Course Outcomes Master of Science in Physics

Semester I

Course: PHY 501, Mathematical Physics

CO1: The students will be able to develop the required mathematical skills to solve various problems in quantum mechanics, electrodynamics and other fields of theoretical physics.

CO2: The students will also be able to explore some special functions like Bessel's function, Laguerre's polynomial, Legendre polynomial and Hermite function.

CO3: Laplace transforms, Fourier Series *etc.* and their physical significance is learnt by students.

Course: PHY 502, Classical Mechanics

CO1: The students will be able to know about variational principles and Lagrange's equations.

CO2: They will be able to understand Hamiltonian formalism, canonical transformations, small oscillations, and normal nodes.

CO3: The classical background of Quantum mechanics and get familiarized with Poisson brackets and Hamilton -Jacobi equation.

Course: PHY 503, Electromagnetic Theory

CO1: The students will be able to learn about transmission lines, waveguides, and cavity resonators.

CO2: Different types of tensors like covariant tensors, contravariant tensors, Metric tensors and their properties will be known to the students.

CO3: The students will know about the general idea of Minkowsky space and Lorentz transformations.

CO4: The students will develop a general understanding of covariant transformation of electromagnetism, Gauge variance and dynamics of charged particles in static and uniform fields.

Course: PHY 504, Quantum Mechanics I

CO1: The course provides an understanding of the behavior of the systems at microscopic (atomic and nuclear) scale and even smaller to the students.

CO2: Students would learn basic postulates and formulations of quantum Mechanics which help to understand all physical systems in the universe.

CO3: The course includes the study of a brief review of foundations of quantum mechanics, matrix formulation of quantum mechanics, angular momentum algebra, and addition of angular momentum and quantization of wave fields.

Semester II

Course: PHY 505, Quantum Mechanics II

CO1: The course includes the study of time dependent and time independent perturbation theory and their related problems, scattering theory, relativistic wave equations, Dirac equation, and its free particle solution, negative energy states, concept of hole etc.

CO2: The course would describe the nature and behaviour of matter and energy at subatomic level. Theory of scattering gives an understanding collision between a quantum mechanical particle and target.

CO3: The study of relativistic quantum mechanics enables the students to understand the behaviour of objects moving with speeds comparable to that of light.

Course: PHY 506, Statistical Mechanics

CO1: In this course, students will get an understanding and knowledge about equilibrium statistical mechanics (e.g. ensemble theory, partition function, and quantum statistics distributions),

CO2: Students will learn the fluctuations, random walk problem, momentum condensation, Liquid Helium, superfluidity and non-equilibrium statistical mechanics (e.g. Random processes, Markoff process, Langevin Equation and Fokker Planck Equation).

CO3: Students can deal with the problems from equilibrium statistical mechanics for ideal gases and harmonic oscillator, fluctuations, partition functions for monoatomic, diatomic, and polyatomic molecular gases.

CO4: they can solve problems related with Langevin dynamics, Brownian motion, Fluctuations Dissipation Theorem and Nyquist theorem.

Course: PHY 507, Solid State Electronics

CO1: After completion of this course, students will learn the working of BJT and FET along with their applications.

CO2: Electronic regulators are essential in electronic equipment for keeping them safe from any electrical fluctuation.

CO3: They will get an insight of the Designing and working of many instruments such as Oscillator, Power amplifier and various feedback techniques.

CO4: They will also learn how to employ transistors (BJT/FET) in telecommunication systems for radio wave transmission. Oscillators are very important in the field of telecommunication industry as well as laboratory equipment.

Course: PHY 508, Atomic and Molecular Physics

CO1: Students will be able to understand the quantum states of an electron in an atom, quantization of atomic energy states and their designation by spectroscopic terms.

CO2: They will be able to understand fine structure and hyperfine structure of spectral lines, effect of external electric and magnetic field on an atom emitting spectral line.

CO3: They will also be able to understand various causes for width/broadening of spectral lines, theoretical and experimental description of spectroscopic techniques such as X-ray spectroscopy, Electron spin resonance and Nuclear magnetic resonance and their applications.

CO4: The students will also be able to learn the theoretical understanding of the origin of rotational, vibrational, and electronic emission and absorption spectra of diatomic molecules, intensity distribution and the fundamental origin of Raman spectra (Quantum and classical approach) and applications.

Course: PHY 531 (General Lab) /PHY532 (Electronics Lab) For Semester I and II

CO1: After completing this course, the student will have a general understanding of a postgraduate level laboratory. The students will be able to make computer simulation of different Quantum processes and will be able to construct and solve mathematical models. They will also have clear ideas of different experimental setups involving interference, diffraction and polarization at PG level.

CO2: The students will also learn about the laser and their applications in exploring different physical entities.

CO3: Students will learn to design different amplifier circuits using BJT and FET. Students learn to measure the band of a semiconductor. Students also learn to design waveform designing circuits using transistor (multivibrator).

CO4: Students also learn the behavior (characteristics) of BJT at different temperatures and its stability.

Semester III

Course: PHY 601, Condensed Matter Physics

CO1: After completion of this course, students will learn in detail the various methods like Nearly free electron approximation, orthogonalized Plane Wave (OPW) and Pseudo potential methods.

CO2: They will also learn advanced experimental techniques such as de-Hass-van Alphen effect experiment & cyclotron resonance for experimentally study the Fermi surfaces of different materials.

CO3: They will become confident in characterization of different magnetic materials. They will also get a deeper insight into superconductivity and its application in the industry.

Course: PHY 602 Nuclear Physics

CO1: Students will learn the fundamentals of nuclear scattering and different nuclear models. Nuclear models will help to understand the behavior of exotic nuclei.

CO2: Study of compound nucleus will provide a deeper understanding of nuclear fission and fusion of exotic nuclei.

CO3:By studying different decay modes and selection rules students may utilize nuclear techniques in medical and industry. The nuclear techniques can be/are employed in agronomy.

Course: PHY 653, Analog and Digital Electronics (Elective)

CO1: Students will learn the application of Wide band amplifier to design Video amplifier. Using Transient response of amplifier, students will be able to assess the wide band amplifier.

CO2: Students learn the Operational Amplifier (IC 741), its pin diagram and its characteristics. Use of IC741 (Operational Amplifier) as an Integrator, Differentiator, Smith Trigger, Butterworth Filter (first order low pass and high pass).

CO3: Students will also learn the use of Op-Amp for summing, multiplication. In digital electronics, the students will learn the basics of TTL and its use for NAND gate, use of NAND gate to design flip-flop and JK Master Slave flip-flop. Students will also learn to design combinational logic circuits (counters, shift register) using basic logic gates.

Course: PHY 654, Microwave (Elective)

CO1: Students will learn about the waveguide, TE, TM, and TEM mode for bounded EMR, reflection coefficient and SWR.

CO2: Scattering coefficients, directional coupler, microwave tees, hybrid T, cylindrical cavity resonator, wave meter, attenuator, slotted line, magnetic properties of Ferrites, Faraday rotation, Gyrator, Isolator, and Microwave Integrated circuits which are the basic components used in the microwave devices.

CO3: Students will learn different types of microwave generators and amplifiers like Klystron, Magnetron, Traveling wave tube etc.

CO4: Students will know about several microwave measurements like power, frequency, VSWR, impedance, dielectric permittivity, network analyzer and scattering coefficients.

Course: PHY 657, Coherence Theory And Elementary Nonlinear Optics (Elective)

CO1: Students will be able to understand the coherence properties of light and their effect on the interaction between light and matter.

CO2: The students will also be able to understand the interaction of free electrons with electromagnetic radiation.

CO3: They will also be able to understand fundamental concepts of non-linear optics, such as harmonic generation, phase matching, etc.

Course: PHY 658, Quantum States of Radiation (Elective)

CO1: This course provides a platform for the students to describe the concepts of classical and quantum coherence, polarization operators *etc.*

CO2: They will learn Coherent States of Radiation, Coherent State as wave packet, Expansion of States and Operators in Terms of Coherent States, Density Operator of Radiation, Sudarshan-Glauber Representation, Density Operators of Coherent and Chaotic Radiation.

CO3: They will learn Polarization and Stokes Parameters, Annihilation and Creation Operators for Modes with General Polarization. Unpolarized Light. Photoelectron Counting Distribution, Hanbury Brown and Twiss Experiment, Bunching and Antibunching

CO4: They will learn the Example of pure Fock State for Antibunching of Photons, Schwartz Inequalities and Quantum Behavior of Optical Fields, Squeezed States of Radiation (Elementary Discussion).

Semester IV

Course: PHY 603, Experimental Techniques & Control Systems

CO1: Students will be able to understand data, significant figures, precision, and accuracy. They Will also know about the errors and their propagation.

CO2: They will learn about linear and nonlinear curve fitting. The Chi square test will also be known to them.

CO3: The students will learn different types of electronic devices like solar cell, photo detectors and different types of transducers, vacuum pumps, and gauges.

CO4: Student will learn the basics of TTL and its use for NAND gate. Use of NAND gate to design flip-flop, JK Master Slave flip-flop including learn to design combinational logic circuit (counters, shift register) using basic logic gates.

Course: PHY 663 Programming for Numerical Methods (Elective for paper II)

CO1: Students will learn computational language C++ and its applications for writing code on following numerical methods: Newton Raphson method, Iterative method, Integration by Trapezoidal and Simpson 1/3 rule, Interpolation, Matrix manipulations, Euler's method, Runge Kutta (second order and fourth order) method, phase space trajectory, equilibrium points, stability analysis.

CO2: Students will learn and use keywords in C++, various data types, implicit conversions, For loop, While and do-while loops, break and continue statements, switch statement, if-else, conditional operator, functions with default arguments, function overloading, ++ and – operators, Arrays, Structures, Pointers, Compound assignment and Basic concept of Object Oriented Programing.

Course: PHY 664, Electrodynamics and Second Quantization (Elective for paper II)

CO1: The students will be able to learn about radiation from a moving charge and angular distribution of radiation.

CO2: They will also be able to understand radiation reaction, self-force, second quantization of scalar field and electromagnetic field.

Course: PHY 668, Microprocessor (Elective for paper III)

CO1: Students will learn the pin diagram and structure of microprocessor 8085.

CO2: They will be able to design wave generators like Square, Triangular, Saw-tooth using 8085.

CO3: Students will also learn about Assembly language programming and its application on various problems to add, subtract, multiplication, number sorting, prime number.

CO4: Using 8255 as peripheral device, students will learn to design digital to Analog as well as Analog to digital converter.

Course: PHY 669, Electronics: Semiconductor Devices (Elective for paper IV)

CO1: On successful completion of the course, the students will be able to apply the knowledge of semiconductors to illustrate the functioning of basic electronic devices and to classify and describe the semiconductor devices for various applications.

Course: PHY 674, Resonant Interaction of Atoms with Radiation – I (Elective for paper III)

CO1: On completion of this course, students will be able to understand the semi-classical theory of resonant and near-resonant interaction of coherent light with two-level atoms.

CO2: The students will also be able to explore and interpret many of the consequences of coupling the Bloch and Maxwell equations.

CO3: They will also be able to understand the semi-classical discussion of self-induced transparency and photon echo.

Course: PHY 675, Resonant Interaction of Atoms with Radiation – II (Elective for paper IV)

CO1: The aim of the course "Light-matter interaction" is to give the student advanced knowledge on the quantum-mechanical interaction between light and matter and its application in different research fields, such as laser cooling, atoms in strong fields and quantum computers.

CO2: The course includes a study of a Two-Level Model of Atomic Spin Operators and States and their properties, Rotations in Atomic Spin Space. Dicke's Collective Atom Operators and States, Degeneracy of Dicke States of an Assembly of Atoms.

CO3: Elementary Ideas about Entanglement of Two Two-Level Systems and their use in Quantum Teleportation, Schrodinger, Heisenberg and Interaction Pictures, Dipole Approximations, Rotating Wave Approximation, Weisskopf-Wigner Approximation, Welton's Treatment of Lamb Shift. Superradiance etc.

Course: PHY 632, Electronics Lab for Semester III and IV

CO1: Students will learn to design video amplifier using BJT and its transient response.

CO2: Students learn to design the different circuits (summing amplifier, differentiator, integrator, filter *etc.*) using IC741.

CO3: Student study the characteristics of S-band microwave.

CO4: Student also design and study various applications (addition, subtraction, multiplication, wave form generation, ADC and DAC) of 8085 microprocessor and 8255 peripheral devices.

Course: PHY 634, Non-Linear Optics Lab for Semester III and IV

CO1: Students will learn about several electro-optics phenomenon like Kerr effect and Magnetostriction.

CO2: They will learn about photon counting using C++ simulation.

CO3: They will perform various aspects of laser by performing experiments with He-Ne laser.