

CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

PHYSICS

9702/21

Paper 2 AS Level Structured Questions

May/June 2018

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

This document consists of **16** printed pages and **4** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
	$(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

- 1 (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.

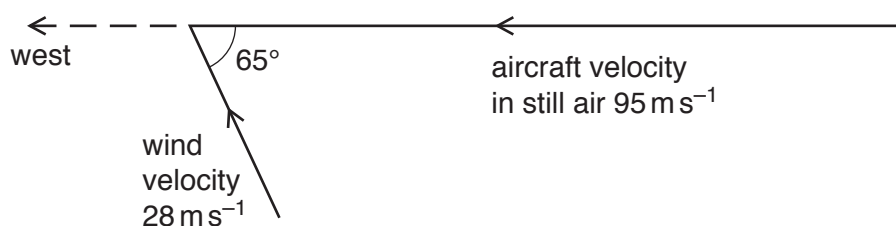


Fig. 1.2

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

[Total: 7]

- 2 (a) State Newton's first law of motion.

.....
[1]

- (b) A block of weight 15N hangs by a wire from a remotely controlled aircraft, as shown in Fig. 2.1.

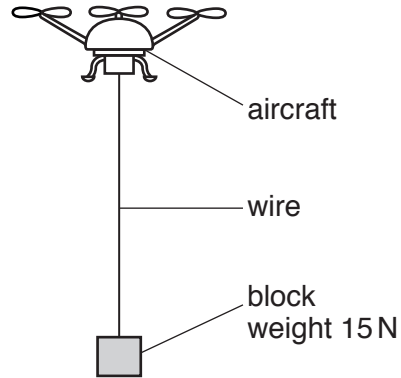


Fig. 2.1

The aircraft is used to move the block only in a vertical direction. The force on the block due to air resistance is negligible.

The variation with time t of the vertical velocity v of the block is shown in Fig. 2.2. The velocity is taken to be positive in the upward direction.

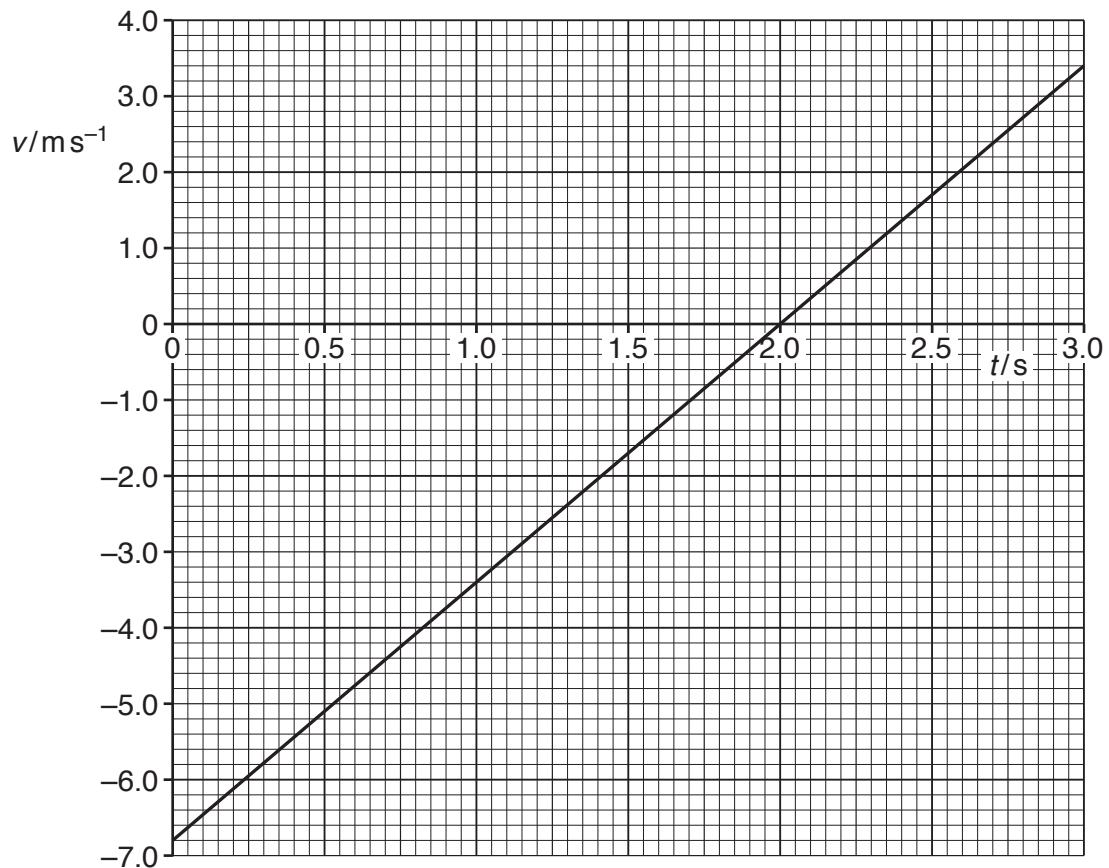


Fig. 2.2

(i) Determine, for the block,

1. the displacement from time $t = 0$ to $t = 3.0$ s,

magnitude of displacement = ... m

direction of displacement [3]

2. the change in gravitational potential energy from time $t = 0$ to $t = 3.0$ s.

change in gravitational potential energy = ... J [2]

(ii) Calculate the magnitude of the acceleration of the block at time $t = 2.0$ s.

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

(iii) Use your answer in (b)(ii) to show that the tension T in the wire at time $t = 2.0$ s is 20 N.

[2]

- (iv) The wire has a cross-sectional area of $2.8 \times 10^{-5} \text{ m}^2$ and is made from metal of Young modulus $1.7 \times 10^{11} \text{ Pa}$. The wire obeys Hooke's law.

Calculate the strain of the wire at time $t = 2.0 \text{ s}$.

strain = ... [3]

- (v) At some time after $t = 3.0 \text{ s}$ the tension in the wire has a constant value of 15 N .

State and explain whether it is possible to deduce that the block is moving vertically after $t = 3.0 \text{ s}$.

.....

[2]

[Total: 15]

BLANK PAGE

- 3 (a) State what is meant by the *mass* of a body.

.....
[1]

- (b) Two blocks travel directly towards each other along a horizontal, frictionless surface. The blocks collide, as illustrated in Fig. 3.1.

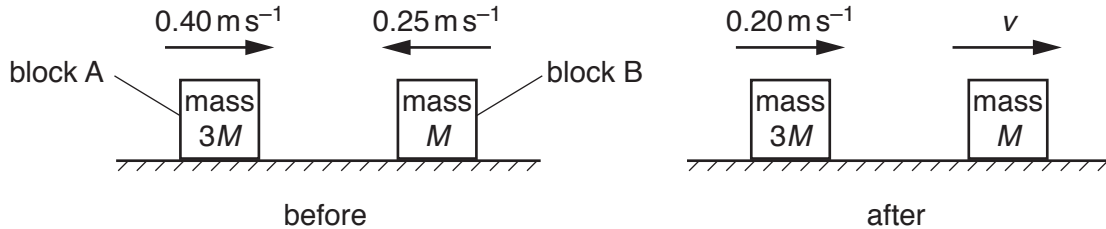


Fig. 3.1

Block A has mass $3M$ and block B has mass M .

Before the collision, block A moves to the right with speed 0.40 ms^{-1} and block B moves to the left with speed 0.25 ms^{-1} .

After the collision, block A moves to the right with speed 0.20 ms^{-1} and block B moves to the right with speed v .

- (i) Use Newton's third law to explain why, during the collision, the change in momentum of block A is equal and opposite to the change in momentum of block B.

.....

[2]

- (ii) Determine speed v .

$v = \dots\dots\dots \text{ ms}^{-1}$ [3]

(iii) Calculate, for the blocks,

1. the relative speed of approach,

relative speed of approach = ... ms^{-1}

2. the relative speed of separation.

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

(iv) Use your answers in (b)(iii) to state and explain whether the collision is elastic or inelastic.

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

[Total: 9]

4 (a) For a progressive wave, state what is meant by

(i) the *period*,

.....
[1]

(ii) the *wavelength*.

.....
[1]

(b) Fig. 4.1 shows the variation with time t of the displacement x of two progressive waves P and Q passing the same point.

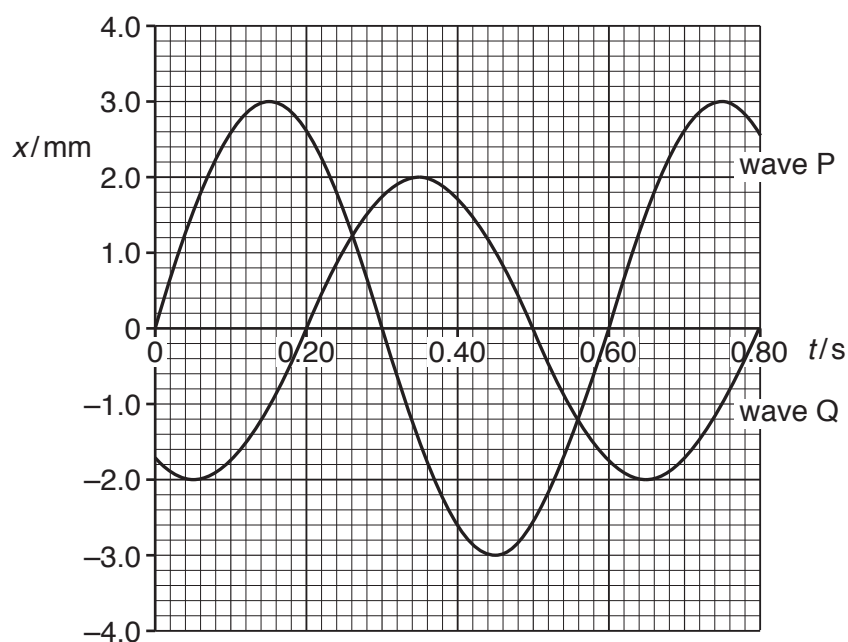


Fig. 4.1

The speed of the waves is 20 cm s^{-1} .

(i) Calculate the wavelength of the waves.

wavelength = ... cm [2]

- (ii) Determine the phase difference between the two waves.

phase difference = ... ° [1]

- (iii) Calculate the ratio

$$\frac{\text{intensity of wave Q}}{\text{intensity of wave P}}$$

ratio = ... [2]

- (iv) The two waves superpose as they pass the same point. Use Fig. 4.1 to determine the resultant displacement at time $t = 0.45$ s.

displacement = ... mm [1]

[Total: 8]

- 5 (a) When monochromatic light is incident normally on a diffraction grating, the emergent light waves have been diffracted and are coherent.

Explain what is meant by

- (i) *diffracted* waves,

.....
[1]

- (ii) *coherent* waves.

.....
[1]

- (b) Light consisting of only two wavelengths λ_1 and λ_2 is incident normally on a diffraction grating.

The third order diffraction maximum of the light of wavelength λ_1 and the fourth order diffraction maximum of the light of wavelength λ_2 are at the same angle θ to the direction of the incident light.

- (i) Show that the ratio $\frac{\lambda_2}{\lambda_1}$ is 0.75.

Explain your working.

[2]

- (ii) The difference between the two wavelengths is 170 nm.

Determine wavelength λ_1 .

$\lambda_1 = \dots\dots\dots$ nm [1]

[Total: 5]

- 6 (a) Define the *volt*.

.....[1]

- (b) A battery of electromotive force (e.m.f.) 4.5 V and negligible internal resistance is connected to two filament lamps P and Q and a resistor R, as shown in Fig. 6.1.

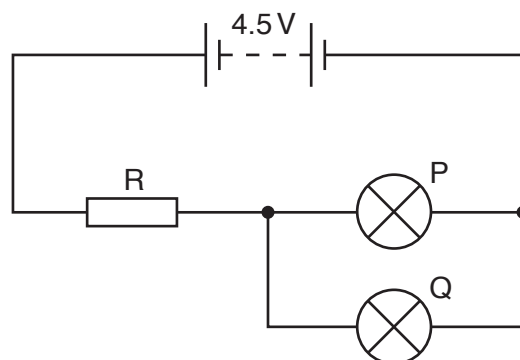


Fig. 6.1

The current in lamp P is 0.15 A.

The I - V characteristics of the filament lamps are shown in Fig. 6.2.

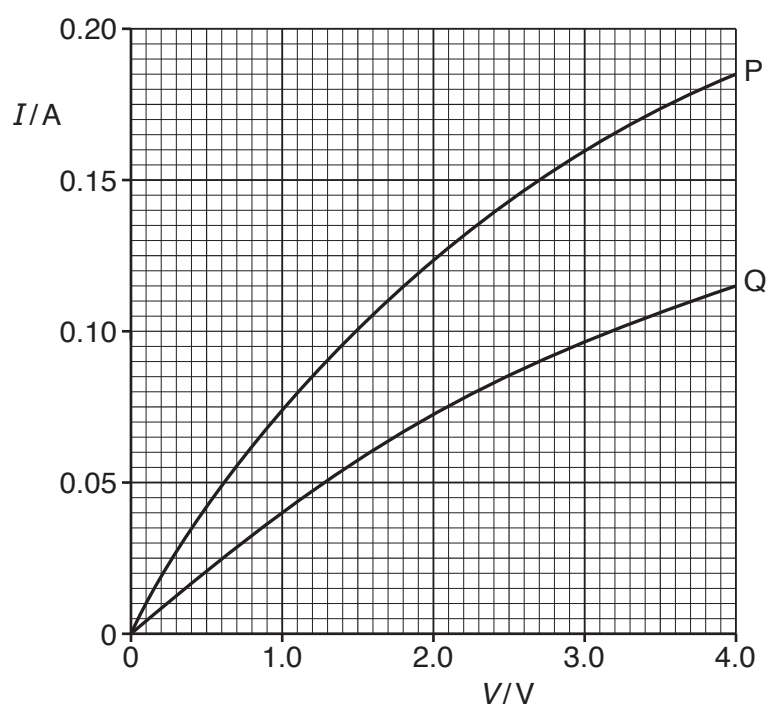


Fig. 6.2

- (i) Use Fig. 6.2 to determine the current in the battery. Explain your working.

current = ... A [2]

- (ii) Calculate the resistance of resistor R.

resistance = ... Ω [2]

- (iii) The filament wires of the two lamps are made from material with the same resistivity at their operating temperature in the circuit. The diameter of the wire of lamp P is twice the diameter of the wire of lamp Q.

Determine the ratio

$$\frac{\text{length of filament wire of lamp P}}{\text{length of filament wire of lamp Q}}$$

ratio = ... [3]

- (iv) The filament wire of lamp Q breaks and stops conducting.

State and explain, qualitatively, the effect on the resistance of lamp P.

.....

 [2]

[Total: 10]

- 7 A β^- particle from a radioactive source is travelling in a vacuum with kinetic energy 460 eV. The particle enters a uniform electric field at a right-angle and follows the path shown in Fig. 7.1.

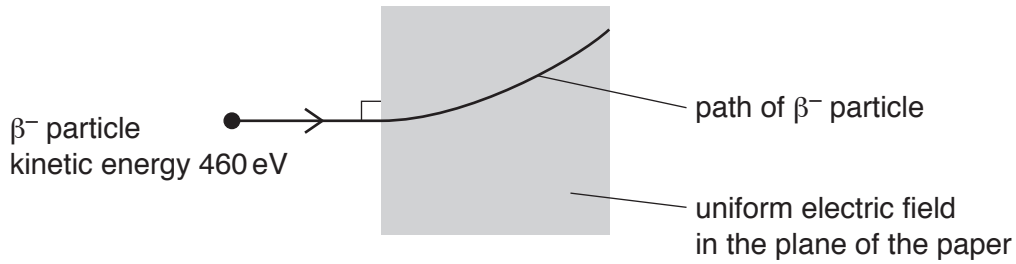


Fig. 7.1

- (a) The direction of the electric field is in the plane of the paper.
On Fig. 7.1, draw an arrow to show the direction of the electric field. [1]
- (b) Calculate the speed of the β^- particle before it enters the electric field.

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

- (c) Other β^- particles from the same radioactive source travel outside the electric field along the same incident path as that shown in Fig. 7.1.

State and briefly explain whether those β^- particles will all follow the same path inside the electric field.

.....

.....

.....

.....[2]

[Total: 6]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

CANDIDATE
NAME

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

PHYSICS

Paper 2 AS Level Structured Questions

9702/22

May/June 2018

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

This document consists of **14** printed pages and **2** blank pages.

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
	$(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

Answer **all** the questions in the spaces provided.

- 1 (a) Define *force*.

.....[1]

- (b) State the SI base units of force.

.....[1]

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

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

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]

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

.....

.....

.....[2]

- (b) A stationary firework explodes into three different fragments that move in a horizontal plane, as illustrated in Fig. 2.1.

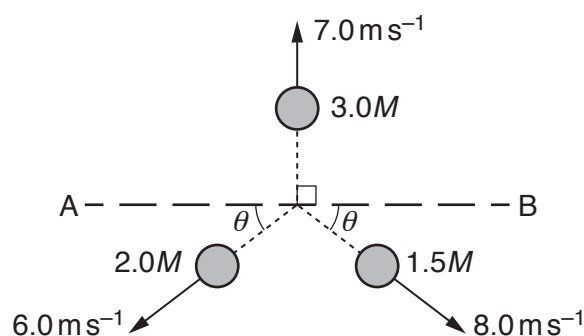


Fig. 2.1

The fragment of mass $3.0M$ has a velocity of 7.0 m s^{-1} perpendicular to line AB.
 The fragment of mass $2.0M$ has a velocity of 6.0 m s^{-1} at angle θ to line AB.
 The fragment of mass $1.5M$ has a velocity of 8.0 m s^{-1} at angle θ to line AB.

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

$$\theta = \dots\dots\dots^\circ \quad [3]$$

- (ii) Calculate the ratio

$$\frac{\text{kinetic energy of fragment of mass } 2.0M}{\text{kinetic energy of fragment of mass } 1.5M}.$$

$$\text{ratio} = \dots\dots\dots [2]$$

[Total: 7]

- 3 A child on a sledge slides down a steep hill and then travels in a straight line up an ice-covered slope, as illustrated in Fig. 3.1.

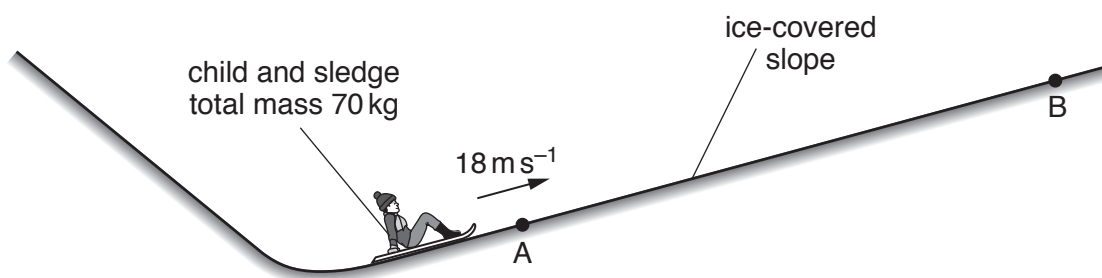


Fig. 3.1 (not to scale)

The sledge passes point A with speed 18 m s^{-1} at time $t = 0$ and then comes to rest at point B. The child applies a brake to the sledge at point B. The brake does not keep the sledge stationary and it immediately slides back down the slope towards A.

The variation with time t of the velocity v of the sledge from $t = 0$ to $t = 24 \text{ s}$ is shown in Fig. 3.2.

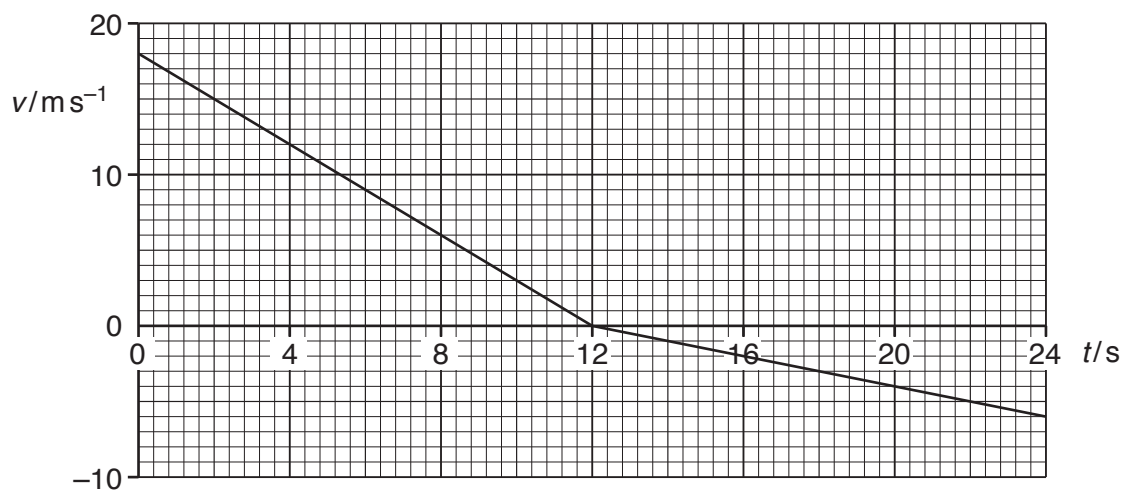


Fig. 3.2

- (a) State the time taken for the sledge to travel from A to B.

time = ... s [1]

- (b) Determine the displacement of the sledge up the slope from point A at time $t = 24$ s.

displacement = ...m [3]

- (c) Show that the acceleration of the sledge as it moves from B back towards A is 0.50 m s^{-2} .

[2]

- (d) The child and sledge have a total mass of 70 kg. The component of the total weight of the child and sledge that acts down the slope is 80 N.

Determine

- (i) the frictional force on the sledge as it moves from B towards A,

frictional force = ... N [2]

- (ii) the angle θ of the slope to the horizontal.

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

- (e) The child on the sledge blows a whistle between $t = 4.0\text{ s}$ and $t = 8.0\text{ s}$. The whistle emits sound of frequency 900 Hz . The speed of the sound in the air is 340 m s^{-1} . A man standing at point A hears the sound.

Use Fig. 3.2 to

- (i) determine the initial frequency of the sound heard by the man,

initial frequency = ... Hz [2]

- (ii) describe and explain qualitatively the variation, if any, in the frequency of the sound heard by the man.

.....
[1]

[Total: 13]

- 4 (a) (i) Define the *wavelength* of a progressive wave.

.....
[1]

- (ii) State what is meant by an *antinode* of a stationary wave.

.....
[1]

- (b) A loudspeaker producing sound of constant frequency is placed near the open end of a pipe, as shown in Fig. 4.1.

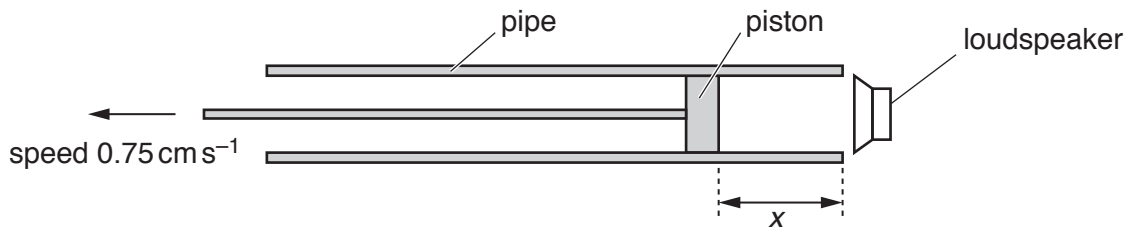


Fig. 4.1

A movable piston is at distance x from the open end of the pipe. Distance x is increased from $x = 0$ by moving the piston to the left with a constant speed of 0.75 cm s^{-1} .

The speed of the sound in the pipe is 340 m s^{-1} .

- (i) A much louder sound is first heard when $x = 4.5 \text{ cm}$. Assume that there is an antinode of a stationary wave at the open end of the pipe.

Determine the frequency of the sound in the pipe.

frequency = ... Hz [3]

- (ii) After a time interval, a second much louder sound is heard. Calculate the time interval between the first louder sound and the second louder sound being heard.

time interval = ... s [2]

[Total: 7]

- 5 A solid cylinder is lifted out of oil by a wire attached to a motor. Fig. 5.1 shows two different positions X and Y of the cylinder during the lifting process.

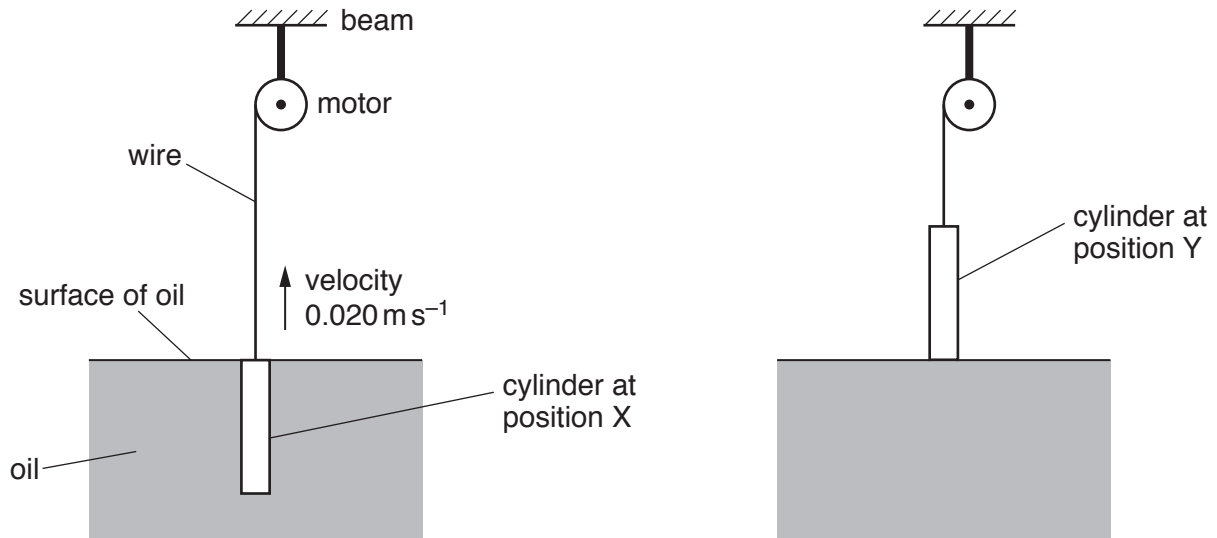


Fig. 5.1

The motor is fixed to an overhead beam.

The cylinder has cross-sectional area 0.018 m^2 , length 1.2 m and weight 560 N .

The density of the oil is 940 kg m^{-3} .

Throughout the lifting process, the cylinder moves vertically upwards with a constant velocity of 0.020 m s^{-1} . The viscous force of the oil acting on the cylinder is negligible.

- (a)** Calculate the density of the cylinder.

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

- (b)** For the cylinder at position X, show that the upthrust due to the oil is 200 N .

[2]

(c) Calculate, for the moving cylinder at position X,

(i) the tension in the wire,

tension = ... N [1]

(ii) the power output of the motor.

power = ... W [2]

(d) The cylinder is raised with constant velocity from position X to position Y.

(i) State and explain the variation, if any, of the power output of the motor as the cylinder is raised. Numerical values are not required.

.....

 [3]

(ii) The rate of energy output of the motor is less than the rate of increase of gravitational potential energy of the cylinder. Without calculation, explain this difference.

.....
 [1]

[Total: 11]

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

.....
[1]

- (ii) Kirchhoff's first law is linked to the conservation of a certain quantity. State this quantity.

.....[1]

- (b) A battery of electromotive force (e.m.f.) 8.0 V and internal resistance $2.0\ \Omega$ is connected to a resistor X and a wire Y, as shown in Fig. 6.1.

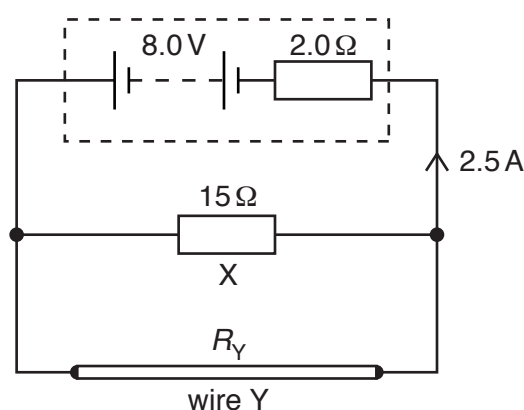


Fig. 6.1

The resistance of X is $15\ \Omega$. The resistance of Y is R_Y . The current in the battery is 2.5 A .

- (i) Calculate

1. the thermal energy dissipated in the battery in a time of 5.0 minutes,

energy = ... J [2]

2. the terminal potential difference of the battery.

terminal potential difference = ... V [1]

- (ii) Determine the resistance R_Y

$$R_Y = \dots\dots\dots \Omega \text{ [3]}$$

- (iii) A new wire Z has the same length but less resistance than wire Y.

1. State two possible differences between wire Z and wire Y that would separately cause wire Z to have less resistance than wire Y.

first difference:

.....

second difference:

.....

[2]

2. Wire Y is replaced in the circuit by wire Z. By considering the current in the battery, state and explain the effect of changing the wires on the total power produced by the battery.

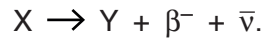
.....

.....

.....[2]

[Total: 12]

- 7 A stationary nucleus X decays to form nucleus Y, as shown by the equation



(a) In the above equation, draw a circle around all symbols that represent a lepton. [1]

(b) State the name of the particle represented by the symbol $\bar{\nu}$.

.....[1]

(c) Energy is released during the decay process. State the form of the energy that is gained by nucleus Y.

.....[1]

(d) By comparing the compositions of X and Y, state and explain whether they are isotopes.

.....

[2]

(e) The quark composition of one nucleon in X is changed during the emission of a β^- particle. Describe this change to the quark composition.

.....
[1]

[Total: 6]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

PHYSICS

9702/23

Paper 2 AS Level Structured Questions

May/June 2018

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

This document consists of **15** printed pages and **1** blank page.

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
	$(\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1})$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

BLANK PAGE

Answer **all** the questions in the spaces provided.

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

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

- (i) a systematic error,

.....
[1]

- (ii) a random error.

.....
[1]

- (b) The potential difference across a resistor is measured as $5.0\text{ V} \pm 0.1\text{ V}$. The resistor is labelled as having a resistance of $125\ \Omega \pm 3\%$.

- (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 = ... $\pm$ W [2]

[Total: 8]

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

.....
[1]

- (b) A diver releases a solid sphere of radius 16 cm from the sea bed. The sphere moves vertically upwards towards the surface of the sea.

The weight of the sphere is 20 N. The upthrust acting on the sphere is 170 N. The upthrust remains constant as the sphere moves upwards.

- (i) Calculate the density of the material of the sphere.

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

- (ii) Briefly explain the origin of the upthrust acting on the sphere.

.....

[1]

- (iii) Calculate the acceleration of the sphere as it is released from rest.

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

- (iv) The viscous (drag) force D acting on the sphere is given by

$$D = kr^2v^2$$

where r is the radius of the sphere and v is its speed.
The constant k is equal to 810 kg m^{-3} .

Determine the constant (terminal) speed reached by the sphere.

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

- (v) The diver releases a different sphere that moves with a constant speed of 6.30 m s^{-1} directly towards a stationary ship. The sphere emits sound of frequency 4850 Hz . The ship detects sound of frequency 4870 Hz as the sphere moves towards it.

Determine, to three significant figures, the speed of the sound in the water.

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

[Total: 11]

- 3 A ball is thrown vertically upwards towards a ceiling and then rebounds, as illustrated in Fig. 3.1.

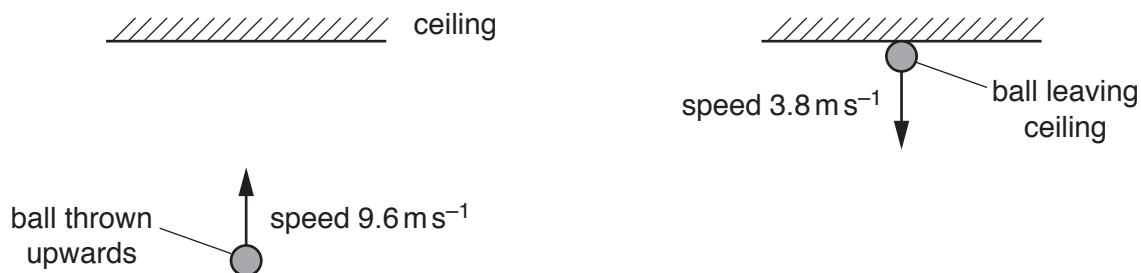


Fig. 3.1

The ball is thrown with speed 9.6 m s^{-1} and takes a time of 0.37 s to reach the ceiling. The ball is then in contact with the ceiling for a further time of 0.085 s until leaving it with a speed of 3.8 m s^{-1} . The mass of the ball is 0.056 kg . Assume that air resistance is negligible.

- (a) Show that the ball reaches the ceiling with a speed of 6.0 m s^{-1} .

[1]

- (b) Calculate the height of the ceiling above the point from which the ball was thrown.

height = ... m [2]

- (c) Calculate

- (i) the increase in gravitational potential energy of the ball for its movement from its initial position to the ceiling,

increase in gravitational potential energy = ... J [2]

- (ii) the decrease in kinetic energy of the ball while it is in contact with the ceiling.

decrease in kinetic energy = ... J [2]

- (d) State how Newton's third law applies to the collision between the ball and the ceiling.

.....

 [2]

- (e) Calculate the change in momentum of the ball during the collision.

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

- (f) Determine the magnitude of the average force exerted by the ceiling on the ball during the collision.

average force = ... N [2]

[Total: 13]

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

.....
[1]

- (b) A metal rod is compressed, as shown in Fig. 4.1.

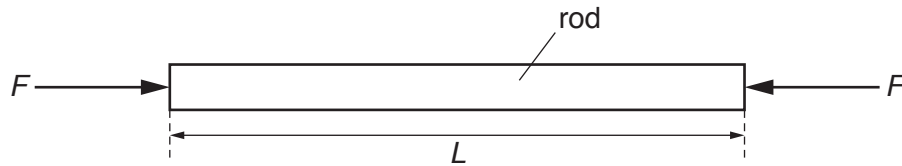


Fig. 4.1

The variation with compressive force F of the length L of the rod is shown in Fig. 4.2.

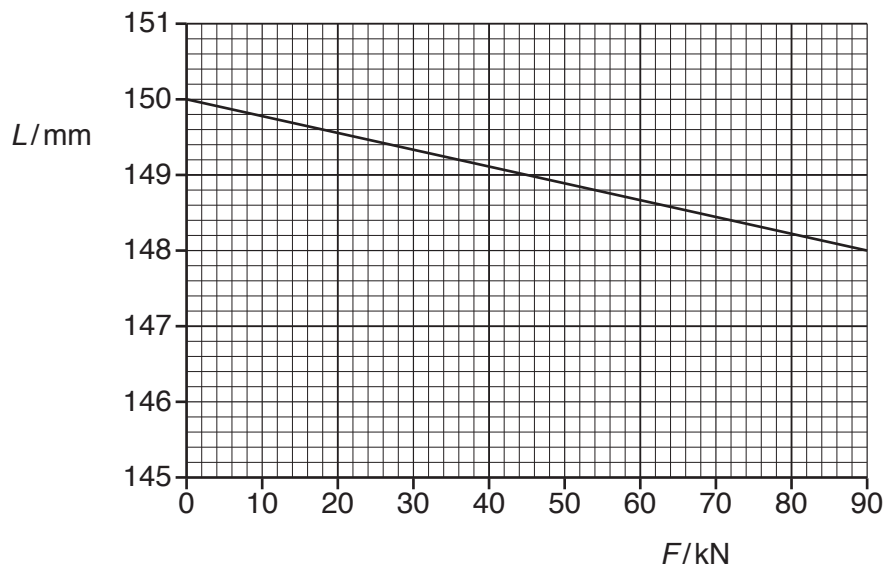


Fig. 4.2

Use Fig. 4.2 to

- (i) determine the spring constant k of the rod,

$k = \dots\dots\dots \text{Nm}^{-1}$ [2]

- (ii) determine the strain energy stored in the rod for $F = 90 \text{ kN}$.

strain energy = ... J [3]

- (c) The rod in (b) has cross-sectional area A and is made of metal of Young modulus E . It is now replaced by a new rod of the same original length. The new rod has cross-sectional area $A/3$ and is made of metal of Young modulus $2E$. The compression of the new rod obeys Hooke's law.

On Fig. 4.2, sketch the variation with F of the length L for the new rod from $F = 0$ to $F = 90 \text{ kN}$.
[2]

[Total: 8]

- 5 (a) State the relationship between the intensity and the amplitude of a wave.

.....
[1]

- (b) Microwaves of the same amplitude and wavelength are emitted in phase from two sources P and Q. The sources are arranged as shown in Fig. 5.1.

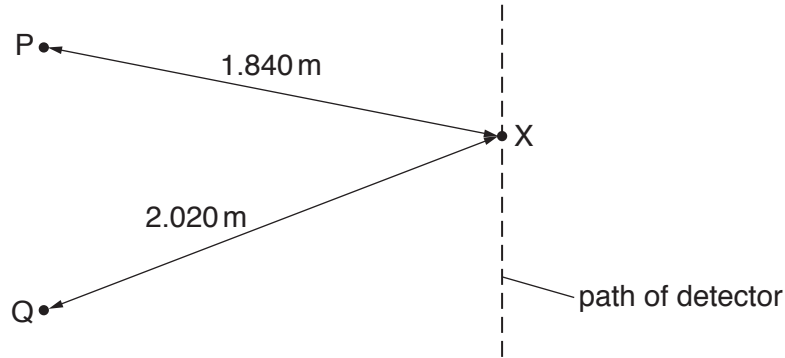


Fig. 5.1

A microwave detector is moved along a path that is parallel to the line joining P and Q. A series of intensity maxima and intensity minima are detected.

When the detector is at a point X, the distance PX is 1.840 m and the distance QX is 2.020 m. The microwaves have a wavelength of 6.0 cm.

- (i) Calculate the frequency of the microwaves.

frequency = ... Hz [2]

- (ii) Describe and explain the intensity of the microwaves detected at X.

.....

[3]

(iii) Describe the effect on the interference pattern along the path of the detector due to each of the following separate changes.

1. The wavelength of the microwaves decreases.

.....

.....

2. The phase difference between the microwaves emitted from the sources changes to 180° .

.....

.....

[2]

[Total: 8]

- 6 A wire X has a constant resistance per unit length of $3.0\ \Omega\text{m}^{-1}$ and a diameter of 0.48 mm.

(a) Calculate the resistivity of the metal of wire X.

resistivity = ... Ωm [3]

(b) The wire X is connected into the circuit shown in Fig. 6.1.

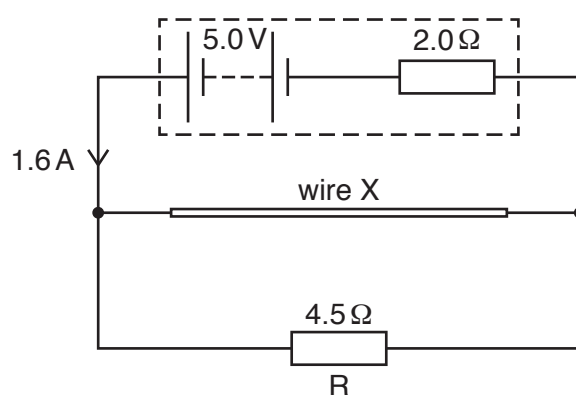


Fig. 6.1

The battery has an electromotive force (e.m.f.) of 5.0 V and an internal resistance of $2.0\ \Omega$. The wire X and a resistor R of resistance $4.5\ \Omega$ are connected in parallel. The current in the battery is 1.6 A.

(i) Calculate the potential difference across resistor R.

potential difference = ... V [1]

(ii) Determine, for wire X,

1. its resistance,

resistance = ... Ω [3]

2. its length.

length = ... m [1]

[Total: 8]

Please turn over for Question 7.

7 A graph of nucleon number A against proton number Z is shown in Fig. 7.1.

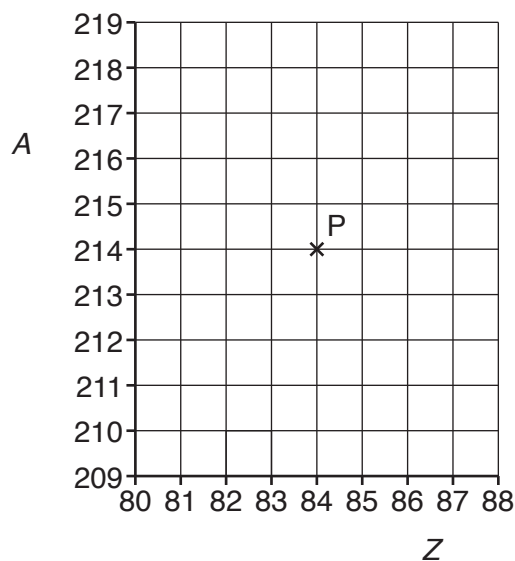


Fig. 7.1

The graph shows a cross (labelled P) that represents a nucleus P.

Nucleus P decays by emitting an α particle to form a nucleus Q.

Nucleus Q then decays by emitting a β^- particle to form a nucleus R.

(a) On Fig. 7.1, use a cross to represent

(i) nucleus Q (label this cross Q), [1]

(ii) nucleus R (label this cross R). [1]

(b) State the name of the class (group) of particles that includes the β^- particle.

.....[1]

(c) The quark composition of one nucleon in Q is changed during the emission of the β^- particle. Describe this change to the quark composition.

.....
[1]

[Total: 4]

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge International Examinations Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cie.org.uk after the live examination series.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.