Semester – VI

PHY06(T-A)

Solid State Physics-II, Electronics-II and FORTRAN Programming

(Lectures: 120)

(Full Marks: 75)

UNIT I (35 Lectures)

Crystal structure: Symmetry in crystals, point groups, space groups. Structure of sodium chloride, cesium chloride, diamond and zinc sulfide.

Diffraction by crystals: Bragg's law; Laue's treatment of diffraction and Laue's equations, need for reciprocal lattice vectors, Wigner-Seitz cell.

Brillouin zones. Reciprocal lattice of sc, bcc and fcc structures. Fourier analysis of basis, structure factor of bcc and fcc, atomic form factor. Experimental techniques, Laue method, powder method, neutron diffraction methods.

Crystal binding: Bonding in covalent crystals, ionic crystals, inert gas crystals, metallic crystals and hydrogen-bonded crystals, and properties of these crystals; Madelung energy and Madelung constant in ionic crystals, London-London interaction in inert gas crystals and cohesive energy.

Lattice vibration, quantization of lattice vibration, vibration of monatomic and diatomic chain of atoms. Lattice heat capacity, phonon density of states, Einstein and Debye theories of heat capacity.

UNIT-II (27 Lectures)

Free electron model: Quantum mechanical treatment of free electrons in metals, concept of Fermi level, density of states, heat capacity of the electron gas, experimental heat capacity of metals, electrical conductivity, experimental electrical resistivity of metals, Matthiessen's rule, plasma frequency, Hall effect, thermal conductivity of metals, Wiedemann-Franz law.

Band Theory: Nearly free electron model, origin of the energy gap, magnitude of the energy gap, concept of bands and band gap; equations of motion; effective mass, effective mass in semiconductors, silicon and germanium, intrinsic carrier concentration, intrinsic mobility; impurity conductivity.

Magnetism: Langevin theory of diamagnetism and paramagnetism; Weiss theory of ferromagnetism; anti-ferromagnetism and ferri-magnetism.

Properties of Superconductor: Heat capacity, energy gap, isotope effect. Thermodynamics of the superconducting transition. Elementary ideas of BCS theory. High temperature superconductivity.

UNIT III (40 Lectures)
FET: Similarities and dissimilarities of FET and BJT, JFET, static and transfer characteristics of JFET, pinch off voltage, idea of MOSFET.

OPAMP: Ideal OPAMP, Inverting and non-inverting OPAMP, differential amplifier, transfer characteristics of OP AMP, offset parameters, differential gain, CMRR. Applications of OP AMP as adder, integrator and differentiator.

Amplifiers: Transistor biasing, Self biasing circuit, Analysis of CE single stage amplifier using h-parameter, multistage amplifiers, analysis of two stage RC coupled and transformer coupled amplifier, feedback amplifiers, gain with feedback.

Osillators: Positive feedback and condition for sustained oscillation, Analysis of Colpitt's and Hartley's oscillators.

Elements of communication systems, features of radio communication.
TTL Logic families, multiplexer, demultiplexer, digital comparator.

UNIT IV (18 Lectures)
Classification of computers: analog and digital. Flowchart and algorithm with examples, FORTRAN (77) characters: integer, constant, real constant, complex constant, logical constant. FORTRAN variables: real variables, double precision, logical variables, subscripted variables, arrays. Library functions. FORTRAN expressions. FORTRAN statements :

(A) Executable statements :(with illustration):
(i) Assignment statement
(ii) Input statement: formatted and unformatted
(iii) Control statement and its classification, i.e.
(a) GOTO statement, unconditional GOTO statement, computed GOTO statement and assigned GOTO statement
(b) IF statement: arithmetic IF, logical IF, IF THEN, ELSE, ENDIF.
(c) DO statement: DO loop, ENDDO.
(d) CONTINUE statement

(e) STOP statement
(f) PAUSE
(iv) Output statement: formatted and unformatted
(v) RETURN statement (related to subprogram)

(B) Non-executable statement (with examples and illustration) DIMENSION statement

IMPLICIT statement
EXPLICIT statement
FORMAT statement
NAMELIST statement
COMMON statement
EQUIVALENCE statement
EXTERNAL statement
END statement
OPEN FILE statement

Text Books:

1. **Fundamentals of Solid State Physics:** Saxena, Gupta and Saxena, Pragati Prakashan, Meerut, 17th Edition, 1999.
2. **Handbook of Electronics:** S.L. Gupta & V. Kumar, Pragati Prakashan, Latest edition.
3. **FORTRAN 77 and NUMERICAL ANALYSIS:** C. Xavier, New Age International, 2001.

Reference Books:

1. **Solid State Physics:** S.O. Pillai, New Age International Publishers, New Delhi, Sixth Edition, 2005.
2. **Solid State Physics:** A.J. Dekker, McMillan,1969.
3. **Introduction to Solid State Physics:** C Kittel, John Wiley-India, New Delhi, Seventh Edition.
4. **Elements of Solid State Physics:** J.P. Srivastava, Prentice Hall of India, 2001.
5. **Introductory Solid State Physics:** H. P. Myers, Viva Book,1998.
6. **Fundamentals of Solid State Physics:** J. R. Chrisman, John Wiley.1988.
7. **Elementary Solid State Physics:** M.A Omar, Addison Wesley, 1993.
8. **Electronics:** Fundamentals and Applications: D Chattopadhyay and PC Rakshit, New Age International, 6th Edition, 2005.
9. **Basic Electronics:** B.L. Theraja, S. Chand & Co., 2005.
10. **Basic Electronics:** D.C. Tayal, Himalaya Publications, 2005.
11. **Electronics Fundamentals and Applications:** J. D. Ryder, Prentice Hall of India Pvt. Ltd., 2003.
12. **Fundamental Principle of Electronics:** B Ghosh, Book and Allied (P) Ltd., Latest edition.
13. **Solid State Electronic Devices:** B.G. Streetman, Prentice Hall of India Pvt. Ltd., 2004.
14. **Computer Programing in Fortran 77:** V. Rajaraman, PHI, 2001.

PHY06 (T-B)

Atomic Physics-II, Molecular Spectroscopy, Nuclear Physics-II, Astrophysics

(Lectures: 120)
(Full Marks: 75)

UNIT I (25 Lectures)

Vector atom model: Space quantization and spinning electron, Stern Gerlach experiment, quantum numbers associated with vector atom model and their physical significance; spin – orbit interaction and its explanation of fine structure. Spectral terms - s,p,d,f notation, magnetic moment due to orbital motion and spin, Bohr magneton, Lande g- factor, Larmor's theorem, gyromagnetic ratio.

Zeeman Effect: Experimental observation, classical and quantum theory of normal Zeeman effect, quantum theory of anomalous Zeeman effect for one electron system only.

Spectrum of Alkali elements: Alkali spectrum and effect of screening on their spectrum, screening constant.

Two electrons system: L-S coupling, j-j coupling, Pauli's exclusion principle, spectra of helium atom and alkaline earth atoms, singlet and triplet fine structure, selection rules.

UNIT II (25 Lectures)

Introduction: Types of molecular spectra – rotational, vibrational and electronic spectra. Pure rotational spectra of a diatomic rigid body rotator – quantum mechanical derivation of energy levels of rigid body rotator, frequency of spectral lines, selection rule and the spectrum.

Vibrating diatomic molecule as a harmonic oscillator – frequency, energy levels, selection rules, spectrum, vibrational – rotational spectra, selection rules.

Electronic spectra: Electronic band systems, sequence and progression, Frank Condon principle.

Raman effect and its brief quantum mechanical explanation, Raman shifts, Stokes and anti-Stokes lines, selection rules, comparison of Raman and IR spectra.

Fundamental ideas of UV and IR spectroscopy, Atomic Emission Spectroscopy (AES), Atomic Absorption Spectroscopy (AAS) and basic ideas about X-ray Fluorescence (XRF) and its applications.

UNIT III (40 Lectures)

Basic properties of nucleus: Brief review, spin and magnetic moment, electric quadruple moment, binding energy, binding energy per nucleon and its variation with mass number of the nucleus. Coulomb energy, volume energy, surface energy, other corrections, explanation of B-E curve

Nuclear models: Liquid drop model, Shell model, Schmidt lines.

Nuclear Forces: Properties of nuclear forces, two nucleon system, square well solution of the deuteron problem.

Radioactivity: Geiger – Nuttal law, Gamow's theory of α decay, Fermi's theory of β - decay (qualitative treatment), neutrinos and anti neutrinos, nuclear radiation, energy levels, biological effects of nuclear and electromagnetic radiations, Maximum permissible radiation levels for safety, precaution against radiation hazards.

Nuclear Reactions: Rutherford's experiments on artificial transmutations, conservation theorems, Q- value, threshold energy, cross section of nuclear reactions.

Nuclear Fission: nuclear fission, Bohr Wheeler theory of nuclear fission, condition of spontaneous fission, four factor formula for a nuclear multiplication factor, chain reaction, criticality, moderators, types of reactors – power, breeder reactor.

Nuclear fusion: Nuclear fusion, fusion reaction in the plasma, condition for maintaining fusion reaction, Tokamak experiment in fusion systems.

UNIT IV (20 Lectures)

Elementary Particles: Discovery of muon, pion, heavy mesons and hyperons in cosmic rays. Concept of antiparticles.

Fundamental interactions, forces and fields.

Associated pair production, strangeness, conservation and violation of strangeness in particle interacttions, isospin, hypercharge. Symmetries and Conservation laws, Baryon and Lepton number conservation.

Resonant particles: discovery and important properties

Gell-mann Nishijima scheme, quark model, colour quantum number, and experimental discoveries of quarks, generations of quarks and leptons

UNIT V (10 Lectures)

Stellar evolution: Life of a star, proto star, stellar processes (nuclear), red giant, red super giant, neutron star, black hole, Chandrasekhar limit.

Spectral Classification of stars: O, B, A, F, G, K, M.

Star systems: Binaries/ Cepheids. HR diagram.

Significance of Sun: Solar cycles, Activity, Butterfly diagram, Photosphoric phenomena.

Text Books:

1. **Elements of Spectroscopy**, Gupta, Kumar & Sharma, Nineteenth edition, Pragati Prakashan, 2008.
2. **Introduction to Atomic Spectra**, H.E. White, Mc Graw Hill, 1934.
3. **Atomic and Nuclear Physics**, A.B. Gupta and Dipak Ghosh, Books and Allied (P) Ltd., 2000.
4. **Perspectives of Modern Physics**, A Beiser, Mc Graw Hill, 1969.
5. **Atomic and Nuclear Physics**, Vols 1 & 2, S.N. Ghoshal, S.Chand and Co. Ltd., 1994.
6. **Spectroscopy**, B.K. Sharma, 17th Revised and enlarged edition, , Krishna Prakashant Media (P) Ltd., 2005.
7. **Astronomy**, Dinah L. Moche, John Wiley and Sons, 2004.
8. **Introduction to elementary particles:** David Griffith, latest edition.

Reference Books:

1. **Molecular Spectroscopy**, G.M. Barrow, McGraw Hill, 1962.
2. **Atomic spectra and atomic structure**, G. Herzberg, Dover Publications, 1944.
3. **Spectra of Diatomic Molecules**, Van G. Herzberg, Nostrand Reinhold Company, 1950.
4. **Principle of Instrumental Analysis**, , Brooks Cole, Latest edition.
5. **Atomic and Nuclear Physics**, T.A. Littlefield and N. Thorley, E.L.B.S. Publications, 1980.

6. **Molecular Spectroscopy,** J.D. Graybeal, Mc Graw Hills International Edition, 1988.
7. **Molecular Structure and Spectroscopy,** G. Aruldhas, Eastern Economy Edition, Prentice Hall of India, Pvt. Ltd., 2004.
8. **Basic Nuclear Physics and Cosmic Rays,** B.N. Srivastava, Pragati Prakashan, 1993. 9. B.L. Cohen, Concepts of Nuclear Physics, Tata Mc Graw Hill, 1990.
9. **Nuclear Physics,** R.R. Roy, B.P. Nigam, New Age International (P) Limited, Publishers., 1996.
10. **Introductory Nuclear Physics,** R.K. Puri, B.K. Babbar, Narosa Publishing House, Delhi., 2005.
11. **Nuclear Physics : An Introduction ,** S.B. Patel, New Age International Pvt.Ltd, 1996.
12. **Introductory Nuclear Physics,** Kenneth S. Krane, John Wiley & Sons, 1988.
13. **Physics of Atoms and Molecules** B. H. BrandSen & C. J. Coachein, Pearson & Co., 2009.
14. **Radiation Detection and Measurement,** Glenn F Knoll, John Wiley and Sons, 4th Edition.
15. **Astrophysics: Star and Galaxies,** KD Abhyankar, University Press (India) Private Ltd, 2009.
16. **Astrophysics: A Modern Perspective,** KS Krishna Swamy, New Age International Publishers, 2010.

PHY06(P)
Experimental Physics-V
(Full Marks : 50)

(Minimum ten experiments to be performed)

List of experiments

1. To study the ripple factor of a full wave rectifier fitted with filter circuits (without filter, Capacitor filter, Inductor filter, L-section filter, π-section) and load regulation (with π-section filter only) .
2. To study the characteristics of a transistor in CB configuration and determine α.
3. To study the characteristics of a transistor in CE configuration and determine β.
4. To study the characteristics of JFET.
5. To design and study AND, OR, NOT and NAND/NOR gates using NOR/NAND gates ICs and to verify their truth tables.
6. To study Lissajous figures using C.R.O. and determine the frequency of an unknown source.
7. To study the frequency response of RC coupled amplifier.
8. To compute the roots of a quadratic equation by using FORTRAN programming.
9. To multiply two given matrices by using FORTRAN programming.
10. To find the sum of an arithmetic series using FORTRAN programming.
11. Study of plateau region of a GM counter.

Text Books:

1. C.L. Arora, B.Sc. Practical Physics, S Chand, 2005.
2. S. Ghosh, A Text Book of Practical Physics, New Central Book, 2001.
3. K.G. Mazumdar A Text Book on Practical Physics, Syndicate Press, 2006.
4. S. Ghosh, A Text Book of Advanced Practical Physics, New Central Book, 2001.
5. C. Xavier, Fortran 77 and Numerical Analysis, New Age International, 2001.
6. V. Rajaraman, Computer Programing in Fortran 77, PHI, 2001.
7. Nuclear radiation detectors: SS Kapoor and VS Ramamurthy, latest edition.