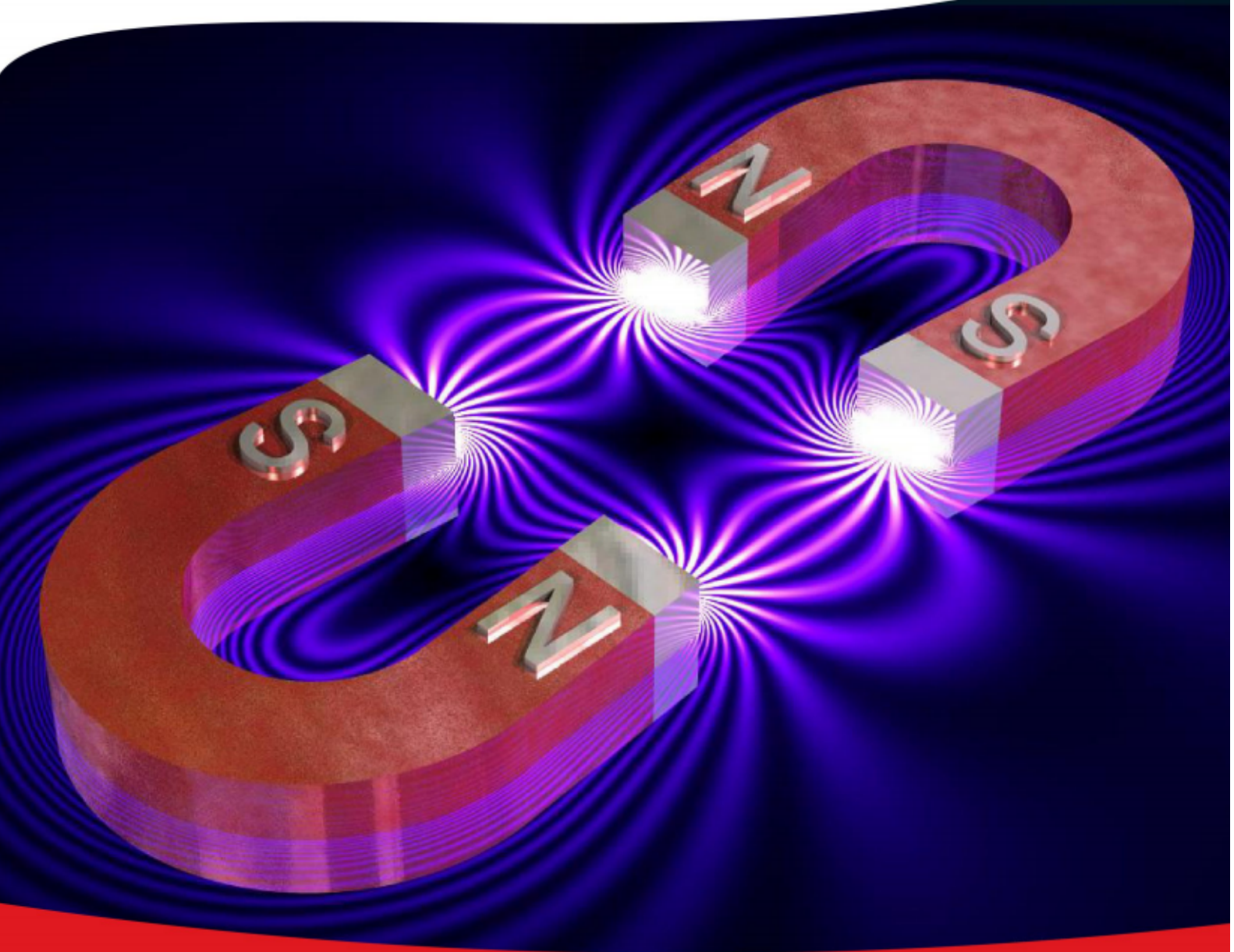
Cambridge International AS & A Level

PHYSICS (9702) P2

TOPIC WISE QUESTIONS + ANSWERS | COMPLETE SYLLABUS



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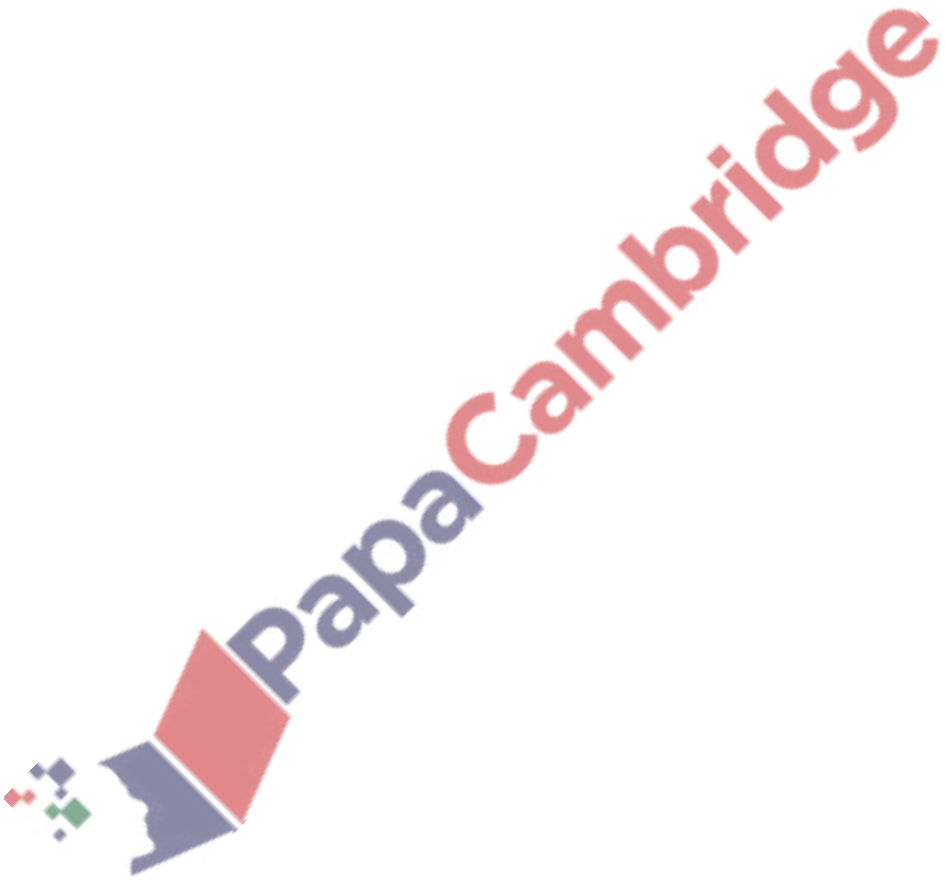
Chapter 2

Measurement techniques



2.1 Errors and uncertainties

11. 9702_m20_qp_22 Q: 1

(a) Length, mass and temperature are all SI base quantities.

State **two** other SI base quantities.

1. .....

2. .....

[2]

(b) The acceleration of free fall g may be determined from an oscillating pendulum using the equation

$$g = \frac{4\pi^2 l}{T^2}$$

where l is the length of the pendulum and T is the period of oscillation.

In an experiment, the measured values for an oscillating pendulum are

$l = 1.50\,\text{m} \pm 2\%$
and $T = 2.48\,\text{s} \pm 3\%$.

(i) Calculate the acceleration of free fall g.

$g =$ ..... m s^{-2} [1]

(ii) Determine the percentage uncertainty in g.

percentage uncertainty = ... % [2]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to determine the absolute uncertainty of the calculated value of g.

absolute uncertainty = ... m s^{-2} [1]

[Total: 6]

12. 9702_s20_qp_21 Q: 1

(a) Use an expression for work done, in terms of force, to show that the SI base units of energy are $\text{kg m}^2\text{s}^{-2}$.

[2]

(b) **(i)** The energy E stored in an electrical component is given by

$$E = \frac{Q^2}{2C}$$

where Q is charge and C is a constant.

Use this equation and the information in **(a)** to determine the SI base units of C.

SI base units ..... [2]

(ii) Measurements of a constant current in a wire are taken using an analogue ammeter.

For these measurements, describe one possible cause of:

1. a random error

.....

.....

2. a systematic error.

.....

.....

[2]

[Total: 6]

13. 9702_s19_qp_22 Q: 1

(a) The diameter d of a cylinder is measured as 0.0125 m ± 1.6%.

Calculate the absolute uncertainty in this measurement.

absolute uncertainty = ... m [1]

(b) The cylinder in **(a)** stands on a horizontal surface. The pressure p exerted on the surface by the cylinder is given by

$$p = \frac{4W}{\pi d^2}.$$

The measured weight W of the cylinder is 0.38 N ± 2.8%.

(i) Calculate the pressure p.

p = ... $\mathrm{N\,m^{-2}}$ [1]

(ii) Determine the absolute uncertainty in the value of p.

absolute uncertainty = ... $\mathrm{N\,m^{-2}}$ [2]

[Total: 4]

14. 9702_w19_qp_21 Q: 1

(a) Make estimates of:

(i) the mass, in g, of a new pencil

mass = ... g [1]

(ii) the wavelength of ultraviolet radiation.

wavelength = ... m [1]

(b) The period T of the oscillations of a mass m suspended from a spring is given by

$$T = 2\pi\sqrt{\frac{m}{k}}$$

where k is the spring constant of the spring.

The manufacturer of a spring states that it has a spring constant of $25\,\text{N m}^{-1} \pm 8\%$. A mass of $200 \times 10^{-3}\,\text{kg} \pm 4 \times 10^{-3}\,\text{kg}$ is suspended from the end of the spring and then made to oscillate.

(i) Calculate the period T of the oscillations.

T = ... s [1]

(ii) Determine the value of T, with its absolute uncertainty, to an appropriate number of significant figures.

T = ... ± ..... s [3]

[Total: 6]

15. 9702_s18_qp_23 Q: 1

(a) An analogue voltmeter is used to take measurements of a constant potential difference across a resistor.

For these measurements, describe **one** example of

(i) a systematic error,

.....

.....[1]

(ii) a random error.

.....

.....[1]

(b) The potential difference across a resistor is measured as 5.0 V ± 0.1 V. The resistor is labelled as having a resistance of 125 Ω ± 3%.

(i) Calculate the power dissipated by the resistor.

power = ... W [2]

(ii) Calculate the percentage uncertainty in the calculated power.

percentage uncertainty = ... % [2]

(iii) Determine the value of the power, with its absolute uncertainty, to an appropriate number of significant figures.

power = ... ± ..... W [2]

[Total: 8]

16. 9702_s17_qp_21 Q: 1

(a) Determine the SI base units of stress.
Show your working.

base units .....[2]

(b) A beam PQ is clamped so that the beam is horizontal. A mass M of 500 g is hung from end Q and the beam bends slightly, as illustrated in Fig. 1.1.

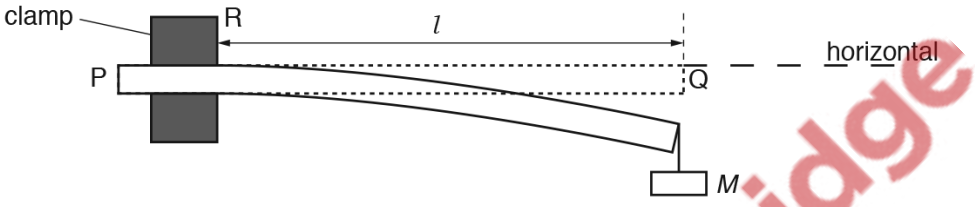


Fig. 1.1

The length l of the beam from the edge of the clamp R to end Q is 60.0 cm. The width b of the beam is 30.0 mm and the thickness d of the beam is 5.00 mm. The material of the beam has Young modulus E.

The mass M is made to oscillate vertically. The time period T of the oscillations is 0.58 s.

The period T is given by the expression

$$T = 2\pi\sqrt{\frac{4Ml^3}{Ebd^3}}.$$

(i) Determine E in GPa.

E = ...GPa [3]

(ii) The quantities used to determine *E* should be measured with accuracy and with precision.

1. Explain the difference between accuracy and precision.

accuracy: .....

.....

precision: .....

.....

[2]

2. In a particular experiment, the quantities l and T are measured with the same percentage uncertainty. State and explain which of these two quantities contributes more to the uncertainty in the value of *E*.

.....

.....

.....[1]

[Total: 8]

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17. 9702_s17_qp_22 Q: 1

(a) State two SI base units other than kilogram, metre and second.

1. .....

2. .....

[1]

(b) Determine the SI base units of resistivity.

base units .....[3]

(c) **(i)** A wire of cross-sectional area 1.5 mm^2 and length 2.5 m has a resistance of 0.030 Ω. Calculate the resistivity of the material of the wire in nΩ m.

resistivity = ...nΩ m [3]

(ii) **1.** State what is meant by *precision*.

.....

.....

2. Explain why the precision in the value of the resistivity is improved by using a micrometer screw gauge rather than a metre rule to measure the diameter of the wire.

.....

.....

.....

[2]

[Total: 9]

18. 9702_w17_qp_22 Q: 1

One end of a wire is connected to a fixed point. A load is attached to the other end so that the wire hangs vertically.

The diameter d of the wire and the load F are measured as

$d = 0.40 \pm 0.02\,\text{mm}$,
$F = 25.0 \pm 0.5\,\text{N}$.

(a) For the measurement of the diameter of the wire, state

(i) the name of a suitable measuring instrument,

.....[1]

(ii) how random errors may be reduced when using the instrument in **(i)**.

.....

.....

.....[2]

(b) The stress σ in the wire is calculated by using the expression

$$\sigma = \frac{4F}{\pi d^2}.$$

(i) Show that the value of σ is $1.99 \times 10^8\,\text{N m}^{-2}$.

[1]

(ii) Determine the percentage uncertainty in σ.

percentage uncertainty = ...% [2]

(iii) Use the information in **(b)(i)** and your answer in **(b)(ii)** to determine the value of σ, with its absolute uncertainty, to an appropriate number of significant figures.

σ = ... ± ..... $N\,m^{-2}$ [2]

[Total: 8]

---

19. 9702_m16_qp_22 Q: 1

The speed v of a transverse wave on a uniform string is given by the expression

$$v = \sqrt{\frac{Tl}{m}}$$

where T is the tension in the string, l is its length and m is its mass.

An experiment is performed to determine the speed v of the wave. The measurements are shown in Fig. 1.1.

quantity	measurement	uncertainty
T	1.8N	± 5%
l	126cm	± 1%
m	5.1g	± 2%

Fig. 1.1

(a) State an appropriate instrument to measure the length l.

..... [1]

(b) **(i)** Use the data in Fig. 1.1 to calculate the speed v.

v = ... $m\,s^{-1}$ [2]

(ii) Use your answer in **(b)(i)** and the data in Fig. 1.1 to determine the value of v, with its absolute uncertainty, to an appropriate number of significant figures.

v = ... ± .....$m\,s^{-1}$ [3]

[Total: 6]

20. 9702_s16_qp_21 Q: 1

(a) Make estimates of

(i) the mass, in kg, of a wooden metre rule,

mass = ... kg [1]

(ii) the volume, in cm^3, of a cricket ball or a tennis ball.

volume = ... cm^3 [1]

(b) A metal wire of length L has a circular cross-section of diameter d, as shown in Fig. 1.1.

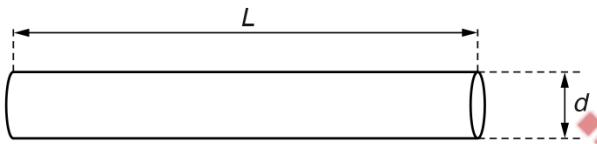

Fig. 1.1

The volume V of the wire is given by the expression

$$V = \frac{\pi d^2 L}{4}.$$

The diameter, length and mass M are measured to determine the density of the metal of the wire. The measured values are:

$d = 0.38 \pm 0.01$ mm,
$L = 25.0 \pm 0.1$ cm,
$M = 0.225 \pm 0.001$ g.

Calculate the density of the metal, with its absolute uncertainty. Give your answer to an appropriate number of significant figures.

density = ... ± ..... $kg\,m^{-3}$ [5]

[Total: 7]

21. 9702_s16_qp_23 Q: 2

(a) Describe the effects, one in each case, of systematic errors and random errors when using a micrometer screw gauge to take readings for the diameter of a wire.

systematic errors: .....

.....

random errors: .....

.....

[2]

(b) Distinguish between precision and accuracy when measuring the diameter of a wire.

precision: .....

.....

accuracy: .....

.....

[2]

[Total: 4]

22. 9702_s15_qp_23 Q: 4

Fig. 4.1 shows the values obtained in an experiment to determine the Young modulus E of a metal in the form of a wire.

quantity	value	instrument
diameter d	0.48 mm	
length l	1.768 m	
load F	5.0 N to 30.0 N in 5.0 N steps	
extension e	0.25 mm to 1.50 mm	

Fig. 4.1

(a) **(i)** Complete Fig. 4.1 with the name of an instrument that could be used to measure each of the quantities. [3]

(ii) Explain why a series of values of F, each with corresponding extension e, are measured.

.....

.....[1]

(b) Explain how a series of readings of the quantities given in Fig. 4.1 is used to determine the Young modulus of the metal. A numerical answer for E is not required.

.....

.....

.....

.....[2]

23. 9702_w15_qp_21 Q: 1

(a) State two SI base quantities other than mass, length and time.

1. .....

2. .....

[2]

(b) A beam is clamped at one end and an object X is attached to the other end of the beam, as shown in Fig. 1.1.

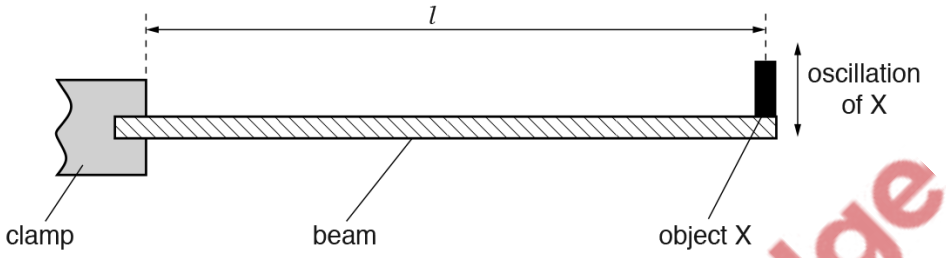

Fig. 1.1

The object X is made to oscillate vertically.

The time period T of the oscillations is given by

$$T = K\sqrt{\frac{Ml^3}{E}}$$

where M is the mass of X,
l is the length between the clamp and X,
E is the Young modulus of the material of the beam
and K is a constant.

(i) 1. Show that the SI base units of the Young modulus are $\text{kg m}^{-1}\text{ s}^{-2}$.

2. Determine the SI base units of K.

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

(ii) Data in SI units for the oscillations of X are shown in Fig. 1.2.

quantity	value	uncertainty
T	0.45	± 2.0%
l	0.892	± 0.2%
M	0.2068	± 0.1%
K	1.48×10^5	± 1.5%

Fig. 1.2

Calculate E and its actual uncertainty.

E = ... ± ..... kg m^{-1} s^{-2} [4]