School of Physics

Course Outline 2021

PHYS3111

Quantum Mechanics

School of Physics

Faculty of Science

T2, 2021

1. Staff

Position	Name	Email	Consultation times and locations	Contact Details
Course Convenor	A/Prof Julian Berengut	Julian.berengut@unsw.edu.au	Consultation time by arrangement via email	(02)
Lecturer	Prof Oleg Sushkov	sushkov@unsw.edu.au	Consultation times: by arrangement via email	(02)
Laboratory Manager	Tamara Reztsova	t.reztsova@unsw.edu.au	Higher Year Lab OMB142	(02) 9385 4577
Teaching Support Officer	Zofia Krawczyk-Bernotas	z.krawczyk-bernotas@unsw.edu.au	School of Physics office G06, Old Main Building	(02) 9065 5719

2. Course information

Units of credit: 6
Pre-requisite(s): PHYS2111 or PHYS2110 and MATH2069 or MATH2521 or MATH2621

Teaching times and locations:
http://timetable.unsw.edu.au/2021/PHYS2113.html

2.1 Course summary

Quantum mechanics is a cornerstone of modern physics, and deals with physical phenomena on microscopic scales. This is the highest undergraduate course in quantum mechanics, and will provide students with a broad and comprehensive introduction and a foundation for further study. Topics to be covered include: Quantum mechanics in three dimensions. Angular momentum. Hydrogen atom. Landau levels. Spin. Identical particles and spin-statistic relation. Clebsch-Gordan Coefficients. Timeindependent perturbation theory and applications: Particle dynamics in 1D weak sinusoidal potential, band structure, Bloch theorem, Brillouin zone, quasimomentum, metals and band insulators. Timedependent perturbation theory. Fermi Golden rule. Adiabatic evolution and Berry phase. Particle wave analysis in scattering theory. Born approximation Dispersion relation for scattering amplitude. Low energy and resonance scattering.

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)

This is the highest undergraduate course in quantum mechanics and will provide students with a broad and comprehensive introduction and a foundation for further study.

Learning outcomes:

- Explain the core principles of quantum mechanics
- Apply the mathematical framework of angular momentum and spin to analyse a variety of 3D systems
- Analyse quantum systems using perturbation theory and scattering theory • Acquire and interpret experimental data

2.4 Relationship between course and program learning outcomes and assessments

Course learning outcomes 1-3 are assessed in the 4 assessment tasks. These assessments are largely of a critical-thinking nature designed to determine students' ability to deploy acquired knowledge to new situations, which is a key graduate attribute for successful university graduates.

3. Strategies and approaches to learning

3.1 Learning and teaching activities

Assumed Knowledge

Pre-requisite(s): PHYS1221 or PHYS1231 or PHYS1241, plus MATH2069 or MATH2011 or MATH2111

Timetable

Lectures: 1x 2hr plus 2x 1hr lectures per week (Weeks 1-5, 7-10)

Tutorial: 1hr per week (Weeks 1-5, 7-10)

Laboratory: 2 x 3hr per term

Lecture Timetable

Day	***Time***	***Location***	***Weeks***
Monday	1300-1500	Online	1-5, 7-10
Tuesday	0900-1000	Online	1-5, 7-10
Thursday	1000-1100	Online	1-5, 7-10

Lecture Information

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

Tutorial: Tuesday 1000-1100 in Burrows Theatre, Weeks 1-5, 7-10

Laboratory Information

Two experiments need to be conducted during the term. The laboratory component of the course will be held in OMB142. For details about lab days, times and class codes, see http://timetable.unsw.edu.au/2021/PHYS2113.html or contact Laboratory Staff (Tamara Reztsova at t.reztsova@unsw.edu.au).

3.2 Expectations of students

We believe that effective learning is best supported by a climate of enquiry, in which students are actively engaged in the learning process. To ensure effective learning, students should participate in class. Effective learning is achieved when students attend all classes, have prepared effectively for classes by reading through previous lecture notes, in the case of lectures, and, in the case of tutorials or laboratories, have made a serious attempt at doing the problems or pre-work themselves prior to the class. Furthermore, lectures should be viewed by the student as an opportunity to learn, rather than just copy down lecture notes. Effective learning is achieved when students have a genuine interest in the subject and make a serious effort to master the basic material. Academic misconduct will not be tolerated in any form in this course. Substantiated instances of cheating, plagiarism or copying answers may result in a failure grade or significant deduction of marks. Please see https://student.unsw.edu.au/plagiarism if you are in any way unsure of what constitutes plagiarism. Assignments in this class are to be done independently.

4. Course schedule and structure

Detailed Syllabus

Note: Timetable is indicative only and subject to change.

Week 1: Angular momentum: Commutation relations, algebra, representations, spherical harmonics, parity.

Week 2: Separation of variables, diatomic molecules, Hydrogen atom; Interaction with magnetic fields: Landau levels.

Week 3: Spin: Integer & half integer; Pauli matrices; Interaction with magnetic field, g-factor; SternGerlach experiment, spin-filtering; ESR & NMR, Rabi oscillations.

Week 4: Identical particles and spin-statistics relation; Pauli spin statistics theorem, bosons and fermions, examples. Addition of two angular momenta in Quantum Mechanics; Clebsch-Gordan coefficients.

Week 5: Variational methods and perturbation theory. Degenerate perturbation theory. Band structure.

Week 6: Time-dependent perturbation theory. Adiabatic evolution and Berry phase.

Week 7: Fermi Golden rule. Time of the wave-packet formation. General scattering theory in 2D and 3D; Partial wave analysis.

Week 8: Unitarity and optical theorem; Born approximation; Dispersion relation for scattering amplitude.

Week 9: Scattering at low energy, scattering from bound states and virtual levels; Resonances, BreitWigner formula, the level width and the level lifetime.

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	15%		Tuesday 22nd June (Week 4)
Assessment 2: Assignment		15%		Thursday 31st July (Week 9)
Assessment 3: Laboratory		10%		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

Assignment Submissions

Unless otherwise specified, assignments should be submitted online by 5pm on the due date.

A downloadable assignment cover sheet is available from https://www.physics.unsw.edu.au/current-students/cover-sheet

Marks will be deducted for late assignments, at a rate of 5% 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:

- 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

Textbook:

Prescribed: Griffiths, Introduction to Quantum Mechanics (2nd ed), Pearson Education

Recommended: Gasiorowicz, Quantum Physics, Wiley Zelevinsky, Quantum Physics Vols. 1 & 2, Wiley

Reference: Landau & Lifshitz, Quantum mechanics: non-relativistic theory, Pergamon Press

Other Resources

Lecture notes will be posted on 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.

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

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