Department of Physics

Semester –I

Course Structure:

Sr. No.	Course Code	Paper Title	Credit
	Core Paper		
1.	PHM 101	Classical Mechanics	4
2.	PHM 102	Mathematical Physics	4
3.	PHM 103	Quantum Mechanics-I	4
4.	PHM 104	Electronics-I	4
5.	PHM 105	Lab	8

Mode of Evaluation: Sessional 30% and End Semester 70%

Semester – II

Course Structure:

Sr. No.	Course Code	Paper Title	Credit
	Core Paper		
1.	PHM 201	Quantum Mechanics-II	4
2.	PHM 202	Electromagnetic Theory	4
3.	PHM 203	Statistical Physics	4
4.	PHM 204	Condensed Matter Physics	4
5.	PHM 205	Lab	8

Mode of Evaluation: Sessional 30% and End Semester 70%

Semester – III

Course Structure:

Sr. No.	Course Code	Paper Title	Credit
	Core Paper		
1.	PHM 301	Nuclear Physics -I	4
2.	PHM 302	Atomic and Molecular Physics	4
3.	PHM 303	Electronics- II	4
4.	PHM 304	Materials Science	4
5.	PHM 305	Lab	8

Mode of Evaluation: Sessional 30% and End Semester 70%

Semester – IV

Course Structure:

Sr. No.	Course Code	Paper Title		Credit
1.	PHM 400	Environmental Physics	**Qualifying Paper**	0
2.	PHM 401	Nuclear Physics -II	**Core Paper**	4
3.	PHM 402	Experimental Techniques	**Core Paper**	2
4.	PHM 411	Laser Technology	**Optional paper- I**	5
5.	PHM 412	Fiber Optics Communication	**Optional paper-II**	5
6.	PHM 413	Nanoscience & Nanotechnology	**Optional paper-III**	5
7.	PHM 414	Biophysics	**Optional paper-IV**	5
8.	PHM 403	Project /Dissertation		8

Mode of Evaluation: Sessional 30% and End Semester 70%

Babasaheb Bhimrao Ambedkar University

(A Central University)

Department of Physics

Syllabus for M.Sc. (Physics)

Semester I

PHM 101: Classical Mechanics

Unit I (12 hours)

Centre of mass, total angular momentum and total kinetic energies of a system of particles, conservation of linear momentum, energy and angular momentum.

Constraints and their classification, degrees of freedom, generalized co-ordinates, example of a disk rolling on the horizontal plane; virtual displacement, D'Alembert's principle, Lagrange's equations of motion of the second kind, uniqueness of the Lagrangian, Simple applications of the Lagrangian formulation: 1. Single free particle in (a)Cartesian Co-ordinates, (b) Plane polar co-ordinates, 2. Atwood's machine, 3. A bead sliding on a uniformly rotating wire in a force-free space, 4. Motion of block attached to a spring, 5. Simple Pendulum, 6. Compound Pendulum.

Symmetries of space and time: Conservation of linear momentum energy and angular momentum.

Unit II (10 hours)

Generalized momenta, canonical variables, Legendre transformations and the Hamilton's equation of motion, Examples of (a) The Hamiltonian of a particle in a central force field, (b) the simple harmonic oscillator. Cyclic co-ordinates and conservation theorems, derivation of Hamilton's equations from variational principle.

Generating functions (four basic types), examples of canonical transformations, the harmonic oscillator in one dimension, Poisson brackets, equations of motion in terms of Poisson brackets, properties of poison brackets (antisymmetry, linearity, and Jacobi identity), Poisson bracket of angular momentum, The Hamilton-Jacobi equation, Linear harmonic oscillator using Hamilton-Jacobi method.

Unit III (10 hours)

Reduction of two particle equations of motion to the equivalent one-body problem, reduced mass of the system, conservation theorems (First integrals of the motion), equations of motion for the orbit, classification of orbits, conditions for closed orbits, The Kepler problem (inverse-square law of force).

General description of scattering, cross-section, impact parameter, Rutherford scattering, center of mass and laboratory co-ordinate systems, transformations of the scattering angle and cross-section between them.

Motion of a particle in a general non-inertial frame of reference, notion of pseudo forces, equations of motion in a rotating frame of reference, the coriolis force, deviation due east of a falling body, the Foucault pendulum.

Unit IV **(12 hours)**

Degrees of freedom of a free rigid body, angular momentum and Kinetic energy of a rigid body, moment of inertia tensor, principal moments of inertia, classification of rigid bodies as spherical, symmetric and asymmetric, Euler's equations of motion for a rigid body, torque free motion of a rigid body, precession of earth's axis of rotation, Euler angles, angular velocity of a rigid body, notions of spin, precession and nutation of a rigid body, brief description of the motion of Heavy symmetric top rotating about a fixed point under the action of gravity.

Types of equilibria, Quadratic forms for kinetic and potential energies of a system in equilibrium, Lagrange's equations of motion, Normal modes and normal frequencies, examples of (i)longitudinal vibrations of two coupled harmonic oscillators (ii)Normal modes and normal frequencies of a linear, symmetric, triatomic molecule, (iii) oscillations of Two linearly coupled plane pendula.

Basic postulates of special relativity, Lorentz transformation, Lagrangian formulation of relativistic mechanics, Motion under constant force.

References:

1. *Classical Mechanics,* H. Goldstein, Narosa Publishing House
2. *Classical Mechanics*, N.C. Rana and P.S. Joag, Tata McGraw Hill
3. *Introdution to Dynamics,* I.C. Percival and D. Richards, Cambridge University Press
4. *Classical Mechanics,* Gupta Kumar, Pragati Prakashan

PHM 102: Mathematical Physics

Unit I **(10 hours)**

Vector analysis in curved coordinates and Tensors: Review of vector algebra and calculus, Gauss and Stokes theorems, Orthogonal coordinates, differential vector operators, special coordinate systems, circular cylindrical coordinates, spherical polar coordinates , tensor analysis, contraction, direct product, quotient rule, psuedotensors, dual tensors, non-Cartesian tensors, covariant differentiation, tensors differentiation operators.

Unit II **(12 hours)**

Special Functions: Second order ordinary differential equations, Frobinus method for solving second order linear ODEs, Beta and Gamma functions, Legendre’s equation, Legendre polynomials and their properties, Bessel’s equation, Bessel function and their properties, confluent hyper geometric equation, its solutions, Laguerre’s equation, its solutions and properties, Hermite equation, Hermite Polynomials and their properties. Green’s function.

Unit III **(12 hours)**

Matrices and Calculus of Residues: Different types of matrices, orthogonal, Hermitian, unitary and normal, eigenvalues and eigen functions of matrices, diagonalisation of matrices, properties of analytic functions, Cauchy’s integral theorem, Cauchy integral formula, Laurent expansion, singularities, Cauchy’s residue theorem, evaluation of definite integrals, dispersion relations.

Unit IV **(10 hours)**

Integral Transforms: Laplace Transform (LT), first and second shifting theorems, LT of derivative and integral of a function, Inverse LT by partial fractions, Solution of initial value problems by using LT
Fourier Series and Fourier Transform: Fourier series, Half range expansion, Arbitrary period, Fourier integral and transforms, FT of delta and Gaussian function.

References

1. *Mathematical method for Physicists,* Arfken & Weber, Elsevier Academic Press
2. *Mathematical Method for Physics and Engineers,* K.F.Reily, M.P.Hobson and S.J.Bence, Cambridge University Press
3. *Advanced Engineering Mathematics,* E. Kreyszig, John Wiley & Sons
4. *Special Functions,* E.D. Rainville, Chelsea Publication Co.
5. *Special Functions for Scientists and Engineers,* W.W. Bell, Dover Publications
6. *Functions of complex variable,* R.V. Churchill, McGraw Hill

PHM 103: Quantum Mechanics I

Unit I **(12 Hours)**

Time-dependent Schrödinger equation, Conservation of probability, Time-independent Schrödinger equation, The potential step: reflection coefficient, The potential barrier: transmission and reflection coefficient, Eigenvalues and eigenfunctions of linear harmonic oscillator - comparison with classical theory, The periodic potential, Spherically symmetric potential, The hydrogen atom.

Unit II **(10 Hours)**

Dynamical variables and operators, Expectation value, Expansion of eigenfunctions, Completeness property, Commutator algebra – Physical significance in Quantum Mechanics, Commuting observables, Unitary transformations, Matrix representations of wave functions and operators, Equations of motion in Schrödinger, Heisenberg and Interaction pictures, Linear harmonic oscillator by operator method.

Unit III **(12 Hours)**

Identical particles with spin: Symmetric and antisymmetric wave functions, Slater's determinantal wave functions, Introduction to classical and quantum scattering theory, Scattering cross section, The Born approximation method, Scattering from screened coulomb potential, Validity of Born approximation, Partial wave analysis, Phase shift, Scattering from square well potential.

Unit IV **(10 Hours)**

Spatial rotations, Orbital angular momentum, Commutation relations – L_x, L_y, L_z and L^2, Eigenfunctions and eigenvalues of L^2 and L_z, particle on a sphere and the Rigid rotator, Spin angular momentum, Pauli spin matrices, Total angular momentum, the spectrum of J^2 and J_z, Ladder operators, Addition of two angular momenta, Clebsch-Gordan coefficients for $j_1=j_2=1/2$ and $j_1=1/2$, $j_2=1$, Spin-Orbit Coupling, Fine-Structure.

References:

1. *Introduction to Quantum Mechanics* by David J. Griffiths, Pearson (2005).
2. *Quantum Mechanics* by G. Aruldhas, PHI, India.
3. *Quantum Mechanics: Concepts and Applications* by N. Zettili, *Wiley*
4. *Quantum Mechanics* by L.I. Schiff, Tata Mcgraw Hill Education Private Limited Tata Mcgraw Hill Education Private Limited (2010).
5. *Modern Quantum Mechanics* by J. J Sakurai, Pearson (1994).
6. *Quantum Mechanics: Theory And Applications* by A. Ghatak, Macmillan India Limited (2004).
7. *Quantum Mechanics: An Introduction* by Walter Greiner, Springer (India) Pvt. Ltd. (2008)
8. *Quantum Physics: Of Atoms Molecules Solids Nuclei And Practicles* by Robert Resnick and Robert Eisberg, Wiley India Pvt Ltd (2006).

PHM 105: Laboratory

List of Experiments

1. Operational Amplifier I
    a. Design and study of
        i. Inverting
        ii. Non inverting
        iii. Summing
    b. Study of frequency of
        i. Differential
        ii. Integral
2. Operational Amplifier II: Design and study of
    a. Clipping and clamping circuits
    b. Comparators, Schmidt trigger
3. Operational Amplifier III
    a. Design & build square wave generator using IC –741.
    b. Design & build triangular wave generator using IC –741.
    c. Design & build sine wave generator using IC –741.
4. Operational Amplifier IV
    a. Design and study frequency response of Notch filter using IC-741
    b. Design and study frequency response of single feedback, low/high/band pass and active filter
5. Digital electronics: Design and verify truth table of-
    a. Flip Flops
        i. Latch, D-type, T-type using RS flip flop
        ii. JK, JK master slave flip flop
        iii. D- & T-type using JK flip flop IC7476
    b. 4-bit register using JK flip flop
    c. 4-bit counters and modified counters using IC7490 and 7493
6. Design of a function generator
7. Measurement of wavelength of He-Ne laser light:-
    a. using ruler
    b. using slit

8. Magnetic susceptibility
9. Hysteresis loop
10. Band Gap of Semiconductor
11. Study of characteristics of Solar cell
    a. Illumination characteristics
    b. I-V characteristics
    c. Areal and spectral characteristics
    d. Illumination characteristics vs distance.
12. Four probe method: Energy Bandgap
13. Faraday Effect
14. Frank-Hertz experment
15. Compton Effect

M.Sc. Semester II

PHM 201: Quantum Mechanics-II

UNIT-I **(15 Hours)**

The WKB approximation method, Time independent perturbation theory for non-degenerate and degenerate cases up to second order energy and eigen function, Application to: Perturbed oscillator, First order Stark effect, Zeeman effect, Variation method: Basic principles, Applications to: One dimensional harmonic oscillator, Ground state energy of hydrogen atom, Ground state of helium atom, Time dependent perturbation theory, Emission and absorption of radiation, Spontaneous emission.

Unit-II **(8 Hours)**

Free particle Klein-Gordan equation, Charge and current densities, Minimal electromagnetic coupling, Dirac's relativistic equation, Covariant form of the Dirac's equation, Adjoint Dirac equation, Continuity equation.

Unit-III **(10 Hours)**

Free particle solutions, Dirac and Feynman interpretation of negative energy states, Dirac equation in electromagnetic field and its non-relativistic reduction, Dirac's equation in a central field: spin angular momentum, spin-orbit energy, the hydrogen atom.

UNIT-IV **(11 Hours)**

Single-particle and Many-particle Hilbert space, Fock Space, Introduction to second quantization, Farmalism for second quantization of wave fields, Occupation number representation, Creation and annihilation operators, Bosons. Representation of operators: Change of basis and the field operator, Representation of one-body and two-body operators. Applications of Second Quantisation.

References:

1. *Quantum Mechanics* by L.I. Schiff, Tata Mcgraw Hill Education Private Limited Tata Mcgraw Hill Education Private Limited (2010).
2. *Introduction To Quantum Mechanics* by David J. Griffiths, Pearson (2005).
3. *Advanced Quantum Mechanics* by J. J Sakurai, Pearson (2005).
4. *Quantum Mechanics: Theory And Applications* by A. Ghatak, Macmillan India Limited (2004).
5. *Relativistic Quantum Fields* by James D. Bjorken, Sidney D. Drell, Dover publications (2012)
6. *A First Book Of Quantum Field Theory* by A Lahiri, Narosa Book Distributors Pvt Ltd (2005).
7. *Quantum Field Theory* by F. Mandl and G. Shaw, John Wiley & Sons (20100525).
8. *Principles of Quantum Mechaincs* by R. Shankar, Springer (2006).

PHM 202: Electromagnetic Theory

UNIT I **(13 hours)**

Electrostatics Differential equation for electric field, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems, examples of image method and Green's function method, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions, dielectrics, polarization of a medium, electrostatic energy.

Magnetostatics Biot-Savart law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions, examples of magnetostatic problems, Faraday's law of induction, magnetic energy of steady current distributions.

UNIT II **(14 hours)**

Maxwell's Equations Displacement current, Maxwell's equations, vector and scalar potentials, gauge symmetry, Coulomb and Lorentz gauges, electromagnetic energy and momentum, conservation laws, inhomogeneous wave equation and Green's function solution.

Electromagnetic Waves Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities.

UNIT III **(10 hours)**

Radiation Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, antenna, radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.

UNIT IV **(7 hours)**

Concepts of Plasma Physics Formation of plasma, Debye theory of screening, plasma oscillations, motion of charges in electromagnetic fields, magneto-plasma, plasma confinement, hydromagnetic waves.

References:

1. **J.D. Jackson,** *Classical Electrodynamics.*
2. **D.J. Griffiths,** *Introduction to Electrodynamics.*
3. **J.R. Reitz, F.J. Milford and R.W. Christy,** *Foundations of Electromagnetic Theory.*
4. **W.K.H. Panofsky and M. Phillips,** *Classical Electricity and Magnetism.*
5. **F.F. Chen,** *Introduction to Plasma Physics and Controlled Fusion.*

PHM 203: Statistical Physics

Unit-I **(12 hours)**

Introduction to statistical physics, phase space and phase space trajectory, concept of a statistical ensemble, distribution function, mean value of a physical quantity, statistical equilibrium, statistical independence and quasi-closed systems. Liouville's theorem (no derivation) and its significance, Entropy and law of increase of entropy. Thermodynamic quantities: temperature, pressure, free energy and thermodynamic potential. Theorem of small increments (no derivation), dependence of thermodynamic quantities on number of particles.

Unit-II **(12 hours)**

Microcanonical distribution in classical statistics. Gibb's canonical distribution. Partition function, grand canonical distribution, free energy and equation of state of an ideal gas, chemical potential of a monoatomic ideal gas. Statistical distribution in quantum statistics.

Energy fluctuation in canonical and concentration fluctuation in grand canonical ensembles, Fluctuations and its dependence on number of particles.

Unit-III **(10 hours)**

Boltzmann distribution, Fermi-Dirac and Bose-Einstein distribution, F-D and B.E gases of elementary particles.

First-and second-order phase transitions. Ising model. Diffusion equation.

Unit-IV **(10 hours)**

The electron gas in metals, Degenerate electron gas-equation of state, degeneracy temperature, specific heat.

Degenerate Bose Gas, Specific heat and pressure, B-E condensation. Black body radiation: Planck's formula and Boltzmann's law.

Reference Books:

1. **F. Reif,** *Fundamentals of Statistical and Thermal Physics.*
2. **K. Huang,** *Statistical Mechanics.*
3. **R.K. Pathria,** *Statistical Mechanics.*
4. **D.A. McQuarrie,** *Statistical Mechanics.*
5. **S.K. Ma,** *Statistical Mechanics.*

PHM 204: Condensed Matter Physics

UNIT-I **(10 hours)**

Crystal structure and Diffraction: Crystalline solids, unit cell and direct lattice, fundamental types of lattices and Bravais lattice, closed packed structures. Basics of bonding of solids, Laue formulation, diffraction conditions, Ewald construction, Laue equations. Miller indices of planes and directions, relation between Miller Indices of a family of planes and interplanar spacing for an orthorhombic crystal. Concept of Brillouin zone; reciprocal lattice, its significance, relationships between direct and reciprocal primitive translation vectors. Determination of crystal structure by X-ray diffraction, Bragg's law of X-ray diffraction, Bragg's X-ray Spectrometer, Construction of reciprocal lattices; determination of reciprocal lattice of SC, BCC, FCC.

Symmetry element: Proper rotation axis, improper rotation axis, rotoreflection, rotoinversion, glide planes, screw axes, space groups and point groups.

UNIT-II **(12 hours)**

Lattice Vibration and Phonon: Lattice Vibrations, Elastic vibrations of continuous media, Group velocity of harmonic wave trains, Wave motion of one dimensional atomic lattice, Group velocity and phase velocity, Force constants, Brillouin zones, Normal modes of vibration in one dimensional atomic lattice of finite length, Lattice with two atoms per primitive cell, Optical properties in the infrared, Phonons, Momentum of phonons, Inelastic scattering of photons by long wavelength phonons, Local phonon model.

Crystal imperfections: Basics of Point (Schottky Defects and Frenkel Defects), line and stacking faults, volume imperfections. Ordered phases of matter: translational and orientational order, kind of liquid crystalline order, quasi crystals, superfluidity.

UNIT-III **(12 hours)**

Free electron theory of Metals: Drude model of electrical and thermal conductivity, Sommerfeld model of free election gas; Motion of electrons in a one-dimensional periodic potential, Band Theory of Solids: Metals, insulators and intrinsic semiconductors; Kroning-Penney Model. Basic of Hall Effect, quantum Hall effect, band gap of semiconductor, Magnetoresistance, Hall Effect in semiconductors**.**

Fermi surface: Construction of Fermi Surfaces, Fermi surface and Brillouin zones, Experimental Methods in Fermi Surface Studies, de Hass van Alphen effect.

Transport property: Boltzmann transport equation, Boltzmann transport equation for electrons and Lorentz Solution, Sommerfeld's theory of electrical conductivity.

UNIT-IV **(10 hours)**

Magnetism: Origin of magnetism in metallic and ceramic materials, paramagnetism, diamagnetism, antiferro magnetism, ferromagnetism, ferrimagnetism, magnetic hysterisis.

Superconductivity: Occurrence of superconductivity, Meissner effect, London equation, effect of magnetic field, type I and type II superconductors. Cooper pairs and elementary discussion of BCS Theory, Josephson effect.

Text and References Books

1. **M.P. Marder:** *Condensed Matter Physics.*
2. **C. Kittel:** *Introduction to Solid State Physics.*
3. **J.M. Ziman:** *Principles of the Theory of Solids.*
4. **B.** D. Cullity : Elements of X-Ray diffraction.
5. **A.J. Dekker:** *Solid State Physics.*
6. **M.A. Wahab**: Solid State Physics-Structure and Properties of Materials
7. **N.W. Ashcroft and N.D. Mermin:** *Solid State Physics.*
8. **P.M. Chaikin and T.C. Lubensky**: Principels of Condensed Matter Physics
9. **S.O. Pillai:** *Solid State Physics.*
10. **G. Burns:** *Solid State Physics.*
11. **S.L. Kakani:** *Materials Science*

PHM 205: Laboratory

List of Experiments

1. Compton scattering.
2. Measurement of Adiabatic compressibility of:-
    a. Distilled water
    b. Piezoelectric crystal
3. Study of Solid-liquid phase diagram for a mixture.
4. Study of Magneto-resistance and its field dependence
5. Hall effect: Determination of
    a. Hall coefficient,
    b. Mobility
6. Uncertainty Principle
7. Photoelectric effect
8. Determination of Band Gap energy of given thermistor
9. Study of RC coupled and feedback amplifier
    a. Frequency response of RC coupled amplifier using transistor
    b. Gain of feedback amplifier using opamp in various modes of operation.
10. Specific heat

M.Sc. (Physics)
Semester III
PHM 301: Nuclear Physics I

UNIT -I **(10 Hours)**

Fundamental properties of Nucleus - Charge, mass and radius determination methods, Nuclear magnetic dipole moments, Molecular beam resonance method, Electric quadrupole moment, Binding energy, Semi-empirical mass formula.

Nuclear radiation measurements - Ionization Chamber, Proportional Counter, Geiger Muller Counter, Scintillation Counters.

UNIT -II **(10 Hours)**

Interaction of radiation with matter, Interaction of ionized radiation with matter – Stopping power, Bethe's formula.

Nuclear fission, Bohr-Wheeler theory of nuclear fission, Controlled chain reaction, Nuclear reactors, Nuclear Fusion.

UNIT-III **(10 Hours)**

Alpha decay, Alpha decay paradox, Gamow's theory of alpha decay, Beta decay- Concept of neutrino and its detection, Fermi theory of beta decay, Selection Rules, Allowed and forbidden transitions, Non-conservation of parity, Wu's experiment, Gamma decay- Multiple transitions selection rules, Idea of internal conversion, Coulomb excitation.

UNIT-IV **(10 Hours)**

Nuclear reactions and their types, Q-equation, Solution of Q-equation, Threshold energy, Nuclear reaction cross section and its measurement, Compound reaction mechanism, Level width, Nuclear resonances and single level Breit Wigner formula.

Books

1. *Nuclear Physics* by Irving Kaplan, Narosa (2002).
2. *Nuclear Physics* by S. N. Ghoshal, S. Chand Publisher (1994).
3. *Concepts of Nuclear Physics* by B. L.Cohen, Tata Mcgraw Hill Education Private Limited (2005).
4. *Introductory Nuclear Physics* by Samuel S. M. Wong, Wiley-VCH; 2nd edition (1999)
5. *Theoretical Nuclear Physics* by John M. Blatt and V. F. Weisskopf, Dover (10/2010).
6. *Basic Ideas and Concepts in Nuclear Physics, An Introductory Approach* by Kris L. G. Heyde, Taylor & Francis Group (2004).
7. *Nuclear Physics: An Introduction* by S. B. Patel, New Age Publications.
8. *Elementary Nuclear Theory* by H. A. Bethe, John Wiley (1947)
9. *Introduction to Elementary Particles* by David J. Griffiths, Wiley-vch Verlag (2008).

PHM 302: Atomic and Molecular Physics

Unit I **(8 hours)**

Application of Schrödinger equation for hydrogen atom, interpretation of the results of Schrodinger equation, atomic energy levels, dependence of wave function on the angle θ and ϕ and radial dependence of wave function, Pauli exclusion principle, maximum number of electrons in a given group or subgroup.

Unit II **(12 hours)**

Different series in alkali spectra, term values in alkali spectra and quantum defect, spin-orbit interaction, doublet structure in alkali spectra coupling schemes. LS coupling, JJ coupling interaction energy in L-S coupling & JJ coupling, fine structure & hyperfine structure (qualitative) Line-broadening mechanisms (general ideas), normal and anomalous Zeeman effect, Paschen-Back effect and Stark effect.

Unit III **(12 hours)**

Rotation of molecules, classification of molecules, interaction of radiation with rotating molecule, rotational spectra of rigid diatomic molecules. Isotope effect in rotational spectra, intensity of rotation lines, non-rigid rotator, linear polyatomic molecules, symmetric top molecules, asymmetric top molecules, Microwave spectrometer, information derived from rotational spectra.
Vibrational energy of a diatomic molecule, infrared spectra (preliminaries) Morse curve and the energy levels of a diatomic molecules. Vibrating diatomic molecule, diatomic vibrating rotator, vibration of polyatomic molecules, normal modes of vibration in crystal, interpretation of vibrational spectra, Infrared spectroscopy, I-R spectrophotometer instrumentation.

Unit IV **(12 hours)**

Raman spectroscopy, Frank Condon principle and selection rules, Photoelectron Spectroscopy, Mössbauer spectroscopy, Nuclear Magnetic Resonance, Chemical Shift, and Electron Spin Resonance (Introduction and their principles only).
Basic principles of laser, Einstein coefficients, light amplification, threshold condition, Semiconductor laser operating principle, application of laser: (1) material processing, (2) LIDAR, (3) Medicine

Refrences:

1. *Introduction to Atomic Spectra*, H.E. White, McGraw Hill
2. *Molecular Structure & Spectroscopy*, G. Aruldhas, Prentice Hall of India
3. *Elements of Spectroscopy*, Gupta, Kumar & Sharma, Pragati Prakashan
4. *Fundamentals of molecular spectroscopy*, C. Banwell & E. McCash, Tata McGraw Hill
5. *Introduction to Molecular Spectroscopy*, G.M. Barrow, McGraw Hill
6. *An Introduction to Molecular Spectroscopy*, Gerhard Herzberg, Nostrand Co.

PHM 303: Electronics II

UNIT I **(14 hours)**

Modulation Techniques: Various frequency bands used for communication, types of communication and need of modulation. Introduction to AM, FM, PM, Frequency spectrum of AM Waves, Representations of AM, Power relation in AM waves, Need and description of SSB, suppression of carrier, suppression of unwanted side bands, Independent side band system, vestigial side band system, Frequency spectrum of the FM waves, Wide band and narrow band FM, Phase modulation, comparison between analog and digital modulation, Sampling theorem, frequency division multiplexing and time division multiplexing. Binary phase shift keying, differential phase shift keying, differential encoded PSK, quadrate PSK, Quadrate Amplitude shift keying (QASK), Binary frequency shift keying.

UNIT II **(10 hours)**

AM Transmitters and Receivers: AM TRANSMITTERS: Generation of AM, low level and high level modulation, comparison of levels, AM transmitter block diagram, collector class C modulator, Base modulator, Transistor Vander Bil modulator, DSB S/C modulator. AM RECEIVER: Tuned radio frequency (TRF) receiver,Superheteterodyne receiver, AM receiver characteristics, RF section and characteristics, mixers, frequency changing and tracking, IF rejection and IF amplifiers. Detection and automatic gain control (AGC).

UNIT III **(10 hours)**

FM Transmitters and Receivers: FM TRANSMITTERS: Basic requirements and generation of FM, FM Modulation methods: Direct methods, variable capacitor modulator, varactor diode modulator, FET reactance modulator, Transistor reactance modulator, Pre-emphasis, direct FM modulator, AFC in reactance modulators, disadvantages of direct method, Indirect modulators, RC phase shift modulator, Armstrong FM systems. FM RECIVERS: Limiters, single and double tuned demodulator, balanced slope detector, foster seely or phase discriminator, de-emphasis, ratio detector, block diagram of FM receiver, RF amplifiers, FM receiver characteristics.

UNIT IV **(10 hours)**

Radio Wave Propagation - Basic ideas of ground wave, propagation, reflection at the surface of a finitely conducting plane, earth (on ground), space and surface waves, tilt of the surface wave, troposphere waves-reflection, refraction, duct propagation. The ionosphere, formation of the various layers, their effective characteristics, reflection and refraction of waves by ionosphere, virtual height, maximum frequency, skip distance, regular and irregular variation of ionosphere, ordinary and extraordinary waves.

References:

1. Electronic communication Systems by George Kennedy.
2. Principle of Communication Systems by Taub and Schilling.
3. Electronic Communication System by Tomasi.
4. Electronic communication Systems by Dennis Roddy and John Coolen
5. Electromagnetic waves & radiating System by F.C. Jordan & B.C.Balmann, (P.H.I).

PHM 304 : Materials Science

Unit I **(16 hours)**

Introduction to Materials Science: Historical Perspective, basic structure, terminology, properties, Classification of Materials, Functional classification of materials, Environmental and Other Effects, Materials Design and Selection.

Metals and Alloys: Dislocations and strengthening mechanisms of metals: Mechanisms of Strengthening in Metals, Cold, Hot working of metals, Recovery, Recrystallization and Grain growth; Solid solutions, solubility limit, Gibb's phase rule, Binary phase diagrams, The Lever rule, intermediate phases, The kinetics of Solid State Reactions, Multiphase transformations, Applications of Phase transformations intermetallic compounds, Heat treatment of steels, Microstrcture, properties and applications of ferrous alloys.

Ceramics: Structure, properties, applications and processing of traditional and advanced ceramics.

Polymers: Classification, Polymerization, Structure and Properties, Additives for polymer products, Crystal polymers, Applications and Processing of conventional and advanced polymers.

Composites: General Characteristics, Particle-Reinforced Composites, Fibre-Reinforced Composites, Fabrication and applications of few important composites.

Advanced Materials: Smart materials exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, nanostructured materials, properties and applications of advanced materials, superalloys, shape memory alloys.

Unit II **(16 hours)**

Mechanical Properties: stress-strain diagrams of metallic, ceramic and polymeric materials, modulus of elasticity, yield strength, tensile strength, toughness, elongation, plastic deformation, viscoelasticity, hardness, impact strength, creep, fatigue, ductile and brittle fracture.

Heat Treatment: Introduction, Heat-Treatment Processes, Annealing, Annealing Operations, Mass Effect, Furnaces, Major Defects in Metals or Alloys due to Faulty Heat Treatment, Surface finishing after heat treatment.

Thermal Properties: Specific heat, Classical Theory, Einstein's Theory, Debye's Theory, thermal conductivity, thermal expansion of materials.

Optical Properties: Introduction, Interaction of light with solids, Atomic and Electronic Interactions, Optical Properties of Metals and Non metals, Applications of Optical Phenomena.

Dielectric Properties: Introduction, The microscopic concept of Polarisation, Langevin's theory of polarisation in Polar dielectrics, Local Field, Clausius-Mosotti Relation, Lorentz-Lorentz Formula, The static dielectric constant of solids and liquids.

Unit III **(12 hours)**

Materials Characterization Techniques: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Atomic force microscopy (AFM), Scanning tunneling microscopy (STM), XPS, Fourier Transform Infrared Spectroscopy (FTIR), Ultraviolet-Visible Infrared Spectroscopy (UV-IR) , Raman Spectroscopy, Low Energy Electron Diffraction (LEED), Reflection High Energy Electron Diffraction (RHEED) and Auger Electron Spectroscopy (AES), Thermal gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Brunauer-Emmett-Teller (BET) surface area analysis, Particle size analysis and Ellipsometry.

References

1. James F. Shackelford, Introduction to Materials Science for Engineers, 7th Edition, Pearson Prentice Hall (2009)

2. W. D. Callister, Fundamentals of Materials Science and Engineering, Wiley (2007)

3. C. Kittle, Introduction to Solid State Physics, Wiley (2007)

4. Peter Hassen Material Science and Technology, Volume 5, Phase Transformation in Materials

5. Elton N. Kaufmann, Characterization of Materials, 2 Volumes Set Wiley 2003

6. Douglas B. Murphy Fundamental of Light Microscopy and Electronic Imaging Kindle Edition 2001.

7. Bradley D. Fahlman, Materials Chemistry, Kindle Edition 2008.

8. B.D. Cullity, Elements of X-ray Diffraction Addision Wesely Reading Mass 1978.

9. David D. Brandon and Wayne D. Kaplan Microstructural Characterization of Materials.

10. Dawn Bonnel, Scanning Probe Microscopy and Spectroscopy: Theory, Techniques, and Applications 2000.

11. C. Julian Chen, Introduction to Scanning Tunneling Microscopy Monographs on the Physics and Chemistry of Materials.

12. Ray F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM Springer, 2008

13. Joachim Frank Three-Dimensional Electron Microscopy of Macromolecular Assemblies: Visualization of Biological Molecules in Their Native State, Kindle 2006.

14. Materials Science, S.L. Kakani and Amit Kakani, New Age International (P) Limited, Publishers, New Delhi.

PHM 305: Laboratory

List of Experiments

1. G.M. Counter: End point energy and absorption coefficient of the absorber
2. Determination of Numerical Aperture of optical fiber:
    a. From far field pattern using trigonometric means
    b. Using scanning photodetector and rotating stage.
3. To study the dielectric constant of solid using microwave
4. To study magic Tee, directional coupler, Isolators and Circulators
5. Measurement of piezoelectric coefficient
6. Production of plasma and measurement of its characteristics
7. SCR characteristics
8. Surface roughness by multiple beam interferometry
9. To determine magnetoresistance of a Bismrith crystal as a function of magnetic field
10. To study the ferroelectric transition in TGS crystal and measurement of Curie temperature
11. Identification of unknown sample using powder diffraction method.
12. Measurement of lattice parameter and indexing of powder photograph
13. Raman spectroscopy
14. UV-Visible spectroscopy
15. IR spectroscopy

M.Sc. (Physics) Semester IV

PHM 400: Environmental Physics

This will be basically seminar based interactive course. Total **15** seminars based on following topics. Evaluation will be done on the basis of essay writing.

Essentials of Environmental Physics: Elements of weather and climate modeling. Basic equation and dynamics of atmosphere, Structure and thermodynamics of the atmosphere, Transport of matter, energy and momentum in nature, Stratification and stability of atmosphere, Hydrostatic equilibrium.

Radiation Physics: Physics of radiation, Interaction of light with matter, Rayleigh and Mie scattering, Laws of radiation and their implication for radiative processes on earth and its environment, UV radiation, Ozone depletion problem.

Environmental Pollution and Renewable: Composition of air, Factors governing air, water and noise pollution. Greenhouse effect, Urban Heat Island effect, Global warming and climate change. Sources of Energy, Renewable sources of energy, Solar energy, wind energy, bio-energy, hydropower, fuel cells and nuclear energy.

References:

1. Fleagle, RG & Businger, JA: An Introduction to Atmospheric Physics (Academic Press)
2. Houghton, J.T: The physics of Atmosphere (Cambridge)
3. Murry, SL: Fundamentals of Atmospheric Physics (Academic Press)
4. Twidll,J&Weir,J:Renewable Energy resources (ELBS)
5. McGaffie, K & Seller, AH: A Climate Modelling Primer (John Wiley)

M.Sc. (Physics)
Semester IV
PHM 401: Nuclear Physics II

UNIT -I **(08 Hours)**

Nuclear Models, Shell model- Evidence of shell structure, magic numbers, spin-orbit coupling, Extreme single particle model, Predictions of spin, parity and magnetic moments. Collective model- Vibrational and rotational spectra.

UNIT -II **(14 Hours)**

Nuclear two-body problem, Theory of deuteron, Nuclear forces- Spin dependence and non-central features, Low energy n-p scattering, Scattering length and effective range theory, Low energy p-p scattering, Charge symmetry and charge independence of nuclear forces, Meson theory of nuclear forces.

UNIT-III **(10 Hours)**

Classification of elementary particles, Types of interactions between elementary particles, Exact conservation laws, Approximate conservation laws- Isospin, parity, strangeness, charge conjugation, time reversal, CP violation, CPT theorem, Resonances and their properties, SU(3) classification of particles and resonances.

UNIT-IV **(8 Hours)**

Quarks-Quark flavor and color, Quark model of hadrons, Cabbibo theory, Strangeness oscillation, CP non-conservation in K_0 decays, Regeneration phenomenon, Basic idea about the standard model.

Books

1. *Nuclear Physics* by Irving Kaplan, Narosa (2002).
2. *Nuclear Physics* by S. N. Ghoshal, S. Chand Publisher (1994).
3. *Concepts of Nuclear Physics* by B. L.Cohen, Tata Mcgraw Hill Education Private Limited (2005).
4. *Elementary Nuclear Theory* by H. A. Bethe, John Wiley (1947)
5. *Introductory Nuclear Physics* by Samuel S. M. Wong, Wiley-VCH; 2nd edition (1999)
6. *Theoretical Nuclear Physics* by John M. Blatt and V. F. Weisskopf, Dover (10/2010).
7. *Basic Ideas and Concepts in Nuclear Physics, An Introductory Approach* by Kris L. G. Heyde, Taylor & Francis Group (2004).
8. *Quarks and Leptons* by F. Halzen and A. D. Martin, John Wiley (1983).
9. *Introduction to Elementary Particles* by David J. Griffiths, Wiley-vch Verlag (2008).
10. *Theory of Nuclear Structure* by M. K. Pal, EWP (1982).

Optional Paper I

PHM 411: Laser Technology

Unit-I (12 hours)

Introduction. the Einstein's coefficients. Population inversion. threshold condition. Optical resonator, line broadening mechanisms (natural, collision, Doppler qualitative ideas)basic concepts of energy-level manifolds in gain media, particularly in respect of population inversion and saturation effects; conditions for oscillator stability in laser resonator configurations and transverse and longitudinal cavity mode descriptions; single longitudinal mode operation for spectral purity and phase locking of longitudinal modes for the generation of periodic sequences of intense ultrashort pulses (i.e. laser mode locking); illustrations of line-narrowed and mode locked lasers and the origin and exploitability of intensity-induced optical effects.

Unit-II (12 hours)

Advanced Laser Physics Quantitative treatment of laser physics embracing both classical and semi classical approaches; transient/dynamic behaviour of laser oscillators including relaxation oscillations, amplitude and phase modulation, frequency switching, Q-switching, cavity dumping and mode locking; design analysis of optically-pumped solid state lasers; laser amplifiers including continuous-wave, pulsed and regenerative amplification; dispersion and gain in a laser oscillator-role of the macroscopic polarization; unstable optical resonators, geometric and diffraction treatments; quantum mechanical description of the gain medium; coherent processes including Rabi oscillations; semi classical treatment of the laser; tunable lasers.

Unit-III (10 hours)

Semiconductor laser: Laser structure and properties, Junction laser operating principle, Threshold condition, Density of a semiconductor laser treated as two level system, Threshold current density, Power output, Temperature dependence of threshold current.

Application of lasers: Measurement of distance, velocity, rotation etc with lasers. Principle of LIDAR, Monitoring of clouds and atmospheric pollutions. Laser communications-sources, modulation, transmission, optical filters, detection and demodulation, Laser induced fusion, laser welding, hole drilling, laser cutting, lasers in medicine. Laser as a heat source- its application in material processing and surgery. Holography- Simple mathematical analysis, Practical holography, Holographic interferometry, character recognition, stress analysis, data storage, holographic microscopy

Unit-IV (10 hours)

Non linear optical effects: Wave propagation in anisotropic crystal, polarization response of materials to light, second and third order non-linear optical processes, sum and difference frequency generation, non linear optical materials.

Pico/femtosecond techniques: Standing wave and travelling wave resonators. Active and passive mode locking schemes, Saturable gain and loss, nonlinear optical effects for enhanced modelocking. Application examples and measurement techniques associated with ultrashort laser pulses.

Ultrafast Photonics: Principle, structure and theory of Heterojunction laser, Distributed feedback laser and Quantum well laser; Reflectors of QuantumWell Lasers and of Other Lasers. Ultrashort pulse lasers and amplifiers, wavelength conversion, time-resolved experiments. Applications of ultrashort pulses.

Reference

1. *Laser fundamentals*, William T. Silfvast, Cambridge University Press.
2. *Optical Electronics*, Ghatak & Thyagarajan, Cambridge University Press.
3. *Lasers: Fundamentals and Applications,* Ghatak & Thyagarajan, Springer.
4. *Essentials of Optoelectronics*, A. Rogers, Chapman Hall.
5. *Basics of Laser Physics,*K. F. Renk, Springer Heidelberg Dordrecht London New York.

Optional Paper II

PHM 412: Fiber Optic Communication

Unit I (15 hours)

Need for fiber Optic Communication, evolution of light wave systems, lightwave system components, Optical fibers - their classification, essentials of electromagnetic theory - total internal reflections, Goos Hanchen shifts, Analysis of Optical fiber waveguides, electromagnetic modes, Characteristic equation of step-index fiber, modes and their cut-off frequencies, single-mode fibers, Dispersion in Single mode fiber, fiber losses, Non liner optical effects and polarization effect. Theory for optical propagation attenuation and single distortion in optical waveguide, weakly guiding fibers, linearly polarized modes, power distribution, Graded-index fibers - WKB and other analysis, propagation constant, leaky modes, power profiles, dispersions - material, modal & waveguide, impulse response.

Unit II (9 hours)

Physics and Technology of Optical Fiber Passive photonic components: FO cables, Splices, Connectors, Couplers, Optical filter , Isolator, Circulator and Attenuator. , switches, MEMS.
Fabrication of optical fibers; MCVD, OVD, VAD, PCVD. Drawing of optical fibers; measurement of RI, attenuation etc. Fiber devices, fiber Bragg gratings, long period gratings, fiber amplifiers and fiber lasers. Application of optical fibers in science, industry, medicine and defense.

UNIT III (10 hours)

Optical fiber systems, modulation schemes, Digital and analog fiber communication system, system design consideration, emitter design, detector design, fiber choice, wavelength conversion, switching and cross connect Semiconductor Optical amplifier (SOA), characteristics, advantages and drawback of SOA , Raman amplifier, erbium doped fiber amplifier, gain and
noise in EDFA, Brillouin fiber amplifier wideband Hybrid amplifier, Noise characteristics, amplifier spontaneous emission, Noise amplifier, Noise figure, Cumulative and effective noise figure, Noise impairments, amplifier applications.

UNIT IV (10 hours)

Optical Transmitters: Basic concepts, Light emitting diodes, Semiconductor laser, Laser characteristics, Transmitter design. Optical Receivers: Basic concepts, P-n and pin photo detectors, Avalanche photo detector MSM photo detector, Receiver design, Receiver noise, Receiver sensitivity, Sensitivity degradation, Receiver performance. Wavelength division multiplexing (WDM) : Multiplexing Techniques, Topologies and architectures, Wavelength shifting and reverse, Switching WDM demultiplexer, optical Add/drop multiplexers. Dense wavelength division multiplexing (DWDM): System considerations, Multiplexers and demultiplexers, Fiber amplifier for DWDM, SONET/ SDH Transmission, Modulation formats, NRZ and RZ signaling, DPSK system modeling and impairments.

Reference Books

1. *Optical fiber communications: Principles and Practice*, John M. Senior, Prentice Hall of India.
2. *Optical fiber communications*, Gerd Keiser, McGraw Hill, 3rd edition.
3. *Fiber optic communication technology*, D. K. Mynbaev and L. L. Scheiner, Pearson Technology.
4. *Fiber optics and optoelectronics*, R. P. Khare, Oxford University press.
5. *Optical Communication Systems*, John Gowar, Prentice Hall of India.
6. *Light wave Communication Systems: A practical prospective,* R Papannareddy, Penrum International Publishing.
7. *Fiber Optic Communication Systems*, G.P. Agrawal, John Wiley and Sons.

Optional Paper: III

PHM 413: Nanoscience & Nanotechnology

Unit I (16 hours)

Nanomaterials

Introduction, Bulk to Nano Transitions. Size effects, Nanoparticles, Brief History of Nanoscience, Nanotechnology in nature, Quantum Dots, Quantum Wires and Quantum Wells.

Nature of Carbon Clusters, Discovery of C60 Structures, Fullerenes; chemical and physical properties, species of Fullerenes, Term and Nomenclature, Geometry of Fullerenes-General, 5/6 Fullerenes, Graphene.

Introduction to Carbon Nanotubes, Carbon Nanotubes and related structures, Single-walled Carbon Nanotubes (SWNTs), Chirality, Multi-walled Carbon Nanotubes (MWNTs).

Unit II (16 hours)

Methods of Synthesis of Nanoparticles:

Critical issues for nanostructure synthesis and assembly, Nanoparticle synthesis strategies.

Chemical Methods: Sol-gel Method Principle, Typical process, Process control, Hydrothermal / Solvothermal Synthesis: Principle, Typical process, Process control, Aerosol method: Principle, Typical process, Process control, Citrate gel (Penchini) method: Principle, Typical process, Process control and their applications.

Chemical Vapor Deposition - Reaction chemistry and thermodynamics of CVD; Thermal CVD, laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition.

Physical Methods: Ball Milling, Sonication, Low temperature Combustion Synthesis (LCS) method: Principle, Typical process, Process control.

Physical Vapor Deposition – Introduction to Deposition and Growth, Langmuire-Knudsen Relation, mass evaporation rate; Thickness Deposition Rate, Knudsen cell, Directional distribution of evaporating species, Evaporation of elements, compounds, alloys, Raoult's law; e-beam, pulsed laser and ion beam evaporation, Glow Discharge and Plasma, Sputtering - mechanisms and yield, dc and rf sputtering, reactive sputtering, Hybrid and Modified PVD-Ion plating, reactive evaporation,

Unit III (12 hours)

Applications of Nanostructured Materials; Humidity Sensor, Gas Sensor-LPG, Hydrogen, Nitrogen and CO_2, solar cell etc., as Hydrogen Storage Materials and Corrosion-Resistant Materials, Biomedical Applications: Nanoparticles in drug delivery system.

Ballistic electron transport and coherence; coulomb blockade and quantum transport: Single electron transistor (SET).

Reference Books:

1. Encyclopedia of Nanoscience and Nanotechnology, Ed. H.S. Nalwa, American Scientific Publishers, Los Angels, 2004.
2. The Chemistry of Nanomaterials, Vol.1 & 2, C.N.R. Rao, A. Muller & A.K. Cheetham
3. Nanomaterials: Synthesis, properties and Applications, A.S. Edelstein
4. Nanostructured Materials: Processing properties and Applications, Carl C. Koch
5. NANO: The Essentials, T. Pradeep, Mc Graw Hill Publications.
6. Nanomaterials, A.K. Bandyopadhyay, New Age International.
7. Milton Ohring, The Materials Science of Thin Films, Academic Press Sanden, 1992
8. Kasturi L. Chopra, Thin Film Phenomena, Mc Graw Hill (NewYork), 1969
9. Ray F. Egerton, Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM Springer, 2008
10. Frank Three-Dimensional Electron Microscopy of Macromolecular Assemblies: Visualization of Biological Molecules in Their Native State, Kindle 2006.

Optional IV

PHM 414: Biophysics

Unit 1 (12 Hours)

Nucleic Acids: Nucleosides and nucleotides, primary, secondary and tertiary structure of DNA, Watson - Crick model, backbone conformation, sugar puckering, different forms of DNA, Z-DNA, structure of RNA, different forms of RNA and their biological functions. The central dogma, DNA replication, RNA transcription and protein biosynthesis, reverse transcription, mutation and regulation of genes.
Proteins: Amino acids, peptide bond, disulphide bridge, Primary, secondary, (α- helix and β- sheet), tertiary and quaternary structure of proteins. Protein conformation, torsion and dihedral angles, Ramachandran map, structure of heamoglobin and myoglobin.

Unit 2 (10 Hours)

Membranes: Cell membrane, Micelle. Bilayer and liposome; structure of membrane, conformational properties of membranes, passive membrane transport; Donnan equilibrium, Hodgkin – Katz formula, Active membrane transport and transport of charged particles through membranes. Simple idea of molecular reception – smell reception and taste reception.

Nerve Impulse: The neuron and Axon and Action potential, recording of action potential, Chronaxie and rheobase; depolarization and reporalization of axon membrane, mechanism of propagation of nerve 26mpulse; Ionic channels, Elementary idea of synaptic transmission.

Unit 3 **(10 Hours)**

Radiation Biophysics: Types of ionizing radiations, interaction between radiation and matter, radiation dose and dose rate, radiation effect on living cell, protein, nucleic acid and membrane. Radiation hazards and radiation protection.

Unit 4 **(10 Hours)**

Basic concepts on characterization Techniques for Bio-macromolecules:
X – ray methods: Basic principle of X – ray diffraction, structure factor, Analysis of Laue, Rotation and Powder photographs.
NMR: Basic theory of Nuelear Magnetic Resonance, Chemical shift and spin-spin coupling, relaxation effect, NMR spectrometers and FT spectroscopy, Applications.
ORD and CD: Basic concept of circular dichoism and optical rotation, Drude equation, Molecular basis of 26ocusin power, Rotatory 26ocusing of macromolecules, Moffit plots for helical and random coil structure.
Sedimentation: Sedimentation velocity, apparatus and procedures for sedimentation studies, sedimentation equilibrium, Archibald method;Density gradient sedimentation.
Electrophoresis: Transport in an electric field, isoelectric 26ocusing, orientation of molecules in electric fields.
Chromatography: Basic idea of Molecular – Sieve chromatography; Gel filteration, analysis of the shape of eluting bands; Determination of shape and size of macromolecules.

References

1. *Molecular Biology of the Genes* by J. D. Watson (Benjamin Inc, California)
2. *Principles of Nucleic Acid Structure* by W. Saenger (Springer Verlag, New York)
3. *Biophysics*; Ed. W. Hoppe et. al. , (Springer Verlag, New York)
4. *Introduction to Biophysics* by P.S. Narayanan
5. *Biophysics* by M. V. Volkenstein (MIR publishers)
6. *Biophysics* by V. Pattabhi & N. Gauttam
7. *Physical Biochemistry* by K. E. van Holde, (Prentice Hall, N, J.)

Optional V

PHM 415: Medical Electronics and Biomedical Instrumentation

Unit 1 **(12 Hours)**

Introduction of Medical Electronics; Human Cell: structure, behavior, electrical characteristics; Basis of bioelectrical potentials: Cardiovascular system, Central Nervous system, Muscles action and sensory system

Unit 2 **(10 Hours)**

Amplifiers: basics of Op-Amp and Op-Amp based circuits for data manipulations, Biomedical amplifier; Tranducers: definitions and types of transducers, biomedical transducers; Basic digital building blocks: encoder, decoder, digital-to-analog and analog-to-digital convertor, multiplexer and demultiplexer

Unit 3 **(10 Hours)**

Biomedical Instruments: working principles of instruments such as Electrocardiography (ECG), Electroencephalography (EEG), Electromyography, Spirometer, Audiometry, X-ray and radiography, Electronic instruments for affecting human body such as stimulators, defibrillators, pacemaker, diathermy

Unit 4 **(10 Hours)**

Patient monitoring and intensive care system, Patient safety and electromedical equipments, computer applications in medicine

The medical electronic department and the patient

1. *Principles of Biomedical Instrumentation and Measurements* by R. Aston, Merrill Publishing Company, Ohio, USA
2. *The Biomedical Engineering Handbook (Vol 1 and 2)* by J. D. Bronzino, CRC Press, USA
3. *Biomedical Instrumentations and Measurements* by Cromwell, Weibell and Pfeiffer, PHI, New Delhi
4. *Descriptive Medical electronics and instrumentation* by T. Karselis, Charles B Slack Inc., USA
5. *Principles of Medical Electronics and Biomedical Instrmentation* by Rao and Guha, University Press
6. *A short introduction to Biomedical Engineering* by S. N. Sarbadhikari, University Press.

PHM-403: PROJECT AND DISSERTATION

The dissertation topics will be based on special papers or elective papers and topics of current interest. A departmental committee will distribute the topics.