PHYS7905

Quantum Information and Computation

Session 1, In person-scheduled-weekday, North Ryde 2022

School of Mathematical and Physical Sciences

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General Information

Unit convenor and teaching staff
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Credit points
10

Prerequisites
Admission to MRes

Corequisites

Co-badged status

Unit description
This unit introduces students to the growing field of quantum information science and technology. A general formalism is introduced involving the concept of Hilbert space, states represented by density matrices, open systems evolution via operator sum decompositions, and generalised measurement theory. Much of the unit covers the physics and quantum information aspects of leading physical implementations for a quantum engineered device, including: atomic, (neutral and trapped ion), photonic, superconducting and semiconductor devices. There is a laboratory component based on photonic systems with experiments on quantum correlations in single photons, tests of quantum nonlocality, and generation of entangled photons.

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 the basic theoretical concepts and elements needed for quantum information processing

ULO2: solve basic analytical and numerical problems in quantum information theory

ULO3: critically evaluate the potential and limitations of a quantum computer

ULO4: describe and model currently existing atom-based implementations of a quantum computer and their technical limitations

Assessment Tasks

Name	Weighting	Hurdle	Due
Problem-based assignments	60%	No	see iLearn
Final examination	40%	No	see iLearn

Problem-based assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 32 hours
Due: **see iLearn**
Weighting: **60%**

Sets of problems based on lecture content

On successful completion you will be able to:

- explain the basic theoretical concepts and elements needed for quantum information processing
- solve basic analytical and numerical problems in quantum information theory
- critically evaluate the potential and limitations of a quantum computer
- describe and model currently existing atom-based implementations of a quantum computer and their technical limitations

Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 20 hours
Due: **see iLearn**
Weighting: **40%**

Final examination covering all course content

On successful completion you will be able to:

- explain the basic theoretical concepts and elements needed for quantum information processing
- solve basic analytical and numerical problems in quantum information theory
- critically evaluate the potential and limitations of a quantum computer
- describe and model currently existing atom-based implementations of a quantum

computer and their technical limitations

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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
- the Writing Centre 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

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 ask.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/

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/.

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.

Topics covered in this course

* Measurement theory * Tensor products * Fidelity * No-cloning * Quantum teleportation * Superdense coding * Classical computation with quantum gates * Clean function evaluation (|x>|0> -> |x>|f(x)>) * Phase oracles * Deutsch-Jozsa algorithm * Bernstein-Vazirani algorithm * Simon's algorithm * Period finding * Shor's algorithm * Grover's algorithm * Amplitude amplification * Phase Estimation * Hamiltonian simulation * Quantum channels: GHJW theorem, POVMs, Krauss representations of superoperators, Lindblad form of master eqs. *Stabilizer Formalism * Brief into to classical error correction* Quantum stabilizer codes including the Steane code and the toric code, fault tolerant gates and the threshold theorem. * Alternatives to the circuit model of quantum computation: measurement based quantum computation