Measurement Techniques

Question paper 1

Level	International A Level
Subject	Physics
Exam Board	CIE
Topic	Measurement Techniques
Sub Topic	
Paper Type	Theory
Booklet	Question paper 1

Time Allowed: **89 minutes**

Score: **/74**

Percentage: **/100**

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

1 (a) Define *pressure*.

.... [1]

(b) A cylinder is placed on a horizontal surface, as shown in Fig. 2.1.

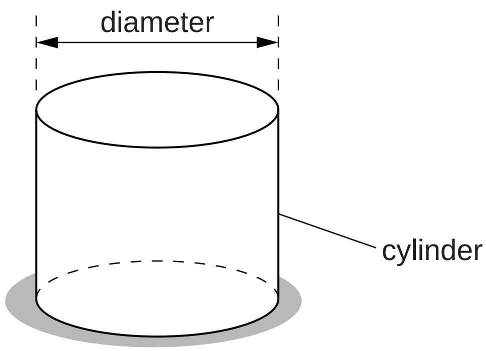

Fig. 2.1

The following measurements were made on the cylinder:

mass = 5.09 ± 0.01 kg
diameter = 9.4 ± 0.1 cm.

(i) Calculate the pressure produced by the cylinder on the surface.

pressure = ... Pa [3]

(ii) Calculate the actual uncertainty in the pressure.

actual uncertainty = ... Pa [3]

(iii) State the pressure, with its actual uncertainty.

pressure = ... ± .... Pa [1]

2 A coin is made in the shape of a thin cylinder, as shown in Fig. 2.1.

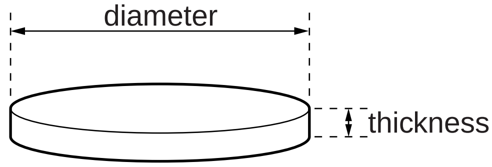

Fig. 2.1

Fig. 2.2 shows the measurements made in order to determine the density ρ of the material used to make the coin.

quantity	measurement	uncertainty
mass	9.6 g	± 0.5 g
thickness	2.00 mm	± 0.01 mm
diameter	22.1 mm	± 0.1 mm

Fig. 2.2

(a) Calculate the density ρ in kg m^{-3}.

ρ = ...kg m^{-3} [3]

(b) (i) Calculate the percentage uncertainty in ρ.

percentage uncertainty = ... [3]

(ii) State the value of ρ with its actual uncertainty.

ρ = ... ± .... kg m^{-3} [1]

3 The time T for a satellite to orbit the Earth is given by

$$T = \sqrt{\left(\frac{KR^3}{M}\right)}$$

where R is the distance of the satellite from the centre of the Earth,
M is the mass of the Earth,
and K is a constant.

(a) Determine the SI base units of K.

SI base units of K .... [2]

(b) Data for a particular satellite are given in Fig. 2.1.

quantity	measurement	uncertainty
T	8.64×10^4 s	± 0.5%
R	4.23×10^7 m	± 1%
M	6.0×10^{24} kg	± 2%

Fig. 2.1

Calculate K and its actual uncertainty in SI units.

K = ... ± .... SI units [4]

4 **(a)** Define electrical *resistance*.

....

.... [1]

(b) A circuit is set up to measure the resistance *R* of a metal wire. The potential difference (p.d.) *V* across the wire and the current *I* in the wire are to be measured.

(i) Draw a circuit diagram of the apparatus that could be used to make these measurements.

[3]

(ii) Readings for p.d. *V* and the corresponding current *I* are obtained. These are shown in Fig. 2.1.

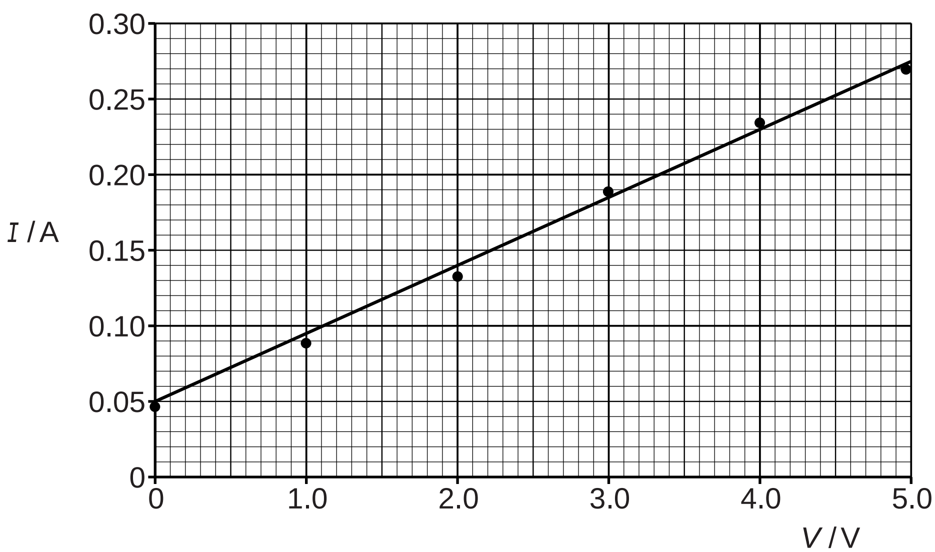

Fig. 2.1

Explain how Fig. 2.1 indicates that the readings are subject to

1. a systematic uncertainty,

....

.... [1]

2. random uncertainties.

....

.... [1]

(iii) Use data from Fig. 2.1 to determine *R*. Explain your working.

R = ... Ω [3]

(c) In another experiment, a value of *R* is determined from the following data:

Current $I = 0.64 \pm 0.01\,A$ and p.d. $V = 6.8 \pm 0.1\,V$.

Calculate the value of *R*, together with its uncertainty. Give your answer to an appropriate number of significant figures.

R = ... ± ....Ω [3]

5 The volume V of liquid flowing in time t through a pipe of radius r is given by the equation

$$\frac{V}{t} = \frac{\pi P r^4}{8Cl}$$

where P is the pressure difference between the ends of the pipe of length l, and C depends on the frictional effects of the liquid.

An experiment is performed to determine C. The measurements made are shown in Fig. 1.1.

$\frac{V}{t}$ / $10^{-6}\,m^3\,s^{-1}$	P / $10^3\,N\,m^{-2}$	r / mm	l / m
1.20 ± 0.01	2.50 ± 0.05	0.75 ± 0.01	0.250 ± 0.001

Fig. 1.1

(a) Calculate the value of C.

C = ... $N\,s\,m^{-2}$ [2]

(b) Calculate the uncertainty in C.

uncertainty = ... $N\,s\,m^{-2}$ [3]

(c) State the value of C and its uncertainty to the appropriate number of significant figures.

C = ... ± .... $N\,s\,m^{-2}$ [1]

6 Measurements made for a sample of metal wire are shown in Fig. 1.1.

quantity	measurement	uncertainty
length	1750 mm	± 3 mm
diameter	0.38 mm	± 0.01 mm
resistance	7.5 Ω	± 0.2 Ω

Fig. 1.1

(a) State the appropriate instruments used to make each of these measurements.

(i) length

.... [1]

(ii) diameter

.... [1]

(iii) resistance

.... [1]

(b) **(i)** Show that the resistivity of the metal is calculated to be $4.86 \times 10^{-7}\,\Omega\,m$.

[2]

(ii) Calculate the uncertainty in the resistivity.

uncertainty = ± .... Ω m [4]

(c) Use the answers in **(b)** to express the resistivity with its uncertainty to the appropriate number of significant figures.

resistivity = ... ± .... Ω m [1]

7 (a) For each of the following, tick [✓] one box to indicate whether the experimental technique would reduce random error, systematic error or neither. The first row has been completed as an example.

	random error	systematic error	neither
keeping your eye in line with the scale and the liquid level for a single reading of a thermometer		✓	
averaging many readings of the time taken for a ball to roll down a slope			
using a linear scale on an ammeter			
correcting for a non-zero reading when a micrometer screw gauge is closed			

[2]

(b) The measurement of a particular time interval is repeated many times. The readings are found to vary. The results are shown in Fig. 1.1.

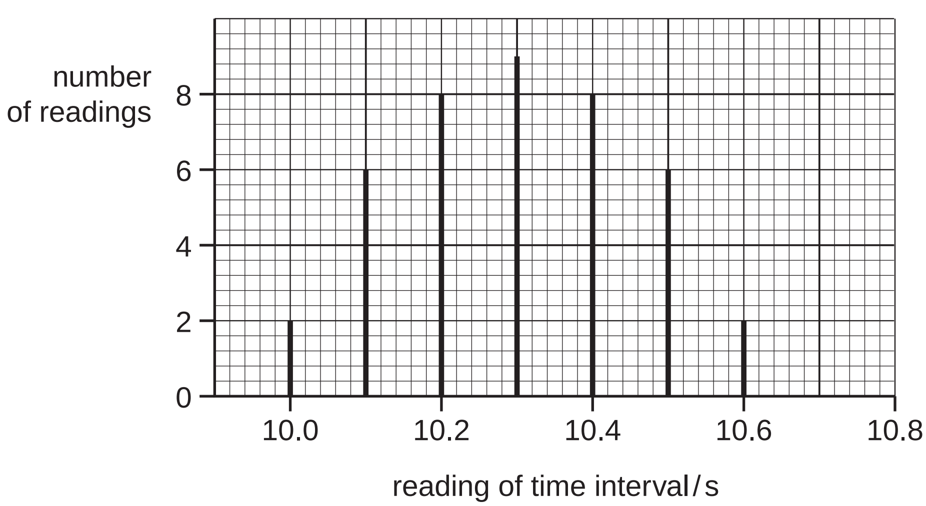

Fig. 1.1

The true value of the time interval is 10.1 s.

(i) State how the readings on Fig. 1.1 show the presence of

1. a systematic error,

....

....[1]

2. a random error.

....

....[1]

(ii) State the expected changes to Fig. 1.1 for experimental measurements that are

1. more accurate,

....

....[1]

2. more precise.

....

....[1]

8 A loudspeaker produces a sound wave of constant frequency.

Outline how a cathode-ray oscilloscope (c.r.o.) may be used to determine this frequency.

....

....

....

....

.... [4]

9 A student takes measurements to determine a value for the acceleration of free fall. Some of the apparatus used is illustrated in Fig. 4.1.

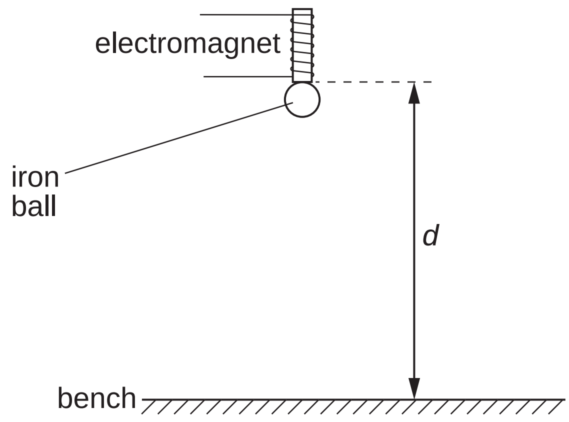

Fig. 4.1

The student measures the vertical distance *d* between the base of the electromagnet and the bench. The time *t* for an iron ball to fall from the electromagnet to the bench is also measured.
Corresponding values of t^2 and *d* are shown in Fig. 4.2.

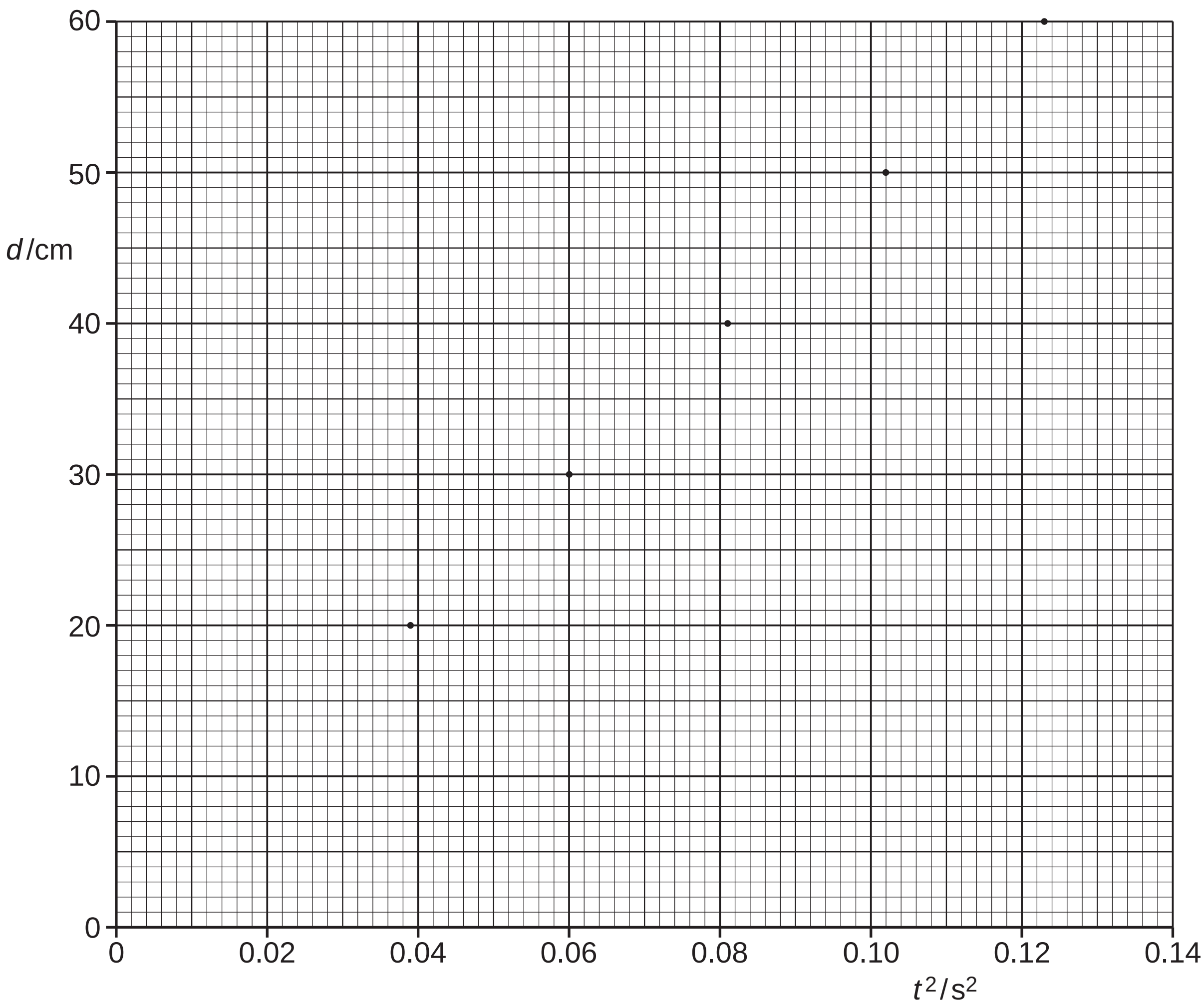

Fig. 4.2

(a) On Fig. 4.2, draw the line of best fit for the points. [1]

(b) State and explain why there is a non-zero intercept on the graph of Fig. 4.2.

....

....

.... [2]

(c) Determine the student's value for

(i) the diameter of the ball,

diameter = ... cm [1]

(ii) the acceleration of free fall.

acceleration = ... $m\,s^{-2}$ [3]

10 A metal wire has a cross-section of diameter approximately 0.8 mm.

(a) State what instrument should be used to measure the diameter of the wire.

.... [1]

(b) State how the instrument in **(a)** is

(i) checked so as to avoid a systematic error in the measurements,

....

.... [1]

(ii) used so as to reduce random errors.

....

....

.... [2]

11 A digital voltmeter with a three-digit display is used to measure the potential difference across a resistor. The manufacturers of the meter state that its accuracy is ±1% and ±1 digit.
The reading on the voltmeter is 2.05V.

(a) For this reading, calculate, to the nearest digit,

(i) a change of 1% in the voltmeter reading,

change = ...V [1]

(ii) the maximum possible value of the potential difference across the resistor.

maximum value = ...V [1]

(b) The reading on the voltmeter has high precision. State and explain why the reading may not be accurate.

....

....

....[2]