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9702/21

May/June 2020

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 **16** pages. Blank pages are indicated.

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ ms}^{-1}$
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	$h = 6.63 \times 10^{-34} \text{ Js}$
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	$R = 8.31 \text{ JK}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ JK}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ ms}^{-2}$

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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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

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

[2]

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

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

where Q is charge and C is a constant.

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

SI base units [2]

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

For these measurements, describe one possible cause of:

1. a random error

.....

2. a systematic error.

.....

[2]

[Total: 6]

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

.....
 [1]

- (b) A delivery company suggests using a remote-controlled aircraft to drop a parcel into the garden of a customer. When the aircraft is vertically above point P on the ground, it releases the parcel with a velocity that is horizontal and of magnitude 5.4 m s^{-1} . The path of the parcel is shown in Fig. 2.1.

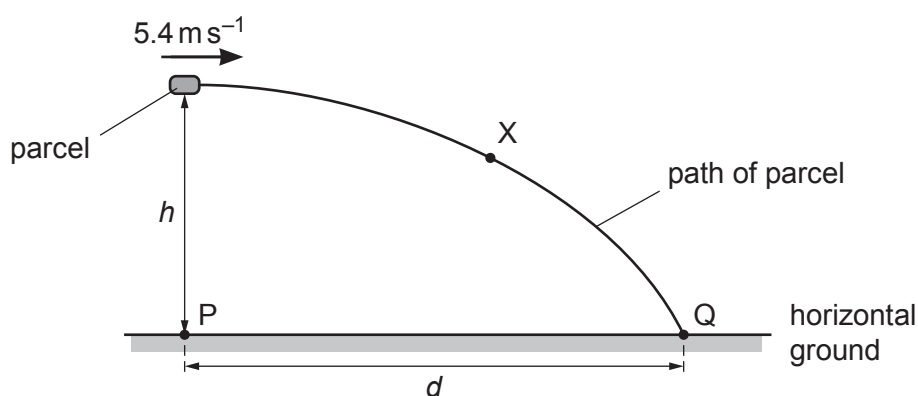


Fig. 2.1 (not to scale)

The parcel takes a time of 0.81 s after its release to reach point Q on the horizontal ground. Assume air resistance is negligible.

- (i) On Fig. 2.1, draw an arrow from point X to show the direction of the acceleration of the parcel when it is at that point. [1]
- (ii) Determine the height h of the parcel above the ground when it is released.

$$h = \dots\dots\dots \text{ m [2]}$$

- (iii) Calculate the horizontal distance d between points P and Q.

$$d = \dots\dots\dots \text{ m [1]}$$

- (c) Another parcel is accidentally released from rest by a different aircraft when it is hovering at a great height above the ground. Air resistance is now significant.
- (i) On Fig. 2.2, draw arrows to show the directions of the forces acting on the parcel as it falls vertically downwards. Label each arrow with the name of the force.

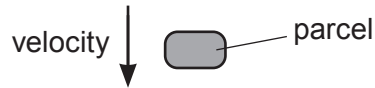


Fig. 2.2

[2]

- (ii) By considering the forces acting on the parcel, state and explain the variation, if any, of the acceleration of the parcel as it moves downwards before it reaches constant (terminal) speed.

.....

.....

.....

.....

.....

..... [3]

- (iii) Describe the energy conversion that occurs when the parcel is falling through the air at constant (terminal) speed.

.....

..... [1]

[Total: 11]

- 3 (a) State **two** conditions for an object to be in equilibrium.

1.

.....

2.

.....

[2]

- (b) A sphere of weight 2.4 N is suspended by a wire from a fixed point P. A horizontal string is used to hold the sphere in equilibrium with the wire at an angle of 53° to the horizontal, as shown in Fig. 3.1.

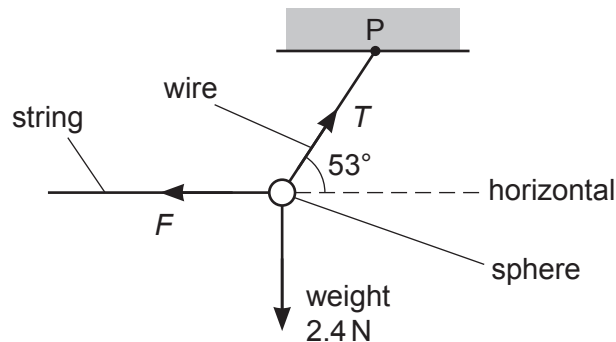


Fig. 3.1 (not to scale)

- (i) Calculate:

1. the tension T in the wire

$$T = \dots\dots\dots \text{ N}$$

2. the force F exerted by the string on the sphere.

$$F = \dots\dots\dots \text{ N}$$

[2]

- (ii) The wire has a circular cross-section of diameter 0.50 mm. Determine the stress σ in the wire.

$$\sigma = \dots\dots\dots \text{ Pa} \quad [3]$$

- (c) The string is disconnected from the sphere in (b). The sphere then swings from its initial rest position A, as illustrated in Fig. 3.2.

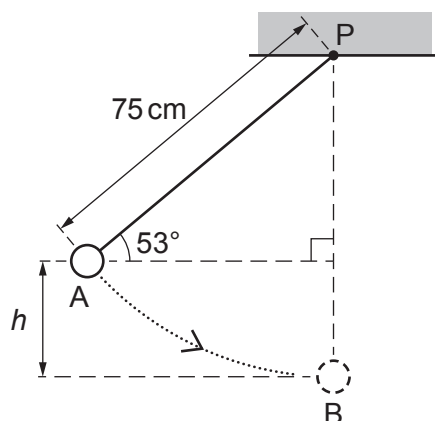


Fig. 3.2 (not to scale)

The sphere reaches maximum speed when it is at the bottom of the swing at position B. The distance between P and the centre of the sphere is 75 cm. Air resistance is negligible and energy losses at P are negligible.

- (i) Show that the vertical distance h between A and B is 15 cm.

[1]

- (ii) Calculate the change in gravitational potential energy of the sphere as it moves from A to B.

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

- (iii) Use your answer in (c)(ii) to determine the speed of the sphere at B. Show your working.

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

[Total: 13]

- 4 (a) (i) By reference to the direction of propagation of energy, state what is meant by a *longitudinal wave*.

.....
 [1]

- (ii) State the principle of superposition.

.....

 [2]

- (b) The wavelength of light from a laser is determined using the apparatus shown in Fig. 4.1.

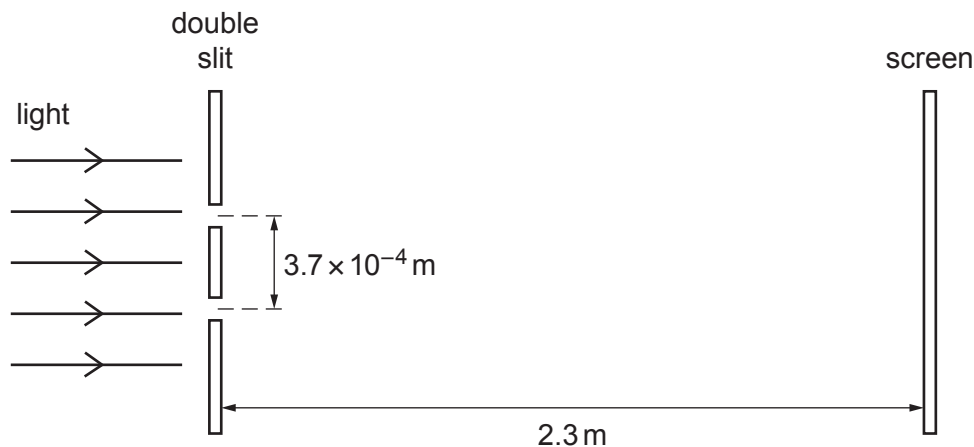


Fig. 4.1 (not to scale)

The light from the laser is incident normally on the plane of the double slit.

The separation of the two slits is $3.7 \times 10^{-4} \text{ m}$. The screen is parallel to the plane of the double slit. The distance between the screen and the double slit is 2.3 m .

A pattern of bright fringes and dark fringes is seen on the screen. The separation of adjacent bright fringes on the screen is $4.3 \times 10^{-3} \text{ m}$.

- (i) Calculate the wavelength, in nm, of the light.

wavelength = ... nm [3]

- (ii) The intensity of the light passing through each slit was initially the same. The intensity of the light through **one** of the slits is now reduced.

Compare the appearance of the fringes before and after the change of intensity.

.....

.....

.....

..... [2]

[Total: 8]

- 5 (a) Metal wire is used to connect a power supply to a lamp. The wire has a total resistance of $3.4\,\Omega$ and the metal has a resistivity of $2.6 \times 10^{-8}\,\Omega\text{m}$. The total length of the wire is 59 m.

(i) Show that the wire has a cross-sectional area of $4.5 \times 10^{-7}\text{ m}^2$.

[2]

(ii) The potential difference across the total length of wire is 1.8 V.

Calculate the current in the wire.

current = ... A [1]

(iii) The number density of the free electrons in the wire is $6.1 \times 10^{28}\text{ m}^{-3}$.

Calculate the average drift speed of the free electrons in the wire.

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

- (b) A different wire carries a current. This wire has a part that is thinner than the rest of the wire, as shown in Fig. 5.1.

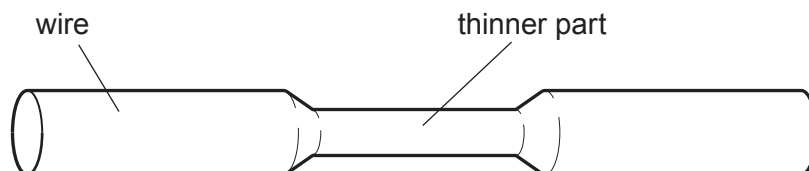


Fig. 5.1

- (i) State and explain qualitatively how the average drift speed of the free electrons in the thinner part compares with that in the rest of the wire.

.....

 [2]

- (ii) State and explain whether the power dissipated in the thinner part is the same, less or more than the power dissipated in an equal length of the rest of the wire.

.....

 [2]

- (c) Three resistors have resistances of $180\ \Omega$, $90\ \Omega$ and $30\ \Omega$.

- (i) Sketch a diagram showing how **two** of these three resistors may be connected together to give a combined resistance of $60\ \Omega$ between the terminals shown. Ensure you label the values of the resistances in your diagram.



[1]

- (ii) A potential divider circuit is produced by connecting the three resistors to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance. The potential divider circuit provides an output potential difference V_{OUT} of 8.0 V . Fig. 5.2 shows the circuit diagram.

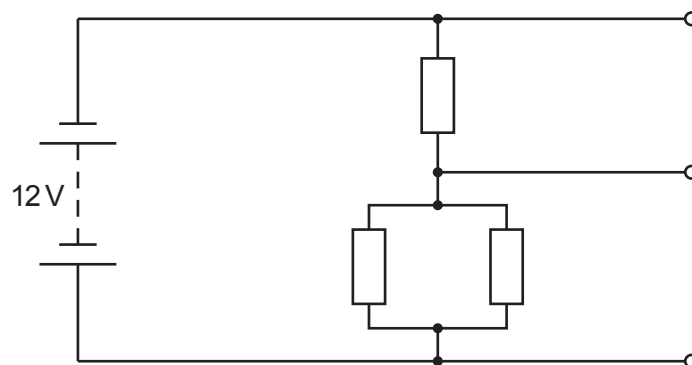


Fig. 5.2

On Fig. 5.2, label the resistances of all three resistors and the potential difference V_{OUT} .

[2]

[Total: 12]

[Turn over]

- 6 (a) Two horizontal metal plates are separated by a distance of 2.0 cm in a vacuum, as shown in Fig. 6.1.

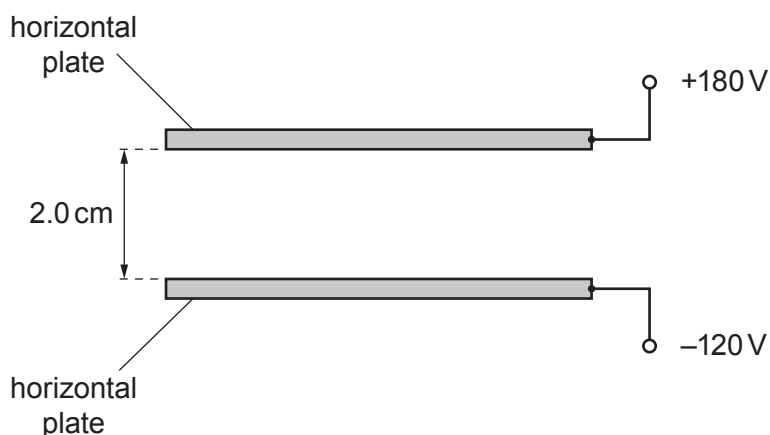


Fig. 6.1

The top plate has an electric potential of +180 V and the bottom plate has an electric potential of -120 V.

- (i) Determine the magnitude of the electric field strength between the plates.

electric field strength = ... NC^{-1} [2]

- (ii) State the direction of the electric field.

..... [1]

- (b) An uncharged atom of uranium-238 (${}^{238}_{92}\text{U}$) has a change made to its number of orbital electrons. This causes the atom to change into a new particle (ion) X that has an overall charge of $+2e$, where e is the elementary charge.

- (i) Determine the number of protons, neutrons and electrons in the particle (ion) X.

number of protons = ...

number of neutrons = ...

number of electrons = ...

[3]

- (ii) The particle (ion) X is in the electric field in (a) at a point midway between the plates.

Determine the magnitude of the electric force acting on X.

force = ... N [2]

- (iii) The nucleus of uranium-238 (${}^{238}_{92}\text{U}$) decays in stages, by emitting α -particles and β^- particles, to form a nucleus of thorium-230 (${}^{230}_{90}\text{Th}$).

Calculate the total number of α -particles and the total number of β^- particles that are emitted during the decay of uranium-238 to thorium-230.

number of α -particles = ...

number of β^- particles = ... [2]

[Total: 10]

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9702/22

May/June 2020

1 hour 15 minutes

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[Turn over

Data

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the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
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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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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

- 1 (a) Define *velocity*.

.....
 [1]

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

$$F_D = v^2 Ak$$

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

Determine the SI base units of k .

SI base units [2]

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

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

Determine the speed of the car.

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

[Total: 6]

- 2 (a) Fig. 2.1 shows the velocity–time graph for an object moving in a straight line.

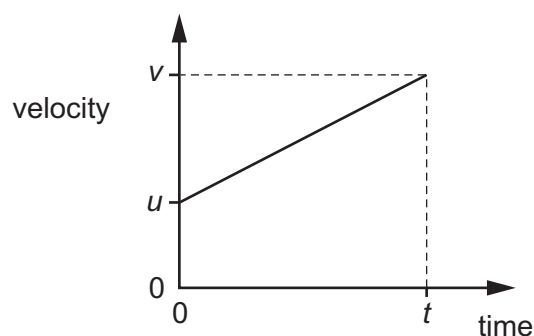


Fig. 2.1

- (i) Determine an expression, in terms of u , v and t , for the area under the graph.

area = ... [1]

- (ii) State the name of the quantity represented by the area under the graph.

..... [1]

- (b) A ball is kicked with a velocity of 15 m s^{-1} at an angle of 60° to horizontal ground. The ball then strikes a vertical wall at the instant when the path of the ball becomes horizontal, as shown in Fig. 2.2.

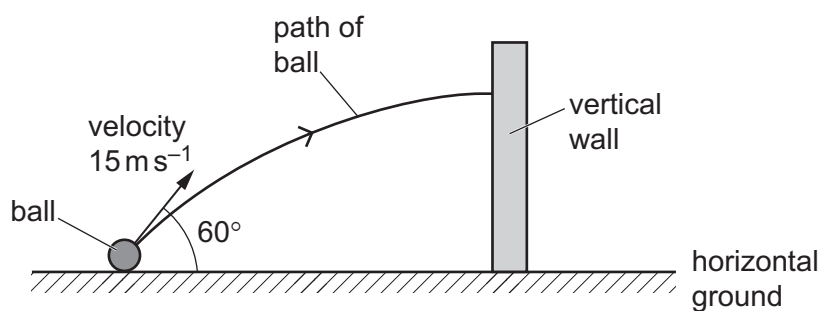


Fig. 2.2 (not to scale)

Assume that air resistance is negligible.

- (i) By considering the vertical motion of the ball, calculate the time it takes to reach the wall.

time = ... s [3]

- (ii) Explain why the horizontal component of the velocity of the ball remains constant as it moves to the wall.

.....
 [1]

- (iii) Show that the ball strikes the wall with a horizontal velocity of 7.5 m s^{-1} .

[1]

- (c) The mass of the ball in (b) is 0.40 kg . It is in contact with the wall for a time of 0.12 s and rebounds horizontally with a speed of 4.3 m s^{-1} .

- (i) Use the information from (b)(iii) to calculate the change in momentum of the ball due to the collision.

change in momentum = ... kg m s^{-1} [2]

- (ii) Calculate the magnitude of the average force exerted on the ball by the wall.

average force = ... N [1]

[Total: 10]

- 3 (a) Explain what is meant by *work done*.

.....
 [1]

- (b) A ball of mass 0.42 kg is dropped from the top of a building. The ball falls from rest through a vertical distance of 78 m to the ground. Air resistance is significant so that the ball reaches constant (terminal) velocity before hitting the ground. The ball hits the ground with a speed of 23 m s^{-1} .

- (i) Calculate, for the ball falling from the top of the building to the ground:

1. the decrease in gravitational potential energy

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

2. the increase in kinetic energy.

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

- (ii) Use your answers in (b)(i) to determine the average resistive force acting on the ball as it falls from the top of the building to the ground.

average resistive force = ... N [2]

- (c) The ball in (b) is dropped at time $t = 0$ and hits the ground at time $t = T$. The acceleration of free fall is g .

On Fig. 3.1, sketch a line to show the variation of the acceleration a of the ball with time t from time $t = 0$ to $t = T$.

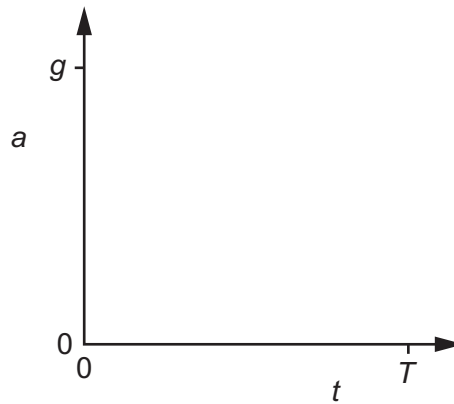


Fig. 3.1

[2]

[Total: 9]

- 4 (a) State the difference between progressive waves and stationary waves in terms of the transfer of energy along the wave.

.....
 [1]

- (b) A progressive wave travels from left to right along a stretched string. Fig. 4.1 shows part of the string at one instant.

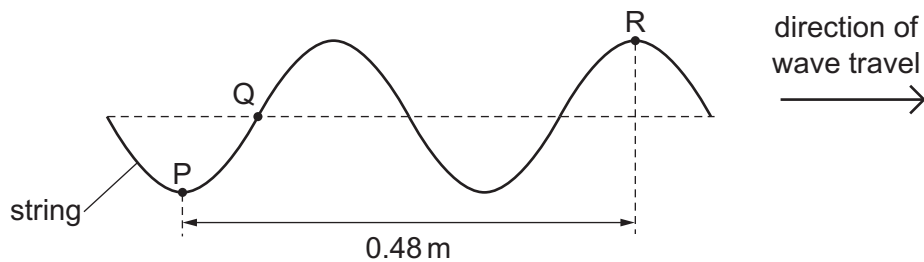


Fig. 4.1

P, Q and R are three different points on the string. The distance between P and R is 0.48 m. The wave has a period of 0.020 s.

- (i) Use Fig. 4.1 to determine the wavelength of the wave.

wavelength = ... m [1]

- (ii) Calculate the speed of the wave.

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

- (iii) Determine the phase difference between points Q and R.

phase difference = ... $^{\circ}$ [1]

- (iv) Fig. 4.1 shows the position of the string at time $t = 0$. Describe how the displacement of point Q on the string varies with time from $t = 0$ to $t = 0.010$ s.

.....

.....

.....

..... [2]

- (c) A stationary wave is formed on a different string that is stretched between two fixed points X and Y. Fig. 4.2 shows the position of the string when each point is at its maximum displacement.

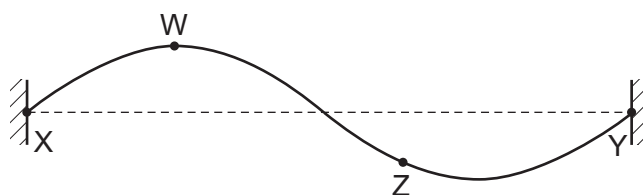


Fig. 4.2

- (i) Explain what is meant by a *node* of a stationary wave.

..... [1]

- (ii) State the number of antinodes of the wave shown in Fig. 4.2.

number = ... [1]

- (iii) State the phase difference between points W and Z on the string.

phase difference = ...° [1]

- (iv) A new stationary wave is now formed on the string. The new wave has a frequency that is half of the frequency of the wave shown in Fig. 4.2. The speed of the wave is unchanged.

On Fig. 4.3, draw a position of the string, for this new wave, when each point is at its maximum displacement.

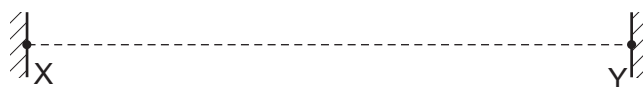


Fig. 4.3

[1]

[Total: 11]

- 5 One end of a wire is attached to a fixed point. A force F is applied to the wire to cause extension x . The variation with F of x is shown in Fig. 5.1.

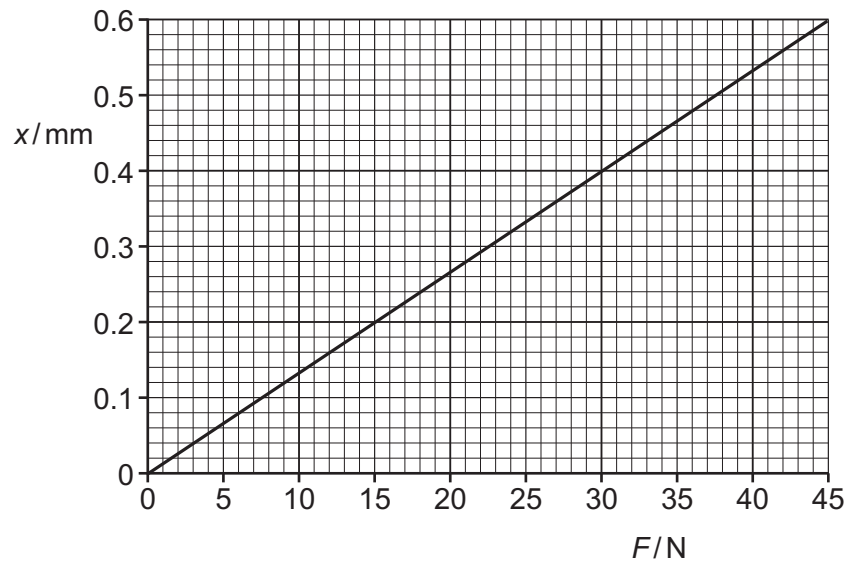


Fig. 5.1

The wire has a cross-sectional area of $4.1 \times 10^{-7} \text{ m}^2$ and is made of metal of Young modulus $1.7 \times 10^{11} \text{ Pa}$. Assume that the cross-sectional area of the wire remains constant as the wire extends.

- (a) State the name of the law that describes the relationship between F and x shown in Fig. 5.1.
 [1]

- (b) The wire has an extension of 0.48 mm.

Determine:

- (i) the stress

stress = ... Pa [2]

- (ii) the strain.

strain = ... [2]

- (c) The resistivity of the metal of the wire is $3.7 \times 10^{-7} \Omega \text{ m}$.

Determine the change in resistance of the wire when the extension x of the wire changes from $x = 0.48 \text{ mm}$ to $x = 0.60 \text{ mm}$.

change in resistance = ... Ω [3]

- (d) A force of greater than 45 N is now applied to the wire.

Describe how it may be checked that the elastic limit of the wire has not been exceeded.

.....

..... [1]

[Total: 9]

- 6 (a) A battery of electromotive force (e.m.f.) 7.8 V and internal resistance r is connected to a filament lamp, as shown in Fig. 6.1.

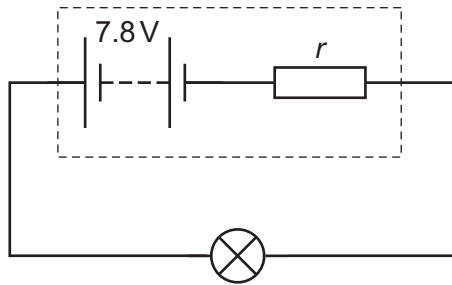


Fig. 6.1

A total charge of 750 C moves through the battery in a time interval of 1500 s . During this time the filament lamp dissipates 5.7 kJ of energy. The e.m.f. of the battery remains constant.

- (i) Explain, in terms of energy and without a calculation, why the potential difference across the lamp must be less than the e.m.f. of the battery.

.....
 [1]

- (ii) Calculate:

1. the current in the circuit

current = ... A [2]

2. the potential difference across the lamp

potential difference = ... V [2]

3. the internal resistance of the battery.

internal resistance = ... Ω [2]

(b) A student is provided with three resistors of resistances $90\ \Omega$, $45\ \Omega$ and $20\ \Omega$.

- (i) Sketch a circuit diagram showing how **two** of these three resistors may be connected together to give a combined resistance of $30\ \Omega$ between the terminals shown. Label the values of the resistances on your diagram.



[1]

- (ii) A potential divider circuit is produced by connecting the three resistors to a battery of e.m.f. 9.0 V and negligible internal resistance. The potential divider circuit provides an output potential difference V_{OUT} of 3.6 V . The circuit diagram is shown in Fig. 6.2.

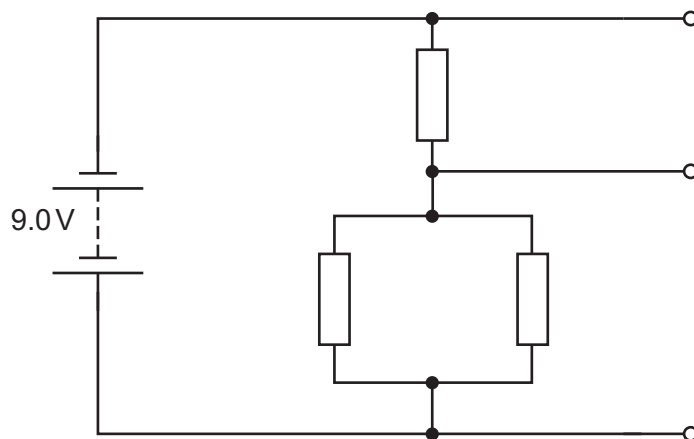


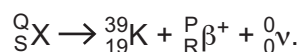
Fig. 6.2

On Fig. 6.2, label the resistances of all three resistors and the potential difference V_{OUT} .

[2]

[Total: 10]

- 7 (a) A nucleus of an element X decays by emitting a β^+ particle to produce a nucleus of potassium-39 (${}^{39}_{19}\text{K}$) and a neutrino. The decay is represented by



- (i) State the number represented by each of the following letters.

P

Q

R

S

[2]

- (ii) State the name of the interaction (force) that gives rise to β^+ decay.

..... [1]

- (b) A hadron is composed of three identical quarks and has a charge of $+2e$, where e is the elementary charge.

Determine a possible type (flavour) of the quarks.

Explain your working.

.....

..... [2]

[Total: 5]

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PHYSICS

9702/23

Paper 2 AS Level Structured Questions

May/June 2020

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. Blank pages are indicated.



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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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

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

similarity:

.....

difference:

.....

[2]

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

Describe what is meant by:

- (i) *high precision*

.....

..... [1]

- (ii) *low accuracy*.

.....

..... [1]

[Total: 4]

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

.....
 [1]

- (b) A skier is pulled in a straight line along horizontal ground by a wire attached to a kite, as shown in Fig. 2.1.

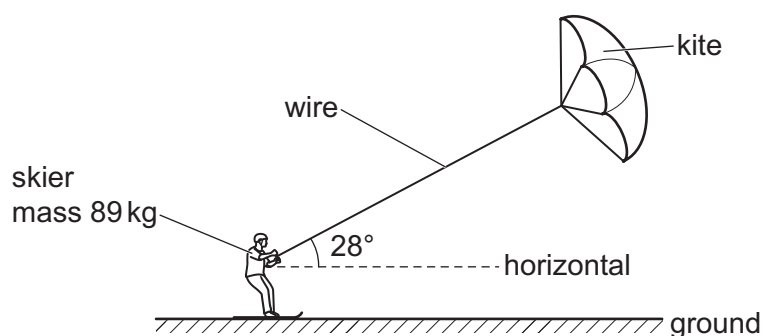


Fig. 2.1 (not to scale)

The mass of the skier is 89 kg. The wire is at an angle of 28° to the horizontal. The variation with time t of the velocity v of the skier is shown in Fig. 2.2.

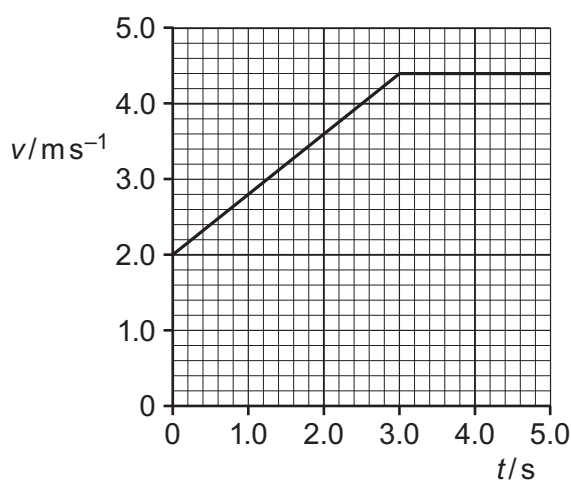


Fig. 2.2

- (i) Use Fig. 2.2 to determine the distance moved by the skier from time $t = 0$ to $t = 5.0$ s.

distance = ... m [2]

- (ii) Use Fig. 2.2 to show that the acceleration a of the skier is 0.80 ms^{-2} at time $t = 2.0 \text{ s}$.

[2]

- (iii) The tension in the wire at time $t = 2.0 \text{ s}$ is 240 N .

Calculate:

1. the horizontal component of the tension force acting on the skier

horizontal component of force = ... N [1]

2. the total resistive force R acting on the skier in the horizontal direction.

$R =$ N [2]

- (iv) The skier is now lifted upwards by a gust of wind. For a few seconds the skier moves horizontally through the air with the wire at an angle of 45° to the horizontal, as shown in Fig. 2.3.

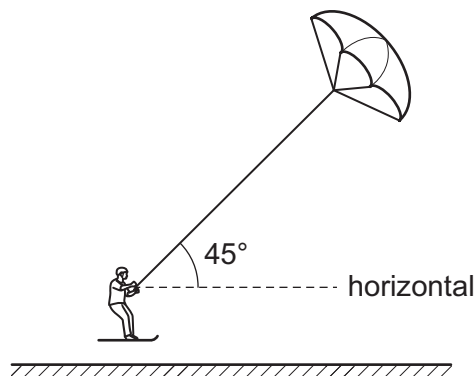


Fig. 2.3 (not to scale)

By considering the vertical components of the forces acting on the skier, determine the new tension in the wire when the skier is moving horizontally through the air.

tension = ... N [2]

[Total: 10]

[Turn over]

- 3 (a) State the principle of moments.

.....

 [2]

- (b) In a bicycle shop, two wheels hang from a horizontal uniform rod AC, as shown in Fig. 3.1.

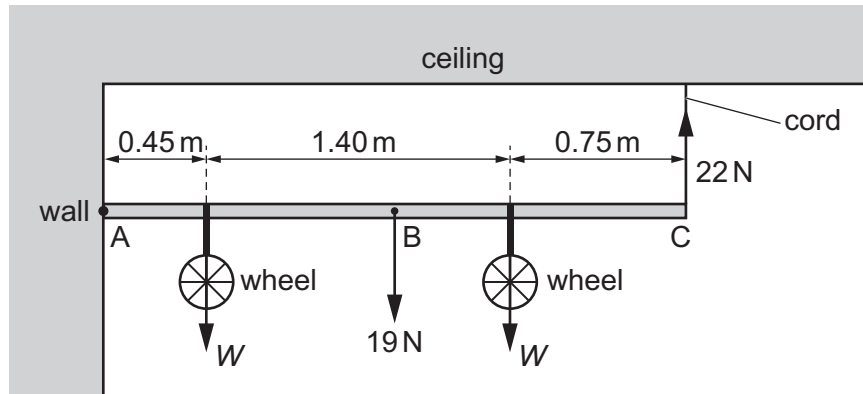


Fig. 3.1 (not to scale)

The rod has weight 19 N and is freely hinged to a wall at end A. The other end C of the rod is attached by a vertical elastic cord to the ceiling. The centre of gravity of the rod is at point B. The weight of each wheel is W and the tension in the cord is 22 N.

- (i) By taking moments about end A, show that the weight W of each wheel is 14 N.

[2]

- (ii) Determine the magnitude and the direction of the force acting on the rod at end A.

magnitude = ... N

direction

[2]

- (c) The unstretched length of the cord in (b) is 0.25 m. The variation with length L of the tension F in the cord is shown in Fig. 3.2.

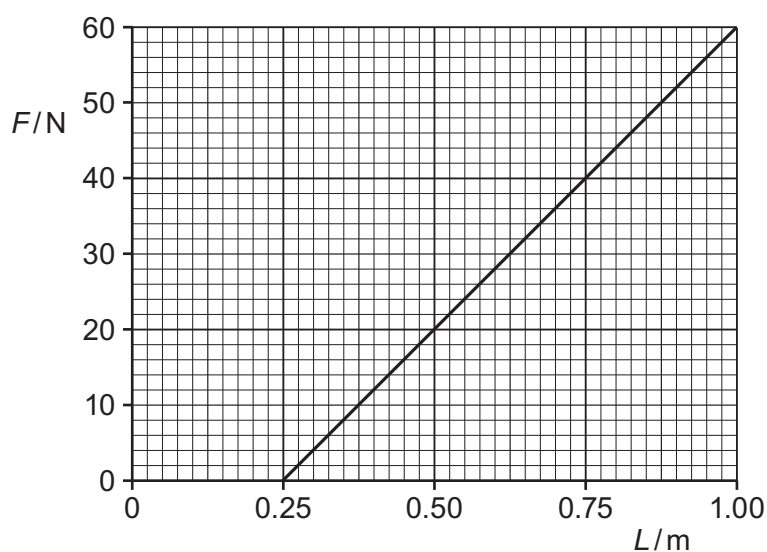


Fig. 3.2

- (i) State and explain whether Fig. 3.2 suggests that the cord obeys Hooke's law.

.....

 [2]

- (ii) Calculate the spring constant k of the cord.

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

- (iii) On Fig. 3.2, shade the area that represents the work done to extend the cord when the tension is increased from $F = 0$ to $F = 40$ N. [1]

[Total: 11]

- 4 Two progressive sound waves Y and Z meet at a fixed point P. The variation with time t of the displacement x of each wave at point P is shown in Fig. 4.1.

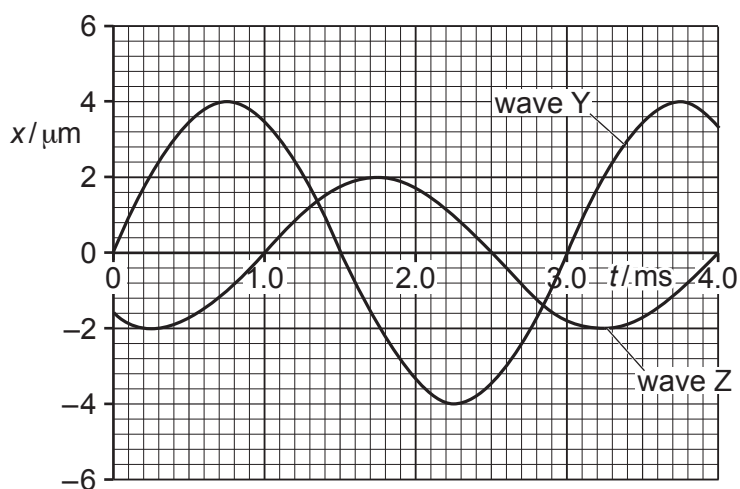


Fig. 4.1

- (a) Use Fig. 4.1 to state **one** quantity of waves Y and Z that is:

(i) the same

..... [1]

(ii) different.

..... [1]

- (b) State and explain whether waves Y and Z are coherent.

.....
 [1]

- (c) Determine the phase difference between the waves.

phase difference = ... ° [1]

- (d) The two waves superpose at P. Use Fig. 4.1 to determine the resultant displacement at time $t = 0.75$ ms.

resultant displacement = ... μm [1]

- (e) The intensity of wave Y at point P is I .

Determine, in terms of I , the intensity of wave Z.

intensity = ... [2]

- (f) The speed of wave Z is 330 ms^{-1} .

Determine the wavelength of wave Z.

wavelength = ... m [3]

[Total: 10]

- 5 (a) Define the *volt*.

.....
 [1]

- (b) Fig. 5.1 shows a network of three resistors.

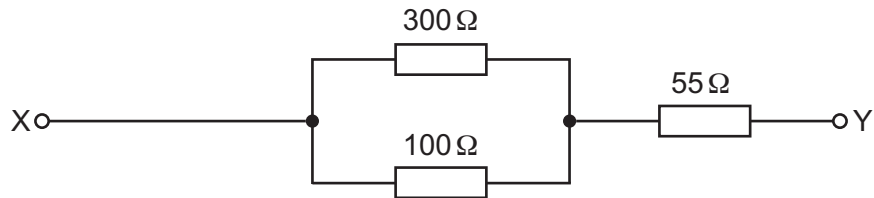


Fig. 5.1

Calculate:

- (i) the combined resistance of the two resistors connected in parallel

combined resistance = ... Ω [1]

- (ii) the total resistance between terminals X and Y.

total resistance = ... Ω [1]

- (c) The network in (b) is connected to a power supply so that there is a potential difference between terminals X and Y. The power dissipated in the resistor of resistance 55 Ω is 0.20 W.

- (i) Calculate the current in the resistor of resistance:

1. 55 Ω

current = ... A

2. 300 Ω.

current = ... A
 [3]

- (ii) Calculate the potential difference between X and Y.

potential difference = ... V [1]

[Total: 7]

- 6 The current I in a metal wire is given by the expression

$$I = Anve$$

where v is the average drift speed of the free electrons in the wire and e is the elementary charge.

- (a) State what is meant by the symbols A and n .

A :

n :

[2]

- (b) Use the above expression to determine the SI base units of e .
Show your working.

base units [2]

- (c) Two lamps P and Q are connected in series to a battery, as shown in Fig. 6.1.

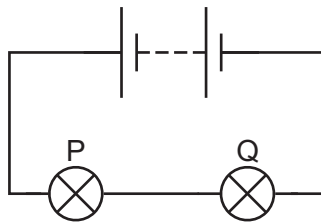


Fig. 6.1

The radius of the filament wire of lamp P is twice the radius of the filament wire of lamp Q.
The filament wires are made of metals with the same value of n .

Calculate the ratio

$$\frac{\text{average drift speed of free electrons in filament wire of P}}{\text{average drift speed of free electrons in filament wire of Q}}.$$

ratio = ... [2]

[Total: 6]

- 7 A potential difference is applied between two horizontal metal plates that are a distance of 6.0 mm apart in a vacuum, as shown in Fig. 7.1.

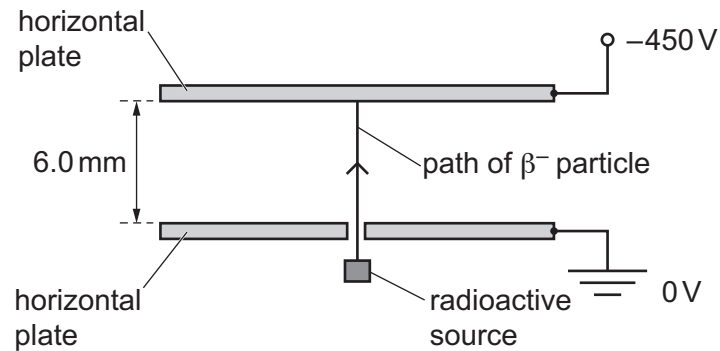


Fig. 7.1

The top plate has a potential of -450 V and the bottom plate is earthed. Assume that there is a uniform electric field produced between the plates.

A radioactive source emits a β^- particle that travels through a hole in the bottom plate and along a vertical path until it reaches the top plate.

- (a) (i) Determine the magnitude and the direction of the electric force acting on the β^- particle as it moves between the plates.

magnitude of force = ... N

direction of force [4]

- (ii) Calculate the work done by the electric field on the β^- particle for its movement from the bottom plate to the top plate.

work done = ... J [2]

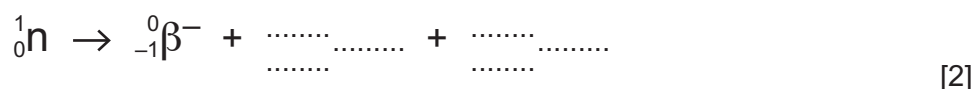
- (b) The β^- particle is emitted from the source with a kinetic energy of $3.4 \times 10^{-16} \text{ J}$.

Calculate the speed at which the β^- particle is emitted.

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

- (c) The β^- particle is produced by the decay of a neutron.

- (i) Complete the equation below to represent the decay of the neutron.



- (ii) State the name of the group (class) of particles that includes:

1. neutrons

.....

2. β^- particles.

.....

[2]

[Total: 12]

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