PHYS2010

Classical and Quantum Oscillations and Waves

Session 1, Weekday attendance, North Ryde 2020

Department of Physics and Astronomy

Contents

General Information

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Credit points
10

Prerequisites
(PHYS106 or PHYS1020 or PHYS143 or PHYS1520) and (MATH133 or MATH136 or MATH1020 or MATH1025)

Corequisites

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://www.mq.edu.au/study/calendar-of-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.

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.

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

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.

Assessment Tasks

Coronavirus (COVID-19) Update

Assessment details are no longer provided here as a result of changes due to the Coronavirus (COVID-19) pandemic.

Students should consult iLearn for revised unit information.

Find out more about the Coronavirus (COVID-19) and potential impacts on staff and students

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

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Delivery and Resources

Coronavirus (COVID-19) Update

Any references to on-campus delivery below may no longer be relevant due to COVID-19.

Please check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

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

Coronavirus (COVID-19) Update

The unit schedule/topics and any references to on-campus delivery below may no longer be relevant due to COVID-19. Please consult iLearn for latest details, and check here for updated delivery information: https://ask.mq.edu.au/account/pub/display/unit_status

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	Jason Twamley	Interference from 2 sources, 2 slit interference (Young's interference), interference from a linear array of N equal sources.
Week 8	Jason Twamley	Huygens wavelets and Huygens-Fresnel Principle, Fraunhofer diffraction through a slit.
Week 9	Jason Twamley	Einstein-de Broglie equations, the wave function, Uncertainty principle, size of H atom
Week 10	Jason Twamley	2 slit interference and wave-particle duality, the Born probability interpretation of the wave function, probability theory interlude.
Week 11	Jason Twamley	Infinite 1-D potential well, Schrödinger's wave equation.
Week 12-13	Jason Twamley	Harmonic oscillator, evolution of quantum states in the Harmonic Oscillator and the potential step.

Laboratories

Experimental laboratory

Sessions are held in 14SCO (E7B) 217 in weeks 5, 6, 8, and 9. The experiments are described below.

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

Python numerical lab

The classes are held in 14SCO (E7B) 209 during weeks 2-4, 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.

Policies and Procedures

Macquarie University policies and procedures are accessible from Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central). 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 *(**Note:** The Special Consideration Policy is effective from 4 December 2017 and replaces the Disruption to Studies Policy.)*

Students seeking more policy resources can visit the Student Policy Gateway (https://students.mq.edu.au/support/study/student-policy-gateway). It is your one-stop-shop for the key policies you need to know about throughout your undergraduate student journey.

If you would like to see all the policies relevant to Learning and Teaching visit Policy Central (https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policy-central).

Student Code of Conduct

Macquarie University students have a responsibility to be familiar with the Student Code of Conduct: https://students.mq.edu.au/study/getting-started/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.