PHYS7905

Quantum Information and Computation

Session 1, Weekday attendance, North Ryde 2021

Archive (Pre-2022) - Department of Physics and Astronomy

Contents

Notice

As part of Phase 3 of our return to campus plan, most units will now run tutorials, seminars and other small group activities on campus, and most will keep an online version available to those students unable to return or those who choose to continue their studies online.

To check the availability of face-to-face activities for your unit, please go to timetable viewer. To check detailed information on unit assessments visit your unit's iLearn space or consult your unit convenor.

General Information

Unit convenor and teaching staff
Convenor
Gavin Brennen
gavin.brennen@mq.edu.au
Contact via 98504445
2.407 7 WW
Monday 3pm-5pm

Dominic Berry
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Credit points
10

Prerequisites
Admission to MRes

Corequisites

Co-badged status
PHYS8905

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	Weeks 3,6,9,12
Final examination	40%	No	Exam period

Problem-based assignments

Assessment Type [1]: Problem set
Indicative Time on Task [2]: 32 hours
Due: **Weeks 3,6,9,12**
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: **Exam period**
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

Delivery and Resources

1. Lectures in a standard lecture room or (if necessary) in the PC lab. Suggested textbooks are:
    - Quantum Information, Computation and Communication, Jonathan A. Jones and Dieter Jaksch (introductory)
    - Quantum Computation and Quantum Information, Isaac Chuang and Michael Nielsen (advanced)
    - more texts with reference to individual chapters to be announced during the course
2. Course content:
3. * 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. * Quantum error correction: brief into to classical error correction, quantum stabilizer codes including Steane code and toric code, fault tolerant gates and the threshold theorem. * Alternatives to the circuit model of quantum computation: measurement based quantum computation, topological quantum

computation * Physical architectures for quantum computation: trapped ions and superconducting qubits.

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
- Grade Appeal Policy
- Complaint Management 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

Student Support

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

Learning Skills

Learning Skills (mq.edu.au/learningskills) provides academic writing resources and study strategies to help you improve your marks and take control of your study.

- Getting help with your assignment

- Workshops
- StudyWise
- 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

Students with a disability are encouraged to contact the Disability Service who can provide appropriate help with any issues that arise during their studies.

Student Enquiries

For all student enquiries, visit Student Connect at ask.mq.edu.au

If you are a Global MBA student contact globalmba.support@mq.edu.au

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.