Cambridge Assessment International Education

Cambridge International AS & A Level

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PHYSICS **9702/23**

Paper 2 AS Level Structured Questions **May/June 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
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- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **20** pages. Any blank pages are indicated.

[Turn over

1 The drag force F_D acting on a sphere falling through a liquid is given by

$$F_D = 6\pi\eta r v$$

where r is the radius of the sphere,
v is the speed of the sphere in the liquid and
η is a property of the liquid called the viscosity.

(a) Show that the SI base units of viscosity are $kg\,m^{-1}\,s^{-1}$.

[2]

(b) The sphere has a radius of 3.0 cm and is falling vertically downwards at a terminal velocity of $2.0\,m\,s^{-1}$ through the liquid. The drag force acting on the sphere is 0.096 N.

Calculate the viscosity of the liquid.

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

(c) The sphere is shown in Fig. 1.1.

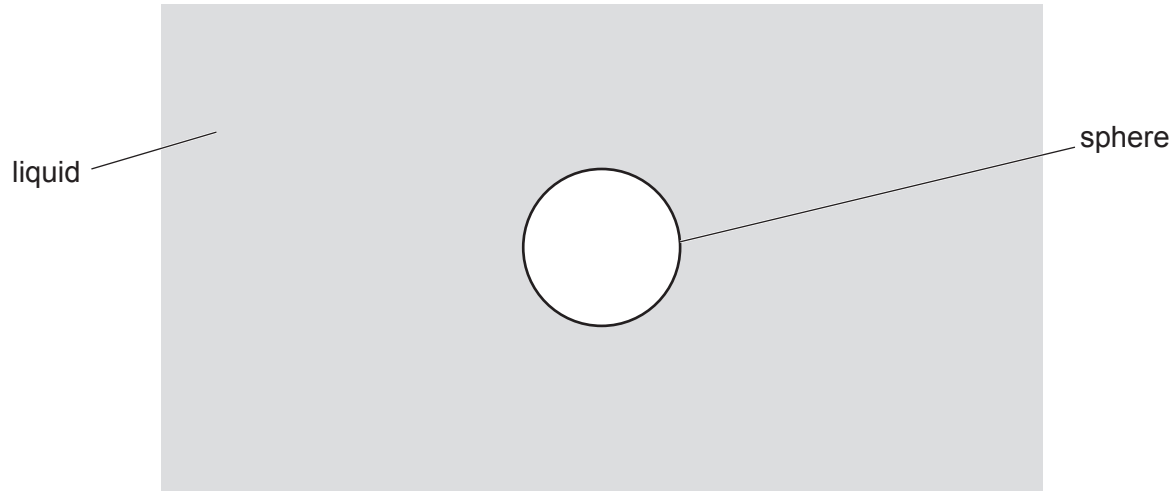

Fig. 1.1

On Fig. 1.1, draw and label arrows to represent the directions of the **three** forces acting on the sphere as it falls at terminal velocity through the liquid. [2]

(d) (i) The density of the liquid is 920 kg m^{-3}.

Show that the upthrust acting on the sphere is 1.0 N.

[2]

(ii) Calculate the mass of the sphere.

mass = ... kg [2]

[Total: 10]

2 **(a)** Define displacement from a point.

.....

..... [1]

(b) An object is projected horizontally at a speed of $6.0\,m\,s^{-1}$ from a slope, as shown in Fig. 2.1.

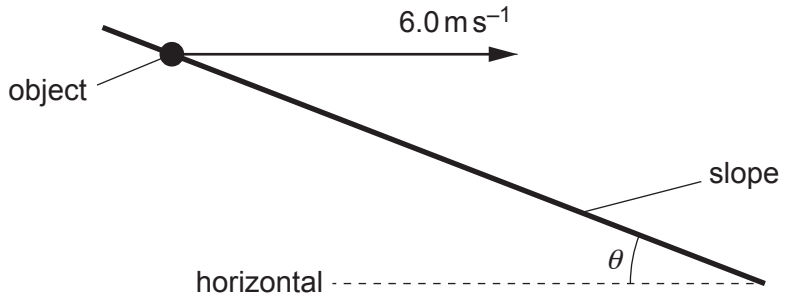

Fig. 2.1 (not to scale)

The slope is at an angle θ to the horizontal. Air resistance is negligible.

The object lands on the slope a time of 0.71 s later and stops without rolling or bouncing.

(i) Determine the horizontal distance travelled by the object.

distance = ... m [1]

(ii) Determine the vertical distance travelled by the object.

distance = ... m [2]

(iii) Use your answers in **(b)(i)** and **(b)(ii)** to calculate θ.

θ = ... ° [2]

(iv) Determine the magnitude of the displacement of the object from its original position.

displacement = ... m [2]

(v) By considering energy, calculate the speed of the object just before it lands.

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

[Total: 11]

3 **(a)** State Hooke's law.

.....

..... [1]

(b) The variation of the applied force with the extension for a sample of a material is shown in Fig. 3.1.

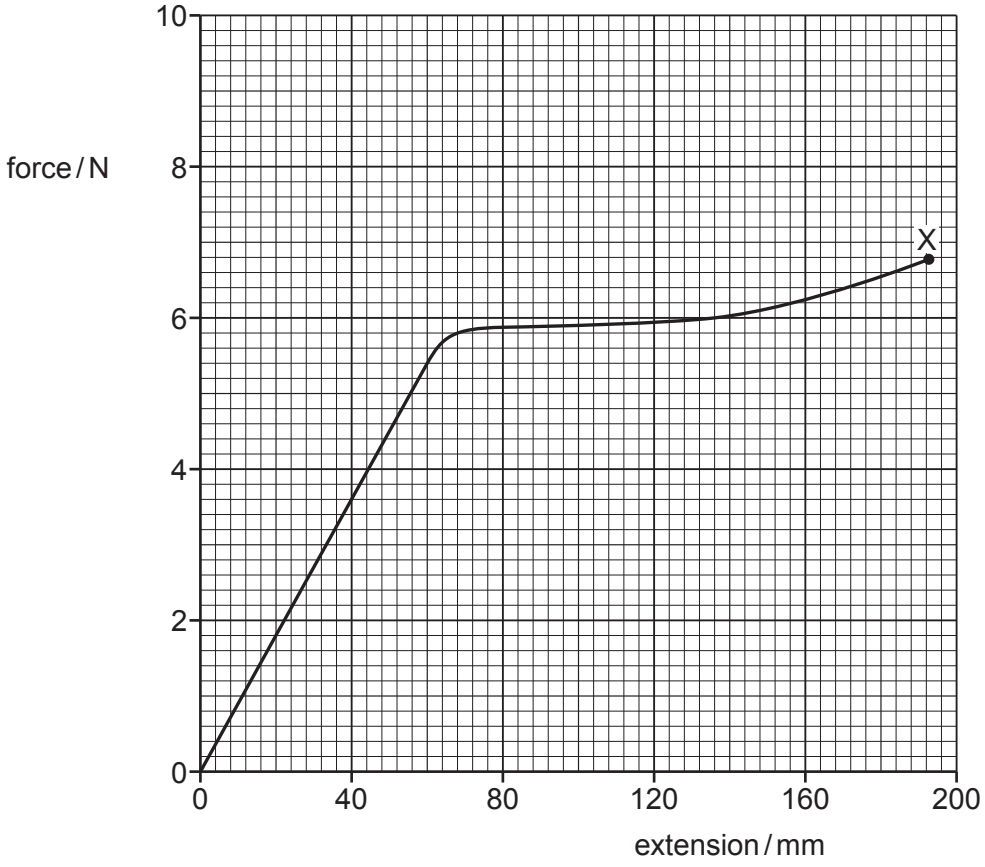

Fig. 3.1

The sample behaves elastically up to an extension of 80 mm and breaks at point X.

(i) On the line in Fig. 3.1, draw a cross (×) to show the limit of proportionality. Label this cross with the letter P. [1]

(ii) On the line in Fig. 3.1, draw a cross (×) to show the elastic limit. Label this cross with the letter E. [1]

(c) The sample in **(b)** has a cross-sectional area of 0.40 mm^2 and an initial length of 3.2 m.

For deformations within the limit of proportionality of the sample, determine:

(i) the spring constant of the sample

spring constant = ... N m^{-1} [2]

(ii) the Young modulus of the material from which the sample is made.

Young modulus = ... Pa [3]

(d) Determine an estimate of the work done on the sample as it is extended from zero extension to its breaking point. Explain your reasoning.

work done = ... J [2]

(e) A second sample of the same material has a larger cross-sectional area than the original sample but the same initial length. The two samples are each deformed with the limit of proportionality.

State and explain qualitatively how the spring constant of the second sample compares with that of the original sample.

.....

.....

..... [2]

[Total: 12]

4 A progressive transverse wave travelling from left to right is shown at an instant in time in Fig. 4.1.

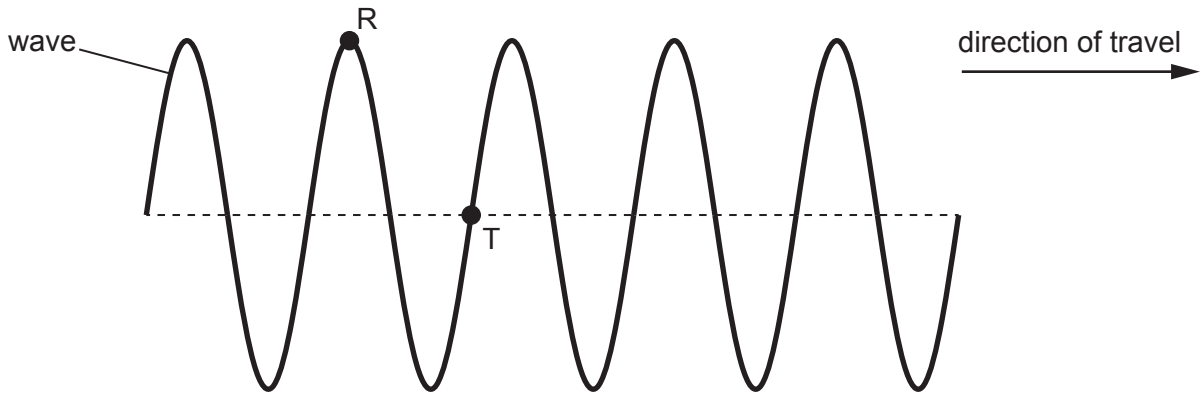

Fig. 4.1

R and T are points on the wave.

(a) State the phase difference between the points R and T.

phase difference = ... ° [1]

(b) On Fig. 4.1, draw an arrow at point T to show the direction of movement of point T at the instant shown. [1]

(c) The horizontal distance between R and T is 0.62 cm, as shown in Fig. 4.2.

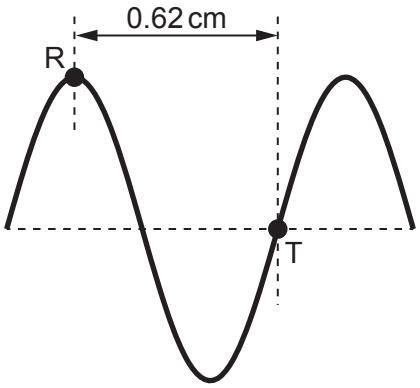

Fig. 4.2 (not to scale)

The speed of the wave is 0.27 m s^{-1}.

Calculate the frequency of the wave.

frequency = ... Hz [3]

(d) The wave is a water wave produced by a dipper S_1 attached to a vibrator in a ripple tank.

An identical dipper S_2 is attached to the same vibrator. The two dippers produce an interference pattern on the water in the tank, as shown in Fig. 4.3.

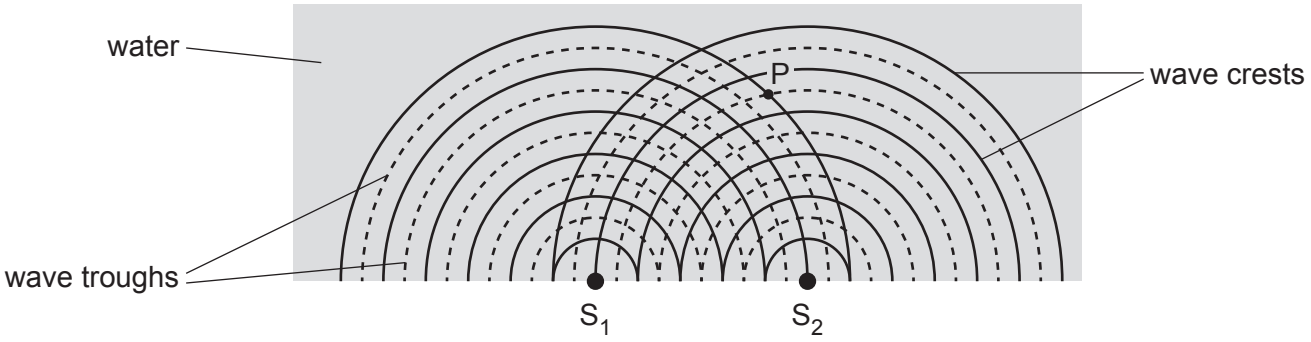

Fig. 4.3 (not to scale)

The wave crests from each source are represented by solid lines on Fig. 4.3 and the wave troughs are represented by dashed lines.

At point P in Fig. 4.3, the wave from S_1 has the same amplitude *A* as the wave from S_2.

Describe and explain the amplitude of the resultant wave at point P.

.....

.....

.....

..... [3]

[Total: 8]

5 **(a)** **(i)** State Kirchhoff's second law.

.....

.....

..... [1]

(ii) State the conservation law that gives rise to Kirchhoff's second law.

..... [1]

(b) A circuit contains a cell of internal resistance r and two resistors of resistances R_1 and R_2, as shown in Fig. 5.1.

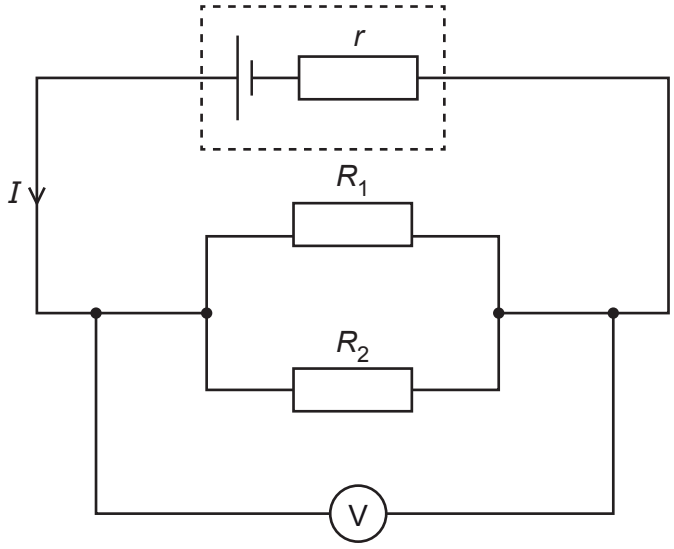

Fig. 5.1

The potential difference (p.d.) across the two resistors is V.

The current in the cell is I.

(i) Use Kirchhoff's laws to show that the total resistance R_T of the external circuit is given by

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}.$$

[2]

(ii) The electromotive force (e.m.f.) of the cell is 1.50 V.

When the values of R_1 and R_2 are 10 Ω and 15 Ω respectively, the p.d. measured by the voltmeter is 1.38 V.

Calculate the internal resistance r of the cell.

r = ... Ω [3]

(c) A third resistor is added in parallel with R_1 and R_2 in the circuit in Fig. 5.1.

State and explain the effect, if any, of this change on:

(i) the current in the cell

.....

.....

..... [2]

(ii) the p.d. measured by the voltmeter.

.....

.....

..... [2]

[Total: 11]

6 Nuclei of an isotope of samarium (Sm) each contain 62 protons and 85 neutrons.

(a) State the nuclide notation in the form ${}^{A}_{Z}X$ for this isotope of samarium.

[1]

(b) This isotope of samarium is radioactive and decays by emitting particles. Gamma-radiation is **not** emitted. The energy spectrum of the emitted particles is shown in Fig. 6.1.

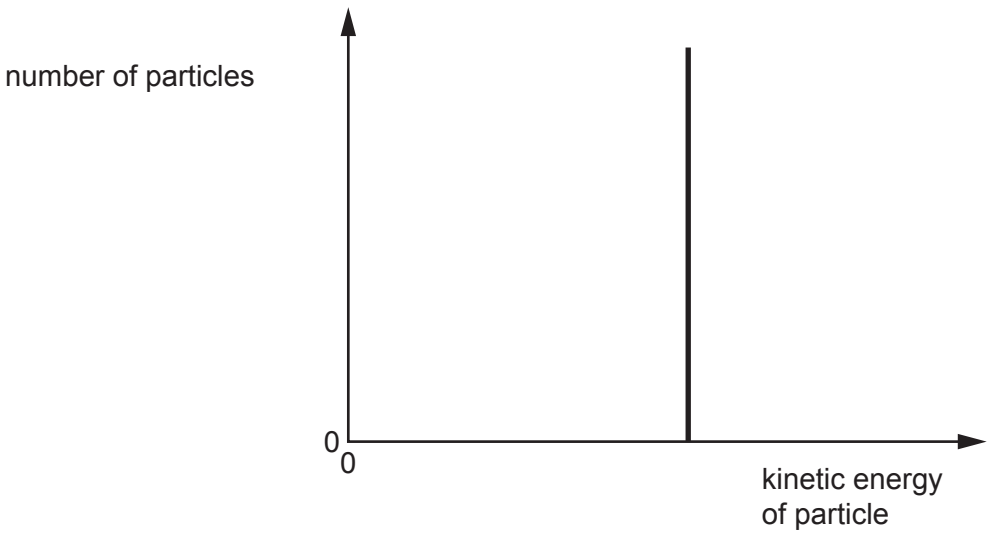

Fig. 6.1

(i) Explain how Fig. 6.1 shows that this isotope of samarium emits α-particles and does **not** emit β-particles.

.....

.....

.....

..... [2]

(ii) This isotope of samarium decays to an isotope of neodymium (Nd).

Give the radioactive decay equation for this decay. Include the nucleon and proton numbers of **all** the particles involved.

[2]

(c) A baryon is composed of three quarks which all have different flavours. The baryon has a charge of 0.

Two of the quarks in the baryon are an up quark and a bottom quark.

(i) Determine, in terms of the elementary charge *e*, the charge on the third quark in the baryon.

charge = ... *e* [2]

(ii) State a possible flavour for the third quark in the baryon.

..... [1]

[Total: 8]

20

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PHYSICS **9702/21**

Paper 2 AS Level Structured Questions **October/November 2024**

1 hour 15 minutes

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1 **(a)** Define density.

.....

..... [1]

(b) Fig. 1.1 shows a cuboidal glass block.

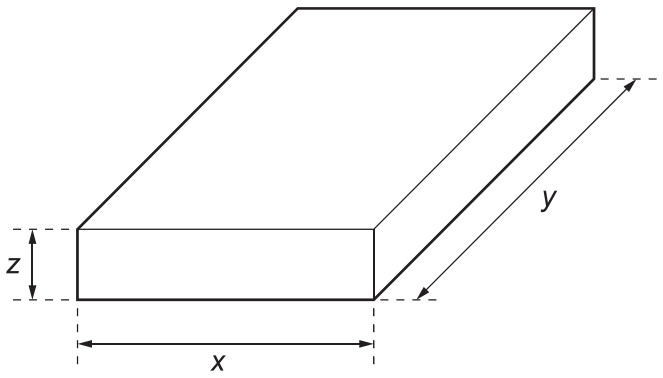

Fig. 1.1 (not to scale)

A student measures the mass *m* of the block and the side lengths *x*, *y* and *z*. The measurements are shown in Table 1.1.

Table 1.1

quantity	measurement
m	(0.243 ± 0.001) kg
x	(5.41 ± 0.01) cm
y	(11.09 ± 0.01) cm
z	(1.62 ± 0.01) cm

(i) Determine the density of the glass.

density = ... kg m^{-3} [2]

(ii) Calculate the percentage uncertainty in the density.

percentage uncertainty = ...% [3]

(c) The true value of the density of the glass is different from the answer in **(b)(i)** because of a systematic error in the measurements.

Suggest **one** possible cause of this systematic error.

.....

.....

..... [1]

[Total: 7]

2 **(a)** Define linear momentum.

.....

..... [1]

(b) A car of mass 1800 kg is moving in a straight line. Fig. 2.1 shows the variation with time t of the momentum p of the car.

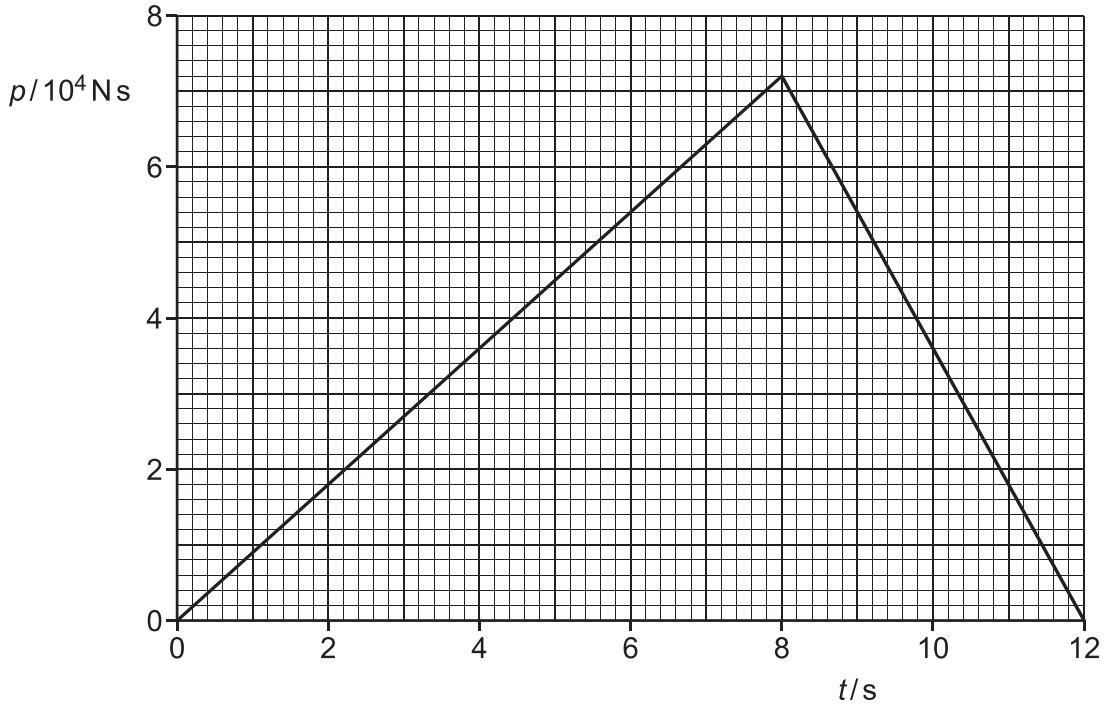

Fig. 2.1

(i) Calculate the maximum speed reached by the car.

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

(ii) Calculate the maximum kinetic energy of the car.

maximum kinetic energy = ... J [2]

(iii) Show that the acceleration of the car at time $t = 4.0\,s$ is $5.0\,m\,s^{-2}$.

[2]

(iv) Determine the distance travelled by the car between times $t = 0$ and $t = 12.0\,s$.

distance = ... m [2]

(c) On Fig. 2.2, sketch the variation with time t of the acceleration a of the car in **(b)** from $t = 0$ to $t = 12.0\,s$.

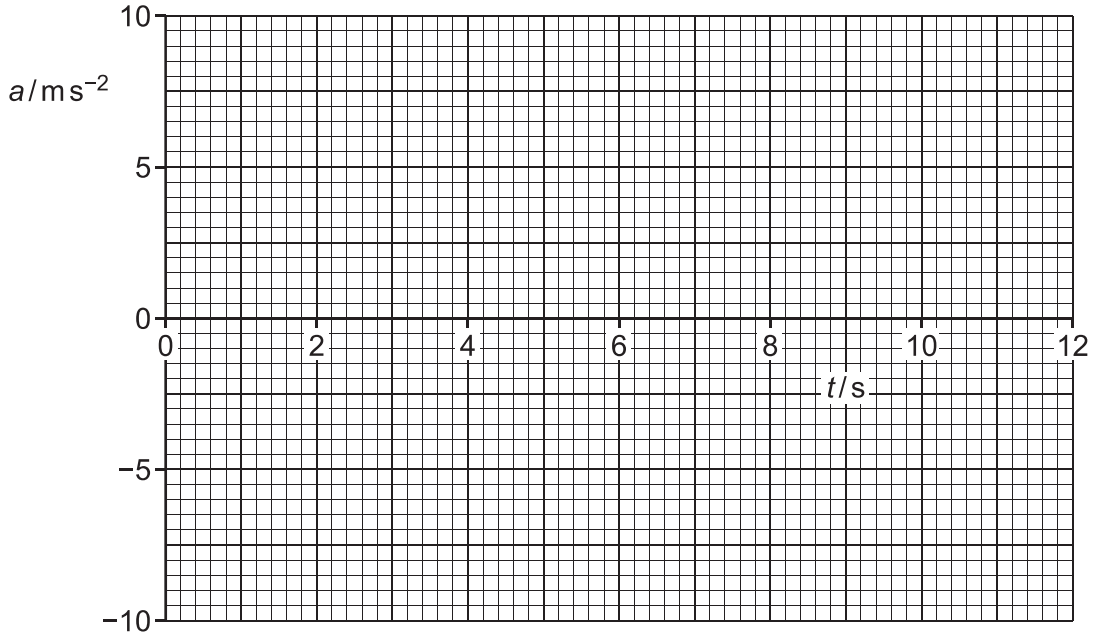

Fig. 2.2

[3]

[Total: 11]

3 **(a)** State what is meant by the work done by a force.

.....

..... [1]

(b) A block of mass m is raised vertically at constant speed. The vertical height gained by the block is Δh, as shown in Fig. 3.1.

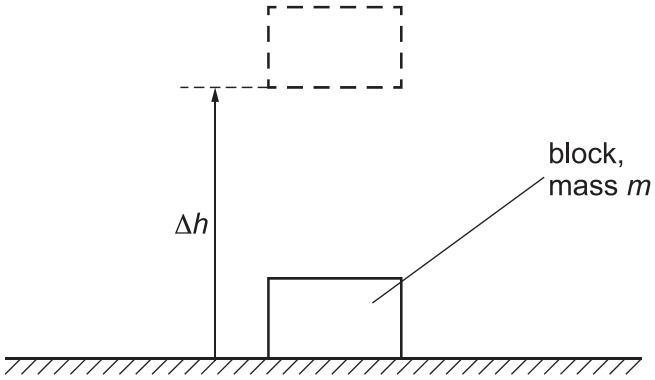

Fig. 3.1

Derive an expression, in terms of m and Δh, for the change in gravitational potential energy ΔE_P of the block. State the meaning of any other symbols you use.

[2]

(c) An electric motor has an input power of 900 W. The motor takes 1.0 minute to lift a load of weight 240 N at constant speed through a vertical height of 150 m. Resistive forces are negligible.

(i) Show that the work done by the motor on the load in 1.0 minute is 36 kJ.

[1]

(ii) Determine the useful output power of the motor.

power = ... W [2]

(iii) Use your answer in **(c)(ii)** to determine the efficiency of the motor.

efficiency = ... [2]

(iv) Some of the power wasted in the motor is dissipated by the resistance of its coil. This dissipated power is 280 W.

The coil of the motor is made from wire of total length 23 m. The wire has a cross-sectional area of $2.6 \times 10^{-8}\,m^2$ and is made from metal of resistivity $1.7 \times 10^{-8}\,\Omega m$.

Calculate the current in the coil.

current = ...A [3]

[Total: 11]

4 **(a)** Define the Young modulus of a material.

.....

..... [1]

(b) A metal wire P that obeys Hooke's law is stretched within its limit of proportionality.

(i) On Fig. 4.1, sketch the variation of tensile force F in the wire with its extension x.

Fig. 4.1

[1]

(ii) State the name of the quantity represented by the gradient of the line in Fig. 4.1.

..... [1]

(iii) State the name of the quantity represented by the area under the line in Fig. 4.1.

..... [1]

(c) Another wire Q is made from a metal that has twice the Young modulus of the metal of wire P in **(b)**. Wire Q has the same volume as wire P but has double the cross-sectional area of wire P.

The two wires are extended by equal tensile forces within their limits of proportionality.

State and explain how the extension of wire Q compares with the extension of wire P.

.....

.....

.....

.....

..... [3]

[Total: 7]

5 **(a)** Potassium-40 ($^{40}_{19}K$) undergoes β^- decay to form a nuclide of element X. Particle Z is emitted during the decay. The equation for the decay is shown.

$$^{40}_{19}K \rightarrow {}^{P}_{Q}X + {}^{R}_{S}\beta^- + Z$$

(i) State the values of *P*, *Q*, *R* and *S*.

P = ... *R* = ...

Q = ... *S* = ...

[2]

(ii) State the name of particle Z.

..... [1]

(iii) State the name of the class of fundamental particle to which both the β^- particle and particle Z belong.

..... [1]

(b) Determine the quark composition of an alpha-particle.

quark composition ..... [3]

[Total: 7]

6 Two coherent sources X and Y of microwaves of frequency 2.5×10^{10} Hz are a distance of 0.18 m apart in a vacuum, as shown in Fig. 6.1.

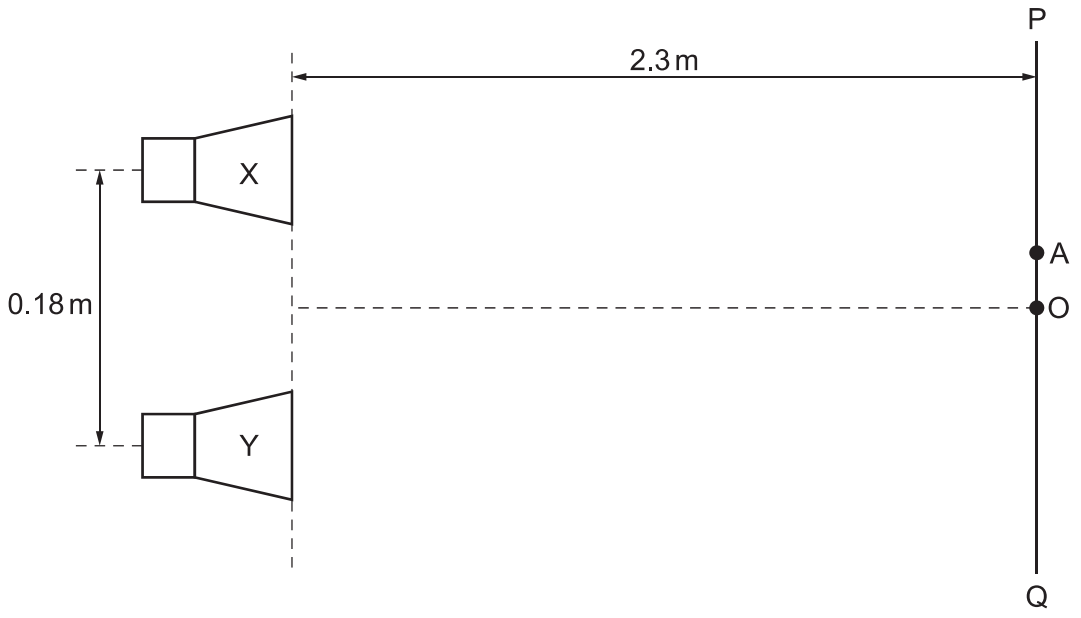

Fig. 6.1 (not to scale)

There is a phase difference of 90° between the waves emitted at the two sources.

A microwave detector moves along the line PQ, which is parallel to the line joining the two sources and 2.3 m away from it.

Point O is on the line PQ at a position that is equidistant from the two sources.
Point A is the position on line PQ where the intensity of the microwaves is the greatest.

(a) (i) Explain why the position of greatest intensity is **not** at point O.

.....

.....

.....

..... [2]

(ii) On Fig. 6.1, draw a cross (×) to show the position of the point on line PQ where the intensity minimum that is the closest to point O occurs. Label this point B. [2]

(b) (i) Show that the wavelength of the microwaves is 0.012 m.

[2]

(ii) For point A on line PQ, determine the difference in the distances Δx travelled by the microwaves from X and the microwaves from Y.

Δx = ... m [1]

(iii) Use the formula for the double-slit interference of light to calculate the distance between adjacent intensity maxima on line PQ.

distance = ... m [2]

[Total: 9]

7 **(a)** Fig. 7.1 shows two resistors connected in series with a cell of electromotive force (e.m.f.) 1.50 V and internal resistance 0.28 Ω.

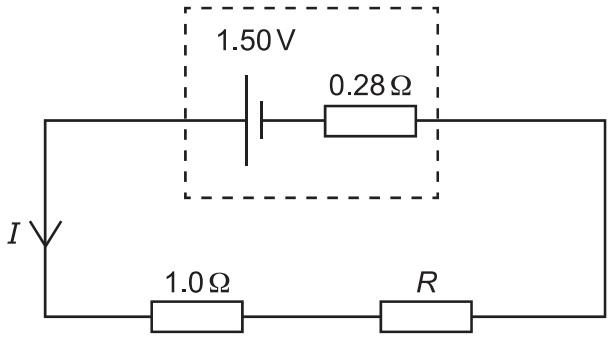

Fig. 7.1

One of the resistors has resistance 1.0 Ω. The other resistor has resistance *R*.
The terminal potential difference (p.d.) across the cell is 1.36 V.

(i) Show that the current *I* in the circuit is 0.50 A.

[2]

(ii) Calculate the combined resistance of the two resistors.

resistance = ... Ω [2]

(iii) Use your answer in **(a)(ii)** to determine resistance *R*.

R = ... Ω [1]

(b) The circuit in Fig. 7.1 is disconnected and the two resistors are reconnected to the cell, now in parallel with each other.

(i) On Fig. 7.2, complete the circuit diagram to show this arrangement.

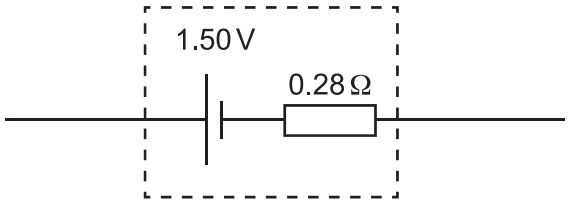

Fig. 7.2

[1]

(ii) Explain, without calculation, whether the terminal p.d. across the cell is now less than, equal to or greater than 1.36 V.

.....

.....

..... [2]

[Total: 8]

Cambridge Assessment International Education

Cambridge International AS & A Level

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5942866629

PHYSICS **9702/22**

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1 **(a)** State what is meant by a vector quantity.

.....

..... [1]

(b) A sphere falls vertically through a liquid that has density 830 kg m^{-3}. The sphere has radius r and constant velocity v, as shown in Fig. 1.1.

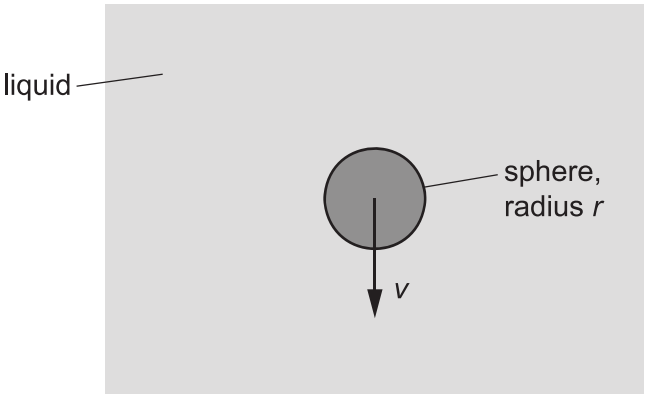

Fig. 1.1

(i) The drag force D acting on the sphere is given by

$$D = 6\pi r\eta v$$

where η is a property of the liquid.

Determine the SI base units of η.

SI base units ..... [3]

(ii) State an equation showing the relationship between the magnitudes of the weight W, drag force D and upthrust U acting on the sphere.

..... [1]

(iii) The volume of the sphere is $4.6\,cm^3$. The drag force D is 0.32 N.

Calculate the weight of the sphere.

weight = ... N [2]

[Total: 7]

2 **(a)** Define momentum.

.....

..... [1]

(b) A child stands on a scooter on horizontal ground. The combined mass of the child and the scooter is 16 kg.
The child starts from rest and pushes once on the ground with her foot which causes her to accelerate. The push lasts for a time of 1.1 s. The speed of the child and the scooter after the push is 0.60 m s^{-1}.

Determine the average resultant force acting horizontally on the child and the scooter during the push.

average force = ... N [2]

(c) Later, the child in **(b)** travels down a slope at a constant angle to the horizontal, as shown in Fig. 2.1.

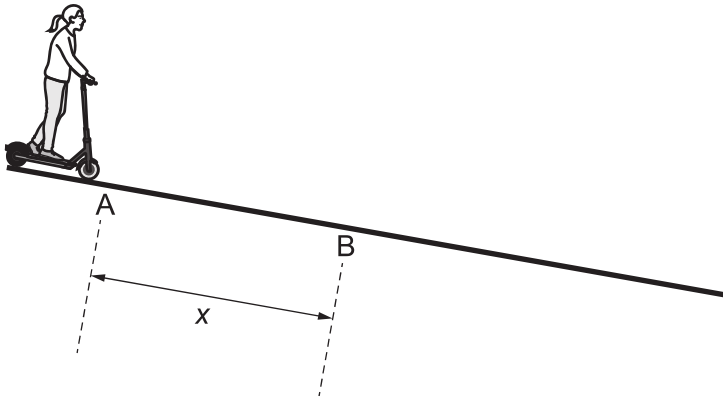

Fig. 2.1 (not to scale)

At point A her speed is 0.60 m s^{-1}. She has a constant acceleration of 0.85 m s^{-2} parallel to the slope. After a time of 3.7 s, she reaches point B.

Calculate the distance x travelled by the child along the slope from A to B.

x = ... m [2]

(d) At point B, the child in **(c)** applies the brake with a constant force to maintain a constant velocity. Point C is 18 m from point B, as shown in Fig. 2.2.

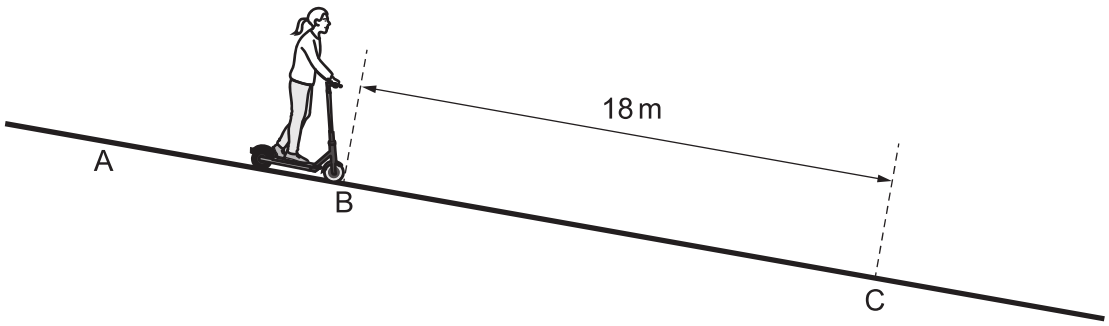

Fig. 2.2 (not to scale)

The work done by the braking force between B and C is 250 J.

(i) Determine the magnitude of the braking force.

force = ... N [2]

(ii) On Fig. 2.3, sketch the variation of the kinetic energy of the child and scooter with distance travelled from point A to point C.
Numerical values for kinetic energy are not required.

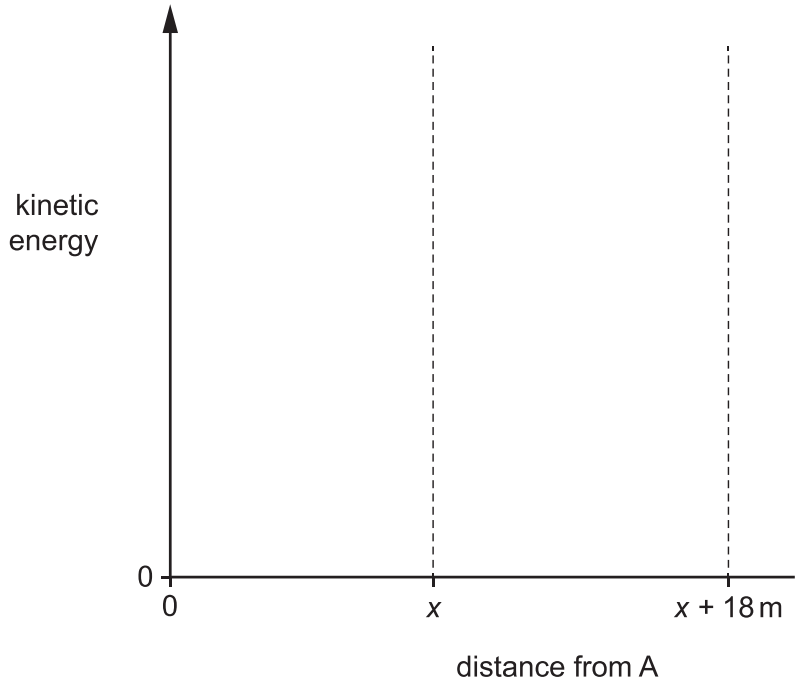

Fig. 2.3

[3]

[Total: 10]

3 **(a)** The variation of stress with strain for a metal P is shown in Fig. 3.1.

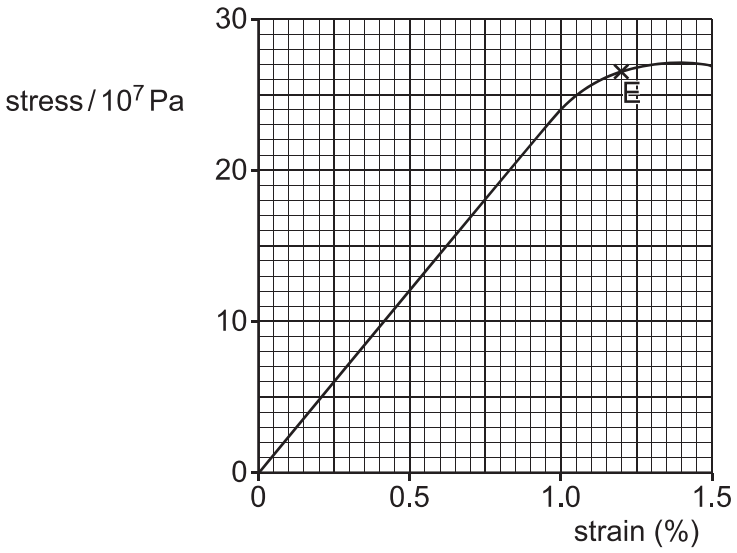

Fig. 3.1

Point E is the elastic limit of the metal.

(i) Use Fig. 3.1 to determine the Young modulus for P.

Young modulus = ... Pa [2]

(ii) On the line in Fig. 3.1, draw a cross (×) to show the limit of proportionality.
Label this point Q. [1]

(b) State the conditions necessary for an object to be in equilibrium.

.....

.....

..... [2]

(c) A wire is used to hold a uniform shelf AB horizontally in equilibrium as shown in Fig. 3.2.

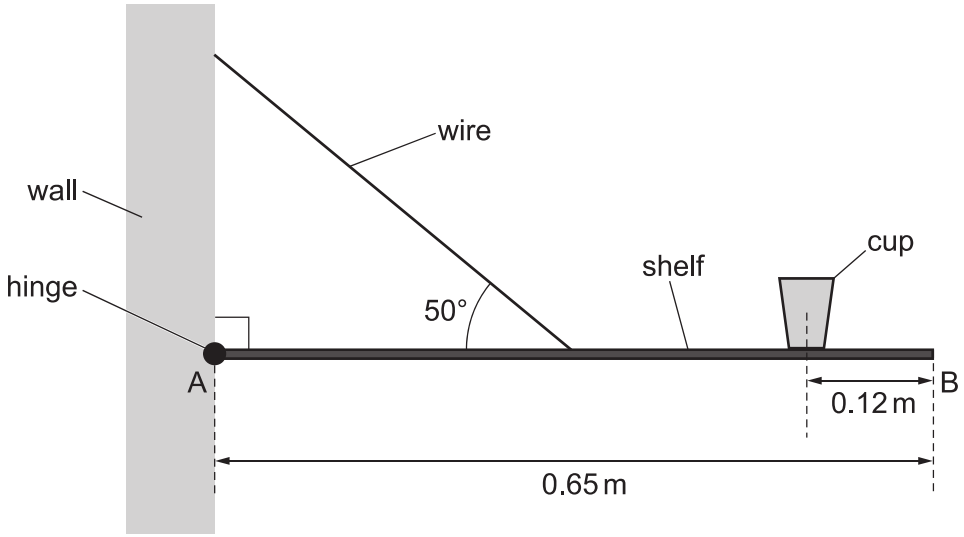

Fig. 3.2 (not to scale)

The wire is connected to the midpoint of shelf AB at an angle of 50° to the horizontal. The shelf is attached to a wall by a hinge at A. The length of shelf AB is 0.65 m and its weight is 33 N.
A cup of weight 1.5 N rests on the shelf with its centre of gravity at a horizontal distance of 0.12 m from B.

(i) By taking moments about A, determine the tension in the wire.

tension = ... N [3]

(ii) The stress in the wire is 1.5×10^7 Pa.

Determine the radius of the wire.

radius = ... m [2]

(iii) More items are added to the shelf, doubling the stress in the wire. The wire is made of the metal P from **(a)**.

Use Fig. 3.1 to state and explain whether the wire will behave plastically or elastically as the stress doubles.

.....

.....

.....

.....

..... [2]

[Total: 12]

4 **(a)** With reference to the direction of transfer of energy, compare the oscillations of transverse and longitudinal progressive waves.

.....

.....

.....

..... [2]

(b) A pipe is open at one end and closed at the other with a piston. The piston can slide freely and is at a distance of 4.5×10^{-2} m from the open end of the pipe.

A loudspeaker is positioned near the open end of the pipe and emits a sound wave of a single constant frequency. A stationary wave is formed in the pipe, as illustrated in Fig. 4.1.

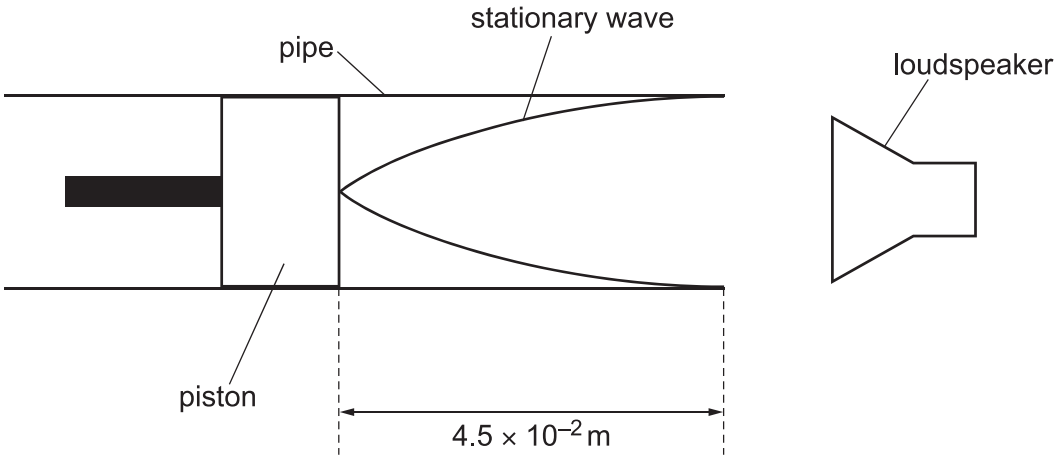

Fig. 4.1

(i) On Fig. 4.1, draw a letter A at the position of an antinode. [1]

(ii) The speed of sound in air is 340 m s^{-1}.

Determine the frequency of the sound wave.

frequency = ... Hz [3]

(iii) The piston is moved to the left. The frequency of the sound wave emitted by the loudspeaker is then changed so that a stationary wave is formed with same number of antinodes as in Fig. 4.1.

State and explain the change that is made to the frequency of the sound wave.

.....

.....

.....

..... [2]

[Total: 8]

5 **(a)** Define electric potential difference (p.d.).

.....

..... [1]

(b) A power supply, three resistors and a component X are connected in the circuit shown in Fig. 5.1.

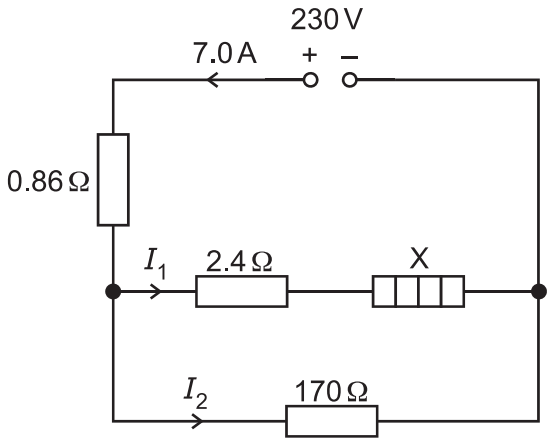

Fig. 5.1

The power supply has an electromotive force (e.m.f.) of 230 V and negligible internal resistance. The current in the power supply is 7.0 A.

(i) Identify component X.

..... [1]

(ii) Show that the p.d. across the resistor of resistance 0.86 Ω is 6.0 V.

[1]

(iii) Determine the current I_1.

I_1 = ...A [2]

(iv) Calculate the p.d. across component X.

p.d. = ... V [2]

(v) Calculate the power dissipated in component X.

power = ... W [2]

(vi) The purpose of the circuit is to provide power to component X.

Determine the percentage efficiency of the circuit.

efficiency = ...% [2]

(vii) The resistor of resistance 170 Ω is removed, leaving an open circuit in the lower branch of the circuit. There is no change to the resistance of component X.

State whether the current in the power supply increases, decreases or remains the same.

..... [1]

[Total: 12]

6 **(a)** Compare an α-particle with a β^+ particle in terms of their masses and charges.

.....

.....

.....

.....

..... [3]

(b) Nucleus P undergoes α-decay to form nucleus Q. Nucleus Q then undergoes a further decay to form nucleus R. The proton and nucleon numbers of P and R are shown in Fig. 6.1.

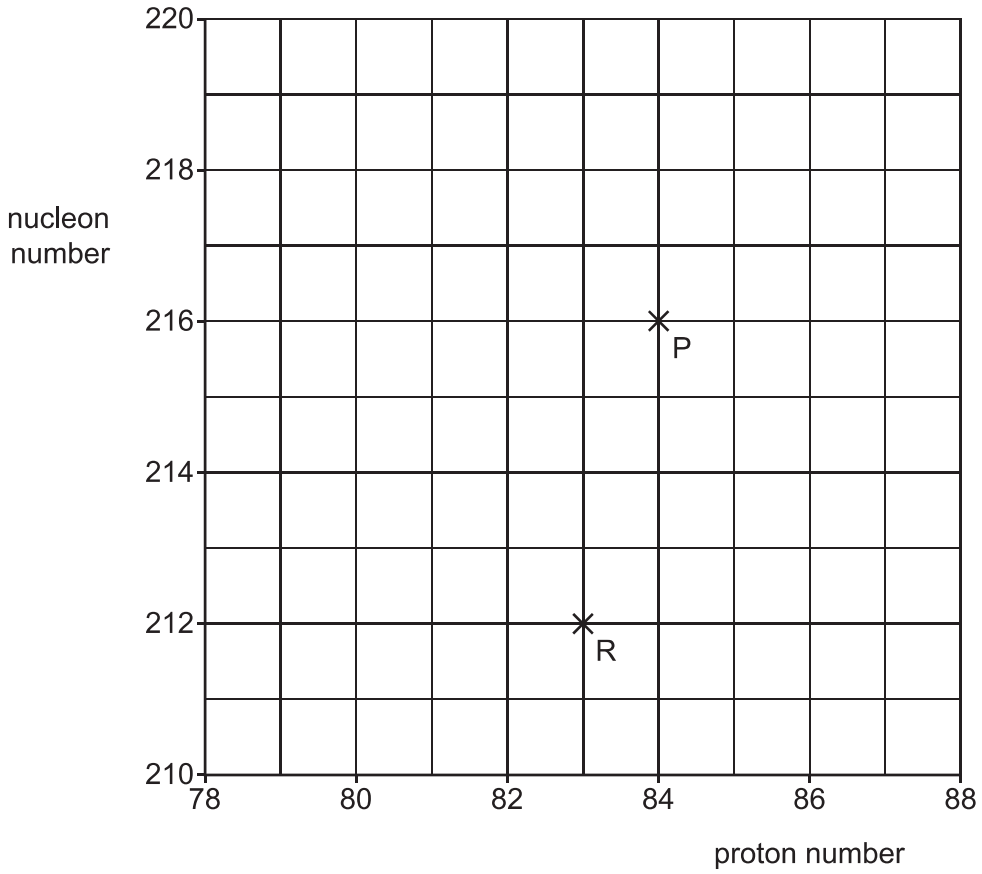

Fig. 6.1

(i) On Fig. 6.1, draw a cross (×) to show the proton number and nucleon number of Q. Label your cross Q. [1]

(ii) State the names of the particles emitted as Q decays to form R.

.....

..... [2]

(c) Before the α-decay, P is travelling at a constant velocity. After the decay, Q has a velocity of $1.3 \times 10^5\,m\,s^{-1}$ at an angle of 68° to the original path of P.
The α-particle has a velocity of $150 \times 10^5\,m\,s^{-1}$ at an angle of θ to the original path of P, as shown in Fig. 6.2.

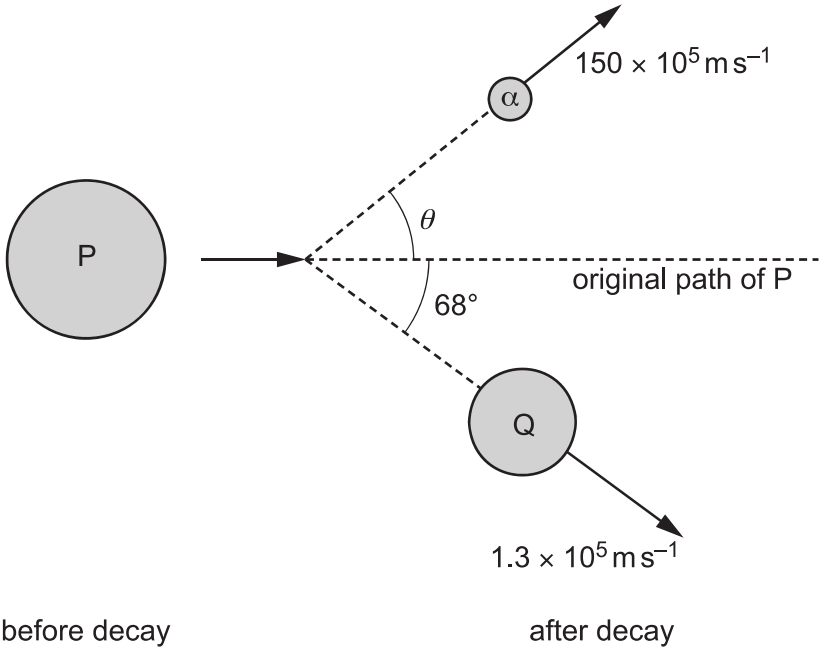

Fig. 6.2 (not to scale)

(i) Use the principle of conservation of momentum to determine θ.

θ = ...° [3]

(ii) Calculate the kinetic energy of the α-particle.

kinetic energy = ... J [2]

[Total: 11]

Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/23**

Paper 2 AS Level Structured Questions **October/November 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

[Turn over

1 **(a)** Define acceleration.

.....

..... [1]

(b) A small aircraft is flying horizontally at a speed of 42 m s^{-1} at a height of 63 m above horizontal ground, as shown in Fig. 1.1.

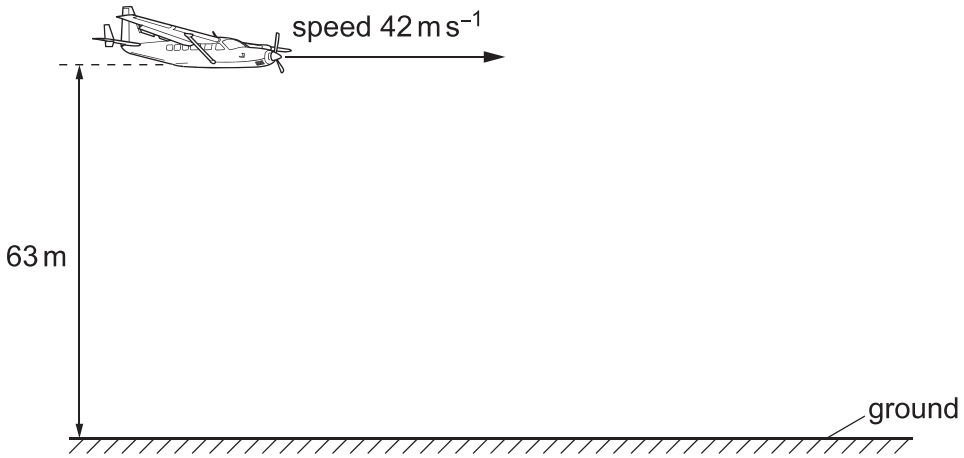

Fig. 1.1

The aircraft drops a small parcel. The parcel is released from the aircraft at the instant shown in Fig. 1.1. Air resistance is negligible.

(i) On Fig. 1.1, draw a line to show the path of the parcel as it falls from the aircraft to the ground. [1]

(ii) Calculate the time taken from the instant of release to the instant the parcel reaches the ground.

time = ... s [2]

(iii) Calculate the vertical component of the velocity of the parcel immediately before it reaches the ground.

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

(iv) Determine the speed at which the parcel reaches the ground.

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

[Total: 7]

2 **(a)** State the principle of conservation of momentum.

.....

.....

..... [2]

(b) A ball X has mass 240 g and moves in a straight line on a horizontal frictionless surface with an initial speed of 16 m s^{-1}. The ball collides with a stationary ball Y that has mass 480 g. After the collision, ball X is stationary, as shown in Fig. 2.1.

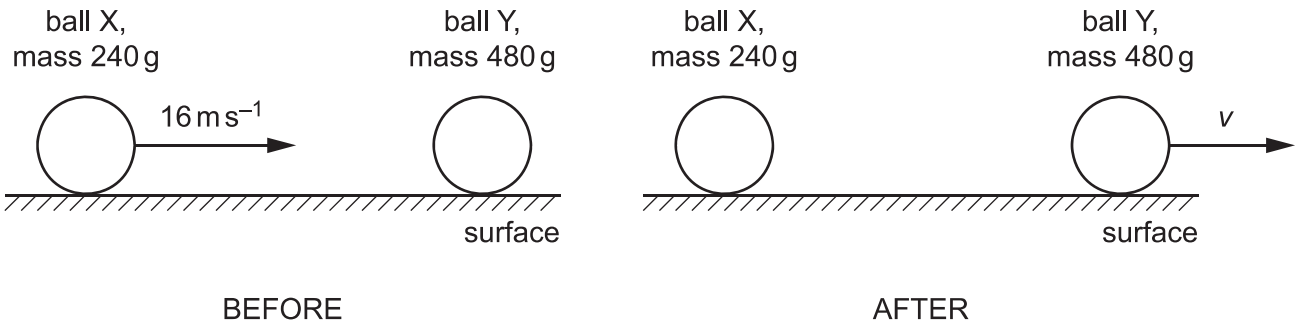

Fig. 2.1

(i) Show that the speed v of ball Y after the collision is 8.0 m s^{-1}.

[1]

(ii) Calculate the change in the total kinetic energy ΔE_K of the balls due to the collision.

ΔE_K = ... J [3]

(c) The collision in **(b)** lasts for a time of 2.0 ms. Assume that the contact force between the balls is constant during this time.

(i) Determine the magnitude and direction of the force exerted on ball X by ball Y during the collision.

magnitude = ... N

direction .....

[3]

(ii) Compare the magnitude and direction of the force exerted on ball Y by ball X during the collision with the answers in **(c)(i)**. No further calculations are required.

.....

.....

..... [2]

[Total: 11]

3 **(a)** State the principle of moments.

.....

.....

..... [1]

(b) A rigid uniform beam rests on a pivot at its centre, as shown in Fig. 3.1.

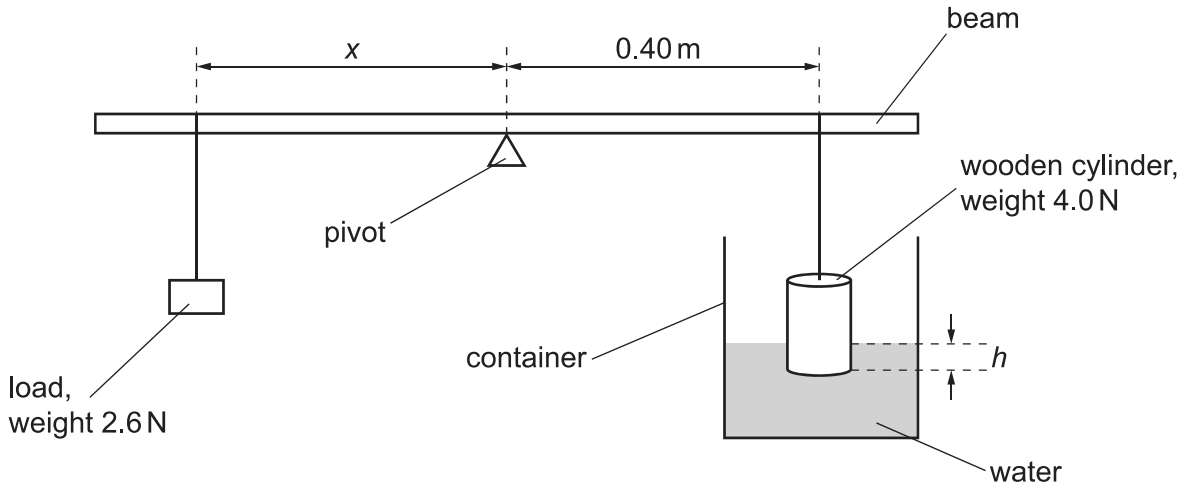

Fig. 3.1 (not to scale)

A load of weight 2.6 N is suspended from the beam at distance *x* from the pivot.

A wooden cylinder of weight 4.0 N is suspended from the beam at a distance of 0.40 m from the pivot on the opposite side of the pivot to the load. The cylinder rests in a container of water. The lower part of the cylinder is immersed in the water to depth *h*.

Initially, *h* is equal to 0.10 m and *x* is equal to 0.40 m. The system is in equilibrium.

(i) Use the principle of moments to show that the upthrust *U* exerted by the water on the cylinder is 1.4 N.

[2]

(ii) The density of the water is $1.0 \times 10^3\,\text{kg m}^{-3}$.

Calculate the area A of the circular cross-section of the cylinder.

$A =$ ..... m^2 [3]

(c) More water is gradually added to the container in **(b)**, so that depth h in Fig. 3.1 gradually increases. The length x is continuously adjusted so that the system remains in equilibrium.

On Fig. 3.2, sketch the variation of x with h. Use the space below for any working.

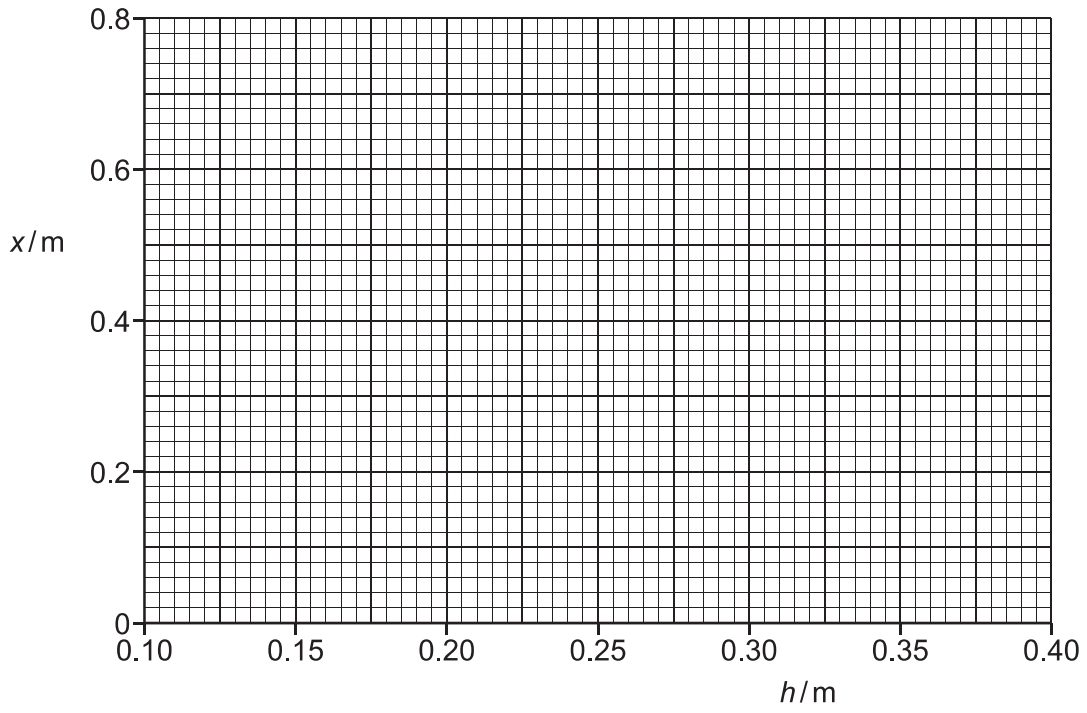

Fig. 3.2

[3]

[Total: 9]

4 **(a)** Define:

(i) stress

.....

..... [1]

(ii) strain.

.....

..... [1]

(b) Two wires X and Y, with equal unstretched lengths of 0.84 m, are suspended from fixed points that are at the same horizontal level. The lower ends of the wires are attached to a beam of negligible mass. The beam is horizontal and in equilibrium, as shown in Fig. 4.1.

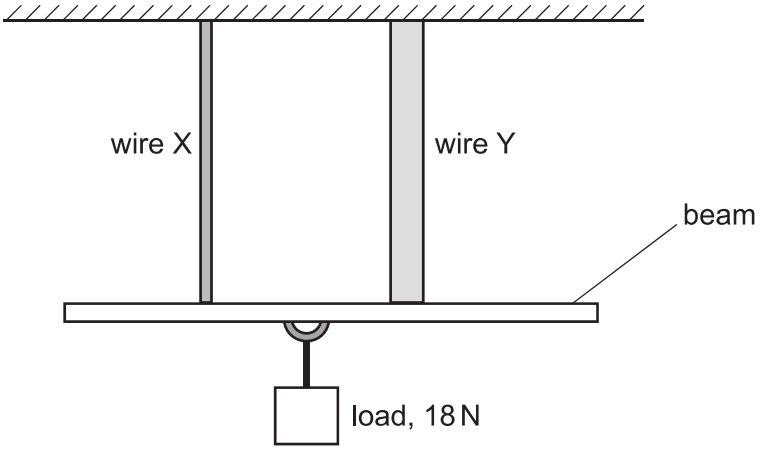

Fig. 4.1

Wire X is made from a metal that has a Young modulus of 1.9×10^9 Pa.
Wire Y is made from a different metal.

A load of weight 18 N is suspended from the beam at a point that is equidistant from the two wires. This load causes both wires to extend by 0.47 mm.

(i) Determine the cross-sectional area of wire X.

cross-sectional area = ... m^2 [3]

(ii) Wire Y has a greater diameter than wire X.

Explain, without calculation, whether the Young modulus of the metal from which wire Y is made is less than, the same as or greater than 1.9×10^9 Pa.

.....

.....

.....

..... [2]

[Total: 7]

5 **(a)** A stationary wave is formed on a string XY that has a length of 0.48 m. Fig. 5.1 shows the string at one instant in time.

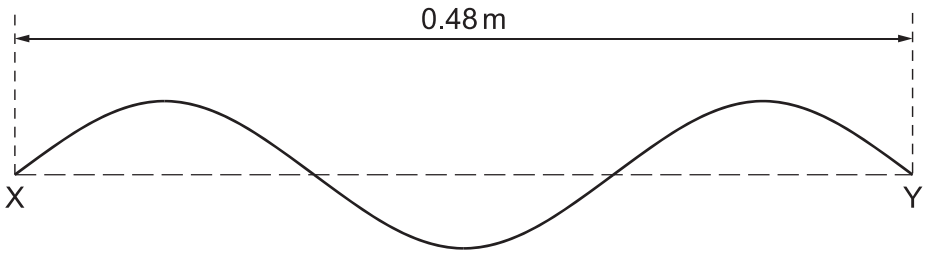

Fig. 5.1

The speed of the wave on the string is 1400 m s^{-1}.

(i) On Fig. 5.1, draw a cross (×) at **one** position that is a node and another cross at **one** position that is an antinode. Label the node N and the antinode A. [1]

(ii) Show that the wavelength of the wave produced is 0.32 m. Explain your reasoning.

[1]

(iii) Calculate the frequency of the wave.

frequency = ... Hz [2]

(b) A source of sound waves of frequency 780 Hz is on a rotating platform. The speed of the source is $39\,m\,s^{-1}$.

The sound is detected by an observer that is a large distance from the rotating platform, as shown in Fig. 5.2.

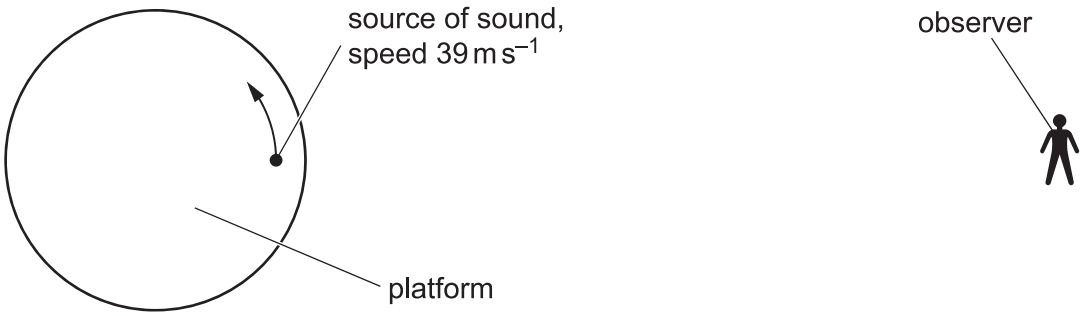

Fig. 5.2 (not to scale)

(i) The speed of sound in air is $320\,m\,s^{-1}$.

Calculate the maximum frequency of the sound detected by the observer.

maximum frequency = ... Hz [2]

(ii) At time $t = 0$, the observer detects the sound emitted by the source when it was in the position shown in Fig. 5.2.

On Fig. 5.3, sketch the variation with t of the frequency f of the sound detected by the observer for one complete rotation of the platform. Calculations are not required.

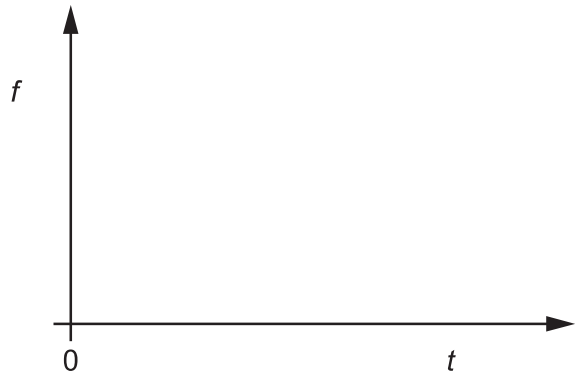

Fig. 5.3

[2]

[Total: 8]

6 **(a)** Define resistance.

.....

..... [1]

(b) A cylindrical metal wire of length 2.4 m and cross-sectional area $8.0 \times 10^{-6}\,m^2$ has a resistance of 0.33 Ω. There is a current in the wire of 4.7 A.

(i) Determine the resistivity of the metal from which the wire is made.

resistivity = ... Ω m [2]

(ii) Calculate the charge that passes through the wire in a time of 5.0 minutes.

charge = ... C [2]

(iii) The free electrons (charge carriers) in the wire have an average drift speed of $0.16\,mm\,s^{-1}$.

Determine the number density of charge carriers in the metal.

number density = ... m^{-3} [2]

(c) The wire in **(b)** may be considered to be a fixed resistor. It is connected in series with a thermistor to a battery that has negligible internal resistance.

(i) Use circuit symbols to complete Fig. 6.1 to show the circuit diagram of this arrangement.

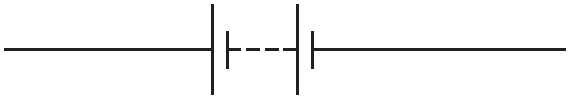

Fig. 6.1

[1]

(ii) Explain, without calculation, how the power dissipated in the wire changes as the temperature of the thermistor is increased.

.....

.....

.....

..... [2]

[Total: 10]

7 **(a)** Complete Table 7.1 to show the charges, in terms of the elementary charge *e*, on each of the flavours of quark and antiquark shown.

Table 7.1

flavour	charge / *e*	
	quark	antiquark
up		
down		
strange		

[3]

(b) **(i)** State the name of the class (group) of fundamental particles to which baryons and mesons belong.

..... [1]

(ii) Compare baryons and mesons in terms of their constituent particles.

.....

.....

..... [2]

(c) Describe β^+ decay in terms of the fundamental particles involved.

.....

.....

.....

..... [2]

[Total: 8]