UNSW Course Outline

PHYS3111 Quantum Mechanics - 2024

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General Course Information

Course Code : PHYS3111
Year : 2024
Term : Term 2
Teaching Period : T2
Is a multi-term course? : No
Faculty : Faculty of Science
Academic Unit : School of Physics
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Undergraduate
Units of Credit : 6

Useful Links

Handbook Class Timetable

Course Details & Outcomes

Course Description

Quantum mechanics is a cornerstone of modern physics and deals with physical phenomena on microscopic scales. This Level 3 undergraduate course will provide students with a broad and comprehensive introduction and a foundation for further study. Topics to be covered include:

quantum mechanics in three dimensions; angular momentum; Hydrogen atom; Landau levels; Spin; variational methods; time-independent perturbation theory and applications; time-dependent potentials; Fermi Golden rule; adiabatic evolution and Berry phase; particle wave analysis in scattering theory and the Born approximation; low energy and resonance scattering. This course consists of lectures, tutorials, and laboratory work.

Course Aims

The aim of this course is to introduce important formalisms of quantum mechanics and provide key examples of its manifestations in experiments. This course builds upon the Quantum Physics (PHYS2111) course by refining the mathematical basis of quantum mechanics; introducing two and three-dimensional systems like the Hydrogen atom; including angular momentum and spin degrees of freedom; methods of approximation; and important formalisms to understand time-dependent fields and scattering processes. The subject aims to prepare students for advanced studies and modern research including quantum engineering.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Explain the core principles of quantum mechanics.
CLO2 : Apply the mathematical framework of angular momentum and spin to analyse a variety of 3D systems.
CLO3 : Analyse quantum systems using perturbation theory and scattering theory.
CLO4 : Acquire, record, and interpret experimental data.

Course Learning Outcomes	Assessment Item
CLO1 : Explain the core principles of quantum mechanics.	• Assignment • Final exam • Mid-term test
CLO2 : Apply the mathematical framework of angular momentum and spin to analyse a variety of 3D systems.	• Assignment • Final exam • Mid-term test
CLO3 : Analyse quantum systems using perturbation theory and scattering theory.	• Assignment • Final exam • Mid-term test
CLO4 : Acquire, record, and interpret experimental data.	• Laboratory

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Laboratory Assessment Format: Individual	10%	
Assignment Assessment Format: Individual	15%	
Final exam Assessment Format: Individual	60%	
Mid-term test Assessment Format: Individual	15%	

Assessment Details

Laboratory

Assessment Overview

You will be expected to complete 2 four-hour laboratory experiments over the Term. The first is generally scheduled within the first three weeks of the Term, while the second is generally scheduled during Weeks 4 to 8.
Each lab is worth 5% for your total mark for the course. Assessments will be based on the written account and accompanying interview with an academic marker in the week after the experiment. Marks will be allocated based on (i) an understanding of the underlying physical principles, (ii) the quality of the experimental results and analysis, and (iii) the presentation of the lab book. Feedback is provided on the same day as the interview.

Course Learning Outcomes

- CLO4 : Acquire, record, and interpret experimental data.

Assignment

Assessment Overview

An assignment will be made available to you between Week 8 and 10. It will consist of several problems which require analytical or numerical solution. These will be based on topics covered up to that point, including three-dimensional systems, approximation methods, and time-dependence. You will have at least one week to complete the assignment.

Feedback is provided within two weeks of the submission.

Course Learning Outcomes

- CLO1 : Explain the core principles of quantum mechanics.
- CLO2 : Apply the mathematical framework of angular momentum and spin to analyse a variety of 3D systems.
- CLO3 : Analyse quantum systems using perturbation theory and scattering theory.

Final exam

Assessment Overview

You will sit a 2-hour final exam during the formal examination period. It will consist of several questions requiring analytical solutions which may include diagrams or graphs. All topics from lectures and tutorials may be assessed.

Feedback is available through inquiry with the course convenor.

Course Learning Outcomes

- CLO1 : Explain the core principles of quantum mechanics.
- CLO2 : Apply the mathematical framework of angular momentum and spin to analyse a variety of 3D systems.
- CLO3 : Analyse quantum systems using perturbation theory and scattering theory.

Mid-term test

Assessment Overview

You will complete a 50-minute, in-class test to take place around Week 4. The test will consist of a few questions (with sub-parts) based on topics covered in the first few weeks of the lectures and tutorials. You will be expected to solve analytical problems as well as display understanding of the concepts covered to that point.
Marks and written feedback will be returned within 2 weeks following the test sitting.

Course Learning Outcomes

- CLO1 : Explain the core principles of quantum mechanics.
- CLO2 : Apply the mathematical framework of angular momentum and spin to analyse a variety of 3D systems.
- CLO3 : Analyse quantum systems using perturbation theory and scattering theory.

General Assessment Information

Grading Basis

Standard

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 27 May - 2 June	Topic	Brief revision of second year quantum mechanics. Introduction to 3-dimensional Schrödinger equation and angular momentum in a central potential.
Week 2 : 3 June - 9 June	Topic	Separation of variables; Coulomb problem; Hydrogen atom.
Week 3 : 10 June - 16 June	Topic	Particle in a magnetic field; Landau levels.
Week 4 : 17 June - 23 June	Topic	Spin and its coupling to a magnetic field. Rabi oscillations.
Week 5 : 24 June - 30 June	Topic	Addition of angular momenta in quantum mechanics.
	Assessment	Midsession test (50 min) is held in Week 5.
Week 7 : 8 July - 14 July	Topic	Approximate methods to solve Schrödinger equation: variational methods and perturbation theory.
Week 8 : 15 July - 21 July	Topic	Degenerate perturbation theory. Time-evolution of non-stationary states. Time-dependent perturbations. Two-level system.
Week 9 : 22 July - 28 July	Topic	Time-dependent perturbation theory; Fermi Golden rule; the adiabatic approximation and Berry's phase.
	Assessment	Assignment due in Week 9.
Week 10 : 29 July - 4 August	Topic	Scattering theory in quantum mechanics; Born approximation; low energy scattering. Inelastic scattering and resonances.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

As with all higher-year physics courses, we expect that you will spend approximately 3 hours working at home for every one hour of lectures. This should be sufficient to revise the lecture material and do the tutorials ahead of the designated tutorial slot.

Course Resources

Prescribed Resources

Griffiths, Introduction to Quantum Mechanics, Pearson Education

Recommended Resources

Recommended textbook: Griffiths, Introduction to Quantum Mechanics, Pearson Education

More advanced textbooks:

Gasiorowicz, Quantum Physics, Wiley

Zelevinsky, Quantum Physics Vols. 1 & 2, Wiley

Landau & Lifshitz, Quantum mechanics: non-relativistic theory, Pergamon Press

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Julian Berengut					No	Yes
Year coordinator	Elizabeth Angstmann					No	No
Lecturer	Oleg Sushkov					No	No
Lab director	Tamara Rezstova					No	No
Administrator	Zofia Krawczyk					No	No

Other Useful Information

Academic Information

Upon your enrolment at UNSW, you share responsibility with us for maintaining a safe, harmonious and tolerant University environment.

You are required to:

- Comply with the University's conditions of enrolment.
- Act responsibly, ethically, safely and with integrity.
- Observe standards of equity and respect in dealing with every member of the UNSW community.
- Engage in lawful behaviour.
- Use and care for University resources in a responsible and appropriate manner.
- Maintain the University's reputation and good standing.

For more information, visit the UNSW Student Code of Conduct Website.

Academic Honesty and Plagarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.
Further information about referencing styles can be located at https://student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect,

responsibility and courage. At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.
Further information about academic integrity, plagiarism and the use of AI in assessments can be located at:

- The Current Students site,
- The ELISE training site, and
- The Use of AI for assessments site.

The Student Conduct and Integrity Unit provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct

Submission of Assessment Tasks

Penalty for Late Submissions

UNSW has a standard late submission penalty of:

- 5% per day,
- for all assessments where a penalty applies,
- capped at five days (120 hours) from the assessment deadline, after which a student cannot submit an assessment, and
- no permitted variation.

Any variations to the above will be explicitly stated in the Course Outline for a given course or assessment task.

Students are expected to manage their time to meet deadlines and to request extensions as early as possible before the deadline.

Special Consideration

If circumstances prevent you from attending/completing an assessment task, you must officially apply for special consideration, usually within 3 days of the sitting date/due date. You can apply by logging onto myUNSW and following the link in the My Student Profile Tab. Medical documentation or other documentation explaining your absence must be submitted with your application. Once your application has been assessed, you will be contacted via your student email address to be advised of the official outcome and any actions that need to be taken from there. For more information about special consideration, please visit: https://student.unsw.edu.au/special-consideration

Important note: UNSW has a “fit to sit/submit” rule, which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit to do so and cannot later apply for Special Consideration. This is to ensure that if you feel unwell or are faced with significant circumstances beyond your control that affect your ability to study, you do not sit an examination or submit an assessment that does not reflect your best performance. Instead, you should apply for Special Consideration as soon as you realise you are not well enough or are otherwise unable to sit or submit an assessment.

Faculty-specific Information

Additional support for students

- The Current Students Gateway
- Student Support
- Academic Skills and Support
- Student Wellbeing, Health and Safety
- Equitable Learning Services
- UNSW IT Service Centre
- Science EDI Student Initiatives, Offerings and Guidelines