PHY-916 Group Theory for Physicists

Credit Hours: 3-0

Prerequisite: None

Course Objectives: This course builds the foundation of the applications of group theory to Quantum mechanics and particle physics.

Core Contents: Group axioms, Introduction to finite groups, Continuous group, and its application in physics.

Detailed Course Contents: Definition of group, Introduction to finite groups, Subgroup and classes, Group representation and characters, Schur's Lemma and Orthogonality theorem, Symmetry group and the irreducible representation of symmetry group S3,The rotation group SO(2), The generator of SO(2), Irreducible representation of SO(2),Generators and Lie groups of SO(3), Irreducible representation of SO(3) Lie algebra, The Lorentz group and Poincare group, Homogeneous Lorentz group, The proper Lorentz group, Decomposition of Lorentz group, Irreducible representation of Lorentz and Poincare group.

Course Outcomes: On successful completion of this course, students will be able to

- Understand the finite and continuous group and its application in Quantum mechanics and Particle Physics
- Understand the Lorentz and Poincare group.
- Apply group theory to build the different models in Particle Physics.

Textbooks:

1. J. Mathews and R. Walker, Mathematical Methods of Physics), 2nd ed. Addison Wesley 1971. (Refereed as MW)
2. Wu-Ki-Tung, Group Theory in Physics, World Scientific Publishing (1993).

Reference Books:

1. Group Theory in a Nutshell for Physicist, Princeton University Press (2016).

Weekly Breakdown		
Week	***Section***	***Topics***
1	MW 16.1-16.2	Definition of group, Introduction to finite groups, Subgroup and classes
2	MW 16.3	Group representation and characters, Schur's Lemma and Orthogonality theorem, Symmetry group and the irreducible representation of symmetry group S3.
3	MW 16.4, 16.6	Group Characters, Character table of symmetry group S3, Infinite groups, Generators of continuous group
4	WT 6.1-6.3	The rotation group SO(2), The generator of SO(2), Irreducible representation of SO(2)
5	WT 6.4, 7.1	Invariant integration measures, Orthonormality and completeness relation, Description of group SO(3)
6	WT 7.3	Generators and Lie groups of SO(3), Irreducible representation of SO(3) Lie algebra.
7	WT 7.4-7.5	Properties of the rotational matrices, Application of Particles in a central potential such as Characterization of states, asymptotic plane wave states.
8	WT 7.6, 7.8	Transformation properties of wave functions and operators, Irreducible tensor and Weigner Eckart theorem.
9	WT 8.1-8.3	The relationship between SO(3) and SU(2), Invariant integration, Orthogonality and completeness relation of SU(2)
10	WT 8.4	Projection operators and their physical applications such as single particle state with spin, Two particle states with spin
11	WT 8.5-8.6	Differential equation satisfied by Dj functions, Group theoretical interpretation of spherical harmonics.
12	WT 10.1.-	The Lorentz group and Poincare group, Homogeneous Lorentz group, The proper Lorentz group, Decomposition of Lorentz group

	10.1.4	
13	WT 10.1.5, 10.2	Four dimensional Translations and the Poincare group, Generators of Lorentz and Poincare group, Lie algebra of Lorentz group.
14	WT 10.3	Irreducible representation of Lorentz group
15	WT 10.4	Irreducible representation of Poincare group