



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/21

May/June 2024

1 hour 15 minutes

No additional materials are needed.

- 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.

- 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.

Data

acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

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- 1 The drag force F_D acting on an object falling through air is given by

$$F_D = \frac{1}{2} C \rho A v^2$$

where A is the cross-sectional area of the object,
 v is the velocity of the object in the air,
 ρ is the density of the air and
 C is a constant called the drag coefficient.

- (a) Use SI base units to show that the drag coefficient has no units.

[3]

- (b) Fig. 1.1 shows a sphere falling at terminal velocity in air.

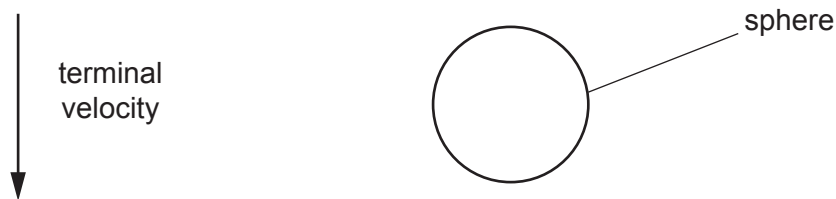


Fig. 1.1

Assume that the upthrust on the sphere is negligible.

On Fig. 1.1, draw and label arrows to show the directions of the **two** forces acting on the sphere. [2]

- (c) The mass of the sphere is 49 g.

Calculate the drag force F_D acting on the sphere.

$$F_D = \dots\dots\dots \text{ N [2]}$$

- (d) The sphere is falling in air at a terminal velocity of 25 in SI base units.
The density of the air is 1.2 in SI base units.
The diameter of the sphere is 0.060 in SI base units.

Use your answer in (c) to calculate the drag coefficient C for the sphere.

$C =$ [3]

[Total: 10]

- 2 (a) Define velocity.

.....
 [1]

- (b) A student throws a ball over a vertical wall of height h , as shown in Fig. 2.1.

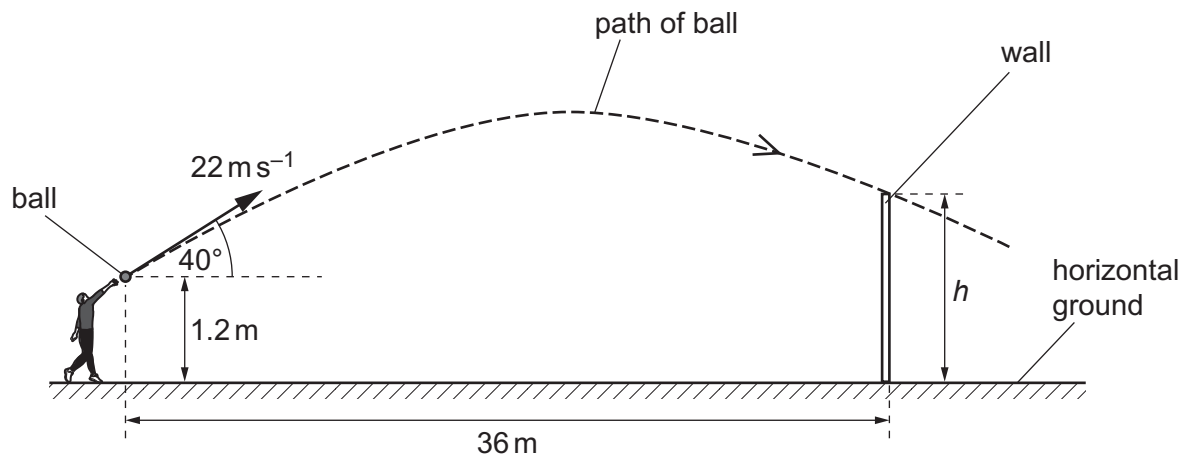


Fig. 2.1 (not to scale)

The ball leaves the hand of the student at a height of 1.2 m above the horizontal ground. The ball has an initial velocity of 22 m s^{-1} at an angle of 40° to the horizontal. The wall is a horizontal distance of 36 m from where the student releases the ball.

Air resistance is negligible.

- (i) Determine the time taken for the ball to reach the wall.

time taken = ... s [2]

- (ii) Calculate the vertical component u of the initial velocity of the ball.

$$u = \dots\dots\dots \text{ms}^{-1} \quad [1]$$

- (iii) The ball just goes over the wall.

Calculate the height h of the wall.

$$h = \dots\dots\dots \text{m} \quad [3]$$

[Total: 7]

- 3 (a) State the principle of conservation of momentum.

.....

.....

..... [2]

- (b) An object of mass $2m$ is travelling at a speed of 5.0 m s^{-1} in a straight line. It collides with an object of mass $3m$ which is initially stationary, as shown in Fig. 3.1.

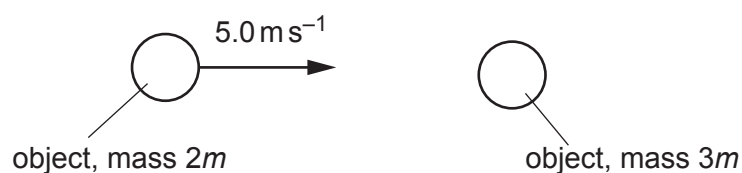


Fig. 3.1

After the collision, the object of mass $2m$ moves with velocity v at an angle of 30° to its original direction of motion.

The object of mass $3m$ moves with velocity w also at an angle of 30° , as shown in Fig. 3.2.

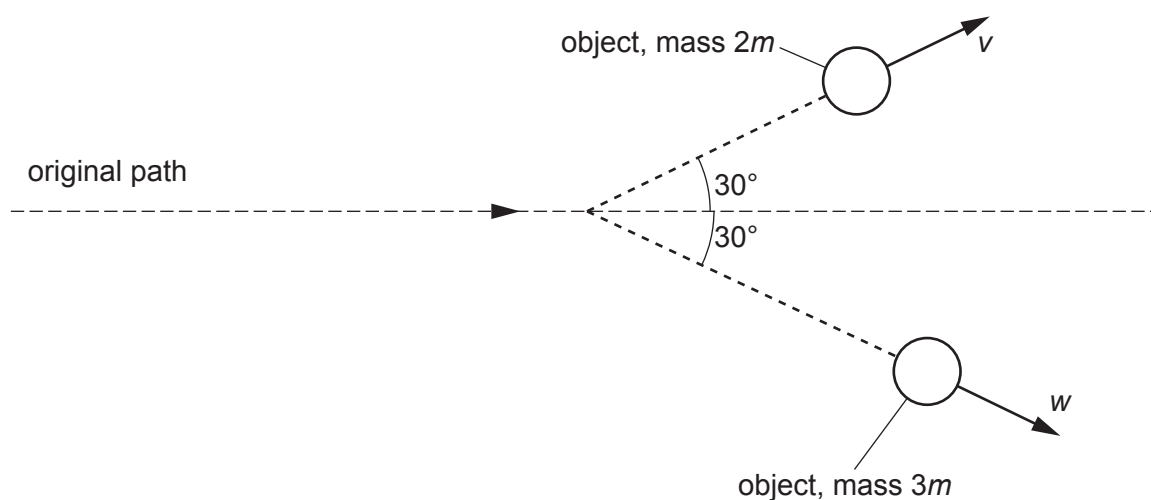


Fig. 3.2

By considering the conservation of momentum in two dimensions, calculate the magnitudes of v and w .

$$v = \dots\dots\dots \text{ms}^{-1}$$

$$w = \dots\dots\dots \text{ms}^{-1}$$

[4]

- (c) An object of mass 4.2 kg is travelling in a straight line at a speed of 6.0 ms^{-1} . The object is brought to rest in a distance of 0.050 m by a constant force.

Calculate the magnitude of this force.

$$\text{force} = \dots\dots\dots \text{N} \quad [3]$$

[Total: 9]

- 4 (a) Define strain.

.....
..... [1]

- (b) A copper wire of length 4.0 m has a uniform cross-sectional area of $4.5 \times 10^{-7} \text{ m}^2$.

A tensile force of 18 N is applied to the wire. This causes the wire to extend by 1.4 mm up to its limit of proportionality.

- (i) Calculate the Young modulus of the wire.

Young modulus = ...Pa [3]

- (ii) On Fig. 4.1, draw a line to show how the stress varies with the strain for the wire up to its limit of proportionality.

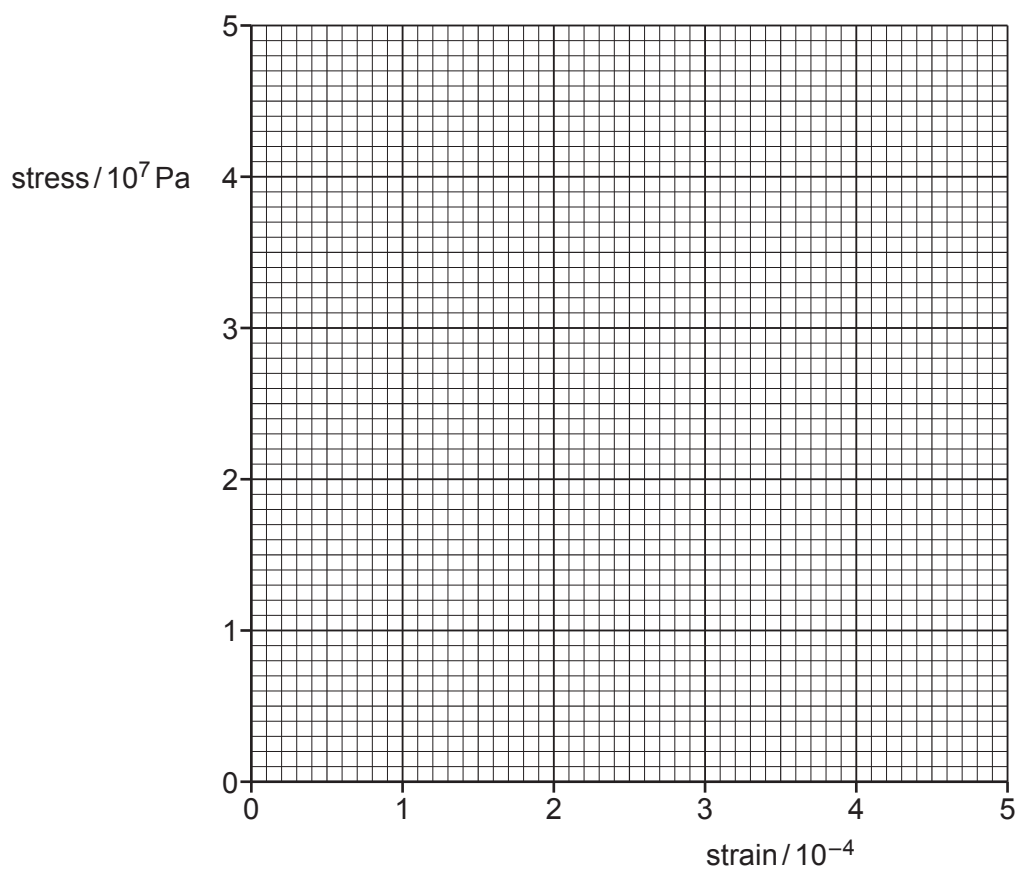


Fig. 4.1

[2]

- (c) A second copper wire has the same length as the wire in (b) but a larger diameter. Both wires are subjected to a tensile force of 18 N.

By placing a tick (✓) in each row, complete Table 4.1 to compare the stress and strain of the two wires.

Table 4.1

	greater in second wire	less in second wire	the same in both wires
stress			
strain			

[2]

[Total: 8]

- 5 A stretched string PQ has length 1.2 m. One end of the string is attached to a vibration generator and the other end is attached to a wall, as shown in Fig. 5.1.

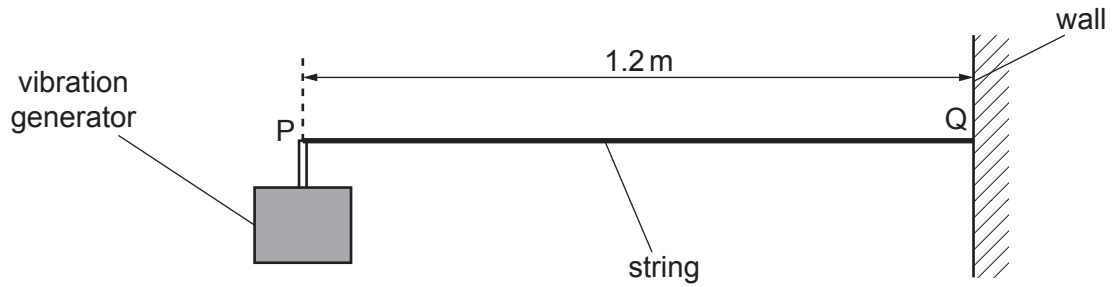


Fig. 5.1

The vibration generator is switched on and a stationary wave is formed on the string. The string is shown at one instant of time in Fig. 5.2.

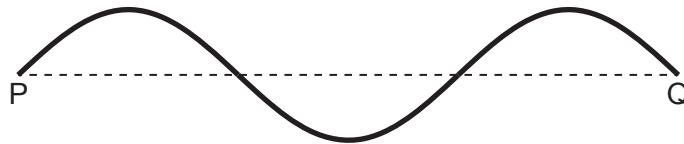


Fig. 5.2

- (a) Explain how a stationary wave is formed between the vibration generator and the wall.

.....

.....

.....

..... [2]

- (b) Calculate the wavelength of the stationary wave shown in Fig. 5.2.

wavelength = ... m [1]

- (c) Fig. 5.3 shows the stationary wave at time $t = 0$ when all points on the wave are at their maximum displacements.

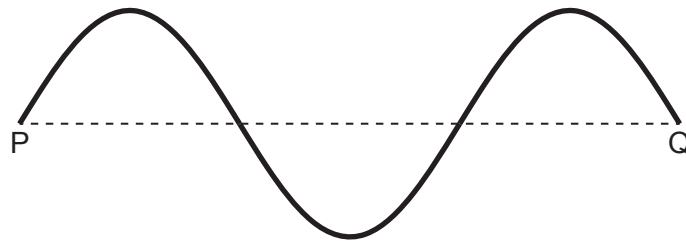


Fig. 5.3

The period of the wave is 0.16 s.

On Fig. 5.3, sketch the shape of the stationary wave at time $t = 0.24$ s. [2]

- (d) Points R and T on the string are a horizontal distance of 0.30 m apart and in the positions shown in Fig. 5.4.

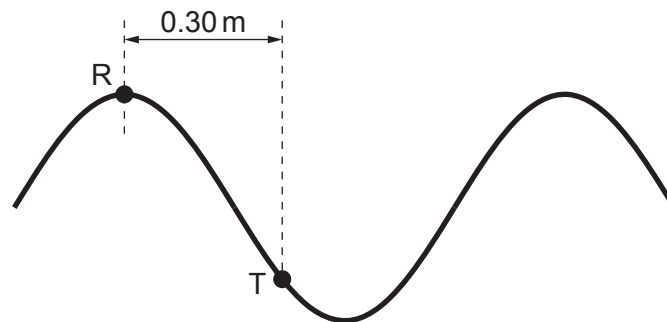


Fig. 5.4

State the phase difference between the oscillations of points R and T.

phase difference = ... ° [1]

- (e) Calculate the speed of the progressive waves on the stretched string.

speed = ... ms^{-1} [2]

[Total: 8]

- 6 (a) State Kirchhoff's first law.

.....
 [1]

- (b) A cell with internal resistance r is connected to two resistors of resistances R_1 and R_2 as shown in Fig. 6.1.

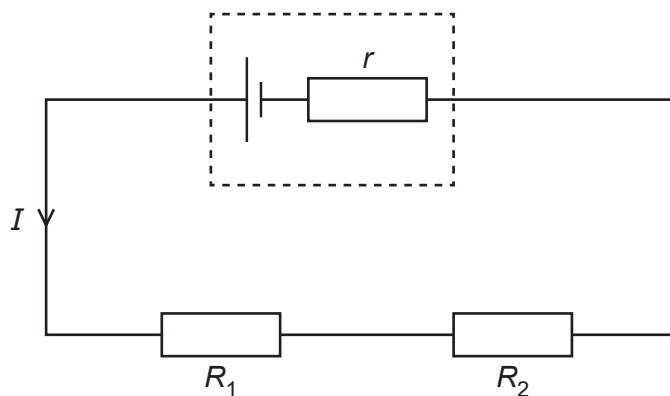


Fig. 6.1

The potential differences (p.d.s) across R_1 and R_2 are V_1 and V_2 respectively.
 The terminal p.d. across the cell is V .
 The current in the circuit is I .

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

$$R_T = R_1 + R_2 .$$

[2]

- (c) The electromotive force (e.m.f.) of the cell in Fig. 6.1 is 1.50 V.

The values of R_1 and R_2 are $10\ \Omega$ and $15\ \Omega$ respectively. The terminal p.d. of the cell is 1.35 V.

Calculate the internal resistance r of the cell.

$r = \dots\dots\dots\ \Omega$ [3]

- (d) A resistor of resistance R_3 is added to the circuit in Fig. 6.1, so that the circuit is as shown in Fig. 6.2.

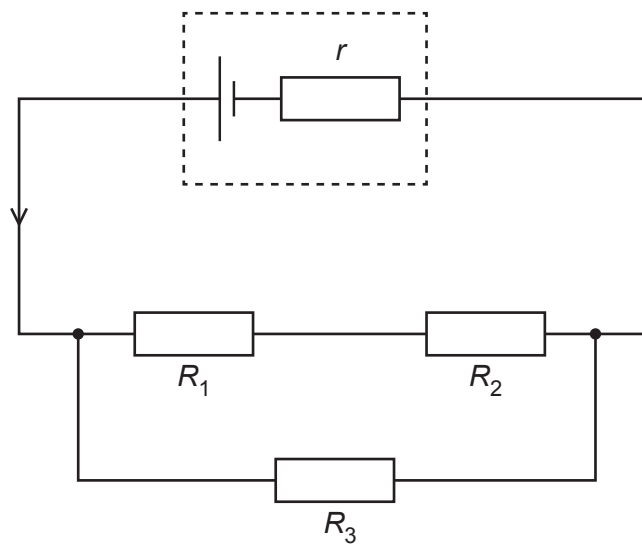


Fig. 6.2

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

- (i) the current in the cell

.....

 [2]

- (ii) the terminal p.d. of the cell.

.....

 [2]

- 7 Nuclei of an isotope of copper (Cu) each have 29 protons and 37 neutrons. This isotope is a β^- emitter.

(a) State the nuclide notation in the form ${}^A_Z\text{X}$ for this nucleus of copper.

[1]

- (b) The energy spectrum of the β^- radiation emitted by a sample of this isotope is shown in Fig. 7.1.

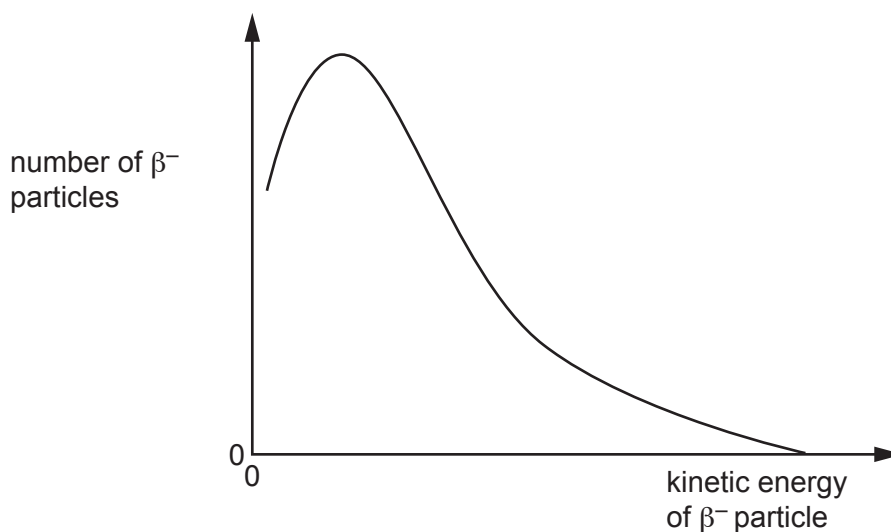


Fig. 7.1

- (i) Use Fig. 7.1 to explain why other particles apart from the β^- particles must be emitted during this decay.

.....

 [3]

- (ii) State the name of the other particle emitted during the decay of this isotope.

..... [1]

- (iii) The copper isotope decays to an isotope of zinc (Zn).

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

[3]

[Total: 8]

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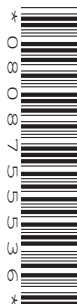
Cambridge International AS & A Level

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PHYSICS

9702/22

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.
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- Do **not** write on any bar codes.
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INFORMATION

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- The number of marks for each question or part question is shown in brackets [].

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



Data

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upthrust	$F = \rho g V$
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electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$



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- 1 (a) The list below shows some SI quantities.

Underline the quantity that is **not** an SI base quantity.

charge

current

length

time

[1]

- (b) A square solar panel with sides of length 1300 mm is shown in Fig. 1.1.

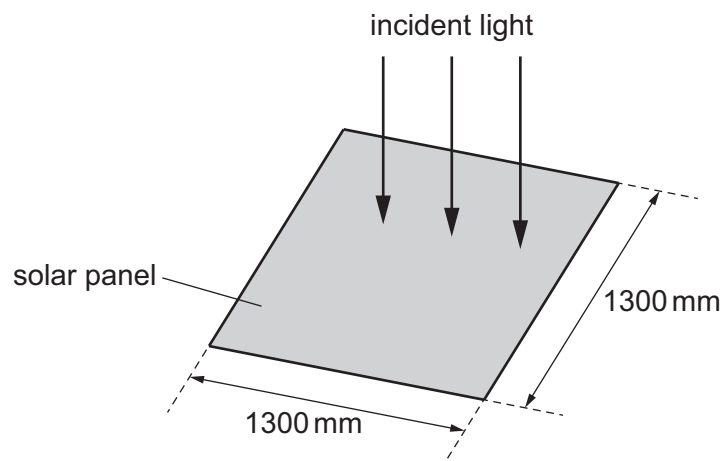


Fig. 1.1 (not to scale)

Light is incident normally on the solar panel.

- (i) The power of the light incident on the solar panel is 750 W.

Calculate the intensity of the light.

intensity = ... Wm^{-2} [3]

- (ii) The percentage uncertainty in the incident power is $\pm 3\%$.
The uncertainty in the length of each side is $\pm 5 \text{ mm}$.

Calculate the percentage uncertainty in the intensity of the light.

percentage uncertainty = ... % [2]





- (iii) The useful power output of the solar panel is 160 W.

Calculate the percentage efficiency of the solar panel.

efficiency = ... % [1]

- (iv) Another square solar panel is placed so that light of the same intensity is incident normally on it. The new panel has shorter sides than the original panel. The new panel has the same power output as the original panel.

State and explain whether the efficiency of the new panel is greater than, less than or the same as the efficiency of the original panel.

.....
.....
.....
.....
..... [3]

[Total: 10]



- 2 A skydiver jumps from an aircraft at time $t = 0$ and falls vertically downwards. The variation with t of her velocity v is shown in Fig. 2.1.

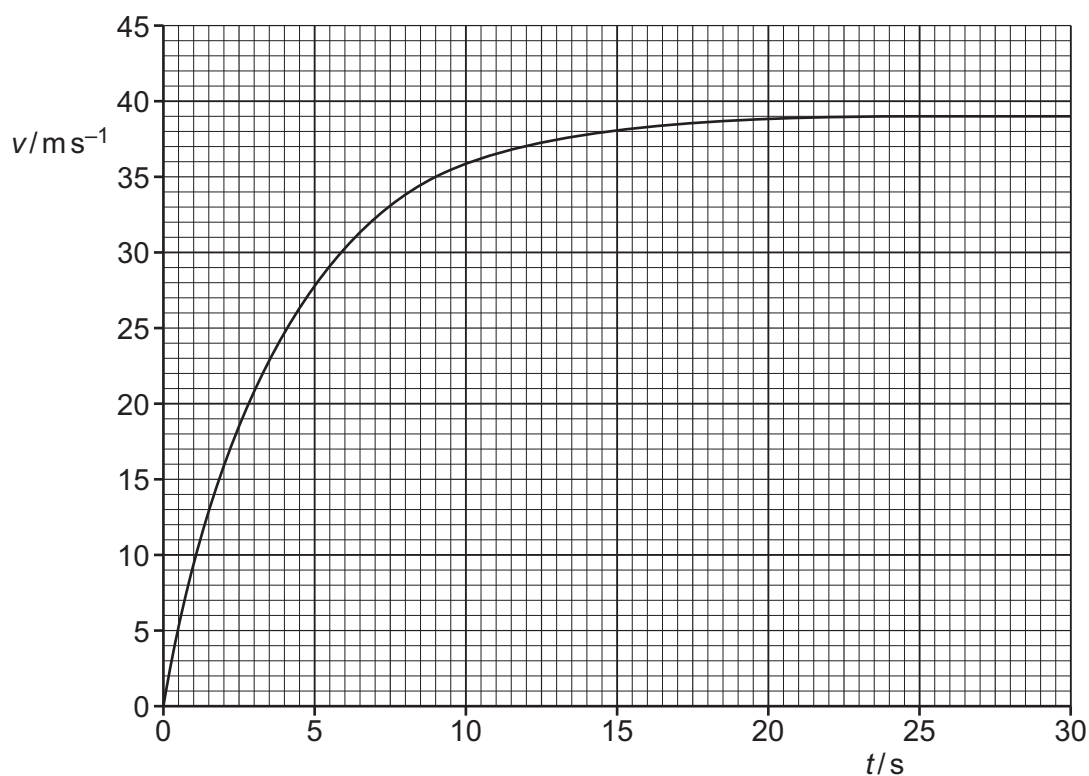


Fig. 2.1

- (a) (i) Using Fig. 2.1, state the terminal velocity of the skydiver.

terminal velocity = ... ms^{-1} [1]

- (ii) By drawing a suitable line on Fig. 2.1, determine the acceleration of the skydiver at time $t = 9.0\text{ s}$.

acceleration = ... ms^{-2} [2]



- (b) The mass of the skydiver and her equipment is 68 kg. The upthrust on the skydiver is negligible.

After reaching terminal velocity, the skydiver opens her parachute at time t_1 . A total drag force of 1800 N acts on the skydiver.

Determine the magnitude and direction of the acceleration of the skydiver at time t_1 .

acceleration = ... ms^{-2}

direction = ... [3]

- (c) The parachute is fully open at time t_2 . At a later time t_3 the skydiver reaches a constant velocity of 5.7 ms^{-1} .

- (i) Describe and explain the variation with time of the magnitude of her acceleration between time t_2 and time t_3 .

.....

 [2]

- (ii) Calculate the change in momentum of the skydiver between time t_1 and time t_3 .

change in momentum = ... N s [2]

[Total: 10]





- 3 Lightning occurs when charge builds up in the atmosphere, creating a potential difference between the ground and the atmosphere.

During a lightning strike there is an average current of $3.3 \times 10^4 \text{ A}$ for a time of $2.6 \times 10^{-5} \text{ s}$.

- (a) Calculate the charge transferred during the lightning strike.

charge = ... C [2]

- (b) The potential difference between the ground and the atmosphere is $3.0 \times 10^7 \text{ V}$.

Calculate the average power, in GW, transferred during the lightning strike.

power = ... GW [2]

- (c) A lightning rod is attached to a tall building to conduct charge safely to the ground. The lightning rod is modelled as a uniform cylindrical copper cable of total length 95m that runs from the ground to the top of the building, as shown in Fig. 3.1.

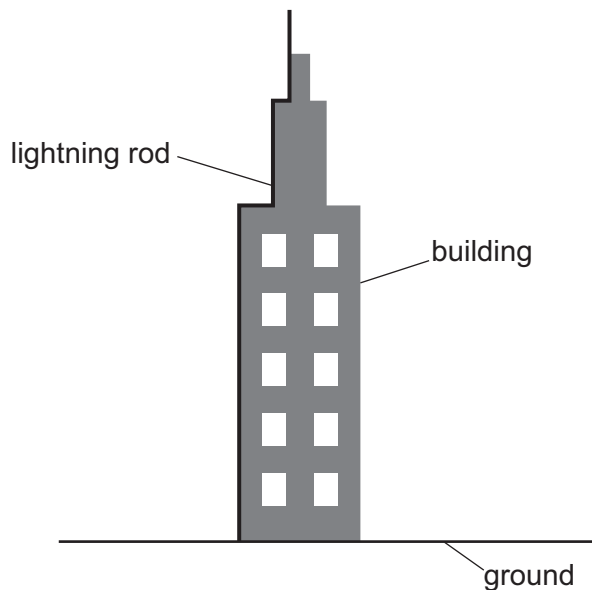


Fig. 3.1



- (i) The resistance of the lightning rod is $9.6\ \Omega$.
The resistivity of copper is $1.7 \times 10^{-8}\ \Omega\text{m}$.

Determine the radius of the lightning rod.

radius = ... m [3]

- (ii) The radius of the copper lightning rod is doubled with no change to its length.

State the effect of this change on the resistance of the lightning rod.

..... [1]

- (d) A section of the lightning rod of length 0.12m is removed for testing. A tensile stress of $1.9 \times 10^6\text{Pa}$ is applied, as shown in Fig. 3.2.

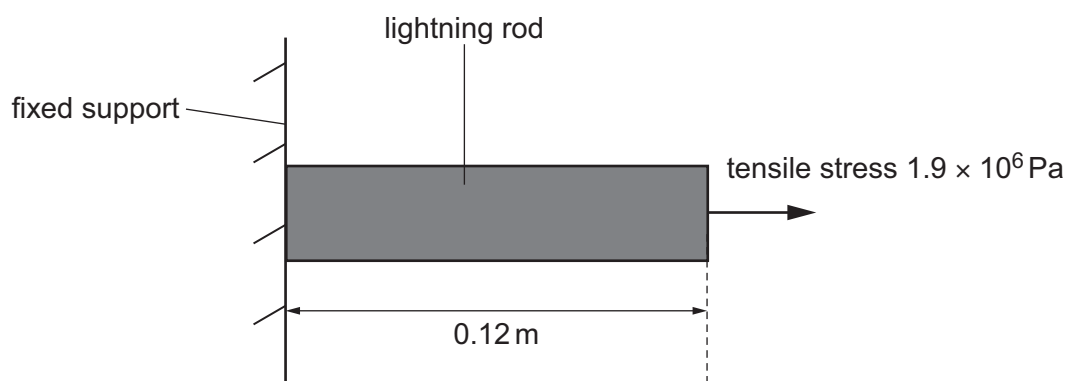


Fig. 3.2 (not to scale)

The section of the rod obeys Hooke's law. The Young modulus of copper is $1.3 \times 10^{11}\text{Pa}$.

Calculate the extension of the section.

extension = ... m [3]

[Total: 11]





- 4 A pinball machine uses a spring to launch a small metal ball of mass $4.5 \times 10^{-2} \text{ kg}$ up a ramp. The spring is compressed by $8.0 \times 10^{-2} \text{ m}$ and held in equilibrium, as shown in Fig. 4.1.

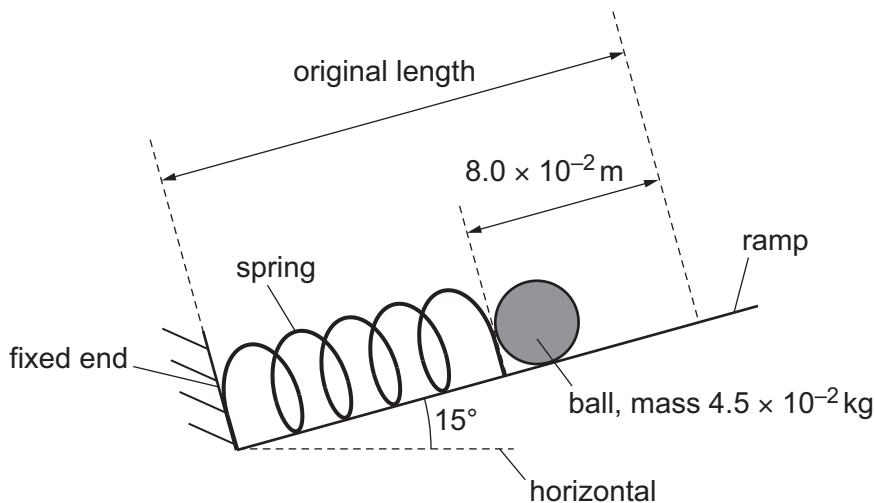


Fig. 4.1 (not to scale)

The ramp is at an angle of 15° to the horizontal.

- (a) The spring obeys Hooke's law and has a spring constant of 29 N m^{-1} .

Calculate the elastic potential energy in the compressed spring.

elastic potential energy = ... J [2]

- (b) The spring is released and expands quickly back to its original length.

- (i) Calculate the increase in gravitational potential energy of the ball when the spring returns to its original length.

increase in gravitational potential energy = ... J [3]



- (ii) The ball leaves the spring when the spring reaches its original length. Assume that all the elastic potential energy of the spring is transferred to the ball.

Calculate the speed of the ball as it leaves the spring.

speed = ... ms^{-1} [3]

- (c) The ball comes to rest on a horizontal trapdoor of negligible mass at a distance d from its pivot.
A force F acts vertically downwards at a distance of 2.0 cm from the pivot, as shown in Fig. 4.2.

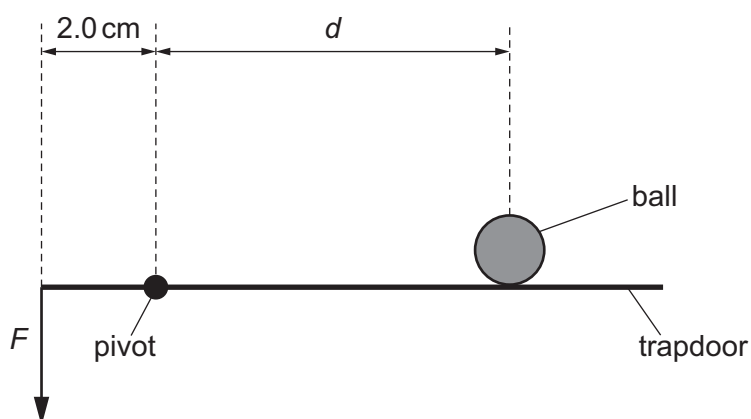


Fig. 4.2 (not to scale)

- (i) The trapdoor is in equilibrium when F is 1.7 N.

Calculate d .

$d = \dots\dots\dots$ m [2]

- (ii) Force F is decreased from 1.7 N.

State the direction of the resultant moment about the pivot on the trapdoor.

..... [1]





5 (a) State Kirchhoff's second law.

.....
 [1]

(b) A battery of electromotive force (e.m.f.) 9.0V and negligible internal resistance is connected in series with a variable resistor X and a thermistor Y as shown in Fig. 5.1.

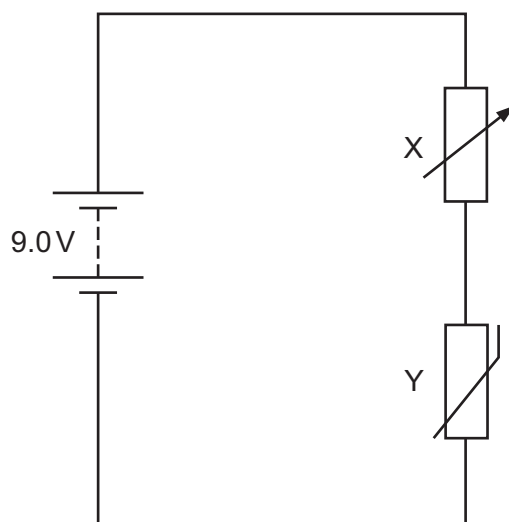


Fig. 5.1

Fig. 5.2 shows the relationship between temperature and resistance for the thermistor.

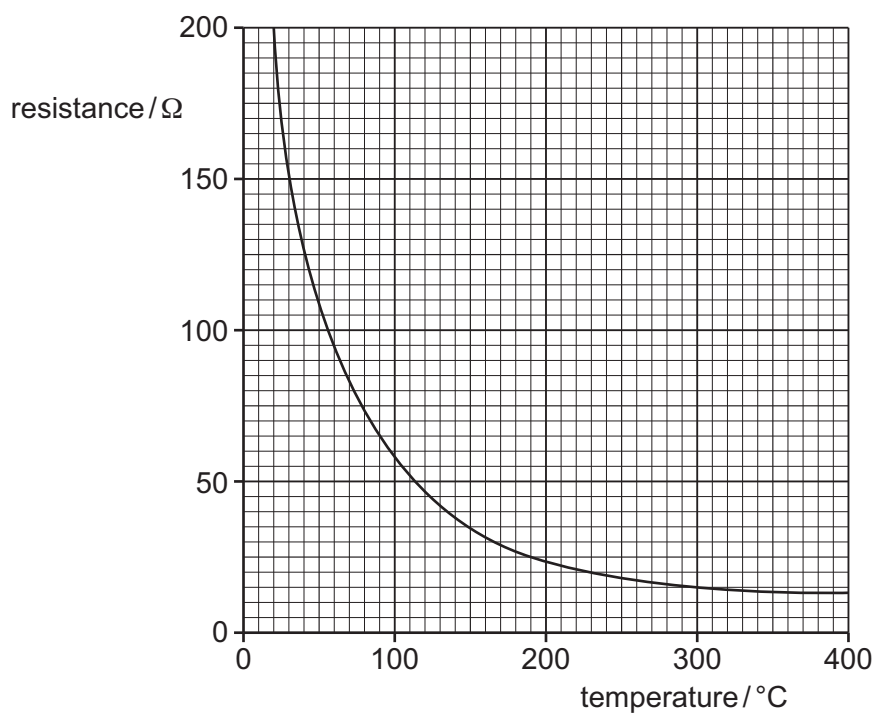


Fig. 5.2





- (i) The current in the circuit is $1.1 \times 10^{-2} \text{ A}$. The potential difference across Y is 4.0 V.

Calculate the resistance of X.

resistance = ... Ω [2]

- (ii) The temperature of Y is changed to 190°C . The resistance of X remains unchanged.

Determine the new potential difference across Y.

potential difference = ... V [3]

- (iii) The resistance of X is increased. The temperature of Y remains at 190°C .

By reference to the current in the circuit, state and explain the effect of this change, if any, on the potential difference **across Y**.

.....

.....

.....

.....

.....

..... [3]

[Total: 9]





- 6 Light of a single frequency is incident normally on a diffraction grating. An interference pattern of bright and dark fringes forms on the semicircular screen shown in Fig. 6.1.

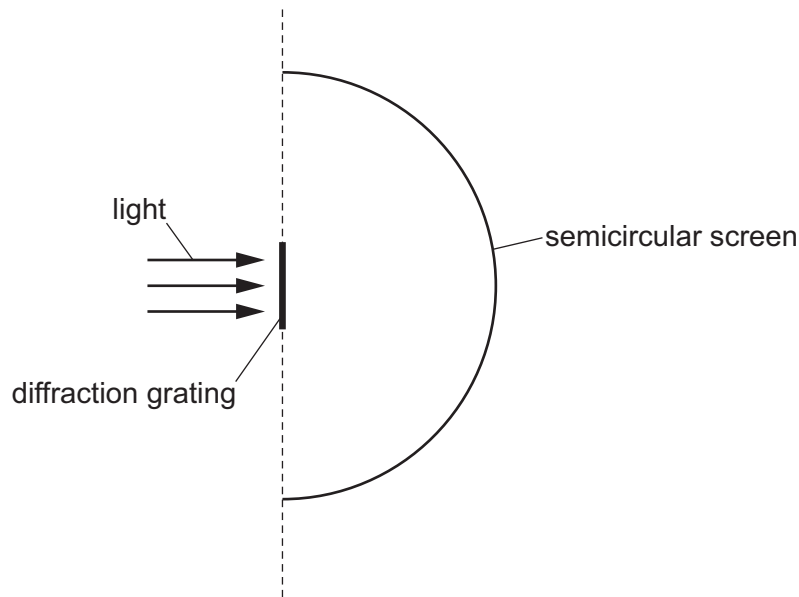


Fig. 6.1 (not to scale)

The light has wavelength 520 nm.

The separation of the lines in the grating is 3.8×10^{-6} m.

- (a) Determine the total number of bright fringes formed on the screen.

number of bright fringes = ... [3]





(b) The light is replaced with red light of a single frequency.

- (i) State whether the frequency of the red light is greater than, less than or the same as the frequency of the original light.

..... [1]

- (ii) State and explain the effect of this change on the number of bright fringes formed on the screen. A calculation is not required.

.....

.....

.....

..... [2]

[Total: 6]





7 A particle Q and a particle R are each composed of one quark and one antiquark.

(a) State the name of the class (group) of particles that includes Q and R.

..... [1]

(b) Q has a charge of $-1e$, where e is the elementary charge. R has a charge of 0.

Complete Table 7.1 to show a possible second quark in each of Q and R.

Table 7.1

	charge	first quark	second quark
Q	$-1e$	strange	
R	0	anti-up	

[2]

[Total: 3]

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9702/23

May/June 2024

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- 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.

- 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.

Data

acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$
speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Stefan–Boltzmann constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
hydrostatic pressure	$\Delta p = \rho g \Delta h$
upthrust	$F = \rho g V$
Doppler effect for sound waves	$f_o = \frac{f_s v}{v \pm v_s}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

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

$$F_D = 6\pi\eta rv$$

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 $\text{kg m}^{-1} \text{s}^{-1}$.

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

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

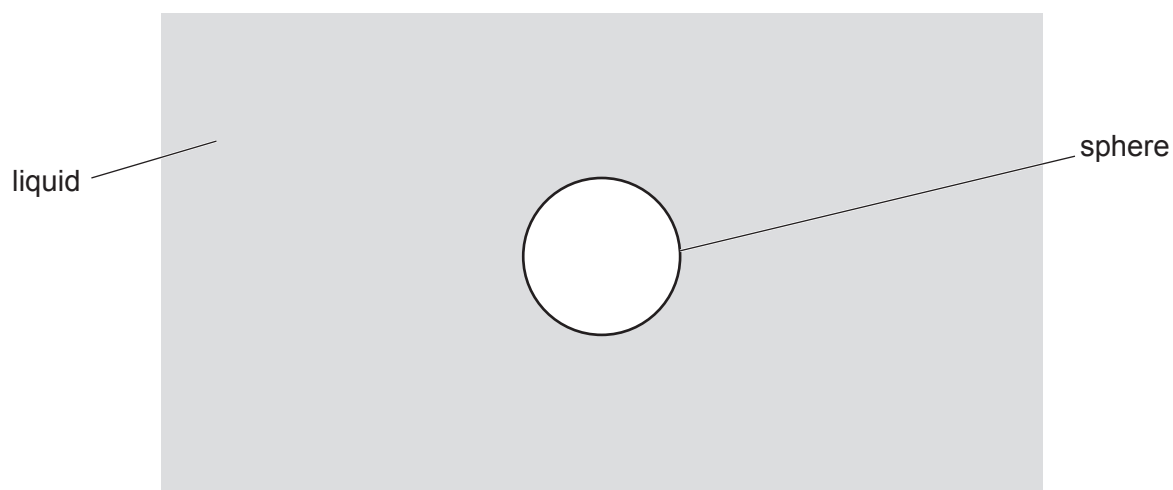


Fig. 1.1

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. [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.

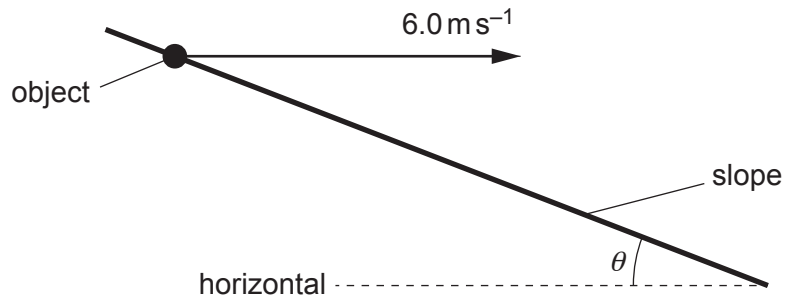


Fig. 2.1 (not to scale)

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 .

$$\theta = \dots\dots\dots^\circ \quad [2]$$

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

$$\text{displacement} = \dots\dots\dots \text{ m} \quad [2]$$

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

$$\text{speed} = \dots\dots\dots \text{ m s}^{-1} \quad [3]$$

[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.

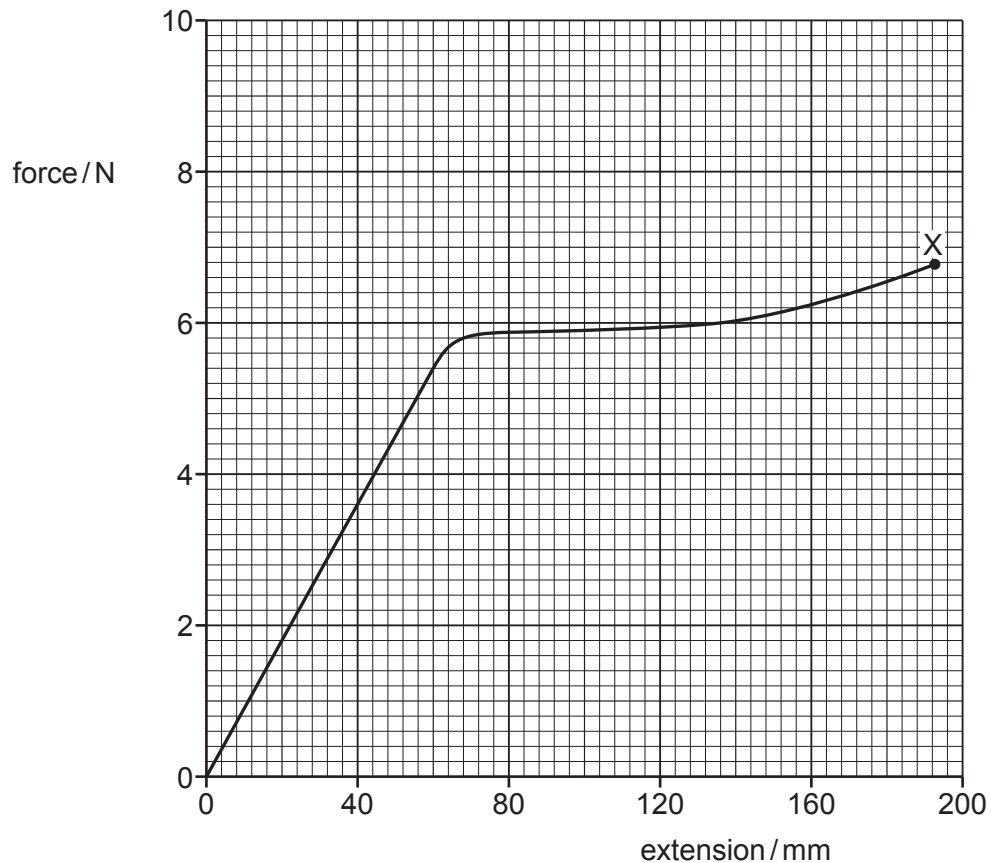


Fig. 3.1

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]

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

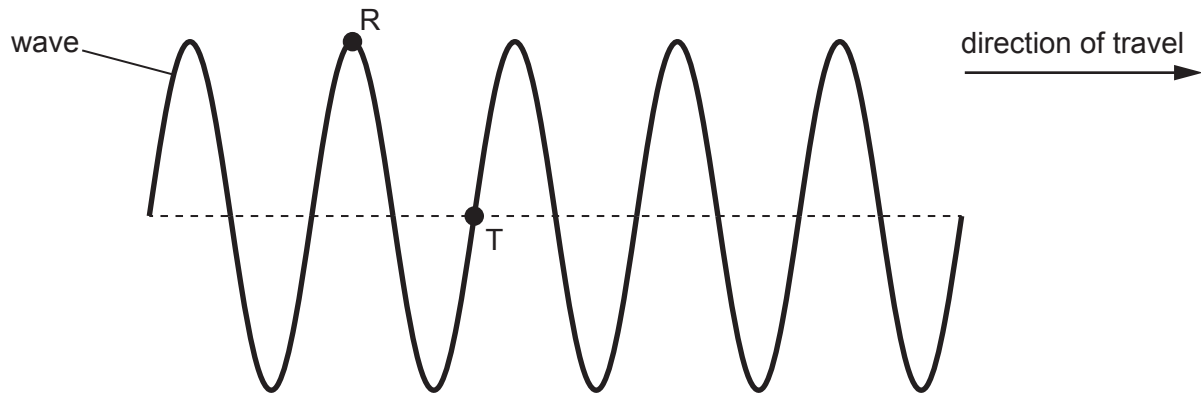


Fig. 4.1

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.

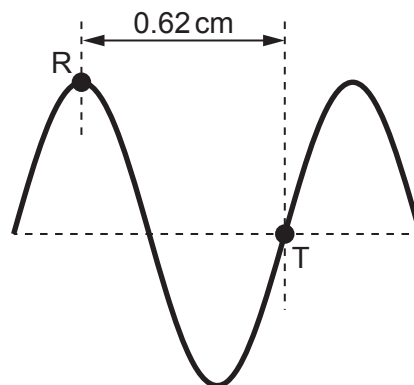


Fig. 4.2 (not to scale)

The speed of the wave is 0.27 ms^{-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.

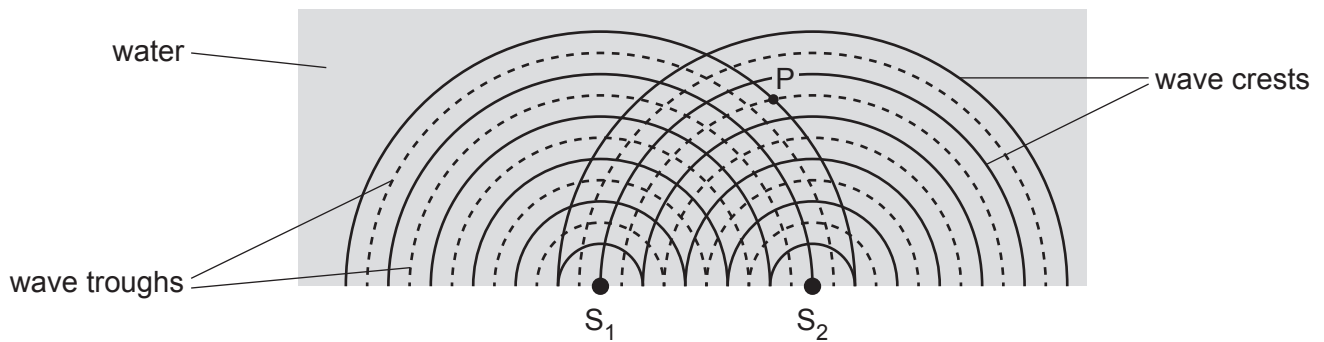


Fig. 4.3 (not to scale)

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.

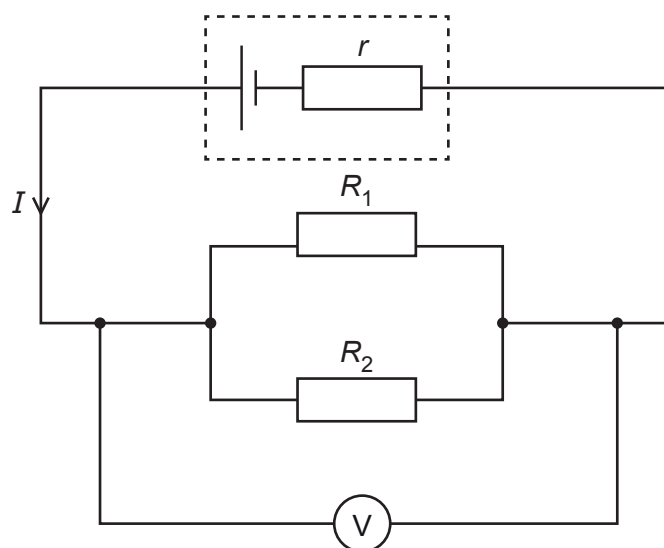


Fig. 5.1

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 $10\,\Omega$ and $15\,\Omega$ respectively, the p.d. measured by the voltmeter is 1.38 V.

Calculate the internal resistance r of the cell.

$r = \dots\dots\dots \Omega$ [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]

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

(a) State the nuclide notation in the form ${}^A_Z\text{X}$ 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.

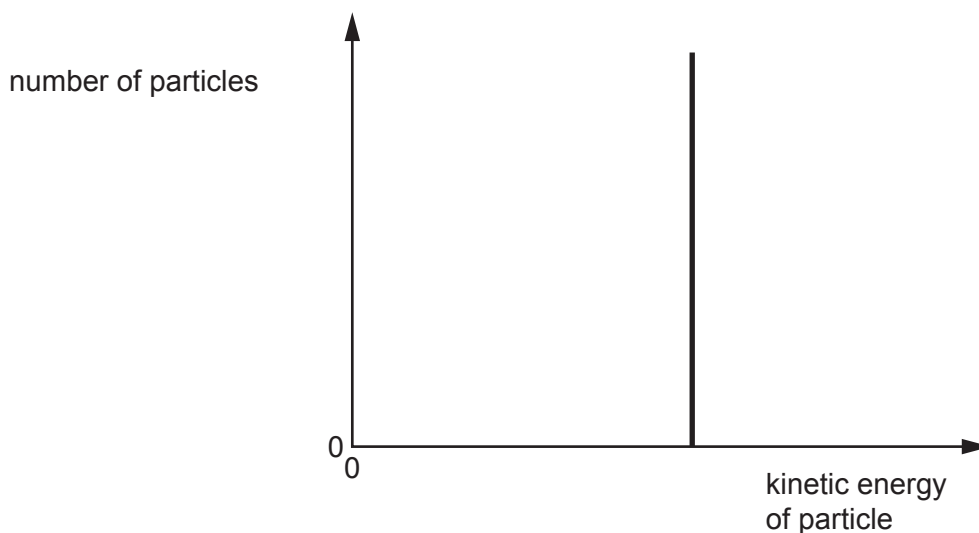


Fig. 6.1

- (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]

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