PHYS201

Classical and Quantum Oscillations and Waves

S1 Day 2017

Dept of Physics and Astronomy

Contents

General Information

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Credit points
3

Prerequisites
((PHYS106 and PHYS107) or (PHYS140 and PHYS143)) and (MATH133 or MATH136)

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:

> To appreciate 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.

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

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

To gain of 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.

To develop laboratory skills, in undertaking experiments, presenting and analysing the results and drawing conclusions based on the results

To develop programming skills in the Python languages and apply it in an 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 assessable task in the laboratory (practical and numerical).

Assessment Tasks

Name	Weighting	Hurdle	Due
Final exam	45%	Yes	University Examination Period
Major In-Tutorial Test	20%	No	Weeks 3, 6, 9, 12
Minor In-Tutorial Tests	10%	No	See Unit Schedule
Laboratory workbook	10%	Yes	See Unit Schedule
Numerical lab	15%	Yes	See Unit Schedule

Final exam

Due: **University Examination Period**
Weighting: **45%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

You should have a scientific calculator for use during the final examination. Note that calculators with text retrieval are not permitted for the final examination.

The final examination is a hurdle requirement. You must obtain a mark of at least 40% to be eligible to pass the unit. If your mark in the final examination is between 30% and 39% inclusive then you will be a given a second and final chance to attain the required level of performance.

You are expected to present yourself for the final examination at the time and place designated in the University examination timetable (http://www.timetables.mq.edu.au/exam/). The timetable will be available in draft form approximately eight weeks before the commencement of examinations and in final form approximately four weeks before the commencement of examinations.

If you apply for Disruption to Study for your final examination, you must make yourself available for the week of July 24 – 28, 2017. If you are not available at that time, there is no guarantee an additional examination time will be offered. Specific examination dates and times will be determined at a later date.

Second-chance hurdle examinations will also be offered in the week of July 24 - 28. Results will be released on July 13. You will be notified shortly after that date of your eligibility for a hurdle retry and you must also make yourself available during that week to take advantage of this opportunity.

On successful completion you will be able to:

- To appreciate 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.
- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- To explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.
- To gain of 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.

Major In-Tutorial Test

Due: **Weeks 3, 6, 9, 12**
Weighting: **20%**

There will be four major in-tutorial tests throughout the term. Each test will be similar to a single final exam problem and take 30 mins. This assessment aims to give students the opportunity to solve problems that require an in-depth understanding of the course material covered to-date.

On successful completion you will be able to:

- To appreciate 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.

- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- To explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.

Minor In-Tutorial Tests

Due: **See Unit Schedule**
Weighting: **10%**

There will be a ten-minute test during each tutorial from week 3 to week 13 (except for the 4 major tests = 7 minor tests). The tests will comprise a single question, based on the material covered in the tutorial of the previous week. The results of your best 5 tests from the total of seven will contribute 10% of your final mark.

On successful completion you will be able to:

- To appreciate 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.
- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- To explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.
- To gain of 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.

Laboratory workbook

Due: **See Unit Schedule**
Weighting: **10%**
This is a hurdle assessment task (see assessment policy for more information on hurdle assessment tasks)

Second Year Physics Laboratories are found in E7B217. You should enter from the northern veranda on the second level of E7B.

The laboratory component of this unit consists of three experiments illustrating oscillations in mechanical and electrical systems.

If you miss a laboratory, you should apply for disruption of studies, or make up the missed lab by arrangement with the Lab manager.

Laboratory Experiments

Each experiment will be recorded in a laboratory notebook which you must provide for the first laboratory session. In the laboratory notebook you will log your activity in the laboratory, including the activities of your partner, sketches of your laboratory, preliminary data and everything else needed to understand (and potentially repeat) your activities during lab time. You need to add a final report on the experiment, including your data analysis, error analysis, outcomes and interpretation of the experimental results. You can take your laboratory notebook home to add the final report. Both the laboratory log and the final report of each experiment will be marked each week. The final report in your laboratory notebook may be brief, but must include:

- Title of the experiment,
- Date performed and name of partner,
- Aims and Methods of the Experiment Results,
- Calculations, graphs, error estimates etc.,
- Comparison with theory, as necessary.
- The answers to any questions found in the notes and any comments that you think may help your report and clarify matters for the marker.

We ask you to write your reports with proper sentences and paragraphs. You should also pay special attention to details such as measurement uncertainties, labelling axes of graphs, using appropriate headings and tabulating results.

The Laboratory demonstrators may also meet briefly, during the lab period, with each student for a short period (~5-minutes), to discuss their progress, and in particular, to discuss their development in executing laboratory experiments and in their notebook writeups. This will help the student understand better any assessment comments made in their notebooks or advice on their performance of the experiments.

Laboratory Safety

A condition of entry to the laboratory is thorough knowledge of the safety requirements in the laboratory. Students should revise these and they should be observed during all laboratory sessions. The safety aspects of the laboratory can be found in the front of the PHYS 201 Laboratory Notes and also on posters in the laboratory.

On successful completion you will be able to:

- To appreciate 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.
- To develop laboratory skills, in undertaking experiments, presenting and analysing the results and drawing conclusions based on the results

Numerical lab

Due: **See Unit Schedule**
Weighting: **15%**

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

Python is a modern programming language that is incredibly useful for scientific and engineering tasks. There will be seven weeks of python instruction. 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. Each session will be assessed.

On successful completion you will be able to:

- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- To develop laboratory skills, in undertaking experiments, presenting and analysing the results and drawing conclusions based on the results
- To develop programming skills in the Python languages and apply it in an laboratory setting

Delivery and Resources

Technology used and required

Unit web page

The web page for this unit can be found at http://ilearn.mq.edu.au

Please check this web page regularly for announcements and material available for downloading. Some learning resources for the unit will be provided in hardcopy rather on-line.

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

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

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

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

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

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

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

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

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

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

Teaching and Learning Strategy

This unit is taught through lectures and tutorials. We strongly encourage students to attend lectures because they provide a much more interactive and effective learning experience than studying a textbook. Questions during and outside lectures are strongly encouraged in this unit - please do not be afraid to ask, as it is likely that your classmates will also want to know the answer. You should aim to read the relevant sections of the textbook before and after lectures and discuss the content with classmates and lecturers.

You should aim to spend 3 hours per week working on tutorial problems and exercises. You may wish to discuss these problems with other students and the lecturers. This guided study in your own time is one of the key learning activities for this unit. It is by applying knowledge learned from lectures and textbooks to solve problems that you are best able to test and develop your skills and understanding of the material.

The experimental aspects of the unit require students to attend laboratories where they will be expected to set up experiments, take data, analyse the data within the context of the physical phenomena that are being studied, maintain a laboratory log-book, and report on their findings in clearly written laboratory reports.

Unit Schedule

Schedule of assessable tasks and related materials

Lecture schedule

Schedule..	Lecturer	Topic
Weeks 1-2	David Spence	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	David Spence	Damped harmonic motion
Weeks 3-4	David Spence	Forced oscillation, resonance.
Week 5	David Spence	Coupled oscillations.
Weeks 6-7	David Spence	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.

Laboratory experiments

The laboratory sessions are held in E7B217 in weeks *6* to 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 E7B209 during weeks 2-5, 10-12, Python is a modern programming language that is incredibly useful for scientific and engineering 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. Students should be aware of the following policies in particular with regard to Learning and Teaching:

Academic Honesty Policy http://mq.edu.au/policy/docs/academic_honesty/policy.html

Assessment Policy http://mq.edu.au/policy/docs/assessment/policy_2016.html

Grade Appeal Policy http://mq.edu.au/policy/docs/gradeappeal/policy.html

Complaint Management Procedure for Students and Members of the Public http://www.mq.edu.au/policy/docs/complaint_management/procedure.html

Disruption to Studies Policy (in effect until Dec 4th, 2017): http://www.mq.edu.au/policy/docs/disr uption_studies/policy.html

Special Consideration Policy (in effect from Dec 4th, 2017): https://staff.mq.edu.au/work/strategy-planning-and-governance/university-policies-and-procedures/policies/special-consideration

In addition, a number of other policies can be found in the Learning and Teaching Category of 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/support/student_conduct/

Results

Results shown in *iLearn*, 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.

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 improve your marks and take control of your study.

- Workshops
- StudyWise
- Academic Integrity Module for Students
- Ask a Learning Adviser

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

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.

Graduate Capabilities

Creative and Innovative

Our graduates will also be capable of creative thinking and of creating knowledge. They will be imaginative and open to experience and capable of innovation at work and in the community. We want them to be engaged in applying their critical, creative thinking.

This graduate capability is supported by:

Learning outcomes

- To appreciate 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.
- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- To gain of 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.
- To develop laboratory skills, in undertaking experiments, presenting and analysing the results and drawing conclusions based on the results
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Assessment tasks

- Final exam
- Major In-Tutorial Test
- Laboratory workbook

Capable of Professional and Personal Judgement and Initiative

We want our graduates to have emotional intelligence and sound interpersonal skills and to demonstrate discernment and common sense in their professional and personal judgement. They will exercise initiative as needed. They will be capable of risk assessment, and be able to handle ambiguity and complexity, enabling them to be adaptable in diverse and changing environments.

This graduate capability is supported by:

Learning outcome

- To develop laboratory skills, in undertaking experiments, presenting and analysing the results and drawing conclusions based on the results

Assessment task

- Major In-Tutorial Test

Commitment to Continuous Learning

Our graduates will have enquiring minds and a literate curiosity which will lead them to pursue knowledge for its own sake. They will continue to pursue learning in their careers and as they participate in the world. They will be capable of reflecting on their experiences and relationships with others and the environment, learning from them, and growing - personally, professionally and socially.

This graduate capability is supported by:

Learning outcomes

- To appreciate 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.
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Assessment tasks

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- Major In-Tutorial Test
- Minor In-Tutorial Tests
- Laboratory workbook
- Numerical lab

Discipline Specific Knowledge and Skills

Our graduates will take with them the intellectual development, depth and breadth of knowledge, scholarly understanding, and specific subject content in their chosen fields to make them competent and confident in their subject or profession. They will be able to demonstrate, where relevant, professional technical competence and meet professional standards. They will be able to articulate the structure of knowledge of their discipline, be able to adapt discipline-specific knowledge to novel situations, and be able to contribute from their discipline to inter-disciplinary solutions to problems.

This graduate capability is supported by:

Learning outcomes

- To appreciate 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.
- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
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- Laboratory workbook
- Numerical lab

Critical, Analytical and Integrative Thinking

We want our graduates to be capable of reasoning, questioning and analysing, and to integrate and synthesise learning and knowledge from a range of sources and environments; to be able to critique constraints, assumptions and limitations; to be able to think independently and systemically in relation to scholarly activity, in the workplace, and in the world. We want them to have a level of scientific and information technology literacy.

This graduate capability is supported by:

Learning outcomes

- To appreciate 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.
- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- To explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.
- To gain of 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.

- To develop laboratory skills, in undertaking experiments, presenting and analysing the results and drawing conclusions based on the results
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Problem Solving and Research Capability

Our graduates should be capable of researching; of analysing, and interpreting and assessing data and information in various forms; of drawing connections across fields of knowledge; and they should be able to relate their knowledge to complex situations at work or in the world, in order to diagnose and solve problems. We want them to have the confidence to take the initiative in doing so, within an awareness of their own limitations.

This graduate capability is supported by:

Learning outcomes

- To appreciate 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.
- To derive and solve the mathematical description of oscillatory behaviour including damped, driven, and coupled systems.
- To explain the continuum limit of discrete oscillators as the basis of wave motion, and to predict basic wave phenomena.
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- Minor In-Tutorial Tests
- Laboratory workbook
- Numerical lab

Effective Communication

We want to develop in our students the ability to communicate and convey their views in forms effective with different audiences. We want our graduates to take with them the capability to read, listen, question, gather and evaluate information resources in a variety of formats, assess, write clearly, speak effectively, and to use visual communication and communication technologies as appropriate.

This graduate capability is supported by:

Learning outcome

- To develop laboratory skills, in undertaking experiments, presenting and analysing the results and drawing conclusions based on the results

Assessment tasks

- Final exam
- Major In-Tutorial Test
- Minor In-Tutorial Tests
- Laboratory workbook

Changes from Previous Offering

The LabVIEW programming section of this unit has been removed, and the python section has been expanded. The lab sections have been reduced from 12 to 11 weeks.

The midsession exam has been replaced by four major in-tutorial tests. These 30 minute tests will give a more regular exposure to exam-style questions throughout the session.

A hurdle requirement has been added to the final examination.

Feedback

Student Liaison Committee

The Physics Department values quality teaching and engages in periodic student evaluations of its units, external reviews of its programs and course units, and seeks formal feedback from students via focus groups and the Student Liaison Committee. Please consider being a member of this committee, which meets once during the semester (lunch provided), with the purpose of improving teaching via student feedback. The class will be asked to nominate two students as representatives for the PHYS201 unit on the student liaison committee. This nomination process will be conducted during lectures and the lecturer will forward the names to the Head of Department. The SLC meetings are minuted and student representatives receive copies of the minutes from the two preceding SLC meetings prior to the meeting. An update on the responses that have been made by the department to the feedback obtained at the two preceding SLC meetings are reported by the Head of Department at the beginning of each SLC meeting. These responses are also minuted. The feedback is acted upon in a number of ways mostly initiated via Department of Physics and Astronomy meetings, where decisions on actions are taken.

Prizes

The Dick Makinson prize is awarded for proficiency in 200-level units in physics (including certain 200-level electronics units) totalling no less than 9 credit points. All students (day, part time or evening) are eligible for the prize. The Makinson prize takes the form of a certificate and cheque for $150.