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9702/21

May/June 2019

1 hour 15 minutes

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

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

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

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

- 1 (a) Define *velocity*.

.....
[1]

- (b) The speed v of a sound wave through a gas of pressure P and density ρ is given by the equation

$$v = \sqrt{\frac{kP}{\rho}}$$

where k is a constant that has no units.

An experiment is performed to determine the value of k . The data from the experiment are shown in Fig. 1.1.

quantity	value	uncertainty
v	$3.3 \times 10^2 \text{ m s}^{-1}$	$\pm 3\%$
P	$9.9 \times 10^4 \text{ Pa}$	$\pm 2\%$
ρ	1.29 kg m^{-3}	$\pm 4\%$

Fig. 1.1

- (i) Use data from Fig. 1.1 to calculate k .

$k = \dots\dots\dots$ [2]

- (ii) Use your answer in (b)(i) and data from Fig. 1.1 to determine the value of k , with its absolute uncertainty, to an appropriate number of significant figures.

$k = \dots\dots\dots \pm \dots\dots\dots$ [3]

[Total: 6]

- 2 A block X slides along a horizontal frictionless surface towards a stationary block Y, as illustrated in Fig. 2.1.

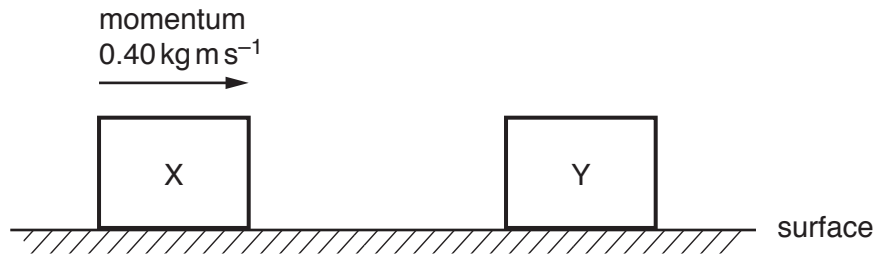


Fig. 2.1

There are no resistive forces acting on block X as it moves towards block Y. At time $t = 0$, block X has momentum 0.40 kg m s^{-1} . A short time later, the blocks collide and then separate.

The variation with time t of the momentum of block Y is shown in Fig. 2.2.

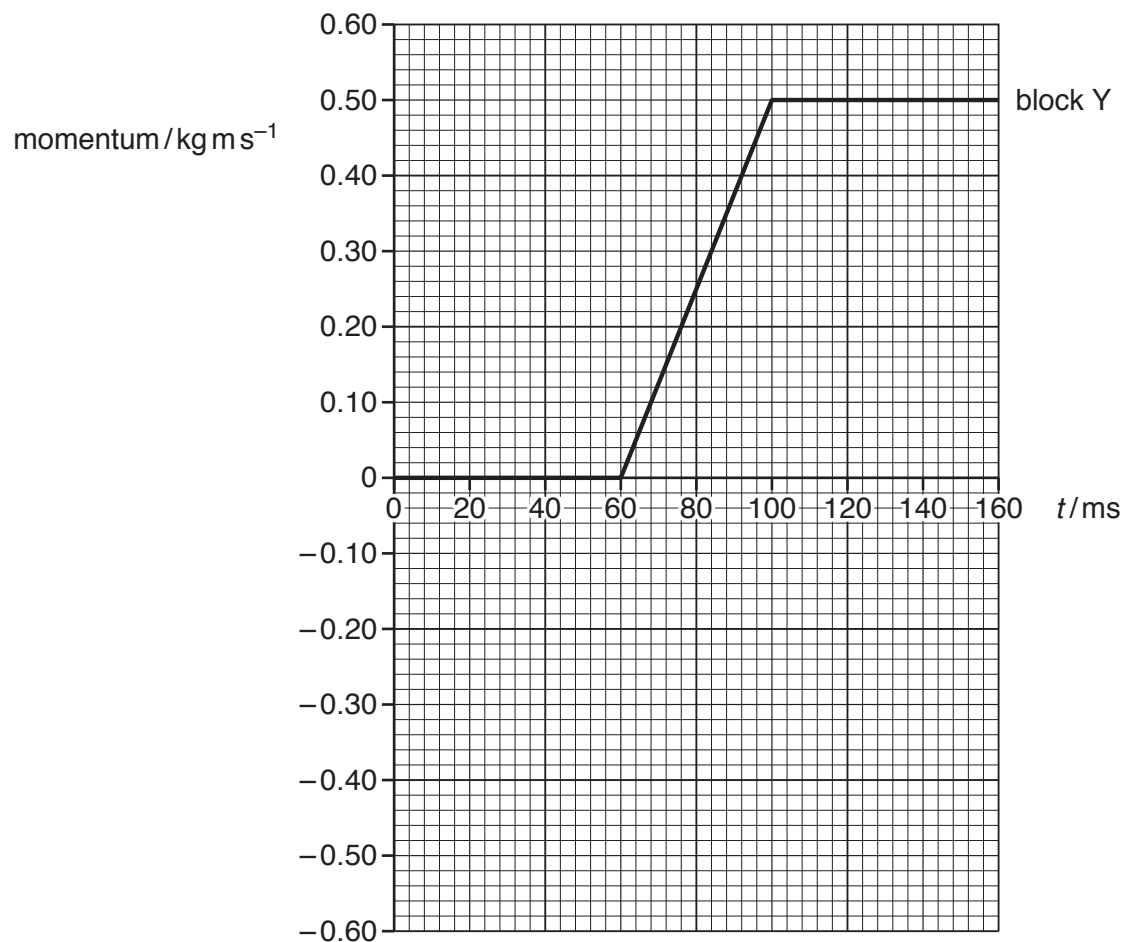


Fig. 2.2

(a) Define *linear momentum*.

.....[1]

(b) Use Fig. 2.2 to:

(i) determine the time interval over which the blocks are in contact with each other

time interval = ... ms [1]

(ii) describe, without calculation, the magnitude of the acceleration of block Y from:

1. time $t = 80$ ms to $t = 100$ ms

.....

2. time $t = 100$ ms to $t = 120$ ms.

.....

[2]

(c) Use Fig. 2.2 to determine the magnitude of the force exerted by block X on block Y.

force = ... N [2]

(d) On Fig. 2.2, sketch the variation of the momentum of block X with time t from $t = 0$ to $t = 160$ ms. [3]

[Total: 9]

- 3 The variation with extension x of the force F acting on a spring is shown in Fig. 3.1.

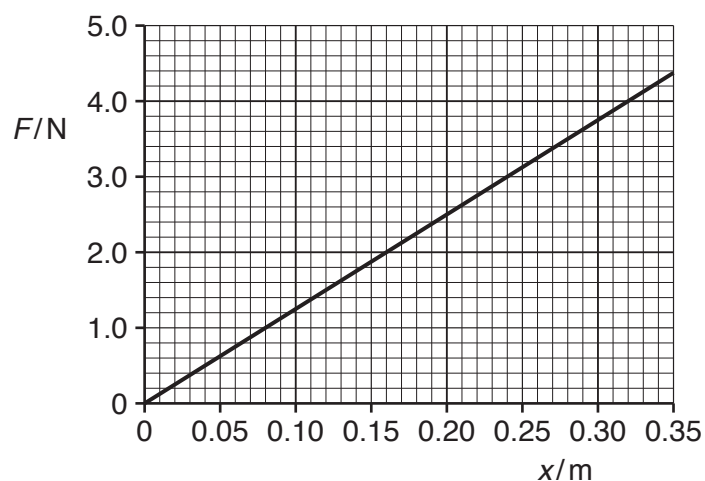


Fig. 3.1

The spring of unstretched length 0.40 m has one end attached to a fixed point, as shown in Fig. 3.2.

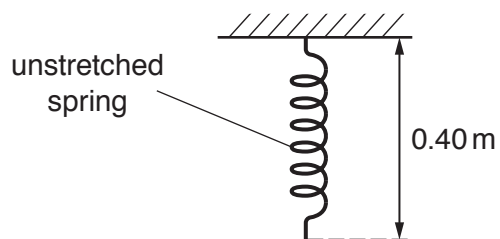


Fig. 3.2

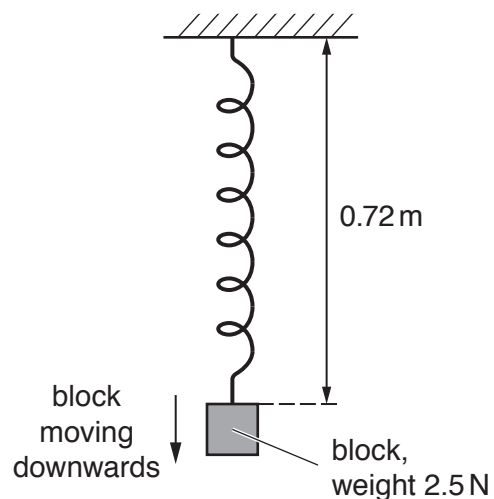


Fig. 3.3

A block of weight 2.5 N is then attached to the spring. The block is then released and begins to move downwards. At one instant, as the block is continuing to move downwards, the spring has a length of 0.72 m, as shown in Fig. 3.3.

Assume that the air resistance and the mass of the spring are both negligible.

(a) For the change in length of the spring from 0.40 m to 0.72 m:

(i) use Fig. 3.1 to show that the increase in elastic potential energy of the spring is 0.64 J

[2]

(ii) calculate the decrease in gravitational potential energy of the block of weight 2.5 N.

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

(b) Use the information in **(a)(i)** and your answer in **(a)(ii)** to determine, for the instant when the length of the spring is 0.72 m:

(i) the kinetic energy of the block

kinetic energy = ... J [1]

(ii) the speed of the block.

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

[Total: 7]

- 4 (a) A spherical oil drop has a radius of $1.2 \times 10^{-6} \text{ m}$. The density of the oil is 940 kg m^{-3} .

(i) Show that the mass of the oil drop is $6.8 \times 10^{-15} \text{ kg}$.

[2]

(ii) The oil drop is charged. Explain why it is impossible for the magnitude of the charge to be $8.0 \times 10^{-20} \text{ C}$.

.....
[1]

(b) The charged oil drop in (a) is in a vacuum between two horizontal metal plates, as illustrated in Fig. 4.1.

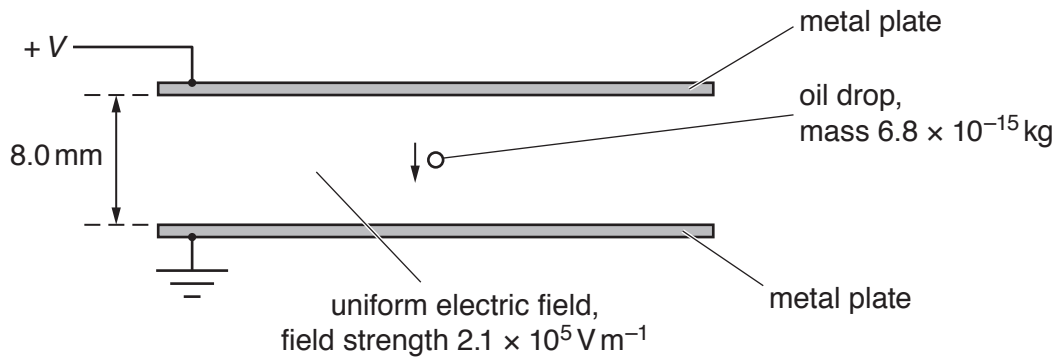


Fig. 4.1

The plates are separated by a distance of 8.0 mm. The electric field between the plates is uniform and has a field strength of $2.1 \times 10^5 \text{ V m}^{-1}$.

The oil drop moves vertically downwards with a constant speed.

(i) Calculate the potential difference V between the plates.

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

(ii) Explain how the motion of the oil drop shows that it is in equilibrium.

.....
[1]

- (iii) Determine the charge on the oil drop.

charge = ... C

sign of charge [3]

- (c) The magnitude of the potential difference between the plates in (b) is decreased.

- (i) Explain why the oil drop accelerates downwards.

.....

 [2]

- (ii) Describe the change to the pattern of the field lines (lines of force) representing the uniform electric field as the potential difference decreases.

.....
 [1]

- (d) Two types of force, X and Y, can act on an oil drop when it is in air, but cannot act on an oil drop when it is in a vacuum. Force X can act on an oil drop when it is stationary or when it is moving. Force Y can only act on an oil drop when it is moving.

State the name of:

- (i) force X

..... [1]

- (ii) force Y.

..... [1]

[Total: 14]

- 5 (a) A loudspeaker oscillates with frequency f to produce sound waves of wavelength λ . The loudspeaker makes N oscillations in time t .

(i) State expressions, in terms of some or all of the symbols f , λ and N , for:

1. the distance moved by a wavefront in time t

distance = ...

2. time t .

time t = ...

[2]

- (ii) Use your answers in (i) to deduce the equation relating the speed v of the sound wave to f and λ .

[1]

- (b) The waveform of a sound wave is displayed on the screen of a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 5.1.

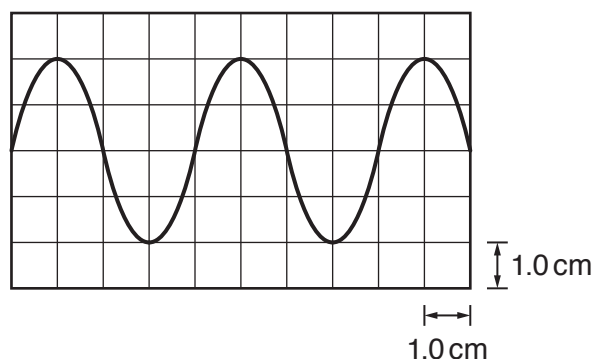


Fig. 5.1

The time-base setting is 0.20 ms cm^{-1} .

Determine the frequency of the sound wave.

frequency = ... Hz [2]

- (c) Two sources S_1 and S_2 of sound waves are positioned as shown in Fig. 5.2.

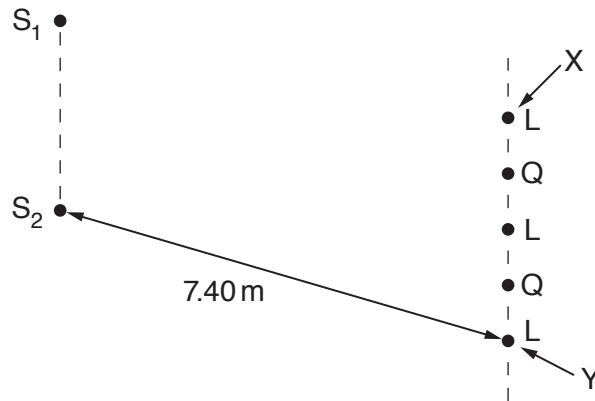


Fig. 5.2 (not to scale)

The sources emit coherent sound waves of wavelength 0.85 m. A sound detector is moved parallel to the line S_1S_2 from a point X to a point Y. Alternate positions of maximum loudness L and minimum loudness Q are detected, as illustrated in Fig. 5.2.

Distance S_1X is equal to distance S_2X . Distance S_2Y is 7.40 m.

- (i) Explain what is meant by *coherent* waves.

.....
[1]

- (ii) State the phase difference between the two waves arriving at the position of minimum loudness Q that is closest to point X.

phase difference = ... ° [1]

- (iii) Determine the distance S_1Y .

distance = ... m [2]

[Total: 9]

- 6 A battery of electromotive force (e.m.f.) E and internal resistance r is connected to a variable resistor of resistance R , as shown in Fig. 6.1.

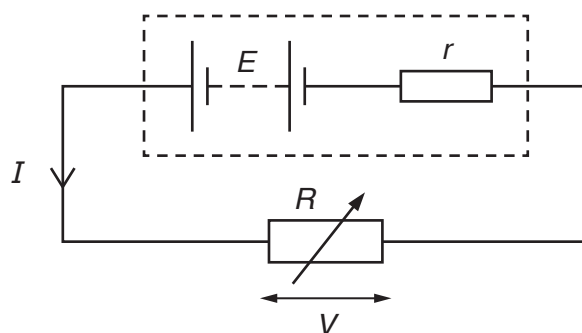


Fig. 6.1

The current in the circuit is I and the potential difference across the variable resistor is V .

- (a) Explain, in terms of energy, why V is less than E .

.....
[1]

- (b) State an equation relating E , I , r and V .

.....[1]

- (c) The resistance R of the variable resistor is varied. The variation with I of V is shown in Fig. 6.2.

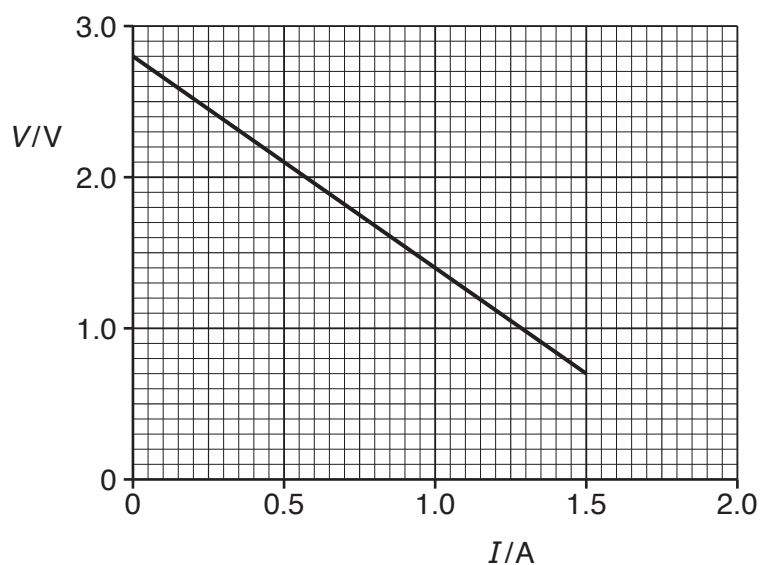


Fig. 6.2

Use Fig. 6.2 to:

- (i) explain how it may be deduced that the e.m.f. of the battery is 2.8 V

.....
[1]

- (ii) calculate the internal resistance r .

$r = \dots\dots\dots \Omega$ [2]

- (d) The battery stores 9.2 kJ of energy. The variable resistor is adjusted so that $V = 2.1$ V. Use Fig. 6.2 to:

- (i) calculate resistance R

$R = \dots\dots\dots \Omega$ [1]

- (ii) calculate the number of conduction electrons moving through the battery in a time of 1.0 s

number = ... [1]

- (iii) determine the time taken for the energy in the battery to become equal to 1.6 kJ.
 (Assume that the e.m.f. of the battery and the current in the battery remain constant.)

time taken = ... s [3]

[Total: 10]

- 7 (a) One of the results of the α -particle scattering experiment is that a very small minority of the α -particles are scattered through angles greater than 90° .

State what may be inferred about the structure of the atom from this result.

.....

.....

.....

.....[2]

- (b) A hadron has an overall charge of $+e$, where e is the elementary charge. The hadron contains three quarks. One of the quarks is a strange (s) quark.

- (i) State the charge, in terms of e , of the strange (s) quark.

charge = ... [1]

- (ii) The other two quarks in the hadron have the same charge as each other.

By considering charge, determine a possible type (flavour) of the other two quarks.
Explain your working.

.....

.....[2]

[Total: 5]

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PHYSICS

9702/22

Paper 2 AS Level Structured Questions

May/June 2019

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

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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

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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) The diameter d of a cylinder is measured as $0.0125 \text{ m} \pm 1.6\%$.

Calculate the absolute uncertainty in this measurement.

absolute uncertainty = ... m [1]

- (b) The cylinder in (a) stands on a horizontal surface. The pressure p exerted on the surface by the cylinder is given by

$$p = \frac{4W}{\pi d^2}.$$

The measured weight W of the cylinder is $0.38 \text{ N} \pm 2.8\%$.

- (i) Calculate the pressure p .

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

- (ii) Determine the absolute uncertainty in the value of p .

absolute uncertainty = ... Nm^{-2} [2]

[Total: 4]

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

.....
[1]

- (b) A car of mass 850 kg tows a trailer in a straight line along a horizontal road, as shown in Fig. 2.1.

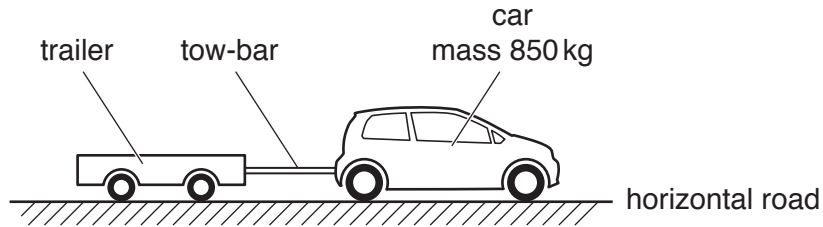


Fig. 2.1

The car and the trailer are connected by a horizontal tow-bar.

The variation with time t of the velocity v of the car for a part of its journey is shown in Fig. 2.2.

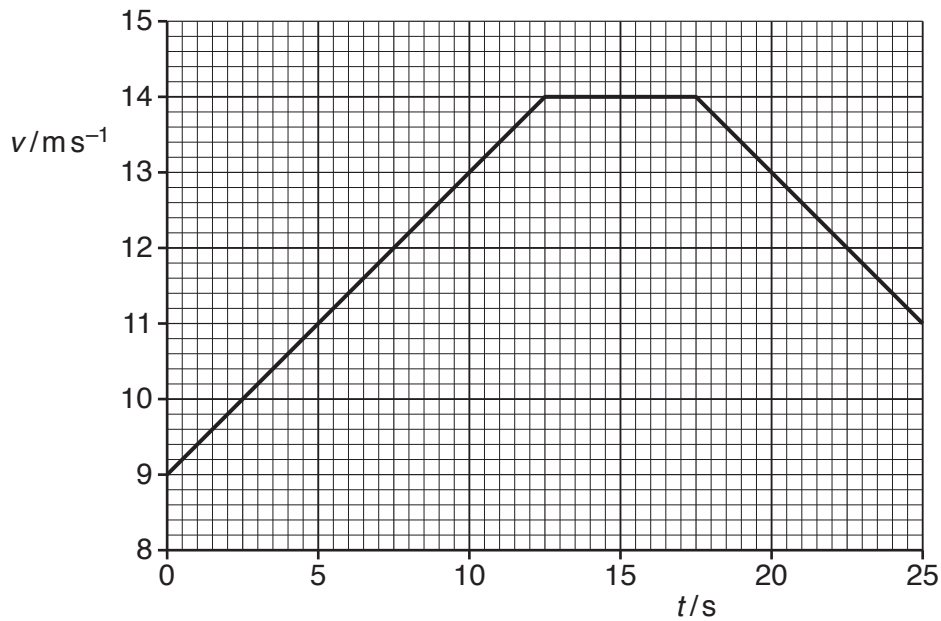


Fig. 2.2

- (i) Calculate the distance travelled by the car from time $t = 0$ to $t = 10$ s.

distance = ... m [2]

- (ii) At time $t = 10$ s, the resistive force acting on the car due to air resistance and friction is 510 N. The tension in the tow-bar is 440 N.

For the car at time $t = 10$ s:

1. use Fig. 2.2 to calculate the acceleration

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

2. use your answer to calculate the resultant force acting on the car

resultant force = ... N [1]

3. show that a horizontal force of 1300 N is exerted on the car by its engine

[1]

4. determine the useful output power of the engine.

output power = ... W [2]

- (c) A short time later, the car in (b) is travelling at a constant speed and the tension in the tow-bar is 480 N.

The tow-bar is a solid metal rod that obeys Hooke's law. Some data for the tow-bar are listed below.

Young modulus of metal = 2.2×10^{11} Pa

original length of tow-bar = 0.48 m

cross-sectional area of tow-bar = 3.0×10^{-4} m²

Determine the extension of the tow-bar.

extension = ... m [3]

- (d) The driver of the car in (b) sees a pedestrian standing directly ahead in the distance. The driver operates the horn of the car from time $t = 15$ s to $t = 17$ s. The frequency of the sound heard by the pedestrian is 480 Hz. The speed of the sound in the air is 340 m s^{-1} .

Use Fig. 2.2 to calculate the frequency of the sound emitted by the horn.

frequency = ... Hz [2]

[Total: 14]

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

.....
[1]

- (b) A uniform square sign with sides of length 0.68 m is fixed at its corner points A and B to a wall. The sign is also supported by a wire CD, as shown in Fig. 3.1.

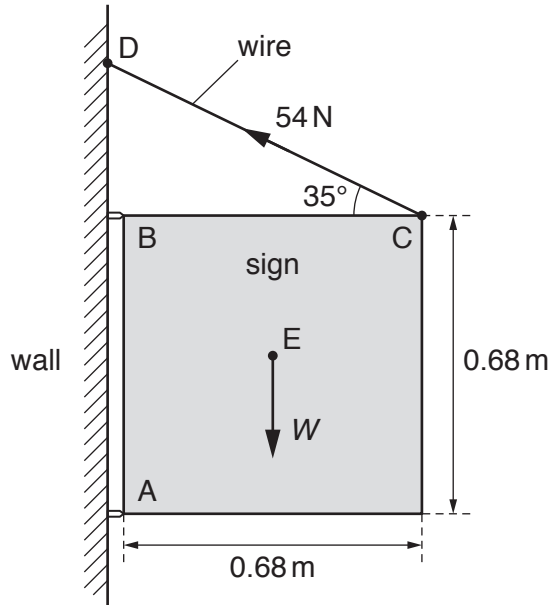


Fig. 3.1 (not to scale)

The sign has weight W and centre of gravity at point E. The sign is held in a vertical plane with side BC horizontal. The wire is at an angle of 35° to side BC. The tension in the wire is 54 N.

The force exerted on the sign at B is only in the vertical direction.

- (i) Calculate the vertical component of the tension in the wire.

vertical component of tension = ... N [1]

- (ii) Explain why the force on the sign at B does not have a moment about point A.

.....
[1]

- (iii) By taking moments about point A, show that the weight W of the sign is 150 N.

[2]

- (iv) Calculate the total vertical force exerted by the wall on the sign at points A and B.

total vertical force = ... N [1]

- (c) The sign in (b) is held together by nuts and bolts. One of the nuts falls vertically from rest through a distance of 4.8 m to the pavement below. The nut lands on the pavement with a speed of 9.2 m s^{-1} .

Determine, for the nut falling from the sign to the pavement, the ratio

$$\frac{\text{change in gravitational potential energy}}{\text{final kinetic energy}}.$$

ratio = ... [4]

[Total: 10]

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

(i) *displacement*

.....
[1]

(ii) *amplitude*.

.....
[1]

(b) Two coherent waves X and Y meet at a point and superpose. The phase difference between the waves at the point is 180° . Wave X has an amplitude of 1.2 cm and intensity I . Wave Y has an amplitude of 3.6 cm.

Calculate, in terms of I , the resultant intensity at the meeting point.

intensity = ... [2]

(c) (i) Monochromatic light is incident on a diffraction grating. Describe the diffraction of the light waves as they pass through the grating.

.....

[2]

- (ii) A parallel beam of light consists of two wavelengths 540 nm and 630 nm. The light is incident normally on a diffraction grating. Third-order diffraction maxima are produced for each of the two wavelengths. No higher orders are produced for either wavelength.

Determine the smallest possible line spacing d of the diffraction grating.

$$d = \dots\dots\dots \text{ m [3]}$$

- (iii) The beam of light in (c)(ii) is replaced by a beam of blue light incident on the same diffraction grating.

State and explain whether a third-order diffraction maximum is produced for this blue light.

.....

[2]

[Total: 11]

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

.....
[2]

- (b) A battery of electromotive force (e.m.f.) 5.6 V and internal resistance r is connected to two external resistors, as shown in Fig. 5.1.

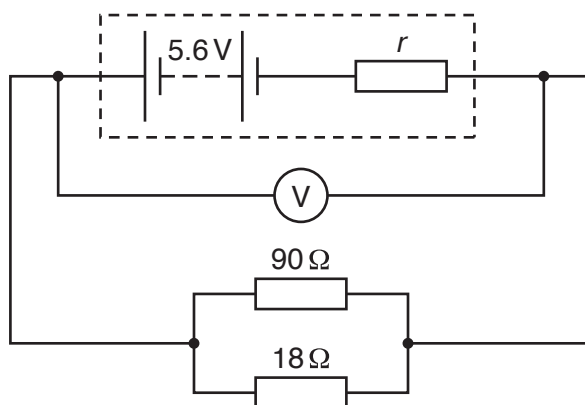


Fig. 5.1

The reading on the voltmeter is 4.8 V .

- (i) Calculate:

1. the combined resistance of the two resistors connected in parallel

combined resistance = ... Ω [2]

2. the current in the battery.

current = ... A [2]

- (ii) Show that the internal resistance r is 2.5Ω .

[2]

(iii) Determine the ratio

$$\frac{\text{power dissipated by internal resistance } r}{\text{total power produced by battery}}.$$

ratio = ... [3]

- (c) The battery in (b) is now connected to a battery of e.m.f. 7.2 V and internal resistance 3.5 Ω. The new circuit is shown in Fig. 5.2.

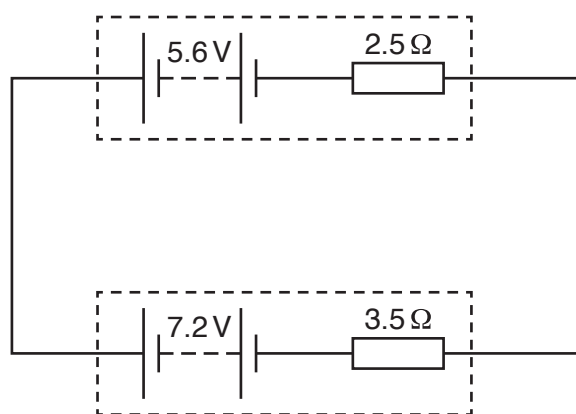


Fig. 5.2

Determine the current in the circuit.

current = ... A [2]

[Total: 13]

- 6 (a) State what is meant by a *field line* (*line of force*) in an electric field.

.....
[1]

- (b) An electric field has two different regions X and Y. The field strength in X is less than that in Y. Describe a difference between the pattern of field lines (lines of force) in X and in Y.

.....
[1]

- (c) A particle P has a mass of 0.15 u and a charge of $-1e$, where e is the elementary charge.

- (i) Particle P and an α -particle are in the same uniform electric field. Calculate the ratio

$$\frac{\text{magnitude of acceleration of particle P}}{\text{magnitude of acceleration of } \alpha\text{-particle}} .$$

ratio = ... [3]

- (ii) Particle P is a hadron composed of only two quarks. One of them is a down (d) quark.

By considering charge, determine a possible type (flavour) of the other quark.
 Explain your working.

.....
[3]

[Total: 8]

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9702/23

May/June 2019

1 hour 15 minutes

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

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

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

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

- 1 (a) (i) Define *resistance*.

.....
[1]

- (ii) A potential difference of 0.60 V is applied across a resistor of resistance 4.0 GΩ.

Calculate the current, in pA, in the resistor.

current = ... pA [2]

- (b) The energy E transferred when charge Q moves through an electrical component is given by the equation

$$E = QV$$

where V is the potential difference across the component.

Use the equation to determine the SI base units of potential difference.

SI base units [3]

[Total: 6]

- 2 (a) A resultant force F moves an object of mass m through distance s in a straight line. The force gives the object an acceleration a so that its speed changes from initial speed u to final speed v .

(i) State an expression for:

1. the work W done by the force, in terms of a , m and s

$$W = \dots\dots\dots [1]$$

2. the distance s , in terms of a , u and v .

$$s = \dots\dots\dots [1]$$

(ii) Use your answers in (i) to show that the kinetic energy of the object is given by

$$\text{kinetic energy} = \frac{1}{2} \times \text{mass} \times (\text{speed})^2.$$

Explain your working.

[2]

- (b) A ball of mass 0.040 kg is projected into the air from horizontal ground, as illustrated in Fig. 2.1.

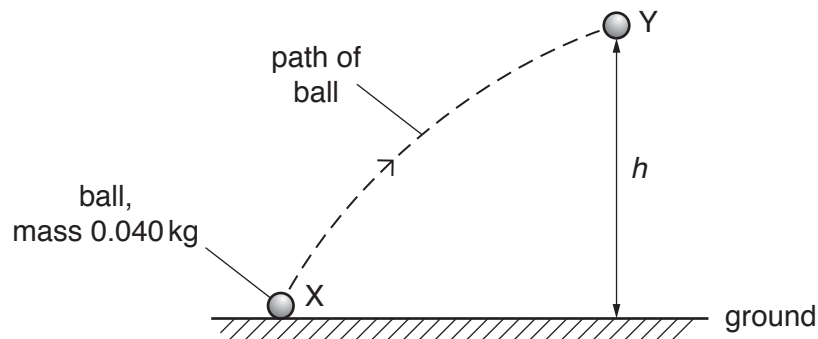


Fig. 2.1

The ball is launched from a point X with a kinetic energy of 4.5 J . At point Y, the ball has a speed of 9.5 ms^{-1} . Air resistance is negligible.

(i) For the movement of the ball from X to Y, draw a solid line on Fig. 2.1 to show:

1. the distance moved (label this line D)
2. the displacement (label this line S).

[2]

(ii) By consideration of energy transfer, determine the height h of point Y above the ground.

$h = \dots\dots\dots$ m [3]

(iii) On Fig. 2.2, sketch the variation of the kinetic energy of the ball with its vertical height above the ground for the movement of the ball from X to Y. Numerical values are not required.

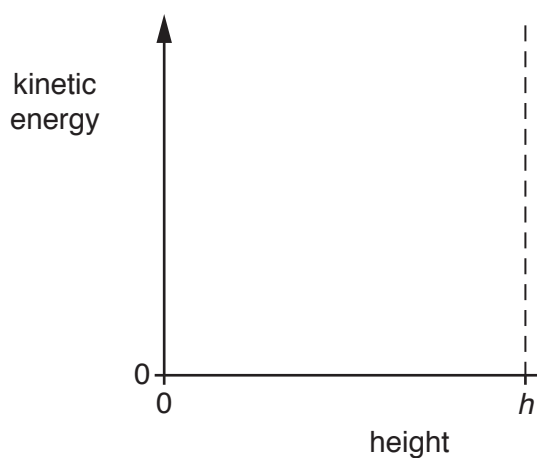


Fig. 2.2

[2]

[Total: 11]

- 3 A cylindrical disc of mass 0.24 kg has a circular cross-sectional area A , as shown in Fig. 3.1.

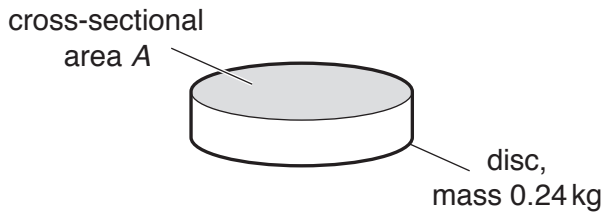


Fig. 3.1

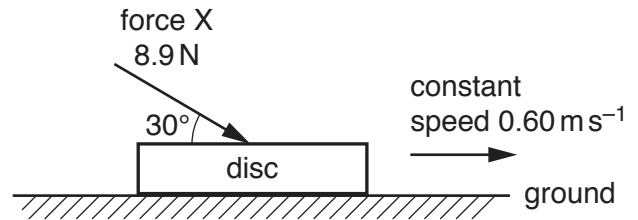


Fig. 3.2

The disc is on horizontal ground, as shown in Fig. 3.2. A force X of magnitude 8.9 N acts on the disc in a direction of 30° to the horizontal. The disc moves at a constant speed of 0.60 m s^{-1} along the ground.

- (a) Determine the rate of doing work on the disc by the force X .

rate of doing work = ... W [2]

- (b) The force X and the weight of the disc exert a combined pressure on the ground of 3500 Pa.

Calculate the cross-sectional area A of the disc.

$A = \dots\dots\dots \text{ m}^2$ [3]

- (c) Newton's third law describes how forces exist in pairs. One such pair of forces is the weight of the disc and another force Y . State:

- (i) the direction of force Y

.....[1]

- (ii) the name of the body on which force Y acts.

.....[1]

[Total: 7]

- 4 Two vertical metal plates in a vacuum are separated by a distance of 0.12 m. Fig. 4.1 shows a side view of this arrangement.

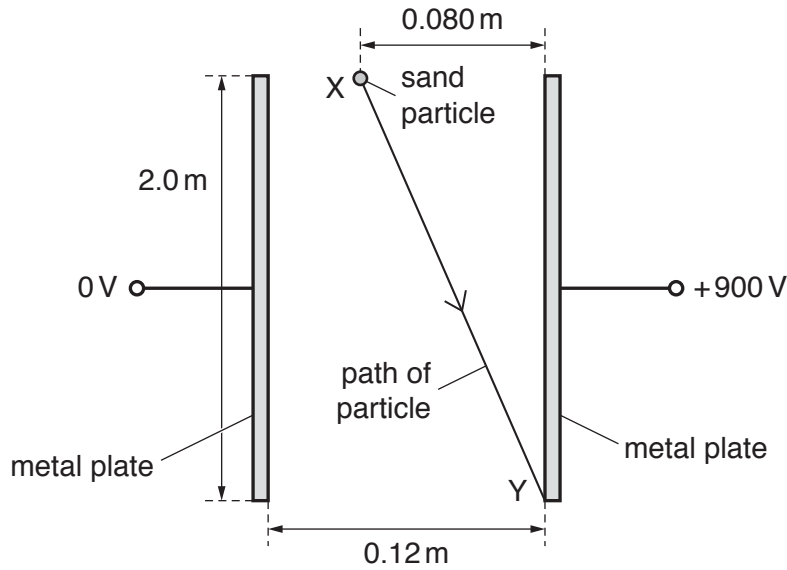


Fig. 4.1 (not to scale)

Each plate has a length of 2.0 m. The potential difference between the plates is 900 V. The electric field between the plates is uniform.

A negatively charged sand particle is released from rest at point X, which is a horizontal distance of 0.080 m from the top of the positively charged plate. The particle then travels in a straight line and collides with the positively charged plate at its lowest point Y, as illustrated in Fig. 4.1.

- (a) Describe the pattern of the field lines (lines of force) between the plates.

.....

[2]

- (b) State the names of the **two** forces acting on the particle as it moves from X to Y.

.....[1]

- (c) By considering the vertical motion of the sand particle, show that the time taken for the particle to move from X to Y is 0.64 s.

[2]

- (d) Calculate the horizontal component of the acceleration of the particle.

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

- (e) (i) Calculate the magnitude of the electric field strength.

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

- (ii) The sand particle has mass m and charge q . Use your answers in (d) and (e)(i) to determine the ratio $\frac{q}{m}$.

ratio = ... C kg^{-1} [2]

- (f) Another particle has a smaller magnitude of the ratio $\frac{q}{m}$ than the sand particle. This particle is also released from point X.

For the movement of this particle, state the effect, if any, of the decreased magnitude of the ratio on:

- (i) the vertical component of the acceleration

.....[1]

- (ii) the horizontal component of the acceleration.

.....[1]

[Total: 13]

- 5 A vertical tube of length 0.60 m is open at both ends, as shown in Fig. 5.1.

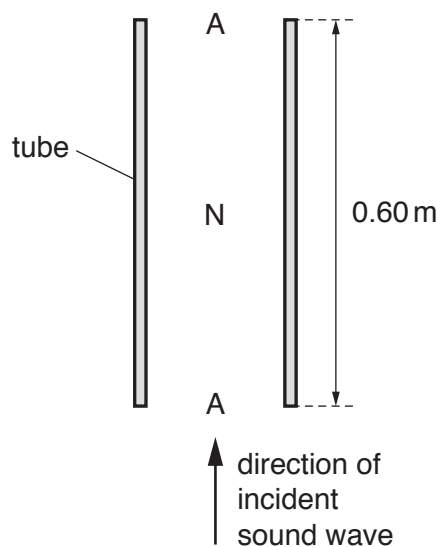


Fig. 5.1

An incident sinusoidal sound wave of a single frequency travels up the tube. A stationary wave is then formed in the air column in the tube with antinodes A at both ends and a node N at the midpoint.

- (a) Explain how the stationary wave is formed from the incident sound wave.

.....

.....

.....

.....[2]

- (b) On Fig. 5.2, sketch a graph to show the variation of the amplitude of the stationary wave with height h above the bottom of the tube.

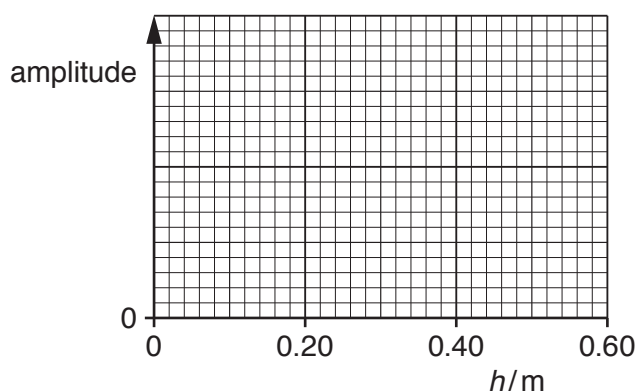


Fig. 5.2

[2]

(c) For the stationary wave, state:

- (i) the direction of the oscillations of an air particle at a height of 0.15 m above the bottom of the tube

.....[1]

- (ii) the phase difference between the oscillations of a particle at a height of 0.10 m and a particle at a height of 0.20 m above the bottom of the tube.

phase difference = ... ° [1]

(d) The speed of the sound wave is 340 m s^{-1} .

Calculate the frequency of the sound wave.

frequency = ... Hz [2]

(e) The frequency of the sound wave is gradually increased.

Determine the frequency of the wave when a stationary wave is next formed.

frequency = ... Hz [1]

[Total: 9]

- 6 (a) Define the *ohm*.

.....[1]

- (b) A battery of electromotive force (e.m.f.) E and internal resistance 1.5Ω is connected to a network of resistors, as shown in Fig. 6.1.

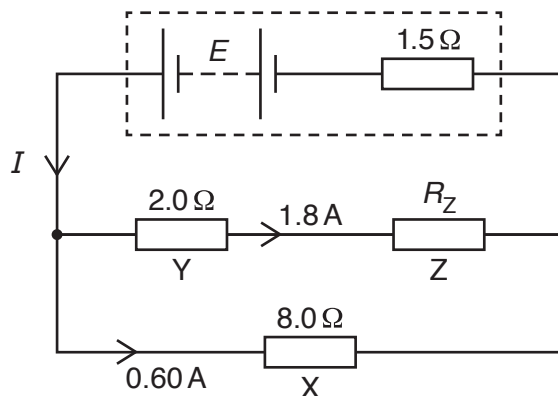


Fig. 6.1

Resistor X has a resistance of 8.0Ω . Resistor Y has a resistance of 2.0Ω . Resistor Z has a resistance of R_Z . The current in X is 0.60A and the current in Y is 1.8A .

- (i) Calculate:

1. the current I in the battery

$I = \dots\dots\dots \text{A}$ [1]

2. resistance R_Z

$R_Z = \dots\dots\dots \Omega$ [2]

3. e.m.f. E .

$E = \dots\dots\dots \text{V}$ [2]

- (ii) Resistors X and Y are each made of wire. The two wires have the same length and are made of the same metal.

Determine the ratio:

1.
$$\frac{\text{cross-sectional area of wire X}}{\text{cross-sectional area of wire Y}}$$

ratio = ... [2]

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

ratio = ... [2]

[Total: 10]

Please turn over for Question 7.

- 7 A sample of a radioactive substance may decay by the emission of either α -radiation or β -radiation and/or γ -radiation.

State the type of radiation, one in each case, that:

- (a) consists of leptons

.....[1]

- (b) contains quarks

.....[1]

- (c) cannot be deflected by an electric field

.....[1]

- (d) has a continuous range of energies, rather than discrete values of energy.

.....[1]

[Total: 4]

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