



# PHYS7910

## Engineering Quantum Matter

Session 2, In person-scheduled-weekday, North Ryde 2022

*School of Mathematical and Physical Sciences*

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## General Information

Unit convenor and teaching staff

Gavin Brennen

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Credit points

10

Prerequisites

PHYS714 or PHYS7905

Corequisites

Co-badged status

PHYS8910

Unit description

This unit teaches fundamentals and emerging topics in engineered quantum materials. As originally envisioned by Feynman, quantum simulation is a process where one set of controllable quantum systems can be made to simulate a complex quantum system that is too hard to model classically. In this unit we will explain how quantum simulators work to mimic natural and unnatural, or synthetic, materials. Theoretical skills taught will be standard techniques from condensed matter, as well as tools used in quantum information. You will learn how a quantum system can be programmed to simulate another either via an analogue simulation using an engineered Hamiltonian, or via a digital gate-based quantum simulation. We will cover the physics of experimental quantum simulation architectures including trapped ions and neutral atoms, and colour centres in diamond. Applications of synthetic quantum matter for quantum error correction and sensing will be covered. To better understand the physics of many body quantum systems you will learn numerical techniques including quantum simulation code and approximation methods known as tensor networks in order to simulate ground states and dynamics of many body quantum 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:** Apply essential skills for solving problems in quantum many body physics.

**ULO2:** Model quantum simulations using Hamiltonian based and gate based

approaches.

**ULO3:** Explain how to use the toolbox of interactions in an experimental architecture to perform a quantum simulation.

**ULO4:** Numerically model the physics of entangled many body systems via tensor network algorithms and quantum simulation software.

**ULO5:** Effectively communicate ideas in quantum engineering.

## General Assessment Information

Late Assessment Submission Penalty From 1 July 2022, Students enrolled in Session based units with written assessments will have the following university standard late penalty applied. Please see <https://students.mq.edu.au/study/assessment-exams/assessments> for more information. Unless a Special Consideration request has been submitted and approved, a 5% penalty (of the total possible mark) will be applied each day a written 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. Submission time for all written assessments is set at 11:55 pm. A 1-hour grace period is provided to students who experience a technical concern. For any late submission of time-sensitive tasks, such as scheduled tests/exams, performance assessments/presentations, and/or scheduled practical assessments/labs, students need to submit an application for Special Consideration. Assessments where Late Submissions will be accepted In this unit, late submissions will accepted as follows:

- Assessment Written assignments – YES, Standard Late Penalty applies
- Assessment Report – YES, Standard Late Penalty applies
- Assessment Final exam - NO, unless Special Consideration is Granted

## Assessment Tasks

Name	Weighting	Hurdle	Due
<a href="#">Written assignments</a>	40%	No	Weeks 3,6,9,12
<a href="#">Final exam</a>	40%	No	Exam period
<a href="#">Report</a>	20%	No	Week 13

### Written assignments

Assessment Type <sup>1</sup>: Problem set

Indicative Time on Task <sup>2</sup>: 24 hours

Due: **Weeks 3,6,9,12**

Weighting: **40%**

Four problems sets spread throughout the session.

On successful completion you will be able to:

- Apply essential skills for solving problems in quantum many body physics.
- Model quantum simulations using Hamiltonian based and gate based approaches.
- Explain how to use the toolbox of interactions in an experimental architecture to perform a quantum simulation.
- Effectively communicate ideas in quantum engineering.

## Final exam

Assessment Type <sup>1</sup>: Examination

Indicative Time on Task <sup>2</sup>: 20 hours

Due: **Exam period**

Weighting: **40%**

An examination in the University Examination period covering all of the course content.

On successful completion you will be able to:

- Apply essential skills for solving problems in quantum many body physics.
- Model quantum simulations using Hamiltonian based and gate based approaches.
- Explain how to use the toolbox of interactions in an experimental architecture to perform a quantum simulation.
- Effectively communicate ideas in quantum engineering.

## Report

Assessment Type <sup>1</sup>: Report

Indicative Time on Task <sup>2</sup>: 16 hours

Due: **Week 13**

Weighting: **20%**

Report on computational project

On successful completion you will be able to:

- Apply essential skills for solving problems in quantum many body physics.
- Model quantum simulations using Hamiltonian based and gate based approaches.

- Numerically model the physics of entangled many body systems via tensor network algorithms and quantum simulation software.
  - Effectively communicate ideas in quantum engineering.
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<sup>1</sup> 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
- the [Writing Centre](#) for academic skills support.

<sup>2</sup> Indicative time-on-task is an estimate of the time required for completion of the assessment task and is subject to individual variation

## Delivery and Resources

Notes for the course are on iLearn.

## Policies and Procedures

Macquarie University policies and procedures are accessible from [Policy Central \(https://policies.mq.edu.au\)](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 \(https://students.mq.edu.au/support/study/policies\)](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 \(https://policies.mq.edu.au\)](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 [ask.mq.edu.au](http://ask.mq.edu.au) or if you are a Global MBA student contact [globalmba.support@mq.edu.au](mailto: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/>

## The Writing Centre

[The Writing Centre](#) provides resources to develop your English language proficiency, academic writing, and communication skills.

- [Workshops](#)
- [Chat with a WriteWISE peer writing leader](#)
- [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 Enquiries

Got a question? Ask us via [AskMQ](#), or contact [Service Connect](#).

## IT Help

For help with University computer systems and technology, visit [http://www.mq.edu.au/about\\_us/offices\\_and\\_units/information\\_technology/help/](http://www.mq.edu.au/about_us/offices_and_units/information_technology/help/).

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.