



THE UNIVERSITY OF SYDNEY

School of Physics

PHYS 1002 Physics 1 (Fundamentals) – Semester 1, 2011

Module 3 – Waves

This module is one of 3 comprising PHYS 1002 Physics 1 (Fundamentals). This document describes details of this module and should be read in conjunction with the more general unit of study outline for PHYS 1002 Physics 1 (Fundamentals).

GENERAL GOALS OF THIS MODULE

This module will reinforce many of the goals from the previous two modules – Language of Physics and Mechanics.

- To improve your ability in “thinking like a physicist” in describing and understanding our physical world.
- To use scientific language in describing oscillating objects and how energy is transferred by waves.
- Understanding our physical world at a more sophisticated level than in the first and second modules.
- To improve your use of scientific explanation in describing and accounting for physical phenomena associated with energy transfer.
- To improve your use of mathematics as a tool for answering both qualitative and quantitative questions.
- To know and understand basic wave phenomena that are essential for further study in areas as diverse as music, optical fibres, mobile phones, satellite communications and television, microscopy, medical imaging and astronomy.
- To understand that there are only two fundamental mechanisms for transporting energy and momentum, a streaming of particles and a “flowing” of waves.

TIMETABLE

All **lectures** are held in the Physics Building. There will be two streams of the Waves module, each with 12 lectures. You will be scheduled into one lecture stream, with three one-hour lectures per week.

Stream	Lecture Theatre	Lecture times	Lecturer	Room No.
1	LT1	Mon, Wed, Fri – all at 10am start Fri 6 May, end Wed 1 June	Ian Cooper	104
2	LT1	Mon, Wed, Thu – all at 2pm start Thurs 5 May, end Wed 1 June	Ian Cooper	104

You should also attend a single one-hour **workshop tutorial** per week in Room 331 Madsen Building and a one three-hour **laboratory** session per week in the Carslaw Building on Level 4 (rooms 401, 402, 407 and 408).

Note: There is no lab on some weeks (consult the back cover of your Lab Manual for details).

You should also plan to spend about 6 hours per week on **independent study** to read through and understand the textbook, work through assigned examples and complete assignments, and to study for progressive tests and the final examination and to review the web-based materials specific to this module at

TEXTBOOK

This module is defined in terms of the text: Knight, Jones & Field, *College Physics*, 2nd ed. published by Pearson, Addison Wesley, 2010.

MASTERING PHYSICS – TUTORIAL and ASSIGNMENT QUESTIONS

MasteringPhysics may be accessed at <http://www.masteringphysics.com>. At this stage of the semester you should be familiar with using your chosen username and password to login to *MasteringPhysics* (you should be taken automatically to course ID **SUPHYS1002Y2011**).

Questions in *MasteringPhysics* are presented in groups (called 'assignments' by the system) with a title such as *Oscillations & Waves - Assignment 3 and Tutorial Questions*. There is one 'assignment' for this Module.

Oscillations and Waves – Assignment 3 and Tutorial Questions To be completed by 7pm Friday 3 June

Each assignment is divided into two components.

- **Tutorial Questions.** These mostly feature the full *MasteringPhysics* Socratic dialogue - when you get stuck in answering a problem it offers a simpler problem and provides feedback tailored to your answers. These have been selected by your lecturers to help your understanding and problem solving ability. They are not assessed but we strongly recommend you look at some of these questions, which will remain available after the assignment deadline until the end of the semester.
- **Assignment Questions** are compulsory questions and represent the *minimum* use you should make of the system. 8 questions are offered, each worth 5 marks even though some are a little longer than others. Each assignment is worth about 2% towards your total assessment (see the unit of study outline for full details of how marks count towards your final assessment). The questions are a mix: tutorial-style questions teaching you concepts and problem solving techniques; and end-of-chapter problems from the textbook. The tutorial-style questions have full hints and feedback, while the end-of-chapter questions do not.

The marking scheme gives a small reward when answers are achieved without using the hints, but no penalty if you do use them. See the *MasteringPhysics* FAQ at http://sydney.edu.au/science/physics/pdfs/current/jphys/MP_faq.pdf for more details.

Assignment questions must be completed by 7pm (local time) on the date noted in the table above. Available assignment marks ramp down to zero in the five hours after the assignment deadline. It is therefore essential that you seek permission if you need to submit the assignment late. Assignment questions remain accessible to you for review (but no more marks!) until the end of the semester.

Read and/or print each problem, then work on it *before* trying to enter your answer. We don't want you to sit down and type in the answers without working on and thinking about them first. Try the problem without a hint first, then, if you get stuck, try the hint. For assignment questions, we give you eight chances to get the correct answer (although there is a small penalty for wrong answers). The objective is to get the right answer using as much help as it takes.

Your answers need to be formatted correctly so be smart and use the help the system provides:

- Values of constants can be found using the 'constants' button near the top of the page.
- See the Help linked from "?" at the right end of relevant boxes for more help with formatting.
- Move your mouse over symbols in the question to see how to type them in the correctly.

We encourage students to cooperate in understanding all the questions since the objective is to understand concepts and develop your problem solving ability. However **all Assignment Questions using MasteringPhysics must be completed individually.** Simply copying the work of another person without acknowledgment is plagiarism and contrary to University policies on **Academic Honesty in Coursework** (see http://sydney.edu.au/ab/policies/Academic_Honesty_Cwk.pdf).

MasteringPhysics marks the assignments automatically and you immediately know your result. Worked solutions to all Assignment Questions will be posted on the web, although you should have the answer once you complete each *MasteringPhysics* question. Note that some assignment questions use randomised values - i.e. different students see the question with different values.

Question/Problems?

Help in using *MasteringPhysics* can be obtained from:

- Extensive on-line help
- An FAQ list at http://sydney.edu.au/science/physics/pdfs/current/jphys/MP_faq.pdf
- A discussion group on eLearning for this unit is monitored by Physics staff.

If for any reason you cannot complete the assignment on-line, you may request a paper copy of the assignment and permission to submit a paper copy of the solution. You must submit an Application for Consideration of Special Circumstances by Physics (see the Unit Outline or <http://sydney.edu.au/science/physics/current/consideration.shtml>). Paper-based assignments will not be accepted unless permission is obtained beforehand, since the objective is for you to use the tutoring ability of *MasteringPhysics* to improve your ability to solve problems and your understanding of concepts.

REMINDERS

eLearning

Unit web pages are provided under eLearning, which can be accessed from links on the Junior Physics web pages (<http://sydney.edu.au/science/physics/current/jpc.shtml>) or your MyUni pages (<http://sydney.edu.au/myuni>). A brief introduction to help you with web access is available on the Junior Physics web page at http://sydney.edu.au/science/physics/pdfs/current/jphys/webct_handout.pdf.

Email

The University provides you with email access based on your username. We may use this email address to provide you with important information regarding this unit of study. **We expect you to periodically read the your email account or to forward mail from it to an email account you do read (eg. a hotmail account).**

Where to go for help

If you need help, you can

as a first step, always check your unit eLearning pages for information, documents and links go to the Physics Student Services Office, Room 202 in the Physics building, or phone 9351 3037

ask your lecturer or tutor

ask other students using the Discussion forum provided in the *Communication* link on the unit eLearning page.

ask a Duty Tutor - a staff member who is available Tuesday – Friday, 1-2 pm, in Physics LT4 to help you with problems with physics course material available from *Week 3* of semester.

consult one of the many services provided by the University, such as the Maths Learning Centre. These can be found by choosing *Junior Physics Resources and Links* from the unit eLearning page or your *MyUni* pages (<http://sydney.edu.au/myuni>).

Consideration of factors affecting your study

If your academic performance in a Science Faculty unit of study is adversely affected by **illness or some other serious event**, such as an accident, you should notify the **Faculty of Science Student Information Office** (level 2 of the Carslaw building) within 7 days after the period for which consideration is sought, by completing an *Application for Special Consideration* with accompanying documentation. This is especially important if you miss an examination.

If you have another reason for the Science Faculty to take account of your circumstances - religious commitments, legal commitments (e.g. Jury duty), elite sporting or cultural commitments (representing the University, state or country), or Australian Defence Force commitments (e.g. Army Reserve) - you should notify the **Faculty of Science Student Information Office** (level 2 of the Carslaw building) at least 7 days **BEFORE** the period for which consideration is sought, by completing an *Application for Special Arrangements* with accompanying documentation.

These two forms of Consideration should cover most allowable circumstances. However, if you have **another reason** for requiring the School of Physics to take account of your circumstances, you should notify the **School of Physics Student Services Office** immediately.

You should **not** submit an application of any type if there is no assessment associated with a missed class, or you have a reasonable opportunity to make up any work you missed.

If for example, you miss an assignment, an application for appropriate Consideration is required to allow late submission, but we do expect the assignment to be submitted. Sometimes catching up may be impossible, in which case we will consider a pro-rata adjustment of your marks on the basis of an application for Consideration.

Special Consideration or Special Arrangements

To submit an application for *Special Consideration* or *Special Arrangements* you should:

Obtain the appropriate Application pack from the Student Information Office of the Faculty of Science, the Faculty website at <http://sydney.edu.au/cstudent/ug/forms.shtml>, or the Physics Student Services Office.

Complete the forms and obtain whatever original documentary evidence is appropriate. Note especially that the Professional Practitioner's Certificate is essential for Special Consideration on grounds of serious illness - Medical Certificates will NOT be accepted.

Take the original copy of all forms and documents, plus sufficient copies for each unit of study affected and yourself, to the Faculty of Science Student Information Office (NOT any other Faculty Office if you are seeking Consideration in a unit taught by Physics). They will sign/stamp both the original application form and the copies. In the case of Physics units, one copy of the documentation must then be submitted to the Physics Student Services Office. Keep one copy yourself. A formal decision on your application will be sent to your **university email** address within 14 days.

Further details on University policy regarding Considerations can be found in policy documents entitled *Assessment and Examination* at the University Policy web site (<http://sydney.edu.au/policy/>).

Students unsure what type of Consideration is appropriate, or unhappy with a Consideration decision, should consult the Physics Student Services Office.

It is important to realise that the policies on *Special Consideration* and *Special Arrangements* apply throughout the University. Policies on other forms of Consideration are specific to Physics and may be different in Departments responsible for your other units of study.

MODULE DEFINITION – OSCILLATIONS AND WAVES

PREAMBLE

This Module covers two major topics in Physics:

Oscillations

We focus our attention on a variety of oscillations, including simple harmonic motion; damped oscillations; driven oscillations and resonance. We examine the mathematical description of simple harmonic motion, the force law and consider the different contributions to the total energy of the system. We examine a qualitative and graphical description of damped oscillations and resonance effects.

Waves

We study the behaviour of waves as a means of transferring energy. (1) Mechanical waves – types and mathematical description. (2) Sound waves – propagation and Doppler Effect. (3) Electromagnetic waves - electromagnetic spectrum. (4) Principle of Superposition - interference of waves and standing waves (string and wind musical instruments), beats. (5) Electromagnetic waves - refraction and thin film interference.

For each chapter from the textbook *College Physics* (Knight, Jones, Field) covered in this Unit of Study we have defined broadly what we expect you to learn and understand. Understanding implies that you should be able to discuss and explain fundamental concepts and principles including examples of their applications. Understanding will be tested in the examination by asking you to write descriptive answers to qualitative questions and by evaluating your explanations of physical principles and reasoning in answers to quantitative questions. Ability to memorise formulas and manipulate them without understanding the associated physics will not be rewarded.

The **Specific Objectives** define what you should learn and understand about the detailed content of each chapter. Understanding a term or concept means that you should be able to

- explain its meaning in writing and give examples,
- interpret it correctly when you read or hear it,
- use it correctly in your own writing,
- apply it correctly to examples and to both qualitative and quantitative problems.

You need to be knowledgeable about the **equations** in the textbook for each specified section. You should be able to state the meaning and be able to interpret each symbol appearing in the equation as well as knowing its S.I. unit. You should know when the equation is applicable and be able to represent the equation in a graphical form. An equation **Formula Sheet** is included in your final examination paper. A sample copy of the Formula Sheet is included in your Laboratory Manual. It is most important that you are familiar with your Formula Sheet.

You should work through each of the **worked examples** and try the *Stop to Think* problems and attempt the *Conceptual Questions*, *Multiple-choice Questions* and *Problems* relevant to the content.

MODULE CONTENT – Textbook Sections and Specific Objectives

Chapter 8.3 Springs and Elastic Materials

- Springs and Hooke's Law, spring constant, proportional relationship, graphical representation.
- Elastic and plastic materials, elastic, elasticity, restoring force, equilibrium position, equilibrium length.

Chapter 10.4 Potential Energy

- Work, kinetic energy, potential energy, gravitational potential energy, elastic potential energy, total energy, conservation of energy.

Chapter 14 Oscillation (exclude section 14.5)

- Period, frequency, amplitude, sine curve - sinusoidal, simple harmonic motion (SHM), uniform circular motion and SHM, displacement, velocity, acceleration, energy, damping, damped oscillations, driven oscillations, resonance, driven oscillations, driving frequency, natural frequency, resonance frequency, response curve, hearing.
- Mathematical description of SHM.
- Graphical description of SHM, damped oscillations and driven oscillations.
- The interchange of potential and kinetic energy in mechanical oscillations.
- Use energy conservation in solving problems of an oscillating system.
- Applications – vibrating mass on spring, diving board (springboard), bungee jump, car suspension system.

Chapter 15 Traveling Waves and Sound

- Wave model, mechanical waves, medium, disturbance, progressive or travelling waves, electromagnetic waves, matter waves, transverse waves, longitudinal waves, waves on a string, sound waves, sinusoidal wave, harmonic.
- Wave description: amplitude, phase, frequency, period, angular frequency, wavelength, wave number (propagation constant), wave function. *Text does not use angular frequency or wave number.*
- Sound waves – compression, rarefactions, ultrasound, power, energy, intensity, loudness, decibel scale, Doppler Effect (sound only) and Shock waves.
- Electromagnetic waves, spectrum, visible 700 nm to 400 nm.
- Mathematical description of waves.
- Graphical representation – traveling waves (transverse and longitudinal), sinusoidal representation.
- The equation used to describe the Doppler Effect for sound waves is

$$f_o = f_s \frac{v \pm v_o}{v \pm v_s} \quad \text{different to textbook.}$$

Chapter 16 Superposition and Standing Waves

- Superposition principle - interference, constructive interference, destructive interference, interference of two sound waves, beats.
- Standing waves on strings - reflection, modes, mode number, natural frequency, resonance, resonance frequency, fundamental, harmonics, overtones, stringed musical instruments.
- Standing sound waves - pipes (open/open, open/closed, closed/closed), pressure distributions, displacement distributions, ear canal, wind instruments.
- Graphical representation – standing waves (strings, pipes – pressure and particle displacement), two source interference, beats.

Chapter 17 Wave Optics Only sections 17.1 and 17.4

- Light, models of light (wave and particle), speed of light, frequency, wavelength, spectrum, refraction, refractive index, transparent materials.
- Thin film interference, phase, phase changes on reflection, interference, optical path length, fringes, maxima (constructive interference) & minima (destructive interference).
- Thin films of air, iridescent feathers, colours of soap films and oil slicks, antireflective coatings.
- Graphical representation – thin film interference.
- Thin-film interference - the **phase difference** between the two waves is

$$\Delta\phi = 2\pi \left(\frac{2d n_f}{\lambda_o} \right) + \phi_{back} - \phi_{front} \quad \text{different to textbook.}$$

The ϕ 's are determined from the reflections at the interfaces. Remember a pulse traveling down a thin string is reflected with a phase shift of π rad (inverted) at the interface with a heavy string. So a reflected light wave has a π change of phase when it is incident upon a material that has a greater refractive index (optically more dense).

Constructive interference $\Delta\phi = m (2\pi)$ rad

$$m = 1, 2, 3, \dots$$

Destructive interference $\Delta\phi = (2m-1)(\pi)$ rad