BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI-HYDERABAD CAMPUS
SECOND SEMESTER 2021-2022
COURSE HANDOUT

Date:15.01.2022

Course No **: PHY F412**
Course Title **: Introduction to Quantum Field Theory**
Instructor-in-Charge **: Prasant Samantray**
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Course Description:
Klein-Gordon equation, SU(2) and rotation group, SL(2,C) and Lorentz Group, antiparticles, construction
of Dirac Spinors, algebra of gamma matrices, Maxwell and Proca equations, Lagrangian Formulation of particle mechanics, real scalar field and Noether's theorem, real and complex scalar fields, Yang-Mills field, geometry of gauge fields, canonical quantization of Klein-Gordan, Dirac and Electromagnetic field, spontaneously broken gauge symmetries, Goldstone theorem.

Scope & Objectives:

The course aims to establish how to reconcile quantum theory with special relativity via introducing fields as the basic ingredients of nature. At the end of the course, students will be able to:

- Appreciate the role of symmetries (specifically application of group theory techniques) to describe fundamental fields.
- Describe various classical field theories arising out of symmetry principles.
- Especially link symmetry and conserved charges for the special case of complex scalar quantum field and to understand this as as an example of Noether's theorem.
- Understand quantization procedures for scalar and Maxwell field theories.
- Derive Feynman diagrams for simple field theories, and use them to study the scattering of particles in perturbation theory.

TextBook:

T1 : “An Introduction to Quantum Field Theory” by M. Peskin & D. Schroeder [Sarat Book House].

T2 : “Quantum Field Theory in a Nutshell” by A. Zee [Princeton University Press].

Reference Books:

R1: Quantum Field Theory for the Gifted Amateur by Tom Lancaster & Stephen J. Blundell [Oxford University Press].

R2: A First Book of Quantum Field Theory by Amitabha Lahiri & Palash B. Pall [Narosa Publishing House].

R3: Quantum Field Theory by Claude Itzykson & Jean-Bernard Zuber [McGraw-Hill Book Company].

Course Plan:

Lecture No.	**Learning Objectives**	**Topics to be covered**	**Chapter in the Text Book**
1-8	Preliminaries	What is QFT? Why QFT? Natural Units, Special Relativity and Lorentz Group	**T1 (3.1); T2(I.1-I.3)**; R1 (0.4)
9-12	Construction of Various Field Theories	Lorentz group representations of Scalar, Vector and Spinor Fields.	**T1(2, 3.2); T2(II.1, II.3)**; R1 (9)
13-17	Scalar Field Theory	Lagrangian for real and complex scalar fields.First look at Noether’s theorem.	**T1(2); T2(I.10)**; R1 (10)
18-26	Quantization of Scalar Field Theories	Canonical and path integral quantization in QM and quantum field theories. Generating functional and the Feynman propagator for a real scalar field.	**T1(2); T2(I.2, I.8, I.9)**; R1 (11,12, 23,24)
27-34	Feynman Rules and Perturbation Theory for scalar fields.	Examples of interacting Quantum field theories. The S-matrix, Feynman diagrams, and a first look at infinities.	**T1(4); T2(I.7)**; R1 (19)
35-39	Spontaneous Symmetry Breaking	The Anderson-Higgs Mechanism and Goldstone’s theorem.	**T1(11.1); T2(IV.1)**; R1 (26)
40-42	The Dirac Equation and en route to QED	The Dirac spinor, Gamma matrices and their algebra. Gauge invariance and the action for QED.	**T1(3.1-3.3);T2(II.1)**; R1 (28,36)

Evaluation Scheme:

EC No.	***Evaluation scheme***	***Duration***	***Weightage (%)***	***Date, Time(Tentative)***	***Nature of component***
1	Assignment 1	1 Week	20		Take Home
2	Mid Semester Exam	90 mins	30	10/03 11.00am to12.30pm	Open Book
4	Assignment 2	1 Week	15		Take Home
6	Comprehensive Exam.	120 mins	35	10/03 11.00am to12.30pm	Open Book

- **Notices:** Notices for the course will be displayed on the Department **of Physics** notice board or/and uploaded on **CMS**.
- **Chamber Consultation hour :** 12 noon – 13:00 pm all working Mondays.

- **Make-up Policy: Very strict**, **genuine cases only** i.e.

  (i) **Sickness leading to hospitalization**.(No make up for stomach-ache, diarrhea, vomiting, and head-ache unless seriousness is verified by medical test. **RMO's prescription is NOT enough**)

  (ii) Out of station with **prior intimation** & **permission**.

  (iii) No make-up for tutorials.

Academic Honesty and Integrity Policy: Academic honesty and integrity are to be maintained by all the students throughout the semester and no type of academic dishonesty is acceptable.

Instructor-in-Charge

PHY F412