LIST OF B. TECH. ELECTIVES

PH 451: Plasma Physics 3-0-0-6

General definition and properties of plasma, Motion of the charged particles in space and time varying electromagnetic field, Kinetic theory and thermodynamics of Plasma, Debye shielding, Boltzman and Fokker-Planck equation, Transport and collision in plasma, plasma fluid theory, hydrodynamics and magneto hydrodynamics, magnetic mirror, waves in plasma, plasma instabilities, plasma radiation and Plasma spectroscopy, Boltzman –Saha equation, neutral and non neutral plasma, Generation and diagnostics of plasma, plasma processing and other industrial applications industrial, Tokamak, nuclear fusion.

Texts and References:


PH 452: Magnetic Recording 3-0-0-6

(Pre-requisite: PH415 or equivalent)

History and overview of magnetic recording, Physics of Magnetism, Various forms of magnetic energies, Hard and Soft magnetic materials, Fundamental recording theory, Media magnetization, Erasure and Overwrite, Recording Zone and losses, Play Back Theory, Magnetic head circuits, Magnetoresistance, Anisotropic Magnetoresistance (AMR), Giant Magnetoresistance (GMR) Heads, Tunneling Magnetoresistance (TMR) heads, Spin Valves, Field from Magnetic Heads, Perpendicular head fields, Flux linkage and leakage, Particulate media, Thin magnetic films, Flexible media and Rigid disk substrates, Magnetic Properties of the media, Effects of Time and Temperature; Storage stability; measurement of spin polarization, Recording of a single transition, Narrow-track and short-gap recording, Perpendicular recording, Ultrahigh density recording, Future projection on recording and devices based on magnetoelectronics.

Texts and References:

PH 453: Robotics Fundamentals  3-0-0-6
Prerequisite: PH-211 Classical Mechanics (or equivalent)


Texts and References:


PH 454: Antenna Theory and Applications  3-0-0-6
Prerequisite: PH-301 Electromagnetics (or equivalent)


Texts and References:


PH 455: Microwave Theory and Applications  3-0-0-6
Prerequisite: PH-301 Electromagnetics (or equivalent)

Texts and References:

**PH 456: Physics of Carbon-Based Materials**

(8th semester)

Prerequisites: PH 415/Equivalent


*Fullerenes*: Production, intercalation compounds, synthesis, characterization, physical properties and technological applications of fullerenes.

*Carbon Nanotubes*: Formation of carbon allotropes, nanoscale numerical simulation techniques, interatomic potentials and forces in nanotubes, continuum and atomistic theories of mechanical properties, thermal transport in nanotubes, fluid flow in nanotubes and technological applications of carbon nanotubes.

*Graphene*: Atomic structure of graphene, band description, quasiparticles and the Dirac cone, relativistic dispersion and anomalous Hall effect, Klein paradox and proposed technological applications.

Texts and References:
PH 457: Nuclear Science and Technology 3-0-0-6

Review of nuclear physics: general nuclear properties, models of nuclear structure, nuclear reactions, nuclear decays and fundamental interactions.

Nuclear radiation: radioactivity, radiation dosimetry, dosimetry units and measurement; radiation protection and control; applications of radiation: medical applications, industrial radiography, neutron activation analysis, instrument sterilization, nuclear dating.

Nuclear fission: nuclear energy, fission products, fissile materials, chain reactions, moderators, neutron thermalization, reactor physics, criticality & design; nuclear power engineering; energy transport and conversion in reactor systems, nuclear reactor safety; nuclear fusion: controlled fusion, nuclear fusion reactions, fusion reactor concepts, magnetic confinement, tokamak, inertial confinement by lasers.

Nuclear waste management: components and material flow sheets for nuclear fuel cycle, waste characteristics, sources of radioactive wastes, compositions, radioactivity and heat generation; waste treatment and disposal technologies; safety assessment of waste disposal. Particle accelerators and detectors: interactions of charged particles, gamma rays and neutrons with matter, electrostatic accelerators, cyclotron, synchrotron, linear accelerators, colliding beam accelerators, gas-filler counters, scintillation detectors, and semiconductor based particle detectors.

Texts and References:


PH 458: Applied Superconductivity 3-0-0-6

(7th/8th semester)

Basics of superconductivity, superconducting materials, Electrodynamics of superconductors, London's model, flux quantization, type II superconductors, critical magnetic fields, pinning, the critical state model, electrodynamic behaviour at high (microwave) frequencies both at weak and strong applied fields for both isotropic and anisotropic superconductors, Josephson Junctions, Dc and rf superconducting quantum devices (SQUID), equivalent circuits,
Josephson logic circuits, high-speed superconducting electronics, and quantized circuits for quantum computing. Architecture of superconducting magnets, Elements of Superconducting levitation, Levitation forces and schemes, superconducting bearings, dynamics of levitated systems, magnetic levitation transportation.

Texts and References:


**PH 459: Nonlinear Fiber Optics and applications** 3-0-0-6

Basic characteristics of an optical fiber: Fiber losses, Chromatic dispersion, Polarization mode dispersion, Fiber nonlinearities, fiber modes, single-mode fiber.

Nonlinear pulse propagation: Derivation of The Nonlinear-Schrödinger equation (NLSE), variational and numerical methods to solve NLSE.

Optical solitons: Modulation instability, physics of optical soliton formation in optical fiber, bright and dark solitons, soliton-soliton interactions, effect of higher order perturbations.

Highly nonlinear fibers: Fibers with silica cladding, tapered fibers with air cladding, non-silica fibers, microstructured fibers.

Applications: Nonlinear fiber gratings, slow light, nonlinear fiber coupler, fiber-lasers, pulse compression, super continuum generation, soliton communication system.

Texts and references:


**PH 460: Electroceramics** 3-0-0-6

**Fabrication of ceramics:** General methods and new developments in ceramic processing. Sintering and microstructure development: Solid state sintering, densification vs. coarsening processes, grain boundary mobility mechanisms, porosity evolution, viscous densification, liquid phase sintering, constrained sintering.

**Dielectrics and insulators:** Capacitive and ferroelectric applications. Dielectric properties for low-, medium- and high-permittivity ceramics.

**Measurement techniques:** Basic principles and techniques for dielectric, ferroelectric and piezoelectric property measurements. Structure and property correlations.

**Piezoelectric ceramics:** General characteristics and commercial applications of typical piezoceramics.

**Pyroelectric materials:** Properties and measurements of pyroelectric coefficients of ceramics, thermal and infrared detection.

**Electro-optic ceramics and Magnetic ceramics:** Basic concepts, properties and applications of model ferrites.

**Texts:**


**References:**


**PH 461: Electron transport in Nanostructures**

**Pre-requisite:** PH 302/PH 405 for B. Tech/M. Sc

Basics of electron transport: Two dimensional electron gas, characteristic length scales, ballistic and diffusive transport, confinement and quantization of electronic states in quantum wires and quantum dots, Magnetic field and Hall effect, Quantum Hall effect, screening and collective excitations in low dimensional systems; Drude model: coherent and incoherent transport, Kubo formula, Fluctuation-dissipation theorem, generalization to spin-dependent transport, Boltzmann equation, approaches to local equilibrium; Transport in semiconductor nanostructures: Landauer formalism, Greens functions, S-Matrix, Self energy, Landauer-Buttiker formula, generalization to the multi-channel case, transport in quantum waveguide structures, Coulomb blockade effects in two terminal devices and single
electron transistors; Transport through metal-superconductor interfaces: Proximity effect, basic theory of Andreev reflection, point contact and crossed Andreev reflection, Andreev interferometer.

**Texts/References:**


**PH 462: Quantum Technology and Phenomena in Macroscopic systems**

**Pre-requisite:** Quantum Mechanics (PH 204)  

Review of the harmonic oscillator and two-level atomic systems, Ladder operators, Coherent states, Bloch vector, Rabi-oscillations, Basic idea about quantization of electromagnetic fields, Cooper pair box and its approximation as a two-level system, Microwave transmission line, Quantization of the transmission line and resonator, Jaynes-Cummings model in circuit QED, Dissipation in quantum systems, Lindblad Markoff master equations, Application to relaxation in a two-level system and harmonic oscillator, Bloch equations for a dissipative two-level system, Multi-qubit architectures, multi-qubit entanglement, strongly-driven artificial atoms, Cavity optomechanics, Quantum description of optomechanics, Mechanical cooling and squeezing.

**Texts and References:**


**PH 463: Theory of relativity**

**Pre-requisite:** Classical Mechanics (PH 201), Electromagnetics (PH 202)  

Review of basic concepts of special theory of relativity; Relativistic mechanics: Four dimensional formulation, Action function for a free particle, energy and momentum, Lagrangian and Hamiltonian formulation, decay of particles, elastic collision of particles, mechanics of continuous media; Relativistic electrodynamics: Invariance of electric charge and covariance of Maxwell's equations, Four vector potential, Field tensors, Gauge invariance, Lorentz transformation of the electromagnetic (EM) field, dual of the EM field tensors, Lorentz force and EM energy momentum tensor, action function for the EM field; Basics of General Relativity: mathematical preliminaries, distance and time intervals, covariant differentiation, metric tensor and Christoffel symbols, the curvature tensor,
properties of the curvature tensor, action function for the gravitational field, the energy momentum tensor, the Einstein's equation, solution of Einstein's equation in spherically symmetric background.

Text/References:


PH 464: Fundamentals of Cosmology 3-0-0-6

Pre-requisite: Classical Mechanics (PH 201)

A brief review of General Relativity; The Observed Universe and its Dynamics, Friedmann-Lemaître-Robertson-Walker (FLRW) metric, Friedmann equation and its solutions; Thermal history of the Universe, Matter-Radiation equality, Formation of cosmic microwave background (CMB), Recombination, Neutrino decoupling and Cosmic neutrino background; Calculation of relic abundance, Boltzmann equation; Composition of the Universe, Origin of matter, Big Bang Nucleosynthesis, abundance of light elements, dark matter and dark energy, Cosmological constant as dark energy, Origin of matter-antimatter asymmetry, Baryogenesis; Structure formation in the Universe, perturbations, gravitational instability, Newtonian and relativistic theory of evolution of density perturbations, evolution of structure, Power spectrum, CMB anisotropies; Beyond the standard model of cosmology, Horizon, flatness and monopole problems in the standard model of cosmology, Cosmic Inflation as a solution to these problems, Models of inflation, Origin of primordial perturbations.

Text/References: