School of Physics

Course Outline 2020

PHYS2111

Quantum Physics

School of Physics

Faculty of Science

T1, 2020

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	Professor Adam Micolich	adam.micolich@gmail.com	Consultation time by arrangement via email	(02) 9385 6132
Lecturer	Dr Emanuela Dimastrogiovanni	e.dimastrogiovanni@unsw.edu.au	Consultation times: by arrangement via email	(02) 9385 4544
Teaching Support Officer	Zofia Krawczyk-Bernotas	z.krawczyk-bernotas@unsw.edu.au	School of Physics office G06, Old Main Building	(02) 9385 5969

2. Course information

Units of credit: 6

Pre-requisite(s): PHYS1221 or PHYS1231 or DPST1024 or PHYS1241 and MATH1231 or DPST1014 or MATH1241

Teaching times and locations:

http://timetable.unsw.edu.au/2020/PHYS2111.html

2.1 Course summary

Quantum mechanics is cornerstone of modern physics, and deals with physical phenomena on microscopic scales. This first course in quantum mechanics will provide students with a broad and comprehensive introduction and a foundation for further study. Topics to be covered include:

Fundamental Constants. Interference. Particle-wave duality. Double-slit experiment. De Broglie relation. Schrödinger Equation. Principle of superposition. Probability and probability current. Copenhagen interpretation. Searches for violation of Quantum Mechanics. Stationary states. Time-independent Schrödinger Equation. Infinite square well. Spectrum and localization. 1D scattering problems. Scattering from finite square well. Notion of deep and shallow level. Bound states in a finite square well. Dirac delta-function. Bohr-Sommerfeld quantization. Semiclassical approximation. Two- level systems. Harmonic oscillator. General mathematical structure of quantum mechanics and matrix mechanics. Commutators. Relation to Heisenberg uncertainty principle. Time-dependent Schrödinger Equation. Time dependence of expectation value. Ehrenfest theorem.

2.2 Course aims

Graduate Attributes Developed in this Course

- Research, inquiry and analytical thinking abilities
- Capability and motivation for intellectual development
- Ethical, social and professional understanding
- Communication in a scientific/technical context
- Collaborative and management skills
- Information literacy

2.3 Course learning outcomes (CLO)

At the successful completion of this course you (the student) should be able to:

1. Explain the core principles of quantum mechanics.
2. Apply the associated mathematical frameworks to analyse a variety of problems related to two- and three-level systems using Heisenberg matrix mechanics formalism.
3. Apply the associated mathematical frameworks to analyse a variety of 1D quantum systems from the perspective of Schrödinger wave-mechanics formalism.
4. Acquire and interpret experimental data for laboratory experiments related to basic quantum mechanical phenomena

2.4 Relationship between course and program learning outcomes and assessments

Course learning outcomes 1-3 are assessed by the midsession test, assignment and final exam. These assessments are largely of a problem-solving nature designed to determine students' ability to deploy acquired knowledge to new situations, which is a key graduate attribute for successful physics-trained graduates. Course learning outcomes 1 and 4 are also assessed via the laboratory component of the assessment.

3. Strategies and approaches to learning

3.1 Learning and teaching activities

Assumed Knowledge

Appropriate Physics 1 courses (e.g. PHYS1121 or PHYS1131 or PHYS1141 and PHYS1221 or 1231 or PHYS1241), plus MATH1131 or MATH1141 and MATH1231 or MATH1241 courses and a knowledge of partial differential equations.

Timetable

Lectures: 2 x 2hr lectures per week (Weeks 1-10)

Tutorial: 1hr per week (Weeks 1-10)

Laboratory: 3 x 3hr per term

Lecture Timetable

Day	*Time*	*Location*	*Weeks*
Monday	0900-1100	Electrical Engineering G23	1-8, 10
Friday	0900-1100	Electrical Engineering G23	1-7, 9-10

Lecture Information

Lecturer: This course is taught by two lecturers teaching 18 hours each.

Tutorial: Friday 1300-1400 in Chemical Sciences Building M18, Weeks 1-5, 6-7, 9-10

Tuesday 1300-1400 in Chemical Sciences Building M18, Week 11

Laboratory Information

The laboratory component of the course will be held in the Physics Laboratory, Room 142, Old Main Building. For details about labs, see http://timetable.unsw.edu.au/2019/PHYS2111.html or contact Laboratory Staff or Student Advisor

3.2 Expectations of students

Students are expected to attend 80% of all classes.

Academic misconduct will not be tolerated in any form in this course. Substantiated instances of cheating, plagiarism or copying of answers may result in a failure grade or significant deduction of marks. Please ensure you are fully familiar with the University's requirements and rules on plagiarism, which are detailed at http://student.unsw.edu.au/plagiarism. Claims of being unaware of the rules and/or the requirement for you to meeting them will not be accepted as mitigating circumstances.

The School endorses interactive group learning and fully understands that you may discuss the content of your courses including tutorial and assignment problems during your studies. However, submitted assignments should be your own work outlining your own reasoning and demonstrating your own knowledge related to the assessment. Copying will not be tolerated (we are good at spotting it); please ensure you know where the line between studying together and cheating on assessments lies. We will expect you to stay firmly on the correct side of that line.

4. Course schedule and structure

Week	Topics
1	Quantum measurement (APM) States as vectors (APM) Projections and basis states (APM) Operators as observables (APM)
2	Fundamental theorem of quantum mechanics (APM) Principles of quantum mechanics (APM) Pauli vector and expectation values (APM) Time evolution and the Hamiltonian (APM)

3	Commutators and correspondence (APM) The Statistics of the Uncertainty Principle (APM) The Generalised Uncertainty Principle (APM) Entanglement (APM)
4	Triplet states (APM) Quantum computation (APM) Extending matrix/vector notation towards Schrödinger wave mechanics – Part 1 (APM) Extending matrix/vector notation towards Schrödinger wave mechanics – Part 2 (APM)
5	Mid-session exam (in Wk 5 2 hr lecture block). Introduction to course, Probability waves (ED) Schrödinger equation (ED)
6	Wavefunctions, uncertainty principle (ED) Copenhagen interpretation (ED) Fourier transforms, probability flux (ED) Stationary states – Part 1 (ED)
7	Stationary states – Part 2 (ED) Infinite square well (ED) Harmonic oscillator – Part 1 (ED) Harmonic oscillator – Part 2 (ED)
8	Harmonic oscillator – Part 3 (ED) Free particle (ED) Delta function potential – Part 1 (ED) Delta function potential – Part 2 (ED)
9	Reflection and transmission coefficients (ED) Finite square well (ED) Step potential (ED)
10	Revision sessions only (ED/APM)

5. Assessment

5.1 Assessment tasks

Course assessment comprises assignments, in-session test, laboratory and final examination.

Assessment task	**Length**	**Weight**	**Mark**	**Due date** *(normally midnight on due date)*
Assessment 1: Mid-session test	50 mins	10%		Thursday 19 March (Week 5)
Assessment 2: Assignment		10%		Friday 17 April (Week 9)

Assessment 3: Laboratory		20%		See above note regarding lab classes
Assessment 4: Final Exam	2 hours	60%		See Exam Schedule - TBA

Information about Special Consideration is available from https://student.unsw.edu.au/special-consideration

Further information

UNSW grading system: student.unsw.edu.au/grades

UNSW assessment policy: student.unsw.edu.au/assessment

5.2 Assessment criteria and standards

Please see Moodle for a marking rubric for each assessment task.

5.3 Submission of assessment tasks

Unless otherwise specified, assignments should be submitted via Moodle/Turnitin by 5pm on the due date. Assignments will not be accepted in hard-copy form or via email. Marks will be deducted for late assignments, at a rate of 10% of the maximum possible mark for the assignment per day. A weekend will count as two days. An assignment submitted after the solutions have been posted will automatically receive 0%.

5.4. Feedback on assessment

Please see Moodle for details on how feedback will be provided for each assessment task

6. Academic integrity, referencing and plagiarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.

Further information about referencing styles can be located at student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits**:** honesty, trust, fairness, respect, responsibility and courage.[1] At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.

Further information about academic integrity and **plagiarism** can be located at:

[1] International Center for Academic Integrity, 'The Fundamental Values of Academic Integrity', T. Fishman (ed), Clemson University, 2013.

- The *Current Students* site student.unsw.edu.au/plagiarism, and
- The *ELISE* training site subjectguides.library.unsw.edu.au/elise

The *Conduct and Integrity Unit* provides further resources to assist you to understand your conduct obligations as a student: student.unsw.edu.au/conduct.

7. Readings and resources

Prescribed resources:

Introduction to Quantum Mechanics, 2nd Ed, David J Griffiths, ISBN-13 978-0131118928, Pub. Pearson Education

Recommended resources:

Quantum Mechanics, 5th Edition, Alistair Rae, ISBN 13: 9781584889700; Pub. Chapman and Hall.

Quantum Mechanics, Third Edition, Eugene Merzbacher, ISBN 13: 978-0471887027, Pub. John Wiley and Sons.

Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles Second Edition; Robert Eisberg and Robert Resnick, ISBN 13: 978-0471873730, Pub. John Wiley and Sons.

The Meaning of Quantum Theory, Jim Baggott, ISBN 978 19 855575, Pub. Oxford University Press

Laboratory Information

Three experiments needed to be conducted during the laboratory period. These are conducted in the Higher Year Laboratory on the first level of the Old Main Building. Before your first lab class, you must complete the online OH&S induction on Moodle. Lab classes are streamed; you will have selected your stream upon enrolment. For details of lab days, times and class codes please see http://timetable.unsw.edu.au/2019/PHYS2111.html

Other Resources

The PHYS2111 lecture notes will be posted to Moodle

Additional resources such as articles, papers, websites, other published material will be referred to during lectures and listed at the Moodle site.

8. Administrative matters

Communications

Students should check their UNSW email account regularly as all official university communication will be sent to that address. Students should use their university email account when writing to UNSW staff and should always include their name and student number.

Health and Safety

The School of Physics is actively committed to the health, safety and welfare of its staff and students. Information on relevant UNSW Occupational Health and Safety policies and expectations is available at: www.ohs.unsw.edu.au and https://www.physics.unsw.edu.au/about/safety

Recommended Internet Sites

The School of Physics website is www.physics.unsw.edu.au. Under the "Current Students" link students will find information about degrees, courses, and assessment.

The University website my.unsw.edu.au provides links to the UNSW Handbook, Timetables, Calendars and other student information.

Student Complaint Procedures

UNSW has procedures for dealing with complaints. These aim to solve grievances as quickly and as close to the source as possible. Information is available here: student.unsw.edu.au/complaints. Staff who can assist include:

School Contacts:

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9. Additional support for students

- The *Current Students* Gateway: student.unsw.edu.au
- Academic Skills and Support: student.unsw.edu.au/skills
- Student Wellbeing, Health and Safety: student.unsw.edu.au/wellbeing
- Disability Support Services: student.unsw.edu.au/disability
- UNSW IT Service Centre: www.it.unsw.edu.au/students