THE UNIVERSITY OF SYDNEY

School of Physics

PHYS 1002 Physics 1 (Fundamentals) – Semester 1, 2015

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.

MODULE DEFINITION – OSCILLATIONS AND WAVES

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 knowledge 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

$$f_{\mathrm{o}} = f_{\mathrm{s}} \frac{v \pm v_{\mathrm{o}}}{v \pm v_{\mathrm{s}}}$$ *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

$$\Delta\phi = 2\pi\left(\frac{2d\,n_f}{\lambda_o}\right) + \phi_{back} - \phi_{front}$$ *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

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

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

