SI UNITS

SI stands for Système International.

SI base units

Quantity	Unit	Symbol
Mass	kilogram	kg
Distance	metre	m
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Derived units with special names

Quantity	Unit	Symbol	Equivalent
Force	newton	N	$kg.m.s^{-2}$
Pressure	pascal	Pa	$N.m^{-2} = kg.m^{-1}.s^{-2}$
Energy	joule	J	$N.m = kg.m^2.s^{-2}$
Power	watt	W	$J.s^{-1} = kg.m^2.s^{-3}$
Frequency	hertz	Hz	s^{-1}

Prefixes for units

name	symbol	value	name	symbol	value
kilo	k	10^3	centi	c	10^{-2}
mega	M	10^6	milli	m	10^{-3}
giga	G	10^9	micro	μ	10^{-6}
tera	T	10^{12}	nano	n	10^{-9}
peta	P	10^{15}	pico	p	10^{-12}
exa	E	10^{18}	femto	f	10^{-15}
			atto	a	10^{-18}

Syntax for units

1. Symbols for those units named after scientists are given capital letters but the unit name is not capitalised; e. g. the force unit is newton, symbol N.

2. Full stops are not used to indicate abbreviations; however they are used to separate symbols and thus prevent ambiguity: for example ms^{-2} and $m\ s^{-2}$ are symbols for two different quantities and are better distinguished by writing the latter as **m.**s^{-2}.

3 Double prefixes (e.g. mμ for n) are not allowed.

4. Use of double solidus (/) is not allowed (e.g. m/s/s is not an acceptable symbol for the unit of acceleration; use m/s^2 or $m\ s^{-2}$ or, preferably, **m.**s^{-2}).

THE UNIVERSITY OF SYDNEY

PHYSICS 1 (LIFE SCIENCES)

FORCES AND ENERGY

TWENTIETH EDITION

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FORCES AND ENERGY is one of six units for the course **PHYSICS 1 (LIFE SCIENCES)**.

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THE PHYSICS 1 (LIFE SCIENCES) COURSE

COURSE INFORMATION

GENERAL

This course is the compulsory first year Physics course for students in the Faculties of Agriculture, Medicine and Veterinary Science.

Students in the Faculty of Science can choose between Physics 1 (Life Sciences) and Physics 1. They should be guided in this choice by the following considerations.

(i) Physics 1 (Life Sciences) does not normally lead on to any further physics courses. If you secure a credit or better in this course and have passed Mathematics 1 you may do further courses in Physics, if you wish.

(ii) Physics 1 (Life Sciences) has been designed for those students whose interest is in the biological rather than the physical sciences.

(iii) Mathematics 1 is a required companion subject for Physics 1; there are no mathematical corequisites for Physics 1 (Life Sciences).

Do not jump to the conclusion that Physics 1 (Life Sciences) is an easier subject than Physics 1. It has been designed for a different type of student: one who may not have as much knowledge of, or aptitude for, mathematics, but who needs an understanding of the basic concepts of physics as a grounding for those subjects that are more central to the student's University course.

LECTURES

The lecture part of the Physics 1 (Life Sciences) course comprises six units. Three units are covered each semester. The units are:

Forces and Energy,
Thermal Physics,
Electricity,
Light,
Atoms and Nuclei,
Properties of Matter.

Each unit is presented in eight lectures, most of which include a video presentation, and four other one-hour lecture periods. Each video lecture corresponds to one chapter of this book. Each chapter is divided into three sections: PRE-LECTURE, LECTURE and POST-LECTURE.

Material that is assumed to be known in the lecture is covered in the PRE-LECTURE section. This section may also contain questions designed to stimulate you and get you thinking along the lines of the lecture. You should study this section and attempt any questions *before* attending the lecture. You should also read (but not study) the LECTURE section *before* attending the lecture.

This LECTURE section covers the main points of the lecture. They are given there so that you do not have to spend time copying down notes during the lecture. However, there are demonstrations and illustrations used in the lectures that are not described fully in the notes; you may wish to take notes to remind yourself of these.

The POST-LECTURE section contains questions (numerical and non-numerical) to aid your understanding of the course material. Sometimes you will find discussion of topics not treated in the televised lecture there; some of these topics will be dealt with further in the ‘live’ lecture.

The course is defined in the lists of objectives given at the start of each chapter. The material in the book covers these objectives.

TUTORIALS

There is a large component of tutorial assistance in this course. The four non-televised lecture periods in each unit will be of the nature of tutorial assistance. The mode of approach will vary for different faculty groups, because of the different backgrounds and interests of the students in each Faculty. Generally assistance will be directed to those who have not done a physics course before.

LABORATORY WORK

During the first week of first semester you should report for laboratory work to floor 4 of the Carslaw Building at the time indicated in your faculty handbook or personal timetable. (Veterinary science students report in the first week of second semester.) No prior registration is required.

EXAMINATIONS

There will be two three-hour examinations: one at the end of each semester. Each exam covers the work of the preceding semester and only that work. The year's total assessment is made up of contributions from the written examinations and from the laboratory work.

Students can be failed because of unsatisfactory laboratory work even though they perform satisfactorily in the written examinations.

They can also be failed as a result of a grossly poor performance in the examination work of any one unit.

DIRECTOR

Dr Brian McInnes is the Director of First Year Courses. His office is in Room 201, ground floor, Physics Building. If you are having difficulties with your work or if you have any suggestions regarding the course, Dr McInnes is ready to discuss these with you. No appointment is necessary to see him.

Mrs Elizabeth Hing is the First Year Secretary. Her office is Room 202A, Physics Building. She may be consulted regarding any routine aspects of Physics 1 (Life Sciences).

NOTES ON THE OBJECTIVES

At the beginning of each chapter in this course there is a statement of educational objectives. Firstly, we give a brief statement of the broad **Aims** of the chapter in terms of ideas and principles that you should aspire to understand and appreciate together with the kind of factual knowledge that you will need in order to underpin that understanding. This is followed by a more specific list of **Minimum learning goals**, which spell out in some detail those things which you ought to be able to do in order to demonstrate your understanding and knowledge. These detailed objectives are used to design exam questions.

The first goal in each chapter always contains a list of the scientific terms which are introduced or defined for the first time in that chapter. Although formal definitions of many (but not all) of these terms may be found in the text which follows, in most cases it is much more important that you can demonstrate your understanding of a term by interpreting it correctly (e.g. when you see it in an exam question or a later part of the text) and by using it correctly in your own writing. For this reason the first goal usually starts with the words 'explain, interpret and use ...'. Sometimes there are several terms which have essentially the same meaning. We indicate this in the objectives by including the alternative terms in square brackets; for example: *total force [resultant force, net force].*

As well as being able to achieve each of the minimum learning goals you should also aim to integrate your understanding by analysing and discussing situations using concepts and principles from all chapters of this unit. Many exam questions require application of knowledge from several chapters. Also, later units of this course will require a reasonably good understanding of the concepts and principles presented here.

It is worth noting that the objectives do not include memorisation of formulas. Instead the emphasis is on understanding the physical meaning behind the mathematics and in recognising situations where the various mathematical relations can be applied. To emphasise that you don't need to memorise formulas we have prepared a one-page list of the common basic formulas for each unit of the course. **A copy of the relevant formula sheets, as they appear in the current editions of these books, will be provided in the exam.** These lists are incomplete insofar as we don't define all the symbols used; you are expected to be able to recognise the standard symbols for physical quantities. Also, we do not spell out all the limitations which apply to each equation. Again, that is something that you should strive to appreciate.

Learning goals which refer to these standard relations are often expressed using the words 'state' and 'apply'. When you are asked to **state** a relation, not only should you be able to find it in the list, but you should be able to add the explanation of what the symbols mean and to describe the limitations or special conditions on the validity of the relation. And part of being able to **apply** a formula includes the ability to recognise situations in which it is relevant.

Most of the relations included in the formula sheets also appear as numbered equations in the text. On the other hand, many of the equations and formulas quoted in the text are not dignified with numbers - which means that they are not important enough to be remembered even by people who like remembering formulas. Such unimportant formulas are usually just examples of special cases which can be derived from more basic relations, or looked up in books, when they are needed. Unless the learning goals explicitly state otherwise you are not expected to be able to reproduce mathematical derivations from this text. The few mathematical derivations which are included in the text are intended as aids to understanding, not as things to be remembered

HOW TO USE THIS TEXT

This text and its five companion volumes define the course, so they are your primary reference and study material. Four of the six units are accompanied by one video lecture for each chapter of the text. The video lectures and live lectures are supplementary resources, but they do not define the course. Some, but not all, chapters of the text have a section labelled LECTURE which usually follows the same sequence as the video lecture. However if you try to read the book while watching the video lecture - a practice which is not recommended - you may find some discrepancies. Where differences do occur, the text version is to be preferred. (You probably won't even notice the differences unless you constantly refer to the book during the lectures.)

Some of the differences between text and videos include the following.

- There are some changes in symbols used for physical quantities. The text has been changed to achieve consistency throughout the course or to match the most commonly used symbols.
- There are some references in the video lectures to early versions of the course ‘notes’ and to other things that are no longer considered to be relevant. Just ignore these if they don't appear in the text.

FORCES AND ENERGY

INTRODUCTION

This is not a traditional mechanics course. As the name of the unit implies, we have concentrated on two concepts: *force* and *energy*.

Forces are required to support plants and vertebrates and to enable birds, animals and marine creatures to move in their environment. Forces transport materials within the cells and blood streams of organisms. These applications would not be discussed in conventional mechanics courses.

The concept of energy has undoubtedly been the largest single contribution of physics to the life sciences. A reasonable definition of a living object is one capable of organising the flow of energy to meet its own requirements. In the second half of this unit we deal with the forms of mechanical energy and the transfers and balances that occur. These ideas will be carried over into the later units which treat other forms of energy: electrical, thermal, light and nuclear.

We have deliberately emphasised graphical techniques rather than formal manipulations of mathematical equations because we feel that this is more appropriate for a life sciences course. Many, if not most, of the elegant mathematical models of physics can be used in life sciences applications only if somewhat gross approximations are made. The underlying physical laws, however, continue to apply. Even if it is impossible to write down a mathematical expression for the quantities that enter, precise information can still be extracted from graphs.

The most important contribution to the learning process is the work you do yourself.

Don't make the mistake of taking on a passive role: simply attending lectures and/or reading through the notes and the answers to the post-lecture questions. At best, this will give you a superficial impression of the course material. What you need is practice in trying to answer questions that you have not seen before.

We suggest that after each video lecture you go through the objectives at the start of that chapter and, with the help of the notes, try to attain those objectives. You should also read the POST-LECTURE material and attempt the REVIEW QUESTIONS. If you have difficulty with a particular question go back over the relevant section of the notes and then try again. Consult the answer in the back only after you have made a serious attempt to complete the question. If your answer does not agree with the one given, make a note of the question and try it again at a later date; if you can't understand the answer given, see your lecturer.

OBJECTIVES

Minimum learning goals

When you have finished studying this unit you should be able to do all of the following.

1. Recall and use SI units and symbols for dynamical quantities including the SI prefixes giga (G), mega (M), kilo (k), milli (m), micro (μ), nano (n) and pico (p).

2. Recall and use the following data :

acceleration due to gravity	≈	10 $m.s^{-2}$
mass of an apple	≈	0.1 kg
weight of an apple	≈	1 N
mass of a person	≈	70 kg
weight of a person	≈	700 N
density of water	=	1.0×10^3 $kg.m^{-3}$
atmospheric pressure	≈	1×10^5 Pa (100 kPa, 0.1 MPa).

INTERLUDE 1 - THE RANGE OF LENGTHS IN THE UNIVERSE