PHYS2030

Quantum Physics

Session 2, In person-scheduled-weekday, North Ryde 2026

School of Mathematical and Physical Sciences

Contents

General Information

Unit convenor and teaching staff Michael Steel michael.steel@mq.edu.au
Credit points 10
Prerequisites PHYS2010 and (MATH2010 or MATH2055)
Corequisites
Co-badged status
Unit description This unit provides a first formal introduction to quantum mechanics, the most successful and accurate physical theory yet devised. As well as being the theory that underlies most of modern physics, it also provides a viewpoint about the nature of the physical world that is completely at odds with our everyday intuition. In the first half of the unit, we meet the concept of spin and use it to intuit the formal structure of quantum mechanics in terms of a set of basic principles and their expression in the mathematical language of vector spaces and operators. The second half addresses the solution of a range of quantum mechanical problems using the famous Schrodinger equation in the “position representation” including the behaviour of 1D potential wells and barriers and the most important model in physics: the simple harmonic oscillator. After comparing the classical and quantum behaviour of some 2D wave problems, we conclude by deriving the algebra of spin operators and predict the behaviour of simple two-spin systems.

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://www.mq.edu.au/study/calendar-of-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

> **ULO1:** Explain key experiments and physical observations that have led to the modern formulation of quantum mechanics and phenomena such as superposition, commuting and non-commuting observables, entanglement and measurement.

ULO2: Discuss the interpretation and roles of state vectors, operators and observables in the Hilbert space formulation of quantum mechanics and apply these to pose and solve physical quantum problems in two and three-dimensional discrete spaces
ULO3: Explain the distinction between discrete and continuous quantum systems and how these are unified in the Hilbert space picture problems including the wave function in position representation
ULO4: Apply the one-dimensional Schrödinger equation to explain the physics of bound states, scattering problems and harmonic oscillator in the position representation
ULO5: Apply the Schrodinger equation to simple 2D problems such as the electron confined to a circular well and compare the behaviour to analogous classical systems.
ULO6: Understand and describe the role of quantum effects in a modern engineered quantum device such as a quantum photonic circuit or quantum dot array.
ULO7: Write, modify and apply python code to solve and visualise problems involving discrete and continuous quantum system in one and multiple dimensions.

General Assessment Information

Requirements to pass the unit

To pass this unit, you must achieve a total mark equal to or greater than 50% from the following three tasks.

Task 1: Skill development: Problem Solving

In the week 7 SGTA (Monday 7 September, 3pm), you will demonstrate your problem solving skills on the first half material on the Dirac formalism of quantum mechanics. These written questions will be similar to those you have seen in prior SGTA sessions. This assessment is observed, and the use of AI or other computation tools is not permitted.

Task 2: Report on wavefunction physics

Report on analysis of a multi-faceted problem in continuous quantum mechanics, requiring the use of analytical and numerical tools developed throughout the unit.

On successful completion you will be able to:

- Describe and apply procedures for applying the multi-dimensional Schrödinger equation to explain the physics of systems such as single and multi-electron atoms and other multi-dimensional potentials.
- Write, modify and apply python code to solve and visualise problems involving discrete and continuous 1D and 2D quantum systems.
- This task is AI-open.
- The assignment description will be released by 28 September.

Task 3: End-of-session examination

There will be a 3 hour end-of-session final exam to be held in the University Examination Period.

You should have a scientific calculator for use during the final examination. Note that calculators with text retrieval are not permitted for the final examination.

If you receive special consideration for the final exam, a supplementary exam will be scheduled. By making a special consideration application for the final exam you are declaring yourself available for a resit during the supplementary examination period and will not be eligible for a second special consideration approval based on pre-existing commitments. Please ensure you are familiar with the policy prior to submitting an application. Approved applicants will receive an individual notification one week prior to the exam with the exact date and time of their supplementary examination.

Late Assessment Submission Penalty

Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark of the task) will be applied for each day a written report or presentation assessment is not submitted, up until the 7th day (including weekends). After the 7th day, a grade of '0' will be awarded even if the assessment is submitted. The submission time for all uploaded assessments is **11:55 pm**. A 1-hour grace period will be provided to students who experience technical concerns. For any late submission of Assessment Task 2, please apply for Special Consideration. For example, if the assignment is worth 8 marks (of the entire unit) and your submission is late by 19 hours (or 23 hours 59 minutes 59 seconds), 0.4 marks (5% of 8 marks) will be deducted. If your submission is late by 24 hours (or 47 hours 59 minutes 59 seconds), 0.8 marks (10% of 8 marks) will be deducted, and so on.

Assessments where Late Submissions will be accepted

- Assessment 1- NO, unless Special Consideration is Granted
- Assessment 2 – YES, Standard Late Penalty applies
- Assessment 3 - NO, unless Special Consideration is Granted

Special considerations and short extensions

Special Consideration

The Special Consideration Policy aims to support students who have been impacted by short-term circumstances or events that are serious, unavoidable and significantly disruptive, and which may affect their performance in assessment. If you experience circumstances or events that affect your ability to complete any of the assessments in this unit on time, please inform the convenor and submit a Special Consideration request through connect.mq.edu.au.

Short Extensions

Short extensions are accepted for Assessment Task 2 only. For this task, students may request an extra 3 calendar days to complete the task. No reason or evidence is required.

Assessment Tasks

Name	Weighting	Hurdle	Due	Groupwork/Individual	Short Extension	AI Approach
Final Exam	50%	No	Scheduled centrally during the formal exam period	Individual	No	Observed
Wavefunction Problems	25%	No	01/11/2026	Individual	Yes	Open
Skill Development: Problem solving	25%	No	Week 7 SGTA session: 3-5 pm, Monday 7 September	Individual	No	Observed

Final Exam

Assessment Type [1]: Examination
Indicative Time on Task [2]: 20 hours
Due: **Scheduled centrally during the formal exam period**
Weighting: **50%**
Groupwork/Individual: Individual
Short extension [3]: No
AI Approach: Observed

You will undertake a final examination during the formal examination period.

On successful completion you will be able to:

- Explain key experiments and physical observations that have led to the modern formulation of quantum mechanics and phenomena such as superposition, commuting and non-commuting observables, entanglement and measurement.
- Discuss the interpretation and roles of state vectors, operators and observables in the Hilbert space formulation of quantum mechanics and apply these to pose and solve physical quantum problems in two and three-dimensional discrete spaces
- Explain the distinction between discrete and continuous quantum systems and how these are unified in the Hilbert space picture problems including the wave function in position representation
- Apply the one-dimensional Schrödinger equation to explain the physics of bound states, scattering problems and harmonic oscillator in the position representation
- Apply the Schrodinger equation to simple 2D problems such as the electron confined to

a circular well and compare the behaviour to analogous classical systems.
- Understand and describe the role of quantum effects in a modern engineered quantum device such as a quantum photonic circuit or quantum dot array.

Wavefunction Problems

Assessment Type [1]: Problem-based task
Indicative Time on Task [2]: 18 hours
Due: **01/11/2026**
Weighting: **25%**
Groupwork/Individual: Individual
Short extension [3]: Yes
AI Approach: Open

You will complete a problem-solving assignment based on wavefunctions in quantum mechanics.

On successful completion you will be able to:

- Explain the distinction between discrete and continuous quantum systems and how these are unified in the Hilbert space picture problems including the wave function in position representation
- Apply the one-dimensional Schrödinger equation to explain the physics of bound states, scattering problems and harmonic oscillator in the position representation
- Apply the Schrodinger equation to simple 2D problems such as the electron confined to a circular well and compare the behaviour to analogous classical systems.
- Write, modify and apply python code to solve and visualise problems involving discrete and continuous quantum system in one and multiple dimensions.

Skill Development: Problem solving

Assessment Type [1]: Problem-based task
Indicative Time on Task [2]: 18 hours
Due: **Week 7 SGTA session: 3-5 pm, Monday 7 September**
Weighting: **25%**
Groupwork/Individual: Individual
Short extension [3]: No
AI Approach: Observed

You will demonstrate solving problems on the spot in this assessment. You will work independently to demonstrate your acquisition of the concepts and skills that are foundational to analytical mechanics. To help you prepare, you will be given example problems in each SGTA.

On successful completion you will be able to:

- Explain key experiments and physical observations that have led to the modern formulation of quantum mechanics and phenomena such as superposition, commuting and non-commuting observables, entanglement and measurement.

- Discuss the interpretation and roles of state vectors, operators and observables in the Hilbert space formulation of quantum mechanics and apply these to pose and solve physical quantum problems in two and three-dimensional discrete spaces
- Explain the distinction between discrete and continuous quantum systems and how these are unified in the Hilbert space picture problems including the wave function in position representation

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[1] If you need help with your assignment, please contact:

- the academic teaching staff in your unit for guidance in understanding or completing this type of assessment
- Academic Success for academic skills support.

[2] Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation.

[3] An automatic short extension is available for some assessments. Apply through the Service Connect Portal.

Delivery and Resources

Week 1 classes

Lectures and SGTAs start in week 1. PC labs start in week 2

Methods of communication

We will communicate with you via your university email and through announcements on iLearn. Queries to convenors can either be placed on the iLearn discussion board, the individual dialog link, or sent to the unit convenor via the contact email on iLearn.

Content

The unit teaches theoretical and numerical quantum mechanics.

The theoretical content is taught through lecture and one active-learning SGTA each week. Materials for these classes will be posted in iLearn by the week before. You are encouraged to review and attempt the SGTA questions in advance of the class.

The numerical content is taught through active Python laboratories that will run in even-numbered weeks starting in week 2. The material and skills developed in these classes will be important for the home assignment on wave mechanics that is due at the end of week 12.

Succeeding in studying quantum physics

As with all branches of physics, the key to success is *practising* the skills by actively solving problems. It's important to engage with the lectures, SGTAs and labs to be introduced to the content and see examples of its application. It's also important to spend time reviewing the lecture notes and other materials, and identifying any parts that are confusing or unclear, and asking for help from your instructors.

But watching lectures and reviewing notes are examples of what we call *passive learning* - you are watching or reading someone else doing physics. What really makes the material come alive and stick in your head is applying it by doing problems yourself, which is *active learning*. This includes repeating the examples shown in lectures and attempting the questions we'll see in SGTAs.

There are plenty of good books and videos on quantum physics that you may also find helpful and interesting, and we've provided some links in the Reading list below. But ***please***, don't let time you devote to reading and videos reduce your focus on the primary task of solving problems yourself. That's the key to understanding the material and doing well in the final exam.

Reading list

The **unit content is defined by the lecture notes**, both in online videos and the live lectures.

There is no single textbook and the notes provided should be your primary resource, but if you would like to sample other sources, the following books and online materials are all valuable.

Part 1 - Dirac algebra

- J.J. Sakurai and Jim Napolitano, *Modern Quantum Mechanics*, (Cambridge University Press, 2020)
- David McIntyre, *Quantum Mechanics. A paradigms approach*, (Cambridge University Press, 2022)
- David A. B Miller, *Quantum mechanics for scientists and engineers*, (Cambridge University Press, 2008)
- David Griffiths, *Introduction to quantum mechanics*, (Cambridge University Press, 1995)

Part 2 - Wave mechanics

- C. J. Foot, *Atomic Physics*, (Oxford, 2004)
- R. Eisberg and R. Resnick, *Quantum physics of atoms, molecules, solids, nuclei, and particles*, (Wiley, 1985)

Changes to the unit from last offering

This unit has been significantly revised from the previous version named PHYS2030 - The Structure of Matter. This is to reflect the removal of wave mechanics in S1 2026 from PHYS2010. The first half on the Dirac formulation is unchanged. However, the second half spends more time on elementary wave mechanics and will place less emphasis on advanced topics in atomic physics. Indication will be provided during the session of material from previous exams that can be ignored.

Unit Schedule

The unit will be taught in two halves, addressing the two most important framings of quantum mechanics.

Part 1: approx weeks 1-6

The first half of the unit introduces the axioms and algebra of the quantum mechanics of discrete systems using the *bra-ket* formalism introduced by P.A.M. Dirac. This includes the concepts of quantum states, operators, measurement and time evolution with particular focus on two and three dimensional systems, such as the physics of spin-1/2 systems.

Part 2: approx weeks 7-13

The second half covers *wave mechanics* as formulated by Erwin Schrodinger in early 1926, exactly 100 years ago. This material provides the description of *continuous* variable quantum mechanics and is applied to important systems such as the particle-in-a-box, the harmonic oscillator and the hydrogen atom.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://policies.mq.edu.au). Students should be aware of the following policies in particular with regard to Learning and Teaching:

- Academic Appeals Policy
- Academic Integrity Policy
- Academic Progression Policy
- Assessment Policy
- Fitness to Practice Procedure
- Assessment Procedure
- Complaints Resolution Procedure for Students and Members of the Public
- Special Consideration Policy

Students seeking more policy resources can visit Student Policies (https://students.mq.edu.au/support/study/policies). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

To find other policies relating to Teaching and Learning, visit Policy Central (https://policies.mq.edu.au) and use the search tool.

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/admin/other-resources/student-conduct

Results

Results published on platform other than eStudent, (eg. iLearn, Coursera etc.) or released directly by your Unit Convenor, are not confirmed as they are subject to final approval by the University. Once approved, final results will be sent to your student email address and will be made available in eStudent. For more information visit connect.mq.edu.au or if you are a Global MBA student contact globalmba.support@mq.edu.au

Academic Integrity

At Macquarie, we believe academic integrity – honesty, respect, trust, responsibility, fairness and courage – is at the core of learning, teaching and research. We recognise that meeting the expectations required to complete your assessments can be challenging. So, we offer you a range of resources and services to help you reach your potential, including free online writing and maths support, academic skills development and wellbeing consultations.

Student Support

Macquarie University provides a range of support services for students. For details, visit http://students.mq.edu.au/support/

Academic Success

Academic Success provides resources to develop your English language proficiency, academic writing, and communication skills.

- Ask a Study Coach
- Access StudyWISE
- Upload an assignment to Studiosity
- Complete the Academic Integrity Module

The Library provides online and face to face support to help you find and use relevant information resources.

- Subject and Research Guides
- Ask a Librarian

Student Services and Support

Macquarie University offers a range of Student Support Services including:

- IT Support
- Accessibility and disability support with study
- Mental health support

- Safety support to respond to bullying, harassment, sexual harassment and sexual assault
- Social support including information about finances, tenancy and legal issues
- Student Advocacy provides independent advice on MQ policies, procedures, and processes

Student Enquiries

Got a question? Ask us via the Service Connect Portal, or contact Service Connect.

IT Help

For help with University computer systems and technology, visit https://students.mq.edu.au/support/technology/service-desk.

When using the University's IT, you must adhere to the Acceptable Use of IT Resources Policy. The policy applies to all who connect to the MQ network including students.

Unit information based on version 2026.04 of the Handbook