City University of Hong Kong
Course Syllabus

offered by Department of Physics
with effect from Semester A 2022/23

Part I Course Overview

Course Title:

Advanced Quantum Mechanics

Course Code:

PHY8251

Course Duration:

1 semester

Credit Units:

3 credits

Level:

R8

Medium of Instruction:

English

Medium of Assessment:

English

Prerequisites:
(Course Code and Title)

AP3251/PHY3251 Quantum Physics or equivalent

Precursors:
(Course Code and Title)

AP1203/PHY1203 General Physics III or equivalent

Equivalent Courses:
(Course Code and Title)

Nil

Exclusive Courses:
(Course Code and Title)

PHY6251 Advanced Quantum Mechanics

Part II Course Details

1. 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.

2. Course Intended Learning Outcomes (CILOs)

No.	CILOs	Weighting* (if applicable)	Discovery-enriched curriculum related learning outcomes (please tick where appropriate)		
			A1	*A2*	*A3*
1.	Recognize and use appropriately important technical terms and definitions		✔		
2.	Use appropriate mathematical notations and apply in concise form the laws of quantum mechanics to the study of modern physics problems		✔	✔	
3.	Apply the laws of quantum mechanics to the study of modern physics problems		✔	✔	✔
4.	Solve real and hypothetical problems in quantum physics by identifying the underlying physics and analysing the problem		✔	✔	✔
		100%			

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 self-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.

3. Teaching and Learning Activities (TLAs)

TLA	Brief Description	CILO No.						Hours/week (if applicable)
		1	2	3	4			
Lecture	Explain key concepts and theory of topics of the course	✔	✔	✔				2 hrs/wk
Tutorial	Explain how some problems are solved and the techniques used explain some concepts	✔	✔	✔	✔			1 hr/wk

4. Assessment Tasks/Activities (ATs)

Assessment Tasks/Activities	CILO No.						Weighting*	Remarks
	1	2	3	4				
Continuous Assessment: 60%								
Homework, Quizzes etc.	✔	✔	✔	✔			60%	
Examination^ (duration: 2 hours)	✔	✔	✔	✔			40%	
							100%	

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

5. Assessment Rubrics

Applicable to students admitted in Semester A 2022/23 and thereafter

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B)	Marginal (B-, C+, C)	Failure (F)
1. Assignment	1. Capacity for using physics knowledge and theory to solve problems 2. Demonstrate correct understanding of key concepts.	Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format	Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format
2. Examination	1. Capacity for using physics knowledge and theory to solve problems 2. Demonstrate correct understanding of key concepts and physics theory.	Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit some deficiencies in understanding about experimental methods and the interpretation of results	Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

Applicable to students admitted before Semester A 2022/23

Assessment Task	Criterion	Excellent (A+, A, A-)	Good (B+, B, B-)	Fair (C+, C, C-)	Marginal (D)	Failure (F)
1. Assignment	1. Capacity for using physics knowledge and theory to solve problems 2. Demonstrate correct understanding of key concepts.	Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a basic level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit some deficiencies in understanding, explaining, and integrating the knowledge in written format	Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

2. Examination	1. Capacity for using physics knowledge and theory to solve problems 2. Demonstrate correct understanding of key concepts and physics theory.	Will exhibit a high level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a good level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit a basic level of competence in understanding, explaining, and integrating the knowledge in written format	Will exhibit some deficiencies in understanding about experimental methods and the interpretation of results	Will exhibit lack of competence in understanding, explaining, and integrating the knowledge in written format

Part III Other Information

1. 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

2. Reading List

2.1 Compulsory Readings

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)

2.2 Additional Readings

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).