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:	PHY6251
Course Duration:	1 semester
Credit Units:	3 credits
Level:	P6
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)*	PHY8251 Advanced Quantum Mechanics

Part II Course Details

1. Abstract

(A 150-word description about the course)

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)

(CILOs state what the student is expected to be able to do at the end of the course according to a given standard of performance.)

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		✔	✔	✔
	** If weighting is assigned to CILOs, they should add up to 100%.*	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)

(TLAs designed to facilitate students' achievement of the CILOs.)

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)

(ATs are designed to assess how well the students achieve the CILOs.)

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

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

5. Assessment Rubrics

(Grading of student achievements is based on student performance in assessment tasks/activities with the following 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	Will exhibit a good level of competence in understanding, explaining, and integrating the	Will exhibit a basic level of competence in understanding, explaining, and integrating the	Will exhibit some deficiencies in understanding, explaining, and integrating the	Will exhibit lack of competence in understanding, explaining, and integrating the

		knowledge in written format	knowledge in written format	knowledge in written format	knowledge in written format	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 (more details can be provided separately in the teaching plan)

1. Keyword Syllabus

(An indication of the key topics of the course.)

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

(Compulsory readings can include books, book chapters, or journal/magazine articles. There are also collections of e-books, e-journals available from the CityU Library.)

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

(Additional references for students to learn to expand their knowledge about the subject.)

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).