

PHYSICS DEPARTMENT

Program Linked Basket of Courses

A. Principles of Electronic Materials (3-0-0)

Metals:

Kronig Penney model and Energy bands in solids, Classification of metals, semiconductors and insulators; Density of states and Fermi-Dirac distribution; Free electron model, Conductivity in metals and alloys – classical and quantum mechanical models; Concepts of Fermi level, effective mass and holes, Brillouin zones; Hall-effect and concept of holes in metal; Concept of phonons, Thermoelectricity.

(12 lectures+2 problem solving sessions)

Semiconductors:

Intrinsic, extrinsic and degenerate semiconductors, Fermi level variation by carrier concentration and temperature, charge carrier mobility; Metal-semiconductor junction - rectifying and ohmic, p-n junction, Diffusion and drift transport, carrier life time and diffusion length; Direct and indirect band gaps, Optical transitions, photon absorption, Excitons; Recombination, photoconductivity, photovoltaic effect.

(12 lectures+2 problem solving sessions)

Dielectrics and Magnetism:

Dielectrics and electrical polarization, Depolarization field, Clausius-Mossotti relation; Drude model, Electronic polarization and its mechanisms, Dielectric breakdown; Piezoelectricity, Pyroelectricity and Ferroelectricity; Magnetism in materials – types of interactions, Magnetic susceptibility, Curie and Neel temperatures; Domains and domain walls, Magnetic anisotropies, Spin-orbit interaction.

(12 lectures+2 problem solving sessions)

Books:

1. Electronic Properties of Materials by R. E. Hummel
2. Principles of Electronic Materials and Devices by S. O. Kasap
3. Introduction to the Electronic Properties of Materials by D. Jiles

Faculty:

Prof. D. K. Pandya, Prof. Neeraj Khare, Prof. Pankaj Srivastava, Prof. Sujeet Chaudhary

B. Advanced Mechanics and Thermodynamics (3-0-0)

Dynamics of a single and system of particles through energy approach, Hamilton's principle, the principle of least action, Canonical transformation, implication to mechanical systems, Poisson, bracket, Concepts of phase space, Liouville's theorem, principle of stochastic cooling.

(12 lectures + 2 problem solving sessions)

Concepts of non linear dynamics, contraction of phase space volume, attractors, classical chaos, periodic motion, chaotic trajectories, bifurcations, driven damped harmonic oscillator, fractals and dimensionalities, various examples of nature, transition from discrete to continuous systems and fields.

(12 lectures + 2 problem solving sessions)

Laws of thermodynamics, Carnot's cycle, adiabatic and isothermal processes, principle of ideal engine and refrigeration; Definition of entropy, enthalpy, free energy, Maxwell's relations, Concepts of transport of heat and mass; Energy removal in power reactor, Thermal circuit concept in one and three dimension with and without heat source, Mathematical analysis of heat exchange in reactor.

(12 lectures + 2 problem solving sessions)

Books:

1. Classical Mechanics by W. Griener, Springer
2. Treatise of Heat by Saha and Srivastava
3. Energy Removal in Reactors by Glasstone and Sesonke, Von Nostrand Publishers.

Faculty:

Dr. Santanu Ghosh, Dr. Sankalpa Ghosh, Dr. Varsha Banerjee, Prof. Ajit Kumar

C. Physics of Nanomaterials (3-0-0)

Semiconducting Nanomaterials:

Basic concepts for bulk, Basics semiconductor concepts, Quantum dot, nanoparticle and clusters, critical size for low dimensional effects and magic numbers. Size induced modifications in band gap, Tight binding and effective mass approximations. Density of states of quantum dot, quantum wire, quantum well, superlattice and monolayer structures. Quantum Hall effect, Thermoelectrical properties of nanostructured materials.

(12 lectures + 2 problem solving sessions)

Metal and Magnetic Nanomaterials:

Basic concepts for bulk, Optical properties of metal nanoparticles, Core-shell nanoparticles. Size, shape and matrix effects, surface plasmon resonance, intrinsic and extrinsic effects. Applications of surface plasmon resonance in sensor devices. Magnetic properties of bulk and nanostructured materials. Single domain and multiple domain super paramagnetic phases, ZFC and FC measurements. Giant magnetoresistance effect.

(12 lectures + 2 problem solving sessions)

Synthesis and Applications:

Chemical and Physical methods of synthesis of nano-particles and nano-structures, size selection methods; Measurements of size and its distribution, Characterization by AFM, STM and STS; Applications - Single electron effect and resonant tunneling devices. QW lasers, CNT and Graphene, GMR magnetic sensor, Nanostructured solar cell, Thermoelectric devices.

(12 lectures + 2 problem solving sessions)

Books:

1. The Physics of Low dimensional semiconductors by John H. Davis, Cambridge University Press.
2. Introduction to Nanotechnology by Charles P. Poole and Frank J Owens, Wiley Interscience

Faculty:

Prof. B. R. Mehta, Prof. R. K. Soni, Dr. J. P. Singh, Dr. Rajendra Singh

D. Optics & Lasers (3-0-0)

Basic Optics:

Interference by division of wavefront and division of amplitude; Phase change on reflection, Non-reflecting films; Michelson interferometer. Fraunhofer diffraction: Single slit, circular aperture; limit of resolution. Diffraction grating, Resolving power. Various states of Polarization, Malus' law, Brewster's law; Double refraction, Wave plates, Faraday effect and Optical Isolator.

(9 lectures + 2 problem solving sessions)

Lasers:

Interaction of radiation and matter, Einstein coefficients, line shape function, condition for amplification; Optical resonators, resonator losses and the quality factor Q. Condition for laser oscillation; Longitudinal- and transverse modes of a laser, Some Laser Systems.

(9 lectures + problem solving session)

Fiber Optics:

Light propagation in optical fibers, Optical fiber communication, Attenuation and dispersion; Pulse dispersion in multimode fibers; Single-mode fibers, material dispersion; Fiber amplifiers and lasers, Fiber optic sensors.

(9 lectures + 2 problem solving sessions)

Fourier Optics and Holography:

Basics of Fourier transformation, definition of spatial frequency, FT by diffraction and by lens, Spatial filtering, Phase contrast microscope, some applications; Holographic principles, on-axis and off-axis hologram recording and reconstruction, Types of holograms, some applications.

(9 lectures + problem solving session)

Book: OPTICS, Ajoy Ghatak, Tata McGraw Hill, New Delhi, (5th Edition), 2012.

Faculty:

Prof. K. Thyagarajan, Prof. Arun Kumar, Prof. M.R. Shenoy, Prof Joby Joseph, Prof. Anurag Sharma

Supplementary Reference Books:

1. OPTICS, E. Hecht, Addison-Wesley Longman Inc. (Third Edition), 1998.
2. FUNDAMENTALS OF OPTICS, F. A. Jenkins and H.E. White, McGraw-Hill, New York, 1957.
3. OPTICAL ELECTRONICS, A. K. Ghatak and K. Thyagarajan, Cambridge University Press, Cambridge, 1989.
4. LASERS: FUNDAMENTALS AND APPLICATIONS, K. Thyagarajan and A. K. Ghatak, 2nd Ed. Macmillan Publishers Ltd. 2011
5. POLARIZATION OF LIGHT WITH APPLICATIONS IN OPTICAL FIBERS, A. K. Ghatak and Arun Kumar. Tata McGraw Hill, New Delhi, 2012.