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PHYSICS

9702/21

Paper 2 AS Level Structured Questions

October/November 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

(i) *displacement*,

.....
 [1]

(ii) *acceleration*.

.....
 [1]

(b) A remote-controlled toy car moves up a ramp and travels across a gap to land on another ramp, as illustrated in Fig. 1.1.

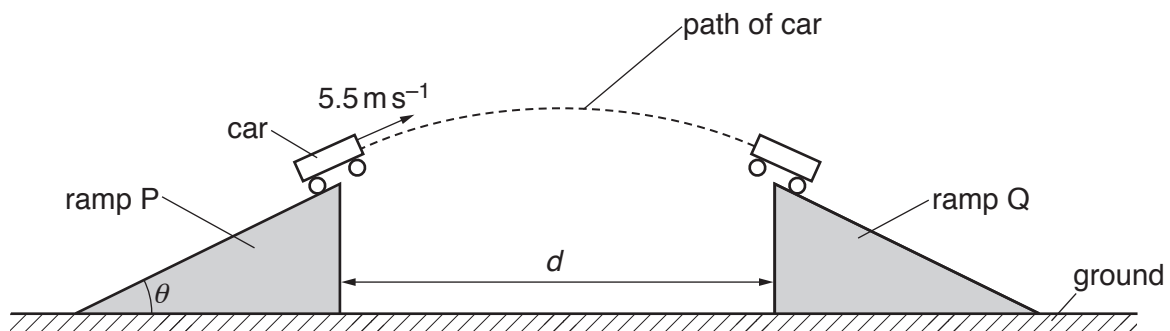


Fig. 1.1

The car leaves ramp P with a velocity of 5.5 m s^{-1} at an angle θ to the horizontal. The horizontal component of the car's velocity as it leaves the ramp is 4.6 m s^{-1} . The car lands at the top of ramp Q. The tops of both ramps are at the same height and are distance d apart. Air resistance is negligible.

(i) Show that the car leaves ramp P with a vertical component of velocity of 3.0 m s^{-1} .

[1]

(ii) Determine the time taken for the car to travel between the ramps.

time taken = ... s [2]

- (iii) Calculate the horizontal distance d between the tops of the ramps.

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

- (iv) Calculate the ratio

$$\frac{\text{kinetic energy of the car at its maximum height}}{\text{kinetic energy of the car as it leaves ramp P}} .$$

$$\text{ratio} = \dots\dots\dots [3]$$

- (c) Ramp Q is removed. The car again leaves ramp P as in (b) and now lands directly on the ground. The car leaves ramp P at time $t = 0$ and lands on the ground at time $t = T$.

On Fig. 1.2, sketch the variation with time t of the vertical component v_y of the car's velocity from $t = 0$ to $t = T$. Numerical values of v_y and t are not required.

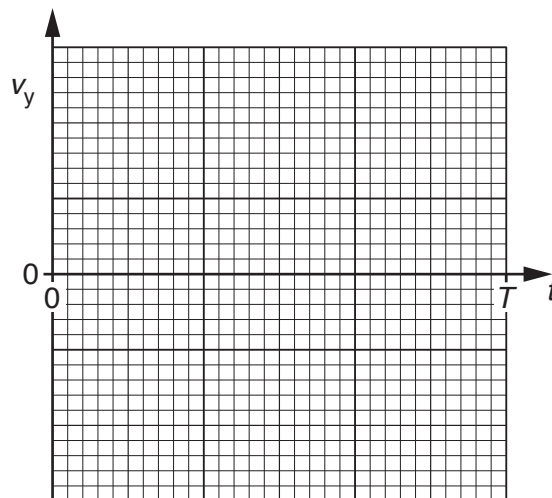


Fig. 1.2

[2]

[Total: 11]

[Turn over]

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- 2 A wooden block moves along a horizontal frictionless surface, as shown in Fig. 2.1.

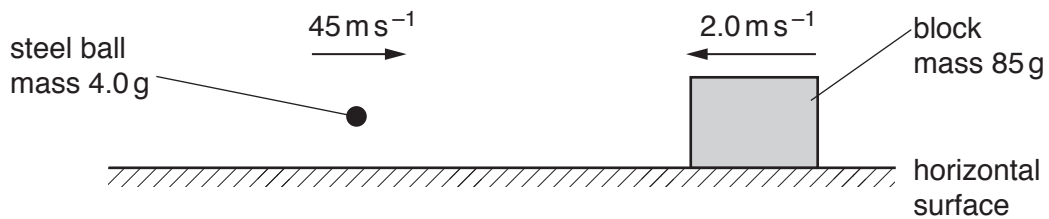


Fig. 2.1

The block has mass 85 g and moves to the left with a velocity of 2.0 m s^{-1} . A steel ball of mass 4.0 g is fired to the right. The steel ball, moving horizontally with a speed of 45 m s^{-1} , collides with the block and remains embedded in it. After the collision the block and steel ball both have speed v .

- (a) Calculate v .

$$v = \dots \text{ m s}^{-1} \quad [2]$$

- (b) (i) For the block and ball, state

1. the relative speed of approach before collision,

$$\text{relative speed of approach} = \dots \text{ m s}^{-1}$$

2. the relative speed of separation after collision.

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

- (ii) Use your answers in (i) to state and explain whether the collision is elastic or inelastic.

.....
 [1]

- (c) Use Newton's third law to explain the relationship between the rate of change of momentum of the ball and the rate of change of momentum of the block during the collision.

.....

 [2]

[Total: 6]

- 3 (a) (i) Define *power*.

.....
 [1]

- (ii) State what is meant by *gravitational potential energy*.

.....
 [1]

- (b) An aircraft of mass 1200 kg climbs upwards with a constant velocity of 45 m s^{-1} , as shown in Fig. 3.1.

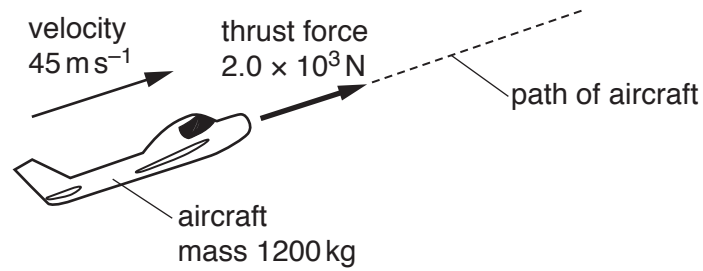


Fig. 3.1 (not to scale)

The aircraft's engine produces a thrust force of $2.0 \times 10^3\text{ N}$ to move the aircraft through the air. The rate of increase in height of the aircraft is 3.3 m s^{-1} .

- (i) Calculate the power produced by the thrust force.

power = ... W [2]

(ii) Determine, for a time interval of 3.0 minutes,

1. the work done by the thrust force to move the aircraft,

work done = ... J [2]

2. the increase in gravitational potential energy of the aircraft,

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

3. the work done against air resistance.

work done = ... J [1]

(iii) Use your answer in (b)(ii) part 3 to calculate the force due to air resistance acting on the aircraft.

force = ... N [1]

(iv) With reference to the motion of the aircraft, state and explain whether the aircraft is in equilibrium.

.....

 [2]

[Total: 12]

[Turn over]

- 4 (a) State the principle of superposition.

.....

.....

..... [2]

- (b) An arrangement for demonstrating the interference of light is shown in Fig. 4.1.

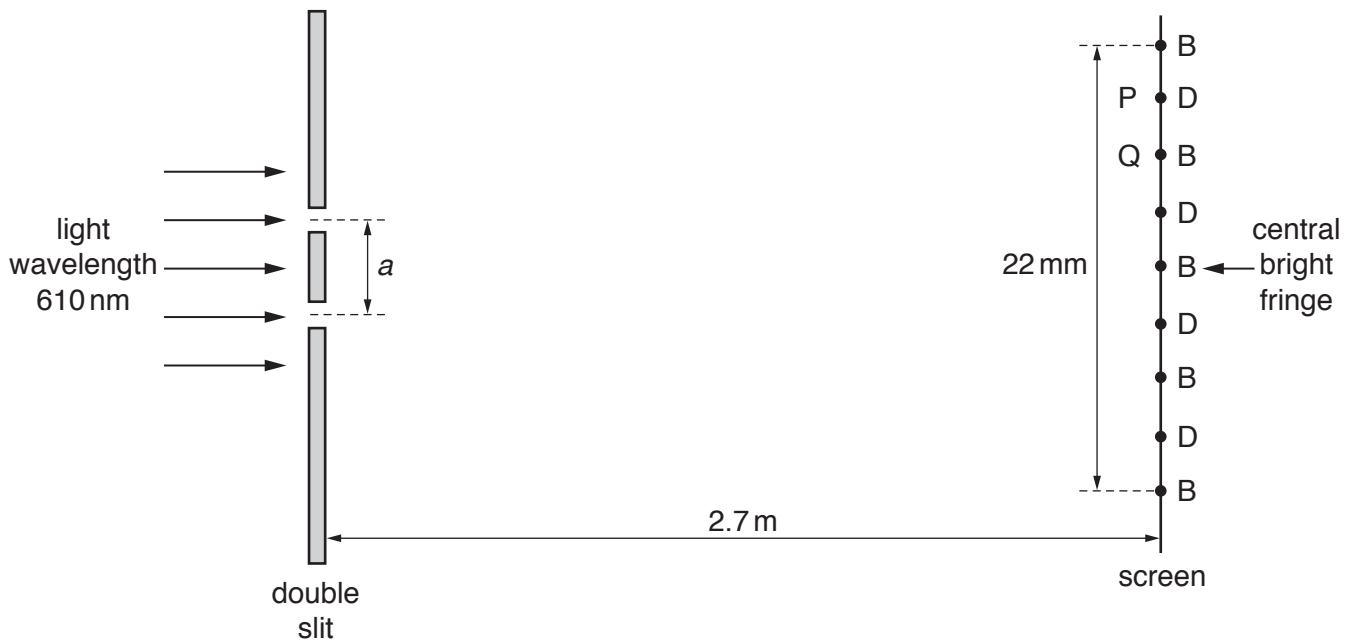


Fig. 4.1 (not to scale)

The wavelength of the light is 610 nm. The distance between the double slit and the screen is 2.7 m.

An interference pattern of bright fringes and dark fringes is observed on the screen. The centres of the bright fringes are labelled B and centres of the dark fringes are labelled D. Point P is the centre of a particular dark fringe and point Q is the centre of a particular bright fringe, as shown in Fig. 4.1. The distance across five bright fringes is 22 mm.

- (i) The light waves leaving the two slits are coherent.

State what is meant by *coherent*.

.....

..... [1]

- (ii) 1. State the phase difference between the waves meeting at Q.

phase difference = ... °

2. Calculate the path difference, in nm, of the waves meeting at P.

path difference = ... nm
[2]

- (iii) Determine the distance a between the two slits.

$a =$ m [3]

- (iv) A higher frequency of visible light is now used. State and explain the change to the separation of the fringes.

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

- (v) The intensity of the light incident on the double slit is now increased without altering its frequency. Compare the appearance of the fringes after this change with their appearance before this change.

.....
.....
.....
..... [2]

[Total: 11]

- 5 (a) State what is meant by an *electric field*.

.....
 [1]

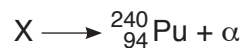
- (b) A particle of mass m and charge q is in a uniform electric field of strength E . The particle has acceleration a due to the field.

Show that

$$a = \frac{Eq}{m}.$$

[2]

- (c) A stationary nucleus X decays by emitting an α -particle to form a nucleus of plutonium, ${}^{240}_{94}\text{Pu}$, as shown.



- (i) Determine the number of protons and the number of neutrons in nucleus X.

number of protons = ...

number of neutrons = ...

[2]

- (ii) The total mass of the plutonium nucleus and the α -particle is less than that of nucleus X. Explain this difference in mass.

.....

 [2]

- (iii) The plutonium nucleus and the α -particle are both accelerated by the same uniform electric field.

Use the expression in (b) to determine the ratio

$$\frac{\text{acceleration of the } \alpha\text{-particle}}{\text{acceleration of the plutonium nucleus}} .$$

ratio = ... [2]

[Total: 9]

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

.....

 [2]

- (b) An electric heater containing two heating wires X and Y is connected to a power supply of electromotive force (e.m.f.) 9.0 V and negligible internal resistance, as shown in Fig. 6.1.

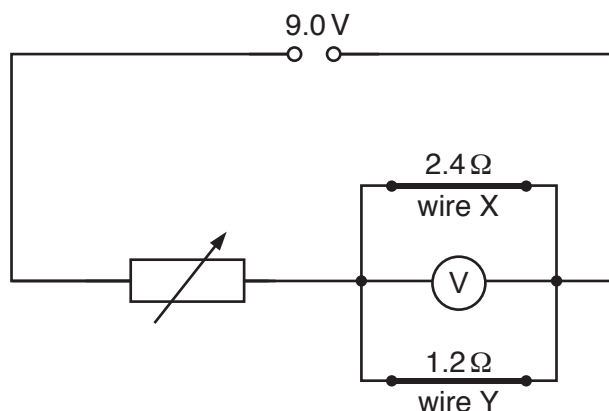


Fig. 6.1

Wire X has a resistance of $2.4\ \Omega$ and wire Y has a resistance of $1.2\ \Omega$. A voltmeter is connected in parallel with the wires. A variable resistor is used to adjust the power dissipated in wires X and Y.

The variable resistor is adjusted so that the voltmeter reads 6.0 V.

- (i) Calculate the resistance of the variable resistor.

resistance = ... Ω [3]

- (ii) Calculate the power dissipated in wire X.

power = ... W [2]

- (iii) The cross-sectional area of wire X is three times the cross-sectional area of wire Y. Assume that the resistivity and the number density of free electrons for the metal of both wires are the same.

Determine the ratio

1. $\frac{\text{length of wire X}}{\text{length of wire Y}}$,

ratio = ... [2]

2. $\frac{\text{average drift velocity of free electrons in wire X}}{\text{average drift velocity of free electrons in wire Y}}$.

ratio = ... [2]

[Total: 11]

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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 golfer strikes a ball so that it leaves horizontal ground with a velocity of 6.0 m s^{-1} at an angle θ to the horizontal, as illustrated in Fig. 1.1.

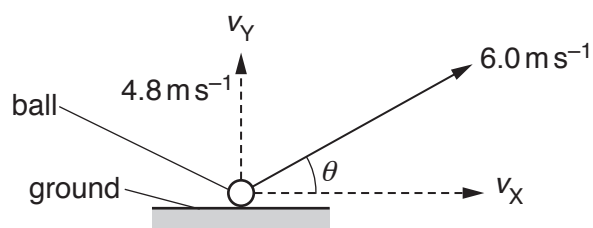


Fig. 1.1 (not to scale)

The magnitude of the initial vertical component v_y of the velocity is 4.8 m s^{-1} . Assume that air resistance is negligible.

- (a) Show that the magnitude of the initial horizontal component v_x of the velocity is 3.6 m s^{-1} .

[1]

- (b) The ball leaves the ground at time $t = 0$ and reaches its maximum height at $t = 0.49$ s.

On Fig. 1.2, sketch separate lines to show the variation with time t , until the ball returns to the ground, of

- (i) the vertical component v_y of the velocity (label this line Y), [2]

- (ii) the horizontal component v_x of the velocity (label this line X). [2]

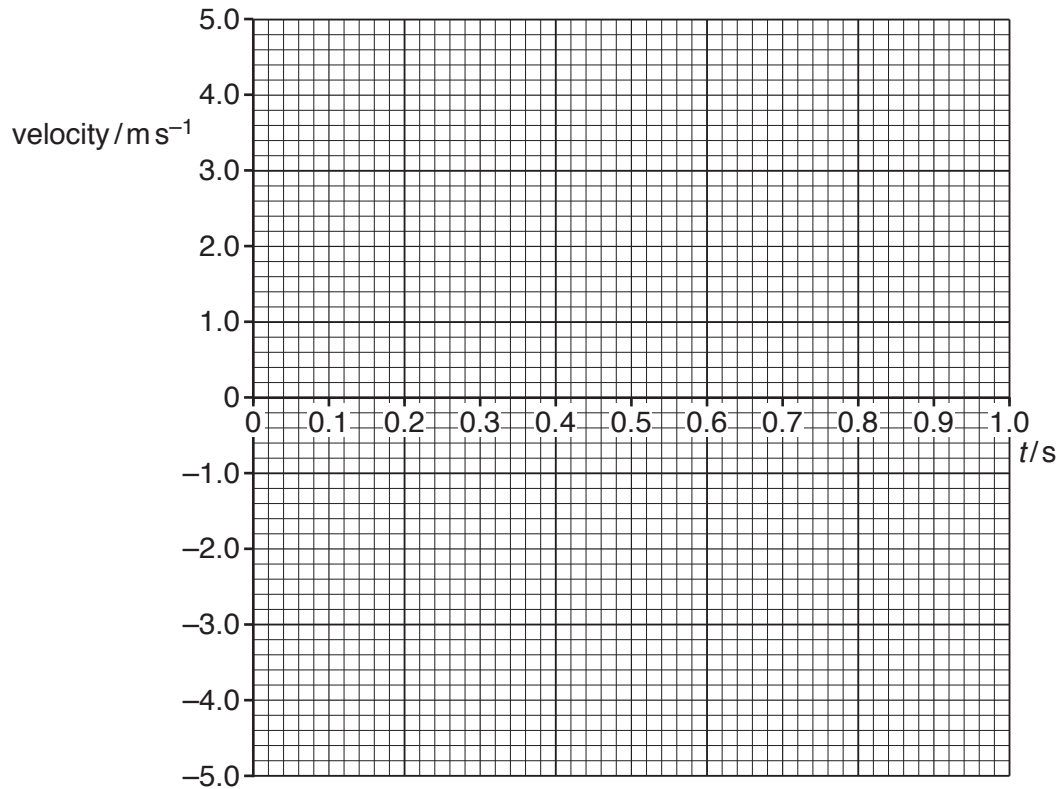


Fig. 1.2

- (c) Calculate the maximum height reached by the ball.

maximum height = ... m [2]

- (d) For the movement of the ball from the ground to its maximum height, determine the ratio
- $$\frac{\text{kinetic energy at maximum height}}{\text{change in gravitational potential energy}}.$$

ratio = ...[4]

- (e) In practice, significant air resistance acts on the ball. Explain why the actual time taken for the ball to reach maximum height is less than the time calculated when air resistance is assumed to be negligible.

.....

.....

.....[1]

[Total: 12]

- 2 (a) The kilogram, metre and second are all SI base units.

State two other SI base units.

1.

2.

[2]

- (b) A uniform beam AB of length 6.0 m is placed on a horizontal surface and then tilted at an angle of 31° to the horizontal, as shown in Fig. 2.1.

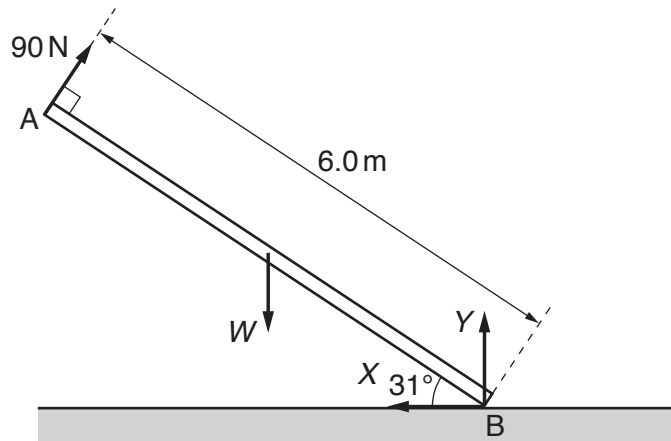


Fig. 2.1 (not to scale)

The beam is held in equilibrium by four forces that all act in the same plane. A force of 90 N acts perpendicular to the beam at end A. The weight W of the beam acts at its centre of gravity. A vertical force Y and a horizontal force X both act at end B of the beam.

- (i) State the name of force X .

.....[1]

- (ii) By taking moments about end B, calculate the weight W of the beam.

$W =$ N [2]

- (iii) Determine the magnitude of force X .

magnitude of force $X =$ N [1]

[Total: 6]

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

.....

.....

.....[2]

- (b) The propulsion system of a toy car consists of a propeller attached to an electric motor, as illustrated in Fig. 3.1.

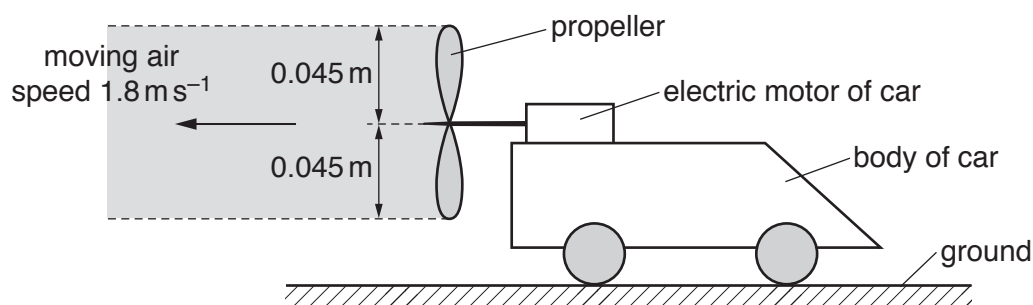


Fig. 3.1

The car is on horizontal ground and is initially held at rest by its brakes. When the motor is switched on, it rotates the propeller so that air is propelled horizontally to the left. The density of the air is 1.3 kg m^{-3} .

Assume that the air moves with a speed of 1.8 m s^{-1} in a uniform cylinder of radius 0.045 m . Also assume that the air to the right of the propeller is stationary.

- (i) Show that, in a time interval of 2.0 s , the mass of air propelled to the left is 0.030 kg .

[2]

(ii) Calculate

1. the increase in the momentum of the mass of air in **(b)(i)**,

increase in momentum = ... N s

2. the force exerted on this mass of air by the propeller.

force = ... N
[3]

(iii) Explain how Newton's third law applies to the movement of the air by the propeller.

.....
.....
.....[2]

(iv) The total mass of the car is 0.20 kg. The brakes of the car are released and the car begins to move with an initial acceleration of 0.075 m s^{-2} .

Determine the initial frictional force acting on the car.

frictional force = ... N [2]

[Total: 11]

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

.....
[1]

- (b) A stationary sound wave in air has amplitude A . In an experiment, a detector is used to determine A^2 . The variation of A^2 with distance x along the wave is shown in Fig. 4.1.

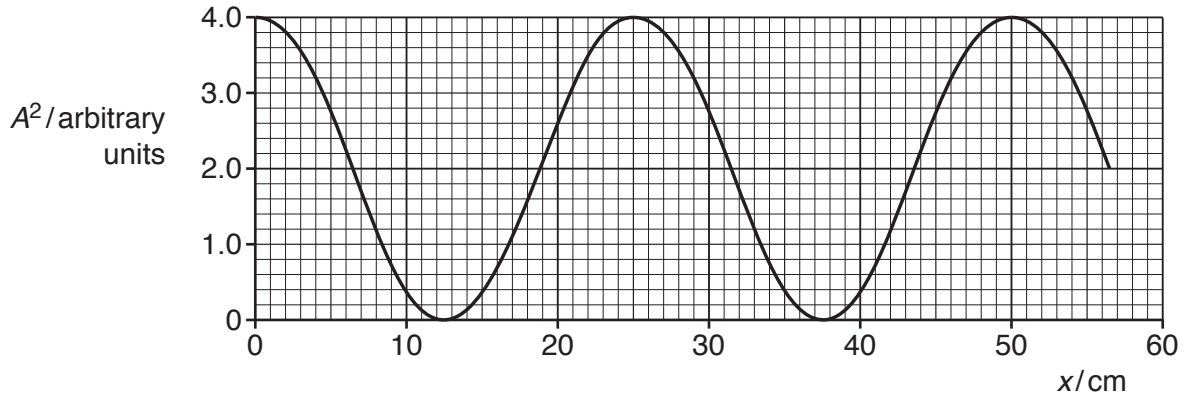


Fig. 4.1

- (i) State the phase difference between the vibrations of an air particle at $x = 25$ cm and the vibrations of an air particle at $x = 50$ cm.

phase difference = ... ° [1]

- (ii) The speed of the sound in the air is 330 ms^{-1} . Determine the frequency of the sound wave.

frequency = ... Hz [3]

- (iii) Determine the ratio

$$\frac{\text{amplitude } A \text{ of wave at } x = 20 \text{ cm}}{\text{amplitude } A \text{ of wave at } x = 25 \text{ cm}}$$

ratio = ... [2]

[Total: 7]

- 5 Red light of wavelength 640 nm is incident normally on a diffraction grating having a line spacing of 1.7×10^{-6} m, as shown in Fig. 5.1.

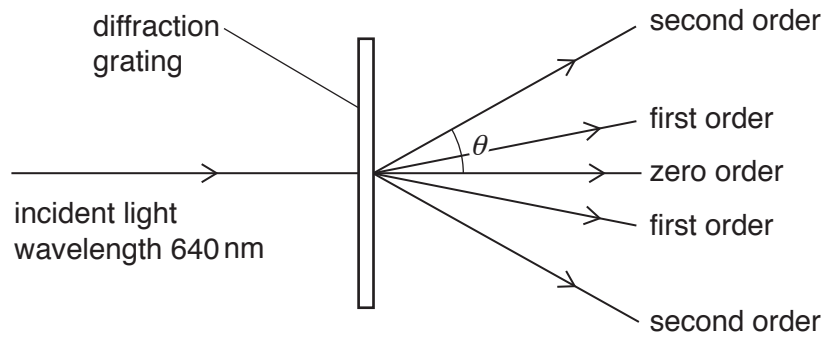


Fig. 5.1 (not to scale)

The second order diffraction maximum of the light is at an angle θ to the direction of the incident light.

- (a) Show that angle θ is 49° .

[3]

- (b) Determine a different wavelength of **visible** light that will also produce a diffraction maximum at an angle of 49° .

wavelength = ... m [2]

[Total: 5]

- 6 (a) Define the *volt*.

.....
[1]

- (b) A battery of electromotive force (e.m.f.) 7.0 V and negligible internal resistance is connected in series with three components, as shown in Fig. 6.1.

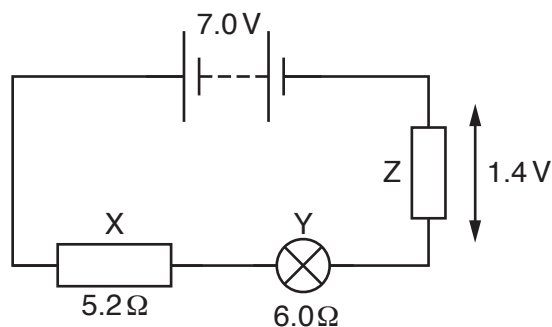


Fig. 6.1

Resistor X has a resistance of $5.2\ \Omega$. The resistance of the filament wire of lamp Y is $6.0\ \Omega$. The potential difference across resistor Z is 1.4 V.

- (i) Calculate the current in the circuit.

current = ... A [2]

- (ii) Determine the resistance of resistor Z.

resistance = ... Ω [1]

- (iii) Calculate the percentage efficiency with which the battery supplies power to the lamp.

efficiency = ... % [3]

- (iv) The filament wire of the lamp is made of metal of resistivity $3.7 \times 10^{-7} \Omega \text{ m}$ at its operating temperature in the circuit.

Determine, for the filament wire, the value of α where

$$\alpha = \frac{\text{cross-sectional area}}{\text{length}}.$$

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

[Total: 9]

- 7 (a) The current I in a metal wire is given by the expression

$$I = Anve.$$

State what is meant by the symbols A and n .

A :

n :

[2]

- (b) The diameter of a wire XY varies linearly with distance along the wire as shown in Fig. 7.1.

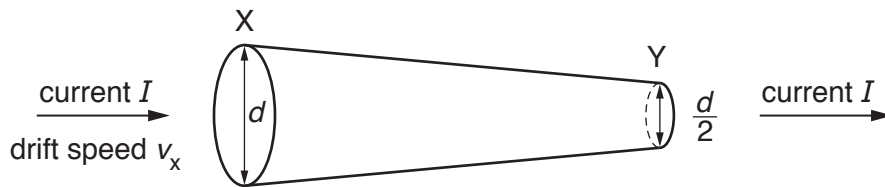


Fig. 7.1

There is a current I in the wire. At end X of the wire, the diameter is d and the average drift speed of the free electrons is v_x . At end Y of the wire, the diameter is $\frac{d}{2}$.

On Fig. 7.2, sketch a graph to show the variation of the average drift speed with position along the wire between X and Y.

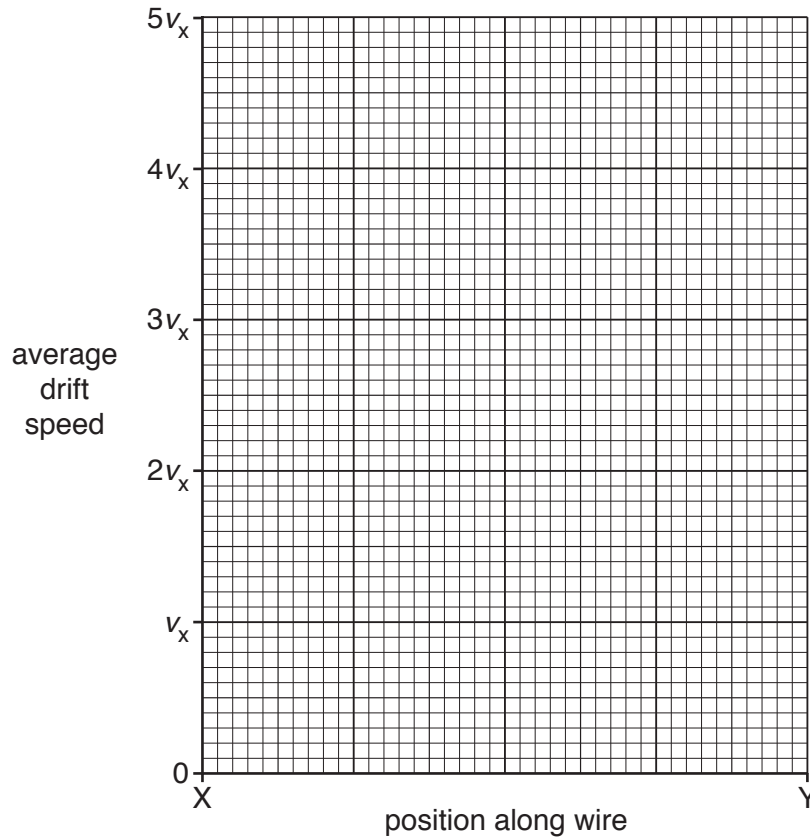


Fig. 7.2

[2]

[Total: 4]

- 8 (a) In the following list, underline all particles that are leptons.

antineutrino positron proton quark [1]

- (b) A stationary nucleus of magnesium-27, ${}^{27}_{12}\text{Mg}$, decays by emitting a β^- particle and γ radiation. An incomplete equation to represent this decay is



- (i) State the nucleon number and the proton number of nucleus X.

nucleon number = ...

proton number = ...

[2]

- (ii) State the name of the interaction that gives rise to this decay.

.....[1]

- (iii) State **two** possible reasons why the sum of the kinetic energy of the β^- particle and the energy of the γ radiation is less than the total energy released during the decay of the magnesium nucleus.

1.

.....

2.

.....

[2]

[Total: 6]

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PHYSICS

9702/23

Paper 2 AS Level Structured Questions

October/November 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	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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

- 1 (a) Mass, length and time are all SI base quantities.

State two other SI base quantities.

1.

2.

[2]

- (b) A wire hangs between two fixed points, as shown in Fig. 1.1.

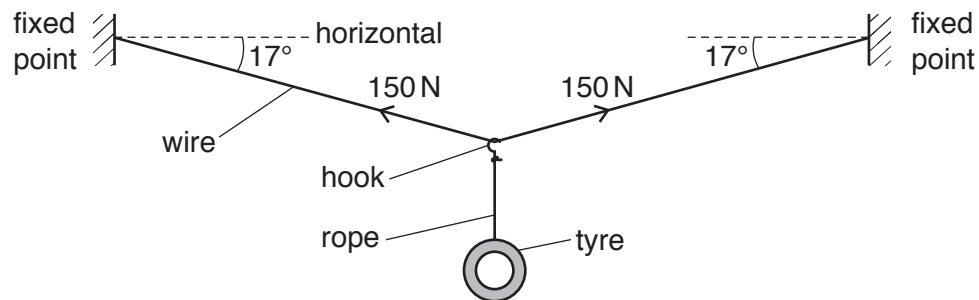


Fig. 1.1 (not to scale)

A child's swing is made by connecting a car tyre to the wire using a rope and a hook. The system is in equilibrium with the wire hanging at an angle of 17° to the horizontal. The tension in the wire is 150 N. Assume that the rope and hook have negligible weight.

- (i) Determine the weight of the tyre.

weight = ... N [2]

- (ii) The wire has a cross-sectional area of 7.5 mm^2 and is made of metal of Young modulus $2.1 \times 10^{11} \text{ Pa}$. The wire obeys Hooke's law.

Calculate, for the wire,

1. the stress,

stress = ... Pa [2]

2. the strain.

strain = ... [2]

[Total: 8]

- 2 (a) State what is meant by *kinetic energy*.

.....
 [1]

- (b) A cannon fires a shell vertically upwards. The shell leaves the cannon with a speed of 80 ms^{-1} and a kinetic energy of 480 J . The shell then rises to a maximum height of 210 m . The effect of air resistance is significant.

- (i) Show that the mass of the shell is 0.15 kg .

[2]

- (ii) For the movement of the shell from the cannon to its maximum height, calculate

1. the gain in gravitational potential energy,

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

2. the work done against air resistance.

work done = ... J [1]

- (iii) Determine the average force due to the air resistance acting on the shell as it moves from the cannon to its maximum height.

force = ... N [2]

- (iv) The shell leaves the cannon at time $t = 0$ and reaches maximum height at time $t = T$.

On Fig. 2.1, sketch the variation with time t of the velocity v of the shell from time $t = 0$ to time $t = T$. Numerical values of v and t are not required.

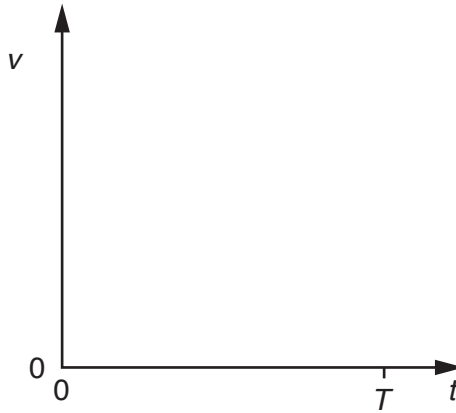


Fig. 2.1

[2]

- (v) The force due to the air resistance is a vector quantity.

Compare the force due to the air resistance acting on the shell as it rises with the force due to the air resistance as it falls.

.....

.....

.....

.....

.....[2]

[Total: 12]

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

.....
[1]

- (b) A toy rocket consists of a container of water and compressed air, as shown in Fig. 3.1.

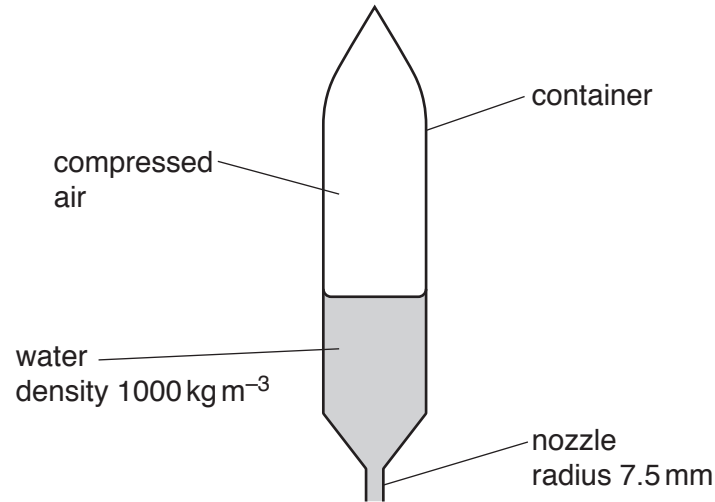


Fig. 3.1

Water is pushed vertically downwards through a nozzle by the compressed air. The rocket moves vertically upwards.

The nozzle has a circular cross-section of radius 7.5 mm. The density of the water is 1000 kg m^{-3} . Assume that the water leaving the nozzle has the shape of a cylinder of radius 7.5 mm and has a constant speed of 13 m s^{-1} relative to the rocket.

- (i) Show that the mass of water leaving the nozzle in the first 0.20 s after the rocket launch is 0.46 kg.

[2]

(ii) Calculate

1. the change in the momentum of the mass of water in **(b)(i)** due to leaving the nozzle,

change in momentum = ... N s

2. the force exerted on this mass of water by the rocket.

force = ... N
[3]

(iii) State and explain how Newton's third law applies to the movement of the rocket by the water.

.....

 [2]

(iv) The container has a mass of 0.40 kg. The initial mass of water before the rocket is launched is 0.70 kg. The mass of the compressed air in the rocket is negligible. Assume that the resistive force on the rocket due to its motion is negligible.

For the rocket at a time of 0.20 s after launching,

1. show that its total mass is 0.64 kg,

2. calculate its acceleration.

acceleration = ... ms^{-2}
[3]

[Total: 11]

- 4 (a) On Fig. 4.1, complete the two graphs to illustrate what is meant by the amplitude A , the wavelength λ and the period T of a progressive wave.

Ensure that you label the axes of each graph.

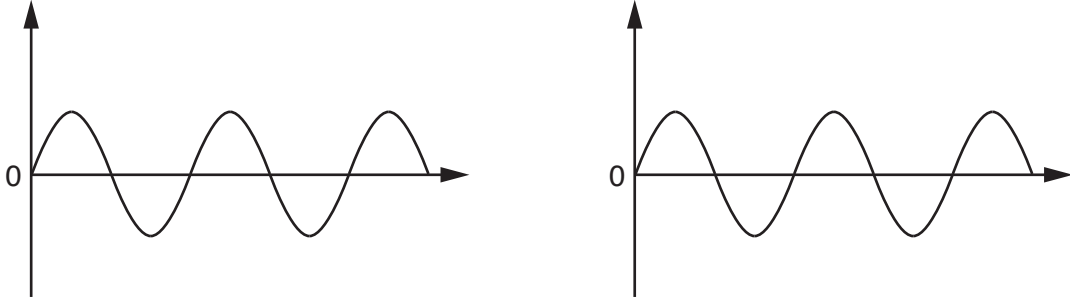


Fig. 4.1

[3]

- (b) A horizontal string is stretched between two fixed points X and Y. A vibrator is used to oscillate the string and produce a stationary wave. Fig. 4.2 shows the string at one instant in time.

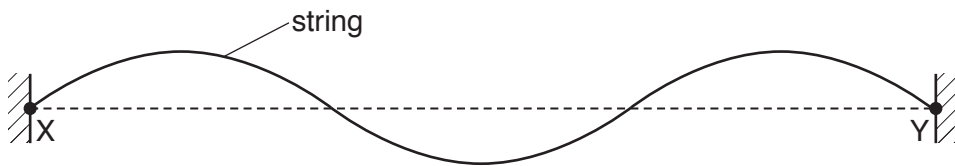


Fig. 4.2

The speed of a progressive wave along the string is 30 ms^{-1} . The stationary wave has a period of 40 ms .

- (i) Explain how the stationary wave is formed on the string.

.....

.....

.....

.....[2]

- (ii) A particle on the string oscillates with an amplitude of 13 mm. At time t , the particle has zero displacement.

Calculate

1. the displacement of the particle at time $(t + 100 \text{ ms})$,

displacement = ... mm

2. the total distance moved by the particle from time t to time $(t + 100 \text{ ms})$.

distance = ... mm
[3]

- (iii) Determine

1. the frequency of the wave,

frequency = ... Hz [1]

2. the horizontal distance from X to Y.

distance = ... m [3]

[Total: 12]

- 5 A particle of mass m and charge q is in a uniform electric field of strength E . The particle has acceleration a due to the field.

(a) Show that

$$\frac{q}{m} = \frac{a}{E}.$$

[2]

- (b) The particle has a charge of $4e$ where e is the elementary charge. The electric field strength is $3.5 \times 10^4 \text{ V m}^{-1}$. The acceleration of the particle is $1.5 \times 10^{12} \text{ m s}^{-2}$.

Use the expression in (a) to show that the mass of the particle is 9.0 u .

[2]

- (c) The particle is a nucleus. State the number of protons and the number of neutrons in the nucleus.

number of protons = ...

number of neutrons = ...

[1]

- (d) A second nucleus that is an isotope of the nucleus in (c) is in the same uniform electric field.

State and explain whether the electric field produces, for the two nuclei, the same magnitudes of

(i) force,

.....
[1]

(ii) acceleration.

.....
[1]

[Total: 7]

- 6 (a) Define the *coulomb*.

.....
[1]

- (b) An electric current is a flow of charge carriers.

In the following list, underline the possible charges for a charge carrier.

$8.0 \times 10^{-19} \text{ C}$ $4.0 \times 10^{-19} \text{ C}$ $1.6 \times 10^{-19} \text{ C}$ $1.6 \times 10^{-20} \text{ C}$ [1]

- (c) The diameter of a wire ST varies linearly with distance along the wire as shown in Fig. 6.1.

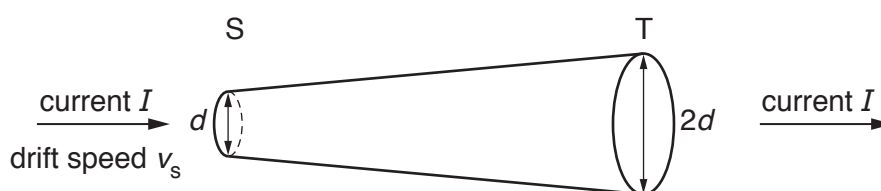


Fig. 6.1

There is a current I in the wire. At end S of the wire, the diameter is d and the average drift speed of the free electrons is v_s . At end T of the wire, the diameter is $2d$.

On Fig. 6.2, sketch a graph to show the variation of the average drift speed with position along the wire between S and T.

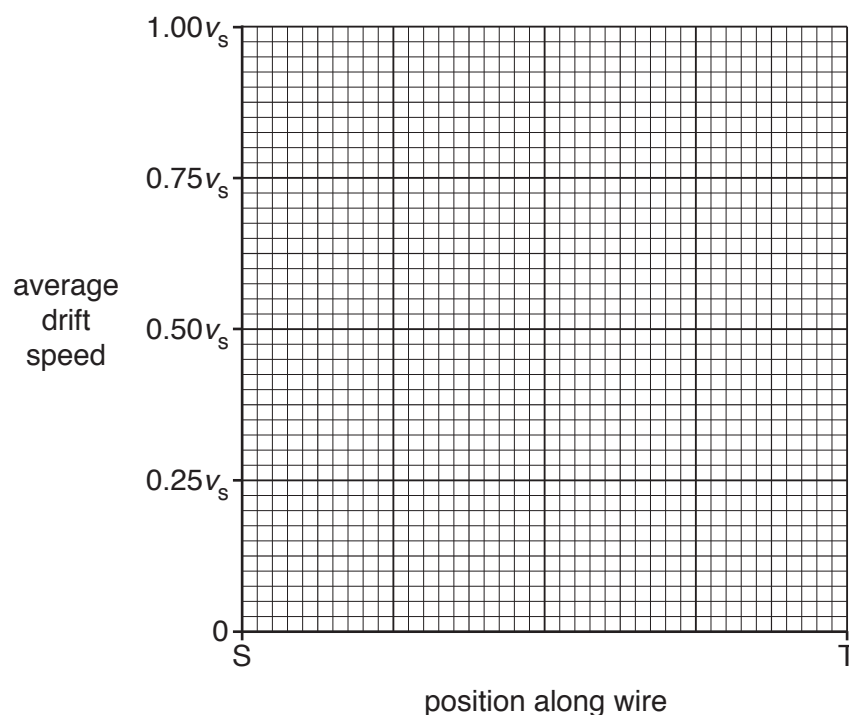


Fig. 6.2

[2]

[Total: 4]

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

.....
[1]

- (b) A potentiometer is connected to a battery of electromotive force (e.m.f.) 9.6 V and negligible internal resistance, as shown in Fig. 7.1.

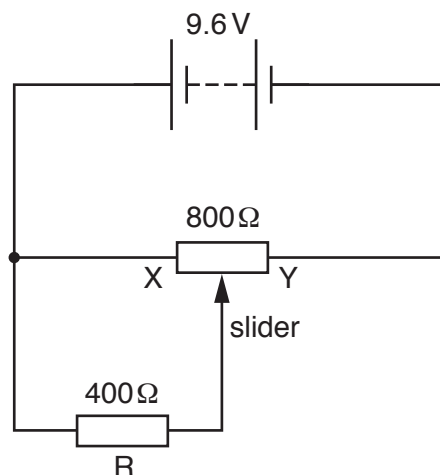


Fig. 7.1

The maximum resistance of the potentiometer is $800\ \Omega$. A resistor R of resistance $400\ \Omega$ is connected between the slider and end X of the potentiometer.

- (i) State the potential difference across resistor R when the slider is positioned

1. at end X of the potentiometer,

potential difference = ... V

2. at end Y of the potentiometer.

potential difference = ... V
 [2]

- (ii) Calculate the potential difference across resistor R when the slider is positioned half-way between X and Y.

potential difference = ... V [3]

[Total: 6]

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