Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: A **600 level elective** number requested**.**
2. Course Title: ***Introduction to Quantum Field Theory***
3. No. of Lectures per week: 3 (L), Tutorial: 1 (T), Laboratory: 0 (P), Additional Hours[0-2]: 0 (A),

   Credits (3*L+2*T+P+A): 11 Duration of Course: Full Semester
4. Proposing Department/IDP : PHY.

   Other Departments/IDPs which may be interested in the proposed course: MTH.

   Other faculty members interested in teaching the course: Joydeep Chakrabortty, Diptarka Das, Nilay Kundu, Apratim Kaviraj, Debtosh Chowdhury, Sabyasachi Chakraborty.
5. Proposing Instructor: Arjun Bagchi (PHY)
6. Course Description:

   A) Objectives: Quantum field theory is the basic framework of understanding the laws of nature and the basic building blocks of the universe. This is fundamental to all branches of theoretical physics starting from condensed matter physics to the theory of elementary particles. This course is a first course on the subject aimed at students who have a background of quantum mechanics and statistical mechanics.

   B) Contents:

S. No.	Broad Title	Topics	No. of Lectures
1.	Introduction and Classical field theory	• Why QFT • From point particles to classical fields • Some basics of Lie groups and Lie algebras • Symmetries and Noether's theorem	**6**
2.	Canonical Quantization of free scalar fields	• Klein-Gordon Equation • Simple Harmonic Oscillator • Free Quantum Fields • Complex Scalar Fields • Causality and Propagators	**7**
3.	Interacting fields	• Interaction Picture, Scattering, Wick's Theorem. • Feynman Diagrams and Feynman Rules • Amplitudes, Decays and Cross Sections, Green's Functions • Connected Diagrams and Vacuum Bubbles	**9**
4.	Fermions and their quantization	• Lorentz Group, Clifford Algebras and Spinor Representation • The Dirac Lagrangian and the Dirac equation • Symmetries and Currents, Plane Wave Solutions • Fermionic Quantization • Propagators, Feynman Rules	**8**
5.	Quantum Electrodynamics	• Gauge Invariance and Quantization • Including Matter • Propagators, Feynman Rules • QED Processes.	**9**
		Total number of lectures:	**39**

C) Pre-requisites: PHY421, PHY431, PHY 432, PHY422 (Desirable).

D) Short summary for including in the Courses of Study Booklet: Quantum field theory is the basic framework of understanding the laws of nature and the basic building blocks of the universe. This is fundamental to all branches of theoretical physics starting from condensed matter physics to the theory of elementary particles. This course is a first course on the subject aimed at students who have a background of quantum mechanics and statistical mechanics.

7. Recommended books:
    - M. Peskin and D. Schroeder: *An Introduction to Quantum Field Theory*
    - S. Weinberg: *The Quantum Theory of Fields: Vol 1.*
    - M. Scredniki: *Quantum Field Theory*
    - L. Ryder: *Quantum Field Theory*
    - A. Zee: *Quantum Field Theory in a Nutshell.*

Dated: 31 March 2024. Proposer: Arjun Bagchi ( ).

Dated: 31 March 2024 DPGC Convener (PHY):_____

The course is approved / not approved

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Chairman, SPGC

Dated:_____