Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NPHD520	Quantum Many Body Physics	3	0	0	3

Prerequisites: Mathematical Physics, Quantum Mechanics, Statistical Mechanics.

Course Objective

- The course will focus on modern age quantum materials that are intricately quantum in nature.
- This course will go beyond the conventional one-body quantum mechanics course that mostly deal with non-interacting problems in physics.
- It will train the students with the mathematical frameworks that are required to understand quantum many-body phenomena and guide them into beyond text book problems and one-body Schrodinger equation.
- It will also focus on the concepts and physical pictures behind various phenomena that appear in interacting many-body systems.

Learning Outcomes

- This will help students go beyond one-body quantum mechanics and understand the role of quantum mechanics in modern materials that hold the prospects of displaying quantum boosted functionalities.
- Students will get obtain a general overview of electronic correlations, topology and its possible interplay in condensed matter systems and related physical systems.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcomes
1	Theoretical background: introduction to many-body theory, quantum fields for bosonic and fermionic systems, review of second quantization.	5	To gain or review basic knowledge on the theoretical techniques and mathematical background required for understanding quantum many-body systems. the understand module-1. The students will have an idea about their manifestations in experiments.
2	Concept of emergent quasiparticles: Fermi liquid, many-body Greens functions (correlators and propagators) at zero temperature and Matsubara formalism	8	Students will be able to understand the key role of the quantum effects and emergent phenomena, quantum phases associated with these phenomena.
3	non-perturbative many-body techniques, diagrammatic techniques: Feynman diagrams, mean-field theories (analytical)	8	Students will learn analytic mean field calculations beyond standard Hartree-Fock theory.
4	numerical techniques: exact diagonalisation, quantum Monte Carlo etc., calculation of transport, two-particle response functions	7	Students will learn about state-of-the-art numerical techniques that are commonly used to learn about various phenomena in these systems.
5	Model systems displaying quantum phases and their connection to experiments: Kondo Effect and the Physics of the Anderson Impurity Model, Quantum spin chain	8	Students will be exposed to basic theoretical models and how they manifest in experiments through hands-on calculations.
6	Topological Insulators, Topological Phase transitions, Low dimensional systems	6	To understand the role of topology in condensed matter systems that holds possible applications in quantum computation.
	Total	42	

Text Books:

1. Many-Body Quantum Theory in Condensed Matter Physics: An Introduction, Henrik Bruus and Karsten Flensberg, OUP Oxford (Oxford Graduate Texts), 2004
2. Many-Particle Physics (Physics of Solids and Liquids), G. D. Mahan, Springer, 2000
3. Topological Phases of Matter, Moessner and Moore, Cambridge University Press, 2021

Reference Books:

1. Quantum Theory of Many-Particle Systems, Fetter and Walecka, Dover Publications, 2003
2. Topological Phase Transitions and new developments, Brink, Gunn, Jose, Kosterlitz, and Phua, World Scientific Publishing Co Pte Ltd, 2018