Syllabus for Postgraduate Programs

(Approved in the 53th Academic Council Meeting dated 19 December 2016)

Department of Physics

2016

Courses and Syllabusfor Post Graduate Programs

List of Courses

Dissertation

Ph 6000: Thesis
(Credit: 18 hrs. for M Sc., 30 hrs. for M Phil. and 45 hrs. for Ph D.)

Theory Courses **Credit**

1. Advanced Physics

Ph 6101: AdvancedQuantum Mechanics
Ph 6102: Advanced Plasma Physics
Ph 6103: Advanced Nuclear Physics
Ph 6104: Solid State Physics (Condense Matter Physics)
Ph 6105: Electronics & Information Science

2. Materials Science and Technology

Ph 6201: X-ray Crystallography
Ph 6202: Magnetism
Ph 6203: Low Temperature Physics and Vacuum Techniques
Ph 6204: Physics of Semiconductorsand Superconductors
Ph 6205: Physics of Superconductors
Ph 6206: Materials Science
Ph 6207: Surface Science
Ph 6208: Nano Science and Technology
Ph 6209: Spintronics
Ph 6210: Experimental Techniques in Solid State Physics
Ph 6211: Polymer Physics
Ph 6212: Textile Physics
Ph 6213: Crystal Growth and Thin film Technology
Ph 6214: Laser Physics

3. Health & Medical Physics

Ph 6301: Biophysics
Ph 6302: Radiation Biophysics
Ph 6303: Radiation Protection
Ph 6304: Medical Physics
Ph 6305: Health Physics

Ph 6306: Physics of Radiology
Ph 6307: Physics of Radiotherapy

4. Environmental Physics

Ph 6401: Basic Atmospheric Physics
Ph 6402: Atmospheric Pollution
Ph 6403: Meteorology
Ph 6404: Climatology
Ph 6405: Remote Sensing and GIS
Ph 6406: Environmental Management
Ph 6407: Environmental Impact Assessment

5. Renewable & High Energy Physics

Ph 6501: Reactor Physics
Ph 6502: Solar and Renewable Energy
Ph 6503: Advanced Plasma Physics
Ph 6504: Neutron Scattering

Note:

First digit is for Postgraduate Program
Second digit is for Field of Specialization
Third and Fourth digits are for course serial

Detailed Syllabus

Dissertation

Ph 6000: Thesis
(Credit: 18 hrs. for M Sc. 30 hrs. for M Phil. and 45 hrs. for Ph D)

Theory Courses

1. Advanced Physics

Ph 6101: Quantum Mechanics **Credit: 3 hrs**

Schrödinger Wave Equation: One dimensional problem, Particle in a box, Tunneling through a potential barrier, Linear harmonic oscillator, Kronig-Penney (K-P) model; Particle in a Central Potential: Hydrogen atom, Wentzel-Kramers-Brillouin (WKB) approximation method; Perturbation Theory for Degenerate & Non-degenerate Cases: First and second order perturbation; Applications: Zeeman effect and Stark effect, Time dependent perturbation theory; Variation Method: Application to He atom and van der Waals interaction between two hydrogen atoms, Pauli spin matrices; Dirac Equation: System of identical particles, Hatree and Hatree-Fock approximation.

Ph 6102: Fundamentals of Plasma Physics **Credit: 3 hrs**

Basic Concepts of Plasma:What is plasma, Plasma temperature, Debye shielding, Plasmaparameters, Quasi-neutrality, Collective behavior; Single Particle Motions**:** Uniform E and B field, Nonuniform E and B field, Time varying E and B field, Magnetic mirrors; Plasma as Fluid:Relation of plasma physics to ordinary electromagnetic, The fluid equationof motion, The plasma approximation; Waves in Plasma:Group and phase velocity, Plasma oscillations, Electron plasma waves,Sound waves, Ion waves, Validity of plasma approximation, Comparison of ion and electron waves, Electrostatic electron oscillations perpendicular to B, Electrostatic ion waves perpendicular to B, The lower and upper hybrid frequency.

Ph 6103: Nuclear Physics **Credit – 3hrs**

Introduction to Nuclear Physics: Atomic structure, The nucleus, Semi-empirical mass formula and binding energy, Radioactive decay, Theories of alpha-decay, beta-decay and gamma emission, Nuclear reaction, Fission and fusion, Artificial radioactivity, Accelerators, Radiation detectors; Compound Nucleus: Statistical theory, Breit-Wigner dispersion formula, Level density, Angular distribution,

Energy spectra, Resonance, Giant-Resonance, Isobaric-spin, Isobaric analogue states, Analogue resonance; Direct Reaction: Inelastic scattering, Stripping and pick-up reaction, Butler's theory, Distorted wave Born-approximation theory, Assignment of J-values of nuclear levels; Nuclear Model: Shell model, Single particle model, Independent particle model, Collective model, Liquid drop model, Models of even-even nuclei, Optical model, Kapur-Peierls dispersion formula.

Ph – 6104: Solid State Physics **Credit: 3 hrs**

Introduction to Solid State Physics: Lattice dynamics of one, two and three dimensional lattices, Specific heat, Elastic constants, Phonon dispersion relations, Localized mode; Dielectric and Optical Properties of Insulators: AC conductivity, Dielectric constant, Dielectric losses; Transport Theory: Free electron theory of solids, Density of states, Fermi sphere, Electrons in a periodic potential; Band Theory of Solids: Nearly free electron theory, Tight binding approximation, Brillouin zones, Effective mass of electrons and holes.

Ph – 6105: Electronics and Information Science **Credit: 3 hrs**

Basic Electronics: Diodes, Amplifiers, Operational amplifiers (Op-Amp), Filters, Op-Amp RC oscillator, Converter, Transducer; Opto-Electronics: Light emitingdiods (LEDs), Liquid crystal displays (LCDs), Photodetectors and photoconductors (photoresistor), Photodiodes, Solar cells, Phototransistors and photodarlington, Photofield effect transistor, Opto-isolators, Laser diodes; Digital Electronics: Clock waveforms, Logic operation and description of RTL, DTL, TTL, and ECL logic families, Different 555 Timer multi-vibrator, Multiplexer, De-multiplexer, Encoder and decoder, Arithmetic logic unit (ALU), Data bus single and bi-directional, Serial and parallel transfer of data; Microprocessors and Interfacing: Microprocessor & microcomputer, Read and write operations; Communication Fundamentals: Analog and digital communications, Transmission of voices and picture data, Basic constituents of communication system, Fiber optics in communications, Computer communication network.

2. Materials Science and Technology

Ph – 6201: X-ray Crystallography **Credit: 3hrs**

X-ray: Production and properties of X-ray, Continuous and discrete X-ray spectrum, Reciprocal lattice, Structure factor and its application, Scattering of X-rays: Scattering by single electron, atoms and regular arrays of atoms; X-ray diffraction from a crystal; X-ray Techniques: Weissangerg and precession methods, Identification of crystal structure from powder photograph and diffraction traces, Laue photograph for single crystal, Geometrical and physical factors

affecting X-ray intensities, Analysis of amorphous solids and fiber textured crystal; Determination of Crystal Structure and Defects: Indexing of patterns-graphical and analytical method, Determination of number of atoms in a unit cell and atoms position, Scherrer method, Williamson-Hall method, Warren and Averbach method, Method of variance and fourth moment, Order-Disorder Transformation: Long-range order, Short-range order, Detection of superlattice lines.

Ph – 6202: Magnetism **Credit: 3hrs**

Magnetic Materials: Classification of magnetic materials, Quantum theory of paramagnetism, Pauli paramagnetism, Properties of magnetically ordered solids, Weiss theory of ferromagnetism, Interpretation of exchange interaction in solids, Ferromagnetic domains, Intrinsic magnetization of alloys, Theory of antiferromagnetic and ferrimagnetic ordering, Ferrimagnetic oxides and compounds; Magnetic Anisotropy: Pair model and one ion model of magnetic anisotropy, Phenomenology of magnetostriction, Law of approach of saturation, Structure of domain Wall, Technological applications of magnetic materials.

Ph – 6203: Low Temperature Physics and Vacuum Techniques Credit: 3hrs

Introduction to Low Temperature Physics: Production of low temperature, Thermodynamics of liquefaction, Joule-Thompson liquefiers; Cryogenic System Design: Cryostat design, Heat transfer, Temperature control, Adiabatic demagnetization; Cryogenic Thermometry: Gas and vapour pressure thermometers, Resistance, Semiconductor, and diode capacitance thermometers, Thermocouples, Magnetic thermometry; Vacuum Gauges: Mclead gauges, Thermal conductivity ionization gauges; Different Types of Pumps: Rotary, Diffusion and ion pumps, Turbo-molecular pump.

Ph – 6204: Physics of Semiconductors **Credit: 3 hrs**

Introduction to Semiconductors: Intrinsic, extrinsic, degenerate, non-degenerate and compensated semiconductors; Semiconductors in Equilibrium: Charge carriers in semiconductors, Extrinsic semiconductors; Carrier Transport Phenomena: Carrier drift and diffusion, Mobility effect, Conductivity, Einstein relation, Hall effect; Non-equilibrium Excess Carriers in Semiconductors: Carrier generation and recombination, Characteristics of excess carriers, Excess carriers lifetime; The p-n Junction: Basic structure of the p-n junction, Zero and reverse applied bias, p-n junction current, Generation and recombination current, Junction Breakdown; Transistor: The bipolar transistor action, Low frequency common base current gain, MOS structure, The basic MOSFET operation, The CMOS technology, JFET concepts, JFET devices characteristics.

Ph–6205: Physics of Superconductors **Credit: 3 hrs**

Phenomena of Superconductivity: Zero resistance, Response to magnetic field, Meissner effect, Energy gaps, Isotope effect, Type-I and type-II superconductors; Thermodynamics of Superconducting Phase Transition: Entropy of superconducting state, Specific heat, Thermal conductivity, Gibbs free energy; London theory, The Microscopic Theory of Superconductivity: Ginzburg-Landau theory, Cooper pairs, BCS theory, Flux quantization, Josephson effects, Hubbard model, Resonating valence bond theory; Ceramic Superconductors: Synthesis, Composition, Structures; Thermal and Transport Properties: Normal state transport properties, Specific heat, Role of phonon; Interplay between Magnetism and Superconductivity: Possible mechanism other than electron-phonon interaction for superconductivity.

Ph – 6206: Materials Science **Credit: 3hrs**

Introduction to Materials: Classification of materials, Crystalline and Non-crystalline materials, Properties of metals and non-metals, Electrical properties of alloys, ceramics and polymers and other advanced materials, Application of advanced materials; Microstructure: Microscopy of surfaces, Crystal grains and grain boundaries, Energy of grain boundaries; Solidification: Homogeneous and heterogeneous nucleation, Crystal growth techniques, Sintering of materials, Theory of liquid-solid phase transformation; Equilibrium Phase Diagrams: Hume-Rothery electron compounds, order disorder phase transformation; Materials for Optical-Communication and Semiconductor Devices: Optical-communication devices, Signal sources, LED for Fiber optics; Composite Materials: Metal matrix and ceramic-matrix composites, Formation of composites, Open-mold and closed-mold process of preparation, Elastic properties of composites, Strength and toughness of fiber reinforced composites.

Ph – 6207: Surface Science **Credit: 3hrs**

Introduction to Surface Science: Adsorption of molecules, physisorbtion and chemisorbotion; Vacum Concepts: UHV technology, UHV materials and pumping system, Preparation of atomically clean surfaces, Cleavage, Heating, Chemical Treatment, Ion sputtering and annealing, UHV deposition technology; Surface analysis : Low-energy electron diffraction (LEED) pattern, Reflection high- energy electron difraction (RHEED) pattern, Near edge X-ray absorption fine structure (NEXAFS),Theory of inner shell excitation spectra, Experimental and calculated K-shell spectra of free molecules, Analysis of K-shell excitation spectra by curve

fitting, The angular dependence of resonance intensities, Electron energy loss spectroscopy (EELS), High-resolution electron energy loss spectroscopy(HREELS), X-ray photoelectron spectroscopy (XPS) and Auger eletron spectroscopy (AES).

Ph – 6208: Nano Science and Technology **Credit: 3hrs**

Introduction to Nanomaterials: Low dimension structure, Quantum well, Quantum dots, Nanoparticles; Semiconductor Nanostructure: Metal-semiconductor nanoparticles, Fullerences, Carbon nanotubes, Porous silicon and other special nanomaterials; Electronic Band Structure and its Application: Electronic states of 3D, 2D, 1D and O-D solids, Strong and weak confinement; Organic Optoelectronic and Photonic Nanostructures: Organic and polymeric light-emitting diodes, Photovoltaic polymers, Self-assembled organic nonlinear optical materials, Photonic band structures and band gaps; Electronic Nanodevices: Single-electron transistors, Esaki and resonant tunneling diodes; Magnetoresistive Nanomaterials and Devices: Basic concepts of magnetoresistance, Read-write heads and MRAM, Fundamentals of magnetic storage, Fabrication technology and scaling, Spintronics devices; Photonic Nanodevices: Semiconductor quantum dots, Photonic crystals, Metamaterials.

Ph – 6209: Spintronics **Credit: 3hrs**

Introduction to Spintronics and Quantum Theory of Spin: Electronic structure of GaAs, Optical transition in semiconductors, Interaction between electron and nuclear spins in semiconductors, Quantum information processing using spins, Diluted magnetic semiconductors, Exchange interaction and magnetism in semiconductors, sp-d exchange interaction, Transport phenomena in magnetic semiconductors; Carrier-Induced Ferromagnetism: Ferromagnetic metals and their magnetization process, Anisotropic magneto-resistance (AMR), Giant magneto-resistance (GMR), Tunnel magneto-resistance (TMR), Landau-Lifshitz-Gilbert (LLG) equation and magnetization reversal, Spin injection, detection, and spin Hall effect; Spintronic Devices: Magnetic random access memory (MRAM), Spin FET, Spin bipolar transistor (SBT).

Ph – 6210: Experimental Techniques in Solid State Physics **Credit: 3hrs**

Measurements of DC conductivity, Determination of dielectric constant and dielectric loss as a function of temperature and frequency, Magnetization measurement methods (VSM and SQUID), Magnetic anisotropy and magnetostriction measurements, Optical spectroscopy (UV-VIS), Infrared spectroscopy (IR, FTIR and ATIR), Low energy electron diffraction (LEED), Reflection high energy electron diffraction (RHEED), Atomic force microscopy

(AFM), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Differential thermal analysis (DTA) and thermo gravimetric analysis (TGA), Deposition and growth of thin films by vacuum evaporation, Single crystal growth techniques, Electron spin resonance (ESR), Ferromagnetic resonance (FMR) and nuclear magnetic resonance (NMR), X-ray diffraction (XRD), X-ray photo electron spectroscopy (XPS), Auger electron spectroscopy (AES).

Ph – 6211: Polymer Physics **Credit: 3hrs**

Introduction to Macromolecular Physics: The chemical structure of polymers, Internal rotations, configurations and conformations, Flexibility of macromolecules, Morphology of polymers, The structure of crystalline polymers; The Physical States of Polymers: The rubbery state, Elasticity, The glassy state, Glass transition temperature,etc., Viscosity of polymers; Advanced Polymeric Materials: Plasma polymerization, Properties and application of plasma-polymerized organic thin films; Polymer Blends and Composites: Compounding and mixing of polymer, Their properties of application; Electrical Properties of Polymers: Basic theory of the dielectric properties of polymers, Dielectric properties of cyrstalline and amorphous polymers.

Ph – 6212: Textile Physics **Credit: 3hrs**

Physical Structure of Fibers: Fiber morphology, Methods for investigating fiber structure, General problem of fiber structure, Crystallinity; Moisture Absorption: Equilibrium absorption of water, Heat of sorption, Swelling and theories of moisture sorption; Mechanical Properties: Tensile, Flexural and Torsional, Stress/strain relations under various conditions, Frictional Properties: Friction, Coefficient of friction, Measurement of fiber friction, Theory of the directional frictional effect, Importance of friction in textile processing, Relationship of frictional properties of knitting, stitching and sewing; Thermal Properties: Structural changes in fibers on heating, Thermal contraction and expansion of textile fibers; Electrical Properties: Measurements of electrical resistance, Dielectric constants of fibers, Yarns and fabrics; Optical Properties: Reflection, Refraction, Scattering, Polarization, Birefringence, Absorption and dichroism, Reflex ion and luster.Application of nanotechnology in textile: Nanofibers.

Ph – 6213: Crystal Growth and Thin Film Technology **Credit: 3hrs**

Introduction to Crystal Growth and Growth Techniques: Low and High temperature solution growth, Melt growth, Vapour growth-metal organic chemical vapour deposition (MOCVD), Moleculer beam epitaxy (MBE), etc, Crystal Theory of Nucleation: Gibbs-Thomson equation for vapour; Models on Surface Roughness: The Kossel-Stranski-Volmer theory, The Burton-Cabera-

Frank theory, Formation of Thin Films: Condensation, Nucleation and Growth of thin films, Defects in thin films; The Thin Film Deposition Techniques: Chemical vapor deposition, Dipping and withdrawing, Sol-gel method, Electroplating, Spray pyrolysis technique, Thermal vacuum evaporation, Sputtering, Epitaxial growth, Pulsed laser deposition, Thermal oxidation technique etc.; Films thickness measurement methods; Structure of Films: Crystalline size, Surface roughness, Density of thin films, Lattice constant of thin films, Size effect of thin films; Electrical Properties: Electrical conduction in discontinuous and continuous films, Photoconduction in semiconductor films, Field effect thin film transistor (TFT); Optical Properties: Optical constants of thin films, size effects in optical properties, Thin film absorption and photoemission phenomenon.

Ph – 6214: Laser Physics **Credit: 3 hrs**

Introductory Concepts: Properties of laser beams, Theory of blackbody radiation, Absorption and stimulated emission, Spontaneous emission, Nonradiative decay, Line broadening mechanisms, Saturation, Degenerate levels, Molecular systems; Pumping Processes: Introduction, Pumping schemes, Optical pumping, Electrical pumping; Passive Optical Resonators: Introduction, Plane parallel resonator, Confocal resonator, generalized, Spherical resonator, Unstable resonators; Continuous Wave (CW) and Transient Laser Behavior: Introduction, rate equations,CW laser behavior, Transient laser behavior; Types of Lasers: Solid state lasers, Gas lasers, Liquid lasers, Chemical Lasers; Applications of Lasers.

3. Health & Medical Physics

Ph – 6301: Biophysics **Credit: 3hrs**

The Cell: Animal cell and plant cell; Cell Structure and Anatomy: Prokaryote and eukaryote cells, The cell membrane, Cell Nucleus; Chromosomes: Mitosis and meiosis, Mitocondria, Chloroplasts, Endoplasmic reticulum and ribosomes; Some Biological Important Molecules: Carbohydrates (saccharides), Lipids (fats), Proteins, Porphyrins; Chlorophylls and hemoglobin, Nucleic acids; Molecular Forces: Nature of chemical interaction, lone-ion, lone-dipole, Dipole-dipole and Van der waals interactions, Hydrogen bonds, Bonds between H, C, N, and O atoms and molecules; Transport Process and Diffusion: Fick's law, One and three dimension flow; Nerve impulses and voltage across nerve membranes, The action potential, Molecular model of membrane conductivity, Transport information in the nervous system; DNA and Protein: DNA and the gene, The genetic code, RNA and the synthesis of proteins, Transformation of genetic information, regulation and control, Cloning structure and function of proteins, Enzymes kinetics.

Ph – 6302: Radiation Biophysics

The nucleus, Ionizing radiations, Radiation doses, Interaction of radiation with matter, Cell structure, Radiation effects on independent cell systems, Oxygen effect, Hyperthermia, LET and RBE, Lethal, Potentially lethal and sub-lethal radiation damage, Dose-rate effect, Acute effects of radiation, Somatic effects, Late effects, Non-specific life shortening and carcinogenesis, Genetic changes, Nominal standard dose (NSD), Time dose fractionation (TDF), Standquist curve.

Ph – 6303: Radiation Protection **Credit: 3hrs**

Radiation protection guides, ICRP, IAEA, ILO, ICRU, NCRP's recommendations, Philosophy and objectives of radiation protection, Radiation hazards, External and internal radiation, Exposure from man made sources and nuclear installations, Medical exposure, Low-level exposure, Maximum permissible dose, Basic radiation safety criteria, Basic safety standards, Safety regulations in nuclear installations, Radiation safety and legal aspects in transport of radioactive materials, Radio-active waste disposal, Radiation protection in diagnostic radiology, Therapy and nuclear medicine.

Ph – 6304: Medical Physics **Credit: 3hrs**

Introduction, Forces on and in the body, Energy, work and power of the body, Pressure, Physics of the lungs and the breathing, Physics of the cardiovascular system, Electricity within the body, Application of electricity and magnetism in medicine, Physics of the ear and hearing, Physics of eyes and vision, Light in medicine, Sound in medicine.

Ph – 6305: Health Physics **Credit: 3hrs**

Atomic and nuclear structures, Isotopes, Binding energy and nuclear stability, Radio-activity, Specific activity, Alpha rays, Beta rays, Gamma rays, Interaction of different radiations with matter, Radiation dosimetry, Absorbed dose, Exposure, Exposure measurements, Bragg-Gray principle, Kerma, Stopping-power ratio, Energy fluence and exposure, Internally deposited radioisotopes, Effective half-life, Dose commitment, MIRD method, Measurement of absorbed does, Film badges, Pocket dosimeter, Fricke dosimeter, Calorimetric method, Thermoluminescent dosimeter (TLD).

Ph–6306: Physics of Radiology **Credit: 3hrs**

The production and properties of X-ray, Diagnostic and therapy X-ray tubes, X-ray circuit with rectification, Electron interaction, Characteristic radiation, Bremsstrahlung, Angular distribution of X-ray, Quality of X-ray, Beam restricting devices, The grid, Radiographic film, Radiographic quality, Factors affecting the image, Image modification, Image intensification, Contrast media, Modulation transfer function, Exposure in diagnostic radiology, Fluoroscopy, Computed tomography, Ultrasound, Magnetic resonance imaging.

Ph–6307: Physics of Radiotherapy **Credit: 3hrs**

Introduction, Superficial and deep X-ray machines, Teletherapy, Linear accelerator, Radiation fields within a patient, Single isodose curve, Multiple-field isodose curve patterns, Percentage depth dose (PDD), Back-scattering factor (BSF), Electron therapy, Tissue air ratio (TAR), Tissue maximum ratio (TMR), Treatment planning.

4. Environmental Physics

Ph–6401: Basic Atmospheric Physics **Credit: 3hrs**

Structure and composition of the atmosphere, Atmospheric parameters, Physical properties of gases, Solar and terrestrial radiation, Radiative transfer, Heat balance of the terrestrial atmosphere, Thermodynamics of the atmosphere, Temperature-Pressure diagram, Elements of cloud physics, Atmospheric instruments, Meteorological analysis, Synoptic chart, Analysis of 500, 300 and 200 mb charts, Combined analysis using conventional data and satellite images.

Ph–6402: Atmospheric Pollution **Credit: 3hrs**

Introduction: Air pollutants, Effects on humans beings and environment, Source of air pollutants, Pollutant concentration and emission measurements; Air Pollution Control: Control mechanisms, Particulate control, Indoor air quality; Chemicals in Motion at Atmosphere: Primary and secondary air pollution, Greenhouse gases; Regional and Global Issues: Global warning, Stratospheric ozone, aerosols, smog, acid and mercury deposition, Climate change and adaptation, Major laws and treaties.

Ph– 6403: Meteorology **Credit: 3hrs**

Geophysical Fluid Dynamics: Navier-Stoke's equation, Rotating and stratified flow, Scale analysis, Hydrostatic approximation, Coriolis force, Geopotential, etc., Gradient and thermal wind, Vorticity and circulation theorems, ProudmenTauylor theorem, Atmosphericwave, Atmosphericturbulence, Barotroicndbaroclinic

instabilities, Numerical weather fore-casting, Quasi-geotropic approximation, Barotropicvoticity equation, Primitive eqution, Multilayered models, Tropical cyclones, Norwesters and Tornadoes, The monsoons, Dynamical climatology; Physics of Upper Atmosphere: Geomagnetism, Neutral atmosphere, Ionosphere and magnetosphere; Monsoon Meteorology: Survey of tropical disturbance, Monsoon climeterology, Zonally averaged tropical circulation, Meridinal and zonal asymmetries, Radiative process in the tropics, Tropical cloud physics, Tropical boundary layer, Tropical cyclone theories, Monsoon modelling, Monsoon depressions and Monsoon rainfall.

Ph−6404: Climatology **Credit: 3hrs**

Concept of weather and climate, Climatic elements, Climatic factors, Cause of seasons, Climatology of Bangladesh, Global distribution of insulation, Albedo of different surfaces, Air temperature, Mean sea level pressure and wind, Diurnal and annual variations of surface air temperature at different latitudes and over the globe, Global distribution of precipitation, Global heat budget, Diurnal and annual variation of precipitation, Global distribution of atmospheric perils, Air masses and their classifications, Source regions, Modified of associated weather, El Nino, La Nina, Southern oscillation, Madden-Julian oscillation, North atlantic oscillation, Indian ocean dipole oscillation, Northern annular mode or Arctic oscillation, Northern pacific index, Pacific decadal oscillation, Interdecadal pacific oscillation; Introduction to Climate System: Role of greenhouse gases, Global warming, Sea level rise, Effects of climate extremes, Statistical background for climate variability.

Ph−6405: Remote Sensing and GIS **Credit: 3hrs**

Fundamentals of Remote Sensing: Remote sensing for earth observation, Remote Sensing systems, Application of remote sensing, Scanners; Electromagnetic (EM) Radiation and Energy: Introduction to EM energy and spectrum, Absorption and transmission, Sensing of EM energy; Aerial Photography and Image Processing: Fundamentals of aerial photography, Remote sensing versus. aerial photography, Cameras for remote sensing, Image processing system, Image visualization and interpretation, Satellite, Satellite imagery; Stereoscopy Correction: Correction and calibrations, Radiometric calibration, A main elements of sensor calibration, Atmospheric and geometric calibration; Sensors: Types of sensors, Active sensors, Radar, Principle of imaging radar, Distortion and interpretation of radar images; Geographic Information System (GIS): Introduction to GIS, Remote sensing and GIS, Basic function of GIS.

Ph–6406: Environmental Management **Credit – 3hrs**

Environment and Sustainable Development: Global and regional approach to environmental management; Environmental Implications of Sectoral Development: Infrastructure, Water resources, Industry, Agriculture, Transport and communication, Energy, Health and population, Mineral resources, Tourism, Land use and urbanization; Environmental Management at Project Level: Environmental resource management and conservation strategies; Environmental Policy and Legislation: Environmental quality standards (EQS), Economics of environmental management.

Ph–6407: Environmental Impact Assessment (EIA) **Credit – 3hrs**

Historical Development: Definiton, Aims and objectives of environmental impact assessment (EIA); Environmental Issues Related to Development Projects: Project screening, Initial environmental examination (IEE), Impact identification, prediction analysis and evaluation; EIA methodologies: Adhoc, Checklists, Matrices, Network, Simulation modeling workshops (SMW), Environmental evaluation system (EES), Overlays, Geographical information system guidelines, Environmental impact statement (EIS), Impact mitigation plan, Environmental moitoring and post develoment audits; Organization of EIA: Scope, Work plan, Resource requirements and costs of EIA, TOR for EIA, EIA in developing countries, Case studies.

5. Renewable & High Energy Physics

Ph – 6501: Reactor Physics **Credit – 3hrs**

Interactions of neutrons with matter, Cross-sections for neutron reactions, Thermal neutron cross-sections, Nuclear fission, Energy release in fission, Neutron multiplication, Nuclear chain reaction, Steady state reactor theory, Criticality condition, Homogeneous and heterogeneous reactor system, Neutron moderation, Neutron diffusion, Control of nuclear reactions, Coolant; Types of Nuclear Reactors: Power reactor, Research reactor, Fast reactor, Breeder reactor, etc, Reactor shielding, Reactor safety.

Ph–6502: Solar and Renewable Energy **Credit – 3hrs**

Basic principles for solar energy utilization, Energy, ecology and environment, Energy demands, Thermal conversion of solar radiation, Passage of solar radiation through atmosphere, Transmission and reflection of radiation, Flat plate collector

principles and performances, General analysis of flat plate collectors, Solar cells for direct conversion, Technique for construction of solarcells and panels, Arrays and photovoltaic power plants, Solar heating and cooling of buildings, Solar drying, Solar cookers, Solar stills, Solar engines, Solar pumps, Solar furnace. Wind energy availability, Velocity and power distribution curves, Winter shaft power, Wind mills and wind generation.

Ph – 6503: Advanced Plasma Physics **Credit: 3 hrs**

Nonlinear Plasma:The planer sheath equation, The Bohm sheath criterion, Ion acoustic **s**hock waves, The Sagdeev potential, The critical mach numbers, Wave steepening, Double layers (DL), Ponderomotive force and its effect, Solitary wave, Equations of nonlinear plasma physics, Korteweg-de Vries equation; Dusty Plasma:Charging of dust particles, Secondary emission, Photoemission, Dust **c**harge, Dusty plasma parameter space, Dust acoustic (DA) wave, Dust ion acoustic (DIA) wave, Korteweg-de Vries equation for dust ion wave; Plasma Source and Diagnostics:DC electrical discharge, Glow discharge, Arcdischarge, Examples of laboratory plasma sources, Direct current (DC) glow discharges source, Capacitively coupled (CC) radio-frequency (RF) discharges source, Pulsed glow discharges source, Atmospheric pressure glow discharges (APGDs) source, Corona discharges source, Electron cyclotron resonance sources (ECRs) source, Microwave induced plasmas source, Plasma Diagnostics**,** Remote diagnostics method, Local diagnostics method.

Ph–6504: Neutron Scattering **Credit: 3 hrs**

Neutron sources, Continuous and pulsed sources, Monochromatization, Collimation and moderation of neutrons, Neutron detectors, Scattering of neutrons and its advantages, Elastic scattering of neutrons, Magnetic scattering and determination of magnetic structure, Inelastic scattering, Thermal vibration of crystal lattices, Lattice dynamics and phonons, Neutron polarization, Polarized neutron applications, Scattering by liquids and molecules, Van-Hovev correlation formalism, Some experimental results of scattering by liquids and molecules, Small angle neutron scattering and its application in the study of biological molecules and defects, Experimental techniques of scattering measurements, Tim-of-flight method, Crystal diffraction techniques, Neutron diffractometer and triple-axis spectrometer, Constant “Q” method.