Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NPHD524	Theoretical Physics	3	0	0	3

Prerequisite: Mathematical Physics, Classical Mechanics, Quantum Mechanics, Condensed Matter Physics, Statistical Mechanics.

Course Objective
• To convey the scholars some of the concepts of higher levels of physics; • To prepare them for research in advanced physical fields.
Learning Outcomes
After attending the course the scholars will have some of the advanced concepts of quantum mechanics, condensed matter physics, statistical mechanics, general theory of relativity, high energy physics and nonlinear optics, likely to be useful in forefront areas of research.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	***Quantum Mechanics:*** Schrödinger Picture, **Time independent perturbation theory:** Theory and an example; **Scattering theory:** Quantum theory, Partial wave analysis (one example), Born Approximation and its validity (One example); **Path integral formulation:** propagator, Schrödinger wave equation from path integral, e.g. free particles; Introduction to second quantization; **Quantum field theory**: quantization of scalar field and Dirac field.	9	Learn some advanced concepts in quantum mechanics (with applications) and build foundations for field theoretic methods crucial to understand particle physics and condensed matter physics.
2	***Condensed Matter Physics:*** **Electronic Structure Calculation:** Hartree-Fock Theory, Introduction to Density Functional Theory; **Correlated Electron States:** Mott Transition, Hubbard Model, Magnetic impurities and Kondo Model; **Quantum Hall Effect:** Integer and fractional Hall Effect; Laughlin wave function; **Magnetism:** Mean-field approximation for Heisenberg Hamiltonian model for Ferromagnetism.	9	Familiarity with some basic methods used to understand the electronic structure of both, weakly- and strongly-correlated solids; as well as experimental and theoretical phenomenology of a number of interesting phases exhibited by correlated electronic systems.
3	***Statistical Mechanics:***Landau theory for phase transitions; Ising model: transfer matrix method; Onsager solution of 2-dimensional Ising model. **Non-equilibrium Statistical Mechanics:** Response function and susceptibility; fluctuation-dissipation theorem; irreversibility and master equation; Fokker-Planck and diffusion equations.	7	Understand basic description of equilibrium phase transition using phenomenological models, and evolution of a non-equilibrium system.
4	***General Theory of Relativity:***Equivalence principle and its applications: gravity as a curvature of space-time; geodesics as trajectories under the influence of gravitational field; generalization to massless particles.	5	Learn basic axioms of Einstein's theory of gravity and its application to describe the motion of a test mass in a gravitational field.
5	**High Energy Physics:** Introduction to relativistic kinematics, Review of experimental methods: fixed target and collider experiments, Introduction of four forces and interactions, Feynman diagrams Basics of quantum electrodynamics: Glashow-Salam-Weinberg model, Standard Model Physics.	7	Familiarity with some experimental and theoretical methods used in particle physics and a concrete understanding of elementary particles and their interactions.
6	***Nonlinear Optics:***Nonlinear wave propagation in Anisotropic media; Second Harmonic Generation (SHG); Phase Matching Techniques; Three-Wave Interactions; Third Harmonic Generation (THG); Density Matrix and Perturbation approach to Nonlinear susceptibility	5	Learn a number of nonlinear optical phenomena displayed by materials interacting with highly intense light.
	Total	**42**	

Text Books:

1. Introduction of Quantum Mechanics; David J. Griffiths; Pearson Education; 2010.
2. Principle of Quantum Mechanics; R. Shankar; Springer; 1994.
3. Introduction to Condensed Matter Physics; F. Duan, J. Guojun; World Scientific; 2007.
4. Statistical Mechanics: R. K. Pathria; Elsevier; 2002.
5. Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, Steven Weinberg; Wiley; 2013.
6. Introduction to Elementary Particles; David J. Griffiths; Wiley; 2008.
7. Introduction to High Energy Physics, Donald Perkins; Cambridge University Press; 2000.
8. Nonlinear Optics, 3rd Ed; R. W. Boyd, Academic Press; 2008.

Reference Books:

1. Quantum Mechanics 2nd Ed; Bransden and Joachain; Pearson; 2000.
2. Quantum Mechanics and Path Integral; Feynmann and Hibbs, McGraw-Hill College; 1965.
3. Many-particle Physics; G. D. Mahan; Springer US; 2000; DOI: 10.1007/978-1-4757-5714-9.
4. Advanced Condensed Matter; L. M. Sander; Cambridge University Press; 2009.