Annexe A: New/Revised Course Content in OBTL+ Format

Course Overview

Expected Implementation in Academic Year	AY2025-2026
Semester/Trimester/Others (specify approx. Start/End date)	Semester 2
Course Author * Faculty proposing/revising the course	Justin Song
Course Author Email	justinsong@ntu.edu.sg
Course Title	Quantum Mechanics 1
Course Code	PH2101
Academic Units	3
Contact Hours	38
Research Experience Components	Not Applicable

Course Requisites (if applicable)

Pre-requisites	(MH1802 & MH1803 & PH1107) OR (CY1307, CY1601 & CY1602) OR (MH1101 & MH1200 & PH1107) OR (CM1804 and MH1802 and PH1107)
Co-requisites	
Pre-requisite to	
Mutually exclusive to	
Replacement course to	
Remarks (if any)	

Course Aims

Quantum mechanics is the most successful theory of the physical world. This course aims to introduce quantum mechanics through two lenses: (i) the major physical phenomena that led to (and necessitated) the development of quantum mechanical principles and (ii) quantum wavefunctions and the Schrodinger equation. Experiments fundamental to physics will be discussed, along with real-life applications. We will also provide an introduction to the matrix formalism to bridge the gap between higher level courses.

Course's Intended Learning Outcomes (ILOs)

Upon the successful completion of this course, you (student) would be able to:

ILO 1	Understand the experimental motivations for quantum theory (e.g., photoelectric effect)
ILO 2	Use Einstein's photon postulate to explain the photoelectric effect.
ILO 3	Explain wave-particle duality and its manifestations
ILO 4	Use de Broglie's relation to investigate matter waves
ILO 5	Discuss simple quantum models and their limitations.
ILO 6	Explain the interpretation of wave functions as states, and expectation values as physical measurements in quantum mechanics.
ILO 7	Explain the probabilistic interpretation associated with linear superpositions of wave functions.
ILO 8	Be able to compute the expectation and variance of physical measurements from the wave function of a system.
ILO 9	Solve the eigenvalue problem given by the time-independent Schrodinger equation for given potential functions.
ILO 10	Solve and explain transmission probabilities across potential barriers
ILO 11	Solve and explain the solution of the quantum harmonic oscillator
ILO 12	Explain origin and consequences of Heisenberg uncertainty principle
ILO 13	Explain the solution of hydrogen atom and hydrogen energy levels.
ILO 14	Explain the concept and consequences of "spin" via Stern-Gerlach experiment.
ILO 15	Explain and use Dirac notation of quantum mechanics
ILO 16	Perform matrix and vector operations in quantum mechanics, eg: normalization of vectors, calculation of eigenvalues and eigenvectors
ILO 17	Explain the matrix formalism of quantum mechanics and how it is related to wavefunction approach of quantum mechanics

ILO 18	Apply quantum mechanical principles in statistics of particles

Course Content

Foundational Quantum Principles:

- Photoelectric effect
- Wave-particle duality
- De Broglie's relation of matter waves
- Bohr Model

Modern Quantum Theory:

- Wavefunction
- Expectation, variance, and probability of measured physical outcomes
- Schrodinger equation
- Eigenstates in a Potential Wells
- Transmission probabilities
- Heisenberg Uncertainty Relation
- Solution of Harmonic Oscillator
- Solution of hydrogen atom
- Stern-Gerlach experiment
- Spin
- Hydrogenic energy levels
- Dirac notation of quantum mechanics
- Matrix formalism and wave formalism of quantum mechanics
- Applications of quantum theory in statistical physics of particles

Reading and References (if applicable)

1. Griffiths, David (2005) "An introduction to quantum mechanics" Second Edition ISBN: ISBN : 0131118927; Third Edition: ISBN 978-1107189638

2. Eisberg, R.M., & Resnick, R. (1985). "Quantum physics of atoms, molecules, solids, nuclei, and particles (2nd ed.)"Wiley. ISBN 978-0471873730

3. J.J. Sakurai, Jim Napolitano (2011), "Modern Quantum Mechanics (2nd ed.)", Addison-Wesley, U.S.A. ISBN 978-0201539295

NOTE: The above listing comprises the foundational readings for the course and more up-to-date relevant readings will be provided when they are available.

Planned Schedule

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
1	Why we need quantum mechanics	1-3		In-person	
2	Preliminary Quantum theories	4-5		In-person	Tutorial 1
3	Introduction to the Schrodinger Equation and quantum wavefunctions	6-8		In-person	Tutorial 2
4	Schrodinger Equation (Potential Problems)	9		In-person	Tutorial 3
5	Schrodinger Equation (Transmission)	10		In-person	Tutorial 4
6	Harmonic Oscillator and the Schrodinger equation	11		In-person	Tutorial 5
7	Applications of Quantum Eigen-energies and Superpositions (Synthesis)	6-11		In-person	Tutorial 6; Midterm Test either Week 7 or Week 8
8	Uncertainty Relation	12		In-person	Tutorial 7; Midterm Test either Week 7 or Week 8
9	Hydrogen Atom	13		In-person	Tutorial 8

Week or Session	Topics or Themes	ILO	Readings	Delivery Mode	Activities
10	Stern-Gerlach Experiment and Spin	14		In-person	Tutorial 9
11	Dirac Notation	15		In-person	Tutorial 10
12	Quantum matrix operations	16-17		In-person	Tutorial 11
13	Applications of quantum mechanics (Synthesis)	6-18		In-person	Tutorial 12

Learning and Teaching Approach

Approach	How does this approach support you in achieving the learning outcomes?
Use of Wooclap (lecture)	It is used to set you out of your comfort zone, to stimulate your thinking and compare your understanding with others.
Lectures	Lectures describe the primary content to be learned.
Tutorial	You will review main concepts learned in lectures with TAs. This helps you to digest and understand better.
Homework	The homework comprises more difficult problems that may require more time to solve.

Assessment Structure

Assessment Components (includes both continuous and summative assessment)

No.	Component	ILO	Related PLO or Accreditation	Weightage	Description of Assessment Component	Team/Individual	Rubrics	Level of Understanding
1	Summative Assessment (EXAM): Final exam(Final Examination)	All		55	Final Examination	Individual	Analytic	Relational
2	Continuous Assessment (CA): Assignment(CA1: Homework)	All		20	2 Homeworks problem sets (equal weightage) will be assigned: here you will encounter more challenging problems that may require more time to solve.	Individual	Analytic	Relational
3	Continuous Assessment (CA): Test/Quiz(CA3: Mid-term Test)	Range (1-11)		20	Midterm Test will test material covered from Week 1 to Week 6/7	Individual	Analytic	Relational
4	Continuous Assessment (CA): Class Participation()			5	Participation in Wooclap sessions; this will be used as a means of reinforcing learned concepts	Individual	Analytic	Relational

Description of Assessment Components (if applicable)

*You would be expected to synthesise the physics concepts learnt in the course to propose scientifically valid approaches to given situations or problems.

Formative Feedback

Formative feedback is given through discussion within tutorial lessons.

Formative feedback is given via response application Wooclap where you are required to answer on your mobile devices questions posted during lecture/tutorial.

Feedback will be provided in case you have a serious misconception on a provided problem.

Feedback is also given after the midterm on the common mistakes and level of difficulty of the problems.

Past exam questions are made available for you via the library, but the solutions will not be provided.

NTU Graduate Attributes/Competency Mapping

This course intends to develop the following graduate attributes and competencies (maximum 5 most relevant)

Attributes/Competency	Level
Adaptability	Intermediate
Creative Thinking	Intermediate
Problem Solving	Basic
Self-Management	Basic
Sense Making	Basic

Course Policy

Policy (Academic Integrity)

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values. As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. On the use of technological tools (such as Generative AI tools), different courses / assignments have different intended learning outcomes. Students should refer to the specific assignment instructions on their use and requirements and/or consult your instructors on how you can use these tools to help your learning. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.

Policy (General)

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Policy (Absenteeism)

Absence Due to Medical or Other Reasons
If you are sick and unable to attend your class, you have to:

1. Send an email to the instructor regarding the absence.
2. Submit the Medical Certificate* or official letter of excuse to administrator.
3. Watch lectures and discuss with instructor/TA about material missed.

If you are sick and unable to attend your midterm test you have to provide a medical certificate. A make-up test may be arranged; you need to come for this make-up test if it is arranged.

*The medical certificate mentioned above should be issued in Singapore by a medical practitioner registered with the Singapore Medical Association.

Policy (Others, if applicable)

Diversity and inclusion policy

Integrating a diverse set of experiences is important for a more comprehensive understanding of science.

It is our goal to create an inclusive and collaborative learning environment that supports a diversity of perspectives and learning experiences, and that honours your identities; including ethnicity, gender, socioeconomic status, sexual orientation, religion or ability.

To help accomplish this:

- If you are neuroatypical or neurodiverse, have dyslexia or ADHD (for example), or have a social anxiety disorder or social phobia;

- If you feel like your performance in the class is being impacted by your experiences outside of class;
- If something was said in class (by anyone, including the instructor) that made you feel uncomfortable;

Please speak to your teaching team, our school pastoral officer or a peer or senior (either in-person or via email) about how we can help facilitate your learning experience.

As a participant in course discussions, you should also strive to honour the diversity of your classmates. You can do this by: using preferred pronouns and names; being respectful of others opinions and actively making sure all voices are being heard; and refraining from the use of derogatory or demeaning speech or actions.

All members of the class are expected to adhere to the NTU anti-harassment policy. if you witness something that goes against this or have any other concerns, please speak to your instructors or a faculty member.

Students are strongly advised to attend tutorials and lectures. Announcements made during the lectures/tutorials may not be repeated on NTU learn or other channels.