pointon: Introduction to Statistical Physics
6. Huang: Statistical Mechanics
7. Wanier: Statistical Physics

SOP/FOS/PHY/C0010: QUANTUM MECHANICS

Section A

Introduction:
A brief review of foundations of quantum mechanics, basic postulates of quantum mechanics, uncertainty relations, Schrodinger wave equation, expectation value and Ehrenfest theorem. Relationship between space and momentum representation. **Applications:** One dimensional potential step, tunneling, Hydrogen atom, particle in a three dimensional box.

Section B.

Matrix Formulation of Quantum Mechanics:
Vector representation of states, transformation of Hamiltonian with unitary matrix, representation of an operator, Hilbert space. Dirac bra and ket notation, projection operators, Schrodinger, Heisenberg and interaction pictures. Relationship between Poisson brackets and commutation relations. Matrix theory of Harmonic oscillator.

Section C

Symmetry in Quantum Mechanics:
Unitary operators for space and time translations. Symmetry and degeneracy. Rotation and angular momentum; Commutation relations, eigenvalue spectrum, angular momentum matrices of J_+, J_-, J_z, J^2. Concept of spin, Pauli spin matrices. Addition of angular momenta, Clebsch-Gordon coefficients and their properties, recurssion relations. Matrix elements for rotated state, irreducible tensor operator, Wigner-Eckart theorem. Rotation matrices and group aspects. Space inversion and time reversal: parity operator and anti-linear operator. Dynamical symmetry of harmonic oscillator.

Applications: non-relativistic Hamiltonian for an electron with spin included. C. G. coefficients of addition for j =1/2, 1/2; 1/2, 1; 1, 1.

Section D

Approximation Methods for Bound State:
Time independent perturbation theory for non-degenerate and degenerate systems upto second order perturbation. Application to a harmonic oscillator, first order Stark effect in hydrogen atom, Zeeman effect with electron spin. Variation principle, application to ground state of helium atom, electron interaction energy and extension of variational principle to excited states. WKB approximation: energy levels of a potential well, quantization rules. Time-dependent perturbation theory; transition probability (Fermi Golden Rule), application to constant perturbation and harmonic perturbation. Semi-classical treatment of radiation. Einstein coefficients; radiative transitions.

Books Recommended

1. L. I. Schiff, Quantum Mechanics (McGraw Hill).
2. V. K. Thankappan, Quantum Mechanics (Wiley Eastern).
3. P. M. Mathews and K. Venkatesan, A Text-Book of Quantum Mechanics (TMH)
4. C. Cohen-Tannoudji, Bernard Diu, Franck Loloe, Quantum Mechanics Vols-I&II (John Wiley).
5. J. J. Sakurai, Modern Quantum Mechanics (Addison-Wesley).
6. A. K. Ghatakh and S. Lokanathan, Quantum Mechanics 3rd ed. (MacMillan).

SOP/FOS/PHY/C011: Laboratory Course-I

SOP/FOS/PHY/C012: Laboratory Course-II

List of experiments: At least 10 experiments are to be performed

1. Multivibrator bistable/monostable/Astable
2. Ionisatin potential of Mercury using gas filled diodes
3. Michelson interfermeter
4. Fabry Pert interferometer
5. Fresnals law
6. Determination of absorption coeficient of iodine vapour
7. B-H curve
8. Study of amplitude modulation and demodulation
9. Study of frequency modulation and demodulation
10. Lecher wire experiment
11. Determination of magnetic susceptibility
12. Study of CRO.
13. Velocity of Ultrasonic waves
14. Linear Air track
15. Determination of Planks constant

Seminar: Two seminars for each student are compulsory

Laboratry Course: Internal assessment through a written test

M.Sc. Semester III

SOP/FOS/PHY/C013: ADVANCED QUANTUM MECHANICS

Section A

Scattering Theory:
General considerations; kinematics, wave mechanical picture, scattering amplitude, differential and total cross-section. Green's function for scattering. Partial wave analysis: asymptotic behaviour of partial waves, phase shifts, scattering amplitude in terms of phase shifts, cross-sections, Optical theorem. Phase shifts and its relation to potential, effective range theory. Application to low energy scattering; resonant scattering, Breit-Wigner formula for one level and two levels, non-resonant scattering. s-wave and p-wave resonances. Exactly soluble problems; Square-well, Hard sphere, coulomb potential. Born approximation; its validity, Born series.

Section B

Identical Particles:
The Schrodinger equation for a system consisting of identical particles, symmetric and anti-symmetric wave functions, elementary theory of the ground state of two electron atoms; ortho- and Para-helium. Spin and statistics connection, permutation symmetry and Young tableaux. Scattering of identical particles.

Section C

Relativistic Wave Equations:
Generalization of the Schrodinger equation; Klein-Gordon equation, plane wave solutions, charge and current densities, interaction with electromagnetic fields, Hydrogen-like atom (to show it does not yield physical spectrum), non-relativistic limit. Extension of Klein-Gordon equation to spin 1 particles.

Dirac Equation; relativistic Hamiltonian, probability density, expectation values, Dirac gamma matrices, and their properties, non-relativistic limit of Dirac equation. Covariance of Dirac equation and bilinear covariance, plane wave solution, energy spectrum of hydrogen atom, electron spin and magnetic moment, negative energy sea, hole interpretation and the concept of positron. Spin-orbit coupling, hyperfine structure of hydrogen atom.

Section D

Quantization of wave fields: The quantization of wave fields, Classical and quantum field equations quantization of non-relativistic Schrodinger equation, second quantization, N-representation, creation and annihilation operators.

Books Recommended

1. P. M. Mathews and K. Venkatesan, A Text book of Quantum Mechanics (TMH)
2. A. S. Davydov, Quantum Mechanics (Pergamon).
3. L. I. Schiff, Quantum Mechanics (McGraw Hill).
4. J. D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics (McGraw Hill).
5. J. J. Sakurai, Advanced Quantum Mechanics (Addison Wesley).
6. V. K. Thankappan, Quantum Mechanics (Wiley Eastern).
7. R.P Feynman and A.R.Hibbs; Quantum Mechanics and Path Integrals.
8. L.H. Ryder, Quantum field Theory (Academic Press).

SOP/FOS/PHY/C014 : NUCLEAR PHYSICS

Unit I

General Properties & Models-: Nuclear size, nuclear angular momentum (Spin), Nuclear magnetic moments, statistics, Binding energy, Liquid drop model, Shell model, Collective model.

Unit II

Nuclear Forces and Detectros – Ground state of deuteron, Low energy neutron-proton scattering and proton-proton scattering, Exchange and tensor forces, G.M. Counter, Electron & Proton Synchrotron.

Unit III

Radioactive decay: Radioactive decay equation equilibrium units, Gamow's theory of alpha decay and Geiger Nuttal law, Fermi's theory of beta decay, parity violation in beta decay, electromagnetic decays.

Unit IV

Nuclear Reactions- Q-value of nuclear reaction, Bohr's Theory of compound nucleus, Scattering cross section of nuclear reaction (phase shift method), Breit Wigner single level resonance formula for scattering cross section.

References Books:

1- I. Kaplan: Nuclear Physics
2- H.A. Enge : Nuclear Physics
3- R.Roy & B.P. Nigam : Nuclear Physics
4- R.D. Evans: Nuclear Physics
5- W.E. Bucham & M. Jobes : Nuclear & Particle Physics (AWL)
6- D. Halliday : Nuclear Physics
7- E. Segre : Nuclei & Particles.
8- B.R. Martin : Nuclear & Particle Physics.
9- B.L. Cohen : Concepts of Nuclear Physics.
10- S.S.M. Wong : Introductory Nuclear Physics
11- S.B. Patel : Nuclear Physics
12- M.K. Pal : Theory of Nuclear Structure
13- S.N. Ghoshal : Nuclear Physics.

SOP/FOS/PHY/C015: Laboratory Course- I (General)

List of experiments: At least10 experiments are to be performed

1. e/m by Zeeman effect
2. G.M.counter
3. Study of IC- Based Power supply
4. Absorption spectroscopy by spectrophotometer
5. Study of optoelectronic devices
6. Design and study of FET amplifier

7. Design and study of Mosfet amplifier
8. Study of SCR
9. Measurement of wavelength of He-Ne laser using interference and diffraction pattern
10. Measurement of thickness of thin wire using laser.
11. Logicom AND/or/NAND/NOR/NOT gates
12. Design and study of UJT relaxation oscillator
13. Study of pin connection and biasing of various linear IC's and timers 555
14. Design and study of phase shift oscillator
15. Study of operational amplifier

Seminar: Two seminars for each student are compulsory

Laboratory Course: Internal assessment through a written test

SOP/FOS/PHY/E001 : CONDENSED MATTER PHYSICS- A

Unit-1

Defects in crystals:Point defect, Impurities, Vacancies, Frenkel defects, Schottky defects, Intrinsic vacancies, Concentration of Schottky defects, Concentration of frankel defects, extrinsic vacancies, Diffusion, Colour centres, F-Centre, V-Centre, dislocation, Line defects, edge dislocation, screw dislocation, Burger vector.

Unit-2

Magnetism: Dia, Para and ferromagnetism, Langvin"s theory of paramagnetism, Ferromagnitiam, Weiss molecular theory, Ferromagnetic domains, Antiferromagnitism, Neel"s theory, Two sublattice model, ferrites.

Unit-3

Energy Bands: Origin of energy gap, Magnitude of the energy gap, Bloch function, Bloch theorem, Kronig penny model, Number of possible wave fuction in a band, crystal momentum, the concept of effective mass, concept of holes, hole band construction, metal, insulator and semiconductor.

Unit-4

Dielectric and electrical properties of insulators: Macroscopic description of dielectric constants, static, electronic and ionic polarizability of molecules, orientational polarization, Internal Lorentz field static dielectric constant, Complex dielectric constant, Dielectric loss and relaxation time, Optical absorption.

Reference Books:

1. Kittel: Introduction to solid state Physics
2. Ziman: Principles of theory of solids
3. J. Callaway: Quantum theory of solids
4. A.J. Dekker: Solid State Physics
5. Animalu: Intermediate Quantum theory of crystalline solids
6. Solid State Physics: N W Ashcroft and N David Mermin

7. Solid State Physics: Ajay Kumar Saxena

SOP/FOS/PHY/E002 : ELECTRONICS- A

Unit I

Number Systems, Boolean Algebra & Basic Logic Gates: Binary, Octal, Decimal & Hexadecimal Numbers, Base conversions and arithmetic, Complements, Signed Binary numbers, Binary codes (Weighted,BCD,2421,Gray code, Excess 3 code, Error detecting code, Error correcting codes, ASCII,EBCDIC), Conversion among codes.

Boolean postulates and laws, Dual & Complement, De-Morgan's Theorem, Boolean expressions and functions , Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS), Minterms & Maxterms, Karnaugh maps and minimization.

Unit II

Logic Gates & Combinational Circuits: Logic Gates: AND, OR, NOT, NAND, NOR, XOR, XNOR, Universal Gates, Positive and Negative Logic, Implementations of Logic Functions using gates, TTL and CMOS Logic and their characteristics, 7400 Series. Adders, Subtractors, Serial adder/ Subtractor, Parallel adder/ Subtractor, Carry look ahead adder, BCD adder, Magnitude Comparator, Multiplexer, Demultiplexer, Encoder, Decoder, Parity-checker, Code converters

Unit III

Sequential Circuits: Flip flops: Latches, RS, JK, T, D and Master-Slave, Characteristic table and equation, Edge triggering, Level Triggering. Registers & Counters: Asynchronous/ Ripple counters, Synchronous counters, Modulo–n Counters, Shift registers, Universal shift register, Shift counters, Ring counters.

Unit IV

Memory Devices & IC-Technology: Classification of memories, RAM organization, Write/Read operations, Memory cycle, Timing wave forms, Memory decoding, Memory expansion , Static RAM Cell-Bipolar RAM cell, MOSFET RAM cell, Dynamic RAM cell, ROM organization – PROM, EPROM, EEPROM, EAPROM ,Programmable Logic Devices, Programmable Logic Array (PLA), Programmable Array Logic (PAL)

Basic Ideas of IC-Technology, Monolithic IC's, IC Components- Resistors (Integrated, Diffused, Thin Film), MOS Capacitors, Inductors, Bipolar Transistors, Thin Film Technology, LSI, MSI.

Reference Books:

1. Malvino & Leach: Digital Principles and Applications
2. Morris Mano: Digital Design
3. Thomas L. Floyd: Digital Fundamentals
4. Millman & Halkias: Integrated Electronics

SOP/FOS/PHY/E003: LASER PHYSICS- A

Unit I

Basic principles: Basic principles and theory of absorption and emission of radiation, Einstein's coefficients, line-broadening mechanisms, rate equations for three and four level laser systems, population inversion, theory of optical resonators, laser modes, spatial and temporal coherence,

Unit II

Types of lasers: Gas lasers, He-Ne, argon ion, N_2, CO_2 lasers; dye lasers, solid state, Semiconductor lasers: Ruby, Nd:YAG and Nd:glass lasers, Fabrication technology of lasers, diode lasers, colour centre and spin flip lasers, laser spikes, mode locking Q-switching, CW and pulsed lasers.

Unit III

Non linear optics: Theory of non linear phenomenon, second and third harmonic generation, phase matching, parametric generation, self focussing,

Unit IV

Laser spectroscopy: Laser fluorescence spectroscopy using CW and pulsed lasers, Single photon counting, Laser Raman apectroscopy, multiphoton processes, photo accoustic and photon electron spectroscopy, stimulated Raman spectroscopy, Coherent antistokes Raman spectroscopy.

Reference Books:

1. Ghatak and Thyagrajan: Lasers
2. O. Svelto: Principles of Lasers
3. Silvfast: Lasers
4. B.B.Loyd: Lasers

SOP/FOS/PHY/E004: HIGH ENERGY PHYSICS A

Section A

Classical and Quantum Field Equations, Coordinates of the field, Classical Lagrangian Equation, Classical Hamiltonian Equations, Quantum Equations for the Field, Fields with more than one component, Complex Field, Quantization of the Non-relativistic Schrodinger Equation, Classical Lagrangian and Hamiltonian Equations, Quantum Equations, The N-representation, Creation and Destruction Operators, Number Operators, Anticommutation Relations, Equations of Motion, Physical Implications of Anticommutation, Representation of Anticommuting operators

Section B

Quantization of fields: Quantization of neutral and complex scalar fields, U (1) Gauge Invariance, Quantization of Dirac field covariant anticommutation relations, Quantization of electromagnetic field. Interaction Lagrangian for the fields, QED Lagrangian.

Section C

Scattering Matrix and Feynman Rules: The S-Matrix reduction of S- Matrix chronological product, Wicks theorem Furry's theorem Covariant perturbation theory interaction lagrangian for QED, Feynman Diagrams and Feynman rules for QED in configuration and momentum space, Electron- Positron scattering, Coulomb scattering of Electrons, electron – positron annihilation , Compton scattering.

Section D

Renormalization of QED: Self energy correction, vacuum polarization and vertex correction, classification of Divergences, Renormalization of mass and charge, wave function renormalization .

Reference:

1. Theory of photons and electrons, J.M. Jauch and E. Rohrlich
2. Relativistic Quantum field, J.D. Bjorken and S. D. Drell.
3. Quantum electrodynamics , A.I. Akhiezer and Berestetski
4. Quantum Electrodynamics, Walter Greiner

SOP/FOS/PHY/E005 : ASTROPHYSICS- A

Unit I

Physics of the Stars : Apparent and Mean Position of stars. Effects of atmospheric refraction, aberration, parallax, precession, nutation and proper motion on the coordinates of stars. Reduction from apparent to mean places and vice versa. Spectra of Stars. Distribution of stars in space. Statistical parallaxes. Local standard of rest. Solar motion and its determination. Peculiar velocities. Single and Two star stream hypothesis. Velocity ellipsoid. Comparison with solar neighbourhood. Bottlinger's diagram. HR diagram, HD and MK spectral classification of stellar spectra. Radiation laws and basic ideas on spectral line formation. Explanation of stellar spectra in terms of Boltzmann and Saha equations. Spectroscopic parallax.

Unit II

Fundamental Equations: Equation of mass distribution. Equation of hydrostatic equilibrium. Equation of energy transport by radiative and convective processes. Equation of thermal equilibrium. Equation of state. Stellar opacity. Stellar energy sources.Stellar models:The overall problem and boundary conditions. Russell-Voigt theorem. Dimensional discussions of mass-luminosity law. Polytropic configurations. Homology transformations.

Unit III

Stellar Evolution : Abundance of elements in the sun by the method of fine analysis-Stromgren's method, use of weight functions, abundances of elements in normal stars. Composition of differences in population I and II stars. Anomalous abundances in cool stars. Peculiar A stars and metallic line stars. Magnetic field in stars. Jean's criterion for gravitational contraction and its difficulties. Pre-main-sequence contraction under radiative and convective equilibrium. Evolution in the main sequence. Growth of isothermal core and subsequent development. Ages of galactic and globular clusters.

Unit IV

Superdense Objects : Mechanism of Mass transfer in Binary Stars. Use of polytropic models for completely degenerate stars. Mass-radius relation. Non-degenerate upper layers and abundance of Hydrogen. Stability of white dwarfs. Final cooling of white dwarfs. Accretion by white dwarfs and its consequences. Pressure ionisation and mass-radius relation for cold bodies. Formation , features and properties of Neutron stars, Pulsars and black holes.

Reference Books:

1. D.Mihalas: Galactic Astronomy
2. S.Chandrasekhar: Principles of Stellar Dynamics
3. James Binney and Scoth Tremaine: Galactic Dynamics (Princeton University Press)
4. K.C.Freeman: Galaxies and Universe
5. D.Mihalas and J.Binney: Galactic Astronomy
6. S.D.M.White: The Origin and Evolution of Galaxies
7. S.M.Alladin: Lecture notes on "Dynamics of Stellar Systems".
8. W.M.Smart: Text book of Spherical Astronomy
9. K.D.Abhyankar: Astrophysics:Stars and Galaxies (Tata McGraw Hill Publication)
10. G.Abell: Exploration of the Universe.

SOP/FOS/PHY/E006: Laboratory Course (Circuit Design)

Electronics:

List of experiments : At least 5 experiments are to be performed

1. Study of regulated power supply (723).
2. Study of Timer (555).
3. A to D and D to A convertor
4. 1 of 16 Decoder/Encoder
5. Study of Multiplexer/Demultiplexer
6. Study of Comprator and Decoder
7. Study of different flip- flop circuits (RS, JK, Dk type, T-type, Master slave).
8. Study of Digital combinational and sequential circuits
9. Study of Microprocessor (8085)
10. Study of SCR, DIAC, TRIAC
11. Study of IC- Based Power supply
12. Microwave experiment.
13. Shift Registers
14. Fiber Optics communication

High Energy Physics:

List of experiments : At least 5 experiments are to be performed

1. Characteristic curve of a GM Detector and Absorption coefficient of a using aluminum GM Detector.
2. Energy spectrum of gamma rays using gamma ray spectrometer.
3. Absorption coefficient of aluminum using gama-ray spectrometer.
4. Characteristics of Scintillation Detector.
5. Study of gama-gama unperturbed angular correlations.
6. Study of particle tracks using a Nuclear Emulsion Detector.
7. Classification of tracks in interaction with Nuclear Emulsion and determination of excitation energy.
8. Mossbauer spectrometer

Condensed Matter Physics:

List of experiments : At least 5 experiments are to be performed

1. Determination of elastic constant of crystals by optical methods
2. Study of fluorescence spectra of a given compound
3. Study of colour centers
4. Determination of lattice parameters using powder method.
5. Determination of hall coefficient using Hall effect
6. Determination of Energy gay of a semiconductor by four probe method
7. ESR
8. Dielectric constant

Astrophysics:

List of experiments : At least 5experiments are to be performed

1. Study of Hubble's law (from given data)
2. Study of constant density neutron star
3. Study of the static parameters of a Neutron Star model with inverse square density distribution
4. Study of star cluster from a given data
5. Study of Extinction coefficients
6. Study of variability of stars

Laser Physics:

List of experiments : At least 5 experiments are to be performed

1. Study of the vibrational levels of Iodine.
2. Measurement of the fluorescence spectra of Uranyl Nitrate Hexahydrate.
3. Determination of the intrinsic life time for a dye molecule.
4. Determination of change in dipole moment in excited state using Solvatochromic shift method.
5. Measurement of non radiative decay rate for a known sample.
6. Determination of the quantum yield of known samples using steady state spectroscopy.
7. Study of electro optic effect
8. Study of Acousto-optic effect

M.Sc. Semester IV

SOP/FOS/PHY/C016 : COMPUTATIONAL PHYSICS

Unit I

Roots of functions, interpolation, extrapolation, integration by trapezoidal and Simpson's rule, Runge-Kutta Method, Least square fitting method.

Unit II

Eigenvalues and eigenvectors of matrices, power and Jacobi method, solution of simultaneous linear equations Gaussian elimination, Pivoting, Iterative method, matrix inversion.

Unit III

Flowchart and algorithons-Problem analysics flowchart of some basic problems. The concept and properties of algorithmic languages, elementary algorithm development algorithm involving decision and loops.

Unit IV

C-Programming : selection of C and Fortran 90/95 programming loops and control, constructs, arithmetic and logic operators, Strings, arrays, pointers, floats and other types, input, output, control constructs, recursion structures, sub programmes and modules.

Reference Books:

1.B.D.Hahn: Fortran 90 for Scientists and engineers.
2.V Rajaraman: Computer Programming in c.
3.Rajaraman: Computer Oriented numerical methods.
4.Wong: Computational methods in Physics and engineering.
5.S.Balachandra Rao: Numerical Methods.
6.Stephen j Chapman: Fortran 90/95 for Scientists and Engineers.

SOP/FOS/PHY/C017: PARTICLE PHYSICS

Unit I : **Classification and Properties of Elementary Particles**

Elementary Particles,their classification on the basis of their mass and spins

(Leptons, Mesons, Baryons) and field quanta. Their general properties (mass, spins, life time and their production and decay modes), Antiparticles.

Unit II: Conservation Laws and Gauge Invariances

Conservation of Energy, Linear and Angular momentum, Spin, Charge, Lepton No., Baryon No. Isospin, Hypercharge, Parity, Strangeness, Charge conjugation, Time Reversal,CP, CPT theorem, Global and Local gauge invariances.

Unit III: Fundamental Interaction

Qualitative ideas (Relative strengths, Ranges, Characteristic times and Mediators) of Gravitational, Electromagnetic, Strong and Weak Nuclear interactions. General idea of Electro-week and Grand unifications.

Unit IV: Quark Model

Eight fold way, Quarks as building blocks of hadrons, six quarks (u,d,s,c,t and b), Antiquarks, General properties of quarks (Charge, Mass, Colour - A new degree of freedom, quark confinement, Asymptotic freedom) Evidences for Quarks (Lepton scattering, Hadron Spectroscopy, Jet production), Quark compositions of Mesons and Baryons. General idea of Standard Model. Idea of Higgs Boson.

Books and References:

1- Introduction to High Energy Physics-D.H.Perkins. (Addision – Wesley-1986)
2- Introduction to Nuclear & Particle Physics-VK Mittal, R.c. Verma & S.C.Gupta (Prentice Hall of India, Pvt.Ltd., New Delhi, 2009) (All units approx.)
3- Concepts of Modern Physics- Arthur Beiser (Tata Mc Graw Hill Edu.Pvt Ltd., New Delhi, Sixth Ed. 2009) Chapter 13 page 529.
4- Quarks and Leptons- An Introductory course in Modern Particle Physics-Francis Halzen & A D.Martin(John Wiley & Cons,Inc. Canada,1984),Gauge invariance page-314,315,316, Unit III and Unit IV
5- Nuclear and Particle Physics-W.E. Burcham & M. Jobes(Essex,England ISE Reprint 1998) Unit-II, III, & IV Gauge Invariances pages 484, 485, 486, 487
6- Introduction to Particle Physics-M.P. Khanna (Prentice Hall of India, 1999) Unit II,III,IV
7- Introduction to Elementary Particle Physics-D.Griffiths (John Wiley 4 sons,1987)
8- Elementary Particle Physics-Gasiorowicz (John Wiley & sons, 1966).
9- Nuclear & Particle Physics-B.R. Martin & G. Shaw(John wiley & sons, 1997)
10- A Modern Introduction to Particle Physics- Riyazuddin and Fayazuddin
11- Particle Physics- M.Leon
12- Principles of Physics- Resnick, Halliday & Walker (John wiley & sons,England) 9th Extended edition, 2013, chapter 44)

SOP/FOS/PHY/C018 : Laboratory Course

List of experiments:

1. Study of computational softwares
2. Study of numerical techniques.
3. Computer programming.

SOP/FOS/PHY/E007: **CONDENSED MATTWER PHYSICS- B**

Unit-1:

Nearly free electron model, One dimensional free electron case, Nearly free electron case, energy bands in one dimension, tight binding approximation, energy surfaces, Wigner Seitz cellular method, Orthogonalized plane wave (OPW) method, Pseudo potential method, Limitations of band theory (Mott Transition)

Unit-2

Dielectrics and ferroelectrics: Polarization, Macroscopic electric field, depolarization fiels, local electric field at an atom, fields of dipoles inside cavity, dielectric constant and polarizability, electronic polarizability, structural phase transition, ferroelectric crystals, classification of ferroelectric crystals, displacive transition, soft optical phonons, landau theory of phase transition, Second and first order transition, antiferroelectricity, ferroelectric domains, piezoelectricity, ferroelasticity, optical ceramics.

Unit-3

Superconductivity: Experimental Survey, Occirance of super conductivity, destruction of superconductivity by magnetic field and temperature, Meissner effects, Type-I and Type-II superconductors, Isotope effect, Thermodynamics of Superconducting transition, London Equations, Coherence length, BCS Theory, Cooper pairs, Josephson superconductor tunneling, AC & DC Josephson effect, High temperature superconductors, critical fields and critical currents.

Unit-4

Nano Material Science and Technology: History, Origin, Quantum dots, Synthesis, Applications and advantages, Quantum wires, Quantum well & application, Fullerenes, Carbon nanobuds, carbon nanotubes as quantum wires, Areas of Nanotechnology, nanomaterials, nanoelectronics, nanobiotechnology, nanofabrication, microelectromechanical systems (MEMS)

Text and Reference books

1. Principle of condensed matter Physics : Chaikimand Lubensky
2. Solid State Physics : Kubo and Ngamia
3. Elements of Solid State Physics : Srivastava
4. Introduction to Solid State Physics : Madelung
5. Introduction to Solid State Physics : Paterson
6. Introduction to Solid State Physics : Kittel
7. Solid State Physics-N W Ashcroft & N David Mermin
8. Solid State Physics-Ajay Kumar Saxena

SOP/FOS/PHY/E008 : ELECTRONICS- B

Unit I

Modulation – Amplitude Modulation-Theory, Plate Modulated class C amplifier, Balanced Modulator, Single Side Band modulation (phase shift method), Frequency modulation – Theory, Reactance tube modulator, transistor reactance modulator, FET reactance modulator.

Demodulation- Envelope diode detector, super regenerative detection, Foster Seely phase discriminator, Ratio Detector.

Transmitters & Receivers- A.M Transmitter, F.M. transmitter, TRF Receiver, Super heterodyne receiver, amplitude limiting.

Unit II

Transmission Lines– TL Equations and their solutions, characteristic impedance, lossless open and short circuited lines, standing wave ratio and refection coefficient, stub matching, quarter wave length and half wave length lines.

Antenna – Radioactive field strength, power and radiation patterns of an elementary electric doublet and linear antenna, effects of ground reflection. Hertz antenna, Marconi antenaa, Yagi antenna, loop antenna, direction finding, Resonant & Non resonant Antenna, Antenna array (Broad side & End fire arrays), T.V. aerials. Horn Antenna, Parabolic reflectors, Lens Antenna.

Unit III

Propagation of Radio Waves-

Electes-Larmor theory, Applecton – Hartree theory of sky wave propagation, skip distance and maximum usable frequency, Chapmann's theory of layer formation.

Pulse method for measuring the height of ionospheric region.

Unit IV

Television Systems-

General Principle of Image transmission and reception of signals, pick up instruments (Iconoscope, Image orthian and Videocon) Image scanning sequence, scanning synchronization, composite video signal, colour television.

Radar Systems-

Principle of Radar, Basic arrangement of Radar system, Azimuth and Range measurement, operating characteristics of systems, Radar transmitters and Receivers, Duplexers, Indicator unit, maximum range of a Radar set.

References Books :

1. F.E. Terman – Radio Engineering
2. G. Kennedy & B. Davis – Electronic Communication Systems
3. G.K. Mithal – Radio Engineering Vol. II
4. G. Keiser – Optical Fiber Communication
5. C.K. Sirkar & S.K. Sirkar, Fiber optical Communication Systems.
6. Gupta & Kumar – Handbook of Electronics
7. S.D. Parsonick – Fiber Opitics
8. Introduction to Fiber optics – Ghatak & Thyagarajan.
9. Frenzel – Communication Electronics
10. Rody & Coolen - Communication Electronics.
11. L.E. Frenzel – Communication Electronics
12. A. Ghatak & K. Tyagrajan – Fiber optics & Lasers.
13. M. Satish Kumar – Optical Fiber Communication

SOP/FOS/PHY/E009: LASER PHYSICS- B

Unit I

Electro optic effect, longitudinal and transverse phase modulation, consideration of modulator designs and circuit aspects, acousto optic effect, Raman Nath and Bragg regimes, acousto optic modulators, magneto-optic effect, integrated optics, optical directional couplers and optical switches, phase modulators.

Unit II

Optical sources and detectors: Laser devices, radiation pattern and modulation, LED structures, light source materials, liquid crystal diodes, photoelectric, photovoltaic and photconductive methods of detection of light, photodiodes: structure, materials and working, PIN photodiodes, avalanche photodiodes, microchannel plates, photodetector noise responsivity and efficiency, photomultipliers, image intensifier tubes, Videocon and CCD.

Unit III

Fibre optics: Basic characterstics of optical fibres, fibre structure and fundamentals of waveguides, step and graded index fibres, signal degradation in optical fibres, absorption scattering, radiation and core cladding losses, Design considerations of a fibre optical communication system, analogue and digital modulation, optical fibre amplifiers.

Unit IV

Holography: Basic principles, construction and reconstruction of holograms, applications of holography, laser interferometry, laser applications in industry and medicines

Reference Books:

1. Ghatak and Thyagrajan :Optical Electronics
2. Hawks : Optoelectronics
3. Keiser : Optical fibre communications
4. Ghatak and Thyagrajan:Introduction to fibre optics
5. I.P. Csorba: Image tubes
6. Ed.L.M.Bibermman and S.Hudelman : Photoelectronics

SOP/FOS/PHY/E010: HIGH ENERGY PHYSICS- B

Section-A

Symmetries and conservation laws, Noether's Theorem, U (1) Gauge Invariance, Baryon and Lepton number conservation, The concept of gauge invariance; Global and Local gauge invariance, spontaneous Breaking of Global gauge invariance, Goldstone Bosons, the Higgs mechanism, Generalized local gauge invariance-Abelian and non Abelian gauge invariance.

Section-B

Weinberg- Salam theory of electroweak unification, The matter fields, the gauge fields, the gauging of SU (2) XU (1), The vector bosons, The fermion sector, Helicity states, parity, charge conjugation Fermion masses, Fermion assignments in the electroweak model, spontaneous symmetry break down, Fermion Mass generation, The color gauge theory of strong interactions.

Section C

Color gauge invariance and QCD, The standard model of fundamental interaction, general mass terms, Cabibbo Angle, Kobayashi- Maskawa matrix and CP violation, The SU (5) Grand unified theory, The generators of SU (5), The choice of Fermion representations spontaneous breaking of SU (5) symmetry Fermion masses and mixing angles.

Section D

The classic predictions of SU (5) Grand Unified, Theory, quark and Lepton masses, The SO(N), The SO (10) Grand Unified Theory, Fermion Masses in SO (10), Neutrino Mass in SO (10).

References:

1. A Modern Introduction to Particle Physics, Riazuddin and Fayyazudin.
2. Modern Elementary Particle Physics G. L. Kane (Addison- Wesley 1987).
3. Grand Unified theories, Graham Ross.
4. Gauge Theories of Strong, Weak and Electromagnetic Interactions, C. Quigg (Addison – Wesley)
5. Gauge Theory of Elementary Particle Physics , T.D. Cheng and Ling Fong Li (Clarendon Oxford)

SOP/FOS/PHY/E011 : ASTROPHYSICS- B

Unit-1

Detectors ,Photometry and Spectroscopy: Detectors for optical and infrared regions. Application of CCD's to stellar imaging, photometry and spectroscopy. Techniques of observations of astronomical sources from space in infrared. EUV, X-ray and gamma-ray regions of the electromagnetic spectrum.

Astronomical photometry. Simple design of an astronomical photometer. Observing technique with a photometer Correction for atmospheric extinction. Tansformation to a standard photometric system. Astronomical spectroscopy. Spectral classification. Simple design of astronomical spectrograph. Radial velocity measurements.Radio Astronomy Techniques. Electro-magnetic spectrum. Radio window. Design and construction of a simple radio telescope. Receiver systems and their calibration. Design and construction of a simple radio interferometer.

Unit-2

Galactic System: Interstellar Matter:Composition and properties. of interstellar matter. Oort limit. Interstellar extinction. Estimate of colour excess. Visual absorption. Interstellar reddening law and Polarisation. Spin temperature. Interstellar magnetic fields. Stromgren's theory of H II regions. Physical processes in planetary nebulae. Gallastic Structure: General galactic rotational law. Oort’s theory of galactic rotation. Determination of Oort’s constants. Spiral structure of our Galaxy from optical and radio Observations. Size and mass of our galaxy.

.**Unit -3**

Extragalactic Systems:Classification of galaxies and clusters of galaxies. Hubble sequence. Galaxy interactions. Determination of the masses. Determination of extragalactic distances. Active Galaxies: Active galaxies and galactic nuclei. Properties of Radio galaxies and Quasars. Their energy problem and accretion discs. Dark matter in galaxies and clusters of galaxies.

Unit-4

Gravitation & Cosmology: Conceptual foundations of GR and curved spacetime: Principle of equivalence, Connection between gravity and geometry,Form of metric in Newtonian, limit Metric tensor and its properties, Einstein's field equations, observational tests of general relativity. Models of the universe : Steady State Models. Standard Model: The expanding universe, Hubble's law . Microwave background radiation Friedmann-Robertson-Walker models, The early universe, Thermodynamics of the early universe Primordial neutrinos. Elementary ideas on structure formation . Implications of the dark matter in modern cosmology.

References Books :

1. A.Unsold: New Cosmos.
2. Baidyanath Basu: Introduction to Astrophysics.
3. Harold Zirin: Astrophysics of the Sun.
4. Gibson: The Quiet Sun.
5. G.Abell: Exploration of the Universe.
6. K.D. Abhayankar: Astrophysics of the solar system.
7. M.Schwarzschild:Stellar Evolution
8. S.Chandrasekhar:Stellar Structure
9. K.D.Abhyankar:Astrophysics: Stars and Galaxies
10. Menzel,Bhatnagar and Sen:Stellar Interiors.
11. Cox and Guili:Principles of Stellar Interiors - Vol.I and II.
12. Shapiro and Tevkolsky: White Dwarfs, Neutron Stars and Black Holes.
13. R.Bowers and T.Deeming:Astrophysics(John and Barlett.Boston).

SOP/FOS/PHY/E012 : Project work for all specializations

This course will be based on preliminary research oriented topics both in theory and experiment. The teachers who will act as supervisors for the projects will float projects and any one of them will be allocated to the students. At the completion of the project by the semester end, the student will submit Project Report in the form of dissertation which will be examined by the examiners. The examinations shall consist of presentation and comprehensive viva-voce. Marks allotment- **Project and viva of Project-Evaluation by internal + External- -Project =60, Viva=20, (Separately sealed), Internal assessment=20(Separate sealed envelope for internal evaluation)**

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SELF STUDY COURSE/PAPERS

Any one of the following, in third or fourth semester, will be conducted and evaluated at Department level

SOP/FOS/PHSS001: QUANTUM ELECTRODYNAMICS

Dirac equations, Properties of Dirac Matrices, Projection Operators, Traces< Feynman's theory of Position.

Second quantization of Klein Gordon field,Creation and annihilation operators, commutation relations, Quantisation of electromagnetic field, Creation and annihilation operators, commutation relation, Fock space representation, interaction fields. Dirac (interaction) picture, S-matrix and ita expansion. Ordering theorems, Feynman graph and Feynman rules. Application to some problems, like Rutherford Scattering and Compton scattering, calculations of cross sections using Feynman graphs.

Reference Books:

1.Bjorken and Drell: Relativistic Quantum Fields

2. Muirhead: The Physics of Elementary Particles

3. Schweber, Bethe and Hoffman: Mesons and Fields

4.Sakurai: Advanced Quantum Mechanics

5.Mandal: Introduction to Field Theory

6. Lee: Particle Physics and Introduction to Field Theory

SOP/FOS/PHSS002: PHYSICS OF LIQUID CRYSTALS

Introduction: States of Matter, Liquid crystals, Symmetry, Structure and order, Mesogenic Molecules, Liquid Crystals of Chiral and Chiral Molecules, Calamitic, disc Shape and Polymer liquid Crystals.

Physical Properties: Order parameters, measurement by magnetic resonance spectroscopy, Optical anisotropy, refractive index, Dielectric anisotropy, Dielectric Permittivity, diamagnetic anisotropy, magnetic susceptibility, Transport Properties, Eleastic Constants, Continum Description.

Statistical Theories of Nematic Order: Landau- de- Gennes, Theory, hard particle, Maier Saupe and Van der Walls type theories.

Nematic-Smectic A Transition: Phenomenological description, McMillan Theory, polymorphism in smectic A Phase.

Ciral Liquid Crystals: Chirality in liquid crystals, Chiral nematic Phase, Optical Properties, field induced nematic Cholesteric Phase Change, Distortion of Structure by magnetic field, Blue Phase, Chiral smectic phases,

origin of ferroelectricity: Structure, symmetry and ferroelectric ordering in Chiral Smectic C Phase, Antiferroelectric and ferroelectric Chiral smectic C Phase.

Application of Liquid Crystals.

Reference Books:

1. Liquid Crystals: S Chandrashekhar
2. 2.The Physics of Liquid Crystals: P G de Gennes and J Prost
3. Liquid Crystals, Fundamentals: S Singh

SOP/FOS/PHSS003: ATMOSPHERIC PHYSICS

Introduction to Atmosphere:

Atmosphere and its composition; Physical and Dynamical processes on layer formation Troposphere, Stratosphere and ionosphere; Vertical variation of temperature, ozone and its spatial and temporal variation; Measurement of ionization density, Ozone Density; Temperature, pressure and wind distribution in the atmosphere and general circulation.

Mathematical and Statistical Methods:

First and second order differential coefficients and their applications to atmosphere variabilities. Autocorrelation theory, Standard statistical distributions (Normal, binomial, gamma, students, t, x2). Application of Auto correlation and auto regressive processes applied to atmospheric variabilities. Error Analysis, Sampling and Test of Hypothesis, Analysis of variance. Interpolation and de extrapolation techniques, Grid point interpolation. Harmonic analysis and Spectral analysis and their use in atmosphere science.

Observational Techniques leading to understanding of the atmosphere:

Working principle, application and circuit description in blocks of the system: Ionospnde, Radiosonde,, Ozone sonde, LIDARS, DIAL, SODARS, AWS, Weather satellites, Doppler Radar, ST Radar and MST Radar

Atmosphere and their role in the wave propagation:

Super and refraction conditions and mm/cm propagation. Rain attenuation of waves in atmosphere, Ionopshere and its role in brief on radio propagation.

Atmospheric Thermodynamics and radiation budget:

Radiative Transfer in the Atmosphere, aerosol scattering (Rayleigh, Mie), Role of aerosol and atmospheric dust in radiation balance; Calculation of radiative heating and Cooling and energy balance. Energy exchange processes through waves and instabilies

Reference Books:

1.H G Houghton: Physical Meteorology

2.J M Vallance and P V Hobbs: Atmospheric Sciences: An Introductory Survey

3.R R Rogers: A Short Course on Cloud Physics

4.J R Holton:An Introduction to Dynamic Meterology

5. S L Hess: Introduction to Theoretical Meterology

6. T Beer: Atmospheric Waves

7.Chapman and Lindzen Riedel: Atmospheric Tides

SOP/FOS/PHSS004: BIO PHYSICS

Introduction to Bio Physics: Molecular Organisation, Different levels, Organization of Proteins- Primary, Secondary, teriary and quaternary structures, Osmosis, Diffusion and Donnan Equilibrium.

Conformational Analysis: Nucleic acids and their organization in living cells; interactions of Nucleic acids.

Methods in BioPhysical Analysis: CD, ORD & Fluorescence Spectroscopy, Raman Spectroscopy,

Separation and Characterization of bio molecules using centrifugal, electrophoretic and chromatographic techniques.

Absorption and Emission Spectroscopy- Principles and applications of visible, UV, IR, AAS, NMR, ESR and MS Spectroscopy.

Characterization of macromolecules using X-ray diffraction analysis.

Use of analytical microscopy in elucidating the structure function relationship in-

Prokaryotes: Electron Microscopy, Phase Contrast and Fluorescence microscopy and scanning tunneling microscopy.

Radio Isotope Techniques: Detection and measurement of radioactivity, Geiser Muller Counters, Scintillation counting, Autoradiography and RIA; Applications of isotopes in biological studies.

Reference Books-

1.David Freifelder: Physical Biochemistry

2.Willard Merrit, Dean and Settle: Instrumental methods of analysis

3.D R Browning: Spectroscopy

4. Wilson and Walker: Principles and Techniques of Practical Biochemistry

5. D A Skoog: Instrumental methods of analysis

SOP/FOS/PHSS005: PHYSICS OF NANO MATERIALS

Nanoparticles: Synthesis and Properties:

Method of Synthesis: R F Plasma Chemical Methods, Thermolysis, Pulsed laser Methods, Biological Methods, Synthesis using micro-organisms, Synthesis using Plant extract, Metal Nanoclusters, Magic Numbers, modeling of Nano Particles, Bulk of Nano Transitions.

Carbon Nano Structures:

Nature of Carbon Clusters, Discovery of C60, Structure of C60 and its crystal, Superconductivity in C60, **Carbon Nano Tubes:** Synthesis, structure, Electrical and Mechanical Properties. **Graphene**: Discovery, Synthesis and Structural Characterization through TEM, Elementary concept of its applications.

Quantum Wells, Wires and Dots:

Preparation of Quantum Nano Structures, Size Effects, Conduction Electrons and Dimensionality, Properties Dependent on Density of States.

Analysis Techniques for Nano Structures/Particles:

Scanning Probe Microscopes(SPM), Diffraction Techniques, Spectroscopic Techniques, Magnetic Measurements.

Bulk Nano Structure Materials:

Methods of Synthesis, Solid Disorders Nano Structures, Mechanical Properties, Nano Structure Multilayers, Metal Nano Cluster, Composite Glases, Porous Silicon.

Reference Books:

1. Introduction to Nano Technology: Poole and Owners
2. Quantum Dots: Jacak, Hawrylak and Wojs
3. Handbook of Nano Structureed Materials and Nano Technology: Nalva(Editor)
4. Nano Technology/ Principles and Practices: S K Kulkarni
5. Carbon Nano Tubes: Silvana Fiorito
6. Nano Technology: Richard Booker and Earl Boysen

SOP/FOS/PHSS006: ENVIRONMENTAL PHYSICS

Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere. Composition of air, Green House Effect, Tramnsport of Matter, Energy and momentum in Nature. Stratification and stability of atmosphere.Laws of motion, hydrostatic equilibrium.

Solar and Terrestrial: Physics of Radiation, Interaction of light with matter,Rayleigh and Mie scattering, laws of radiation(Kirchoff's law, Plank's law, Wein's displacement law etc.) , solar and terrestrial spectra, UV radiation. Ozone depletion problem, I R absorption.

Environmental Pollution and Degradation: Elementry fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors Governing air, water and noise Pollution, Air and water quality standards. Waste Disposal. Gaseous and particulate matters, wet and dry deposition.

Environmental Changes and Remote Sensing: Energy sources and combustion processes. Renewable Sources of energy: Solar energy, wind energy, bioenergy, hydropower, fuel cells, Nuclear energy.

Global and regional Climate: Elements of whether and climate. Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, viscous forces.

Inertia forces, Reynolds number, enhanced Greenhouse effect, Global Climate Models.

Referene Books:

1. Egbert Boeker & Rienk Van Groundelle : Enviromental Physics (john wiley)
2. J.T. Hougtion : The Physics of Atmosphere (Cambridge Univ.Press. 1977)
3. J. Twidell and J.Weir : Renewable Energy Resources (Elbs, 1988)
4. Sol Wieder : An Introduction to Solar Energy for Scientists and Engineers (John Wiley,1982
5. R.N. Keshavsamurthy and M.Shankar Rao : The Physics of Monsoons(Allied Publuishers,1992)
6. J. Haltiner and R.T. Williams : Numerical Weather Prediction (John Wiley, 1980**)**

SOP/FOS/PHSS007: PLASMA PHYSICS

Plasma Physics : Elementary concepts, plasma oscillations, Debye shielding, Plasma Parameters, Magneto Plasma, Plasma Confinement, First , Second and Third Adiabatic Invariants(Pinch effect, Magnetic Mirrors), Formation of Van Allen Belt.

HydrDynamical Description of Plasma:

Fundamental Equations, Hydromagnetic Waves, Magnetosonic and Alfven Waves, Magnetoconvection and sun spots, Bipolar magnetic regions and magnetic Buoyancy, Magnetised winds (Solar Wind).

Wave Phenomena in Magnetoplasma:

Polarisation, Phase velocity, Group velocity, cut offs, resonance for Electromagnetic Wave Propagating Parallel and Perpendicular to the Magnetic Field, Propagation at Finite angle.

Reference Books:

1- W.K.H. Panofsky and M. Phillips : Classical Electricity and Magnetism.
2- A Bittencourt : Plasma Physics
3- F.F. chen : Palsma Physics and Controlled fusion
4- J.D.Jackson : Classical Electrodynamics

Department of Biotechnology

M. Sc. Biotechnology

Course Contents

&

Syllabus

Hemvati Nandan Bahuguna Garhwal University

(A Central University)

Srinagar, Garhwal, 246 174, Uttarakhand

M. Sc. Biotechnology

(Effective from July 2020)

Code	Course Contents	L T P C	M.M
Semester I (July to November)			
S0LS/MBT/C0001	Biochemistry	3 0 0 3	100
S0LS/MBT/C0002	Cell Biology & Membrane Biophysics	3 0 0 3	100
S0LS/MBT/C0003	Molecular Biology & Genetics	3 0 0 3	100
S0LS/MBT/C0004	Bio-Analytical Techniques	3 0 0 3	100
S0LS/MBT/C0005	Lab Course based on course C0001 & C0002	0 0 3 3	100
S0LS/MBT/C0006	Lab Course based on course C0003 & C0004	0 0 3 3	100
	Core Credits= 18		**600**
Semester II (December to April)			
S0LS/MBT/C0007	Immunology	3 0 0 3	100
S0LS/MBT/C0008	Microbiology & Microbial Genetics	3 0 0 3	100
S0LS/MBT/C0009	Genetic Engineering & Applications	3 0 0 3	100
S0LS/MBT/C0010	Biostatistics & Bioinformatics	3 0 0 3	100
S0LS/MBT/C0011	Lab Course based on course C0007 & C0008	0 0 3 3	100
S0LS/MBT/C0012	Lab Course based on course C0009 & C0010	0 0 3 3	100
S0LS/MBT/SS001	Epigenetics & Cancer Biology	0 0 0 3	100
S0LS/MBT/SS002	Biomedical Technology		
	Core Credits = 18		**600**
Semester III (July to November)			
S0LS/MBT/C0013	Plant Biotechnology	3 0 0 3	100
S0LS/MBT/C0014	Intellectual Property Rights, Bioethics, Bio-Entrepreneurship	3 0 0 3	100
S0LS/MBT/C0015	Lab Course based on course C0013 & C0014	0 0 3 3	100
S0LS/MBT/E0001a	Protein engineering	3 0 0 3	100
S0LS/MBT/E0001b	Immunotechnology		
S0LS/MBT/E0001c	Nanobiotechnology		
S0LS/MBT/E0002a	Food & Beverages Biotechnology	3 0 0 3	100
S0LS/MBT/E0002b	Animal Biotechnology		
S0LS/MBT/E0002c	Enzymology & Enzyme Technology		
S0LS/MBT/E0003	Lab Course based on course E0001 & E0002	0 0 3 3	100
S0LS/MBT/SS003	Research Methodology: Tools & Techniques	0 0 0 3	100
S0LS/MBT/SS004	Science Communication & Scientific Writing		
	Core Credits 09 + Elective Credits 09; Total Credits = 18		**600**
Semester IV (December to April)			
S0LS/MBT/C0016	Environmental Biotechnology	3 0 0 3	100
S0LS/MBT/C0017	Fermentation & Bioprocess Technology	3 0 0 3	100
S0LS/MBT/C0018	Lab Course based on course C0016 & C0017	0 0 3 3	100
S0LS/MBT/E0004a	Advanced Bioinformatics	3 0 0 3	100
S0LS/MBT/E0004b	Herbal Biotechnology		
S0LS/MBT/E0004c	Genomics & Proteomics		
S0LS/MBT/E0005	Dissertation	0 0 0 6	100
S0LS/MBT/SS005	Vaccines & Drug Development	0 0 0 3	100
S0LS/MBT/SS006	Molecular Virology		
	Core Credits 09 + Elective Credits 09; Total Credits = 18		**500**
	Grand Total Credits: Core - 54 + Elective - 18 = 72		**2300**

Max. Marks (MM) for each paper: 100 (Two Sessional Tests of 20 each + 60 End Term Test)

Sessional Tests:- (Mid Term Test, Assignment, Tutorials, Classroom Seminar & Lab Work, Journal Club; winter / summer training / Internship; Academic tours / visits to Industries / Institutes / Universities; training based report writing & presentation**)**

All 2-year Master's Programs will have the following components, *viz.*

(i) Core Course **(C)**: Minimum 54 Credits
(ii) Electives **(E)**: Minimum 18 Credits
(iii) Self study **(SS)**: Maximum 09 credits (one minimum 03Creditscourse shall be mandatory but not to be included while calculating the grades)

Paper - I: Biochemistry

(Course Code: S0LS/MBT/C0001)

No. of Credits = 3

UNIT - I

Enzymes: Classification (rationale, overview and specific examples) 0.5
Zymogens and their activation (Protease and Prothrombin)
Enzyme substrate complex: Concept of E-S complex, binding sites, active site, specificity, Lock and Key Hypothesis, Induced-Fit Hypothesis, Michaelis-Menten equation and its derivation, Different plots for the determination of Km and Vmax, Enzyme Inhibition

UNIT - II

Carbohydrate – Classification, structure and functions 0.75
Carbohydrate Metabolism I: Pathway and regulation of Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis
Carbohydrate Metabolism II: Citric acid cycle and its regulation, Electron transport Chain and Oxidative phosphorylation, Pentose phosphate pathway and its regulation.

UNIT - III

Amino acids – structure and functional group properties, peptides and 0.75
covalent structure of proteins, primary and higher order structures, Ramachandran plot.
Protein – Classification, structure and functions
Amino Acid Metabolism: overview of amino-acid biosynthesis and degradation
Urea cycle (Linkage between urea cycle and citric acid cycle) and its regulation.
Conversion of nitrogen to ammonia by microorganisms

UNIT - IV

Fatty Acids - Classification and structure. 0.5
Fatty Acid Metabolism: Fatty Acid Oxidation and regulation, β-oxidation, Oxidation of unsaturated fatty acids and odd chain fatty acids, β-oxidation in peroxisomes, Ketone bodies and their overproduction.
Fatty Acid Biosynthesis and Regulation. Reactions of fatty acid synthase, Synthesis of triglycerols, Cholesterol biosynthesis and regulation.

UNIT - V

Nucleic Acid - structure and functions. Nucleic Acid Metabolism: Purine 0.5
biosynthesis and its regulation, Pyrimidine biosynthesis and its regulation.
Formation of deoxyribonucleotides. Salvage pathway for Purine and Pyrimidine nucleotides, Degradation of purines and pyrimidines into uric acid and urea.

Recommended Books: -

1. Lehninger: Principles of Biochemistry, 4th ed., Nelson & Cox, WH Freeman and Company, 2007
2. Voet & Voet: Biochemistry, 2nd ed., Wiley & Sons.
3. Berg, Tymoczko, Stryer: Biochemistry, 5th ed., WH Freeman and Company, 2003.
4. Garett & Grisham: Biochemistry, 4th ed., Brooks/Cole Cengage learning, 2010.
5. Murray, Granner, Rodwell: Harper's Illustrated Biochemistry, 27th ed. McGraw Hill, 2006.
6. Conn & Stumpf: Outlines of Biochemistry, 5th ed., Willey India, 2007.

Paper - II: Cell Biology & Membrane Biophysics

(Course Code: S0LS/MBT/C0002)

No. of Credits = 3

UNIT - I

Plasma membrane: Structure, Organisation, Lipid bilayer, Proteins and Glycoconjugates, Liposomes, lipid protein interactions,membrane rafts, hydrophobiceffect. Elasticity of the membrane. Function- ionic transport, Types of transport (symport, antiport, active & passive), Channel proteins-Introduction. 0.5

UNIT - II

Intracellular compartmentalization:Structure, organization and functions of Nucleus, Mitochondria, Lysosome, Golgi body, Chloroplast, Peroxisome, Endoplasmic reticulum (Rough and smooth). Cell motility and Shape: Structure and functions, Microfilament, Microtubules and Intermediate filament. 0.5

UNIT - III

Protein Sorting: Anterograde & Reterograde mode of protein trafficking, Vesicular traffic in the secretory and Endocytic pathway: Transport from Endoplasmic reticulum through the Golgi network to Lysosome, Endocytosis, Exocytosis, Molecular mechanisms of vesicular transport and maintenance of compartments diversity. Cell signaling : General principles (Types of signaling), Cell surface receptor mediated signaling (ion channel, G protein and enzyme linked). 0.75

UNIT - IV

Cell cycle: Molecular events and regulation. Cell division: General strategy & regulation, Molecular mechanism of mitosis and meiosis. Cancer- Biology: Types of cancer, Onset of cancer, Proto-oncogenes and tumor suppressor genes, Oncogenic mutations affecting cell proliferation, Cell cycle and Genome stability, Programmed cell death, Apoptosis 0.5

UNIT - V

Membrane transport, diffusion, electro-diffusion, types of transportation, thermodynamic model, chemical potential, osmotic pressure, water permeability, structure, selectivity & permeability of channel proteins, Voltage-gated channels, Ligand-gated channels, Na^+, K^+ and Ca^{2+} channels, pumps as channels. Conduction of electrical activity Spread of electrical signals: passive vs. active, the action potential and its propagation through nerves, chloride channels and muscle excitability, Target cell adaptation 0.75

Recommended Books: -

1. Lodish et al.: Molecular Cell Biology (4th ed.)
2. Alberts et al.: Molecular Biology of the cell (3rd ed.)
3. Scott F. Gilbert: Developmental Biology (5th ed.)
4. Zubay, Parson & Vance: Principles of Biochemistry
5. Joshua Zimmerberg, Membrane Biophysics. Current Biology Vol 16 No 8 R272, https://www.cell.com/current-biology/pdf/S0960-9822(06)01347-9.pdf
6. Mohammad Ashrafuzzaman and Jack Tuszynski: Membrane Biophysics, Part of the Biological and Medical Physics, Biomedical Engineering book series (BIOMEDICAL), Springer

Paper - III: Molecular Biology & Genetics

(Course Code: SOLS/MBT/C0003)

No. of Credits = 3

UNIT - I

Chemical and physical properties of nucleic acids 0.5
Structure and types of RNA and DNA, The Watson-Crick model. DNA as genetic material. Different forms of DNA.
Topological properties of DNA. DNA renaturation kinetics.

UNIT - II

Mechanism of DNA replication in prokaryotes and eukaryotes. 0.75
Mechanism of transcription in prokaryotes and eukaryotes. Reverse transcription.
Post transcriptional processing of RNA: (capping, polyadenylation, splicing, RNA editing)
Mechanism of translation in prokaryotes and eukaryotes.

UNIT - III

Concept of genetic code, Gene expression and regulation in prokaryotes (Lac operon and trp operon). Gene expression and regulation in eukaryotes. 0.5
Introduction to various types of DNA damage and repair.

UNIT - IV

Mendelism: Basic principles and applications of inheritance, exceptions to Mendelian law. Chromosomal basis of Mendelism (chromosomal theory of heredity) 0.75
The molecular structure of chromosome in eukaryotes: structure of chromatin and higher order packaging in chromosome. Centromere and Telomere,
Giant chromosome: Polytene and Lampbrush chromosome.
Linkage, recombination and chromosome mapping in eukaryotes. Cytoplasmic inheritance.

UNIT - V

Chromosomal Aberrations: Change in number and structure 0.5
Allelic variation and gene function. Sex chromosome and sex determination.
Dosage compensation of X-linked gene. Sex linked genes in human. Pedigree analysis.

Recommended Books: -

1. Lewin: Genes, Vol. VII Oxford, 1998, Indeed.
2. Snustad et al: Principles of Genetics 1997, John Wiley & Sons,
3. De Robertes & Robertis: Cell & Molecular Biology, 1987, Lee & Fabiger Philadelplna
4. Strickberger: Genetics, 1996, Prentice Hall
5. Friefelder: Molecular Biology (2nd ed.), 1996 Narosa Publ. House,
6. Alberts et al: Molecular biology of the cell (4th ed.) 1994, Garland Publ. New York.
7. Elliott & Elliott: Biochemistry and Molecular Biology, 1996, Oxford

Paper - IV: Bio-Analytical Techniques

(Course Code: S0LS/MBT/C0004)

No. of Credits = 3

UNIT - I

Chromatography - General principles and applications. 0.75
Adsorption chromatography, Partition chromatography, Gas chromatography, Liquid chromatography, Paper chromatography, Thin layer chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, HPLC (High Performance/Pressure Liquid chromatography).

UNIT - II

Electrophoresis - General principle and applications 0.5
Paper electrophoresis, Moving boundary method, Gel electrophoresis (Native, Denaturing & Reducing), Disc gel electrophoresis, Slab gel electrophoresis, Isoelectric focussing (IEF), Isotachophoresis

UNIT - III

Centrifugation: Basic principles, Common centrifuges used in laboratory, Clinical 0.5
High speed & Ultra centrifuges. Sedimentation rate, Sedimentation coefficient, Zonal Centrifugation, Equilibrium density gradient centrifugation. Types of rotors (fixed angle, swinging bucket), Types of centrifugation: Preparative, Differential & Density gradient

UNIT - IV

Basic knowledge of the principles and applications of Microscopy: Light, Phase 0.5
Contrast, Fluorescence and Confocal Microscopy, Scanning and Transmission Electron Microscopy. Biosensors: Introduction & principles, Cell based biosensors, Enzyme immunosensors.

UNIT - V

Spectroscopic methods: Principle and applications of UV-visible, IR, NMR, ESR 0.75
Spectroscopy. Principle & applications of X-ray crystallography. Applications of radioisotopes in biology. Properties and units of radioactivity. Radioactive isotopes and half life. Measurement of radioactivity: GM Counter, Gamma & Liquid scintillation counter.

Recommended Books: -

1. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill, 1991.
2. Alberts et al.: Molecular Biology of the cell (2nd ed.), Garland, 1989.
3. Biochemical Technique: Theory & Practical J.F. Robyt& B.J. White. Waveland Press, Inc.
4. Wilson & Walker: Practical Biochemistry (4th ed) University of Hertfordshire Cambridge University Press
5. Jayraman: Laboratory Manual in Biochemistry
6. Arnold L. Demain& Julian E. Davies: Manual of Industrial Microbio. & Biotech. 2nd ed.

Paper - V: Immunology

(Course Code: S0LS/MBT/C0007)

No. of Credits = 3

UNIT - I

Overview of the Immune system; Cells and organs of the immune system 0.5
Antigens, Antigenicity vs. Immunogenicity; Haptens & Epitopes;
Immunoglobulins: Structure and function

UNIT - II

Organization & Expression of Immunoglobulin Genes: Multigene organization of 0.75
Genes, variable- region gene rearrangements, Generation of antibody diversity,
Class switching among constant-region genes, Expression of Ig genes
Major Histocompatibility Complex; Antigen processing and presentation

UNIT - III

Structure and functions of BCR & TCR. Cytokines, Properties, General physiology, 0.75
Interferons, Application of cytokine for therapy. The complement system
Cell mediated cytotoxicity: Mechanism of T cell & NK cell mediated lysis,
Ab-dependent cell mediated cytotoxicity (ADCC)

UNIT - IV

Overview of hypersensitivity, Autoimmunity and there types 0.5
Organ transplantation: Introduction, Types and Challenges, Graft rejection
Vaccines: Active and Passive Immunization

UNIT - V

Overview of Monoclonal Antibodies and Hybridoma Technology, 0.5
Types of Antigen-Antibody Interactions: Precipitation reaction, Agglutination reactions,
RIA, ELISA, Western Blotting, Immuno-precipitation, Immuno-fluorescence

Recommended Books: -

1. Roitt, Male & Brostof : Immunology (3rd ed).
2. Kuby : Immunology (4th ed.)
3. Elgert & Elgert : Immunology
4. Wilson & Walker: Practical Biochemistry (4th ed.)
5. Practical Immunology, 4th Ed., F.C. Hay, O.M.R. Westwood, Blackwell Publishing, 2002
6. Selected Methods for Antibody and Nucleic Acid probes, Vol. 1, S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. Pintar, L. Silberstein, Cold Spring Harbor Laboratory Press, 1993.
7. Antibodies Laboratory Manual, Ed Harlow, David Lane, Cold Spring Harbor, Laboratory Press, 1988.

Paper - VI: Microbiology & Microbial Genetics

(Course Code: SOLS/MBT/C0008)

No. of Credits = 3

UNIT - I

Classification of living organisms and general account of microorganisms: Bacteria, Fungi and Viruses. 0.75
Introduction to bacteriology: Classification; Fine structure of bacteria;
Laboratory identification and staining techniques
Introduction toMycology: Classification, general structure, characteristics of fungi.

UNIT - II

Media for microbial culture, Selective, Differential and Enriched media, Pure culture techniques, Sterilization techniques. 0.5
Introduction to virology: Classification, General structure and reproduction of viruses.
Cultivation of bacteriophages, Plant Viruses, Animal Viruses.

UNIT - III

Microbial growth: Synchronous &Diauxic, Factors affecting microbial growth, 0.5
Measurement of microbial growth (cell number & cell count).
Modes of nutrition: Photoautotrophs, Photo-organotrophs, Chemolithotrophs, Chemo-organotrophs.
Microbial metabolism: Overview of energy production and utilization, N_2 fixation.

UNIT - IV

Modes of genetic recombination in bacteria: Conjugation, F-factor, conjugal transfer process, high frequency recombination (Hfr) strains. 0.75
Transformation – competence, DNA uptake by competent cells.
Mechanism of transformation.

UNIT - V

Transduction – General & specialized transduction. 0.5
Genetics of bacteriophages: Lytic and lysogenic cycle, expression of phage genes
In regulation of lytic and lysogenic circuit.

Recommended Books: -

1. Tortora, Funke, Case: Microbiology, (9th ed.) Pearson Education, Inc, 2009.
2. Prescott, Harley & Kliens: Microbiology (7th ed.) McGraw-Hill International Edition, 2008.
3. Michael J. Pelezar, E.C.S. Chan, Noel R. Krieg: Microbiology (5th ed.) Tata McGrall-Hill, 2008.
4. Alcamo's Jeffrey C. Pommerville: Fundamental of Microbiology (8th ed.) Jones & Bartlet Publ. 2007.

Paper - VII: Genetic Engineering & Applications

(Course Code: SOLS/MBT/C0009)

No. of Credits = 3

UNIT - I

Introduction to Recombinant DNA technology and applications. 0.75
Cloning vectors: Plasmids, Phages, Cosmids, Yeast cloning vectors,
Animal and plant viruses as vectors. BAC, PAC & YAC.
Nucleic acid modifying enzymes. Restriction endonucleases.
Isolation of nucleic acid from Plant, animal & bacteria.

UNIT - II

Basic steps of gene cloning: Cloning strategies. 0.75
Synthesis of cDNA. Construction of cDNA and genomic libraries.
Selection of r DNA clones and their expression products, Chromosome walking.
Expression of cloned genes in heterologous host.

UNIT - III

DNA sequencing: Chemical and enzymatic methods. 0.5
PCR: Types and applications. Real Time PCR. Site directed mutagenesis.
Ribonuclease protection assay, Gel retardation assay,
DNA foot printing, DNA finger printing, DNA profiling.

UNIT - IV

Genomic analysis: S-1 mapping, RFLP, RAPD, AFLP. 0.5
Probe labeling and hybridization. Blotting techniques: Southern, Northern and
Western blotting (Methodologies and applications)

UNIT - V

Transgenic Technology: Types, approaches & applications (Plant & Animals), 0.5
Gene therapy: Principles, strategies and ethics of gene therapy.
Genome editing technologies: Principles and applications.

Recommended Books: -

1. Gene cloning T.A Brown:
2. Molecular Biotechnology, Glick & Pasternak: Panima Publ. Corporation, 1994
3. Molecular biology & Biotechnology (3rded), Walker &Gingold: Panima Publ. Corporation,1999
4. Lewin: Genes, Vol. VII Oxford, 1998, Inded.
5. Straehan& Read: Human Molecular Genetics 1999, John Wiley & Sons Pte. Ltd.
6. Gene cloning, Glover: 1984
7. Recombinant DNA, Watson et al: 1983
8. Genetic Engineering Vol. 1-4, Villiamson (ed)
9. Genetic Engineering Vol. 1-7 Setton and Bolanden (ed)

Paper - VIII: Biostatistics & Bioinformatics

(Course Code: S0LS/MBT/C0010)

No. of Credits = 3

UNIT - I

Importance of statistics in biological research. 0.75
Primary and Secondary data, Methods of data collection. Mean, Mode, Median, Range, Mean deviation, Standard deviation.
Standard error, Skewness & Kurtosis. Correlation & Regression, Probability

UNIT - II

Characteristics, Validity and Applications of Chi square test 0.5
Test for significance- comparison of means of two samples,
Comparison of means of three or more samples (f-test, t-test).
Tabulation and Graphical representation of Statistical data.
Data calculation in MS Excel & Power point presentation.

UNIT - III

Introduction to bioinformatics: Objectives, application and scopes, 0.5
Information technology in biology, Bioinformatics resources on NET, Internet,
Word wide web, Web Browsers.
Biological databases-Primary, Secondary database, GEN BANK,
EMBL, DDBJ, PDB, UNIPROT. Search engine-Entrez, SRS, Web Server-NCBI, EBI.

UNIT - IV

Sequence alignment and applications: Sequence similarity searching tools – 0.75
FASTA, BLAST; Statistical and biological significance.
Multiple sequence alignment and applications, Software and tools for MSA.
Phylogenetic analysis, Tools for phylogenetic analysis, Applications

UNIT - V

Protein Structure Prediction Tools, Molecular Modeling (Homology modeling); 0.5
Refinement, Validating structural model; Visualization tools, Pymol, Chimera, Ligplot.
Annotation of proteins, Assignment of function to proteins.

Recommended Books: -

1. Lesk: Introduction to Bioinformatics, Wiely Publication.
2. ROM and Holmas EC: Molecular Evolution: a phylogenetic approach, Blackwell science.
3. Des Higgins and Willie Taylor: Bioinformatics: Sequences, structure and databanks, Oxford University Press
4. Sharma, Munjal, Shankar: A Text Book of Bioinformatics, Rastogi Publication
5. Bioinformatics: Methods and Applications Genimics Proteomics and Drug Discovery, S C Rastogi, N Mendiratta, P. Rastogi: Prentice Hall of India Private Ltd
6. Mahajan: Methods in Biostatistics (4thed.) Jaypee Bros. 1984.
7. Sokal & Rohlf: Introduction to Biostatistics, Freeman, Toppan, 1993

Paper - IX: Epigenetics & Cancer Biology

(Course Code: S0LS/MBT/SS001)

No. of Credits = 3

UNIT - I

Introduction: Growth characteristics of cancer cells; Morphological and ultrastructural properties of cancer cells. Types of growth: Hyperplasia, Dysplasia, Anaplasia and Neoplasia. Nomenclature of neoplasms. Differences between benign and malignant tumors. 0.75

UNIT - II

Cancer biology and biochemistry: Aberrant metabolism during cancer development; Para-neoplastic syndromes; Tumor markers; Cellular proto oncogenes- oncogene activation. Growth factors-EGF, TNF, TGF and growth factor receptors. Signal transduction in cancer. Role of transcription factors. 0.5

UNIT - III

Carcinogenesis: Radiation and chemical carcinogenesis, Stages in chemical carcinogenesis- Initiation, promotion and progression. Free radicals, Antioxidants in cancer. Cell Cycle Regulation: Tumor suppressor genes p53, p21, Rb, BRACA1 and BRACA2. Telomeres, Telomerase, and Immortality; Cell adhesion-invasion and metastasis - VEGF signaling, angiogenesis. 0.75

UNIT - IV

Epigenetics-Role of DNA methylation in gene silencing- epigenetic silencing of tumor-suppressor genes; Apoptosis in cancer-Cell death by apoptosis, Role of caspases; Death signaling pathways-Mitochondrial and death receptor pathways. 0.5

UNIT - V

Detection of Cancer, Prediction of aggressiveness of Cancer, Different forms of therapy, Chemotherapy, Radiation therapy, and Immuno therapy: Advantages and limitations. Epigenetics of cancer, Identification of targets for drug development. 0.5

Recommended Books: -

1. The Biological Basis of Cancer: R. G. McKinnell, et al 2nd Ed, Cambridge University Press, 2006.
2. The Biology of Cancer: R. A. Weinberg. Garland Science. 2006.
3. The Molecular Biology of Cancer: S. Pelengaris, M. Khan. Blackwell Publication.
4. Introduction to modern Virology, Dunmock N.J and Primrose.S.B., Blackwel Scientific Publications. Oxford, 1988.
5. An Introduction to Cellular & Molecular Biology of Cancer, Oxford Medical publications, 1991
6. Gene expression systems. Joseph M. Fernandez & James P. Hoeffler. Academic Press, 1999.
7. Cancer Biology IV Ed Volume 2 Raymond W Ruddon M.D.(2007)
8. Cancer Biology (3rd_Edition) Roger J.B. et al (2006)
9. Advances in Cancer Stem Cell Biology, Roberto Scatena, Alvaro Mordente& Bruno Giardina (Ed) – Springer (2012)

Paper - IX: Biomedical Technology

(Course Code: S0LS/MBT/SS002)

No. of Credits = 3

UNIT - I

Cellular Pathology: Causes of cell injury, necrosis, biochemical mechanism, Ischemic and hypoxic injury. Apoptosis (Biochemical features, mechanisms) Immunological basis of diseases: Hypersensitivity (I – IV). Autoimmune diseases Preparation of polyclonal antisera: Characterization of antisera, Immunodiagnostic techniques 0.75

UNIT - II

Mutations and Genetic disorders. Single gene disorders, Receptor proteins (hypercholesterolemia). Cytogenic disorders (Trisomy, Klinefelters). Mutation in mitochondrial genes (LHDN), Fragile X-Syndrome. 0.5

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UNIT - III

Types and grading of cancer. Introduction to molecular diagnosis of cancer. (Southern & Northern blot analysis, PCR based diagnosis). Gene therapy, immunotherapy and chemotherapy of cancer cells. 0.75

UNIT IV

Chemical mutagens. Carcinogenic agents and their cellular interactions. Radiation as health hazard. (Types, measurements, effects & protective measures) Introduction to DNA damage and repair mechanism. 0.5

UNIT - V

Molecular diagnosis (genetic disease, gene diagnosis, gene tracking & other diagnostic application of RDT) MRI, CT-SCAN. Reproductive Health Technologies – Intracytoplasmic sperm injection (ICSI), In-vitro fertilization (IVF). 0.5

Recommended Books: -

1. Biomedical Technology and Devices Handbook, James E Moore, George Zouridakis, CRC Press(2004)
2. Palermo GD, O'Neill CL, Chow S, et al. Intracytoplasmic sperm injection: state of the art in humans. Reproduction. 2017;154(6):F93-F110. doi:10.1530/REP-17-0374
3. Alukal JP, Lamb DJ. Intracytoplasmic sperm injection (ICSI)--what are the risks?.UrolClin North Am. 2008;35(2):277-x. doi:10.1016/j.ucl.2008.01.004
4. Wang J, Sauer MV. In vitro fertilization (IVF): a review of 3 decades of clinical innovation and technological advancement. TherClin Risk Manag. 2006;2(4):355-364. doi:10.2147/tcrm.2006.2.4.355

Paper - X: Plant Biotechnology

(Corse Code: SOLS/MBT/C0013)

No. of Credits = 3

UNIT - I

Laboratory and materials requirement for plant tissue culture technologies, Aseptic techniques, Plant tissue culture media-composition & preparation, Totipotency Clonal propagation / micropropagation, types and its applications Meristem culture, Callus culture, organogenesis, suspension culture, Conservation of plant genetic resources *in vitro*, its applications and limitations. 0.5

UNIT - II

Haploid culture: Androgenesis & Gynogenesis, Embryo culture & Embryo rescue, Protoplast culture & protoplast fusion – Cybrids, Symmetric & Asymmetric hybrid. Somatic embryogenesis and Somaclonal variation, cryo-preservation, production of synthetic seeds. Selection of stress tolerant cell lines: resistance to cold, high temperature, salt, drought, diseases and inhibitors. 0.75

UNIT - III

Transformation techniques, *Agrobacterium* mediated gene transfer, Biolistics, Comparison of DNA delivery techniques in plants, Integration of transgenes, action of transgenes, Antisense RNAi, and Overexpression approach for transgenics, Biotechnology related to fruit ripening, miRNA and stress response 0.5

UNIT - IV

Insect resistance, Bt crops, Cry protein and action, Molecular mechanisms- Flavr-savr tomato, Golden Rice and, Terminator gene technology. Plant pathogen interactions, strategies utilized by pathogens, genetic basis of plant pathogen interactions, Resistance genes (R genes) in plants, Phytohormones and cross talk, Molecular mechanisms of Oxidative stress and heat stress (HSPs etc.) in plants and genes related for stress tolerance. 0.75

UNIT - V

Plant growth promoting bacteria, PGPR traits, uses and applications, Biofertilisers, Phyto-priming for stress responses, Plants for cleaning contaminated soils- phytovolatization, phytodegradation, phytostalilization, phytoextraction, Arsenic related biotechnological aspects 0.5

Recommended Books: -

1. P.K. Gupta: Elements of Biotechnology, Rastogi and Co. Meerut, 1996
2. R.J. Hanry: Practical Application of Plants Molecular Biology, Champan and Hall, 1997
3. H.D. Kumar: Modern Concepts of Biotechnology, Vikas Publ. Pvt. Ltd.
4. B.D. Singh: Biotechnology, Kalyani Publ.
5. Bhojwani SS and Razdan MK: Plant Tissue Culture: Theory and Practice- Elsevier
6. Stewart CN. Plant Biotechnology and Genetics. 2007. Wiley.

Paper - XI: Intellectual Property Rights, Bioethics & Bio-entrepreneurship

(Corse Code: S0LS/MBT/C0014)

No. of Credits = 3

UNIT - I

Introduction to intellectual property (IP); History and evolution of patent law, types of IP: patents, trademarks, copyright & related rights, Idea-expression dichotomy, industrial design, traditional knowledge, geographical indications, Significance of IPR. Introduction & Classifications of Patents, Patentability criteria. 0.75

UNIT - II

International conventions and Treaties- History of GATT & TRIPS Agreement, World Trade Organization, Post TRIPS scenario, Madrid Agreement; Hague Agreement; Budapest Treaty; Patent Cooperation Treaty; Indian Patent Act 1970 & recent Amendments, International framework for the protection of IP, India's IPR policy, World Intellectual Property Organization (WIPO) 0.5

UNIT - III

Discovery vs Invention, concept of 'prior art', invention in context of "prior art" Complexity arising in IP of Biotechnology, Case studies- Diamond vs Chakraborty IP as a factor in R&D; IPs of relevance to biotechnology, Legal and IPR issues in Biotechnology, Different Categories of IPR Instruments to Protect a Biotechnology IP, Licensing and compulsory licensing; Patent infringement, legal action, 0.5

UNIT - IV

Introduction to bioethics- definition, scope, Principles, significance. Issues of-ownership, monopoly, biodiversity, traditional knowledge access & benefit sharing., Social ethical issues in biotechnology. Biological weapons and their social and ethical implications, Bioethical issues in GMOs, Ethical issues in human cloning 0.5

UNIT - V

Concept of entrepreneurship, Introduction and scope in Bio-entrepreneurship, Risk and Benefits. General idea of the strategy and operations of bio-sector firms, Steps involved in commercialization of a biotechnological product, Introduction to the entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), Incubation Centre, Start-Up India 0.75

Recommended Books: -

1. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub.
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication Oct.
4. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
5. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies, MIT Press
6. World Trade Organisation. http://www.wto.org
7. World Intellectual Property Organisation. http://www.wipo.int

Paper - XII: Protein Engineering

(Corse Code: S0LS/MBT/E0001a)

No. of Credits = 3

UNIT - I

Protein engineering – Introduction, definition and applications; Protein engineering as a tool to alter affinity and specificity; Spectroscopic properties; Stability to changes in parameters as pH, temperature and amino acid sequence, aggregation propensities, etc. Protein engineering with unnatural amino acids and its applications. 0.75

UNIT - II

Protein stability measurement; Spectroscopic study of physicochemical properties of proteins: Fluorescence; UV absorbance; CD & ORD; Hydrodynamic properties–viscosity, hydrogen-deuterium exchange; Introduction to NMR spectroscopy and its importance in protein studies 0.5

UNIT - III

Protein stabilizing forces – Van der Waals, electrostatic, hydrogen bonding and weakly polar interactions, hydrophobic effects; Entropy – enthalpy compensation; Experimental methods of protein engineering: directed evolution like gene site saturation mutagenesis; Module shuffling; Guided protein recombination, etc. 0.5

UNIT - IV

Optimization and high throughput screening methodologies like GigaMetrix, High throughput microplate screens etc., Engineering antibody affinity by yeast surface display; Applications to vaccines, Peptidomimetics and its use in drug discovery. 0.5

UNIT - V

Computational approaches to protein engineering: sequence and 3D structure analysis, Data mining, Ramachandran map, Mechanism of stabilization of proteins from psychrophiles and thermophiles vis-à-vis those from mesophiles; Protein design, Directed evolution for protein engineering and its potential. 0.75

Recommended Books: -

1. Edited by T E Creighton, (1997), Protein Structure: a Practical Approach, 2nd Edition, Oxford university press.
2. Cleland and Craik, (2006), Protein Engineering, Principles and Practice, Vol 7, Springer Netherlands.
3. Mueller and Arndt, Protein Engineering Protocols, 1st Edition, Humana Press. Ed. Robertson DE, Noel JP, (2004), Protein Engineering Methods in Enzymology, 388, Elsevier Academic Press.
4. J Kyte; (2006), Structure in Protein Chemistry, 2nd Edition, Garland publishers.

Paper - XII: Immunotechnology

(Course Code: S0LS/MBT/E0001b)

No. of Credits = 3

UNIT - I

Antigen – Antibody Interactions: Precipitation Reactions and application, Immunlogical Assays: Immunodiffusion, Immunoelectrophoresis, Immunohistochemistry, Immunohistopathology; Agglutination Reactions and application, Complement Fixation, RIA, ELISA, Immunofluorescence, Western Blotting 0.5

UNIT - II

Introduction & production of monoclonal antibodies and hybridoma technology, Advantages and limitations of monoclonal Antibodies, Characterization & storage of monoclonal Antibodies, Commercial production of monoclonal antibodies, 0.5

UNIT - III

Monoclonal Ab production by recombinant DNA technology, Hybridoma technology vs RDT, application in diagnosis. Engineered Monoclonal Antibodies: Chimeric and hybrid Monoclonal Antibodies, Monoclonal Antibodies constructed from Ig-gene libraries, Catalytic Monoclonal Antibodies (Abzymes). Cancer Immunotherapy 0.75

UNIT - IV

General physiology of cytokines, Application of cytokine for therapy, Future development in cytokine therapy, Interferon colony stimulating factor, Preparation of lymphokines by r-DNA Technology. Vaccines: Introduction and Types: Inactivated, Attenuated, Toxoid, Subunit And Multivalent vaccines, Purified macromolecules, Conjugate Vaccines. 0.5

UNIT - V

New generation vaccines: Synthetic peptide vaccines, Recombinant antigen vaccines, DNA vaccines. Immune stimulants, Adjuvants, Novel vaccine delivery systems. Vaccines for specific diseases: Tuberculosis, Malaria, HIV/AIDS. New emerging diseases and vaccine development: Ebola virus disease, SARS. 0.75

Recommended Books: -

1. Practical Immunology, 4th Ed., F.C. Hay, O.M.R. Westwood, Blackwell Publishing, 2002
2. Selected Methods for Antibody and Nucleic Acid probes, Volume1, S. Hockfield, S. Carlson, C. Evans, P. Levitt, J. Pintar, L. Silberstein, Cold Spring Harbor Laboratory Press,1993.
3. Antibodies Laboratory Manual, Ed Harlow, David Lane, Cold Spring Harbor, Laboratory Press, 1988.
4. Spicuzza L, Spicuzza A, La Rosa M, Polosa R, Di Maria G. New and emerging infectious diseases. Allergy Asthma Proc. 2007 Jan-Feb;28(1):28-34. doi: 10.2500/aap.2007.28.2870. PMID: 17390754.
5. Trovato Maria, Sartorius Rossella, D'Apice Luciana, Manco Roberta, De BerardinisPiergiusepp. Viral Emerging Diseases: Challenges in Developing Vaccination Strategies . Frontiers in Immunology 2020 Vol. 11:2130
6. The Vaccine Book (2nd Ed.), Rafi Ahmed, Roy M. Anderson et. al.Editor(s): Barry R. Bloom, Paul-Henri Lambert, Academic Press, 2016, Pages xxi-xxiv, ISBN 9780128021743.

Paper - XII: Nanobiotechnology

(Course Code: S0LS/MBT/E0001c)

No. of Credits = 3

UNIT - I

Introduction to Nanobiotechnology; Concepts, historical perspectives. 0.75
Nanoparticles and nanotechnology, History, origin, principles.
Chemical synthesis approach of nanoparticles, Physical synthesis of nanoparticles, Green synthesis approach for different nanoparticles applications and uses.
Applications and limitations using physical and chemical approach.
Advantages of using green synthesis using different examples

UNIT - II

Characterization of synthesized nanoparticles using XRD, SEM, TEM, HR-TEM, 0.5
FTIR, UV spectrophotometer, Dynamic light scattering etc., Different types of nanoparticles and applications with examples, Safety and toxicity aspects of nanoparticles

UNIT - III

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for 0.75
suitability of administration through various routes of delivery, advantages, strategies for enhanced permeation through various anatomical barriers

UNIT - IV

Nanocomposites: Properties and applications; Nanoparticles for diagnostics and 0.5
imaging (theranostics); Clinical Applications of Nanopaticles, Nanotech and cancer,

UNIT - V

Environmental impact of nanomaterials – Exposure and risk assessment – Mechanism 0.5
of toxicity, Toxicological impacts of Nanomaterials-Ecotoxicological impact of Nanomaterials, Nanotechnology in Agriculture, Nanofactories

Recommended Books: -

1. Gero Decher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials*, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*; Wiley-Liss
3. Neelina H. Malsch (2005), *Biomedical Nanotechnology*, CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
Recent review papers in the area of Nanomedicine

Paper - XIII: Food & Beverages Biotechnology

(Course Code: S0LS/MBT/E0002a)

No. of Credits = 3

UNIT - I

Food and Microorganism: Microorganism in food & beverage industry, contamination of food. General principles underlying spoilage and chemical changes 0.5

UNIT - II

Contamination and spoilage of different kinds of food & beverages: 0.75
Cereals & Cereal products, sugar and sugar products,
Vegetables and Fruits, Meat, Fish, Poultry & Eggs, Sea food, Milk & Milk products,
Canned foods, Alcohol & alcoholic beverages
Fruit juices & soft drinks etc.

UNIT - III

Biotechnology of food and feed; Cultures & Fermentation, 0.5
Beverage production: Alcohol & Alcoholic beverages, Fruit furies, Soft drinks, Feed production, SCP, Fats, Amino acid, Food additives.

UNIT - IV

Food, Beverages & Disease: Food borne illness due to bacterial food poisoning, 0.5
Infection and Intoxication.
Food-borne disease outbreaks, Disease-investigation, Materials & Equipments,
Laboratory testing, Field analysis, Interpretation of data and preventive measures.

UNIT - V

Food hygiene: Food sanitation, Bacteriology of water and food products, Food manufacturing practice. Hazard analysis critical points. 0.75
Food control: International agencies, Federal agency and law of state agencies,
Processing industry and microbial criteria of food. Principles of food preservation,
Preservation by high temperature, low temperatures, drying, food additives and radiation.

Recommended Books: -

1. Ashok Pandey, Guocheng Du, Maria Ángeles Sanromán, Carlos Ricardo Soccol, Claude-Gilles Dussap (2016) Current Developments in Biotechnology and Bioengineering. Food and Beverages Industry [1 ed.] Elsevier
2. Food Biotechnology. S.Bielecki, et al - (Ed) Elsevier Science (2000)
3. Food Biotechnology. Kalidas Shetty et al – CRC Press (2005)
4. Guadalupe Virginia Nevárez-Moorillón (editor), Arely Prado-Barragán (editor), José Luis Martínez-Hernández (editor), Cristobal Noé Aguilar (editor) (2016) Food Microbiology and Biotechnology: Safe and Sustainable Food Production [1 ed.] Apple Academic Press
5. Johnson-Green, Perry (2018) Introduction to Food Biotechnology Ed. 1. CRC Press

Paper - XIII: Animal Biotechnology

(Course Code: S0LS/MBT/E0002b)

No. of Credits = 3

UNIT - I

Animal cell culture: History; Basic requirements; Cell culture media and reagents; Animal cell, tissue and organ cultures; Primary culture, secondary culture; Continuous cell lines; Suspension cultures; Transfection andtransformation of cells; Stem cells and their application; Induced Pluripotency. 0.5

UNIT - II

Animal reproductive biotechnology: structure of sperms and ovum; cryopreservation of sperms and ova of livestock; artificial insemination; embryo recovery and *in vitro* fertilization; cryopreservation of embryos; embryo transfer technology. Transgenic Animals: applications of transgenic animal technology; Techniques of gene transfer: Microinjection, Lipofection, Electroporation, Chemical based transformation, Viral Vectors. 0.75

UNIT - III

Animal Genomics: Introduction to animal genomics; Different methods for for characterization of animal genomes, SNP, STR, RFLP, RAPD, proteomics, metabolomics; Genetic basis for disease resistance; Gene knock out technology and animal models for human genetic disorders. Animal cloning - basic concept, cloning for conservation for conservation endangered species 0.75

UNIT - IV

Applications of Animal Cell Cultures: Cell Culture based products, Vaccines, Hybridoma technology, Monoclonal antibodies, *In vitro* testing of drugs; Production of pharmaceutical proteins; Stem Cells and their Use, Using Animals Cells for heterologous gene expression. Introduction to the concept of vaccines, conventional methods of animal vaccine production. 0.5

UNIT - V

Immunological and nucleic acid based methods for identification of animal species; DNA Barcoding; Detection of adulteration in meat using DNA based methods; Detection of food/feed adulteration with animal protein; Identification of wild animal species using DNA based methods. 0.5

Recommended Books: -

1. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press
2. Primrose, S. B., &Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. Malden, MA: Blackwell Pub.
3. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
4. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker
5. R.E. Spier and J.B. Griffiths (1985). Animal Cell Biotechnology. Vol I and II, Academc Press.

Paper - XIII: Enzymology & Enzyme Technology

(Course Code: S0LS/MBT/E0002c)

No. of Credits = 3

UNIT - I

Properties of enzymes : Catalytic power, specificity, Holoenzymes, Apoenzyme, Coenzyme and Cofactor. Nomenclature and classification of enzymes, active site- Fischer and Koshland models. Collision theory, activation energy and transition state energy, the law of mass action and order reaction. 0.5

UNIT - II

Enzyme kinetics: Kinetics of single substrate enzyme catalyzed reaction, Equilibrium steady state assumption (Michaelis-Menten), transformation of Michaelis Menten equation, Lineweaver Burk, Eadie-Hofstee, Hanes plots. Determination of Vmax, Km, Kcat and their significance. Effect of pH, temperature, enzyme and substrate concentration on enzyme activity. Single displacement and double displacement reaction. 0.75

UNIT - III

Enzyme Inhibition: Reversible inhibition- competitive, uncompetitive and non competitive inhibition, allosteric and irreversible inhibitions. Assay of enzymes: Coupled kinetic assay, units of enzyme activity (IU), Turnover number, purification of enzymes and criteria of purity. 0.5

UNIT - IV

Enzyme catalysis: Tapping the enzyme -substrate complex, use of substrate analogues, enzyme modifications by chemical procedures affecting aminoacid chain, treatment with protease, site directed mutagenesis,
Allosteric enzymes with special reference to aspartate transcarbomylase and phosphofructokinase. Concerted and sequential models. Isozymes- special reference to lactate dehydrogenase. Ribozymes. 0.75

UNIT - V

Mechanism of enzyme action: General mechanistic principle, Factors contributing to the catalytic efficiency-proximity and orientation, nucleophilic and covalent covalent catalysis, acid-base catalysis, metal ion catalysis. 0.5
Mechanism of reactions catalyzed by enzymes: Specific examples (Chymotrypsin, Lysozyme, Ribonuclease and Carboxypeptidase).

Recommended Books: -

1. Lehninger Principles of Biochemistry, Seventh Ed. 2017, Nelson & Cox, Macmillan Publishers.
2. Text book of Biochemistry, West, E.S., Todd, Manson & Vanbruggen. Macmillon.
3. Organic Chemistry Vol 2: Stereochemistry and the Chemistry of Natural Products, 5th, Fifth Edition
4. Biochemistry, Zubay, G. Fourth Edition, Wm.C. Brown Publishers, 1998.
5. Enzymology, Devasena T. 2010. Oxford University Press.

Paper - XIV: Research Methodology: Tools & Techniques

(Course Code: S0LS/MBT/SS 003)

No. of Credits = 3

UNIT - I

Importance and need of scientific research. 0.75
Problem identification, objectives, significance, scope and limitations.
Literature survey: Use of books, journals, libraries, online survey.
Importance and designing of the problem to be undertaken.

UNIT - II

Field survey, site selection, source selection for data acquisition. 0.5
Sampling techniques: Simple and random sampling,
Systematic sampling, Stratified sampling, Multistage sampling,
Cluster sampling, Multiphase sampling, Sample size,
Frequency, Bias, Error.

UNIT - III

Methods: Data collection, types of data, qualitative and quantitative data. 0.75
Primary and secondary data, data summarization
Data representation: Tabular and diagrammatic representation of data.
Measures of central tendency: Use of mean, mode, median. Data interpretation.

UNIT - IV

Measures of dispersion: Use of range, variance, standard deviation, standard error. 0.5
correlation, multiple correlations,
regression, multiple regressions, standard error of estimate.
Test of significance: t-test, 95% confidence limit,
Chi square test, F-test, Multivariate test.

UNIT - V

Project Report Preparation: Introduction of the problem, Materials and methods, 0.5
Review of literature, Results, Discussion (interpretation of results),
Referencing technique, Summary of research/Abstract etc.
Publication of scientific data, writing research paper & report.

Recommended Books: -

1. Holmes, Moody, Dine: Research Methods for the Biosciences, 1st Indian ed., Oxford University Press, 2006.
2. N. Gurumani: Research Methodology for Biological Sciences, 1st ed., MJP Publishers, 2008.
3. Schmauder: Methods in Biotechnology, Taylor & Francis Publishers, 2003

Paper - XIV: Science Communication & Scientific Writing

(Course Code: S0LS/MBT/SS004)

No. of Credits = 3

UNIT – I

Concept of effective communication- setting clear goals for communication; determining outcomes and results; initiating communication; avoiding breakdowns while communicating; creating value in conversation; 0.75

UNIT - II

Barriers to effective communication; power of effective listening; Presentation skills - formal presentation skills; preparing and presenting using over-head projector, PowerPoint; defending interrogation; scientific poster preparation & presentation; participating in group discussions; 0.5

UNIT - III

Use of ICT in Biology, Computing skills for scientific research - web browsing for information search; search engines and their mechanism of searching; Keywords and its importance in scientific research; internet as a medium of interaction between scientists;
effective email strategy for communication with peers and collaborators/scientists. 0.75

UNIT - IV

Importance of communicating science, problems during communication
Technical writing skills - types of reports; layout of a formal report;
Scientific writing skills – types; importance Importance of reading scientific communications
Platforms for scientific reading 0.5

UNIT - V

Plagiarism, why there is need to plagiarize, Image and text plagiarism, softwares for plagiarism; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; plagiarism; characteristics of effective technical communication; scientific presentations; ethical issues; scientific misconduct. 0.5

Recommended Books: -

1. Valiela, I. (2001). *Doing Science: Design, Analysis, and Communication of Scientific Research.* Oxford: Oxford University Press.
2. *On Being a Scientist: a Guide to Responsible Conduct in Research.* (2009). Washington, D.C.: National Academies Press.
3. Gopen, G. D., & Smith, J. A. *The Science of Scientific Writing*. American Scientist, 78 (Nov-Dec 1990), 550-558.
4. Mohan, K., & Singh, N. P. (2010). *Speaking English Effectively*. Delhi: Macmillan India.
5. Movie: Naturally Obsessed, The Making of a Scientist

Paper - XV: Environmental Biotechnology

(Course Code: XIX:S0LS/MBT/C0016)

No. of Credits = 3

UNIT - I

Introduction to environment; pollution types and its control; pollution indicators; sources of wastes and pollutants of water and soil, waste management: Domestic, industrial treatment of liquid waste, aerobic and anaerobic waste water treatment, Treatment of solid waste, Landfills, hazards of landfill contributions of biotechnology to waste treatment 0.5

UNIT - II

Bioremediaton: Fundamentals, methods and strategies 0.5
Phytoremediation: Fundamentals and description of major methods and application
Application of bacteria and fungi in bioremediation uses, advantages vs disadvantages.
Bioremediation of metals, radionuclides, organic pollutants (PAHs, PCBs, Pesticides, TNT, xenobiotic compounds), technological aspects of bioremediation (*in situ, ex situ*)

UNIT - III

Environmental Biotechnology and biofuels: biogas; bioethanol; biodiesel; biohydrogen; microorganisms involved and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers 0.5

UNIT - IV

Biofungicides: Description of mode of actions and mechanisms (e.g.*Trichoderma, Pseudomonas fluorescens)*; Biofertilizers: Plant growth promoting rhizobacteria (PGPR) – uses, practical aspects and problems, PGPR and heavy metals, Halotolerant PGPR and prospects, Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration, phytostabilization), Biotechnological aspects of phytoremediation, biodegradation of xenobiotic compounds, 0.75

UNIT - V

Bioinsecticides and biopesticides: *Bacillus thuringiensis*, genetic modifications and aspects of safety in their use; Role of GMOs in environment clean-up, Dye removal using biotechnological interventions, Oil spillage and biotechnological remedies, Biosensors for environment monitoring and analysis, Nanotechnology and its applications, metallic nanoparticle uses, Green nanomaterials for environmental cleaning, Algal biotechnology- concepts, uses and applications, Use of mixed microbial populations 0.75

Recommended Books: -

1. Frederick W Pontinus, Water Quality & Treatment. American water works Association, MC Graw Hill
2. Fundamentals of Environmental Science: G. S. Dhaliwal, G. S. Sangha and P. K. Raina, Kalyani Publication
3. Perry L. McCarty; Bruce E. Rittmann (2020) Environmental biotechnology: principles & applications 2nd Ed Springer
4. Pramod Kumar; Vipin Kumar (2018) Textbook of Environmental Biotechnology. Woodhead Publishing India
5. Raman Kumar, Anil Kumar Sharma, Sarabjeet Singh Ahluwalia (eds.) (2017) Advances in Environmental Biotechnology [1 ed.] Springer Singapore

Paper XVI: Fermentation & Bioprocess Technology

(Course Code: S0LS/MBT/C0017)

No. of Credits = 3

UNIT - I

Introduction to fermentation and its types, Isolation, screening, improvement and preservation of Industrially important microbes; Microbial growth kinetics in batch, continuous and fed-batch processes. 0.5

UNIT - II

Media formulation for industrial fermentation, Requirement of precursors, inducers and antifoam agents as media additives; Medium optimization; Volumetric mass-transfer coefficient and its measurement, Kinetics of sterilization. 0.5

UNIT - III

Types of bioreactors (CSTR, bubble column, airlift, fluidized bed, packed bed): General configuration and applications; Scale up and scale down; Measurement and control of bioprocess parameters 0.75

UNIT - IV

Down Stream Processing: Cell disruption techniques; Separation techniques: filtration, centrifugation, sedimentation, flocculation, liquid-liquid extraction, precipitation, reverse osmosis, ultrafiltration; Drying; Crystallization; Storage and packaging. 0.5

UNIT - V

Industrial production (Microorganisms and raw material/media used, fermentation conditions and purification steps) and uses of fermentation products: Ethanol, Butanol, Antibiotics (Penicillin, Tetracycline), Alcoholic beverages, Enzymes (Glucose isomerase, Protease), Xanthan gum, Baker's yeast. Solid state fermentation and its applications 0.75

Recommended Books: -

1. Shuler, M. L., &Kargi, F. (2002). Bioprocess Engineering: Basic Concepts.Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F. & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.
4. Bailey, J. E., &Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

Paper - XVII: Advanced Bioinformatics

(Course Code: SOLS/MBT/E0004a)

No. of Credits = 3

UNIT - I

Introduction, definition and history of Bioinformatics. 0.5
Introduction to Internet, bibliographic and non bibliographic search, PubMed
Introduction biological databases (primary, secondary and composite databases).
Biological information system: SRS, ENTREZ (Structure and use on web).

UNIT - II

Introduction to Data mining**:** Classification, clustering, data collection, 0.75
data Warehousing, data preprocessing, Applications of data mining and genomes mining. Databases: Nucelotide sequence information sources: GenBank, EMBL, EBI, DDBJ, UCSC. Protein sequence information sources: PIR, ExPASy, UniProt KB, SwissProt, TrEMBL,
Protein structure information sources: PDB, SCOP, CATH, HSSP.

UNIT - III

Biocomputing **:** Introduction to String matching algorithms, 0.75
Database search techniques, sequence comparison and alignment techniques, Use of Biochemical scoring matrices, Introduction to Graph Matching Algorithms, Automated genome comparison and its implication, Automatedgene prediction, Gene arrays, Analysis of gene arrays. Introduction to signaling pathways and pathway regulation (KEGG), Systems biology-an introduction

UNIT - IV

Genoinformatics, Genome Annotation: Introduction, ORF's. 0.5
Gene mapping and applications: Genetic and physical mapping,
Transcriptome and Proteome- General account. Sequence Alignment: Pairwise and multipule alignment, Dynamic programming. Softwares (SSearch, BLAST, FASTA, CLUSTAL W), Phylogenetic analysis: Phenatic and Cladistic approach.
Phylogenetic tree construction (rooted and unrooted method),
Completed Genomes: Bacterium, nematode, plant and human

UNIT - V

Production of protein structure & modeling. Protein primary & secondary structure, 0.5
prediction Methods – Introduction to various methods. Tertiary structure prediction (Homology & Threading Methods) Profiles, Motifs – Regular expressions. Repeat finding and pattern recognition. Molecular modeling, Docking and rational Drug design.

Recommended Books: -

1. Moorhouse & Barry: Bioinformatics, Biocomputing and Perl (Wiley-liss publications).
2. Jones & Prvzner: Introduction to Bioinformatics Algorithm, Anne Press.
3. Pevsner: Bioinformatics & Functional Genomics, Wiley-publication.
4. Bourne &Weissig: Structural Bioinformatics, Wiley-Liss Publication.
5. Gustafson, Shoemaker, Snape: Genome Data Mining Exploitation: the Genome.
6. Richard S Larson: Bioinformatics and drug discovery,humana press.
7. Sharma, Munjal& Shankar: A Text Book of Bioinformatics, Rastogi Publication

Paper - XVII: Herbal Biotechnology

(Course Code: SOLS/MBT/E0004b)

No. of Credits = 3

UNIT - I

Herbal medicines: history and scope. Local health traditions, ethnomedicines 0.5
Important Medicinal and aromatic plants (MAPs) of Garhwal Himalayas- their diversity, distribution, traditional knowledge,

UNIT - II

Phytochemistry - active principles of herbal drugs-Biological testing, phytochemical 0.75
screening for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds, fatty acids, tannins, glycosides and volatile oils etc.)
Knowledge of few important MAPs, their uses etc. *Aconitum*, *Andrographis*, *Nardostachys jatamansi, Picrorhiza, Coleus, Rhododendron, Acorus calamus, Swertia chirata, Tinospora cordifolia, Berberis* etc.

UNIT - III

Phytometabolites of medicinal importance, Important genes and proteins related to 0.5
metabolites, Signaling pathways, Transgenic plants- Overexpression and downregulation approach to manipulate the metabolite levels in few medicinal plants like *Andrographis paniculata* etc.

UNIT - IV

Diseases associated with raw/processed medicinal plants, and diagnostics related 0.75
Few initiatives for cultivation and conservation of medicinal plants,
Plant Tissue culture as an alternative for conservation of MAPs- prospects and challenges, Demand and supply, Herbal Industries at national and state levels.
Ministry of AYUSH, National/ State Medicinal plant board- Organization, aims, objectives and mandate Ayurveda Biology, Role of herbal drugs at International levels

UNIT - V

Economic importance, biotechnological applications and challenges of 0.5
herbal biotechnology. Green synthesis of nanoparticles using medicinal plants
Phytopharmaceuticals: examples and applications
Neutraceuticals: examples and applications

Recommended Books: -

1. B.D. Singh A textbook of biotechnology.
2. G. Patrick, Medicinal Chemistry. (2002)
3. Shah and Seth, Text book of Pharmacognosy and phytochemistry (2010) Elsevier publications

Paper - XVII: Genomics & Proteomics

(Course Code: SOLS/MBT/E0004c)

No. of Credits = 3

UNIT - I

Basics of genomics and proteomics, Brief overview of prokaryotic and eukaryotic genome organization; Chromatin organization; Extra-chromosomalDNA: bacterial plasmids, mitochondria and chloroplast. 0.5

UNIT - II

Genome mapping, Genetic and physical maps; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, comparative gene mapping 0.5

UNIT - III

Genome sequencing projects; Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. 0.75
Comparative genomics; Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs.

UNIT - IV

Proteomics; Aims, strategies and challenges in proteomics; proteomics technologies: MALDI-TOF, yeast 2-hybrid system, Surface Plasmon Resonance (SPR), proteomicsdatabases. 0.5

UNIT - V

Functional genomics and proteomics; Transcriptome analysis, functional annotation of gene, Contig assembly, mining functional genes in genome, gene function- forward and reverse genetics, protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics. 0.75

Recommended Books: -

1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
2. Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology.*Totowa, NJ: Humana Press.
3. Campbell, A. M., &Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics*. San Francisco: Benjamin Cummings

Paper - XVIII: Vaccines & Drug Development

(Course Code: S0LS/MBT/ SS005)

No. of Credits = 3

UNIT - I

Molecular Basis of Disease: Bacterial, Overview of Pathogenesis, diagnosis and treatment; Viral Overview of Pathogenesis, diagnosis and treatment, Host-virus Interaction, Progression of viral disease in host, Challenges in treatment. 0.5

UNIT - II

Biology of Parasites: Malaria, Dengue, Filariasis, Amebiasis. Parasite life cycle, Parasite-vector interactions, Parasite-Host Interactions, Pathogenesis, Diagnosis, Treatment and drug resistance. 0.5

UNIT - III

Drug Designing, Molecular Modeling, Molecular docking, Structure based Drug Designing, rational drug design, Lead Molecule Identification and optimization, validation. Drug Target Discovery, *in silico* drug discovery, Mechanism of action. Challenges 0.5

UNIT - IV

History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine, vector vaccines, anti-idiotype vaccines; Multivalent subunit vaccines; immune stimulants. 0.75

UNIT - V

Vaccine delivery systems (liposome, microsphere and nanoparticle mediated) and immunostimulatory adjuvants, Edible vaccines. General account of the different stages in development of new vaccines and clinical trials, Overview of the different steps in vaccine manufacture. 0.75

Recommended Books: -

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., &Kuby, J. (2013). Kuby Immunology. W.H. Freeman.
3. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines
5. https://www.nature.com/subjects/structure-based-drug-design
6. D.J. Abraham, Structure-Based Drug Design – A Historical Perspective & the Future, Ed(s): John B. Taylor, David J. Triggle, Comprehensive Medicinal Chemistry II, Elsevier, 2007, Page 65-86.
7. J.S. Mason, Introduction to the Volume and Overview of Computer-Assisted Drug Design in the Drug Discovery Process, Editor(s): John B. Taylor, David J. Triggle, Comprehensive Medicinal Chemistry II, Elsevier, 2007, Pages 1-11,

Paper - XVIII: Molecular Virology

(Course Code: S0LS/MBT/SS006)

No. of Credits = 3

UNIT - I

History of Virology and Biosafety: History and principles of virology, Virus taxonomy. Structures of animal and plant viruses and their morphology. 0.75
Principles of biosafety, containment facilities, maintenance and handling of laboratory animals, and requirements of virology laboratory.

UNIT - II

Virus Replication: Structure and replication strategies of bacteriophages - T7, λ, ΦX174, and plant viruses - ss RNA virus (TMV) and ds DNA virus (CaMV). Structure and replication strategies of animal viruses - Influenza virus, Adeno virus and Retro virus. 0.5

UNIT - III

Interferon and Antiviral Agents: Viral Interference and interferons. Nature and source of interferons, Classification of interferons. Induction of interferon. 0.5
Antiviral agents (chemical and biological) and their mode of actions.

UNIT - IV

Cultivation of Viruses and Viral Vaccines: Cultivation of viruses in embryonated egg, Tissue culture and Laboratory animals. Conventional vaccines - Killed and attenuated. 0.5
Modern vaccines - Recombinant proteins, subunits, DNA vaccines, peptides, Immunomodulators (cytokines). Vaccine delivery and adjuvants, Large-scale manufacturing.

UNIT - V

Virological Methods: Methods for purification of viruses with special emphasis on ultracentrifugation methods. Quantitative diagnostic methods - Haemagglutination, Complement fixation, neutralization, 0.75
Nucleic acid based diagnosis - PCR, microarray and nucleotide sequencing.

Recommended Books: -

1. General Virology - Luria and Darnel Virology and Immunology - Jokli
2. Text book of Virology - Rhodes and Van Royen
3. Genetics of bacteria and their viruses - W. Hayes
4. Molecular Biology of the gene - Watson, Roberts, Staitz and Weiner
5. Virological Procedures - MitchalHaskingVirologoy - Wilson and Topley
6. Infection and Immunity DH Davies, MA Halablab,, et al (1998) Taylor & Francis Ltd, 1, London

DEPARTMENT OF BOTANY AND MICROBIOLOGY

REVISED SYLLABUS

M.Sc. (MICROBIOLOGY)

Effective from academic session 2015-2016

H.N.B. Garhwal University
(A Central University)
Srinagar-Garhwal, Uttarakhand

SYLLABUS

HNB GARHWAL UNIVERSITY, SRINAGAR-GARHWAL

DEPARTMENT OF BOTANY & MICROBIOLOGY

Master of Science

MICROBIOLOGY

(Two Year Course- Semester System)

2015 Onwards

Admission to Master's Program in Microbiology shall be through entrance examination conducted by University and the program shall be based on the choice based credit system in which credit defines the quantum of content/ syllabus prescribed for a course system and determines the number of hours of instruction per week.

The student shall be eligible for admission to a Master's Degree Program in Microbiology after he/she has successfully completed a three year undergraduate degree or earned prescribed number of credits through the examinations conducted by University as equivalent to an undergraduate degree. The fee structure would be as per University ordinances but the fee once deposited by the candidate would not be refundable under any circumstances barring security fee.

Core courses prescribed for every Semester shall be mandatory for all students registered for the Master's Program in Microbiology and shall carry minimum 54 credits. There shall be Elective courses offered in semester III and IV and shall carry a minimum of 18 credits. A self-study course would comprise of maximum 09 credits of which minimum 03 credits shall be mandatory which shall not be included while calculating grades. The student may choose self-study course either only in one of the three semesters (II/III/IV) or one each in all the three semesters. The self study course shall be based on advanced topics of elective courses of III semester.

In order to qualify for a two year master's degree, a student must acquire a minimum of 72 credits including a minimum of 18 credits in electives choosing at least two elective (leading to a minimum 06 credits) in Semester III offered either by the parent department or other departments and one qualifying self-study course of minimum 03 credits.

The dissertation is a semester long elective course of 10 credits and is mandatory for every student. The dissertation would be allotted in the beginning of III Semester and candidate would submit the report during IV Semester examination. The dissertation may be in the form of a field based minor research work/ project work/ practical training. The students may complete the dissertation work in the department/ other research institutes/ industries/ hospitals etc.

A candidate has to secure a minimum of 51 percent marks in aggregate (Two Sessional Tests marks plus End-Term Examination marks) to pass.

SCHOOL OF LIFE SCIENCES
PAPER CODES
PROGRAMME- M.Sc. MICROBIOLOGY

M.Sc. I Semester

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/C001	General Microbiology	4	0	0	4	100
SLS/MIC/C002	Fundamentals of Biochemistry	4	0	0	4	100
SLS/MIC/C003	Cell Biology	4	0	0	4	100
SLS/MIC/C004	Molecular Biology and Microbial Genetics	4	0	0	4	100
SLS/MIC/C005	Laboratory Course-I	0	0	3	3	100
SLS/MIC/C006	Laboratory Course-II	0	0	3	3	100
				Total		**600**

Core Credits= 22

M.Sc. II Semester

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/C007	Microbial Physiology and Metabolism	4	0	0	4	100
SLS/MIC/C008	Immunology	4	0	0	4	100
SLS/MIC/C009	Biological Techniques	4	0	0	4	100
SLS/MIC/C010	Recombinant DNA Technology	4	0	0	4	100
SLS/MIC/C011	Laboratory Course-I	0	0	3	3	100
SLS/MIC/C012	Laboratory Course-II	0	0	3	3	100
				Total		**600**

Core Credits= 22 with additional 03 Credits of Self Study*

M.Sc. III Semester

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/C013	Medical Microbiology	4	0	0	4	100
SLS/MIC/C014	Industrial Microbiology	4	0	0	4	100
SLS/MIC/C015	Laboratory Course-I	0	0	3	3	100
SLS/MIC/E01A	Food and Dairy Microbiology	3	0	0	3	100
SLS/MIC/E01B	Drug Designing and Nanobiotechnology	3	0	0	3	100
SLS/MIC/E01C	Genomics and Proteomics	3	0	0	3	100
SLS/MIC/E01D	Epidemiology	3	0	0	3	100
SLS/MIC/E01E	Bioprocess Technology	3	0	0	3	100
SLS/MIC/E01F	Environmental Microbiology	3	0	0	3	100
SLS/MIC/E02A	Agricultural Microbiology	3	0	0	3	100
SLS/MIC/E02B	Microbial Diversity	3	0	0	3	100
SLS/MIC/E02C	Pharmaceutical Microbiology	3	0	0	3	100
SLS/MIC/E02D	Infection and Immunity	3	0	0	3	100
SLS/MIC/E02E	Intellectual Property Rights	3	0	0	3	100
SLS/MIC/E02F	Research Methodology	3	0	0	3	100
SLS/MIC/E003	Laboratory Course-II	0	0	3	3	100
				Total		**600**

Total Credits = 20 (Core Credits= 11+ Elective Credits= 09) with additional 03 Credits of Self Study*

M.Sc. IV Semester

Code	Paper	Credits				MM
		L	T	P	C	
SLS/MIC/E004	Dissertation	0	0	10	10	200
					Total	**200**

Total Credits = 10 with additional 03 Credits of Self Study*

Grand Total: Core Credits 55+ Elective Credits 19= 74

***** With a total of 09 Credits (3+3+3 Credits in II, III and IV semester) of Self Study (2 Seminars equivalent to 2 Sessional Tests plus one End term written examination).

Maximum Marks for each paper is 100 (Sessional Tests-40 + End Term Test- 60).

** 01 Credit= 01 hour of lecture/instructions per week; 01 Credit course= 15 hours of lectures per semester.

*** 03 hours of laboratory course shall be considered equivalent to 01 hour of lecture.

The 2- Year Masters Programme will have the following components:

1. **Core course:** Minimum 54 credits.

2. **Elective course:** Minimum 18 credits choosing at least two Electives (leading to a minimum 06 credits) in Semester III offered either by the parent department or other departments and one Elective course as Dissertation (10 credits) in IV Semester.

3. **Self study course:** Maximum 09 credits (one minimum 03 credits shall be mandatory but not to be included while calculating grades).

Dissertation

Dissertation is an elective mandatory for every student. The dissertation is to be allotted in the beginning of III Semester and report would be submitted at the time of IV Semester examination.

The distribution of marks for the Dissertation will be as below:

Periodical Presentation : 40 Marks
Dissertation : 120 Marks
Viva Voce : 40 Marks
Total : 200 Marks

The dissertation would carry 10 credits in all. Dissertation shall be evaluated jointly by the supervisor and one external examiner.

SYLLABUS OF M.Sc. MICROBIOLOGY
I & II SEMESTERS

I SEMESTER

SLS/MIC/C001: GENERAL MICROBIOLOGY

Unit I: History and Classification

Discovery of microorganisms; Conflicts over spontaneous generation; Golden era of microbiology; Kingdom classification of microorganisms: Haeckel's three kingdom concept, Whittaker's five kingdom concept, Six kingdom classification, Eight kingdom classification, Three domain concept of Carl Woese; Differences between prokaryotes and eukaryotes; Techniques used in microbial classification (Morphological, chemotaxonomic and genetic methods); Tools for systematics (Phylogenetic, numerical and polyphasic taxonomy); Scope and relevance of microbiology.

Unit II: Basics of Microbiology

Microbial nutrition; Culture media; Culture techniques for isolation of pure culture; Cultivation of aerobic and anaerobic bacteria; Preservation methods; Microbial growth: Growth curve of batch and continuous cultivation, Diauxic growth curve, Generation time, Growth kinetics, Asynchronous and synchronous growth, Measurement of growth, Factors affecting growth; Control of microbial growth: Physical and chemical agents.

Unit III: General Bacteriology

Bergey's system of bacterial classification; Brief account of Gracilicutes, Fermicutes, Mendosicutes and Tenericutes; Ultrastructure of bacterial cell: Morphology of bacteria, Structure and properties of cell wall and cell membrane, Cell wall synthesis, Capsule (Types, composition and function), Ultrastructure and functions of flagella, cilia, pili, s-layer, cytoplasmic inclusions, ribosomes and nucleoid; Bacterial reproduction; Characteristic features of Archaea.

Unit IV: General Virology

Discovery of viruses; Characteristic feature of viruses, viroids, virusoids and prions; Baltimore scheme of classification; Morphology and ultrastructure: Capsids and their arrangements, Types and composition of envelopes, Viral genome (Types and structures); Isolation and cultivation of viruses using embryonated eggs, experimental animals and cell culture; Serological tests; Multiplication of viruses; Assay of viruses by physical and chemical methods (Protein, nucleic acid, radioactive tracers and electron microscopy); Genetic analysis of viruses by classical genetic methods (PCR and nucleic acid hybridization); Infectivity assay (Plaque method, pock method and end point methods); Bacteriophage: Structural organization, Cultivation, Replication, One step growth curve, Eclipse phase, Phage production, Burst size.

Unit V: General Mycology, Phycology and Protozoology

Mycology: General features, Mycelial organization and structure, Nutrition, Cultivation, Reproduction, Classification (Basis and general outline), Salient features of Ascomycetes, Basidiomycetes, Zygomycetes and Deuteromycetes, Characteristics of Lichens and Mycorrhiza; Phycology: General features of different algal groups with respect to thallus structure, nutrition and reproduction, Cultivation of algae, Distribution of microalgae in different classes, Classification of algae (Basis and general outline), Economic aspects of algae; Systemic position of cyanobacteria; Distinguishing characters of cyanobacteria and diatoms; Protozoology: Cell structure, Nutrition, Reproduction, Life cycle, Classification (Basis and general outline); Salient features of Dinoflagellates.

Reference Books

1. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York.
2. Black, J.G. Microbiology: Principles and exploration. John Wiley and Sons, New Jersey.
3. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
4. Pommerville, J.C. Alcamo's fundamentals of microbiology. Jones and Bartlett Learning, Sudbury.
5. Wheelis, M. Principles of modern microbiology. Jones and Bartlett Learning, Sudbury.
6. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L. and Painter, P.R. General microbiology. MacMillan Press, London.
7. Sclegel, H.G. General microbiology. Cambridge University Press, Cambridge.
8. Pelczar, M.J., Chan, E.C.S. and Kreig, N.R. Microbiology. McGraw-Hill, New York.
9. Tiwari, S.P., Sharma, R. and Singh, R.K. Recent advances in microbiology. Nova Science, New York.
10. Topley, W.W.C., Wilson, S.G.S. and Parker, M.T. Topley and Wilson's principles of bacteriology, virology and immunity. Edward Arnold, London.
11. Dimmoc, N.J., Easton, A.J. and Leppard, K.N. Introduction to modern virology. Wiley-Blackwell, New Jersey.
12. Levy, J.A., Conrat, H.F. and Owens, R.A. Virology. Prentice Hall, New Jersey.
13. Primrose, S.B. Introduction to modern virology. John Wiley and Sons, New Jersey.
14. Burnett, J.H. Fundamentals of mycology. St. Martin's Press, New York.
15. Mehrotra, R.S. and Aneja, K.R. An introduction to mycology. New Age International (P) Limited, New Delhi.
16. Alexopoulos, C.J. and Bold, H.C. Algae and fungi. MacMillan Press, London.
17. Graham, L.E. and Wilcox, L.W. Algae. Prentice Hall, New Jersey.
18. Vashishta, B.R. Algae. S. Chand and Company, New Delhi.
19. Sharma, O.P. Textbook of algae. Tata McGraw-Hill Education, New Delhi.
20. Kumar, H.D. Introductory phycology. East-West Press, New Delhi.

I SEMESTER

SLS/MIC/C002: FUNDAMENTALS OF BIOCHEMISTRY

Unit I: Acid-base Chemistry and Bioenergetics

Acid-base chemistry: Bronsted concept of conjugate acid-conjugate base pairs, Ionization of solutions, pH, Important biological buffers, Henderson-Hasselbalch equation, Buffer capacity, Polyproteic acids, Amphoteric salt, Ionic strengths; Bioenergetics: Concept of free energy, Standard free energy, Enthalpy, Entropy, High energy phosphate compounds, Phosphate group transfer, Free energy of hydrolysis of ATP, Oxidation-reduction, Redox potential; Energy generation in biological systems: Phosphorylation and electron transport chain, Electron carriers, Artificial electron donors, Inhibitors and uncouplers of oxidative phosphorylation, Chemiosmotic theory of ATP synthesis.

Unit II: Carbohydrates

Classification, nomenclature, structure, general properties and functions of simple carbohydrates; Complex carbohydrates: Mucopolysaccharides, Amino sugars, Bacterial cell wall sugars, Sugar alcohols, Glycoconjugates.

Unit III: Lipids

General properties, nomenclature and classification of lipids; Lipid functions: Cell signals, cofactors, prostaglandins; Fatty acids; Saponification, acid value and iodine value of fats; Rancidity of fats; Storage and structural lipids; Special mention of sphingomyelins, cerebrosides and gangliosides; Vitamins: Structure and function of fat soluble vitamins; Metabolism: Biosynthesis of fatty acids, triacylglycerols, membrane phospholipids, cholesterol, steroids and isoprenoids, Beta oxidation and its regulation, LDL and HDL, Regulation of cholesterol biosynthesis.

Unit IV: Proteins and Nucleotides

Proteins: Structural features and classification of amino acids, General reactions of amino acid metabolism (Transamination, decarboxylation, oxidative and non-oxidative deamination of amino acids), Peptide bond, Properties and functions of primary, secondary, tertiary and quaternary structure of proteins, Ramachandran plot, Factors affecting secondary and tertiary structures, Hydropathy index, Protein domain and motifs; Nucleotides: Structure of purines and pyrimidines, Synthesis of purines and pyrimidines, Regulation of nucleotide biosynthesis, Degradation of purines and pyrimidines.

Unit V: Enzymes

General characteristics of enzymes; Co-enzymes; Holoenzymes; Prosthetic groups; Enzyme nomenclature; Classification of enzymes; Active site; Transition state; Activation energy; Enzyme activity; Specific activity and turn over number; Isozymes; Mechanism of enzyme catalysis; Enzyme kinetics for single substrate and multi-substrate reactions; Reaction mechanisms of enzymes (Acid base and covalent catalysis); Reversible and irreversible inhibition of enzymes; Effect of pH and temperature on enzyme activity; Allosteric enzymes; Determination of active site and turn over number.

Reference Books

1. Atkins, P. and Paula, J.D. Atkins' physical chemistry. Oxford University Press, Oxford.

2. Segel, I.H. Biochemical calculations. John Wiley and Sons, New York.
3. Nelson D.L. and Cox, M.M. Lehninger principles of biochemistry. W.H. Freeman and Company, New York.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. Biochemistry. W.H. Freeman and Company, New York.
5. Garrett, R.H. and Grisham, C.M. Biochemistry. Cole Publishing Company, California.
6. Voet, D. and Voet, J.G. Biochemistry. John Wiley and Sons, New York.
7. Conn, E.E., Stumpf, P.K., Bruening, G. and Doi, R.Y. Outlines of biochemistry. John Wiley and Sons, New York.
8. Robert, M., Bender, D., Botham, K.M., Kennelly, P.J., Rodwell, V. and Weil, P.A. Harper's illustrated biochemistry. McGraw-Hill, New York.
9. White, A., Handler, P., Smith, E., Hill, R. and Lehman, J. Principles of biochemistry. Mc-Graw Hill, New York.
10. Jain, J.L. Fundamentals of biochemistry. S. Chand and Company, New Delhi.
11. Palmer, T. Enzymes: Biochemistry, biotechnology and clinical chemistry. Horwood Publishing Company, Chinchester.

I SEMESTER

SLS/MIC/C003: CELL BIOLOGY

Unit I: Intracellular Compartmentalization of Cell

Structure, organization and functions of nucleus, mitochondria, chloroplast, endoplasmic reticulum, golgi body, peroxisome, lysosome and endosomes; Cytoskeleton: Actin filaments, microtubules and intermediate filaments; Cell motility; Integrating cell into tissue: Cell junctions, Cell- Cell adhesions, Cell – extracellular matrix adhesion; Molecular mechanism of vesicular trafficking.

Unit II: Architecture of Plasma Membrane and Solute Transport

Plasma membrane: Composition of membrane, Fluid mosaic model, Membrane fluidity, Membrane dynamics, Membrane fusion; Solute transport across membranes: Diffusion (Simple and facilitated), Active transport (Primary and secondary), Pumps and transporters, Ion channels (Ligand gated and voltage gated channels), Trans-epithelial transport, Mechanism of regulation of intracellular transport.

Unit III: Cell Signaling

Basic signaling mechanisms (Paracrine, endocrine and autocrine signaling); Mechanism of signal transduction: Signaling molecules, Ligand-receptors interaction, Transmembrane and intracellular signaling, Cell surface receptors (G protein-coupled, enzyme-linked and ion channel-linked receptors), Second messengers and their role in signal transduction, Signal integration, Signal amplification.

Unit IV: Cell Cycle and Cell Division

Cell cycle: Molecular events, Cyclin, CDKs, Checkpoints in cell cycle, Intracellular control of cell cycle events, Abnormalities in cell cycle: Oncogenesis (Causes, proto-oncogenes and tumor suppresser genes, Oncogenic mutations); Cell division: Molecular mechanism of mitosis and meiosis.

Unit V: Cell Death Pathways

Necrosis; Autophagy; Senescence; Apoptosis: Mechanisms of apoptosis, Signals triggering apoptosis, Apoptosis inducing factors, Apoptosis in cancer, Role of immune system in organ transplantation.

Reference Books

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. Molecular biology of the cell. Garland Science, New York.
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. Molecular cell biology. W.H. Freeman and Company, New York.
3. Cooper, G.M. and Hausman, R.E. Cell: Molecular approach. ASM Press, Washington, D.C.
4. de Robertis, E. D. P. and de Robertis, E.M.F. Cellular and molecular biology. Saunders, Philadelphia.
5. Pollard, T.D., Earnshaw, W.C. and Schwartz, J.L. Cell biology. Saunders, Philadelphia.
6. Karp, G. Cell and molecular biology- Concepts and experiments. John Wiley and Sons, New York.

I SEMESTER

SLS/MIC/C004: MOLECULAR BIOLOGY AND MICROBIAL GENETICS

Unit I: Chromosome Structure

Experimental evidences for nucleic acid as carrier of genetic information; Chemical and physical properties of genetic material; Structure and types of DNA; DNA denaturation and renaturation kinetics; C- value paradox; Packaging of DNA into chromosome; Chromosome banding; Centromere and Telomere; Giant chromosome.

Unit II: Replication and Transcription

DNA replication in prokaryotes and eukaryotes: Experimental evidence, Modes of replication, Mechanism of replication, Inhibitors of replication; Transcription in prokaryotes and eukaryotes: RNA polymerases, Mechanism of transcription, Post transcriptional modifications of mRNA, rRNA and tRNA, Inhibitors of transcription; Structural features and functions of mRNA, t-RNA and r-RNA.

Unit III: Translation and Regulation of Gene Expression

Basic features of genetic code; Translation in prokaryotes and eukaryotes: Structure of ribosomes, Mechanism of translation, Post translational modifications, Protein degradation, Non-ribosomal polypeptide synthesis, Inhibitors of translation; Regulation of gene expression: Structure and regulation of *lac*, *trp* and *arb* operon, DNA binding motifs in regulatory proteins, Role of activators, enhancers, insulators, RNA interference and antisense RNA.

Unit IV: Recombination, Transposition, Mutation and Repair mechanism

Recombination: Types, Models for homologous recombination (The Holliday model and Double strand break repair model), Proteins involved in recombination; Transposition: Insertion sequences and transposable elements in prokaryotes and eukaryotes, Mechanism of transposition; Mutations: Types of mutations, Mutagens, Screening chemicals for mutagenicity; DNA repair: Photoreactivation, Methyl directed mismatch repair, Very short - patch mismatch repair, Nucleotide excision repair, Base excision repair, SOS system.

Unit V: Microbial Genetics

Bacterial plasmids: Types of plasmids, Compatibility and incompatibility, Mobilizable plasmids, Copy number of plasmids, Fertility inhibition, Donation and conduction; Gene transfer mechanisms: Transformation (Competence factor, natural and artificial transformation), Conjugation (F^+ X F^- mating, Hfr, Hfr X F^-, and F', mechanism of conjugation and sexduction), Transduction (Mechanism of generalized and specialized transduction, LFT and HFT lysate), Phage genetics: Life cycle of lambda and M13 phage, Regulation of lytic and lysogeny in lambda phage.

Reference Books

1. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Scott, M.P., Bretscher, A., Ploegh, H. and Matsudaira, P. Molecular cell biology. W.H. Freeman and Company, New York.
2. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. Lewin's genes. Jones and Bartlett Learning Publishers, Sudbury.
3. Nelson D. L. and Cox, M.M. Lehninger principles of biochemistry. W.H. Freeman and Company, New York.
4. Snustad, D.P. and Simmons, M.J. Principles of genetics. John Wiley and Sons, New York.

5. Malacinski, G.M. and Friefelder, D. Essentials of molecular biology. Jones and Bartlett Learning, Sudbury.
6. Synder, L.J., Peters, E., Henkins, T.M. and Champness, W. Molecular genetics of bacteria. ASM Press, Washington, D.C.
7. Maloy, S.R., Cronan, J.E. and Freifelder, D.M. Microbial genetics. Jones and Bartlett Learning, Sudbury.
8. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.
9. Weaver, R. Molecular biology. McGraw-Hill, New York.
10. Watson, J.D., Baker, T., Bell, S.P., Gann, A., Levine, M. and Lodwick, R. Molecular biology of the gene. Pearson Education, New Jersey.
11. Karp, G. Cell and molecular biology- Concepts and experiments. John Wiley and Sons, New York.
12. Klug, W.S. and Cummings, M.R. Concepts of genetics. Prentice Hall, New Jersey.

I SEMESTER

SLS/MIC/C005: LAB COURSE-I
(Based on Theory Papers SLS/MIC/C001 and SLS/MIC/C002)

1. Safety rules of working in microbiology lab, disposal of cultures, calibration, validation and maintenance of instruments.
2. Principles and working of instruments used in microbiology lab.
3. Media preparation and its sterilization.
4. Isolation and enumeration of bacteria and fungi from given sample.
5. Isolation and maintenance of pure culture of bacteria and fungi.
6. Isolation and enumeration of bacteriophage from sewage water.
7. Staining of bacterial cell (Simple staining, gram staining and negative staining).
8. Staining of fungal cell.
9. Staining of endospore and capsule.
10. Study of morphology of algae.
11. Symptomatology of infection of plant pathogens.
12. Measurement of bacterial cell size using micrometer.
13. Safety rules of working in lab, hazard from chemicals, handling of chemicals, disposal of chemicals, recording of scientific experiments, calibration, validation and maintenance of instruments.
14. Calculation of moles, molarity, molality and normality of given solution.
15. Calculation of pH of given solution.
16. Preparation of solutions and buffers of different concentrations and pH.
17. Qualitative tests for sugars, amino acids, proteins and lipids in given sample.
18. Quantitative estimation of sugar in given sample.
19. Quantitative estimation of protein in given sample.
20. Estimation of lipid concentration in given sample.
21. Determination of acid value, saponification and iodine value of fats and oils.
22. Determination of activity of given enzyme.
23. Determination of K_m and V_{max} of given enzyme.
24. Determination of optimum pH and temperature of given enzyme.
25. Determination of temperature and pH stability of given enzyme.

Reference Books

1. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/Cummings Publishing Company, San Francisco.
2. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.
3. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
4. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis.
5. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.
6. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.
7. Jayaraman, J. Laboratory manual in biochemistry. New Age International (P) Limited, New Delhi.

8. Sawhney, S.K. and Singh, R. Introductory practical biochemistry. Narosa Publishing House, New Delhi.
9. Segel, I.H. Biochemical calculations. John Wiley and Sons, New York.
10. Plummer, D.T. Introduction to practical biochemistry. Mc-Graw Hill, New York.
11. Boyer, R.F. Modern experimental biochemistry. Prentice Hall, New Jersey.
12. Gerhardt, P. Manual of methods for general bacteriology. ASM Press, Washington, D.C.
13. Barnett, M. Microbiology laboratory exercises. William C. Brown, Dubuque.
14. Wilson, K. and Walker, J.M. Principles and techniques of practical biochemistry. Cambridge University Press, Cambridge.

I SEMESTER

SLS/MIC/C006: LABCOURSE-II
(Based on Theory Papers SLS/MIC/C003 and SLS/MIC/C004)

1. Study of different stages of mitosis.
2. Study of different stages of meiosis.
3. Study of mechanism of diffusion.
4. Study of mechanism of exosmosis and endosmosis.
5. Effect of isotonic, hypotonic and hypertonic solutions on cell.
6. Preparation of splenocytes.
7. Quantitative estimation of DNA by diphenyl amine (DPA) and spectrophotometric method.
8. Quantitative estimation of RNA by orcinol and spectrophotometric method.
9. Determination of quality of DNA by spectrophotometric method.
10. Isolation of genomic DNA from bacterial culture.
11. Visualization of DNA by agarose gel electrophoresis.
12. Determination of T_m of given DNA sample.
13. Study of effect of temperature and pH on denaturation of DNA.
14. Study of effect of different concentrations of urea on denaturation of DNA.
15. Mutagenesis in given bacterial culture by U.V. radiation.
16. Demonstration of photoreactivation mechanism in bacteria.
17. Demonstration of dark repair mechanism in bacteria.
18. Demonstration of conjugation in bacteria.
19. Isolation of antibiotic resistant bacteria by gradient plate method.

Reference Books

1. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
2. Miller, J.H. Experiments in molecular genetics. Cold Spring Harbor Lab Press, New York.
3. Murray, R.G.F., Wood, W.A. and Krieg, N.B. Methods for general and molecular bacteriology. ASM Press, Washington, D.C.
4. Chaitanya, K.V. Cell and molecular biology: A lab manual. PHI Learning, New Delhi.
5. Celis, J.E. Cell biology: A laboratory handbook. Elsevier, Amsterdam.

II SEMESTER

SLS/MIC/C007: MICROBIAL PHYSIOLOGY AND METABOLISM

Unit I: Microbial Photosynthesis and Inorganic Metabolism

Photosynthesis: General characteristics of photosynthetic bacteria, Brief account of photosynthetic and accessory pigments, Mechanism of oxygenic and anoxygenic photosynthesis, Photosynthetic electron transport system, Photophosphorylation, Dark reaction; Inorganic metabolism: Characteristic features of chemolithotrophs, Mechanism of sulphur, iron, hydrogen and nitrogen oxidations; Mechanism of energy generation in methylotrophs and methanogens.

Unit II: Nitrogen and Sulphur Metabolism

Nitrogen metabolism: Nitrogen fixation (Characteristics of nitrogen fixing bacteria, biochemistry of nitrogenase complex, nitrogenase types, functions of *nif* genes, symbiotic nitrogen fixation and regulation of nitrogenase), Inorganic nitrogen metabolism, Assimilation of inorganic nitrogen, Regulation of nitrate assimilation; Sulphur metabolism: Free and bound pathways of assimilation of sulphate into cysteine, Glutathione and its role in sulphur metabolism.

Unit III: Microbial Respiration and Fermentation

Respiration: Aerobic respiration, Components of electron transport chain in aerobic bacteria, Anaerobic respiration, Mechanism of oxygen toxicity; Fermentation: Glucose, acetic acid, lactic acid, butyric acid, propionic acid and mixed acid fermentation.

Unit IV: Microbial Transport and Communication

Bacterial transport system: Donnan equilibrium, Thermodynamics of various transport systems, Osmosis, Plasmolysis, Osmotic pressure of electrolyte and non-electrolyte transport protein, PEP-PTS system in relation to catabolite repression, ABC transporter, Protein secretion pathways in bacteria; Communication mechanisms in prokaryotes: Intercellular signaling (Pheromones mediated signaling and quorum sensing), Intracellular signaling (Two component system and phosphorelay system).

Unit V: Microbial Stress Response

Osmotic stress and osmoregulation, Mechanism of transition from aerobic to anaerobic, Oxidative stress and its regulation, pH stress and acid tolerance response, Thermal stress and heat shock response, Nutrition stress and starvation-stress response, Stringent response, Sporulation and morphogenesis (Endospores: Physiological and genetic aspects of sporulation, Activation, germination and outgrowth).

Reference Books

1. Foster, J.W. and Spector, M.P. Microbial physiology. John Wiley and Sons, New York.
2. Gottschalk, G. Bacterial metabolism. Springer-Verlag, New York.
3. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
4. Brun, Y.V. and Shimkets, L.J. Prokaryotic development. ASM Press, Washington, D.C.
5. Rose, A.H. Advances in microbial physiology. Academic Press, New York.
6. David, W., Drummond, J.T. and Fuqua, C. Physiology and biochemistry of prokaryotes. Oxford University Press, New York.
7. Caldwell, D. R. Microbial physiology and metabolism. Star Publishers, California.

8. Lengeler, J.W., Drews, G. and Schlegel, H.G. Biology of the prokaryotes. Blackwell Science, New York.
9. Rhodes, P.M. and Stanbury, P.F. Applied microbial physiology: A practical approach. IRL Press, Oxford.

II SEMESTER

SLS/MIC/C008: IMMUNOLOGY

Unit I: Immune System and Immunity

History of immunology; Innate and acquired immunity; Determinants of innate immunity; Hematopoiesis; Cells and organs of immune system: B lymphocyte, T lymphocyte, NK cells, Monocyte/Macrophages, Dendritic cells, Eosinophils, Basophils, Neutrophils, Mast cells, Organization and structure of lymphoid organs and their role in immunity; Humoral and cell-mediated immunity; Nonspecific immune mechanisms: Surface defenses, Tissue defenses, Opsonization, Inflammatory reactions.

Unit II: Antigens and Antibodies

Antigens: Structure and properties; Haptens; Adjuvents; Immunogenicity; Immunoglobulin: Structures, Heterogeneity, Types and subtypes, Properties (Physiochemical and biological), Antibody effector mechanism, Antibody receptors, Antibody diversity, Immunoglobulin gene recombination, Theories of antibody production, Effect of somatic mutations on the antibody diversity, Ab class switching, Antibody responses *in vivo*, Affinity maturation development of memory, Recombinant antibodies, Monoclonal antibodies (General properties and applications), Hybridoma technology; Antigen – antibody reactions: Precipitation and agglutination reactions; Immunodiagnostic techniques: Immunoelectrophoresis, RIA, ELISA, Chemiluminescence immunoassay, Western blotting, Complement fixation test, Immunofluorescence, Flow cytometry.

Unit III: Complement system, Cytokines and Major Histo-compatibility Complex

Complement System: Structure, properties and functions of different components, Complement activation pathways (Classical, alternate and lectin pathways), Biological consequences of complement activation, Complement assay; Structure and function of various cytokines; Cytokine receptors; Antigen presenting cells; Structure and functions of MHC and HL-A system; Antigen processing and presentation.

Unit IV: Humoral and Cell Mediated Immune Response and Regulation

B- cell receptor; Development and differentiation of B cells; Negative regulation; T – cell receptor complex; Genomic organization of T- cell receptor locus; Development and differentiation of T cells; Positive and negative regulation; Immune Response: T -Cell independent defense mechanisms, T- Cell dependent defense mechanisms; Cell mediated cytotoxicity: T cytotoxic cells, Natural Killer (NK) Cells,Antibody dependent cell cytotoxicity (ADCC), Macrophage-mediated cytotoxicity.

Unit V: Immunopathology and Transplantations

Immunopathology: Rh- blood groupings, Hypersensitivity reactions (Antibody mediated type I, anaphylaxis, type II- antibody dependent cell cytotoxicity, type III-immune complex mediated reactions and type IV-delayed hypersensitivity reactions), Immune surveillance, Self tolerance, Autoimmune diseases, Immunodeficiency; Tumor immunology: Tumor specific antigens, Immune response to tumor, Tumor escape mechanisms, Immunotherapy of cancer, Immunotoxins; Transplantation: Graft vs. host reaction and rejection; Immunization: Active and passive; Vaccines.

Reference Books

1. Kindt, T.J., Goldsby, R.A., Osborne, B.A. and Kuby, J. Kuby immunology. W.H. Freeman and Company, New York.
2. Male, D.K. Immunology: An illustrated outline. Elsevier Health Sciences, Philadelphia.
3. Abbas, A.K., Lichtman, A.H.H. and Pillai, S. Cellular and molecular immunology. Saunders, Philadelphia.
4. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's essential immunology. Wiley-Blackwell, New Jersey.
5. Tizard, I.R. Immunology: An introduction. Saunders, Philadelphia.
6. Playfair, J.H.L. Immunology at a glance. Blackwell Scientific Publications, Oxford.
7. Abbas, A.K. and Lichtman, A.H.H. Basic immunology: Functions and disorders of the immune system. Saunders, Philadelphia.
8. Chapel, H., Haeney, M., Misbah, S. and Snowden, N. Essentials of clinical immunology. Wiley, New Jersey.
9. Palyfair, J.H.L. and Chain, B.M. Immunology at a glance. Wiley- Blackwell, New Jersey.
10. Coico, R. and Sunshine, G. Immunology: A short course. Wiley- Blackwell, New Jersey.
11. Rao, C.V. Immunology. Alpha Science International, New Delhi.
12. Pathak, S. and Palan, U. Immunology: Essential and fundamental. Science, New Hampshire.

II SEMESTER

SLS/MIC/C009: BIOLOGICAL TECHNIQUES

Unit I: Microscopy and Biosensors

Microscopy (Principles and applications): Light, phase contrast, fluorescence and confocal microscopy, Scanning and transmission electron microscopy; Biosensors: Introduction and principles, First, second and third generation instruments, Cell based biosensors, Enzyme immunosensors, DNA biosensor.

Unit II: Centrifugation

Basic principle and applications of centrifugation; Centrifugal force; Sedimentation rate; Sedimentation coefficient; Common centrifuges used in laboratory (Clinical, micro, high speed, ultra and industrial centrifuges); Types of rotors (Fixed- angle, swinging bucket and continuous tubular); Types of centrifugation (Principle and applications): Preparative (Differential and density gradient centrifugation) and analytical centrifugation.

Unit III: Chromatography

General principle and applications of chromatography; Types of chromatography (Principles and applications): Adsorption chromatography, Ion exchange chromatography, Affinity chromatography, Size exclusion chromatography, Thin layer chromatography, Gas chromatography, High pressure liquid chromatography (HPLC), Supercritical fluid chromatography.

Unit IV: Electrophoretic Techniques

General principle and applications of electrophoresis; Types of electrophoresis (Principles and applications): Paper electrophoresis, Moving boundary electrophoresis, Isotachophoresis, Agarose gel electrophoresis, Polyacrylamide gel electrophoresis (SDS-PAGE, Native-PAGE, Denaturing-PAGE and Reducing-PAGE), Isoelectric focusing (IEF), Pulse field gel electrophoresis (PFGE), Disc gel electrophoresis.

Unit V: Spectroscopy and Radiotracer Techniques

Spectroscopic methods (Principle and applications): UV, Visible, IR, NMR, Fluorescence, ESR, Atomic absorption, CD, ORD and Raman Spectroscopy; Mass Spectrometry: Principles and application of MALDI-MS, Ionization methods; Radiotracer techniques: Applications of radioisotopes in biology, Properties and units of radioactivity, Radioactive isotopes and half-life, Safety rules in handling of radioisotopes, Measurement of radioactivity (GM counter, gamma counter, wilson cloud chamber and liquid scintillation counter), Autoradiography: Principle and its applications.

Reference Books

1. Wilson, K. and Walker, J. Principles and techniques of biochemistry and molecular biology. Cambridge University Press, Cambridge.
2. Robyt, J.F. and White, B.J. Biochemical techniques: Theory and practice. Waveland Press, Long Grove.
3. Holme, D.J. and Peck, H. Analytical biochemistry. Longman Group Limited, London.
4. Chatwal, G. and Anand, S. Instrumental methods of chemical analysis. Himalaya Publishing House, Mumbai.

5. Miller, J. Chromatography: Concepts and contrasts. John Wiley and Sons, New York.
6. Message, G.M. Practical aspects of gas chromatography/ mass spectrometry. John Wiley and Sons, New York.
7. Kremmer, T. and Boross, L. Gel chromatography: Theory, methodology, applications. John Wiley and Sons, New York.
8. Hamilton, R.J. and Sewell, P.A. Introduction to high performance liquid chromatography. Chapman and Hall Limited, London.
9. Sharma, V.K. Techniques in microscopy and cell biology. Tata McGraw-Hill, New Delhi.
10. Westermeier, R. Electrophoresis in practice. Wiley-Blackwell, New Jersey.
11. Hames, B.D. Gel electrophoresis of proteins: A practical approach. Oxford University Press, Oxford.
12. Ford, T.C. and Graham, J.M. An introduction to centrifugation. Bios, New York.
13. Spencer, M. Fundamentals of light microscopy. Cambridge University Press, Cambridge.
14. Hayat, M.A. Principles and techniques of electron microscopy: Biological applications. Cambridge University Press, Cambridge.
15. Price, R.L. and Jerome, W.G. Basic confocal microscopy. Springer-Verlag, New York.
16. Rost, F.W.D. Fluorescence microscopy. Cambridge University Press, Cambridge.
17. Ploem, J.S. and Tanke, H.J. Introduction to fluorescence microscopy. Oxford University Press, Oxford.
18. Keeler, J. Understanding NMR spectroscopy. John Wiley and Sons, New York.
19. Straughan, B.B. and Walker, S. Spectroscopy. Chapman and Hall Limited, London.
20. Davies, A.M.C. and Creaser, C.S. Analytical applications of spectroscopy. Royal Society of Chemistry, California.
21. Thornburn, C.C. Isotopes and radiations in biology. Butterworths, Oxford.
22. Wang, C.H. and Willis, D.L. Radiotracer methodology in biological science. Prentice Hall, New Jersey.
23. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.

II SEMESTER

SLS/MIC/C010: RECOMBINANT DNA TECHNOLOGY

Unit I: Principles and Tools of Gene Cloning

Isolation of nucleic acids: DNA (Genomic, plasmid and bacteriophage), RNA; Enzymes used in genetic engineering (Restriction endonucleases, ligase, polymerases, kinase, alkaline phosphatase and terminal transferase); Cloning vectors: Characteristic features and applications of vectors based on plasmids (*E. coli* and yeast), phages (λ and M13 bacteriophage), cosmids, phasmids, artificial chromosome vectors (BAC and YAC), vectors for plants and animal cells and shuttle vectors.

Unit II: Strategies of Gene Cloning

Gene cloning: Steps of cloning, Formation of DNA fragments using linkers, adaptors and homopolymer tails, Introduction of DNA into host cells (Bacteria, plant and animal cells); Library construction: Synthesis of cDNA, Construction of cDNA and genomic library; Obtaining clone of a specific gene: Problem of selection, Direct selection, Selection strategies for recombinant produced by different vectors, Methods of identification of clone from gene library.

Unit III: Expression of Cloned Gene in Heterologous System: Prokaryotes and Eukaryotes

Basic architecture of an expression vector; Critical components of an expression vector; Expression of fusion protein; Characteristic features of pEt, pcDNA3 and cytomegalovirus expression system; Model host systems: *E. coli*, Fungi, Mammalian cell lines, Insect cells, Transgenic plants and animals; Screening strategies; Identification and study of translation product of a cloned gene: HRT and HART techniques.

Unit IV: Sequence Detection, Amplification and Modification Techniques

Blotting techniques (Methodologies and applications): Southern, Northern and Western blotting; Probe labelling and hybridization; DNA sequencing (Chemical, enzymatic and automated methods); Sequence assembly for whole genome analysis; PCR: Principle and applications; Types of PCR (Principle and applications): Degenerate PCR, Multiplex PCR, Hot start PCR, *In situ* PCR, Nested PCR, Q-PCR, RACE, Real Time PCR, RT-PCR; Site directed mutagenesis (Methods and applications).

Unit V: Genome Analysis and Applications of RDT

Principles and applications of techniques used in genome analysis: Exon trapping, R loop analysis, S1–mapping, Chromosome walking, Ribonuclease protection assay, Gel retardation assay, DNA foot printing, DNA fingerprinting, Antisense technology, Ribozyme technology; Applications of recombinant DNA technology in forensic science, therapeutics and agriculture.

Reference Books

1. Brown, T.A. Gene cloning and DNA analysis: An introduction. Wiley-Blackwell, New Jersey.
2. Primrose, S.B. and Twyman, R. Principles of gene manipulation and genomics. Wiley-Blackwell, New Jersey.
3. Nicholl, D.S.T. An introduction to genetic engineering. Cambridge University Press, Cambridge.

4. Glick, B.R., Pasternak, J.J. and Patten, C.L. Molecular biotechnology: Principles and applications of recombinant DNA. ASM Press, Washington, D.C.
5. Hartwell, L. Genetics: From genes to genome. McGraw-Hill, New York.
6. Old, R.W. and Primrose, S.B. Principles of gene manipulations. Blackwell Science, Oxford.
7. Winnacker, E.L. From genes to clones: Introduction to gene technology. Wiley-VCH, Germany.
8. Kingsman, S.M. and Kingsman, A.J. Genetic engineering: An introduction to gene analysis and exploitation in eukaryotes. Blackwell Science, Oxford.
9. Greene, J.J. and Rao, V.B. Recombinant DNA principles and methodologies. Marcel Dekker, New York.
10. Brown, T.A. Genomes. Wiley-Liss, Oxford.
11. Pevsner, J. Bioinformatics and functional genomics. Wiley-Blackwell, New Jersey.
12. Sambrook, J. and Russell, D.W. Molecular Cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
13. Reece R.J. Analysis of genes and genomes. John Wiley and Sons, New York.
14. Recombinant DNA safety guidelines. Department of Biotechnology, Ministry of Science and Technology, Government of India, New Delhi.

II SEMESTER

SLS/MIC/C011: LAB COURSE-I
(Based on Theory Papers SLS/MIC/C007 and SLS/MIC/C008)

1. Study of effect of temperature, pH and salt concentration on growth of bacteria.
2. Determination of ability of bacteria to reduce nitrate.
3. Determination of ability of bacteria to produce H_2S.
4. Determination of presence of cytochrome oxidase in bacteria.
5. Determination of presence of catalase in bacteria.
6. Determination of ability of bacteria to produce acidic or neutral end product from glucose.
7. Determination of ability of bacteria to utilize sugars by oxidative or fermentative mode.
8. Study of different stages of sporulation in *Bacillus*.
9. Effect of pH, sugars, amino acids and inorganic ions on spore germination.
10. Separation and preservation of serum and plasma.
11. Determination of blood group and Rh factor.
12. Demonstration of agglutination reaction of bacterial cultures by slide agglutination test.
13. Quantitative estimation of antigen by radial immunodiffusion.
14. Detection and quantification of either antibody or antigen by ouchterlony double diffusion method.
15. Determination of concentration of antigen by rocket immunoelectrophoresis.
16. Determination of the presence of specific antibody for its antigen by Dot-ELISA method.
17. Determination of concentration of antigen by sandwich ELISA.
18. Detection of the presence of either specific antibody or specific antigen in a patient's serum by complement fixation test.

Reference Books

1. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/Cummings Publishing Company, San Francisco.
2. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.
3. White, D. and Hegeman, G.D. Microbial physiology and biochemistry laboratory: A quantitative approach. Oxford University Press, New York.
4. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
5. Atlas, R.M., Brown, A.E. and Parks, L.C. Laboratory manual of experimental microbiology. Mosby College Publishing Company, St. Louis.
6. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.
7. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.
8. Rose, N.R., Hamilton, R.G. and Detrick, B. Manual of clinical laboratory immunology. ASM Press, Washington, D.C.
9. Weir, D.M. Handbook of experimental immunology. Blackwell Scientific Publications, New Jersey.
10. Stafseth, H.J., Stockton, J.J. and Newman, J.P. A laboratory manual for immunology. Burgess Publishing Company, Stockland.

II SEMESTER

SLS/MIC/C012: LAB COURSE-II
(Based on Theory Papers SLS/MIC/C009 and SLS/MIC/C010)

1. Separation and identification of amino acids by ascending and descending paper chromatography.
2. Separation and identification of sugars by paper chromatography.
3. Separation and identification of sugars by thin layer chromatography.
4. Verification of Lambert Beer's law.
5. Determination of molecular weight of DNA by agarose gel electrophoresis.
6. Separation and determination of molecular weight of proteins by SDS-PAGE.
7. Visualization of enzyme activity by NATIVE-PAGE.
8. Interpretation of UV spectra.
9. Interpretation of IR spectra.
10. Interpretation of NMR spectra.
11. Interpretation of Mass spectra.
12. Isolation of genomic DNA from plant sample.
13. Isolation of plasmid DNA from bacterial cell culture.
14. PCR amplification of DNA.
15. Restriction digestion of vector and DNA.
16. Ligation of DNA construct and vector.
17. Preparation of competent cells.
18. Introduction of recombinant DNA into bacterial cells and selection of recombinant clones.
19. Demonstration of inducible enzyme β-galactosidase in *E. coli*.
20. Expression of gene in *E. coli*.
21. Determination of similarity between different bacterial isolates using RFLP.

Reference Books

1. Jayaraman, J. Laboratory manual in biochemistry. New Age International (P) Limited, New Delhi.
2. Sawhney, S.K. and Singh, R. Introductory practical biochemistry. Narosa Publishing House, New Delhi.
3. Boyer, R.F. Modern experimental biochemistry. Prentice Hall, New Jersey.
4. Wilson, K. and Walker, J.M. Principles and techniques of practical biochemistry. Cambridge University Press, Cambridge.
5. Sambrook, J. and Russell, D.W. Molecular cloning: A laboratory manual. Cold Spring Harbor Lab Press, New York.
6. Miller, J.H. Experiments in molecular genetics. Cold Spring Harbor Lab Press, New York.

SYLLABUS OF M.Sc. MICROBIOLOGY
III & IV SEMESTERS

III SEMESTER

SLS/MIC/C013: MEDICAL MICROBIOLOGY

Unit I: Basics of Medical Microbiology

Normal microbiota of human body; Role of resident flora and human host; Routes of transmission of pathogens; Nosocomial infections; Collection, transportation and processing of clinical samples; Isolation and identification of pathogenic organisms; Quality control in medical microbiology laboratory.

Unit II: Pathogenesis and Antimicrobial Chemotherapy

Pathogenicity islands; Mechanism of pathogenesis: Mechanism of bacterial adhesion, colonization and invasion, Protein toxins (Classification and mode of action), Cytoskeletal modulation of host cell; Mechanism of action of antimicrobial agents; Methods of drug susceptibility testing: Kirby-Bauer's disc diffusion method, Stokes method, Agar dilution method, Broth dilution method, E-strip method; Emergence of drug resistance in bacteria (MRSA, ESBL and MDR TB); Resistance mechanism; Various types of vaccines for prevention of infectious diseases; National immunization program and immunization schedule.

Unit III: Bacterial Diseases

Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of bacterial diseases and clinical syndromes: Cholera, Leprosy, Diphtheria, Tetanus, Meningitis, Conjunctivitis, Pneumonia and Gastroenteritis.

Unit IV: Viral Diseases

Clinical features, transmission, characteristics of causative organism, pathogenesis, laboratory diagnosis, prevention and control of viral diseases: Herpes, Chikungunya, Influenza, Measles, Mumps, Hepatitis, HIV, Viral cancer.

Unit V: Protozoal and Fungal Diseases

Clinical features, transmission, pathogenesis, laboratory diagnosis, prevention and control of protozoal diseases: Amoebiasis, Giardiasis, Leishmaniasis, Malaria; Clinical features, transmission, pathogenesis, laboratory diagnosis, prevention and control of fungal diseases: Aspergillosis, Cryptococcosis, Candidiasis, Blastomycosis.

Reference Books

1. Murrey, P.R., Rosenthal, K.S., Kobayashi, G.S. and Pfaller, M.A. Medical microbiology. Saunders, Philadelphia.
2. Baron, E.J., Peterson, L.R. and Finegold, S.M. Bailey and Scott's diagnostic microbiology. Mosby, St. Louis.
3. Dockrell, H., Zuckerman, M., Roitt, I.M. and Chiodini, P.L. Mim's medical microbiology. Elsevier, London.
4. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. Mackie and McCartney practical medical microbiology. Churchill Livingstone, London.
5. Ananthanarayanan, R. and Panicker, C.K.J. Text book of microbiology. Orient Longman, Hyderabad.
6. Koneman, E.W. Koneman's color atlas and textbook of diagnostic microbiology. Lippincott Williams and Wilkins, Philadelphia.

7. Topley, W.W.C., Wilson, S.G.S and Parker, M.T. Topley and Wilson's principles of bacteriology, virology and immunity. Edward Arnold, London.
8. Greenwood, D., Slack, R.B. and Peutherer, J.F. Medical microbiology. Churchill Livingstone, London.
9. Mahon, C.R. and Manuselis, G. Textbook of diagnostic microbiology. Saunders, Philadelphia.
10. Maza, L.M.D.L. Color atlas of medical bacteriology. ASM Press, Washington, D.C.
11. Garcia, L.S and Isenberg, H.D. Clinical microbiology procedures handbook. ASM Press, Washington, D.C.
12. Balows, A., Hausler, W.J., Ohashi, M. and Turano, A. Laboratory diagnosis of infectious diseases: Principles and practice. Springer-Verlag, New York.
13. Chakraborthy, P. A textbook of microbiology. New Central Book Agency Private Limited, Calcutta.
14. Morag, C. and Timbury, M.C. Medical virology. Churchill Livingston, London.
15. Dimmock, N.J. and Pimrose, S.B. Introduction to modern virology. Blackwell Scientific Publications, Oxford.
16. Flint, S.J., Racaniello, V.R., Enquist, L.W., Rancaniello, V.R. and Skalka, A.M. Principles of virology: Molecular biology, pathogenesis and control of animal viruses. ASM Press, Washington, D.C.
17. Karyakarte, R.P. and Damle, A.S. Medical parasitology. Books and Allied Private Limited, Kolkatta.
18. Paniker, J. Text book of medical parasitology. Jaypee Brothers Medical Private Limited, New Delhi.
19. Chander, J. A text book of medical mycology. Interprint, New Delhi.

III SEMESTER

SLS/MIC/C014: INDUSTRIAL MICROBIOLOGY

Unit I: Introduction to Industrial Microbiology
Primary and secondary metabolites; Structure of fermentor/bioreactor; Types of fermentor/bioreactors; Scale up and scale down processes; Types of fermentation (Solid state, surface and submerged fermentation).

Unit II: Basic Aspects of Fermentation
Media formulation; Sterilization; Inoculum development; Effect of temperature, pH and high nutrient concentration on fermentation; Operational modes of fermentation (Batch, fed- batch and continuous); Downstream processing.

Unit III: Microbial Strain Improvement
Strategies for isolation and cultivation of desired microorganisms; Screening for the desired product; Strategies for strain improvement: Mutation, Protoplast fusion, Recombinant DNA technology, Novel strategies (Metabolic engineering, genome shuffling, ribosome engineering and epigenetic modification); Preservation of cultures after strain improvement programme.

Unit IV: Industrial Production Aspects I
Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of antibiotics (Penicillin, D-cycloserine, streptomycin, tetracycline, bacitracin and grieseofulvin), amino acid (Glutamic acid and lysine), biopolymers (Dextran, alginate, xanthan and pullulan) and steroids biotransformation.

Unit V: Industrial Production Aspects II
Production aspects (Microbial strains, substrate, flow diagrams, product optimization and applications): Production of enzymes (Pectinase, amylase, lipase, protease, cellulase and xylanase), alcohol and alcoholic beverages, vitamins (B12 and riboflavin), organic acids (Citric acid, acetic acid and lactic acid), ergot alkaloids and bioplastics (PHB and PHA).

Reference Books

1. Hershnergev, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.
2. Crueger, W. and Crueger, A. Biotechnology: A textbook of industrial microbiology. Sinauer Associates, Sunderland.
3. Reed, G. Prescott and Dunn's industrial microbiology. Globe Bookservices, London.
4. Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
5. Casida, J.E. Industrial microbiology. Wiley Eastern, New Delhi.
6. Patel, A.H. Industrial microbiology. MacMillan India Limited, New Delhi.
7. Stanbury, A.H., Whittaker, A. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.
8. Richard, H., George, B., Hagemann, D. and Paul, L. Industrial microorganisms: Basic and applied molecular genetics. ASM Press, Washington, D.C.

III SEMESTER

SLS/MIC/C015: LAB COURSE-I
(Based on Theory Papers SLS/MIC/C013 and SLS/MIC/C014)

1. Biosafety guidelines and biosafety levels.
2. Prevalence of pathogenic microorganisms in clinical sample.
3. Isolation and biochemical characterization of pathogenic bacteria.
4. Isolation and identification of fungal pathogens from clinical specimens.
5. Determination of antimicrobial susceptibility of pathogens by disc diffusion test.
6. Determination of MIC and MBC concentration of antibiotics by broth dilution test.
7. Isolation and screening of bacterial and fungal cultures for enzyme production.
8. Estimation of enzyme production by microbial culture *via* liquid state fermentation.
9. Estimation of enzyme production by microbial culture *via* solid state fermentation.
10. Media formulation for enhanced enzyme production by microbial culture *via* liquid and solid state fermentation.
11. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* liquid and solid state fermentation.
12. Production of wine from fruit juice.
13. Monitoring of sugar reduction during wine production.
14. Estimation of alcohol concentration in wine.
15. Estimation of vicinal diketone in beer.
16. Improvement of strain for increased yield by U.V. mutagenesis.

Reference Books

1. Collee, J.C., Duguid, J.P., Fraser, A.C. and Marimon, B.P. Mackie and McCartney practical medical microbiology. Churchill Livingstone, London.
2. Garcia, L.S and Isenberg, H.D. Clinical microbiology procedures handbook. ASM Press, Washington, D.C.
3. Murray, P.R., Baron, E.J., Jorgensen, J.H., Pfaller, M.A. and Yoke, R.H. Manual of clinical microbiology. ASM Press, Washington, D.C.
4. Balows, A., Hausler, W.J., Ohashi, M. and Turano, A. Laboratory diagnosis of infectious diseases: Principles and practice. Springer-Verlag, New York.
5. Faddin, J.F.M. Biochemical tests for identification of medical bacteria. Williams and Wilkins, Baltimore.
6. Baltz, R.H., Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
7. Leboffe, M.J. and Pierce, B.E. Microbiology: Laboratory theory and application. Morton Publishing Company, Englewood.
8. Singer, S. Experiments in applied microbiology. Academic Press, New York.
9. Kannan, K. Laboratory manual in general microbiology. Panima, New Delhi.
10. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.

III SEMESTER

SLS/MIC/E01A: FOOD AND DAIRY MICROBIOLOGY

Unit I: Principles of Food Preservation
Factors influencing microbial growth in food; Asepsis; Food preservation: Principles, Physical methods (Dehydration, freeze drying, heat and irradiation), Chemical methods (Chemical preservatives and food additives); Canning; Processing for heat treatment (D, Z and F values) and working out treatment parameters; Microbiological quality standards of food.

Unit II: Contamination and Spoilage
Characterization of contamination and spoilage of cereals, vegetables, fruits, meat and meat products, milk and milk products, fish and sea foods, beer and wines; Spoilage of fermented foods and canned foods.

Unit III: Foodborne Infections and Intoxications
Bacterial and nonbacterial infections and intoxications of *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio*, *Yersinia*, *Listeria*, nematodes, protozoa, algae, fungi and viruses; Structure and functions of aflatoxins; Laboratory testing procedures.

Unit IV: Food Safety and Quality Assurance
Microbiological quality standards of food; Food control agencies and their regulations: FDA, EPA, CDC and ISI; Good Manufacturing Practice; Plant sanitation (Employees health standards, waste treatment and disposal); Hazard Analysis and Critical Control Point (HACCP) system; Food Safety Act and Trade Regulations.

Unit V: Production of Fermented Foods
Industrial production methods of bread, cheese, fermented vegetables (Olives and cucumber), fermented dairy products (Acidophilus milk, cheese and yoghurt), single cell proteins, sauerkraut, meat and fishery products (Sausages and fish sauces); Production of oriental foods (Mycoprotein, tempeh, soya sauce, idli, natto and poi) and beverages (Vinegar, cider, sake and palm wines); Alcoholic beverages of Himalayan region; Genetically modified foods; Probiotics.

Reference Books

1. Adams, M.R., and Moss, M.O. Food microbiology. Royal Society of Chemistry Publication, Cambridge.
2. Frazier, W.C. and Westhoff, D.C. Food microbiology. Tata McGraw Hill, New Delhi.
3. Stanbuty, P.F. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.
4. Banwart, G.J. Basic food microbiology. CBS Publishers and Distributors, New Delhi.
5. Robinson, R.K. Dairy microbiology. Elsevier Applied Sciences, London.
6. James M.J. Modern food microbiology. CBS Publishers and Distributors, New Delhi.
7. Wood, B.J. Microbiology of fermented foods. Elsevier Applied Sciences, London.
8. Ayres, J.C., Mundt, O. and Sandinee, W.E. Microbiology of foods. W.H. Freeman and Company, New York.
9. Jay, M.J., Loessner, M.J. and Golden, D.A. Modern food microbiology. Springer Science and Business Media, New York.
10. Hobbs, B.C. and Roberts, D. Food poisoning and food hygiene. Edward Arnold, London.

III SEMESTER

SLS/MIC/E01B: DRUG DESIGNING AND NANOBIOTECHNOLOGY

Unit I: Drug Receptor Interactions

Receptors: Classification of receptors and receptor subtypes, Structure of receptors, Blood cell receptors for endogenous compounds, Neurotransmitters and their receptors, Receptor modulation and mimics, Receptor sites, Receptor cross-talk, Organ receptors, Non-liganded and constitutive receptor activation, r-DNA receptor bioassays, Desensitization of receptors, Receptors as targets for vaccines and newer drug development; Drug-receptor interactions: Active transport, Affinity and efficacy, Allosteric binding sites, Chirality and receptor binding, Signal transduction and second messenger system, Introduction of various classes of drugs based on their interaction with target site, Interaction of drugs with receptors, enzymes, DNA and carbohydrates.

Unit II: Drug Targeting and Drug Delivery Systems

Introduction and historical perspectives of drug delivery systems; Controlled, targeted and delayed drug delivery systems; Oral dosage forms: Diffusion, Dissolution system, Osmotic pumps, Ion exchange resin; Soluble delivery systems: Micro and nano systems; Injections; Routes of drug delivery systems; Stability profile; Barriers to proteins and peptide delivery; Lymphatic transportation of proteins; Site specific protein modification; Toxicology profile characterization; Cellular level events in targeting; Carrier systems for targeting; Specialized liposomes for drug targeting.

Unit III: Structure Activity Relationship

Structure activity relationship (SAR): Introduction and scope, Structure activity relationship illustrated with examples from sulphonamides, β-lactams, quinolones, nucleosides and alkaloids; Quantitative structure activity relationship (QSAR): Role of physicochemical, electronic (Hammett equation), lipophilicity (Hansch equation) and steric parameter (Taft equation).

Unit IV: Molecular Modelling

Quantum mechanical and molecular orbital methods; Introduction to semiempirical, molecular mechanics and *ab initio* techniques; Potential energy surface; Docking and modelling substrate-receptor interactions; Introduction to software tools for CADD.

Unit V: Nanobiotechnology

Functional principles of nanobiotechnology; Basic biology principles and practice of micro fabrication techniques; Atomic force microscopy; Biological production of metal nanoparticles and macromolecular assemblies; Bacterial structure relevant to nanobiotechnology; Cubosomes; Dendrimers; DNA nanoparticle conjugates; DNA octahedron; Fullerenes; Nanoshells; Carbon nanotubes; Nanopores; Nanostructured silicon; Viruses as nanoparticles; DNA based nanostructures: DNA-protein nanostructures, Self-assembled DNA nanotubes, Drug delivery tools *via* nanobiotechnology; Protein and peptide delivery; Tumor targeting and other diagnostic applications; Nanoparticle based immobilization assays; Quantum dots technology and its application; Immuno- nanotechnology; Biosensors and nanobiotechnology.

Reference Books

1. Silverman, R. Organic chemistry of drug design and drug action. Elsevier, London.

2. Gorden, E.M. and Kerwin, J.F. Combinatorial chemistry and molecular diversity in drug discovery. Wiley-Liss, Oxford.
3. Pirrung, M.C. Molecular diversity and combinatorial chemistry: Principles and applications. Elsevier, London.
4. Larsen, P.K. and Stromgaard, K. Textbook of drug design and discovery. CRC Press, Boca Raton.
5. Silverman, R.B. The organic chemistry of drug design and drug action. Elsevier, London.
6. Patrick, G.L. An introduction to medicinal chemistry. Oxford University Press, Oxford.
7. Gregoriadis, G. Drug carriers in biology and medicine. Academic Press, New York.
8. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.
9. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
10. Eisenberg, D. and Crothers, D. Physical chemistry with applications to the life sciences. Benjamin/ Cummings Publishing Company, Melano Park.
11. Niemeyer, C.M. and Mirkin, A. Nanobiotechnology: Concepts, applications and perspectives. Wiley, New York.
12. Donald, M. Nanobiotechnology of biomimetic membranes. Springer Verlag, New York.
13. deVilliers, M.M., Aramwit, P. and Kwon, G.S. Nanotechnology in drug delivery. Springer-Science, New York.
14. Kulkarni, S.S. Nanotechnology: Principles and practices. Capital Publishing Company, New Delhi.
15. Goosell, D.S. Bionanotechnology: Lessons from nature. John Wiley and Sons, New York.

III SEMESTER

SLS/MIC/E01C: GENOMICS AND PROTEOMICS

Unit I: Genome Anatomies

Introduction to structural, comparative and functional genomics; Applications of genomics; Anatomy of eukaryotic and prokaryotic genome; Genome size and complexity; Repetitive DNA content of genome; Introduction to gene networks and epigenetic analysis; DNA methylation analysis: Global DNA methylation analysis, Gene-specific methylation analysis, Methylation sensitive PCR, Quantitative methods of DNA methylation analysis; Sequencing of genome: Shot gun sequencing, High throughput sequencing; Methods for sequence assembly: Whole genome shot gun approach, Clone contig approach.

Unit II: Mapping Genomes

Genetic mapping: DNA markers used (RFLP, SSLP and SNP), Gene mapping by linkage and pedigree analysis, Genetic mapping in bacteria, Limitations of genetic mapping; Physical mapping: Restriction mapping, Fluorescence *in situ* hybridization, Sequence tagged site mapping.

Unit III: Genome Sequence Analysis

Location of gene by sequence inspection; Techniques used for gene location: Northern hybridization, Zoo blotting, cDNA sequencing; Techniques used for transcript mapping (RACE and heteroduplex analysis); Location of exon and exon-intron boundaries; Determining function of individual genes: Homology analysis, Gene inactivation by homologous recombination (Gene targeting and gene trapping), genome-wide mutagenesis, transposon tagging and RNA interference; Overexpression of genes; Directed mutagenesis; Determining pattern of gene expression: Reporter gene and immunocytochemistry; Human Genome Project: Strategies and implications.

Unit IV: Transcriptomics

Serial analysis of gene expression (SAGE); Massively parallel signature sequencing (MPSS); DNA chip and microarray; Tiling arrays; Applications of transcriptomics.

Unit V: Proteomics

Techniques used to study proteome: 2-D PAGE, Mass-Spectrometry, MALDI-TOF, Identifying proteins with post-translational modifications; Fast parallel proteolysis; Protein sequencing; Identifying protein – protein interactions: Yeast two-hybrid system, Phage display library, Protein microarray, Affinity purification, Protein interaction maps; Chromatin immunoprecipitation; Applications of proteomics.

Reference Books

1. Brown, T.A. Genomes. Wiley-Liss, Oxford.
2. Pevsner, J. Bioinformatics and functional genomics. Wiley-Blackwell, New Jersey.
3. Reece, R.J. Analysis of genes and genomes. John Wiley and Sons, New York.
4. Gibson, G. and Muse, S.V. A primer of genome science. Sinauer Associates, Massachusetts.
5. Campbell, A.M. and Heyer, L.J. Discovering genomics, proteomics and bioinformatics. Benjamin/ Cummings Publishing Company, San Francisco.

III SEMESTER

SLS/MIC/E01D: EPIDEMIOLOGY

Unit I: **Basics of Epidemiology**
Introduction; Scope and applications of epidemiology in health care; Role, ethics and responsibilities of an epidemiologist; Relation between virulence and spread; Reservoirs of infection (Human, animal and non-living reservoirs); Types of carriers; Portals of entry and exit.

Unit II: Transmission of Disease
Sources of infection; Modes of disease transmission; Disease cycle; Role of remote sensing and geographical information in recognition of an epidemic; Serological surveys; Influence of behavioral or spatial factors on transmission; Spatial, temporal and social distributions of communicable diseases; History of outbreaks: SARS, Chikungunya, Hantavirus infection, Swine flu, Haiti cholera.

Unit III: Mathematical Modelling I
Transmission dynamics: Incidence, Prevalence, Morbidity, Mortality; Public health surveillance: Purpose and characteristics, Identifying health problems for surveillance, Collection of data for surveillance, Analysis and interpretation of data, Disseminating data and interpretation, Evaluating and improving surveillance.

Unit IV: Mathematical Modelling II
Epidemiological studies: Collection of frequency data, Descriptive, analytical and experimental studies, Cross-sectional, case-control and cohort studies, Models for developing epidemiological theory, Modelling tools, Population dynamics, Epidemiological statistics relating exposure and disease; Measures of risks: Frequency measures, Morbidity and mortality frequency measures, Natality measures, Measures of association, Measures of public health impact.

Unit V: Control of Epidemics
Cycle of epidemics; Emerging and re-emerging infectious diseases and pathogens; Control of transmission: Isolation, Quarantine, Threat of bioterrorism, Global travel and health considerations; Community based control by vaccination, mass vaccination and herd immunity; Public health organizations for control: Centre of Disease Control (CDC), Guidelines issued by CDC and WHO, Health standards for international epidemics.

Reference Books

1. Rothman, K.J. and Greenland, S. Modern epidemiology. Lippincott-Raven, Philadelphia.
2. Dockrell, H., Zuckerman, M., Roitt, I.M. and Chiodini, P.L. Mim's medical microbiology. Elsevier, London.
3. Gordis, L. Epidemiology. Saunders, Philadelphia.
4. Anderson, R.M. and May, R.M. Infectious diseases of humans: Dynamics and control. Oxford University Press, Oxford.
5. Giesecke, J. Modern infectious disease epidemiology. Edward Arnold, London.
6. Clayton, D. and Hills, M. Statistical models in epidemiology. Oxford University Press, Oxford.
7. Rothman K.J., Greenland, S. and Lash, T.L. Modern epidemiology. Lippincott Williams and Wilkins, Philadelphia.

8. Vynnycky, E. and White, R.G. An introduction to infectious disease modelling. Oxford University Press, Oxford.
9. Gerstman, B.B. Epidemiology kept simple: An introduction to classic and modern epidemiolgy. John Wiley and Sons, New York.
10. Vynnycky, E. and White, R. An introduction to infectious disease modelling. Oxford University Press, Oxford.
11. Kestenbaum, B. Epidemiology and biostatistics: An introduction to clinical research. Springer-Verlag, New York.

III SEMESTER

SLS/MIC/E01E: BIOPROCESS TECHNOLOGY

Unit I: Bioreactor Design

Introduction to fermentation technology; Ideal bioreactor; Types of bioreactor (Stirred tank bioreactor, airlift bioreactor, continuous stirred tank bioreactor, immobilized cell reactors, plug flow reactor, tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors and trickle flow reactors); Designing of a bioreactor: Bioreactor configuration, Design features, Parts of bioreactor; Reactor with non-ideal mixing; Sterilization reactors; Multiphase bioreactors; Animal and plant cell reactor technology.

Unit II: Fermentation Process and Kinetics

Types of fermentation; Media formulation; Sterilization (Batch and continuous); Inoculum development; Operational modes (Applications, advantages and limitations of batch, fed-batch and continuous processes); Scaling up of process; Specific growth rate; Kinetics of microbial growth in batch, continuous and fed batch culture; Kinetics of substrate utilization and product yield; Multistage system; Feedback systems and its kinetics; Biomass productivity and metabolic productivity; Basic principles of operation; Optimization and modelling of fermentation process: Single variable design, Multivariate screening designs, Critical factor analysis, Optimization designs for two or more factors, Singlet method, Metabolic and flux control analysis.

Unit III: Mass and Energy: Transfer and Balance

Aeration: Principles and methods; Oxygen requirement in industrial fermentation; Theory of oxygen transfer in bubble aeration; Oxygen transfer kinetics (Oxygen uptake rate, Oxygen transfer rate and C_{crit}); Determination of kLa; Functions of agitation; Flow patterns with different types of impellers; Fermentation broth rheology and power requirements for agitation: Concept of Newtonian and non-Newtonian fluids, Effect of broth rheology on heat, nutrient and oxygen transfer, Reynold's number, Power number, Aeration number; Conversion and balance of nutrient and biomass, Heat balance and affecting factors, Heat transfer.

Unit IV: Downstream Processing

Biomass separation by centrifugation, filtration, flocculation and other recent developments; Cell disintegration: Physical, chemical and enzymatic methods; Extraction (Solvent, two phase, liquid extraction, whole broth and aqueous multiphase extraction); Purification by different methods; Concentration by precipitation, ultra-filtration and reverse osmosis; Drying and crystallization.

Unit V: Instrumentation and Control

Methods of measuring process variability and their control: Temperature, Flow, Pressure, Dissolved oxygen and free CO_2, pH and other chemical factors; Control systems: Manual control, Automatic control systems (Two-position controllers (ON/OFF), proportional controllers, integral controllers and derivative controllers); Combinations of methods of control; Computers application in process control.

Reference Books

1. Crueger, W. and Crueger, A. Biotechnology: A textbook of industrial microbiology. Sinaeur Associates, Sunderland.
2. Stanbury, A.H., Whittaker, A. and Hall, S.J. Principles of fermentation technology. Pergamon Press, Oxford.

3. Casida, J.E. Industrial microbiology. Wiley Eastern, New Delhi.
4. Bhosh, T.K., Fiechter, A. and Blakebrough, N. Advances in biochemical engineering. Springer Verlag, New York.
5. Veith, W.F. Bioprocess engineering kinetics, mass transport, reactors and gene expressions. John Wiley and Sons, New York.
6. Pauline, D. Bioprocess engineering principles. Academic Press, New York.
7. Lydersen, B., Elia, N.A.D. and Nelson, K.M. Bioprocess engineering: Systems, equipment and facilities. John Wiley and Sons, New York.
8. Hershnergev, C.L., Queener, S.W. and Hedemen, Q. Genetics and biotechnology of industrial microorganisms. ASM Press, Washington, D.C.
9. Reed, G. Prescott and Dunn's industrial microbiology. Globe Bookservices, London.
10. Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
11. Patel, A.H. Industrial microbiology. MacMillan India Limited, New Delhi.
12. Richard, H., George, B., Hagemann, D. and Paul, L. Industrial microorganisms: Basic and applied molecular genetics. ASM Press, Washington, D.C.
13. Kalaichelvan, P.T. and Arulpandi, I. Bioprocess technology. MPJ Publishers, Chennai.
14. Asenjo, J.A. Separation process in biotechnology. Marcel Dekker, New York.
15. Belter, P.A. Cussler, E.L. and Hu, W.S. Bioseparation: Downstream processing for biotechnology. John Wiley and Sons, New York.
16. Peppler, H.J. and Perlman, D. Microbial technology. Academic Press, New York.

III SEMESTER

SLS/MIC/E01F: ENVIRONMENTAL MICROBIOLOGY

Unit I: Fundamentals of Microbial Ecology

Ecosystem; Biotic and abiotic components; Habitat and Niche; Population and guilds; Concept of community; Stability hypothesis; Intermediate-disturbance hypothesis; Concept of ecological niche; Ecosystem organization: Structure and functions, Primary production, Energy dynamics (Trophic organization and energy flow pathways); Microbial community dynamics: r and k strategies of population selection within communities.

Unit II: Air and Aquatic Microbiology

Aerobiology: Droplet nuclei, Aerosol, Assessment of air quality, Solid and liquid impingement methods, Brief account of air born transmission of microbes; Aquatic microbiology: Zonation and microbiota of fresh water (Ponds, lake and rivers) and marine habitats (Estuaries and deep sea), Upwelling and downwelling, Eutrophication, Food chain, Mechanism of dissolved organic matter production, Microbial assessment of water quality, Water purification.

Unit III: Microbial Interactions

Positive and negative interactions amongst microbial populations: Cooperation, Neutralism, Commensalism, Synergism, Mutualism, Competition, Amensalism, Parasitism, Predation; Interactions between microorganisms and plants: Rhizobacteria, Mycorrhiza, Epiphytic and endophytic microorganisms; Interactions between microorganisms and animals: Predation on microorganisms by animals, Cultivation of microorganisms by animals for food and food processing.

Unit IV: Pollution and its Control

Air pollution and its control: Sources, Major pollutants, Adverse effect on living organisms (Acid rain and its impact on ecosystem, greenhouse effect, global warming, ozone layer depletion and its effect, smog), Control through biotechnology (Deodorization, reduction in CO_2 emission, bioscrubbers, biobeds and biofilters); Water pollution and its control: Sources, Ground water contamination, Wastes: Characterization of solid and liquid wastes, Solid waste treatment (Landfills, incineration, composting, anaerobic digestion and pyrolysis), Waste water treatment (Pretreatment, primary, secondary and tertiary treatment, Application of biofilm in waste water treatment); Environment impact assessment.

Unit V: Impact of Microbes on Environment

Biodegradation of recalcitrant compounds: Pesticides and Petroleum; Bioremediation: *In situ* and *Ex situ* remediation, Bioremediation of oil spills; Bioaugmentation; Biomagnification; Biomineralization; Metal corrosion: Mode of deterioration, Microorganisms involved, Mode of prevention; Bioleaching of ore; Microbial plastics; Biodiesel.

Reference Books

1. Alexander, M. Microbial ecology. John Wiley and Sons, New York.
2. Eldowney, S., and Waites, S. Pollution: Ecology and biotreatment. Longman, Harlow.
3. Baker, K.H. and Herson, D.S. Bioremediation. McGraw- Hill, New York.
4. Marshal, K.C. Advances of microbial ecology. Plenum Press, New York.

5. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
6. Chapman, J.L. and Reiss, M.J. Ecology: Principles and applications. Cambridge University Press, Cambridge.
7. Heywood, V.H. and Watson, R.T. Global biodiversity assessment. Cambridge University Press, Cambridge.
8. Kormondy, E.J. Concepts of ecology. Prentice-Hall, New Delhi.
9. Odum, E.P. Basic ecology. Saunders, Philadelphia.
10. Mitchell, R. and Gu, J.D. Environmental microbiology. Wiley-Blackwell, New Jersey.
11. Maier, R., Pepper, I. and Gerba, C. Environmental microbiology. Academic Press, San Diego.
12. Evans, G.M. and John, J.C.F. Environmental biotechnology: Theory and applications. John Wiley and Sons, New York.
13. Satyanarayana, T., Littlechild, J. and Kawarabayasi, Y. Thermophilic microbes in environmental and industrial biotechnology. Springer Science and Business Media, Dordrecht.
14. Satyanarayana, T., Johri, B.N. and Prakash, A. Microorganisms in environmental management: Microbes and environment. Springer Verlag, New York.

III SEMESTER

SLS/MIC/E02A: AGRICULTURAL MICROBIOLOGY

Unit I: Abiotic and Biotic Components of Soil

Physico-chemical characteristics of soil; Soil enzymes and significance; Soil microbes; Influence of microbial metabolism on soil chemistry and humus formation; Organic matter dynamics in soil: Microbial decomposition of cellulose, hemicellulose and lignin, Factors affecting organic matter decomposition.

Unit II: Rhizosphere and Rhizoplane Microorganisms

Rhizosphere; Rhizoplane; Composition of root exudates; Factors affecting exudation; Plant growth promoting rhizobacteria; Mycorrhiza; Rhizosphere effect; Factors affecting microbial community in soil; Mechanism of plant growth promotion: Mechanism of nitrogen fixation, Mechanism of phosphate solubilization and phosphate mobilization, Mechanism of iron chelation, Production of plant growth promoting hormones from bacteria and fungi, Production of antibiotics by plant growth promoting microorganisms.

Unit III: Plant Pathogens

Symptoms, casuative organisms, disease cycle and control measures of plant diseases: Blight of rice, Citrus canker, Wilt of potato, *Pythium* seed rot, Grapes downy mildew, Potato early and late blights, Fusarial wilt, Wheat-smut and rust, Tikka leaf spot in groundnut, Common viral diseases of plants (Paddy, cotton, potato, tobacco, cauliflower, tomato and sugarcane); Biochemical and genetic basis of virulence in plant pathogens.

Unit IV: Biocontrol Agents for Agriculturally Important Crop Plants

Biopesticides: Source organisms (*Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium anisopliae*, *Trichoderma* and Baculoviruses); Mechanism of biocontrol; Other means of pathogen control: Application of viral proteins in controlling viral diseases, Antisense RNA technology in disease control and RNAi in controlling plant pathogens.

Unit V: Biofertilizers

Isolation, purification, mass multiplication, inoculum production and method of application of biofertilizers: *Azospirillum*, *Azotobacter*, *Rhizobium*, Cyanobacteria, AM fungi, Phosphate solubilizer, Algal biofertilizers; Storage, shelf life, quality control and marketing of biofertilizers.

Reference Books

1. Subba Rao, N.S. Soil microorganisms and plant growth. Oxford and IBH Publishing Company, New Delhi.
2. Alexander, M. Introduction to soil microbiology. John Wiley and Sons, New York.
3. Kononova, M.M. Soil organic matter: Nature, its role in soil formation and in soil fertility. Pergamon, Oxford.
4. Burges, A. and Raw, F. Soil biology. Academic Press, London.
5. Rangasami G. and Bagyarai, D.J. Agricultural microbiology. Prentice-Hall, New Delhi.
6. Agrios, G.N. Plant pathology. Academic Press, San Diego.
7. Mathews, R.E. Functionals of plant virology. Academic Press, San Diego.
8. Adrian, G. and Harrison, B. Plant virology: The principles. Edward Arnold, London.

9. Board, N. The complete technology book on biofertilizer and organic farming. National Institute of Industrial Research, India.
10. Sharma, A.K. Biofertilizers for sustainable agriculture. ABD Publishers, Jaipur.
11. Goel, P.K. and Pathade, G.R. Biotechnological applications in environment and agriculture. ABD Publishers, Jaipur.
12. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
13. Tilak, K.V.B.R. Bacterial biofertilizers. IARI Publications, New Delhi.
14. Venkataraman, G.S. Algal biofertilizers and rice cultivation. Today and Tomorrow's Printers and Publishers, New Delhi.

III SEMESTER

SLS/MIC/E02B: MICROBIAL DIVERSITY

Unit I: Microbial Evolution and Biodiversity

Evolution of earth and early life forms; Genetic basis for evolution; Stromatolites; Evolution of microbes and eukaryotes; Evolution of physiological diversity; Prokaryote-eukaryote evolutionary relationship; Methods for determining evolutionary relationships: Evolutionary chronometers, Ribosomal RNA analyses, Signature sequences, Phylogenetic probes; Search for life on Mars: Biology box, gas exchange, label release and pyrolytic release experiments, Alterations in load of microbial flora of astronauts; Microbial diversity: Tools used for studying culturable and non culturable microbial diversity, Indices (Diversity, dominance and species richness indices).

Unit II: Bacterial Diversity I

Classification of bacteria into different phylums; General characteristics, ecology, physiology and metabolism of bacterial phylums: Acidobacteria, Actinobacteria, Aquificae, Bacteroidetes, Chlamydiae, Chlorobi, Chloroflexi, Chrysiogenetes, Deferribacteres, Deinococcus-Thermus, Dictyoglomi, Fibrobacteres, Fusobacteria.

Unit III: Bacterial Diversity II

General characteristics, ecology, physiology and metabolism of bacterial phylums: Nitrospira, Planctomycetes, Proteobacteria, Spirochaetes, Synergistetes, Thermodesulfobacteria, Thermotogae, Verrucomicrobia.

Unit IV: Archaea Diversity

Phylum Euryarchaeota: Halobacteria, Methanogens, Thermoplasms, Thermococcales; Phylum Crenarchaeota: Desulfurococcales, Thermoproteales, Sulfolobales; Phylum Korarchaeota; Phylum Nanoarchaeota: Nanoarchaeum.

Unit V: Physiology and Molecular Adaptations of Extremophiles

Characteristic features, classification, physiology, molecular adaptations and applications of acidophiles, alkalophiles, psychrophiles, thermophiles, barophiles, halophiles, oligotrophs, osmophiles, radiophiles, metallophiles and xerophiles.

Reference Books

1. Madigan, M.T., Martinko, J.M. and Parker, J. Brock biology of microorganisms. Prentice Hall, New Jersey.
2. Wiley, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's microbiology. McGraw-Hill, New York.
3. Colwd, D. Microbial diversity. Academic Press, New York.
4. Holt, J.S., Krieg, N.R., Sneath, P.H.A. and Williams, S.S.T. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkins, Philadelphia.
5. Satynarayana, T. and Johri, B.N. Microbial diversity: Current perspectives and potential applications. I.K. International (P) Limited, New Delhi.
6. Antranikian, G. Biotechnology of extremophiles. Springer- Verlag, New York.
7. Johri B.N. Extremophiles. Springer Verlag, New York.
8. Kushner, D.J. Microbial life in extreme environments. Academic Press, New York.

9. Edward, C. Microbiology of extreme environments. McGraw-Hill, New York. .
10. Heinrich, M.R. Extreme environment: Mechanism of microbial adaptation. Academic Press, New York.
11. da Costa, M.S., Duarate, J.C. and Williams, R.A.D. Microbiology of extreme environments and its potential for biotechnology. Elsevier Applied Science, London.
12. Horikoshi, K. and Grant, W.D. Extremophiles: Microbial life in extreme environments. Wiley-Liss, New York.

III SEMESTER

SLS/MIC/E02C: PHARMACEUTICAL MICROBIOLOGY

Unit I: Drug Discovery

Introduction to pharmacogenomics; High throughput screening; Phases of drug discovery: Bioprospecting, Principles of extraction, purification and characterization of bioactive molecules from natural resources, Candidate drug selection, Preclinical trials, Clinical trial phase I/II/III; Toxicological evaluation of drug; Drug interactions; Drug metabolism (Activation / inhibition of drug *in vivo*); Adverse drug reactions; FDA guidelines for approval of new drugs and their use; Drug distribution in body; Bio-availability and pharmacokinetic studies; Bioequivalence studies.

Unit II: Development of Antimicrobial Agent

Screening and development strategies for new antimicrobial agents; Bioassay of antimicrobial agents using standard guidelines; Factors affecting bioassay; Laboratory methods to assess activity of antimicrobial combinations (Antagonism, synergism and additive effect).

Unit III: Microbial Production and Spoilage of Pharmaceutical Products

Manufacturing procedures and in process control of pharmaceuticals; Pharmaceuticals produced by microbial fermentations (Streptokinase and streptodornase); Vaccines: Multivalent subunit vaccines, Purified macromolecules, Synthetic peptide vaccines, Immuno-adhesions, Recombinant antigen vaccines, Vector vaccines, Anti-idiotype vaccines, Targeted immune stimulants, New generation vaccines; Microbial contamination and spoilage of pharmaceutical products (Sterile injectibles, non-injectibles, ophthalmic preparations and implants) and their sterilization.

Unit IV: Quality Assurance and Validation

Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry; Basic principles of quality control (QC) and quality assurance (QA); Regulatory aspects of quality control; Quality assurance and quality management in pharmaceuticals: Guidelines for QA and QC (Raw materials, sterilization, media, stock cultures and products), ISO, WHO and US certification; Sterilization control and sterility testing: Heat sterilization, D value, Z value, Survival curve, Radiation, gaseous and filter sterilization, Chemical and biological indicators, Validation study; LAL test; Sterility testing and bioassay; Biosensors in pharmaceuticals; Design and layout of sterile product manufacturing unit.

Unit V: Regulatory Practices and Applications in Pharmaceuticals

Financing R&D capital and market outlook; IP, BP and USP; Government regulatory practices and policies; FDA perspective; Reimbursement of drugs and biological; Legislative perspective; Introduction to pharmacopoeia; Immobilization procedures for pharmaceutical applications; Macromolecular, cellular and synthetic drug carriers; Application of microbial enzymes in pharmaceuticals.

Reference Books

1. Hugo, W.B. and Russell, A.D. Pharmaceutical microbiology. Blackwell Science, London.
2. Cooper, M.S. Quality control in the pharmaceutical industry. Academic Press, New York.
3. Vyas, S.P. and Dixit, V.K. Pharmaceutical biotechnology. CBS Publishers, New Delhi.

4. Willig, S.H., Tuckerman, M.M. and Hitchings, W.S. Good manufacturing practices for pharmaceuticals. Marcel Dekker, New York.
5. Gregoriadis, G. Drug carriers in biology and medicine. Academic Press, New York.
6. Bhatia, R. and Ihhpunjani, R.L. Quality assurance in microbiology. CBS Publishers and Distributors, New Delhi.
7. Burn, J.H. Principles of therapeutics. Blackwell Scientific Publications Limited, Oxford.
8. Chatwal, G.P. Biopharmaceutics and pharmacokinetics. Himalaya Publishing House, Mumbai.
9. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.
10. Dewick, P.M. Medicinal natural products: A biosynthetic approach. John Wiley and Sons, New York.
11. Gale E.F., Cundliffe, E., Reynolds, P.E., Richmond, M.H. and Waring, M.J. The molecular basis of antibiotic action. John Wiley and Sons, New York.
12. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
13. Satoskar, R.S. and Bhandarkar, S.D. Pharmacology and pharmacotherapeutics. Popular Prakashan, Mumbai.

III SEMESTER

SLS/MIC/E02D: INFECTION AND IMMUNITY

Unit I: Infectious Agents

Infection and its types; Infectious agents: Viruses, Bacteria, Fungi, Protozoa, Helminthes (worms), Parasites, Prions; Pathogens and immunity; Immunogenicity of pathogens; Virulence and susceptibility; Pathogen associated molecular patterns.

Unit II: Immune Regulation of Infection

Barriers preventing establishment of infection; Mechanism of establishment of infection: Invasion, Survival in intracellular and cytoplasmic space, Role of molecular factors in establishment of infection, Role of cells and molecules of immune system in infection, Adoptive immunity to infection, Immune elimination of infection, Mechanisms of escape from immune-mediated destruction, Infection in immuno-compromised host.

Unit III: Immune Responses to Infection

Immune alteration during early and late phases of infection; Immunological basis of infection; Infection and antigen presentation; Recognition of molecular pattern of pathogen; Phagocytosis and killing of infectious agents; Humoral and cell-mediated immunity against infection; Infection associated immunosuppression; Immunodeficiency and infection; Acquired immuno-deficiencies; Nosocomial and community acquired infections; Co-infections; Immunity in local and systemic infection (Bacterimia and viremia); Septic infection and immunity; Immunological memory against infection and secondary responses; Immunization: Active and passive; Vaccination.

Unit IV: Immunity against Bacterial, Viral and Prions Infections

Immune responses and immunological control of bacterial infection (*Staphylococcus* and *Mycobacterium*), viral diseases (Influenza and hepatitis) and prion infections.

Unit V: Immunity against Fungal and Parasite Infections

Immune responses and immunological control of fungal infection (Candidiosis and aspergillosis) and parasitic diseases (Malaria, leishmaniasis, schistisomasis and filarisas).

Reference Books

1. Kindt, T.J., Goldsby, R.A., Osborne, B.A. and Kuby, J. Kuby immunology. W.H. Freeman and Company, New York.
2. Abbas, A.K., Lichtman, A.H.H. and Pillai, S. Cellular and molecular immunology. Saunders, Philadelphia.
3. Delves, P.J., Martin, S.J., Burton, D.R. and Roitt, I.M. Roitt's essential immunology. Wiley-Blackwell, New Jersey.
4. Palyfair, J.H.L. and Chain, B.M. Immunology at a glance. Wiley- Blackwell, New Jersey.
5. Coico, R. and Sunshine, G. Immunology: A short course. Wiley- Blackwell, New Jersey.
6. Rao, C.V. Immunology. Alpha Science International Limited, New Delhi.
7. Gooi, H.C. and Chapel, H. Clinical immunology: A practical approach. Oxford University Press, Oxford.
8. Pathak, S. and Palan, U. Immunology: Essential and fundamental. Science Publishers, New Hampshire.

9. Playfair, J.H.L and Bancroft, G.J. Infection and immunity. Oxford University Press, Oxford.
10. Pier, G.B., Lyczak, J.B. and Wetzler, L.M. Immunology, infection and immunity. ASM Press, Washington, D.C.

III SEMESTER

SLS/MIC/E02E: INTELLECTUAL PROPERTY RIGHTS

Unit I: Basic Aspects of Intellectual Property Rights
Introduction to IPR; Intellectual property; WIPO; Types of Intellectual Property Rights: Copyrights, Trademarks (Collective marks, certification marks and well-known marks), Industrial designs, Geographical indications, Patents, Plant breeder's rights; Importance and business interest of IPR for industry and academia; Relationship of IPRs with biotechnology; Trade secrets; Non-disclosure agreements.

Unit II: International Treaties for Protection of Intellectual Property
Brief background of different treaties: WIPO copyright treaty, Berne convention, Rome convention, TRIPS agreement, WIPO performances and phonograms treaty, Madrid agreement, Madrid protocol, Paris convention, Lisbon agreement, Hague agreement, Patent Cooperation Treaty; Relationship between IPR and trade: WTO, TRIPS agreement, GATT, Enforcement and dispute settlement under the TRIPS agreement, Implication of TRIPS for developing countries in the overall WTO system.

Unit III: Patents
Patent terminology; Patent claims; Patent life and geographical boundaries; Utilization of intellectual patents; Licensing of patents; Elements of patentability; Procedure for grant of patent in India, USA and Europe; PCT application; Patent search invention in context of "prior art"; Patent search methods; Patent databases and libraries; Country-wise patent searches (USPTO, EPO, ARIPO and India); Patent mapping; Patent harmonization; Case studies of patents in biotechnology.

Unit IV: Patent Acts, Issues in Pharmaceuticals and Patent Infringement
Patent acts and latest amendments of Indian, European and US patent systems; Patent issues in drugs and pharmaceuticals: Generics, Compulsory licensing, Exclusive marketing rights, Bolar provision, Bayh-Dole act, Second medical use; Patent infringement (Case studies, defenses to infringement including experimental use, patent misuse, legal considerations, enforcement measures, patent valuations, competition and confidentiality issues); Assignment of Intellectual Property Rights; Technology Transfer Agreements.

Unit V: Protection of Plant Varieties and Traditional Knowledge
Protection of plant varieties: Interface between technology and IPRs in the context of plants, Key features of UPOV 1978, UPOV 1991 and TRIPS with respect to IPRs on plants, Indian law on protection of plant varieties, DUS criteria, *Sui* generis system for protection, Patenting of genetically modified plants, Significance of IPRs in agricultural biotechnology, Case studies; Traditional knowledge: Importance and relevance of traditional knowledge for developing nations, Various approaches for protecting traditional knowledge, Case studies of patenting of health foods.

Reference Books

1. Subbaram N. Patents. Pharma Book Syndicate, Hyderabad.
2. Ganguli, P. Intellectual property rights. Tata Mc-Graw Hill, New Delhi.

3. Shippey, K.C. A short course in international intellectual property rights: Protecting your brands, marks, copyrights, patents, designs and related rights worldwide. World Trade Press, Petaluma.
4. Bently, L. and Sherman, B. Intellectual property law. Oxford University Press, Oxford.
5. Parulekar, A. and D'Souza, S. Indian patent law: Legal and business implications. MacMillan Press, London.
6. Grubb, P.W. Patents for chemicals, pharmaceuticals and biotechnology: Fundamentals of global law, practice and strategy. Oxford University Press, Oxford.
7. Knight, H.J. Patent strategy: For researchers and research managers. John Wiley and Sons, New York.
8. Bryant, J.L. Protecting your ideas: The inventor's guide to patents. Academic Press, New York.
9. Durham, A.L. Patent law essentials: A concise guide. Quorum books, Westport.
10. Gordon, T.T. and Cookfair, A.S. Patent fundamentals for scientists and engineers. CRC Press, Boca Raton.
11. Halpern, S. Fundamentals of United States intellectual property law: Copyright, patent and trademark. Springer-Verlag, New York.
12. Santaniello, V., Evenson, R.E., Zilberman, D. and Carlson, G.A. Agriculture and Intellectual Property Rights: Economic, institutional and implementation issues in biotechnology. CABI Publications, New York.

III SEMESTER

SLS/MIC/E02F: RESEARCH METHODOLOGY

Unit I: Formulating Research Problem and Experimental Planning

Selection of an area for research; Importance and need of research in that field; Literature survey; Planning of experimental work: Importance and designing of the problem to be undertaken, Defining the aim and objectives of the research work planned, Importance of prior collection of protocols, Time bound frame of work plan, Designing of experimental protocol; Description of strategies to meet the objectives using state-of-the-art techniques and proper citation of standard procedures.

Unit II: Data Collection and Analysis

Types of data: Qualitative and quantitative data, Primary and secondary data; Site selection for sample collection; Source selection for data acquisition; Sampling techniques: Simple and random sampling, Systematic sampling, Stratified sampling, Multistage sampling, Cluster sampling, Multiphase sampling; Sample size; Recording of data and data summarization; Significance of triplicate readings; Measures of dispersion: Range, Quartile deviation, Mean deviation, Standard deviation, Coefficient of variation; Probability: Random experiment, Events, Sample space, Mutually exclusive events, Independent and dependent events, Statement of addition and multiplication theorems of probability.

Unit III: Statistical Basis of Biological Assay

Response-Dose metameter; Direct and indirect assays; Quantal responses; LD_{50}, ED_{50} and PD_{50}; Standard line interpolation assay; Parallel line assay (4 point and 6 point assays); Slope ratio assay; Count data: Examples of count data (Bacterial cell count, radioactivity count, colony counts and plaque counts); Statistical treatment to count data: Poisson distribution, Skewness and kurtosis, Standard error; Statistical treatment to proportion data (MPN, sterility testing of medicines, therapeutic trial of drugs and vaccines); Properties and uses of tests of significance (t-test, z-test and chi-square tests of heterogeneity and independence of attributes, F-test).

Unit IV: Analysis of Variance

Principles of experimental designs; Randomized block and latin square designs; One- way and two-way classifications with single observation per cell; Standard curves: Correlation, Linear regression (Fitting of best line through a series of points), MLR, Multiple collinearity, Standard curves and interpolation of unknown Y-values.

Unit V: Basics of Bioinformatics and Technical Writing

Bioinformatics: Introduction to various biological databases (Primary, secondary and composite databases); Introduction to biological information system: SRS, ENTREZ; Sequence comparison and alignment: Sequence similarity searching tools (FASTA and BLAST), Multiple sequence alignment and applications; Introduction of data mining: Classification, Clustering, Data collection, Data warehousing, Data preprocessing, Applications of data mining and genome mining; Databases: Nucleotide sequence information sources (GenBank, EMBL, EBI, DBJ and UCSC), Protein sequence information sources (PIR, ExPASY, UniProt KB, SwissProt and TrEMBL); Phylogenetic analysis: Phenetic and cladistic approach; Phylogenetic tree construction (Rooted and unrooted method); Prediction of protein structure and modelling: Introduction to various methods for prediction of primary and secondary structure, Homology and threading methods for tertiary structure prediction; Technical writing: Selection of

appropriate title, Abstract, Introduction, Aims and objectives, Review of literature, Methodology, Results, Discussion, Summary and Conclusions, Bibliography.

Reference Books

1. Bhattacharyya, D.K. Research methodology. Excel Books, New Delhi.
2. Kumar, R. Research methodology: A step-by-step guide for beginners. SAGE Publications, California.
3. Singh, Y.K. Research methodology. APH Publishing Corporation, New Delhi.
4. Khan, J.A. Research methodology. APH Publishing Corporation, New Delhi.
5. Gupta, S. Research methodology and statistical techniques. Deep and Deep Publications, New Delhi.
6. Khanzode, V.V. Research methodology. APH Publishing Corporation, New Delhi.
7. Goddard, W. and Melville, S. Research methodology: An introduction. Juta and Company Limited, Landsdown.
8. Dawson, C. Practical research methods: A user-friendly guide to mastering research techniques and projects. How to Books Limited, London.
9. Daniel, P.S. and Sam, A.G. Research methodology. Gyan Publishing House, New Delhi.
10. Murray, R. How to write a thesis. McGraw-Hill, New York.
11. Glantz, S.A. Primer of biostatistics. McGraw-Hill, New York.
12. Dawson, B., Trapp, R.G., Dawson, B. and Trapp, R. Basic and clinical biostatistics. McGraw-Hill, New York.
13. Bliss, C.I.K. Statistics in biology. McGraw-Hill, New York.
14. Campbell R.C. Statistics for biologists. Cambridge University Press, Cambridge.
15. Wardlaw, A.C. Practical statistics for experimental biologists. John Wiley and Sons, New York.
16. Claverie J.M. and Notredame, C. Bioinformatics for dummies. Wiley, New York.
17. Mount, D.W. Bioinformatics: Sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.
18. Higginns, D. and Taylor, W. Bioinformatics: Sequence, structure and databanks – A practical approach. Oxford University Press, Oxford.
19. Baxevanis A.D and Ouellette, B.F.F. Bioinformatics – A practical guide to the analysis of genes and proteins. Wiley – Interscience, New York.
20. Gibson, G. and Muse, S.V. A primer of genome science. Sinauer Associates, Sunderlands.
21. Attwood, T.K. and Smith, D.J.P. Introduction to bioinformatics. Pearson Education Asia, Singapore.

III SEMESTER

SLS/MIC/E003: LAB COURSE-II
(Based on Theory Papers SLS/MIC/E01 and SLS/MIC/E02)

Lab exercises based on theory paper SLS/MIC/E01A

1. Microbiological examination of food.
2. Assay of quality of milk sample using MBRT test.
3. Adulteration tests for milk.
4. Microbial production of curd.
5. Isolation and identification of *Lactobacillus* from fermented dairy products.
6. Isolation and biochemical identification of microorganisms from contaminated food and dairy samples.
7. Determination of D value in heat treatment of foods.
8. Effect of freezing temperatures on microorganisms in food
9. Production of sauerkraut.
10. Estimation of lactic acid production in sauerkraut.
11. Effect of salt concentration on lactic acid production in sauerkraut.
12. Estimation of acidity of vinegar.

Lab exercises based on theory paper SLS/MIC/E01B

1. Testing of presence of drug in the given biological sample.
2. Structure analysis of different medicinal compounds using software.
3. Computational approach for sequence design of DNA nanostructures.

Lab exercises based on theory paper SLS/MIC/E01C

1. Data mining using NCBI, SWISSPROT, EBI, PDB and MBGD.
2. Database search.
3. Determination of protein structure.
4. Genome sequence analysis.
5. Determining homology between different microorganisms based on their rDNA sequence in database.
6. Pairwise sequence alignment and multiple sequence alignment.

Lab exercises based on theory paper SLS/MIC/E01D

1. Universal precautions and recommendations from CDC for personnel employed in clinical laboratories.
2. Study of morbidity and mortality weekly reports (MMWR) issued by CDC.
3. Calculation of mortality, morbidity and prevalence rate in data procured from websites of health organisations.

Lab exercises based on theory paper SLS/MIC/E01E

1. Determination of Thermal Death Point (TDP) and Thermal Death Time (TDT) of microorganisms for design of a sterilizer.
2. Inoculum preparation for bioreactor.
3. Media formulation for enhanced enzyme production by microbial culture *via* batch fermentation.
4. Extraction of intracellular and extracellular enzyme produced by microbial culture *via* batch fermentation.

5. Optimization of culture conditions for enhanced enzyme production by microbial culture *via* batch fermentation.
6. Determination of oxygen transfer rate.
7. Determination of substrate degradation profile.
8. Immobilization of microbial cells and enzyme.

Lab exercises based on theory paper SLS/MIC/E01F

1. Isolation of antibiotic producing microbes from soil sample.
2. Isolation and identification of symbiotic bacteroids of *Rhizobium* sp. from root nodules of leguminous plants.
3. Study of microbial community succession in decomposing litter.
4. Study of symptoms of bacterial diseases of plants.
5. Study of symptoms of fungal diseases of plants.
6. Study of symptoms of viral diseases of plants.
7. Isolation and identification of pathogenic microorganisms from diseased plant sample.
8. Isolation of xenobiotic compound degrading bacteria by enrichment culture technique.
9. Determination of indices of pollution by measuring BOD and COD of different effluents.

Lab exercises based on theory paper SLS/MIC/E02A

1. Isolation and biochemical identification of *Azotobacter* from soil.
2. Isolation and biochemical identification of *Rhizobium* from root nodule of leguminous plant.
3. Isolation of phosphate solubilizers from soil.
4. Isolation and biochemical identification of PGPR from plant rhizosphere.
5. Determination of siderophore production by PGPR.
6. Determination of phosphorus solubilization by PGPR.
7. Determination of rhamnolipid production by PGPR.
8. Study of symptoms of bacterial, fungal and viral diseases of plants.
9. Isolation and identification of pathogenic microorganisms from diseased plant sample.

Lab exercises based on theory paper SLS/MIC/E02B

1. Determination of diversity of microbial community in different habitats.
2. Determination of species richness and evenness in microbial community in different habitats.
3. Isolation and characterization of thermophilic microorganisms.
4. Isolation and characterization of acidophilic and alkalophilic microorganisms.

Lab exercises based on theory paper SLS/MIC/E02C

1. Screening of plant extracts for antimicrobial potential.
2. Evaluation of synergistic antimicrobial potential of antibiotics and plant extracts.
3. Determination of MIC and MBC concentration of plant extracts by broth dilution test.
4. Sterility testing of pharmaceutical products.

Lab exercises based on theory paper SLS/MIC/E02D

1. Determination of antibody synthesis after vaccination in mouse.
2. cDetermination of infection induced alteration in TLC and DLC.
3. Isolation of macrophages from mouse peritoneal cavity.
4. *In vitro* activation of macrophages by bacterial cell wall components.
5. Phagocytosis of bacterial and yeast cells by macrophages.
6. Determination of effect of infection on cytokine level in blood.

7. Determination of alteration in cytokine production by infected macrophages.

Lab exercises based on theory paper SLS/MIC/E02E

1. Online search for patents in WIPO site.
2. Case studies of different patents: Basmati, Neem, Turmeric, Oncomouse, Bald mouse, Novartis gleevec, Cre-lox, Diamond versus Chakrabarty, Round up ready crops.
3. Theoretical exrercises for identifying the protection of different elements of a common discovery under different types of IPR.

Lab exercises based on theory paper SLS/MIC/E02F

1. Literature survey on selected problem and its proper citation.
2. Defining aim and objectives of the problem.
3. Writing a review article for a journal.
4. Statistical and graphical representation of data.
5. Calculation of mean, median and mode.
6. Linear equation analysis (Regression analysis).
7. Exponential equation analysis (Survival curve).
8. Chi square test.
9. Normal distribution.
10. Data mining using NCBI, SWISSPROT, EBI, PDB and MBGD.
11. Database search- Working on various BLAST programs.
12. Pairwise sequence alignment and multiple sequence alignment.
13. Phylogenetic analysis.

Reference Books

1. McLandsborough, L. Food microbiology laboratory. CRC Press, Boca Raton.
2. Harrigan, W.F. Laboratory methods in food microbiology. Gulf Professional Publishing, Houston.
3. Leboffe, M.J. and Pierce, B.E. Microbiology: Laboratory theory and application. Morton Publishing Company, Englewood.
4. Gunasekaran, P. Laboratory manual in microbiology. New Age International, New Delhi.
5. Graly, J.O. and Joubert, P.H. Handbook of phase I / II clinical drug trials. CRC Press, Boca Raton.
6. Higginns, D. and Taylor, W. Bioinformatics: Sequence, structure and databanks – A practical approach. Oxford University Press, Oxford.
7. Baxevanis A.D and Ouellette, B.F.F. Bioinformatics – A practical guide to the analysis of genes and proteins. Wiley – Interscience, New York.
8. Ausubel, F.M., Breut, R., Kingston, R.E., Moore, D.D., Siedman, J.G., Smith, J.A. and Struhl, K. Short protocols in molecular biology. Wiley, New York.
9. Clayton, D. and Hills, M. Statistical models in epidemiology. Oxford University Press, Oxford.
10. Kestenbaum, B. Epidemiology and biostatistics: An introduction to clinical research. Springer-Verlag, New York.
11. Baltz, R.H., Demain, A.L and Davies, J.E. Manual of industrial microbiology and biotechnology. ASM Press, Washington, D.C.
12. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.

13. Aneja, K.R. Experiments in microbiology, plant pathology and biotechnology. New Age International (P) Limited, New Delhi.
14. Holt, J.G. and Krieg, N.R. Bergey's manual of determinative bacteriology. Lippincott Williams and Wilkin, Philadelphia.
15. Chorghade, M.S. Drug discovery and development. John Wiley and Sons, New York.
16. Dewick, P.M. Medicinal natural products: A biosynthetic approach. John Wiley and Sons, New York.
17. Rose, N.R., Hamilton, R.G. and Detrick, B. Manual of clinical laboratory immunology. ASM Press, Washington, D.C.
18. Weir, D.M. Handbook of experimental immunology. Blackwell Scientific Publications, New Jersey.
19. Stafseth, H.J., Stockton, J.J. and Newman, J.P. A laboratory manual for immunology. Burgess Publishing Company, Stockland.
20. Burrell, R.G. and Mascoli, C.C. Experimental immunology. Burgess Publishing Company, Stockland.
21. Grubb, P.W. Patents for chemicals, pharmaceuticals and biotechnology: Fundamentals of global law, practice and strategy. Oxford University Press, Oxford.
22. Pepper, I.L., Gerba, C.P. and Brendecke, J.W. Environmental microbiology: A laboratory manual. Academic Press, San Diego.
23. Hurst, C.J., Crawford, R.L., Garland, J.L., Lipson, D.A., Mills, A.L. and Stetzenbach, L.D. Manual of environmental microbiology. ASM Press, Washington, D.C.
24. Dawson, C. Practical research methods: A user-friendly guide to mastering research techniques and projects. How to Books Limited, London.
25. Wardlaw, A.C. Practical statistics for experimental biologists. John Wiley and Sons, New York.
26. Mount, D.W. Bioinformatics: Sequence and genome analysis. Cold Spring Harbor Laboratory Press, New York.

IV SEMESTER

SLS/MIC/E004: DISSERTATION

Topics for Dissertation

1. Drug Discovery
2. Drug Resistance
3. Infection and Immunity
4. Plant- Microbes Interaction
5. Microbial Diversity
6. Bioremediation
7. Prevalence and Characterization of Pathogenic Microorganisms
8. Food Adulteration and Food borne Pathogens
9. Fermented Foods
10. Strain Improvement
11. Enzyme Production
12. Microbial Biotechnology
13. Biomass and Bioenergy Production

Any other topic suggested by departmental committee may also be considered for the dissertation.

SYLLABUS

FOR

M.Sc. (Computer Science) Programme

H. N. B. GARHWAL UNIVERSITY
SRINAGAR (GARHWAL)

H. N. B. Garhwal University Srinagar Garhwal
M. Sc. (Computer Science)

Programme Structure

SEMESTER - I

SET/CSE/MCS/C101 : Computer Fundamental & Programming in 'C'

SET/CSE/MCS/C102 : Combinatorics & Graph Theory

SET/CSE/MCS/C103 : Relational Data Base Management System

SET/CSE/MCS/C104 : Digital Electronics & Computer System Architecture

SET/CSE/MCS/C105 : Operating System with Case Study of UNIX/LINUX

SET/CSE/MCS/CP11: Programming & Problem Solving in 'C'

SET/CSE/MCS/CP12 : Shell Programming

SEMESTER - II

SET/CSE/MCS/C201 : Data Structures

SET/CSE/MCS/C202 : Object Oriented Programming in C++

SET/CSE/MCS/C203: Theory of Computation

SET/CSE/MCS/C204: Software Engineering

SET/CSE/MCS/C205: Data Communication and Computer Networks

SET/CSE/MCS/CP21 : Data Structures Using 'C'

SET/CSE/MCS/CP22 : Data Communication and Computer Networks

SET/CSE/MCS/SS21: Self Study*

SEMESTER - III

SET/CSE/MCS/C301: Network Security and Cryptography

SET/CSE/MCS/C302: Design and Analysis of Algorithm

SET/CSE/MCS/C303: Mobile and Wireless Computing

SET/CSE/MCS/E1: Elective I

SET/CSE/MCS/E2: Elective II

SET/CSE/MCS/EP31: Elective I

SET/CSE/MCS/EP32: Elective II

SET/CSE/MCS/SS31: Self Study*

SEMESTER - IV

SET/CSE/MCS/E3: Elective III

SET/CSE/MCS/PR41: Project

SET/CSE/MCS/SS41: Self Study*

FIRST SEMESTER:

S.No	Course No.	Subject	Evaluation – Scheme								Credit
			Period			Sessional			Examination		
			L	T	P	TA	CT	TOT	ESE	Sub. Total	
Theory											
1.	SET/CSE/MCS/C101	Computer Fundamental & Programming in 'C'	3	-	-	10	30	40	60	100	3
2.	SET/CSE/MCS/C102	Combinatorics & Graph Theory	3	-	-	10	30	40	60	100	3
3.	SET/CSE/MCS/C103	Relational Database Management System	3	-	-	10	30	40	60	100	3
4.	SET/CSE/MCS/C104	Digital Electronics & Computer System Architecture	2	-	-	10	30	40	60	100	2
5.	SET/CSE/MCS/C105	Operating System with Case Study of UNIX/LINUX	3	-	-	10	30	40	60	100	3
Practical											
1.	SET/CSE/MCS/CP11	Programming & Problem Solving in 'C'	-	-	3	40	-	40	60	100	2
2.	SET/CSE/MCS/CP12	Shell Programming	-	-	3	40	-	40	60	100	2
		Total	**14**	**-**	**6**	**130**	**150**	**280**	**420**	**700**	**18**

SECOND SEMESTER:

S.No	Course No.	Subject	Evaluation – Scheme								Credit
			Period			Sessional			Examination		
			L	T	P	TA	CT	TOT	ESE	Sub. Total	
Theory											
1.	SET/CSE/MCS/C201	Data Structures	3	-	-	10	30	40	60	100	3
2.	SET/CSE/MCS/C202	Object Oriented Programming in C++	3	-	-	10	30	40	60	100	3
3.	SET/CSE/MCS/C203	Theory of Computation	3	-	-	10	30	40	60	100	3
4.	SET/CSE/MCS/C204	Software Engineering	2	-	-	10	30	40	60	100	2
5.	SET/CSE/MCS/C205	Data Communication and Computer Networks	3	-	-	10	30	40	60	100	3
Practical											
1.	SET/CSE/MCS/CP21	Data Structures Using 'C'	-	-	3	40	-	40	60	100	2
2.	SET/CSE/MCS/CP22	Object Oriented Programming in C++	-	-	3	40	-	40	60	100	2
		Total	**14**	**-**	**6**	**130**	**150**	**280**	**420**	**700**	**18**
1.	SET/CSE/MCS/SS21	Self Study	2	1	-	-	-	-	-	-	3

TA : Teacher Assessment
CT : Class Test
ESE : End Semester Examination
SUB TOT. : Subject Total
TOT. : Total

THIRD SEMESTER:

S.No	Course No.	Subject	Evaluation – Scheme								Credit
			Period			Sessional			Examination		
			L	T	P	TA	CT	TOT	ESE	Sub. Total	
Theory											
1.	SET/CSE/MCS/C301	Network Security and Cryptography	2	-	-	10	30	40	60	100	2
2.	SET/CSE/MCS/C302	Design and Analysis of Algorithm	3	-	-	10	30	40	60	100	3
3.	SET/CSE/MCS/C303	Mobile and Wireless Computing	3	-	-	10	30	40	60	100	3
4.	SET/CSE/MCS/E1	Elective I	3	-	-	10	30	40	60	100	3
5.	SET/CSE/MCS/E2	Elective II	3	-	-	10	30	40	60	100	3
Practical											
1.	SET/CSE/MCS/EP31	Elective I	-	-	3	40	-	40	60	100	2
2.	SET/CSE/MCS/EP32	Elective II	-	-	3	40	-	40	60	100	2
		Total	**14**	**-**	**6**	**130**	**150**	**280**	**420**	**700**	**18**
1.	SET/CSE/MCS/SS31	Self Study	2	1	-	-	-	-	-	-	3

FOURTH SEMESTER:

S.No	Course No.	Subject	Evaluation – Scheme								Credit
			Period			Sessional			Examination		
			L	T	P	TA	CT	TOT	ESE	Sub. Total	
Theory											
1.	SET/CSE/MCS/E3	Elective III	3	-	-	10	20	30	70	100	3
2.	SET/CSE/MCS/E4	Elective IV	3	-	-	10	20	30	70	100	3
Practical											
1.	SET/CSE/MCS/EP41	Elective III	-	-	3	30	-	30	70	100	2
2.	SET/CSE/MCS/PR41	Project	-	2	12	-	-	-	400	400	10
		Total	**6**	**2**	**15**	**50**	**40**	**90**	**610**	**700**	**18**
1.	SET/CSE/MCS/SS41	Self Study	2	1	-	-	-	-	-	-	3

TA : Teacher Assessment
CT : Class Test
ESE : End Semester Examination
SUB TOT. : Subject Total
TOT. : Total

Elective I
(Choose any one)

E1.1 Computer Graphics

E1.2 Computer Organisation

E1.3 C#

Elective II

(Choose any one)

E2.1 ASP.NET

E2.2 Compiler Designing

E2.3 Human- Computer Interaction

Elective III

(Choose any one)

E3.1 Image Processing

E3.2 Unified Modeling Language

E3.3 Multimedia Technology and Applications

Elective IV

(Choose any one)\

E4.1 Artificial Intelligence

E4.2 Wireless Networks

E4.3 Data Mining & Data Warehousing

E4.4 Genetic Algorithms and Machine Learning

***Self Study**
(Choose any one for semester II, III& IV)

Speech Recognization
Biometrics
Robotics
Pattern Recognistaion Techniques
Cloud Computing
E-Governance
Fuzzy logic & Neural Networks
Ethical Hacking

SET/CSE/MCS/C101: Computer Fundamental & Programming in 'C'

Introduction to Computers: Computer hardware Components, Disk Storage, memory, keyboard, mouse, printers, monitors, CD etc., and their functions, Comparison Based analysis of various hardware components.

Basic Operating System Concepts: MS-DOS, WINDOWS, Functional knowledge of these operating systems. Introduction to Basic Commands of DOS, Managing File and Directories in various operating Systems, Introduction to internet, Basic terms related with Internet, TCP/IP.

Programming in C: History, Introduction to C Programming Languages, Structure of C programs, compilation and execution of C programms. Debugging Techniques, Data Types and Sizes, Declaration of variables, Modifiers, Identifiers and keywords, Symbolic constants, Storage classes (automatic, external, register and static), Enumerations, command line parameters, Macros, The C Preprocessor

Operators: Unary operators, Arithmetic & logical operators, Bit wise operators, Assignment operators and expressions, Conditional expressions, precedence and order of evaluation. Control Statements: if-else, switch, break, continue, the comma operator, go to statement. Loops: for, while, do-while.

Functions: built-in and user-defined, function declaration, definition and function call, parameter passing: call by value, call by reference, recursive functions, multifile programs. Arrays: Linear arrays, multidimensional arrays, Passing arrays to functions, Arrays and strings.

Structure and Union: Definition and differences, self-referential structure. And address of (&) operator, pointer to pointer, Dynamic Momory Allocation, calloc and malloc functions, array of pointers, function of pointers, structures and pointers.

References:

1. V. Rajaraman, "Fundamentals of Computers", PHI
2. Pater Norton's "Introduction to Computer", TMH
3. Hahn, "The Internet complete reference", TMH
4. Peter Nortton's, "DOS Guide", Prentice Hall of India
5. Gottfried, "Programming in C, Schaum's Series Tata McGraw Hill

SET/CSE/MCS/C102 : Combinatorics & Graph Theory

Rules of sum and products, Permutation, Combination, Permutation groups and application, Probability, Remsey Theory, Discrete numeric function and generating function, combinatorial problems, Difference equation.
Recurrence Relation: Introduction, Linear recurrence relation with constant coefficient, Homogeneous solution, Particular solution, Total solution, Solution by the method of generating function.

Graphs, sub-graphs, some basic properties, Walks, Path & circuits, Connected graphs, Disconnected graphs and component, Eular and Hamiltonian graphs, Various operation on graphs, Tree and fundamental circuits, Distance diameters, Radius and pendent vertices, Rooted and binary trees, Counting trees, Spanning trees, Finding all spanning trees of a graph and a weighted graph.

Cut-sets and cut vertices, some basic properties, All cut sets in a graph, Fundamental circuit and cut sets, Connectivity and seperatability, Network flows, Planner graphs, Combinatorial and geometric dual, Kuratowski to graph detection of planarity, Geometric dual, Some more criterion of planarity, Thickness and Crossings, Vector space of a graph and vectors, basis vectors, cut set vector, circuit vector, circuit and cut set verses sub spaces, orthogonal vector and sub space. Indicidence matrix & adjacency matrix of graphs.

Coloring and covering partitioning of graph, Chromatic number, Chromatic partitioning, Chromatic polynomials, Matching, covering, Four color problem, Directed graph, Types of directed graphs, Directed paths and connectedness, Euler digraph, Tree and directed edges, Fundamental circuit in digraph, Matrices A,B,C of digraph adjacency matrix of digraph, Enumeration and its types, counting of labeled and unlabeled trees, Polya's theorem, Graph enumeration with polyas theorem, Graph theoretic algorithm.

References:

1. Deo Narsing, :Graph Theory with applications to engineering and computer science", PHI
2. Tremblay and Manohar, :Discrete mathematical structures with applications to computer Science:, TMH
3. Joshi K.D., "Fundamental of discrete mathematics:, New Age International
4. John Truss, "Discrete mathematics of computer scientist"
5. C.L. Liu, "Discrete mathematics"

SET/CSE/MCS/C103: Relational Data Base Management System

Introduction to database systems-Operational Data, File Management Vs Data Management, characteristics of Database approach, An Architecture for a Database System, Advantages and Disadvantages of DBMS, Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model Classification, Entity Relationship Model,Relational Data Model, Network Data Model, Hierarchical Data Model .Objects – Relational Model Objects, Relationship, Composite Objects, Procedures, Types and Inheritance.

Relational data structure-A Review of Set Theory, Relations, Domains and Attributes, Tuples, Keys. Integrity Rules Extensions And Intensions, Base Tables, Indexes Relational Algebra and Operations, Retrieval Operations, Relational Calculus and Domain Calculus.

Relational database design-Universal Relation, Anomalies in a Database, Normalization Theory, Functional Dependencies. Closure of a Set of F.D Covers, Non Redundant and Minimum Cover, Canonical Cover, First, Second and Third Normal Forms, Relations with more than one Candidate Key, Good and Bad Decompositions, Boyce Codd Normal Form, Multivalued Dependencies and Fourth Normal Form, Join Dependencies and Fifth Normal Form.

Query processing-Query Processing Stages, Query Interpretation, Equivalence of Expression, Query Execution Statistics. Query Execution Plan, Query Estimation, Query Evaluation, View Processing, Integrity & Security, Need for Integrity and Security Integrity Constraints.
The distributed databases -Motivation for Distributed Database . Distributed Database concepts, Types of Distribution Architecture of Distributed Databases, The Design of Distributed Databases, Distributed Query Processing, Recovery In Distributed Systems, Commit Protocols for Distributed Databases, Multi Database System.

References:

1. Date C.J. "An Introduction to Database System". Addision Wesley
2. Korth, Silbertz, Sudarshan, "Database Concepts" McGraw Hill
3. Database Management System: V. K. Jain, Wiley dreamtech
4. Elmasri, Navathe, "Fundamentals of Database Systems" Addision Wesley
5. Paul Beynon Davis, "Database Systems" Palgrave Macmillan
6. Bipin C. Desai, "An introduction to Database Systems", Galgotia Pub.
7. Begining SQL: Paul Wilton, Wiley dreamtech

SET/CSE/MCS/C104 : Digital Electronics & Computer System Architecture

Representation of information & Basic Building Blocks: Introduction to Computer, Computer hardware generation, Number System: Binary, Octal, Hexadecimal, Character Codes (BCD), ASCII, EBCDIC and their conversion. Logic gates, Boolean Algebra, K-map simplification, Half Adder, Full Adder, Subtractor, Decoder, Encoders, Multiplexer, Demultiplexer, Carry look ahead adder, Combinational logic Design, Flip-Flops, Registers, Counters (Synchronous and asynchronous), ALU, Micro-operation. ALU-chip, Faster Algorithm and Implementation (multiplication & Division).

Basic Organization: Operational flow chart (Fetch, Execute, Instruction Cycle), Organization of Central Processing Unit, Hardwired & micro programmed control unit, Single Organization, General Register Organization, Stack Organization, Addressing modes, Instruction formats, data transfer & Manipulation, I/O Organization, Bus Architecture, Programming Registers.

Memory Organization: Memory hierarchy, Main memory (RAM/ROM) chips), Auxiliary memory, Associative memory, Cache memory, Virtual memory, Memory Management Hardware, hit/miss ratio, magnetic disk and its performance, magnetic Tape etc.

I/O Organization: Peripheral devices, I/O interface, Modes of Transfer, Priority Interrupt, Direct Memory Access, Input-Output Processor, and Serial Communication. I/O Controllers, Asynchronous data transfer, Strobe Control, Handshaking.

References:

1. Willam Stalling, "Computer Organization & Architecture" Pearson Education Asia
2. Mano Morris, "Computer System Architecture" PHI
3. Zaky & Hamacher, "Computer Organization: McGraw Hill
4. B. Ram, "Computer Fundamental Architecture & Organization" New Age
5. Tannenbaum, "Structured Computer Organization" PHI.

SET/CSE/MCS/C105 : Operating System with Case Study of UNIX/LINUX

Introduction: Definition, Design Goals, Evolution; Concept of User, job and Resources; Batch processing, Multi-programming, Time sharing; Structure and Functions of Operating System.Process Management: Process states, State Transitions, Process Control Structure, Context Switching, Process Scheduling, Threads.

Memory Management: Address Binding, Dynamic Loading and Linking Concepts, Logical and Physical Addresses, Contiguous Allocation, Fragmentation, Paging, Segmentation, Combined Systems, Virtual Memory, Demand Paging, Page fault, Page replacement algorithms, Global Vs Local Allocation, Thrashing, Working Set Model, Paging.

Concurrent Processes: Process Interaction, Shared Data and Critical Section, Mutual Exclusion, Busy form of waiting, Lock and unlock primitives, Synchronization, Classical Problems of Synchronization, Semaphores, Monitors, Conditional Critical Regions, System Deadlock, Wait for Graph, Deadlock Handling Techniques: Prevention, Avoidance, Detection and Recovery.

File and Secondary Storage Management: File Attributes, File Types, File Access Methods, Directory Structure, File System Organization and Mounting, Allocation Methods, Free Space management; Disk Structure, Logical and Physical View, Disk Head Scheduling, Formatting, Swap Management. Protection & Security.
Case Study of UNIX/LINUX

References:

1. Silberschatz and Galvin, Operating System Concepts 6/ed, Addison Wesley.
2. William Stalling, Operating Systems: Internals and Design Principles 5/ed, PHI.
3. Tanenbaum, Modern operating Systems, PHI.
4. J Bach, The Design of UNIX Operating System, Pearson Education.
5. Vijay Mukhi, The C Odessy, BPB.
6. Peterson and Silberschatz, Operating System Concepts, Addison Wesley.
7. P. B. Hansen, Operating System Principles, PHI.
8. K. Christian, The UNIX Operating System, John Wiley.
9. A. N. Haberman, Introduction to Operating System Design, Galgotia.

SET/CSE/MCS/C201 : Data Structures

Introduction to data structures, Abstract data types

Stacks - Introduction to stack & primitive operation on stack, Stack as an abstract data type, Stack's applications - Infix, post fix & Prefix expressions, Recursion, Multiple stacks Queues -Introduction to queues, Primitive Operations on the Queues, Queue as an abstract data type, Circular queue, Dequeue, Priority queue.

Linked List - Introduction to the Linked List, Operation on Linked List, Linked List representation of stack and Queue,Header nodes.

Types of Linked List - Doubly Linked List, Circular Linked List

Application of Linked List.

Trees -Basic Terminology of Trees, Binary Trees, Tree Representations as Array & Linked List Binary tree representation, Traversal of binary trees - In order, Preorder & post order, Application of Binary tree, Threaded binary tree

Balanced tree, AVL tree, B-tree, B+ & B* trees, Conversion of General Tree to Binary Tree, Counting Binary Trees, 2-3 Trees, algorithm for manipulating 2-3 Trees.

Searching - Sequential Searching, Binary search and their Comparison.

Sorting - External & Internal sorting, Insertion sort, Selection sort, Quick sort, Bubble sort, Heap sort, Merge sort, Comparison of sorting methods Algorithms of sorting and searching in Linked list and Arrays.

Tables - Hash table,Collision resolution Techniques.

Graphs - Introduction to graphs, Basic Terminology, Directed, Undirected & Weighted graph, Representation of graphs, Warshall's algorithem for path matrix and shortest path

Graph Traversals-Depth first & Breadth first search.

References:

1. Lipshutz, Data Structure, McGraw Hill.
2. Standish, Data Structure, Addison-Wesley.
3. B. Salzberg, File Structures, Prentice-Hall, 1988.
4. A.L. Tharp, File Organization and Processing, John Wiley and Sons, 1988.
5. A. M. Tennenbaum, Y. Langsam and M. J. Augenstein, Data Structures using C, PHI, 1991.
6. S. Lipschutz, Data Structure, Schaum Series.
7. D. E. Knuth, Fundamental Algorithms, Narosa Publication.

SET/CSE/MCS/C 202: Object Oriented Programming using C++

OOAD and OOP, Object Oriented Programming paradigm and design; General Concepts: Object, Class, Data Abstraction and Encapsulation, Inheritance, Polymorphism, Dynamic Binding, Message Passing; Benefits of OOP, Object-oriented Languages.

Object oriented Programming using C++: Data Types, Operators, Classes and Objects, Constructors and Destructors, Operator Overloading, Type Conversions, Inheritance, Pointers, Virtual Functions, Polymorphism,

Stream I/O in C++, File Processing, Templates, Standard Template Library, Program defined exceptions, Events; Introduction to Class Wizard, Application Wizard and MFC.

Use of OOAD and OOP concepts in different areas: - Object-oriented Software Engineering, Object-oriented OS.

References:

1. B. Stroustrup, The C++ Programming Language, Addison-Wesley.
2. E. Balagurusamy, Object oriented Programming with C++, 2/ed, TMH.
3. G. Booch, Object Oriented Analysis and Design, Addison-Wesley.
4. Rumbagh et. Al., Object Oriented Modeling, PHI.
5. R. S. Pressman, Software Engineering – A Practitioner's Approach, McGraw Hill.

SET/CSE/MCS/C 203 : Theory of Computation

A brief review of Finite Automata, Regular expressions, Regular languages, Deterministic and non-deterministic computations. Pumping Lemma for Regular languages,

Context free languages, Pushdown automaton, Pumping Lemma for Context free languages, Grammar types and Chomsky Hierarchy.

Turing Machines (TM), Variations of TM's, Universal Turing Machines (UTM),

Church-Turing Thesis, Relation of Languages to Automata. Turing computable functions, Halting problem, Solvability, Undecidability and Computability.

References:

1. J.E.Hopcraft, R. Motwani and J.D. Ullman, "Introduction to Automata Theory, Languages and Computation", Pearson Education
2. Cohen, "Introduction to Computer Theory", John Wiley.
3. M. Sipser, Introduction to Theory of Computation, PWS Publishing Corporation, 1997.
4. J.E. Hopcroft, J.D. Ullman, Introduction to Automata Theory, Languages and Computation, Addison-Wisley, 1979.
5. T.C. Martin, Theory of Computation, Tata McGraw-Hill
6. H.R. Lewis, C.H. Papadimitrou, Elements of the Theory of Computation, PHI.

SET/CSE/MCS/C 204 : Software Engineering

Software **:** software characteristics, components & applications, software engineering - a layered technology, software process models - linear sequential model, prototype & rad model., evolutionary software process model – incremental model and spiral model.

Software project management **:** project management concepts – people problem and process

S/w process and project metrics : metrics in the process and project domains . Software measurement –size oriented, function oriented metrics, extended function

Software project planning: objectives, scope, project estimation, decomposition techniques, empirical estimation models.

Analysis concept and principles : requirement analysis, communication techniques, analysis principles, software prototyping, specifications.

Analysis modeling: elements of the analysis modeling, data modeling . Functional modeling and information flow, behavioral modeling, data dictionary.

Design concepts and principles: design process, design concepts, design principles, effective modular design .

Design methods : architectural design process, transform mapping and transaction mapping,interface design, - internal and external design, human omputer interface design, interface design guidelines, procedural design,

S/w quality assurance : quality concepts, matrix for software quality, quality movement, s/w q a, s/w review, formal technical reviews, formal approaches to sqa, s/w reliability, iso 9000quality standards

S/w testing models : s/w testing fundamentals, test case design, white and black box testing, basic path testing, control structure

S/w testing strategies : strategic approach to s/w testing, unit testing, integration testing, validation testing, system testing, debugging

S/w reuse : reuse process,building reuse components, classified and retrieving components, economics of s/w reuse

Computer aided s/w engineering: introducing of case, building block for case, taxonomy of case tools, integrating case environment, integrating architecture, case repository

References:

1. Software Engineering By R.S.Pressman
2. An Integrated Approach To Software Engineering By Pankaj Jalote

SET/CSE/MCS/C 205 : Data Communication and Computer Networks

Introduction to Computer Networking: Use, advantage, structure of the communications network topologies the telephone network, analog to digital communication.

Communication Between Analog Computers & Terminals Layered Protocols, Network & The OSI Models, Traffic control and accountability wide area and local area networks, connection oriented and connectionless networks, classification of communication protocols polling/selection systems, non-priority system priority system, rotation for layered protocols foals of layered protocols, network design problems, communication between layers, A parametric illustration, introduction to standards organizations and the ISO standard.

Polling/Selection, Satellite and Local area Networks: Binary synchronous control, other BSC system, conversion using satellite communication SPUS, and the Tele-port primary attribute of a LAN, IEEE LAN standards, LAN topology and protocols.

Switching and routing in Network: Telephone switching system, message switching, packet switching, packet switching support to circuit switching networks.

The X.25 & Digital Networks: Layers of x.25, features of x.25 flow control principles, other packet type, x.25 logical channel states time out and time limits, packet formats, flow control and windows x.25 facilities, other standards layer the pad, communication networks communication between layers, advantage of digital networks, Digital's switching, voice transmission by packet.

Personal Computer Network: Personal computer communications, characteristics, using the personal computers as server linking the personal computer to mainframe computers, semaphores of vendor offerings. File transfer on personal computers, personal computer and local area networks. Personal computer networks and the OSI models.

TCP/IP: TCP/IP and internetworking, example of TCP/IP operations, related protocols ports and sockets. The IP address structure, major features of IP, IP datagram, Major IP services. IP source routing, value of the transport layer, TCP, Major features of TCP, passive and active operation, the transmission control block (TCB), route discovery protocols, examples of route discovery protocols, application layer protocols.

References:

1. Tannanhaum, A.S. : Computer Network, PHI – 1995.
2. Martin J.: Computer Network and Distributed processing, 1985.
3. Black : Computer Network; Protocols, Standards and Interface PHI – 1995.
4. Black : Data Network; Concepts, Theory and Practices, PHI
5. Starlings, William : Local Networks; and Introduction Mack Publishing Co.
6. Comer; Internetworking : Principles, Protocols Architecture, PHI with TCP/IP
7. Crichlow : Introduction to Distributed and Parallel Comp.
8. Ahuja : Design and Analysis of Computer Communication Network, McGraw Hill Co.
9. Chorafas: Designing and Implementing Networks, McGraw Hill Co.

SET/CSE/MCS/C 301 : Network Security and Cryptography

Introduction of Cryptography: Introduction To security: Attacks, Services and Mechanisms, Security, Attacks, Security Services, Conventional Encryption: Classical Techniques, Conventional Encryption Model, and steganography, Classical Encryption Techniques. Modern Techniques: Simplified DES, Block Cipher Principles, DES Standard, DES Strength, Differential and Linear Cryptanalysis, Block Cipher Design Principles, Block Cipher Modes of Operations.

Conventional Encryption Algorithms: Triples DES, Blowfish, International Data Encryption Algorithm, RCS, CAST-128, CR2 Placement and Encryption Function, Key Distribution, Random Number Generation, Placement of Encryption Function.
Public Key Encryption: Public-Key Cryptography: Principles of Public-Key Cryptosystems, RSA Algorithm, Key, Key Management, Fermat's and Euler's Theorm, Primality, Chinese Remainder Theorem.

Hash Functions: Message Authentication and Hash Functions: Authentication Requirements, Authentication Functions, Message Authentication Codes, Hash Function Birthday Attacks, Security of Hash Function and MACS, MD5 Message Digest Algorithm, Secure Hash Algorithm (SHA), Digital Signatures: Digital Signature, Authentication Protocol, Digital Signature Standard (DDS) Proof of Digital Signature Algorithm.

Network and System Security: Authentication Applications: Kerberos X-509, Directory Authentication Service, Electronic Mail Security, Pretty Good Privacy (PGP),S/Mine Security: Architecture, Authentication Header, Encapsulating Security Payloads, Combining Security Associations, Key Management, Web Security: Secure Socket Layer and Transport Layer Security, Secure Electronic Transaction (Set), System Security: Intruders, Viruses, Firewall Design Principles, Trusted Systems.

References:

1. 1.William Stallings, "Cryptography and Network Security: Principles and Practice"' Prentice hall, New Jersey
2. Johannes A. Buchmann, "Introduction to Cryptography" Springer-Verlag
3. Atul Kahate, "Cryptography and Network Security" TMH
4. Network Security Bible : Eric Cole, Wiley dreamtech India Pvt. Ltd.
5. 5.Practical Cryptography "Bruce Schneier" Wiley dreamtech India Pvt. Ltd.

SET/CSE/MCS/C 302: Design and Analysis of Algorithm

Elementary Data Structures, Basic Computational Models.

Simple Algorithms. Analyzing Algorithms, Asymptotic Notation.

Design Methods : General Consideration, Algorithm design paradigms and representative problems: Divide and Conquer (Binary search, Merge Sort, Quick Sort, Arithmetic with Large integers, etc.), Greedy Method (Minimal Spanning Tree, Shortest Paths, Knapsack, etc.), Dynamic Programming (Chained Matrix Multiplication, Optimal Storage on Tapes, Shortest Paths, Optimal Search Trees, etc.), Backtracking (8-queens problem, Graph Colouring, Hamiltonian Cycles, etc.), Branch and Bound (0/1 Knapsack problem, Travelling Salesperson, etc.),

Approximation (Graph Colouring, Task Scheduling, Bin Packing, etc.), Probabilistic Algorithms (Numerical Integration, Primality Testing, etc.).

Graph Algorithms: BFS, DFS and its applications.

Polynomial Evaluation and Interpolation, Fast Fourier transforms.

Intractable Problems : Basic Concepts, Nondeterministic Algorithms, NP Completeness, Cook's Theorem, Examples of NP-Hard and NP-Complete problems. Problem Reduction.

Lower Bound Techniques: Comparison tree, Reduction, Adversary argument.

References:

1. A.Aho, J. Hopcroft and J.Ullman, The Design and Analysis of Computer Algorithms, Addison Wesley.
2. E. Horowitz and S. Sahani, Fundamentals of Computer Algorithms, Galgotia, New Delhi.
3. S.E.Goodman and S.T.Hedetniemi, Introduction to the Design and Analysis of Algorithms, McGraw Hill.
4. G.Brassard and P.Bratley, Algorithmics, PHI.
5. S.K.Basu, Design Methods and Analysis of Algorithms, PHI, 2005.

SET/CSE/MCS/C 303: Mobile & Wireless Computing

Introduction to Personal Communications Services (PCS): PCS Architecture, Mobility management, Networks signalling. Global System for Mobile Communication (GSM) system overview: GSM Architecture, Mobility management, Network signalling.

General Packet Radio Services (GPRS): GPRS Architecture, GPRS Network Nodes. Mobile Data Communication: WLANs (Wireless LANs) IEEE 802.11 standard,

Mobile IP.

Wireless Application Protocol (WAP): The Mobile Internet standard, WAP Gateway and Protocols, wireless mark up Languages (WML). Wireless Local Loop(WLL): Introduction to WLL Architecture, wireless Local Loop Technologies.

Third Generation (3G) Mobile Services: Introduction to International Mobile Telecommunications 2000 (IMT 2000) vision, Wideband Code Division Multiple Access (W-CDMA), and CDMA 2000, Quality of services in 3G.

Global Mobile Satellite Systems; case studies of the IRIDIUM and GLOBALSTAR systems. Wireless Enterprise Networks: Introduction to Virtual Networks, Blue tooth technology, Blue tooth Protocols.

Reference :

1. "Pervasive Computing", Burkhardt, Pearson
2. "Mobile Communication", J. Schiller, Pearson
3. "Wireless and Mobile Networks Architectures", Yi-Bing Lin & Imrich Chlamtac, John Wiley & Sons, 2001
4. "Mobile and Personal Communication systems and services", Raj Pandya, Prentice Hall of India, 2001.
5. "Guide to Designing and Implementing wireless LANs", Mark Ciampa, Thomson learning, Vikas Publishing
6. House, 2001.
7. "Wireless Web Development", Ray Rischpater, Springer Publishing,
8. "The Wireless Application Protocol", Sandeep Singhal, Pearson .
9. "Third Generation Mobile Telecommunication systems", by P.Stavronlakis, Springer Publishers,

E1.1 Computer Graphics

Introduction to computer graphics & graphics systems

Overview of computer graphics, representing pictures, preparing, presenting & interacting with pictures for presentations; Visualization & image processing; RGB color model, direct coding, lookup table; storage tube graphics display, Raster scan display, 3D viewing devices, Plotters, printers, digitizers, Light pens etc.; Active & Passive graphics devices; Computer graphics software.

Points & lines, Line drawing algorithms; DDA algorithm, Bresenham's line algorithm, Circle generation algorithm; Ellipse generating algorithm; scan line polygon, fill algorithm, boundary fill algorithm, flood fill algorithm.

2D transformation & viewing Basic transformations: translation , rotation, scaling ; Matrix representations & homogeneous coordinates, transformations between coordinate systems; reflection shear; Transformation of points, lines , parallel lines, intersecting lines. Viewing pipeline, Window to viewport co-ordinate transformation , clipping operations , point clipping , line clipping, clipping circles , polygons & ellipse.

3D transformations: translation, rotation, scaling & other transformations. Rotation about an arbitrary axis in space, reflection through an arbitrary plane; general parallel projection transformation; clipping, viewport clipping, 3D viewing.

Curves Curve representation, surfaces , designs , Bezier curves , B-spline curves, end conditions for periodic B-spline curves, rational B-spline curves.

Hidden surfaces Depth comparison, Z-buffer algorithm, Back face detection, BSP tree method, the Printer's algorithm, scan-line algorithm; Hidden line elimination, wire frame methods , fractal - geometry.

Color & shading models Light & color model; interpolative shading model; Texture;

Text Books:

1. Hearn, Baker – " Computer Graphics (C version 2nd Ed.)" – Pearson education
2. Z. Xiang, R. Plastock – " Schaum's outlines Computer Graphics (2nd Ed.)" – TMH
3. D. F. Rogers, J. A. Adams – " Mathematical Elements for Computer Graphics
4. Mukherjee, Fundamentals of Computer graphics & Multimedia, PHI
5. Sanhker, Multimedia –A Practical Approach, Jaico
6. Buford J. K. – "Multimedia Systems" – Pearson Education
7. Andleigh & Thakrar, Multimedia, PHI
8. Mukherjee Arup, Introduction to Computer Graphics, Vikas
9. Hill,Computer Graphics using open GL, Pearson Education

E1.2 Computer Organisation

Introduction: Function and structure of a computer, Functional components of a computer, Interconnection of components, Performance of a computer. Representation of Instructions: Machine instructions, Operands, Addressing modes, Instruction formats, Instruction sets, Instruction set architectures - CISC and RISC architectures.

Processing Unit: Organization of a processor - Registers, ALU and Control unit, Data path in a CPU, Instruction cycle, Organization of a control unit - Operations of a control unit, Hardwired control unit, Microprogrammed control unit.

Memory Subsystem: Semiconductor memories, Memory cells - SRAM and DRAM cells, Internal Organization of a memory chip, Organization of a memory unit, Error correction memories, Interleaved memories, Cache memory unit - Concept of cache memory, Mapping methods, Organization of a cache memory unit, Fetch and write mechanisms, Memory management unit - Concept of virtual memory, Address translation, Hardware support for memory management.

Input/Output Subsystem: Access of I/O devices, I/O ports, I/O control mechanisms -Program controlled I/O, Interrupt controlled I/O, and DMA controlled I/O, I/O interfaces- Serial port, Parallel port, PCI bus, SCSI bus, USB bus, Firewall and Infiniband, I/O peripherals - Input devices, Output devices, Secondary storage devices.

References

1. C. Hamacher, Z. Vranesic and S. Zaky, "Computer Organization", McGraw- Hill, 2002.
2. W. Stallings, "Computer Organization and Architecture - Designing for Performance", Prentice Hall of India, 2002.
3. D. A. Patterson and J. L. Hennessy, "Computer Organization and Design - The Hardware/Software Interface", Morgan Kaufmann,1998.
4. J .P. Hayes, "Computer Architecture and Organization", McGraw-Hill, 1998.

E1.3 C#

MS.NET Framework Introduction

The .NET Framework - an Overview , Framework Components , Framework Versions

Types of Applications which can be developed using MS.NET , MS.NET Base Class Library , MS.NET Namespaces , MSIL / Metadata and PE files.

The Common Language Runtime (CLR) ,Managed Code , MS.NET Memory Management / Garbage Collection , Common Type System (CTS) , Common Language Specification (CLS)

Language Basics

Datatypes & Variables Declaration , Implicit and Explicit Casting , Checked and Unchecked Blocks – Overflow Checks , Casting between other datatypes Operator Overloading, Partial Class, Attributes, Reflection, Configuration

Boxing and Unboxing , Enum and Constant , Operators , Control Statements , Working with Arrays,

Working with Methods , Pass by value and by reference and out parameters

Exception Handling

What is Exception , Rules for Handling Exception , Exception classes and its important properties,

Understanding & using try, catch keywords , Throwing exceptions

Importance of finally block , "using" Statement , Writing Custom Exception Classes.

Working With Collections and Generics

Importance of IList and IDictionary., Using ArrayList and Hashtable. , Understanding IEnumerable and IEnumerator. Sorting Items in the collection using IComparable.

Typesafety issue with ArrayList and Hashtable classes. Writing custom generic classes.

Working with Generic Collection Classes.

WinForms

Introduction, Controls, Menus and Context Menus, MenuStrip, ToolbarStrip.

Graphics and GDI , SDI and MDI Applications , Dialogbox (Modal and Modeless)

Form Inheritance, Developing Custom, Composite and Extended Controls

Other Misc topics., Working with Resource Files , Working with Settings

Data Access using ADO.NET – DataSet

Dataset, Advantages of DataSet, DataSet Object Model, Fetching data using Fill methods of Data Adapter and filling data into Dataset to create a DataTable, Showing DataTable in DataGridView

E2.1 ASP.NET

Introduction to ASP

Introduction to ASP. Types of Path. Examples using Response object of ASP. Working with FORM tag. Important Points about the FORM submission. Problem with ASP.

Validation Controls

BaseValidator, ValidationSummary, RequiredFieldValidator, CompareValidator RangeValidator, RegularExpressionValidator, CausesValidation Property of Button Grouping Controls for Validation

Applying Themes and Styles to Controls

Working with CSS ,Using Themes to Customize a Site , Named Skins within a Theme Server-side Styles using Themes , Contents of a Theme and Skin, Themes and Profiles

ASP.NET Architecture

What is AppDomain, Life cycle of a WebForm when requested by a client., How does a control manages its state, EnableViewState property, Event Handling in WebForms , Writing / Using Custom Classes in WebApplication

Page Navigation Options

Response.Redirect, Server.Transfer, CrossPagePostBack property of Button a. Accessing controls of PreviousPage b. Accessing Properties of PreviousPage c. PreviousPageType page directive

Creating a Layout Using Master Pages

Why Master Pages. , Significance of ContentPlaceHolder Tag in MasterPage and Content Tag in WebForm. How a control of MasterPage can be accessed / programmed in WebForm. a. Master.FindControl b. Public property in MasterPage and <%@MasterType directive in WebForm. Load and LoadComplete events of the Page and MasterPage classes. Understanding ClientID and UniqueID properties.

E2.2 Compiler Designing

Compiler Structure: Compilers and Translators, Various Phases of Compiler, Pass Structure of Compiler, Bootstrapping of Compiler.

Programming Language: High level languages, lexical and syntactic structure of a language, Data elements, Data Structure, Operations, Assignments, Program unit, Data Environments, Parameter Transmission. Lexical Analysis: The role of Lexical Analyzer, A Simple approach to the design of Lexical Analyzer, Regular Expressions, Transition Diagrams, Finite state Machines, Implementation of Lexical Analyzer, Lexical Analyzer Generator: LEX, Capabilities of Lexical Analyzer.

The Syntactic Specification of Programming Languages: CFG, Derivation and Parse tree, Ambiguity, Capabilities of EFG.

Basic Parsing Techniques: Top-Down parsers with backtracking, Recursive descent Parsers, Predictive Parser, Bottom-up Parsers, Shift-Reduce Parsing, Operator Precedence Parsers, LR parsers (SLR, Canonical LR, LALR) Syntax Analyzer Generator: YACC

Intermediate Code Generation: Different Intermediate forms: Three address code, Quadruples & Triples, Syntax Directed Translation mechanism and attributed definition. Translation of Declaration, Assignment, Control flow, Boolean expression, Array References in arithmetic expressions, procedure calls, case statements, postifix translation.

Run Time Memory Management: Static and Dynamic storage allocation, stack based memory allocation schemes, Symbol Table management.

Error Detection and Recovery: Lexical phase errors. Syntactic phase errors, semantic errors.

Code Optimization and Code Generation: Local optimization, Peephole optimization, Basic blocks and flow Graphs, DAG, Data flow analyzer, Machine Model, Order of evaluation, Register allocation and code selection.

References:

1. Alfred V Aho, Jeffrey D. Ullman, "Principles of Compiler Design", Narosa
2. A.V. Aho, R. Sethi and J.D.Ullman, "Compiler Principle, Tech & tools" AW
3. H.C. Holub "Compiler Design in C", Printice Hall Inc.
4. Apple, "Modern Computer Implementation in C: Basic Design" Cambridge Press
5. Modern Compiler Design: Dick Grune, Wiley dreamtech India Pvt. Ltd.
6. Starting Out with Modern Compiler " David Gaddis Wiley dreamtech India Pvt. Ltd.

E2.3 Human- Computer Interaction

Introduction: Importance of user Interface – definition, importance of good design. Benefits of good design. A brief history of Screen design,

The graphical user interface – popularity of graphics, the concept of direct manipulation, graphical system, Characteristics, Web user – Interface popularity, characteristics- Principles of user interface.

Design process – Human interaction with computers, importance of human characteristics human consideration, Human interaction speeds, understanding business junctions.

Screen Designing:- Design goals – Screen planning and purpose, organizing screen elements, ordering of screen data and content – screen navigation and flow – Visually pleasing composition – amount of information – focus and emphasis – presentation information simply and meaningfully – information retrieval on web – statistical graphics – Technological consideration in interface design.

Windows – New and Navigation schemes selection of window, selection of devices based and screen based controls.

Components – text and messages, Icons and increases – Multimedia, colors, uses problems, choosing colors.

Software tools – Specification methods, interface – Building Tools.

Interaction Devices – Keyboard and function keys – pointing devices – speech recognition digitization and generation – image and video displays – drivers.

References:

1. Human – Computer Interaction. Alan Dix, Janet Fincay, Gre Goryd, Abowd, Russell Bealg, Pearson Education
2. Interaction Design Prece, Rogers, Sharps. Wiley Dreamtech,
3. User Interface Design, Soren Lauesen , Pearson Education.

E3.1 Image Processing

Introduction: Digital Image Processing, The origins of Digital Image Processing, Examples of Digital Image Processing application, Fundamental steps in Digital Image processing, Components of Image Processing system Fundamentals: Elements of Visual Perception, Light and Electromagnetic Spectrum, Image Sensing and Acquisition, Image Sampling and Quantization, Some basic Relationships between Pixels, Linear and Nonlinear Operations.

Image Enhancement in the spatial domain: Background, Some basic gray level transformation, Introduction of Histogram processing, Enhancement using Arithmetic/Logic operations, Basics of spatial filtering, Smoothing spatial filters, Sharpening spatial filters, Image Enhancement in the Frequency Domain: Introduction.

Image Restoration: Model of the Image Degradation/Restoration process, Noise Models, Restoration in the presence of noise only spatial filtering, Inverse filtering, Minimum Mean Square Error (Wiener) filtering, Geometric mean filter, Geometric Transformations, Image Compression: Fundamentals, Lossy Compression, Lossless Compression, Image Compression models, Error-free Compression : Variable length coding, LZW coding, Bit plane coding, Run length coding, Introduction to JPEG.

Morphology: Dilation, Erosion, Opening and Closing, Hit-and Miss transform, Morphological Algorithms : Boundry Extraction, Region filling, Extraction of connected components, Convex Hull, Image Segmentation: Definition, characteristics of segmentation Detection of Discontinuities, Edge Linking and Boundary Detection, Thresholding, Region based segmentation. Introduction to Representation & Description, Introduction to Object Recoginition.

References:

1. Digital Image Processing: Rafael C. Gonzalez and Richard E.Woods. Addision Wesley.
2. Fundamentals of Digital Image Processing. Anil K. Jain, PHI.
3. Digital Image Processing and Analysis : B. Chanda & D. Dutta Majumber, PHI.
4. Image Processing in C : Dwayne Phillips, BPB.

E3.2 Unified Modeling Language

Introduction: The Evolution of Technology, Structured Analysis and Design, Object-Oriented Technologies, Comparison between the main technologies.

The Unified Process and Features: Unified Process, Static Structure: Process Representation, Dynamic Structure: iterative development, an architecture-centric process, A use-case-driven process, Use case models, Notations and Terminology.

Process Components (Workflows): Business Modeling Workflow, Requirement Workflow, Analysis and Design Workflow, Deployment workflow.

Understanding Object –Oriented Technologies, Current status of Object Technologies, The static object model- Class, Collaborations and Object Diagrams, Generalization, Composition, Aggregation, Multiplicity & Association with concept and examples.

Use Case Analysis: Discussion on use cases, terminology, notations and analysis, what they are and aren't, Use case- an example, Use case- formal Scenario template.

Static chart Diagram: Composite states, nested states, Events, Simple transitions.

UML Activity and sequence diagrams: Usage and Syntax, Guarded Transitions, Synchronization Bars, Swim lanes Purpose, Proper Usage of Activity diagram. Transition time sequence diagram: Objective and Modeling guidelines, Objective Interaction, Sequence diagram- UML notation, Object and Stereotypes.

References:

1. UML distilled by Martin Fouler- Pearson Education.
2. Object –Oriented Modeling by James Raumbaugh, PHI.
3. UML a nutshell by Dan Pillone, O'Reilly Publication.
4. The elements of UML by Scott Amber, Cambridge University Press.
5. Designing Object-Oriented Software by Rebecca Wirf Brock, PHI.

E3.3 Multimedia Technology and Applications

Evolution of Multimedia and its objects, Scope of multimedia in business & work, production and planning of Multimedia applications. Multimedia hardware, Memory of Storage Devices, Communication Devices, Multimedia Software, Presentation and object generation tools, Video, sound, Image capturing Authoring Tools, Card & Page Based Authoring Tools.

Production and Planning of Multimedia building blocks, Text, sound (MIDI), Digital Audio, Audio File Formats, MIDI under Windows environment, Audio & Video Capture.
Macromedia products, Basic drawing techniques, Advance animation techniques, Creating Multi layer combining interactivity and multiple scenes, Creating transparency effects using text in Flash, Flash animation.

Digital Audio Concepts, Sampling variables, Loss Less compression, of sound, Lossy compression & Silence compression.

Multimedia monitor bitmaps, Vector drawing , Lossy graphic compression, Image file formatic animations, Image standards, JPEG compression, Zig Zag coding. Video representation, colors, video compression, MPEG standards, MHEG standard, recent development in multimedia. Multimedia Application Planning, Costing, Proposal preparation, and Financing-Case study of a typical industry.

References:

1. Andreas Halzinger, "Multimedia Basics" Vol-I to VOL-III Firewall Media
2. Tay Vaughan, "Multimedia Making It work" Tata McGraw Hill
3. Buford, "Multimedia Systems" Addison Wesley
4. Agarwal and Tiwari, "Multimedia Systems" Excel
5. Rosch, "Multimedia Bible" Sams Publishing
6. Digital Multimedia "Nigel Chapman" Wiley dreamtech India Pvt. Ltd.
7. Sleinreitz, "Multimedia Bible" Sams Publishing
8. Ken Milburn, John Ckroteau, "Flash 4 Web special Effects, Animation & Design Handbook" Dreamtech Press
9. John. Villamil-Casanova & Louis Molina, "Multimedia-Production, Planning & Delivery" PHI
10. Flash MX 2004 Bible: Robert , Wiley dreamtech India Pvt. Ltd.

E4.1 Artificial Intelligence

Introduction: Definition and meaning of artificial intelligence, A.I. techniques, pattern recognition, Level of, speech recognition representation in A.I. properties of internal representation.

Production System: Different types of tracing, strategies, graph search strategies, Heuristic graph, search procedure, AND/OR graph, relationship between decomposional and compatible systems, searching Gate Tree, min-max search game playing, actual game playing.

Introduction to Predicate Calculus: Predicates and Arguments, connectives, Simplifications of strategies, extracting answers from Resolution Refutation. Control strategies.

Rule Based Deduction Systems: Forward and backward deduction system, resoling with AND/OR graph, computation, deduction and program synthesis, central knowledge for rules based deduct systems.

Managing Plans of Action: Plan interpreter, planning decisions, execution monitoring and re-planning domain of application robot motion planning and game playing.

Structural Object Representation: Semantic networks semantic market matching deductive operations on structured objects.

Architectural for A.I. Systems: Knowledge, acquisitions representation IMAGES PROCESSING, Natural language processing.

References:

1. Introduction to artificial Intelligence Eugene Charnik Drew MC mott
2. Artificial Intelligence Elaine Rice.
3. Principal of Artificial Intelligence, Nelson, Springer-Verlag.
4. Artificial Intelligence Application Programming: Tim Jones, Wiley dreamtech

E4.2 Wireless Networks

Introduction to Wireless Networks

Elements of a wireless communication system – signal and noise - the radio – frequency spectrum –Analog modulation schemes -Amplitude modulation –frequency and phase modulation – sampling – pulse code modulation – delta modulation – data compression.

Digital Modulation and Radio Propagation

Digital communication- sampling –pulse code modulation – delta modulation - Frequency shift keying – Phase shift keying – Multiplexing and Multiple access – spread spectrum systems - radio propagation.

Principles of Cellular Communication And Multiple Access Techniques

Cellular terminology - Cell structure and Cluster – Frequency reuse concept – Cluster size and system capacity – method of locating co channel cells – frequency reuse distance – frequency division multiple access – time division multiple access – space division multiple access – code division multiple access.

GSM and CDMA Digital Cellular Standards

GSM network architecture –GSM signaling protocol architecture – Identifiers in GSM – GSM channels – GSM handoff procedures – Edge technology – wireless local loop – DECT system – GPRS

Emerging Wireless Technologies

IEEE 802.11 system architecture – mobile ad hoc networks – Mobile IP and mobility management – Mobile TCP - wireless sensor networks – RFID technology – Blue tooth – Wi –Fi standards – Wimax standards. – Femtocell network – Push -to –talk technology for SMS.

References:

1. Roy Blake, *"Wireless communication technology"* CENGAGE Learning , sixth Indian reprint 2010. (Chapter 1,2,3,4,7,14)
2. Singal T.L. , *"Wireless communication"* Tata Mc Graw Hill Education private limited , 2011.**(** chapter 4,8,11,13,14**)**
3. Dharma Prakash Agrawal , Qing –An Zeng , *" Introduction to wireless and mobile systems"* CENGAGE Learning, first edition 2012.(chapter 16)

E4.3 Data Mining & Data Warehousing

Fundamentals : Data Mining, Data Processing And Data Warehouses

Data Mining – History – Strategies – Techniques – Applications – Challenges – Future- Types of Data – Data Warehouses – Data Processing - Quality Measure – OLAP – Sampling.

Data Types, Input And Output Of Data Mining Algorithms – Different Types of features – Concept Learning – Output of Data Mining Algorithms.

Preprocessing In Data Mining – Steps – Discretization – Feature Extraction, Selection and construction – Missing Data and Techniques for dealing it.

Model Evaluation Techniques: Accuracy Estimation- ROC-Lift Charts- Cost –Bagging and Boosting- Model Ranking Approach.

Association Rule Mining: Concepts, Relevance, Functions of Association rule Mining – Apriori Algorithm- Strengths and Weaknesses of ARM- Applications

Clustering And Estimation

Clustering Task: Introduction- Distance Measure – Types – KNN for clustering – validation - Strengths and Weaknesses of Algorithms – Applications.

Estimation Task: Scatter Plots and Correlation – Linear regression Models – Logistic regression – Regression Analysis - Strengths and Weaknesses of Estimation- Applications.

Introduction to Data Warehouse – Data warehouse delivery method – system process – typical process flow within a Data ware house – query management process – process

architecture.

Design Aspects

Design aspects – Designing dimension tables – Designing star flake schema – Multi dimensional schema – partitioning strategy aggregations – Data marting- Meta data – System Data warehouse process manager.

Hardware Hardware and operational design – server hardware, network hardware – parallel technology – Security input on design of Hardware – backup and recovery –

Service level Agreement – Operating the data warehouse.

References:

1. Shawkat Ali A B M, Saleh A. Wasimi*, "Data Mining: Methods and Techniques*", Third Indian Reprint, Cengage Learning, 2010.
2. Sam Anahory & Dennis Murray, "*Data Warehousing in the real world*",Pearson Education Ltd., 2011
3. Prabhu C.S.R. , "Data Ware housing: Concepts, Techniques, Products and *Applications*", Prentice Hall of India, 2011,

E4.4 Genetic Algorithm and Machine Learning

Introduction To Genetic Algorithm And Machine Learning

Robustness of Traditional Optimization and Search methods – Goals of optimization-GA versus Traditional methods – Simple GA; Machine learningexplanation-machine learning Vs artificial intelligence-supervised and unsupervised machine learning-examples of machine learning.

Mathematical Foundations Of Genetic Algorithm

The fundamental theorem - Schema processing at work. – The 2-armed & karmed

Bandit problem. –The building Block Hypothesis. – Minimal deceptive problem.

GA Operators

Data structures – Reproduction- Roulette-wheel Selection – Boltzmann Selection – Tournament Selection-Rank Selection – Steady –state selection –Crossover &mutation – Mapping objective functions to fitness forum. – Fitness scaling.

Applications Of GA

The rise of GA – GA application of Historical Interaction. – Dejung & Function optimization – Current applications of GA - Advanced operators & techniques in genetic search: Dominance, Diploidy & abeyance.

Applications Of Genetics-Based Machine Learning

The Rise of GBML – Learning classifier system--Development of CS-1, the first classifier system. – Smitch's Poker player –GBML for sub problems of learning-- Other Early GBML efforts –Current Applications.

References:

1. David E. Gold Berg, *"Genetic Algorithms in Search, Optimization & Machine Learning"*, Pearson Education, 2013.

Chemistry Syllabus

(Approved in the Board of Studies Meeting dated 9th and 10th October 2017)

Semester wise to be effective from July 2018

Note:

1. In all 72 credits are to be completed in M.Sc. out of which18 credits shall be taken by the student in one semester.
2. In semester III and IV the student will opt one branch out of three branches i.e. Inorganic, Organic and Physical according to the availability of faculty in the department. The student will also take 18 credits in III and IV semesters out of which 9 credits i.e. two core courses will be compulsory and rest of 9 credits i.e. three courses of each three credits shall be opted out of 4 optional in each semester and in each branch.

M.S.c. I

Semester I	**Course**	**MM**	**Credits**
1. Inorganic Chemistry I	C001	100	3
2. Organic Chemistry I	C002	100	3
3. **Physical Chemistry I (Revised)**	C003	100	3
4. Group Theory & Spectroscopy	C004	100	3
5. Laboratory Course IA	C005	100	3
6. Laboratory Course IB	C006	100	3
Semester II	**Course**	**MM**	**Credits**
1. Inorganic Chemistry II	C007	100	3
2. Organic Chemistry II	C008	100	3
3. Physical Chemistry II	C009	100	3
4. Spectroscopy & Separation Methods	C010	100	3
5. Laboratory Course IIA	C011	100	3
6. Laboratory Course IIB	C012	100	3

M.S.c. II

Semester III	**Course**	**MM**	**Credits**
[A] Inorganic Chemistry			
1. Laboratory Course Inorganic IIIA	C013	100	3
2. Laboratory Course Inorganic IIIB	C014	100	3
3. Organometallic Chemistry	C015	100	3
4. Spectroscopy, X-ray & Solid State	E001	100	3
5. Bioinorganic, Bioorganic, Biophysical I	E002	100	3
6. Bioinorganic & Supramolecular Chemistry I	E003	100	3
7. Analytical Chemistry	E004	100	3
[B] Organic Chemistry			
1. Laboratory course- Organic IIIA	C016	100	3
2. Laboratory course- Organic IIIB	C017	100	3
3. Organic Synthesis & Photochem.	C018	100	3
4. Bioorganic, Bioorganic & Bio. Physical Chemistry I	E002	100	3
5. Spectroscopy & Solid State	E005	100	3

6. Organometallic reagents and Organic Synthesis	E006	100	3
7. Medicinal Chemistry	E007	100	3
[C] Physical Chemistry			
1. Laboratory Course Physical IIIA	C019	100	3
2. Laboratory Course Physical IIIB	C020	100	3
3. Chemistry of Materials	C021	100	3
4. Spectroscopy, X-ray & Solid State	E001	100	3
5. Bioinorganic, Bioorganic and Biophysical Chemistry I	E002	100	3
6. Analytical Chemistry	E004	100	3
7. Liquid State	E008	100	3

M.Sc. II

Semester IV	**Course**	**MM**	**Credits**
[A] Inorganic Chemistry			
1. Laboratory Course Inorganic IVA	C022	100	3
2. Laboratory Course Inorganic IVA	C023	100	3
3. Inorganic Polymers	C024	100	3
4. Spectroscopy	E009	100	3
5. Bioinorganic, Bioorganic and Biophysical Chemistry II	E010	100	3
6. Photoinorganic Chemistry	E011	100	3
7. Environmental Chemistry	E012	100	3
[B]Organic Chemistry]			
1. Laboratory Course Organic IVA	C025	100	3
2. Laboratory Course Organic IVB	C026	100	3
3. Natural Products	C027	100	3
4. Spectroscopy	E009	100	3
5. Bioinorganic, Bioorganic and Biophysical Chemistry II	E010	100	3
6. Environmental Chemistry	E012	100	3
7. Heterocyclic Chemistry	E013	100	3
[C]Physical Chemistry]			
1. Laboratory Course Physical IVA	C028	100	3
2. Laboratory Course Physical IVB	C029	100	3
3. Advanced Quantum Chemistry	C030	100	3
4. Spectroscopy	E009	100	3
5. Bioinorganic, Bioorganic and Biophysical Chemistry II	E010	100	3
6. Environmental Chemistry	E012	100	3
7. Polymers	E014	100	3

S.No.	Paper	Category	Paper Code	L	T	P	C
1	Inorganic Chemistry - I	Core	SOS/C001	3	0	0	3
2	Organic Chemistry - I	Core	SOS/C002	3	0	0	3
3	Physical Chemistry - I	Core	SOS/C003	3	0	0	3
4	Group Theory & Spectroscopy	Core	SOS/C004	3	0	0	3
5	Laboratory Course-IA	Core	SOS/C005	0	0	9	3
6	Laboratory Course-IB	Core	SOS/C006	0	0	9	3
7	Inorganic Chemistry - II	Core	SOS/C007	3	0	0	3
8	Organic Chemistry - II	Core	SOS/C008	3	0	0	3
9	Physical Chemistry II	Core	SOS/C009	3	0	0	3
10	Spectroscopy and Separation Methods	Core	SOS/C010	3	0	0	3
11	Laboratory Course-IIA	Core	SOS/C011	0	0	9	3
12	Laboratory Course-IIB	Core	SOS/C012	0	0	9	3
13	Laboratory Course- Inorganic IIIA	Core	SOS/C013	0	0	9	3
14	Laboratory Course- Inorganic IIIB	Core	SOS/C014	0	0	9	3
15	Organometallic Chemistry	Core	SOS/C015	3	0	0	3
16	Spectroscopy, X-ray and Solid State	Elective	SOS/E001	3	0	0	3
17	Bioinorganic, Bioorganic Biophysical Chemistry-I	Elective	SOS/E002	3	0	0	3
18	Bioinorganic and Supramolecular Chemistry	Elective	SOS/E003	3	0	0	3
19	Analytical Chemistry	Elective	SOS/E004	3	0	0	3
20	Laboratory Course-Org IIIA	Core	SOS/C016	0	0	9	3
21	Laboratory Course-Org IIIB	Core	SOS/C017	0	0	9	3
22	Organic Synthesis and Photochemistry	Core	SOS/C018	3	0	0	3
23	Spectroscopy and Solid State	Elective	SOS/E005	3	0	0	3
24	Organometallic Reagents and Organic Synthesis	Elective	SOS/E006	3	0	0	3
25	Medicinal Chemistry	Elective	SOS/E007	3	0	0	3
26	Laboratory Course Phy.-IIIA	Core	SOS/C019	0	0	9	3
27	Laboratory Course Phy.-IIIB	Core	SOS/C020	0	0	9	3
28	Chemistry of Materials	Core	SOS/C021	3	0	0	3
29	Liquid State	Elective	SOS/E008	3	0	0	3
30	Laboratory Course-Inorg. IVA	Core	SOS/C022	0	0	9	3
31	Laboratory Course-Inorg. IVB	Core	SOS/C023	0	0	9	3
32	Inorganic Polymers	Core	SOS/C024	3	0	0	3
33	Spectroscopy	Elective	SOS/E009	3	0	0	3
34	Bioinorganic, Bioorganic, Biophysical Chemistry-II	Elective	SOS/E010	3	0	0	3
35	Photoinorganic Chemistry	Elective	SOS/E011	3	0	0	3
36	Environmental Chemistry	Elective	SOS/E012	3	0	0	3
37	Laboratory Course Org.-IVA	Core	SOS/C025	0	0	9	3
38	Laboratory Course Org.-IVB	Core	SOS/C026	0	0	9	3
39	Natural Products	Core	SOS/C027	3	0	0	3
40	Heterocyclic Chemistry	Elective	SOS/E013	3	0	0	3
41	Laboratory Course Phy.-IVA	Core	SOS/C028	0	0	9	3
42	Laboratory Course Phy.-IVB	Core	SOS/C029	0	0	9	3
43	Advanced Quantum Chemistry	Core	SOS/C030	0	0	0	3
44	Polymers	Elective	SOS/E014	3	0	0	3

Semester- I

SOS/C001	Inorganic Chemistry - I	L	T	P	C	MM
		3	0	0	3	100

Unit I

Stereochemistry and Bonding in Main Group Compounds

VSEPR model and its shortcomings. Hybridization and three-center bonds. Bents rule and energetics of hybridization.

Walsh's diagrams for tri and tetraatomic molecules. pπ-pπ and pπ-dπ bonding.

Unit II

Metal-Ligand Equilibria in Solution

Thermodynamic and kinetic stability of complexes. Stepwise and overall formation constants and their interaction.Trends in K value. Irving-Willams series.Chelate effect and its thermodynamic origin. Factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand.

Detection of complexes in solution. Determination of binary formation constants by pH-metry and spectrophotometric method.

Unit III

Reaction Mechanism of Transition Metal Complexes

Energy profile of a reaction and reactivity of metal complexes.Inert and labile complexes. Ligand substitution reactions in octahedral complexes i.e. SN^1,SN^2 and SN^1CB mechanism. Anation reactions without metal ligand bond cleavage. Electron transfer reactions(Redox reactions). Outer and inner sphere mechanism (OSM and ISM).Reactions of coordinated ligands.

Substitution reactions in square-planer complexes.

Unit IV

Theories of Coordination Compounds

Crystal field theory, factors affecting the magnitude of Δ_0. Consequences of crystal field splitting. merits and limitations of CFT Jahn-Teller distortion and its consequences on complex formation.

Evidence of covalent character in Metal-Ligand bonding. Molecular orbital theory as applied to octahedral, tetrahedral and square planar complexes.

Books suggested

1 Advanced Inorganic Chemistry Vth Ed., F.A. Cotton and G. Wilkinson, John Wiley, (1988).
2 Advanced Inorganic Chemistry VIth Ed., F.A. Cotton, G Wilkinson, C.A. Murillo and M. Bochmann, John Wiley,(1999).
3 Inorganic Chemistry, J.E.House, Academic Press, (2008)
4 Inorganic chemistry, A Unified Approach, IInd Ed., W W. Porterfield, Academic Press,(1993).
5 Coordination Chemistry ,IIIrd Ed., D Banerjea, Asian Book Pt. ltd.,(2009)
6 Inorganic Chemistry, 3th Ed., G L Miessler and D.A.Tarr, Pearson Education,Inc. (2004)
7 Concise Inorganic Chemistry, J.D. Lee, 5th Ed., Chapman & Hall (1996).
8 Inorganic Chemistry, 3rd Ed., Shriver & Atkins, Oxford (1999).
9 Inorganic Chemistry, 3rd Ed., Alan G. Sharpe, Addison-Wesley (1992).
10 Inorganic Chemistry, 4th Ed., J.E. Huheey, Harper & Row (2000).
11 Chemistry of the Elements, 2nd Ed., N.N. Greenwood and A. Earnshaw, Butterworth. Heinemann (1997).

12 Inorganic Electronic Spectroscopy, 2nd Ed., A.B.P. Lever, Elsevier (1986).
13 Magnetochemistry, R.L. Carlin, Springer Verlag (1986).
14 Comprehensive Coordination Chemistry Eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon (1987).

SOS/C002	Organic Chemistry - I	L	T	P	C	MM
		3	0	0	3	100

Unit I

Nature of Bonding in Organic Molecules

Hyperconjugation, bonding in fullerenes, tautomerism.

Aromaticity in benzenoid and non benzenoid compounds, alternant and non alternant hydrocarbons. Huckel's rule, energy level of π-molecular orbitals, annulenes, antiaromaticity, homo-aromaticity, PMO approach.

Bonds weaker than covalent, crown ether complexes and cryptands, inclusion compounds, cyclodextrin, catenanes and rotaxanes.

Unit II

Stereochemistry

Conformational analysis of cycloalkane, decalins, effect of conformation on reactivity, conformation of sugars, steric strain due to unavoidable crowding, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis. Asymmetric synthesis, chirality due to helical shape. Stereochemistry of the compounds containing nitrogen, sulphur and phosphorus.

Unit III

Reaction Mechanism : Structure and Reactivity

Types of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle. Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects.

Effect of structure on reactivity – resonance and field effects, steric effect, quantitative treatments. Hammett equation and linear free energy relationship, substituent and reaction constants. Taft equation.

Unit IV

Aliphatic Nucleophilic Substitution

S_N1, S_N2 and mixed S_N1 and S_N2 mechanism. The neighbouring group mechanism, neighbouring group participation (by π- and σ bonds). Anchimeric assistance. S_N1 mechanism- Nucleophilic substitution at an allylic, aliphatic trigonal and vinylic carbon. Reactivity effects of substrate structure, attacking nucleophilic group, leaving group and reaction medium, ambident nucleophile.

Unit V

Aliphatic Electrophilic Substitution

Bimolecular mechanism- SE2 and SEi. The SE1 mechanism, electrophilic substitution accompanied by double bond shift. Effect of substrates, leaving group and the solvent polarity on the reactivity.

Books suggested:-

1. Advanced Organic Chemistry, Reaction, Mechanism and Structure, Jerry March, 6th Ed., John Wiley.
2. Advanced Organic Chemistry, Carey and Sundberg, Springer Verlag, Germany.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes.

4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, Boyd and Morrison, Prentice Hall of India.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, Norman and Coxon, Blackwell.
8. Reaction Mechanism in Organic Chemistry, Mukherji and Singh, Macmillan.
9. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
10. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

SOS/C003	Physical Chemistry - I	L	T	P	C	MM
		3	0	0	3	100

Unit I :

Quantum Chemistry: Introduction to Exact Quantum Mechanical Results

The Schrodinger equation and the postulates of quantum mechanics. Discussion of solutions of the Schrodinger equation to some model systems viz. particle in a box, the harmonic oscillator, the rigid rotor, the hydrogen atom.

Unit II

Quantum Chemistry: Approximate Methods

The variation theorem, linear variation principle, perturbation theory (first order and nondegenerate). Applications of variation method and perturbation theory to the Helium atom.

Unit III

Quantum Chemistry:Angular Momentum

Ordinary angular momentum, generalized angular momentum, eigenfunctions for angular momentum, eigenvalues of angular momentum, operator using ladder operators, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle.

Unit IV

Quantum Chemistry : Electronic Structure of Atoms

Electronic configuration, Russell-Saunders terms and coupling schemes, Slater-Condon parameters, term separation energies of the p^{π} configuration, term separation energies for the d^{π} configurations, magnetic effects: spin-orbit coupling and Zeeman splitting, introduction to the methods of self-consistent field, the viral theorem.

Unit V

Thermodynamics: Classical Thermodynamics

Brief resume of concepts of laws thermodynamics, free energy, chemical potential and entropies. Partial molar properties: partial molar free energy, partial molar volume and partial molar heat content and their significance. Determination of these quantities.

Concept of fugacity and determination of fugacity.

Non-ideal systems: Excess functions for non-ideal solutions. Activity, activity coefficient.

Debye-Huckel theory for activity coefficient of electrolytic solutions, determination of activity and activity coefficients, ionic strength.

Unit VI

Surface Chemistry: Adsorption

Surface tension, capillary actions, pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, estimation of surface area (BET equation), surface films on liquids (Electro-kinetic phenomenon), catalytic activity at surfaces.

Books suggested

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
3. Quantum Chemistry, Ira N. Levine, Prentice Hall.
4. Coulson's Valence, R. McWeeny, ELBS.

SOS/C004	Group Theory & Spectroscopy	L	T	P	C	MM
		3	0	0	3	100

Unit I

Symmetry and Group Theory in Chemistry

Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroups, conjugacy relation and classes. Point symmetry group, Schonflies symbols, representations of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, D_{nh} etc. group to be worked out explicitly). Character of a representation. The great orthogonalilty theorem (without proof) and its importance. Character tables and their use in spectroscopy.

Unit II

Unifying Principles

Electromagnetic radiation, interacton of electromagnetic radiation with matter. Absorption, emission, transmission, reflection, refraction, dispersion, polarization and scattering. Uncertainty relation and natural line width and natural line broadening, transition probability, result of the time dependent perturbation theory, transition moment, selection rules, intensity of special lines, Born-oppenheimer approximation, rotational, and electronic energy levels.

Unit III

Atomic Electronic Spectroscopy

Energies of atomic orbitals, vector representation of momenta and vector coupling, spectra of hydrogen atom and alkali metal atoms.

Unit IV

Microwave Spectroscopy

Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities, non-rigid rotor, Stark effect, nuclear and electron spin interaction and effect of external field. Applications.

Unit V

Infrared Spectroscopy

Review of linear harmonic oscillator, vibrational energies of diatomic molecules, Zero point energy, force constant and bond strengths; anharmonicity, Morse potential energy diagram, virbration-rotation spectroscopy; P,Q,R branches. Selection rules, normal modes of vibration, group frequencies, overtones, hot bands, factors affecting the band positions and intensities, far IR region., metal-ligand vibrations.

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
3. Chemical Applications of Group Theory, F.A. Cotton.
4. Introduction of Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
6. Symmetry and Spectroscopy of Molecules, K. Veera Reddy, New Age International.

SOS/C005	Laboratory Course-IA	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 12 marks each from Inorganic, Organic and Physical sections.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

Inorganic Chemistry

Qualitative Analysis

Qualitative analysis of mixtures by semi-micro methods containing not more than six cations and anions including:

(i). Rare-earth elements

(ii). Anions, which have not been done in under graduate practicals.

(iii). Insolubles.

Organic Chemistry

Qualitative Analysis

Separation, purification and identification of compounds of binary mixture (solid-solid or liquid and solid) using TLC and Paper Chromatography, Chemical tests and spectroscopic analysis.

Physical Chemistry

Chemical Kinetics

1. Determination of the effect of (a) Change of temperature (b) Change of concentration of reactants and catalyst and (c) ionic strength of the media on the velocity constant of hydrolysis of an ester/ionic reactions.

2. Determination of the velocity constant of hydrolysis of an ester.
3. Determination of the rate constant for the oxidation of iodide ions by hydrogen peroxide studying the kinetics of the reaction.
4. Flowing clock reactions (Ref: Experiments in Physical Chemistry by Showmaker).
5. Determination of the primary salt effect on the kinetics of ionic reactions and testing of the Bronsted relationship (iodide ion is oxidized by persulphate ion).

SOS/C006	Laboratory Course-IB	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 12 marks each from Inorganic, Organic and Physical sections.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

Inorganic Chemistry

Chromatography

Separation of cations and anions by-

Paper Chromatography

Thin Layer Chromatography

Ion Exchange Chromatography

Organic Chemistry

Organic Synthesis

Acetylation: Acetylation

Oxidation: Adipic acid by chromic acid oxidation of cyclohexanol.

Grignard reaction: Synthesis of triphenylmethanol from benzoic acid.

Sandmeyer reaction: p-Chlorotoluene from p-toluene

Physical Chemistry

Electrochemistry

Conductometry

1. Determination of the velocity constant, order of the reaction and energy of activation for saponification of ethyl acetate by sodium hydroxide conductometrically.
2. Determination of solubility and solubility product of sparingly soluble salts (e.g., $PbSO_4$, $BaSO_4$) conductometrically.
3. Determination of the strength of strong and weak acids in a given mixture conductometrically.
4. To study the effect of solvent on the conductance of $AgNO_3/CH_3COOH$ and to determine the degree of dissociation and equilibrium constant in different solvents and in their mixtures (DMSO, DMF, dioxane, acetone, water) and to test the validity of Debye-Huckel-Onsager theory.
5. Determination of the activity coefficient of zinc ions in the solution of 0.002 M zinc sulphate using Debye Huckel's limiting law.

Semester- II

SOS/C007	Inorganic Chemistry - II	L	T	P	C	MM
		3	0	0	3	100

Unit I

Electronic Spectra & Magnetic Properties of Transition Metal Complexes.

Types of absorption spectra. Spectral terms. Russell-Saunders states. Selection rules for electronic transitions in complexes. Width of absorption spectral bands, Terms generated in ligand fields. Orgel and Tanabe-Sugano correlation diagrams for d^1 to d^9 states. Racah parameters. Charge transfer spectra. Magnetic moments, magnetic exchange coupling and spin crossover.

Unit II

Metal-π-Complexes and organometallic Compounds.

Metal carbonyl complexes. Preparation, properties and uses. Nature of bonding in metal carbonyls and carbon monoxide analogs i.e. nitrosyls and dinitrogen complexes. Evidence for back bonding in complexes.

Nature of M-C bond Synthesis, bonding and uses of organometallic compounds, two electron ligands (olefinic and acetylenic complexes), three electron ligands (allylic complexes), four electron ligand (butadiene and cyclobutadiene complexes), five electron ligand (ferrocene complexes).

Unit III

Metal Clusters

Polyhedral boranes and boran anions. Synthesis, reactivity, bonding and topology of boranes.. Wade's rules. Carboranes, metalloboranes and metallocarboranes.

Metal carbonyls and halides as clusters. Metal carbonyl hydrides.

Unit IV

Silicates

Principles of silicates. Structure and classification of silicates. Asbestos, Zeolites and Ultramarines as silicate materials. Silicates in technology

Books suggested

1. Advanced Inorganic Chemistry Vth Ed., F.A. Cotton and G. Wilkinson, John Wiley, (1988).
2. Advanced Inorganic Chemistry VIth Ed., F.A. Cotton, G Wilkinson, C.A. Murillo and M. Bochmann, John Wiley,(1999).
3. Inorganic Chemistry, J.E.House, Academic Press, (2008)
4. Inorganic chemistry, A Unified Approach, IInd Ed., W W. Porterfield, Academic Press,(1993).
5. Coordination Chemistry ,IIIrd Ed., D Banerjea, Asian Book Pt. ltd.,(2009)
6. Inorganic Chemistry, 3th Ed., G L Miessler and D.A.Tarr, Pearson Education,Inc. (2004)
7. Concise Inorganic Chemistry, J.D. Lee, 5th Ed., Chapman & Hall (1996).
8. Inorganic Chemistry, 3rd Ed., Shriver & Atkins, Oxford (1999).
9. Inorganic Chemistry, 3rd Ed., Alan G. Sharpe, Addison-Wesley (1992).
10. Inorganic Chemistry, 4th Ed., J.E. Huheey, Harper & Row (2000).
11. Chemistry of the Elements, 2nd Ed., N.N. Greenwood and A. Earnshaw, Butterworth. Heinemann (1997).
12. Inorganic Electronic Spectroscopy, 2nd Ed., A.B.P. Lever, Elsevier (1986).
13. Magnetochemistry, R.L. Carlin, Springer Verlag (1986).
14. Comprehensive Coordination Chemistry Eds., G. Wilkinson, R.D. Gillars and J.A. McCleverty, Pergamon (1987).

SOS/C008	Organic Chemistry - II	L	T	P	C	MM
		3	0	0	3	100

Unit I

Aromatic Electrophilic Substitution

Orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems. Quantitative treatment of reactivity in substrate and electrophiles. Diazonium coupling, Vilsmeir Haak reaction, Gattermann-Koch reaction.

Unit II

Aromatic Nuecleophilic Substitution

The SNAr, SN1, benzyne and SRN1 mechanisms. Reactivity- effect of substrate structure, leaving group and attacking nucleopile. The von Rictor, Sommelet-Hauser, and Smiles rearrangements.

Unit III

Free Radical Reactions

Types of free radical reactions, free radical substitution mechanism, mechanism of an aromatic substrate, neighboring group assistance. Reactivity for aliphatic and aromatic substrates at a bridgehead. Reactivity in the attacking radicals. The effect of solvents on reactivity.

Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts. Sandmeyer reaction. Free radical rearrangement. Hunsdiecker reaction.

Unit IV

Addition to Carbon-Carbon Multiple Bonds

Mechanism and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselectivity, orientation and reactivity. Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration. Michael reaction. Sharpless asymmetric epoxidation.

Unit V

Addition to Carbon-Hetero Multiple Bonds

Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds, acids, esters and nitriles. Wittig reaction.

Mechanism of condensation reactions involving enolates- Knoevenagel, Claisen, Mannich Benzoin, Perkin and Stobbe reactions.

Hydrolysis of esters and amides, ammonolysis of esters.

Unit VI

Elimination Reactions

The E2, E1 and E1cB mechanisms and their stereochemistry. Orientation of the double bond. Reactivity- effects of substrate structures, attacking base, the leaving group and the medium.

Mechanism and orientation in pyrolytic elimination.

Unit VII

Pericyclic Reactions

Molecular orbital symmetry, Frontier orbitals of ethylene, 1, 3-butadiene, 1, 3, 5-hexatriene and allyl system. Classification of pericyclic reactions. Woodward-Hoffmann.

Correlation diagrams. FMO and PMO approach. Electrocyclic reactions-conrotatory and suprafacial additions, 4n, and 4n+2 systems. Cycloadditions-antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1, 3 dipolar cycloadditions and cheleotropic reactions. Sigmatropic rearrangements- suprafacial and antarafacial shiffs of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5- sigmatropic rearrangements. Claisen, Cope and aza- Cope rearrangements. Fluxional tautomerism. Ene reaction.

Books suggested:-

1. Advanced Organic Chemistry- Reaction, Mechanism and Structure, Jerry March, John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, R.T. Morrison and R.N. Boyd, Prentice-Hall.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackwell.
8. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
9. Reaction Mechanism in Organic Chemistry, S.M. Mukherji and S.P. Singh, Macmillan.
10. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
11. Stereochemistry of Organic Compounds, P.S. Kalsi, New Age International.

SOS/C009	Physical Chemistry II	L	T	P	C	MM
		3	0	0	3	100

Unit I

Chemical Dynamics

Methods of determining rate laws, collision theory of reaction rates, steric factor, activated complex theory, Arrhenius equation and the activated complex theory; ionic reactions, kinetic salt effects, steady state kinetics, kinetic and thermodynamic control of reactions, treatment of unimolecular reactions.

Dynamic chain (hydrogen-bromine reaction, pyrolysis of acetaldehyde, decomposition of ethane), photochemical (hydrogen-bromine and hydrogen-chlorine reactions) and oscillatory reactions (Belousov-Zhabotinsky reaction), homogeneous catalysis, kinetics of enzymes reactions, general features of fast reactions, study of fast reactions by flow method, relaxation method, flash photolysis and the nuclear magnetic resonance method.

Dynamics of molecular motions, probing the transition state, dynamics of barrierless chemical reactions in solution, dynamics of unimolecular reactions (Lindemann-Hinshelwood and Rice-Ramsperger-Kassel-Marcus [RRKM] theories of unimolecular reactions).

Unit II

Statistical Thermodynamics

Concept of distribution, thermodynamic probability and most probable distribution. Ensemble averaging, postulates of ensemble averaging. Canonical, grand canonical and microcanonical ensembles, corresponding distribution laws- (using Lagrange's method of undetermined multipliers).

Partition functions- translational, rotational, vibrational and electronic partition functions.

Calculation of thermodynamic properties in terms of partition functions. Applications of partition functions.

Heat capacity behaviour of solids- chemical equilibria and chemical equilibrium constant in terms of partition functions, Fermi-Dirac statistics, distribution law and applications to metal.
Bose-Einstein statistics – distribution law and application to helium.

Non-Equilibrium Thermodynamics
Thermodynamic criteria for non-equilibrium states, entropy production and entropy flow, entropy balance equations for different irreversible processes (e.g., heat flow, chemical reaction etc.) transformations of the generalized fluxes and forces, non-equilibrium stationary states, phenomenological equations, microscopic reversibility and Onsager's reciprocity relations, electrokinetic phenomena, diffusion, electric conduction, irreversible thermodynamics for biological systems, coupled reactions.

Unit III
Electrochemistry
Electrochemistry of solutions, Debye-Huckel, Onsager treatment and its extension, ion solvent interactions.Thermodynamics of electrified interface equations. Structure of electrified interfaces. Guoy Chapman, Stern. Over potentials, exchange current density, derivation of Butler-Volmer equation, Tafel plot.

Semiconductor interfaces-theory of double layer at semiconductor, electrolyte solution interfaces, structure of double layer interfaces. Electrocatalyis – influence of various parameters. Hydrogen electrode. Bioelctrochemistry, threshold membrane phenomena. Polarography theory, Ilkovic equation, half wave potential and its significance. Introduction to corrosion, homogeneous theory, forms of corrosion, corrosion monitoring and prevention methods.

Books suggested:-

1. Physical Chemistry, P.W. Atkins, ELBS.
2. Coulson's Valence, R. McWeeny, ELBS.
3. Modern Electrochemistry, Vol. I & II, J.O.M. Bockris and A.K.N. Reddy, Plenum.
6. Introduction to Quantum Chemistry, A.K. Chandra, Tata McGraw Hill.
7. Quantum Chemistry, Ira N. Levine, Prentice Hall.

SOS/C010	Spectroscopy and Separation Methods	L	T	P	C	MM
		3	0	0	3	100

Unit I
Molecular Electronic Spectroscopy
Energy levels, molecular orbitals, vibronic transitions, vibrational progressions and geometry of excited states, Franck-Condon principle, Dissociation and pre-dissociation, electronic spectra of polyatomic molecules. Emission spectra, radiative and non-radiative decay, internal conversion,

Unit II
Raman Spectroscopy
Classical and quantum theories of Raman effect. Pure rotational, vibrational and vibrational-roatational Raman spectroscopy, selection rules, mutual exclusion principle. Resonance Raman spectroscopy, coherent anti Stokes Raman spectroscopy (CARS).

Unit III

Magnetic Resonance Spectroscopy

Nuclear Magnetic Resonance Spectroscopy

Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, chemical shift and its measurement, factor influencing chemical shift, deshielding, spin-spin interaction, factors influencing coupling constant 'J'. Classification (ABX, AMX, ABC, A_2B_2 etc.), spin decoupling, basic ideas about instrument, NMR studies of nuclei other than proton-^{13}C, ^{19}F and ^{31}P. FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.

Unit IV

Chromatographic Methods

Principle, instrumentation and applications of gas liquid chromatography and HPLC. Ion exchange chromatography: cationic and anionic exchanges and their applications. Van-Deemter equation (no derivation), concept about HEPT-plate theory and rate theory. Applications.

Unit V

Radio Analytical Methods

Basic principles and types of measuring instruments, isotope dilution techniques: principle of operations and uses. Applications.

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood.
3. Physical Method for Chemistry, R.S. Drago, Saunders Company.
4. Introduction of Molecular Spectroscopy, G.M. Barrow, McGraw Hill.
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
6. Theory and Applications of UV Spectroscopy, H.H. Jaffe and M. Orchin, IBH-Oxford.
7. Introduction to Magnetic Resonance, A. Carrington, A.D. Maclachalan, Harper & Row.
8. High Performance Liquid Chromatography, **Heinz** Engelhardt.
9. Instrumental Methods of Chemical Analysis, Willard, Meritt, Dean & Settle (Wiley Eastern).

SOS/C011	Laboratory Course-IIA	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 12 marks each from Inorganic, Organic and Physical sections.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

Inorganic Chemistry

Quantitative Analysis

Quantitative Analysis of mixtures of two metal ions involving Volumetric (by complexometric titration using masking and demasking agents) and gravimetric analysis.

Organic Chemistry

Organic Synthesis

Acetoacetic ester Condensation: Synthesis of ethyl-n-butylacetoacetate by A.E.E. condensation.
Cannizzaro reaction: 4-Chlorobenzaldehyde as substrate
Aromatic electrophilic Substitutions: Synthesis of p-nitroaniline and p-bromoaniline.
The products may be characterized by Spectral Techniques where possible.

Physical Chemistry

Solutions

1. Determination of molecular weight of non-volatile and non-electrolyte/electrolyte by cryoscopic method and to determine the activity coefficient of an electrolyte.
2. Determination of the degree of dissociation of weak electrolyte and to study the deviation from ideal behaviour that occurs with a strong electrolyte.

SOS/C012	Laboratory Course-IIB	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 12 marks each from Inorganic, Organic and Physical sections.

Viva 09 marks
Seminar/Attendance/Assessment/Record 15 marks.

Inorganic Chemistry

Preparations

Preparation of selected inorganic compounds:
$VO(acac)_2$
$TiO(C_9H_8NO)_2.2H_2O$
$cis\text{-}K[Cr(C_2O_4)_2(H_2O)_2]$
$Na[Cr(NH_3)_2(SCN)_4]$
$Mn(acac)_3$
$K_3[Fe(C_2O_4)_3]3H_2O$
Prussian Blue, Tumbull's Blue
$Co[(NH_3)_6]Cl_3$
$[Cu(en)_2(H_2O)_2]I_2$
Cu_2HgI_4
$[Co(Py)_2Cl_2]$
$[Ni(NH_3)_6]Cl_2$
Tris-(thiourea) copper (I) sulphate $[Cu(tu)_3]SO_4.2H_2O$
$K_3[Cr(C_2O_4)_3]$

Organic Chemistry

Quantitative Analysis

Determination of the percentage or number of hydroxyl groups in an organic compound by acetylation method.
Estimation of amines/phenols using bromate bromide solution/or acetylation method.
Determination of Iodine and Saponification values of an oil sample
Determination of DO, COD and BOD of water sample.

Physical Chemistry

Electrochemistry

Potentiometry/pH-metry

1. Determination of strengths of halides in a mixtures potentiometrically.
2. Determination of the valency of mercurous ions potentiometrically.
3. Determination of the strength of strong and weak acids in a given mixture using a potentiometer/pH meter.
4. Determination of temperature dependence of EMF of a cell.
5. Determination of the formation constant of silver-ammonia complex and stiochiometry of the complex potentiometrically.
6. Acid-base titration in a non-aqueous media using a pH meter.
7. Determination of activity and activity coefficient of electrolytes.
8. Determination of the dissociation constant of acetic acid in DMSO, DMF, acetone and dioxane by titrating it with KOH.
9. Determination of the dissociation constant of monobasic/dibasic by Albert-Serjeant method.
10. Determination of thermodynamic constants ΔG, ΔS and ΔH for the reaction by e.m.f. method.

$$Zn + H_2SO_4 \longrightarrow ZnSO_4 + 2H$$

Semester- III

Inorganic Chemistry

		L	T	P	C	MM
SOS/C013	Laboratory Course-IIIA Inorganic	0	0	**9**	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 36 marks.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

Preparation

Synthesis of selected inorganic compounds/complexes and their characterization by IR, electronic spectra (UV & Visible), NMR, Mossbauer, ESR and magnetic susceptibility etc. measurement. Selection can be made from the following or any other from the existing literature.

(i). Cis and Trans isomers of $[Co(en)_2Cl_2]$ Cl.
J. Chem. Soc., 1960, 4369.

(ii). Metal acetylacetonates: $Cr(acac)_3$; Vanadyl acetylacetonate, $Cu(acac)_2.H_2O$ etc.
Inog. Synth., 1957, 5, 130; 1, 183.
(iii). Ferrocene
J. Chem. Edu., 1966, 43, 73; 1976, 53, 730.
(iv). Cr(III) complexes: $[Cr(H_2O)_6](NO_3)_3.3H_2O$;$[Cr(H_2O)_4\ Cl_2]\ Cl.2H_2O$; $[Cr(en)_3]Cl_3$
Inorg. Synth., 1972, 13, 184.
(v). Tin (IV) iodide, Tin (IV) chloride, Tin (II) iodide.
Inorg. Synth., 1953, 4, 119.
(vi). Mixed valence dinuclear complexes of manganese (III, IV).
(vii). Preparation of triphenyl phosphine and its transition metal complexes.
(viii). Reaction of Cr (III) with multidentate ligand, a kinetic experiment (visible spectra of Cr-EDTA complex). J. Am. Chem. Soc., 1953, 75, 5670.
(ix). Other new synthesis reported in literature.
(x). Bromination of $Cr(acac)_3$.
J. Chem. Edu., 1986, 63, 90.
(xi). Preparation of copper glycine complex-cis and trans bis glycinato copper (II).
J. Chem. Edu., 1982, 59, 1052.
(xii). Relative stability of Tin (IV) and Pb (IV), Preparation of ammonium hexachlorostannate,$(NH_4)_2SnCl_6$ and ammonium hexachloroplumbate; $(NH_4)_2\ PbCl_6$.

Books Suggested

1. Vogel's Text Book of Qualitative Analysis, ELBS .
2. Vogel's Text Book of Quantitative Analysis, ELBS.
3. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.

SOS/C014	Laboratory Course-IIIB Inorganic	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 36 marks.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

Analysis of ores, alloys and inorganic substances by various chemical methods.

Books Suggested

1. Vogel's Text Book of Qualitative Analysis, ELBS .
2. Vogel's Text Book of Quantitative Analysis, ELBS.
3. Synthesis and Characterization of Inorganic Compounds, W.L. Jolly, Prentice Hall.

SOS/C015	Organometallic Chemistry	L	T	P	C	MM
		3	0	0	3	100

I. Alkyls and Aryls of Transition Metals

Alkyls and aryls of transition metals, nature of metal carbon bond, routes of synthesis, stability and decomposition pathways and their structure. Alkyls and aryls of s-block and p-block elements. Comparison of such transition and non-transition element derivatives. Organocopper in organic synthesis.

II. Compounds of Transition metal-carbon multiple bonds

Alkylidenes, alkylydines, low valent carbenes and carbynes-synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis.

III. Transition Metal π-Complexes

Transition Metal π-Complexes with unsaturated organic molecules. Alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes; preparation, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis.

IV. Metal Compounds with bonds to Hydrogen

Transition metal compounds with bonds to hydrogen.

V. Homogeneous Catalysis

Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerization of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladation reaction, activation of C-H bond.

VI. Fluxional Organometallic Compounds

Fluxionality and dynamic equilibria in compounds such as η^2-olefin, η^3-allyl and dienyl complexes, their characterization.

Books Suggested:

1. Principle and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.P. Norton and R.G. Finke. University Science Books.
2. The Organometallic Chemistry of the Transition Metals, R.H. Crabtree, John Wiley.
3. Metallo-organic Chemistry, A.J. Pearson, Wiley.
4. Organometallic Chemistry, R.C. Mehrotra and A. Singh; New Age International.
5. Organometallic Compounds, NLH Green, Chapman & Hall, U.K.
6. Principles of Organometallic Chemistry, G.E. Coates, MLH Green, P. Powell, Chapman & Hall, U.K.

SOS/E001	Spectroscopy, X-ray and Solid State	L	T	P	C	MM
		3	0	0	3	100

I. Ultraviolet and Visible Spectroscopy

Instrumentation, source, monochromators, detectors, single and double beam instruments, applications.

II. Infrared Spectroscopy

Instrumentation, source, monochromators, optics of double beam instruments, detectors, sample preparation, applications.

III. X-Ray Diffraction

Bragg condition, Miller indices, Laue method, Bragg method, Debye-Scherrer method of X-ray structural analysis of crystals, index reflections, identification of unit cells from systematic absences in diffraction pattern. Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules, Ramchandran diagram.

IV. Electron Diffraction

Scattering intensity vs. scattering angle, Wire equation, measurement technique, elucidation of structure of simple gas phase molecules. Low energy electron diffraction and structure of surfaces.

V. Neutron Diffraction

Scattering of neutrons by solids and liquids, magnetic scattering, measuring techniques. Elucidation of structure of magnetically ordered unit cell.

VI. Solid State Chemistry

Solid State Reactions

General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

Books Suggested:

1. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
2. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS.
3. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
4. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
5. Solid State Chemistry and its Applications, A.R. West, Plenum.
6. Solid State Chemistry, D.K. Chakrabarty, New Age International.
7. Symmetry and Spectroscopy, K. Veera Reddy, New Age International, 1998.
8. Instrumental Methods of Analysis, Willard et al., 7th Edn., CBS Publishers.

SOS/E002	Bioinorganic, Bioorganic Biophysical Chemistry-I	L	T	P	C	MM
		3	0	0	3	100

A) Bioinorganic Chemistry

I. Metal Ions in Biological Systems, Na^+/K^+ Pump

Essential and trace metals. Role of metal ions in biological processes. Na^+/K^+ Pump.

II. Bioenergetics and ATP Cycles

DNA polymerization, glucose storage, metal complexes in transmission of energy; chlorophylls, photo system I and photo system II in cleavage of water. Model systems.

III. Transport and Storage of Dioxygen

Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, model synthetic complexes of iron, cobalt and copper.

B) Bioorganic Chemistry

I. Enzymes & Mechanism of Enzyme Action

Introduction and historical perspective, chemical and biological catalysis, properties of enzymes-catalytic power, specificity and regulation. Fischer's lock and Koshland's induced fit hypothesis, concept and identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed, mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible inhibition. Transition-state theory, acid-base catalysis, covalent catalysis, strain of distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.

II. Kinds of Reactions Catalysed by Enzymes

Nucleophillic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Transfer of sulphate, addition and elimination reactions, enolic intermediates in isomerization reactions, β-cleavage and condensation, some isomerization and rearrangement reactions. Enzyme catalyzed carboxylation and decarboxylation.

C) Biophysical Chemistry

I. Biological Cell and its Constituents, Cell Membrane and Transport of Ions

Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition. Structure and functions of cell membrane, ion transport through cell membrane.

II. Bioenergetics

Standard free energy change in biological reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.

Books Suggested

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
2. Bioinorganic Chemistry, I. Berteni, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Bioinorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.

4. Understanding Enzymes, Trevor Palmer, Prentice Hall.
5. Enzyme Chemistry: Impact and Applications, Ed. Colliins J Sucking, Chapman and Hall.
6. Enzymes Mechanism Ed, M.I. Page and A. Williams, Royal Society of Chemistry.
7. Fundamentals of Enzymology, N.C. Price and L. Stevens, Oxford University Press.
8. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
9. Enzymatic Reaction Mechanism, C. Walsh, W.H. Freeman.
10. Enzymatic Structure and Mechanism, W.H. Freeman.
11. Principles of Biochemistry, A.L. Lehninger, Worth Publishers.
12. Biochemistry, L. Stryer, W.H. Freeman.
13. Biochemisty, J. David Rawn, Neil Patterson.
14. Biochemistry, Voet and Voet, John Wiley.
15. Outlines of Biochemistry, E.E. Conn and P.K. Stumpf, John Wiley.
16. Macromolecules: Structure and function, F. World, Prentice Hall.

SOS/E003	Bioinorganic and Supramolecular Chemistry	L	T	P	C	MM
		3	0	0	3	100

Unit I
Metal Storage Transport and Biomineralization
Ferritin, Transferrin, and siderophores
Unit II
Calcium in Biology
Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes, extracellular binding proteins.

Unit III
Metalloenzymes
Zinc enzymes-carboxypeptidase and carbonic anhydrase. Iron enzymes-catalase, peroxidase and cytochrome P-450. Copper enzymes-superoxide dismutase. Molybdenum oxatransferase enzymes-xanthine oxidase. Coenzymes vitamin B_{12}.

Unit IV
Metal-Nucleic Acid Interactions
Metal ions and metal complex interactions. Metal complexes-nucleic acids.

Unit V
Metals in Medicine
Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy with particular reference to anticancer drugs.

Unit VI
Supramolecular Chemistry
Molecular recognition: Molecular receptors for different types of molecules including arisonic substrates, design and synthesis of co-receptor molecules and multiple recognition. H-bonds in

supramolecular structures. Use of H-bond in crystal engineering and molecular recognition. Chelate and macrocyclic effects. Cation binding hosts, binding of anions, binding of neutral molecules, binding of organic molecules. Supramolecular reactivity and catalysis. Transport processes and carrier design. Supramolecular devices, supramolecular photochemistry, supramolecular electronic, ionic and switching devices. Some examples of self-assembly in supramolecular chemistry.

Books Suggested:

1. Supramolecular Chemistry, J.M. Lehn, VCH.
2. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
3. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
4. Inorganic Biochemistry, vols I and II. Ed. G.L. Eichhorn, Elsevier.
5. Progress in inorganic Chemistry, vols 18 and 38 ed. J.J. Lippard, Wiley.

		L	T	P	C	MM
SOS/E004	Analytical Chemistry	3	0	0	3	100

Unit I

Introduction

Role of analytical chemistry. Classification of analytical methods-classical and instrumental. Types of instrumental analysis. Selecting an analytical method. Neatness and cleanliness. Laboratory operations and practices. Analytical balance. Techniques of weighing, errors. Volumetric glassware-cleaning and calibration of glassware. Sample preparations-dissolution and decompositions. Gravimetric techniques. Selecting and handling of reagents. Laboratory notebooks. Safety in the analytical laboratory.

Unit II

Errors

Determinate and indeterminate errors, minimization of determinate errors, random distribution of indeterminate errors.

Unit III

Statistical data analysis

Accuracy and precision, significant figures and computations, mean and standard deviation, distribution of random errors, reliability of results, confidence interval, comparison of results, comparison of means of two samples, paired t-test, number of replicate determinations and its use, correlation and regression, linear regression, analysis of variance, rejection of data.

Unit IV

Application of analytical chemistry in the study of water and soil pollutions, analysis of fuel, body fluids and drugs

Books Suggested:

1. Analytical Chemistry, G.D. Christian, J. Wiley.
2. Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, W.B. Saunders.
3. Analytical Chemistry-Principles, J.H. Kennedy, W.B. Saunders.

4. Analytical Chemistry-Principles and Techniques, L.G. Hargis, Prentice Hall.
5. Principles of Instrumental Analysis, D.A. Skoog and J.L. Loary, W.B. Saunders.
6. Quantitative Analysis, R.A. Day, Jr. and A.L. Underwood, Prentice Hall.
7. Environmental Solution Analysis, S.M. Khopkar, Wiley Eastern.
8. Basic Concepts of Analytical Chemistry, S.M. Khopkar, Wiley Eastern.
9. Handbook of Instrumental Techniques for Analytical Chemistry, F. Settle, Prentice Hall.

Organic Chemistry

		L	T	P	C	MM
SOS/C016	Laboratory Course-Org IIIA	0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 36 marks.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

Qualitative Analysis

Separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid), using TLC for checking the purity of the separated compounds. Preparation of derivatives and spectral analysis.

Books Suggested

1. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
2. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
3. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.
4. Laboratory Manual of Organic Chemistry, RK Bansal, New Age International, Delhi.

		L	T	P	C	MM
SOS/C017	Laboratory Course-Org IIIB	0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 36 marks.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

Multi-step Synthesis of Organic Compounds

The exercise should illustrate the use of organic reagents and may involve purification of the products by chromatographic techniques.

Photochemical reaction

Benzophenone ⟶ Benzpinacol ⟶ Benzpinacolone

Beckmann rearrangement: Benzanilide from benzene

Benzene ⟶ Benzophenone ⟶ Benzophenone oxime ⟶ Benzanilide

Benzilic acid rearrangement: Benzilic acid from benzoin

Benzoin ⟶ Benzil ⟶ Benzilic acid

Synthesis of heterocyclic compounds

Skraup synthesis: Preparation of quinoline from aniline. Fisher-Indole synthesis: Preparation of 2-phenyl indole from phenylhydrazine.

Enzymatic Synthesis

Enzymatic reduction: Reduction of ethyl acetoacetate using Baker's yeast to yield enantiomeric excess of S (+) ethyl-3-hydroxybutanoate and determine its optical purity.

Biosynthesis of ethanol from sucrose

Synthesis using microwaves

Alkylation of diethyl malonate with benzyl chloride.

Synthesis using phase transfer catalyst.

Alkylation of diethyl malonate or ethylacetoacetate with an alkyl halide.

Books Suggested

1. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
2. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
3. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.
4. Laboratory Manual of Organic Chemistry, RK Bansal, New Age International, Delhi.

		L	T	P	C	MM
SOS/C018	Organic Synthesis and Photochemistry	3	0	0	3	100

Unit I

Disconnection Approach

An introduction to synthons and synthetic equivalents disconnection approach, functional group interconversions, the importance of order of events in organic synthesis, one group C-X and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions and amine synthesis.

Unit II

Protecting Groups

Principle of protection of alcohols, amine, carbonyl and carboxyl groups

Unit III

One Group and Two Group C-C Disconnections

Alcohols and carbonyl compounds regioselectivity. Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis. Diels-Alder reaction, 1,3-difunctional compounds, α,β-unsaturated carbonyl compounds, control in carbonyl condensations. Micheal addition and Robinson annelation.

Unit IV

Determination of Reaction Mechanism

Classification, rate constants and life times of reactive energy states-determination of rate constants of reactions. Effect of light intensity on the rate of photochemical reactions. Types of photochemical reactions, photo-dissociation, gas-phase photolysis.

Unit V

Photochemical Reactions

Intramolecular reactions of the olefinic bond-geometrical isomerism, cyclisation reactions, rearrangement of 1,4-and 1,5-dienes.

Intramolecular reactions of carbonyl compounds-saturated cyclic and acyclic, β,γ-unsaturated and α,β-unsaturated compounds. Cyclohexadienones.

Intramolecular cycloaddition reactions-dimerisation and oxetane formation.

Isomerisation, additions and substitutions.. Photo-Fries rearrangement, Barton reaction.

Books Suggested:

1. Modern Synthetic Reactions, H.O. House, W.A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3. Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March, John Wiley.
4. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
5. Advanced Organic Chemistry Part B, F.A. Carey and R.J. Sundberg, Plenum Press.
6. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
7. Designing Organic Synthesis, S. Warren, Wiley.
8. Organic Synthesis-Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, Verlag VCH.
9. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, New Age International
10. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication
11. Molecular Photochemistry, N.J. Turro, W.A. Benjamin
12. Introductory Photochemistry, A. Cox and T. Camp, McGraw Hill
13. Photochemistry, R.P. Kundall and A. Gilbert, Thomson Nelson
14. Organic Photochemistry, J. Coxon and B. Halton, Cambridge University Press

SOS/E005	Spectroscopy and Solid State	L	T	P	C	MM
		3	0	0	3	100

Unit I

Ultraviolet

and Visible Spectroscopy

Effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.

Unit II

Infrared Spectroscopy

General idea of the vibrational frequencies of aliphatic and aromatic hydrocarbons, amines, carbonyl compounds, acid and acid derivatives and conjugated carbonyl compounds, effect of hydrogen bonding and solvent on IR.

Unit III

Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD)

Definition, deduction of absolute configuration and octant rule for ketones.

Unit IV

Solid State Chemistry

(a). Solid State Reactions

General principles, experimental procedures, co-precipitation as a precursor to solid state reactions, kinetics of solid state reactions.

(b). Organic Solids, Fullerene, Molecular devices

Electrically conducting solids, organic charge transfer complex, organic metals, magnetism in organic materials, fullerenes and doped fullerenes, organic superconductors, molecular rectifiers, transistors, artificial photosynthetic devices, molecular memory, switches and sensors.

Books Suggested

1. Physical Method for Chemistry, R.S. Drago, Saunders Company.
2. Structural Method in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS.
3. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
4. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
5. Solid State Chemistry and its Applications, A.R. West, Plenum.
6. Solid State Chemistry, D.K. Chakrabarty, New Age International.

		L	T	P	C	MM
SOS/E006	Organometallic Reagents and Organic Synthesis	3	0	0	**3**	100

Unit I

Principles, preparations, properties and applications of the following in organic synthesis with mechanistic details.

Group I and II metal organic compounds

Li and Hg compounds.

Transition metals

Pd, Ni and Cr compounds.

Other elements

Si and B compounds.

Unit II

Oxidation

Introduction. Different oxidative processes.

Hydrocarbons- alkenes, aromatic rings, saturated C-H groups (activated and inactivated).

Alcohols, diols, aldehydes, ketones, ketals and carboxylic acids.
Amines, hydrazines, and sulphides.
Oxidations with ruthenium tetraoxide, iodobenzene diacetate and thallium (III) nitrate.

Unit III
Reduction
Introduction. Different reductive processes.
Reduction of hydrocarbons- alkenes, alkynes and aromatic rings.
Reduction of carbonyl compounds (aldehydes, ketones, acids and their derivatives). Epoxides.
Reduction of nitro, nitroso, azo and oxime groups.
Hydrogenolysis.

Unit IV
Rearrangements
General mechanistic considerations-nature of migration, migratory aptitude, memory effects
A detailed study of the following rearrangements
Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert synthesis, Neber, Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction

Unit V
Metallocenes, Nonbenzenoid Aromatics and Polycyclic Aromatic Compounds
General considerations, synthesis and reactions of some representative compounds

Books Suggested:

1. Modern Synthetic Reactions, H.O. House, W.A. Benjamin.
2. Some Modern Methods of Organic Synthesis, W. Carruthers, Cambridge Univ. Press.
3. Advanced Organic Chemistry, Reactions Mechanisms and Structure, J. March, 6th Edn., John Wiley.
4. Principles of Organic Synthesis, R.O.C. Norman and J.M. Coxon, Blackie Academic & Professional.
5. Advanced Organic Chemistry Part B, F.A. Carey and R.J. Sundberg, Plenum Press.
6. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
7. Designing Organic Synthesis, S. Warren, Wiley.
8. Organic Synthesis-Concept, Methods and Starting Materials, J. Fuhrhop and G. Penzillin, Verlag VCH.

SOS/E007	Medicinal Chemistry	L	T	P	C	MM
		3	0	0	3	100

Unit I
Drug Design
Development of new drugs, procedures followed in drug design, concepts of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAR) factors affecting bioactivity, resonance, inductive effect, isosterism, bio-isosterism, spatial considerations. Theories of drug activity: occupancy theory, rate theory, induced fit theory. Quantitative structure activity relationship. History and development of QSAR. Concepts of drug receptors. Elementary treatment of drug receptor interactions. Physico-chemical parameters: lipophilicity, partition coefficient, electronic ionization constant, steric, Shelton and surface activity parameters and redox potentials. Free Wilson

analysis, Hansch analysis, relationships between Free-Wilson and Hansch analysis. LD-50, ED-50 (Mathematical derivations of equations excluded).

Unit II

Pharmacokinetics

Introduction to drug absorption, disposition, elimination using pharmacokinetics, important pharmacokinetic parameters in defining drug disposition and in therapeutics. Mention of uses of pharmacokinetics in drug development process.

Unit III

Pharmacodynamics

Introduction, elementary treatment of enzyme stimulation, enzyme inhibition, sulphonamides, membrane active drugs, drug metabolism, xenobiotic, biotransformation, significance of drug metabolism in medicinal chemistry.

Unit IV

Antineoplastic Agents

Introduction, cancer chemotherapy, special problems, role of alkylating agents and antimetabolites in treatment of cancer. Mention of carcinolytic antibiotics and mitotic inhibitors. Synthesis of mechlorethamine, cyclophosphamide, melphalan, uracil, mustards, and 6-mercaptopurine. Recent development in cancer chemotherapy. Hormone and natural products.

Unit V

Antibiotics

Cell wall biosynthesis inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis. Synthesis of penicillin G, penicillin V, ampicillin, amoxycillin, chloramphenicol, cephalosporin, tetracycline and streptomycin.

Books suggested

1. Introduction to Medicinal Chemistry, A. Gringuage, Wiley-VCH.
2. Wilson and Gisvold's: Text Book of Organic Medicinal and Pharmaceutical Chemistry, Ed. Robert F. Dorge.
3. An Introduction to Drug Design, S.S. Pandeya and J.R. Dimmock, New Age International.
4. Burger's Medicinal Chemistry and Drug Discovery, Vol-I, Ed. M.E. Wolff, John Wiley.
5. Goodman and Gilman's Pharmacological Basis of Therapeutics, McGraw-Hill.
6. The Organic Chemistry of Drug Design and Drug Action, R.B. Silverman, Academic Press.
7. Strategies for Organic Drug Synthesis and Design, D. Lednicer, John Wiley.

Physical Chemistry

SOS/C019	Laboratory Course Phy.IIIA	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 36 marks.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

1. Verification of the law of photochemical equivalence.
2. Order of reaction by:
(a). Isolation Method.
(b). Half life period method
(c). Integration method
3. Temperature coefficient of a reaction.
4. Energy of activation of a reaction.
5. Entropy of a reaction.
6. Determination of pH by following methods:
(a). Electrical Conductivity.
(b). E.M.F.
(c). Polarography

SOS/C020	Laboratory Course Phy.-IIIB	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do one exercise of 36 marks.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

1. Hydrolysis of the salts by following methods:
(a). Cryoscopic
(b). Electrical Conductivity.
(c). E.M.F.
2. Study of complex formation by the following methods and determination of stability constant wherever practicable:
(a). Cryoscopic
(b). Electrical Methods.
(c). E.M.F.
3. Determination of solubility of sparingly soluble salts by the following methods:
(a). Electrical Conductivity.
(b). E.M.F.
4. Dissociation constants of polybasic acids.

SOS/C021	Chemistry of Materials	L	T	P	C	MM
		3	0	0	3	100

Unit I

Multiphase Materials

Ferrous alloys; Fe-C phase transformations in ferrous alloys; stainless steels, non-ferrous alloys, properties of ferrous and non-ferrous alloys and their applications

Unit II

Glasses, Ceramics, Composites and Nanomaterials

Glassy state, glass formers and glass modifiers, applications. Ceramic structures, mechanical properties, clay products. Refractories, characterizations, properties and applications.
Microscopic composites; dispersion-strengthened and particle-reinforced, firbe-reinforced composites, macroscopic composites. Nanocrystalline phase, preparation procedures, special properties, applications.

Unit III
Thin Films and Langmuir-Blodgett Films
Preparation techniques; evaporation/sputtering, chemical processes, MOCVD, sol-gel etc.
Langmuiur-Blodgett (LB) film, growth techniques, photolithography, properties and applications of thin and LB films.

Unit IV
Liquid Crystals
Mesomorphic ehavior, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases; smectic-nematic transition and clearing temperature-homeotropic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic C phases, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals.

Unit V
Polymeric Materials
Molecular shape, structure and configuration, crystallinity, stress-strain ehavior, thermal ehavior, polymer types and their applications, conducting and ferro-electric polymers.

Unit VI
Ionic Conductors
Types of ionic conductors, mechanism of ionic conductors, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors.

Unit VII
High T_c Materials
Defect perovskites, high T_c superconductivity in cuprates, preparation and characterization of 1-2-3 and 2-1-4 materials, normal state properties; anisotropy; temperature dependence of electrical resistance; optical phonon modes, superconducting state; heat capacity; coherence length, elastic constants, position lifetimes, microwave absorption-pairing and multigap structure in high T_c materials, applications of high T_c materials.

Books Suggested

1. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Saunders College.
2. Material Science and Engineering, An Introduction, W.D. Callister, Wiley.
3. Principles of the Solid State, H.V. Keer, Wiley Eastern.
4. Materials Science, J.C. Anderson, K.D. Leaver, J.M. Alexander and R.D. Rawlings, ELBS.
5. Thermotropic Liquid Crystals, Ed., G.W. Gray, John Wiley.
6. Handbook of Liquid Crystals, Kelker and Hatz, Chemie Verlag.
7. Inorganic Materials:Recent Advances,Editors D.Bahadur *et al.*,Narosa
8. Ion Conducting Materials: Theory and Applications, Editor A. R. Kulkarni, Narosa.

		L	T	P	C	MM
SOS/E008	Liquid State	3	0	0	3	100

Unit I

General Properties of Liquids

(a) Liquids as dense gases, liquids as disordered solids, some thermodynamics relations, internal pressure and its significance in liquids. Equations of state, critical constants. Different types of intermolecular forces in liquids, different potential functions for liquids. Additivity of pair potential approximation.

(b) A classical partition function for liquid for liquids, correspondence principle, configuration integral, configuration properties.

Unit II

Theory of Liquids

Theory of liquids, partition function method or model approach, single cell models, communal energy and entropy, LTD model, significant structure model.

Unit III

Distribution Function and Related Equations

Radial distribution function method, equation of state in terms of RDF, Molecular distribution functions, pair distribution function. Relationship between pair distribution function and pair potential function. The IBG equation, the HNC equation, the PY equation, cluster expansion.

Unit IV

Methods for Structure Determination and Computational Techniques

Spectroscopic techniques for liquid dynamic structure studies, Neutron and X-ray scattering spectroscopy.

Computation Techniques- Monte Carlo and molecular dynamics methods.

Unit V

Supercooled and Ionic Liquids.

Supercooled and ionic liquids, theories of transport properties; non Arrhenius ehavior of transport properties, Cohen-Turnbull free volume model, configurational entropy model, Macedo-Lltovitz hybrid model, glass transition in supercooled liquids.

Books Suggested

1. An Introduction to Liquid State, P.A. Egeistaff, Academic Press.
2. The Dynamic Liquid State, A.F.M. Barton, Longman.
3. Introduction to Statistical Thermodynamics, T.L. Hill, Addison Wiley.
4. The Liquid State, J.A. Pryde.
5. Significant Liquid Structures, H. Eyring and M.S. John.

SEMESTER IV

Inorganic Chemistry

SOS/C022	Laboratory Course-Inorg. IVA	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do two exercise of 18 marks each.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

I. Spectrophotometric Determinations

(a). Manganese/chromium/vanadium in steel sample.
(b). Nickle/molybdenum/tungsten/vanadium/uranium by extractive Spectrophotometric method.
(c). Fluoride/nitrite/phosphate.
(d). Iron-phenanthroline complex: Job's Method of continuous variation.
(e). Zirconium-alizarin Red-S complex: Mole-ratio method.
(f). Copper-ethylene diamine complex: Slope –ratio method.

II. Flame Photometric Determinations

(a). Sodium and Potassium when present together.
(b). Lithium/Calcium/barium/strontium.
(c). Cadmium and magnesium in tap water.

SOS/C023	Laboratory Course-Inorg. IVB	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do two exercises of 18 marks each.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

I. Nephelometric Determinations

(a). Sulphate
(b). Phosphate
(c). Silver

II. Chromatographic separations: Paper or TLC and determination of Rf values:

(a). Cadmium and Zinc.
(b). Silver, Lead and Mercury.
(c). Nickel, Magnesium, Cobalt and Zinc.

SOS/C024	Inorganic Polymers	L	T	P	C	MM
		3	0	0	3	100

Unit I

Inorganic polymer synthesis, step-growth and step condensation synthesis of metal containing polymers.

Unit II
Condensation of functionalised metal containing species, condensation through bridged ligand coordination, bridging ligand formation during condensation, synthesis of main group condensation polymer.

Unit III
Polycarboranes, polycarbosilanes, polythalocyanines, polysiloxanes.

Unit IV
Chain polymerisations, radical and cationic polymerisations.

Unit V
Inorganic polymer characterization, methods of characterizing average molecular masses.

Unit VI
Glass transition temperature measurement, spectroscopic characterization specific to inorganic polymers, use of NMR and EPR in characterization of inorganic polymers, use of electronic, vibrational, Mossbauer spectroscopies in charaterization of inorganic polymers, visco-elasticity measurements. Crystallinity characterization.

Unit VII
Polymer elastomers, inorganic dental polymers, adhesives, inorganic high temperature fluids and lubricants.

Unit VIII
Inorganic polymer conductivity, metal containing polymers, metal containing polymers in non linear optics, luminescent inorganic polymers.

Books suggested
1. Inorganic and Organometallic Polymers, Ronald D. Archer, Wiley VCH, 2001.
2. Inorganic Polymers, J. E. Mark et al., Prentice Hall, 1992.

SOS/E009	Spectroscopy	L	T	P	C	MM
		3	0	0	3	100

Unit I
Electron Spin Resonance Spectroscopy
Principle and theory, Kramer degeneracy, g factor, electron-nuclear coupling (hyperfine structure), line shape and width, Mc Connell relationship, endor and eldor, electron-electron coupling. Techniques of measurement, application of ESR to organic free radicals and to transitional metal complexes (having and unpaired electron) including biological systems.

Unit II

Nuclear Magnetic Resonance Spectroscopy

(a). Chemical shift values for protons bonded to carbon (aliphatic, olelinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, carboxylic acids, amines, amides), chemical exchange, effects of deuteration, Karplus curve-variation of coupling constant with dihedral angle.

(b). Carbon-13 NMR Spectroscopy

General consideration, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl compound), coupling constants.

(c). **Nuclear Quadrupole Resonance:** Principle, Theory and applications

Unit III

Mass Spectrometry

Principle and theory, fundamental mass equation, ionization methods, odd and even electron ions, base peak, isotopic ions, fragmentation patterns, Mc Lafferty rearrangement and RD cleavage, Instrumentation; ESIMS, various analyzers used in mass spectrometry, application of mass spectrometry to the structure elucidation of organic molecules

Unit IV

Photoelectron Spectroscopy

Basic principles, photoelectric effect, ionization process, Koopman's Theorem, photoelectron spectra of simple molecules, ESCA, chemical information from ESCA, Auger electron spectroscopy-basic idea.

Books Suggested

1. Physical Method for Chemistry, R.S. Drago, Saunders Company.
2. Structural Method in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
3. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood.
4. Practical NMR Spectroscopy, M.L. Martin, J.J. Delpeuch and G.J. Martin, Heyden.
5. Spectrometric Identification of Organic Compounds, R.M. Silverstein, G.C. Bassler and T.C. Morrill, John Wiley.
6. Introduction to NMR Spectroscopy, R.J. Abraham, J. Fisher and P. Loftus, Wiley.
7. Spectroscopic Methods in Organic Chemistry, D.H. Williams, I. Fleming, Tata McGraw-Hill.
8. Introduction to Spectroscopy, D.L. Pavia, G.M. Lampman, G.S. Kritz, Thompson Asia Pvt. Ltd., Singapore.
9. Electronic spectroscopy, D.N. Sathyanarayan, Universities Press.
10. Interpretation of Mass Spectra, F.W. McLafferty, University Science Books,California.

SOS/E010	Bioinorganic, Bioorganic, Biophysical Chemistry-II	L	T	P	C	MM
		3	0	0	3	100

Unit I

Bioinorganic Chemistry

1. **Electron Transfer in Biology**

   Structure and function of metalloproteins in electron transport processes-cytochromes and ion-sulphur proteins, synthetic models.

2. **Nitrogenase**

   Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

Unit II

Bioorganic Chemistry

1. **Co-Enzyme Chemistry**
   Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD^+, $NADP^+$, FMN, FAD, lipoic acid, vitamin B_{12}. Mechanisms of reactions catalyzed by the above cofactors.
2. **Enzyme Models**
   Host-guest chemistry, chiral recognition and catalysis, molecular recognition, molecular asymmetry and prochirality. Biomimetic chemistry, crown ethers, cryptates. Cyclodextrins, cyxlodextrin-based enzyme models, calixarenes, ionophores, micelles, synthetic enzymes.
3. **Biotechnological Applications of Enzymes**
   Large-scale production and purification of enzymes, techniques and methods of immobilization of enzymes, use of enzymes in food and drink industry, brewing and cheese-making, syrups from corn starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

Unit III

Biophysical Chemistry

1. **Statistical Mechanism in Biopolymers**
   Chain configuration of macromolecules, statistical distribution, end-to-end dimensions, calculation of average dimensions for various chain structures. Polypeptide and protein structures, introduction to protein folding problem.
2. **Biopolymer Interactions, Thermodynamics of Biopolymer Solutions**
   Forces involved in biopolymer interactions. Electrostatic charge and molecular expansion, hydrophobic forces, dispersion force interactions. Multiple equilibria and various types of binding processes in biological systems. Thermodynamics of biopolymer solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in mechanochemical system.
3. **Biopolymers and their Molecular Weights**
   Evaluation of size, shape, molecular weight and extent of hydration of biopolymers by various experimental techniques. Sedimentation equilibrium, hydrodynamic methods, diffusion, sedimentation velocity, viscosity, electrophoresis and rotational motions.

Books Suggested

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Bioinorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.
4. Understanding Enzymes, Trevor Palmer, Prentice Hall.
5. Enzyme Chemistry: Impact and Applications, Ed. Colliins J Sucking, Chapman and Hall.
6. Enzymes Mechanism Ed, M.I. Page and A. Williams, Royal Society of Chemistry.
7. Fundamentals of Enzymology, N.C. Price and L. Stevens, Oxford University Press.
8. Immobilized Enzymes: An Introduction and Applications in Biotechnology, Michael D. Trevan, John Wiley.
9. Enzymatic Reaction Mechanism, C. Walsh, W.H. Freeman.
10. Enzymatic Structure and Mechanism, W.H. Freeman.
11. Principles of Biochemistry, A.L. Lehninger, Worth Publishers.
12. Biochemistry, L. Stryer, W.H. Freeman.
13. Biochemisty, J. David Rawn, Neil Patterson.
14. Biochemistry, Voet and Voet, John Wiley.

15. Outlines of Biochemistry, E.E. Conn and P.K. Stumpf, John Wiley.
16. Macromolecules: Structure and function, F. World, Prentice Hall.

SOS/E011	Photoinorganic Chemistry	L	T	P	C	MM
		3	0	0	3	100

Unit I
Basics of photochemistry
Absorption, excitation, photochemical laws, electronically excited states-life times, measurements of the times. Flash photolysis, stopped flow techniques. Energy dissipation by radiative and non-radiative process, absorption spectra, Franck-Condon principle, photochemical stages-primary and secondary processes.

Unit II
Properties of Excited States
Structure, dipole moment, acid-base strengths, reactivity. Photochemical kinetics-calculation of rates of radiative processes. Biomolecular deactivation-quenching.

Unit III
Excited States of Metal Complexes
Excited states of metal complexes: Comparison with organic compounds, electronically excited states of metal complexes. Charge-transfer spectra, charge transfer excitations, methods for obtaining charge-transfer spectra.

Unit IV
Ligand Field Photochemistry
Photosubstitution, photo oxidation and photo reduction, lability and selectivity, zero vibrational levels of ground state and excited state, energy content of excited state, zero-zero spectroscopic energy, development of the equations for redox potentials of the excited states.

Unit V
Redox Reactions by Excited Metal Complexes
Energy transfer under conditions of weak interaction and strong interaction-exciplex formation; conditions of the excited states to be useful as redox reactants, excited electron transfer, metal complexes as attractive candidates (2,2'-bipyridine and 1,10-phenanthroline complexes), illustration of reducing and oxidizing character of Ruthenium^{2+}, (bipyridyl complex, comparison with Fe (bipy)$_3$); role of spin-orbit coupling, life time of these complexes. Application of redox processes of electronically excited states for catalytic purpose, transformation of low energy reactants into high-energy products, chemical energy into light.

Unit VI
Metal Complex Sensitizers
Metal complex sensitizer, electron relay, metal colloid system, semiconductor supported metal or oxide systems, water photolysis, nitrogen fixation and carbon dioxide reduction.

Books Suggested:
1. Concepts of Inorganic Photochemistry, A.W. Adamson and P.D. Fleischauer, Wiley.
2. Inorganic Photochemistry, J. Chem. Educ., vol. 60, no. 10, 1983.
3. Progress in Inorganic Chemistry, vol. 30, ed. S.J. Lippard, Wiley.

4. Co-ordination Chem. Revs., 1975, 15, 321; 1981, vol. 39, 121, 131; 1990, 97, 313.
5. Photochemistry of Co-ordination Compounds, V. Balzari and V. Carassiti, Academic Press.
6. Elements of Inorganic Photochemistry, G.J. Ferraudi, Wiley.
7. Fundamentals of Photochemistry, K.K. Rohtagi-Mukherji, Wiley-Eastern.
8. Essentials of Molecular Photochemistry, A. Gilbert and J. Baggott, Blackwell Scientific Publication.
9. Molecular Photochemistry, N.J. Turro, W.A. Benjamin.
10. Introductory Photochemistry, A. Cox

SOS/E012	Environmental Chemistry	L	T	P	C	MM
		3	0	0	3	100

Unit I
Environment
Introduction, composition of atmosphere, vertical temperature, heat budget of the earth atmospheric system, vertical stability atmosphere. Biogeochemical cycles of C, N, P, S and O. Bio distribution of elements.

Unit II
Hydrosphere
Aquatic pollution- inorganic, organic, pesticides, agricultural, industrial and sewage, detergents, oil spills and oil pollutants. Water quality parameters-dissolved oxygen, biochemical oxygen demand, solids, metals, content of chloride, sulphate, phosphate, nitrate and micro-organisms. Water quality standards. Analytical methods for measuring BOD, DO, COD, F, Oils, metals (As, Cd, Cr, Hg, Pb, Se etc.) residual chloride and chlorine demand. Purification and treatment of water.

Unit III
Soils
Composition, micro and macro nutrients, Pollution of fertilizers, pesticides and metals.

Unit IV
Atmosphere
Chemical and photochemical reactions in atmosphere, smog formation, oxides of N, C, S, O and their effect, pollution by chemicals, petroleum, minerals chlorofluorohydrocarbons. Analytical methods for measuring air pollutants. Continuous monitoring instruments.

Unit V
Industrial Pollution
Pollution from cement, sugar, distillery, drug; paper and pulp, thermal power plants, nuclear power plants, metallurgy, polymers and drugs etc.

Unit VI
Environmental Toxicology
Chemical solutions to environmental problems, biodegradability, principles of decomposition, better industrial processes.

Books suggested
1. Environmental Chemistry, S.E. Manahan, Lewis Publishers.
2. Environmental Chemistry, Sharma and Kaur, Krishna Publishers.

3. Environmental Chemistry, A.K. De, Wiley Eastern.
4. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern.
5. Standard Method of Chemical Analysis, F.J. Welcher Vol. III, Van Nostrand Reinhold Co.
6. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.
7. Elemental Analysis of Airborne Particles, Ed. S. Landsberger and M. Creatchman, Gordon and Breach Science Publication.
8. Environmental Chemistry, C. Baird, W.H. Freeman.

Organic Chemistry

		L	T	P	C	MM
SOS/C025	Laboratory Course Org.-IVA	0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do two exercises of 18 marks each.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

I. Extraction of Organic Compounds from Natural Sources

1. Isolation of caffeine from tea leaves.
2. Isolation of casein from milk (the students are required to try some typical colour reactions of proteins).
3. Isolation of lactose from milk (purity of sugar should be checked by TLC and PC and Rf value reported).
4. Isolation of nicotine dipicrate from tobacco.
5. Isolation of cinchonine from cinchona bark.
6. Isolation of piperine from black pepper.
7. Isolation of lycopene from tomatoes.
8. Isolation of β-carotene from carrots.
9. Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid).
10. Isolation of eugenol from cloves.
11. Isolation of limonene from citrus fruits.

II. Paper Chromatography

Separation and identification of the sugars present in the given mixture of glucose, fructose and sucrose by paper chromatography and determination of Rf values.

Books Suggested

1. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
2. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
3. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.
4. Laboratory Manual of Organic Chemistry, RK Bansal, New Age International, Delhi.

SOS/C026	Laboratory Course Org.-IVB	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do two exercises of 18 marks each.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

I. Spectroscopy

Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS)

II. Spectrophotometric (UV/VIS) Estimations

1. Amino acids
2. Proteins
3. Carbohydrates
4. Cholesterol
5. Ascorbic acid
6. Aspirin
7. Caffeine

Books Suggested

5. Introduction to Organic Laboratory Techniques (Third Edition), DL Pavia, GM Lampman and GS Kriz, Saunders College Publishing, Philadelphia, New York.
6. Operational Organic Chemistry, A Laboratory Course, Second Edition, JW Lehman, Allyn & Bacon, Inc. Boston.
7. Microscale Organic Experiments KL Willianson, DC Health & Co. Le Xington.
8. Laboratory Manual of Organic Chemistry, RK Bansal, New Age International, Delhi.

SOS/C027	Natural Products	L	T	P	C	MM
		3	0	0	3	100

Unit I

Terpenoids and Carotenoids

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule Structures of abietic acid and β-carotene.

Unit II

Alkaloids

Isolation, structure and synthesis of ephedrine, quinine.

Unit III

Steroids

Structure determination of cholesterol and bile acids (without synthesis). Chemistry of testosterone, estrone and progestrone.

Unit IV

Pigments

(a) Plant Pigments: Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of cyanidin, and quercetin.

(b) Porphyrins

General Introduction of haemoglobin and chlorophyll. Chemistry of chlorophyll (without synthesis). Structure and synthesis of haem.

Unit V

Prostaglandins

Occurrence, nomenclature, classification, biogenesis and physiological effects

Synthesis of Key intermediate, PGE_2 and $PGF_{2\alpha}$

Books Suggested

1. Natural Products: Chemistry and Biological Significance, J.Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Longman, Essex.
2. Organic Chemistry, Vol 2, I.L. Finar, ELBS.
3. Stereoselective Synthesis: A Practical Approach, M. Nogradi, VCH.
4. Rodd's Chemistry of Carbon Compounds, Ed. S. Coffey, Elsevier.
5. Chemistry, Biological and Pharmacological Properties of Medicinal Plants from the Americas, Ed. Kurt. Hostettmann, M.P. Gupta and A. Marston, Harwood Academic Publishers.
6. Introduction to Flavonoids, B.A. Bohm, Harwood Academic Publishers.
7. New Trends in Natural product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood Academic Publishers

		L	T	P	C	MM
SOS/E013	Heterocyclic Chemistry	3	0	0	3	100

Unit I

Nomenclature of Heterocycles

Replacement and Systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles

Unit II

Aromatic and Non-aromatic Heterocycles

General chemical behaviour of aromatic heterocycles, classification (structural type), Heteroaromatic reactivity and tautomerism in aromatic heterocycles

Strain –bond angle and torsional strains and their consequences in small ring heterocycles.

Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interactions.

Stereo-electronic effects, aromatic and related effects. Attractive interactions - hydrogen bonding and intermolecular nucleophilic, electrophilic interactions.

Unit III
Small Ring Heterocycles
Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes

Unit IV
Benzo-Fused Five-Membered Heterocycles
Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes

Unit V
Six-Membered Heterocycles with One, Two or More Heteroatoms
Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and pyridones
Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones Synthesis and reactions of diazines, triazines, tetrazines and thiazines

Unit VI
Seven-and Large-Membered Heterocycles
Synthesis and reactions of azepines, oxepines, thiepines, diazepines thiazepines, azocines, diazocines, dioxocines and dithiocines

Books Suggested:

1. Heterocyclic Chemistry Vol. 1 & 2, R.R. Gupta, M. Kumar and V. Gupta, Springer Verlag
2. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
3. Heterocyclic Chemistry, J.A. Joule, K. Mills and G.F. Smith, Chapman and Hall.
4. Heterocyclic Chemistry, T.L. Gilchrist, Longman Scietific Technical
5. Contemporary Heterocyclic Chemistry, G.R. Newkome and W.W. Paudler, Wiley-Inter Science.
6. An introduction to the Heterocyclic Compounds, R.M. Acheson, John Wiley
7. Comprehensive Heterocyclic Chemistry, A.R. Katritzky and C.W. Rees, eds. Pergamon
8. Natural Products: Chemistry and Biological Significance, J.Mann, R.S. Davidson, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Longman, Essex.
9. Organic Chemistry, Vol 2, I.L. Finar, ELBS.
10. Stereoselective Synthesis: A Practical Approach, M. Nogradi, VCH

Physical Chemistry

SOS/C028	Laboratory Course Phy.-IVA	L	T	P	C	MM
		0	0	9	3	100

Note: The duration of examination will be of eight hours spread over two days. Students are required to do two exercises of 18 marks each.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

1. Determination of transport number.
2. Determination of liquid junction potential.
3. Determination of the charge on colloidal particle.
4. Polarography.
5. Beer's law verification.

SOS/C029	Laboratory Course Phy.-IVB	L	T	P	C	MM
		0	0	9	3	1000

Note: The duration of examination will be of eight hours spread over two days. Students are required to do two exercises of 18 marks each.

Viva 09 marks

Seminar/Attendance/Assessment/Record 15 marks.

1. Decomposition of potential determination.
2. Validity of Freundlich's adsorption isotherm.
3. Validity of Langmuir's adsorption isotherm.
4. Determination of partial molar volume of solute.
5. Determination of CMC of surfactants.

SOS/C030	Advanced Quantum Chemistry	L	T	P	C	MM
		3	0	0	3	100

(Pre-requisite: mathematics at least up to First Year B.Sc. level is necessary. At least one PC among 4 students should be available)

Unit I

Theoretical and Computational Treatment of Atoms and Molecules, Hartree-Fock Theory

Review of the principles of quantum mechanics, Born-Oppenheimer approximation. Slater-Condon rules, Hartree-Fock equation, Koopmans and Brillouin theories, Roothan equation, Gaussian basis sets.

Unit II

Configuration Interaction and MC-SCF

Introduction to CI; full and truncated CI theories, size consistency, Introductory treatment of coupled cluster and MC-SCF methods.

Unit III

Semi-Empirical Theories

A review of the Huckel, EHT and PPP treatments, ZDO approximation, detailed treatment of CNDO and INDO theories. A discussion of electronic energies and properties. An introduction to MOPAC and AMI with hands on experience on personal computer.

Unit IV

Density Functional Theory

Derivation of Hohenberg-Kohn theorem, Kohn-Sham formulation, N- and V- representabilities; review of the performance of the existing local (e.g. Slater Xa and other methods) and non-local functionals, treatment of chemical concepts with the density functional theory.

Unit V

Computer Experiments

Computer experiments using quantum chemistry- software packages such as GAUSSIAN/GAMESS/MOPAC and modeling software e.g. MM2/ AMBER/ CHARM etc.

Books Suggested

1. Modern Quantum Chemistry, N.S. Ostlund and a. Szabo, McGraw Hill.
2. Methods of Molecular Quantum Mechanics, R. Mcweeny and B.T. Sutcliffe, Academic Press
3. Density Functional Theory of Atoms and Molecules, R.G. Parr and W. Yang, Oxford.
4. Exploring Chemistry with Electron Structure Methods, J.B. Foresman and e. Frish, Goussian Inc.
5. Semi-empirical MO Theory, J. Pople and D.L. Beveridge.

SOS/E014	Polymers	L	T	P	C	MM
		3	0	0	3	100

Unit I

Basics

Importance of polymers. Basic concepts: Monomers, repeat units, degree of polymerization. Linear, branched and network polymers. Classification of polymers. Polymerization: condensation, addition, radical chain, ionic and co-ordination and co-polymerization. Polymerization conditions and polymer reactions. Polymerization n homogenous and heterogeneous systems.

Unit II

Polymer Characterization

Polydispersion-average molecular weight concept. Number, weight and viscosity average molecular weights. Polydispersity and molecular weight distribution. The practical significance of molecular weight. Measurement of molecular weights. End-group, viscosity, light scattering, osmotic and ultracentrifugation methods. Analysis and testing of polymers-chemical analysis of polymers, spectroscopic methods, X-ray diffraction study. Microscopy. Thermal analysis and physical testing-tensile strength. Fatigue, impact. Tear resistance. Hardness and abrasion resistance.

Unit III

Structure and Properties

Morphology and order in crystalline polymers, configurations of polymer chains. Crystal structure of polymers, strain-induced morphology, crystallization and melting. Polymer structure and physical properties, crystalline melting point Tm, melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, Tg. Relationship between Tm and Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking. Property requirements and polymer utilization.

Unit IV

Polymer Processing

Plastic, elastomers and fibres. Compounding. Processing techniques: Calendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fibre spinning.

Books Suggested

1. Textbook of Polymer Science, F.W. Billmeyer Jr, Wiley.
2. Polymer Science, V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.
3. Functional Monomers and Polymers, K. Takemoto, Y. inaki and R.M. Ottanbrite.
4. Contemporary Polymer Chemistry, H.R. Alcock and F.W. Lambe, Prentice Hall.
5. Physics and Chemistry of Polymers, J.M.G. Cowie, Blackie Academic and Professional.

Department of Zoology

M.Sc. Zoology

M.Sc. Zoology

Course Contents & Syllabi

HNB Garhwal University

(Central University)

Srinagar Garhwal

Uttaranchal

M.Sc. Zoology

M.Sc. 1st Semester (July to November)

Code	Course	L T P C	MM
SOLS/Zool/C 001	Animal Diversity I – (Lower Non-Chordata)	3 0 0 3	100
SOLS/Zool/C 002	Cell Biology & Molecular Biology	3 0 0 3	100
SOLS/Zool/C 003	Genetics, Evolution & Taxonomy	3 0 0 3	100
SOLS/Zool/C 004	Developmental Biology & Parasitology	3 0 0 3	100
SOLS/Zool/C 005	Lab Course I Based on C001 & C002	0 0 3 3	100
SOLS/Zool/C 006	Lab Course II Based on C003 & C004	0 0 3 3	100
	Core Credits = 18		**600**

M.Sc. 2nd Semester (December to April)

Code	Course	L T P C	MM
SOLS/Zool/C 007	Animal Diversity-II (Higher Non-Chordata)	3 0 0 3	100
SOLS/Zool/C 008	Animal Physiology	3 0 0 3	100
SOLS/Zool/C 009	Instrumentation, Computer Application and Biostatistics	3 0 0 3	100
SOLS/Zool/C 010	Elementary Biotechnology & Microbiology	3 0 0 3	100
SOLS/Zool/C 011	Lab Course I Based C007 & C008	0 0 3 3	100
SOLS/Zool/C 012	Lab Course II Based C009 & C010	0 0 3 3	100
		Total	**600**
SOLS/Zool/SS01	Basic Bioinformatics	0 0 0 3	100
SOLS/Zool/SS02	Human Population Genetics	0 0 0 3	100

	Core Credits = 18

M.Sc. 3rd Semester (July to November)

Code	**Course**	**L T P C**	**MM**
SOLS/Zool/C 013	Animal Diversity (Chordata)	3 0 0 3	100
SOLS/Zool/C 014	Ecology & Wildlife	3 0 0 3	100
SOLS/Zool/C 015	Lab Course Based on C013 & C014	0 0 3 3	100
SOLS/Zool/E 01a SOLS/Zool/E 01b SOLS/Zool/E 01c SOLS/Zool/E 01d	Fish Biology I Entomology I Environmental Biology I Reproductive Biology I	3 0 0 3	100
SOLS/Zool/E 02a SOLS/Zool/E 02b SOLS/Zool/E 02c SOLS/Zool/E 02d	Fish Biology II Entomology II Environmental Biology II Reproductive Biology II	3 0 0 3	100
SOLS/Zool/E 03	Lab Course Based on E001a/b/c/d & E002 a/b/c/d	0 0 0 3	100
		Total	**600**
SOLS/Zool/SS03	Biological & Radiotracer Techniques	0 0 0 3	100
SOLS/Zool/SS04	Aquatic Biodiversity	0 0 0 3	100
	Core Credits 09 + Elective Credits 09; Total Credits = 18		

M.Sc. 4th Semester (December to April)

Code	Course	L T P C	MM
SOLS/Zool/C 016	Endocrinology & Animal Behaviour	3 0 0 3	100
SOLS/Zool/C 017	Biochemistry & Immunology	3 0 0 3	100
SOLS/Zool/C 018	Lab Course Based on C016 & C017	0 0 3 3	100
SOLS/Zool/E 04a SOLS/Zool/E 04b SOLS/Zool/E 04c SOLS/Zool/E 04d	Fisheries Science Applied Entomology Applied Environmental Biology Applied Reproductive Biology	3 0 0 3	100
SOLS/Zool/E 05a SOLS/Zool/E 05b SOLS/Zool/E 05c SOLS/Zool/E 05d	Methodology in Fishery Science Methodology in Entomology Methodology in Environmental Biology Methodology in Reproductive Biology	3 0 0 3	100
SOLS/Zool/E 06	Lab Course Based E004 a/b/c/d & E005 a/b/c/d	0 0 3 3	100
SOLS/Zool/E 07	Dissertation *	0 0 6 6	100
		Total	**500/600***
SOLS/Zool/E 008	Report based on Field work/Excursion –organized by the Department	0 0 3 3	100
SOLS/Zool/SS05	Cold Water Fisheries	0 0 0 3	100
SOLS/Zool/SS06	Environmental Biotechnology	0 0 03	100
*** Students securing Minimum 7.5 CGPA in I & II Semester together can opt for dissertation**			

Grand Total:Core Credit 54 + Elective Credits 18 = 72

Max. Marks for each paper: 100 (40 – Sessional Tests + 60 End Term Test)

Sessional (Mid Term Test, Assignment, Classroom Seminar & Laboratory Work, Internship, Industrial/Institutional visits, Winter/Summer Training based report Writing & Presentation, Report based on field trips, excursion organized by Department etc.)

All 2-year Master's Programmes will have the following components, viz.

(i) Core Course **(C)**	Minimum 54 credits
(ii) Electives **(E)**	Minimum 18 credits
(iii) Self study course **(SS)**	Maximum 09 credits (one minimum 03 credits course shall be mandatory but not to be included while calculating the grades)

* M.Sc. 4th Semester – Core Course 3 (2 Theory +1 Lab Courses of 3 credits each), Elective Courses 3 (2 Theory + 1 Lab Courses of 3 credits each) / 1 Theory of 3 Credits + 1 Dissertation of 6 Credits), Dissertation be allotted in the beginning of 3rd semester to the students securing more than 7.5 CGPA & Second Semester together).

M.Sc. Zoology 1st Sem.

SOLS/Zool/C001 Animal Diversity I (Lower Non-Chordata)

No. of Credits = 3

UNIT I

Major and minor Invertebrate phyla: General characters, organization, classification up to order and their types. Origin and evolution of lower and higher invertebrates. Overview of economic importance of invertebrates.

UNIT II

Protozoa: Comparative morphology of all classes. Locomotor organelles and locomotion. Nutrition: holophytic, holozoic, saprozoic, myxotrophic and parasitic. Reproduction: A sexual and sexual reproduction, parthenogenesis, regeneration.

UNIT III

Porifera: Comparative morphology of allclasses. Types of canal system Reproduction: A sexual, sexual reproduction and regeneration in sponges.

UNIT IV

Coelenterata: Comparative morphology of all classes. Polymorphism, Coral reefs & formation, Affinities of Ctenophora.

Helminthes: Comparative external and internal morphology of platyhelminthes and Aschelminthes.

Recommended Books :

1. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington: Invertebrate Structure and function, Nelson, 1987.
3. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
4. Hickman, Roberts & Hickman: Integrated principles of Zoology (7th ed)

   Times-Mirror, Mosby, 1984.
5. Kotpal, Agrawal & Khetrapal: Modern Text-book of Zoology, Invertebrates. Rastogi, 1976.
7. Marshall & William: Text book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillian, 1972.

SOLS/Zool/C002Cell Biology & Molecular Biology

No. of Credits = 3

Cell Biology

UNIT I

Ultra structure of pro-and eukaryotic cells.

Plasma membrane: Structure - organisation, lipid bilayer, proteins & glycoconjugates, liposomes. Function- Ionic transport, transporter proteins, types of transport (symport, antiport, active & passive, endocytosis, exocytosis).

Endomembrane system: Intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathways.

Cytoskeleton: Components & functions & derived organelles (cilium, flagellum).

Mitochondria: Structure function & genetic organisation. Ribosome: Biosynthesis & formation in nucleolus.

UNIT II

Signal Transductions

Cell signaling-types of signaling. Cell surface receptor mediated signaling.

Cell cycle: Molecular events during interphase, genetic regulation of cell cycle (including yeast as model system).

Cellular transformation and malignancy. Retroviruses, Apoptosis and causes of cancer.

Molecular Biology

UNIT III

The central Dogma of Molecular Biology.

DNA: Structure and conformation, supercoiling, packing of DNA into chromosomes. Structural polymorphism of DNA & RNA. Three dimensional structure of t-RNA.

UNIT IV

DNA replication. Genetic code.

Transcription and translation in prokaryotes and eukaryotes. RNA processing. Mutations & DNA repair systems.

Recommended Books:

1. Mayr : Animal species and Evolution Belknap Press, 1966.
2. Moody : Introduction to evolution (Indian Edition) Kalyani Publ., 1978.
3. Strickberger : Evolution, (Indian Edition). CBS Publ., 1994.
4. Richard Swann Lull: Organic Evolution Seema Publications, 1976
5. Simpson G.G.: Principles of Animal Taxonomy, Columbia Univ. Press, 1961.
6. Mayr, E. Systematics and the Origin of Species, Columbia Univ. Press, 1942.
7. Blackwelder RE: Guide to the Taxonomic Literature of Vertebrates, Iowa State Univ. Press, 1972.

SOLS/Zool/C003 Genetics, Evolution & Taxonomy

No. of Credits = 3

Genetics

UNIT I

Monohybrid and Dihybrid crosses with molecular explanations. Incomplete and Co dominance, Gene interaction, Lethal Alleles, Multiple Alleles, Pedigrees.

Modification of Dihybrid Ratios and their biochemical basis. Fine structure of Gene. Statistical Applications in Genetics (Probability and Significance Testing).

UNIT II

Linkage and Crossing over, Genetic mapping techniques. Sex Linked inheritance and genetic disorders.

Mutations and Chromosomal Aberrations.

Operon hypothesis, Lac operon (positive and negative control). Regulation of gene expression in eukaryotes.

Population Genetics: Hardy Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic Drift.

Evolution

UNIT III

Natural Selection: Types of Selection and Selection coefficient. Role of Mutation in Evolution, (Gene mutation, Mutation Rates, Mutation and selection, Genetic Polymorphism).

Speciation: Isolating mechanism, Modes of Speciation (Allopatric, Sympatric, Parapatric).

Micro and Macroevolution.

Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna). Island Biogeography theory. Fossils and fossilization.

Taxonomy

UNIT IV

Theories of biological classification, Linnaean hierarchy.

Stages in taxonomy, Importance of Taxonomy.

Nomenclature: ICZN, Taxon, Rank and Categories. Important rules of Nomenclature, Latin words and abbreviations.

Biological Species Concepts (Polytypic and monotypic species, Subspecies).

Taxonomic characters and taxonomic keys. Preservation of collected material and curating

Recommended Books:

1. Gardner, Gimmons and Snustad: Principles of Genetics, John Wiley & Sons.
2. Robert, H. Tamarin: Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
3. Daniel L. Hartl and M. Ruvolo: Genetics Analysis of Genes and Genomes, Jones and Bartlett India Pvt. Ltd.
4. William S. Klung Cummings, Spencer and Palldino: Concepts of Genetics, Pearson Education, Pearson Benjamin Cummings.
5. Benjamin A. Peirce: Genetics A conceptual Approach, W.H. Freeman and Company
6. TA Brown: Gene Cloning and DNA Analysis and Introduction, Wiley-Blackwell.
7. Allendorf, Luikart, Aitken: Conservation and the Genetics of Populations, Wiley-Blackwell.
8. Strickberger: Evolution, Jones and Bartlett Publishers.
9. Species Evolution: Role of Chromosomal Change, Cambridge University Press.
10. Ernst Mayr and Ashlock: Principles of Systematic Zoology, McGraw-Hill.
11. Ashok Verma: Principles of animal Taxonomy, Alpha Science International Ltd.
12. Judith E. Winston: Describing Species Practical and Taxonomic procedure for biologists, Columbia University Press.
13. V.C. Kapoor: Theory and Practice of Animal Taxonomy, Oxford and IBH Publishing Co. Pvt. Ltd.

SOLS/Zool/C004 Developmental Biology & Parasitology

No. of Credits = 3

Developmental Biology

UNIT I

Development and differentiation of sperm and oocytes, capacitation, vitellogenesis.

Mechanism of fertilization acrosomal reaction, cortical reaction and fertilization membrane.

Blocks to polyspermy, Parthenogenesis.

Cellular differentiation (transcriptional regulation of gene expression, differential RNA processing and translation).

Concept of organiser and embryonic inductions: primary, secondary & tertiary cellular interactions.

Eye morphogenesis.

UNIT II

Development in Drosophila: Cleavage, gastrulation; Molecular basis of development, maternal-effect genes, segmentation genes and homeotic selector genes.

Metaplasia & trans differentiation.

Lymphocyte differentiation and genomic alterations.

Limb morphogenesis. Regeneration, Teratogens.

Metamorphosis: Insect, Amphibian metamorphosis.

Parasitology

UNIT III

Parasitism and evolution of parasitism.

Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Entamoeba histolytica,* Trypanosomes, *Leishmania donovani*, *Trichomonas vaginalis, Giardia intestinalis & Plasmodium).*

UNIT IV

Parasitic adaptations in Platyhelminthes and Aschelminthes. Common trematode, cestode and nematode parasites. Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris, Schistosoma, Fasciola, Wuchereria, Taenia*)

Introduction to arthropods and vectors of human diseases (mosquitoes, lice, flies & ticks).

Parasitism in Crustacea

Recommended Books

1. Gilbert: Developmental Biology. Sinauers Associates Publ. Massachusetts, 1997.

2. Balinsky: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London.

3. Berill: Development Biology. Tata McGraw Hill Publishing Co. Ltd

4. Casselman : Histochemical techniques, John Wiley, 1959.

5. Smyth (1994): Introduction to Animal Parasitology Cambridge University Press

6. Chatterjee: Parasitology, Chatterjee Medical Publisher, 1981.

7. Read: Animal Parasites, Prentice Hall, 1977.

8. Schmidt & Roberts 1989 Wiliam & WilkinsFoundations of Parasitology (IVth ed.)

SOLS/Zool/C 005 Lab Course Based on C001 & C002

SOLS/Zool/C 006 Lab Course Based on C003 & C004

SOLS/Zool/C007 Animal Diversity II (Higher Non-Chordata)

No. of Credits = 3

UNIT I

Minor Group: Classifications to order level, Characters and Affinities of Phoronida and Rotifera.

UNIT II

Annelida: Classification to order level, Comparative morphology of all classes, Coelom, Segmental organs.

Arthropoda: Classification to order level, Appendages & Mouth parts in insects, Larval forms in Crustacea, Arachnida.

Organization and Affinities of Onychophora.

UNIT III

Mollusca: Classification to order level, Comparative morphology of all classes, Major features of the Respiratory and Reproductive Systems, Larval forms, Torsion, Pearl formation.

UNIT IV

Echinodermata: Classification to order level, Water vascular system, Larval forms and affinities.

Recommended Books :

1. Kotpal R.L: Modern Text Book of Zoology: Invertebrates, Rastogi Publications.
2. Nigam H C: : Biology of Non-Chordates, Nagin Chand, 1985.
3. Parker TJ & Haswell WA: A Text book of Zoology Vol I & II, McMillan
4. Hyman L: Invertebrate Series, Academic Press
5. Starr et al: Biology, The Unity and Diversity of Life
6. Twenhofel et al: Principles of Invertebrate Palaeontology
7. Doyle P: Understanding Fossils Invertebrate Palaeontology

SOLS/Zool/C008 Animal Physiology

No. of Credits = 3

UNIT I

Physiology of respiration: Exchange of respiratory gases at the pulmonary surface. Transport of respiratory gases by blood. Factors affecting oxyhaemoglobin dissociation. Neural and chemical control of respiration.

Physiology of digestion & absorption: Functional anatomy of the gastrointestinal tract. Gastrointestinal motility and its regulation. Secretions of the gastrointestinal tract. Liver and biliary system.

Digestion and absorption of proteins, fats and carbohydrates.

Physiology of excretion: Formation of urine: Functional anatomy of the kidney. Glomerular filtration and its control. Reabsorptions & secretions in the tubules. Mechanisms of active transport. Excretion and control of urea, sodium, potassium and other ions.

UNIT II

Physiology of cardiovascular system: Characteristics of vertebrate cardiac muscle. Initiation, conduction and regulation of heart beat. Cardiac cycle and cardiac output.

Regulation of cardiac amplitude and frequency. ECG and myocardial infarction. Blood pressure and its regulation.

Circulation (open and closed, blood composition and function). Blood groups.

The cascade of biochemical reactions involved in coagulation of blood. Blood groups. Lymphatic systems.

UNIT III

Nervous system: Neuron - the basic functional unit, the sensory & motor divisions.

Ionic basis of resting and action potentials of neurons, significance of myelinated nerve fibers and velocity of conduction. Physiologic anatomy of the synapse.

Mechanism of synaptic transmission, transmitters (acetylcholine, norepinephrine, histamine, GABA). Reflexes and types of reflexes.

Neuromuscular physiology: Structural proteins of muscle cells, actin myosin complex and source of energy for contraction. Sliding filament theory of muscle contraction. Excitation-contraction coupling.

UNIT IV

Sensory physiology: The eye and visual processes - Functional anatomy of the structural elements of the retina. Photochemistry of vision. Extraretinal photoreception. Visual adaptations in vertebrates.

The ear and auditory processes - Tympanic membrane and the ossicular system. Conduction of sound from tympanum to cochlea. Functional anatomy of cochlea. Sound transmission in cochlea.

Mechanism of thermoregulation in poikilotherms, homeotherms and heterotherms. Aestivation and hibernation.

Recommended Books.

1.Knut Schmidt-Nielsen. Animal physiology-Adaptation and Environment. Cambridge University Press (1979) (1)

2.Lauralee Sherwood, Hillar Klandorf, and Paul Yancey. Animal Physiology: From Genes to Organisms. Cengage Learning (2012)

3.Richard W. Hill, Gordon A. Wyse, Margaret Anderson - Animal Physiology, 3rd Ed-Sinauer Associates, Inc. (2012)

4. Srivastava A K. Animal Physiology and Biochemistry S. Chand Publications (1986)

5.Singh H. R and Kumar N. Animal Physiology and Biochemistry. Vishal Publishing Co.

6. Guyton and Hall: Text Book of Medical Physiology. W B Saunders Company

M.Sc. Zoology 2nd Sem.

SOLS/Zool/C009 Instrumentation, Computer Application and Biostatistics

No. of Credits = 3

Instrumentation

UNIT I

Principles and applications of Microscopy: Light, phase contrast, transmission electron microscopy (TEM & SEM).

Colorimeter, Spectrophotometer.

UNIT II

Centrifugation. Clinical, high-speed and ultracentrifuges.

Chromatography: Paper, thin layer chromatography, GLC.

Electrophoresis: Agarose, Polyacrylamide, two-dimensional gel electrophoresis

Computer Application

UNIT III

Introduction to Computers: Mini, micro, mainframe and super computers; Components of a computer system (CPU, I/O units). Data storage device, Memory concepts.

Software and types of software.

Computer applications in biology and information communications (databases, e-mail and local networks).

Biostatistics

UNIT IV

Biostatistics: Importance of statistics in biological research. Introduction to some distributions of random variables: Binomial, Poisson, normal. Basic/Descriptive statistics: Measures of central tendency and measures of dispersion. Skewness & kurtosis. Simple correlation and linear regression (scatter diagram, regression coefficients, regression lines).

Elementary idea of random variables. Students-t, chi-square and F-Tests of Significance testing and their purpose: Introduction to Statistical softwares. MS Excel and their purpose.

Recommended Books:

1. Hoel, P.G.: Elementary Statistics. John Wiley & Sons, Inc. New York.
2. Mahajan: Methods in Biostatistics, (4th ed.). Jaypee Bros. 1984.
3. Milton & Tsokos: Statistical Methods in Biological and Health Sciences, McGraw Hill, 1983.
4. Sokal & Rohlf: Introduction to Biostatistics. Freeman, Toppan, 1973.
5. D. Rajaraman & V. Rajaraman: Computer Primer (2nd ed.). Prentice Hall of India, New Delhi.
6. Roger Hunt & John Shelley : Computer and Commonsense. Prentice Hall of India, New Delhi.
7. Peter Norton's: Introduction to Computers with CD-ROM, 2nd ed.. Tata McGram Hill.
8. Zar JH: Biostatistical Analysis. Pearson.
9. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill
10. Baunthiyal, Ravi and Saxena, Comprehensive Laboratory Mannual of Life Science, Scientific Publishers.

SOLS/Zool/C010 Elementary Biotechnology & Microbiology

No. of Credits = 3

Biotechnology

UNIT I

Biotechnology: History, definition & Scope.

General steps of Gene cloning-cutting, legation, transformation and analysis of clones, genomic & C-DNA library.

A general idea of cloning vectors based on plasmid & phages, blotting techniques, DNA-sequencing, polymerase chain reaction.

UNIT II

Gene therapy, DNA finger printing, Transgenic animals and plants. Potential hazards of recombinant DNA technology.

Products of recombinant DNA technology, Human genome project and its applications.

Microbiology

UNIT III

Microbiology: Bacteria - classification, staining techniques, pathological significance.

Physiology, genetics & reproduction of viruses of plants and animals, Bactriophage, lysogenic & lytic cycle, Bacterial genetics.

Microbial culture techniques & media enrichment techniques.

Microbial fermentation: Microbes in decomposition and recycling processes.

Microbes as pathological agents in plants, animals and man.

UNIT IV

Laboratory facilities, culture media for animal cell culture, Primary culture, cell lines and cloning, Tissue and organ culture, Transfection methods & transgenic animals. Molecular markers CRFLPs, RAPDs, minisatellites, microsatellites. Application of animal cell culture.

Recommended Books:

1. Pelczar: Microbiology, Tata McGraw Hill,1993
2. Davis: Microbiology (3rd ed.) Harper & Row, Publ. Inc., 1980
3. R C Dubey: Text Book of Biotechnology, S Chand and Co.
4. Ananthanaraya and Paniker: Text Book of Microbiology. Orient Longman Pvt Ltd.
5. P K Gupta: Elements of Biotechnology, Rastogi Publications

SOLS/Zool/C 011 Lab Course Based on C007 & C008

SOLS/Zool/C 012 Lab Course Based on C009 & C010

Self Study Course

SOLS/Zool/SS01 Basic Bioinformatics

No. of Credits = 3

UNIT I

Biology & IT, Computers in biology & medicine, Introduction to Genomics, Proteomics, Drug Design, etc.

Introduction to networking. Networking protocols. LAN, MAN, WAN, Internet (www), FTP.

UNIT II

Biological sequence data banks (GENBANK, EMBL, PDB, SWISSPROT).

Sequence alignments (Global & Local), Algorithms used (Dynamic & Heuristic) –

Needleman Wunsch, Smith Waterman, BLAST, FASTA; Substitution matrices .

UNIT III

Sequence analysis using s/w tools (DNASIS, GENESCAN).

Introduction to Phylogenetic trees, Algorithms for construction of phylogenetic trees.

UNIT IV

Molecular structure prediction, RNA secondary structure prediction and algorithm used.

Introduction to Human genome project.

Introduction to Bio Perl.

Recommended Books.

1. Attwood & Smith: Introduction to Bioinformatics, Pearson Education Pt. Ltd., 2004.
2. Arsthur M. Lest: Introduction to Bioinformatics, Oxford University Press, 2002.
3. Bioinformatics-Sequence, structure and Databanks, 4th ed. Oxford University Press, 2006.
4. Lacroix and Critchlow: Bioinformatics-Managing Scientific Data, 1st ed., Margan Kaufmann Publishers, 2003.
5. Misener and Krawetz: Bioinformatics-Methods & Protocol, Vol. 132, Human Press, New Jersey, 2003.

SOLS/Zool/SS02 Human Population Genetics

No. of Credits = 3

UNIT I

Definition, aim and scope of population genetics, Mendelian principles of inheritance and their relevance to human populations. The Mendelian population, gene pool.

UNIT II

Mutations in Man- Determining the human mutation rate, selection, Fitness, Balance. Hardy – Weinberg Law and its applications in human populations genetics.

Population distance – Genetic Distance, Morphological distance and population heterogeneity.

UNIT III

Genetic polymorphism – Concept, Balanced and transient stages models explaining maintenance of genetic polymorphism.

Heterozygans selection, Intra uterine selection, fitness as a function of gene frequency.

UNIT IV

Genetic isolates – Formation and disintegration, genetic consequences of isolate formation with special reference to genetic drift.

Genetic and variability of (i) Skin pigmentation (normal & induced) (ii) dermal ridge patterns (iii) serological traits (ABO, MN, Rh & secreted factors).

Recommended Books.

1. Caualli-Sforza, L.L.: The genetic of Human Population Crow.
2. Kimura, M: An Introduction to Population Genetic Theory, Harrison and Boyce.
3. Stern, Curt: Principles of Human Genetics.
4. Vogel, F. & Matulsky A.G.: Human Genetics: Problems & Approaches.

SOLS/Zool/C 013 Animal Diversity (Chordata)

No. of Credits = 3

UNIT I

General Characters, classification, development of Urochordata and Cephalochordata.

Affinities of Hemichordata, Urochordata & Cephalochordata.

UNIT II

General Characters, Classification and affinities of Cyclostomata

Salient features of different groups of fishes; comparison between Chondrichthyes and Osteichthyes; Dipnoi.

Origin and evolution of Amphibia; Parental care in Amphibia

UNIT III

General characters and classification of Reptilia and Aves.

Origin of Reptilia and adaptive radiation in Reptilia. Characters and affinities of Chelonia and Rhynchocephalia

Origin and ancestory of birds, Characters and affinities of Ratitae

Origin and mechanism of flight in birds. ; Palate in birds.; Migration in birds.

UNIT IV

General characters and classification of mammals.

Origin of mammals.

Characters and affinities of Prototheria and Metatheria; Dentition in mammals

Aquatic and flying adaptations in mammals; Adaptive radiation in mammals.

Recommended Books:

1. Parker T.J. & Haswell WA: A Text Book of Zoology, Vol II, ed. 7th, Macmillan & Co. Ltd, London, 1962.
2. Young JZ: The Life of Vertebrates, Oxford, 1950.
3. R L Kotpal: Modern Text Book of Zoology Vertebrates; Rastogi Publications.

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SOLS/Zool/C014 Ecology & Wildlife

No. of Credits = 3

UNIT I

Ecology:

Limiting Factors: Biotic and Abiotic Factors Limits population Distribution. Liebig's law of minimum, Shelford's law of tolerance. Factor interactin.

Habitat Ecology: Concepts of habitats (Desert, Arid and Semi-arid, Subtropical, Temperate, Alpine, Wetlands, Marshes, Riverine, Lakes). Forest Types, Vegetation Structure and Storeys, Ecotone, Edges, Habitat fragmentation. Habitat Management. Use of Toposheets and GIS Imageries.

UNIT II

Population: Concepts and Attributers; Biotic potential, Density, Natality, Intrinsic rate of natural Increase .

Population Growth: Logistic theory, Stochastic models.

Species Interaction: Predation, Prey-predator relationship, Mutualism, minimum viable population.

UNIT III

Wildlife

Biodiversity: Factors influencing biodiversity, species diversity, Endemism, Indicator species.

Physiography of India: Biogeographic zones, biotic provinces and their faunal composition.

Himalayan Region: Habitat types, distribution of endangered fauna.

UNIT IV

Wildlife population estimation techniques: Transects, Drive counts, Aerial Counts, Point counts, Quadrates.

Population indices: Camera traps, natural marking, pug marks, cells, dung, pallets, scats, tags, rings.

Capturing, Handling and Immobilization of Wildlife: Types of Traps, Trap setting. Methods for Capturing.

(Fish, Reptiles, Birds and Mammals). Darts and Guns, Drugs and Antagonists used.

Radiotelemetry: Radio collars, antenna and receivers, satellite collars (insects to mammals).

IUCN categories for Conservation, Indian Wildlife Protection Act, CITES, WWF.

Captive Breeding: Role of Central Zoo Authority in Conservation.

Use of Biotechnology in Conservation: Collection, Extraction and Preservation of DNA samples from Wild. Amplification, Sequencing and Molecular markers. Ancient DNA.

Recommended Books.

1. Odum: Fundamentals of Ecology, Saunders Co. Publ., 1993 Indian ed.
2. Ricklef : Ecology, Newton Mass, Chiron Press.
3. Krebs: Ecology (4th ed.) Harper Collins College Publisher
4. Majupuria T C: Wildlife Wealth of India Craftsman Press Service, Bangkok
5. Robert H. Giles: Wildlife Management Techniques (3rd ed.) Natraj Publishers, Dehradun, 1981
6. Menon, Vivek: Indian Mammals: A Field Guide. Hachette Book Publishing India Pvt. Ltd.
7. Sutherland, William: Ecological Census Techniques. Cambridge University Press
8. Richard D. Teague: A Manual of Wildlife Conservation Nataraj Publishers, 1989.
9. Smith RL: Ecology and Field Biology, Harper Collins Publ. 1996.
10. Bookhout, A. Theodore: Research and Management Techniques for Wildlife Habitats. The Wildlife Society, Bethesda, 1996
11. Prater, S.H.: The Book of Indian Animals, BNHS, Oxfor University Press 1993.

SOLS/Zool/C 015 Lab Course Based on C013 & C014

SOLS/Zool/E 01 a) Fish Biology I

No. of Credits = 3

UNIT I

Systematics and Phylogeny

Introduction and History of Ichthyology. Zoogeographical distribution, Origin, evolution, and phylogeny of fishes. Schemes of classification of fossil and recent fishes. General Characters of Teleost and Elasmobranch fishes.

UNIT II

Agnatha: Characters, basic biology and affinities of Cyclostomes and Ostracoderms.
Placoderms: General characters and affinities.
Holocephali: Salient features external and internal morphology and affinities.
Dipnoi: Salient features and affinities.

UNIT III

Comparative Morphology of Teleosts and Elasmobranchs

Integuments (Teleosts and Elasmobranchs), colouration and its significance, mechanism of colour change.
Exoskeleton: Structure and development of placoid and nonplacoid scales.Fins and their origin.
Skeletal system : Skull. Vertebrae, Girdles, Opercular bones, Pharyngeal bones in teleosts and elasmobranch.

UNIT IV

Comparative morphology of following organs in teleosts and elasmobranchs.
Alimentary canal and associated glands. Modifications based on different feeding behaviour.
Structure of heart, afferent and efferent branchial arteries.
Structure of a Gill and Pseudobranch.
Brain and cranial nerves. Urinogenital system.

Recommended Books:

1. Kyle: The Biology of Fishes, 2007.
2. Khanna S. S. & Singh H.R. : A Text Book of Fish Biology & Fisheries, Narendra Publ. House, 2014
3. Srivastava C.B.L.: Fish Biology, Narendra Publication House, 2008.
4. S K Gupta and P K Gupta: General and Applied Ichthyology, S Chand and Co.

SOLS/Zool/E 01b Entomology I

No. of Credits = 3

UNIT I

Introduction to external morphology: body wall, segmentation. The head: structure of head; appendages, and antennae. The thorax: pro, meso and metathorax; legs. The wings: origin, structure and articulation. The abdomen: structure, appendages; external female and male genitalia.

UNIT II

Classification of insect with special reference to that of different orders. General characters, habits, habitats, importance of the insect orders-Collembola, Protura, Diplura, Thysanura, Ephimerida, Placoptera, Odonata.

General characters, habits, habitats, importance of the insect orders-Embioptera, Orthoptera, Phasmida, Dermaptera, Blattaria, Menteodea, Isoptera, Zoraptera.

UNIT III

General characters, habits, habitats, importance of the insect orders-Psocoptera, Thysanoptera, Heteroptera, Homoptera, Anoplura, Neuroptera, Megaloptera, Trichoptera.

UNIT IV

General characters, habits, habitats, importance of the insect orders-Coleoptera, Strepsiptera, Hymenoptera, Lepidoptera, Diptera.

Recommended Books.

1. Metcal & Flint: Destruction and useful Insects, Tata McGraw-Hill, 1979.
2. Ayyar, TVR: Hand Book of Economic Entomology for South India, International Book & Periodical Supply Service, 1984.
3. Pruthi HS: Text Book on Agricultural Entomology, ICAR Publication, 1969.
4. Fernald HT, HH Shepard: Applied Entomology, McGraw-Hill, 1955
5. Frost SW: Insect life and insect Natural History, Dover Publication, New Yark, 1959.
6. Mehta PR & Varma BK: Plant Protection, Directorate of Extention, Ministry of Food, Community development & Co –operation, New Delhi, 1968.
7. Ananthakrishnan TR: Applied Entomology
8. Evans JW: Insect Pests and Their Control, Periodical Expert Book Agency, 1984.
9. Bhutani DK & Jotwani MG: Insects in Vegetables, Periodical Expert Book Agency

SOLS/Zool/E 01c Environmental Biology I

No. of Credits = 3

UNIT I

Introduction to Environmental biology, its multidisciplinary nature and scope.

Components of Environment: atmosphere, lithosphere & hydrosphere.

Climate (micro, regional and global); Hydrological cycle; Soil profile.

Changing interactions between man and environment (cultural, political, ecological).

UNIT II

Terrestrial biomes of the world their characteristics and major biota (Grassland, Desert, Forest, Tundra).

Aquatic biomes (lotic, lentic, marine, estuaries, coral reef), their status.

Wetlands of India. Environmental adaptations: Aquatic, Aerial, Desert, Arboreal, Fossorial, Defensive.

UNIT III

Island biogeography theory.

Habitat fragmentation, Habitat selection, Corridors, Community patterns (gradients and Continuum), Community indices. Ecological niche.

Population cycles and fluctuations; Dispersal. Intra & Inter specific relationship.

Models of succession; Pioneer & climax concept.

UNIT IV

Concept of biological indicators; biological monitoring; Indicator organisms.

Invasive species and its impact.

Biological control: Biomagnification, Bioassimilation & Bioaccumulation.

Elementary Toxicology, Xenobiotics: Carcinogenic (heavy metals, radioactive substances and

pesticides) their chemical nature.

Recommended Books:

1. Dash and Dash, Fundamentals of Ecology, Tata Mc Graw Hill Co.
2. Singh and Kumar, Ecology and Environmental Science, Vishal Publishing Co, Jalandhar
3. Sharma, P D. Ecology and Environment, Rastogi Publications, meerut
4. Joshi and Joshi, A Text Book of Ecology and Environment, Himalaya Publishing House.

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SOLS/Zool/E 01d Reproductive Biology I

No. of Credits = 3

UNIT I

Sex Genetics: Sex determination, Gondal Differentiation and development.

Role of Y chromosomes (mammals) and autosomes and sex hormones.

Sex hormones and differentation of brain and reproductive behaviour.

UNIT II

Hormones of Reproduction: Gonadotropins, Chemistry and Synthesis.

Sex steroids: Synthesis (/\4 and /\5 pathways) & excretion of steroids.

Mechanism of action: GnRH, androgens, estradiol and progesterone.

UNIT III

Endocrine control of male reproduction (rat/man).

Hormonal control of spermatogenesis, Androgen binding protein (ABP), Inhibin.

Neurendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epitheluim, LH-effects on Leydig cells, negative feedback regulation).

UNIT IV

Endocrine control of female reproduction (rat/man)

Hormonal control of ovulation. The ovary and the reproductive tract. The ovarian cycle.

Folliculogenesis, Ovulation, formation & degeneration of corpus luteum. Neurendocrine control of ovarian function. (GnRH secretion, FSH LH-effects on developing follicles, ovulation, corpus luteum formation & function, cellular effects of LH, FSH in hormone production). Foetoplacental Unit and Feedback mechanisms. Estrus & menstrual cycles. The Role of CNS, Hypothalamus and Pineal in Reproduction. Reproduction in wild animals. Timing of reproduction Phenomenon of seasonality. The Biological clock.

Recommended Books

1. Richard W. Hill, Gordon A. Wyse, Margaret Anderson - Animal Physiology, 3rd Ed-Sinauer Associates, Inc. (2012)

2. Singh H. R and Kumar N. Animal Physiology and Biochemistry. Vishal Publishing Co.

3. Guyton and Hall: Text Book of Medical Physiology. W B Saunders Company

4. Negi, CS, Introduction to Endocrinology, PHI Learning PVT LTD

SOLS/Zool/E 02a Fish Biology II

No. of Credits = 3

UNIT I

Specialized Characters

Accessory Respiratory organs in fishes.
Swim Bladder and its modifications, Blood supply of Air bladder, Gas secreting complex, Functions
Weberian ossicles: Structure and arrangement, Working mechanism and functions.
Electric organs: Structure, Mechanism of electric discharge, Functions.
Bioluminescence: Luminiscent organs, Mechanism of light emission, Significance.
Sound production in fishes

UNIT II

Fish Behaviour

Fish behavior: Social, ecological, reproductive, migratory, foraging behavior. Parental care in fishes.
Receptor organs: Eye, Acoustico-Lateralis system, olfactory organs and Taste buds
Migration in fishes: Pattern, Causes and Factors influencing. Parental care and viviparity in fishes.
Pheromones and their role in sexual behavior of fish

UNIT III

Fish Physiology and Embryology

Fertilization and development of fish egg (Teleost). Cleavage, Blastulation, Gastrulation and fate map.
Hatching and post-embryonic development.
Respiration: Functional organization of Gill lamellae, Blood supply of gill, Mechanism of gas exchange, Counter current mechanism.
Physiology of excretion and osmo-regulation, Mechanism of water- salt balance in freshwater, marine and estuarine fishes.
Reproductive physiology: Spawning patterns and stimulating factors, Follicular atresia.
Haemopoiesis: Composition of Blood, haemopoietic tissues, synthesis of Haemoglobin.
Physiology of Thermo-regulation in fishes.

UNIT IV

Fish Endocrinology and Biochemistry

Pituitary gland: Micro-anatomy, Hormones of Pituitary and their physiological actions.
Thyroid gland: Structure and function
Structure and functions of Pancreatic islets in fishes.
Location and functions of Corpuscles of Stannius, Pineal and Urophysis in fishes.

Recommended Books

1. Kyle: The Biology of Fishes, 2007.

2. Singh H.R. : Advances in Fish Biology, Hindustan Publishing Corp., 1994.

3. Khanna S. S. & Singh H.R. : A Text Book of Fish Biology & Fisheries, Narendra Publ. House, 2014

4. Srivastava C.B.L.: Fish Biology, Narendra Publication House, 2008.

SOLS/Zool/E 02b Entomology II

No. of Credits = 3

UNIT I

Digestive system: structure, physiology of digestion and absorption of different types of food. Structure of circulatory system: haemolymph its composition and function. Physiology of respiration; the tracheal system, spiracles, respiration in aquatic insects. Nervous system: structural basis, Excretion: structure and physiology of malpighian tubules and its secondary functions. Reproduction: male and female gonads.

UNIT II

Structure of compound eye, mosatic vision. Production and reception of sound. Light producing organs. Hormones: neurosecretion and co-ordination, Metamorphosis: types, hormonal control of metamorphosis, Pheromones.

UNIT III

Structure of the insect egg, maturation, cleavage, formation of blastoderm, gastrulation, blastokinesis, germ layers, Various types of larvae and pupae, moulting, diapauses, Oviparity, viviparity, ovo-viviparity in insects.

UNIT IV

Abiotic factors: effect of temperature, light and humidity on growth of insect population; biotic potential, Malthusian principle and dynamics of population fluctuation, hibernation, aestivation. Biotic factors: parasitism, predation and social life in insects, phase theory of locust, parental care.

Recommended Books.

1. Mani MS: An Introduction to Entomology, National Book Trust, 1971.
2. Mani MS, Introduction to High Entomology, Mathuen & Coy. Ltd. 1962.
3. Snodgrass RE: Arthropod Anatomy, Comstock Publ. Associates, NY, 1952.
4. Wigglesworth VB: Insect Physiology, Cambridge University Press, 1954.
5. Essig EO: College Entomology, Satish Book Enterprise, Agra, 1982.
6. Fox RM & Fox JW: Introduction to Comparative Entomology. Affiliated East-West Press Pvt. Ltd. New Delhi, 1968.
7. Little VA: General & Applied Entomology, Oxford & IBH Publ. Copy, 1963.
8. Imms AD: Insect Natural History, Collinns St. James's Place London, 1947.
9. Elzinga RJ: Fundamentals of Entomology, Prentice Hall of India Pvt. Ltd., 1978.
10. Comstock JH: An Introduction to Entomology, Comstock Publ. Coy. INC., 1950.
11. Richard DW and Davies RG: A General Text Book of Entomology, Mathuen & Coy., Ltd.

SOLS/Zool/E 02c Environmental Biology II

No. of Credits = 3

UNIT I

Natural Resources: Management & conservation; Renewable & non-renewable resources;

Concept and currencies of Sustainable development.

Biodiversity & its conservation. Environment Protection laws. Earth Summit, Rio+20.

UNIT II

Concept of Protected areas: Sanctuary, National Parks & Biosphere Reserves. IUCN. Categories Biodiversity hot spots, conventions on biodiversity.

International efforts in biodiversity conservation (UNFP, IUCN, WWF); CITES; UNESCO's World heritage mission; Convention on Biological Diversity (CBD).

UNIT III

Global Environmental Problems: Climate change, Green house effect; Acid rain; Ozone layer depletion; Deforestation; Desertification; Marine pollution; Urbanization.

Elementary Toxicology:

Exposure to Toxicants: Routes & sites of exposure (inhalation, injection & through food or intestinal).

Duration & frequency of exposure: Acute, subacute, chronic & subchronic.

Chemical nature of toxicants:

Mechanism of action: Receptors (Proteins), mechanism of action of DDT, Lead (Pb) & UV rays.

UNIT IV

Environmental Problems/Hazards in Hills: Earthquake; Land slide; Soil erosion;

Sedimentation; Cloud burst; Flash floods; Glacial retreat.

Application of Remote sensing & Geographical Information Systems (GIS) in environment management.

Disasters, their types and management

Recommended Books.

1. D.E. Hathwny: Molecularly aspects of Toxicology: The Royal Society of Chemistry, Burlington House, London.
2. V.V. Metelev, A.I. Kanaev & N.G. Dzasokhova: Water Toxicology Amerind Pub. Co. Pvt. Ltd., New Delhi.
3. Omkar: Concepts of Toxicology, Shoban Lal Nagin Chand & Co. 64. B Bunglow Road, Delhi
4. Majupuria T C: Wildlife Wealth of India Craftsman Press Service, Bangkok

SOLS/Zool/E 02d Reproductive Biology II

No. of Credits = 3

UNIT I

Abiotic & Biotic factors influencing life. Zoogeographical regions of the world.

Physiographic diversity of Indian main land. Biogeography of India. Himalayan Biogeography.

Forest types of India. Representative fauna from different biogeographic zones.

Biological diversity: Genetic diversity. Taxonomic diversity, Functional diversity, Measurement of biodiversity (morphological & karyotypic variation, protein & DNA markers).

Evolution of diversity (e.g. birds). Species and speciation, Variation within species.

UNIT II

Population Ecology: Density, Dispersion, Age Structure, Sex ratio, Mortality, (Survivorship & Mortality curves). Natality. Population growth & regulation: Population growth (Exponential, Logistic) & Fecundity. Prey predator relationship. Interspecific and intraspecific competition: Territoriality and Home range. Resource partitioning and utilization.

UNIT III

Population Genetics: Genetic variation and evolution, Genetic heterozygocity (genotypes, phenotypes, sources of variation, Hardy-Weinberg equilibrium, nuclear and Mt DNA).

Gene flow, Inbreeding depression, Coefficients, Genetic drift, Minimal viable population.

UNIT IV

Reproductive patterns (mating, sexual selection, resource-based, genes based, Lek behaviour).

Reproductive isolation, ecological isolation. Reproductive efforts (Parental care, parental investment, parental energy budget). r selection, k selection. Endangered species: Cheetah, Project Elephant, Gir Lions, Tiger project, Musk deer. Sanctuaries and National parks of India.

Wildlife Trade. Role of NGO's, IBWL, WWF, IUCN, CITES. Wetlands, Wildlife Protection Act.

Recommended Books:

1. Dash and Dash, Fundamentals of Ecology, Tata Mc Graw Hill Co.
2. Singh and Kumar, Ecology and Environmental Science, Vishal Publishing Co, Jalandhar
3. Sharma, P D. Ecology and Environment, Rastogi Publications, meerut
4. Joshi and Joshi, A Text Book of Ecology and Environment, Himalaya Publishing House.
5. Majupuria T C: Wildlife Wealth of India Craftsman Press Service, Bangkok

SOLS/Zool/E 03 Lab Course Based on E 01 a/b/c/d & E 02 a/b/c/d

Self Study Course

SOLS/Zool/SS 03 Biological & Radiotracer Techniques

No. of Credits = 3

UNIT I

Analytical separation methods : Chromatography - General principle and application ; Adsorption chromatography, Partition chromatography, Gas chromatography, liquid chromatography, Paper chromatography, Thin layer chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, HPLC (High Performance/Pressure Liquid chromatography).

UNIT II

Electrophoresis - General principle and application ; Paper electrophoresis, Moving boundary method, Gel electrophoresis (Native, Denaturing & Reducing), Disc Gel electrophoresis, Slab Gel electrophoresis, Isoelectrofocussing (IEF), Isotachophoresis.

UNIT III

Centrifugation: Basic principles. Common centrifuges used in laboratory (clinical, high speed & ultra centrifuges). Sedimentation rate, Sedimentation coefficient, Zonal centrifugation, Equilibrium density gradient centrifugation

Types of rotors (fixed angle, swing bucket), Types of centrifugation: Preparative, differential & density gradient.

Microscopy: Light, phase contrast, Fluorescence and Confocal microscopy, Scanning and Transmission Electron microscopy.

UNIT IV

Biosensors: Introduction & principles. First, second & third generation instruments**,** cell based biosensors, enzyme immunosensors.
Spectroscopic methods: principle and applications of UV-visible, IR, NMR, ESR Spectroscopy. Principle & application of X-ray crystallography.

Application of radioisotopes in biology. Properties and units of radioactivity., Radioactive isotopes and half life.

Measurement of radioactivity: GM Counter, gamma counter, liquid scintillation counter. Tracer techniques of Autoradiography, Radioimmunoassay., Safety rules in handling of radioisotopes and hazardous chemicals.

Recommended Books:

1. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill, 1991.
2. Alberts et al.: Molecular Biology of the cell (2nd ed.), Garland, 1989.
3. Biochemical Technique: Theory & Practical J.F. Robyt & B.J. White $ 30.95
   Waveland Press, Inc.
4. Wilson & Walker: Practical Biochemistry (4th ed) University of Hertfordshire
   Cambridge University Press
5. Jayraman: Laboratory Manual in Biochemistry

SOLS/Zool/SS 04 Aquatic Biodiversity

No. of Credits = 3

UNIT I

Biodiversity: Definition, Concept, Scope and measurement of biodiversity; Types of Biodiversity: Species, Genetic, Community, Ecosystem.; Factors governing biodiversity: Historical & Proximate; Endemic species: Definition, Concept, Scope, Hot spots

UNIT II

Types of aquatic ecosystem & biomes and their characteristics.; Freshwater biodiversity. ; Marine biodiversity.; Biodiversity data bases of CMFRI, CIFRI, NBFGR.

UNIT III

Threats to habitats and Biological diversity in Freshwater and marine ecosystems.

Endangered species: Definition, Concept, Scope.; Conservation; Definition, Concept, Scope.

Physical and chemical characteristics of freshwater rivers, lakes, reservoirs and wetlands.

Over view of freshwater biodiversity in important Rivers, Lakes Reservoirs and Wetlands of India with emphasis on Himalaya.

UNIT IV

Impact of Hydroelectric Projects (HEP) on aquatic biodiversity.; Environmental Impact Assessment (EIA): Case studies.; Environmental flows: Importance for the aquatic flora & fauna.; Environmental flows assessment methodology: Hydrological, hydraulics rating, habitat simulation & holistic.

Recommended Books:

1. KJ Gaston & JI Spicer: Biodiversity: An Introduction
2. WT Edmondson: Freshwater Biology
3. VG Jhingran: Fish & Fisheries of India
4. EP Odum: Ecology
5. HBN Hynes: Freshwater Ecology
6. WK Dodds: Freshwater Ecology
7. Rivers for Life: Managing water for people and nature, Sandra Postel, Brain D. Richter
8. Nautiyal P & Singh H R Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009
9. Nautiyal et al Ecology & Diversity of Freshwater Environments Transmedia, Srinagar Garhwal, 2005

SOLS/Zool/C016 Endocrinology & Animal Behaviour

No. of Credits = 3

Endocrinology

UNIT I

Endocrine messengers: hormones, neurohormones, hormone like substances (neuronal peptides, autocoids, pheromones, neurosecretion).

Hormones and Physiological actions of the following endocrine glands in vertebrates: Thyroid, Parathyroid, Pancreas, Gastro-intestinal tract, Adrenal cortex and Medulla, Thymus & Pineal.

Hormone biosynthesis: Protein peptide hormones (gonadotrophins, thyrotrophin, corticotrophin, Steroids and catecholamines).

Mechanism of action of Protein hormones and Catecholamines: membrane bound receptors, G-protein and control of adynelate cyclase, Cyclic nucleotide cascade.

UNIT II

Organisation & physiological actions of the Testis: Androgen binding protein (ABP), Inhibin. Neurendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epitheluim, LH-effects on Leydig cells, negative feed back regulation).

Organisation & physiological actions of the Ovary: Folliculogensis, Ovulaton, Luteinization, Ovarian cycles; Seasonal reproductive cycles; sexual dysfunctions in man.

Animal Behaviour

UNIT III

The science of behaviour: History, scope and terminology. Proximate and ultimate causes of behaviour.

Instinct: Definition and characteristics (sign stimuli and Fixed Action Pattern).

Learning behaviour: Definition. Spatial learning. Associative learning, classical conditioning, operant conditioning, language learning. Imprinting. Kin recognition. Instinct versus learning behaviour.

Timing of behaviour: Biological rhythms. The Biological Clock. Circadian rhythms and their synchronisation seasonal rhythms. Photoperiodism.

UNIT IV

Communication: Visual, olfactory, accoustic. Bird songs. Amphibian calls. Communication in bats.

(echolocation in bats, electrolocation in fish)

Chemoreception: Chemicals (pheromones) as signals in insects, fish and mammals. Role of olfaction in communication behaviour (territorial, sex recognition, feeding etc) in fish and mammals.

Neural control of behavior:

Components of brain involved in various behaviours. Neural control of drinking, learning,

eating, activity & rest, sleep, aggression, sexual behaviour.

Hormonal Control of behaviour. Hormone brain relationships. Sexual behaviour in mammals (eg. rat).

Sociobiology: Elements of sociality and social grouping in animals.

Recommended Books:

1. Alcock : Animal behaviour Sinaur Associates, Inc. 1989.
2. Goodenough et al.: Perspectives on animal behaviour. Wiley & Sons, New Youk. 1993.
3. Grier : Biology of animal behaviour, Mosby 1984.
4. Krebs & Davies : An introduction to behavioural ecology (3rd ed.) Blackwell 1993.
5. Lehner : Handbook of ethological methods, Garland STPM Press, New York, 1979.
6. Halliday, T.R.: Animal Behaviour Vol. 1 & 2 Communication, 1983.
7. Saunders : Insect Clocks Pergamon Press. 1982.
8. Palmer: An Introduction to Biological Rhythms Academic Press New York.1976
9. Ross & Salisbury: Plant Physiology, Indian ed. (FOR BIOLOGICAL RHYTHMS)
10. Mac E. Hadley: Endocrinology, Prentice-Hall International ed.1988/1992.
11. G J Goldsworthy et al: Endocrinology, Blackie, 1981.
12. Maurice Goodman: Basic and Medical Endocrinology, Raven Press.
13. F.S. Greenspan & P.H. Forsham: Basic and Clinical Endocrinology Maruzen Asian Ed. Lange Medical Publ. USA, Singapore
14. Chester-Jones: Fundamentals of Comparative Vertebrate Endocrinology Plenum Press, New York & London, 1987.
15. P.J Bentley: Comparative Vertebrate Endocrinology S. Chand & Company Ltd, Ram Nagar New Delhi, 1980
16. Wilson Foster: Williams Textbook of Endocrinology, Seventh ed.Saunders International ed. London, 1985.

SOLS/Zool/C017 Biochemistry and Immunology

No. of Credits = 3

UNIT I

Enzymes: Classification (rationale, overview and specific example) Zymogens and their activation (protease and Prothrombin).

Enzyme substrate complex : concept of E-S complex, binding sites, active site, specificity, Lock and Key Hypothesis, Induced –Fit Hypothesis, Michaelis- Menten equation and its derivation, Different plots for the determination of Km and Vmax.

Carbohydrate Metabolism I: Pathway and regulation of Glycolysis, Gluconeogenesis, Glycogenolysis, Glycogenesis.

Carbohydrate Metabolism II: Citric acid cycle and its regulation, electron transport chain and oxidative phosphorylation, pentose phosphate pathway and its regulation.

UNIT II

Amino Acid Metabolism: Overview of Amino acid degradation, Urea cycle (conversion of ammonia into urea, linkage between urea cycle and citric acid cycle) and its regulation.

Conversion of nitrogen to ammonia by microorganisms, overview of amino-acid biosynthesis.

Fatty Acid Metabolism: Fatty Acid Oxidation and regulation β-oxidation, Oxidation of unsaturated fatty acids and odd chain fatty acids. β-oxidation in peroxisomes, ketone bodies and their overproduction.

Fatty Acid Biosynthesis and Regulation. Reactions of fatty acid synthase, synthesis of triglycerols, membrane phospholipids & prostaglandins.

Cholesterol biosynthesis and regulation.

UNIT III

Nucleic Acid Metabolism: Purine biosynthesis and its regulation, pyrimidine biosynthesis and its regulation. Formation of deoxyribonucleotides.

Salvage pathway for purine & pyramid in nucleotides, Degradation of purines and pyrimidines into uric acid and urea. Integration of Metabolism.

Overview of The Immune System. Cells and Organs of The Immune System. Antigens, Antigenicity versus Immunogenicity. Haptens & Epitopes

Immunoglobulins: Structure and Function. Major Histocompatibility Complex. Antigen processing and presentation. Structure and functions of BCR & TCR.

UNIT IV

Cytokines. The Complement System. Cell mediated cytotoxicity: Mechanism of T cell & NK cell mediated lysis. Ab-dependent cell mediated cytotoxicity (ADCC)

Overview of Hypersensititivity and Autoimmunity. Introduction to Transplantation.

Vaccines: Active and Passive Immunization

Introduction to Monoclonal Antibodies and Hybridoma technology.

Antigen-Antibody Interactions: Precipitation Reaction, Agglutination Reactions, RIA, ELISA,

Western Blotting, Immuno precipitation, Immuno-fluorescence.

Recommended Books

1. Lehninger: Principles of Biochemistry, 4th ed., Nelson & Cox, WH Freeman and Company, 2007
2. Voet & Voet: Biochemistry, 2nd ed., Wiley & Sons.
3. Berg, Tymoczko, Stryer: Biochemistry, 5th ed., WH Freeman and Company, 2003.
4. Garett & Grisham: Biochemistry, 4th ed., Brooks/Cole Cengage learning, 2010.
5. Murray, Granner, Rodwell: Harper's Illustrated Biochemistry, 27th ed. McGraw Hill, 2006
6. Conn & Stumpf: Outlines of Biochemistry, 5th ed., Willey India, 2007.
7. Kuby : Immunology (4th ed.).
8. Roitt, Male & Brostof : Immunology (3rd ed).
9. Elgert & Elgert : Immunology.
10. Wilson & Walker: Practical Biochemistry (4th ed.).
11. Rama Rao. Text Book of Biochemistry, UBSPD.

SOLS/Zool/C 018 Lab Course Based on C016 & C017

SOLS/Zool/E 04a Fishery Science

No. of Credits = 3

UNIT I

Aquaculture:

Scope, importance and present status.

Concept of different culture systems: Extensive and intensive fish culture,

Fish culture in ponds and reservoirs.

Culture in rice fields, bheries, Cage culture, Pen culture, Monoculture and polyculture.

Preparation and maintenance of fish farm: Fertility and pH maintenance. Role of fertilizers, required water quality and its maintenance.

Control of aquatic weeds, insects and predatory fishes.

Fish nutrition: Development of natural food and supplementary feeding.

Culture techniques Procurement of stocking material from natural sources, Induced breeding and use of new generation drugs, ovaprim, different hatching techniques.

Transport of fish seed.

UNIT II

Culture Practices:

Culture of Common carp and Exotic Trouts.;

Prawn culture.;

Sewage – fed Fisheries and Integrated fish farming

Common fish diseases and their control. ;

Mahseer and Schizothoracid fishery. Current status, problems and perspectives.; Culture of Larvicidal fishes. Characters and importance

UNIT III

Harvesting and Post harvesting

Fishing gears used in inland waters and seas. ;

Fish preservation and processing techniques.

Fish by-products and their uses.;

Fish spoilage: Causes of rigor mortis, precautions to control rancidity, microbial spoilage.;

Nutritive value of fish, biochemistry of fish flesh of Indian major carps.

Storage, transportation and marketing.

UNIT IV

Capture and Ornamental Fishery:

Rivers, Lakes, Dams / Reservoir fishery- Problems and perspectives in Capture fisheries.

Estuarine fishery. Characteristics and species dynamics.

Marine fishery: Coastal, Off shore and deep sea fishery.

Exclusive Economic Zone.

(Hilsa, Oil sardine, mackerel, Bombay duck, Sole, Ribbon, Shark and Rays).

Recreational fishery and Cooperative movements. Fish Farmers Development Agencies (FFDA). Climate change and fishery.; Major, Marine and freshwater ornamental fishes, their food & breeding needs.

Health management of ornamental fishes. Specific diseases and their cure.; Setting and maintenance of aquaria.

Recommended Books

1. S.K. Gupta, P.C. Gupta: General and Applied Ichthyology, S. Chand & Comp., 2006.
2. Vadapalli Satyanarayana: Fish Culture, Narendra Publ. House, 2002.
3. R.K. Rath: Freshwater Aquaculture, 2nd ed., Scientific Publishers, 2000.
4. Singh & Mittal: Dictionary of Aquaculture, Daya Publishing House, 1963.
5. Tor G. Heggberget: The Role of Aquaculture in World Fisheries, Oxford University Press, 1996.
6. Jhingran V G: Fish and Fisheries of India.Hindustan Publication Corp.
7. V P Agarwal, Recent Advances in Aquaculture. Agarwal Printers Meerut.

SOLS/Zool/E 04b Applied Entomology

No. of Credits = 3

UNIT I

Insects in relation to man: sericulture, apiculture and lac culture and its parasites, predators and diseases. Insect of veterinary importance; sand fly, horse fly, sucking louse, fleas.

UNIT II

Brief knowledge of important household, vegetable, store grain and fruit pests with special reference to distribution, habits, habitat, nature of damage, life history and control.

Cut worm (*Agrotis ipsilon*)

Cabbage cateripillar (*Pieris brassicae*)

Rice weevil (*Sitophilus oryzae*)

Mustard aphid (*Lipaphis erysimi*)

Red cotton bug (*Dysdercus cingulatus*)

Woolly apply aphid (*Eriosoma lanigerum*)

Termite: important termites of Fam. Termatidae (*Odontotermis sp*.)

UNIT III

Origin of pests,

Insect pest control; mechanical, physical, culture, biological. Fenetical control: chemosterilants, radiation.

UNIT IV

Integrated Pest Management (IPM), Role of pheromones and hormones in insect pest management. Legislative control of insect pests and quarantine law.

Nomenclature and classification of insecticides on the basis of mode of action, chemical nature. Environmental factors influencing effectiveness of insecticides, persistence, biodegradability, hazards of insecticides, precaution and antidodes.

SOLS/Zool/E 04c Applied Environmental Biology

No. of Credits = 3

UNIT I

Air: Air pollutants (chemistry, sources & control); Air Quality standards, carbon credits, carbon footprint, Thermal pollution sources and effect.

Water: Biochemical aspects of water pollutants (domestic, industrial & agricultural

waste). Waste water treatment (Aerobic & anaerobic treatment processes); Water quality standards.

Case study-Ganga Action Plan.

Noise Pollution: Effects of noise and its control.

UNIT II

Radioactive fallouts its effects & safe disposal.

Solid waste management: Sources & control methods (composting, Vermi Culture, Biogas).

Hazardous waste & their management.

Bioremediation (herbicides, pesticides, hydrocarbons, oil spills).

Ecological Restoration: wasteland & its reclamation & restoration.

UNIT III

Environmental Impact Assessment (EIA): Case study of River valley projects & Mining.

Bioassay: Dose-response relationships; Frequency; Response & cumulative response; statistical concepts (LD50-potency v/s Toxicity).

Concept of hyper & hypo sensitivity factors affecting Toxicity.

UNIT IV

Ecological experimentation & models: Theories & hypothesis; experimentation; Inductive & deductive methods.

Models: Analytical & simulation models; Validation & verification.

Biological pest control: Use of predators; Parasites, parasitoids & pathogenes; Integrated Pest

Management.

SOLS/Zool/E 04d Applied Reproductive Biology

No. of Credits = 3

UNIT I

Wildlife Maps: Toposheet (use and interpretation), Satellite Imageries, Habitat mapping, Food, shelter and cover). Interpretation of Satellite data, GIS and GPS systems. Computers, softwares used for interpretation.

Wildlife Habitat Studies: Understanding forest types, quality and age. Vegetation structure and storeys. Techniques for the assessment of wildlife Habitat and vegetation cover (Quadrat, Transects, PCQ etc.).

UNIT II

Wildlife Census: Indirect signs of wildlife (Pallets, pug marks, hoof marks, scratches, dens, Burrows etc). Estimating Wildlife Populations: Transects in different habitats, landscapes. Transects for different groups of animals. Estimating wildlife in Himalayan Ecosystem. Camera traps in wildlife census and behavioural studies. Animal body signs and population estimation. Wildlife photography.

UNIT III

Capturing and Handling Wildlife: Types of traps and trap setting. Methods for Capturing carnivores, large and small mammals, birds, reptiles, ungulates, rodents, fishes.

Types of Darts and guns used in capturing wildlife. Drugs used for immobilizing wildlife. Antagonists used. Handling and care of captured wildlife animals.

Radio telemetry and collaring: Types of collars, radio tags (insects to large mammals). Transmitters, radio receivers, antenna.

UNIT IV

Collection and preservation of samples (pallets, dungs, scats) from wild. Analyzing food contents. Application of biotechnology to Wildlife Conservation: Sample Collection and preservation. DNA extraction procedures and amplification. Ancient DNA extraction. Molecular marks used in amplification. Sequencing. Instruments used for setting up Conservation genetics laboratory.

SOLS/Zool/E 05a Methodology in Fishery Science

No. of Credits = 3

UNIT I

Habitat Ecology (Abiotic characteristics)

Physiography of pond, lake, streams, river, reservoir. Substrate conditions, hard and soft substrate, partied size sampling for determining abiotic conditions; sample type sampling frequency, sampling and preservation of water for laboratory analysis.
Methods for determining physical environment: Air and water temperature, current velocity, turbidity, transparency.
Methods for estimation of chemical environment, pH conductivity DO, Free CO_2, Alkalinity, Hardness, Chlorides, Phosphate and Nitrate.

UNIT II

Habitat Ecology (Biological characteristic)

Qualitative analysis, Inventory of floral and faunal elements in aquatic ecosystems to class/order level.
Collection and quantitative analysis of biotic communities (density, % composition) plankton and benthic communities (periphyton, macro invertebrates). Multivariate analysis for comparing communities at different locations.
Computation of indices; species richness, species diversity, Margalef diversity index. Similarity index-lidentification of fish fauna (carps, catfish); use of keys, monographs.

UNIT III

Life history traits

History of Fisheries Science, Fish stocks; concept, test of homogeneity using morphometric and meristic analysis, truss analysis, molecular techniques.
Length-weight relationship, Relative Condition Factor, Quantitative estimation of dietary components; Numerical, volumetric, gravimetric, Points method.
Determining category of food (basic, secondary etc) and dietary habits (herb-omni, carnivore), feeding intensity (Gastrosomatic index, Kn).
Determining stages of sexual maturity (macroscopic and microscopic methods), size at first maturity, spawning season and frequency (Gonado-Somatic index) fecundity.

UNIT IV

Determination of age and growth in fishes by hard parts (Scale, otolith and operculum), Length frequency method. Identification of annuli, Growth rate, back calculation method.
Estimation of harvestable size of fish.
Fishery biology of snow trout and Golden mahseer.
Stock assessment, growth parameters, mortality exploitation rate and ratio. FiSAT software.
Fishing gears, Catch Per Unit Effort (CPUE).

Recommended Books

1. Nautiyal P: Methods in fisheries Science & Aquatic Ecology. Bishen Singh Mahendra Pal Singh, Dehradun 2019
2. Carlander: Handbook of Freshwater Fishery Biology, vol. 2, Iowa State Univ. Press,1977.
3. Nautiyal P: The Golden Mahseer (A Threatened Fish of Himalaya). Lambert Academic Publishing, Amazon Distribution GmbH,, Leipzig,2012
4. Nautiyal P: (Compiled & Edited) Mahseer – The Game Fish [Natural History, Status and Conservation practices in India and Nepal] Jagdamba Prakashan, Dehradun 1994
5. Bahuguna and Dobriyal, Biology of the ornamental fish Puntius conchonius (Ham. Buch.) NPH, Delhi, 2019

SOLS/Zool/E 05b Methodology in Entomology

No. of Credits = 3

UNIT I

Introductory Entomology

Research methodology in entomology in introduction. Role of entomology in agriculture (Beneficial and Harmful insects).

Medical entomology: Disease vectors (Mosquito, Sand fly, tsetse fly, pathogens, lifecycle and diseases).

Veterinary entomology: Vector insect (Ticks, Mites, Flies, pathogens, lifecycle and diseases). Forensic.

Entomology: Principle, Forensic entomological flies, use of human lice in forensic entomology, Importance.

UNIT II

Entomological techniques –I

Type of sampling survey, Different Collection Methods, Collection of wild flies and Domestic insects. Collecting Insect in the wild area-Tools and Equipments, Preparing and using baits, Collecting from natural substances, Collection permission from govt. agency like forest department State Biodiversity Board (SBB), National Biodiversity Authority (NAB), Transporting live adults or larvae.

UNIT III

Preservation of insects, classification of insects up to the level of families with hands-on experience in identifying the families of insects and Catalogues.

Insect Laboratory and rearing equipment, Experimental designs in field and Laboratory Observation techniques and Molecular techniques in insect taxonomy.

Mortality correction, Bioassay: Principles, Importance, Factor affecting, Procedures apparatus used.

UNIT IV

Entomological Techniques –II

Trophic relationships.

Use of ecological data, insect diversity: Indices, richness, rarity.

Population estimates.

Coexistence and Competition.

Distribution patterns.

Study of terrestrial/aquatic insect biodiversity, physic-chemical parameters of water (turbidity/transparency, velocity, pH, temperature, estimation of CO2, O2 hardness).

SOLS/Zool/E 05c Methodology in Environmental Biology

No. of Credits = 3

UNIT I

Importance and need of environmental research. Problem identification, objectives, significance, scope and limitations.

Literature survey. Importance and designing of the problem to be undertaken.

Field survey: Site selection, source selection for data acquisition.

Sampling strategies, Sample size, Frequency, Bias, Error. Project Report Preparation.

UNIT II

Measurement of solar radiation, wind velocity, air quality monitoring, measurement of oxides of nitrogen, carbon, sulphur, lead, tropospheric ozone, methane, aerosol, pesticide.

Stack sampling, sample collection for particulate matters (Dustfall collection, High volume sampler), indoor air pollutants (radon) measurement.

UNIT III

Water quality analysis: Measurement of water temperature, velocity, depth, transparency, dissolved oxygen, free carbon dioxide, pH, turbidity, hardness, alkalinity, BOD, COD, dissolved nutrients (Nitrates, phosphates, sodium, potassium, chloride, etc.), heavy metals.

Sampling methods for terrestrial flora and fauna (quadrate method).

UNIT IV

Sampling methods for aquatic fauna and flora (plankton, periphyton, micro and macroinvertebrates, nekton, etc.).

Soil types, measurement of soil pH, water holding capacity, organic matter, soil nutrients (nitrate, nitrite, calcium and magnesium), Sampling of soil fauna.

Sampling of soil for microbial diversity.

Application of statistical Descriptive and regression analysis in Environmental Science: Parameteric and Nonparameteric Tests, Hypothesis testing, t-test, Z-test, F-test, multivariate test chi square test, Kruskal Wallis test.

Statistical Foftwares: Excel, Statistica, SPSS, etc.

SOLS/Zool/E 05d Methodology in Reproductive Biology

No. of Credits = 3

UNIT I

Collection and cryopreservation of gametes and embryos; Assessment of sperm function; Capacitation.

In vitro fertilization.

Multiple ovulation & Embryo transfer technology for farm animals, artificial insemination.

Recovery and maturation of oocyte.

Assessment of reproductive cycles of wildlife in captive and natural conditions.

Reproductive Cycles of some endangered species.(musk deer, elephant, tiger, pheasants) and farm animals (cattle, sheep, goat and Pig). Real-time ultrasonic scanning.

Hormones of Pregnancy. Pregnancy tests.

UNIT II

Principles and methods of fertility control (rhythm method, diaphragm, condom, IUD, oral contraceptives, surgical intervention, pregnancy termination).

Immunoendocrinology, immunoreproduction and immunocontraception – basic principles;

candidate vaccines; Gamete antigens and their immuno contraceptive potential. Male and female infertility (causes and dignosis). Hysterosalpingeography, Laproscopy.

UNIT III

Captive breeding programs. Role of CZA in Conserving endangered wildlife. Techniques for improving reproductive efficiency. Superovlulatory response and associated factors.
Infrastructure required to setup laboratory.

UNIT IV

Gene cloning and reproduction. Cloning of animals by nuclear transfer. Impact of artificial insemination technology.Embryo transfer and associate techniques. Factors influencing cloning techniques. Production and applications of transgenic animals and knock outs.

Bioethics

SOLS/Zool/E 06 Lab Course Based on E 04 a/b/c/d & E 05 a/b/c/d

M.Sc. Zoology 4th Sem.

Self Study Course

SOLS/Zool/SS 05 Cold Water Fisheries

No. of Credits = 3

UNIT I

Coldwater fisheries in India: Concept and scope.
Natural and man-made coldwater fishery resources, their distribution and extent in various states of India (Himalaya and Peninsular India).
Coldwater fish fauna in India and Nepal Himalaya and their threat status.

UNIT II

Source (glacier and spring fed) based classification of fluvial resources.
Origin based classification of lacustrine resources.
The physical and chemical environment of fluvial and lacustrine resources their characteristic biota and communities.

UNIT III

Coldwater capture fisheries in lotic and lentic ecosystems.
Coldwater culture fishery, history in India, cultivable fishes fundamentals of coldwater fish culture, fish farm for trout and mahseer.
Mahseer and trout culture techniques.

UNIT IV

Fish stocks, concept and importance in capture fishery.
Morphometric and meristic analysis for determining the homogeneity of stocks.
Life history traits of barils, mahseer, snow trout and exotic carps (common grass, silver).
Stock assessment features: growth parameters mortality, ratio and rate of exploitation.
Statistical techniques in fishery science.

Recommended Books

1. Singh H R & Lakra W S: Cold Water Aquaculture and Fisheries, Narendra Publication House, 2000.
2. Carlander: Handbook of Freshwater Fishery Biology, vol. 2, Iowa State Univ. Press,1977.
3. Nautiyal P: The Golden Mahseer (A Threatened Fish of Himalaya). Lambert Academic Publishing, Amazon Distribution GmbH,, Leipzig,2012
4. Nautiyal P: (Compiled & Edited) Mahseer – The Game Fish [Natural History, Status and Conservation practices in India and Nepal] Jagdamba Prakashan, Dehradun 1994

SOLS/Zool/SS 06 Environmental Biotechnology

No. of Credits = 3

UNIT I

Environmental Biotechnology: Concept.

Air pollution and its control through Biotechnology (deodorization, reduction in CO_2 emission, bioscrubbers, biobeds, biofilters etc).

Water pollution and its controls: Sources of water pollution, waste water treatment-physical, chemical and biological processes (aerobic & anaerobic processes)

Solid waste: Sources and management (composting, vermiculture and biogas production)

UNIT II

Xenobiotics in Environment: Xenobiotic compounds, Recalcitrance, Bioleaching and Biomining.

Bioremediation: Types, in situ and ex situ bioremediation; Bioremediation for herbicides,Pesticides, hydrocarbons and oil spills

Hospital wastes, hazardous waste and their management.

Biopesticides in integrated pest management.

Biofertilizers.

UNIT III

Global Environmental Problems: Ozone depletion, UV-B, green-house effect and acid rain, their impact and biotechnological approaches for management.

Restoration of waste land/degraded ecosystem.

Industrial pollution and its control: Pulp & Paper, Tannery, Dairy and Petroleum.

Basic concepts of Environmental Impact Assessment (EIA)

Environment Management: Concept & Approaches

UNIT IV

Introduction to fermentation processes and types of fermentation

Microbial Growth Kinetics; Isolation, Preservation and Improvement of industrially important microorganisms

Production of solvents (Ethanol, Butanol), Antibiotics (Penicillin, Tetracycline) and Alcoholic beverages by fermentation.

Revised syllabus of B.Sc. Chemistry from 2016-17

CBCS system – BSc - CHEMISTRY Courses

	DSC 6 credits each	**SEC** 2 credits each (maximum two)	**DSE** 6 credits each
Semester I	DSC-2A-Theory Inorganic Chemistry-I Organic Chemistry-I DSC-2A-Practical		
Semester II	DSC-2B-Theory Physical Chemistry-I Organic Chemistry-II DSC-2B-Practical		
Semester III	DSC-2C-Theory Physical Chemistry-II Organic Chemistry-III DSC-2C-Practical	SEC-1	
Semester IV	DSC-2D-Theory Inorganic Chemistry-II Physical Chemistry-III DSC-2D-Practical	SEC-2	
Semester V		SEC-3	DSE-2A-Chemistry
Semester VI		SEC-4	DSE-2B-Chemistry

Chemistry Course [**DSC – 2**]

(Sem I)

DSC-2A - Atomic Structure Bonding, & General Organic Chemistry, Aliphatic hydrocarbon
Inorganic Chemistry-I
Organic Chemistry-I

DSC-2A Lab- Atomic Structure Bonding, & General Organic Chemistry, Aliphatic hydrocarbon
Inorganic Chemistry-I
Organic Chemistry-I

(Sem II)

DSC-2B ï Chemical Energetics, Equilibria & Functional Organic Chemistry
Physical Chemistry-I
Organic Chemistry-II

DSC-2B Lab - Chemical Energetics, Equilibria & Functional Organic Chemistry

Physical Chemistry-I
Organic Chemistry-II

(Sem III)

DSC-2C ï Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional group Organic Chemistry
Physical Chemistry-II
Organic Chemistry-III

DSC-2C Lab ï Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional group Organic Chemistry
Physical Chemistry-II
Organic Chemistry-III

(Sem IV)

DSC-2D ï **Coordination chemistry,** States of Matter & Chemical Kinetics
Inorganic Chemistry-II
Physical Chemistry-III

DSC-2D Lab ï **Coordination chemistry,** States of Matter & Chemical Kinetics
Inorganic Chemistry-II
Physical Chemistry-III

Chemistry Courses [**SEC**]

Basic Analytical Chemistry
Green Methods in Chemistry
Chemistry and Cosmetics & Perfumes
Pesticides Chemistry

Chemistry Courses [**DSE**]

Semester- V (Any one)
Analytical Methods in Chemistry
Polymer Chemistry
Green Chemistry
Semester – VI (Any one)
Instrumental Methods of Chemical Analysis
Organometallics, Bio-inorganic, Polynuclear Hydrocarbon, UV and IR Spectroscopy
Molecules of Life

Semester I

CHEMISTRY-DSC 2A: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Section A: Inorganic Chemistry-1 **(30 Periods)**

Atomic Structure: *Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.*

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s. Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number (m_s).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

(14 Lectures)

Chemical Bonding and Molecular Structure

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

(16 Lectures)

***Section B: Organic Chemistry-1* (30 Periods)**

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückelôs rule.

(8 Lectures)

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis* - *trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

(10 Lectures)

Aliphatic Hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbeôs synthesis, from Grignard reagent. *Reactions:* Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeffôs rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoffôs and anti-Markownikoffôs addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

(12 Lectures)

Reference Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of*

Structure and Reactivity, Pearson Education India, 2006.
- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
- Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.

CHEMISTRY LAB: DSC 2A LAB: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS
60 Lectures
Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.

2. Estimation of oxalic acid by titrating it with $KMnO_4$.

3. Estimation of water of crystallization in Mohrôs salt by titrating with $KMnO_4$.

4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)

2. Separation of mixtures by Chromatography: Measure the R_f value in each case (combination of two compounds to be given)

Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography

Identify and separate the sugars present in the given mixture by paper chromatography.

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

Semester II

CHEMISTRY-DSC 2B: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Section A: Physical Chemistry-1 **(30 Lectures)**

Chemical Energetics

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature ï Kirchhoffôs equation.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

(10 Lectures)

Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G^{o}, Le Chatelierôs principle. Relationships between K_p, K_c and K_x for reactions involving ideal gases.

(08 Lectures)

Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts ï applications of solubility product principle.

(12 Lectures)

Section B: Organic Chemistry-2 **(30 Lectures)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Aromatic hydrocarbons

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craftôs reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

(8 Lectures)

Alkyl and Aryl Halides

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1, S_N2 and S_Ni) reactions.

Preparation: from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamsonôs ether synthesis: Elimination vs substitution.

Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by ï OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

(8 Lectures)

Alcohols, Phenols and Ethers (Upto 5 Carbons)
Alcohols: *Preparation:* Preparation of 1^{ts}, 2^{ts} and 3^{ts} alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houbenï Hoesch Condensation, Schotten ï Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions ï Reaction with HCN, ROH, $NaHSO_3$, NH_2 -G derivatives. Iodoform test. Aldol Condensation, Cannizzaroôs reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

(14 Lectures)

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7^{th} Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New Delhi (1988).
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).

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60 Lectures

CHEMISTRY LAB- DSC 2B LAB: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO_3, NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of *H*.

Ionic equilibria pH measurements

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
b) Preparation of buffer solutions:
(i) Sodium acetate-acetic acid
(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol/Aniline
(b) Benzoylation of amines/phenols
(c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

Reference Books

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

Semester III

CHEMISTRY-DSC 2C: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II (Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Section A: Physical Chemistry-2 **(30 Lectures)**

Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoultôs law, deviations from Raoultôs law ï non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

(8 Lectures)

Phase Equilibrium

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius ï Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only).

(8 Lectures)

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

(6 Lectures)

Electrochemistry

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: *G*, *H* and *S* from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.

pH determination using hydrogen electrode and quinhydrone electrode.

Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

(8 Lectures)

Section B: Organic Chemistry-3 **(30 Lectures)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic)

Preparation: Acidic and Alkaline hydrolysis of esters.

Reactions: Hell ï Vohlard - Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

(6 Lectures)

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic): (Upto 5 carbons)

Preparation: from alkyl halides, Gabrielôs Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten ï Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation.

Diazonium salts: *Preparation:* from aromatic amines.
R*eactions:* conversion to benzene, phenol, dyes.

(6 Lectures)

Amino Acids, Peptides and Proteins:

Preparation of Amino Acids: Strecker synthesis using Gabrielôs phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of ï COOH group, acetylation of ï NH_2 group, complexation with Cu^{2+} ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and Cï terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

(10 Lectures)

Carbohydrates: Classification, and General Properties, Glucose and Fructose (open chain and cyclic

structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

(8 Lectures)

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
- Mahan, B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co.: New York (1985).
- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7th Ed.,* W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

CHEMISTRY LAB-DSC 2C LAB: SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL ORGANIC CHEMISTRY-II

60 Lectures

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq) + I^-(aq) \quad I_3^-(aq)$

$Cu^{2+}(aq) + xNH_2(aq) \quad [Cu(NH_3)_x]^{2+}$

Phase equilibria

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Conductance

I. Determination of cell constant
II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
III. Perform the following conductometric titrations:
   i. Strong acid vs. strong base
   ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

i. Strong acid vs. strong base
ii. Weak acid vs. strong base
iii. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

I Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. Titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing and a nonreducing sugar.

Reference Books:

- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,* Universities Press.

Semester IV

CHEMISTRY-DSC 2D: COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Transition Elements (3d series)

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu.

Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

(12 Lectures)

Coordination Chemistry

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6.

Drawbacks of VBT. IUPAC system of nomenclature.

(8 Lectures)

Crystal Field Theory

Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_d complexes, Tetragonal distortion of octahedral geometry.

Jahn-Teller distortion, Square planar coordination.

(10 Lectures)

Section B: Physical Chemistry-3 **(30 Lectures)**

Kinetic Theory of Gases

Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation.

Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO_2.

Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation ï derivation not required) and their importance.

Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

(8 Lectures)

Liquids

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

(6 Lectures)

Solids

Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. Xï Ray diffraction by crystals, Braggôs law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

(8 Lectures)

Chemical Kinetics

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Halfï life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.

Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

(8 Lectures)

Reference Books:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
- Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
- Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- Cotton, F.A. & Wilkinson, G. *Basic Inorganic Chemistry,* Wiley.
- Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
- Wulfsberg, G. *Inorganic Chemistry,* Viva Books Pvt. Ltd.
- Rodgers, G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd., 2008.

CHEMISTRY LAB-DSC 2D LAB: COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS

60 Lectures

Section A: Inorganic Chemistry

Semi-micro qualitative analysis using H_2S of mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations : NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+

Anions : CO_3^{2-} , S^{2-}, SO^{2-}, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-,SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^-

(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.
3. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Jobôs method.
4. Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

5. Estimation of total hardness of a given sample of water by complexometric titration.
6. Determination of concentration of Na^+ and K^+ using Flame Photometry.

Section B: Physical Chemistry

(I) Surface tension measurement (use of organic solvents excluded).

a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
b) Study of the variation of surface tension of a detergent solution with concentration.

(II) Viscosity measurement (use of organic solvents excluded).

a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwaldôs viscometer.
b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
   c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methyl acetate

Reference Books:

- Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

Skill Enhancement Course
(Credit: 02 each, Any two maximum)- SEC1 to SEC4

BASIC ANALYTICAL CHEMISTRY (Credits: 02)

30 Lectures

Introduction: Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

Determination of pH of soil samples.

Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

Determination of pH, acidity and alkalinity of a water sample.

Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products: Nutritional value of foods, idea about food processing and food preservations and adulteration.

Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
Analysis of preservatives and colouring matter.

Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

Paper chromatographic separation of mixture of metal ion (Fe^{3+} and Al^{3+}).
To compare paint samples by TLC method. **Ion-exchange:** Column, ion-exchange chromatography etc.

Determination of ion exchange capacity of anion / cation exchange resin (using batch procedure if use of column is not feasible).

Analysis of cosmetics: Major and minor constituents and their function

Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Suggested Applications (Any one):

To study the use of phenolphthalein in trap cases.
To analyze arson accelerants.
To carry out analysis of gasoline.

Suggested Instrumental demonstrations:

Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry.

Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.

Spectrophotometric Identification and Determination of Caffeine and Benzoic Acid in Soft Drink.

Reference Books:

Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.

Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.

Skoog, D.A.; West, D.M. & Holler, F.J. *Fundamentals of Analytical Chemistry 6th Ed.,* Saunders College Publishing, Fort Worth (1992).

Harris, D. C. *Quantitative Chemical Analysis*, W. H. Freeman.

Dean, J. A. *Analytical Chemistry Notebook*, McGraw Hill.

Day, R. A. & Underwood, A. L. *Quantitative Analysis*, Prentice Hall of India.

Freifelder, D. *Physical Biochemistry 2nd Ed.,* W.H. Freeman and Co., N.Y. USA (1982).

Cooper, T.G. *The Tools of Biochemistry,* John Wiley and Sons, N.Y. USA. 16 (1977).

Vogel, A. I. *Vogel's Qualitative Inorganic Analysis 7th Ed.,* Prentice Hall.

Robinson, J.W. *Undergraduate Instrumental Analysis 5th Ed.,* Marcel Dekker, Inc., New York (1995).

GREEN METHODS IN CHEMISTRY (Credits: 02)

Theory: 30 Lectures

Theory and Hand-on Experiments

Introduction: Definitions of Green Chemistry. Brief introduction of twelve principles of Green Chemistry, with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability

The following Real world Cases in Green Chemistry should be discussed:

Surfactants for carbon dioxide ï Replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.

Designing of environmentally safe marine antifoulant.

Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.

An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

Practicals

Preparation and characterization of biodiesel from vegetable oil.
Extraction of D-limonene from orange peel using liquid CO_2 prepared from dry ice.
Mechano chemical solvent free synthesis of azomethine.
Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper(II).

Reference Books:

Anastas, P.T. & Warner, J.K. *Green Chemistry- Theory and Practical*, Oxford University Press (1998).

Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).

Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).

Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).

Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. *Green Chemistry Experiments: A monograph* I.K. International Publishing House Pvt Ltd. New Delhi, Bangalore.

Lancaster, M. *Green Chemistry: An introductory text* RSC publishing, 2nd Edition.

Sidhwani, I.T., Saini, G., Chowdhury, S., Garg, D., Malovika, Garg, N. Wealth from waste:
A green method to produce biodiesel from waste cooking oil and generation of useful products from waste further generated *"A Social Awareness Project", Delhi University Journal of Undergraduate Research and Innovation*, **1(1)**: 2015

CHEMISTRY OF COSMETICS & PERFUMES (Credits: 02)

30 Lectures

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Practicals
Preparation of talcum powder.
Preparation of shampoo.
Preparation of enamels.
Preparation of hair remover.
Preparation of face cream.
Preparation of nail polish and nail polish remover.

Reference Books:

E. Stocchi: *Industrial Chemistry*, Vol -I, Ellis Horwood Ltd. UK.

P.C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut (1996).

PESTICIDE CHEMISTRY (Credits: 02)

30 Lectures

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (

Chloranil), Anilides (Alachlor and Butachlor).

Practicals

To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.

Preparation of simple organophosphates, phosphonates and thiophosphate

Reference Book:

Cremlyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, New York, 1978

CHEMISTRY-DSE I-IV (ELECTIVES)

DSE-2A-Chemistry (Semester V, Select any one course)

1. CHEMISTRY-DSE: ANALYTICAL METHODS IN CHEMISTRY
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Qualitative and quantitative aspects of analysis:

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

(5 Lectures)

Optical methods of analysis:

Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambertôs law.

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Jobôs method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques.

Structural illustration through interpretation of data, Effect and importance of isotope substitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

(25 Lectures)

Thermal methods of analysis:

Theory of thermogravimetry (TG), basic principle of instrumentation.

Techniques for quantitative estimation of Ca and Mg from their mixture.

(5 Lectures)

Electroanalytical methods:

Classification of electroanalytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pK_a values.

(10 Lectures)

Separation techniques:

Solvent extraction: Classification, principle and efficiency of the technique.

Mechanism of extraction: extraction by solvation and chelation.

Technique of extraction: batch, continuous and counter current extractions.

Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique.

Mechanism of separation: adsorption, partition & ion exchange.

Development of chromatograms: frontal, elution and displacement methods.

Qualitative and quantitative aspects of chromatographic methods of analysis: IC, GLC, GPC, TLC and HPLC.

Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Role of computers in instrumental methods of analysis.

(15 Lectures)

Reference Books:

Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley & Sons, 1989.

Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.

Christian, G.D; *Analytical Chemistry*, 6th Ed. John Wiley & Sons, New York, 2004.

Harris, D. C. *Exploring Chemical Analysis*, Ed. New York, W.H. Freeman, 2001.

Khopkar, S.M. *Basic Concepts of Analytical Chemistry*. New Age, International Publisher,

2009.
Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
Ditts, R.V. *Analytical Chemistry; Methods of Separation*, van Nostrand, 1974.

PRACTICALS- DSE LAB: ANALYTICAL METHODS IN CHEMISTRY

60 Lectures
I. Separation Techniques

1. Chromatography:

(a) Separation of mixtures

(i) Paper chromatographic separation of Fe^{3+}, Al^{3+}, and Cr^{3+}.

(ii) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

(b) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their R_f values.

(c) Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

(i) To separate a mixture of Ni^{2+} & Fe^{2+} by complexation with DMG and extracting the Ni^{2+}-DMG complex in chloroform, and determine its concentration by spectrophotometry.

(ii) Solvent extraction of zisconium with amberliti LA-1, separation from a mixture of irons and gallium.

3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.

4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.

5. Analysis of soil:

(i) Determination of pH of soil.

(ii) Total soluble salt (iii) Estimation of calcium, magnesium, phosphate, nitrate

6. Ion exchange:

(i) Determination of exchange capacity of cation exchange resins and anion exchange resins.

(ii) Separation of metal ions from their binary mixture.

(iii) Separation of amino acids from organic acids by ion exchange chromatography.

III Spectrophotometry

1. Determination of pK_a values of indicator using spectrophotometry.

2 Structural characterization of compounds by infrared spectroscopy.
3 Determination of dissolved oxygen in water.
4 Determination of chemical oxygen demand (COD).
5 Determination of Biological oxygen demand (BOD).
6 Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Jobôs method.

Reference Books:

- Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley & Sons, 1989.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
- Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
- Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
- Ditts, R.V. *Analytical Chemistry; Methods of Separation*, van Nostrand, 1974.

2. CHEMISTRY-DSE: POLYMER CHEMISTRY

(Credits: Theory-06, Practicals-02)
Theory: 60 Lectures

Introduction and history of polymeric materials:

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.

(4 Lectures)

Functionality and its importance:

Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.

(8 Lectures)

Kinetics of Polymerization:

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

(8 lectures)

Crystallization and crystallinity:

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

(4 Lectures)

Nature and structure of polymers-Structure Property relationships.

(2 Lectures)

Determination of molecular weight of polymers (M_n, M_w, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance.

Polydispersity index.

(8 Lectures)

Glass transition temperature (Tg) and determination of Tg, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).

(8 Lectures)

Polymer Solution ï Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

(8 Lectures)

Properties of Polymers (Physical, thermal, Flow & Mechanical Properties).

Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes,

Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

(10 Lectures)

Reference Books:

- Seymour, R.B. & Carraher, C.E. *Polymer Chemistry: An Introduction,* Marcel Dekker, Inc. New York, 1981.
- Odian, G. *Principles of Polymerization*, 4th Ed. Wiley, 2004.
- Billmeyer, F.W. *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
- Ghosh, P. *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
- Lenz, R.W. *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers, New York, 1967.

CHEMISTRY PRACTICAL - DSE LAB: POLYMER CHEMISTRY

60 Lectures

1. **Polymer synthesis**

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) / Acrylic acid (AA).
    a. Purification of monomer
    b. Polymerization using benzoyl peroxide (BPO) / 2,2ô-azo-bis-isobutylonitrile (AIBN)
2. Preparation of nylon 66/6

1. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
    a. Preparation of IPC
    b. Purification of IPC
    c. Interfacial polymerization
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Microscale Emulsion Polymerization of Poly(methylacrylate).

Polymer characterization

1. Determination of molecular weight by viscometry:
    (a) Polyacrylamide-aq.$NaNO_2$ solution
    (b) (Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of ñhead-to-headò monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis
   *at least 7 experiments to be carried out.

Reference Books:

- M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press, 1999.
- H.R. Allcock, F.W. Lampe & J.E. Mark, *Contemporary Polymer Chemistry*, 3rd ed. Prentice-Hall (2003)
- F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed. Wiley-Interscience (1984)
- J.R. Fried, *Polymer Science and Technology*, 2nd ed. Prentice-Hall (2003)
- P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. John Wiley & Sons (2002)
- L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons (2005)
- M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press (2005).
- Seymour/ Carraherôs Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

3. CHEMISTRY-DSE: GREEN CHEMISTRY
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Introduction to Green Chemistry

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations/ Obstacles in the pursuit of the goals of Green Chemistry

(4 Lectures)

Principles of Green Chemistry and Designing a Chemical synthesis

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

- Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts; maximum incorporation of the materials used in the process into the final products , Atom Economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions.
- Prevention/ minimization of hazardous/ toxic products reducing toxicity. risk =

  (function) hazard × exposure; waste or pollution prevention hierarchy.

- Green solventsï supercritical fluids, water as a solvent for organic reactions, ionic liquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solvents and how to compare greenness of solvents.
- Energy requirements for reactions ï alternative sources of energy: use of microwaves and ultrasonic energy.
- Selection of starting materials; avoidance of unnecessary derivatization ï careful use of blocking/protecting groups.
- Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents; catalysis and green chemistry, comparison of heterogeneous and homogeneous catalysis, biocatalysis, asymmetric catalysis and photocatalysis.
- Prevention of chemical accidents designing greener processes, inherent safer design, principle of ISD ñWhat you donât have cannot harm youò, greener alternative to Bhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (safer route to cyclohexanol) subdivision of ISD, minimization, simplification, substitution, moderation and limitation.
- Strengthening/ development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes.

(30 Lectures)

Examples of Green Synthesis/ Reactions and some real world cases

1. Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis)
2. Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoic acid, oxidation of toluene and alcohols; microwave assisted reactions in organic solvents Diels-Alder reaction and Decarboxylation reaction
3. Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonic alternative to Iodine)

4 Surfactants for carbon dioxide ï replacing smog producing and ozone depleting solvents with CO_2 for precision cleaning and dry cleaning of garments.
5 Designing of Environmentally safe marine antifoulant.
6 Rightfit pigment: synthetic azopigments to replace toxic organic and inorganic pigments.
7 An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.
8 Healthier fats and oil by Green Chemistry: Enzymatic interesterification for production of no Trans-Fats and Oils
9 Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting

(16 Lectures)

Future Trends in Green Chemistry

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C^2S^3); Green chemistry in sustainable development.

(10 Lectures)

Reference Books:

- Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, Anamalaya Publishers (2005).
- Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, Oxford University Press (1998).
- Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
- Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington (2000).
- Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).
- Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.

CHEMISTRY PRACTICAL - DSE LAB: GREEN CHEMISTRY

60 Lectures

1. Safer starting materials

- Preparation and characterization of nanoparticles of gold using tea leaves.

2. Using renewable resources

- Preparation of biodiesel from vegetable/ waste cooking oil.

3. Avoiding waste

Principle of atom economy.

- Use of molecular model kit to stimulate the reaction to investigate how the atom economy can illustrate Green Chemistry.
- Preparation of propene by two methods can be studied

(I) Triethylamine ion + OH^- Ÿ propene + trimethylpropene + water

H_2SO_4/Δ

(II) 1-propanol ⟶ propene + water

- Other types of reactions, like addition, elimination, substitution and rearrangement should also be studied for the calculation of atom economy.

4. Use of enzymes as catalysts

- Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.

5. Alternative Green solvents

Extraction of D-limonene from orange peel using liquid CO_2 prepared form dry ice.

Mechanochemical solvent free synthesis of azomethines

6. Alternative sources of energy

- Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
- Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference Books:

- Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice,* Oxford University Press (1998).
- Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
- Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American Chemical Society, Washington DC (2002).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN 978-93-81141-55-7 (2013).
- Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, American Chemical Society (2008).

DSE-2B-Chemistry (Semester VI, select any one course)

1. CHEMISTRY-DSE: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Introduction to spectroscopic methods of analysis:

Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation.

(4 Lectures)

Molecular spectroscopy:

Infrared spectroscopy:

Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier

Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection.

UV-Visible/ Near IR ï emission, absorption, fluorescence and photoaccoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoaccoustic, fluorescent tags).

(16 Lectures)

Separation techniques

Chromatography: Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

Immunoassays and DNA techniques

Mass spectroscopy: Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

(16 Lectures)

Elemental analysis:

Mass spectrometry (electrical discharges).

Atomic spectroscopy: Atomic absorption, Atomic emission, and Atomic fluorescence.

Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

(8 Lectures)

NMR spectroscopy: **P**rinciple, Instrumentation, Factors affecting chemical shift, Spin-coupling, Applications.

(4 Lectures)

Electroanalytical Methods: Potentiometry & Voltammetry

(4 Lectures)

Radiochemical Methods

(4 Lectures)

X-ray analysis and electron spectroscopy (surface analysis)

(4 Lectures)

Reference books:

- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- P.W. Atkins: Physical Chemistry.
- G.W. Castellan: Physical Chemistry.
- C.N. Banwell: Fundamentals of Molecular Spectroscopy.
- Brian Smith: Infrared Spectral Interpretations: A Systematic Approach.
- W.J. Moore: Physical Chemistry.

PRACTICALS-DSE LAB: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS

60 Lectures

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform and carbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/Ferricyanide Couple
14. Nuclear Magnetic Resonance
15. Use of fluorescence to do ñpresumptive testsò to identify blood or other body fluids.
16. Use of ñpresumptive testsò for anthrax or cocaine
17. Collection, preservation, and control of blood evidence being used for DNA testing
18. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y chromosome only or multiple chromosome)
19. Use of sequencing for the analysis of mitochondrial DNA
20. Laboratory analysis to confirm anthrax or cocaine
21. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
22. Detection of illegal drugs or steroids in athletes
23. Detection of pollutants or illegal dumping
24. Fibre analysis

At least 10 experiments to be performed.

Reference Books:

- Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
- Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
- Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society (2008).

- Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.
- Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach,* W.B.Saunders, 1995.

2. DSE: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

(Credits: Theory-04, Practicals-02) Theory:

60 Lectures

***Section A: Inorganic Chemistry-4* (30 Lectures)**

Chemistry of 3d metals

Oxidation states displayed by Cr, Fe, Co, Ni and Co.

A study of the following compounds (including preparation and important properties);

Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$.

(6 Lectures)

Organometallic Compounds

Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

(12 Lectures)

Bio-Inorganic Chemistry

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump; Role of Mg^{2+} ions in energy production and chlorophyll. Role of Ca^{2+} in blood clotting, stabilization of protein structures and structural role (bones).

(12 Lectures)

***Section B: Organic Chemistry-4* (30 Lectures)**

Polynuclear and heteronuclear aromatic compounds:

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene , Furan, Pyrrole, Thiophene, and Pyridine.

(6 Lectures)

Active methylene compounds:

Preparation: Claisen ester condensation. Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).

(6 Lectures)

Application of Spectroscopy to Simple Organic Molecules

Application of visible, ultraviolet and Infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions, λ_{max} & Ůmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating l max of conjugated dienes and Ǔ,ɓ ï unsaturated compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

(18 Lectures)

Reference Books:

- James E. Huheey, Ellen Keiter & Richard Keiter: *Inorganic Chemistry: Principles of Structure and Reactivity,* Pearson Publication.
- G.L. Miessler & Donald A. Tarr: *Inorganic Chemistry,* Pearson Publication.
- J.D. Lee: *A New Concise Inorganic Chemistry,* E.L.B.S.
- F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry*, John Wiley & Sons.
- I.L. Finar: *Organic Chemistry* (Vol. I & II), E.L.B.S.
- John R. Dyer: *Applications of Absorption Spectroscopy of Organic Compounds,* Prentice Hall.
- R.M. Silverstein, G.C. Bassler & T.C. Morrill*: Spectroscopic Identification of Organic Compounds*, John Wiley & Sons.
- R.T. Morrison & R.N. Boyd: *Organic Chemistry,* Prentice Hall.
- Peter Sykes: *A Guide Book to Mechanism* in *Organic Chemistry,* Orient Longman.
- Arun Bahl and B. S. Bahl: *Advanced Organic Chemistry,* S. Chand.

DSE LAB
60 Lectures
Section A: Inorganic Chemistry

1. Separation of mixtures by chromatography: Measure the R_f value in each case. (Combination of two ions to be given)

Paper chromatographic separation of Fe^{3+}, $A1^{3+}$ and Cr^{3+} or

Paper chromatographic separation of Ni^{2+}, Co^{2+}, Mn^{2+} and Zn^{2+}

2. Preparation of any two of the following complexes and measurement of their conductivity:

(i) tetraamminecarbonatocobalt (III) nitrate

(ii) tetraamminecopper (II) sulphate

(iii) potassium trioxalatoferrate (III) trihydrate

Compare the conductance of the complexes with that of M/1000 solution of NaCl, $MgCl_2$ and $LiCl_3$.

Section B: Organic Chemistry

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

Reference Books:

- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

3. DSE: MOLECULES OF LIFE

(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Unit 1: Carbohydrates (10 Periods)

Classification of carbohydrates, reducing and non-reducing sugars, General Properties of Glucose and Fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof).
Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose.
Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Unit 2: Amino Acids, Peptides and Proteins (12 Periods)

Classification *of Amino Acids,* Zwitterion structure and Isoelectric point.
Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and Cï terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

Unit 3: Enzymes and correlation with drug action (12 Periods)

Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action(Including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non-competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure ï activity relationships of drug molecules, binding role of ï OH group,-NH_2 group, double bond and aromatic ring,

Unit 4: Nucleic Acids (10 Periods)

Components of Nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides **(nomenclature**), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA(**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

Unit 5: Lipids (8 Periods)
Introduction to lipids, classification.
Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number.

Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

Unit 6: Concept of Energy in Biosystems (8 Periods)

Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy,
ATP hydrolysis and free energy change.
Conversion of food into energy. Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates.

Recommended Texts:

- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7th Ed.,* W. H. Freeman.
- Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

DSE LAB

60 Lectures

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/ nonreducing sugar.
9. Extraction of DNA from onion/cauliflower
10. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

Recommended Texts:

- Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. *Vogel's Textbook of Practical Organic Chemistry*, ELBS.
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry,*

Universities Press.

Bachelor's Degree Programme (Four Year Programme) with Hounours/Research

Semester-I					
Core subject-1 (CS-1)- 6 credits Mechanics and Properties of Matter Theory-1-4credits Practical-1- 2 credits	Core subject-2(CS-2) 6 credits Other subject	Additional/Interdisciplinary subject/ Mechanics-4 credits (2+2) credits (Theory-2+Practical-2)	Skill course/Vocational course-I-Skill course Basic Electronics-2credits	Extracurricular course/cc- 2 credits Basics of Environment	Total credits-20
Semester-II- (Note : Student will opt skill course of Physics either in 1st year (1-2 semester) or 2nd year (3-4 semester)					
Core subject-1 (CS-1)- 6 credits Electricity and Magnetism Theory-1-4 credits Practical-1-2 credits	Core subject-2(CS-2) 6 credits Other subject	Additional/Interdisciplinary subject/ Basic electromagnetism-4 credits (2+2) credits (Theory-2+Practical-2)	Skill course/Vocational course-I Waves and Oscillations-2credits	Life skill and personality development/cc	Total credits-20
Semester-III					
Core subject-1 (CS-1)- 6 credits Heat and Thermodynamics Theory-1-4 credits Practical-1-2 credits	Core subject-2(CS-2) 6 credits Other subject	Additional/Interdisciplinary subject/ Thermodynamics-4 credits (2+2) credits (Theory-2+Practical-2)	Skill course/Vocational course-I Basic Electronics-2credits	Indian Knowledge system IKS-I -2 credits	Total credits-20
Semester-IV					
Core subject-1 (CS-1)- 6 credits Optics Theory-1-4 credits Practical-1-2 credits	Core subject-2(CS-2) 6 credits Other subject	Additional/Interdisciplinary subject/ Elementary optics-4 credits (2+2) credits (Theory-2+Practical-2)	Skill course/Vocational course-I Waves and Oscillations-2credits	Indian Knowledge system IKS-II -2 credits	Total credits-20

B.Sc. Physics
Semester I
Core Subject-1
Mechanics and properties of Matter

(Credits: Theory-04, Practicals-02)

Laws of Motion and conservation laws: Frames of reference, Newton's Laws of motion, Work and energy, uniform circular motion, Conservation of energy and momentum. Conservative and non-conservative forces, Motion of rocket, Motion of a particle in a central force field, Kepler's laws of planetary motion, Newton's Law of Gravitation, Gravitational field, potential and potential energy, Gravitational potential and field intensity for spherical shell. Satellite, Basic idea of global positioning system (GPS).

Rotational Motion: Dynamics of a system of particles, Centre of mass, Angular velocity and momentum, Torque, Conservation of angular momentum, Equation of motion, Moment of inertia, theorem of parallel and perpendicular axis, moment of inertia of rod, rectangular lamina, disc, solid sphere, spherical shell, kinetic energy of rotation, rolling along a slope.

Fluids: Surface Tension and surface energy, Excess pressure across surface: application to spherical drops and bubbles, variation of surface tension with temperature - Jaeger's method. Viscosity: Flow of liquid, equation of continuity, energy of fluid, Bernoulli's theorem, Poiseuille's equation and method to determine coefficient of viscosity, Variations of viscosity of a liquid with temperature

Elasticity: Hooke's law, Stress –strain, Elastic potential energy, Elastic moduli: Young's, Bulk and shear modulus of rigidity, Poisson's ratio, relation between elastic constants Work done in stretching and in twisting a wire, Twisting couple on a cylinder, Strain energy in twisted cylinder, Determination of Rigidity modulus by statical and dynamical method (Barton's and Maxwell's needle), Torsional pendulum, Young's modulus by bending of beam, Determination of Y, η and σ and moment of inertia by Searle's method.

Reference Books:

1. Mechanics Berkeley Physics course, vol.1: Charles Kittel,et.al.2007,Tata McGraw-Hill
2. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley.
3. Mechanics: Mathur and Hemne, S Chand Publications.
4. Fundamentals of Mechanics: J. C. Upadyaya, Himalyan Publication.
5. Mechanics and General Properties of Matter: P. K. Chakraborty, Books and Allied Pvt. Ltd.
6. Elements of mechanics, Prakash & Agrawal, Pragati Prakashan Meerut.

List of Experiments: MECHANICS AND PROPERTIES OF MATTER

1. To determine the Modulus of Rigidity by static method
2. To determine the Moment of Inertia of a Flywheel.
3. To determine the Moment of Inertia of an irregular body by Inertia Table
4. To determine the Young's Modulus by Bending of Beam Method.
5. of a Wire by Maxwell's needle.

6. To determine g by Bar Pendulum.
7. To determine the Elastic Constants of a Wire by Searle's method.
8. To determine the Young's Modulus of a Wire by Optical Lever Method.
9. To determine g by Kater's Pendulum.
10. To study the Motion of a spring and to determine (a) Spring Constant (b) Value of g

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, AsiaPublishing House.
2. Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

B. Sc Physics (AIDP-1)

Semester I

Additional/Interdisciplinary subject/: MECHANICS

(Credits: Theory-02, Practical-2)

Laws of Motion: Frames of reference, Newton's Laws of motion, Dynamics of a system of particle, Centre of Mass.

Momentum and Energy: Conservation of momentum, Work and energy, Conservation of energy , and Motion of rockets.

Rotational Motion: Angular velocity and angular momentum. Torque, Conservation of angular momentum.

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant).Kepler's Laws (statement only).

Reference Books:

1. University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison-Wesley
2. Mechanics Berkeley Physics course, v.1: Charles Kittle, et. Al. 2007, Tata McGraw-Hill.
3. Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

List of Experiments: MECHANICS AND PROPERTIES OF MATTER

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2. Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th

Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

B.Sc. PHYSICS SKILL COURSE / VOCATIONAL COURSE FIRST

SEMESTER- Semester Ist or 3rd
BASIC ELECTRONICS (02 CREDITS)

BASIC ELECTRONICS

Diode, valve, triode Valve, Tetrode Valve, their characteristics, P-N Junction, Transistors, PNP, and NPN, their characteristics, common emitter, common base, and common base configurations.

Rectifier half wave and Full wave, Filter L-section and π −section, principles of CRO, Principle of operational amplifier.

Boolean algebra, logic Gates, Binary hexadecimal, octal decimal systems, LED, Photodiode. Tunnel diode, Point contact diode, Schotkey diode, SCR.

Reference Books

1. Electricity and electronics – Saxena, Arora and Prakash (Pragrati Prakashan Meerut).
2. Principles of electrical engineering and electronics, v K Metha and Rohit Mehta (S Chand Publication Delhi).

Semester II
Core Subject-1

ELECTRICITY AND MAGNETISM

**(Credits: Theory-04,
Practicals-02)**

Vector Analysis: Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors

(statement only).

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge,

uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

Magnetism: Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current, Divergence and curl of magnetic field, Magnetic vector potential, Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field.

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization.

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education
2. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin.

PRACTICALS

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) Dc current, and (d) checking electrical fuses.

2. Ballistic Galvanometer:
   (i) Measuring of charge and current sensitivity
   (ii) Measurement of CDR
   (iii) Determine a high resistance by Leakage Method
   (iv) To determine Self Inductance of a Coil by Rayleigh's Method
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality factor
7. To study parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge
9. To verify the Thevenin and Norton Theorem
10. To verify the Superposition and Maximum Power Transfer Theorem

Reference Books

- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

Semester II

(AIDP-2)

Additional/Interdisciplinary subject/ Basic Electromagnetism (Credits: Theory-02+Practical-2)

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, Uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculationof electric field from potential, Capacitance of an isolated spherical conductor, Parallel

plate, spherical and cylindrical condenser, Energy per unit volume in electrostatic field, Dielectric medium, Polarization, Displacement vector, Gauss's theorem in dielectrics Parallel plate capacitor completely filled with dielectric.

Magnetism:

Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

Reference Books:

1. Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education..
2. Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ.Press.
3. Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
4. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
5. D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998,Benjamin Cummings.

PRACTICALS

1.To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c)

Dc current, and (d) checking electrical fuses.

2. Ballistic Galvanometer:
   (v) Measuring of charge and current sensitivity
   (vi) Measurement of CDR
   (vii) Determine a high resistance by Leakage Method
   (viii) To determine Self Inductance of a Coil by Rayleigh's Method
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality factor
7. To study parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge
9. To verify the Thevenin and Norton Theorem
10. To verify the Superposition and Maximum Power Transfer Theorem

Reference Books

- Advanced Practical Physics for students, B.L. Flint & H.T. Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

  Advanced level Physics Practical's, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

B Sc PHYSICS, SKILL COURSE / VOCATIONAL COURSE FIRST

SEMESTER- 2nd or 4th
WAVES AND OSCILLATIONS (02 CREDITS)

HAMONIC OSCILLATION

Solution of equation of harmonic motion, simple pendulum, compound pendulum, motion of a vertically loaded spring, LC circuit, energy in simple harmonic motion, addition of simple harmonic motion, damped vibrations, relaxation time, forced harmonic oscillator, sharpness of resonance.

WAVES

Nature, production, and propagation, equation of progressive wave, forms of wave equation, longitudinal waves, superposition of waves, stationary waves, their characteristics, and their analytical treatment, phenomenon of beats, Fourier analysis, Fourier theorem, evaluation of constants, A_0, A_n and B_n , applications of Fourier analysis, square wave, saw tooth wave, vibration of a stretched strings, velocity, vibrations of a rectangular membrane, velocity, Doppler's shift, ultrasonic waves-definition, production and applications.

Reference Books

1. A textbook of waves and oscillations, Ashok K Ganguli (S Chand).
2. Oscillations and waves, Satya Prakash (Pragrati Prakashan Meerut).

Semester III
Core Subject-1

Heat and Thermodynamics

(Credits: Theory-04, Practicals-02)

Thermodynamic Description of system and laws of thermodynamics: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law, Reversible & irreversible processes.

Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Clausius Clapeyron Equation, Joules Law, Joule Thomson effect.

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications. Clausius- Clapeyron Equation, Expression for $(C_P - C_V)$, C_P/C_V, TdS equations.

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases, mono-atomic and diatomic gases.

Theory of radiation: Black body radiation, Spectral distribution, Concept of energy density, Derivation of Planck's law, Deduction of Wein's distribution law, Rayleigh Jeans law, Stefan Boltzmann law and Wein's displacement law from Plank's law.

Maxwell Boltzmann law- distribution of velocity- Quantum statistics, Phase space, Fermi-Dirac distribution law, electron gas, Bose-Einstein distribution law, photon gas, comparison of three statistics.

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears &G.L.Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Practicals

1. To determine Mechanical Equivalent of Heat, J, by Callender and

Barne's constantflow method.

2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4. To determine the coefficient of thermal conductivity of copper by Searle'sApparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom'sMethod.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee andCharlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple withtemperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-BalanceBridge

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint & H. T. Workshop, 1971, AsiaPublishing House.

2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.

3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, Kitab Mahal, New Delhi.

4. A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal,1985, Vani Publication.

Semester III

(AIDP-3)

Additional/Interdisciplinary subject/ Thermodynamics

(Credits: Theory-02+Practical-2)

1. Laws of Thermodynamics: Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P&

C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes.

2. Second law & Entropy,Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero.

Reference Books:

1. Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
2. A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
3. Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
4. Thermodynamics, Kinetic theory & Statistical thermodynamics, F. W. Sears &G. L. Salinger. 1988, Narosa
5. University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

Practicals

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constantflow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.
4 .To determine the coefficient of thermal conductivity of copper by Searle'sApparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom'sMethod.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee andCharlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple withtemperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10 To calibrate Resistance Temperature Device (RTD) using Null Method/Off-BalanceBridge

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint & H. T. Workshop,

1971, AsiaPublishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers.
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, Kitab Mahal, New Delhi.
4.A Laboratory Manual of Physics for Undergraduate Classes, D.P. Khandelwal,1985, Vani Publication.

B.Sc. PHYSICS SKILL COURSE / VOCATIONAL COURSE FIRST

Semester Ist or 3rd
BASIC ELECTRONICS (02 CREDITS)

Diode, valve, triode Valve, Tetrode Valve, their characteristics, P-N Junction, Transistors, PNP, and NPN, their characteristics, common emitter, common base, and common base configurations.

Rectifier half wave and Full wave, Filter L-section and π −section, principles of CRO, Principle of operational amplifier.

Boolean algebra, logic Gates, Binary hexadecimal, octal decimal systems, LED, Photodiode. Tunnel diode, Point contact diode, Schotkey diode, SCR.

Reference Books

1.Electricity and electronics – Saxena, Arora and Prakash (Pragrati Prakashan Meerut).
2. Principles of electrical engineering and electronics, v K Metha and Rohit Mehta (S Chand Publication Delhi).

Semester IV
Core Subject-1
OPTICS

(Credits: Theory-04, Practicals-02)

Superposition of Two Collinear Harmonic oscillations: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats).

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses.

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves, Spherical waves, Wave intensity.

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions, Kinetic and Potential Energy, Total Energy and their time averages, Damped oscillations.

Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem, Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings:Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditorium.

Wave Optics: Electromagnetic nature of light, Definition and Properties of wave front, Huygens Principle.

Interference: Interference: Division of amplitude and division of wavefront, Young's Double Slit experiment, Lloyd's Mirror and Fresnel's Biprism, Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes, Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index.

Michelson's Interferometer: (1) Idea of form of fringes (no theory needed), (2) Determination of wavelength, (3) Wavelength difference, (4) Refractive index, (5) Visibility of fringes.

Diffraction: Fraunhofer diffraction: Single slit; double Slit. Multiple slits & Diffraction grating, Fresnel Diffraction: Half-period zones. Zone plate, Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis.

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis, Circular and elliptical polarization.

Reference Books:

1. Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill.
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing.
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, S. ChandPublication.
4. University Physics, F W Sears, M.W. Zemansky and, H. D. Young.

Practicals

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify $\lambda_2 - T$ Law.
3. To study Lissajous Figures.
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a given Prism using Sodium
7. Light.
8. To determine Dispersive Power of the Material of a given Prism using MercuryLight.
9. To determine the value of Cauchy Constants of a material of a prism.
10. To determine the Resolving Power of a Prism.
11. To determine wavelength of sodium light using Fresnel Biprism.
12. To determine wavelength of sodium light using Newton's Rings.
13. To determine the wavelength of Laser light using Diffraction of Single Slit.
14. To determine wavelength of (1) Sodium & (2) Mercury light using plane diffraction Grating. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns ofsingle and double slits.

Reference Books:

1. Advanced Practical Physics for students, B. L. Flint & H. T. Workshop, 1971, Asia Publishing House.
2. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
3. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, Kitab Mahal, New Delhi.

Semester IV

(AIDP-4)

Additional/Interdisciplinary subject/Multidisciplinary Subject-

Elementary optics

(Credits: Theory-02+Practical-2)

Electromagnetic nature of light, Definition and Properties of wave front, Huygens Principle. Aberration in lenses, Eye-pieces. Resolving power of Telescope and Microscope.

Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment

Diffraction: Fraunhofer diffraction: Single slit . Diffraction grating. Fresnel Diffraction. Fresnel Diffraction pattern of a straight edge,

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization.

Reference Books:

1. Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill
2. Principles of Optics, B.K. Mathur, 1995, Gopal Printing
3. Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publication
4. University Physics, FW Sears, MWZemanskyandHDYoung13/e,1986. Addison-Wesley.

Practicals

1. To investigate the motion of coupled oscillators.
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ_2 – T Law.
3. To study Lissajous Figures.
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a given Prism using Mercury Light.
8. To determine the value of Cauchy Constants of a material of a prism.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium & (2) Mercury light using planediffraction

Grating. To determine the Resolving Power of a Plane Diffraction Grating.

14. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Reference Books:

- Advanced Practical Physics for students, B. L. Flint & H. T. Workshop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition,2011, Kitab Mahal, New Delhi.

BSC PHYSICS SKILL COURSE / VOCATIONAL COURSE FIRST

SEMESTER- 2nd or 4th

WAVES AND OSCILLATIONS (02 CREDITS)

HAMONIC OSCILLATION

Solution of equation of harmonic motion, simple pendulum, compound pendulum, motion of a vertically loaded spring, LC circuit, energy in simple harmonic motion, addition of simple harmonic motion, damped vibrations, relaxation time, forced harmonic oscillator, sharpness of resonance.

WAVES

Nature, production, and propagation, equation of progressive wave, forms of wave equation, longitudinal waves, superposition of waves, stationary waves, their characteristics, and their analytical treatment, phenomenon of beats, Fourier analysis, Fourier theorem, evaluation of constants, $A_0, A_n \text{ and } B_n$, applications of Fourier analysis, square wave, saw tooth wave, vibration of a stretched strings, velocity, vibrations of a rectangular membrane, velocity, Doppler's shift, ultrasonic waves-definition, production and applications.

Reference Books

1. A textbook of waves and oscillations, Ashok K Ganguli (S Chand).
2. Oscillations and waves, Satya Prakash (Pragrati Prakashan Meerut).

CHOICE BASED CREDIT SYSTEM

B. SC. (PHYSICS) PROGRAM

SEMESTER	COURSE OPTED	COURSE NAME	Credits
I	Core course-I	Mechanics	4
	Core Course-I Practical/Tutorial	Mechanics Lab	2
II	Core course-II	Electricity and Magnetism	4
	Core Course-II Practical/Tutorial	Electricity and Magnetism Lab	2
III	Core course-III	Thermal Physics and Statistical Mechanics	4
	Core Course-III Practical/Tutorial	Thermal Physics and Statistical Mechanics Lab	2
	Skill Enhancement Course -1	SEC-1*	4
IV	Core course-IV	Waves and Optics	4
	Course-IV Practical/Tutorial	Waves and Optics Lab	2
	Skill Enhancement Course -I	SEC -I	4
V	Skill Enhancement Course -I	SEC -I	4
	Discipline Specific Elective -1	DSE-1A	6
VI	Skill Enhancement Course -II	SEC –II**	4
	Discipline Specific Elective -II	DSE-1B	6

***Electronics I.** Electronics II.**

Semester I

PHYSICS-DSC 1 A: MECHANICS
(Credits: Theory-04, Practicals-02)
Theory: 60 Lectures

Vectors: Vector algebra. Scalar and vector products. Derivatives of a vector with respect to a parameter. **(4 Lectures)**

Ordinary Differential Equations: 1^{st} order homogeneous differential equations. 2^{nd} order homogeneous differential equations with constant coefficients. **(6 Lectures)**

Laws of Motion: Frames of reference. Newton's Laws of motion. Dynamics of a system of particles. Centre of Mass. **(10 Lectures)**

Momentum and Energy: Conservation of momentum. Work and energy. Conservation of energy. Motion of rockets. **(6 Lectures)**

Rotational Motion: Angular velocity and angular momentum. Torque. Conservation of angular momentum. **(5 Lectures)**

Gravitation: Newton's Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's Laws (statement only). Satellite in orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). **(8 Lectures)**

Fluids: Surface Tension: Synclastic and anticlastic surface - Excess of pressure - Application to spherical and cylindrical drops and bubbles - variation of surface tension with temperature - Jaegar's method. Viscosity: Viscosity - Rate flow of liquid in a capillary tube - Poiseuille's formula - Determination of coefficient of viscosity of a liquid - Variations of viscosity of a liquid with temperature lubrication. **(6 Lectures)**

Elasticity: Hooke's law - Stress-strain diagram - Elastic moduli-Relation between elastic constants - Poisson's Ratio-Expression for Poisson's ratio in terms of elastic constants - Work done in stretching and work done in twisting a wire - Twisting couple on a cylinder - Determination of Rigidity modulus by static torsion - Torsional pendulum-Determination of Rigidity modulus and moment of inertia - q, η and $\sigma$by Searles method **(8 Lectures)**

Special Theory of Relativity: Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.

(7 Lectures)

Note: *Students are not familiar with vector calculus. Hence all examples involve differentiation either in one dimension or with respect to the radial coordinate.*

Reference Books:

- University Physics. FW Sears, MW Zemansky and HD Young13/e, 1986. Addison-Wesley
- Mechanics Berkeley Physics course,v.1:Charles Kittel, et. Al. 2007, Tata McGraw-Hill.
- Physics – Resnick, Halliday & Walker 9/e, 2010, Wiley
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PHYSICS LAB: DSC 1 LAB: MECHANICS

60 Lectures

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. To determine the Height of a Building using a Sextant.
3. To determine the Moment of Inertia of a Flywheel.
4. To determine the Young's Modulus of a Wire by Optical Lever Method.
5. To determine the Modulus of Rigidity of a Wire by Maxwell's needle.
6. To determine the Elastic Constants of a Wire by Searle's method.
7. To determine g by Bar Pendulum.
8. To determine g by Kater's Pendulum.
9. To determine **g** and velocity for a freely falling body using Digital Timing Technique
10. To study the Motion of a Spring and calculate (a) Spring Constant (b) Value of g

Reference Books:

- Advanced Practical Physics for students, B.L.Flint and H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Semester II

PHYSICS-DSC 2: ELECTRICITY AND MAGNETISM (Credits: Theory-04, Practicals-02) Theory: 60 Lectures

Vector Analysis: Scalar and Vector product, gradient, divergence, Curl and their significance, Vector Integration, Line, surface and volume integrals of Vector fields, Gauss-divergence theorem and Stoke's theorem of vectors (statement only).

(12 Lectures)

Electrostatics: Electrostatic Field, electric flux, Gauss's theorem of electrostatics. Applications of Gauss theorem- Electric field due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charged sheet, charged conductor. Electric potential as line integral of electric field, potential due to a point charge, electric dipole, uniformly charged spherical shell and solid sphere. Calculation of electric field from potential. Capacitance of an isolated spherical conductor. Parallel plate, spherical and cylindrical condenser. Energy per unit volume in electrostatic field. Dielectric medium, Polarisation, Displacement vector. Gauss's theorem in dielectrics. Parallel plate capacitor completely filled with dielectric.

(22 Lectures)

Magnetism:

Magnetostatics: Biot-Savart's law & its applications- straight conductor, circular coil, solenoid carrying current. Divergence and curl of magnetic field. Magnetic vector potential. Ampere's circuital law.

Magnetic properties of materials: Magnetic intensity, magnetic induction, permeability, magnetic susceptibility. Brief introduction of dia-, para- and ferro-magnetic materials.

(10 Lectures)

Electromagnetic Induction: Faraday's laws of electromagnetic induction, Lenz's law, self and mutual inductance, L of single coil, M of two coils. Energy stored in magnetic field. **(6 Lectures)**

Maxwell`s equations and Electromagnetic wave propagation: Equation of continuity of current, Displacement current, Maxwell's equations, Poynting vector, energy density in electromagnetic field, electromagnetic wave propagation through vacuum and isotropic dielectric medium, transverse nature of EM waves, polarization. **(10 Lectures)**

Reference Books:

- Electricity and Magnetism, Edward M. Purcell, 1986, McGraw-Hill Education..
- Electricity and Magnetism, J.H. Fewkes & J. Yarwood. Vol. I, 1991, Oxford Univ. Press.
- Electricity and Magnetism, D C Tayal, 1988, Himalaya Publishing House.
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.
- D.J. Griffiths, Introduction to Electrodynamics, 3rd Edn, 1998, Benjamin Cummings.

PHYSICS LAB- DSC 2 LAB: ELECTRICITY AND MAGNETISM
60 Lectures

1. To use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, and (d) checking electrical fuses.
2. Ballistic Galvanometer:
   (i) Measurement of charge and current sensitivity
   (ii) Measurement of CDR
   (iii) Determine a high resistance by Leakage Method
   (iv) To determine Self Inductance of a Coil by Rayleigh's Method.
3. To compare capacitances using De'Sauty's bridge.
4. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).
5. To study the Characteristics of a Series RC Circuit.
6. To study the a series LCR circuit and determine its (a) Resonant Frequency, (b) Quality Factor
7. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
8. To determine a Low Resistance by Carey Foster's Bridge.
9. To verify the Thevenin and Norton theorem
10. To verify the Superposition, and Maximum Power Transfer Theorem

Reference Books

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

Semester III

PHYSICS-DSC 3: THERMAL PHYSICS AND STATISTICAL MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Laws of Thermodynamics:

Thermodynamic Description of system: Zeroth Law of thermodynamics and temperature. First law and internal energy, conversion of heat into work, Various Thermodynamical Processes, Applications of First Law: General Relation between C_P& C_V, Work Done during Isothermal and Adiabatic Processes, Compressibility & Expansion Coefficient, Reversible & irreversible processes, Second law & Entropy, Carnot's cycle & theorem, Entropy changes in reversible & irreversible processes, Entropy-temperature diagrams, Third law of thermodynamics, Unattainability of absolute zero. **(22 Lectures)**

Thermodynamic Potentials: Enthalpy, Gibbs, Helmholtz and Internal Energy functions, Maxwell's relations & applications - Joule-Thompson Effect, Clausius-Clapeyron Equation, Expression for $(C_P - C_V)$, C_P/C_V, TdS equations. **(10 Lectures)**

Kinetic Theory of Gases: Derivation of Maxwell's law of distribution of velocities and its experimental verification, Mean free path (Zeroth Order), Transport Phenomena: Viscosity, Conduction and Diffusion (for vertical case), Law of equipartition of energy (no derivation) and its applications to specific heat of gases; mono-atomic and diatomic gases. **(10 Lectures)**

Theory of Radiation: Blackbody radiation, Spectral distribution, Concept of Energy Density, Derivation of Planck's law, Deduction of Wien's distribution law, Rayleigh-Jeans Law, Stefan Boltzmann Law and Wien's displacement law from Planck's law. **(6 Lectures)**

Statistical Mechanics: Maxwell-Boltzmann law - distribution of velocity - Quantum statistics - Phase space - Fermi-Dirac distribution law - electron gas - Bose-Einstein distribution law - photon gas - comparison of three statistics. **(12 Lectures)**

Reference Books:

- Thermal Physics, S. Garg, R. Bansal and C. Ghosh, 1993, Tata McGraw-Hill.
- A Treatise on Heat, Meghnad Saha, and B.N. Srivastava, 1969, Indian Press.
- Thermodynamics, Enrico Fermi, 1956, Courier Dover Publications.
- Thermodynamics, Kinetic theory & Statistical thermodynamics, F.W.Sears & G.L.Salinger. 1988, Narosa
- University Physics, Ronald Lane Reese, 2003, Thomson Brooks/Cole.

PHYSICS LAB-DSC 3 LAB: THERMAL PHYSICS AND STATISTICAL MECHANICS

1. To determine Mechanical Equivalent of Heat, J, by Callender and Barne's constant flow method.
2. Measurement of Planck's constant using black body radiation.
3. To determine Stefan's Constant.

4. To determine the coefficient of thermal conductivity of copper by Searle's Apparatus.
5. To determine the Coefficient of Thermal Conductivity of Cu by Angstrom's Method.
6. To determine the coefficient of thermal conductivity of a bad conductor by Lee and Charlton's disc method.
7. To determine the temperature co-efficient of resistance by Platinum resistance thermometer.
8. To study the variation of thermo emf across two junctions of a thermocouple with temperature.
9. To record and analyze the cooling temperature of an hot object as a function of time using a thermocouple and suitable data acquisition system
10. To calibrate Resistance Temperature Device (RTD) using Null Method/Off-Balance Bridge

Reference Books:

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.
- A Laboratory Manual of Physics for Undergraduate Classes, D.P.Khandelwal, 1985, Vani Publication.

Skill Enhancement Course (SEC-I) (Semester –III or IV or V)

ELECTRONICS –I (Network Theorems,Solid state Devices, Rectifiers and Filters)

Network analysis and Network Theorem

Kirchhoff's Law, Series parallel corrections, Network Theorems, Superposition, Reciprocity, Theremins, Norton's Maximum power, Transfer Theorem, Low pass and High pass filters, Four terminal Network, Electronic Measuring Instruments: VTVM,CRO.

Solid State Devices

Electronics Devices: General idea of Diode, Triode, Tetrode, Pentode and their characteristics, intrinsic and extrinsic n-type and p-type semiconductors, P-N junction, Semiconductor junction diode, point contact, Zener, varactor, Tunnel diode , Photodiode, Light emitting diode, Junction Transistors, Transistor operation, characteristic Curves, common emitter, common base and common collector configurations, current amplification, Field effect transistor.

Rectifiers and Filters

HW,FW and bridge rectifiers, Filter circuits(Series L, Shunt C.L-Section-II).Unregulated PS Regulated PS Voltage regulation by Zener diode, Voltage multiplier, Binary ,Decimal, Hexadecimal and Octal number systems and interconversions, BCD, Elementary idea of logic gate and Boolean algebra.

Semester IV

PHYSICS-DSC 4: WAVES AND OPTICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Superposition of Two Collinear Harmonic oscillations: Linearity and Superposition Principle. (1) Oscillations having equal frequencies and (2) Oscillations having different frequencies (Beats). **(4 Lectures)**

Superposition of Two Perpendicular Harmonic Oscillations: Graphical and Analytical Methods. Lissajous Figures (1:1 and 1:2) and their uses. **(2 Lectures)**

Waves Motion- General: Transverse waves on a string. Travelling and standing waves on a string. Normal Modes of a string. Group velocity, Phase velocity. Plane waves. Spherical waves, Wave intensity. **(7 Lectures)**

Oscillations: Simple harmonic motion. Differential equation of SHM and its solutions. Kinetic and Potential Energy, Total Energy and their time averages. Damped oscillations. **(6 Lectures)**

Sound: Simple harmonic motion - forced vibrations and resonance - Fourier's Theorem - Application to saw tooth wave and square wave - Intensity and loudness of sound - Decibels - Intensity levels - musical notes - musical scale. Acoustics of buildings: Reverberation and time of reverberation - Absorption coefficient - Sabine's formula - measurement of reverberation time - Acoustic aspects of halls and auditoria. **(6 Lectures)**

Wave Optics: Electromagnetic nature of light. Definition and Properties of wave front. Huygens Principle. **(3 Lectures)**

Interference: Interference: Division of amplitude and division of wavefront. Young's Double Slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: measurement of wavelength and refractive index. **(10 Lectures)**

Michelson's Interferometer: (1) Idea of form of fringes (no theory needed), (2) Determination of wavelength,(3) Wavelength difference,(4) Refractive index, (5) Visibility of fringes. **(3 Lectures)**

Diffraction: Fraunhofer diffraction: Single slit; Double Slit. Multiple slits & Diffraction grating. Fresnel Diffraction: Half-period zones. Zone plate. Fresnel Diffraction pattern of a straight edge, a slit and a wire using half-period zone analysis. **(14 Lectures)**

Polarization: Transverse nature of light waves. Plane polarized light – production and analysis. Circular and elliptical polarization. **(5 Lectures)**

Reference Books:

- Fundamentals of Optics, F A Jenkins and H E White, 1976, McGraw-Hill
- Principles of Optics, B.K. Mathur, 1995, Gopal Printing
- Fundamentals of Optics, H.R. Gulati and D.R. Khanna, 1991, R. Chand Publication
- UniversityPhysics.FWSears,MWZemanskyandHDYoung13/e, 1986.Addison-Wesley

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PHYSICS LAB-DSC 4 LAB: WAVES AND OPTICS

60 Lectures

1. To investigate the motion of coupled oscillators
2. To determine the Frequency of an Electrically Maintained Tuning Fork by Melde's Experiment and to verify λ^2 – T Law.
3. To study Lissajous Figures
4. Familiarization with Schuster`s focussing; determination of angle of prism.
5. To determine the Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
6. To determine the Refractive Index of the Material of a given Prism using Sodium Light.
7. To determine Dispersive Power of the Material of a given Prism using Mercury Light
8. To determine the value of Cauchy Constants of a material of a prism.
9. To determine the Resolving Power of a Prism.
10. To determine wavelength of sodium light using Fresnel Biprism.
11. To determine wavelength of sodium light using Newton's Rings.
12. To determine the wavelength of Laser light using Diffraction of Single Slit.
13. To determine wavelength of (1) Sodium & (2) Mercury light using plane diffraction Grating
14. To determine the Resolving Power of a Plane Diffraction Grating.
15. To measure the intensity using photosensor and laser in diffraction patterns of single and double slits.

Reference Books:

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

Discipline Specific Elective Paper

PHYSICS- DSE: ELEMENTS OF MODERN PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Planck's quantum, Planck's constant and light as a collection of photons; Photo-electric effect and Compton scattering. De Broglie wavelength and matter waves; Davisson-Germer experiment. **(8 Lectures)**

Problems with Rutherford model- instability of atoms and observation of discrete atomic spectra; Bohr's quantization rule and atomic stability; calculation of energy levels for hydrogen like atoms and their spectra. **(4 Lectures)**

Position measurement- gamma ray microscope thought experiment; Wave-particle duality, Heisenberg uncertainty principle- impossibility of a particle following a trajectory; Estimating minimum energy of a confined particle using uncertainty principle; Energy-time uncertainty principle. **(4 Lectures)**

Two slit interference experiment with photons, atoms and particles; linear superposition principle as a consequence; Matter waves and wave amplitude; Schrodinger equation for non-relativistic particles; Momentum and Energy operators; stationary states; physical interpretation of wavefunction, probabilities and normalization; Probability and probability current densities in one dimension. **11 Lectures)**

One dimensional infinitely rigid box- energy eigenvalues and eigenfunctions, normalization; Quantum dot as an example; Quantum mechanical scattering and tunnelling in one dimension - across a step potential and across a rectangular potential barrier. **(12 Lectures)**

Size and structure of atomic nucleus and its relation with atomic weight; Impossibility of an electron being in the nucleus as a consequence of the uncertainty principle. Nature of nuclear force, NZ graph, semi-empirical mass formula and binding energy.

(6 Lectures)

Radioactivity: stability of nucleus; Law of radioactive decay; Mean life & half-life; α decay; β decay - energy released, spectrum and Pauli's prediction of neutrino; γ-ray emission. **(11 Lectures)**

Fission and fusion - mass deficit, relativity and generation of energy; Fission - nature of fragments and emission of neutrons. Nuclear reactor: slow neutrons interacting with Uranium 235; Fusion and thermonuclear reactions.

(4 Lectures)

Reference Books:

- Concepts of Modern Physics, Arthur Beiser, 2009, McGraw-Hill
- Modern Physics, John R.Taylor, Chris D.Zafiratos, Michael A.Dubson,2009, PHI Learning
- Six Ideas that Shaped Physics:Particle Behave like Waves, Thomas A. Moore, 2003, McGraw Hill
- Quantum Physics, Berkeley Physics Course Vol.4. E.H. Wichman, 2008, Tata McGraw-Hill Co.
- Modern Physics, R.A. Serway, C.J. Moses, and C.A.Moyer, 2005, Cengage Learning

PRACTICALS -DSE-1 LAB: ELEMENTS OF MODERN PHYSICS

1. To determine value of Boltzmann constant using V-I characteristic of PN diode.
1. To determine work function of material of filament of directly heated vacuum

diode.

2. To determine value of Planck's constant using LEDs of at least 4 different colours.
3. To determine the ionization potential of mercury.
4. To determine the wavelength of H-alpha emission line of Hydrogen atom.
5. To determine the absorption lines in the rotational spectrum of Iodine vapour.
6. To study the diffraction patterns of single and double slits using laser source and measure its intensity variation using Photosensor and compare with incoherent source – Na light.
7. Photo-electric effect: photo current versus intensity and wavelength of light; maximum energy of photo-electrons versus frequency of light
8. To determine the value of e/m by magnetic focusing.
9. To setup the Millikan oil drop apparatus and determine the charge of an electron.

Reference Books:

- Advanced Practical Physics for students, B.L.Flint & H.T.Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edition, 2011, Kitab Mahal, New Delhi.

PHYSICS-DSE: SOLID STATE PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Crystal Structure: Solids: Amorphous and Crystalline Materials. Lattice Translation Vectors. Lattice with a Basis – Central and Non-Central Elements. Unit Cell. Miller Indices. Reciprocal Lattice. Types of Lattices. Brillouin Zones. Diffraction of X-rays by Crystals. Bragg's Law. Atomic and Geometrical Factor.

(12 Lectures)

Elementary Lattice Dynamics: Lattice Vibrations and Phonons: Linear Monoatomic and Diatomic Chains. Acoustical and Optical Phonons. Qualitative Description of the Phonon Spectrum in Solids. Dulong and Petit's Law, Einstein and Debye theories of specific heat of solids. T^3 law

(10 Lectures)

Magnetic Properties of Matter: Dia-, Para-, Ferri- and Ferromagnetic Materials. Classical Langevin Theory of dia – and Paramagnetic Domains. Quantum Mechanical Treatment of Paramagnetism. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. Discussion of B-H Curve. Hysteresis and Energy Loss.

(12 Lectures)

Dielectric Properties of Materials: Polarization. Local Electric Field at an Atom. Depolarization Field. Electric Susceptibility. Polarizability. Clausius Mosotti Equation. Classical Theory of Electric Polarizability. Normal and Anomalous Dispersion. Cauchy and Sellmeir relations. Langevin-Debye equation. Complex Dielectric Constant. Optical

Phenomena. Application: Plasma Oscillations, Plasma Frequency, Plasmons.

(10 Lectures)

Elementary band theory: Kronig Penny model. Band Gaps. Conductors, Semiconductors and insulators. P and N type Semiconductors. Conductivity of Semiconductors, mobility, Hall Effect, Hall coefficient. **(10 Lectures)**

Superconductivity: Experimental Results. Critical Temperature. Critical magnetic field. Meissner effect. Type I and type II Superconductors, London's Equation and Penetration Depth. Isotope effect.

(6 Lectures)

Reference Books:

- Introduction to Solid State Physics, Charles Kittel, 8th Ed., 2004, Wiley India Pvt. Ltd.
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of India
- Introduction to Solids, Leonid V. Azaroff, 2004, Tata Mc-Graw Hill
- Solid State Physics, Neil W. Ashcroft and N. David Mermin, 1976, Cengage Learning
- Solid-state Physics, H.Ibach and H Luth, 2009, Springer
- Elementary Solid State Physics, 1/e M. Ali Omar, 1999, Pearson India
- Solid State Physics, M.A. Wahab, 2011, Narosa Publications

PRACTICALS-DSE LAB: SOLID STATE PHYSICS

1. Measurement of susceptibility of paramagnetic solution (Quinck`s Tube Method)
2. To measure the Magnetic susceptibility of Solids.
3. To determine the Coupling Coefficient of a Piezoelectric crystal.
4. To measure the Dielectric Constant of a dielectric Materials with frequency
5. To determine the complex dielectric constant and plasma frequency of metal using Surface Plasmon resonance (SPR)
6. To determine the refractive index of a dielectric layer using SPR
7. To study the PE Hysteresis loop of a Ferroelectric Crystal.
8. To draw the BH curve of iron using a Solenoid and determine the energy loss from Hysteresis.
9. To measure the resistivity of a semiconductor (Ge) crystal with temperature by four-probe method (from room temperature to 150 ^{o}C) and to determine its band gap.
10. To determine the Hall coefficient of a semiconductor sample.

Reference Books

- Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House.
- Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
- A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal, New Delhi
- Elements of Solid State Physics, J.P. Srivastava, 2nd Ed., 2006, Prentice-Hall of

PHYSICS-DSE: MATHEMATICAL PHYSICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

The emphasis of the course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers. **(6 Lectures)**

Fourier Series: Periodic functions. Orthogonality of sine and cosine functions, Dirichlet Conditions (Statement only). Expansion of periodic functions in a series of sine and cosine functions and determination of Fourier coefficients. Complex representation of Fourier series. Expansion of functions with arbitrary period. Expansion of non-periodic functions over an interval. Even and odd functions and their Fourier expansions. Application. Summing of Infinite Series. **(10 Lectures)**

Frobenius Method and Special Functions: Singular Points of Second Order Linear Differential Equations and their importance. Frobenius method and its applications to differential equations. Legendre, Bessel, Hermite and Laguerre Differential Equations. Properties of Legendre Polynomials: Rodrigues Formula, Orthogonality. Simple recurrence relations. **(16 Lectures)**

Some Special Integrals: Beta and Gamma Functions and Relation between them. Expression of Integrals in terms of Gamma Functions. Error Function (Probability Integral). **(4 Lectures)**

Partial Differential Equations: Solutions to partial differential equations, using separation of variables: Laplace's Equation in problems of rectangular, cylindrical and spherical symmetry. **(10 Lectures)**

Complex Analysis: Brief Revision of Complex Numbers and their Graphical Representation. Euler's formula, De Moivre's theorem, Roots of Complex Numbers. Functions of Complex Variables. Analyticity and Cauchy-Riemann Conditions. Examples of analytic functions. Singular functions: poles and branch points, order of singularity, branch cuts. Integration of a function of a complex variable. Cauchy's Inequality. Cauchy's Integral formula.

(14 Lectures)

Reference Books:

- Mathematical Methods for Physicists: Arfken, Weber, 2005, Harris, Elsevier.
- Fourier Analysis by M.R. Spiegel, 2004, Tata McGraw-Hill.
- Mathematics for Physicists, Susan M. Lea, 2004, Thomson Brooks/Cole.

- An Introduction to Ordinary Differential Equations, Earl A Coddington, 1961, PHI Learning.
- Differential Equations, George F. Simmons, 2006, Tata McGraw-Hill.

- Partial Differential Equations for Scientists and Engineers, S.J. Farlow, 1993, Dover Publications.
- Mathematical methods for Scientists and Engineers, D.A. McQuarrie, 2003, Viva Books.

-----PRACTICALS -DSE LAB: MATHEMATICAL PHYSICS

The aim of this course is not just to teach computer programming and numerical analysis but to emphasize its role in solving problems in Physics.

- *Highlights the use of computational methods to solve physical problems*
- *Use of computer language as a tool in solving physics problems (applications)*
- *The course will consist of lectures (both theory and practical) in the Computer Lab*
- *Evaluation done not on the programming but on the basis of formulating the problem*
- *Aim at teaching students to construct the computational problem to be solved* • *Students can use anyone operating system Linux or Microsoft Windows*

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow & overflow-emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.

Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (*If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While-Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops*), Arrays (*1D&2D*) and strings, user defined functions, Structures and Unions, Idea of classes and objects

Programs:	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending-descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of π
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving $\alpha=\tan\alpha; I=I_o[(\sin\alpha)/\alpha]^2$ in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. *sin θ, cos θ, tan θ, etc.*
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice-versa. Find the area of B-H Hysteresis loop

Reference Books:

- Introduction to Numerical Analysis, S.S. Sastry, 5thEdn., 2012, PHI Learning Pvt. Ltd.
- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publications.
- Numerical Recipes in C: The Art of Scientific Computing, W.H. Pressetal., 3rdEdn., 2007, Cambridge University Press.
- A first course in Numerical Methods, Uri M. Ascher and Chen Greif, 2012, PHI Learning
- Elementary Numerical Analysis, K.E.Atkinson,3rdEdn., 2007, Wiley India Edition.
- Numerical Methods for Scientists and Engineers, R.W. Hamming, 1973, Courier Dover Pub.
- An Introduction to Computational Physics, T.Pang, 2ndEdn., 2006, Cambridge Univ. Press

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PHYSICS-DSE: QUANTUM MECHANICS

(Credits: Theory-04, Practicals-02)

Theory: 60 Lectures

Time dependent Schrodinger equation: Time dependent Schrodinger equation and dynamical evolution of a quantum state; Properties of Wave Function. Interpretation of Wave Function Probability and probability current densities in three dimensions; Conditions for Physical Acceptability of Wave Functions. Normalization. Linearity and Superposition Principles. Eigenvalues and Eigenfunctions. Position, momentum & Energy operators; commutator of position and momentum operators; Expectation values of position and momentum. Wave Function of a Free Particle.

(6 Lectures)

Time independent Schrodinger equation-Hamiltonian, stationary states and energy eigenvalues; expansion of an arbitrary wavefunction as a linear combination of energy eigenfunctions; General solution of the time dependent Schrodinger equation in terms of

linear combinations of stationary states; Application to the spread of Gaussian wavepacket for a free particle in one dimension; wave packets, Fourier transforms and momentum space wavefunction; Position-momentum uncertainty principle.

(10 Lectures)

General discussion of bound states in an arbitrary potential- continuity of wave function, boundary condition and emergence of discrete energy levels; application to one-dimensional problem- square well potential; Quantum mechanics of simple harmonic oscillator-energy levels and energy eigenfunctions using Frobenius method.

(12 Lectures)

Quantum theory of hydrogen-like atoms: time independent Schrodinger equation in spherical polar coordinates; separation of variables for the second order partial differential equation; angular momentum operator and quantum numbers; Radial wavefunctions from Frobenius method; Orbital angular momentum quantum numbers l and m; s, p, d,.. shells (idea only) **(10 Lectures)**

Atoms in Electric and Magnetic Fields:- Electron Angular Momentum. Space Quantization. Electron Spin and Spin Angular Momentum. Larmor's Theorem. Spin Magnetic Moment. Stern-Gerlach Experiment. Zeeman Effect: Electron Magnetic Moment and Magnetic Energy, Gyromagnetic Ratio and Bohr Magneton.

(8 Lectures)

Atoms in External Magnetic Fields:- Normal and Anomalous Zeeman Effect.

(4 Lectures)

Many electron atoms:- Pauli's Exclusion Principle. Symmetric and Antisymmetric Wave Functions. Periodic table. Fine structure. Spin orbit coupling. Spectral Notations for Atomic States. Total Angular Momentum. Vector Model. Spin-orbit coupling in atoms-L-S and J-J couplings.

(10 Lectures)

Reference Books:

- A Text book of Quantum Mechanics, P.M.Mathews & K.Venkatesan, 2nd Ed., 2010, McGraw Hill
- Quantum Mechanics, Robert Eisberg and Robert Resnick, 2ndEdn., 2002, Wiley.
- Quantum Mechanics, Leonard I. Schiff, 3rdEdn. 2010, Tata McGraw Hill.
- Quantum Mechanics, G. Aruldhas, 2ndEdn. 2002, PHI Learning of India.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.
- Quantum Mechanics for Scientists & Engineers, D.A.B. Miller, 2008, Cambridge University Press

Additional Books for Reference

- Quantum Mechanics, Eugen Merzbacher, 2004, John Wiley and Sons, Inc.
- Introduction to Quantum Mechanics, David J. Griffith, 2nd Ed. 2005, Pearson Education
- Quantum Mechanics, Walter Greiner, 4thEdn., 2001, Springer

PRACTICAL-DSE LAB: QUANTUM MECHANICS

Use C/C++/Scilab for solving the problems based on Quantum Mechanics
and Laboratory based experiments:

1. Study of Electron spin resonance- determine magnetic field as a function of the resonance frequency
2. Study of Zeeman effect: with external magnetic field; Hyperfine splitting
3. To study the quantum tunnelling effect with solid state device, e.g. tunnelling

current in backward diode or tunnel diode.

Reference Books:

- Schaum's Outline of Programming with C++. J.Hubbard, 2000, McGraw-Hill Publications.
- Numerical Recipes in C: The Art of Scientific Computing, W.H.Press et al., 3rd Edn., 2007, Cambridge University Press.
- Elementary Numerical Analysis, K.E.Atkinson, 3rd Edn., 2007, Wiley India Edition.
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- Simulation of ODE/PDE Models with MATLAB®, OCTAVE and SCILAB: Scientific and Engineering Applications: A. Vande Wouwer, P. Saucez, C. V. Fernández.2014 Springer ISBN: 978-3319067896
- Scilab by example: M. Affouf2012ISBN: 978-1479203444
- Scilab (A Free Software to Matlab): H. Ramchandran, A.S. Nair. 2011 S. Chand and Company, New Delhi ISBN: 978-8121939706
- Scilab Image Processing: Lambert M. Surhone. 2010Betascript Publishing ISBN: 978-6133459274A
- Quantum Mechanics, Leonard I. Schiff, 3rdEdn. 2010, Tata McGraw Hill.
- Quantum Mechanics, Bruce Cameron Reed, 2008, Jones and Bartlett Learning.

Skill Enhancement Course (SEC-II) (Semester –VI)

ELECTRONICS-II (Amplifiers and Oscillators)

Transistor Amplifier

Classification, Basic Amplifier, Load Line, Transistor biasing, Transistor equivalent circuit (h-Parameter). Single stage transistor amplifier,(common emitter, common base) FET amplifier, R.C coupled transistor amplifier, Impedance coupled and Transformer coupled amplifier, Noise and distortion in amplifiers, Power amplifiers(Class A Push pull class B and class C) Decibel, Frequency response bandwidth.

Feedback Amplifiers and Oscillators

Classification, Negative feedback and its advantages, Feedback amplifiers(Voltage and current)Positive feedback oscillators(RC phase shift and Wein bridge, Hartley, Colpit, tuned collector, tuned base)Oscillator, Negative resistance(tuned diode oscillator),Crystal oscillators, Stability, Relaxation oscillators-Multivibrators (astable , monostable and bistable).

Department of Botany
Framework of B Sc Botany NEP -2020
(1st - 4th semester)

Semester 1

1.	Core paper I:	DIVERSITY OF LOWER PLANTS (THEORY and PRACTICAL)	(6 CREDITS)
2.	Additional ID-1:	(AID-1 LOWER PLANT DIVERSITY: PART I) (THEORY and PRACTICAL)	(4 CREDITS)
3.	Skill-1	MUSHROOM CULTIVATION TECHNOLOGY	(2 credits)
4.	VAC	Connecting to Environment	(2 credits)

Semester 2

1.	Core paper II:	MICROBIOLOGY AND PLANT PATHOLOGY (THEORY and PRACTICAL)	(6 CREDITS)
2.	Additional ID-2:	(AID-2: Microbiology & Plant pathology) (THEORY and PRACTICAL)	(4 CREDITS)
3.	Skill- 2	Floriculture	(2 credits)
4.	VAC	Lifeskill and Personality Development	(2Credits)

Semester 3

1.	Core paper III:	PLANT PHYSIOLOGY AND BIOCHEMISTRY (THEORY and PRACTICAL)	(6 CREDITS)
2.	Additional ID-3:	(AID-3: Plant physiology and Biochemistry) (THEORY and PRACTICAL)	(4 CREDITS)
3.	Skill-1	MUSHROOM CULTIVATION TECHNOLOGY	(2 credits)
4.	VAC	IKS/AMDC	(2 Credits)

Semester 4

1.	Core paper IV:	PLANT TAXONOMY AND PLANT EMBRYOLOGY (THEORY and PRACTICAL)	(6 CREDITS)
2.	Additional ID-4:	(AID-4: Taxonomy and Embryology of Plants) (THEORY and PRACTICAL)	(4 CREDITS)
3.	Skill- 2	Floriculture	(2 credits)
4.	VAC	IKS/AMDC	(2 credits)

Note:
1. ADD ID (1,2,3,4) will be opted by those students who don't have Botany as core paper (Reduce the syllabus to 70 %)
2. Skill paper will be opted by Botany students only in 2 semesters (either 1-2 or 3-4)
3. IKS will be in any one semester and AMDC in other.

Syllabus of Botany Courses as per National Education Policy-2020
Department of Botany & Microbiology
H.N.B. Garhwal University
B.Sc. Botany

First Year- Semester I

1. Core Paper-1 Theory

Code: **SOLS/BOT/ C (T) -1** **(MM: 30+70)**
Title of Paper: **DIVERSITY OF LOWER PLANTS (THEORY)**
Total No. of Lectures: 60 **Credits: 4**

Unit 1: Algae (12 Lectures)
General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc, Chlamydomonas, Oedogonium, Vaucheria, Fucus, Polysiphonia*. Economic importance of algae

Unit 2: Fungi (14 Lectures)
Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition , nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Penicillium, Alternaria* (Ascomycota), *Puccinia, Agaricus* (Basidiomycota); Symbiotic Associations- **Lichens**: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit 3: Introduction to Archegoniate (14 Lectures)
Unifying features of archegoniates, Transition to land habit, Alternation of generations.

Bryophytes: General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of *Riccia*, *Anthoceros*, *Marchantia* and *Funaria*. (Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

Unit 4: Pteridophytes (12 Lectures)
General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Selaginella, Equisetum* and *Pteris*. (Developmental details not to be included). Heterospory and seed habit, stelar evolution. Ecological and economical importance of Pteridophytes.

Unit 5: Gymnosperms (8 Lectures)
General characteristics, classification. Classification (up to family), morphology, anatomy and reproduction of *Cycas, Pinus* and *Ephedra*. (Developmental details not to be included). Ecological and economical importance.

First Year- Semester I

1. Core Paper-1 Practical

Code: **SOLS/BOT/ C (P) -1** **(MM: 30+70)**

Title of Paper: **DIVERSITY OF LOWER PLANTS (PRACTICAL)**

Credits: 2

1. Study of vegetative and reproductive structures of *Nostoc, Chlamydomonas* (electron micrographs), *Oedogonium, Vaucheria, Fucus** and *Polysiphonia* through temporary preparations and permanent slides. (* *Fucus* - Specimen and permanent slides)
2. *Rhizopus* and *Penicillium*: Asexual stage from temporary mounts and sexual structures through permanent slides.
3. *Alternaria*: Specimens/photographs and tease mounts.
4. *Puccinia*: Herbarium specimens of Black Stem Rust of Wheat and infected Barberry leaves; section/tease mounts of spores on Wheat and permanent slides of both the hosts.
5. *Agaricus*: Specimens of button stage and full grown mushroom; Sectioning of gills of Agaricus.
6. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose)
7. Mycorrhiza: ecto mycorrhiza and endo mycorrhiza (Photographs)
8. *Marchantia, Riccia* and *Anthoceros*- morphology of thallus, w.m. rhizoids and scales, v.s. thallus through gemma cup, w.m. gemmae (all temporary slides), v.s. antheridiophore, archegoniophore, l.s. sporophyte (all permanent slides).
9. *Funaria*- morphology, w.m. leaf, rhizoids, operculum, peristome, annulus, spores (temporary slides); permanent slides showing antheridial and archegonial heads, l.s. capsule and protonema.
10. *Selaginella*- morphology, w.m. leaf with ligule, t.s. stem, w.m. strobilus, w.m. microsporophyll and megasporophyll (temporary slides), l.s. strobilus (permanent slide).
11. *Equisetum*- morphology, t.s. internode, l.s. strobilus, t.s. strobilus, w.m. sporangiophore, w.m. spores (wet and dry)(temporary slides); t.s rhizome (permanent slide).
12. *Pteris*- morphology, t.s. rachis, v.s. sporophyll, w.m. sporangium, w.m. spores (temporary slides), t.s. rhizome, w.m. prothallus with sex organs and young sporophyte (permanent slide).
13. *Cycas*- morphology (coralloid roots, bulbil, leaf), t.s. coralloid root, t.s. rachis, v.s. leaflet, v.s. microsporophyll, w.m. spores (temporary slides), l.s. ovule, t.s. root (permanent slide).
14. *Pinus*- morphology (long and dwarf shoots, w.m. dwarf shoot, male and female), w.m. dwarf shoot, t.s. needle, t.s. stem, , l.s./t.s. male cone, w.m. microsporophyll, w.m. microspores (temporary slides), l.s. female cone, t.l.s. & r.l.s. stem (permanent slide).

Suggested Readings

1. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West. Press Pvt. Ltd. Delhi. 2nd edition.
2. Tortora, G.J., Funke, B.R., Case, C.L. (2010). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 10th edition.
3. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi & Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley and Sons (Asia), Singapore. 4th edition.
5. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R., (2005). Biology. Tata McGraw

Hill, Delhi, India.
6. Vashishta, P.C., Sinha, A.K., Kumar, A., (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
8. Parihar, N.S. (1991). An introduction to Embryophyta. Vol. I. Bryophyta. Central Book Depot, Allahabad

2. Additional Inter Disciplinary-1 (T)*

Code: **SOLS/BOT/ AID (T)-1** **(MM: 30+70)**
Title of Paper: **(AID-1) LOWER PLANTS DIVERSITY (THEORY)**
Total No. of Lectures: 40 **Credits: 4**

Unit 1: Algae (08 Lectures)
General characteristics; Ecology and distribution; Range of thallus organization and reproduction; Classification of algae; Morphology and life-cycles of the following: *Nostoc, Chlamydomonas, Oedogonium, Vaucheria, Fucus, Polysiphonia*. Economic importance of algae

Unit 2: Fungi (08 Lectures)
Introduction- General characteristics, ecology and significance, range of thallus organization, cell wall composition , nutrition, reproduction and classification; True Fungi- General characteristics, ecology and significance, life cycle of *Rhizopus* (Zygomycota) *Penicillium* (Ascomycota), *Puccinia* (Basidiomycota); Symbiotic Associations- **Lichens**: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance

Unit 3: Introduction to Bryophytes (08 Lectures)

Bryophytes: General characteristics, adaptations to land habit, Classification, Range of thallus organization. Classification (up to family), morphology, anatomy and reproduction of *Marchantia* and *Funaria*. (Developmental details not to be included).

Unit 4: Pteridophytes (08 Lectures)
General characteristics, classification, Early land plants (*Cooksonia* and *Rhynia*). Classification (up to family), morphology, anatomy and reproduction of *Selaginella, Equisetum* (Developmental details not to be included). Ecological and economical importance of Pteridophytes.

Unit 5: Gymnosperms (08 Lectures)
General characteristics. Classification (up to family), morphology, anatomy and reproduction of *Cycas* and *Pinus*. (Developmental details not to be included).

Practical based on Theory:

Additional Inter Disciplinary-1(P)

Code: **SOLS/BOT/ AID (P)-1** **(MM: 30+70)**
Title of Paper: **(AID-1p) LOWER PLANTS DIVERSITY (THEORY)**
Credits: 2

*** Additional Interdisciplinary paper will be opted by those students who do not have Botany as a Core subject.**

3. Botany Skill-1 *

Code: **SOLS/BOT/ Skill-1** **(MM: 30+70)**
Title of Paper: **MUSHROOM CULTIVATION TECHNOLOGY**
Total No. of Lectures: 30 **Credits: 2**

Unit 1: (5 Lectures)
Introduction, history. Nutritional and medicinal value of edible mushrooms;
Poisonous mushrooms. Types of edible mushrooms available in India - *Volvariella volvacea, Pleurotus ostreatus, Agaricus bisporus*.

Unit 2: (5 Lectures)
Cultivation Technology : Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag.

Unit 3: (7 Lectures)
Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation - paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation - Low cost technology, Composting technology in mushroom production.

Unit 4: (8 Lectures)
Storage and nutrition : Short-term storage (Refrigeration – up to 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition - Proteins - amino acids, mineral elements nutrition - Carbohydrates, Crude fibre content - Vitamins.

Unit 5: (5 Lectures)
Food Preparation_: Types of foods prepared from mushroom. Research Centres - National level and Regional level._Cost benefit ratio - Marketing in India and abroad, Export Value.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan, M. (1990) Food and Nutrition. Bappco, The Bangalore Printing and Publishing Co. Ltd., No. 88, Mysore Road, Bangalore - 560018.
3. Tewari, Pankaj Kapoor, S.C., (1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Hand book of Mushrooms, II Edition, Vol. I & Vol. II.

4. VAC-1 Connecting to Environment (2 credits)

(Common to all)

First Year- Semester II

1. Core Paper-2 Theory

Code: SOLS/BOT/ C (T) -2 **(MM: 30+70)**
Title of Paper: MICROBIOLOGY & PLANT PATHOLOGY **(THEORY)**
Total No. of Lectures: 60 **Credits: 4**

Total No. of Lectures: 60

Unit 1: (8 Lectures)
History and scope of Microbiology
General account, distribution and classification of microorganisms.

Unit 2: (12 Lectures)
Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance;

Unit 3: (12 Lectures)
Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance. Role of microorganisms in Nitrogen metabolism

Unit 4: (14 Lectures)
History of Plant Pathology. Modes of Infection and general symptoms, physiology of parasitism, defense mechanism in plants, role of environment in disease development. Control measures of plant diseases. Disease resistance in plants.

Unit 5: (14 Lectures)
General symptoms and control measures for the following plant diseases: Citrus canker, TMV, wilt of tomato, bacterial blight of rice, mosaic of sugarcane and little leaf of brinjal. Late blight of potato, Wilt of *Cajanus cajan*, Loose smut of Wheat, Covered smut of Barley, Green ear disease of bajra, downy mildew of crucifers, rusts of pea and linseed, smut of bajra,

PRACTICAL (Credits 2)

Code: SOLS/BOT/ C (P) -2 **(MM: 30+70)**
Title of Paper: MICROBIOLOGY & PLANT PATHOLOGY **(PRACTICAL)**

1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Types of Bacteria from temporary/permanent slides/photographs; EM bacterium; Binary Fission; Conjugation; Structure of root nodule.
3. Gram staining
4. Study of plant diseases with help of infected plant specimen - TMV, citrus canker, little leaf of brinjal, loose smut of wheat, downy mildew of crucifers, rust of pea, smut of bajra.

Suggested Readings

1. Brock Biology of Microoranisms, 13th edition (2012)
2. Stainier, R.Y. General Microbiology 5th edition (2009) Mc Millan Press Ltd., Hound Mills
3. Talaro, K.P., Chess, B., 2011. Foundation in Microbiology. 8th edition. McGraw-Hill
4. Prescott, Harley and Klein's Microbiology 7th edition (2008). Mc GRAW Hill. Singapore
5. Agrios, G.N., 1988. Plant Pathology, Academic Press, London.
6. Lucas, John, A., 1998. Plant Pathology and Plant Pathogens, Wiley-Blackwell, CRC Press.
7. Singh, R.S. Plant diseases, 9th edition (2009). Oxford and IBH Pub. Co. Pvt. Ltd., New Delhi

2. Additional ID-2: (AID-2: Introductory Microbiology & Plant pathology)
(THEORY) (2 CREDITS)
Code: SOLS/BOT/ AID (T)-2 (MM: 30+70

Total No. of Lectures: 40

Unit 1: (8 Lectures)
History and scope of Microbiology
General account, distribution and classification of microorganisms.

Unit 2: (8 Lectures)
Viruses – Discovery, general structure, replication (general account), DNA virus (T-phage); Lytic and lysogenic cycle, RNA virus (TMV); Economic importance;

Unit 3: (8 Lectures)
Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance.

Unit 4: (8 Lectures)
History of Plant Pathology. Modes of Infection and general symptoms, physiology of parasitism, defense mechanism in plants, role of environment in disease development. Control measures of plant diseases. Disease resistance in plants.

Unit 5: (8 Lectures)
General symptoms and control measures for the following plant diseases: Citrus canker, TMV, wilt of tomato, bacterial blight of rice, mosaic of sugarcane and little leaf of brinjal. Late blight of potato, Loose smut of Wheat, rusts of pea and linseed, smut of bajra,

Additional ID-2: (AID-2: Introductory Microbiology & Plant pathology)
(Practical) (2 CREDITS)
Code: SOLS/BOT/ AID (P)-2 (MM: 30+70

Practical will be conducted Based on Theory paper

3. Botany Skill-2 *

Code: **SOLS/BOT/ Skill-2** **(MM: 30+70)**
Title of Paper: **FLORICULTURE**
Total No. of Lectures: 30 **Credits: 2**

Unit 1: (2 Lectures)
Introduction: History of gardening; Importance and scope of floriculture and landscape gardening.

Unit 2: (8 Lectures)
Nursery Management and Routine Garden Operations: Sexual and vegetative methods of propagation; Soil sterilization; Seed sowing; Pricking; Planting and transplanting; Shading; Stopping or pinching; Defoliation; Wintering; Mulching; Topiary; Role of plant growth regulators.

Unit 3: (4 Lectures)
Ornamental Plants: Flowering annuals; Herbaceous perennials; Divine vines; Shade and ornamental trees; Ornamental bulbous and foliage plants; Cacti and succulents; Palms and Cycads; Ferns and Selaginellas; Cultivation of plants in pots; Indoor gardening; Bonsai.

Unit 4: (8 Lectures)
Principles of Garden Designs: English, Italian, French, Persian, Mughal and Japanese gardens; Features of a garden (Garden wall, Fencing, Steps, Hedge, Edging, Lawn, Flower beds, Shrubbery, Borders, Water garden. Some Famous gardens of India. Landscaping Places of Public Importance: Landscaping highways and Educational institutions.

Unit 5: (8 Lectures)
Commercial Floriculture: Factors affecting flower production; Production and packaging of cut flowers; Flower arrangements; Methods to prolong vase life; Cultivation of Important cut flowers (Carnation, Aster, Chrysanthemum, Dahlia, Gerbera, Gladiolous, Marigold,Rose, Lilium, Orchids). Diseases and Pests of Ornamental Plants.

Suggested Readings
1. Randhawa, G.S. and Mukhopadhyay, A. 1986. Floriculture in India. Allied Publishers.

Second Year- Semester III

1. Core Paper-3 Theory

Code: SOLS/BOT/ C (T) -3 **(MM: 30+70)**
Title of Paper: PLANT PHYSIOLOGY AND BIOCHEMISTRY **(THEORY)**
Total No. of Lectures: 60 **Credits: 4**

Unit 1:
Plant-water relations (8 Lectures)
Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition (8 Lectures)
Essential elements, macro and micronutrients; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps. Sugar translocation

Unit 3: Photosynthesis (12 Lectures)
Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit 4: Respiration (10 Lectures)
Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate cycle, Oxidative Pentose Phosphate Pathway.

Unit 5: Plant growth regulators (12 Lectures)
Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene. Plant response to light and temperature (6 Lectures)
Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.

Unit 6: (10 Lectures)
Biologically important molecules: Carbohydrates, Amino acids, Proteins and Lipids.
Enzymes**:** Structure and properties; Mechanism of enzyme action, coenzymes, allosteric enzyme, isozymes, enzyme inhibition.

Practical:

Code: SOLS/BOT/ C (P) -3 **(MM: 30+70)**
Title of Paper: **PLANT PHYSIOLOGY AND BIOCHEMISTRY (**PRACTICAL
(Credits 2)

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of two environmental factors (light and wind) on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Demonstration of Hill reaction.
5. To study the effect of light intensity and bicarbonate concentration on O2 evolution in photosynthesis.
6. Comparison of the rate of respiration in any two parts of a plant.
7. Separation of amino acids by paper chromatography.

8. Demonstration experiments (any four)
   (i) Bolting.
   (ii) Effect of auxins on rooting.
   (iii) Suction due to transpiration.
   (iv) R.Q.
   (v) Respiration in roots.

Suggested Readings

1. Taiz, L., Zeiger, E., (2010). Plant Physiology. Sinauer Associates Inc., U.S.A. 5th Edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.
4. Berg, J.M., Tymoczko, J.L. and Stryer, L. (2007) Biochemistry (Sixth Edition) W.H. Freman &
Company, New York.
5. Cox, M.M. and Nelson DL (2004) Lehniger Principle of Biochemistry (Third Edition) MacMillan Worth Publishers.
6. Dennis, D.T. & Turpin, D.H. (1993) Plant Physiology, Biochemistry and Molecular Biology. Longman Scientific & Technical, England.

2. Additional Inter Disciplinary-3 (T)

Code: **SOLS/BOT/ AID (T)-3** **(MM: 30+70)**

Title of Paper: **(AID-1) Introductory plant physiology and Biochemistry (THEORY)**

Total No. of Lectures: 40 **Credits: 4**

Unit 1:

Plant-water relations (6 Lectures)

Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition (6 Lectures)

Essential elements, macro and micronutrients; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps. Sugar translocation

Unit 3: Photosynthesis (8 Lectures)

Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit 4: Respiration (6 Lectures)

Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate Cycle, Oxidative Pentose Phosphate Pathway.

Unit 5: Plant growth regulators (7 Lectures)

Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene. Plant response to light and temperature, Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure) Vernalization.

Unit 6: (7 Lectures)

Biologically important molecules: Carbohydrates, Amino acids, Proteins and Lipids.

Enzymes**:** Structure and properties; Mechanism of enzyme action, coenzymes, allosteric enzyme, isozymes, enzyme inhibition.

Practical:

Code: **SOLS/BOT/ C (P) -3** **(MM: 30+70)**

Title of Paper: **INTRODUCTORY PLANT PHYSIOLOGY AND BIOCHEMISTRY** **(**PRACTICAL (Credits 2)

Based on Theory Paper.

3. Skill-1 **MUSHROOM CULTIVATION TECHNOLOGY (Same as Semester I** **(2 credits)**

4. VAC **IKS/AMDC** **(2 Credits)**

Second Year- Semester IV

1. Core Paper-4 Theory

Code: SOLS/BOT/ C (T) -4 **(MM: 30+70)**
Title of Paper: PLANT TAXONOMY AND PLANT EMBRYOLOGY **(THEORY)**
Total No. of Lectures: 60 **Credits: 4**

Unit 1: Introduction to plant taxonomy (10 Lectures)
Identification, Classification, Nomenclature. Taxonomic hierarchy, Ranks, categories and taxonomic groups Identification
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access
Taxonomic evidences from palynology, cytology, phytochemistry and molecular data.

Unit 2: Botanical nomenclature (12 Lectures)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.
Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).
Biometrics, numerical taxonomy and cladistics Characters; variations; OTUs, character weighting and coding; cluster analysis; phenograms, cladograms (definitions and differences).

Unit 3: Taxonomy, important distinguishing characters, classification, and economic importance of the following families: (10 Lectures)
Ranunculaceae, Papaveraceae, Caryophyllaceae, Malvaceae, Brassicaceae, Rutaceae, Fabaceae, Apiaceae, Asteraceae, Solanaceae, Apocyanaceae, Asclepidiaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Liliaceae, Poaceae.

Unit 4: Structural organization of flower (14 Lectures)
Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.
Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit 5: Embryo and endosperm (14 Lectures)
Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship.
Apomixis and polyembryony: Definition, types and practical applications.

2 Core Paper-4 Practical

Code: SOLS/BOT/ C (P) -4 (MM: 30+70)
Title of Paper: PLANT TAXONOMY AND PLANT EMBRYOLOGY PRACTICAL (Credits 2)

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification):Brassicaceae -Brassica, Alyssum / Iberis; Asteraceae -Sonchus/Launaea, Vernonia/Ageratum, Eclipta/Tridax; Solanaceae -Solanum nigrum, Withania; Lamiaceae -Salvia, Ocimum; Liliaceae -Asphodelus / Lilium / Allium; Poaceae – Wheat/ Rice/ Barley/ Maize
2. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label (to be submitted in the record book; 15 plant specimens minimum).
3. Taxonomic treatment of plant species belonging to families mentioned in the syllabus.
4. Study of taxonomic terminology
5. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent slides).
6. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.
7. Female gametophyte: Polygonum (monosporic) type of Embryo sac Development (Permanent slides/photographs).
8. Ultrastructure of mature egg apparatus cells through electron micrographs.
9. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) (Photographs and specimens).
10. Dissection of embryo/endosperm from developing seeds.
11. Calculation of percentage of viable germinated pollen in a given medium.

Suggested Readings

1. Simpson, M.G. (2006). Plant Systematics. Elsevier Academic Press, San Diego, CA, U.S.A.
2. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
3. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.

3 Additional ID-4 (Theory)

Code: **SOLS/BOT/ AID-4 (T)** **(MM: 30+70)**

Title of Paper: **TAXONOMY AND EMBRYOLOGY PLANTS (THEORY)**

Total No. of Lectures: 40 **Credits: 2**

Unit 1: Introduction to plant taxonomy (8 Lectures)

Identification, Classification, Nomenclature. Taxonomic hierarchy, Ranks, categories and taxonomic groups Identification

Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access, Molecular taxonomy

Unit 2: Botanical nomenclature (8 Lectures)

Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Classification: Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).

Biometrics, numerical taxonomy and cladistics Characters; variations; cluster analysis; phenograms, cladograms (definitions and differences).

Unit 3: Taxonomy, important distinguishing characters, classification, and economic importance of the following families: (8 Lectures)

Ranunculaceae, Papaveraceae, Caryophyllaceae, Malvaceae, Brassicaceae, Rutaceae, Fabaceae, Apiaceae, Asteraceae, Solanaceae, Apocyanaceae, Asclepidiaceae, Acanthaceae, Lamiaceae, Euphorbiaceae, Orchidaceae, Liliaceae, Poaceae.

Unit 4: Structural organization of flower (8 Lectures)

Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac. Pollination and fertilization: Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit 5: Embryo and endosperm (8 Lectures)

Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship. Apomixis and polyembryony: Definition, types and practical applications.

Practical

Code: **SOLS/BOT/ AID-4 (P)** **(MM: 30+70)**

Title of Paper: **TAXONOMY AND EMBRYOLOGY OF PLANTS** **PRACTICAL (Credits 2)**

Based on Theory Paper

3. Skill- 2 **Floriculture** **(2 credits)**

(Same as semester II)

4. VAC **IKS/AMDC** **(2 credits)**

B.Sc. Zoology

FOUR-YEAR UNDER GRADUATE PROGRAMME
(Eight-Semester Course)

COURSE CONTENTS & SYLLABUS

(Effective from the Academic Year 2022-2023)

HEMVATI NANDAN BAHUGUNA GARHWAL UNIVERSITY

Srinagar (Garhwal) 246 174 Uttarakhand

Department of Zoology

Hemvati Nandan Bahuguna Garhwal University, Srinagar-Garhwal, Uttarakhand

FOUR YEAR BACHELOR'S DEGREE PROGRAMME
WITH HONOURS/ RESEARCH (B.Sc. ZOOLOGY)

COURSE STRUCTURE & CONTENT

First Year (I Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-1)	4+2	**Animal Diversity-I** (Theory-1; Practical-1)	**Core Course**
	AIZ-1	2+2	**Animal Diversity-1** (Theory-1; Practical-1)	**For students with Core Subjects other than Zoology**
	Skill Course Zoology (SZ-1—SZ-6)	2	**Student will elect one course each in I & II Semester *OR* III & IV Semester**	**Skill Course Basket:** **SZ-1.** Laboratory Techniques in Biology **SZ-2.** Basic Instrumentation **SZ-3.** Public Health and Hygiene **SZ-4.** Aquarium Fish Keeping **SZ-5.** Medical Diagnostics **SZ-6.** Bioinformatics
	Extra-curricular Courses/ CC (EC-1)	2	1. Understanding and connecting with Environment	**Compulsory Course [Common University Syllabus]**
	TOTAL	**20**		

Note: Each Additional Interdisciplinary Course will be of two semesters. The student will opt the course from same subject in I & II Semester.
CZ (Core Course-Zoology); AIZ (Additional Interdisciplinary Course-Zoology); SZ (Skill Course-Zoology); CC (Compulsory Course)

First Year (II Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-2)	4+2	**Animal Diversity-II** (Theory-1; Practical-1)	**Core Course**
	AIZ-2	2+2	**Animal Diversity-II** (Theory-1; Practical-1)	**For students with Core Subjects other than Zoology**
	Skill Course Zoology (SZ-1—SZ-6)	2	**Student will elect one course each in I & II Semester *OR* III & IV Semester**	**Skill Course Basket:** **SZ-1.** Laboratory Techniques in Biology **SZ-2.** Basic Instrumentation **SZ-3.** Public Health and Hygiene **SZ-4.** Aquarium Fish Keeping **SZ-5.** Medical Diagnostics **SZ-6.** Bioinformatics
	Life Skills and Personality Development/ CC (LSPD)	2	1. Life skills and personality development	**Compulsory Course [Common University Syllabus]**
	TOTAL	**20**		

Note: Each Additional Interdisciplinary will be of two semesters. The student will opt the course from same subject in I & II Semester.

- **After completion of 1 year of study, if student opts EXIT, then a Certificate will be awarded subject to fulfilment of the conditions as laid down in NHEQF.**
- **10-credit Bridge Course(s) lasting two months, incl. at least 6-credit job-specific internship/ apprenticeship.**
- **Under Graduate Certificate (Zoology)**

Second Year (III Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-3)	4+2	**Elementary Cell Biology & Molecular Biology** (Theory-1; Practical-1)	**Core Course**
	AIZ-3	2+2	**Elementary Cell Biology & Molecular Biology** (Theory-1; Practical-1)	**For students with Core Subjects other than Zoology**
	Skill Course Zoology (SZ-1—SZ-6)	2	**Student will elect one course each in I & II Semester *OR* III & IV Semester**	**Skill Course Basket:** **SZ-1.** Laboratory Techniques in Biology **SZ-2.** Basic Instrumentation **SZ-3.** Public Health and Hygiene **SZ-4.** Aquarium Fish Keeping **SZ-5.** Medical Diagnostics **SZ-6.** Bioinformatics
	Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC)$^{+}$	2	**Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC)**	**Compulsory Course [Common University Syllabus]**
	TOTAL	**20**		

Note: Student will have the choice to select Skill Course in III & IV Semester from subject other than the one opted in I & II Semester.

$^{+}$Student has to opt either IKS or AMSC in III or IV Semester

Second Year (IV Semester)	Major Subject	Credits	Name of the Course	Remarks
	Core Zoology (CZ-4)	4+2	**Physiology and Elementary Biochemistry** (Theory-1; Practical-1)	**Core Course**
	AIZ-4	2+2	**Physiology and Elementary Biochemistry** (Theory-1; Practical-1)	**For students with Core Subjects other than Zoology**
	Skill Course Zoology (SZ-1—SZ-6)	2	**Student will elect one course each in I & II Semester *OR* III & IV Semester**	**Skill Course Basket:** **SZ-1.** Laboratory Techniques in Biology **SZ-2.** Basic Instrumentation **SZ-3.** Public Health and Hygiene **SZ-4.** Aquarium Fish Keeping **SZ-5.** Medical Diagnostics **SZ-6.** Bioinformatics
	Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC)$^{+}$	2	**Indian Knowledge System (IKS)/ Additional Multidisciplinary Skill Course (AMSC)**	**Compulsory Course [Common University Syllabus]**
	TOTAL	**20**		

Note: Student will have the choice to select Skill Course in III & IV Semester from subject other than the one opted in I & II Semester.

$^{+}$Student has to opt either IKS or AMSC in III or IV Semester

- **After completion of 2 years of study, if student opts exit, then a Diploma will be awarded subject to the fulfilment of the conditions as laid down in NHEQF.**
- **10-credit Bridge Course(s) lasting two months, incl. at least 6-credit job-specific internship/ apprenticeship.**
- **Under Graduate Diploma (Zoology)**

Third Year (V Semester)	Discipline Specific Elective (DSE)	Credits	Name of the Course	Remarks
		4+2	**DSE (Any one)** (Theory-1; Practical-1)	**DSE Basket:** **DSE-1.** Applied Zoology **DSE-2.** Wild Life Conservation & Management **DSE-3.** Principles of Genetics & Evolutionary Biology **DSE-4.** Animal Behaviour & Endocrinology **DSE-5.** Introduction to Developmental Biology **DSE-6.** Basics of Biotechnology
	Vocational Course/ Field Visit/ Entrepreneur-ship Skills	4	**Vocational Course (VCZ):** **1.** Poultry Farming **2.** Apiculture **3.** Sericulture **4.** Aquaculture **5.** Fish Hatchery Operations **6.** Vermiculture	Any one related to either Core Subject 1 or Core Subject 2 ***OR*** Field/ Industrial visit as per requirement of core course (Student will submit a brief report on visit at the end of the semester)
	Extracurricular Course-II/ CC	2	**Culture, Traditions and Moral Values**	**Compulsory Course [Common University Syllabus]**
	Languages-I	2	**Indian, Modern, Regional Language-I**	**Hindi/Sanskrit/English/any other language as proposed by the University**
	TOTAL	**20**		
Note: Student will have the option to study any two languages one each in V & VI Semester.				

Third Year (VI Semester)	Discipline Specific Elective (DSE)	Credits	Name of the Course	Remarks
		4+2	**DSE (Any one)** (Theory-1; Practical-1)	**DSE Basket:** **DSE-1.** Applied Zoology **DSE-2.** Wild Life Conservation & Management **DSE-3.** Principles of Genetics & Evolutionary Biology **DSE-4.** Animal Behaviour & Endocrinology **DSE-5.** Introduction to Developmental Biology **DSE-6.** Basics of Biotechnology
	Vocational Course/ Field Visit/ Entrepreneur-ship Skills	4	**Vocational Course (VCZ):** **1.** Poultry Farming **2.** Apiculture **3.** Sericulture **4.** Aquaculture **5.** Fish Hatchery Operations **6.** Vermiculture	Any one related to either CS-1 or CS-2 ***OR*** Field/ Industrial visit as per requirement of core course (Student will submit a brief report on visit at the end of the semester).
	Communication Skills/ CC	2	**Communication skill Course** (Based on soft skill development)	**Student will select one language course [Common University Syllabus]**
	Languages-II	2	**Indian, Modern, Regional Language-II**	**Hindi/Sanskrit/English/any other language as proposed by the University**
	TOTAL	**20**		
Note: Student will have the option to study any two languages one each in V & VI Semester.				

- **In case of Exit after 3rd year, Graduate degree, Bachelor of Science (B.Sc.) will be awarded (Credits-120)**
- **10-credit Bridge Course(s) lasting two months, incl. at least 6-credit job-specific internship/ apprenticeship.**

Self and Social Development (SSD) course work	This Self and Social Development course work will be compulsory for all student and the student will have the choice to complete any two forms of the following course work in any one of Eight Semester (I to VIII semester) of UG program: (1) Community Connect & Service (2) Extracurricular Activities Both the coursework will carry 2 (Two credits). Student may select any one of the above 2 course work. **Community Connect & Service:** Under community connect there will be a requirement of Minimum 30 hours of community service within any semester (I to IV). The courses will be based on community connect, Swachh Bharat, Ek Bharat Shrestha Bharat, NSS, etc. It will be based on number of hours devoted under this course. Concerned department will verify the fulfilment of minimum hours towards CCS. **Extracurricular Activities:** This course work required student participation in university demarcated activities such as (1) Participation/representation of institution in Intercollegiate activities/State level activities/National level activities. A committee set up by university will verify the student participation in activities for award of credits for the coursework

Student for successfully completing 4 Year U.G. Program degree along with securing the required credits (160 credits- for 4-year UG Program) will have to secure additional 2 credits under SSD.

Student for successfully completing 3 Year U.G. Program degree (if he/she opts to exit after completing 3 years U.G. course) along with securing the required credits (120 credits- for 3-year UG Program) Student will have to secure same 2 credits under SSD.

Fourth Year (VII Semester with Honours)	**Major Subject (One Only) Core Zoology-5 (CZ-5) Core Zoology-6 (CZ-6)**	**Credit**	**Name of Course**	**Remarks**
		3+3+2	**CZ-5. Non-Chordata** (3 Credit) **CZ-6. Cell and Molecular Biology** (3 Credit) **LC-1. Lab Course** (2 Credit)	**These courses will be based on core subject selected by the students for PG and Research**
	Major Elective Zoology (EZ-1)	2+2	**Elective Course (Any one)** (2 Credit) **LC-2. Lab Course** (2 Credit)	**Elective Course Basket** **EZ-1a.** Developmental Biology and Parasitology **EZ-1b.** Elementary Biotechnology and Microbiology **EZ-1c.** Toxicology
	Minor Core Zoology (CZM-1)	3	**CZM-1. Endocrinology & Animal Behaviour** (3 Credit)	**For students with Core subjects other than Zoology (Without Practical)**
	Minor Elective Zoology (EZM-1)	3	**Minor Elective Course** **(Any one)** [3 Credit] **EZM-1a.** Developmental Biology and Parasitology **EZM-1b.** Elementary Biotechnology and Microbiology **EZM-1c.** Toxicology	**For students with Core subjects other than Zoology (Without Practical)**
	Research Writing and Ethics	2	**1. Research Writing and Ethics**	**Compulsory Course [Common University Syllabus]**
	TOTAL	**20**		

Fourth Year (VIII Semester with Honours)	**Major Subject (One Only) Core Zoology-7 (CZ-7)**	**Credit**	**Name of Course**	**Remarks**
		4+4	**CZ-7. Chordata** (4 Credit) **LC-3. Lab Course** (4 Credit)	**This course will be based on core subject selected by the students for PG and Research**
	Major Elective Zoology (EZ-2)	2+2	**Elective Course (Any one)** (2 Credit) **LC-4. Lab Course** (2 Credit)	**Elective Course Basket** **EZ-2a.** Aquatic Biodiversity **EZ-2b.** Genetics, Evolution and Taxonomy **EZ-2c.** Assisted Reproductive Biology Techniques
	Minor Core Zoology (CZM-2)	3	**CZM-2. Biological and Radiotracer Techniques** (3 Credit)	**For students with Core subjects other than Zoology (Without Practical)**
	Minor Elective Zoology (EZM-2)	3	**Minor Elective Course** **(Any one)** [3 Credit] **EZM-2a.** Aquatic Biodiversity **EZM-2b.** Genetics, Evolution and Taxonomy **EZN-2c.** Assisted Reproductive Biology Techniques	**For students with Core subjects other than Zoology (Without Practical)**
	Basic Research Methods	2	**1. Basic Research Methods**	**Compulsory Course [Common University Syllabus]**
	Total	**20**		

Note: After the completion of Four years (eight semesters) with above mentioned courses the student will be awarded Bachelor of Science degree, B.Sc. (Honours).

Fourth Year (VII Semester with Research)	**Major Subject (One Only)** **Core Zoology-5 (CZ-5)** **Core Zoology-6 (CZ-6)**	3+3+2	**CZ-5. Non-Chordata** (3 Credit) **CZ-6. Cell and Molecular Biology** (3 Credit) **LC-1. Lab Course** (2 Credit)	**These courses will be based on core subject selected by the students for PG and Research**
	Research Methodology Zoology (RMZ-1)	4	**RMZ-1. Research Methodology**	Student will learn the basic research methodology with focus on data analysis for application in research-based work to be carried out in VIII Semester
	Elective Course Zoology (EZ-1)	3+3	**Elective Course (Any one)** (3 Credit) **LC-2. Lab Course** (3 Credit)	**Elective Course Basket** **EZ-1a.** Developmental Biology and Parasitology **EZ-1b.** Elementary Biotechnology and Microbiology **EZ-1c.** Toxicology
	Research Writing and Ethics	2	**1. Research Writing and Research Ethics**	**Compulsory Course [Common University Syllabus]**
	TOTAL	**20**		

Fourth Year (VIII Semester with Research)	**Major Subject (One Only)** **Core Zoology-7 (CZ-7)** **Core Zoology-8 (CZ-8)**	3+3+2	**CZ-7. Chordata** (3 Credit) **CZ-8. Biostatistics and Computer Application** (3 Credit) **LC-3. Lab Course** (2 Credit)	**These courses will be based on core subject selected by the students for PG and Research**
	Research Presentation Skills	2	**Research Paper Presentation Skills (Oral and Poster)**	**Compulsory Course [Common University Syllabus]**
	Elective Course Zoology (EZ-2)	3+3	**Elective Course (Any one)** (3 Credit) **LC-4. Lab Course** (3 Credit)	**Elective Course Basket** **EZ-2a.** Aquatic Biodiversity **EZ-2b.** Genetics, Evolution and Taxonomy **EZ-2c.** Assisted Reproductive Biology Techniques
	Dissertation	4	**Dissertation/ Research-based field or industrial report**	Student will conduct minor research work ***OR*** will do research-based field study and submit the dissertation/ report at the end of semester.
	TOTAL	**20**		

Note: After the completion of Four years (eight semesters) with above mentioned courses the student will be awarded Bachelor of Science degree, B.Sc. (Research).

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FOUR YEAR BACHELOR'S DEGREE PROGRAMME WITH HONOURS/ RESEARCH

COURSE CODE

B.Sc. (Zoology)
First, Second & Third Year (I-VI Semester)

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-1	Animal Diversity-I	4	0	0	4
SOLS/ZOO/CZ-2	Animal Diversity-II	4	0	0	4
SOLS/ZOO/CZ-3	Elementary Cell Biology & Molecular Biology	4	0	0	4
SOLS/ZOO/CZ-4	Physiology and Elementary Biochemistry	4	0	0	4
SOLS/ZOO/CZ-1(P)	Animal Diversity-I (Practical)	0	0	2	2
SOLS/ZOO/CZ-2(P)	Animal Diversity-II (Practical)	0	0	2	2
SOLS/ZOO/CZ-3(P)	Elementary Cell Biology & Molecular Biology (Practical)	0	0	2	2
SOLS/ZOO/CZ-4(P)	Physiology and Elementary Biochemistry (Practical)	0	0	2	2
SOLS/ZOO/AIZ-1	Animal Diversity-I	2	0	0	2
SOLS/ZOO/AIZ-2	Animal Diversity-II	2	0	0	2
SOLS/ZOO/AIZ-3	Elementary Cell Biology & Molecular Biology	2	0	0	2
SOLS/ZOO/AIZ-4	Physiology and Elementary Biochemistry	2	0	0	2
SOLS/ZOO/AIZ-1(P)	Animal Diversity-I (Practical)	0	0	2	2
SOLS/ZOO/AIZ-2(P)	Animal Diversity-II (Practical)	0	0	2	2
SOLS/ZOO/AIZ-3(P)	Elementary Cell Biology & Molecular Biology (Practical)	0	0	2	2
SOLS/ZOO/AIZ-4(P)	Physiology and Elementary Biochemistry (Practical)	0	0	2	2
SOLS/ZOO/SZ-1	Laboratory Techniques in Biology	2	0	0	2
SOLS/ZOO/SZ-2	Basic Instrumentation	2	0	0	2
SOLS/ZOO/SZ-3	Public Health and Hygiene	2	0	0	2
SOLS/ZOO/SZ-4	Aquarium Fish Keeping	2	0	0	2
SOLS/ZOO/SZ-5	Medical Diagnostics	2	0	0	2
SOLS/ZOO/SZ-6	Bioinformatics	2	0	0	2
SOLS/ZOO/DSE-1	Applied Zoology	4	0	0	4
SOLS/ZOO/DSE-2	Wild Life Conservation & Management	4	0	0	4
SOLS/ZOO/DSE-3	Principles of Genetics & Evolutionary Biology	4	0	0	4
SOLS/ZOO/DSE-4	Animal Behaviour & Endocrinology	4	0	0	4
SOLS/ZOO/DSE-5	Introduction to Developmental Biology	4	0	0	4
SOLS/ZOO/DSE-6	Basics of Biotechnology	4	0	0	4
SOLS/ZOO/DSE-1(P)	Applied Zoology (Practical)	0	0	2	2
SOLS/ZOO/DSE-2(P)	Wild Life Conservation & Management (Practical)	0	0	2	2
SOLS/ZOO/DSE-3(P)	Principles of Genetics & Evolutionary Biology (Practical)	0	0	2	2
SOLS/ZOO/DSE-4(P)	Animal Behaviour & Endocrinology (Practical)	0	0	2	2
SOLS/ZOO/DSE-5(P)	Introduction to Developmental Biology (Practical)	0	0	2	2
SOLS/ZOO/DSE-6(P)	Basics of Biotechnology (Practical)	0	0	2	2
SOLS/ZOO/VCZ-1	Poultry Farming	4	0	0	4
SOLS/ZOO/VCZ-2	Apiculture	4	0	0	4
SOLS/ZOO/VCZ-3	Sericulture	4	0	0	4
SOLS/ZOO/VCZ-4	Aquaculture	4	0	0	4
SOLS/ZOO/VCZ-5	Fish Hatchery Operations	4	0	0	4
SOLS/ZOO/VCZ-6	Vermiculture	4	0	0	4

B.Sc. (Zoology)
Fourth Year (VII & VIII Semester) [Honours]

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-5	Non-Chordata	3	0	0	3
SOLS/ZOO/CZ-6	Cell and Molecular Biology	3	0	0	3
SOLS/ZOO/CZ-7	Chordata	4	0	0	4
SOLS/ZOO/EZ-1a	Developmental Biology and Parasitology	2	0	0	2
SOLS/ZOO/EZ-1b	Elementary Biotechnology and Microbiology	2	0	0	2
SOLS/ZOO/EZ-1c	Toxicology	2	0	0	2
SOLS/ZOO/EZ-2a	Aquatic Biodiversity	2	0	0	2
SOLS/ZOO/EZ-2b	Genetics, Evolution and Taxonomy	2	0	0	2
SOLS/ZOO/EZ-2c	Assisted Reproductive Biology Techniques	2	0	0	2
SOLS/ZOO/LC-1	Lab Course-1 (Based on CZ-5 & CZ-6)	0	0	2	2
SOLS/ZOO/LC-2	Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c)	0	0	2	2
SOLS/ZOO/LC-3	Lab Course-3 (Based on CZ-7)	0	0	4	4
SOLS/ZOO/LC-4	Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c)	0	0	2	2
SOLS/ZOO/CZM-1	Endocrinology & Animal Behaviour	3	0	0	3
SOLS/ZOO/CZM-2	Biological and Radiotracer Techniques	3	0	0	3
SOLS/ZOO/EZM-1a	Developmental Biology and Parasitology	3	0	0	3
SOLS/ZOO/EZM-1b	Elementary Biotechnology and Microbiology	3	0	0	3
SOLS/ZOO/EZM-1c	Toxicology	3	0	0	3
SOLS/ZOO/EZM-2a	Aquatic Biodiversity	3	0	0	3
SOLS/ZOO/EZM-2b	Genetics, Evolution and Taxonomy	3	0	0	3
SOLS/ZOO/EZM-2c	Assisted Reproductive Biology Techniques	3	0	0	3

B.Sc. (Zoology)
Fourth Year (VII & VIII Semester) [Research]

Course Code	Title of the Course	L	T	P	C
SOLS/ZOO/CZ-5	Non-Chordata	3	0	0	3
SOLS/ZOO/CZ-6	Cell and Molecular Biology	3	0	0	3
SOLS/ZOO/CZ-7	Chordata	3	0	0	3
SOLS/ZOO/CZ-8	Biostatistics and Computer Application	3	0	0	3
SOLS/ZOO/CZ-9	Dissertation/ Research-based field or industrial report	0	0	4	4
SOLS/ZOO/RMZ	Research Methodology	4	0	0	4
SOLS/ZOO/EZ-1a	Developmental Biology and Parasitology	3	0	0	3
SOLS/ZOO/EZ-1b	Elementary Biotechnology and Microbiology	3	0	0	3
SOLS/ZOO/EZ-1c	Toxicology	3	0	0	3
SOLS/ZOO/EZ-2a	Aquatic Biodiversity	3	0	0	3
SOLS/ZOO/EZ-2b	Genetics, Evolution and Taxonomy	3	0	0	3
SOLS/ZOO/EZ-2c	Assisted Reproductive Biology Techniques	3	0	0	3
SOLS/ZOO/LC-1	Lab Course-1 (Based on CZ-5 & CZ-6)	0	0	2	2
SOLS/ZOO/LC-2	Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c)	0	0	3	3
SOLS/ZOO/LC-3	Lab Course-3 (Based on CZ-7& CZ-8)	0	0	2	2
SOLS/ZOO/LC-4	Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c)	0	0	3	3

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FOUR YEAR BACHELOR'S DEGREE PROGRAMME WITH HONOURS/ RESEARCH
(B.Sc. Zoology)

SYLLABUS (*w.e.f.* 2022-23)

B.Sc. First Year (I Semester)

CORE ZOOLOGY (CZ-1 to CZ-4)
(Theory: 4 Credits; Practical: 2 Credits)

ADDITIONAL INTERDISCIPLINARY ZOOLOGY (AIZ-1 to AIZ-4)
(Theory: 2 Credits; Practical: 2 Credits)
[For students with Core Subjects other than Zoology]

SOLS/ZOO/CZ-1 Animal Diversity-I **4 Credits [60 hours]**

Unit I. Introduction to Non-Chordata: General characters; Outline classification up to Classes [4 Hours]

Unit II. Protozoa: Salient features; Study of *Amoeba, Euglena* and *Paramecium* with reference to structure, locomotion, nutrition and reproduction (life history) [8 Hours]

Unit III. Origin of Metazoa.

Porifera: Salient features; Study of *Sycon* with reference to structure, reproduction (life history); Canal system in Syconoid sponge; Skeleton system [6 Hours]

Unit IV. Coelenterata: Salient features; Study of *Aurelia* with reference to morphology and reproduction (life history); Alternation of generation in Coelenterates [6 Hours]

Unit V. Helminthes: Salient features; Study of *Taenia* and *Ascaris* with reference to morphology, reproduction (life-cycle) and parasitic adaptations [6 Hours]

Unit VI. Annelida: Salient features; Types and significance of coelom; Metamerism and its significance; Study of *Nereis* and *Hirudinaria* with reference to morphology and reproduction; Parasitic adaptations of *Hirudinaria*; Trochophore larva and its significance [8 Hours]

Unit VII. Arthropoda: Salient features; Study of *Palaemon* with reference to morphology, respiration, excretion and reproduction; Zoological importance of *Peripatus* and *Limulus*; Economic importance of arthropods [8 Hours]

Unit VIII. Mollusca: Salient features; Study of *Pila* and *Unio* with reference to morphology, respiration and reproduction (life-history) [8 Hours]

Unit IX. Echinodermata: Salient features; Study of *Asterias* with reference to morphology, locomotion, water vascular system, mode of feeding and reproduction [6 Hours]

SOLS/ZOO/AIZ-1 Animal Diversity-I **2 Credits [30 Hours]**

Unit I. Introduction to Non-Chordata: General characters; Outline classification up to Classes.
Protozoa: Salient features; Study of locomotion and nutrition in Protozoa [8 Hours]

Unit II. Origin of Metazoa.
Porifera: Salient features; Study of canal system and skeleton system in sponges.
Coelenterata: Salient features; Alternation of generation in Coelenterates; Corals and Coral reef [6 Hours]

Unit III. Helminthes: Salient features; Parasitic adaptations in helminths.
Annelida: Salient features; Types and significance of coelom; Metamerism and its significance; Trochophore larva and its significance [8 Hours]

Unit IV. Arthropoda: Salient features; Zoological importance of *Peripatus* and *Limulus*; Economic importance of arthropods.
Mollusca: Salient features; Torsion; Pearl formation
Echinodermata: Salient features; Study of water vascular system in star fish [8 Hours]

SUGGESTED READINGS

1. Barnes, RD: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington, EJW: Invertebrate Structure and Function, Nelson, 1987.
3. Hickman, Roberts & Hickman: Integrated Principles of Zoology (7th ed) Times-Mirror, Mosby, 1984.
4. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
5. Kotpal, RL: Modern Text Book of Zoology: Invertebrates, Rastogi Publications, 12th edition, 2019
6. Marshall & William: Text Book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillan, 1972.

SOLS/ZOO/CZ-1(P) Animal Diversity-I (Practical) [2 Credits]
SOLS/ZOO/AIZ-1(P) Animal Diversity-I (Practical) [2 Credits]

Study of museum specimens/slides:
Protozoa: *Amoeba, Euglena, Plasmodium, Paramecium*, *Trichomonas, Trypanosoma, Monocystis, Vorticella*
Porifera: *Sycon* (including T.S. and L.S.), *Hyalonema*, *Euplectella*, *Euspongia*
Coelenterata: *Obelia, Physalia, Aurelia, Tubipora, Metridium*, *Hydra, Gorgonia, Pennatula*
Platyhelminthes: *Taenia solium* and study of its life history stages, *Schistosoma, Fasciola*
Nemathelminthes: Male and female *Ascaris lumbricoides*, *Wuchereria*, *Ancylostoma*
Annelida: *Aphrodite, Nereis, Pheretima, Hirudinaria, Polygordias*
Arthropoda: *Palaemon, Cancer Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis*, *Musca*
Mollusca: *Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus*
Echinodermata: *Pentaceros, Ophiura, Echinus, Cucumaria, Antedon, Holothuria, Astreas*

B.Sc. First Year (II Semester)

SOLS/ZOO/CZ-2 Animal Diversity-II 4 Credits [60 Hours]

Unit I. Introduction to Chordata: General characters and outline classification of Chordates up to Classes.

Hemichordata: General characters and classification; *Balanoglossus*: morphology and development [6 Hours]

Unit II. Urochordata: General characters and classification; *Herdmania*: Morphology, blood vascular system, reproductive system and development [6 Hours]

Unit III. Cephalochordata: Classification and salient features; *Branchiostoma* (=*Amphioxus*): Morphology, digestive, excretory, reproductive system and development [6 Hours]

Unit IV. Cyclostomata: General characters and classification; External features of *Petromyzon* and *Myxine*; Comparison between Lampreys and Hagfishes [4 Hours]

Unit V. Pisces: General characters of cartilaginous and bony fish;
Dipnoi: Distribution, General characters, and affinities;
External features, Digestive, Respiratory, Blood vascular, Nervous and Urinogenital system of *Scoliodon*; Scales and fins of fishes, respiratory organs in fish [11 Hours]

Unit VI. Amphibia: General characters and classification, Elementary idea of parental care [3 Hours]

Unit VII. Reptilia: Terrestrial Adaptations; General characters and distribution of Chelonia, Rhynchocephalia, Ophidia and Crocodilia; Poisonous and non-poisonous snakes; Biting mechanism in snakes; Venom and Antivenom [8 Hours]

Unit VIII. Aves: General characters; Morphology, Digestive, Respiratory and Urinogenital System of *Columba*; Feathers in Birds; Aerial adaptations in birds [8 Hours]

Unit IX. Mammalia: General organization, salient features and distribution of Prototheria, Metatheria and Eutheria [8 Hours]

SOLS/ZOO/AIZ-2 Animal Diversity-II 2 Credits [30 Hours]

Unit I. Introduction to Chordata: General characters and outline classification of Chordates up to Classes.
Hemichordata: General characters, classification and affinities.
Urochordata: General characters, classification and affinities; Retrogressive metamorphosis in *Herdmania*

Cephalochordata: General characters, classification and affinities [8 Hours]

Unit II. Cyclostomata: General characters, classification and affinities; Comparison between Lampreys and Hagfishes.
Pisces: General characters, classification and affinities; Scales, fins and respiratory organs of fishes;
Dipnoi: Distribution, General characters, and affinities [8 Hours]

Unit III. Amphibia: General characters and classification, Elementary idea of parental care.
Reptilia: Terrestrial Adaptations; General characters, distribution and affinities; Poisonous and non-poisonous snakes; Biting mechanism in snakes; Venom and Antivenom [7 Hours]

Unit IV. Aves: General characters and classification; Feathers in Birds; Aerial adaptations in birds.
Mammalia: General characters, classification and distribution of Prototheria, Metatheria and Eutheria [7 Hours]

SUGGESTED READINGS

1. Kotpal, R.L.: Modern Text-book of Zoology, Vertebrates. Rastogi Publication, 2007
2. Jordan, E.L. and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd., 2013
3. Hildebrand, M. Goslow, G.: Analysis of Vertebrate Structure, Wiley, 1998
4. Romer, A.S., T.S. Parsons: Vertebrate Body, Saunders (W.B.) Co Ltd; 5th Revised edition, 1977
5. Pandey, B.N., Mathur, V. Biology of Chordates. PHI Learning Pvt. Ltd., Delhi, 2019

SOLS/ZOO/CZ-2(P) Animal Diversity-II (Practical) [2 Credits]
SOLS/ZOO/AIZ-2(P) Animal Diversity-II (Practical) [2 Credits]

Study of museum specimens/slides:
Protochordata: *Balanoglossus, Herdmania, Branchiostoma*, Agnatha: *Petromyzon*, *Myxine*
Pisces: *Sphyrna, Pristis, Torpedo, Exocoetus, Anguilla*, *Acipenser*, *Latimaria*, *Chimaera*
Amphibia: *Ichthyophis/ Ureotyphlus, Salamandra, Bufo, Hyla*
Reptilia: *Chelone, Hemidactylus, Chamaeleon, Draco, Vipera, Naja, Crocodylus, Gavialis*; Key for Identification of poisonous and non-poisonous snakes
Aves: Study of six common birds from different orders
Mammalia: *Sorex*, Bat, *Funambulus*, Loris, Platypus, Opossum, Kangaroo, Manis, Dolphin, Whale, Lutra, Camel, Polar Bear (Photographs)

An "animal album" containing photographs, cut outs, with appropriate write up about the abovementioned taxa. Different taxa/ topics may be given to different sets of students for this purpose. These need not be repeated as drawings by the album maker.

B.Sc. Second Year (III Semester)

SOLS/ZOO/CZ-3 Elementary Cell Biology & Molecular Biology 4 Credits [60 Hours]

Unit I. Introduction to Cell theory; Comparison of a generalised Pro- & Eukaryote cell.
Elementary idea of cell fractionation; Light & Phase Contrast Microscopy, Confocal and Electron Microscopy (TEM & SEM) [8 Hours]

Unit II. Elementary knowledge of the structure & function of plasma membrane, cytoplasm [4 Hours]

Unit III. Introduction to the organelles constituting endomembrane system (Endoplasmic reticulum, Golgi complex, Lysosome, Peroxisome); Nucleus & Nucleolus; Ribosome; Mitochondria; Chloroplast; Introduction to cytoskeleton [10 Hours]

Unit IV. Basic features of Cell cycle; Mitosis & Meiosis [6 Hours]

Unit V. DNA as genetic material: Structure of DNA, Types of DNA; Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases; primosome, replisome, Rolling circle replication, Unique aspects of eukaryotic chromosome replication [8 Hours]

Unit VI. DNA damage and repair: Causes and types of DNA damage, mechanism of DNA repair: Photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, recombinational repair, non-homologous end joining [6 Hours]

Unit VII. RNA structure and types of RNA: Transcription in prokaryotes—Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains; Transcription in eukaryotes—Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation, promoter clearance and elongation RNA splicing and processing [10 Hours]

Unit VIII. Regulation of gene expression and translation: Regulation of gene expression in prokaryotes—Operon concept (inducible and repressible system), Genetic code and its characteristics; aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides [8 Hours]

SOLS/ZOO/AIZ-3 Elementary Cell Biology & Molecular Biology 2 Credits [30 Hours]

Unit I. Introduction to Cell theory; Comparison of a generalised Pro- & Eukaryote cell.
Elementary knowledge of the structure & function of plasma membrane, cytoplasm [6 Hours]

Unit II. Introduction to the organelles constituting endomembrane system (Endoplasmic reticulum, Golgi complex, Lysosome, Peroxisome); Nucleus & Nucleolus; Ribosome; Mitochondria; Chloroplast; Introduction to cytoskeleton; Basic features of Cell cycle; Mitosis & Meiosis [10 Hours]

Unit III. DNA as genetic material: Structure of DNA, Types of DNA; Replication of DNA in prokaryotes and eukaryotes: Semiconservative nature of DNA replication, Bi-directional replication, DNA polymerases; primosome, replisome [6 Hours]

Unit IV. RNA structure and types of RNA: Transcription in prokaryotes—Prokaryotic RNA polymerase, role of sigma factor, promoter, Initiation, elongation and termination of RNA chains; Transcription in eukaryotes—Eukaryotic RNA polymerases, transcription factors, promoters, enhancers, mechanism of transcription initiation.
Regulation of gene expression and translation: Regulation of gene expression in prokaryotes—Operon concept (inducible and repressible system), aminoacyl tRNA synthetases, Mechanism of initiation, elongation and termination of polypeptides [8 Hours]

SUGGESTED READINGS

1. Alberts et al.: Molecular Biology of the Cell, Garland Pub., New York, 1989.
2. DeRobertis & DeRobertis: Cell & Molecular Biology, 1996
3. Friefelder: Molecular Biology. Narosa Publ. House, 1996
4. Sharma, V.K.: Techniques in Microscopy and Cell Biology, Tata McGraw Hill, 1991
5. Strickberger: Genetics, Prentice Hall, 1996.
6. Verma, P.S. and Agarwal, V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology (S. Chand & Co.)
7. Pandey, B.N. B.Sc. Zoology Series: Cytology, Genetics and Molecular Genetics. Tata McGraw Hill, 2012

SOLS/ZOO/CZ-3(P) Elementary Cell Biology & Molecular Biology (Practical) [2 Credits]
SOLS/ZOO/AIZ-3(P) Elementary Cell Biology & Molecular Biology (Practical) [2 Credits]

1. Photographs of prokaryotic cell
2. Photographs of cell organelles
3. Stages of Mitosis by squash technique
4. Photographs of structure of DNA, RNAs
5. Diagrams of translation, transcription
6. Preparation of solutions for Molecular Biology experiments.
7. Isolation of chromosomal DNA from bacterial cells.
8. Isolation of Plasmid DNA by alkaline lysis method
9. Agarose gel electrophoresis of genomic DNA & plasmid DNA
10. Preparation of restriction enzyme digests of DNA samples
11. Demonstration of AMES test or reverse mutation for carcinogenicity

SOLS/ZOO/CZ-4 Physiology and Elementary Biochemistry 4 Credits [60 Hours]

A. PHYSIOLOGY

Unit I. Nerve and muscle: Introduction to CNS, PNS, ANS; Structure of a neuron, Types of neurons; Types of muscle, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction [6 Hours]

Unit II. Digestion: Comparative Physiology of vertebrate digestion e.g., Digestion in different segments of the alimentary canal; Absorption of carbohydrates, proteins, lipids. Ruminant stomach in ungulates [8 Hours]

Unit III. Respiration: Comparative account of vertebrate respiration**;** Transport of oxygen and carbon dioxide in blood [6 Hours]

Unit IV. Osmoregulation and thermoregulation: Osmoregulation in fishes, structure of nephron, mechanism of urine formation. Thermoregulation in poikilotherms, homeotherms and heterotherms. Aestivation and Hibernation [8 Hours]

Unit V. Cardiovascular system: Blood: Comparative account of circulatory system (Open and Closed), Composition of Blood, Lymph, tissue fluid, comparative anatomy of vertebrate heart and aortic arches. Homeostasis, Heart structure, Origin and conduction of the cardiac impulse, cardiac cycle [6 Hours]

Unit VI. Reproduction and Endocrine Glands: Autocrine, paracrine, juxtacrine and endocrine mode of action; Introduction to Endocrine glands: Structure and function of hypothalamus, pituitary, thyroid, parathyroid, pancreas, adrenal and gonads' Reproductive physiology of male and female fertility [6 Hours]

B. BIOCHEMISTRY

Unit VII. Introduction to Biomolecules: Carbohydrates, Proteins, Lipids: structure, types and functions [6 Hours]

Unit VIII. Introduction to Enzymology: Mechanism of action, Kinetics, inhibition and regulation [6 Hours]

Unit IX. Introduction to metabolism of Carbohydrate, Protein and Lipids: Glycolysis, Kreb's cycle, pentose phosphate pathway, glycogen metabolism, electron transport chain, transamination, deamination, urea cycle, β- oxidation in fatty acids [8 Hours]

SOLS/ZOO/AIZ-4 Physiology and Elementary Biochemistry 2 Credits [30 Hours]

A. PHYSIOLOGY

Unit I. Nerve and muscle: Structure of a neuron, Types of neurons; Types of muscle, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction.
Digestion: Physiology of digestion in different segments of the alimentary canal; Absorption of carbohydrates, proteins, lipids [8 Hours]

Unit II. Respiration: Pulmonary ventilation, Respiratory volumes and capacities**;** Transport of oxygen and carbon dioxide in blood.
Excretion: Structure of nephron, Mechanism of Urine formation.
Cardiovascular system: Open and Closed circulatory system, Composition of Blood; Structure of Heart, Origin and conduction of the cardiac impulse, cardiac cycle.
Reproduction and Endocrine Glands: Physiology of male & female reproduction; Introduction to Endocrine glands [8 Hours]

B. BIOCHEMISTRY

Unit III. Introduction to Biomolecules: Carbohydrates, Proteins and Lipids: structure, types and functions; Introduction to metabolism of Carbohydrate, Protein and Lipids [10 Hours]

Unit IV. Enzymes: Mechanism of action, Kinetics, inhibition and regulation [4 Hours]

SUGGESTED READINGS

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H. Freeman and Co.
2. Hall, John E. (2015). Guyton and Hall Textbook of Medical Physiology, W.B. Saunders Company
3. Jain, A.K. (2018). Textbook of Physiology, Arya Publications

4. Murray, R. K., Granner, D. K., Mayes, P. A. and Rodwell, V. W. (2009). Harper's Illustrated Biochemistry. XXVIII Edition. Lange Medical Books/ Mc Graw Hill
5. Nelson, D. L., Cox, M. M. and Lehninger, A.L. (2009). Principles of Biochemistry. IV Edition. W.H Freeman and Co.
6. Schmidt-Nielsen, Knut (1997). Animal Physiology: Adaptation and Environment, Cambridge University Press
7. Singh, HR and N. Kumar Animal Physiology and related Biochemistry, SL, Nagin Chand and Co, Delhi
8. Tortora, G.J.& Derrickson, B.H. (2009). Principles of Anatomy and Physiology, 12th edn., John Wiley & Sons, Inc.
9. Widmaier, E.P., Raff, H. & Strang, K.T. (2008) Vander's Human Physiology, 11th edn., McGraw Hill

SOLS/ZOO/CZ-4(P) Physiology and Elementary Biochemistry (Practical) [2 Credits]
SOLS/ZOO/AIZ-4(P) Physiology and Elementary Biochemistry (Practical) [2 Credits]

A. PHYSIOLOGY

1. Preparation of hemin crystals
2. Examination of permanent histological sections of mammalian pituitary, thyroid, parathyroid, pancreas, adrenal
3. Examination of permanent slides of spinal cord, duodenum, liver, lung, kidney, bone, cartilage , blood cells
4. Models/ Photographs: Structure of neuron, types and structure of muscles, structure of heart
5. Charts/ Photographs: Glycolysis, Kreb's cycle, electron transport chain

B. BIOCHEMISTRY

1. Identification of unknown carbohydrates in given solutions (Starch, Sucrose, Lactose, Galactose, Glucose, Fructose)
2. Colour reactions to identify functional group in the given solution of proteins
3. Study of activity of salivary amylase under optimum conditions

SKILL COURSE (SZ-1—SZ-6)

(Theory: 2 Credits)
[Student will elect one course each *EITHER* in I & II *OR* in III & IV Semester]

SOLS/ZOO/SZ-1 Laboratory Techniques in Biology 2 Credits [30 Hours]

Unit I. Solutions Preparation: Solute, Solvent, Solution; Water-based or aqueous solution for biological application**,** Methods for dissolving the solute in purified water and adjusting the pH of the solution. Method for addition of the quantity sufficient (QS) to reach the desired volume; Buffer solution; Molarity, Normality [6 Hours]

Unit II. Concentration and Measuring Volumes: Serial dilution, Use of a serial dilution to prepare standards for generating a standard curve; Serological Pipettes, Pipettors use of pipet-aid [4 Hours]

Unit III. Measuring Mass: Analytical balance, Weighing, tarring [2 Hours]

Unit IV. Study the parts of a compound microscope - eye piece and objective lens, condenser lens, mirror, stage, coarse and fine adjustment knobs, and their basic functions. Micrometry- Measuring microscopic organism, measuring cell size in permanent slide viz. protozoan, microscopic invertebrates, egg diameter etc. Recording of microscopic images and videos using microscopic camera [6 Hours]

Unit V. Museum preparation- Preserving macroscopic organisms (invertebrate and vertebrate specimen). Permanent slide preparation: basic histological and histochemical techniques [6 Hours]

Unit VI. Laboratory safety: Laboratory lay out, wet lab, storage of chemicals and glassware. Maintenance of Laboratory equipment (microscopes, centrifuge, incubators, analytical and electronic balances, electrophoretic units, pH meter, turbidity meter etc.); precautions while working in laboratory [6 Hours]

SUGGESTED READINGS

1. Charles R Cantor, Paul R. Schimmel (2008). Biophysical Chemistry (Techniques for the Study of Biological Structure and Function), Part II, W.H. Freeman and Company, ISBN-13: 978-0716711902
2. Plummer David T. (2004). Introduction to Practical Biochemistry, 3rd edition, Tata McGraw Hill, ISBN-9780070994874

3. Wester John G. (2008). Bioinstrumentation, Wiley & Sons, ISBN-97881265136
4. Wilson Keith, John Walker (2010). Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, ISBN-978052173167

SOLS/ZOO/SZ-2 Basic Instrumentation 2 Credits [30 Hours]

Unit I. Principles and applications of Microscopy: Light, phase contrast, confocal, transmission electron microscopy (TEM & SEM) [2 Hours]

Unit II. Principle and application of Colorimeter. Principle of UV-Visible absorption spectrophotometry, instrumentation and applications, Flourimetry: Phenomena of fluorescence, intrinsic and extrinsic fluorescence, instrumentation and applications [6 Hours]

Unit III. Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient, various types of centrifuges, different types of rotors, differential centrifugation, density gradient centrifugation [4 Hours]

Unit IV. Basic principles of chromatography: Partition coefficient, concept of theoretical plates, various modes of chromatography (paper, thin layer, column), preparative and analytical applications, LPLC and HPLC. Principle and applications of: Paper Chromatography, Thin Layer Chromatography. Molecular Sieve Chromatography, Ion Exchange Chromatography, Affinity Chromatography [8 Hours]

Unit V. Basic Principle of electrophoresis, Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE. Agarose gel electrophoresis, buffer systems in electrophoresis. Electrophoresis of proteins and nucleic acids, protein and nucleic acid blotting, detection and identification [6 Hours]

Unit VI. Principle and applications of pH meter, autoclave, biosafety cabinets/practices; polymerase chain reaction; Water analysis kit; Principle and application of Turbidity meter, Conductivity meter, Flow meter; Types of Owen & Incubators-BOD & COD Incubator [4 Hours]

SUGGESTED READINGS

1. Freifelder, D. (1982). Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 2nd ed., W.H. Freeman and Company, New York
2. Plummer D. T. (1998). An Introduction to Practical Biochemistry, 3rd ed., Tata McGraw Hill Education Pvt. Ltd., New Delhi

SOLS/ZOO/SZ-3 Public Health and Hygiene 2 Cedits [30 Hours]

Unit I. Definition of Public health; Types of hygiene; Examples of public hygiene; Importance of public health; Key elements of public health; Scope of Public health and Hygiene; Nutrition and health – classification of foods, Nutritional deficiencies - Vitamin deficiencies [6 Hours]

Unit II. Environment and Health hazards – Environmental degradation, Pollution and associated health hazards [4 Hours]

Unit III. Communicable diseases and their control measures such as Measles, Polio, Chikungunya, Rabies, Plague, Leprosy and AIDS; Pandemic-Covid 19 [6 Hours]

Unit IV. Non-Communicable diseases and their preventive measures such as Hypertension, Coronary Heart diseases, Stroke, Diabetes, Obesity and Mental ill-health [6 Hours]

Unit V. Health Education in India: WHO Programmes, Government and Voluntary Organizations and their health services; Precautions, First Aid and Awareness on sporadic diseases [6Hours]

Unit VI. Relationship of environmental, social, cultural, occupational and political factors and systems on health and health care [2 Hours]

SUGGESTED READINGS

1. Bolduan, Charlest Frederick, Nils William Bolduan 1949. Public Health and Hygiene (4th ed.), Philadelphia: Saunders
2. Dass, K 2021. Public Health and Hygiene, Notion Press ISBN-10: 1639209603, ISBN-13: 978-1639209606
3. Goel, Arvind Kumar 2005. A College Textbook of Health & Hygiene, ABD Publishers, ISBN 8189011863, 9788189011864
4. Kumaresan, V, R. Sorna Raj, Public Health and Hygiene, Saras Publication ISBN: 9789386519689
5. Park, K. 2007. Preventive and Social Medicine, B.B. Publishers

6. Shanmugavel, G., Binu George 2021. Textbook of Public Health and Hygiene, Darshan Publishers, ISBN, 9386739550, 9789386739551
7. Wagh, Sudhir R., Vinod B. Kakade, Jiwan P. Sarwade Public Health and Hygiene Success Publications, ISBN 9789351585053

SOLS/ZOO/SZ-4 Aquarium Fish Keeping **2 Credits [30 Hours]**

Unit I. Introduction to Aquarium Fish Keeping: Scope of Aquarium fish keeping; Types of aquaria, Aquarium setup and accessories, Aquarium filters; Criteria of selection for aquarium fishes [4 Hours]

Unit II. Biology of Aquarium Fishes: Exotic and Endemic species of Aquarium Fishes (Exotic Aquarium Fishes–Puffer, Humphead & Siamese Tiger fish; Endemic Aquarium Fishes – Zebra Danio, Striped Panchax & Honey Gourami); Common characters and sexual dimorphism of Aquarium fishes: Fresh water (Guppy, Gold fish, Angel fish), Brackish water (Molly, Sword tail, Ray fish), and Marine (Moorish idol, Anemone fish & Butterfly fish) [8 Hours]

Unit III. Food and feeding of Aquarium fishes: Use of live fish feed organisms. Preparation and composition of formulated fish feeds [2 Hours]

Unit IV. Aquarium Fish Diseases: Parasitic, Bacterial, Viral, Protozoan, Fungal & Deficiency diseases [4 Hours]

Unit V. Fish Transportation: Live fish transport - Conditioning, packing, transport and quarantine methods; Factors associated with live fish transport [4 Hours]

Unit VI. Maintenance of Aquarium: General Aquarium maintenance; Water quality requirements: Maintenance and Temperature control; Budget for setting up an Aquarium/ ornamental Fish Farm as a Cottage Industry [8 Hours]

SUGGESTED READINGS

1. Bailey, Mary, Gina Sandford (1999). The Complete Guide to Aquarium Fish Keeping, Lorenz Books
2. Hargreaves, Vincent B. (2007). Complete Book of the Freshwater Aquarium 2007 Thunder Bay Pr., ISBN-10: 159223514X, ISBN-13: 978-1592235148
3. Saha, Sanjib (2022). Aquarium Fish Keeping, Techno World, Kolkata

SOLS/ZOO/SZ-5 Medical Diagnostics **2 Credits [30 Hours]**

Unit I. Introduction to Medical Diagnostics and its importance [2 Hours]

Unit II. Diagnostic's Methods Used for Analysis of Blood, Blood composition, Preparation of blood smear and Differential Leucocyte Count (D.L.C) using Leishman's stain, Platelet count using haemocytometer, Erythrocyte Sedimentary Rate (E.S.R), Packed Cell Volume (P.C.V.) [10 Hours]

Unit III. Diagnostic Methods Used for Urine Analysis; Urine Analysis: Physical characteristics; Abnormal constituents [8 Hours]

Unit IV. Non-infectious Diseases: Causes, types, symptoms, complications, diagnosis and prevention of Diabetes (Type I and Type II), Hypertension (Primary and secondary), Testing of blood glucose using Glucometer/ Kit [3 Hours]

Unit V. Infectious Diseases: Causes, types, symptoms, diagnosis and prevention of Tuberculosis and Hepatitis [3 Hours]

Unit VI. Tumours Types (Benign/Malignant), Detection and metastasis; Medical imaging: X-Ray of Bone fracture, PET, MRI and CT Scan (using photographs) [4 Hours]

SUGGESTED READINGS

1. Cheesbrough M., J. McArthur (1976). A Laboratory Manual for Rural Tropical Hospitals, A Basis for Training Courses, Churchill Livingstone ISBN: 9780443011443
2. Godkar P.B. and Godkar D.P. (2014). Textbook of Medical Laboratory Technology, 3rd Edition, Bhalani Publishing House
3. Hall, John E. (2015). Guyton and Hall Textbook of Medical Physiology, Saunders
4. Park, K. (2007), Preventive and Social Medicine, B.B. Publishers
5. Prakash, G. (2012), Lab Manual on Blood Analysis and Medical Diagnostics, S. Chand and Co. Ltd.

SOLS/ZOO/SZ-6 Bioinformatics **2 Credits [30 Hours]**

Unit I. Introduction to Bioinformatics: Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics [2 Hours]

Unit II: Databases in Bioinformatics: Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System [4 Hours]

Unit III: Biological Sequence Databases: National Center for Biotechnology Information (NCBI) - Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database;
EMBL Nucleotide Sequence Database (EMBL-Bank) - Introduction, Sequence Retrieval, Sequence Submission to EMBL, Sequence analysis tools.
DNA Data Bank of Japan (DDBJ) - Introduction, Resources at DDBJ, Data Submission at DDBJ;
Protein Information Resource (PIR) - About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR; Swiss-Prot - Introduction and Salient Features [10 Hours]

Unit IV: Sequence Alignments: Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTAL W, Scoring Matrices, Percent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM) [8 Hours]

Unit V: Molecular Phylogeny: Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction [4 Hours]

Unit VI: Applications of Bioinformatics: Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement [2 Hours]

SUGGESTED READINGS

1. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummings.
2. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
3. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley Blackwell.

B.Sc. Third Year (V & VI Semester)

DISCIPLINE SPECIFIC ELECTIVE (DSE)
(Theory-4 Credits; Practical-2 Credits)
[Student will elect any one in V & VI Semester]

SOLS/ZOO/DSE-1 Applied Zoology **4 Credits [60 Hours]**

Unit I. Introduction to Host-parasite Relationship: Host, Definitive host, Intermediate host, Parasitism, Symbiosis, Commensalism, Reservoir, Zoonosis [4 Hours]

Unit II. Epidemiology of Diseases: Transmission, Prevention and control of diseases—Tuberculosis, swine flu, typhoid, Covid-19 [5 Hours]

Unit III. Rickettsiae and Spirochaetes: Brief account of *Rickettsia prowazekii, Borrelia recurrentis* and *Treponema pallidum* [4 Hours]

Unit IV. Parasitic Protozoa: Life history and pathogenicity of *Entamoeba histolytica, Plasmodium vivax*, *Leishmania donovani* and *Trypanosoma gambiense* [5 Hours]

Unit V. Parasitic Helminthes: Life history and pathogenicity of *Schistosoma haematobium*, *Ancylostoma duodenale* and *Wuchereria bancrofti* [5 Hours]

Unit VI. Insects of Economic Importance: Biology, Control and damage caused by *Helicoverpa armigera*, *Pyrilla perpusilla* and *Papilio demoleus, Callosobruchus chinensis, Sitophilus oryzae* and *Tribolium castaneum*; Safe storage of stored grains [8 Hours]

Unit VII. Insects of Medical Importance: Life cycle, medical importance and control of *Pediculus humanus corporis*, *Anopheles, Culex, Aedes, Xenopsylla cheopis, Phlebotomus argentipes* [10 Hours]

Unit VIII. Animal Husbandry: Domestic animals of economic importance; Preservation and artificial insemination in cattle; Induction of early puberty and synchronization of estrus in cattle [8 Hours]

Unit IX. Poultry Farming: Principles of poultry breeding, Management of breeding stock and broilers, Processing and preservation of eggs [6 Hours]

Unit X. Fish Technology: Genetic improvements in aquaculture industry; Induced breeding and transportation of fish seed [5 Hours]

SUGGESTED READINGS

1. Arora, D. R and Arora, B. (2001). Medical Parasitology. II Edition. CBS Publications and Distributors.
2. Atwal, A.S. (1986). Agricultural Pests of India and South East Asia, Kalyani Publishers.
3. Dennis, H. (2009). Agricultural Entomology. Timber Press (OR).
4. Dunham R.A. (2004). Aquaculture and Fisheries Biotechnology Genetic Approaches. CABI publications, U.K.
5. Hafez, E. S. E. (1962). Reproduction in Farm Animals. Lea & Fabiger Publisher
6. Kumar, Vinay et al. (2014). Robbins And Cotran Pathologic Basis of Disease South Asia Edition
7. Park, K. (2007). Preventive and Social Medicine. XVI Edition. B.B Publishers.
8. Pedigo, L.P. (2002). Entomology and Pest Management, Prentice Hall.

SOLS/ZOO/DSE-1(P) Applied Zoology (Practical) [2 Credits]

1. Study of *Plasmodium vivax, Entamoeba histolytica, Trypanosoma gambiense, Ancylostoma duodenale, Leishmania donovani* and *Wuchereria bancrofti* and their life stages through permanent slides/photomicrographs or specimens.
2. Study of arthropod vectors associated with human diseases: *Pediculus, Culex, Anopheles, Aedes* and *Xenopsylla*.
3. Study of insect damage to different plant parts/stored grains through damaged products/photographs.
4. Identifying feature and economic importance of *Helicoverpa armigera, Papilio demoleus, Pyrilla perpusilla, Callosobruchus chinensis, Sitophilus oryzae* and *Tribolium castaneum*
5. Visit to poultry farm or animal breeding centre and submission of visit report.
6. Preparation and maintenance of freshwater aquarium.

SOLS/ZOO/DSE-2 Wild Life Conservation & Management 4 Credits [60 Hours]

Unit I. Wild life - Values of wild life; Our conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies [4 Hours]

Unit II. Habitat analysis; Evaluation and management of wild life - Physical parameters (Topography, Geology, Soil and Water); Biological Parameters (food, cover, forage, browse and cover estimation); Standard evaluation procedures: remote sensing and GIS [8 Hours]

Unit III. Management of habitats - Setting back succession; Grazing logging; Mechanical treatment; Advancing the successional process; Cover construction; Preservation of general genetic diversity [6 Hours]

Unit IV. Population estimation: Population density, Natality, Birth rate, Mortality, fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation, Hair identification, Pug marks and census method [10 Hours]

Unit V. National Organizations involved in wild life conservation; Wildlife Legislation – Wildlife Protection Act - 1972, its amendments and implementation; CITES; IUCN Red Data Book [6 Hours]

Unit VI. Management planning of wild life in protected areas; Estimation of carrying capacity; Ecotourism / wild life tourism in forests; Concept of climax persistence; Ecology of disturbance [8 Hours]

Unit VII. Management of excess population and translocation; Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wild animal [6 Hours]

Unit VIII. Zoogeographic areas of Indian Subcontinent; Protected Areas: National Parks/ Sanctuaries/Biosphere Reserves of Indian subcontinent; Important features of protected areas in India; Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve [12 Hours]

SUGGESTED READINGS

1. Sharma, BD: High Altitude Wildlife of India. Oxford 7 IBH Publ. Co. Pvt. Ltd. 1994.
2. Negi, SS: Himalayan Wildlife: Habitat and Conservation. Indus Publ. Company, New Delhi 1992.
3. Pullin, AS: Conservation Biology, Cambridge University Press, 2002**.**

SOLS/ZOO/DSE-2(P) Wild Life Conservation & Management (Practical) [2 Credits]

1. Identification of flora, mammalian fauna, avian fauna, herpeto-fauna
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various types of Cameras and lenses)
3. Familiarization and study of animal evidences in the field; Identification of animals through pug marks, hoof marks, scats, pellet groups, nest, antlers etc.
4. Demonstration of different field techniques for flora and fauna
5. PCQ, Ten tree method, Circular, Square & rectangular plots, Parker's 2 Step and other methods for ground cover assessment, Tree canopy cover assessment, Shrub cover assessment.
6. Trail/ transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences)
7. Photograph of wild animals
8. Zoogeographic areas of Indian Subcontinent
9. National Parks/ Sanctuaries/Biosphere Reserves of Indian subcontinent
10. Population estimation: capture-recapture method

SOLS/ZOO/DSE-3 Principles of Genetics & Evolutionary Biology 4 Credits [60 Hours]

A. Genetics

Unit I. Mendel's law; Exceptions to Mendel's law; Chromosomal theory of Inheritance; Sex-linked inheritance & genetic disorders; Linkage & Crossing Over [8 Hours]

Unit II. Chromosome structure; Euchromatin; Heterochromatin; Polytene and lamp brush chromosomes. Chromosome banding, Karyotyping; Fine structure of gene and allelism; Sex determination and Sex Linkage [10 Hours]

Unit III. Cytoplasmic Inheritance, Polygenic Inheritance, Mutation, population and evolution genetics, Hardy-Weinberg Principle [10 Hours]

B. Evolution

Unit IV. Historical development of the concept of evolution**.**

Theories of organic evolution: Lamarckism (Neo-Lamarckism); Darwinism (Neo- Darwinism); Modern synthetic theory.

Evidences in favour of evolution: Comparative anatomy, Comparative Embryology, Palaeontology, Biochemistry & Genetics [10 Hours]

Unit V. Processes of Evolutionary Change: Organic variations; Isolating Mechanisms; Natural selection (Example: Industrial melanism); Types of natural selection (Directional, Stabilizing, Disruptive), Artificial selection.

Species Concept: Biological species concept (Advantages and Limitations); Modes of speciation (Allopatric, Sympatric) [10 Hours]

Unit VI. Palaeontology: Fossils and fossilization, Incompleteness of fossil record, Dating of fossils, Significance of fossil record; Geological distribution of animals; Mass extinction (Causes, five major extinctions, K-T extinction in detail), Role of extinction in evolution;-Evolution of Horse [12 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
6. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
7. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
8. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
9. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
10. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson

11. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
12. Robert, H. Tamarin (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
13. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
14. William S. Klung Cummings, Spencer and Palldino (2019). Concepts of Genetics, Pearson Education, Pearson

SOLS/ZOO/DSE-3(P) Principles of Genetics & Evolutionary Biology (Practical) [2 Credits]

A. Genetics

1. Study of Mendelian Inheritance and gene interactions (Non Mendelian Inheritance) using suitable examples. Verify the results using Chi-square test.
2. Study of Linkage, recombination, gene mapping using the data.
3. Study of Human Karyotypes (normal and abnormal).

B. Evolution

1. Study of fossil evidences from plaster cast models and pictures
2. Study of homology and analogy from suitable specimens/ pictures
3. Charts:
    a. Phylogeny of horse with diagrams/ cut outs of limbs and teeth of horse ancestors
    b. Darwin's Finches with diagrams/ cut outs of beaks of different species
4. Visit to Natural History Museum, submission of report

SOLS/ZOO/DSE-4 Animal Behaviour & Endocrinology 4 Credits [60 Hours]

A. Animal Behaviour

Unit I. The science of behaviour: History, scope and terminology. Proximate and ultimate causes of behaviour.
Instinct: Definition and characteristics (sign stimuli and Fixed Action Pattern).
Learning behaviour: Definition. Spatial learning. Associative learning, classical conditioning, operant conditioning, language learning. Imprinting. Kin recognition. Instinct versus learning behaviour.
Timing of behaviour: Biological rhythms. The Biological Clock. Circadian rhythms and their synchronisation seasonal rhythms. Photoperiodism [12 Hours]

Unit II. Communication: Visual, olfactory, acoustic (bird songs, amphibian calls); echolocation in bats, electrolocation in fish.
Chemoreception: Chemicals (pheromones) as signals in insects, fish and mammals. Role of olfaction in communication behaviour (territorial, sex recognition, feeding etc) in fish and mammals.
Neural control of behaviour: Components of brain involved in various behaviours. Neural control of drinking, learning, eating, activity & rest, sleep, aggression, sexual behaviour.
Hormonal Control of behaviour: Hormone brain relationships. Sexual behaviour in mammals (e.g. rat).
Sociobiology: Elements of sociality and social grouping in animals [15 Hours]

B. Endocrinology

Unit III. Endocrine messengers: hormones, neurohormones, hormone like substances (neuronal peptides, autocoids, pheromones, neurosecretion).
Hormones and Physiological actions of the endocrine glands in mammals: Pituitary, Thyroid, Parathyroid, Pancreas, Gastro-intestinal tract, Adrenal cortex and Medulla, Thymus and Pineal.
Hormone biosynthesis: Protein peptide hormones (gonadotropins, thyrotropin, corticotropin, steroids and catecholamines).
Mechanism of action of Protein hormones and Catecholamines: membrane bound receptors, G-protein and control of adynelate cyclase, Cyclic nucleotide cascade [18 Hours]

Unit IV. Organisation & physiological actions of the Testis: Androgen binding protein (ABP), Inhibin. Neuroendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epithelium, LH- effects on Leydig cells, negative feedback regulation).
Organization & physiological actions of the Ovary: Folliculogensis, Ovulation, Luteinization, Ovarian cycles; Seasonal reproductive cycles; sexual dysfunctions in man [15 Hours]

SUGGESTED READINGS

1. Alcock, John: Animal Behaviour, 4th edition, Sinauer Associates, Inc. 1989.
2. Bentley P.J.: Comparative Vertebrate Endocrinology S. Chand & Company Ltd, Ram Nagar New Delhi, 1980

3. Chester-Jones: Fundamentals of Comparative Vertebrate Endocrinology Plenum Press, New York & London, 1987.
4. Goldsworthy G J et al: Endocrinology, Blackie, 1981.
5. Goodenough et al.: Perspectives on Animal Behaviour. Wiley & Sons, New York. 1993.
6. Goodman Maurice: Basic and Medical Endocrinology, Raven Press.
7. Grier, JW: Biology of Animal Behaviour, Mosby, 1984
8. Hadley, Mac E.: Endocrinology, Prentice-Hall International ed.1988/1992
9. Krebs, NB & JR Davies: An Introduction to Behavioural Ecology (3rd ed.), Blackwell, 1993
10. Wilson, JW et al.: Williams Textbook of Endocrinology, 9th edition, Saunders, 1998

SOLS/ZOO/DSE-4(P) Animal Behaviour & Endocrinology (Practical) [2 Credits]

1. Animal Behaviour photographs/videos/models
2. Slides & Photographs of Endocrine disorders
3. Examination of histological sections from photomicrographs/ permanent slides of rat/human endocrine glands
4. Cholesterol estimation from serum sample
5. Glucose estimation from blood sample

SOLS/ZOO/DSE-5 Introduction to Developmental Biology 4 Credits [60 Hours]

Unit I. Basic concepts in developmental biology;
Gametogenesis: Events in spermatogenesis. Morphology of mature mammalian spermatozoon; Events in Oogenesis, Significance of oogenesis. Vitellogenesis in birds; Comparison between Spermatogenesis & Oogenesis
Fertilization: Mechanism of fertilization; Capacitation, Molecular events - Block to polyspermy. Egg activation; Elementary idea of parthenogenesis.

Unit II. Types of eggs and cleavage. Role of yolk during cleavage; Products of cleavage (Morula and Blastula). Fate map: fate map of early blastula of Frog, Fate of germ layers. Types of morphogenetic movements. Gastrulation in sea urchin, frog, chick and mammal. Neurogenesis & Notogenesis.

Unit III. Extra Embryonic Foetal Membrane (Chick). Development of chick embryo up to 72 hours. Types, formation and function of Placenta in mammals. Metamorphic events in frog life cycle and its hormonal regulation.

Unit IV. Elementary concept of primary organizer; Induction; nature and its mechanism of action; Development of eye and limbs; Totipotency; Teratogenesis; *Drosophila* development up to gastrulation; Differential expression of genes in *Drosophila*.

SUGGESTED READINGS

1. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
2. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
3. Twyman, RM: BIOS Instant Notes in Developmental Biology, Taylor & Francis, 2000.

SOLS/ZOO/DSE-5(P) Introduction to Developmental Biology (Practical) [2 Credits]

1. Frog - Study of developmental stages - whole mounts and sections through permanent slides – cleavage stages, blastula, gastrula, neurula, tail bud stage, tadpole external and internal gill stages.
2. Chick- Study of developmental stages - sections through permanent slides – cleavage stages, primitive streak stage, 24, 36, 48, 72 hours of incubation
3. Study of the different types of placentae- histological sections through permanent slides or photomicrographs.
4. Study of placental development in humans by ultrasound scans.
5. Examination of gametes - frog/rat - sperm and ova through permanent slides or photomicrographs.

SOLS/ZOO/DSE-6 Basics of Biotechnology **4 Credits [60 Hours]**

Unit I. What is Biotechnology?
Historical inputs. Biotechnology as a `tool' not a `product'. Interdisciplinary nature.
Foundation of Biotechnology: Importance of basic Biology disciplines eg. Human, Animal and Plant Physiology, Genetics, Cell and Molecular Biology, Microbiology, Biochemistry, Immunology and Chemical engineering [12 Hours]

Unit II. Introduction to Genetic Engineering. Tools and techniques.
Enzymes, Restriction endonuclease.
Ligases, Alkaline phosphatase, Reverse transcriptase, DNA polymerase, Vectors-plasmids, phages, cosmids. Biotechnology hazards and safety. Social, moral and ethical issues [12 Hours]

Unit III. Biotechnology in health care. Therapeutic products (Hormones, regulatory proteins, antibiotics). Prenatal diagnosis of genetic diseases. Vaccines, Immunodiagnostics (RIA, ELISA, IRMA) and DNA probe for disease identification. Gene therapy. Human Genome and Biomedicine [12 Hours]

Unit IV. Introduction to Environmental Biotechnology. Bioprocessing Techniques. Enzyme Biotechnology. Single cell proteins. Food and Beverage Biotechnology. Biotechnology in animal agriculture. Biotechnology in plant agriculture [12 Hours]

Unit V. Genetics and Biotechnology: Introduction, Animal Cloning (therapeutic and Reproductive), Genetic manipulation at organism level: Transgenesis, Knock in and Knock out models (Cre-Lox P system), CRIPER-CAS9 technology, genome editing in nature and artificial species improvement of plants and animals. Genetic manipulation at cellular and molecular level, transfection technologies, adenoviral and lentiviral based methods; Industrial genetics; Cell fusion and hybridoma techniques [12 Hours]

SUGGESTED READINGS

1. Das H.K.: Textbook of Biotechnology, Wiley India Pvt. Limited, ISBN 8126505567, 2004
2. Dubey R.C.: A Textbook of Biotechnology, S. Chand Publishing, 1993
3. Thieman, William, Michael A. Palladino: Introduction to Biotechnology, Pearson Education India; 3rd edition, ISBN-10: 9789332535060, 2014

SOLS/ZOO/DSE-6(P) Basics of Biotechnology (Practical) **[2 Credits]**

1. Isolation of plasmid DNA from *E. coli*.
2. Transformation of *E. coli* (pUC 18/19) and calculation of transformation efficiency.
3. Restriction Endonuclease Digestion of plasmid DNA.
4. Ligation of Target DNA
5. Gene amplification using PCR
6. DNA sequencing: Interpretation of sequence from the data provided.
7. Analysis of DNA fingerprint
8. Separation of proteins by SDS-PAGE

VOCATIONAL COURSE (VCZ-1—VCZ-6)

(Theory, 4 Credits; 60 Hours)

[Student will elect any one related to Core Subject 1 or Core Subject 2 in V & VI Semester]

SOLS/ZOO/VCZ-1 Poultry Farming **4 Credits [60 Hours]**

Unit I. Introduction: Poultry breeds – description of different breeds – day old chicks, broilers and layers, Japanese Quail, Ducks, Turkey Farming.
Different systems of Poultry Farming – Layers for Egg Production (day old chicks, rearing from 20th week), Broilers for Table purpose and Hatcheries for chick production
Rearing Types/ Systems - Deep litter system and Cage System, multitiered cage system.
External morphology of variety of Fowls: Plymouth Rock, Light Sussex, Minorca, Rhode Island, Red and White Leghorn.
Game and Ornamental purpose varieties [20 Hours]

Unit II. Poultry shed: The layout of Poultry houses; Shed for the placement of chicks – ventilation opening, feeder, water, moisture level, dust.
Infrastructure requirement, Types of Shed and their construction.
Poultry Equipment, their use and maintenance [6 Hours]

Unit III. Feeding of Poultry: Poultry feed classification and principles of feeding; Feed additives and supplements; Feed requirement of chicks, birds, feed chart, balanced feed, waste minimization, proper Feed Conversion Ratio [6 Hours]

Unit IV. Management of a Poultry Farm: Management of Egg Layers – Management of Broilers in large scale farms.
Cleaning, disinfection, sanitization and fumigation of tools/ equipment and shed; maintenance of comfort environment for chicks- adequate light, heat, clean water, feed; Footbath at the entrance (Chemicals/ disinfectants); Handling & caring health management, vaccination etc.; Poultry diseases - Viral, Bacterial, Fungal, Protozoan and Parasitic Lice etc.; Prevention and precautions during vaccination [12 Hours]

Unit V. Progressive plans to promote Poultry as a Self-Employment venture; Support systems available at various District/State/National level; State/Central Government Schemes for giving impetus for entrepreneurship development.
Indian breed of poultry: Aseel, Chittagong, Kadaknath and Busra

Field Visit & Interaction with Poultry Farmers and other Support Agencies [16 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. Poultry Production and Management by J. Prasad, Kalyani Publishers (2015)
2. Poultry Science and Practice by N. Ghosh, CBS Publishers & Distributors (2015)

SOLS/ZOO/VCZ-2 Apiculture **4 Credits [60 Hours]**

Unit I. Biology of Bees: History, classification and biology of honey bees; Species of honey bees (*Apis dorsata*, *Apis cerana* indica, *Apis florea*, *Apis mellifera, Melipona irridipennis*; Specific Characteristics and suitability for geographic condition; Climatic requirement of different bee species; Social organization of honey bee colony [18 Hours]

Unit II: Rearing of Bees. Artificial Bee rearing (Apiary), Beehives – Newton and Langstroth; Flora for apiculture; Selection of Bee Species for Apiculture; Modern method of apiculture – Tools and appliances for modern method.
Enemies and diseases of Honey bee, Control and Preventive measures [16 Hours]

Unit III: Harvesting, Processing and Preservation of Honey. Methods of harvesting honey; Processing of honey; Preservation of honey; Indigenous method for extraction of honey [6 Hours]

Unit IV: Economic Importance. Honey, Bees Wax, Propolis etc.- Production, Chemical composition of Honey bee wax; Economic, nutritional and medicinal value [4 Hours]

Unit V: Entrepreneurship in Apiculture. Bee keeping industry – Requirements of Commercial Bee Keeping, Recent efforts, Government sponsored scheme, Modern method in employing honey bees for cross pollination in horticultural gardens.
Field Visit & Interaction with Bee Keepers and other Support Agencies [16 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. Bisht D.S. (2016). Apiculture, ICAR Publication
2. Gupta, JK. (2016). Apiculture ICAR PDF Book
3. Prost, P. J. (1962). Apiculture. Oxford and IBH, New Delhi.
4. Singh S. (1962). Beekeeping in India, Indian council of Agricultural Research, New Delhi

SOLS/ZOO/VCZ-3 Sericulture **4 Credits [60 Hours]**

Unit I. Introduction to Sericulture: Origin and history of sericulture. Ancient silk route and map of India; Temperate and tropical climate for sericulture practice. Distribution and Races Exotic and indigenous races Mulberry and non-mulberry Sericulture

Types of silkworms: Mulberry Silkworm (*Bombyx mori*), Tasar Silkworm (*Antherea paphia*), Muga Silkworm (*Antheraea assama*), Eri Silkworm (*Attacus ricinii*), Oak Silkworm (*Antheraea pernyi*) and Gaint Silkworm (*Attacus alts*) [20 Hours]

Unit II. Biology of Silkworm: Life cycle of *Bombyx mori*, Morphology of the egg, larva, pupa, adult; Structure of silk gland and secretion of silk.
Voltinism in silk worm: univoltine, bivoltine, poly or multivoltine.
Biology of Mulberry: Botanical description of mulberry. Economic importance of mulberry Plant, *Morus* L. and its species [10 Hours]

Unit III. Rearing of Silkworms: Selection of mulberry variety and establishment of mulberry garden, rearing house and rearing appliances disinfectants (formalin, bleaching powder); RKO Silkworm rearing technology: types of mountages, spinning, harvesting and storage of cocoons; Physical and commercial characters of Cocoons, Importance of by-products of Sericulture [10 Hours]

Unit IV. Pests of silkworm: Uzi fly, dermestid beetles and vertebrates.
Silkworm diseases: Protozoan disease, Bacterial disease, Fungal disease, Viral disease, Sotto disease, septicemia, galtine; Control and prevention of pests and diseases [6 Hours]

Unit V. Entrepreneurship in Sericulture: Prospects of Sericulture in India, Sericulture industry in different states, self-employment venture, potential in mulberry and non-mulberry sericulture.
Visit to various sericulture centres [14 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. A Guide for Bivoltine Sericulture: K. Sengupta, Director, CSR & TI, Mysore (1989)
2. An Introduction to Sericulture: Ganga, G., J. Sulochana Chetty, Oxford & IBH Pub. Co. (1991)
3. Appropriate Sericultural Techniques; Ed. M. S. Jolly, Director, CSR & TI, Mysore (1987)
4. Handbook of Practical Sericulture: S.R. Ullal and M.N. Narasimhanna CSB, Bangalore (1987)
5. Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub. Co. Ltd., Tokyo, Japan (1972)
6. Improved Method of Rearing Young age silkworm; S. Krishnaswamy, reprinted CSB, Bangalore (1986)
7. Manual of Silkworm Egg Production: M. N. Narasimhanna, CSB, Bangalore (1988)
8. Principles of Sericulture (Translated from Japanese): Hasao Aruga, Oxford & IBH Pub. Co. Pvt.. Ltd., New Delhi (1994)
9. Silkworm Rearing: Wupang-Chun and Chen Da-Chung, FAO, Rome (1988)

SOLS/ZOO/VCZ-4 Aquaculture — 4 Credits [60 Hours]

Unit I: Aquaculture: Definition and Scope, commercially important cultivable finfish species in freshwater, brackish water and marine water environments; Types of farming systems: extensive, semi-intensive and intensive culture; Cage culture; Integrated fish farming [14 Hours]

Unit II: Fish ponds: types and their management; Fish polyculture with special reference to indigenous & exotic major carps; Induced breeding: Hypophysation and use of synthetic hormone, significance of Induced breeding [12 Hours]

Unit III: Prawn culture, ornamental fish culture and its significance; Commercially important fresh water and marine ornamental fish species; Maintenance of aquaria; Farming of pearl oyster [10 Hours]

Unit IV: Fish feed: Fish feed ingredients; Type of feeds and feeders used in Aquaculture; Commonly occurring diseases in aquaculture and their control [8 Hours]

UNIT V: Field visit to fish farm, hatchery complex, and onsite interactions with progressive fish farmers [16 Hours]

(Students will prepare and submit report on their field visit)

SUGGESTED READINGS

1. A Textbook of Fish Biology and Fisheries, 3rd Edition by S.S. Khanna and H.R. Singh, NPH, Delhi (2014)
2. Aquaculture by John E. Bardach, Wiley India Pvt Ltd (1974)
3. Aquaculture: Principles and Practices by T.V.R. Pillay, Wiley India Pvt Ltd (2011)
4. Introduction to Aquaculture by Matthew Landau, Wiley (1991)
5. Textbook of Fish Culture by Marcel Heut, Fishing News Books Ltd (1972)

SOLS/ZOO/VCZ-5 Fish Hatchery Operations **4 Credits [60 Hours]**

Unit I. Freshwater fish seed resources; Natural breeding of finfishes; Historical perspective of fish seed collection; Sexual maturity, breeding season and development of gonads [10 Hours]

Unit II. Induced breeding of Indian major carps (Catla, Rohu, Mrigala) and exotic carps (Silver carp, Grass carp); Environmental factors affecting spawning; Fish pituitary gland, synthetic hormones for induced breeding of fishes; Fish brood stock management and transportation of brood fish [12 Hours]

Unit III. Different types of fish hatcheries: traditional double-walled hapa, Chinese carp hatchery, glass jar hatchery, Flow throw hatchery; Egg and embryonic developmental stages; Causes of mortality of fish eggs and spawn in hatchery operation and their treatment [12 Hours]

Unit IV. Spawn rearing techniques: nursery and rearing pond management; Packing and transportation of fish seed and use of anaesthetics/ disinfectants in fish breeding and transport; Cryopreservation of semen [10 Hours]

Unit V. Field visits to *Fish hatchery [16 Hours]

(Students will prepare and submit report on their field visits)

* Suggested hatcheries in Uttarakhand: Trout hatchery, Bairangna, District Chamoli; Gangori hatchery, District Uttarkashi; Koteshwar hatchery (Common carp and Masheer fish seed), Koteshwar, District Tehri; Carp hatchery, Kashipur, US Nagar

SUGGESTED READINGS

1. Broodstock Management and Quality Fish Seed Production in Freshwater Fishes by K K Marx, NPH, Delhi (2019)
2. Fish Hatchery Management by Robert G. Piper, Andesite Press (2015)
3. Induced Fish Breeding: A Practical Guide for Hatcheries by Nihar Ranjan Chattopadhyay, Academic Press; 1st edition (2016)
4. Text Book of Breeding and Hatchery Management of Carps by Gupta and Mohapatra, NPH, Delhi (2008)

SOLS/ZOO/VCZ-6 Vermiculture **4 Credits [60 Hours]**

Unit I. Introduction to vermiculture: Definition, meaning, history, economic importance; Role in bio transformation of the residues and production of organic fertilizers; The matter and humus cycle. Ground population, transformation process in organic matter; useful species of earthworms (Local species and Exotic species of earthworms) [12 Hours]

Unit II. The earthworm species: Biology of *Eisenia fetida* (Taxonomy, anatomy, physiology and reproduction of Lumbricidae; Vital cycle of *Eisenia fetida*: alimentation, fecundity, annual reproducer potential and limit factors (gases, diet, humidity, temperature, pH, light, and climatic factors).

Biology of *Eudrilus eugeniae* (Taxonomy anatomy, physiology and reproduction of Eudrilidae; Vital cycle of *Eudrilus eugeniae*: alimentation, fecundity, annual reproducer potential and limit factors) [12 Hours]

Unit III. Earthworm farming: Earthworm compost for home gardens; Conventional commercial composting; Earthworm Farming (Vermiculture), Extraction (harvest), vermicomposting harvest and processing; Nutritional Composition of Vermicompost for plants; Vermiwash collection, composition & use; Enemies of Earthworms, Common problems their prevention and solution [12 Hours]

Unit IV. The working group experience with *E. fetida* populations comportment with farm industrial residues (frigorific, cow places, feed-lot, aviaries exploitations, and solid urban residues); Lineaments to vermicomposting elaboration projects; Considerations about economic aspects of this activity [12 Hours]

Unit V. Demonstration of vermiculture in field [12 Hours]

(Students will prepare and submit report on their visit to demonstration unit)

SUGGESTED READINGS

1. Ahmad, S Rehan: CBCS Skill Enhancement Course Vermicompost Production (Set of 5 Books), Nitya Publications, Bhopal, 2020
2. Edwards, Clive A., Norman Q. Arancon, Rhonda L. Sherman: Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management, CRC Press, 2010
3. Keshav Singh: A Textbook of Vermicompost: Vermiwash and Biopesticides, Biotech Books, 2014
4. NPCS Board of Consultants & Engineers: The Complete Technology Book on Vermiculture and Vermicompost, Asia Pacific Business Press Inc., 2004

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B.Sc. [Honours] Fourth Year (VII & VIII Semester)

B.Sc. VII Semester (Honours)

CORE ZOOLOGY (CZ-5—CZ-6)
[Theory: 3 Credits; Lab Course: 2 Credits]

SOLS/ZOO/CZ-5 Non-Chordata **3 Credits [45 Hours]**

Unit I. Major and minor invertebrate phyla: General characters, organization, classification up to Order and their types; Origin and evolution of lower and higher invertebrates; Overview of economic importance of invertebrates.
Protozoa: Comparative morphology of all classes; Locomotor organelles and locomotion; **Nutrition:** holophytic, holozoic, saprozoic, myxotrophic and parasitic; **Reproduction:** Asexual and sexual reproduction, parthenogenesis and regeneration [12 Hours]

Unit II. Porifera: Comparative morphology of all classes; Types of canal system; **Reproduction:** Asexual, sexual reproduction and regeneration in sponges.
Coelenterata: Comparative morphology of all classes; Polymorphism; Coral reefs & their formation; General characters and affinities of Ctenophora.
Helminthes: Comparative morphology of Platyhelminthes and Aschelminthes [11 Hours]

Unit III. Minor Group: Classifications to order level, characters and affinities of Phoronida and Rotifera.
Annelida: Classification to order level, comparative morphology of all classes; Segmental organs.
Arthropoda: Classification to order level; Appendages and mouth parts in insects; Larval forms in Crustacea; Arachnida.
Organization and affinities of *Onychophora* [12 Hours]

Unit IV. Mollusca: Classification to order level; Comparative morphology of all classes; Major features of the respiratory and reproductive systems; Larval forms, Torsion and Pearl formation.
Echinodermata: Classification to order level; Water vascular system; Larval forms and affinities [10 Hours]

SUGGESTED READINGS

1. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington: Invertebrate Structure and Function, Nelson, 1987.
3. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
4. Hickman, Roberts & Hickman: Integrated Principles of Zoology (7th ed) Times-Mirror, Mosby, 1984.
5. Kotpal: Modern Text-book of Zoology: Invertebrates. Rastogi Publications, Meerut
6. Marshall & William: Text Book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillian, 1972.

SOLS/ZOO/CZ-6 Cell and Molecular Biology **3 Credits [45 Hours]**

A. Cell Biology
Unit I. Ultrastructure of prokaryotic and eukaryotic cells.
Plasma membrane: Structure - organisation, lipid bilayer, proteins & glycoconjugates, liposomes; Function - Ionic transport, transporter proteins, types of transport (symport, antiport, active & passive, endocytosis, exocytosis).
Endomembrane system: Intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathways.
Cytoskeleton: Components, functions & derived organelles (cilium, flagellum).
Mitochondria: Structure function & genetic organisation. Ribosome: Biosynthesis & formation in nucleolus [10 Hours]

Unit II. Signal transductions.
Cell signaling: Types of signaling, Cell surface receptor mediated signaling.
Cell cycle: Molecular events during interphase, genetic regulation of cell cycle (including yeast as model system).
Cellular transformation and malignancy; Retroviruses; Apoptosis and causes of cancer [10 Hours]

B. Molecular Biology

Unit III. The central dogma of Molecular Biology.

DNA: Structure and conformation, supercoiling, packing of DNA into chromosomes; Structural polymorphism of DNA & RNA; Three-dimensional structure of t-RNA [10 Hours]

Unit IV. DNA replication; Genetic code; Transcription and translation in prokaryotes and eukaryotes; RNA processing; Mutations & DNA repair systems; P bodies; Concept of Epigenetics, Chromatin remodelling, Non-Coding RNAs [15 Hours]

SUGGESTED READINGS

1. Alberts et al.: Molecular Biology of the Cell, Garland Pub., New York, 1989.
2. DeRobertis & DeRobertis: Cell & Molecular Biology, CCH, a Wolters Kluwer Business, Lippincott Williams &Wilkins, 1996
3. Friefelder: Molecular Biology. Narosa Publ. House.
4. Sharma, V.K.: Techniques in Microscopy and Cell Biology, Tata McGraw Hill, 1991
5. Strickberger: Genetics, Prentice Hall, 1996.
6. Verma, P.S. and Agarwal, V. K. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology (S. Chand & Co.)

SOLS/ZOO/LC-1 Lab Course-1 (Based on CZ-5 & CZ-6) [2 Credits]

Non-Chordata

1. Slides of Protozoa
2. Slides & Museum specimen of Porifera, Coelenterata, Helminthes, Annelida, Arthropoda, Mollusca & Echinodermata
3. Slides of Phoronida and Rotifera
4. Specimen: *Beroe*, *Peripatus*

Cell Biology

1. Permanent slides of cell division (Mitosis & Meiosis)
2. Study of mitotic cell division by squash technique
3. Slide preparation of interphase nuclei in buccal epithelium
4. Study of meiotic cell division in grasshopper testis
5. Preparation of blood smear

Molecular Biology

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity
7. DNA isolation from animal tissue
8. Separation of DNA molecules from Agarose Gel Electrophoresis
9. RNA isolation from Baker's Yeast
10. Estimation of RNA by orcinol method

MAJOR ELECTIVE ZOOLOGY (EZ-1a—EZ-1c)
(Theory-2 Credits; Lab Course-2 Credits)
[Any one]

SOLS/ZOO/EZ-1a. Developmental Biology and Parasitology 2 Credits [30 Hours]

A. Developmental Biology

Unit I. Early development of Frog and Chick up to gastrulation.
Concept of organiser and embryonic inductions.
Implantation of embryo in human, Placenta (structure, Types and Function) [7 Hours]

Unit II. Metaplasia & trans differentiation; Ageing: mechanism, concepts and theories. Cloning of animals by nuclear transfer.

Regeneration in Vertebrates: Tail, Limb, Lens and retina.
Teratogenesis: Teratogenic agents and their effects on embryonic development [8 Hours]

B. Parasitology

Unit III. Parasitism and evolution of parasitism.
Host parasite relationship, Parasitic adaptations in Protozoa.
Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (Trypanosomes & *Plasmodium)* [7 Hours]

Unit IV. Parasitic adaptations in Platyhelminthes and Aschelminthes.
Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Schistosoma* & *Wuchereria)*.
Introduction to arthropod vectors of human diseases [8 Hours]

SUGGESTED READINGS

1. Arora, D.R, Arora, B.: Medical Parasitology. II Edition. CBS Publications and Distributors. ISBN – 8123915497, 2001
2. Balinsky, BI: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London, 1960
3. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
4. Carlson, B.M.: Patten's Foundations of Embryology. (2014) 6th Edition. ISBN-9780072871708, 2014
5. Chatterjee, K.D.: Parasitology, Protozoology and Helminthology 13 edition, CBS, 2022
6. Dogiel, VA: General Parasitology, 1964
7. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
8. Goel, S.C.: Principles of Animal Developmental Biology, Himalaya Publishing House, 1994
9. Kalthoff, K.O.: Analysis of Biological Developmental. 2nd Edition. ISBN-9780070920378, 2000
10. Lamming, GE: Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 & 2, 1984
11. Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi. ISBN-8180040437, 2008
12. Patten, B.M., B.M. Carlson: Foundations of Embryology, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1996
13. Read, P.W.: Animal Parasites, Prentice Hall, 1977
14. Schmidt, G.D., L.S. Roberts: William & Wilkins Foundations of Parasitology (IV edition), 1989
15. Smyth, J.D.: Introduction to Animal Parasitology, Cambridge University Press, 1994
16. Wolpert, L.: Principles of Development. 5th Edition. ISBN- 9780198709886, 2015

Lab Course based on EZ-1a [2 Credits]

Developmental Biology

1. Study of the reproductive system in mammals with the help of ICT tools/ models/ charts/ photographs etc.
2. Study of whole mounts and sections of developmental stages of frog (Cleavage stages, blastula, gastrula, neurula, tail bud stages) through permanent slides/ ICT tools/ models/ charts/ photographs etc.
3. Study of developmental stages of whole mounts of chick embryo (Primitive streak -13 and 18 hours, 20, 24, 28, 33, 36 and 48 hours of incubation) through permanent slides/ ICT tools/models/photographs.
4. Window preparation in Hen's Egg and through ICT tools (videos)

Parasitology

1. Study of museum specimen of parasites.
2. Study of life stages of *Trypanosoma* & *Plasmodium* through permanent slides/ micro photographs.
3. Study of adult and life stages of *Schistosoma* & *Wuchereria* through permanent slides/micro photographs.

SOLS/ZOO/EZ-1b. Elementary Biotechnology and Microbiology 2 Credits [30 Hours]

A. Biotechnology

Unit I. History & future perspective. General steps of gene cloning technology, genomic & C-DNA library; A general concept of first-generation DNA and Next Generation DNA/RNA Sequencing, tools for nucleic-acid/protein detection, Polymerase chain reaction, Reverse Transcription PCR, Real Time PCR [10 Hours]

Unit II. Gene therapy; DNA finger printing; Products of recombinant DNA technology.
Human genome project and its applications [4 Hours]

B. Microbiology

Unit III. Bacteria, Virus and Fungi - classification, staining techniques, pathological significance. Bacteriophage, lysogenic & lytic cycle; Bacterial genetics [8 Hours]

Unit IV: Microbial culture techniques & media enrichment techniques;
Microbial fermentation: Microbes in decomposition and recycling processes;
Microbes as pathological agents in plants, animals and man; Biology of Covid 19 [8 Hours]

SUGGESTED READINGS

1. Ananthanarayan, R and CK Jayaram Paniker: Paniker's Textbook of Microbiology, Eleventh Edition
2. Davis, D., Dulbeco, L., Eisen, N.H. and Ginsberg, S.H.: Microbiology Including Immunology and Molecular Genetics. Harper International Edition, Harper & Row, New York, 1980
3. Dubey, RC: Text Book of Biotechnology, S Chand and Co., 2014
   Editor: Reba Kanungo, Imprint: Universities Press, 2020
4. Gupta, P K: Elements of Biotechnology, Rastogi Publications, 1994
5. Pelczar, MJ: Microbiology, Tata McGraw Hill,1993

Lab Course based on EZ-1b. [2 Credits]

Biotechnology

1. Isolation of genomic and plasmid DNA
2. Agarose gel electrophoresis
3. SDS-PAGE for protein isolation
4. Restriction digestion, Cloning Vectors

Microbiology

1. Transfer of Bacteria: Aseptic Techniques
2. Preparation of Smears and Simple Staining
3. Gram Staining
4. Acid-Fast Staining

SOLS/ZOO/EZ-1c. Toxicology **2 Credits [30 Hours]**

Unit I. Introduction of toxicology: Definition, history and scope of toxicology;
Kinds and classification of toxic substances: Pesticides, Heavy metals, Industrial chemicals & Radioactive substances [6 Hours]

Unit II. Exposure to Toxicants: Routes & sites of exposure; Factors affecting toxicity;
Duration & frequency of exposure: Acute, subacute, chronic & sub chronic [8 Hours]

Unit III. Dose-response relationship: Measurements of dose-response relationship & dose-response-curve; reversible & irreversible effects [6 Hours]

Unit IV. Bio-distribution, biomagnification biotransformation of xenobiotics and process of elimination; Microplastics [10 Hours]

SUGGESTED READINGS

1. Derelanko Michael J. (2018): The Toxicologist's Pocket Handbook, CRC Press, Taylor & Francis Group, ISBN-10: 0849300096
2. Hodgson Ernest (2010): A Textbook of Modern Toxicology, Wiley; 4th edition, ISBN-10: 047046206X
3. Lee Byung-Mu, Sam Kacew, Hyung Sik Kim (2017): Lu's Basic Toxicology (Fundamentals, Target Organs, and Risk Assessment), Seventh Edition, CRC Press, Taylor & Francis Group, ISBN-10: 9781138032354
4. Pani Balram (2019): Textbook of Toxicology, by, Dreamtech Press, ISBN-10: 9389520274

Lab Course based on EZ-1c. [2 Credits]

1. Care and maintenance of laboratory animals
2. Toxic substances: Wastewater, Carcinogens, Heavy Metals, Pesticides, Insecticides
3. Preparation of various concentrations
4. Study of Acute, subacute, chronic & sub chronic toxicity
5. LC50 for 24, 36, 48, 72 and 96 hours
6. Dose-response relationship
7. Analysis of Toxicants by Chromatography (Paper, TLC, GC)

SOLS/ZOO/LC-2 Major Elective Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c) [2 Credits]

MINOR CORE ZOOLOGY (CZM-1)
[Theory-1; 3 Credits]
(Students with Core subjects other than Zoology can elect any one)

SOLS/ZOO/CZM-1 Endocrinology & Animal Behaviour 3 Credits [45 Hours]

A. Endocrinology

Unit I. Endocrine messengers: hormones, neurohormones, hormone like substances (neuronal peptides, autocoids, pheromones, neurosecretion).

Hormones and Physiological actions of the endocrine glands in mammals: Pituitary, Thyroid, parathyroid, Pancreas, Gastro-intestinal tract, Adrenal cortex and Medulla, Thymus & Pineal.

Mechanism of action of Protein hormones and Catecholamines: membrane bound receptors, G-protein and control of adenylate cyclase, Cyclic nucleotide cascade [12 Hours]

Unit II. Organisation & physiological actions of the Testis: Androgen binding protein (ABP), Inhibin. Neuroendocrine control of testicular functions (Gn RH regulation, FSH- effects on germinal epithelium, LH- effects on Leydig cells, negative feedback regulation).

Organization & physiological actions of the Ovary: Folliculogenesis, Ovulation, Luteinization, Ovarian cycles; Seasonal reproductive cycles [10 Hours]

B. Animal Behaviour

Unit III. The science of behaviour: History, scope and terminology. Proximate and ultimate causes of behaviour.

Instinct: Definition and characteristics (Sign stimuli and Fixed Action Pattern).

Learning behaviour: Definition; Spatial learning, Associative learning, classical conditioning, operant conditioning, language learning. Imprinting. Kin recognition. Instinct versus learning behaviour.

Timing of behaviour: Biological rhythms; The Biological Clock; Circadian rhythms and their synchronisation seasonal rhythms; Photoperiodism [10 Hours]

Unit IV. Communication: Visual, olfactory, acoustic. Bird songs. Amphibian calls. Communication in bats.

Chemoreception: Chemicals (pheromones) as signals in insects, fish and mammals. Role of olfaction in communication behaviour (territorial, sex recognition, feeding etc) in fish and mammals.

Neural control of behaviour: Components of brain involved in various behaviours. Neural control of drinking, learning, eating, activity & rest, sleep, aggression, sexual behaviour.

Hormonal Control of behaviour; Hormone brain relationships; Elements of sociality and social grouping in animals [13 Hours]

SUGGESTED READINGS

1. Alcock, John: Animal Behaviour, 4th edition, Sinauer Associates, Inc. 1989.
2. Bentley P.J.: Comparative Vertebrate Endocrinology S. Chand & Company Ltd, Ram Nagar New Delhi, 1980
3. Chester-Jones: Fundamentals of Comparative Vertebrate Endocrinology Plenum Press, New York & London, 1987.
4. Gardner, David G. & Dolores M. Shobac: Greenspan's Basic and Clinical Endocrinology, 10th edition (A&L Lange Series), McGraw Hill / Medical, 2017
5. Goldsworthy G J et al: Endocrinology, Blackie, 1981.
6. Goodenough et al.: Perspectives on Animal Behaviour. Wiley & Sons, New York. 1993.
7. Goodman Maurice: Basic and Medical Endocrinology, Raven Press.
8. Grier, JW: Biology of Animal Behaviour, Mosby, 1984
9. Hadley, Mac E.: Endocrinology, Prentice-Hall International ed.1988/1992
10. Halliday, T.R.: Animal Behaviour Vol. 1 & 2 Communication, 1983
11. Krebs, NB & JR Davies: An Introduction to Behavioural Ecology (3rd ed.), Blackwell, 1993
12. Lehner, PN: Handbook of Ethological Methods, Garland STPM Press, New York, 1979
13. Palmer, JD et al.: An Introduction to Biological Rhythms, Academic Pres,s New York, 1976
14. Ross, C.W. & F.B. Salisbury: Plant Physiology, Brooks/Cole, 1991
15. Saunders, DS: Insect Clocks Pergamon Press, 1982
16. Wilson, JW et al.: Williams Textbook of Endocrinology, 9th edition, Saunders, 1998

MINOR ELECTIVE ZOOLOGY (EZM-1a—EZM-1c)

[Theory: 3 Credits]

(Students with Core subjects other than Zoology can elect any one)

SOLS/ZOO/EZM-1a. Developmental Biology and Parasitology 3 Credits [45 Hours]

A. Developmental Biology

Unit I. Development and differentiation of sperm and oocytes, capacitation, vitellogenesis; Mechanism of fertilization;
Early development of Frog and Chick up to gastrulation;
Concept of organiser and embryonic inductions;
Implantation of embryo in human;
Limb morphogenesis [13 Hours]

Unit II. Development in *Drosophila* up to gastrulation; Molecular basis of development;
Metaplasia & trans differentiation.
Ageing: mechanism, concepts and theories;
Regeneration, Teratogens.
Regeneration in Vertebrates: Tail, Limb, Lens and retina;
Metamorphosis in Amphibia: morphogenetic and biochemical Changes and hormonal regulation [10 Hours]

B. Parasitology

Unit III. Parasitism and evolution of parasitism.
Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Entamoeba histolytica,* Trypanosomes, *Leishmania donovani* & *Plasmodium)* [10 Hours]

Unit IV. Parasitic adaptations in Platyhelminthes and Aschelminthes; Common trematode, cestode and nematode parasites; Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris, Schistosoma, Fasciola, Wuchereria* & *Taenia*);
Introduction to arthropod vectors of human diseases (mosquitoes, lice, flies & ticks) [12 Hours]

SUGGESTED READINGS

1. Arora, D.R, Arora, B.: Medical Parasitology. II Edition. CBS Publications and Distributors. ISBN – 8123915497, 2001
2. Balinsky, BI: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London, 1960
3. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
4. Carlson, B.M.: Patten's Foundations of Embryology. (2014) 6th Edition. ISBN-9780072871708, 2014
5. Casselman, W.G.: Histochemical Techniques, John Wiley, 1959
6. Chatterjee, K.D.: Parasitology, Protozoology and Helminthology 13 edition, CBS, 2022
7. Dogiel, VA: General Parasitology, 1964
8. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
9. Goel, S.C.: Principles of Animal Developmental Biology, Himalaya Publishing House, 1994
10. Kalthoff, K. O.: Analysis of Biological Developmental. 2nd Edition. ISBN-9780070920378, 2000
11. Lamming, GE: Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 & 2, 1984
12. Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi. ISBN-8180040437, 2008
13. Patten, B.M., B.M. Carlson: Foundations of Embryology, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1996
14. Pedersen, R.A., G.P. Schatten eds.: Current Topics in Developmental Biology, Academic Press, 1996
15. Read, P.W.: Animal Parasites, Prentice Hall, 1977
16. Schmidt, G.D., L.S. Roberts: William & Wilkins Foundations of Parasitology (IV edition), 1989
17. Smyth, J.D.: Introduction to Animal Parasitology, Cambridge University Press, 1994
18. Wolpert, L.: Principles of Development. 5th Edition. ISBN- 9780198709886, 2015

SOLS/ZOO/EZM-1b. Elementary Biotechnology and Microbiology 3 Credits [45 Hours]

A. Biotechnology

Unit I. History, definition & scope.
Introduction to recombinant DNA technology - gene cloning, general idea of cloning vectors, restriction digestion, ligation, competent cell preparation, transformation and analysis of clones; Genomic & C-DNA library; Tools for detecting DNA/RNA and protein, first generation DNA and protein-sequencing, Next Generation RNA sequencing, polymerase chain reaction, Reverse Transcription PCR, Real time PCR **[**15 Hours]

Unit II. Gene therapy; DNA finger printing; Transgenic and knock out animals and plants; Primary culture, and cell lines; Tissue and organ culture; Transfection methods & transgenic and knock out animals; Molecular markers CRFLPs, RAPDs, minisatellites, microsatellites;
Products of recombinant DNA technology; Human genome project and its applications [10 Hours]

B. Microbiology

Unit III. Classification of Virus, Bacteria and Fungi -, staining techniques, pathological significance; Bacteriophage, lysogenic & lytic cycle; Bacterial genetics [10 Hours]

Unit IV: Microbial culture techniques & media enrichment techniques;
Microbial fermentation: Microbes in decomposition and recycling processes.
Microbes as pathological agents in plants, animals and man; Biology of Covid 19 [10 Hours]

SUGGESTED READINGS

1. Ananthanarayan, R and CK Jayaram Paniker: Paniker's Textbook of Microbiology, Eleventh Edition
2. Davis, D., Dulbeco, L., Eisen, N.H. and Ginsberg, S.H.: Microbiology Including Immunology and Molecular Genetics. Harper International Edition, Harper & Row, New York, 1980
3. Dubey, RC: Text Book of Biotechnology, S Chand and Co., 2014
   Editor: Reba Kanungo, Imprint: Universities Press, 2020
4. Gupta, P K: Elements of Biotechnology, Rastogi Publications, 1994
5. Pelczar, MJ: Microbiology, Tata McGraw Hill,1993

SOLS/ZOO/EZM-1c. Toxicology 3 Credits [45 Hours]

Unit I. Introduction of toxicity: Definition, history, scope & sub-divisions of toxicology
Kinds and classification of toxic substances: Pesticides, Heavy metals, Industrial chemicals & Radioactive substances [12 Hours]

Unit II. Exposure to Toxicants: Routes & sites of exposure (inhalation, injection & through food or intestinal); Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms
Mechanism of action: Receptors (Proteins), mechanism of action of DDT, Lead (Pb) & UV rays.
Bio-distribution, biomagnification, biotransformation of xenobiotics and process of elimination.
Duration & frequency of exposure: Acute, subacute, chronic & sub chronic [15 Hours]

Unit III. Dose-response relationship: Measurements of dose-response relationship & dose-response-curve; reversible & irreversible effects [10 Hours]

Unit IV. Chemical nature of toxicants: Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins; Microplastics.
Pesticides, Radioactive compounds & Heavy metals [8 Hours]

SUGGESTED READINGS

1. Derelanko Michael J. (2018) The Toxicologist's Pocket Handbook, CRC Press, Taylor & Francis Group, ISBN-10: 0849300096
2. Hodgson Ernest: A Textbook of Modern Toxicology (2010), Wiley; 4th edition, ISBN-10: 047046206X
3. Lee Byung-Mu, Sam Kacew, Hyung Sik Kim: Lu's Basic Toxicology (Fundamentals, Target Organs, and Risk Assessment), Seventh Edition, (2017), CRC Press, Taylor & Francis Group, ISBN-10: 9781138032354
4. Pani Balram: Textbook of Toxicology, by, Dreamtech Press (2019), ISBN-10: 9389520274

CORE ZOOLOGY (CZ-7)
[Theory: 4 Credits; Lab Course: 4 Credits]

SOLS/ZOO/CZ-7 Chordata **4 Credits [60 Hours]**

Unit I: Origin and evolution of chordata.
General characters, classification and development of Urochordata and Cephalochordata.
Affinities of Hemichordata, Urochordata & Cephalochordata [15 Hours]

Unit II: Origin and evolution of Vertebrates.
General Characters, Classification and affinities of Cyclostomata.
Salient features of different groups of fishes; Comparison between Chondrichthyes and Osteichthyes; Dipnoi & Coelacanths.
Origin and evolution of Amphibia; Gymnophiona; Parental care in Amphibia; Neoteny & Paedogenesis [20 Hours]

Unit III: General characters and classification of Reptilia; Origin of Reptilia and adaptive radiation in Reptilia; Characters and affinities of Chelonia, Rhynchocephalia and Crocodilia.
General characters and classification of Aves; Origin and ancestry of birds; Characters and affinities of Ratitae; Origin and mechanism of flight in birds; Palate in birds; Migration in birds [15 Hours]

Unit IV: General characters and classification of mammals; Origin of mammals; Characters and affinities of Prototheria and Metatheria.
Dentition in mammals; Aquatic and flying adaptations in mammals; Adaptive radiation in mammals [10 Hours]

SUGGESTED READINGS

1. Hildebrand, M. Goslow, G.: Analysis of Vertebrate Structure, Wiley, 1998
2. Jordan, E.L. and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd., 2013
3. Kotpal RL: Modern Text Book of Zoology Vertebrates; Rastogi Publications, 2007
4. Parker T.J. & Haswell WA: A Text Book of Zoology, Vol II, ed. 7th, Macmillan & Co. Ltd, London, 1962.
5. Romer, A.S., T.S. Parsons: Vertebrate Body, Saunders (W.B.) Co Ltd; 5th Revised edition, 1977
6. Young JZ: The Life of Vertebrates, Oxford, 1950.

SOLS/ZOO/LC-3 Lab Course-3 (Based on CZ-7) **[4 Credits]**

1. Slides of Protochordata, whole mount and cross sections of *Balanoglossus, Herdmania* and *Amphioxus*
2. Museum Specimens: Protochordata, Cyclostomata, Pisces, Amphibia, Reptile, Bird & Mammals.
3. General anatomy and neural gland of *Herdmania* using charts and computer software.
4. Afferent and efferent arteries, cranial nerves, membranous labyrinth, eye muscles and their innervation, brain of any fish.
5. Articulated and disarticulated bones of Frog, Varanus, Carapace & Plastron of Tortoise, Fowl and Rabbit
6. Flight muscles, perching mechanism, air sacs and anatomy of the neck region in pigeon through charts/ models/computer software
7. Slides: Scales of fish

MAJOR ELECTIVE ZOOLOGY (EZ-2a—EZ-2c)
(Theory-2 Credits; Lab Course-2 Credits)
[Any One]

SOLS/ZOO/EZ-2a. Aquatic Biodiversity **2 Credits [30 Hours]**

Unit I. Definition, concept, scope and measurement of biodiversity.
Types of Biodiversity: Species, Genetic, Community, Ecosystem.
Factors governing biodiversity: Historical & Proximate [4 Hours]

Unit II. Aquatic ecosystems and their characteristics.
Freshwater biodiversity; Marine biodiversity.
Biodiversity data bases [10 Hours]

Unit III. Threats to habitats and biological diversity in freshwater and marine ecosystems.
Endemic species: Definition, concept and scope; Hot spots
Endangered species: Definition, concept and scope.
Conservation: Definition, concept and scope.
Ramsar Convention [10 Hours]

Unit IV. Impact of Hydroelectric Projects (HEP) on aquatic biodiversity; Environmental Impact Assessment (EIA): Case studies from Himalaya
Environmental flows: Importance for the aquatic flora & fauna. Environmental flows assessment methodology: Hydrological, hydraulics rating, habitat simulation & holistic [6 Hours]

SUGGESTED READINGS

1. AlgaeBase, Diatoms of North America, http://www.insecta.bio.spbu.ru/z/faun-eur.htm; FisBase, (https://www.fishbase.se/identification/RegionSpeciesList.php?resultPage=3&e_code=7&SortBy=family; https://aqgrisi.nbfgr.res.in/listing/family/71)
2. Dodds WK: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
3. Edmondson WT: Freshwater Biology, John Wiley & Sons Inc; 2nd edition (1959)
4. Gaston KJ & JI Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
5. Hynes HBN: Ecology of Running Waters, Blackburn Press (1971)
6. Jhingran VG: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)
7. Nautiyal et al: Ecology & Diversity of Freshwater Environments Transmedia, Srinagar Garhwal, 2005
8. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
9. Odum EP.: Fundamentals of Ecology, Cengage Learning (2004)
10. Postel Sandra & Brian Richter: Rivers for Life - Managing Water For People And Nature, Island Press (2003)

Lab Course based on EZ-2a. [2 Credits]

1. Sampling and analysis of plankton
2. Sampling and analysis of benthic organisms
3. Chlorophyll estimation of periphytic algae
4. Study of ecological indices
5. Study of endangered species and protection
6. Study of local fish fauna
7. Study of river/ natural pond habitat and organisms

SOLS/ZOO/EZ-2b. Genetics, Evolution and Taxonomy 2 Credits [30 Hours]

A. Genetics
Unit I. Monohybrid and Dihybrid crosses with molecular explanations; Incomplete and Co dominance, Gene interaction, Lethal alleles, Multiple alleles.
Modification of Dihybrid ratios and their biochemical basis [6 Hours]

Unit II. Linkage and Crossing over; Sex Linked inheritance and genetic disorders; Mutations and chromosomal aberrations.
Operon hypothesis, Lac operon (positive and negative control).
Population Genetics: Hardy-Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic Drift [10 Hours]

B. Evolution
Unit III. Natural Selection: Types of selection; Role of Mutation in Evolution.
Micro and Macroevolution; Genetic drift and gene flow
Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna); Island Biogeography theory; Fossils and fossilization, Geological distribution of animals.
Evolution of Horse [8 Hours]

C. Taxonomy
Unit IV. Systematics, Types of Taxonomy, Importance of Taxonomy; Theories of biological classification, Linnaean hierarchy.

Biological Species Concept.
Nomenclature: ICZN, Taxon, Rank and Categories; Important rules of Nomenclature, Latin words and abbreviations [6 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Cummings, William S. Klung, Spencer and Palldino (2019). Concepts of Genetics, Pearson Education, Pearson
6. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
7. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
8. Ernst Mayr and PD Ashlock (1991): Principles of Systematic Zoology, McGraw-Hill
9. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
10. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
11. Judith E. Winston (199): Describing Species Practical and Taxonomy Procedure for Biologists, Columbia University Press
12. Kapoor, V.C. (2008): Theory and Practice of Animal Taxonomy, 6th edition, Oxford and IBH Publishing Co. Pvt. Ltd.
13. King, Max (1995). Species Evolution: Role of Chromosomal Change, Cambridge University Press
14. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
15. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson
16. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
17. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
18. Tamarin, Robert, H. (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
19. Verma, Ashok (2015): Principles of animal Taxonomy, Alpha Science International Ltd.

Lab Course based on EZ-2b. [2 Credits]

Genetics

1. Genetics problems related to Mendelian inheritance
2. Preparation of Drosophila Polytene Chromosome Squashes

Evolution

1. Evidences of organic evolution
2. Photographs/ Models of Evolution

Taxonomy

1. List of animals with common and zoological names
2. List of household pests with common and zoological names
3. Classification of 10 common fish, amphibia, reptiles, bird and mammals

SOLS/ZOO/EZ-2c. Assisted Reproductive Biology Techniques — 2 Credits [30 Hours]

Unit I. Scope of reproductive technologies; functional anatomy of male & female reproductive system; Induced release of gametes and its significance [7 Hours]

Unit II. Multiple ovulation, superovulation; In-vitro oocyte maturation; Biochemistry of semen, semen composition and formation; Cryopreservation of gametes [8 Hours]

Unit III. Intra-cytoplasmic sperm injection, gamete intrafallopian transfer; In-vitro fertilization; Transgenic animals and their uses [7 Hours]

Unit IV. Contraception; Immunocontraception; Other contraception technologies: surgical methods, hormonal method, physical barrier, IUCD [8 Hours]

SUGGESTED READINGS

1. Allahbadia, Gautam Nand et al.: The Art & Science of Assisted Reproductive Techniques (ART), Jaypee Brothers Medical Publishers (P) Ltd.; 2nd edition (2017)
2. Jones, R.E. And Lopez, K.H: Human Reproductive Biology (Third Edition), Academic Press (2006)

3. Weissman, Ariel, Colin M. Howles, Zeev Shoham: Textbook of Assisted Reproductive Techniques, Volume 1: Laboratory Perspectives, CRC Press (2018)

Lab Course based on EZ-2c. [2 Credits]

1. Study of functional anatomy of male reproductive system with the help of photographs, chart and models
2. Study of functional anatomy of female reproductive system with the help of photographs, chart and models
3. Study of the histological details of testes, ovary and pituitary with the help of permanent slide, photographs and charts.
4. Physical examination of cryopreserved semen of bull for sperm count
5. Preparation of chart and model based on theory topics

SOLS/ZOO/LC-4 Major Elective Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c) [2 Credits]

MINOR CORE ZOOLOGY (CZM-2)
[Theory-1; 3 Credits]
(For students with Core subjects other than Zoology)

CZM-2. Biological and Radiotracer Techniques 3 Credits [45 Hours]

Unit I. Analytical separation methods: Chromatography - General principle and application; Adsorption chromatography, Partition chromatography, Gas chromatography, liquid chromatography, Paper chromatography, Thin layer chromatography, Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, HPLC (High Performance/Pressure Liquid chromatography) [12 Hours]

Unit II. Electrophoresis: General principle and application; Paper electrophoresis, Moving boundary method, Gel electrophoresis (Native, Denaturing & Reducing), Disc Gel electrophoresis, Slab Gel electrophoresis, Isoelectrofocussing (IEF), Isotachophoresis [8 Hours]

Unit III. Centrifugation: Basic principles. Common centrifuges used in laboratory (clinical, high speed & ultracentrifuges). Sedimentation rate, Sedimentation coefficient, Zonal centrifugation, Equilibrium density gradient centrifugation.
Types of rotors (fixed angle, swing bucket), Types of centrifugation- Preparative, differential & density gradient.
Microscopy: Light, phase contrast, Fluorescence and Confocal microscopy, Scanning and Transmission Electron microscopy, Cryo-electron microscopy and Atomic force microscopy [10 Hours]

Unit IV. Biosensors: Introduction & principles. First, second & third generation instruments**,** cell based biosensors, enzyme immunosensors.
Spectroscopic methods: Principle and applications of UV-visible, IR, NMR, ESR Spectroscopy. Principle & application of X-ray crystallography.
Application of radioisotopes in biology. Properties and units of radioactivity. Radioactive isotopes and half-life.
Measurement of radioactivity: GM Counter, gamma counter, liquid scintillation counter.
Tracer techniques of Autoradiography, Radioimmunoassay.
Safety rules in handling of radioisotopes and hazardous chemicals [15 Hours]

SUGGESTED READINGS

1. Sharma, V.K.: Techniques in Microscopy and Cell Biology Tata McGraw Hill, 1991.
2. Alberts et al.: Molecular Biology of the cell (2nd ed.), Garland, 1989.
3. J.F. Robyt & B.J. White, Biochemical Technique: Theory & Practical, Waveland Press, Inc.
4. Wilson & Walker: Practical Biochemistry (4th ed) University of Hertfordshire Cambridge University Press
5. Jayraman: Laboratory Manual in Biochemistry

MINOR ELECTIVE ZOOLOGY (EZM-2a—EZM-2c)

[Theory: 3 Credits]

(Students with Core subjects other than Zoology can elect any one)

SOLS/ZOO/EZM-2a. Aquatic Biodiversity **3 Credits [45 Hours]**

Unit I. Definition, concept, scope and measurement of biodiversity; Biodiversity loss (causes & effects).
Types of Biodiversity: Species, Genetic, Community, Ecosystem.
Factors governing biodiversity: Historical & proximate [7 Hours]

Unit II. Types of aquatic ecosystem & biomes and their characteristics.
Freshwater biodiversity: Physical and chemical characteristics of freshwater rivers, lakes, reservoirs and wetlands; Over view of freshwater biodiversity in important rivers, lakes, reservoirs and wetlands of India with emphasis on Himalaya.
Introduction to Marine biodiversity.
Biodiversity data bases [15 Hours]

Unit III. Threats to habitats and their conservation.
Endemic species & Endangered species: Definition, concept, scope.
Conservation: Definition, concept, scope.
Ramsar Convention; Physical and chemical characteristics of wetlands.
Over view of biodiversity in Wetlands of India with emphasis on Himalaya [15 Hours]

Unit IV. Impact of Hydroelectric Projects (HEP) on aquatic biodiversity; Environmental Impact Assessment (EIA): Case studies.
Environmental flows: Importance for the aquatic flora & fauna. Environmental flows assessment methodology (Hydrological, hydraulics rating, habitat simulation & holistic). Ecosystem Services: Concept & scope [8 Hours]

SUGGESTED READINGS

1. AlgaeBase, Diatoms of North America, http://www.insecta.bio.spbu.ru/z/faun-eur.htm; FisBase, (https://www.fishbase.se/identification/RegionSpeciesList.php?resultPage=3&e_code=7&SortBy=family; https://aqgrisi.nbfgr.res.in/listing/family/71)
2. Dodds WK: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
3. Edmondson WT: Freshwater Biology, John Wiley & Sons Inc; 2nd edition (1959)
4. Gaston KJ & JI Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
5. Hynes HBN: Ecology of Running Waters, Blackburn Press (1971)
6. Jhingran VG: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)
7. Nautiyal et al: Ecology & Diversity of Freshwater Environments Transmedia, Srinagar Garhwal, 2005
8. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
9. Odum EP.: Fundamentals of Ecology, Cengage Learning (2004)
10. Postel Sandra & Brian Richter: Rivers for Life - Managing Water for People and Nature, Island Press (2003)

SOLS/ZOO/EZM-2b. Genetics, Evolution and Taxonomy **3 Credits [45 Hours]**

A. Genetics

Unit I. Monohybrid and Dihybrid crosses with molecular explanations; Incomplete and Co dominance, Gene interaction, Lethal alleles, Multiple alleles, Pedigree analysis; Eugenics.
Modification of Dihybrid ratios and their biochemical basis; Fine structure of Gene; Statistical tools (Probability and Significance Testing) [10 Hours]

Unit II. Linkage and Crossing over, Genetic mapping techniques; Sex linked inheritance and genetic disorders; Mutations and chromosomal aberrations.
Operon hypothesis, Lac operon (positive and negative control); Regulation of gene expression in eukaryotes.
Population Genetics: Hardy-Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic drift and gene flow [12 Hours]

B. Evolution

Unit III. Natural Selection: Types of selection and selection coefficient; Role of mutation in evolution (Gene mutation, Mutation Rates, Mutation and selection, Genetic Polymorphism).
Micro and Macroevolution; Genetic drift and gene flow
Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna); Island Biogeography theory.

Palaeontology: Fossils and fossilization, mass extinction, geological time scale; Evolution of Horse; Evolution of Man [10 Hours]

C. Taxonomy

Unit IV. Systematics and Taxonomy: Definition, concepts, history, scope and application of biosystematics; **Principles of Zoological Classification:** Theories of biological classification, hierarchies of categories and the higher taxa.

Concept of Species: Species category, different concepts and intraspecific categories.

Modern trends in taxonomy: Behavioural taxonomy, cytotaxonomy and molecular taxonomy.

Systematics, Types of Taxonomy, Importance of Taxonomy; Theories of biological classification, Linnaean hierarchy.

Nomenclature: ICZN, Taxon, Rank and Categories; Important rules of Nomenclature, Latin words and abbreviations.

Taxonomic characters and taxonomic keys; Preservation of collected material and curating [13 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.
3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Cummings, William S. Klung, Spencer and Palldino (2019). Concepts of Genetics, Pearson Education, Pearson
6. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
7. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
8. Ernst Mayr and PD Ashlock (1991): Principles of Systematic Zoology, McGraw-Hill
9. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
10. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
11. Judith E. Winston (199): Describing Species Practical and Taxonomy Procedure for Biologists, Columbia University Press
12. Kapoor, V.C. (2008): Theory and Practice of Animal Taxonomy, 6th edition, Oxford and IBH Publishing Co. Pvt. Ltd.
13. King, Max (1995). Species Evolution: Role of Chromosomal Change, Cambridge University Press
14. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
15. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson
16. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
17. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
18. Tamarin, Robert, H. (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
19. Verma, Ashok (2015): Principles of animal Taxonomy, Alpha Science International Ltd.

SOLS/ZOO/EZM-2c. Assisted Reproductive Biology Techniques 3 Credits [45 Hours]

Unit I. Scope of mammalian reproductive technologies, Functional anatomy of male and female reproductive system, Induced release of gametes and its significance [10 Hours]

Unit II. Multiple ovulation, superovulation. In-vitro oocyte maturation. Biochemistry of Semen, Semen composition and formation. Assessment of sperm functions. Cryopreservation of gametes and embryos [12 Hours]

Unit III. Intra-cytoplasmic sperm injection, gamete intrafallopian transfer, zygote intrafallopian transfer, In-vitro fertilization, embryo transfer. Transgenic animals and their uses [12 Hours]

Unit IV. Contraception; Immunocontraception: Antibody mediated fertilization block and termination of gestation. Other contraception technologies: surgical methods, hormonal method, physical barrier, IUCD [11 Hours]

SUGGESTED READINGS

1. Allahbadia, Gautam Nand et al.: The Art & Science of Assisted Reproductive Techniques (ART), Jaypee Brothers Medical Publishers (P) Ltd.; 2nd edition (2017)
2. Jones, R.E. And Lopez, K.H: Human Reproductive Biology (Third Edition), Academic Press (2006)
3. Weissman, Ariel, Colin M. Howles, Zeev Shoham: Textbook of Assisted Reproductive Techniques, Volume 1: Laboratory Perspectives, CRC Press (2018)

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B.Sc. [Research] Fourth Year (VII & VIII Semester)

B.Sc. VII Semester (Research)

CORE ZOOLOGY (CZ-5—CZ-6)
[Theory: 3 Credits; Lab Course: 2 Credits]

SOLS/ZOO/CZ-5 Non-Chordata **3 Credits [45 Hours]**

Unit I. Major and minor invertebrate phyla: General characters, organization, classification up to Order and their types; Origin and evolution of lower and higher invertebrates; Overview of economic importance of invertebrates.
Protozoa: Comparative morphology of all classes; Locomotor organelles and locomotion; **Nutrition:** holophytic, holozoic, saprozoic, myxotrophic and parasitic; **Reproduction:** Asexual and sexual reproduction, parthenogenesis and regeneration [12 Hours]

Unit II. Porifera: Comparative morphology of all classes; Types of canal system; **Reproduction:** Asexual, sexual reproduction and regeneration in sponges.
Coelenterata: Comparative morphology of all classes; Polymorphism; Coral reefs & their formation; General characters and affinities of Ctenophora.
Helminthes: Comparative morphology of Platyhelminthes and Aschelminthes [11 Hours]

Unit III. Minor Group: Classifications to order level, characters and affinities of Phoronida and Rotifera.
Annelida: Classification to order level; Comparative morphology of all classes; Segmental organs.
Arthropoda: Classification to order level; Appendages and mouth parts in insects; Larval forms in Crustacea; Arachnida.
Organization and affinities of *Onychophora* [12 Hours]

Unit IV. Mollusca: Classification to order level; Comparative morphology of all classes; Major features of the respiratory and reproductive systems; Larval forms, Torsion and Pearl formation.
Echinodermata: Classification to order level; Water vascular system; Larval forms and affinities [10 Hours]

SUGGESTED READINGS

1. Barnes: Invertebrate Zoology (4th ed.), Holt-Saunders, 1980.
2. Barrington: Invertebrate Structure and Function, Nelson, 1987.
3. Iyer: A Manual of Zoology, Part I. Viswanathan, 1973.
4. Hickman, Roberts & Hickman: Integrated Principles of Zoology (7th ed) Times-Mirror, Mosby, 1984.
5. Kotpal: Modern Text-book of Zoology: Invertebrates. Rastogi Publications, Meerut
6. Marshall & William: Text Book of Zoology, Vol I (Parker & Haswell, 7th ed.) Macmillan, 1972.

SOLS/ZOO/CZ-6 Cell and Molecular Biology **3 Credits [45 Hours]**

A. Cell Biology
Unit I. Ultrastructure of prokaryotic and eukaryotic cells.
Plasma membrane: Structure - organisation, lipid bilayer, proteins & glycoconjugates, liposomes; Function - Ionic transport, transporter proteins, types of transport (symport, antiport, active & passive, endocytosis, exocytosis).
Endomembrane system: Intracellular compartments/organelles involved in protein sorting, secretory and endocytic pathways.
Cytoskeleton: Components, functions & derived organelles (cilium, flagellum).
Mitochondria: Structure function & genetic organisation; Ribosome: Biosynthesis & formation in nucleolus [10 Hours]

Unit II. Signal transductions.
Cell signaling: Types of signaling, Cell surface receptor mediated signaling.
Cell cycle: Molecular events during interphase, genetic regulation of cell cycle (including yeast as model system).
Cellular transformation and malignancy; Retroviruses; Apoptosis and causes of cancer [10 Hours]

B. Molecular Biology
Unit III. The central dogma of Molecular Biology.

DNA: Structure and conformation, supercoiling, packing of DNA into chromosomes; Structural polymorphism of DNA & RNA; Three-dimensional structure of t-RNA [10 Hours]

Unit IV. DNA replication; Genetic code; Transcription and translation in prokaryotes and eukaryotes; RNA processing; Mutations & DNA repair systems; P bodies; Concept of Epigenetics, Chromatin remodelling, Non-Coding RNAs [15 Hours]

SUGGESTED READINGS

1. Alberts et al.: Molecular Biology of the Cell, Garland Pub., New York, 1989.
2. DeRobertis & DeRobertis: Cell & Molecular Biology, CCH, a Wolters Kluwer Business, Lippincott Williams &Wilkins, 1996
3. Friefelder: Molecular Biology. Narosa Publ. House.
4. Sharma, V.K.: Techniques in Microscopy and Cell Biology, Tata McGraw Hill, 1991
5. Strickberger: Genetics, Prentice Hall, 1996.
6. Verma, P.S. and Agarwal, V. K. Cell Biology, Genetics, Molecular biology, Evolution and Ecology (S. Chand & Co.)

SOLS/ZOO/LC-1 Lab Course-1 (Based on CZ-5 & CZ-6) [2 Credits]

Non-Chordata

1. Slides of Protozoa
2. Slides & Museum specimen of Porifera, Coelenterata, Helminthes, Annelida, Arthropoda, Mollusca & Echinodermata
3. Slides of Phoronida and Rotifera
4. Specimen: *Beroe*, *Peripatus*

Cell Biology

1. Permanent slides of cell division (Mitosis & Meiosis)
2. Study of mitotic cell division by squash technique
3. Slide preparation of interphase nuclei in buccal epithelium
4. Study of meiotic cell division in grasshopper testis
5. Preparation of blood smear

Molecular Biology

1. Preparation of solutions for Molecular Biology experiments.
2. Isolation of chromosomal DNA from bacterial cells.
3. Isolation of Plasmid DNA by alkaline lysis method
4. Agarose gel electrophoresis of genomic DNA & plasmid DNA
5. Preparation of restriction enzyme digests of DNA samples
6. Demonstration of AMES test or reverse mutation for carcinogenicity
7. DNA isolation from animal tissue
8. Separation of DNA molecules from Agarose Gel Electrophoresis
9. RNA isolation from Baker's Yeast
10. Estimation of RNA by orcinol method

RESEARCH METHODOLOGY ZOOLOGY (RMZ)
[Theory: 4 Credits]

SOLS/ZOO/RMZ Research Methodology 4 Credits [60 Hours]

Unit I. Foundations of Research: Meaning, Objectives, Motivation: Research Methods vs Methodology, Types of Research: Analytical vs Descriptive, Quantitative vs Qualitative, Basic vs Applied [8 Hours]

Unit II. Research Design: Need for research design— Features of good design, Important concepts related to good design; Observation and Facts, Prediction and Explanation, Development of Models.
Developing a research plan: Problem identification, Experimentation, Determining experimental and sample designs [20 Hours]

Unit III. Data Collection, Analysis and Report Writing, Observation and Collection of Data-Methods of data collection- Sampling Methods, Data Processing and Analysis Strategies, Technical Reports and Thesis writing, Preparation of Tables and Bibliography. Data Presentation using digital technology [16 Hours]

Unit IV. Ethical Issues, Intellectual Property Rights, Commercialization, Copy Right, Royalty, Patent law, Plagiarism, Citation, Acknowledgement [16 Hours]

SUGGESTED READINGS

1. Anthony, M., Graziano, A.M. and Raulin, M.L. 2009. Research Methods: A Process of Inquiry, Allyn and Bacon
2. Coley, S.M. and Scheinberg, C.A. 2008. Proposal Writing: Effective Grantmanship, 3rd edition, Sage Publications
3. Kothari, C.R. 2009. Research Methodology, New Age International
4. Wadhera, B.L. 2002. Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law Publishing
5. Walliman, N. 2011. Research Methods- The Basics. Taylor and Francis, London, New York

ELECTIVE COURSE ZOOLOGY (EZ-1a—EZ-1c)

(Theory-3 Credits; Lab Course-3 Credits)

[Any one]

SOLS/ZOO/EZ-1a. Developmental Biology and Parasitology 3 Credits [45 Hours]

C. Developmental Biology

Unit I. Development and differentiation of sperm and oocytes, capacitation, vitellogenesis; Mechanism of fertilization;
Early development of Frog and Chick up to gastrulation;
Concept of organiser and embryonic inductions;
Implantation of embryo in human;
Limb morphogenesis [13 Hours]

Unit II. Development in *Drosophila* up to gastrulation; Molecular basis of development;
Metaplasia & trans differentiation.
Ageing: mechanism, concepts and theories;
Regeneration, Teratogens.
Regeneration in Vertebrates: Tail, Limb, Lens and retina;
Metamorphosis in Amphibia: morphogenetic and biochemical Changes and hormonal regulation [10 Hours]

D. Parasitology

Unit III. Parasitism and evolution of parasitism.
Protozoan parasites: Biology, life cycle and diseases caused by selected pathogenic protozoans of man their preventive and control measures (*Entamoeba histolytica,* Trypanosomes, *Leishmania donovani* & *Plasmodium)* [10 Hours]

Unit IV. Parasitic adaptations in Platyhelminthes and Aschelminthes; Common trematode, cestode and nematode parasites; Biology, life history and preventive measures of economically important helminth parasites of man and domesticated animals (*Ascaris, Schistosoma, Fasciola, Wuchereria* & *Taenia*);
Introduction to arthropod vectors of human diseases (mosquitoes, lice, flies & ticks) [12 Hours]

SUGGESTED READINGS

1. Arora, D.R, Arora, B.: Medical Parasitology. II Edition. CBS Publications and Distributors. ISBN – 8123915497, 2001
2. Balinsky, BI: An Introduction to Embryology. W.B. Saunders Company. Philadelphia and London, 1960
3. Berrill, NJ: Developmental Biology, Tata McGraw-Hill Publishing Co. Ltd., 1979
4. Carlson, B.M.: Patten's Foundations of Embryology. (2014) 6th Edition. ISBN-9780072871708, 2014
5. Chatterjee, K.D.: Parasitology, Protozoology and Helminthology 13 edition, CBS, 2022
6. Dogiel, VA: General Parasitology, 1964
7. Gilbert, SF: Developmental Biology, 3rd edition, Sinauer Associates, 1991
8. Goel, S.C.: Principles of Animal Developmental Biology, Himalaya Publishing House, 1994
9. Kalthoff, K.O.: Analysis of Biological Developmental. 2nd Edition. ISBN-9780070920378, 2000
10. Lamming, GE: Marshall's Physiology of Reproduction Longmont, Green and Co. London Vol. 1 & 2, 1984
11. Parija, S. C. Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi. ISBN-8180040437, 2008

12. Patten, B.M., B.M. Carlson: Foundations of Embryology, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1996
13. Read, P.W.: Animal Parasites, Prentice Hall, 1977
14. Schmidt, G.D., L.S. Roberts: William & Wilkins Foundations of Parasitology (IV edition), 1989
15. Smyth, J.D.: Introduction to Animal Parasitology, Cambridge University Press, 1994
16. Wolpert, L.: Principles of Development. 5th Edition. ISBN- 9780198709886, 2015

Lab Course EZ-1a. [3 Credits]

Developmental Biology

1. Study of the reproductive system in mammals with the help of ICT tools/ models/ charts/ photographs etc.
2. Study of whole mounts and sections of developmental stages of frog (Cleavage stages, blastula, gastrula, neurula, tail bud stages) through permanent slides/ ICT tools/ models/ charts/ photographs etc.
3. Study of developmental stages of whole mounts of chick embryo (Primitive streak -13 and 18 hours, 20, 24, 28, 33, 36, 48, 72, and 96 hours of incubation) through permanent slides/ ICT tools/models/photographs.
4. Window preparation in Hen's Egg and through ICT tools (videos)
5. Sperm count from any domestic animal (Source of semen: Government Artificial Insemination Centre).
6. Study of the developmental stages and life cycle of *Drosophila* from stock culture.

Parasitology

4. Study of museum specimen of parasites.
5. Study of life stages of *Entamoeba histolytica, Trypanosoma, Leishmania donovani* & *Plasmodium* through permanent slides/ micro photographs.
6. Study of adult and life stages of *Ascaris, Schistosoma, Fasciola, Wuchereria* & *Taenia* through permanent slides/micro photographs.
7. Study of nematode/cestode parasites from the intestine of sheep/goat.

SOLS/ZOO/EZ-1b. Elementary Biotechnology and Microbiology 3 Credits [45 Hours]

C. Biotechnology

Unit I. History, definition & scope.
Introduction to recombinant DNA technology - gene cloning, general idea of cloning vectors, restriction digestion, ligation, competent cell preparation, transformation and analysis of clones; Genomic & C-DNA library; Tools for detecting DNA/RNA and protein, first generation DNA and protein-sequencing, Next Generation RNA sequencing, polymerase chain reaction, Reverse Transcription PCR, Real time PCR **[**15 Hours]

Unit II. Gene therapy; DNA finger printing; Transgenic and knock out animals and plants; Primary culture, and cell lines; Tissue and organ culture; Transfection methods & transgenic and knock out animals; Molecular markers CRFLPs, RAPDs, minisatellites, microsatellites.
Products of recombinant DNA technology; Human genome project and its applications [10 Hours]

D. Microbiology

Unit III. Classification of Virus, Bacteria and Fungi - staining techniques, pathological significance. Bacteriophage, lysogenic & lytic cycle; Bacterial genetics [10 Hours]

Unit IV: Microbial culture techniques & media enrichment techniques.
Microbial fermentation: Microbes in decomposition and recycling processes.
Microbes as pathological agents in plants, animals and man; Biology of Covid 19 [10 Hours]

SUGGESTED READINGS

1. Ananthanarayan, R and CK Jayaram Paniker: Paniker's Textbook of Microbiology, Eleventh Edition
2. Davis, D., Dulbeco, L., Eisen, N.H. and Ginsberg, S.H.: Microbiology Including Immunology and Molecular Genetics. Harper International Edition, Harper & Row, New York, 1980
3. Dubey, RC: Text Book of Biotechnology, S Chand and Co., 2014
   Editor: Reba Kanungo, Imprint: Universities Press, 2020
4. Gupta, P K: Elements of Biotechnology, Rastogi Publications, 1994
5. Pelczar, MJ: Microbiology, Tata McGraw Hill,1993

Lab Course EZ-1b. [3 Credits]

Biotechnology

1. Isolation of genomic and plasmid DNA

2. Agarose gel electrophoresis
3. RNA isolation and estimation
4. SDS-PAGE for Proteins
5. Cloning vectors and Restriction Digestion

Microbiology

1. Transfer of Bacteria: Aseptic Techniques
2. Preparation of Smears and Simple Staining
3. Gram Staining
4. Acid-Fast Staining
5. Isolation of Bacteria by Dilution Techniques
6. Isolation of Bacterial Culture from water & soil sample
7. Special Media for Isolating Bacteria

SOLS/ZOO/EZ-1c. Toxicology **3 Credits [45 Hours]**

Unit I. Introduction of toxicology: Definition, history, scope & sub-divisions of toxicology
Kinds and classification of toxic substances: Pesticides, Heavy metals, Industrial chemicals and Radioactive substances [12 Hours]

Unit II. Exposure to Toxicants: Routes & sites of exposure (inhalation, injection and through food or intestinal); Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms
Mechanism of action: Receptors (Proteins), mechanism of action of DDT, Lead (Pb) and UV rays.
Bio-distribution, biomagnification, biotransformation of xenobiotics and process of elimination.
Duration & frequency of exposure: Acute, subacute, chronic & sub chronic [15 Hours]

Unit III. Dose-response relationship: Measurements of dose-response relationship & dose-response-curve; reversible & irreversible effects [10 Hours]

Unit IV. Chemical nature of toxicants: Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins; Microplastics.
Pesticides, Radioactive compounds & Heavy metals [8 Hours]

SUGGESTED READINGS

1. Derelanko Michael J. (2018) The Toxicologist's Pocket Handbook, CRC Press, Taylor & Francis Group, ISBN-10: 0849300096
2. Hodgson Ernest: A Textbook of Modern Toxicology (2010), Wiley; 4th edition, ISBN-10: 047046206X
3. Lee Byung-Mu, Sam Kacew, Hyung Sik Kim: Lu's Basic Toxicology (Fundamentals, Target Organs, and Risk Assessment), Seventh Edition, (2017), CRC Press, Taylor & Francis Group, ISBN-10: 9781138032354
4. Pani Balram: Textbook of Toxicology, by, Dreamtech Press (2019), ISBN-10: 9389520274

Lab Course EZ-1c. [3 Credits]

1. Care and maintenance of laboratory animals
2. Toxic substances: Wastewater, Carcinogens, Heavy Metals, Pesticides, Insecticides
3. Preparation of various concentrations
4. Study of Acute, subacute, chronic & sub chronic toxicity
5. LC50 for 24, 36, 48, 72 and 96 hours
6. Dose-response relationship
7. Histological/Histopathological study of slides
8. Monitoring of different pollutants in air, water, soil and animals
9. Analysis of Toxicants by Chromatography (Paper, TLC, GC)

SOLS/ZOO/LC-2 Lab Course-2 (Based on EZ-1a/ EZ-1b/ EZ-1c) **[3 Credits]**

CORE ZOOLOGY (CZ-7—CZ-8)
[Theory: 3 Credits; Lab Course: 2 Credits]

SOLS/ZOO/CZ-7 Chordata — 3 Credits [45 Hours]

Unit I: General Characters, classification development of Urochordata and Cephalochordata.
Affinities of Hemichordata, Urochordata & Cephalochordata [12 Hours]

Unit II: General Characters, Classification and affinities of Cyclostomata
Salient features of different groups of fishes; Chondrichthyes, Osteichthyes, Dipnoi and Coelacanth.
Origin and evolution of Amphibia; Neoteny & Paedogenesis [11 Hours]

Unit III: General characters and classification of Reptilia; Origin of Reptilia and adaptive radiation in Reptilia; Characters and affinities of Chelonia and Rhynchocephalia.
General characters and classification of Aves; Origin and ancestry of birds; Characters and affinities of Ratitae; Origin and mechanism of flight in birds; Palate in birds; Migration in birds [12 Hours]

Unit IV: General characters and classification of mammals; Origin of mammals; Characters and affinities of Prototheria and Metatheria.
Dentition in mammals; Adaptive radiation in mammals; Aerial and Aquatic adaptations in mammals [10 Hours]

SUGGESTED READINGS

1. Hildebrand, M. Goslow, G.: Analysis of Vertebrate Structure, Wiley, 1998
2. Jordan, E.L. and P.S. Verma: Chordate Zoology. S. Chand & Co. Ltd., 2013
3. Kotpal RL: Modern Text Book of Zoology Vertebrates; Rastogi Publications, 2007
4. Parker T.J. & Haswell WA: A Text Book of Zoology, Vol II, ed. 7th, Macmillan & Co. Ltd, London, 1962
5. Romer, A.S., T.S. Parsons: Vertebrate Body, Saunders (W.B.) Co Ltd; 5th Revised edition, 1977
6. Young JZ: The Life of Vertebrates, Oxford, 1950

SOLS/ZOO/CZ-8 Biostatistics and Computer Application — 3 Credits [45 Hours]

A. Biostatistics

Unit I. Importance of statistics in biological research; Introduction to some distributions of random variables: Binomial, Poisson, normal; Basic/Descriptive statistics: Measures of central tendency and measures of dispersion**,** Skewness & kurtosis; Simple correlation and linear regression (scatter diagram, regression coefficients, regression lines) [13 Hours]

Unit II. Students-t, chi-square and F-Tests of Significance testing and their purpose; Introduction to Statistical softwares. MS Excel and their purpose [12 Hours]

B. Computer Application

Unit III. Introduction to Computers: Mini, micro, mainframe and super computers; Components of a computer system (CPU, I/O units). Data storage device, Memory concepts [10 Hours]

Unit IV. Software and types of software.
Computer applications in biology and information communications (databases, e-mail and local networks) [10 Hours]

SUGGESTED READINGS

1. Balagurusamy, E.: Fundamentals of Computers, McGraw Hill Education, 2011
2. Khan, Khanum, Shiba Khan: Fundamentals of Biostatistics, Ukaaz Publications, 1994
3. Khanal, A.B.: Mahajan's Methods in Biostatistics, The Health Sciences Publishers, 2015
4. Le, C.T.: Introductory Biostatistics, John Wiley & Sons Publication, 2003
5. Rajaraman, V.: Fundamentals of Computers, 5th edition, PHI Learning Pvt. Ltd., 2010
6. Sinha, P., Sinha, P.K.: Computer Fundamentals: Concepts, Systems and Applications, 8th edition, BPB Publications, 2004
7. Zar, JH.: Biostatistical Analysis, Prentice-Hall/Pearson, 2010

SOLS/ZOO/ LC-3 Lab Course-3 (Based on CZ-7 & CZ-8) [2 Credits]

Chordata

1. Slides of Protochordata, whole mount and cross sections of *Balanoglossus, Herdmania* and *Amphioxus*
2. Museum Specimens: Protochordata, Cyclostomata, Pisces, Amphibia, Reptile, Bird & Mammals.
3. Articulated and disarticulated bones of Frog, Varanus, Carapace & Plastron of Tortoise, Fowl and Rabbit
4. Slides: Scales of fish

Biostatistics and Computer Application

1. Calculation of mean, mode, median from the given data.
2. Calculation of standard deviation, standard error and coefficient of variation from the given data.
3. Calculation of correlation coefficient and regression coefficient from the given data and interpretation of results. Developing regression equation, Drawing the scatter diagram and regression lines and interpretation of results.
4. Calculation of t (paired and unpaired), chi square, and F values from the given data and interpretation of results.
5. Computer components/hardware: Key board, mouse, VDU, CPU, Microprocessor, Hard disk drive, Flash drive, CD ROM drive
6. Computer software: System software (Operating system, BIOS, Device Driver, Assembler, Compiler, Loader), Application software (Word Processing Software, Spreadsheet Software, Enterprise Software, Programming Software), E-mail, LAN, WAN, Statistical calculations with MS Excel.

ELECTIVE COURSE (EZ-2a—EZ-2c)

(Theory-3 Credits; Lab Course-3 Credits)

[Any one]

SOLS/ZOO/EZ-2a. Aquatic Biodiversity 3 Credits [45 Hours]

Unit I. Definition, concept, scope and measurement of biodiversity; Biodiversity loss (causes & effects).
Types of Biodiversity: Species, Genetic, Community, Ecosystem.
Factors governing biodiversity: Historical & proximate [7 Hours]

Unit II. Types of aquatic ecosystem & biomes and their characteristics.
Freshwater biodiversity: Physical and chemical characteristics of freshwater rivers, lakes, reservoirs and wetlands; Over view of freshwater biodiversity in important rivers, lakes, reservoirs and wetlands of India with emphasis on Himalaya.
Introduction to Marine biodiversity.
Biodiversity data bases [15 Hours]

Unit III. Threats to habitats and their conservation.
Endemic species & Endangered species: Definition, concept, scope.
Conservation: Definition, concept, scope.
Ramsar Convention; Physical and chemical characteristics of wetlands.
Over view of biodiversity in Wetlands of India with emphasis on Himalaya [15 Hours]

Unit IV. Impact of Hydroelectric Projects (HEP) on aquatic biodiversity; Environmental Impact Assessment (EIA): Case studies.
Environmental flows: Importance for the aquatic flora & fauna. Environmental flows assessment methodology (Hydrological, hydraulics rating, habitat simulation & holistic). Ecosystem Services: Concept & scope [8 Hours]

SUGGESTED READINGS

1. AlgaeBase, Diatoms of North America, http://www.insecta.bio.spbu.ru/z/faun-eur.htm; FisBase, (https://www.fishbase.se/identification/RegionSpeciesList.php?resultPage=3&e_code=7&SortBy=family; https://aqgrisi.nbfgr.res.in/listing/family/71)
2. Dodds WK: Freshwater Ecology: Concepts and Environmental Applications, Academic Press (2002)
3. Edmondson WT: Freshwater Biology, John Wiley & Sons Inc; 2nd edition (1959)
4. Gaston KJ & JI Spicer: Biodiversity: An Introduction, Wiley-Blackwell, Hoboken (2004)
5. Hynes HBN: Ecology of Running Waters, Blackburn Press (1971)
6. Jhingran VG: Fish & Fisheries of India, Hindustan Pub. Corp., Delhi (1991)

7. Nautiyal et al: Ecology & Diversity of Freshwater Environments Transmedia, Srinagar Garhwal, 2005
8. Nautiyal P & Singh HR: Biodiversity & Ecology of Aquatic Environments. Narendra Publishing House, New Delhi, 2009.
9. Odum EP.: Fundamentals of Ecology, Cengage Learning (2004)
10. Postel Sandra & Brian Richter: Rivers for Life - Managing Water For People And Nature, Island Press (2003)

Lab Course EZ-2a [3 Credits]

1. Sampling and analysis of plankton
2. Sampling and analysis of macrobenthic organisms
3. Determination of mesh size of plankton net and size of plankton
4. Preparation of permanent slides
5. Chlorophyll estimation of periphytic algae
6. Measurement of primary production
7. Study of ecological indices
8. Study of local fish fauna
9. Study of endangered species and protection
10. Study of river habitat and organisms
11. Study of natural pond habitat and organisms

(Candidates will submit a report on field visit to any nearby pond/ lake/ stream/ river during the session)

SOLS/ZOO/EZ-2b. Genetics, Evolution and Taxonomy 3 Credits [45 Hours]

D. Genetics

Unit I. Monohybrid and Dihybrid crosses with molecular explanations; Incomplete and Co dominance, Gene interaction, Lethal alleles, Multiple alleles, Pedigree analysis; Eugenics.
Modification of Dihybrid ratios and their biochemical basis; Fine structure of Gene; Statistical tools (Probability and Significance Testing) [10 Hours]

Unit II. Linkage and Crossing over, Genetic mapping techniques; Sex linked inheritance and genetic disorders; Mutations and chromosomal aberrations.
Operon hypothesis, Lac operon (positive and negative control); Regulation of gene expression in eukaryotes.
Population Genetics: Hardy-Weinberg equilibrium, Genotypic and Allelic frequencies, Inbreeding, Random mating, Genetic drift and gene flow [12 Hours]

E. Evolution

Unit III. Natural Selection: Types of selection and selection coefficient; Role of mutation in evolution (Gene mutation, Mutation Rates, Mutation and selection, Genetic Polymorphism).
Micro and Macroevolution; Genetic drift and gene flow
Animal Distribution: Zoogeographical division of the World (Characteristics and Fauna); Island Biogeography theory.
Palaeontology: Fossils and fossilization, mass extinction, geological time scale; Evolution of Horse; Evolution of Man [10 Hours]

F. Taxonomy

Unit IV. Systematics and Taxonomy: Definition, concepts, history, scope and application of biosystematics; **Principles of Zoological Classification:** Theories of biological classification, hierarchies of categories and the higher taxa.
Concept of Species: Species category, different concepts and intraspecific categories.
Modern trends in taxonomy: Behavioural taxonomy, cytotaxonomy and molecular taxonomy.
Systematics, Types of Taxonomy, Importance of Taxonomy; Theories of biological classification, Linnaean hierarchy.
Nomenclature: ICZN, Taxon, Rank and Categories; Important rules of Nomenclature, Latin words and abbreviations.
Taxonomic characters and taxonomic keys; Preservation of collected material and curating [13 Hours]

SUGGESTED READINGS

1. Allendorf, Fred W., Gordon H. Luikart, Sally N. Aitken (2012). Conservation and the Genetics of Populations, 2nd edition, Wiley-Blackwell
2. Barton, N. H., Briggs, D. E. G., Eisen, J. A., Goldstein, D. B. and Patel, N. H. (2007). Evolution. Cold Spring, Harbour Laboratory Press.

3. Benjamin A. Peirce (2017). Genetics A Conceptual Approach, W.H. Freeman and Company
4. Brown, TA (2020). Gene Cloning and DNA Analysis and Introduction, 8th edition, Wiley-Blackwell
5. Cummings, William S. Klung, Spencer and Palldino (2019). Concepts of Genetics, Pearson Education, Pearson
6. Daniel L. Hartl, Elizabeth W. Jones (2004). Genetics Analysis of Genes and Genomes, 6th edition, Jones and Bartlett Publishers
7. Douglas, J. Futuyma (1997). Evolutionary Biology. Sinauer Associates.
8. Ernst Mayr and PD Ashlock (1991): Principles of Systematic Zoology, McGraw-Hill
9. Gardner, Gimmons and Snustad (2006). Principles of Genetics, 8th edition, John Wiley & Sons.
10. Hall, B. K. and Hallgrimsson, B. (2008). Evolution. IV Edition. Jones and Bartlett Publishers
11. Judith E. Winston (199): Describing Species Practical and Taxonomy Procedure for Biologists, Columbia University Press
12. Kapoor, V.C. (2008): Theory and Practice of Animal Taxonomy, 6th edition, Oxford and IBH Publishing Co. Pvt. Ltd.
13. King, Max (1995). Species Evolution: Role of Chromosomal Change, Cambridge University Press
14. Minkoff, E. (1983). Evolutionary Biology. Addison-Wesley
15. Reece, Jane B. (2011). Campbell Biology, 9th Edition, Pearson
16. Ridley, M. (2004). Evolution. III Edition. Blackwell Publishing
17. Strickberger, M.W. (1989). Evolution, Jones and Bartlett Publishers
18. Tamarin, Robert, H. (2009) Principles of Genetics, Tata McGraw Hill Education Pvt. Ltd.
19. Verma, Ashok (2015): Principles of animal Taxonomy, Alpha Science International Ltd.

Lab Course EZ-2b [3 Credits]

Genetics

1. Genetics problems related to Mendelian inheritance
2. Preparation of Drosophila Polytene Chromosome Squashes

Evolution

1. Evidences of organic evolution
2. Photographs of Evolution
3. Models
4. Fossils

Taxonomy

1. List of animals with common and zoological names
2. List of household pests with common and zoological names
3. Classification of 10 common fish, amphibia, reptiles, bird and mammals
4. Preparation of inventory of roadside trees in the campus

SOLS/ZOO/EZ-2c. Assisted Reproductive Biology Techniques 3 Credits [45 Hours]

Unit I. Scope of mammalian reproductive technologies, Functional anatomy of male and female reproductive system, Induced release of gametes and its significance [10 Hours]

Unit II. Multiple ovulation, superovulation. In-vitro oocyte maturation. Biochemistry of Semen, Semen composition and formation. Assessment of sperm functions. Cryopreservation of gametes and embryos [12 Hours]

Unit III. Intra-cytoplasmic sperm injection, gamete intrafallopian transfer, zygote intrafallopian transfer, In-vitro fertilization, embryo transfer. Transgenic animals and their uses [12 Hours]

Unit IV. Contraception; Immunocontraception: Antibody mediated fertilization block and termination of gestation. Other contraception technologies: surgical methods, hormonal method, physical barrier, IUCD [11 Hours]

SUGGESTED READINGS

1. Allahbadia, Gautam Nand et al.: The Art & Science of Assisted Reproductive Techniques (ART), Jaypee Brothers Medical Publishers (P) Ltd.; 2nd edition (2017)
2. Jones, R.E. And Lopez, K.H: Human Reproductive Biology (Third Edition), Academic Press (2006)
3. Weissman, Ariel, Colin M. Howles, Zeev Shoham: Textbook of Assisted Reproductive Techniques, Volume 1: Laboratory Perspectives, CRC Press (2018)

Lab Course EZ-2c [3 Credits]

1. Study of functional anatomy of male reproductive system with the help of photographs, chart and models
2. Study of functional anatomy of female reproductive system with the help of photographs, chart and models
3. Study of menstrual cycle with the help of photographs, charts and models
4. Study of the histological details of testes, ovary and pituitary with the help of permanent slide, photographs and charts.
5. Physical examination of cryopreserved semen of bull for sperm count
6. Study of sperm motility behaviour of cryopreserved sperm (semen straw may be obtained from nearby veterinary hospital/ artificial semen center)
7. Assessment of sperm functions
8. Thawing of cryopreserved semen straw
9. Transgenic animals and their uses
10. Preparation of chart and model based on theory topics
11. Visit to nearby artificial insemination center of livestock department

(Candidates must produce at the time of practical examination their preparations, collection, practical record books and a report on field visit to artificial insemination center done during the session.)

SOLS/ZOO/LC-4 Lab Course-4 (Based on EZ-2a/ EZ-2b/ EZ-2c)	**[3 Credits]**

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UG (B Sc) Curricular Framework, Department of Chemistry
HNB Garhwal University as per NEP 2020

	Core Paper 6 credits each (4+2)	Additional Inter Disciplinary Paper 4 credit each (2+2)	**SC*** 2credits each
SemesterI	**A Core Paper I (Theory)** (Code:SOS/CHEM/CT-001) Inorganic Chemistry -I Organic Chemistry- I **(Practical)**:(Code: SOS/CHEM/CP-001)	**Additional Inter-Disciplinary Paper-I (Theory)** Code: SOS/CHEM/AID T-I AID-Inorganic Chemistry -I AID-Organic Chemistry- I **Practical:** Code SOS/CHEM/AID P-I	**SC –I** **Code : SOS/CHEM/ SC-I** Basic Analytical Chemistry I OR Green Methods in Chemistry
SemesterII	**Core Paper II (Theory)** (Code:SOS/CHEM/CT-002) Physical Chemistry- I Organic Chemistry-II **(Practical)**:(Code: SOS/CHEM/CP-002)	**AID- Paper II (Theory)** (Code: SOS/CHEM/AIDT-002) AID-Physical Chemistry- I AID-Organic Chemistry-II **(Practical)**: (Code: SOS/CHEM/AIDP-002)	**SC –II** **Code : SOS/CHEM/ SC-II** Basic Analytical Chemistry II or Pesticidal Chemistry
SemesterIII	**Core Paper III (Theory)** (Code:SOS/CHEM/CT-003) Physical Chemistry-II Organic Chemistry-III **(Practical)**:(Code: SOS/CHEM/CP-003)	**AID-Paper III (Theory)** (Code: SOS/CHEM/AIDT-003) AID-Physical Chemistry-II AID-Organic Chemistry-III **(Practical)**: (Code: SOS/CHEM/AIDP-003)	**SC –III** **Code : SOS/CHEM/ SC-III** Basic Analytical Chemistry I OR Green Methods in Chemistry
Semester IV	**Core Paper IV (Theory)** (Code:SOS/CHEM/CT-004) Inorganic Chemistry-II Physical Chemistry- III **(Practical)**:(Code: SOS/CHEM/CP-004)	**AID Paper IV (Theory)** (Code: SOS/CHEM/AIDT-004) AID-Inorganic Chemistry-II AID-Physical Chemistry- III **(Practical)**: (Code: SOS/CHEM/AIDP-004)	**SC –IV** **Code : SOS/CHEM/ SC-IV** Basic Analytical Chemistry II or Pesticide Chemistry

*** Note: Students can opt skill course of chemistry either in 1st Year (1-2 Semester) or in 2nd year (3-4 semester)**

SYLLABUS OF H N B GARHWAL UNIVERSITY AS PER NEP-2020
PROGRAM: B Sc
SUBJECT: CHEMISTRY

1st Year (Semester I)

1. CORE PAPER – I

Title of paper: Inorganic Chemistry –I, Organic Chemistry- I **(Theory)**

(Atomic Structure, Bonding and General Organic Chemistry)

Code: **(SOS/CHEM/CT-001)**

Credits- 04

SYLLABUS:

Section A: InorganicChemistry-1(30 lectures)

Atomic Structure:

Review of: Bohr'stheory and its limitations, dual behaviour of matter and radiation,de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

Quantum mechanics, Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wave functions (atomic orbitals) and their variations for 1*s*, 2*s*, 2*p*, 3*s*, 3*p* and 3*d* orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distributionfunctions and the concept of the most probable distance with special reference to 1*s* and 2*s* atomicorbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers *m* *l*and *ms*.Shapes of *s*, *p* and *d* atomic orbitals, nodal planes. Discovery of spin, spin quantum number (*s*) and magnetic spin quantum number(*ms*).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half- filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Chemical Bonding and Molecular Structure (14 Lectures)

Ionic Bonding*:* General characteristics of ionic bonding *.* Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding*:* VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination for obitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of *s-p* mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

Section B: Organic Chemistry-1 (30 Periods)

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates:Carbocations, Carbanions and free radicals.
Strength of organic acids and bases: Comparative study with emphasis on factor saffecting pK values. Aromaticity: Benzenoids and Huckel's rule.

Stereochemistry (8 lectures)

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; *cis* - *trans* nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E/ Z Nomenclature (for upto two C=C systems).

Aliphatic Hydrocarbons (12 lectures)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). *Preparation:* Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent .*Reactions:* Free radical Substitution: Halogenation.

Alkenes:(Upto 5 Carbons) *Preparation:* Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff'srule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). *Reactions:* cis-addition (alk. KMnO4) and trans-addition (bromine),Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5Carbons) *Preparation:* Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetrahalides and dehydrohalogenation of vicinal-dihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

ReferenceBooks:

Lee,J.D. *Concise Inorganic Chemistry* ELBS,1991.

Cotton,F.A., Wilkinson,G. & Gaus, P.L.*Basic Inorganic Chemistry*,3rd ed.,Wiley.

Douglas,B.E., McDaniel, D.H. & Alexander,J.J. *Concepts and Models in Inorgani cChemistry*,JohnWiley&Sons.

Huheey,J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.

Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).

McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition,2013.

Sykes,P .*A Guide book to Mechanism in Organic Chemistry,* Orient Longman, NewDelhi (1988).

Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.

Finar,I.L. *Organic Chemistry* (Vol. I & II),E.L.B.S.

Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.

Bahl, A. & Bahl, B. S. *Advanced Organic Chemistry,* S. Chand, 2010.

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2. CORE PAPER – I

Title of paper: **Inorganic Chemistry –I, Organic Chemistry- I (Practical)**

(Atomic Structure, Bonding and General Organic Chemistry)

Code: **(SOS/CHEM/CP-001)**

Credits- 02

SYLLABUS:

Section A: Inorganic Chemistry-Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
4. Estimation of Fe(II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu(II) ions iodometrically using $Na_2S_2O_3$.

SectionB:OrganicChemistry

1. Detection of extra elements (N,S,Cl,Br,I) inorganic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)

Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography.

Identify and separate the sugars present in the given mixture by paper chromatography.

ReferenceBooks:

- Svehla, G.*Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham,J.*Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

- Vogel,A.I., Tatchell,A.R., Furnis,B.S., Hannaford,A.J. & Smith,P.W.G., *Text book of Practical OrganicChemistry*, Prentice-Hall, 5th edition, 1996.
- Mann,F.G. & Saunders ,B.C. *Practical Organic Chemistry* Orient-Longman,1960.

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3. ADDITIONAL INTER-DISCIPLINARY PAPER – I

Title of paper: Basic Inorganic Chemistry and Fundamentals of Organic Chemistry (Theory)

Code: (SOS/CHEM/AID T-001)

Credits- 02

SYLLABUS:

Basic Inorganic Chemistry

Atomic Structure

Review of Bohr'stheory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Quantum numbers ,significance of quantum numbers, shapes of s, p and d atomic orbitals.Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals,Anomalous electronic configurations

Chemical Bonding and Molecular Structure

Ionic Bonding*:* General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Born-Haber cycle and its applications.

Covalent bonding*:* VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: InductiveEffect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

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4. ADDITIONAL INTER-DISCIPLINARY PAPER – I PRACTICAL

Title of paper: Basic Inorganic Chemistry and Fundamentals of Organic Chemistry (Practical)

Code: (SOS/CHEM/AID P-001)

Credits- 02

SYLLABUS:

Section A: Inorganic Chemistry-Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.

Section B: Organic Chemistry

1. Detection of extra elements (N,S,Cl,Br,I) inorganic compounds (containing upto two extra elements).

5A. SKILL (CHEMISTRY) PAPER – I

Title of paper: **BASIC ANALYTICAL CHEMISTRY- I**
Code: (SOS/CHEM/SKILL -001)
Credits- 02

SYLLABUS:

Introduction: Introduction to Analytical Chemistry and its inter disciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Analysis of soil: Composition of soil, Concept of pH and pH measurement, Complex ometric titrations, Chelation, Chelating agents, use of indicators.

Determination of pH of soil samples. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water: Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods.

Determination of pH, acidity and alkalinity of a water sample. Determination of dissolved oxygen (DO) of a water sample.
Analysis of food products: Nutritional value of foods, idea about food processing and food preservations and adulteration.
Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc. Analysis of preservatives and colouring matter.

OR

5B. SKILL (CHEMISTRY) PAPER – II

Title of paper: GREEN METHODS IN CHEMISTRY
Code: (SOS/CHEM/SKILL -002)
Credits- 02
SYLLABUS:

1. Introduction: Definitions of Green Chemistry.
2. Brief introduction of twelve principles of Green Chemistry with examples, special emphasis on atom economy, reducing toxicity, green solvents, Green Chemistry and catalysis and alternative sources of energy, Green energy and sustainability
3. The following Real world Casesin Green Chemistry should be discussed:
   Surfactants for carbon dioxide–Replacing smog producing and ozone depleting solvents with CO2 for precision cleaning and dry cleaning of garments.

4. Designing of environmentally safe marine antifoulant.
Rightfit pigment: Synthetic azo pigments to replace toxic organic and inorganic pigments.
An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn.

ReferenceBooks:
Anastas,P.T. & Warner, J.K. *Green Chemistry-Theory and Practical*, Oxford University Press (1998). Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).

1st Year (Semester II)

1. CORE PAPER – II

Title of paper: Physical Chemistry- I, Organic Chemistry-II **(CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY) (Theory)**

Code: (SOS/CHEM/CT-002)

Credits- 04 Theory: 60Lectures

SYLLABUS:

Section A: Physical Chemistry-1 (30Lectures)

Chemical Energetics (10 Lectures)
Review of thermodynamics and the Laws of Thermodynamics.
Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of are action with temperature– Kirchhoff's equation.
Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Chemical Equilibrium:(8 lectures)

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G^{O}, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

Ionic Equilibria : (12 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

SectionB: Organic Chemistry-2 (30Lectures)
Functional group approach for the following reactions (preparations & reactions) to

be studied in context to their structure.

Aromatic hydrocarbons (8 Lectures)
Preparation (Casebenzene): fromphenol, by decarboxylation, from acetylene, from benzene sulphonic acid.
Reactions: (Casebenzene): Electrophilic substitution: nitration, halogenations and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Alkyl and Aryl Halides (8 Lectures)

Alkyl Halides(Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2andSNi)reactions.

Preparation: from alkenes *and* alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides *Preparation:* (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.
Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by–OH group) and effect of nitro substituent. Benzyne Mechanism: KNH_2/NH_3 (or$NaNH_2/NH_3$).
Reactivity and Relative strength of C- Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Alcohols, Phenols and Ethers(Upto 5 Carbons) **(14 Lectures)**

Alcohols: *Preparation:* Preparation of 1^o, 2^o and 3^o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.
Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO4, acidic dichromate, conc. HNO_3). Oppeneauer oxidation *Diols:* (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.
Phenols:(Phenol case) *Preparation:* Cumene hydroperoxide method, from diazonium salts. *Reactions:* Electrophilic substitution: Nitration, halogenations and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten–Baumann Reaction.
Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydesandketones(aliphaticandaromatic):(Formaldehye, acetaldehyde, acetone and benzaldehyde)
Preparation: from acid chlorides and from nitriles.

Reactions– Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

Reference Books:

- Graham Solomon, T.W., Fryhle, C.B. & Dnyder,S.A. *Organic Chemistry,* John

Wiley & Sons(2014).

- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes,P.*A Guide book to Mechanism in Organic Chemistry,* Orient Longman, NewDelh (1988).
- Finar,I.L. *Organic Chemistry* (Vol.I & II), E.L.B.S.
- Morrison,R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl,A. & Bahl,B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
- Barrow,G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan,G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz,J.C., Treichel,P.M. & Townsend,J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., NewDelhi (2009).
- Mahan,B.H. *University Chemistry* 3rd Ed. Narosa (1998).
- Petrucci,R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co. :NewYork (1985).

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2. CORE PAPER – II Practical

Title of paper: **Physical Chemistry- I, Organic Chemistry-II (CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY) (Practical)**

Code: **(SOS/CHEM/CP-002)**

Credits- 02

SYLLABUS:

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts(KNO_3,NH_4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of *H*.

Ionic equilibria :

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.

b) Preparation of buffer solutions:

(i) Sodium acetate-acetic acid

(ii) Ammonium chloride-ammonium hydroxide

Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.

3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.

(a) Bromination of Phenol /Aniline
(b) Benzoylation of amines /phenols
(c) Oxime and 2,4-dinitrophenyl hydrazone of aldehyde/ketone

Reference Books

- Vogel,A.I., Tatchell,A.R., Furnis,B.S., Hannaford,A.J. & Smith,P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann,F.G. & Saunders,B.C. *Practical Organic Chemistry* Orient-Longman,1960.
- Khosla,B.D.; Garg,V.C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co. New Delhi(2011).

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3. ADDITIONAL INTER- DISCIPLINARY PAPER – II THEORY

Title of paper: CHEMICAL ENERGETICS & ORGANIC CHEMISTRY (Theory)
Code: (SOS/CHEM/AID T-002)
Credits- 02

SYLLABUS:

Section A: Physical Chemistry-1
Chemical Energetics

Concept of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature–Kirchhoff' sequation.
Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Section B: Organic Chemistry
Aliphatic Hydrocarbons:

Alkanes:(Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent.
Reactions:Free radical Substitution:Halogenation.

Alkenes: (Upto5Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff'srule); cisalkenes (Partial catalytic hydrogenation)and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5Carbons) Preparation, Reactions:formation of metal acetylides, addition of bromine and alkaline $KMnO_4$,ozonolysis and oxidation with hot alk. $KMnO_4$.

4. ADDITIONAL INTERDISCIPLINARY PAPER – II PRACTICAL

Title of paper: **CHEMICAL ENERGETICS & ORGANIC CHEMISTRY (Practical)**
Code: **(SOS/CHEM/AID P-002)**
Credits- 02

SYLLABUS:

Section :A Inorganic Chemistry

Qualitative analysis of inorganic mixtures:Not more than four ionic species(two anion s and two cations.

Section :B Organic Chemistry :

Systematic Qualitative Organic Analysis of Organic Compounds possessing mono functional groups(-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

5C. SKILL (CHEMISTRY) PAPER – III

Title of paper: **BASIC ANALYTICAL CHEMISTRY- II**
Code: **(SOS/CHEM/SKILL-003)**
Credits- 02

SYLLABUS:

Chromatography: Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.

Paper chromatographic separation of mixture of metal ion ($Fe^{3+}$and Al^{3+}).
To compare paints amples by TLC method.
Ion-exchange: Column, ion-exchange chromatography etc.

Determination of ion exchange capacity of anion / cation exchangers in (using batch procedure if use of column is not feasible).

Analysis of cosmetics: Major and minor constituents and their function. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Reference Books:

Willard,H.H., Merritt,L.L., Dean,J. & Settoe,F.A. *Instrumental Methods of Analysis*. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California,USA,1988.

Skoog,D.A. Holler F.J.& Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.

Skoog,D.A.; West,D.M. & Holler,F.J. *Fundamentals of Analytical Chemistry 6th Ed.,* Saunders College Publishing, FortWorth (1992).

Harris,D.C. *Quantitative Chemical Analysis*, W.H. Freeman. Dean , J.A. *Analytical Chemistry Note book*, McGraw Hill.
Day, R. A. & Underwood, A.L. *Quantitative Analysis*, Prentice Hall of India. Freifelder, D. *Physical Biochemistry 2nd Ed.* ,W .H. Freeman and Co., N.Y.USA (1982). Cooper, T.G. *The Tools of Biochemistry,* John Wiley and Sons, N.Y.USA. 16 (1977).

Vogel,A.I. *Vogel's Qualitative Inorganic Analysis 7th Ed.,* Prentice Hall.

Robinson,J.W. *Undergraduate Instrumental Analysis 5th Ed.,* Marcel Dekker, Inc., New York (1995).

OR

5D: **SKILL (CHEMISTRY) PAPER –IV**
Title of paper: **PESTICIDE CHEMISTRY**
Code: **(SOS/CHEM/SKILL-004)**
Credits- 02
SYLLABUS:

General introduction to pesticides (natural and synthetic), Types : Insecticides, Herbicides, benefits and adverse effects, changing concepts of pesticides, structure activity relationship. Biopesticides, uses and future perspectives
Pesticidal poisoning, synthesis and technical manufacture and uses of representative pesticides in the following classes:
Organochlorines: Gammexene, Organophosphates(Malathion, Parathion, pyrethroids), Carbamates (Carbofuran and carbaryl); Quinones. Pheromones, repellents and rodenticides.

ReferenceBook:
Cremlyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, NewYork,1978

2ND Year (Semester III)

1. CORE PAPER – III (Theory)

Title of paper: Physical Chemistry-II, Organic Chemistry-III
(SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II) **(Theory)**
Code: **(SOS/CHEM/CT-003)**
Credits- 04
SYLLABUS:

Section A: Physical Chemistry (30 Lectures)

Solutions (8 Lectures)

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law– non- ideal solutions. Vapour pressure- composition and temperature-composition curves of ideal and non ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Phase Equilibrium (8 Lectures)

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points(lead-silver,$FeCl_3$-H_2O and Na-K only).

Conductance

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Electrochemistry (6 Lectures)

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: G, H and S from EMF data.
Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.
pH determination using hydrogen electrode and quinhydrone electrode.

Potentiometric titrations –qualitative treatment(acid-base and oxidation-reduction only).

Section B: Organic Chemistry-3(30Lectures)

Functional group approach for the following reactions(preparations& reactions) to be studied in context to their structure.

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic) *Preparation:* Acidic and Alkaline hydrolysis of esters. *Reactions:* Hell–Vohlard-Zelinsky Reaction.

Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) **(6 Lectures**)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. *Reactions:*Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts (6 Lectures)

Amines (Aliphatic and Aromatic):(Upto5carbons)

Preparation: from alkylhalides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO_2, Schotten –Baumann Reaction. Electrophilic substitution (caseaniline): nitration, bromination, sulphonation.

Diazoniumsalts: *Preparation:* from aromatic amines. R*eactions:* conversion to benzene, phenol, dyes.

Amino Acids, Peptides and Proteins (10 Lectures)

Preparation of AminoAcids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of Amino acids: ester of –COOH group, acetylation of–NH_2 group, complexation with Cu^{2+}ions, ninhydrin test.

Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins.

Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid-phase synthesis.

Carbohydrates (8 Lectures)

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

ReferenceBooks:

- Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).

- Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa(2004).
- Kotz,J.C., Treichel, P.M. & Townsend,J.R. *General Chemistry*, Cengage Learning India Pvt. Ltd. :NewDelhi (2009).
- Mahan,B.H. *University Chemistry*, 3rd Ed. Narosa (1998).
- Petrucci,R.H. *General Chemistry*, 5th Ed., Macmillan Publishing Co. :NewYork(1985).
- Morrison,R. T. & Boyd,R.N. *OrganicChemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar,I.L. *Organic Chemistry* (*Volume 1*),Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar,I.L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd. (PearsonEducation).
- Nelson,D.L. & Cox, M.M.*Lehninger's Principles of Bioch*emistry *7th Ed.,* W.H. Freeman.
- Berg,J.M., Tymoczko,J.L. & Stryer,L. *Biochemistry*, W.H. Freeman, 2002.

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4. **Title of paper:** Physical Chemistry-II, Organic Chemistry-III **(SOLUTIONS, PHASE EQUILIBRIUM, CONDUCTANCE, ELECTROCHEMISTRY & FUNCTIONAL GROUP ORGANIC CHEMISTRY-II)** **(Practical)**
Code: **(SOS/CHEM/CP-003)**
SYLLABUS:

Section A: Physical Chemistry

Distribution

Study of the equilibrium of one of the following reactions by the distribution method:

$I_2(aq)+I^-(aq) I_3^-(aq)$

$Cu^{2+}(aq)+xNH_2(aq)[Cu(NH_3)x]^{2+}$

Phase equilibria

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.

b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.

c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Conductance

I. Determination of cell constant

II. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.

III. Perform the following conductometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs. strong base

Potentiometry

Perform the following potentiometric titrations:

i. Strong acid vs. strong base

ii. Weak acid vs . strong base

iii. Potassium dichromate vs. Mohr's salt

SectionB: Organic Chemistry

I Systematic Qualitative Organic Analysis of Organic Compounds possess in mono functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

II

1. Separation of amino acids by paper chromatography
2. Determination of the concentration of glycine solution by formylation method.
3. Titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. Differentiation between a reducing and a non reducing sugar.

ReferenceBooks:

- Vogel,A.I., Tatchell,A.R., Furnis,B.S., Hannaford,A.J. & Smith,P.W.G., *Text book of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
- Mann,F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman,1960.
- Khosla,B. D. ;Garg,V.C. & Gulati,A. *Senior Practical Physical Chemistry,* R. Chand & Co.: NewDelhi (2011).
- Ahluwalia,V.K. & Aggarwal,R. *Comprehensive Practical Organic Chemistry,* Universities Press.

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3. AID PAPER – III (Theory)

Title of paper: **Chemical Equilibrium and Aromatic Hydrocarbon (Theory)**

Code: **(SOS/CHEM/AID T-003)**

Credits- 04

SYLLABUS:

Section A: Physical Chemistry-1

Chemical Equilibrium:

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between G and G^{o}, LeChatelier's principle. Relationships between *Kp, Kc* and *Kx* for reactions involving ideal gases.

Ionic Equilibria:

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization,ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Section :B Organic Chemistry

Aromatic hydrocarbons
Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.
Reactions: (Case benzene): Electrophilic substitution: nitration, halogenations and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkylbenzenes (upto 4 carbons on benzene).

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4. AID PAPER – III (Practical)

Title of paper: **Chemical Equilibrium and Aromatic Hydrocarbon (Practical)**
Code: **(SOS/CHEM/AID P-003)**
Credits- 02
SYLLABUS:

Physical Chemistry
Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

Organic Chemistry :

1. Determination of melting and boiling points.
2. Preparation of :

(a) m- di- nitrobenzene from benzene
(b) p- nitro acetanilide from acetanilide

References

Cann,M.C. & Connely,M.E. *Real-World casesin Green Chemistry*, American Chemical Society, Washington (2000).

Ryan,M.A. & Tinnesand,M. *Introduction to Green Chemistry*, American Chemical Society, Washington (2002).

Sharma,R.K.; Sidhwani,I.T. & Chaudhari,M.K. *Green Chemistry Experiments: A monograph* I.K.I nternational Publishing House Pvt Ltd. New Delhi, Bangalore.
Lancaster, M. *Green Chemistry: An introductory text* RSC publishing, 2nd Edition.
Sidhwani,I.T., Saini,G., Chowdhury,S., Garg,D.,Malovika, Garg,N. Wealth from waste:
A green method to produce biodiesel from waste cooking oil and generation of useful products from Waste further generated *"A Social Awareness Project", Delhi University Journal of Undergraduate Research and Innovation*, **1(1)**: 2015.

2ND Year (Semester IV)

1. CORE PAPER – IV (Theory)

Title of paper: **Inorganic Chemistry-II, Physical Chemistry- III (COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS) (Theory)**

Code: **(SOS/CHEM/CT-004)**

Credits- 04

SYLLABUS: Theory: 60 Lectures

Transition Elements (3dseries) (12 Lectures)

General group trends with special reference to electronic configuration,
Variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states(Latimer diagrams) for Mn, Fe and Cu.
Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Coordination Chemistry (8 Lectures)

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6.
Drawbacks of VBT. IUPAC system of nomenclature.

Crystal Field Theory (10 Lectures)

Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for O_h and T_h complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

Section B: Physical Chemistry-3 (30 Lectures)

Kinetic Theory of Gases (8 Lectures)

Postulates of Kinetic Theory of Gases and derivation of the kinetic gasequation.
Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. Vander Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from vander Waals equation. Andrews isotherms of CO_2.
Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation–derivation not required) and their importance.
Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

Liquids (6 Lectures)
Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

Solids (8 Lectures)
Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Kinetics (8 Lectures)
The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reactionrates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants).Half–life of a reaction.General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation.
Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories(qualitative treatment only).

ReferenceBooks:

- Barrow,G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
- Castellan,G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
- Kotz,J.C., Treichel,P.M. & Townsend,J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., NewDelhi (2009).
- Mahan,B.H. *University Chemistry* 3rd Ed .Narosa (1998).
- Petrucci,R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
- Cotton,F.A. & Wilkinson,G. *Basic Inorganic Chemistry,* Wiley.
- Shriver,D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
- Wulfsberg,G. *Inorganic Chemistry,* Viva Books Pvt. Ltd.
- Rodgers,G.E. *Inorganic & Solid State Chemistry,* Cengage Learning India Ltd. ,2008.

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2. CORE PAPER – IV (Practical)

Title of paper: **Inorganic Chemistry-II, Physical Chemistry- III COORDINATION CHEMISTRY, STATES OF MATTER & CHEMICAL KINETICS (Practical)**

Code: **(SOS/CHEM/CP-004)**

Credits- 02

SYLLABUS:

Section A: Inorganic Chemistry

Semi- micro qualitative analysis using H_2S of mixtures-not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations:NH_4^+,Pb^{2+},Ag^+,Bi^{3+},Cu^{2+},Cd^{2+},Sn^{2+},Fe^{3+},Al^{3+},Co^{2+}, Cr^{3+},Ni^{2+},Mn^{2+},Zn^{2+}, Ba^{2+},Sr^{2+},Ca^{2+},K^+

Anions: CO_3^{2-}, S^{2-}, SO^2 ,$S_2O_3^{2-}$, NO^{3-}, CH_3COO^-, Cl^-, Br^-, I^-, NO^{3-}, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2-}$, F^-.

(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato)nickel (II) or aluminium as oximate in a given solution gravimetrically.

2. Draw calibration curve (absorbance at λ_{max} vs. concentration) for various concentrations of a given coloured compound ($KMnO_4$/ $CuSO_4$) and estimate the concentration of the same in a given solution.

3. Determine the composition of the Fe^{3+}-salicylic acid complex solution by Job's method.

4. Estimation of (i) Mg^{2+}or (ii) $Zn^{2+}$by complexometric titrations using EDTA.

5. Estimation of total hardness of a given sample of water by complexometric titration.

6. Determination of concentration of Na^+ and K^+ using Flame Photometry.

Section B: Physical Chemistry

(I) Surface tension measurement (use of organic solvents excluded).

a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

b) Study of the variation of surface tension of a detergent solution with concentration.

(II) Viscosity measurement (use of organic solvents excluded).

a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

b) Study of the variation of viscosity of an aqueous solution with concentration of solute.

(III) Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethylacetate.
   c. Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methylacetate.

Reference Books:

- Svehla,G.*Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
- Mendham,J.*Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- Khosla,B.D.; Garg,V.C. & Gulati,A. *Senior Practical Physical Chemistry,* R.Chand & Co.: NewDelhi (2011).

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3. AID PAPER –IV (Theory)

Title of paper: **Physical and Inorganic Chemistry (Solutions, S and P block Elements) (Theory)**

Code: **(SOS/CHEM/AID T-004)**

Credits- 02

SYLLABUS:

Section A: Physical Chemistry

Solutions

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law-non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.

Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Section B: Inorganic chemistry

Chemistry of S and P blocks elements:

General characteristics, anomalous behavior, diagonal relationship and role of sodium and potassium ions in biological systems. Oxides of boron, allotropic forms of carbon, carbides, silicates and fertilizers.

Fullerenes and poly halides.

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4. AID PAPER –IV (Practical)

Title of paper: **Physical and Inorganic Chemistry (Solutions, S and P block Elements) (Practical)**

Code: **(SOS/CHEM/AID P-004)**

Credits- 02

SYLLABUS:

Physical Chemistry

Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoo stop revent damage to the glass electrode) using pH-meter.

Organic Chemistry

1. Separation of amino acids by paper chromatography.
2. Differentiation between a reducing and a nonreducing sugar.
3. Determination of COD /BOD and DO of water samples.

Skill (Chemistry)

Note: Skill paper of 1st semester and 3rd semester (Basic Analytical Chemistry I OR Green Methods in Chemistry) and skill of 2nd semester and 4th semester (Basic Analytical Chemistry II or Pesticidal Chemistry) will be the same

DEPARTMENT OF MATHEMATICS

H N B GARHWAL UNIVERSITY (A CENTRAL UNIVERSITY) SRINAGAR-246174

NEP-2020

Syllabus

BACHELOR'S DEGREE PROGRAMME (4YEARPROGRAMME) WITH HONOURS/RESEARCH (SCIENCE)

FirstYear-Semester-I

Semester-I			
Major Subjects	**Credits**		**Comments**
Core Subject-1(CS-1)	**6**	**Major Paper-I(CS-1)** Differential Calculus (Theory-1)	**University with are different subject groups.** **University with the recommendation and suggestions of Deans and Heads will declare the list of subjects withinaspecificgroup.Bothmajorpaperscouldbeselectedbyastudentfromanyone group.** **Total credits of Major Papers = 12 credits**
Core Subject-2(CS-2)	**4+2**	**Major Paper-I(CS-2)** Theory-1 Practical-1	
Additional/ Interdisciplinary subject/Multidisciplinary	**4** **Or** **2+2**	**Additional Course-IPart1 (Theory Minor with or without Practical Interdisciplinary/Multidisciplinary-1)** Basic Calculus	**Thiscoursewillbeoptedfromoutsidethealreadyselectedcoresubjects In case of inter disciplinary course for science subjects, Each department will prepare a minor paper based on its core major paper which can be opted bystudentsasadditionalminorsubject.(Coremajorandadditionalinterdisciplinary cannotbeoptedfromsamesubject).Multidisciplinarycoursecanbeoptedbythestud entsfromaBasketofmultidisciplinarycoursesforwhicheachdepartmentwillcontri buteandprepare at least 2 MDCs. Students will have to opt 2 MDCs of same subject in1st and2nd semesteror3rd and4th semester.**
Skill Course	**2**	**One Skill/Vocational Course-I** Integral Calculus	**Skill courses of one major subject (Either CS-1 or CS-2) has to bepursuedinbothsemestersi.e.(I &IIandofanothersubjectinIII &IVsemester)**

Extra curricular Courses/CC	2	1- **UnderstandingandconnectingwithEnvironment**	**Universitywillprepareacoursewithfocusonconnectingstudentwithenvironment.Tomakestudentmoreenvironmentsensitive.**
Total	**20**		
Note:Eachadditional/multidisciplinarycoursewillonlybeoftwosemesters.Thecourseoptedbyastudentinfirstsemesterwillbecontinuedinthesecondsemester.Thestudentwillhavethechoicetoselectanother Multidisciplinarycourseinthirdsemesterwhich willagainbecontinuedinfourthsemester.			

FirstYear-Semester-II

Semester-II			
MajorSubjects	**Credits**		**Comments**
Core Subject-1(CS-1)	**6**	**MajorPaper-II (CS-1)** Differential Equations (ODE & PDE) (Theory-1)	**Universitywillhavedifferentsubjectgroups.** **Universitywiththerecommendationandsuggestionsof DeansandHeadswilldeclarethelistofsubjects withinaspecificgroup. Bothmajorpaperscouldbeselectedbyastudentfromanyone group.TotalcreditsofMajorPapers=12credits**
Core Subject-2(CS-2)	**4+2**	**MajorPaper-II-(CS-2)** Theory-1 Practical-1	
Additional/Interdisciplinarysubject/Multidisciplinary	**4 Or 2+2**	**Additional Course-IPart-2** **Theory Minor with orwithout Practical(Interdisciplinary/Multidisciplinary-1contd.)** Basic Differential Equations	**Incaseofadditionalinterdisciplinarycourse,part2ofsamesubjectwhichisopted bystudentin1st semesterwillbecontinued.** **Multidisciplinarycourseof onesubject optedbythestudentin1st semesterasPart1willbecontinuedinsecond semesterasPart2**
SkillCourse	**2**	**OneSkill/ VocationalCourse-I** Vector Calculus	**Skillcourseofonemajorsubjecthas to bepursuedinbothsemesters i.e.(I &IIandofanothersubjectinIII &IV semester)**
LifeSkillsandpersonalitydevelopment/CC	2	LifeSkillsandpersonalitydevelopment	**University will prepare the course on Life skills and personalitydevelopment,whichwill focusonthe subjectssuch asstressmanagementthroughYoga,teamwork,cooperation,workethics andpersonalitydevelopmentissues.**
Total	**20**		
Note:	**Incaseofexitaftercompletionoffirstyear/secondsemester,studentwillbeawardedCertificateonthebasisofCore andvocationalpapersstudiedbyhim.Nomenclaturewillbegivenwithsyllabusofeach subject.Awardofcertificateissubject tofulfilmentoftheconditionsaslaiddowninNHEQF**		

For Example: Under Graduate Certificate course inLife Science (Zoology and Botany)/Under Graduate Certificate course inSciences(PhysicsandChemistry/ Physicsand Maths)/UnderGraduate Certificatecourse inEarth Sciences(Geology andGeography)

SecondYear-Semester-III

Semester-III			
MajorSubjects	**Credits**		**Comments**
Core Subject-1(CS-1)	**6**	**MajorPaper-III(CS-1)** Real Analysis (Theory-1)	**Universitywillhavedifferentsubjectgroups.** **Universitywiththerecommendationandsuggestionsof DeansandHeadswilldeclarethelistofsubjects withinaspecificgroup. Bothmajorpaperscouldbeselectedbyastudentfromanyone group.TotalcreditsofMajorPapers=12credits**
Core Subject-2(CS-2)	**4+2**	**MajorPaper-III-(CS-2)** Theory-1 Practical-1	
Additional/Interdisciplinarysubject/Multidisciplinary	**4 Or 2+2**	**AdditionalCourse-IPart 3** **TheoryMinorwithorwithoutPractical (Interdisciplinary/Multidisciplinary-2)** Ancient Indian Mathematics	**Incaseofadditionalinterdisciplinarycourse,part3ofsamesubjectwhichisopted bystudentin1st semesterwillbecontinued.** **Multidisciplinarycoursewillbeoptedbythestudentin3rd semesterfromanothersubject(Outofcoresubjects)**
SkillCourse	**2**	**OneSkill/VocationalCourse-II**	**Skillcourseofanothersubject(CS-1 orCS-2)willbepursuedin3rd and4th semester .**
IKS-1	2	**IndianKnowledgeSystem-I**	**CompulsoryforallU.G.students**
Total	**20**		
Note:Eachmultidisciplinarycoursewillonlybeoftwosemesters.Thecourseoptedbyastudentinfirstsemesterwillbecontinuedinthesecondsemester. Thestudentwillhavethechoicetoselectanother Multidisciplinarycourseinthirdsemesterwhichwillagainbe continuedinfourthsemester.			

SecondYear-Semester-IV

Semester-IV			
MajorSubjects	**Credits**		**Comments**
Core Subject-1(CS-1)	**6**	**MajorPaper-IV(CS-1)** Abstract Algebra-1 (Theory-1)	**Universitywillhavedifferentsubjectgroups.** **UniversitywiththerecommendationandsuggestionsofDeansandHeadswilldeclarethelistofsubjectswithinaspecificgroup.** **Bothmajorpaperscouldbeselectedbyastudentfromanyone group.TotalcreditsofMajorPapers=12credits**
Core Subject-2(CS-2)	**4+2**	**MajorPaper-IV-(CS-2)** Theory -1 Practical-1	
Additional/Interdisciplinarysubject/Multidisciplinary	**4 Or 2+2**	**AdditionalCourse-IPart 4 TheoryMinorwithorwithoutPractical (Interdisciplinary/Multidisciplinary-2contd..)** Basic Statistics	**Incaseofadditionalinterdisciplinary course,part4ofsamesubjectwhichisopted bystudentin1st semesterwillbecontinued.** **SubjectoftheMultidisciplinarycourseoptedbythestudentin3rd semesterwillbecontinuedin4th semesterasPart2**
SkillCourse	**2**	**OneSkill/ VocationalCourse-II contd…**	**Skillcourseof3rd semesterwillbecontinuedin4th semesteraspart2.**
IKS-2	2	**IndianKnowledgeSystem-II**	**CompulsoryforallU.G.students**
Total	**20**		
Note:Eachmultidisciplinarycourse willonlybe oftwo semesters.The course optedbya studentin3rdsemesterwillbecontinuedinthe 4thsemester.			

CompulsoryCommunityconnectCourse

Student will have to qualify a Compulsory Community Connect/Social Service Program/ Minimum 16 hours of service within anysemester(ItoIV).Thiscourseswillbebasedoncommunityconnect,swaachbharat,ekbharatshrestrabharat,NSS etc.It willbebasedonnumberofhoursdevotedunderthiscourse.Concerned departmentwillverify thefulfilmentofminimumhourstowardsCCS.

After completion of 2 years of study, if student opts exit then a Diploma will be awarded subject to fulfilment of the conditions as laid down inNHEQF. Nomenclature of Diploma course will be given in syllabus of each subject. For Example: Under Graduate Diploma course inLifeScience (Zoology and Botany)/Under Graduate Diploma course inSciences (Physics and Chemistry/ Physics and Maths)/ Under GraduateDiplomacourse inEarthSciences(GeologyandGeography)

ThirdYear-Semester-V

Semester-V			
MajorSubjects	**Credits**		**Comments**
Core Subject-1(CS-1)	**4+2**	**MajorPaper-V (CS-1)** Linear Algebra (Theory-1 Practical-1)	**Majorpapersof samecoresubjectsasoptedby studentwillcontinued.**
Core Subject-2(CS-2)	**4+2**	**MajorPaper-V-(CS-2)** Theory-1 Practical-1	
Vocational Course/FieldVisit/ Entrepreneurshipskills	4	**Vocational course/FieldVisit/ Entrepreneurship/Academic-Industry interfaceCourse**	**(Related to any one major either CS-1 or CS-2) A VocationalCourse can be framed/ opted by the department. (OR) Fieldvisits could be conducted for students as per requirement oftheircorepapers.IncaseofField/industrialvisits, theStudent willhavetosubmit abriefreport at theendofthesemester.**
ExtracurricularCourses/Compulsorycourse	2	**Culture, traditions andmoralvalues**	**Universitywillprepareacoursewithfocusonindian/Regionalculture studies.**
Languages-I	2	**Indian, Modern, RegionalLanguage-I**	**Aim of the course- to help student to learn new languages(Focusingmainlyongrammar). Studentwillhavetheoptiontostudy any two languages in two semesters separately.(Hindi/Sanskrit/English/anyotherlanguageasproposed bythe university)**
Total	**20 credits**		
Note:Studentwillhavetheoptiontostudyonelanguage(Indian,ModernorRegionalasperhis/herchoice)inonesemesterand anotherlanguageinthesubsequentsemester.			

ThirdYear-Semester-VI

Semester-VI			
MajorSubjects	**Credits**		**Comments**
Core Subject-1(CS-1)	**4+2**	**DSE-Paper(CS-1)** Complex Analysis (Theory-1)	**Department will prepare a basket of Discipline specific Elective courses (3-4). Anyone will beselectedbystudentinthissemester.**
Core Subject-2(CS-2)	**4+2**	**DSE-Paper(CS-2)** Theory-1 Practical-1	
Vocational Course/FieldVisit/ Entrepreneurshipskills Basedon: eitherCS-1orCS-2	4	**Vocational course/FieldVisit/ Entrepreneurship/Academic-Industry interfaceCourse**	**(Related to any one major either CS-1 or CS-2) A VocationalCourse can be framed/ opted by the department. (OR) Fieldvisits could be conducted for students as per requirement oftheir core papers. In case of Field/industrialvisits, theStudentwillhaveto submitabriefreportattheendofthe semester.**
Communicationskills/CC	**2**	**Communicationskill Course (Basedondevelopingsofts kills)**	**Universitywillprepare communicationcoursesinModern/Indian languages from which student will select onelanguagecourse. Thecoursewillbemoreonappliedsidewith givingstudentsachancetodeveloptheirsoft skills.**
Languages-II	2	**Indian, Modern, RegionalLanguage-II**	**Aim of the course- to help student to learn new languages(Focusingmainlyongrammar). Studentwillhavetheoptionto study any two languages in two semesters separately.(Hindi/Sanskrit/English/anyotherlanguageasprop osedby theuniversity)**
Total	**20**		
Note: Student will have the option to study one language (Indian, Modern or Regional as per his/her choice) in one semester and another languageinthe subsequent semester.			

IncaseofExitafter3rd yearGraduatedegreewillbeawarded (Example-BSc)(Credits-120)

FourthYear-Semester-VII(withResearch)

Semester-VII			
MajorSubject(OneOnly)			
	3+3+2 **OR** **4+4**	**MajorPapers-2with3crediteachand 1 Practicalbasedonbothpaperswith2credits(Practicalsubjects)** **OR** **Majorpapers - 2of4creditseachfornonpracticalsubject(Maths/Statistics)** **Major Paper –I: Numerical Analysis** **Major Paper –II: Integral Transforms**	**Theses papers will be based on core subject selected bythestudentsforPGandResearch(Zoology/Botany.Physics/Chemistry/Maths,etc.)**
ResearchMethodology	**4**	**ResearchMethodology**	Studentwilllearnthebasicresearchmethodologywithfocus on data analysis which he/she could apply in research-based work that he/she will carry out in VIII semester. **Eachdepartmentwillprepareitssyllabusbasedontheir subjectrequirements**
Electivepaper	**3+3**	**Electivepaper 1 Theoryand1Practical(3creditseach) OR 2 Elective Theory papers for Nonpracticalsubject.** **Paper-I: Metric Space** **Paper-II: Financial Mathematics** **Paper III: Mathematical Statistics** **Paper IV: Fluid Dynamics** **Paper V: Number Theory**	**Studentwillhavetoselectelectivepapersfromthebasket prepared by each department for this purpose.ThesepapersmaybeDSEs**
Researchwriting andEthics	**2**	**1-Researchwriting andresearchEthics**	
Total	**20**		

FourthYear-Semester-VIII(withResearch)

Semester-VIII			
MajorSubject(OneOnly)			
	3+3+2 OR 4+4 .0.	MajorPapers-2with3crediteachand 1Practicalbasedonbothpaperswith2credits(Practicalsubjects) OR Majorpapers - 2of4creditseachfornonpracticalsubject(Math s/Statistics) Paper-I: Discrete Mathematics Paper-II: Operations Research-1	Theses papers will be based on core subject selected bythestudentsforPGandResearch(Zoology/Botany.Physics/Che mistry/Maths,etc.)
Researchpresentationskills	2	ResearchPaperpresentationskills (OralandPoster)	.Compulsory
Electivepaper	3+3	Electivepaper 1Theoryand1Practical(3creditseach) OR 2 Elective Theory papers for Nonpracticalsubject. Paper-I: Metric Space Paper-II: Financial Mathematics Paper III: Mathematical Statistics Paper IV: Fluid Dynamics Paper V: Number Theory	Studentwillhavetoselectelectivepapersfromthebasket prepared by each department for this purpose.Thesesmaybe DSEs
Dissertation	4	Dissertation/ Researchbased field or industrialreport	Studentwillconductminorresearchworkandwillsubmit thedissertationattheendofsemesterorwilldoresearch
			basedfieldstudy
Total	20		
Afterthecompletionof8semesterswithabovementionedpapersthestudentwillbeawardedU.G.degreewithresearch.Afteravailingthisdegree studentwillhavetheoptionto go foroneyearP.G.Course/PhD			

FourthYear-Semester-VII(Honours)

Semester-VII			
MajorSubject(OneOnly) **MajorCore-**	4+4	MajorPapers- 1 Theoryand1 Practicalwith4 creditseach(Practicalsubjects) OR 2 Theorypapers fornon-practicalsubject(Maths/Statistics,etc) Major Paper –I: Numerical Analysis Major Paper –II: Integral Transforms	Thesespaperswillbebasedoncoresubject selected by the students for PGandResearch(Zoology/Botany.Physics/Chemistry/Maths,etc.)
MajorElective	4	Therewillbe1Majorelectivefromcorepaper Theory andPractical(2+2)OR1Theory (4) Mathematical Statistics	Thesewillbefrommaincorepaper
MinorCore	3	MinorcorePaper(1)of3 credits Metric Spaces (withoutpractical)	Studentwillhavetooptthispaperfrom othersubjectstudiedbyhiminUG1st and2nd year
MinorElective	3	MinorElectivePaper(1)of3credits(without practical) Special Functions	Student will have to opt this paper fromother subject studied by him in UG 1st and2nd year
Researchwriting andethics	2	1.Corepaper	
Total	20credits		

FourthYear-Semester-VIII(Honours)

Semester-VIII			
MajorSubject(OneOnly)			
MajorCore-	**4+4**	**MajorPapers-** **1Theory and1Practicalwith4 creditseach(Practicalsubjects)**	**Thesespaperswillbebasedoncoresubject selected by the students for PGandResearch(Zoology/Botany.Physics/Chemistry/Maths,etc.)**
		OR **3 Theorypapersfornon-practicalsubject(Maths/Statistics,etc)** **Paper-I: Discrete Mathematics** **Paper-II: Operations Research**	
MajorElective	**4**	**Therewillbe1Majorelectivefromcorepaper** **Theory andPractical(2+2)OR1Theory (4)** **Fluid Dynamics**	**Thesewillbefrommaincorepaper**
MinorCore	**3**	**MinorcorePaper(1)of3 credits** **(withoutpractical)** **Number theory**	**Student will have to opt this paper fromother subject studied by him in UG 1st and2nd year**
MinorElective	**3**	**MinorElectivePaper(1)of3credits(wit** **houtpractical)**	**Student will have to opt this paper fromother subject studied by him in UG 1st and2nd year**

		Financial Mathematics	
BasicResearchMethods	**2**	**OneCorepaper**	
Total	**20**		

(Syllabus under NEP-2020)
Session: 2022-23
B.A./B.Sc.(Mathematics) Syllabus
H.N.B. Garhwal University, Srinagar (Garhwal) U. K.

Semester	Core Subject-1	Additional/Interdisciplinarysubject/Multidisciplinary	One Skill/VocationalCourse-I
1	Differential Calculus Credit-06	Basic Calculus	Integral Calculus
2	Differential Equations (ODE & PDE) (Theory-1) (06 Credits)	Basic Differential Equations	Vector calculus
3	Real Analysis Credit-06 (Theory-05+Tutorial-01)	Ancient Indian Mathematics	
4	Abstract Algebra Credit-06 (Theory-05+Tutorial-01)	Basic Statistics	
5	Linear Algebra (Theory-1 Practical-1) (06 Credit)		
6	Complex Analysis (Theory-1)		

FourthYear(withResearch)

Semester	MajorSubject Core	ResearchMethodology	Elective Papers
7	Major Paper–I: Numerical Analysis (04-Credit) Major Paper–II: Integral Transforms (04-Credit)	Paper I: ResearchMethodology (04-Credit) Paper II: Researchwriting andEthics (02-Credit)	Paper-I: Metric Space Paper-II: Financial Mathematics Paper III: Mathematical Statistics Paper IV: Fluid Dynamics Paper V: Number Theory
8	Paper-I: Discrete Mathematics Paper-II: Operations Research-1		Paper-I: Metric Space Paper-II: Financial Mathematics Paper III: Mathematical Statistics Paper IV: Fluid Dynamics Paper V: Number Theory

FourthYear(Honours)

Semester	MajorSubjectCore	Major Elective	Minor Core	Minor Elective
7	Major Paper–I: Numerical Analysis (04-Credit) Major Paper–II: Integral Transforms (04-Credit)	Mathematical Statistics (04 Credit)	Metric Spaces (03 Credit)	Special Functions (03 Credit)
8	Paper-I: Discrete Mathematics Paper-II: Operations Research-1	Fluid Dynamics (04 Credit)	Number theory (03 Credit)	Financial Mathematics (03 Credit)

Semester-I

CS-1: Differential Calculus (04+02 Credits)

Theory (04-Credits)

Unit-I: Limit and Continuity (ε and δ definition), Types of Discontinuities, Differentiability of functions, Rolle's theorem, Lagrange's Mean Value theorems, Cauchy Mean Value Theorem.

Unit-II: Successive differentiation, Leibnitz's theorem, Taylor's theorem with Lagrange's and Cauchy's forms ofremainder, Taylor's series, Maclaurin's series of sin x, cos x, e^x, log(l+x), $(1+x)^m$

Unit-III: Indeterminate forms. Partial Differentiation, Euler's Theorem for Homogeneous function, Maxima and Minima of Functions of Two Variables.

Unit-IV: Tangents and normal, Curvature. Asymptotes, Singular Points, Tracing of Curves in Cartesian and PolarCoordinates.

Practical (02-Credits)

Unite-V: Learning of Graphical Tolls (MATLAB/MATHEMATICA/DESMOS/GEOGEBRA).
Unite-VI: Applicationsof Limit, Continuity, Differentiability, Mean Value theorems, Expansion of Functions, Maxima and Minima, Tangent and Normal, Tracing of Curves.

Books Recommended

1. H. Anton, I. Bivens and S. Davis,*Calculus*, John Wiley and Sons, Inc., 2011.
2. G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education,2007.

Additional/Interdisciplinarysubject/Multidisciplinary

Basic Calculus (04- Credits)

Unite-I: Limit, Continuity and Differentiability
Unite-II: Rolle's Theorem, Lagrange's Mean Value theorems, Cauchy Mean Value Theorem.Expansion of functions, Taylor's and Maclaurin'sSeries of Functions.

Unit-III: Indeterminate Forms. Partial Differentiation, Euler's Theorem for Homogeneous Function,

Unit-IV: Maxima and Minima of Functions of two variables. Tangents and Normal.

Books Recommended

- H. Anton, I. Bivens and S. Davis, *Calculus*, John Wiley and Sons, Inc., 2011.
- G.B. Thomas and R.L. Finney, *Calculus*, Pearson Education,2007.
- Tom M. Apostol, Calculus Vol. I, John Wiley & Sons, Inc. 2007.

SkillCourse
Integral calculus (02-Credits)

Unit-I: Integration of rational and irrational functions, Properties of definite integrals. Reduction formulae for integrals of rational and trigonometric functions,

Unit-2: Gamma and Beta functions. Areas and lengths of curves in the plane, Volumes and surfaces of solids of revolution. Double and tripleintegrals.

Books Recommended

1. G.B. Thomas and R.L. Finney, *Calculus*, 9th Ed., Pearson Education, Delhi, 2005.
2. H.Anton,I.BivensandS.Davis, *Calculus*,JohnWileyandSons(Asia)P.Ltd.,2002.

Semester-II

Core Subject 1: Differential Equations (ODE & PDE) (Theory-1)
(06 Credits)

Unit-I: Classification of differential equations: their origin and applications, initial value problems, boundary value problems, existence of solution. Separable equation and reducible to this form.

Unit-II: Exact differential equation, integrating factors, special integrating factor and transformations.linear differential equation and Bernoulli equations, first order higher degree equations solvable for x, y, p.

Unit-III: Higher-order differential equations with constant coefficients, basic theory of linear differential equations, The Cauchy-Euler equation, Simultaneous differential equations. Wronskian and its properties Second order linear differential equations with variable coefficients, Inspection Method, Reducible to normal form, Change of Independent Variable, Variation of Parameters. Total differential equations.

Unit-IV: Order and degree of partial differential equations, Concept of linear and non-linear partial differential equations, Formation of first order partial differential equations, Linear partial differential equation of first order, Lagrange's method, Charpit's method.

Books Recommended

1. Shepley L. Ross, *Differential Equations*, 3rd Ed., John Wiley and Sons,1984.
2. I. Sneddon, *Elements of Partial Differential Equations*, McGraw-Hill, International Edition,1967.

OneSkill Course-I
Vector Calculus

Unit I: Multiple products, Reciprocal vectors, Applications of Vector product to the geometry of 3 dimensions

Unit II: Differentiation and partial differentiation of a vector function. Derivatives of sum, dot product and cross product of two vectors.Gradient, Divergence and curl.

Unit III: Vector Integration, Green's, Gauss's and Stoke's theorem.

Unit IV: Line, surface and Volume integrals

Books Recommended

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. H. Anton, I. Bivens and S. Davis, Calculus, John Wiley and Sons (Asia) P. Ltd. 2002.
3. P.C. Matthew's, Vector Calculus, Springer Verlag London Limited, 1998.

Semester-III

MajorPaper-III(CS-1)

Real Analysis (Theory-1, 06 credits)

Unit I: Finite and infinite sets, Examples of countable and uncountable sets, Real line, Bounded sets, Supremum and infimum, Completeness property of R, Archimedean property of R, intervals, Concept of limit points and Bolzano-Weierstrass theorem.

Unit II: Real Sequence, Bounded sequence, Cauchy convergence criterion for sequences, Cauchy's theorem on limits, order preservation and squeeze theorem, monotone sequences and their convergence , monotone convergence theorem.

Unit III: Infinite series. Cauchy convergence criterion for series, Positive term series, Geometric series, Comparison test, p-test, Root test, Ratio test, Alternating series, Leibnitz's test, Cauchy Condensation test, absolute and conditionalconvergence.

Unit IV: Riemann integral : Definition and examples, Properties of Riemann integrals, Necessary and sufficient conditions for inerrability, Fundamental theorem of Calculus.

Books Recommended

1. T. M. Apostol, *Calculus* (Vol. I), John Wiley and Sons (Asia) P. Ltd.,2002.
2. R.G. Bartle and D. R Sherbert, Introduction to Real Analysis, John Wiley and Sons (Asia) P. Ltd., 2000.
3. K.A. Ross, Elementary Analysis- The Theory of Calculus Series- Undergraduate Texts in Mathematics, Springer Verlag, 2003.

AdditionalCourse-I

Part 3

Ancient Indian Mathematics-I (04 Credits)

Unit-I: Multiplication

1. Ekadhikenpurven method (multiplication of two numbers of two digits)
2. Eknunenpurven method (multiplication of two numbers of three digits)
3. Urdhvatiragbhyam method (multiplication of two numbers of three digits)
4. NikhilamNavtashchramamDashtaha (multiplication of two numbers of three digits)
5. Combined Operations

Unit-II: Division and Divisibility

Part A: Division

1. NikhilamNavtashchramamDashtaha (two digits divisor)
2. ParavartyaYojyet method (three digits divisor)

Part B: Divisibility

1. Ekadhikenpurven method (two digits divisor)
2. Eknunenpurven method (two digits divisor)

Unit-III: LCM and HCF
Unit-IV: Power and Root
Power: (i) Square (two digit numbers), (ii) Cube (two digit numbers).
Root: (i) Square root (four digit number) (ii) Cube root (six digit numbers)
Unit-V: Work of Indian Mathematicians in Arithmetic
1. Aryabhatt
2. Brahmagupt
3. Mahaveeracharya
4. Bharti Krishna Tirtha

Recommended Books:
1. Vedic Mathematics, *MotilalBanarsi Das, New Delhi.*
2. Vedic Ganita: Vihangama Drishti-1, *SikshaSanskritiUthana Nyasa, New Delhi.*
3. Vedic GanitaPraneta, *SikshaSanskritiUthana Nyasa, New Delhi.*
4. Vedic Mathematics: Past, Present and Future, *SikshaSanskritiUthana Nyasa, New Delhi.*
5. Leelavati, *ChokhambbaVidyaBhavan, Varanasi.*
6. Bharatiya Mathematicians, *Sharda Sanskrit Sansthan, Varanasi.*

MajorPaper-IV(CS-1)

Abstract Algebra-1 (Theory-1, 06 Credits)

Unit I: Definition and examples of groups, Examples of abelian and non-abelian groups, the group
Zn of integers under addition and multiplication modulo n, Cyclic groups, Complex roots of unity, Circle group.
Unit II: The general linear group GLn (n,R), Groups of symmetries of (i) an isosceles triangle, (ii) an equilateral triangle,(iii) a rectangle, and (iv) a square, Permutation groups, Even and odd permutations, Group of quaternions.
Unit III: Homomorphism and isomorphism of groups, Subgroups, Necessary and sufficient condition, Examples of subgroups including the center of a group, Order of an element , Cosets, Index of subgroup, Lagrange's theorem, Normal subgroups: Definition and examples and characterizations, Quotient groups.
Unit IV: Definition and examples of rings, Examples of commutative and non-commutative rings:
rings from number systems, Zn the ring of integers modulo n, Ring of real quaternions, Ring of matrices, Subrings and ideals, Integral domains and fields, Examples of fields: Zp, Q, R and C.

Books Recommended

1. John B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson, 2002.
2. M. Artin, Abstract Algebra, 2nd Ed., Pearson, 2011.
3. Joseph A Gallian, Contemporary Abstract Algebra, 4th Ed., Narosa, 1999.

AdditionalCourse-I
Part 4

Basic Statistics (04 Credits)

Unit-I Measure of central tendency and dispersion, merits and demerits of these measures. Moments and factorial moments.Shephard's correction for moments.Skewness and Kurtosis and their Measures. Measures based on quartiles. Bivariate data.
Unit II: Basic Probability, Conditional probability, Bayes Theorem.
Unit III: Discrete and Continuous, random variables, probability mass function, probability density function, expectations and moment generating functions.
Unit IV: Method of least squares for curve fitting. Correlation and regression, rank Correlation (

Spearman's and Kendall's measure), Intra-class correlation, correlation ratio.

TEXT/REFERENCE BOOKS

1. Fundamental of Mathematical Statistics : S.C. Gupta and V.K. Kapoor, S. Chand.

Semester-V

MajorPaper-V(CS-1)

Linear Algebra (Theory-1, 06 credits)

Unit I: Vector spaces, Subspaces, Algebra of subspaces, Quotient spaces, Linear combination of Vectors, Linear span, Linear independence/dependence, Basis and dimension, Dimension of subspaces.

Unit II: Linear transformations, Null space, Range, Rank and nullity of a linear transformation, rank-nullity theorem, Isomorphism, Isomorphism theorems, Inevitability and isomorphism's.

Unit III: Matrix representation of a linear transformation, Algebra of linear transformations, Dual
space, Dual basis, Double dual, Annihilator.

Unit IV: Eigen value and eigen-vectors of Linear Transformation, Characteristics polynomial, algebraic and geometric multiplicities of eigen-value, Applications of eigen-value and eigen-vectors in finding the power of Matrix A, exp(A), sin(A), cos (A), and p(A), similar Matrices, diagonalization of matrix.

Books Recommended

1. Stephen H. Friedberg, Arnold J. Insel, Lawrence E. Spence, Linear Algebra, 4th Ed., Prentice- Hall of India Pvt. Ltd., New Delhi, 2004.
2. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007.
3. S. Lang, Introduction to Linear Algebra, 2nd Ed., Springer, 2005.

Semester-VI

DSE-Paper(CS-1)

Complex Analysis (Theory-1, 06 Credits)

Unit I: Properties of complex numbers, Regions in the complex plane, Functions of complex variable, Limits, Continuity, differentiability of complex functions, Exponential function, Logarithmic function, Trigonometric function.

Unit II: Differentiability and Analyticity, Cauchy-Riemann Equations, Sufficient conditions for analyticity, Harmonic Functions, Harmonic conjugate function, Applications, Examples of analytic functions.

UnitIII: Contours, Contour integrals and its examples, Upper bounds for moduli of contour integral,Cauchy- Goursat theorem, Cauchy integral formula.Cauchy inequality, Liouville's theorem,Morera's theorem.

Unit IV: Sequences and Series, Taylor Series, Laurent Series, Singularities, Classification of singularities, Residues and Residue theorem.

Books Recommended

1. James Ward Brown and Ruel V. Churchill, Complex Variables and Applications, 8th Ed., McGraw-Hill International Edition, 2009.

2. JosephBak and Donald J. Newman, Complex analysis, 2nd Ed., Undergraduate Texts in
Mathematics, Springer-Verlag New York, Inc., New York, 1997.
3. Dennis G. Zill and Patrick D. Shanahan , A First Course in with Applications Complex Analysis, Jones and Bartlett Publishers.

Semester-VII (withResearch/Honours)

Major Paper –I: Numerical Analysis (04-Credit)

Unit I: Solutions of algebraic and transcendental equations using Bisection method, False position method, Secant method, Fixed point iteration method, Newton's Rapson method.
Unit II: Solutions of Linear system of equation, Gauss elimination method, LU decomposition, Gauss-Jacobi, Gauss-Siedel and SOR iterative methods.
Unit III: Calculus of Finite differences, Lagrange and Newton interpolation: linear and higher order, finite difference operators.
Unit IV: Numerical differentiation: forward difference, backward difference and central Difference.Integration: trapezoidal rule, Simpson's rule, Euler's method.

Recommended Books

1. B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007.
2. M.K. Jain, S.R.K. Iyengar and R.K. Jain, Numerical Methods for Scientific and Engineering Computation, 5th Ed., New age International Publisher, India, 2007.

Major Paper –II: Integral Transforms (04-Credit)

Unit I: The concept of transform, Integral transforms and kernel, Linearity property of transforms, Laplace transform, properties of Laplace Transform.
Unit II: Inverse Laplace transform, Convolution theorem, Applications of Laplace transform to solve ordinary differential equations.
Unit III: Fourier series, Half range expansions,Fourier integral, Fourier Sine , Fourier Cosine integrals and their properties.
Unit IV: Fourier transform, Applications of Fourier transform to boundary value problems.

TEXT/REFERENCE BOOKS

1. Integral Transforms and Their Applications by LokenathDebnath&bDambaruBhatta, Chapman & Hall/CRC, Taylor and Francis Group , London, New York, 2007.
2. Integral Transforms in Applied Mathematics by John W. Miles, Cambridge University Press,2010.
3. Ian N. Sneddon, Fourier Transforms , Dover Publications,2010 .
4. Advanced Engineering Mathematics by H.K.Dass, S.Chand , New Delhi,2015.

ResearchMethodology (4-credits)

Unit I:

Unit II:

Unit III:

Unit IV:

Researchwriting andresearchEthics (02-credits)

Unit I: Research and Publication Ethics: Theory: - Philosophy and ethics, Scientific conduct, Publication ethics.

Unite II: Research and Publication Ethics: Practice: - Open access publishing, Publication misconduct, Databases and research metrics.

TEXT BOOK

1. Ethics in Research Practice and Innovation, Antonio Sandu, Ana Frunza and Elena Unguru, IGI Global.

Mathematical Statistics(04 credits)

Unit I: Elements of probability, Sample space, Discrete probability, Baye's theorem, Random variables and distribution functions, Mathematical expectations and moments.
Unit II: Some standard discrete and continuous univariate distributions: Binomial, Poisson, Normal,
Unit III: Correlation, Rank correlation, Regression line, Multiple and partial correlation of three variables only, Data reduction techniques, Canonical correlation.
Unit IV: Concepts of sampling, Stratified sampling and systematic sampling, Test of hypothesis: t,z ,chi square test.

TEXT/REFERENCE BOOKS

2. Fundamental of Mathematical Statistics : S.C. Gupta and V.K. Kapoor, S. Chand.
3. Advanced Theory of Statistics :M.G. Kandall.
4. A first Course on Mathematical Statistics: C.E.Weatherburn, Cambridge Univ. Press, 1968.

Metric Space (03 Credits)

Unit I: Metric on a set, Pseudo-metrics, Equivalent metrics, Limit point, Closed sets, Adherent point, Dense subsets, Interior of a set and its properties, Subspaces, Product spaces.
Unit II: Convergent sequences, Cauchy sequences, Algebra of convergent sequences, Subsequences, Continuity at a point, Continuity over a space, Algebra of real valued continuous functions in a metric space, Homeomorphism, Uniform continuity.
Unit III: Complete metric spaces,Completeness and continuous mappings, Cantor's intersection theorem, Contraction mapping theorem, Connectedness in metric spaces, Properties of connectedness.

Unit IV: Compact spaces, Compact subsets of the real line,Compactness and continuous mappings, Sequential compactness, Countable compactness, B-W property, B-W property and boundedness, B-W property and compactness**.**

TEXT/REFERENCE BOOKS

1. Introduction to Topology and Modern Analysis: G.F. Simmons, Tata McGraw-Hill.
2. Metric Spaces: E.T. Copson, Cambridge University Press, 1968.
3. Topology :RobertH.Kasriel, Dover Pub. , 2009.
4. Topology of Metric Spaces: S.Kumaresan, Alpha Science Int. , 2011.

Special Functions (03 Credits)

Unit I: Legendre Polynomial and its properties.
Unit II: Bessel Polynomial, and its properties.
Unit III: Hermite polynomials, and its properties.
Unit IV: Chebyshev polynomials, and its properties.

TEXT/REFERENCE BOOKS

1. The Special Functions and their Applications: Y. L. Luke, Acad. Press, New York.
2. Special Functions: G.E. Andrews, R. Askey, R. Roy, Cambridge Univ. Press.

Financial Mathematics (03 Credits)

Unit I: Single period model, Definitions of finance- pricing, Forward- one- step binary model, Ternary model- Characterization of no arbitrage, Risk-neutral probability measure
Unit II: Bi normal trees and discrete parameter martingales, Multi-period binary model, American options, Discrete parameter martingales and Markov processes, Martingale theorems, Binomial representation theorem overturn to continuous models
Unit III: Brownian motion, Definition of the process, Levy's construction of brownian motion, The reflection principle and scaling, Martingales, Continuous time.
Unit IV: Stochastic calculus, Non-differentiability of stock prices, Stochastic integration, Ito's formula, Integration by parts and stochastic, Fubini theorem, Girsanov theorem, Brownian martingale representation theorem, Geometric brownian motion, The Feynman- Kac representation.

TEXT/REFERENCE BOOKS

1. A Course in Financial Calculus: Alison Etheridge, Cambridge Univ. Press, 2002.
2. Financial Calculus: An Introduction to Derivatives Pricing : Martin Boxter and Andrew Rennie, Cambridge Univ. Press, 1996.
3. Introduction to Stochastic Calculus Applied to Finance: Damien Lamberton and Bernard Lapeyre, Chapman and Hall, 1996.
4. Martingale Methods in Financial Madeling: MarekMusielaandMarekRuthowshi, SpringerVerlag, New York, 1988.

Number Theory (3 Credits)

Unit I: The division algorithm, The gcd, The Euclidean algorithm, Diophantine equation $ax + by = c$, The fundamental theorem of arithmetic, The sieve of Eratosthenes, Goldbachconjucture.
Unit II: The theory of congruences,Binary and decimal representation of integers,Linearcongruences and Chinese remainder theorem, Fermat's theorem, Wilson's theorem.
Unit III: Number theoretic function, Tau and sigma function, the Mobius inversion formula, The greatest integer function, Euler's phi function, Properties of phi function, Euler theorem.
Unit IV: The order of an integer modulo n, Primitive roots for primes, Composite numbers having primitive roots, The theory of indices, Continued fraction, Approximation of irrationals by rationals.

TEXT/REFERENCE BOOKS

1. Elementary Number Theory: David M. Burton, McGraw-Hill.
2. Theory of Numbers: George Andrews, Courier Corporation, 1994.
3. Elementary Number Theory with Applications: Thomas Koshy, Harcourt Acad. Press.
4. Fundamental of Number Theory:William J. Lereque, Dover Pub. Inc. New York.

Fluid Dynamics (3 Credits)

Unit I: Kinematics of fluids, Lagrangian and Eulerian methods, Local and individual time

rates of change, Equation of continuity, Boundary surface.

Unit II: Equation of motion of inviscid fluids, Euler's equation of motion, Bernoulli's equation, Lagrange's equation, Conservative field of force, Cauchy's Integral, Helm-Holtz's equation.

Unit III: Impulsive motion of a fluid, Energy equation of inviscid fluid, General theory of irrotational motion, Connectivity, Flow and circulation, Kelvin's circulation theorem, Stokes's theorem, Permanence of irrotational motions, Green's theorem, Kinetic energy of finite and infinite liquid, Kelvin's minimum energy theorem

Unit IV: Motion in two dimensions, Stream function, Complex potential, Source, Sink, Doublet, Complex potential and images with respect to straight line and circle, Milne-Circle theorem, Blausius theorem.

TEXT/REFERENCE BOOKS

1. Foundation to Fluid Mechanics: S.W. Yuan, Prentice Hall Pvt. Ltd., 1960.
2. Text book of Fluid Dynamics: F. Chorlton, CBS Pub. & Dist. , 2004.
3. Theoretical Hydro-Dynamics: BansiLal, Skylark Pub., 1999.
4. A text book of Fluid – Dynamics: M. Ray & Sharma, S. Chand & Co. Ltd. 2005.

Semester-VIII (withResearch/Honours)

Major Paper –I: Discrete Mathematics (04-Credit)

Unit I: Recurrence relations, Linear homogeneous recurrence relations, Non-homogeneous recurrence relations, Solutions of recurrence relations.

Unit II: Partially ordered sets, Different type of lattices, Sub-lattices, Direct product, Ideal Lattice, Modular and distributive lattices.

Unit III: Boolean algebra, Ideals in Boolean algebra, Boolean rings, Boolean functions, Karnaugh maps, Application of Boolean algebra to switching theory.

Unit IV: Graphs, Direct graphs, Undirected graphs, Relations and graphs, Path and circuits, Eulerian and Hamiltonian graphs, Planner graphs, Connected graphs.

TEXT/REFERENCE BOOKS

1. Element of Discrete Mathematics: C. I. Liu, Mcgraw Higher Edu. ,2012.
2. Discrete Mathematical Structures : H. G. S. Rao, Galgotia Pub. Pvt. Ltd.
3. Lattice and Boolean Algebra: V. K. Khanna, Vikash Pub. House.
4. Discrete Mathematics: R. Johnsonbaugh , Pearson Edu. Ltd., 2014.

Semester-VIII (withResearch/Honours)

Major Paper –II: Operations Research (04-Credit)

Unit I: An introduction to operations research, Methodology of O.R., Features of O.R. problems, Different models in O.R., Opportunities and shortcomings of O.R. approach.

Unit II: Dual simplex method, Revised simplex method,Sensitivity analysis.

Unit III: Assignment and Transportation problems.

Unit IV: Theory of games, Integer linear programming.

TEXT/REFERENCE BOOKS

1. Operations Research: KantiSwarup, P.K. Gupta & Man Mohan, S. Chand, 1978.
2. Operations Research: Theory and Applications: J.K. Sharma, Trinity Press, 2016.
3. Operations Research: H.A. Taha, Prentice Hall of India, 2011.
4. Operations Research: R. Bronson,Schaum's Outline Series McGraw Hill, 1982.