



विक्रमाजीत सिंह सनातन धर्म कालेज कानपुर-208002  
VIKRAMAJIT SINGH SANATAN DHARMA COLLEGE KANPUR - 208002

भौतिक विज्ञान विभाग

DEPARTMENT OF PHYSICS

(NAAC द्वारा 2009 तथा 2016 में A ग्रेड प्रदत्त)

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**COURSE OUTCOMES (COs) of M.Sc. Physics Courses**

On completion of Physics courses in M.Sc. Physics, a student will be able to:

Course Outcomes (COs) of Physics courses in M.Sc. Physics		
Semester	Course Title/Code	Course Outcomes (COs)
Sem-1	Mathematical Physics I PCT101	<ul style="list-style-type: none"><li>○ Have confidence in solving mathematical problems arising in physics by a variety of mathematical techniques.</li><li>○ complex functions, Cauchy's integral, singularities, Zeroes and poles, theorems and Problems on complex variables.</li><li>○ solve linear and second order differential equations. formula and other properties of various polynomials and their applications in Physics.</li><li>○ Able to review linear vector spaces, Eigenvalues and eigenvectors, different operators, mathematical functions and their properties.</li><li>○ To comprehend probability statistics, random variables, statistical distributions and Data Analysis in Statistics.</li><li>○ Understanding coordinate transformations and tensors as well as practical examples of tensors in physics.</li></ul>
Sem-1	Classical Mechanics PCT102	<ul style="list-style-type: none"><li>○ Understand the fundamental concepts of the Lagrangian and the Hamiltonian methods and apply them to various problems.</li><li>○ Comprehend the physics of small oscillations and its applications.</li><li>○ Grasp the concepts of canonical transformations and Poisson brackets. Learn Hamilton-Jacobi theory and its importance.</li><li>○ Basic ideas of central forces and rigid body dynamics.</li><li>○ Understanding of Euler angles, Inertia tensor. Compute equations of motion for simple coupled systems.</li><li>○ Basic concepts in variational principle and Principle of Least Actions.</li></ul>
Sem-1	Electromagnetic Theory PCT103	<ul style="list-style-type: none"><li>○ Understanding the origin of displacement current. Derive and apply modified Maxwell's equations in vacuum and matter.</li><li>○ Analyse the propagation of electromagnetic waves in vacuum, linear dielectrics, conductor and plasma.</li></ul>

	B010703T	<ul style="list-style-type: none"> <li>○ Obtain the boundary conditions of electromagnetic fields and study the behaviour of electromagnetic waves at the interface of two different media.</li> <li>○ Understand the basic concept of scalar potential formation of electromagnetic fields and different gauge transformations.</li> <li>○ Discuss the principles of propagation of electromagnetic waves in bounded medias namely rectangular, cylindrical and cavity resonator waveguides.</li> </ul>
Sem-1	Quantum Mechanics-I PCT104	<ul style="list-style-type: none"> <li>○ Understanding the difference between classical and quantum mechanical theory and approach.</li> <li>○ Linear vector space, Hilbert space, operators and tools to calculate the Eigen values in matrix mechanics and wave mechanics representations.</li> <li>○ Clarity on uncertainty principle and Schrodinger wave equation and solution of simple harmonic oscillator problem.</li> <li>○ Knowledge of symmetries and conservation laws in quantum mechanics.</li> <li>○ Understanding the commutation relation of angular momentum, spin angular momentum, identical particles and many particle systems.</li> </ul>
Sem-1	General Lab PCP105	<ul style="list-style-type: none"> <li>○ This general lab improves student's experimental skills by performing physics practicals like study of L-C and R-C transmission line, Verifying digital logic gates and RAM, characteristics of FET, common source amplifier, Band gap of p-n junction diode and SCR characteristics, Optical fiber experiment using opto-electronic kit etc.</li> </ul>
Sem-2	Mathematical Physics II PCT201	<ul style="list-style-type: none"> <li>○ Understand the partial differential equations for solving Laplace, Poisson, Diffusion and Wave equations in different co-ordinate systems.</li> <li>○ Study some important functions like Green's function, Dirac delta function and transformations like Fourier, Laplace and its applications.</li> <li>○ Understand the basic concepts of Group theory and special continuous groups <math>SO(3)</math>, <math>SU(2)</math>, <math>SU(3)</math>.</li> <li>○ Study methods of Numerical analysis: Interpolation, Simpson's rule, Runge-Kutta method etc.</li> <li>○ The students acquire skills to apply different mathematical techniques for solving problem in the areas like Electromagnetic theory, Fluid mechanics, Quantum mechanics, Quantum field theory, Astrophysics and Cosmology.</li> </ul>
Sem-2	Solid State Physics PCT202  Paper Code – B010802T	<ul style="list-style-type: none"> <li>○ Describe and analyse crystal structures, lattice parameters and Miller Indices.</li> <li>○ Discuss the principle of X-ray diffraction using different methods. Understand the basic concept of reciprocal lattice and Brillouin zones of SC, BCC and FCC lattices.</li> <li>○ Drive and apply Drude's model for metals and outline the basic concept of free electrons model.</li> <li>○ Discuss Classical, Einstein and Debye theories of specific heat for solid.</li> </ul>

		<ul style="list-style-type: none"> <li>○ Difference between metal, insulator and semiconductor on the basis of band theory of solids.</li> <li>○ Describe and analyse the properties of intrinsic and extrinsic semiconductors.</li> <li>○ Understand the basic concept of superconductivity and types of superconductors.</li> </ul>
Sem-2	Statistical Mechanics PCT203	<ul style="list-style-type: none"> <li>○ Grasp the fundamentals of Foundation of Statistical Physics, Postulates of statistical mechanics, Random walk and equal a priori probability.</li> <li>○ Understanding the statistical Ensembles, Partition functions, and representing quantities in terms of partition function in connection with thermodynamics.</li> <li>○ Comprehending Quantum statistics, Indistinguishability, Maxwell-Boltzman, Bose-Einstein and Fermi-Dirac statistics.</li> <li>○ Analyzing Interacting systems for their solutions and understanding phase transitions, Critical exponents and Order parameters.</li> </ul>
Sem-2	Electronics PCT204	<ul style="list-style-type: none"> <li>○ Understanding basic concepts of Operational Amplifier.</li> <li>○ Develop idea of various applications of Operational amplifier and design of integrator, differentiator, summing amplifier etc.</li> <li>○ Designing of electronic circuits such as A/D &amp; D/A convertor, Wave generators and Multivibrator.</li> <li>○ Understand fundamentals of photon absorption and emission electron-hole pair generation in semiconductors.</li> <li>○ Comprehend construction principle and working of LED, Photodiode, Solar cell.</li> <li>○ Understand the basic principle, construction, and working of optical fibers.</li> <li>○ Comprehend the underlying physical principles and mechanism of optical fiber communication.</li> </ul>
Sem-2	General Lab PCP205	<ul style="list-style-type: none"> <li>○ This general lab improves student's experimental skills by performing general physics practicals such as, Voltage regulation studies, Susceptibility and ESR measurements, Transistor basing and h-parameters, differential, FET amplifier, Resistivity by four probe method, Study of Multivibrators, Basic operations using Op-Amp application trainer etc.</li> </ul>
Sem-2	Research Project PRP206	<ul style="list-style-type: none"> <li>○ Cultivate the skills to acquire and use appropriate learning resources to stay abreast of recent developments and use this in literature review of relevant chosen area of research project. Identify and analyze research problems.</li> </ul>
Sem-3	Classical Electrodynamics & Plasma Physics PCT301	<ul style="list-style-type: none"> <li>○ Understanding the basics of Homogeneous and inhomogeneous Lorentz groups, Pseudo-Euclidean spacetime, Matrix representation of transformations, Four-vectors, tensors.</li> <li>○ continuity equation, field-strength tensor, Canonical approach to electrodynamics</li> <li>○ comprehend the concepts of relativistic electrodynamics, Lagrangian and Hamiltonian formulation for relativistic charged particles.</li> </ul>

		<ul style="list-style-type: none"> <li>○ Retarded and advanced potentials, Lienard-Wiechert potentials for a moving point charge, Radiation from an accelerated charge and its relativistic generalization.</li> <li>○ Elementary concepts of plasma, Plasma oscillation, Debye shielding, plasma confinement, magnetosonic waves, Alfvén waves.</li> </ul>
Sem-3	Quantum Mechanics-II PCT302	<ul style="list-style-type: none"> <li>○ Understand the application of Schrodinger equation to solve real problems using time independent and time dependent perturbation theory.</li> <li>○ Comprehend various trivial theoretical calculations and integrals which are used to get insight into sub atomic domain.</li> <li>○ Develop idea to convert relevant physical parameters of scattering phenomenon from laboratory to centre of mass frame of reference.</li> <li>○ Understand basic mathematical operations &amp; tools used in the domain of high energy physics and nuclear physics.</li> <li>○ Develop idea about how atomic level phenomena change quantum mechanics at speed of light.</li> <li>○ Comprehend the new physical phenomena which arise due to infusion of quantum mechanics and relativity.</li> </ul>
Sem-3	Nuclear Physics-I PCT303	<ul style="list-style-type: none"> <li>○ Study basic properties of atomic nuclei like size, spin, parity, isospin, magnetic moment and electric quadrupole moment etc.</li> <li>○ understand the concepts of nuclear decays like Alpha decay, Beta decay, Fermi theory of Beta decay, Fermi and Gamow-Teller rules for allowed and forbidden transition.</li> <li>○ Study the concept of Gamma emission and selection rules.</li> <li>○ understand nuclear reactions, conservation laws and Q-value of nuclear reactions.</li> <li>○ Study characteristics of nuclear fission, fusion and nuclear reactors.</li> <li>○ The students develop basics to solve the problems of nuclear physics and their limitations in nature.</li> </ul>
Sem-3	Electronics-I PET304	<ul style="list-style-type: none"> <li>○ Understand the fundamental concepts of EM wave propagation, ground wave, space wave and sky wave. Introduction to fibre optics and wireless communication.</li> <li>○ Describe and analyse Antenna, its array and its basic applications. Understand the principle, operation and applications of RADAR.</li> <li>○ Outline the concept of signal to noise ratio and its enhancement in instrumentation and communication. Understand the principle of phase locking and lock-in amplifier.</li> <li>○ Introduction to microcomputers, memory, input/output interfacing devices. 8085 microprocessor, its architecture and initiated operations. 8085 programming and writing simple programs for mathematical operations of two numbers.</li> <li>○ understanding basic principles and working of microwave devices like two-cavity klystron, reflex klystron, magnetron and travelling wave tube (TWT).</li> <li>○ Differentiate advantages and disadvantages of microwave communication, propagation of microwaves and atmospheric effects.</li> </ul>

Sem-3	Practical- Electronics I PEP305	<ul style="list-style-type: none"> <li>○ Experiments on electronics provide excellent opportunity to the students to design and perform the experiments. Hands on experience on different experiments designed on the characteristics and applications of Op-Amp and fiber optic trainer. To study and understand various electronic circuit using discrete component trainer as well as dedicated circuits like wave shaping circuits, Active filters, data processing circuits etc. Verification of Boolean theorems and discrete components.</li> </ul>
Sem-3	Condensed Matter Physics-I PET304	<ul style="list-style-type: none"> <li>○ To study transport properties of solids and understand the basic concept of Quantum Hall effect.</li> <li>○ To study Dielectrics properties of solids and discuss the concept of Piezoelectric crystals.</li> <li>○ Describe and analyse plasmonic properties of metals. Determination of band gap in semiconductor by optical method.</li> <li>○ To study the magnetic behaviour of solids and understand the basic concept of Paramagnetism, Ferromagnetism and Antiferromagnetism.</li> <li>○ Discuss the basic concept of superconductivity and understand the origin of superconductivity by BCS theory</li> </ul>
Sem-3	Practicals- CMP I PEP305	<ul style="list-style-type: none"> <li>○ This lab provides experimental facilities in condensed matter physics where the students learn to find out dielectric constant of materials, magneto resistance, and X-ray diffraction simulations.</li> </ul>
Sem-4	Atomic and Molecular Physics PCT401	<ul style="list-style-type: none"> <li>○ Basic understanding of atomic structure and spectra of typical one- electron and two-electron systems.</li> <li>○ To understand Fine structure of hydrogen spectra and effects of spin-orbit interaction in atomic spectra.</li> <li>○ To understand Effects of magnetic field in the atomic spectra, principle of ESR and NMR.</li> <li>○ To comprehend electronic, rotational, and vibrational spectra of diatomic molecule.</li> <li>○ To understand the basics of Raman spectroscopy and the nonlinear Raman effects.</li> <li>○ Critical thinking ability is developed by studying the Franck Condon principle.</li> <li>○ Understanding of working Principle of Laser, physical interpretation of the Laser spectroscopy, and its applications.</li> </ul>
Sem-4	Nuclear Physics II PCT402	<ul style="list-style-type: none"> <li>○ Understand the nuclear two body problem, scattering theory in nucleon and meson theory of nuclear forces.</li> <li>○ Understand the different models of nucleon that explain the behaviour and characteristics.</li> <li>○ Understand the elementary particles, types of forces and various conservation laws.</li> <li>○ Basic ideas about quarks and standard model.</li> </ul>
Sem-4	Electronics-II PET403	<ul style="list-style-type: none"> <li>○ To understand analog and digital communication electronics; in general AM, FM, PM, pulse and digital modulation systems.</li> <li>○ To learn techniques of amplitude, frequency and phase modulations.</li> <li>○ To comprehend the Quantization of signals and their encoding</li> </ul>

		<ul style="list-style-type: none"> <li>○ To learn the fundamentals of different digital modulation techniques.</li> <li>○ To study mathematical representation of noise, sources of noise, Noise bandwidth.</li> <li>○ Gain knowledge of quantization noise, Noise in pulse code &amp; delta modulation system.</li> </ul>
Sem-4	Practicals- Electronics II PEP403	<ul style="list-style-type: none"> <li>○ This experimental lab provides comprehensive understanding of transition from analog to digital electronics and relates verifications. Understanding pulse modulation/demodulation, studying and understanding various electronic circuit such as flip-flops, counters, registers. A/D &amp; D/A converters. Performing basic operations using 8085 microprocessor and linear IC trainer.</li> </ul>
Sem-4	Condensed Matter Physics-II PET403	<ul style="list-style-type: none"> <li>○ To understand imperfections, dislocations and plane defects, Grain, tilt and twin boundaries, whiskers in Crystals.</li> <li>○ To have an idea about Exotic, glassy and amorphous Solids, Liquid Crystals, Quasi Crystals, polymers and their electronic structures, optical, electrical, thermal and dielectric properties.</li> <li>○ Exploring nano world, Nano structured C60, C80 and C240, Fullerene, Graphene, carbon nanotubes, their formation, characterization and applications:</li> <li>○ Study of surface topography of Thin films using SEM, TEM, STM, AFM and basic ideas of surface states in semiconductors.</li> </ul>
Sem-4	Practicals- CMP II PEP403	<ul style="list-style-type: none"> <li>○ In this lab the students who have opted for specialisation in condensed matter physics do the experiments based on the specialisation. Primarily internal friction, specific heat of solid and other material properties are studied. Thermal luminescence of F centers in alkali halides is also studied.</li> </ul>
Sem-4	Physics of Liquid crystals PEO404	<ul style="list-style-type: none"> <li>○ Comprehend various type of liquid crystalline phases, their structure and properties.</li> <li>○ Understand various theories of phase transitions in liquid crystals.</li> <li>○ Comprehend various properties of nematic liquid crystals such as elasticity dielectric constant.</li> <li>○ Understand the behaviour of liquid crystals under electric field and reorientation of molecules.</li> <li>○ Comprehend basic design of liquid crystal displays.</li> </ul>
Sem-4	Laser Physics and applications PEO404	<ul style="list-style-type: none"> <li>○ Understand the theory of lasing and related aspects, different laser systems, their construction and working principles.</li> <li>○ Comprehend the dynamics of laser output processing, generation of ultrashort pulses.</li> <li>○ To understand the qualities of laser light and correspondingly different application of lasers in various fields.</li> <li>○ Understand and explain optical fiber structures, their types and applications in optical fiber communication.</li> </ul>
Sem-4	Physics of nano- materials PEO404	<ul style="list-style-type: none"> <li>○ Understand Quantum Nature of the Nanoworld, quantum well, Quantum wire &amp; and Quantum dots nanostructures.</li> <li>○ Quantum confinements and its effect on the properties of semiconductor and metal nanomaterials, Carbon Nanostructures</li> </ul>

		<p>(Fullerenes, Carbon Nanotubes and Graphene) and their Renewable Energy Applications.</p> <ul style="list-style-type: none"> <li>○ Learning Synthesis of 0, 1 &amp; 2 Dimensional nanomaterials by Top down and Bottom-up Approach using different fabrication techniques.</li> <li>○ Understanding structural, Microscopic, spectroscopic and surface characterization of Nano Structures and materials:</li> </ul>
Sem-4	Elements of atmospheric & space science PEO404	<ul style="list-style-type: none"> <li>○ The composition of our atmosphere and laws that govern the dynamics of our atmosphere</li> <li>○ Basic ideas about ionosphere, magnetosphere and storm-sub storm phenomenon.</li> <li>○ The structure of sun and their atmosphere with sun spots and their properties.</li> <li>○ Solar cycle, activities and their effects on the earth</li> </ul>
Sem-4	Master dissertation PRP405	<ul style="list-style-type: none"> <li>○ Demonstrate knowledge and scientific understanding to identify research problems, design experiments, use appropriate methodologies, analyse and interpret data. Exhibit writing and presentation skills and the ability to manage time and resources.</li> </ul>

### **PROGRAMME OUTCOMES (POs): Master of Science (M. Sc) Physics**

Physics is the science of physical events of everyday life. At the same time, modern human life is thoroughly shaped by technologies that are largely based on the foundations of physics. The emphasis of our M.Sc. program is upon the courses that constitute this core foundation, while providing students with a bouquet of specialization and optional papers covering almost all advance topics of physics. The program is designed to provide students with a deep and comprehensive understanding of the fundamental principles, advanced concepts and adequate hands-on experience to students who may go on to work in applied fields of modern technology. The M.Sc. Physics program not only provides knowledge, general competence, and analytical skills needed in industry, it also equips students with the skills required to pursue research, academics, and professional careers in various fields of physics and related disciplines. Upon completion of the program, students will have achieved the following outcomes:

- Students will have a thorough understanding of core areas in physics, including mathematical physics, classical mechanics, quantum mechanics, electrodynamics, atomic, molecular, nuclear, and particle physics, statistical mechanics, electronics and condensed matter physics, as well as specialized knowledge in areas such as, Lasers, liquid crystals or atmospheric physics.
- will develop analytical and quantitative skills, enabling them to formulate and solve complex problems using mathematical models supported by theories and experimental techniques.
- will enable the student to demonstrate an in-depth knowledge of the subject and to give his/her opinion supported by logical reasoning and problem-solving skills.
- will acquire advanced experimental skills, including the use of sophisticated laboratory equipment, data acquisition, and analysis techniques. They will be proficient in conducting experiments, interpreting results, and understanding the limitations of experimental methods.

- will learn proper resource utilization by using appropriate learning resources including library, e-learning resources, ICT tools to enhance knowledge-base and stay abreast of recent developments.
- Learn to analyze problems starting from first principles, evaluate and validate experimental results, and draw logical conclusions thereof.
- Will acquire the knowledge and skills in the design and development of Electronics circuits to fulfill the needs of Electronic Industry.
- will gain proficiency in conducting independent research projects. They will be able to critically evaluate scientific literature, formulate research questions, and apply appropriate methodologies to generate new knowledge in physics.
- will be able to demonstrate the ability of effective communication: to write dissertations and reports, make presentations, and effectively communicate complex scientific concepts and research findings through oral/visual representations using ICT.
- will be well-prepared for pursuing doctoral studies/ research in any branch of physics/ physics related areas.
- Since Physics is the subject that is well connected to various disciplines; e.g. education, technology, health-care, bio-physics, space-science, defence etc. students will also be equipped to enter careers in academia, research institutions, industry, and other sectors that require advanced knowledge and skills in physics.

### **PROGRAMME SPECIFIC OUTCOMES (PSOs): M.Sc. Physics**

After the completion of M.Sc. Physics program students:

- Gain deep knowledge of basic concepts in Physics.
- Acquire functional knowledge of the fundamental theoretical concepts and experimental methods of physics.
- Understand fundamental and advanced level knowledge in the fields of electronics, material science, lasers, liquid crystals and nano materials for their applications.
- The student will learn to carry out experiments in basic as well as certain advanced areas of physics such as condensed matter physics, semiconductor devices, lasers and electronics.
- Ability to apply fundamentals of electronics in various domains of electronic systems as well as apply advanced theoretical and/or experimental methods, including the use of numerical methods in investigations and innovations in the physics related areas.
- Students will realize and develop an understanding of the impact of Physics on society and can apply conceptual understanding of the physics in real life and diverse phenomena observed in nature.
- It helps the students to enhance general competence, critical thinking and analytical skills on an advanced level as well as .to develop knowledge to identify the problems.
- Equips the students to pursue suitable careers in Physics; in research, academics, industries in physical science and public administration.
- The course as a whole opens up several career doors for the students interested in various areas of science and technology in private, public and government sectors.

- Students may get job opportunities in higher education, research organizations, physics consultancy, radiology, radiation oncology and many others. Some of the institutions where physics students can start their carrier are: PRL, NPL, IPR, SINP, BARC, ISRO, DRDO, IITs, IISc, NITs, etc.