1. **(a)** Underline **all** the SI base units in the following list.

ampere coulomb current kelvin newton [1]

(b) A toy car moves in a horizontal straight line. The displacement *s* of the car is given by the equation

$$s = \frac{v^2}{2a}$$

where *a* is the acceleration of the car and *v* is its final velocity.

State **two** conditions that apply to the motion of the car in order for the above equation to be valid.

1 ....

2 ....
[2]

(c) An experiment is performed to determine the acceleration of the car in **(b)**. The following measurements are obtained:

$s = 3.89\,\text{m} \pm 0.5\%$
$v = 2.75\,\text{m}\,\text{s}^{-1} \pm 0.8\%.$

(i) Calculate the acceleration *a* of the car.

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

(ii) Determine the percentage uncertainty, to two significant figures, in *a*.

percentage uncertainty = ... % [2]

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

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

[Total: 7]

2. (a) State what is meant by work done.

....

.... [1]

(b) Use the answer to **(a)** to determine the SI base units of power.

SI base units .... [2]

(c) The maximum useful output power P of a car travelling on a horizontal road is given by

$$P = v^3 b$$

where v is the maximum speed of the car and b is a constant.

For the car,

$P = 84\,\text{kW} \pm 5\%$
and $b = 0.56 \pm 7\%$ in SI units.

(i) Calculate the value of v.

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

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

absolute uncertainty = ... $\text{m}\,\text{s}^{-1}$ [2]

[Total: 7]

3. (a) The boxes in Fig. 1.1 contain terms on the left-hand side and examples of these terms on the right-hand side.

Draw a line between each term on the left and the correct example on the right.

base quantity	coulomb
base unit	electric current
derived quantity	force
derived unit	kilogram

Fig. 1.1

[2]

(b) A set of experimental measurements is described as precise and not accurate.

State what is meant by:

(i) precise

....

.... [1]

(ii) not accurate.

....

.... [1]

(c) An object of mass m travels with speed v in a circle of radius r. The force F acting on the object is given by

$$F = \frac{mv^2}{r}.$$

The percentage uncertainties of three of the quantities are given in Table 1.1.

Table 1.1

quantity	percentage uncertainty
F	±3%
m	±4%
r	±5%

The value of v is determined from F, m and r.

(i) Calculate the percentage uncertainty in v.

percentage uncertainty = ... % [2]

(ii) The value of v is $15.0\,\mathrm{m\,s^{-1}}$.

Calculate the absolute uncertainty in v.

absolute uncertainty = ... $\mathrm{m\,s^{-1}}$ [1]

[Total: 7]

4. A solid metal sphere has a diameter of (3.42 ± 0.02) cm and a mass of (67 ± 2) g.

(a) Calculate the density, in $g\,cm^{-3}$, of the metal.

density = ... $g\,cm^{-3}$ [3]

(b) Determine the percentage uncertainty in the density.

percentage uncertainty = ... % [2]

[Total: 5]

5. (a) In the following list, underline all units that are SI base units.

ampere degree Celsius kilogram newton [1]

(b) Fig. 1.1 shows a horizontal beam clamped at one end with a block attached to the other end.

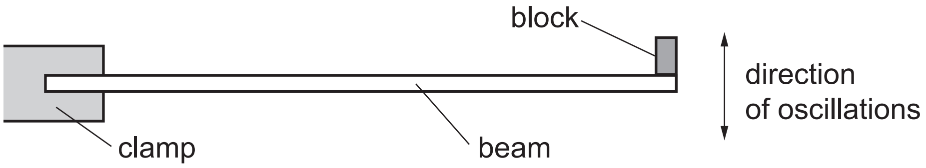


Fig. 1.1

The block is made to oscillate vertically.

The Young modulus *E* of the material of the beam is given by

$$E = \frac{kM}{T^2}$$

where *M* is the mass of the block,
T is the period of the oscillations
and *k* is a constant.

A student determines the values and percentage uncertainties of *k*, *M* and *T*.
Table 1.1 lists the percentage uncertainties.

Table 1.1

quantity	percentage uncertainty
k	±2.1%
M	±0.6%
T	±1.5%

The student uses the values of *k*, *M* and *T* to calculate the value of *E* as 8.245×10^9 Pa.

(i) Calculate the percentage uncertainty in the value of *E*.

percentage uncertainty = ... % [2]

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

E = (.................................... ± ....) × 10^9 Pa [2]

[Total: 5]

6. A sphere of radius 2.1 mm falls with terminal (constant) velocity through a liquid, as shown in Fig. 1.1.

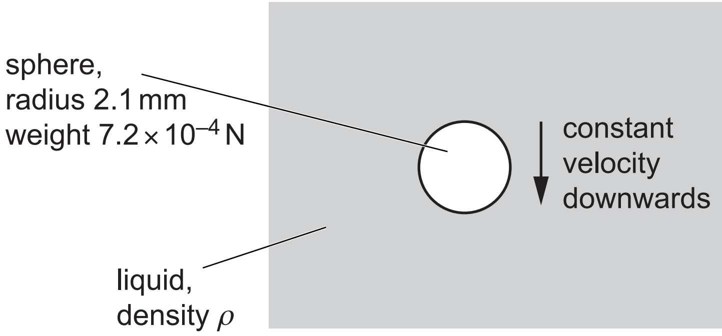


Fig. 1.1

Three forces act on the moving sphere. The weight of the sphere is 7.2×10^{-4} N and the upthrust acting on it is 4.8×10^{-4} N. The viscous force F_V acting on the sphere is given by

$$F_V = krv$$

where r is the radius of the sphere, v is its velocity and k is a constant. The value of k in SI units is 17.

(a) Determine the SI base units of k.

SI base units .... [2]

(b) Use the value of the upthrust acting on the sphere to calculate the density ρ of the liquid.

ρ = ... kg m^{-3} [3]

(c) **(i)** On the sphere in Fig. 1.1, draw three arrows to show the directions of the weight *W*, the upthrust *U* and the viscous force F_V. Label these arrows *W*, *U* and F_V respectively. [1]

(ii) Determine the magnitude of the terminal (constant) velocity of the sphere.

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

[Total: 8]

9702/22/O/N/21 Q1

7. **(a)** A unit may be stated with a prefix that represents a power-of-ten multiple or submultiple.

Complete Table 1.1 to show the name and symbol of each prefix and the corresponding power-of-ten multiple or submultiple.

Table 1.1

prefix	power-of-ten multiple or submultiple
kilo (k)	10^3
tera (T)	
( )	10^{-12}

[2]

(b) In the following list, underline all the units that are SI base units.

ampere coulomb metre newton [1]

(c) The potential difference V between the two ends of a uniform metal wire is given by

$$V = \frac{4\rho LI}{\pi d^2}$$

where d is the diameter of the wire,
I is the current in the wire,
L is the length of the wire,
and ρ is the resistivity of the metal.

For a particular wire, the percentage uncertainties in the values of some of the above quantities are listed in Table 1.2.

Table 1.2

quantity	percentage uncertainty
d	±3.0%
I	±2.0%
L	±2.5%
V	±3.5%

The quantities listed in Table 1.2 have values that are used to calculate ρ as $4.1 \times 10^{-7}\,\Omega\,m$.

For this value of ρ, calculate:

(i) the percentage uncertainty

percentage uncertainty = ... % [2]

(ii) the absolute uncertainty.

absolute uncertainty = ... $\Omega\,m$ [1]

[Total: 6]

9702/21/O/N/21 Q1

8. (a) Define *density*.

....

.... [1]

(b) A smooth pebble, made from uniform rock, has the shape of an elongated sphere as shown in Fig. 1.1.

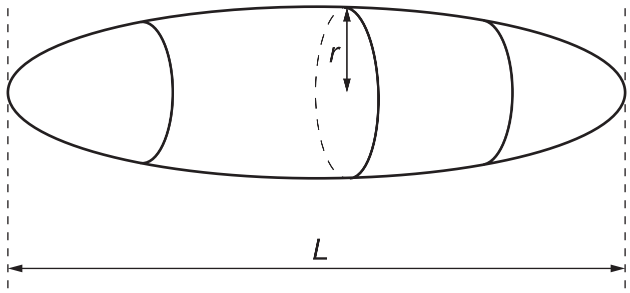


Fig. 1.1

The length of the pebble is L. The cross-section of the pebble, in the plane perpendicular to L, is circular with a maximum radius r.

A student investigating the density of the rock makes measurements to determine the values of L, r and the mass M of the pebble as follows:

$$L = (0.1242 \pm 0.0001)\,\text{m}$$
$$r = (0.0420 \pm 0.0004)\,\text{m}$$
$$M = (1.072 \pm 0.001)\,\text{kg}.$$

(i) State the name of a measuring instrument suitable for making this measurement of L.

.... [1]

(ii) Determine the percentage uncertainty in the measurement of r.

percentage uncertainty = ... % [1]

(c) The density ρ of the rock from which the pebble in **(b)** is composed is given by

$$\rho = \frac{Mr^n}{kL}$$

where n is an integer and k is a constant, with no units, that is equal to 2.094.

(i) Use SI base units to show that n is equal to –2.

[2]

(ii) Calculate the percentage uncertainty in ρ.

percentage uncertainty = ... % [3]

(iii) Determine ρ with its absolute uncertainty. Give your values to the appropriate number of significant figures.

ρ = (...................................... ± ....) $kg\,m^{-3}$ [3]

[Total: 11]

9702/23/M/J/21 Q1

9. (a) A property of a vector quantity, that is not a property of a scalar quantity, is direction. For example, velocity has direction but speed does not.

(i) State **two** other scalar quantities and **two** other vector quantities.

scalar quantities: .... and ....

vector quantities: .... and ....
[2]

(ii) State **two** properties that are possessed by both scalar and vector physical quantities.

1. ....

2. ....
[2]

(b) A ship at sea is travelling with a velocity of $13\,\mathrm{m\,s^{-1}}$ in a direction 35° east of north in still water, as shown in Fig. 1.1.

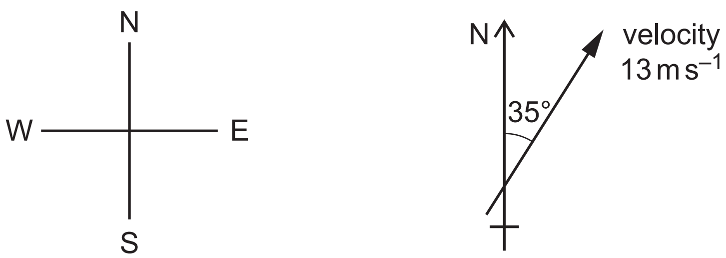


Fig. 1.1

(i) Determine the magnitudes of the components of the velocity of the ship in the north and the east directions.

north component of velocity = ... $\mathrm{m\,s^{-1}}$

east component of velocity = ... $\mathrm{m\,s^{-1}}$
[2]

(ii) The ship now experiences a tidal current. The water in the sea moves with a velocity of 2.7 m s^{-1} to the west.

Calculate the resultant velocity component of the ship in the east direction.

resultant east component of velocity = ... m s^{-1} [1]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to determine the magnitude of the resultant velocity of the ship.

magnitude of resultant velocity = ... m s^{-1} [2]

(iv) Use your answers in **(b)(i)** and **(b)(ii)** to determine the angle between north and the resultant velocity of the ship.

angle = ...° [2]

[Total: 11]

9702/22/M/J/21 Q1

10. **(a)** Complete Table 1.1 by stating whether each of the quantities is a vector or a scalar.

Table 1.1

quantity	vector or scalar
acceleration	
electrical resistance	
momentum	

[2]

9702/21/M/J/21 Q1

11. **(a)** Define *density*.

....

.... [1]

(b) Fig. 1.1 shows a solid pyramid with a square base.

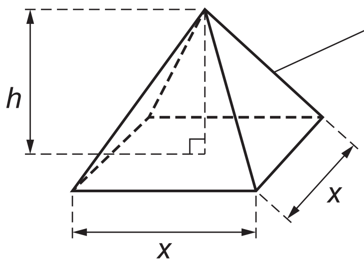


Fig. 1.1

The mass m of the pyramid is given by

$$m = \frac{1}{3}\rho h x^2$$

where ρ is the density of the material of the pyramid,
h is the height, and
x is the length of each side of the base.

Measurements are taken as shown in Table 1.1.

Table 1.1

quantity	measurement	percentage uncertainty
m	19.5 g	±2%
x	4.0 cm	±5%
h	4.8 cm	±4%

(i) Calculate the absolute uncertainty in length x.

absolute uncertainty = ... cm [1]

(ii) The density ρ is calculated from the measurements in Table 1.1.

Determine the percentage uncertainty in the calculated value of ρ.

percentage uncertainty = ... % [2]

(c) The square base of the pyramid in **(b)** rests on the horizontal surface of a bench.

Use data from Table 1.1 to calculate the average pressure of the pyramid on the surface of the bench. The uncertainty in your answer is not required.

pressure = ... Pa [3]

[Total: 7]

9702/22/F/M/21 Q1

12. (a) Complete Table 1.1 by stating whether each of the quantities is a vector or a scalar.

Table 1.1

quantity	vector or scalar
acceleration	
power	
work	

[2]

9702/22/O/N/20 Q1

13. **(a)** Complete Table 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

Table 1.1

quantity	scalar	vector
acceleration		
density		
temperature		
momentum		

[2]

9702/21/O/N/20 Q1

14. **(a)** **(i)** Define the *moment* of a force about a point.

....

.... [1]

(ii) Determine the SI base units of the moment of a force.

base units .... [1]

(b) A uniform rigid rod of length 2.4 m is shown in Fig. 1.1.

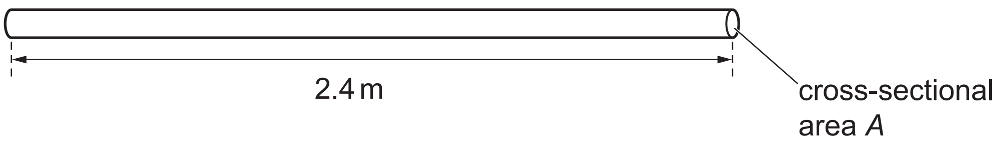


Fig. 1.1

The rod has a weight of 5.2 N and is made of wood of density 790 kg m^{-3}.

Calculate the cross-sectional area *A*, in mm^2, of the rod.

A = ... mm^2 [3]

9702/23/M/J/20 Q1

15. **(a)** State **one** similarity and **one** difference between *distance* and *displacement*.

similarity: ....

....

difference: ....

....
[2]

(b) A student takes several measurements of the same quantity. This set of measurements has high precision, but low accuracy.

Describe what is meant by:

(i) *high precision*

....

.... [1]

(ii) *low accuracy*.

....

.... [1]

[Total: 4]

9702/22/M/J/20 Q1

16.(a) Define *velocity*.

....

.... [1]

(b) The drag force F_D acting on a car moving with speed v along a straight horizontal road is given by

$$F_D = v^2 A k$$

where k is a constant and A is the cross-sectional area of the car.

Determine the SI base units of k.

SI base units .... [2]

(c) The value of k, in SI base units, for the car in **(b)** is 0.24. The cross-sectional area A of the car is $5.1\,m^2$.

The car is travelling with a constant speed along a straight road and the output power of the engine is 4.8×10^4 W. Assume that the output power of the engine is equal to the rate at which the drag force F_D is doing work against the car.

Determine the speed of the car.

speed = ... $m\,s^{-1}$ [3]

[Total: 6]

9702/21/M/J/20 Q1

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

[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]

9702/22/F/M/20 Q1

18. **(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]

9702/22/O/N/19 Q1

19.(a) Distinguish between vector and scalar quantities.

....

....

.... [2]

(b) The electric field strength E at a distance x from an isolated point charge Q is given by the equation

$$E = \frac{Q}{x^2 b}$$

where b is a constant.

(i) Use the definition of electric field strength to show that E has SI base units of $\text{kg m A}^{-1}\,\text{s}^{-3}$.

[2]

(ii) Use the units for E given in **(b)(i)** to determine the SI base units of b.

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

[Total: 6]

9702/21/O/N/19 Q1

20. **(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]

9702/23/M/J/19 Q1

21. **(a)** **(i)** Define *resistance*.

....

....[1]

(ii) A potential difference of 0.60 V is applied across a resistor of resistance 4.0 GΩ.

Calculate the current, in pA, in the resistor.

current = ... pA [2]

(b) The energy E transferred when charge Q moves through an electrical component is given by the equation

$$E = QV$$

where V is the potential difference across the component.

Use the equation to determine the SI base units of potential difference.

SI base units .... [3]

[Total: 6]

9702/22/M/J/19 Q1

22. **(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]

9702/21/M/J/19 Q1

23.(a) Define *velocity*.

....

....[1]

(b) The speed v of a sound wave through a gas of pressure P and density ρ is given by the equation

$$v = \sqrt{\frac{kP}{\rho}}$$

where k is a constant that has no units.

An experiment is performed to determine the value of k. The data from the experiment are shown in Fig. 1.1.

quantity	value	uncertainty
v	$3.3 \times 10^2\,\mathrm{m\,s^{-1}}$	± 3%
P	$9.9 \times 10^4\,\mathrm{Pa}$	± 2%
ρ	$1.29\,\mathrm{kg\,m^{-3}}$	± 4%

Fig. 1.1

(i) Use data from Fig. 1.1 to calculate k.

k = ... [2]

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

k = ... ± .... [3]

[Total: 6]

9702/22/F/M/19 Q1

24. (a) The ampere, metre and second are SI base units.

State **two** other SI base units.

1. ....

2. .... [2]

(b) The average drift speed v of electrons moving through a metal conductor is given by the equation:

$$v = \frac{\mu F}{e}$$

where e is the charge on an electron
F is a force acting on the electron
and μ is a constant.

Determine the SI base units of μ.

SI base units ....[3]

[Total: 5]

9702/23/M/J/18 Q1

25. **(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]

9702/22/M/J/18 Q1

26. (a) Define *force*.

....[1]

(b) State the SI base units of force.

....[1]

(c) The force F between two point charges is given by

$$F = \frac{Q_1 Q_2}{4\pi r^2 \varepsilon}$$

where Q_1 and Q_2 are the charges,
r is the distance between the charges,
ε is a constant that depends on the medium between the charges.

Use the above expression to determine the base units of ε.

base units ....[2]

[Total: 4]

9702/21/M/J/18 Q1

27. (a) State what is meant by a *scalar* quantity and by a *vector* quantity.

scalar: ....

....

vector: ....

....
[2]

(b) Complete Fig. 1.1 to indicate whether each of the quantities is a vector or a scalar.

quantity	vector or scalar
power	
temperature	
momentum	

Fig. 1.1

[2]

(c) An aircraft is travelling in wind. Fig. 1.2 shows the velocities for the aircraft in still air and for the wind.

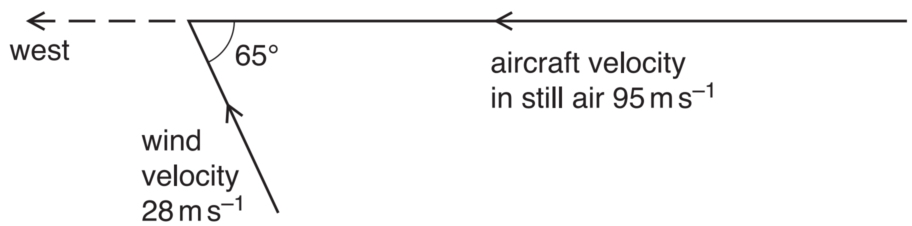


Fig. 1.2

The velocity of the aircraft in still air is $95\,m\,s^{-1}$ to the west.
The velocity of the wind is $28\,m\,s^{-1}$ from 65° south of east.

(i) On Fig. 1.2, draw an arrow, labelled R, in the direction of the resultant velocity of the aircraft. [1]

(ii) Determine the magnitude of the resultant velocity of the aircraft.

magnitude of velocity = ... $m\,s^{-1}$ [2]

[Total: 7]

9702/22/O/N/17 Q1

28. 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 $1.99 \times 10^8\,\text{N}\,\text{m}^{-2}$.

[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]

9702/21/O/N/17 Q1

29. **(a)** The drag force F_D acting on a sphere moving through a fluid is given by the expression

$$F_D = K\rho v^2$$

where K is a constant,
ρ is the density of the fluid
and v is the speed of the sphere.

Determine the SI base units of K.

base units ....[3]

(b) A ball of weight 1.5 N falls vertically from rest in air. The drag force F_D acting on the ball is given by the expression in **(a)**. The ball reaches a constant (terminal) speed of 33 m s^{-1}.

Assume that the upthrust acting on the ball is negligible and that the density of the air is uniform.

For the instant when the ball is travelling at a speed of 25 m s^{-1}, determine

(i) the drag force F_D on the ball,

F_D = ... N [2]

(ii) the acceleration of the ball.

acceleration = ... m s^{-2} [2]

(c) Describe the acceleration of the ball in **(b)** as its speed changes from zero to 33 m s^{-1}.

....

....

....

....[3]

[Total: 10]

9702/23/M/J/17 Q1

30. (a) Two forces, with magnitudes 5.0 N and 12 N, act from the same point on an object. Calculate the magnitude of the resultant force *R* for the forces acting

(i) in opposite directions,

R = ... N [1]

(ii) at right angles to each other.

R = ... N [1]

(b) An object X rests on a smooth horizontal surface. Two horizontal forces act on X as shown in Fig. 1.1.

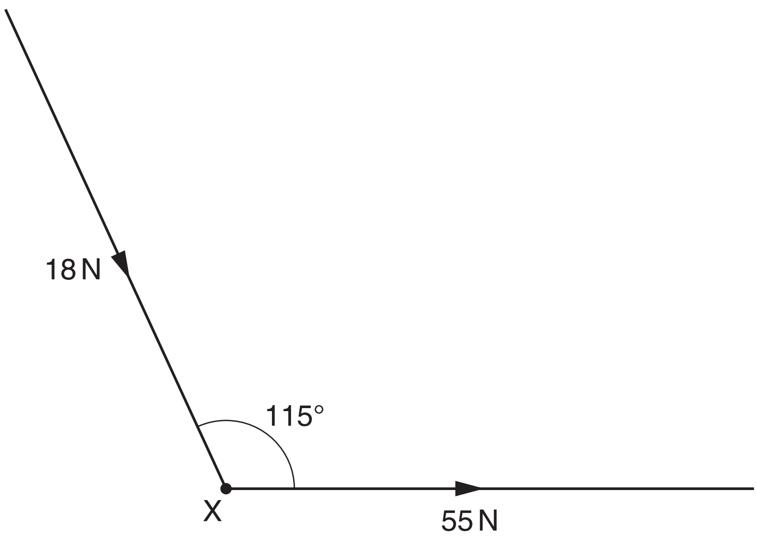


Fig. 1.1 (not to scale)

A force of 55 N is applied to the right. A force of 18 N is applied at an angle of 115° to the direction of the 55 N force.

(i) Use the resolution of forces or a scale diagram to show that the magnitude of the resultant force acting on X is 65 N.

[2]

(ii) Determine the angle between the resultant force and the 55 N force.

angle = ... ° [2]

(c) A third force of 80 N is now applied to X in the opposite direction to the resultant force in **(b)**.

The mass of X is 2.7 kg.

Calculate the magnitude of the acceleration of X.

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

[Total: 9]

9702/22/M/J/17 Q1

31. (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]

9702/21/M/J/17 Q1

32. (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.

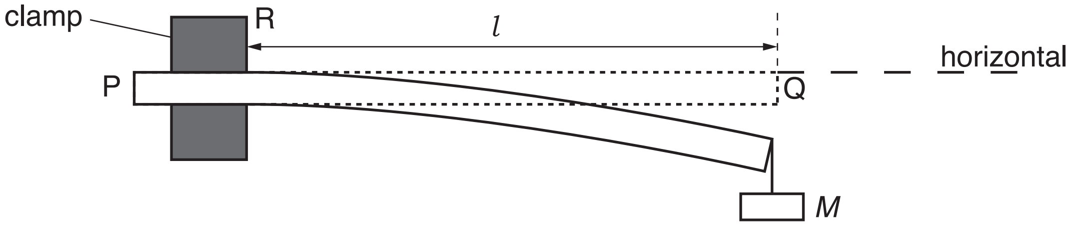


Fig. 1.1

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]

9702/22/F/M/17 Q1

33. **(a)** Complete Fig. 1.1 by putting a tick (✓) in the appropriate column to indicate whether the listed quantities are scalars or vectors.

quantity	**scalar**	**vector**
acceleration		
force		
kinetic energy		
momentum		
power		
work		

Fig. 1.1

[2]

9702/22/O/N/16 Q1

34. (a) (i) Define *pressure*.

....

....[1]

(ii) Show that the SI base units of pressure are $\text{kg}\,\text{m}^{-1}\,\text{s}^{-2}$.

[1]

(b) Gas flows through the narrow end (nozzle) of a pipe. Under certain conditions, the mass m of gas that flows through the nozzle in a short time t is given by

$$\frac{m}{t} = kC\sqrt{\rho P}$$

where k is a constant with no units,
C is a quantity that depends on the nozzle size,
ρ is the density of the gas arriving at the nozzle,
P is the pressure of the gas arriving at the nozzle.

Determine the base units of C.

base units ....[3]

[Total: 5]

9702/21/O/N/16 Q1

35. (a) Define *density*.

....

....[1]

(b) The mass m of a metal sphere is given by the expression

$$m = \frac{\pi d^3 \rho}{6}$$

where ρ is the density of the metal and d is the diameter of the sphere.

Data for the density and the mass are given in Fig. 1.1.

quantity	value	uncertainty
ρ m	$8100\,\mathrm{kg\,m^{-3}}$ $7.5\,\mathrm{kg}$	± 5% ± 4%

Fig. 1.1

(i) Calculate the diameter d.

d = ... m [1]

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

d = ... ± .... m [3]

[Total: 5]

9702/23/M/J/16 Q1

36. (a) A list of quantities that are either scalars or vectors is shown in Fig. 1.1.

quantity	scalar	vector
distance	✓	
energy		
momentum		
power		
time		
weight		

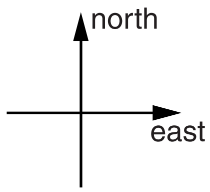
Fig. 1.1

Complete Fig. 1.1 to indicate whether each quantity is a scalar or a vector.

One line has been completed as an example. [2]

(b) A girl runs 120 m due north in 15 s. She then runs 80 m due east in 12 s.

(i) Sketch a vector diagram to show the path taken by the girl. Draw and label her resultant displacement R.



[1]

(ii) Calculate, for the girl,

1. the average speed,

average speed = ... $m s^{-1}$ [1]

2. the magnitude of the average velocity *v* and its angle with respect to the direction of the initial path.

magnitude of *v* = ... $m s^{-1}$

angle = ... °
[3]

[Total: 7]

9702/23/M/J/16 Q2

37. (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]

9702/21/M/J/16 Q1

38. **(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.

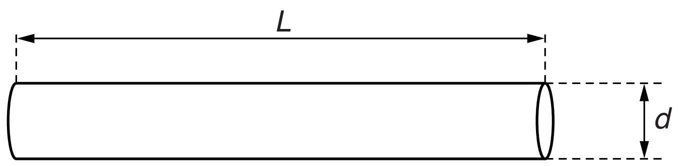


Fig. 1.1

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]

9702/22/F/M/16 Q1

39. 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 = ... $\mathrm{m\,s^{-1}}$ [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 = ... ± ....$\mathrm{m\,s^{-1}}$ [3]

[Total: 6]