

# About IIT



Kharagpur - a dusty town tucked away in the eastern corner of India, famous until 1950 as home to the longest railway platform in the world - became the nursery where the seed of the IIT system was planted in 1951. IIT Kharagpur started its journey in the old Hijli Detention Camp in Eastern India, where some of the country's great freedom fighters toiled and sacrificed their lives for India's independence. Spurred by the success of IIT Kharagpur, four younger IITs sprouted around the country in the two following decades, and from these five came thousands of IITians, the brand ambassadors of modern India. It was the success of this one institution at Kharagpur that wrote India's technological odyssey.

The Institute takes pride in its relentless effort to provide the best platform for both education as well as research in the areas of science and technology, infrastructure designs, entrepreneurship, law, management, and medical science and technology. IITKGP is not just the place to study technology, it is the place where

stud  
bear  
work

## Program Features/ Structure

Classroom lectures – 80%  
Numerical/ Problem solving, Case study and Activity – 10%  
Tutorial – 10%

## Program Schedule and Venue

**1 week**  
24 – 28 July 2023  
(2:30 PM – 6:30 PM)  
S. N Bose Auditorium  
IIT Kharagpur

## Last day of Registration

**17**  
July 2023

## Who will benefit (Eligibility)

you are an advanced B. Tech, B. S, MSc, MTech, PhD Scholar in Physics and Master degree holder teachers at Engineering Colleges / Degree colleges

## Program Fee

Nil

## Accommodation & Food

No accommodation will be provided  
Food you can get from the staff canteen on chargeable basis.

## How to Apply

Use the link: to apply ONLINE

[https://docs.google.com/forms/d/e/1FAIpQLSfH5xDWxICAkPBCpR2cqrH5B8llsBDPdR\\_IGHTE5nD7dpDydg/viewform?usp=pp\\_url](https://docs.google.com/forms/d/e/1FAIpQLSfH5xDWxICAkPBCpR2cqrH5B8llsBDPdR_IGHTE5nD7dpDydg/viewform?usp=pp_url)

## Contact Us

**Sonjoy Majumder & Tamoghna Das:**  
Department of Physics

**Syamsundar De:**  
Advance Technology Development Centre

## Short course on Quantum Information & Computation



Department of Physics &  
Advance Technology Development Centre  
**Indian Institute of Technology Kharagpur**  
2023

1 Week  
24 – 28 July 2023

## Introduction / Overview

Quantum information and computation is a field of study that combines the principles of quantum mechanics, classical information theory and the knowledge of computer science to explore the fundamental aspects of information and develop new computational paradigms. It harnesses the unique properties of quantum systems, such as superposition, entanglement, non-locality to process and transmit information in ways that are fundamentally different from the existing classical protocols. It encompasses a wide range of applications, including Shor's algorithm for prime factorization, super dense coding, secure quantum key distribution, and quantum teleportation. Other areas of focus include quantum sensing, Grover's search algorithm, quantum error correction, quantum machine learning, and quantum simulation. Quantum information processing benefits from precise control and manipulation of subatomic particles. Various physical systems, such as atoms, ions, photons, and superconducting circuits, serve as the basic building blocks for realizing these phenomena. Present state of art experiments made quantum computation possible in real life.

## Program Objectives

This short course would introduce the basics building blocks of quantum formalism towards the developments of quantum information and computation. The fundamental concepts like quantum gates, quantum algorithm, classical information transmission with and without security, teleportation will be introduced. The discussion on 2022 Physics Nobel prize, on the experimental demonstration of non-locality will help the students to understand the foundation of quantum mechanics. This course can provide individuals with valuable knowledge, career opportunities, and a deeper understanding of the quantum world and can actively contribute to the cutting-edge research and innovations. It equips them with skills that are increasingly in demand in various industries, while also fostering a sense of intellectual growth and exploration.

## What you will learn

### Program Content

- 1) Basic formalism of Quantum Mechanics & Quantum Computations
  - Quantum States (Pure & Mixed), Qubit, Qutrit
  - Bipartite States & Entanglement
  - Quantum Gates, Quantum Algorithms
  - Simple Quantum Circuit
- 2) Computing: from Classical to Quantum
  - Shannon's Information Theory
  - Classical codes
- 3) Introduction to Quantum Information and Communication
  - Holevo bounds, communication complexity
  - Computational complexity classical and quantum
- 4) Violation of local-realism – Bell inequality
  - Local hidden variable model
- 5) Use of Entanglement: Quantum Communication
  - Dense Coding, probabilistic and deterministic, multiple senders to single and two receivers
  - Quantum cryptography, BB84, Ekert'91
    - Idea of device independent protocol
  - Quantum Teleportation, Repeater
- 6) Quantum optical experiments: From quantum foundations to quantum information and computation
  - Generations, manipulation, and detection of quantum optical states
  - Quantum optical implementation of quantum communication
  - Quantum computational advantage using quantum optical systems.

## About the Faculty

### Tamoghna Das

Assistant Professor, Department of Physics, IIT Kharagpur

**Expertise:** Quantum Information and Computation, Quantum communication networks, Bell non-locality

### Syamsundar De

Assistant Professor, Advance Technology Development Centre, IIT Kharagpur

**Expertise:** Photonic quantum information technologies, experimental quantum optics, light-matter interaction, lasers, nonlinear optics, and integrated photonics

### Bibhas Adhikari

Associate Professor, Department of Mathematics, IIT Kharagpur

**Expertise:** Applied linear algebra, Complex networks, Quantum Information Theory

### Sonjoy Majumder

Professor, Department of Physics, IIT Kharagpur

**Expertise:** Light-matter interaction, Vortex beam, Ultra-Cold Atoms and Molecules, Variational Quantum Algorithm

### Sudebkumar Prasant Pal

Professor, Department of Computer Science and Engineering, IIT Kharagpur

**Expertise:** Quantum Information Processing and Protocols, Graphs and Hypergraphs