# M.Sc. Physics

# Course Outcomes

M.Sc. Physics is a 4-semester course conducted by Dr. Ambedkar College, Deekshabhoomi, Nagpur as per the syllabus provided by Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur. Each semester students have to take four theory papers, two Practicals based on four theory papers, and a Seminar. The fourth semester has a six-month Research Project Work. Third and Fourth Semester has Two Elective papers. Coursework is according to theory papers, practicals, and seminars conducted throughout the program.

**M. Sc. PHYSICS**

**Semester I**

**(Core 1) Paper 1: Mathematical Physics**

*Course outcome: Students will be able to*

CO1. Understand the application of Vector analysis and curvilinear coordinates and Generalized Coordinates

CO2. Demonstrate the theory and application of Tensor analysis, and Tensor algebra. Know Fourier series, Laplace Transforms and its applications.

CO3. Analyze the application of Matrices and complex variables.

CO4. Use of Partial differential equations and Boundary value problems –solutions. Understand the use of Bessel Functions Legendre Polynomials and Hermite Polynomials.

**(Core 2) Paper 2: Complex Analysis and Numerical Methods**

*Course outcome: Students will be able to*

CO1. To get equipped with the understanding of the fundamental concepts of functions of a complex variable along with the concepts of analyticity, Cauchy-Riemann relations and harmonic functions.

CO2. Evaluate complex contour integrals applying the Cauchy's integral theorem and

Cauchy's integral formula.

CO3. Be aware of the use of numerical methods in modern scientific computing, numerical interpolation and approximation of functions

CO4. Apply numerical differentiation and integration whenever and wherever routine methods are not applicable.

**(Core 3) Paper 3: Electronics**

*Course outcome: Students will be able to*

CO1. To study the basics of transistor and its working and implementation, various circuits like UJT, SCR and TRIAC, to know the principle of operation of photoelectronic. devices like photodiode, and LED

CO2. To study applications of semiconductor devices in linear and digital circuits different biasing techniques.

CO3. To outline summing amplifier, inverting and non-inverting configuration. To summaries various amplifier like summing amplifier and Schmitt trigger and understand the basic logic gates.

CO4. Remember and understand the Basic principle of amplitude frequency and phase modulation

**(Core 4) Paper 4: Electrodynamics I**

*Course outcome: Students will be able to*

CO1. Describe the mathematical description of electromagnetic phenomena based on basic physical quantities.

CO2. Illustrate vector potential and electric field of a localized current distribution using multipole expansion problems.

CO3. Understanding of magnetic field, their law and boundary value problem.

CO4. Apply Maxwell equations in analyzing the nature of electromagnetic fields due to time varying charge and current distribution.

**LAB I Practical 1 (Core 1 and 2)**

*Course outcome: Students will be able to*

CO1. Understand the basic concepts of Experimental and Computational Physics

CO2. Solve the Computational problems and Write Programs.

**LAB II Practical 2 (core 3 and 4)**

*Course outcome: Students will be able to*

CO1. Demonstrate proper use of circuit connections of desired experiment.

CO2. Review the observations taken during the experimentation and tabulate the results.

## M. Sc. PHYSICS

## Semester II

### (Core 5) Paper 5: Quantum Mechanics-I

*Course outcome:  Students will be able to*

CO1. Understand General formulation of quantum mechanics. Know Stationary states and Eigen value problems.

CO2. Remember and understand Fundamental postulates of Quantum mechanics.

CO3. Demonstrate and interpret solutions of Schrodinger equation for simple problems.

CO4. Remember and understand theory of angular momentum, spin matrices and compute Clebsch-Gordan Coefficient.

### (Core 6) Paper 6: Statistical Physics

*Course outcome: Students will be able to*

CO1. Remember and understand the concepts, basic idea of probability, phase space, macro and micro states.

CO2. Understand to apply and formulate the Fermi-Dirac distribution to calculate thermal properties of electrons in metals and Bose-Einstein distribution to calculate properties of black body radiation.

CO3. Demonstrate Fermi Dirac condensation on the basis of BCS theory and its application for free electron gas in metal

CO4. Describe phase transition phenomenon using lsing model and Landau theory.

### (Core 7) Paper 7: Classical Mechanics

*Course outcome: Students will be able to*

CO1. To understand the fundamental concepts of the Lagrangian and the Hamiltonian methods and will be able to apply them to various problems;

CO2. understand the physics of small oscillations and the concepts of canonical transformations and Poisson brackets. Learn Hamilton-Jacobi theory and its importance.

CO3. To understand the basic ideas of central forces and rigid body dynamics.

CO4. Understand Euler angles, lnertia tensor. Compute equations of motion for simple coupled systems

**(Core 8) Paper 8: Electrodynamics II**

*Course outcome: Students will be able to*

CO1. Use of Maxwell equations in analyzing the electromagnetic field due to time varying charge and current distribution. Describe the nature of electromagnetic wave and its propagation through different media and interfaces

CO2. Explain charged particle dynamics and radiation from localized time varying electromagnetic sources

CO3. Formulate and solve electrodynamic problems in relativistically covariant form in four-dimensional space-time

CO4. Be familiar with some elementary phenomena and concepts in quantum electrodynamics.

**LAB I Practical 3 (core 5 and 6)**

*Course outcome: Students will be able to*

CO1. Tabulate the appropriate experimental data accurately and keep systematic record of general laboratory experiments.

CO2. Interpret professional quality of textual and graphical presentations of laboratory data and computational results.

**LAB II Practical 4 (core 7 and 8)**

*Course outcome: Students will be able to*

CO1. Evaluate possible causes of discrepancy in practical experimental observations and results in comparison to theoretical results.

CO2. Analyze various experimental results by developing analytical abilities to address real applications.

**M. Sc. PHYSICS**

**Semester III**

**(Core 9) Paper 9: Quantum Mechanics-II**

*Course outcome: Students will be able to*

CO1. Solve simple problems using perturbation theory and be able to apply them to various quantum systems

CO2. To understand the basics of time dependent perturbation theory and its application to semi-classical theory of atom radiation interaction. Solve barrier problem using WKB method

CO3. To understand the theory of identical particles and its application to helium. To understand the idea of Born approximation and the method of partial waves.

CO4. To aware the basic concepts of relativistic quantum mechanics. Know about Klein-Gordon equations, Dirac equations. Solve for Hydrogen atom using Dirac's theory.

**(Core 10) Paper 10: Solid State Physics and Spectroscopy**

*Course outcome: Students will be able to*

CO1. Clear basic concept of crystal classes, lattices, symmetries and to understand the relationship between real and reciprocal lattice.

CO2. Explore with the knowledge of different crystal defect and its influence on basic physical behavior of crystals and basic knowledge of dielectric properties of materials

CO3. Understand the spectra of single and multiple electrons atoms including fine and hyperfine structure of alkaline, Helium like atoms, spin and relativity correction, different type of coupling such as L-S and J-J couplings.

CO4. Understand and analyze the spectra of diatomic molecules such as electronic, rotational, vibrational spectra and a basic introductory idea about the Raman Spectroscopy.

**Paper – 11 (Core Elective 1) Atomic and Molecular Physics I**

*Course outcome: Students will be able to*

CO1. Understand the atomic structure and spectra of typical one- electron and two-electron systems.

CO2. Learn about the physical interpretation of the Laser spectroscopy and its application.

CO3. Analyses consequences to explain electronic, rotational, and vibrational spectra of diatomic molecules, explain IR spectroscopy. Know the basics of Raman spectroscopy and the nonlinear Raman effects

CO4. Skill of empirical model developing is created by studying the Born-Oppenheimer approximation. Critical thinking ability is developed by studying the Franck Condon principle.

**Paper – 12 (Foundation Paper I) S1.2 Nanoscience and Nanotechnology**

*Course outcome: Students will be able to*

CO1. Clear basic concept of quantum approach for density of states for quantum well, wires and dots.

CO2. Understanding the different methods of preparing nanostructure using chemical and physical process.

CO3. Structural and chemical characterization of nano structure. Explore with the knowledge of different instrumentation useful to analyses materials at nanoscale.

CO4. Understanding the properties nanomaterials for technology application.

**LAB I Practical 5 (core 9 and 10)**

*Course outcome: Students will be able to*

CO1. Understand how to apply and verify the theoretical concepts and facts through laboratory experiments.

CO2. Basics of different components of spectroscopy in experimental setup.

**LAB II Practical 6 (elective)**

*Course outcome: Students will be able to*

CO1. Students will learn the sample preparation methods and sample handling.

CO2. Students will acquire the ability to analyze the data obtained from the techniques.

## M. Sc. PHYSICS

## Semester IV

### (Core 11) Paper 13: Nuclear and Particle Physics

*Course outcome: Students will be able to*

CO1. Clear basic concept of nuclear properties; its size, radii, shape charge distribution, spin, parity, mass, nuclear stability and also to understand binding energy, semi empirical mass formula, liquid drop model, laws of radioactive decay.

CO2. Gains the knowledge of elementary particles, decay of nuclei, their classification, characteristics, selection rule and their theories.

CO3. Understand the concepts of the interaction of charged particles and electromagnetic radiation with matter along with principles of radiation detectors including G-M Counter, proportional counter, Na(Tl) Scintillation detectors, semiconductor detectors.

CO4. Understand the interaction between elementary particles and the conservation laws in particle physics.

### (Core 12) Paper 14: Solid State Physics

*Course outcome: Students will be able to*

CO1. Understand the band theory of solid and introduction to quantum theory of magnetism.

CO2. Understanding the lattice vibrations of a three-dimensional polyatomic vibrating crystal.

CO3. Understand the free electron theory of metals and know the fundamental principles of semiconductors and be able to estimate the charge carrier mobility and density.

CO4. Rigorous study of various theoretical treatments of superconductivity, including BCS theory and understanding the Josephson junction effects and their applications

### Paper – 15 (Core Elective 1) Atomic and Molecular Physics II

*Course outcome: Students will be able to*

CO1. Remember and understand the time-dependent and independent perturbation theory and Fourier transform.

CO2. Understand the saturation and absorption spectroscopy and its application.

CO3. Understand the theory of stimulated Raman scattering and fluorescence spectroscopy

CO4. Understand the Matrix isolation spectroscopy, Fourier transforms spectroscopy and Application of group theory

**Paper – 16 ((Foundation Paper II) S2.2: Experimental Techniques in Physics**

*Course outcome: Students will be able to*

CO1. Remember and explain different types of radiation, their sources and detectors which are commonly used in experimental techniques. Clear the conceptual understanding of functionality of different types of sensors

CO2. Demonstrate different X-ray and thermal analysis based experimental techniques used for materials characterization in Physics

CO3. Understand the different microscopy study Morphological Characterization and instrumentation for Magnetic Characterization

CO4. Understanding principle, instrumentation and working of Spectroscopic characterization for spectroscopy analysis

**LAB I Practical 7**

*Course outcome Students will be able to*

CO1. Apply appropriate laboratory techniques to measure semiconductor device characteristics.

CO2. Understand the mode and decay behaviour of various particles.

**Project (Code: 4PROJ1)**

Every student is required to carry out a project work in semester IV. The project can be of following types. A) Experimental Project Work; OR B) Field Based Project Work; OR C) Review writing based Project Work. The knowledge gained during their project work play a key role in the students' career to pursue Ph. D degree and start their career in research in scientific institutions.

*Course outcome: Students will be able to*

CO1. Develop the critical thinking ability and communication skills.

CO2. Understand and apply the scientific method.

CO3. Develop the aptitude to work on a scientific problem and look for alternative solution.

CO4. Write their findings in a form of a thesis and defend it by presenting it in front of their teachers and examiners.

CO5. Experience and embrace the habit of ethical practice in performing experiments and communicating them.

**Seminar (Code: 1S1, 2S1, 3S1 and 4S1)**

CO1. Class seminars are conducted every semester to develop and test the communication skills of students. Students will be able to comprehend the current research and should be able to put forward major ideas in front of their colleagues and teachers. Students will be evaluated on the basis of their presentation and questions and answer session.