PHY8251: ADVANCED QUANTUM MECHANICS

Effective Term
Semester A 2025/26

Part I Course Overview

Course Title
Advanced Quantum Mechanics

Subject Code
PHY - Physics
Course Number
8251

Academic Unit
Physics (PHY)

College/School
College of Science (SI)

Course Duration
One Semester

Credit Units
3

Level
R8 - Research Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
AP3251/PHY3251 Quantum Physics or equivalent

Precursors
AP1203/PHY1203 General Physics III or equivalent

Equivalent Courses
Nil

Exclusive Courses
PHY6251 Advanced Quantum Mechanics

Part II Course Details

Abstract
This course aims to equip graduate students with advanced knowledge of quantum mechanics necessary to conduct research and understand literature. It will consist of four different parts: (i) The theory of angular momentum; (ii)

Symmetries in quantum mechanics; (iii) Perturbation theory in quantum mechanics; (iv) Introduction to modern many-body theory. This course will mainly focus on the applications of quantum mechanics in condensed matter physics and materials science. In particular, this course will expose the students to some of the latest developments in topological phases of matter, including the physics of topological insulators and topological superconductors.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Recognize and use appropriately important technical terms and definitions		x		
2	Use appropriate mathematical notations and apply in concise form the laws of quantum mechanics to the study of modern physics problems		x	x	
3	Apply the laws of quantum mechanics to the study of modern physics problems		x	x	x
4	Solve real and hypothetical problems in quantum physics by identifying the underlying physics and analysing the problem		x	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	Lecture	Explain key concepts and theory of topics of the course	1, 2, 3	2 hrs/wk
2	Tutorial	Explain how some problems are solved and the techniques used explain some concepts	1, 2, 3, 4	1 hr/wk

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Homework, Quizzes etc.	1, 2, 3, 4	60	-	Yes

Continuous Assessment (%)

60

Examination (%)

40

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

0

Minimum Examination Passing Requirement (%)

20

Additional Information for ATs

^ For a student to pass the course, at least 20% of the maximum mark for the examination must be obtained.

Assessment Rubrics (AR)

Assessment Task

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

Criterion

1. Capacity for using physics knowledge and theory to solve problems 2. Demonstrate correct understanding of key concepts.

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 a basic level of competence 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

---

Assessment Task

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

Criterion

1. Capacity for using physics knowledge and theory to solve problems
2. Demonstrate correct understanding of key concepts and physics theory.

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 a basic level of competence 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

---

Assessment Task

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

Criterion

1. Capacity for using physics knowledge and theory to solve problems 2. Demonstrate correct understanding of key concepts and physics theory.

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 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

---

Assessment Task

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

Criterion

1. Capacity for using physics knowledge and theory to solve problems 2. Demonstrate correct understanding of key concepts and physics theory.

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 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

---

Part III Other Information

Keyword Syllabus

Theory of Angular Momentum; Symmetry in Quantum Mechanics; Basic Group Theory; Schrödinger, Heisenberg and the interaction picture; Perturbation theory; Identical particles and spins; Second quantization; Introduction to modern many-body physics

Reading List

Compulsory Readings

	Title
1	J. J. Sakurai, Modern Quantum Mechanics (Second Edition) (Cambridge University Press, 2017)
2	David J. Griffiths, Introduction to Quantum Mechanics, (Cambridge University Press, 2018)

Additional Readings

	Title
1	R. Shankar, Principles of Quantum Mechanics (Plenum Press, 2011)
2	A. Zee, Group Theory in a Nutshell for Physicists, Princeton University Press (2016).
3	A. Altland and B. Simons, Condensed Matter Field Theory, Cambridge University Press, 2nd edition (2010).
4	Gerald D. Mahan, Many-Particle Physics (Physics of Solids and Liquids) 3rd ed. (Springer, 2000)
5	B. Andrei Bernevig, Topological Insulators and Topological Superconductors, Princeton University Press (2013).