PHYS2010

Classical and Quantum Oscillations and Waves

Session 1, Special circumstances, North Ryde 2021

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

Lecturer and Unit Convenor
Mark Wardle
mark.wardle@mq.edu.au
7WW 2.702

Lecturer
Deb Kane
deb.kane@mq.edu.au
7WW 2.701

Python Laboratory Manager and Tutor
Alexei Gilchrist
alexei.gilchrist@mq.edu.au
7WW 2.610

Experimental Laboratory Manager
Adam Joyce
adam.joyce@mq.edu.au
14SCO 214

Python and Experimental Lab Tutor
David Spence
david.spence@mq.edu.au
7WW 2.709

Experimental Lab Tutor
Andrei Zvyagin
andrei.zvyagin@mq.edu.au
7WW 2.707

Python Lab Tutor
Daniel Zucker
daniel.zucker@mq.edu.au
7WW 2.705

Credit points
10

Prerequisites (PHYS106 or PHYS1020 or PHYS143 or PHYS1520) and (MATH133 or MATH136 or MATH1020 or MATH1025)	
Corequisites MATH2010 or MATH2055 or MATH235	
Co-badged status	
Unit description Harmonic oscillation and wave motion are central to many areas of physics, ranging from the mechanical vibrations of machinery and nanoscale springs, to the propagation of sound and light waves, and the probability-amplitude waves encountered in quantum mechanics. This unit is concerned with describing the properties of harmonic oscillations and wave motion. The first half of the unit covers such topics as resonance, transients, coupled oscillators, transverse and longitudinal waves. The second half looks at interference and diffraction, firstly as important properties of waves in general, and then using the interference of matter waves as the starting point in studying the dual wave-particle nature of matter and the wave mechanics of Schrodinger, the basis of modern quantum mechanics. The laboratory program combines development of experimental skills such as problem solving, data analysis and report writing with a first course in computational physics (conducted in the python programming language) as well as techniques in electronic data acquisition widely used in industry and research.	

Important Academic Dates

Information about important academic dates including deadlines for withdrawing from units are available at https://students.mq.edu.au/important-dates

Learning Outcomes

On successful completion of this unit, you will be able to:

ULO1: discuss how oscillatory dynamics is ubiquitous in the physical world and to be able to formulate a basic description of the oscillatory behaviour regardless of system.

ULO2: derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.

ULO3: explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.

ULO4: demonstrate an understanding of the wave function formalism of quantum wave mechanics, the physical motivations behind this formalism, and its use to solve a range of basic problems.

ULO5: demonstrate skill in undertaking detailed experimental investigations, presenting and analysing results and drawing conclusions based on the results.

ULO6: demonstrate programming skill in the Python language and apply it in a laboratory setting.

General Assessment Information

This unit has a hurdle requirement, specifying a minimum standard that must be attained in the final exam. To pass this unit you must obtain a mark of at least:

- 50% in the unit overall, as well as

- 40% in the final examination, and

- 40% in **each individual assessable task** in the laboratory (practical and numerical), and

- must not miss more than four in-tute quizzes.

Important information regarding the final exam:

If you receive special consideration for the final exam, a supplementary exam will be scheduled after the end of the normal exam period. By making a special consideration application for the final exam you are declaring yourself available for a resit during the supplementary examination period and will not be eligible for a second special consideration approval based on pre-existing commitments. Please ensure you are familiar with the policy prior to submitting an application. Approved applicants will receive an individual notification one week prior to the exam with the exact date and time of their supplementary examination.

If your mark in the final examination is between 30% and 39% inclusive, you may be a given a second and final chance to attain the required level of performance; the mark awarded for the second exam towards your final unit mark will be capped at 40%, and you will be allowed to sit the second exam only if this mark would be sufficient to pass the unit overall. If you are given a second opportunity to sit the final examination as a result of failing to meet the minimum mark required, you will be offered that chance during the same supplementary examination period and will be notified of the exact day and time after the publication of final results for the unit.

Assessment Tasks

Name	Weighting	Hurdle	Due
Final examination	45%	Yes	University Examination Period
Python labs	15%	Yes	See Unit Schedule on iLearn
Lab reports	10%	Yes	See Unit Schedule on iLearn
Weekly quiz	30%	Yes	Weeks 2-13

Final examination

Assessment Type [1]: Examination
Indicative Time on Task [2]: 20 hours
Due: **University Examination Period**
Weighting: **45%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

Examination in the university exam period, covering all the content from the unit.

On successful completion you will be able to:

- discuss how oscillatory dynamics is ubiquitous in the physical world and to be able to formulate a basic description of the oscillatory behaviour regardless of system.
- derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.
- demonstrate an understanding of the wave function formalism of quantum wave mechanics, the physical motivations behind this formalism, and its use to solve a range of basic problems.

Python labs

Assessment Type [1]: Programming Task
Indicative Time on Task [2]: 0 hours
Due: **See Unit Schedule on iLearn**
Weighting: **15%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

A series of computational tasks in the python language.

On successful completion you will be able to:

- demonstrate programming skill in the Python language and apply it in a laboratory setting.

Lab reports

Assessment Type [1]: Lab report
Indicative Time on Task [2]: 12 hours
Due: **See Unit Schedule on iLearn**
Weighting: **10%**

This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

Report for each experimental task.

On successful completion you will be able to:

- demonstrate skill in undertaking detailed experimental investigations, presenting and analysing results and drawing conclusions based on the results.
- demonstrate programming skill in the Python language and apply it in a laboratory setting.

Weekly quiz

Assessment Type [1]: Quiz/Test
Indicative Time on Task [2]: 0 hours
Due: **Weeks 2-13**
Weighting: **30%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

A series of short quizzes, taken in SGTAs.

On successful completion you will be able to:

- discuss how oscillatory dynamics is ubiquitous in the physical world and to be able to formulate a basic description of the oscillatory behaviour regardless of system.
- derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.
- demonstrate an understanding of the wave function formalism of quantum wave mechanics, the physical motivations behind this formalism, and its use to solve a range of basic problems.

---

[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 Learning Skills Unit 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

Required and Recommended Texts and/or Materials

The first half of the course will follow "The Physics of Vibrations and Waves", Sixth Edition; H.J. Pain, Wiley (2005).

There is no single text book for the second half of the course. Recommended reading includes, the above text, as well as

1. The Feynman Lectures on Physics, Vol. 1, R.P. Feynman, R.B. Leighton and M. Sands (QC23.F47)

2. Vibrations and Waves in Physics, Second Edition, I.G. Main, Cambridge University Press (QC136.M34)

3. Oscillations and Waves, R. Buckley, Adam Hilger (1985) (QC157.B82).

4. Vibrations and Waves, A.P. French, Norton (1971) (QC235.F74).

5. Wave Physics, R.E.I. Newton, Edward Arnold (QC157.N48).

6. The Physics of Vibrations and Waves, Fourth Edition, H.J. Pain, Wiley (1993) QC231.P3/1993.

7. The Physics of Vibrations and Waves, Fifth Edition, H.J. Pain, Wiley (1999)QC231.P3/1999.

8. Fundamentals of Optics, F.A. Jenkins and H.E. White, McGraw-Hill (QC355.2.J46).

9. Optics, E. Hecht, Addison-Wesley (QC355.H42).

10. Quantum Mechanics Demystified, David McMahon, McGraw-Hill Education; 2 edition (May 14, 2013) - a few typos

11. Quantum Physics: What Everyone Needs to Know, Michael Raymer, Oxford University Press - Audible (free)

12. QUANTUM PHYSICS for Beginners in 90 Minutes without Math: All the major ideas of quantum mechanics, from quanta to entanglement, in simple language

13. No-Nonsense Quantum Mechanics: A Student-Friendly Introduction, Jakob Schwichtenberg, Amazon

Unit Schedule

Note: there may be some adjustments to this schedule as the semester proceeds.

Schedule	Lecturer	Topic
Weeks 1-2	Deb Kane	Examples of the use of the physics covered in this unit in modern contexts, including nanoscience. General overview of weeks 1-4. Simple harmonic motion, energy of oscillations, superposition.

Weeks 2-3	Deb Kane	Damped harmonic motion
Weeks 3-4	Deb Kane	Forced oscillation, resonance.
Week 5	Deb Kane	Coupled oscillations.
Weeks 6-7	Deb Kane	Transverse wave motion, wave equations and solutions, reflection and transmission at boundaries. Standing waves, wavegroups, group velocity, bandwidth theorem.
Weeks 7	Mark Wardle	Interference from 2 sources, 2 slit interference (Young's interference), interference from a linear array of N equal sources.
Week 8	Mark Wardle	Huygens wavelets and Huygens-Fresnel Principle, Fraunhofer diffraction through a slit.
Week 9	Mark Wardle	Einstein-de Broglie equations, the wave function, Uncertainty principle, size of H atom
Week 10	Mark Wardle	2 slit interference and wave-particle duality, the Born probability interpretation of the wave function, probability theory interlude.
Week 11	Mark Wardle	Infinite 1-D potential well, Schrödinger's wave equation.
Week 12-13	Mark Wardle	Harmonic oscillator, evolution of quantum states in the Harmonic Oscillator and the potential step.

Tutorials start in Week 1 and are held every week of semester. From Week 2 onwards they include a 20-minute written test.

Laboratories

Python numerical lab classes are held in 14SCO 209 during weeks 2-4 and 10-13.

Python is a modern programming language that is incredibly useful for scientific, engineering, and data analysis tasks. The first four weeks of labs will introduce Python's syntax and structure as well as some of its numerical and scientific libraries. The final three weeks of labs will make use of Python skills developed earlier to tackle case studies in modelling oscillatory and quantum systems.

Experimental laboratory sessions are held in 14SCO 217 in weeks 5, 6, 8, and 9. The experiments are:

- Coupled oscillators (2 weeks) - The mechanical oscillator (1 week) - Resonance and Q in electric circuits (1 week)

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 Enquiry Service

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

Equity 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.

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.