Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NPHD501	Quantum Field Theory	3	0	0	3

Prerequisites: Classical Mechanics and Special Theory of Relativity, Methods of Mathematical Physics, Quantum Mechanics.

Course Objective
Quantum field theory is the formulation that is foundational for fields of Physics like Theoretical and Experimental High Energy Physics, Particle Physics, Nuclear Physics, Condensed Matter Physics, and many more. This course aims to make the students familiar with this framework so that they can use it in research in these fields.
Learning Outcomes
After completing this course, students will be prepared to take advanced specialized courses such as Quantum Field Theory - II, Conformal Field Theory, String Theory, etc., as well as advanced topics in Condensed Matter Theory. They will also be able to calculate scattering amplitudes in a perturbative framework using Feynman diagrams.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Definition of field, Euler-Lagrange equation of classical, field, Space-time symmetry, Noether's theorem,	3	This unit serves as the motivation for using quantum field theory to describe relativistic quantum systems.
2	**Symmetry Representations and One-Particle States:** Poincare group and its generators, spin and mass, Quantum Poincare transformations, one-particle states: massive and massless with spins 0, ½, and 1.	7	To help the student understand the notion of one-particle states as irreducible representations of the Poincare group.
3	**Quantization of a Real Scalar Field:** Klein-Gordon equation for Free real scalar field, canonical quantization: creation and annihilation operators, causality, retarded and Feynman propagators	6	Introduction to the canonical quantization of fields with the simplest example of real scalar, and to the concept of propagators.
4	**Interacting field theory:** Phi^4 theory, Wick's theorem, vertex operators, Time ordered correlation functions, Feynman rules: coordinate and momentum space, Feynman diagrams: Tree and 1-loop.	7	Understanding the formulation of an interacting field theory as a perturbation theory, introduction to Feynman diagrams.
5	**Scattering amplitudes:** Scattering theory, LSZ reduction formula, In and out states, Scattering matrix from correlation functions, unitarity of S-matrix.	6	To learn how Feynman diagrams can be used to calculate scattering amplitudes in the QFT framework.
6	**Quantization of spin ½ fields:** Free Dirac field, Dirac Lagrangian and Dirac equation, spinors, Clifford algebra, Canonical quantization of spinors, Spinor technology, propagators	7	Quantization of spinor fields that is the basis of the quantization of fermions, which constitute all known matter.
7	**Quantization of spin 1 fields**: Maxwell equations, gauge invariance, Canonical quantization of electromagnetic fields in coulomb gauge, photons and polarizations, propagators.	6	Quantization of spin-1 bosons, which will prepare the student for Quantum Electrodynamics, and quantization of nonabelian gauge fields.
	Total	**42**	

Textbooks:

1. Quantum Field Theory, Mark Srednicki, Cambridge University Press (2007),
2. The Quantum Theory of Fields, Volume I - Foundations, Steven Weinberg, Cambridge University Press (1995),
3. An introduction to Quantum Field Theory, Michael E. Peskin and Daniel V. Schroeder, CRC press (2018).

Reference books:

1. Relativistic Quantum Mechanics: Wave equations, Walter Greiner, D.A. Bromley, 3rd Edition, Springer (2000),
2. Quantum Field Theory, Lowell S. Brown, Cambridge University Press (1992),
3. Quantum Field Theory, Lewis H. Ryder, 2nd edition, Cambridge University Press (1996).