M.Sc (Physics)
Specialization: Solid State Physics

The Master of Science in Physics program provides the candidate with knowledge, general competence, and analytical skills on an advanced level, needed in industry, consultancy, education, and research.

On completion of program, the post graduates will

- Apply the knowledge and skill in the design and development of Electronics circuits to fulfill the needs of Electronic Industry.
- Become professionally trained in the area of electronics, optical communication, nonlinear circuits, materials characterization and lasers.
- Pursue research related to Physics and Materials characterization.
- Demonstrate highest standards of Actuarial ethical conduct and Professional Actuarial behavior, critical, interpersonal and communication skills as well as a commitment to life-long learning.

Semester –I

Mathematical Physics-I (Paper I)

Objectives:

- This course is to introduce mathematical physics models which will help to encounter problems in classical physics, quantum physics, electrodynamics, and theoretical condensed matter physics.

Outcomes:

- It gives the complex analysis in solving physical problems.
- It gives the solve ordinary/partial differential equations of second order.
- It gives to get some knowledge in linear equations, vector spaces, matrices, linear transformations, determinants, eigen value, eigen vectors, Laplace transform methods and Fourier series.

Classical mechanics (paper II)

Objectives:

- To demonstrate knowledge and understanding of the following fundamental concepts in:
  The dynamics system of particles.
  Lagrangian and Hamaitonian formulation of mechanics.
- To develop mathematical skills for applied to physics.

Outcomes:

- Students learn about Lagrangian and Hamaltonian formulation of Classical mechanics.
- Have a deep understanding of newton's laws.
- Theory of small oscillations in detail along with basis of free vibrations.

Paper – III: Quantum Mechanics-I

Paper-III: Quantum Mechanics-I

After completion of this course, it is intended that a student will be able to:

1. The students gain knowledge of states and operators of quantum mechanics, measurements, hermitian operators, unitary operators and uncertainty principle.
2. The students will gain knowledge of Schrodinger, Heisenberg picture and interaction pictures, Linear harmonic oscillator-Solution to Schrodinger equation, Eigen values and Eigen functions, properties of stationary states. Linear harmonic oscillator- Solution by operator's method. Raising and Lowering operators, the number operator.
3. The students learn the Symmetries in Quantum Mechanics; Space and time displacements – unitary operators of space and time displacements and equations of motion.Generators of infinitesimal rotations.Space inversion and unitary inversion operator - intrinsic parity. Time reversal operator – anti-linear operator- time reversal operator for spin zero and non- zero spin particles.
4. The students will gain knowledge of orbital, spin and generalized angular momentum and addition of angular momenta and properties.

Objectives:

- Understand the need for quantum mechanical formalism and its basic principles.
- Explain the operator formulation of quantum mechanics.
- Understanding the concepts of commutation relations.
- Appreciate the importance and implication of vector spaces, Dirac ket bra notations, eigen value problem.
- Understand the implications of generalized uncertainty principle in QM.
- Better understanding of the mathematical foundations of spin and angular momentum for a system of particles.
- Solve Schrodinger equation for various QM systems using approximate methods.
- To develop understanding of postulates of quantum mechanics and to learn to apply them to solve some quantum mechanical systems.

Course Outcomes:

- Describe the fundamental of the quantum mechanics basics principles by using mathematical concepts.
- Identify the fundamental notations of quantum mechanics
- Apply elementary operations to develop more sophisticated applications of quantum computing.

- Understand and explain the differences between classical and quantum mechanics.
- Understand the central concepts and principles in quantum mechanics, such as the Schrodinger equation
- The wave function and its statistical interpretation, the uncertainty principle, stationary and non-stationary states, time evolution of solutions, as well as the relation between quantum mechanics and linear algebra including understanding of elementary concepts in statistics, such as expectation values and variance.
- They will master the concepts of angular momentum and spin, as well as the rules for quantization and addition of these.
- Hence they will be able to solve the complex systems by approximation.

Paper-IV: C-Programming and Numerical methods

Course Outcomes:

1. The C-language is a high-level, general-purpose programming language. It provides a straight forward, consistent, powerful interface for programming systems. The student acquires ability to define data types and various statements to manage data structures based on problem subject domain.
2. The students learn and demonstrate declaration of Functions, Array declaration and initializing, processing Arrays, passing an Array to a function, the Linear search and Bubble sort algorithm, binary search algorithm, using arrays with enumeration types, Multidimensional Arrays. Pointers declaration and applications.
3. Students learn numerical way of solving Algebraic equations by various methods to obtain approximate solutions to mathematical problems.
4. Derive numerical methods for various mathematical operations and tasks, such as interpolation, differentiation, integration, the solution of linear and non linear equations, and solution of partial differential equations and writing the program in C-language.

Electronics-V (Paper V)

Objectives:

- This course gives the basic idea of electronic components and circuits.
- This course gives the knowledge on construction and working function of semiconductor devices.

Outcomes:

- It gives the knowledge of diodes, transistors, MOSFET, DAIC, TRAIC, UJT etc., which are embedded in various electronic devices.
- It gives the ability to design and analyze simple regulated power supplies.
- It helps to understand feedback amplifiers and oscillators.
- It helps to understand fundamental principles of audio/video communication.
- It gives the ability to analyze the multi-vibrators.
- It will assist to build-up student's careers in electronic industries.
- It will motivate to set-up a small scale industry in electronic based industries.

Semester –II

Electromagnetic theory (Paper I)

Objectives:

- This course is introducing the basic mathematical concepts which are useful in electromagnetic vector fields.
- This course helps to student to understand concepts of electrostatics, electric potential, energy density and their applications.
- This course helps to student to get some knowledge in concepts of Faraday‘s law, induced emf, Maxwell‘s equations, concepts of electromagnetic waves, and Transmission lines.

Outcomes:

- It helps to understand and physical interpretation, and apply Maxwell’s equations to determine field waves, potential waves, energy and charge conservation conditions.
- It gives the influence of boundaries on waves which assist the application of boundary conditions for fields, Brewster’s angle to eliminate reflections and polarize radiation, total reflection from a boundary.

Statistical mechanics (Paper-II)

Outcomes:

After completion of this course a student should be able to

1. Define and discuss the concepts of phase space, Ensembles of different models, microstate and microstate of a model system, Density distribution in phase space- Liouville’s theorem, Discuss the concepts and roles of entropy and free energy from the view point of statistical mechanics.
2. Define the Maxwell Boltzman and Bose-Einstein distributions; state where they are applicable; understand how they differ and show when they reduce to the Boltzmann distribution.
3. Understand and learn how to apply the Fermi-Dirac distribution to the calculation of thermal properties of electrons in metals.
4. Students can understand Fluctuations in energy, volume and concentration Brownian motion- Phase transitions of first and second kind: Ising model, Bragg-Williams approximation-One dimensional Ising model a application to Ferro magnetic systems-Order-Disorder transition.

Quantum mechanics-II (Paper III)

Objectives:

- This is an advanced level course in Quantum mechanics which objects to teach about various approximation methods in physics to calculate the approximate values of energy for various systems.
- This course is emphasis the beauty of Quantum mechanics in the form of the Born approximation and its validity.

- This course helps to solve problems in Quantum mechanics.

Outcomes:

- It provides an entry point to understanding contemporary research in Quantum mechanics.
- It assists to Approximate methods for solving the Schrodinger equation (The Variational method, Perturbation theory, and Born approximations).
- It encourages to calculate the ground state and excited state energies of various real life systems by using principle, WKB method, and Perturbation methods.
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General Solid State Physics (Paper IV)

Objectives:

- This course is one of the branches of physics which deals with the study of "physics" insight into solid materials.
- This course provides an introduction of basic concepts in Solid State Physics.
- This course give the knowledge to understand the material properties like physical, electrical, magnetic, optical etc.

Outcomes:

- It gives the knowledge about various instruments such as CT scan, MR imaging, digital camera, photo detectors etc. how it works, which are used in our daily life.
- It helps to understand the nanotechnology. Nanotechnology is the technology of how the material can be made in a size as small as in nanometer range, which are drastically improved the various material properties such as electric, magnetic, mechanic, and optical properties etc.
- It will assist to build-up student's careers in scientific field such as researcher/scientist in various research fields.
- It will motivate to set-up a small scale industry in material based industries.
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Electronics – II Paper- V

Objectives:

- To impart knowledge about the operational amplifier and communication systems.
- To introduce the fundamental concepts relevant to operational amplifier and its electronic circuits and different modulation techniques used in communication.
- OPAMP based analog circuits and introduction to digital electronics so that they can use these in various branches of physics as per their requirement.
- The concepts of Boolean algebra is introduced to give a feel of the future electronics devices equations and it 's applications
- The microprocessor is that these are general purpose electronics processing devices which can be programmed to execute a number of tasks, Compact size, High speed, Low power consumption, It is portable, It is very reliable. Less heat generation. The microprocessor is very versatile.

Course Outcomes:

- Design op-amp circuits to perform arithmetic operations.
- Design simple analog circuits and understand fundamental principles of operational amplifiers and its applications.
- Design Analog and Digital Instruments and their applications.
- Apply Boolean algebra and Karnaugh maps.
- Design the Sequential and Integrated circuits.
- This results in these A/D and D/A converter solutions being used in wireless base stations, optical transceivers, transponders, and in industrial I/O module applications, as well as systems such as programmable logic controllers, control systems, and building control due to their versatility and flexibility, as well as their software configurable I/Os.
- The microprocessor is used to processing, manipulation of data by a computer. It includes the conversion of raw data to machine-readable form, flow of data through the CPU and memory to output devices, and formatting or transformation of output. Any use of computers to perform defined operations on data can be included under data processing.

Semester III

Modern Optics (Paper-I)

Outcomes:

1. The student will gain knowledge of laser principle, rate equations.
2. The students will gain knowledge of some gas lasers, dye lasers and solid state lasers.
3. The students will gain the knowledge of holography, recording and construction of images.
4. The students will gain the knowledge of Fourier optics and nonlinear optics.

Advanced Solid State Physics (Paper II)

Objectives:

- This course is insight into in-depth of some of the advanced properties of materials.
- The emphasis of this course is on phenomena such as electrical, dielectric, ferroelectric, magnetism, and superconductivity with reference to today's research.

Outcomes:

- It gives the insight into electrical properties of materials, which are used in various applications such as agriculture, food processing, and material based industries.
- It helps us to understand the behavior of dielectric properties of materials such as capacitors, High-K/low-K materials (where K refers to permittivity or dielectric constant), Display applications, Piezoelectrics, Ferroelectrics etc., which are used in various electronic devices.

- It gives the basic idea of magnetic properties of materials. Magnetic materials play a crucial role in the progress of industrial development and scientific growth.
- It gives the knowledge about magnetic materials based devices such as power generation and transmission, electronic devices, analog and digital data storage, medical devices, magnetic therapy and drug delivery, sensors and scientific equipment, etc., which are encounter in our daily life.
- It helps to understand the behavior of superconductors, which are useful in measurement systems and various purposes such as squid, superconducting trains etc.

Crystal Physics and Physical Properties (Paper III)

Objectives:

- This course is insight into in-depth of some of the advanced group theory, symmetry of crystals and crystal properties.
- The emphasis of this course is to understand group theory, symmetry of crystals, rank of the tesnosrs, properties such as dielectric, piezoelectric, ferroelectric and elastic properties with reference to today's research. And also to gain the knowledge on surface science using the high resolution microscopes.

Outcomes

- Understanding of crystal structures. It will begin with basic fundamentals and take the students to advanced concepts of point and space groups symmetry and vector and tensor applications in crystallography.
- Symmetry based classification of crystals: 32 Crystal classes and 230 space groups. Possible proper rotation axes for crystals. Possible combination of pure rotation axes: Euler's construction.
- Development of 32 point groups.
- Second-rank tensor properties: electrical and thermal conductivity, thermal expansion coefficient.
- Elasticity and fourth rank tensors. Elastic stiffness and compliance. Calculation of useful elastic properties such as modulus, Poisson ratio etc using tensor methods.

Physics of Phonons and Structural Phase Transitions (Paper IV)

Objectives:

- This course helps to study the condensed matter physics in theoretically and experimentally.
- This course gives the basic idea of studied the physical structure such as crystal vibrations in materials.
- This course gives the knowledge of anharmonic effect and non-equilibrium process in materials.

Outcomes:

- It gives the knowledge of phonon vibrations which are play a crucial role to determine the various properties such as electrical, magnetic, superconductivity etc.
- It emphasis the structure analyze of materials such as inelastic neutron scattering etc.
- It helps to understand phase transition from first order to second order.
- It helps to understand diffusion mechanism in materials.

Paper – V: Band theory and electrical properties

Course Objectives:

- A goal of Solid State Physics is to try to understand how the macroscopic properties of solids result from their microscopic, atomic scale properties. So, Solid State Physics forms the theoretical basis of Reciprocal lattice. It also has direct applications to Brillouinion zones.
- The band theory accounts for many of the electrical and thermal properties of solids and forms the basis of the technology of solid-state electronics.
- The E-K curve explains how the energy levels are distributed in different bands or Zones.
- To enable the students to understand the factors that affect thermal, electrical and dielectric behavior of solids.

Course Outcomes:

- Identify different concepts of crystallography, different theories of heat and electric conduction, dielectrics, semiconductors.
- The students could be learn how the *Bloch's theorem* states that solutions to the Schrödinger equation in a periodic potential take the form of a plane wave.
- Fermi surfaces in description of electric and magnetic properties of solids, conduction in semiconductors.
- Understand the electron motion in periodic solids and origin of energy bands in semiconductors.
- Differentiate between various lattice types based on their lattice dynamics and then explain thermal properties of crystalline solids.
- To explain the basic transport theory for understanding the transport phenomenon in solids by using various theories.

Semester IV

Nuclear physics (Paper I) in M. Sc (Physics) IV Semester

Objectives:

- Nuclear physics is an important purist because the study of the nucleus of the atom is at the heart of our ability to understand the universe.

- It provides answers and expands our knowledge of both the infinitely small and extremely large.
- It gives to understand nuclear interactions and elementary particles involved in the interactions.

Outcomes:

- It describes the shell and liquid drop models of the nucleus.
- It can express nuclear binding energy and nuclear masses.
- It encourages to solve problems of nuclear physics and their limitations in nature.
- It identifies elementary particles and describes their role in the process of interaction.
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Spectroscopy (Paper II)

Objectives: The course aims to impart knowledge of origin of basic principles of spectroscopy and its applications to rotational, vibrational, Raman, electronic and NMR spectroscopy.

Outcomes:

- Understand the concepts of spectroscopy. Use atomic terms symbols to ascribe transitions to specific angular momenta states described by atomic term symbols.
- Analyse the relationship between rotational, vibrational and electronic spectroscopy.
- Describe working principle and selection rule of rotational, vibrational, Raman and electronic spectroscopy.
- Distinguish between various spectroscopic transitions and interpret data for molecular characterization.
- Raman spectroscopy: Classical and quantum theories of Raman effect, molecular polarizability, selection rules, rotational Raman spectra-linear molecules, symmetric top and spherical top molecules, vibrational Raman spectra and rotational-vibrational Raman spectra of diatomic molecule, mutual exclusion principle, polarized and depolarized Raman spectra.
- Understanding the Fundamentals of the NMR phenomenon, Larmor precession, mechanism of spin-spin and spin-lattice relaxations and quantitative treatment of relaxations, quantum mechanical treatment.

Optical Phenomena in Solids (Paper III)

Objectives:

- This course emphasis on optical properties of materials.
- This course is insight into luminescence phenomena.

Outcomes:

- It gives the insight into relation between the dielectric and optical properties, which is useful to understand behavior of materials in higher frequency range.
- It helps to understand the optical band transitions of materials.
- It gives the basic idea of luminescence materials, which are used in our daily life such as emissive displays, fluorescent lamps and LEDs and systems to detect X-rays or γ-rays.
- It helps to understand luminescence phenomenon.
- It gives the ability to design and analyze the solar cells.

Resonance Phenomenon in solids (Paper – IV)

Course Objectives:

- Students has to know structural properties of varies magnetic materials.
- The paper gives the knowledge of different experimental techniques like Nuclear Magnetic resonance, Electronic spin resonance and Nuclear Quadrapole Resonance spectra.
- Understand classical/quantum description of Mossbauer effect and it's applications.

Course Outcomes:

- Students can learn the structural properties of different magnetic materials and applications.
- Understand structure and theoretical properties and their application
- Understand use of various spectroscopic techniques and their application to describe atomic arrangement of solids.
- Describe various structural and chemical bonding aspects of Biomolecules.
- Equipped with the basic knowledge about the experimental methods used in the various laboratories.

Studies on reduced dimensionality in Solids (Paper V)

Out comes:

- Students can Basic concepts of artificial structures of Si, Ge etc.,; Semiconductor hetero-junction superlattices, Optical absorption, Resonance tunneling, Negative differential conductivity, Modulation doped hetero-junction superlattices, n-i-p-i structures, Inversion layers in MOSFETS and MODFETS.
- Students will be able to understand classification nano materials and learn more on Zero and one dimensional nano materials and their properties.
- Student will learn various methods of preparation of thin films like Physical evaporation, Epitaxial deposition, different type of sputtering methods, Chemical vapor deposition methods.

- Student can learn interface between insulator – metal and semiconductor – conductor and mechanisms governed within the contacts of these thin films, and photovoltaic and photoconduction.