PHY6603: INTRODUCTION TO QUANTUM INFORMATION

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Introduction to Quantum Information

Subject Code
PHY - Physics
Course Number
6603

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
PHY8603 Introduction to Quantum Information

Part II Course Details

Abstract

Quantum information science extends classical information science such as computation and communication to the physical regime of quantum superposition. This course aims to bring the students up to the level of being able to access the research literature in the field.

Firstly, the key theoretical formalism is described, including how to model states, measurements and dynamics. A tour of some key insights concerning the use of quantum superposition and entanglement as resources for information science tasks follows, including quantum key distribution, teleportation, and quantum computation. Entropy is discussed as a means of quantifying information. Shannon's theorems of information theory are introduced followed by their quantum analogues.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Understand how to model states and measurements (Dirac notation, Born rule, mixed states, quantum interference, generalised measurements).		x	x	
2	Understand how to model dynamics (unitary dynamics, measurement update rules, some open systems).		x	x	
3	Understand key theoretical protocols in quantum information science (teleportation, communication over quantum channels, quantum key distribution).		x	x	
4	Understand entropy as a method to quantify information (classical entropy, quantum entropy, information compression, mutual information and channel capacity).		x	x	
5	Understand essential idea of quantum computation (Quantum search and hidden subgroup algorithms).		x	x	
6	Quantum optical implementation of quantum computing.		x	x	

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lectures	Presentation of course material	1, 2, 3, 4, 5, 6	3hrs

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Tests	1, 2, 3, 4, 5, 6	0	-	No
2	Assignments	1, 2, 3, 4, 5, 6	40	-	No

Continuous Assessment (%)

40

Examination (%)

60

Examination Duration (Hours)

2

Assessment Rubrics (AR)

Assessment Task

Tests (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

Criterion

Capacity for using physics knowledge and theory to solve problems

Excellent

(A+, A, A-) Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format

Good

(B+, B, B-) Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format

Fair

(C+, C, C-) Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format

Marginal

(D) Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format

Failure

(F) Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

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Assessment Task

Assignments (for students admitted before Semester A 2022/23 and in Semester A 2024/25 & thereafter)

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Good

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Fair

(C+, C, C-) Will exhibit some deficiencies in understanding about experimental methods and the interpretation of results

Marginal

(D) Will exhibit some deficiencies in understanding about experimental methods and the interpretation of results

Failure

(F) Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

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Assessment Task

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Assessment Task

Tests (for students admitted from Semester A 2022/23 to Summer Term 2024)

Criterion

Capacity for using physics knowledge and theory to solve problems

Excellent

(A+, A, A-) Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format

Good

(B+, B) Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format

Marginal

(B-, C+, C) Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format

Failure

(F) Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

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Assessment Task

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Part III Other Information

Keyword Syllabus

1. States and measurements (Dirac notation, Born rule, mixed states, quantum interference, generalised measurements).
2. Dynamics (unitary dynamics, measurement update rules, some open systems).
3. Key theoretical protocols in quantum information science (teleportation, communication over quantum channels, quantum key distribution).
4. Entropy as a method to quantify information (classical entropy, quantum entropy, information compression, mutual information and channel capacity).
5. Quantum computation (Quantum search and hidden subgroup algorithms).

Reading List

Compulsory Readings

	Title
1	Michael A. Nielsen, Isaac L. Chuang Quantum Computation and Quantum Information CUP 2010. https://doi.org/10.1017/CBO9780511976667

Additional Readings

	Title
1	Caltech, Course Information for Physics 219/Computer Science 219 Quantum Computation: theory.caltech.edu/~preskill/ph229/