School of Information and Physical Sciences

PHYS3211: Quantum Information Science

Callaghan
Semester 2 - 2023

COURSE OUTLINE

www.newcastle.edu.au
CRICOS Provider 00109J

OVERVIEW

Course Description

Quantum Information Science studies the quantum mechanics and atomic physics needed to understand the development of quantum computing using entanglement and Qubits.

Quantum Information Science deals with the application of quantum mechanics to represent and process information. It is fundamental to the development of more realistic modelling on a practical timescale which will have a broad impact in a range of areas essential to the modern world. These include drug design, sustainable power generation, and the development of new materials.

Blended problem-based conceptual learning (lectorials) will be used to gain an understanding of key developments, ideas and theories covered in quantum information science. Blended problem-based hands-on learning (laboratory and computational workshops) will be used to gain an understanding of key experiments, models and analysis covered in quantum information science.

Requisites

Students must have successfully completed MATH2310, and either PHYS2211,PHYS 2170 or PHYS2240 to enrol in this course. If students have successfully completed PHYS3350 they cannot enrol in this course.

Assumed Knowledge

MATH2310, PHYS2211 (or equivalent)

Contact Hours

Callaghan
Laboratory
Face to Face On Campus
3 hour(s) per Week for 11 Weeks

Lectorial
Face to Face Off Campus
2 hour(s) per Week for Full Term starting Week 1

Unit Weighting

10

Workload

Students are required to spend on average 120-140 hours of effort (contact and non-contact) including assessments per 10 unit course.

CONTACTS

Course Coordinator **Callaghan**

Dr Lachlan Rogers
lachlan.rogers@newcastle.edu.au
(02) 4055 7574
Consultation: By appointment

Teaching Staff Other teaching staff will be advised on the course Canvas site.

School Office

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SR233, Social Sciences Building
Callaghan
CESE-SIPS-Admin@newcastle.edu.au
+61 2 4921 5513
9am-5pm (Mon-Fri)

SYLLABUS

Course Content

The topics to be covered include:

- Advanced Quantum Mechanics: the basic concepts of quantum mechanics; principle of superposition and compatible observables in quantum mechanics; conservation theorems in quantum mechanics; the harmonic oscillator and second quantisation; angular momentum; three dimensional systems.
- Advanced Atomic/Molecular Physics: angular momentum in the hydrogen atom; dipole radiation; fine and hyperfine structure; atoms in electric and magnetic fields; laser cooling of atoms.
- Quantum Computing: entanglement; qubits; quantum logic gates; realisation of quantum computers.

Course Learning Outcomes

On successful completion of this course, students will be able to:

1. Apply their knowledge in the field of advanced quantum mechanics to describe the use of atomic systems to develop quantum computers.

2. Solve qualitative and quantitative problems, using appropriate mathematical and computational techniques.

3. Perform experiments which involve making correct and appropriate use of a range of scientific equipment, keeping an accurate record of experimental work and analysing results and reaching non-trivial conclusions from them.

4. Communicate the results of both theoretical and experimental work in various forms including written reports, oral presentations and poster presentations.

5. Contribute to team and group work for scientific investigations and for the process of learning.

Course Materials

Lecture Materials:

Lecture materials on Canvas

Other Resources:

A selection of resource texts are in the third year laboratory. The laboratory notes contain adequate theory for the experiments.

ASSESSMENTS

This course has 4 assessments. Each assessment is described in more detail in the sections below.

	Assessment Name	Due Date	Involvement	Weighting	Learning Outcomes
1	Weekly Quiz	Monday 9:00am	Individual	12%	1, 2
2	In Term Test	Week 10 Laboratory session	Individual	18%	1, 2
3	Tutorial/Laboratory exercises	Listed in each lab manual	Individual	30%	3, 4, 5
4	Formal Examination	During Examination period.	Individual	40%	1, 2

Late Submissions The mark for an assessment item submitted after the designated time on the due date, without an approved extension of time, will be reduced by 10% of the possible maximum mark for that assessment item for each day or part day that the assessment item is late. Note: this applies equally to week and weekend days.

Assessment 1 - Weekly Quiz

Assessment Type Quiz
Purpose To keep you current
Description Online quiz
Weighting 12%
Due Date Monday 9:00am
Submission Method Online
Assessment Criteria Display recall and comprehension of key concepts from the lectures.
Return Method Online
Feedback Provided

Assessment 2 - In Term Test

Assessment Type In Term Test
Purpose Progressive assessment and a catalyst for exam preparation.
Description A timed, written formal examination of QM and part of the Atomic Physics course material. Students are required to bring a non-programmable scientific calculator that they are proficient in using.
Students may bring one single double-sided A4 memory aid.
Weighting 18%
Length 2 hrs
Due Date Week 10 Laboratory session
Submission Method In Class
Assessment Criteria
Return Method In Person
Feedback Provided Online - . Feedback in graded response to test.

Assessment 3 - Tutorial/Laboratory exercises

Assessment Type Tutorial / Laboratory Exercises
Purpose Hands-on experience of techniques and important measurements.
Description Detailed and short Laboratory Reports following Lab Sessions.
Weighting 30%
Due Date Listed in each lab manual
Submission Method Online
Assessment Criteria Assessment criteria are specifically recorded in the lab manual for each experiment.
Return Method Online
Feedback Provided Online - .

Assessment 4 - Formal Examination

Assessment Type	Formal Examination
Description	A timed, written formal examination of course material. Students are required to bring a non-programmable scientific calculator that they are proficient in using. Students may bring one single double-sided A4 memory aid.
Weighting	40%
Length	2 hrs
Due Date	During Examination period.
Submission Method	Formal Exam
Assessment Criteria	Solve qualitative and quantitative problems, using appropriate mathematical and computational techniques.
Return Method	Not Returned
Feedback Provided	In Person - .

ADDITIONAL INFORMATION

Grading Scheme

This course is graded as follows:

Range of Marks	Grade	Description
85-100	High Distinction (HD)	Outstanding standard indicating comprehensive knowledge and understanding of the relevant materials; demonstration of an outstanding level of academic achievement; mastery of skills*; and achievement of all assessment objectives.
75-84	Distinction (D)	Excellent standard indicating a very high level of knowledge and understanding of the relevant materials; demonstration of a very high level of academic ability; sound development of skills*; and achievement of all assessment objectives.
65-74	Credit (C)	Good standard indicating a high level of knowledge and understanding of the relevant materials; demonstration of a high level of academic achievement; reasonable development of skills*; and achievement of all learning outcomes.
50-64	Pass (P)	Satisfactory standard indicating an adequate knowledge and understanding of the relevant materials; demonstration of an adequate level of academic achievement; satisfactory development of skills*; and achievement of all learning outcomes.
0-49	Fail (FF)	Failure to satisfactorily achieve learning outcomes. If all compulsory course components are not completed the mark will be zero. A fail grade may also be awarded following disciplinary action.

*Skills are those identified for the purposes of assessment task(s).

Attendance

Attendance/participation will be recorded in the following components:

Laboratory (Method of recording: Scan ID at door)

Communication Methods

Communication methods used in this course include:

Canvas Course Site: Students will receive communications via the posting of content or announcements on the Canvas course site.

Course Evaluation

Each year feedback is sought from students and other stakeholders about the courses offered in the University for the purposes of identifying areas of excellence and potential improvement.

Oral Interviews (Vivas)

As part of the evaluation process of any assessment item in this course an oral examination (viva) may be conducted. The purpose of the oral examination is to verify the authorship of

	the material submitted in response to the assessment task. The oral examination will be conducted in accordance with the principles set out in the Oral Examination (viva) Procedure. In cases where the oral examination reveals the assessment item may not be the student's own work the case will be dealt with under the Student Conduct Rule.
Academic Misconduct	All students are required to meet the academic integrity standards of the University. These standards reinforce the importance of integrity and honesty in an academic environment. Academic Integrity policies apply to all students of the University in all modes of study and in all locations. For the Student Academic Integrity Policy, refer to https://policies.newcastle.edu.au/document/view-current.php?id=35.
Adverse Circumstances	The University acknowledges the right of students to seek consideration for the impact of allowable adverse circumstances that may affect their performance in assessment item(s). Applications for special consideration due to adverse circumstances will be made using the online Adverse Circumstances system where: 1. the assessment item is a major assessment item; or 2. the assessment item is a minor assessment item and the Course Co-ordinator has specified in the Course Outline that students may apply the online Adverse Circumstances system; 3. you are requesting a change of placement; or 4. the course has a compulsory attendance requirement. Before applying you must refer to the Adverse Circumstance Affecting Assessment Items Procedure available at: https://policies.newcastle.edu.au/document/view-current.php?id=236
Important Policy Information	The Help button in the Canvas Navigation menu contains helpful information for using the Learning Management System. Students should familiarise themselves with the policies and procedures at https://www.newcastle.edu.au/current-students/no-room-for/policies-and-procedures that support a safe and respectful environment at the University.

This course outline was approved by the Head of School. No alteration of this course outline is permitted without Head of School approval. If a change is approved, students will be notified and an amended course outline will be provided in the same manner as the original.