PHY-904 Quantum Field Theory-II

Credit Hours: 3-0

Prerequisite:

Course Objectives: The purpose of this course is to introduce the advanced calculations in Quantum Field Theory such as renormalized perturbation theory, Renormalization group equation. This course will help students to understand research problems in the field of high energy physics, more precisely students can understand the hardcore calculations of Quantum chromodynamics also known as QCD.

Detailed Course Contents: Systematics of Renormalization: Counting of ultraviolet divergences, Renormalized perturbation theory, Renormalization of Quantum Electrodynamics (QED), Renormalized perturbation theory: One-loop structure of QED, Renormalization beyond the leading order, The renormalization group: The Callan-Symanzik equation, Renormalization conditions, Calculating the dimensionless parameters (beta and gamma), Renormalization of local operators, Evolution of mass parameters, The geometry of gauge invariance, The Yang-Mills Lagrangian, The gauge invariant Wilson loop, Basic facts about Lie algebras: Classification of Lie algebras, Representations, The Casimir operator, Interactions of non-abelian gauge bosons: Feynman rules for fermions and gauge bosons, Equality of coupling constants, Faddeev-Poppov procedure, Ghosts and unitarity, BRST symmetry, One-loop divergence of non-abelian gauge theory: Gauge boson self-energy, The beta function: Calculating the counter terms, Relations among counter terms. Asymptotic freedom: A qualitative explanation

Learning Outcomes: At the end of this course, students will be able to

- understand Renormalization perturbation theory and renormalization group equation
- geometry of gauge invariance. The Yang Mill's Lagrangian.
- interactions of non-abelian gauge bosons
- Heavy Quark effective Theory (HQET)

Textbook: Michael E. Peskin, Daniel V. Schroeder Introduction to Quantum Field Theory, 9th ed. John Wiley and Sons 2011. (referred as PS)

Recommended Books:

1. Matthew D. Schwartz (MDS), Quantum Field Theory and the Standard Model, Cambridge University Press 2014.
2. Mark Srednicki (MS), **Quantum Field Theory**, Cambridge University Press 2012.
3. Steven Weinberg, The Quantum Theory of Field, Cambridge University Press, 1995.

Weekly Breakdown		
Week		***Topics***
1	PS 10.1, 10.2, PS 10.3	Systematics of Renormalization: Counting of ultraviolat divergences, Renormalized perturbation theory, Renormalization of Quantum Electrodynamics (QED)
2	PS 10.2, 10.3, 10.4	Renormalized perturbation theory: One-loop structure of QED, Renormalization beyond the leading order.
3	PS 12.2	The renormalization group: The Callan-Symanzik equation, Renormalization conditions, Calculating the dimensionless parameters (beta and gamma)
4	PS 12.3	Evolution of coupling constants: Solution of the Callan-Symanzik equation, An application to QED
5	PS 12.4, 12.5	Renormalization of local operators, Evolution of mass parameters
6	PS 15.1, 15.2, 15.3	The geometry of gauge invariance, The Yang-Mills Lagrangian, The gauge invariant Wilson loop
7	PS 15.4	Basic facts about Lie algebras: Classification of Lie algebras,

		Representations, The Casimir operator
8	PS 16.1, 16.2	Interactions of non-abelian gauge bosons: Feynman rules for fermions and gauge bosons, Equality of coupling constants, Faddeev-Poppov procedure
9	PS 16.2, 16.3, 16.4, 16.5	Ghosts and unitarity, BRST symmetry, One-loop divergence of non-abelian gauge theory: Gauge boson self-energy
10	PS 16.5	One-loop divergence of non-abelian gauge theory: Three-gauge boson vertex, Four-gauge boson vertex, Ghost loop
11	PS 16.5, 16.7	The beta function: Calculating the counter terms, Relations among counter terms. Asymptotic freedom: A qualitative explanation
12	MDS 35.2	Heavy Quark effective Theory (HQET): Lagrangian and Feynman rules for heavy quark effective theory. Normalization of the states.
13	MDS 35.3.1	Reparametrization invariance, Renormalization in HQET
14	MDS 35.4	Power corrections in HQET Lagrangian, Calculations of Hadron Masses.
15	Handouts	Light cone coordinates and Introduction to method of regions.