

UNIT 1: Quantities and their measurement

Recommended Prior Knowledge Students should be aware of the nature of a physical measurement, in terms of a magnitude and a unit. They should have experience of making and recording simple measurements in a laboratory.

Context Unit 1 provides an introduction to quantities, units and their measurement. Quantities and units are an essential part of all Units. Furthermore, the skills of measurement must be practised throughout the whole course. The content of this Unit is assessed not only in the 'theory' papers but also as part of the practical assessment.

Outline Part of the content of this Unit should be revision. However, students will learn to appreciate that quantities have a magnitude and unit. Furthermore, quantities can be categorised as scalars or vectors and these require different treatments when combining them. Techniques of measurement of the quantities will be practised with the objective of introducing and developing skills. A consideration of precision and accuracy will lead to a critical approach to the choice of techniques of measurement.

Learning Outcomes		Suggested Teaching Activities	Resources
	Candidates should be able to		
1.(a)	show an understanding that all physical quantities consist of a numerical value and a unit.	Question / Answer – general discussion List quantities / units with which students are familiar.	Reference should be made to the list of textbooks printed in the Syllabus document. Note that some of these texts are more suitable as reference texts for the teacher whilst others are more suitable as student texts. Some Internet sites are shown within certain topics. The list of sites is by no means comprehensive but provides examples of what is available. Material may provide a link with O-level and IGCSE studies, thus providing background experience, as well as reinforcing AS studies. All examples of examination questions are taken from Physics 8702 and 9702 Papers.

1.(f)	use the following prefixes and their symbols to indicate decimal sub-multiples or multiples of both base and derived units: pico (p), nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G), tera (T).	<p>Introduce their symbols. Use of index notation, rather than solidus</p> <p>Students will mention 'kilometres', 'millimetres' etc. rather than just 'metres'. Draw up table in order of magnitude of the multiples and sub-multiples, their symbols and 'powers of ten'. Consider $m\ s^{-1}$ and ms to emphasise careful spacing etc</p>	<p>Measuring instruments with sub-multiples and multiples e.g. metre rules, ammeters, milliammeters, timers</p> <p>See also Specimen Paper 2, question 1</p>
1.(g)	make reasonable estimates of physical quantities included within the syllabus.	<p>Students to work in pairs – estimate and write down estimate of various quantities. Then measure quantity and compare! e.g. height of bench, length of room / pencil diameter of pencil / pencil lead volume of brick / liquid in drinking cup mass of brick / person / nail time between heartbeats / period of pendulum</p> <p>N.B. estimates to be made in all of Units 1 – 5 wherever appropriate.</p>	<p>metre rule, measuring cylinder, stopclocks spring balance, top-pan balance Prepared worksheet.</p> <p>See May/June 2001, Paper 1, question 3 May/June 2002, Paper 2, question 1</p>
1.(b)	<p>recall the following base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K).</p> <p>n.b. Amount of substance (mol) is in A2</p>	<p>Question / Answer – general discussion. List units and symbols Why base units?</p> <p>N.B. It is important to realise that the work on measurement techniques is an introduction to the topic so that students may be aware of the various means of measurement that they are expected to carry out. Throughout the whole course, the techniques must be revised and practised, as and when appropriate to the</p>	<p>See Oct/Nov 2001, Paper 1, question 1 May/June 2002, Paper 1, question 1</p>

2(a)	use techniques for the measurement of length, volume, angle, mass, time, temperature and electrical quantities appropriate to the ranges of magnitude implied by the relevant parts of the syllabus. In particular, candidates should be able to	<p>'theory' work.</p> <p>Students do need time to practise measurement techniques. Although the fundamentals may be demonstrated, they should be given an opportunity to try out the procedures for themselves. These procedures can be practised either as each one is introduced or as a number of 'circus' sessions.</p> <p>Students to be encouraged to think about, and write down the 'accuracy' of their measurements.</p>	
2.(a)1	measure lengths using a ruler, vernier scale and micrometer.	<p>Use of set square with a metre rule – parallax errors.</p> <p>Discuss how to measure the thickness of a sheet of paper / the diameter of a wire.</p> <p>Introduce vernier callipers, micrometer screw gauge.</p> <p>Need for 'zero error' reading, here and when taking other measurements.</p>	<p>For longer exercises based on Learning Outcome 2(a), it is recommended that reference is made to the questions in Specimen Paper 3 May/June 2001, Paper 3 Oct/Nov 2001, Paper 3 May/June 2002, Paper 3</p> <p>short lengths of wire of different diameters and lengths</p> <p>pendulum (about 80 cm long) metre rule, set square</p> <p>micrometer screw gauge half-metre / metre rule</p>

		<p>Expt: measure the length of a pendulum</p> <p>Expt: measure the diameter and volume of a short length of wire</p> <p>Expt: measuring the internal and external diameter of a tube</p>	<p>short lengths of tubing e.g. water pipe</p> <p>vernier calipers</p> <p>See also Specimen Paper 1, question 5</p>
2(a)2	measure weight and hence mass using spring and lever balances.	<p>Revise use of spring balance (newton-meter) / top-pan balance / lever balance</p> <p>Expt: measure the mass of 145 cm³ water</p> <p>Expt: Find the weight of a brick</p>	<p>top-pan balance, measuring cylinder</p> <p>brick, string, newton-meter</p>
2(a)3	measure an angle using a protractor.	<p>Revise correct use of a protractor.</p> <p>Expt: Measure angle of incidence and refraction</p>	<p>Paper, ray box, rectangular glass block</p> <p>protractor</p>
2(a)4	measure time intervals using clocks, stopwatches.	<p>Revise correct use of stopwatch / timer.</p> <p>Need for repeat readings, timing multiple oscillations, starting count at 0 and not 1 etc.</p> <p>Expt: Period of oscillation of a simple pendulum / a cantilever</p>	<p>stopwatch / stopclock, simple pendulum, cantilever (a clamped metre rule with a 200 g mass attached to its free end is suitable)</p>
2(a)5	measure temperature using a thermometer as a sensor.	<p>Revise correct use of liquid-in-glass thermometer.</p> <p>Introduce solid-state temperature probe if available.</p> <p>Introduce data logging (if available)</p> <p>Expt: cooling curve of two different masses of water</p>	<p>Solid-state probe and display</p> <p>-10°C to 110°C thermometer, 250 cm³ beaker, hot water, stopclock</p> <p>Data logger with means of storage and display</p>
2(a)6	use ammeters and voltmeters with appropriate scales.	<p>Revise correct connection of meters in circuits.</p> <p>Changing ranges of meters</p>	<p>ammeter, voltmeter, low voltage power supply, switch, resistors, connecting leads (digital and analogue meters and variable range meters, if available)</p> <p>Data logger with means of storage and display</p>
2.(b)	use both analogue and digital displays.	<p>Use of analogue and digital meters (if available)</p> <p>Expt: Measuring current and voltage in series / parallel circuits</p>	

2(a)7	use a galvanometer in null methods.	Demonstration only – to be re-introduced in Unit 3 Demonstration: p.d. along a current-carrying wire	potentiometer, current-carrying wire, galvanometer, metre rule
2(a)8	use a cathode-ray oscilloscope.	Introduction to / revision of c.r.o. - the Y-plate sensitivity and use for measuring voltages Expt: measuring direct and alternating voltages (and currents?)	resistor connected to d.c. / a.c. supply c.r.o., leads
2(a)4	measure time intervals using the calibrated time-base of a cathode-ray oscilloscope (c.r.o).	Introduction to / revision of c.r.o. - the timebase and use for measuring times Expt: measuring the time period of a low-voltage a.c. supply	low-voltage a.c. supply, c.r.o. connecting leads See Specimen Paper 1, question 6 Oct/Nov 2001, Paper 1, question 4 May/June 2001, Paper 1, question 4
2(c)	use calibration curves.	Use of a calibration curve Expt: temperature measurement using a bead thermistor	bead thermistor, ohm-meter, 10°C - 40°C water bath, mercury-in-glass thermometer
2.(e)	show an understanding of the distinction between precision and accuracy.	Discussion :look at different length-measuring instruments - what is the smallest distance that can be measured? Precision of instrument - idea of precision of instruments - record as e.g. 14.2 ± 0.2 cm Accuracy of readings Re-visit of recording of readings in previous experiments	metre rule, 30 cm rule, vernier callipers, micrometer screw gauge See May/June 2001, Paper 1, question 5 May/June 2002, Paper 2, question 2(b)

2.(d)	show an understanding of the distinction between systematic errors (including zero errors) and random errors.	Discussion of experiments to identify random errors and systematic errors. How to reduce / eliminate such errors. (i.e. omit eliminate)	Apparatus used under learning outcome 2(a) See Specimen Paper 1, question 4 Oct/Nov 2001, Paper 1, question 3 Oct/Nov 2001, Paper 2, question 2(b) May/June 2001, Paper 1, question 5 May/June 2002, Paper 2, question 2(a)
2.(f)	assess the uncertainty in a derived quantity by simple addition of actual, fractional or percentage uncertainties (a rigorous statistical treatment is not required).	Equations and combining uncertainties – rules Expression of final result: significant figures	Worksheet including Oct/Nov 2001, Paper 1, question 5 May/June 2001, Paper 1, question 6 May/June 2002, Paper 1, question 5
1.(e)	show an understanding and use the conventions for labelling graph axes and table columns as set out in the ASE publication <i>SI Units, Signs, Symbols and Abbreviations</i> , except where these have been superseded by <i>Signs, Symbols and Systematics (The ASE Companion to 5-16 Science, 1995)</i>	Discussion / revision – plotting a graph – drawing a tangent – determining a gradient – determining an intercept Discussion / revision - table columns and headings - sig. figs. in columns Note: this Outcome is on-going. An introduction is provided here. Discussion	Worksheet: exercise to plot and evaluate information from a graph. <i>SI Units, Signs, Symbols and Abbreviations</i> <i>Signs, Symbols and Systematics (The ASE Companion to 5-16 Science, 1995)</i>
1.(c)	express derived units as the products or quotients of the base units and use the named units listed on pages 45 and 46 of the Syllabus as appropriate.	Discussion and class examples Work ($\text{kg m}^2 \text{s}^{-2}$) and moment of force ($\text{kg m}^2 \text{s}^{-2}$)	Handout: Summary of Key Quantities, Symbols and Units (to be found in the Syllabus document) Examples handout including Specimen Paper 1, question 2 May/June 2001, Paper 2, question 1(a)

1.(d)	use base units to check the homogeneity of physical equations	Units of a constant e.g. power = $P = Fv$ or $E = \frac{1}{2}mv^2 + mgh$ Check of $p + \frac{1}{2}\rho v^2 = \text{constant}$	Examples handout including May/June 2001, Paper 2 question 1(b) May/June 2002, Paper 1, question 3
1.(j)	distinguish between scalar and vector quantities and give examples of each.	Discussion: speed and velocity distance moved and displacement Concept of scalar and vector Examples of each discussed	Examples sheet including Specimen Paper 1, question 1 May/June 2001, Paper 1, question 1
1.(k)	add and subtract coplanar vectors.	Discussion: vector represented as an arrow idea of a resultant of two vectors use of vector triangle Expt: 'verify' use of vector triangle Discussion: examples of use of triangle - scale drawing - sketch and calculation	Three newton meters, thread, chalk, white paper
1.(l)	represent a vector as two perpendicular components	Discussion of vector subtraction Discussion: Single vector as two perpendicular components Use of $\sin\theta$ and $\cos\theta$ Why resolve into components	Examples sheet including May/June 2001, Paper 1, question 2 Oct/Nov 2001, Paper 1 question 2 Oct/Nov 2001, Paper 2, question 3(b) May/June 2002, Paper 1, question 2