SYLLABUS

Core 7: IPH3CR01 – Classical Physics – I

Credit: 3 (54 Hours)

Module I (18 hrs)

Mechanics of a system of particles, Constraints, D'Alembert's principle and Lagrange's equations, Velocity dependent potentials and Dissipation function, Hamilton's principle, Calculus of variations, Derivation of Lagrange's equations, Conservation theorems and symmetry.

Module II (16 hrs)

Central force problem as a one-body problem, Classification of orbits, Equation for orbit, Condition for closed orbits, Kepler problem, Laplace-Runge-Lenz vector, Scattering in a central
force field, scattering in Laboratory frame.

Module III (20 hrs)

Coordinates of a rigid body, Euler angles, Euler's theorem, Cayley-Klein parameter, Rotations and orthogonal transformations, Rate of change of a vector, Coriolis effect, Angular momentum and kinetic energy, Moment of inertia tensor, Principal axes, Euler equations of motion, Torque free motion.
Small oscillations: Lagrange's equations, Principal axis transformation, normal coordinates, Linear triatomic molecule

Text: 1. H. Goldstein, C. Poole and J. Safko, ``Classical Mechanics".

References:

1. Classical Mechanics – J. C Upadhyayamn - Chapter 1,2& 3
2. Concepts of Modern Physics - Arthur Beiser, TMH.
3. Classical Mechanics - Tawale and Puranik, TMH.
4. Classical Mechanics - K Sankara Rao, PHI

Core 8: IPH3CR02 – Quantum Mechanics - I
Credit: 3 (72 Hours)

Module I (18 hours)
Historical development and origin of quantum theory

Failure of classical physics- Black Body radiation-Planck's radiation law, Photoelectric effect- Einstein's explanation, De Broglie hypothesis, Davisson-Germer Experiment. Quantum behaviour - Young's double slit experiment.

Text Book:

1. A Textbook of Quantum Mechanics- G Aruldhas-Chapter 1
2. Quantum Mechanics - Griffith, Pearson
3. Feynman lectures in Physics vol III – R P Feynman 1.1 – 1.8, 2.1, 2.2, 3.1, 3.2

Module II (18 hours)
General Formalism of Quantum Mechanics

Linear vector space- Hilbert space- Orthogonality- Linear operator- Eigen functions and eigen values- Hermitian operator- Postulates of Quantum Mechanics- wave function, Operators, Expectation value, Eigen value, Time development- Simultaneous measurability-Uncertainty relation.

Text Book:

1. A Textbook of Quantum Mechanics- G Aruldhas-Chapter 3 and 8
2. Quantum Mechanics - Griffith, Pearson

Module III (18 hours)
Schrodinger Equation

Time dependent Schrödinger equation- interpretation of wave function, Probability density, Probability current density, Ehrenfest theorem- Extension to three dimensions, Time independent Schrödinger equation- Stationary states- Admissibility conditions of wave function-general properties of one dimensional Schrödinger equation, the free particle – box normalisation.

Text Book:

1. A Textbook of Quantum Mechanics- G Aruldhas
2. Quantum Mechanics - Griffith, Pearson

Module IV (18 hours)
Exactly solvable problems

Particle in a box, Linear Harmonic oscillator- the Schrodinger method. Particle moving in a spherically symmetric potential, Two body problem, rigid rotator, Hydrogen atom - energy eigenvalues, eigen functions of a hydrogen-like atom.

Text Book:

1. A Textbook of Quantum Mechanics- G Aruldhas
2. Quantum Mechanics - Griffith, Pearson

References:

1. Introductory Quantum Mechanics - RI Liboff, Pearson
2. Quantum Physics - Gasiorowicz, John Wiely

Core 9: IPH3CR03 – Astronomy & Astrophysics
Credit: 2 (54 Hours)

Module I (20 hours)

Celestial Sphere and Time

Constellations. The celestial sphere. Equatorial, ecliptic system of coordinates. Seasons, Sidereal, Apparent and Mean solar time. Calendar. Julian date. Stellar Distances and Magnitudes : Distance scale in astronomy. Determination of distances to planets and stars. Magnitude scale. Atmospheric extinction. Absolute magnitudes and distance modulus. Colour index. Theories of formation of the Solar System, The Sun: Photosphere, chromosphere and corona of the Sun. Sunspots and magnetic fields on the sun. Solar activity, solar wind. Planets and their Satellites : Surface features, atmospheres and magnetic fields of Earth, Moon and Planets. Satellites and rings of planets. Asteroids, Meteors, Meteorites and Comets.

Module II- (18 hours)

Stars

Basics of Star formation & Evolution. The HR diagram. Pre-main sequence contraction, main sequence stage and formation of super dense objects - White

dwarfs, Neutron stars & Pulsars. Black holes. The Milky Way Galaxy & Galaxies beyond : Structure of the Milky Way Galaxy Galactic and globular clusters. Introduction to Cosmology : The expanding universe. Big Bang and Steady State models of the universe. Dark matter.

Module III (16 hours)

Magnitudes

Apparent and Absolute stellar magnitudes, distance modulus, Bolometric and radiometric magnitudes, Color - index, Color temperature, effective temperature, Brightness temperature, luminosities of stars. Equatorial, ecliptic and galactic system of coordinates. Apparent and Mean solar time and their relations. Classification of stars, H-D classification, Hertzsprung-Russel (H-R) diagram.

Text Books

1. Astrophysics - Stars and Galaxies, K. D. Abhyankar, University Press, 2001.
2. S.Chandrasekhar:Stellar Structure
3. H. Karttunen, P Kroger, H Oja, M Poutanen & K. J. Donner editors. Fundamental Astronomy, 5 th Edition, Springer-Verlag (2007)
4. Textbook of astronomy and astrophysics with elements of cosmology, V.B.Bhatia, Narosa publishing house, 2001.

Core Practical: IPH3CP06 – Physics Practical - III

Credit: 2 (36 Hours)

(The student has to complete a minimum of 10 experiments)

1. Torsion Pendulum (Method of equal masses) – Determination of rigidity modulus (n) and moment of inertia (I)
2. Measurement of density of a solid – Sensibility method to find mass using beam balance and screw gauge / vernier calipers for dimension measurements

3. Stokes's method – Determination of viscosity of a liquid

4. Determination of moment of inertia of rotationally symmetric body (solid sphere OR cylinder OR disc) from their period of oscillation on a torsion axle.

5. Spring constant - Hooke's law – oscillation

6. Asymmetric Compound Pendulum- Determination of moment of inertia and acceleration due to gravity (g)

7. To find the torque and hence to find the moment of inertia of a flywheel.

8. To find the moment of inertia of a rectangular bar about an axis through its CG by the method of coincidence.

9. Melde's string – Determination of frequency of given tuning fork

10. Sonometer – Determination of frequency of AC

11. Sonometer – Determination of frequency of given tuning fork, unknown mass and verification of laws of strings

12. Simulation of transfer orbits

13. Planck's constant using LEDs of at least 4 different colors.

14. To become familiar with the astronomical objects visible to naked eye in the night sky using the software stellarium

15. Becoming familiar with constellations using Stellarium software

References:

1. Advanced course in Practical Physics by D Chattopadhyay

2. Practical Physics- Anchal Sreevasthava, R.K. Shukla

3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers

4. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Maha

Core Practical: IPH3CP07– Physics Practical - IV

Credit: 2 (36 Hours)

(The student has to complete a minimum of 10 experiments)

1. To determine e/k using a Si or Ge transistor.
2. To study the characteristics of a photocell or photoelectric cell.
3. Law of conservation of energy and momentum – hanging sphere method.
4. Young's modulus- Koenigs double mirror method
5. Kundt's tube – Determination of velocity of sound.
6. To show the tunneling effect in tunnel diode using I-V characteristics.
7. Determination of e/m by Thomson's Method.
8. Optocoupler – Characteristics
9. Determination of Planck's constant (Photoelectric effect).
10. Op-amp- inverter, non inverter, buffer, study of gain.
11. Optical fibre- Numerical Aperture.
12. He-Ne laser – slit width.
13. LDR- Characteristics.
14. Photodiode - Characteristics.
15. JFET – Characteristics.

References:

1. Advanced course in Practical Physics by D Chattopadhyay
2. Practical Physics- Anchal Sreevasthava, R.K. Shukla
3. Electronic Lab Manual-K.A.Nawas
4. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Maha

Core 10: IPH4CR02 – Statistical Mechanics - I
Credit: 2 (54 Hours)

Unit I- Statistical Basics of Thermodynamics (18 Hours)

Probability - principle of equal a-priori probability - probability and frequency - Thermodynamic probability - Basic rules of probability theory - permutations and combinations - microstate and macrostate - constraints on a system - static and dynamic systems - most probable state - Ensemble and average properties.

Degrees of freedom - momentum space - phase space - mu space - gamma space - division of phase space - Examples : one dimensional harmonic oscillator, a free particle.

Textbook :

Heat, Thermodynamics and Statistical Physics - Brij Lal, Subrahmanyam and Hemne, Chapter 9 , S Chand, Revised Edition

Unit II- Universal Laws in Statistical Mechanics (18 hours)

Fundamental postulates of statistical mechanics - density of quantum states of energy of a particle - statistical ensembles - micro canonical ensemble - canonical ensemble - grand canonical ensemble - comparison of ensembles - equilibrium between two systems in thermal contact - bridge with macroscopic physics - entropy and probability - Boltzmann's canonical distribution law - application - the equipartition of energy - statistical interpretation of second law of thermodynamics - partition function and relation with thermodynamic quantities.

Textbook :

Heat, Thermodynamics and Statistical Physics - Brij Lal, Subrahmanyam and Hemne, Chapter 10 , S Chand, Revised Edition

Unit III- Statistical Distributions (18 hours)

Classical particles, Bosons and Fermions - M. B statistics, applicable to ideal gas - M. B energy distribution law - Applications of M. B distribution law - total internal energy and sp. Heat at constant volume of a gas - M. B speed distribution law - mean, rms and most probable speed - Doppler broadening of spectral lines - limitations of M. B method

Fermi-Dirac and Bose - Einstein Statistics

Textbook :

Heat, Thermodynamics and Statistical Physics - Brij Lal, Subrahmanyam and Hemne, Chapter 11 , S Chand, Revised Edition

References

1. R.B. Singh - Thermal and Statistical Physics
2. Kerson Huang - Introduction to Statistical Physics, CRC Press (2012)
3. Herbert Callen - Thermodynamics and an Introduction to Thermostatistics, Wiley (2006).
4. R.K Pathria - Statistical Mechanics, Pergamon Press, Orford

Core 11: IPH4CR03 –Electrodynamics - I
Credit: 2 (54 Hours)

Module I (24 hours)

Electric currents: Current density, steady current in a conductor, electrical conductivity and Ohm's law, resistors, Ideal voltage and current sources-Network theorems, current and voltage sources, Thevenin's theorem, Norton's theorem, reciprocity theorem, superposition theorem, maximum power transfer theorem.

Time dependent circuits: LR and RC circuits, LCR circuits- series and parallel.

Alternating currents: Wattless current, Skin effect-Impedance and reactance, LCR circuits with alternating currents.

Module II (12 hours)

Electric Fields around conductors: Conductors and Insulators, Capacitors, Energy Stored in a Capacitor

Electric Fields in Matter:

Dielectrics, Induced dipoles, Polarization, Field of a polarized object, bound charges, Electric Displacement, Boundary conditions, Susceptibility, Permittivity dielectric constant.

Module III (18 hours)

Electrodynamics:

Maxwell's equations, Maxwell's equation in matter (dielectrics and conductors), boundary conditions, continuity equation, Poynting theorem.

Electromagnetic waves:

Electromagnetic waves-Boundary conditions-Reflection and Transmission-Polarization-Energy and Momentum in Electromagnetic waves-Electromagnetic waves in matter (dielectrics and conductors)-Propagation in Linear media-Reflection and Transmission at Normal incidence, Reflection at conducting surface(Normal incidence) –Dispersion in Dielectrics, Superposition of waves, Group velocity.

Text Books

1. Electricity and Magnetism, R Murugeshan
2. Introduction to Electrodynamics, David J Griffith

References

1. Electricity and magnetism D Chattopadhyay and P C Rakshit , New Central Book Agency.

2. Electricity and Magnetism, Purcell, Berkeley Physics Course Volume 2, Tata McGraw-Hill Ltd.

3. Electricity and Magnetism, J.H.Fewkes & J.Yarwood. Vol.I, 1991, Oxford Univ. Press.

4. Electricity and Magnetism, R. Murugeshan, 1stEdition(Revised) 2006, S Chand.

5. Principles of Electromagnetics, Mathew N.O Sadiku- 4 th Edition 2009, Oxford.

6. Fundamentals of Magnetism and Electricity, D.N Vasudeva , S Chand.

7. Electricity and Magnetism, KK Tewari, S Chand.

8. Electricity and Electronics, Saxena, Arora and Prakash, Pragati Prakashan.

9. Classical Electromagnetism, Jerrold Franklin, Pearson.
10. Electromagnetic Fields and Waves, KD Prasad, Satya Prakashan.
11. Field and wave Electromagnetics, David K Cheng, Pearson.

Core Practical: IPH4CP06 – Physics Practical - V
Credit: 2 (36 Hours)

(The student has to complete a minimum of 10 experiments)

1. Moving coil galvanometer – figure of merit
2. Conversion of galvanometer into voltmeter
3. Conversion of galvanometer into ammeter
4. Searle's vibration magnetometer – magnetic moment
5. Carey Foster's bridge – Measurement of resistivity of wire
6. To study the Characteristics of a Series RC Circuit.
7. To study a series LCR circuit and determine its (a) Resonant Frequency (b) Quality Factor
8. To study a parallel LCR circuit and determine its (a) Anti-resonant frequency and (b) Quality factor Q
9. Verification of Thevenin's theorem.
10. Verification of Norton's theorem.
11. Verification of Superposition theorem.
12. Verification of Maximum power transfer theorem.
13. Determination of Dielectric constant of a non-polar liquid.
14. Determination of Dielectric constant of a thin sheet.

References:

1. Advanced course in Practical Physics by D Chattopadhyay

2. Practical Physics- Anchal Sreevasthava, R.K. Shukla

3. Electronic Lab Manual-K.A.Nawas

4. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Maha

Core Practical: IPH4CP07 – Physics Practical - VI
Credit: 2 (36 Hours)
(The student has to complete a minimum of 10 experiments)

1. Ballistic Galvanometer: (i) Measurement of charge and current sensitivity

2. Ballistic Galvanometer: (ii) Measurement of CDR

3. Ballistic Galvanometer: (iii) Determine a high resistance by Leakage Method

4. Ballistic Galvanometer: (iv) To determine Self Inductance of a Coil by Rayleigh's Method.

5. To compare capacitances using De'Sauty's bridge.

6. Measurement of field strength B and its variation in a Solenoid (Determine dB/dx).

7. To draw the magnetic induction-magnetic field (B-H) loop of the core material of an anchor ring.

8. Determination of magnetic force in a current carrying conductor.

9. To construct a one ohm coil.

10. Monte-Carlo simulation of an ideal gas

11. Monte Carlo simulation of 2 dimensional Ising model

12. Thermistor – Resistance – Temperature characteristics and temperature coefficient of resistance.

13. To study the variation of thermo emf (Seebeck effect) across two junctions of a thermocouple with temperature.

14. Thermal conductivity of bad conductor – Lee's Disc

15. To study the variation of junction temperature (Peltier effect) across two junctions of a thermocouple with current.

References:

1. Advanced course in Practical Physics by D Chattopadhyay
2. Practical Physics- Anchal Sreevasthava, R.K. Shukla.
3. Electronic Lab Manual-K.A.Nawas.
4. A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Edn, 2011,Kitab Maha.
5. Mark Newman, Computational Physics (2012).
6. N. Giordano and H. Nakanishi, Computational Physics, Pearson (2005)
7. Daniel V. Schroeder, Interactive Molecular Dynamics, Am. J. Phys. 83 (3),210–218 (2015).
8. Practical Physics, CL Arora, S.Chand.

Core 12: IPH5CR01 – Environmental Physics & Human Rights
Credit: 4 (72 Hours)

Module 1 (16 hours)

Water Resources and Its Management (3 Hours)

Water resources: Use and over-utilization of surface and ground water, floods, drought, dams benefits and problems. Water harvesting-Importance of rain water harvesting in Kerala.

Remote sensing (3 Hours)

Remote sensing-principles, spectral reflectance of earth's surface features, Remote sensing satellites and sensors, aerial photography, Applications of Remote Sensing in environmental monitoring and assessment.

Environmental Pollution (10 Hours)

Environment and human health; Environmental pollution- Primary and secondary pollutants; Air pollution- Sources, Effects and its Control/Treatment methods; Acid Rain; Ozone layer depletion; Green house gases; Global warming - Climatic effects; Water pollution- Sources, Effects and Control/Treatment methods; Groundwater pollution; Marine pollution; Soil pollution; Noise pollution- Sources and measurement indices of noise pollution, Noise exposure level and standards, Noise control measures, Impact of noise on human health, ; Environmental pollution due to environmental disasters; Consumerism and waste products; E-waste-an emerging environmental threat. Disaster management: floods, earthquake, cyclone and landslides.

Module II (12 Hours)

Waste Management (8Hours)

Waste minimization and resource conservation:- Source reduction, Recycling, Value-added products; Waste minimization promotional methods- awareness generation, control methods and economic benefits; Benefits of waste minimization; Management of solid wastes- Municipal solid wastes, Hazardous solid waste-characteristics and management of HSW, Waste treatment and disposal methods- physical, biological and chemical process.

Environment Impact Assessment and Control (4 Hours)

Basic ideas of environment impact assessment; Environment ethics; Environmental laws and constitutional provisions to control pollutions in India- The general acts; Air (prevention and control of pollution) act; Water (prevention and control of pollution) act; Wild life protection act; Forest conservation act; Environment protection acts.

Module III (12 Hours)

Non-renewable and Renewable Energy Sources (12 Hours)

Non-renewable energy sources:-Coal, Oil, Natural gas; Nuclear fission energy; Merits and demerits of non-renewable energy. Renewable energy sources: Biomass energy- Biofuels, Biogas plant - Fixed dome type and moving drum type; Wind energy; Wave energy; Tidal energy; Hydroelectricity; Geothermal energy conversion; Ocean thermal energy conversion; Fusion energy; Hydrogen

energy- Production and storage; Merits and demerits of each renewable energy sources; Storage of intermittently generated renewable energy.

Module IV (12 Hours)

Solar energy (12 Hours)

Sun as a source of energy- Solar radiation, Solar Constant, Spectral distribution; Solar pond - Convective and salt gradient types; Flat plate collector; Solar water heater - Direct and indirect systems- Passive and active systems; Optical concentrator - Parabolic trough reflector - Mirror strip reflector - Fresnel lens collector; Solar desalination; Solar dryer - Direct and indirect type; Solar cooker; Solar heating of buildings; Solar green houses; Need and characteristics of photovoltaic (PV) systems; Solar cells - Principle, Equivalent circuits, V-I characteristics, fill factor, conversion efficiency; PV Sun tracking systems; Merits and demerits of solar energy.

Module - V (20 Hours)

Unit 1

Human Rights An Introduction to Human Rights, Meaning, concept and development –History of Human Rights Different Generations of Human Rights- Universality of Human Rights- Basic International Human Rights Documents - UDHR ,ICCPR,ICESCR.-Value dimensions of Human Rights

Unit 2

Human Rights and United Nations Human Rights co-ordination within UN system- Role of UN secretariat- The Economic and Social Council- The Commission of Human Rights-The Security Council and Human rights- The Committee on the Elimination of Racial Discrimination- The Committee on the Elimination of Discrimination Against Women- the Committee on Economic, Social and Cultural Rights- The Human Rights Committee- Critical Appraisal of UN Human Rights Regime.

Unit 3

Human Rights National Perspective Human Rights in Indian Constitution – Fundamental Rights- The Constitutional Context of Human Rights-directive

Principles of State Policy and Human Rights- Human Rights of Women-children – minorities- Prisoners- Science Technology and

Human Rights- National Human Rights Commission- State Human Rights Commission- Human Rights Awareness in Education.

Reference Books:

1. Non-conventional energy sources - G.D Rai- Khanna Publishers, New Delhi
2. A textbook of Environmental Studies- E Bharucha - University Grants Commission, 2004
3. Environmental Science: Principles and Practice- R.C. Das and D.K. Behera - PHI Learning Pvt. Ltd
4. Renewable Energy Sources and Emerging Technologies: Edition 2, D.P. Kothari K. C. Singal, Rakesh Ranjan - PHI Learning Pvt. Ltd, 2011.
5. Solar energy - M P Agarwal - S Chand and Co. Ltd.
6. Solar energy - Suhas P Sukhative Tata McGraw - Hill Publishing Company Ltd.
7. Renewable Energy, Power for a sustainable future, Edited by Godfrey Boyle, Oxford University Press, 2012.
8. Solar Energy: Resource Assesment Handbook- Dr. P Jayakumar APCTT 2009
9. A textbook of Environmental Studies- S.Satyanarayan, S.Zade, S.Sitre and P.Meshram - Allied Publishers, New Delhi, 2009
10. Remote Sensing: Principles and Interpretation, Floyd F. Sabins, Waveland Pr Inc; 3 edition (2007)

Human Rights

1. Amartya Sen, The Idea Justice, New Delhi: Penguin Books, 2009.
2. Chatrath, K. J.S., (ed.), Education for Human Rights and Democracy (Shimla: Indian Institute of Advanced Studies, 1998)
3. Law Relating to Human Rights, Asia Law House, 2001.
4. Shireesh Pal Singh, Human Rights Education in 21st Century, Discovery Publishing House Pvt.Ltd, New Delhi,
5. S.K.Khanna, Children and the Human Rights, Common Wealth Publishers, 1998. 2011.
6. Sudhir Kapoor, Human Rights in 21st Century, Mangal Deep Publications, Jaipur, 2001.

7. United Nations Development Programme, Human Development Report 2004: Cultural Liberty in Today's Diverse World, New Delhi: Oxford University Press, 2004

Core 13: IPH5CR02 – Atomic and Molecular Physics - I
Credit: 3 (54 Hours)

Module I

Atomic Spectroscopy (18 Hrs)

Historical introduction. Electrostatic spectrum. Types of spectra. Absorption and emission of light by atoms, quantum theory, early atom models – Bohr model, electron spin and magnetic moment, Exclusion principle, Stern-Gerlach experiment, Vector atom model, quantum numbers associated with vector atom models, Total angular momentum and LS coupling, fine structure of Sodium D lines, Zeeman effect, quantum mechanical explanation for anomalous Zeeman effect, Paschen-Back effect.

Module II

Molecular Spectroscopy (18 Hrs)

Molecular energy levels. Electronic, rotational and vibrational energies, rotationalspectra, explanation in terms of rigid rotator model, vibrational energy levels,explanation in terms of harmonic oscillator. Electronic energy levels of atoms, Fluorescence and phosphorescence, Raman effect – experimental arrangement and result, classical theory and its failure, quantum theory of Raman effect. IR and Microwave spectroscopes.

Text Book:

1. Fundamentals of Molecular Spectroscopy, Colin N.Banwell and Elaine M. McCash, McGraw-Hill.

2. Molecular Structure and Spectroscopy, G.Aruldhas, PHI Learning Pvt. Ltd.

Module III

Resonance Spectroscopy (18 Hrs)

Electron Spin Resonance(ESR)– Principle of ESR, Relaxation process, g factor, Experimental setup, ESR spectrometer; characteristics of the g-factor. Total Hamiltonian for an electron; Hyperfine Structure- ESR spectrum of hydrogen atom.Nuclear Magnetic Resonance (NMR)– Principle of NMR, resonance condition; Relaxation processes, Chemical shift; indirect spin–spin interaction CW NMR spectrometer;Applications, Magnetic Resonance Imaging.

Text Book:

1. Molecular Structure and Spectroscopy, G.Aruldhas, 2nd ed.,PHI Learning Pvt. Ltd.
2. Fundamentals of Molecular Spectroscopy, Colin N.Banwell and Elaine M. McCash, McGraw-Hill
3. Modern Physics, Kenneth S Krane (2nd Edition), John Wiley.
4. Concepts of Modern Physics, Arthur Beiser (6th Edition), SIE.

References:

1. Spectroscopy,B.P. Straughan and S. Walker –(Vol.1) John Wiley
2. Fundamentals of Molecular Spectroscopy, C.N Banwell –(4th edition) TMH
3. Introduction to Atomic Spectra, H.E. White, TMH
4. Elements of Spectroscopy,Guptha, Kumar, and Sharma,Pragathi Prakash.
5. Introduction to Special Relativity,R. Resnick, John Wiley.
6. Mechanics,D.S.Mathur, S.Chand.
7. Mechanics, J.C. Upadhayaya, Ram Prasad.
8. Semiconductor Physics and Optoelectronics, V Rajendran, J Hemalatha and M S M Gibson, Vikas Pub.

Core 14: IPH5CR03 – Nuclear Physics - I
Credit: 3 (72 Hours)

Module I- Nuclear structure & General properties of nuclei (24 hrs)

Nuclear composition, Discovery of neutrons, Nuclear electrons, Classification of nuclei – Isotopes, Isobars, Isomers, Mirror nuclei. General properties of nucleus – size, nuclear mass, density, charge, angular momentum, nuclear magnetic dipole moments, electric quadrupole moment, Mass defect, binding energy, B.E. curve, packing fraction, nuclear stability. Theories of nuclear composition – proton-electron hypothesis – proton-neutron hypothesis. Properties of Nuclear forces – Meson theory of nuclear forces. Models of nuclear structure- Liquid drop model-Semi empirical binding energy formula with correction factors, Nuclear shell model, Collective model, Nilsson Model, Rotational and Vibration States.. Measurement of nuclear radius, parity, statistics of nuclei, properties of ground state of Deuterium nucleus, nuclear energy level scheme-explanation of magic numbers, fermi gas model of the nucleus.

Module II- Radioactivity (24 hrs)

Natural radioactivity – Fundamental laws of radioactivity- Soddy Fajan's Displacement Law- Radioactive disintegration law, half life – Mean life Radioactive series. Measurement of Decay constant, Units of Radioactivity, Law of successive disintegration, radiative dating, the age of earth, biological effects of nuclear radiations, Radiation hazards-radiation levels for safety- radiation protection methods-nuclear disasters-nuclear waste disposal.

Module III- Nuclear Fission & Fusion (24 hrs)

Discovery of nuclear fission – Fission products. Neutron emission in fission. Energy release in fission. Nuclear fission on the basis of liquid drop model, chain reaction – Nuclear reactor – uses of nuclear reactors- pressurized water reactor, boiling water reactor, Breeder reactor, neutron cycle in a thermal nuclear reactor, Plasma confinement- magnetic bottle-tokamak, inertial confinement. Nuclear fusion Energy production in stars – Proton-Proton cycle and Carbon - Nitrogen cycle, Peaceful utilization fusion power Controlled thermonuclear reactions Toroidal confinement – Tokamak Nuclear waste disposal and radiation hazards from nuclear explosion – radiation dosage.

References

1. Modern Physics, R. MurugesanS.Chand
2. Concepts of Modern Physics, Arthur Beiser, Tata McGraw-Hill Edition
3. Atomic and Nuclear Physics (Ch.2) S.N Ghoshal)S.Chand

4. Atomic and Nuclear Physics (Ch. 14) S.N Goshal
5. Introductory Nuclear Physics, K. S. KraneJohnWiley
6. Elements of nuclear physics, M.L. Pandya, R.P.S Yadav
7. Concepts of Nuclear Physics, Bernard Cohen, Tata McGraw-Hill Edition

Core 15: IPH5CR04 – Solid State Physics
Credit: 2 (54 Hours)

Module I

Crystal structure (12 hours)

Solid state, crystalline, polycrystalline and amorphous materials, crystal lattice, periodicity, translation vectors, unit cell, basis, symmetry operations, bravais lattice in two and three dimensions, miller indices, interplanar spacing, simple crystal structures-hcp, fcc, bcc and simple cubic, Structures of NaCl, Diamond and ZnS, Reciprocal lattice system and its properties, X-ray diffraction from crystals- Bragg's law, powder method.

Module II

Free electron theory and elementary band theory (12 hours)

Free electron gas in one dimension, three dimensions, electronic specific heat. Band theory: Bloch theorem, Kronig-Penney model (derivation not expected), energy-wave vector relations, different zone schemes, velocity and effective mass of electron, distinction between metals, insulators and semiconductors.

Semiconducting properties of materials (10 hours)

Intrinsic and extrinsic semiconductors, drift velocity, mobility and conductivity of intrinsic semiconductors, carrier concentration and Fermi level for intrinsic semiconductor, carrier concentration, conductivity and Fermi level for extrinsic semiconductor. Hall Effect, Direct and Indirect band gap.

Module III

Dielectric and Magnetic properties of materials (12 hours)

Polarization and susceptibility, local filed, dielectric constant and polarizability, sources of polarizability, Clausius-Mossoti relation, piezoelectricity. Response of materials to magnetic field, classification of magnetic materials, Langevin's classical theory of diamagnetism and paramagnetism, ferromagnetism, Weiss theory, domain theory, antiferromagnetism and ferrimagnetism (qualitative idea only).

Superconductivity (8 hours)

Origin of superconductivity, Meissner effect, super current and penetration depth, critical field and critical temperature, type-I and type –II superconductors, isotope effect, Josephson effect and tunneling- SQUID, BCS theory-Cooper pairs-Existence of bandgap.

Text book: 1. Solid State Physics by Puri and Babbar (S. Chand)

References:

1. Solid State Physics, M.A. Wahab, (2nd Edition), Narosa
2. Solid state physics, S O Pillai, New Age
3. Introduction to Solid State Physics, Charles Kittel, (7th Edition), Wiley
4. Elementary Solid State Physics, M. Ali Omer, Pearson.
5. Crystallography applied to solid state Physics, AR Verma, ON Srivastava, New age
6. Solid State Physics, AJ Dekker- Macmillian.

Core 16: IPH5CR05 –Linear Integrated Circuits
Credit: 2 (54 Hours)

Module I (18 hours) Operational Amplifiers:

Introduction – Operational Overview – Op-Amp supply voltages – IC Identification – Packages – Parameters-common mode configuration- common mode rejection ratio-input offset voltage-input offset current-total output voltage. Op-amp as an Voltage Amplifier-Inverting Amplifier – Non inverting amplifier –inverting–Voltage follower(buffer) – Summing Amplifier – Differential Amplifier- Op. Amp frequency response – Frequency versus gain Characteristics

Module II (18 hours) Op-amp with negative feedback:

Feedback configuration, voltage series feedback amplifier-negative feedback-closed loop voltage gain-difference input ideally zero-input resistance with feedback-output resistance with feedback-bandwidth with feedback-total output offset voltage with feedback-voltage follower. Voltage shunt feedback amplifier-closed loop voltage gain-inverting input terminal at virtual ground-input resistance with feedback-output resistance with feedback-bandwidth with feedback-total output offset voltage with feedback-current to voltage converter-inverter. Differential amplifier-differential amplifier with one op-amp-differential amplifier with two op-amp.

Module III (18 hours) Op-amp Applications:

Comparators- Integrator – Differentiator – Audio amplifier – High Impedance, Voltmeter – Op-Amp based oscillator circuits: Wein Bridge Oscillator – Colpitts Oscillator, Crystal Oscillator, Triangular wave Oscillator, Voltage-Controlled Sawtooth Oscillator, Square Wave Relaxation Oscillator. Active Filters: Low-pass Filters, High Pass Filters, Band Pass Filters, Notch Filter

Textbooks :

1. A Text book of Applied Electronics, R.S. Sedha – S. Chand (2005).
2. Electronic Devices and Circuits, J.B.Gupta-S.K.Kataria & Sons Linear Integrated Circuits, M.P.A.Jaleel-Maliyakkal Publishers, Calicut.
3. Op-Amps and Linear Integrated Circuits – Ramakant A Gayakwad

Core Practical: IPH5CP06 – Physics Practical - VII

Credit: 2 (36 Hours)

(The student has to complete at least 10 experiments)

1. Op-amp – Square Wave Generator

2. Op-amp – First Order Low Pass Filter (Design, Construction, Study)
3. Op-amp – First Order High Pass Filter (Design, Construction, Study)
4. Op-amp – Pulse Width Modulation
5. Op-amp – Digital/Analog Converter
6. Op-amp – A /D Converter
7. Op-amp –Summing Amplifier
8. OP-Amp – inverter, non-inverter, buffer for A.C input voltages
9. Decade Counter (BCD Counter) (IC 7490)
10. Bistable multivibrator using IC 555
11. Amplitude Modulator (Set up – Study using CRO)
12. Demodulator (Set up – Study using CRO)
13. IF Tuned amplifier (Frequency response)
14. Frequency modulation using IC 555
15. Pulse width modulation using IC 555

Core Practical: IPH5CP07 – Physics Practical - VIII
Credit: 2 (36 Hours)
(The student has to complete at least 10 experiments)

1. Spectrometer- Stoke's formula
2. Spectrometer - wavelength of Sodium D1 and D2 lines
3. Characteristics of solar cell
4. Absorption spectrum –KMnO4 solution / Iodine vapour –
5. Study of physical properties of crystals
6. Study of electrical properties of a thin film (sheet resistance)
7. Study the temperature dependence of dielectric constant of a ceramic capacitor and verify Curie-Wiess law
8. Study the dipole moment of an organic molecule (acetone).
9. Determine the dielectric constant of a non-polar liquid
10. Determination of Stefan's constant of radiation from a hot body
11. Determine the Hall coefficient, carrier concentration and carrier mobility.
12. Curie temperature of a magnetic material.
13. Dielectric Constant and Curie temperature of ferroelectric Ceramics.
14. Draw the hysteresis curve (B – H Curve) of a ferromagnetic material and determination of retentivity and coercivity.

15. Cornu's method- Determination of elastic constant of a transparent material

References:

1. A course of Experiments with He-Ne Laser- R.S Sirohi (2nd Edition) Wiley Eastern Ltd
2. Advanced course in Practical Physics by D Chattopadhyay
3. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
4. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
5. A Text Book of Practical Physics, I.Prakash& Ramakrishna, 11th Edn, 2011,Kitab Maha
6. Advanced Practical Physics, S.P singh, PragatiPrakasan,
7. Practical Physics, Gupta, Kumar, PragatiPrakasan

Core Practical: IPH5CP08 – Physics Practical - IX

Credit: 2 (36 Hours)

(The student has to complete at least 10 experiments)

1. To measure Specific Resistance of a material using Carey Foster's Bridge
2. To determine the self-inductance of the coil (L) using Anderson's bridge.
3. To determine the volume magnetic susceptibility of Manganese sulphate solution at different concentrations by Quincke's method.
4. To study polarization of light using He-Ne Laser.
5. To find the elastic constants of the Perspex beam using Cornus interference method.
6. To study various crystals structures.
7. To determine the refractive index of a thin glass plate using Michelson's Interferometer.
8. To find the refractive index of given liquid using Newton's rings experiment.

9. To determine the wavelength of a laser using the Michelson interferometer.
10. To study the phase change of a substance from liquid to solid by plotting the cooling curve.
11. To determine the melting point of the given substance and to find out the transition time.
12. To find the thermal conductivity of a material by the two slabs guarded hot plate method.
13. To find the thermal resistance of the sample.
14. To calculate the adiabatic compressibility of the given liquid using ultrasonic interferometer.
15. To calculate the velocity of ultrasonic sound through different liquid media using ultrasonic interferometer.

MAHATMA GANDHI UNIVERSITY
UG BOARD OF STUDIES (MATHEMATICS)
COMPLEMENTARY COURSE FOR INTEGRATED M.Sc. PROGRAMME IN BASIC SCIENCES -PHYSICS

SEMESTER

III

IPH3CM04

DIFFERENTIAL EQUATIONS AND VECTOR CALCULUS

5 hours/ week (Total Hours: 90)
4 credits

Text Books:-

1. A. H. Siddiqi, P. Manchanada : A first Course in Differential Equations with Applications (Macmillan India Ltd 2006).

2. Ian Sneddon : Elements of Partial Differential Equations (Tata Mc Graw Hill).
3. George B. Thomas, Jr: Thomas' Calculus (12th Edition), Pearson.

Module I: Ordinary Differential Equations

(24 hours)

Separable Variables, Exact Differential Equation, Equations reducible to exact form, Linear Equations, Solutions by Substitutions, Homogeneous equations and Bernoulli's Equations.

Text 1: Chapter 2 (Sections 2.1 to 2.5).

Module II: Partial Differential Equations

(22 hours)

Surfaces and Curves in three dimensions (Review of ideas only), Solution of equations of the form $\frac{dx}{P}=\frac{dy}{Q}=\frac{dz}{R}$, Origin of first order and second order partial differential equations, Linear equations of the first order, Lagrange's method.

Text 2: Chapter 1 (Sections 1 and 3), Chapter 2 (Sections 1, 2 and 4).

Module III: Vector valued Functions

(18 hours)

Curves in Space and Their Tangents, Arc Length in Space, Curvature and Normal Vectors of a Curve, Directional Derivatives and Gradient Vectors.

Text 3: Chapter 13 (Sections 13.1, 13.3 and 13.4), Chapter 14 (Section 14.5 only).

Module IV: Integration in Vector Fields

(26 hours)

Line Integrals, Vector Fields and Line Integrals: Work, Circulation and Flux. Path Independence, Conservative Fields and Potential Functions , Green's theorem in the Plane (Statement and problems only), Surfaces and Area, Surface Integrals, Stoke's theorem (Statement and Problems only), The Divergence Theorem (Statement and simple problems only).

Text 3: Chapter 16 (Sections 16.1 to 16.7 and 16.8(Sections of Divergence Theorem only)).

Reference Books:

1. E. Rukmangadachari: Differential Equations, Pearson.
2. R. K. Ghosh, K. C. Maity: An introduction to Differential Equations, New Central Books.
3. Shepley L. Ross: Differential Equations, 3rd Edition, Wiley, India.
4. Harry F. Davis & Arthur David Snider: Introduction to Vector Analysis, 6th ed., Universal Book Stall, New Delhi.
5. Shanti Narayan, P.K. Mittal: Vector Calculus, S Chand & Company.
6. Merle C. Potter: Advanced Engineering Mathematics, Oxford University Press.
7. Murray R. Spiegel: Vector Analysis, Schaum's Outline Series, Asian Student edition.

SEMESTER IV

IPH4CM04

SPECIAL FUNCTIONS, LAPLACE TRANSFORMS AND COMPLEX ANALYSIS

5 hours/ week (Total Hours: 90)
4 credits

Text Book:-

1) Erwin Kreyszig, Advanced Engineering Mathematics, Eighth Edition, Wiley, India.

Module I: Special Functions

(21 hours)

Power series method of solving differential equations, Legendre equation and Legendre Polynomials (including Rodrigues Formula), Bessel's Equation and Bessel Functions.

Chapter 4 (Sections 4.1, 4.3 and 4.5)

Module II: Laplace Transforms (22 hours)

Laplace Transform, Inverse Laplace transform, Linearity, Shifting, Transforms of Derivatives and Integrals, Differential Equations, Differentiation and Integration of Transforms, Laplace Transform General Formulas (relevant formulae only), Table of Laplace Transforms (relevant part only).

Chapter 5 (Sections 5.1, 5.2, 5.4. 5.8 and 5.9) (Proofs of all theorems in this module are excluded.)

Module III: Complex Numbers and Functions (25 hours)

Complex Numbers, Complex Plane, Polar form of Complex Numbers, Powers and Roots, Derivative, Analytic Functions, Cauchy-Riemann Equations, Laplace's Equation, Exponential Function, Trigonometric Functions, Hyperbolic Functions, Logarithm, General Power.

Chapter 12 (Sections 12.1 to 12.4 and 12.6 to 12.8) (Proofs of all theorems in this module are excluded.)

Module IV: Complex Integration (22 hours)

Line Integral in the Complex Plane, Cauchy's Integral Theorem, Cauchy's Integral Formula, Derivatives of Analytic functions.

Chapter 13 (Sections 13.1 to 13.4) (Proofs of all theorems in this module are excluded.)

Reference Books:

1. Murray R. Spiegel, Laplace Transforms, Schaum's Outline Series, McGraw-Hill Education.
2. Dennis G. Zill, A First Course in Differential Equations, 10th Edition, Cengage Private Limited.
3. P.P.G Dyke, An Introduction to Laplace Transforms and Fourier Series, Springer 2005.
4. A. H Siddiqi, P Manchanada: A First Course In Differential Equations With Applications, Macmillan India Ltd, 2006.
5. Michael D. Greenberg, Advanced Engineering Mathematics, Pearson Education, 2002.
6. B. S. Grewal, Higher Engineering Mathematics, 42nd Edition, Khanna Publishers.

7. M R Spiegel, Complex Variables, Schaum's Series.
8. Brown and Churchill, Complex Variables and Applications, McGraw-Hill Higher Education, 8th Edition, 2008.
9. B. Choudhary, The Elements of Complex Analysis, 2nd Edition, New Age International, 1992.

COMPLEMENTARY CHEMISTRY

SEMESTER-III – IPH3CM05 - *FUNDAMENTALS OF PHYSICAL CHEMISTRY*

Credits-3 (54 Hrs)

Unit 1: Solids and Crystalline State (18 Hrs)

Classification of solids: amorphous, crystalline – differences. Lattice, lattice energy (general idea), unit cell, examples of simple cubic, bcc and fcc lattices, calculation of number of atoms in a unit cell, calculation of lattice parameters of cubic unit cell. Theories of Solid: band theory, conductors, semiconductors and insulators, mention of super conductors. Magnetic Properties: classification - diamagnetic, paramagnetic, antiferromagnetic, ferro and ferrimagnetic, permanent and temporary magnets. Symmetry of molecules-symmetry operations and symmetry elements (the identity, centre of symmetry, plane of symmetry,*n*- fold axis of rotation),and crystallographic point groups (eg. H_2O, NH_3, BF_3), Schoenflies symbol. Symmetry elements in crystals - The seven crystal systems – Weiss and Miller indices - Bravais lattices – Bragg's equation (derivation required) and its applications (mention only), structure determination of NaCl by X-ray diffraction.

Unit 2: Liquid State and Solutions (12 Hrs)

Liquids: Intermolecular forces in liquids compared with gases and solids (qualitative idea only), viscosity, surface tension (method of determination not expected), structure of liquids (a qualitative description). Liquid crystals – the intermediate phase between solid and normal liquid phases, thermographic behaviour, classification, structure of nematic and cholesteric phases. Solutions: Kinds of solutions - Solubility of gases in liquids – Henry's law and its applications - Colligative properties - Osmotic pressure - Reverse osmosis and its applications - Determination of molecular mass using colligative properties.

Unit 3: Gaseous State (9hrs)

Gaseous State: Introduction - Kinetic molecular model of gases – Maxwell distribution of velocities and its use in calculating molecular velocities – Average velocity, RMS velocity and most probable velocity (derivations not required) – Boyle's law – Charles's law – Ideal gas equation – Behaviour of real gases – Deviation from ideal behaviour - Van der Waals equation (derivation not required).

Unit 4: Surface Chemistry and Colloids (9 Hrs)

Adsorption – types of adsorption of gases by solids, factors influencing adsorption, Freundlich adsorption isotherm – Langmuir adsorption isotherm (derivation not required).True solution, colloidal solution and suspension. Classification of colloids: Lyophilic, lyophobic, macromolecular, multimolecular and associated colloids with examples. Purification of colloids by electrodialysis and ultrafiltration. Properties of colloids: Brownian movement – Tyndall effect

– Electrophoresis. Origin of charge and stability of colloids – Zeta potential – Coagulation - Hardy Schulze rule – Protective colloids - Gold number. Emulsions. Applications of colloids: Delta formation, medicines, emulsification, cleaning action of detergents and soaps.

Unit 5: Phase Equilibrium (6Hrs)

Equilibrium between phases,the phase rule(derivation not required), definition, one component system – water system, condensed Gibbs Phase rule, two component systems: solid- liquid equilibrium – simple eutectic, lead-silver system, solid solution. Distribution law, partition coefficient, applications.

References

1. B.R. Puri, L.R. Sharma, M.S. Pathania, Elements of Physical Chemistry, 40thedn. Vishal Pub. Co. Jalandhar (2013)
2. B. R. Puri, L.R. Sharma and K.C. kalia, Principles of Inorganic Chemistry, Milestone Publishers New Delhi. 2013.
3. J.A. K. Tareen and T.R. N. Kutty, A basic course in Crystallography, University Press, 2000.
4. Anthony R West, Solid State Chemistry and its Applications", Wiley Eastern
5. V.Ramakrishnan and M.S.Gopinathan, "Group Theory in Chemistry", Vishal Publishing Co.
6. Gurdeep Raj, "Advanced Physical Chemistry", Goel Publishing House.
7. Walter J. Moore, Physical Chemistry, 4thEdn. Longmans Green and Co. Ltd.
8. P. W Atkins, "Physical Chemistry", Oxford University Press.
9. R. J Silby and R.A Alberty, "Physical Chemistry", John Wiley & Son

SEMESTER-IV - IPH4CM05 - *CONCEPTS OF PHYSICAL CHEMISTRY*

Credits-3 (54 Hrs)

Unit 1: Molecular Spectroscopy (9 Hrs)

Interaction of electromagnetic radiation with matter, electromagnetic spectrum, quantization of energy, electronic, vibrational and rotational energy levels, Boltzmann distribution of energy (formula only), population of levels.

UV- Visible Spectroscopy: Beer Lambert's law, molar extinction coefficient and its importance, UV spectrum, λ_{max}, chromophore, auxochrome, red shift, blue shift, types of transition.

Infra-red spectroscopy: vibrational degrees of freedom, types of vibrations – symmetric and asymmetric stretching and bending, calculation of force constant, concept of group frequencies, Fingerprint region in IR spectra.

Rotational Spectroscopy: diatomic molecules, determination of bond length.

Unit 2: Nanochemistry (9 Hrs)

Terminology- scales of nanosystems- nanoparticles. Nanomaterials – Quantum Confinement, synthesis-top down and bottom up approach-chemical precipitation, mechano-chemical method, micro emulsion method, reduction technique, Laser and thermal vapour deposition and sol-gel method (brief study). Properties and applications of fullerenes and carbon nanotubes. Nanochemical devices- optoelectronic devices- photodetectors- LEDs and lasers. Introduction to Morphological characterisations - SEM and TEM.

Unit 3: Kinetics, Catalysis & Photochemistry (18 Hrs)

Kinetics:Rate of reactions, Factors influencing rate of reactions, Order and molecularity - Zero, first, second and third order reactions, Derivation of integrated rate equations for first order and second order reactions (single reactant only), Half-life period for first order reaction, Units of rate constants, Influence of temperature on reaction rates, Arrhenius equation, Calculation of Arrhenius parameters, Theory of Reaction rates - Collision theory and Activated complex theory-basic concepts(no derivationrequired).

Catalysis:Activation energy in chemical transformation-role of catalysts, Types of catalysis – Homogeneous and heterogeneous catalysis. Theories of catalysis: Outline of intermediate compound formation theory and adsorption theory. Examples for catalytic reaction- Fischer–Tropsch process, Contact Process and Haber-Bosch process.

*Photochemistry:*Laws of photochemistry, Grotthuss-Draper law, Stark-Einsten's Law, Beer-Lambert's Law. Photochemical equivalence and quantum explanation for low and high quantum yields. Photosensitization, Jablonski diagram- Fluorescence and phosphorescence, flash photolysis and chemiluminescence.

Unit 4: Electrochemistry (18 Hrs)

Introduction-Electrode and Electrolytes, Electrolysis of Molten NaCl, Faraday's laws of electrolysis, electrochemical equivalent and chemical equivalent, Specific conductance, equivalent conductance and molar conductance – Variation of conductance with dilution - Kohlrausch's law, Degree of ionization of weak electrolytes, Abnormal ionic conductivity of H^+ and OH^-, Application of conductance measurements –Determination of degree of dissociation of weak electrolytes, conductometric titrations involving strong acid- strong base, strong acid- weak base, weak acid- strong base, and precipitationtitration.

Galvanic cells - Electrode and cell potentials - IUPAC sign convention, Daniel Cell, Types of electrodes: Primary and secondary reference electrodes – Standard hydrogen electrode calomel electrode and Ag/AgCl electrodes, Indicator electrodes-metal-metal ion electrodes, Quinhydron electrode and Redox electrodes. Standard electrode potential - Nernst equation, electro chemical series. Gibb's Helmholtz equation and EMF of a cell.

Fuel cells- H_2-O_2 fuel cell-hydrogen as future energy source, Potentiometric titrations of acid-base, redox and precipitation reactions.

References

1. Banwell, C. N. &Mc Cash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed. Tata McGraw-Hill: New Delhi(2006).

2. D. L. Pavia, G. M. Lampman, G. S. Kriz, Introduction to spectroscopy 3rd edn, Thomson Brooks/Cole,2001.

3. V. S. Muraleedharan and A. Subramania, *Nanosciece and nanotechnology*, Ane Books Pvt. Ltd. New Delhi,2009

4. T. Pradeep, *Nano: The Essentials*, McGraw-Hill education, NewDelhi,2006.

5. K.K. Sharma and L.K. Sharma, *A Textbook of Physical Chemistry*, 5th Edition, Vikas Publishing House, New Delhi,2012.

6. B. R. Puri, L.R. Sharma, M. S. Pathania, *Elements of Physical Chemistry*, 40th edn. Vishal Pub. Co. Jalandhar(2003).

7. G. M. Barrow, *Physical Chemistry*, 5th Edition, Tata McGraw Hill Education, New Delhi, 2006.

8. G. K. Vemulapalli, Physical Chemistry, Prentice-Hall of India Pvt. Ltd.(1997)

9. Gurdeep Raj, Photochemistry, 6th Edn, Goel Publishing House,2014.