SCHEME OF STUDY

LIST OF COURSES

Non-Credit Customised courses (common for all specializations):

The departmental committee will determine the eligibility and requirement for NC courses for each individual

S.NO	COURSE CODE	COURSE TITLE	CREDIT HOURS
1.	PH-400	CLASSICAL MECHANICS	NC
2.	PH-401	ELECTROMAGNETIC FIELDS-I	NC
3.	PH-406	MODERN PHYSICS-I	NC
4.	PH-407	MODERN PHYSICS-II	NC

Compulsory Courses (common for all specializations):

S.NO	COURSE CODE	COURSE TITLE	CREDIT HOURS
1.	PH-500	MATHEMATICAL PHYSICS	03
2.	PH-501	ADVANCED COMPUTATIONAL PHYSICS	03
3.	PH-502	ADVANCED QUANTUM MECHANICS	03
4.	PH-503	ADVANCED STATISTICAL MECHANICS	03
5.	PH-504	ELECTROMAGNETIC FIELDS-II	03

ELECTIVE COURSES

a. Elective Courses for MS Physics (Specialization in Physics):

S.NO	COURSE CODE	COURSE TITLE	CREDIT HOURS
1.	PH-510	ADVANCED MATERIAL SCIENCE	3
2.	PH-511	MAGNETIC PROPERTIES OF MATERIALS	3
3.	PH-512	SEMICONDUCTOR PHYSICS	3
4.	PH-513	DIELECTRICS AND THEIR MEASUREMENTS	3
5.	PH-514	ATOMIC STRUCTURE	3
6.	PH-515	MOLECULAR STRUCTURE	3
7.	PH-516	ELECTRON AND PHOTOELECTRON SPECTROSCOPY	3
8.	PH-517	LASER SPECTROSCOPY	3
9.	PH-519	OPTICAL PROPERTIES OF SOLIDS	3
10.	PH-522	RESEARCH METHODOLOGY	NC
11.	PH-523	ENERGY AND ENVIRONMENTAL PHYSICS	3
12.	PH-524	NANOTECHNOLOGY	3
13.	PH-505	ADVANCED EXPERIMENTAL METHODS IN PHYSICS	NC
14.	PH-5002	THESIS	6

b. Elective Courses for MS Physics (Specialization in Optics):

S.NO	COURSE CODE	COURSE TITLE	CREDIT HOURS
1.	PH-518	NON-LINEAR OPTICS	3
2.	PH-520	PHOTONIC DEVICES	3
3.	PH-521	OPTICAL PHYSICS AND LASERS	3
4.	PH-522	RESEARCH METHODOLOGY	NC
5.	PH-530	PHOTONIC SENSING AND MEASUREMENT SYSTEMS	3
6.	PH-531	OPTICAL IMAGING AND PROCESSING	3
7.	PH-532	SOLAR PHOTONICS AND NON-IMAGING OPTICS	3
8.	PH-533	QUANTUM OPTICS	3
9.	PH-534	FOURIER OPTICS	3
10.	PH-5002	THESIS	6

c. Elective Courses for MS Physics (Specialization in Medical Physic):

S.NO	COURSE CODE	COURSE TITLE	CREDIT HOURS
1.	PH-525	MEDICAL RADIATION PHYSICS	3
2.	PH-522	RESEARCH METHODOLOGY	NC
3.	PH-535	RADIATION INTERACTION & DETECTION	3

4.	PH-536	PHYSICS OF RADIOLOGY	3
5.	PH-537	PHYSICS OF NUCLEAR MEDICINE	3
6.	PH-538	LASER TISSUE INTERACTION	3
7.	PH-539	COMPUTING IN MEDICAL PHYSICS	3
8.	PH-540	PHYSICS RADIOTHERAPY	3
9.	PH-541	HEALTH PHYSICS AND RADIATION PROTECTION	3
10.	PH-5002	THESIS	6

COURSE OUTLINE FOR MS IN PHYSICS

CUSTOMISED COURSES

CLASSICAL MECHANICS (PH-400):

Elementary Principles, Brief Survey of Newtonian mechanics of a system of particles, constraints, Alembert's principle, Lagrange's equation and its applications, Virtual work, Variational Principles Calculus of variation and Hamilton's principle, Derivation of Lagrange's equation from Hamilton's principle, Low and least action, Two body problem and its reduction to one body problem, Equation of motion and solution for one body problem, Kepler's Laws and center of mass systems, Rutherford scattering, Orthogonal transformations, Eulerian angles, Euler's theorem, The coriolis force, Angular momentum, Tensors and dyadics, Moment of inertia, Rigid body problems and Euler's equations, Legendre transformation and Hamilton equations of motion, Conservation theorems, Canonical Transformations Examples of canonical transformations, Lagrange and Poison brackets, Liouville's theorem.

ELECTROMAGNETIC FIELDS-I (PH-401):

Electromagnetic Induction, Addition of Laplace equation and methods of images, Magnetic intensity H, Maxwell's equations in differential and integral forms, Poynting theorem and energy conservation, Static Electromagnetic Fields Electrostatic fields in several dielectric media, Magnetostatic fields of magnetized matter, Magneto static field of stationary current, Magnetization current, Time Dependent Electromagnetic Fields, Maxwell's equations for quasi stationery fields, Potentials of a rapidly varying field, Fields of uniformly moving and accelerated charges, Radiation from an accelerated charge, Field of oscillating expansion of electro-magnetic field, Multiple fields, Expansion of emf, Reflection, Refraction and Propagation of Electromagnetic Waves, Laws of reflection and refraction, Fresnel's formula, Total internal reflection, Refraction in conducting media, Reflection from a conducting surface, Monochromatic waves and plane waves, Forced oscillation of an electric

oscillator, Scattering by a bound electron, Dispersion in dilute medium and dense media, dispersion in metallic conductor, Group velocity.

MODERN PHYSICS-I(PH-406)

The Origin of Quantum Mechanics, The hypothesis of de Broglie, Electron Diffraction Experiments, Wave Packets, Phase velocity and Group Velocity, Heisenberg's Uncertainty Principle Gamma-ray Microscope, Some Applications of the Uncertainty Principle, Development of Schrödinger's Wave Equation, Wave function, Expectation Values, Particle in Box, Potential Well, The Hydrogen Atom. Review of Bohr's theory, Somerfield model, Frank Hertz experiment and approximation methods. Fermi Golden rule, Quantum numbers, Atoms in radiation field, Radiative transitions, Einstein coefficients, Selection rules, Normal Zeeman effect, Stark effect, Hyperfine structure. Pauli exclusion principle, Periodic system of the elements, Stern Gerlach experiment, Spin orbit coupling, Central field approximation, Hartree Fock methods and self- consistent field, LS coupling, jj coupling and other types of coupling, X-ray spectra. Ionic and covalent bonding, Diatomic molecules-rotational, vibrational and electronic spectra; Born Oppenhimer approximation, Transition probabilities of diatomic molecules, Electron spin and Hund's cases, Polyatomic molecules (brief introduction), Raman effect, Hydrogen Molecular ion.

MODERN PHYSICS-II(PH-407)

Microscopic and Macroscopic Systems, Calculation of Probabilities, Statistics of an Assembly of Particles, Entropy, Perfect Gas Law, Maxwell-Boltzmann Statistics of a System of Particles Fermi-Dirac Statistics, Specific Heat of Conduction Electrons in Metals, Bose-Einstein Statistics, Planck's Law of Radiation, Classical Calculation of Lattice Specific Heat, Einstein's Theory of Specific Heat, Debye's Theory of Specific Heat, Consequences of the Third Law, Structure of Solids, Classification of Crystals, Some Crystallographic Terms, Bravais Lattices, Some Crystal Structures, Crystal Planes and Miller Indices, Spacing Between Adjacent Planes in the Lattice, The crystal Diffraction, Reciprocal Lattice, Bragg's Law, Laue method, Determination of Crystal Structures of KCI and NaCl From Bragg's Law, A Simple Discussion on the Formation of Energy Bands, Periodic Potential in a Crystalline Solid, The Kronig Penny Model, The Drude Theory, Quantum Mechanical Free Electron Theory, Electrical Conductivity of Semiconductors, Hall Effect, The Static Dielectric Constant, Dipole Moment and Polarization, Static Dielectric Constant of Gases, Internal Field in Solids, State Dielectric Constant of Solids, Ferroelectricity, Magnetization and Magnetic materials.

COMPULSORY COURSES

MATHEMATICAL PHYSICS (PH-500):

Boundary value problems in physics, Boundary value problems and solution, Examples of boundary value problems, Eigen values and eigen functions, Sturm-Liouville problem, Hermitian operators and their eigen values and eigen functions, Calculus of Variations Dependent and independent variable, Applications of Euler equation, Several dependent variables, Several independent variables, Lagrange multipliers, Variation with constraints, Rayleigh Ritz technique, Non-Linear Methods and Chaos, The logistic map, Nonlinear differential equations, Partial Differential Equations, Laplace equation, Steady state temperature in a rectangular plate, The diffusion or heat equation, The wave equation, Vibrating string, Steady state temperature in a cylinder, in a sphere, vibration of a circular membrane, Poisson's equation, integral transform solutions of Partial equations, Probability Definitions, simple properties, Random variables, Binomial Distribution, Poisson distribution, Gauss Normal distribution, Statistics and experimental measurements.

ADVANCED COMPUTATIONAL PHYSICS(PH-501):

Error Analysis, Numerical solution of equation, Finding Roots, Classical Turning Points, A Max-Min Problem, Equilibrium Points, Natural Frequencies of oscillating systems, Energy levels in a Quantum Well, Solving ODEs Symbolically, Projectile in a Viscous Medium, Logistic Growth Damped Harmonic Oscillator, Chain Radioactive Decay, Coupled Oscillators, Standing 'Waves in a String, Infinite Depth Quantum Well and Finding Solutions by Series Methods, Algorithms for Numerical Integration, Newton-Cotes Quadrature, Rearrangements for Computational Efficiency, Assessing Error, Iterative and Adaptive Algorithms, Gaussian Quadrature, Evaluating Integrals Numerically Using Elementary Commands, The Functions, Moment of Inertia, Quantum Probabilities, Integrals as Functions of the Upper Limit, The Error Function, Integrals as Functions of an Internal Parameter, The Off-Axis Electrostatic Potential of Two Rings, Introduction to FDM,FVM and FEM.

ADVANCED QUANTUM MECHANICS(PH-502):

Scattering Theory, Scattering amplitude and cross section, Lippman-Schwinger equation, Born approximation, Optical theorem, Partial wave decomposition, Phase shifts, Analytical properties of the scattering matrix, Inelastic scattering and reactions, Wentzel, Kramers and Brillouin(WKB) Approximation Connection formulae, Bohr-Sommerfeld quantization, Application to scattering, Motion in External Electromagnetic Field, Gauge invariance, Uniform magnetic field, Landau levels, Aharonov-Bohm effect, Electric field, Time Dependent Problems, Time dependent perturbation theory, Sudden and adiabatic approximation, Golden rule, Berry phase, Level crossings, Born-Oppenheimer approximation, Many-Body Systems, Identical particles, Second quantization of bosons and fermions, Field operators, Fermi gas, Hartree-Fock and Thomas-Fermi methods, Particle-hole formalism, Quantization of the Electromagnetic Field and its interaction with matter, Field in quantum mechanics, The elastic string, Hamiltonian quantization of the electromagnetic field, Emission and absorption of radiation, Multipole expansion, Selection Rules, Quantum Information, Quantum bits, Bell states, Quantum gates, Entanglement and teleportation, Quantum computation and Cryptography.

ADVANCED STATISTICAL MECAHNICS (PH-503):

Phase space, Distribution function, Microcanonical ensemble, The most probable distribution, Lagrange multipliers, Maxwell-Boltzmann distribution, Pressure of an ideal gas, Equipartition of energy, Entropy, Relation to thermodynamics, Fluctuations, Boltzmann factor, Collision less and hydrodynamic regimes, Non-viscous hydrodynamics, Sound waves, Diffusion, Conduction, Viscosity, Quantum Statistics, Thermal wavelength, Identical particles, Fermi and Bose statistics, Free energy, Fermi gas at low temperatures, Application to electrons in solids and white dwarfs, The Bose Gas Photons, Phonons, Debye specific heat, Bose-Einstein condensation, Liquid helium, Canonical and Grand Canonical Ensembles, Partition function, Connection with thermodynamics, Minimization of free energy, Photon fluctuations, Pair creation, The order parameter, Broken symmetry, Ising spin model, Ginsburg – Landau theory, Mean-field theory, Critical exponents, Fluctuation-dissipation theorem, Correlation length, Universality.

ELECTROMAGNETIC FIELDS-II (PH-504):

Electric field, Gauss's law, Scalar potential, Distributions of Charges and dipoles, Poisson's and Laplace's equations, Biot and Savart law, Ampere's law, Vector potential, Magnetic induction of a circular loop of current, Faraday's law of induction, Energy in magnetic field, Maxwell's equations, Gauge transformations, Green's function fix time, Independent wave equations, Initial value problem, Kirchhoff's integral representation, Poynting theorem, Macroscopic equations, Waveguides and Resonant Cavities, Fields at the surface of conductor and within a conductor, Cylindrical cavities and waveguides, modes in a rectangular wave guide, Energy flow and attenuation in wave guides, General angular and frequency distribution of radiations from accelerated charges, Frequency spectrum from relativistic charge particle in an instantaneously circular orbit, Synchrotron radiations,

Thomson scattering by quasi free charge,, Simple Radiation Diffraction Fields and radiations of a localized source, Oscillating electrics dipole, Magnetic dipole and quadruple fields, Center field antenna, Kirchhoff's integral for diffraction, Vector equivalent of Kirchhoff's integral, Babinet's principle, Diffraction by circular aperture and by small aperture, Scattering by conduction sphere at short wavelength.

ADVANCED EXPERIMENTAL METHODS IN PHYSICS (PH-505):
Supervised/Guided research/Experimental work, students are required to prepare and submit a short report.

ELECTIVE COURSES FOR MS PHYSICS (SPECIALIZATION IN PHYSICS)

ADVANCED MATERIALS SCIENCE (PH-510):
Ceramics, Polymers, Semiconductors, Superconductors, Magnetic materials, Liquid crystals, Material Characterization Techniques, X-Ray Diffraction Techniques XRD, Electron microscope analysis (Scanning electron microscopy, Transmission electron microscopy), Microprobe Analyzer, Crystal Growth Methods Czochralski Growth, Float Zone method, Bridgmen Method, Molecular Beam Epitaxial (MBE), Metal organic chemical vapor (MOCVD) techniques, Semiconductor Materials Inorganic and organic semiconductors, Polymeric semiconductors, Magnetic semiconductors, Low-dimensional semiconductors, Hybrid semiconductors materials, Quantum confined semiconductor materials, Superconductors and Superconducting materials, High temperature superconductors, Room temperature superconductors, Organic superconductors, Smart Materials, Piezoelectric ceramics, Shape-memory alloys and polymers, Magnetostrictive Materials, Novel Materials, Nanostructure materials, Novel materials for nanoelectronics, Carbon nanotubes, Rehnium materials, Magneto-electric transport in novel materials, Novel polymers, Spintronic Materials: Spin relaxation, Spin transports, Common spintronic materials, Organic spintronic materials, Space Technology Materials (space shuttle, space station, space elevator, space fiber products), Protection of materials and structures from space environment, Structural Integrity and Vacuum compatibility of materials in space, Reactor Materials for fission and fusion reactors, Reactor fuel materials, Materials role in the protection of environment.

MAGNETIC PROPERTIES OF MATERIALS (PH-511):
Theory of Magnetism, Magnetic Properties, Electrostatic origin of magnetic interaction, Magnetic properties of two electron system, Failure of independent electron approximation, (spin, direct, super, indirect and inherent exchange), Magnetic interaction in free electron gas, Kondo theory, Magnetic ordering, Spin waves, High temperature susceptibility, Mean Field Theory, Dipole interaction in ferromagnetic material, Magnetostriction and Anisotropy Magnetic anisotropy, Magnetostriction and effect of stress, Magnetocaloric losses, Magneto-acoustic effects, Magnetic Materials and Applications, Soft and hard magnetic materials, Eddy current losses, Special alloys of soft magnets, ferrites, Nanometer-scale magnets and their physical properties, Magnetic resonance (NMR, ESR, FMR, AFMR).

SEMICONDUCTOR PHYSICS (PH-512):
Solid State Physics, Crystalline structure, Bonding in semiconductors, Crystal structure of semiconductors, Miller indices, X-Ray diffraction, Bragg's law, Identification and lattice parameter determination by X-ray diffraction, Semiconductor Processing, Doping mechanism, Ion implantation, Doping by diffusion, Fick's law of diffusion, Diffusion profiles, Diffusion constant and diffusion length, Ohmic and Schottky contact fabrication, Semiconductor Materials and Properties, Elemental and compound semiconductors, Band model of semiconductors, Carrier concentration in energy bands, Fermi level and energy distribution of carriers inside

band, extrinsic semiconductors, Concept of effective mass, Heavily doped semiconductors, Carrier Transport in Semiconductors, Drift and diffusion of charge carriers in semiconductors, Variation of mobility with temperature and doping level, Conductivity, Hall effect, Einstein's relations, Temperature dependence of carrier concentration and resistivity in semiconductors, P-N Junction, Semiconductor homojunctions and heterojunctions, Field effect and heterojunction transistors, Free Electron Gas, One and two dimensional electron gases, Low dimensional physics, Hot electron systems, Semiconductor Growth, Processing and Characterization Crystal Growth Techniques, Eptaxial Growth, Wafer Processing Techniques, Optical Characterization methods, Electrical charactrization methods, Semiconductor Optical Devices, Semiconductor lasers, Microwave diodes and infrared and solar devices.

DIELECTRICS AND THEIR MEASUREMENTS (PH-513):

Fundamentals of Dielectrics, Dielectrics and Insulators, Energy storage in vacuum and in the presence of a dielectric material, A parallel plate capacitor, Dielectrics in Electrostatics, Electric dipole moment and types of electric polarization mechanism, Distinction between a perfect and a real dielectric, Dielectrics in terms of bound volume and surface charge densities, Polarization
current and polarization current density, The local field, Electric Susceptibility, Electric displacement, Electric permittivity, Molecular Polarization and Clausius-Mossoti equation, Langevin equation, Dielectrics in time varying electric fields, Response of a dielectric in time domain, Energy loss in the time domain, Effect of Frequency Variation on Dielectrics, Frequency domain response and dielectric functions, Permittivity, Conductivity and loss, Kramers-Kronig relations, Dielectrics dispersion, Properties of Dielectrics, Optical properties, Thermal properties, Effect of humidity or other ambient environment, Theories for Interpretation of Data, Debye model, Distribution of relaxation time (DRT), Power law, Universal response, Low frequency dispersion (LFD), Maxwell-Wagner response, Diffusive model, Many body phenomena, Local field theory, Theory of fractals, Measuring Techniques , Effect of frequency on dielectric response, Frequency domain techniques, Time domain technique, D,C measurement, D,C potential probing, Resonance method, Phase method, Schering Bridge, Optical methods, Analysis of Dielectric Measurements , Complex impedance spectroscopy, Complex admittance spectroscopy, Cole-Cole plot, Cole Davison plot, Normalization of dielectric data, Arrhenius plot, Fourier transform of data, Types of responses in frequency domain, Type of response in time domain.

ATOMIC STRUCTURE (PH-514):

Quantum Mechanical Background, Angular momentum, 3j and 6j symbols, Irreducible tensors, Wigner Eckart theorem, Indistinguishably of particles, Slater determinants and matrix elements,
One Electron Atom, Free particle Dirac equation, Dirac equation with electromagnetic coupling, One electron wave functions, Spin orbit coupling, Effect of electric and magnetic field, Hyperfine interaction, Magnetic dipole and electric quadrupole interaction, Hyperfine structure and hyperfine constants, Experimental method of determination of hyperfine structure, Many Electron Atoms Central field approximation, Hartree Fock equations Computational methods, Configuration interaction, Multiplet Wave Function Two electrons multiplets, construction of multiplet wave function, Symmetry properties, j-j coupling, Selection Rules, Transition probabilities, Oscillator strength, Line broadening mechanism, Effect of line broadening mechanisms on hyperfine structure.

MOLECULAR STRUCTURE (PH-515):

General Properties of Molecules Born-Openheimer approximation, Breakdown of the Born Oppenheimer Approximation, Molecular orbital and self-consistent Field method, Electron States of Molecule Hydrogen molecular ion, Symmetry consideration, Hydrogen molecule, Diatomic and linear molecules, Hybrid orbital, π electron approximation, Molecular Spectra Vibrations and rotations of diatomic molecules, Electron spectra of diatomic molecules, Potential energy functions and their importance, Molecular energy states and their

representation, Hund's coupling scheme, Franck Condon Principle, Franck Condon factors, Dissociation, Predissociation, Introduction to the spectra of polyatomic molecules, Raman Spectroscopy.

ELECTRON AND PHOTOELECTRON SPECTROSCOPY (PH-516):

Introduction to Photoelectron Spectroscopy, Information obtained from Electronic and Photoelectron Spectra, Experimental Techniques The sample, Thermal Source, Supersonic Jets, Matrix Isolation, Broadening of Spectroscopic Lines, Natural Broadening, Doppler Broadening, Pressure Broadening, Optical Spectroscopy, Conventional Absorption and Emission Spectroscopy, Laser Induced Fluorescence Spectroscopy, Laser Absorption Spectroscopy, Multiphoton Ionization Spectroscopy, Double Resonance Spectroscopy, Fourier Transform Spectroscopy, Photoelectron Spectroscopy Ultraviolet Photoelectron Spectroscopy, X-ray photoelectron Spectroscopy, Synchrotron Radiation in Photoelectron Spectroscopy, Negative Ion Photoelectron Spectroscopy, Penning Ionization Photoelectron Spectroscopy.

LASER SPECTROSCOPY (PH-517):

Optical Cavity, Optical resonator, Fabry Perot etalon, Fabry Perot etalon as optical spectrum analyzer, Optical resonator with spherical mirrors, Mode stability criteria, Modes in generalized resonator, Losses in optical resonator, Theory of Laser Oscillations Fabry Perot laser, Oscillation frequency, Three and four level lasers, Power in laser oscillator, Multimode laser oscillation and Mode locking, Theory of mode locking, Methods of mode locking, Method of Q switching, Types of Lasers He-Ne laser, Ar ion laser, Organic dye laser and ring dye laser, Tuning of ring dye laser, Optical components of ring dye laser, Doppler Limited Spectroscopy, High sensitivity detection method, Laser magnetic resonance and stark spectroscopy, Laser induce Huorescence spectroscopy, Spectroscopy of excited states, Double resonance methods, Multiphoton spectroscopy, Laser Raman Spectroscopy, Stimulated Raman scattering, Coherent Anti stokes Raman spectroscopy, Experimental techniques of laser Raman spectroscopy, Application of Raman spectroscopy, High Resolution Sub Doppler Laser Spectroscopy, Spectroscopy in collimated atomic and molecular beams, Saturation spectroscopy, Saturated interference spectroscopy, Doppler free multiphoton spectroscopy, Level crossing spectroscopy with lasers, Time Resolved Laser Spectroscopy, Lifetime measurements with lasers, Pico second spectroscopy, coherent transient and pulse Fourier transform spectroscopy.

OPTICAL PROPERTIES OF SOLIDS (PH-519):

Classical Theory of Optical Propagation, Electromagnetic Spectrum, Electronic band structure, Reflectivity, Transmission, Absorption and Dispersion, Maxwell's Equations, Complex dielectric constant, Interaction of electrons, Phonons and photons, Refractive index and extinction coefficient, Absorption Spectrum Fundamental absorption, Absorption edge region, Free carrier absorption, Phonon absorption, Restrahlen region, Excitations, Lyddane Sachs Teller relation Drude Model, Hagen Rubens reflectivity, Plasma edge reflectivity, Lorentz model, Oscillator strengths, Normal and anomalous dispersion, Polaritons, Emission processes, Luminescence Photoluminescence, Electroluminescence, Thermo luminescence, Non Linear Optics, Pockel and Kerr effect, Photon mixing, Harmonic generation, Parametric amplification Birefringence, Complex dielectric tensor, Fresnel equations, Spatial dispersion, Optical activity, Kramers-Kronig relations, Response functions, Optical Devices Solar Cells, Semiconductor GaAs laser, Light Emitting Diodes (LEDs), Porous Si and Blue light LEDs.

RESEARCH METHODOLOGY(PH-522):

Research Process and Methods Problem identification and refinement, understanding and identifying concept, construct and variables, developing research questions/ hypothesis, critical review of literature (accessing relevant literature, reading critically, and ways to write about the reviewed literature), research approaches and methodologies, developing research design and selecting plausible methods, ensuring reliability and validity of the research design, data collection tools and process, data analyses and interpretation, Research Writing and

Publishing Writing research proposals and scientific papers, writing and preparing papers for journals and conferences, writing thesis / dissertation, styles of writing, understanding plagiarism policy and avoiding plagiarism in professional and scientific writings, presenting the research in a conference, thesis / dissertation defense, Ethical Concerns & Issues in Research Understanding issues related to authorship, ownership of data, intellectual property, copyright; patents; maintaining confidentiality, anonymity, safety and well-being of research subjects, sites, resources, data transferring, the ownership of data and research findings.

ENERGY AND ENVIRONMENTAL PHYSICS (PH-523):

Alternate Energy Resources, Renewable energy resources and their sustainable development, Potential and possibilities, Remedial measures, Solar Energy from the Sun, Solar constant, Extra-terrestrial global beam and diffuse solar radiation, Clearness index, Solar incidence and Sun-Earth geometry, Tilted surface, Solar radiation measuring instruments, Estimation of global and diffuse radiation, Solar Thermal Energy Conversion System, Solar collectors, Flat plate collectors, Solar thermal power generation, performance and efficiency of Concentrating Parabolic Concentrators (CPC), Solar energy storage, Solar ponds, Applications of solar collectors, Solar photovoltaic conversion, Solar materials, Efficiency of solar cells, Series and parallel connections of solar cells, PV modules and arrays, PV power plants, Applications, Wind Energy, Nature of wind, Power in the wind, Types of wind machines and their designs, Conversion efficiency, Generation of electricity from wind power, Wind data and energy estimation, Site selection, Wind farms, Wind turbine, Use of wind energy for water pumping, Wind power plants and development prospects, Solar-Wind hybrid storage batteries, Other Sources of Alternate energy, Biomass, Bio fuel and Biogas, Geothermal Energy, Fundamental Concepts in Environmental Studies, Multidisciplinary nature of environmental studies, Ecosystem, Biodiversity and its conservation, Environmental pollution and its control, Human population and the environment, State of Environment Degradation of environment by human activity, Control measures, Remedies, Kyoto protocol, Prospects for clean environment.

NANO TECHNOLOGY (PH-524):

Review of nanotechnology, Processing, synthesis and characterisation of nanomaterials, particles and nanoparticles Carbon nanotubes, C60, SWT and MWT, carbon clusters, synthetic and nanocrystalline diamond, structure, properties and applications, solid fuels, sensors, catalysts and reinforcements, self-assembly phenomenon, Organic and biomedical materials, nanostructured materials, Nanomachines and nanodevices, Example of recent nano developments and product.

ELECTIVE COURSES FOR MS PHYSICS (SPECIALIZATION IN OPTICS)

NON LINEAR OPTICS (PH-518):

Harmonic Generation, Second harmonic generation, Harmonic generation in gases, Measurements of nonlinear optical susceptibilies, Two Photon Absorptions Theory of two photon absorption, Experimental techniques, Two photon absorption spectroscopy, High Resolution Nonlinear Optical Spectroscopy, Quantum beats, Saturation spectroscopy, Two photon Doppler free absorption spectroscopy, High resolution polarization spectroscopy, Optical Ramsey fringes, Four Wave Mixing Third order nonlinear susceptibilities, General theory of four wave mixing, Degenerate four wave mixing, Phase conjugation by four wave mixing, Tunable infrared and ultraviolet generation, Transient four wave mixing, Four Wave Mixing Spectroscopy, Coherent Raman scattering spectroscopy, Raman induced Kerr effect spectroscopy, Multiple resonant four wave 1111xmg, Optical Field Induced Birefringence, General forms of optical field induced refractive indices, Optical Kerr effect and Ellipse rotation, Transient effect, Self Focusing Physical description, Theory of self focusing, Quasi steady state self

focusing, Transient self focusing, Other self focusing phenomena, Strong Interaction of Light with Atoms, Bare atom approach, Dressed atom approach, Experimental demonstration, Multiphoton excitation and ionization, Nonlinear Optics in Waveguides, Experimental studies, Pulse propagation in a fiber.

PHOTONIC DEVICES (PH-520):

Electromagnetic Theory, Maxwell Equations, Wave Equations, Dielectric Media, Constitutive Relations, Anisotropic Media, Absorption and Dispersion, Resonant Medium, Pulse Propagation Optics and Optical Media Optics of Anisotropic Media, Optical Activity and Magneto-Optics, Beam Splitter, Wave plates, Optical Isolator, Dispersion, Grating and Wavelength Separation, Wavelength Switches, Fabry Perot Filters and Bragg Mirrors, Waves and Wave Guides Mirror and Dielectric Waveguides, 2D Waveguides, Optical Coupling in Waveguides, Mode Dispersion, Phase & Group Velocity, Waveguide Loss, Waveguide Materials and Fabrication, Arrayed Waveguide Gratings and Thermo-optic Devices, Compact Photonics, Micro ring Resonator, Photonic Band gap Devices, Electro-optic Waveguide Modulators, Rays and Waves, Field Distribution, Modes, Polarization, and V number, Attenuation and Dispersion, Holey Fiber, Fiber-based Devices, Gratings, Splitters, Sensors, Filters, Dispersion Compensators, Nonlinear Effects in Optical Fiber and Their Effects on Optical Networks, Eribium doped fibre amplifier(EDFA), Semiconductor optical amplifier(SOA) and Raman Amplifiers, Fiber Optical Components in Fiber Communication Systems, Optical Interconnects, Electro-optical switch (OEO), All optical switch (OOO), Wavelength Switches, Time Domain Switches, LEDs, pn-Junctions, Laser Diodes, Vertical cavity surface emitting LASER(VCSEL), Photodetectors and Photoconductors, Photodiodes and Avalanche Photodiodes, Array Detectors, Noise in Photodetectors.

OPTICAL PHYSICS AND LASERS (PH-521):

Lasers EM Radiation, Density of Modes, Blackbody Radiation, Interaction of Radiation and Matter, Homogeneous Broadening Mechanisms and Line shapes, Inhomogeneous Broadening Mechanisms and Line shapes, Interaction of Radiation and Matter in the Presence of Spectral Broadening, Gain Saturation in a Steady State Amplifier, Gain Saturation in a Pulsed Amplifier & Design of Laser Amplifiers, Laser Oscillator Optical Cavities, Threshold and Output Power, Laser Oscillator in Engineering Considerations, Optical Beams and Resonators and types of resonator, Numerical Beam Propagation Methods Split Step/BPM, Spiking and Relaxation Oscillations, Relaxation Oscillations, Q Switching, Mode Locking, Laser Engineering and Applications, Laser Stabilization, Thermal Optical Properties, Pumping Geometry, Scalability, He-Ne, CO2, and Gas Lasers, Solid State Lasers and Thermal Effects, Semiconductor Laser Basics.

PHOTONIC SENSING AND MEASUREMENT SYSTEM (PH-530)

Fundamentals of optical instrumentation, Optical metrology, interferometric instruments and interferogram analysis, coherence and coherence-based instruments, phase measurement and phase-shifting interferometry, two-beam interferometer, heterodyne interferometer, spectroscopic instrumentation, the Fabry- Perot interferometer, and the grating monochromator. Industrial examples/case- studies for optical instrumentations: laser range finders, fabric inspection machines, laser leveling. Fiber-optic measurements, bio-medical measurements.

OPTICAL IMAGING AND PROCESSING (PH-531)

Physical principles of optical imaging, propagation and interference of electromagnetic waves, geometrical optics and the eikonal. plane-wave expansions, diffraction, and the Rayleigh criterion. Image formation and transmission; Optical imaging system and their characteristics; Image processing. Digital image definitions, tools for digital image processing, perception, image sampling, effect of noise, algorithms, and techniques for digital image processing. Imaging sensors and their principles; Image representation and storage, coding, and

compression techniques, lossy versus lossless; Filtering and transform techniques for image processing including two dimensional Fourier transforms, wavelets, and convolution; Spatial transformations and image registration. Segmentation and thresholding techniques; Applications of morphology to image processing including erosion.

SOLAR PHOTONICS AND NON IMAGING TECHNIQUES (PH-532)

Optical sources, Semiconductor LASER Phase speed and group speed, photo detectors, Receiver design, optical transmission system design, wavelength division multiplexing, Solar radiation, Solar thermal collectors, Solar thermal applications. Photovoltaic cells, Photovoltaic systems and applications, Theory of non-imaging optics, non-imaging optical systems. Basic idea of geometrical optics and their uses in non- imaging optical systems, Development, and modifications of compound parabolic concentrator (CPC), CPC Thermal Collectors, CPC Photovoltaic Concentrators, Two-Stage Non-imaging Concentrators for Solar Thermal Applications, Two-Stage Non-imaging Concentrators for Solar Photovoltaic Applications.

QUANTUM OPTICS (PH-533)

Quantum mechanical view of nature, Interpretation and foundational principles of quantum mechanics, quantum mechanical view of photons. The Schrodinger equation, quantum wells, quantum wires, quantum dots and density of states. Quantization of electromagnetic field, Expansion into normal modes, Field quantization in a cavity, States of quantized electromagnetic fields. Atom- field interaction, Single atom single mode interaction, Dipole approach, Hamiltonian, Hamiltonian for two-level atom in radiation field. Optical Bloch equations. Quantum computation, qubits, photon as a qubit, Fourier sampling, quantum Fourier transform.

FOURIER OPTICS (PH-534)

One dimensional Fourier analysis, Analysis of two-dimensional signals and systems, Local spatial frequency, space-frequency localization, linear systems, two dimensional sampling theory, Scalar diffraction theory. Wave-optics analysis of coherent optical systems, Thin lens as a phase transformation, Fourier transforming properties of a lens, Monochromatic Illumination. Frequency analysis of optical imaging, Generalized Treatment of Imaging Systems, Frequency Response for Imaging, Effects of aberrations on Frequency Response. Holography.

ELECTIVE COURSES FOR MS PHYSICS (SPECIALIZATION IN MEDICAL)

MEDICAL RADIATION PHYSICS (PH-525)

Review of the Electromagnetic and Nuclear radiation, and their interactions. Radiation exposure and measurement, absorbed dose, Kerma, Relation between the Exposure kerma and absorbed dose, Quality factors, Conversion of exposure to absorbed dose, attenuation coefficients, mass absorption, Energy transfer coefficients. Absorbed doses in tissues, Bragg Gray cavity theory, HVLS, Tissues dose ratios, Correction factors of doses. Geiger Muller counter, Photomultiplier tubes, scintillation counters, Film detectors, TLD, Electrometers, Pocket dosimeters, Neutron Detectors, Fricke dosimeter, Chambers and sensitive volumes, solid state detectors, Radiation counting statistics, Suitability of detectors and counters, Correction factors of chambers and limits. Radiation hazards, Radiobiology, Relative biological damages, Stochastic and deterministic effects, Alara principle, Dose equivalent, Effective dose equivalent, Dose limits for radiation workers & public. Safe disposal of radioactive materials. X-ray Machines, CT scan, Ultra sound , MRI , Linear accelerator , Cyclotron, Betaron , Nuclear medicines Radioactive tele therapy machines, Brachytherapy machines.

RADIATION INTERACTION AND DETECTION (PH-535)

Radiation sources; Interaction of radiation with matter, Basic principles of radiation detection; Design aspects of ionization chambers, Proportional and Geiger-Muller counters: Various types of scintillators; Scintillation detectors; Radiation spectroscopy using Scintillation detectors: Semiconductors; Various types of semiconductor detectors and their characteristics. Neutron sources; Neutron detection techniques and neutron spectroscopy. Basic electronic circuits and electronic equipment used in nuclear radiation detection systems; Measure of central tendency and dispersion; Concepts of sample space, events, random variables and probability; Probability distributions (discrete & continuous); Curve fitting and tests for goodness of fit; Errors and their propagation; Counting statistics.

PHYSICS OF RADIOLOGY (PH-536)

Production and properties of X-rays, Types of X-ray tubes, Beam restricting devices, Radiographic films, Intensifying screen, Radiographic quality, Mammography, Digital subtraction angiography (DSA); Computed Tomography, Image reconstruction, patient dosimetry; Ultrasound, reflection, transmission, transducers; MRI, relaxation times, k- space, contrast agents, pulse sequence; Quality assurance.

PHYSICS OF NUCLEAR MEDICINE (PH-537)

Introduction to nuclear medicine, Radiopharmaceuticals, Basic principles & licensing considerations, Production of radioisotopes, Radioisotope generators, Dosage control techniques, Quality Control (QC) & Quality Assurance (QA) of radiopharmaceuticals, collimators, types and applications, quality control considerations in collimators, gamma camera and its components, Quality Control and Quality Assurance procedures of gamma camera, maintenance considerations, Computers in nuclear medicine: Creation of digital image, Data Analysis, Data display and formatting, Principles of SPECT and SPECT-CT, QC and QA procedures for SPECT, Introduction to non-imaging probes & solid state gamma cameras. Physics of Positron Emission Tomography (PET) and PETCT, coincidence circuitry, PET-CT camera, Quality assurance and quality control for PET-CT

LASER TISSUE INTERACTION (PH-538)

Principles of lasers, properties of laser radiations, some laser systems. Light matter interaction, reflection, refraction, absorption, scattering, turbid media, measurement of optical properties. Interaction Mechanism: Thermal interaction, photo ablation, plasma- induced ablation, photo disruption, shock wave generation, cavitations, jet formation. New modalities of cancer treatment, photodynamic therapy, laser induced thermal therapy. Medical applications of lasers in: Ophthalmology, gynaecology, urology, etc. Laser safety: laser hazards, eye hazards, skin hazards, laser safety standards and hazard classification, eye protection.

COMPUTING IN MEDICAL PHYSICS (PH-539)

Computing Fundamentals, Memory Management systems, Digital Image processing techniques using Matlab; smoothing, interpolation, edge enhancement, etc., Digital Imaging and Communications in Medicine (DICOM), Picture Archiving and Communication Systems (PACS) Image reconstruction techniques in CT, Nuclear medicine and MRI, Fast Fourier transforms and its application to imaging; Fundamentals of Monte Carlo simulations, GEANT4 Monte Carlo simulation toolkit of radiation. EGSnrc Monte Carlo Simulation code.

PHYSICS OF RADIOTHERAPY (PH-540)

Overview of clinical radiotherapy and radiobiological basis, Radiation therapy equipment, Basic photon radiation therapy, Patient setup, including positioning and immobilization, Simulation, virtual simulation, digitally reconstructed radiographs (DRRs), image registration, Dosimetric functions and basic treatment planning, Dose calculation algorithms and heterogeneity corrections, radiation dosimetry, Point dose calculation, factors affecting

dose distribution Physics of LINAC, Different modalities like IMRT, Gammaknife, Cyberknife, brachytherapy. Quality control of selected modalities

HEALTH PHYSICS AND RADIATION PROTECTION (PH-541)

Basic of anatomy and physiology, cell cycle and structure.

Radiobiology: biological effects of radiation, types of effects of radiation, cell survival curve, effects on tissue, organ and body.

Radiation protection: Introduction, historical perspective, Exponential attenuation, half-value layer (HVL), inverse square law, tenth value, layer (TVL), Shielding calculations, dosimetry units, Legal framework for radiation protection, Occupational, public exposure and annual limits, Emergency procedures.