

BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI-HYDERABAD CAMPUS
FIRST SEMESTER 2019-2020
COURSE HANDOUT

01.08.2019

Course No. : PHY F412
Course Title : Introduction to Quantum Field Theory
Instructor-in-Charge : Rahul Nigam
Instructor : Rahul Nigam

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-Gordon, 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:

- use fields to describe fundamental particle physics.
- describe a scalar (spin zero) particle in terms of a classical field theory,
- link symmetry ($U(1)$ phase symmetry only) and conserved charges for a complex scalar quantum field and to understand this as an example of Noether's theorem
- quantize a scalar field theory, Dirac field theory and Maxwell field theory using canonical quantization and
- derive Feynman diagrams and use them to study the scattering of particles in perturbation theory.

Text Book:

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

Reference Books:

R1: An Introduction to Quantum Field Theory by M. Peskin & D. Schroeder [Sarat Book House].

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].

R4: Quantum Field Theory in a Nutshell by A. Zee [Princeton University Press].

Course Plan:

Lecture No.	Learning Objectives	Topics to be covered	Chapter in the Text Book
1-3	Preliminaries	What is QFT? Why QFT? Special Relativity, Natural Units	T(chap.0) R1(2.1), R2(1.1-1.5)
4-10	Classical Field Theory	Action, Lagrangian, Hamiltonian's Principle, Classical relativistic field theories, Symmetries, Currents and conservation laws	T(chaps.5, 6 & 10) R1(2.2), R2(2.1-2.4)
11-14	Real Scalar Field Theory	Lagrangian density, Quantization, Propagator, Commutation relations	T(chap.11) R1(2.3-2.4), R2(3.1-3.7)
15-19	Complex Scalar Field Theory	Quantization, Charge operator, Propagator, Spontaneous symmetry breaking and the Goldstone theorem events	T(chap.12) R1(11.1), R2(13.4-13.5)
20-24	Dirac Field Theory	Quantization, charge operator, propagator, Anti-commutation relations, Massless Dirac fields	T(chaps.36-38) R1(3.1-3.5), R2(4.1-4.7)
25-30	Electromagnetic Field Theory	Maxwell's equation, quantization, propagator, Quantum electrodynamics	T(chap.39) R2(8.1-8.8)
31-40	Perturbation Theory and Feynman Diagrams	Examples of interacting Quantum field theories, The S-matrix, The LSZ reduction formula, Wick's theorem, Feynman diagrams, Introction to reormalization	T(chaps.18 & 19) R1(4.1-4.8), R2(5.1-5.4,6.1-6.8)

Evaluation Scheme:

EC	Evaluation scheme	Duratio	Weightage	Date, Time	Nature of
----	-------------------	---------	-----------	------------	-----------

No .		<i>n</i>	<i>(%)</i>		<i>component</i>
1	Mid Sem Exam	1.5 hrs	30	1/10, 11.00 -- 12.30 PM	Open Book
2	Quiz 1	50 mins	15		Close Book
3	Quiz 2	50 mins	15		Close Book
4	Comprehensive Exam.	3 Hrs	40	6/12 AN	Close Book

- **Notices:** Notices for the course will be displayed on **Department of Physics** notice board or/and uploaded on **CMS**.
- **Make-up Policy: Very strict to 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