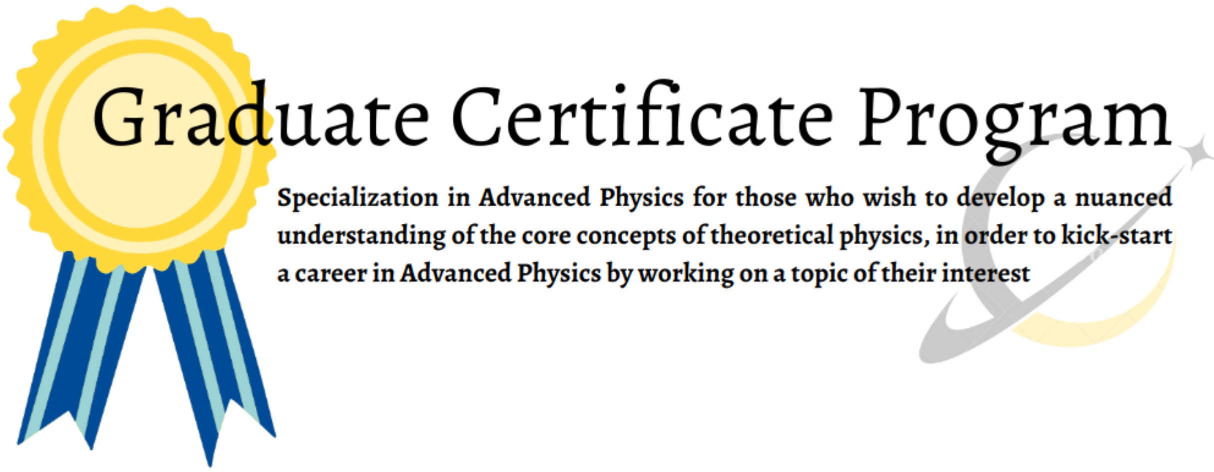
Graduate Certificate Program

Advanced Physics Track



What is the Graduate Certificate Program?

1. The Graduate Certificate in Advanced Physics is an **immersive three-month program with an inclusive research component**
2. Final-year undergraduate students and above are welcome to register. First-year undergraduates with experience in basic quantum mechanics are also welcome to apply
3. You can choose your domain for the final report, ranging from simple particle physics, foundations of quantum mechanics, quantum field theory, and many others.
4. A **60-hour program** to equip students with a comprehensive and in-depth mathematical understanding of the subject.

Why take the GCP?

1. The program is designed to introduce the core concepts which are essential to pursue advanced subjects in Theoretical Physics.
2. The lectures have significant mathematical rigor but are designed to gradually introduce the topics to keep the content suitable for both intermediate-level and advanced-level students.
3. A **complete toolkit** for a student to kick off an active journey in exploring the subject while being able to experience basic research methodologies through a practical approach.
4. The perfect stepping stone for students to pursue more advanced projects after completing the course, and connect with a diverse community of researchers.
5. GCP in Advanced Physics will provide a framework that they can revisit and use in the future to revise their basics. The program offers **lifetime access to our bundle of resources, lectures, and slides.**

Overview

Learning Outcomes

a. The transition from Quantum Mechanics to Fields
b. Scattering cross-sections as observed in experiments
c. Applications of Perturbation Theory
d. Origin of particles: photon, electron, positron, and other bosons and fermions
e. Realization of known quantum mechanics from path integrals
f. Symmetries that describe particles: U(N), SU(N)
g. Mathematical expressions for Feynman Diagrams
h. The reason for the strong force being strong: Quantum Chromodynamics
i. The most successful QFT: Quantum Electrodynamics
j. Quantization of Fields: Scalar, Vector, and Fermion

<u>Tentative timings and Days of Lectures</u>: Classes will be held from **7:30 PM to 8:30 PM** on Mondays, Tuesdays, Thursdays, and Fridays. Informal Discussions if needed will be held on the remaining days.

Module 1: Advanced Quantum Mechanics

<u>Tentative Starting Date:</u> Jan 01, 2023

Lectures are at 7:30 PM on Mondays, Tuesdays, Thursdays, and Fridays. Informal Discussions on the remaining days will be held on our Discord Server: Naxxatra Classroom.

Week 1 - The Basics

- Hilbert Space
- 3-D Quantum Mechanics
- Perturbation Theory

Week 2 - Basic Fields

- Classical Fields
- Maxwell's Equations
- Quantized Radiation

Week 3 - Quantum Mechanics and Special Relativity

- Relativistic Quantum Mechanics
- Covariant Perturbation

Week 4 - Hello Feynman

- Path Integrals

Module 2: Beginners Guide to Particle Physics

Tentative Starting Date: Feb 01, 2023

Tentative Timings and Days of Lectures: Classes will be held from **7:30 PM to 8:30 PM** on Mondays, Tuesdays, Thursdays, and Fridays. Informal Discussions if needed will be held on the remaining days.

Week 1 - The Basics

- Special Relativity
- Quantum Mechanics
- Cross Sections

Week 2 - Relativistic Quantum Mechanics

- Special Relativity
- Klein-Gordon Equation
- Dirac Equation
- Antimatter

Week 3 - Particles and Symmetries

- Electron-Positron
- Electron-Proton
- O(N), U(N), SU(N)

Week 4 - Strong and Weak Interactions

- Color, Gluons, and Confinement
- Asymptotic Freedom
- W-Boson

Week 5 - First Unification

- Charge and Parity
- CP Violation
- Weak Interaction Gauge Group
- Electroweak Unification

Module 3: Quantum Theory of Fields

Tentative Starting Date: Mar 01, 2023

Tentative timings and Days of Lectures: Classes will be held from **7:30 PM to 8:30 PM** on Mondays, Tuesdays, Thursdays, and Fridays. Informal Discussions if needed will be held on the remaining days.

Week 1 - Revision

- SU(N) and QCD
- Special Relativity
- Klein-Gordon Equation
- Dirac Equation

NAXXATRA
A CONSTELLATION OF CURIOUS MINDS

THE IMPULSE LAB
Global STEM Society

Week 2 - Lagrangians

- Lagrangian Formulation
- Electromagnetic Field
- Yang-Mills Field
- Canonical Quantization

Week 3 - Path Integrals and Scalar Fields

- S-Matrix Expansion
- Functional Calculus
- Free Scalar Field Theory
- Propagators

Week 4 - Fermions and Photons

- Free Spinor Fields
- Dirac Propagator
- Lagrangian for Electromagnetic Field
- Coulomb and Lorentz Gauge

Week 5 - Quantum Electrodynamics

- Interacting Field Theory
- Wick's Theorem
- Feynman Diagrams