PH-10001

RADIATION INTERACTION IN MATTER AND DETECTION

SECTION A

Atomic Nuclei and Collisions:- Basics of atomic nuclei; charge, radius and mass of atomic nuclei, nuclear moments, parity and statistics. Basics of collisions; collisions cross section, type of collisions; elastic collision and inelastic collision and the total cross section, application of collisions cross section, laboratory and centre of mass system. Collisions of a free particle with a potential field, collision between two particles.

SECTION B

Ionization of matter by charged particles:- Classical theory of inelastic collisions with atomic electrons, Quantum mechanical theories of inelastic collision with atomic electrons. Comparison of classical and quantum mechanical theories, primary and secondary ionization. Dependence of collisions losses on the physical and chemical state of the absorber. Cerenkov radiations. Elastic scattering of electrons and positrons; scattering of electrons by nuclei and swift electrons by electrons.

Radiative collision of electrons with atomic nuclei; theory of bremsstrahlung and comparison of various interactions between swift electrons and atoms. Passages of heavy charged particles through matter; capture and loss of electrons, energy loss per unit path length, range and energy relationship and ionization of gasses. Straggling and range of fission fragments.

SECTION C

Interactions of gamma rays with Matter:- Compton collisions and the conservation laws, Klien-Nishina cross section for polarized and unpolarized radiation. Compton attenuation coefficients angular distribution of Compton scattered photons and recoil electrons. Energy distribution of Compton electrons and photons, photoelectric effect and pair production. Attenuation and absorption of electromagnetic radiation; attenuation coefficient, energy absorption multiple scattering of photons and distributed gamma ray sources.

SECTION D

Sources for Excitation of Characteristics X- rays and Instrumentations:- Broadband excitation with the sealed x-ray tube, monochromatic excitation using x-ray tubes, significance of drift in the x-ray generator, excitation with radioisotopes, excitation by electron and protons use of synchrotron radiations. X-ray fluorescence spectrometers and their major components, dispersion detection and counting with a wavelength dispersive spectrometer. Energy dispersive X-ray spectrometer.

Statistical fluctuations in nuclear process:- frequency distributions and statistical characterization of data and composite distributions. Statistical testing of hypothesis, least squares curve fittings, analysis of variance and experimental design. Sources of errors in x-ray spectroscopy analysis.

References:-

1. The Atomic Nucleus by Robley D. Evans, Tata McGraw-Hill Publishing company Ltd.
2. Introduction of theory of collisions of electrons with atoms and molecules by S.P.Khare, Kluwer Academic/ Plenum Publishers
3. Quantitative X-ray Spectrometry by Ron Jenkins R.W.Gould and Dale Gedcke, Marcel Dekker,Inc.

PH-10002

INTRODUCTION TO PLASMONICS

SECTION A

Introduction to plasma; Plasma and its type, Condition for the Existence of Plasma, Debye Length, Debye Shielding, Plasma Oscillation; Harmonic Oscillator theory,Plasma oscillation from electromagnetic equation, plasma oscillation in relation to electromagnetic waves (Dispersion relation for EMwaves)

SECTION B

Polarizability, Mossotti relation, Plasmons, Longotudinal plasma oscillation, surface plasmon polarition at metal/ insulator interface; wave equation, surface plasmon polaritons at a single interface, long range & short rang plasmons, Multiplayer system, energy confinement and the effective mode length

SECTION C

Excitation of surface plasmon polarition at planer interface; Prism coupling, grating coupling, excitation using highly focused optical beam, near field excitation, coupling schemes suitable for integration with conventional photonic elements, mie theory, beyond the quasi static approximation, gans theory, and LC model.

SECTION D

Plasmonics applications; plasmon waveguides; planar elements for surface plasmon polarition propagation, chain of nanoparticles, surface plasmon polarition propagation along metal stripes, metal nanowires and conical tapers for high-confinement guiding and focusing, metal nanoparticle waveguides

References:

1. Introduction to solid state physics: Charles Kittel(Hohan Wiley & Sons, New York)
2. Introduction to Unmagnetized Plasmas: Chanchal Uberoi(Prentice Hall of India, New Delhi)
3. Plasmonics: Fundamental and Applications: Maier S.A.(Springer Publications)

PH- 10003

THERMOELECTRICITY AND ITS APPLICATION

SECTION A

Thermoelectricity , Seebeck effect, Peltier effect, and Thomson effect, thermoelectric material series, thermoelectric power coefficients and their relations, figure of merit, thermocouples, use of thermocouples, thermopiles, thermoelectric devices, thermal and electrical conductivity of thermoelectric materials, diffusion theory, and phonon drag theory of thermoelectricity.

SECTION B

Governing equations for thermoelectricity and material (bulk and nanoscale) properties, theoretical approaches to new thermoelectric materials, modeling of thermal and electrical junctions, modules and applications systems.

SECTION C

Introduction to the properties and performance related to thermoelectric conversion of classical thermoelectric materials, oxides, clathrates, silicides, skutterudites, half heusler, thin films, nanostructured, noval(other) and organic thermoelectric materials alongwith structural characterization, thermoelectric, characterization of bulk, thin film and nanoscale materials. Progress in module development with respect to different materials and temperature range, device performance and characterization

SECTION D

Power applications of thermoelectric devices in waste heat recovery, cooling applications, generator applications, thermoelectric conversion for self sustaining power supplies. Markets for thermoelectrics, commodities, production technologies, recycling concepts & environmental aspects

References:

1. Modern thermoelectrics by D.M.Rowe and C.M.Bhandari, Holt Rinehart and Winston(London) and S&AE Scientific and academic editions division of Van Nostranmd Reinhart (New york), 1983
2. CRC Hand book of thermoelectric: Macro to nano by David Michael Rowe, CRC press (1995)USA
3. Thermoelectricity: An introduction to the principles by D.K.C.macdonald, Dover Publications (2006)

PH-10004

Advanced Solid State Physics

Section A

CRYSTAL STRUCTURE: Amorphous and crystalline solid, lattice, unit cell, primitive cell, Bravais lattices, reciprocal lattice, diffraction and structure factor, atomic packing fraction, brillouin zones, diamond structure, sodium chloride structure.

LATTICE VIBRATIONS: Introduction, dynamics of chain of identical atoms, dynamics of diatomic linear chain, central forces and angular forces, dynamics of identical atoms in three dimensions, Quantization of elastic waves, phonon momentum, inelastic scattering by phonons.

Section B

THERMAL PROPERTIES: Introduction, specific heat of solids, classical model, Einstein model, density of states, Debye model, thermal conductivity of solids, thermal conductivity due to electrons, thermal conductivity due to phonons, thermal resistance of solids, thermal resistivity of phonon gas, umklapp process

MAGNETIC PROPERTIES: Diamagnetism, paramagnetism, ferromagnetism, band theory of metals, insulators and semiconductors.

Section C

FREE ELECTRON IN CRYSTALLINE SOLIDS: Introduction, electrons moving in one dimensional potential well, three dimensional potential well, quantum state and degeneracy, density of states.

FERMI DIRAC STATISTICS: Introduction, effect of temperature on Fermi distribution function, electronic specific heat, thermal conductivity of metals, relaxation time and mean free path, electrical conductivity and ohm’s law, thermionic emission, Hall effect.

Section D

BAND THEORY: Bloch theorem, the Kronig penny model, construction of brillouin zones, extended reduced and periodic zone schemes, effective mass of electron, nearly free electron model, tight binding approximation.

SUPERCONDUCTIVITY: Introduction, critical magnetic field, meissner effect, type I and type II superconductors, London equations.

References:

1. Introduction to Solid state physics by C. Kittel, Wiely publication
2. Solid State Physics by Dekker
3. Solid state Physics by H.C. Gupta, Vikas publication

4. Introduction to lattice dynamics by Ghtak and Kothari, Addisson and wessley pub.
5. Introduction to lattice dynamics by M.T.Dove, Cambridge press

PH-10005

MATHEMATICAL METHODS AND COMPUTER PROGRAMMING

Section A

VECTORS: Orthogonal, curvilinear coordinates and expressions of gradient, divergence and curl in them. Gauss's, Stoke's and Green's theorems. Applications to hydrodynamics, heat flow in solids, gravitational potential. Maxwell's equation and wave equation.

TENSORS:Coordinate transformations, scalars, contravariant vectors, covariant vectors.Addition, multiplication and contracton of tensors. Associated tensors, differentiation of tensors. Intrinsic and covariant derivatives of tensors. Tensors of higher order, applications to dynamics of a particle.

MATRICES: Special matrices including orthogonal hermitian and unitary matrices. Number of independent parameters of special matrices. Inverse, linear transformation of matrices, partitioning and rank. Linear equations (simple cases), eigen values and eigen vectors, diagonalization.

Section B

FOURIER AND LAPLACE TRANSFORMS: Differentiation and integration of Fourier series, Orthogonal functions, fourier transform, Analysis of the vibrations of a string. Laplace transforms, inverse transform, partial fraction expansion, Laplace transform derivatives, substitution properties of Laplace transform, application to damped oscillator. RLC analog. Convolution or Faltung theorem.

Section C

INTRODUCTION TO FORTRAN : Introduction, FORTRAN constants, FORTRAN variables, type declaration, integer and real arithmetic, arithmetic operations, assignment statement and expressions, rules for arithmetic expressions, mixed mode assignment statements, elementary FORTRAN intrinsic functions, FORTRAN statements, parameter statement, STOP, PAUSE and END statements, simple examples of FORTRAN 77 programs, additional declaration statements.

CONTROL STRUCTURES ARRAYS SUB PROGRAMME: Introduction, selection or decision structure, GO TO statement, repetition structure, structure of arrays, array declaration statements, one dimensional arrays, multidimensional arrays, programming examples of arrays, Function sub-programs, statement functions, subroutine subprograms, subprogram structure diagrams.

Section D

BEGINNING WITH C++ PROGRAM: Simple program, input/ output operator, comments in C++, conditional statement- If, If else, nested If else, switch, loop statement- for and while loop.

CLASSES AND OBJECTS: Class, declaration of class in C++, writing body of member function outside class, creating object, accessing member of class, arrays within a class, array of object.

References

1. Mathematical methods for Physicists – G. Arfken
2. Applied Mathematics for Physicists and Engineers – L. A. Pipes
3. Matrices and Tensors in Physics – A.W. Joshi
4. Computer Oriented Numerical methods – V. Rajaman
5. Fortran Programming: V. Rajaraman