M. Sc., Physics Program and Course Outcome

Program Specific Outcomes

After successful completion of program, students will be able to:

1. Have a proper theoretical understanding of the subject and ability to set up experiments based on these concepts.

2. Demonstrate and explain various mathematical techniques, numerical methods, experimental techniques to broaden independent thinking and scientific temper.

3. Formulate concepts in physics, give effective presentation and acquire good communication skills through seminars and group discussions

4. Enhance experimental, analytical skills and research aptitude in areas such as materials science, thin film technology, radiation dosimetry, solar energy, energy generation and storage for academic research and industrial applications.

5. Develop social awareness through internships and science popularization programs.

6. Emphasize on academic and research ethics, need and value of lifelong learning, importance of awareness on human rights, scientific misconduct, intellectual property rights and issues related to cyber laws and plagiarism

7. Gain a through grounding in the subject and develop good communication skills to be able to teach at university/college or even at school level.

8. Understand the hazardous effects of exposure to nuclear radiations and implement safety measures in the Laboratory and spread awareness amongst people.

9. Understand the importance of interdisciplinary research and working in a team.

10. Appreciate physics as an important discipline that develops a critical attitude and the faculty of logical reasoning that can be applied to various fields.

M.Sc., in Physics: Course Outcomes

Semester I: Paper Title PHYH 1.1 Mathematical methods in Physics

After successful completion of this course, students will be able to: -

1. Acquire necessary mathematical skills required for working with and understanding concepts in physics.
2. Solve problems in involving vectors and tensors. The knowledge of these topics are essential in learning physics: Knowledge of tensors is essential to understand General Relativity
3. Learn essential basics about integral transforms such as Fourier and Laplace transforms. This will enable them to understand important physical concepts in optics and spectroscopy; For Eg., Fourier Transform Infrared Spectroscopy (FTIR) is a characterization technique having immense application in characterization of materials; Theory of diffraction also involves subtle ideas of Fourier transform and the students will be able to comprehend these ideas by hands-on experience with Fourier transforms.
4. Work with special functions such as Hermite polynomials, Spherical harmonics, Laguerre polynomials etc., which are the basic requirement for understanding the concepts in quantum mechanics.
5. Gain deeper knowledge in complex number theory. Evaluating residues, handling singularities, Taylor's and Laurent's expansion of functions of complex variables etc., are helpful for the students in their journey of learning physics.
6. Learn the calculus of variation, Euler-Lagrange equations in one and more dependent and independent variables; These will help them to learn the methods adopted in Classical Mechanics

Semester I: Paper Title PHYH 1.2: Classical Mechanics

After successful completion of this course, students will be able to:-

1. Gain a basic understanding of mechanical systems subjected to constraints
2. Understand the equivalence of Lagrangian and Hamiltonian mechanics with Newtonian mechanics and their need in dealing with mechanical systems subjected to constraints.
3. Analyze the behaviour of objects under central force such as gravitational force and thereby the motion of celestial bodies. In particular, they will learn the importance of theoretical analysis of the motion of astronomical objects through the derivation of the exact form of celebrated Kepler's laws (which were obtained by Kepler based on the data of Tyco Brahe thus being empirical laws.)
4. Learn the methods of Hamiltonian mechanics; Hamilton's equations of motion, Hamilton's least action principle, canonical transformations and illurstrative problems related to these.
5. Gain an insight into the dynamics of fluids, their streamline and turbulent flow; Significance of Navier-Stokes's law; Helps in understanding several phenomena in every-day life: Fluid dynamics being a research area of immense applicability, studying this course will help the students to join in this field of research.

Semester I: Paper Title- PHYH 1.3: Classical Electrodynamics

After successful completion of this course, students will be able to: -

1. Gain a basic understanding of the nature of electric and magnetic field. Distinction between the fields generated by static charges, uniformly moving charges and accelerated charges.
2. Understand the equivalence between electromagnetic waves and light, an observation of immense significance . They will also gain an insight into transmission of light through conductors and plasma. Learn to work on problems to evaluate skin depth of conductors.
3. Establish laws of reflection and refraction, Fresnel's laws of reflection and refraction which helps to evaluate the amplitudes of reflected and refracted light.
4. Prove Poynting theorem, the theorem on energy conservation in electromagnetic field.
5. Understand the atomic model of dispersion, the variation of refractive index with frequency of light, more commonly known as the splitting of light into different colors.
6. Learn the concept of gauge transformations, Coulomb Gauge and Lorentz gauge which respectively are of immense importance in quantum field theory and special theory of relativity
7. Explain the concept of retarded potentials; Work out the Lienard-Wichert potentials and understand their significance.
8. Learn the concept of electric and magnetic dipole radiation, power radiated from a moving point charge, which are of great practical importance.
9. Gain a theoretical understanding of covariant formulation of electrodynamics which helps the student to discern the electromagnetic phenomena happening between two observers in uniform relative motion.

Semester I: Paper Title- PHYH 1.4 : Electronics

After successful completion of this course, students will be able to:-

1. Design and study the performance of various electronic amplifier circuits.
2. Have the experimental expertise in IC 741 and IC 555
3. Design phase shifter using opamp and precision voltage reference.
4. Fabricate electronic devices.
5. Understand need of logic in digital ICs
6. Identify different types of logic families
7. Know about evolution of different logic families
8. Understand the difference between latches and flip flops.
9. Learn about construction and working of RS, D, JK and T flip flops
10. Know the applications of flip flops.
11. Know the construction and working of A/D and D/A converters
12. Know the working of semiconductor memories.

Semester II: Paper Title- PHYH 2.1 Mathematical Methods in Physics-II

After successful completion of this course, students will be able to: -

1. Acquire the mathematical skills to work with wavefunctions associated with subatomic particles. Studying this course, helps them immensely to understand the formalism of the all important area in physics; *Quantum Mechanics*. The entire formalism of quantum mechanics for systems isolated with the surrounding is contained in this course and will benefit the students who aspire to join research in either applied or theoretical physics.
2. Work with matrix representation of linear operators. With the physical quantities of interest such as position, linear and angular momentum etc., being represented by linear operators in quantum mechanical scenario, students will learn an important method to deal with the formalism of measurement in subatomic regimes.
3. Get a purview of Lie groups such as rotation and Lorentz group, their representations in different dimensions and their significance in physics. Especially the students will understand the concept of special relativity with the help of Lorentz group SO(3,1); They will understand and appreciate the nature of elementary particles including Higg's boson through the eight dimensional group SU(3)
4. Learn about integral equations, their different types and methods of solving them. The significance of learning this technique lies in obtaining intensity distribution in diffraction of light and thus helps the students to gain theoretical understanding of the patterns when light is diffracted.
5. Acquire sound knowledge of Green's functions and their properties
6. Gain insights into the significance of Green's functions in dealing with scattering of microparticles (which provide immense information about nature of particles).

Semester II: Paper Title- PHYH 2.2 : Elements of Nuclear and Particle Physics

After successful completion of this course, students will be able to:-

1. Understand the fundamental properties and forces governing nuclear structure.
2. Gain proficiency in analyzing radioactive decay processes and nuclear reactions.
3. Gain mastery of concepts in particle physics including fundamental forces and symmetries.
4. To apply mathematical models in decay processes, Yukawa's theory etc.,
5. Gain competence in calculating cross-sections and understanding nuclear reaction.
6. Acquire thorough knowledge of quark model and its implication on Hadrons structure and interactions.
7. Learn symmetry principles and conservation laws in particle interactions.
8. Acquire capacity to critically evaluate experimental data and theoretical models in nuclear and particle physics.

Semester II: Paper Title- PHYH 2.3: Elements of Condensed Matter Physics

After successful completion of this course, students will be able to:-

1. Know the basics of crystal structure
2. Get to know about the crystal structures of well known crystals such as sodium chloride and diamond
3. Understand the concept of diffraction of X-rays, matter waves (electron, neutron etc.,), from crystals;
4. Understand the significance of Bragg's law and know about the experimental techniques of diffraction
5. Have a knowledge about free electron theory of metals, its successes and failures in explaining the properties of metals
6. Understand the importance of quantum theory in arriving at band structure in solids
7. Gain the basic idea of band theory of solids and the need of band theory to understand the properties of solids.
8. Understand the classification of semiconductors on the basis of conductivity and energy gap.
9. Gain an insight into the magnetic properties of materials based on their response to applied magnetic field
10. Acquire basic knowledge of superconductivity and the elements of the theory explaining the superconducting behavior.
11. Acquire basic knowledge on Alloys, Nanomaterials and glasses
12. Acquire Problem solving skills in condensed matter physics and electronics

Semester II: Paper Title- PHYH: 2.4 Quantum mechanics-I

After successful completion of this course, students will be able to:-

1. Gain insights into the failure of classical physics, need for quantum physics; and a brief history of emergence of quantum mechanics
2. Comprehend the wave nature of light as well as matter.
3. Understand the probabilistic interpretation of wavefunctions
4. Gain insights on the Heisenberg uncertainty principle; Learn to establish a generalized uncertainty relation
5. Solve Schrodinger equation to obtain quantized energy levels in particles executing simple harmonic motion; Learn the importance of this model to explain several phenomena including specific heat of solids.
6. Discern the concepts of Angular momentum algebra; and methods to obtain matrix representation for angular momentum operators, both orbital and spin angular momentum.
7. Solve Schrodinger equation for hydrogen atom to obtain correct values for quantized energy levels.
8. Understand the need for approximation methods such as time-independent perturbation theory, and variational method to evaluate ground state energy of a multi-atom system. Solve problems in each of the approximation methods.

Semester II: Paper Title - PHYE 2.5 Bio-physics

After successful completion of this elective course, students will be able to: -

1. Understand the basic physico-chemical techniques needed to study biomolecules
2. Learn the separation techniques such as chromatography and electrophoresis
3. Familiarize with the basics of neuro biophysics

Semester III: Paper Title- PHYH 3.1 Atomic and Molecular Physics

After successful completion of this course, students will be able to: -

1. Use spectroscopy as a tool for studying the structures of atoms and molecules.
2. Identify analytical methods for finding the constituents of material having unknown chemical composition.
3. Use the knowledge acquired in astronomy to study spectral emission lines of distant galaxies in order to understand rapidly expanding universe.
4. Understand the fine structure and hyperfine structure of spectral line
5. Learn the concepts of rotational energy levels, microwave spectra and instrumentation of microwave spectra
6. Learn the concept of vibrational energy levels, infrared spectra and instrumentation of IR spectroscopy.
7. Outline the importance of Raman spectroscopy and correlations between Raman spectroscopy and IR spectroscopy
8. Develop the skill to get employed in various laboratories, for carrying out research and developmental activities using spectroscopic techniques.
9. Acquaint with different types of atomic clocks and their characterization, stability, accuracy and applications.

Semester III: Paper Title- PHYH 3.2 Quantum Mechanics II

After successful completion of the following courses, students will be able to:-

1. Learn about the different formalisms of quantum dynamics; Schrodinger, Heisenberg and Dirac pictures; Will be able to work in all these formalisms;
2. Arrive at the time evolution of spin vectors under the action of constant and time-varying magnetic fields
3. Learn the concept of density matrices for mixed states, establish their properties and work out expectation values for two-level systems
4. Acquire knowledge of time-dependent perturbation theory and understand how it gives the model for laser action, in terms of spontaneous, stimulated emissions and resonant absorption
5. Learn the terminologies used in scattering of particles;
6. Evaluate Rutherford scattering cross-section in Born approximation;
7. Learn the method of partial wave analysis to understand the low energy scattering processes.
8. Understand the need for relativistic quantum theory; The drawbacks of Klein-Gordon relativistic equation and the adaptability of Dirac equation for fermions.
9. Understand the need for quantum field theory and learn its basics

Semester III: Paper Title- PHYH 3.3 Statistical Mechanics

After successful completion of the following course, students will be able to:-

1. Understand the need for statistical description to explain empirical laws of thermodynamics
2. Gain insights on phase space and probabilistic description for different types of ensembles
3. Comprehend the statistics of distinguishable and indistinguishable particles
4. Understand the concept of partition function and obtain thermodynamic quantities from it.
5. Learn to obtain the classical limit of quantum statistics; Maxwell Boltzmann distribution function from Fermi-Dirac as well as Bose-Einstein distribution functions
6. Understand the physical process in Bose-condensation phenomena
7. Comprehend the statistical approach needed to explain irreversible thermodynamic phenomena
8. Understand the importance of random walk problem in explaining the behaviour of tiny particles immersed in a fluid
9. Gain deeper knowledge on Brownian motion and Einstein's fluctuation-dissipation theorem.

Semester III: Paper Title PHYS 3.4.1 : CONDENSED MATTER PHYSICS – I

After successful completion of the following course, students will be able to:-

1. Familiarize with measurement of electrical conductivity of different metals and study their behavior with temperature,
2. Understand the anisotropy, thermal expansion and thermal conductivity of crystalline solids.
3. Carry out a detailed analysis on dielectrics, ferroelectric and piezoelectric materials based on their anisotropic structures.
4. Learn Experimental techniques on the determination of optical constants of metals.
5. Study the characteristics of various optoelectronic devices.
6. Understand the use of thermoelectric generator as a thermocouple which acts as a temperature sensor.

Semester III, Paper Title: PHYS 3.4.2: Nuclear Physics-I

After successful completion of this course, students will be able to: -

1. Get a good understanding of interaction radiation with matter
2. Be Proficient in employing diverse measurement techniques for radiation detection and analysis.
3. Gain Competence in operating different types of nuclear detectors through a proper understanding of their principles.
4. Analyze and interpret data obtained from Gas-filled detectors, Scintillation and Semiconductor detectors.
5. Acquire skill in designing and implementing radiation measurement setups with appropriate shielding and calibration.
6. Gain a proper understanding of electronic circuits and signal processing techniques for specific radiation detection.
7. Capability to perform spectral analysis and extract meaningful information from radiation spectra.
8. Application of knowledge in nuclear safety, medical imaging, materials analysis and other relevant fields.

Semester III: Paper Title PHYE 3.5: Fundamentals of Radiation Physics
After successful completion of this elective course, students will

1. Understand the basics of radioactivity and different types of nuclear radiations
2. Know about the Radiation Quantities and Units;
3. Learn the different techniques of radiation detection and measurement

Semester IV: Paper Title- PHYS 4.1: Experimental Techniques
After successful completion of this course, students will be able to :

1. Have a good knowledge of experimental methods to produce high vacuum and the different kind of gauges to measure vaccum
2. Learn the experimental techniques of producing magnetic fields of desired magnitude and their measurement
3. Know about the production and measurement of low temperature and design of cryostats
4. Have a vast knowledge of different types of radiation detectors
5. Know about useful ideas of thin film technology

Semester IV: Paper Title- PHYS 4.2.1: Condensed Matter Physics-II
After successful completion of this course, students will be able to :

1. Understand the quantum theory of ferromagnetic, anti-ferromagnetic and ferromagnetic materials and learn about their application
2. Get a sound knowledge of laser action in different types of lasers
3. Study quantum dots and quantum wires and their technological applications
4. Acquire a good knowledge about preparation and characterization of nanomaterials
5. Acquaint with thin film preparation by various methods
6. Have a sound knowledge of working of different types of solar cells
7. Learn the concepts of improving efficiency of solar cells

Semester IV Paper Title- PHYS 4.2.2: Nuclear Physics-II
After successful completion of this course, students will be able to :

1. Gain Comprehensive understanding of nuclear forces, nucleon-nucleon interactions and nuclear models.
2. Get Proficiency in theoretical formalisms and mathematical interpretations to nuclear physics, such as wave equations and scattering theory.
3. Analyze experimental data and interpret the results in the context of nuclear reactions and scattering phenomenon.
4. Gain competence in applying various nuclear models to describe nuclear structure and dynamics.
5. Acquire familiarity with advanced topics like compound nuclear reactions, resonance phenomena and evaporation processes.
6. Acquire skill in performing calculations of cross sections and probabilities for specific nuclear reactions.
7. Get Proficiency in utilizing theoretical models and predict results
8. Gain ethical understanding and responsibility in conducting research and analyse the data in the light of possible hazardous outcomes.

Semester IV: Paper Title PHYS 4.3.1: CONDENSED MATTER PHYSICS
After successful completion of this elective course, students will

1. Acquire a thorough knowledge of crystal defects and their types.
2. Get an experimental knowledge of preparation of glasses
3. Have good theoretical understanding of mechanical properties of different crystal systems
4. Have a deep understanding of the phenomena of superconductivity and superfludity,
5. Get a thorough knowledge of carbon nanomaterials and their technological applications
6. Acquire sufficient necessary background to pursue research in the topics discussed under this course.

Semester IV Paper Title- PHYS 4.3.2: Nuclear Physics-III
After successful completion of this course, students will be able to:

1. Have a sound understanding of nuclear fission and fusion processes.
2. Be proficient in neutron physics, including neutron interaction with matter.
3. Understand diverse measurement techniques of neutron radiations in various detectors
4. Understand working principle of nuclear reactors including criticality calculations and reactor design.
5. Gain good knowledge of nuclear fuels and their properties, cycling and recycling processes.
6. Apply theoretical concepts to practical nuclear engineering problems.
7. Be proficient in using relevant tools and techniques for neutron detection and dosimeter.
8. Gain awareness of safety and regulatory aspects in nuclear engineering.
9. Critical thinking and problem-solving skills in the field of nuclear science.
10. Effective communication and team working skills for handling minor projects.
11. Ethical understanding and responsibility in the practice of nuclear engineering.