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9702/21

May/June 2010

1 hour

No Additional Materials are required.

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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO NOT WRITE IN ANY BARCODES.

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.

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Total	

This document consists of **17** printed pages and **3** 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,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
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 constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
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.,

$$v = v_0 \cos \omega t$$

$$v = \pm \omega \sqrt{(x_0^2 - x^2)}$$

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,

$$W = \frac{1}{2} QV$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \dots$$

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.

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- 1 A unit is often expressed with a prefix. For example, the gram may be written with the prefix 'kilo' as the kilogram. The prefix represents a power-of-ten. In this case, the power-of-ten is 10^3 .

Complete Fig. 1.1 to show each prefix with its symbol and power-of-ten.

prefix	symbol	power-of-ten
kilo	k	10^3
nano	n	
centi		10^{-2}
.....	M	10^6
.....	T	10^{12}

Fig. 1.1

[4]

- 2 (a) Complete Fig. 2.1 to show whether each of the quantities listed is a vector or a scalar.

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Use

	vector / scalar
distance moved	
speed	
acceleration	

Fig. 2.1

[3]

- (b) A ball falls vertically in air from rest. The variation with time t of the distance d moved by the ball is shown in Fig. 2.2.

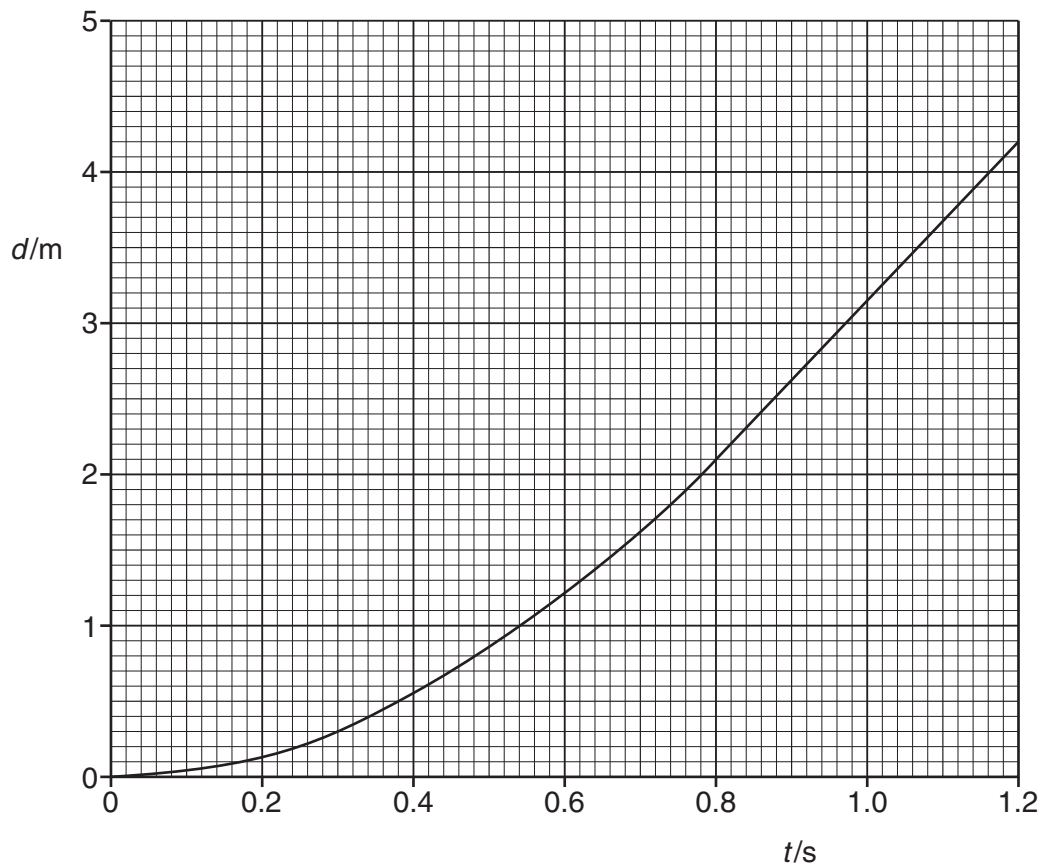


Fig. 2.2

(i) By reference to Fig. 2.2, explain how it can be deduced that

1. the ball is initially at rest,

.....

 [2]

2. air resistance is not negligible.

.....
 [1]

(ii) Use Fig. 2.2 to determine the speed of the ball at a time of 0.40 s after it has been released.

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

(iii) On Fig. 2.2, sketch a graph to show the variation with time t of the distance d moved by the ball for negligible air resistance. You are not expected to carry out any further calculations. [3]

- 3 (a) The variation with extension x of the tension F in a spring is shown in Fig. 3.1.

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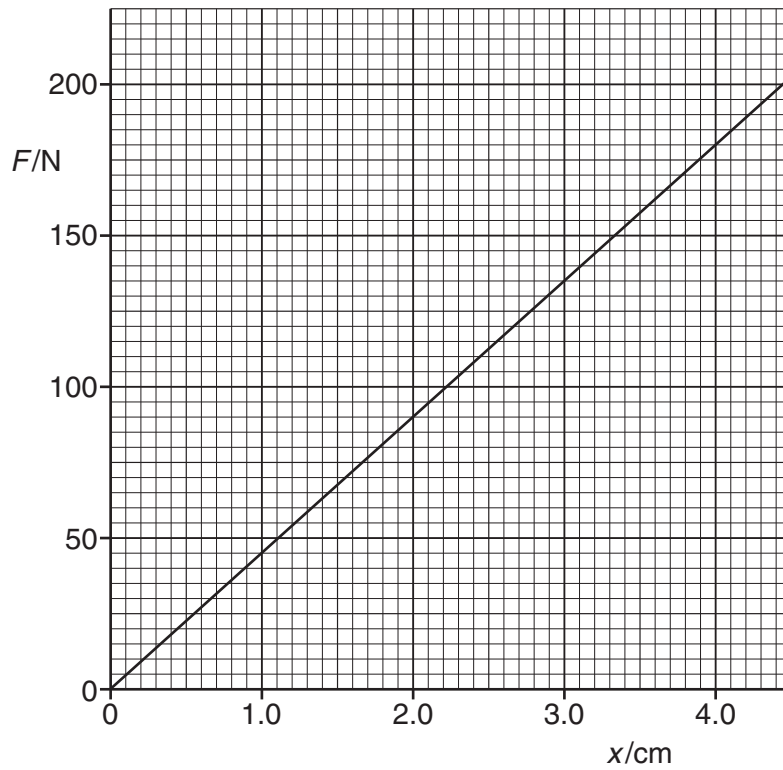


Fig. 3.1

Use Fig. 3.1 to calculate the energy stored in the spring for an extension of 4.0 cm.
Explain your working.

energy = ... J [3]

- (b) The spring in (a) is used to join together two frictionless trolleys A and B of mass M_1 and M_2 respectively, as shown in Fig. 3.2.

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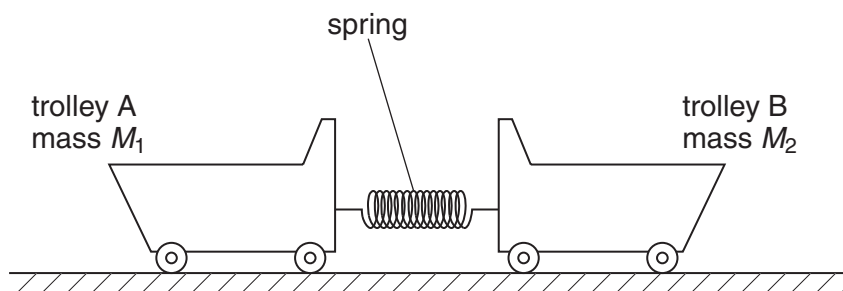


Fig. 3.2

The trolleys rest on a horizontal surface and are held apart so that the spring is extended.

The trolleys are then released.

- (i) Explain why, as the extension of the spring is reduced, the momentum of trolley A is equal in magnitude but opposite in direction to the momentum of trolley B.

.....

 [2]

- (ii) At the instant when the extension of the spring is zero, trolley A has speed V_1 and trolley B has speed V_2 .

Write down

1. an equation, based on momentum, to relate V_1 and V_2 ,

.....
 [1]

2. an equation to relate the initial energy E stored in the spring to the final energies of the trolleys.

.....
 [1]

- (iii) 1. Show that the kinetic energy E_k of an object of mass m is related to its momentum p by the expression

$$E_k = \frac{p^2}{2m}.$$

For
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Use

[1]

2. Trolley A has a larger mass than trolley B.
Use your answer in **(ii) part 1** to deduce which trolley, A or B, has the larger kinetic energy at the instant when the extension of the spring is zero.

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

- 4 (a) State what is meant by the *diffraction* of a wave.

.....

.....

.....[2]

- (b) A laser produces a narrow beam of coherent light of wavelength 632 nm. The beam is incident normally on a diffraction grating, as shown in Fig. 4.1.

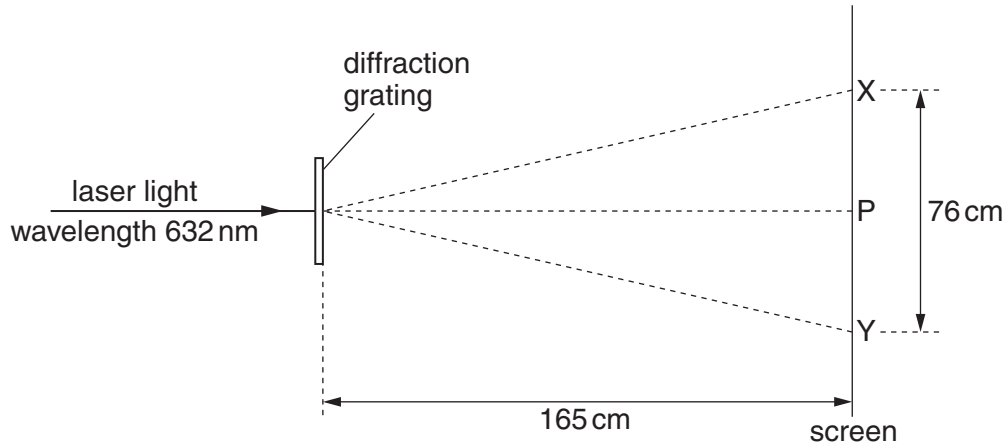


Fig. 4.1

Spots of light are observed on a screen placed parallel to the grating. The distance between the grating and the screen is 165 cm.

The brightest spot is P. The spots formed closest to P and on each side of P are X and Y.

X and Y are separated by a distance of 76 cm.

Calculate the number of lines per metre on the grating.

number per metre = ... [4]

- (c) The grating in (b) is now rotated about an axis parallel to the incident laser beam, as shown in Fig. 4.2.

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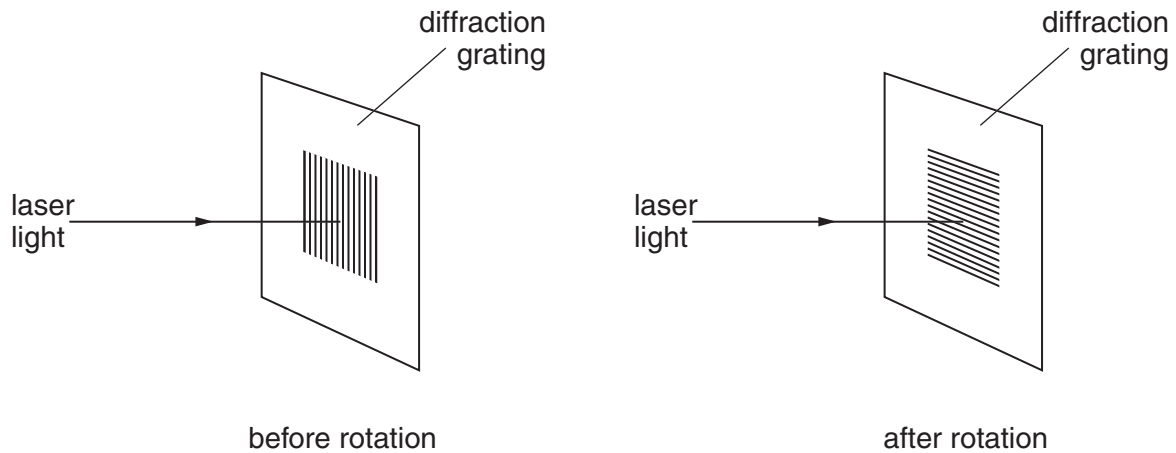


Fig. 4.2

State what effect, if any, this rotation will have on the positions of the spots P, X and Y.

.....

.....

.....

.....[2]

- (d) In another experiment using the apparatus in (b), a student notices that the distances XP and PY, as shown in Fig. 4.1, are not equal. Suggest a reason for this difference.

.....

.....[1]

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

For
Examiner's
Use

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

- (b) The electric field between an earthed metal plate and two charged metal spheres is illustrated in Fig. 5.1.

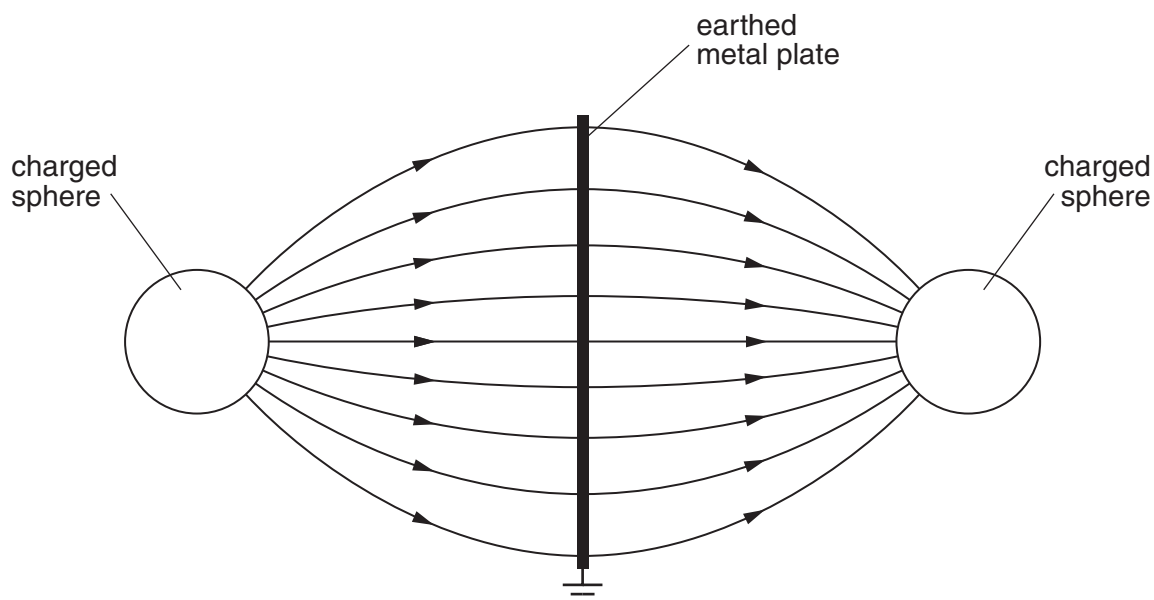


Fig. 5.1

- (i) On Fig. 5.1, label each sphere with (+) or (–) to show its charge. [1]
- (ii) On Fig. 5.1, mark a region where the magnitude of the electric field is
1. constant (label this region C), [1]
 2. decreasing (label this region D). [1]

- (c) A molecule has its centre P of positive charge situated a distance of $2.8 \times 10^{-10} \text{ m}$ from its centre N of negative charge, as illustrated in Fig. 5.2.

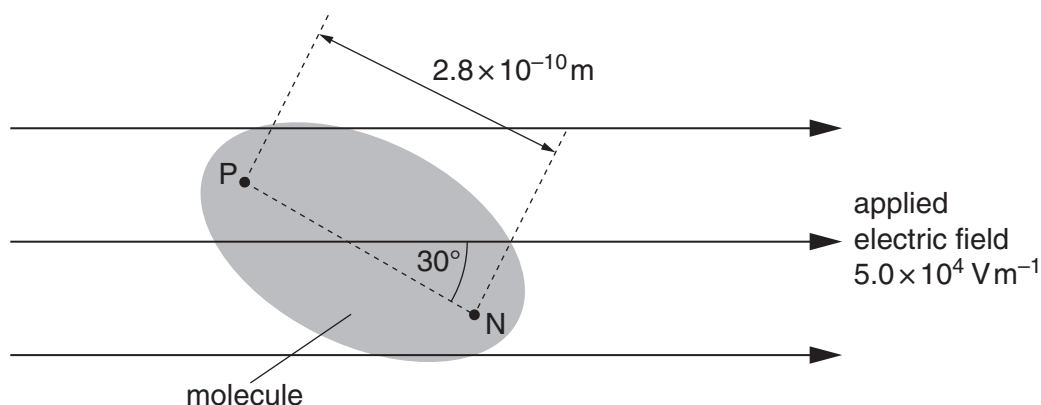


Fig. 5.2

The molecule is situated in a uniform electric field of field strength $5.0 \times 10^4 \text{ V m}^{-1}$. The axis NP of the molecule is at an angle of 30° to this uniform applied electric field. The magnitude of the charge at P and at N is $1.6 \times 10^{-19} \text{ C}$.

- (i) On Fig. 5.2, draw an arrow at P and an arrow at N to show the directions of the forces due to the applied electric field at each of these points. [1]
- (ii) Calculate the torque on the molecule produced by the forces in (i).

torque = ... N m [2]

- 6** An electric heater is to be made from nichrome wire. Nichrome has a resistivity of $1.0 \times 10^{-6} \Omega \text{ m}$ at the operating temperature of the heater. The heater is to have a power dissipation of 60W when the potential difference across its terminals is 12V.

(a) For the heater operating at its designed power,

(i) calculate the current,

current = ... A [2]

(ii) show that the resistance of the nichrome wire is 2.4Ω .

[2]

(b) Calculate the length of nichrome wire of diameter 0.80 mm required for the heater.

length = ... m [3]

- (c) A second heater, also designed to operate from a 12V supply, is constructed using the same nichrome wire but using half the length of that calculated in (b). Explain quantitatively the effect of this change in length of wire on the power of the heater.

For
Examiner's
Use

.....

.....

.....

.....[3]

7 One of the isotopes of uranium is uranium-238 ($^{238}_{92}\text{U}$).

(a) State what is meant by *isotopes*.

.....

.....

..... [2]

(b) For a nucleus of uranium-238, state

(i) the number of protons,

number = ... [1]

(ii) the number of neutrons.

number = ... [1]

(c) A uranium-238 nucleus has a radius of $8.9 \times 10^{-15} \text{ m}$.

Calculate, for a uranium-238 nucleus,

(i) its mass,

mass = ... kg [2]

(ii) its mean density.

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

- (d) The density of a lump of uranium is $1.9 \times 10^4 \text{ kg m}^{-3}$.
Using your answer to (c)(ii), suggest what can be inferred about the structure of the atom.

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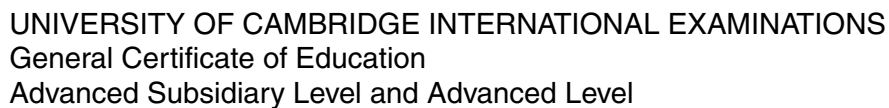
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decay constant,

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

For
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Use

1 A metal wire has a cross-section of diameter approximately 0.8 mm.

(a) State what instrument should be used to measure the diameter of the wire.

.....[1]

(b) State how the instrument in **(a)** is

(i) checked so as to avoid a systematic error in the measurements,

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

(ii) used so as to reduce random errors.

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

- 2 (a) The distance s moved by an object in time t may be given by the expression

$$s = \frac{1}{2}at^2$$

where a is the acceleration of the object.

State two conditions for this expression to apply to the motion of the object.

1.

.....

2.

.....

[2]

- (b) A student takes a photograph of a steel ball of radius 5.0 cm as it falls from rest. The image of the ball is blurred, as illustrated in Fig. 2.1.

The image is blurred because the ball is moving while the photograph is being taken.

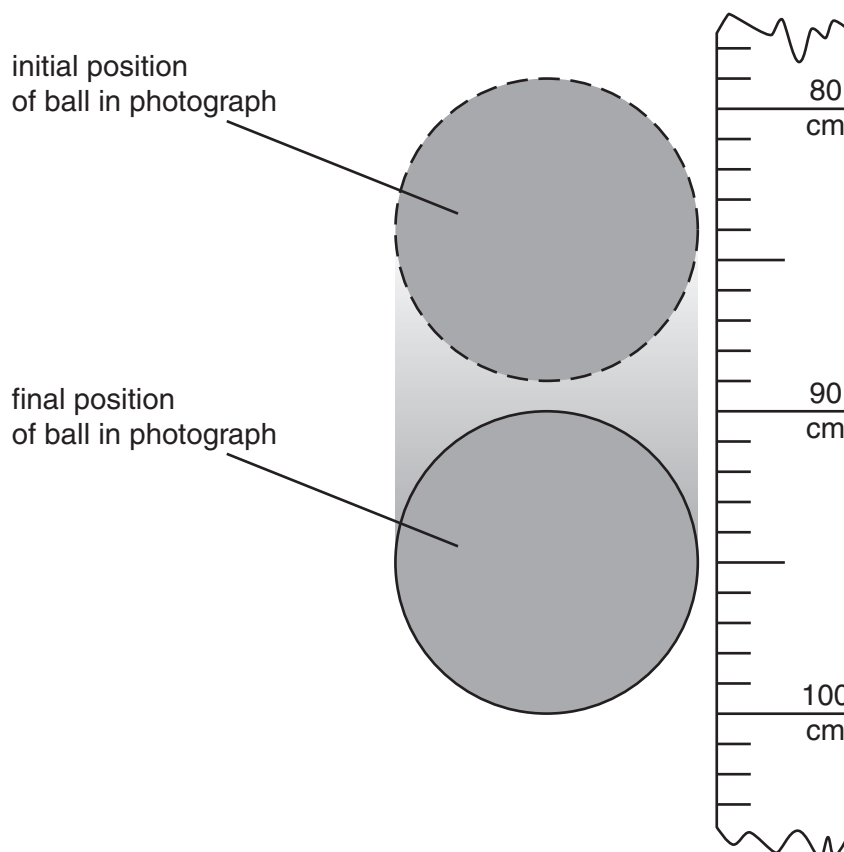


Fig. 2.1

The scale shows the distance fallen from rest by the ball. At time $t = 0$, the top of the ball is level with the zero mark on the scale. Air resistance is negligible.

Calculate, to an appropriate number of significant figures,

- (i) the time the ball falls before the photograph is taken,

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time = ... s [3]

- (ii) the time interval during which the photograph is taken.

time interval = ... s [3]

- (c) The student in (b) takes a second photograph starting at the same position on the scale. The ball has the same radius but is less dense, so that air resistance is not negligible.

State and explain the changes that will occur in the photograph.

.....

 [2]

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

.....
 [1]

- (ii) State Newton's third law of motion.

.....

 [3]

- (b) Two spheres approach one another along a line joining their centres, as illustrated in Fig. 3.1.

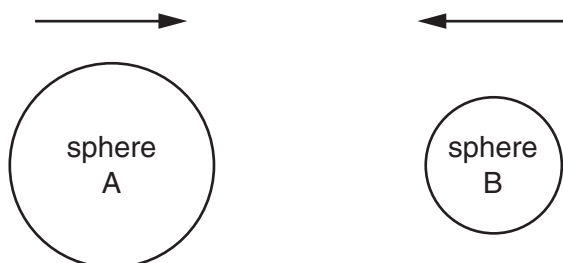


Fig. 3.1

When they collide, the average force acting on sphere A is F_A and the average force acting on sphere B is F_B .

The forces act for time t_A on sphere A and time t_B on sphere B.

- (i) State the relationship between

1. F_A and F_B ,

..... [1]

2. t_A and t_B .

..... [1]

- (ii) Use your answers in (i) to show that the change in momentum of sphere A is equal in magnitude and opposite in direction to the change in momentum of sphere B.

.....
 [1]

- (c) For the spheres in (b), the variation with time of the momentum of sphere A before, during and after the collision with sphere B is shown in Fig. 3.2.

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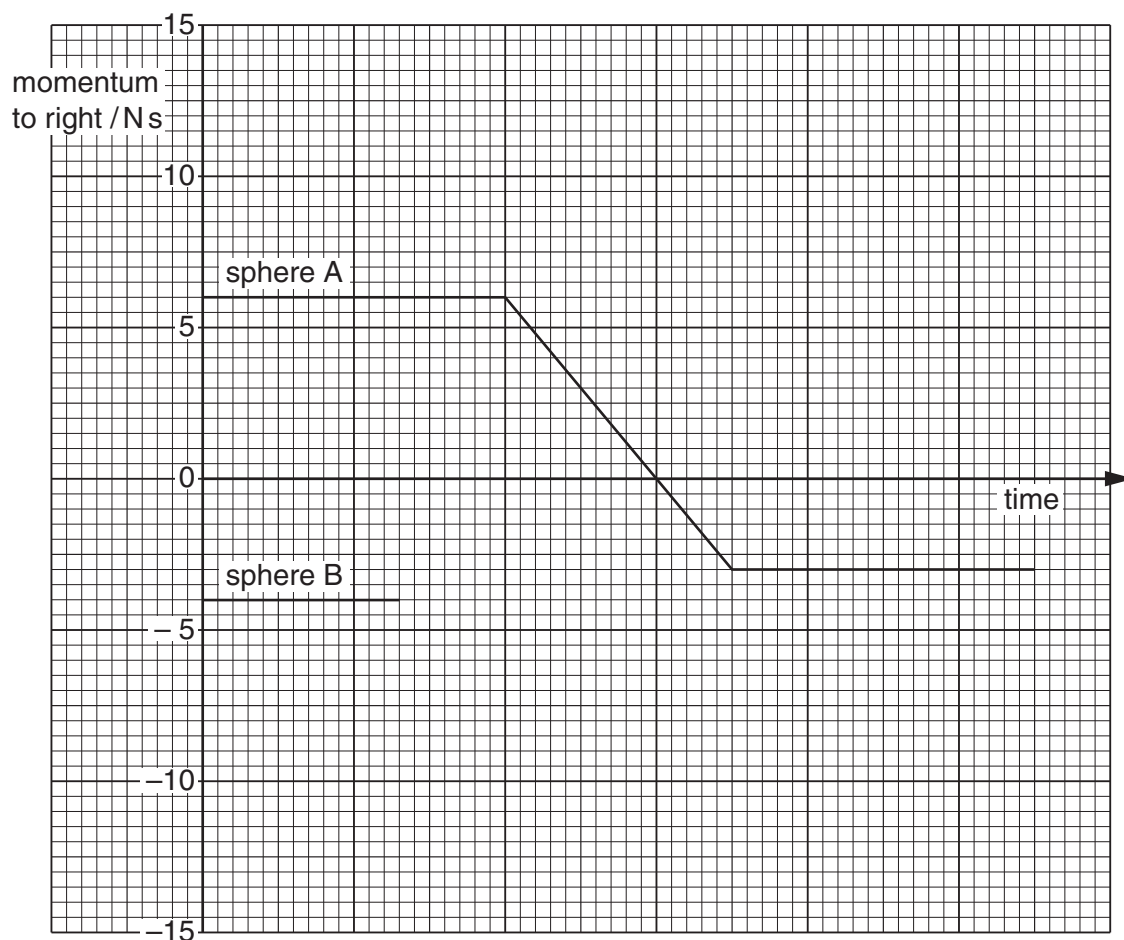


Fig. 3.2

The momentum of sphere B before the collision is also shown on Fig. 3.2.

Complete Fig. 3.2 to show the variation with time of the momentum of sphere B during and after the collision with sphere A. [3]

- 4 (a) State two features of a stationary wave that distinguish it from a progressive wave.

1.

.....

2.

.....

[2]

- (b) A long tube is open at one end. It is closed at the other end by means of a piston that can be moved along the tube, as shown in Fig. 4.1.

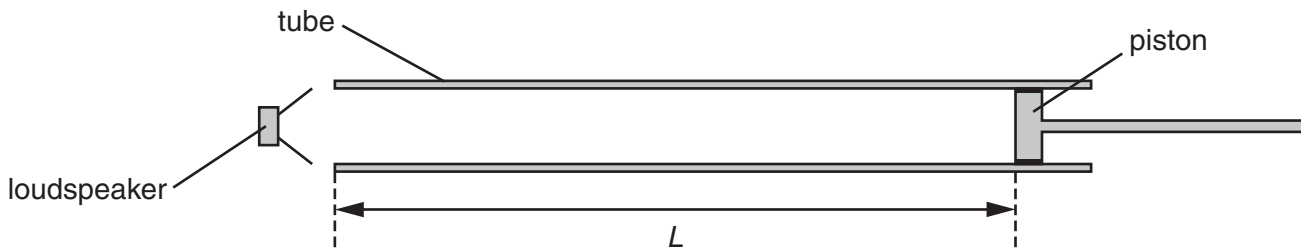


Fig. 4.1

A loudspeaker producing sound of frequency 550 Hz is held near the open end of the tube.

The piston is moved along the tube and a loud sound is heard when the distance L between the piston and the open end of the tube is 45 cm.

The speed of sound in the tube is 330 m s^{-1} .

- (i) Show that the wavelength of the sound in the tube is 60 cm.

[1]

- (ii) On Fig. 4.1, mark all the positions along the tube of

1. the displacement nodes (label these with the letter N),
2. the displacement antinodes (label these with the letter A).

[3]

- (c) The frequency of the sound produced by the loudspeaker in (b) is gradually reduced.

Determine the lowest frequency at which a loud sound will be produced in the tube of length $L = 45\text{ cm}$.

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frequency = ... Hz [3]

- 5 (a) Tensile forces are applied to opposite ends of a copper rod so that the rod is stretched. The variation with stress of the strain of the rod is shown in Fig. 5.1.

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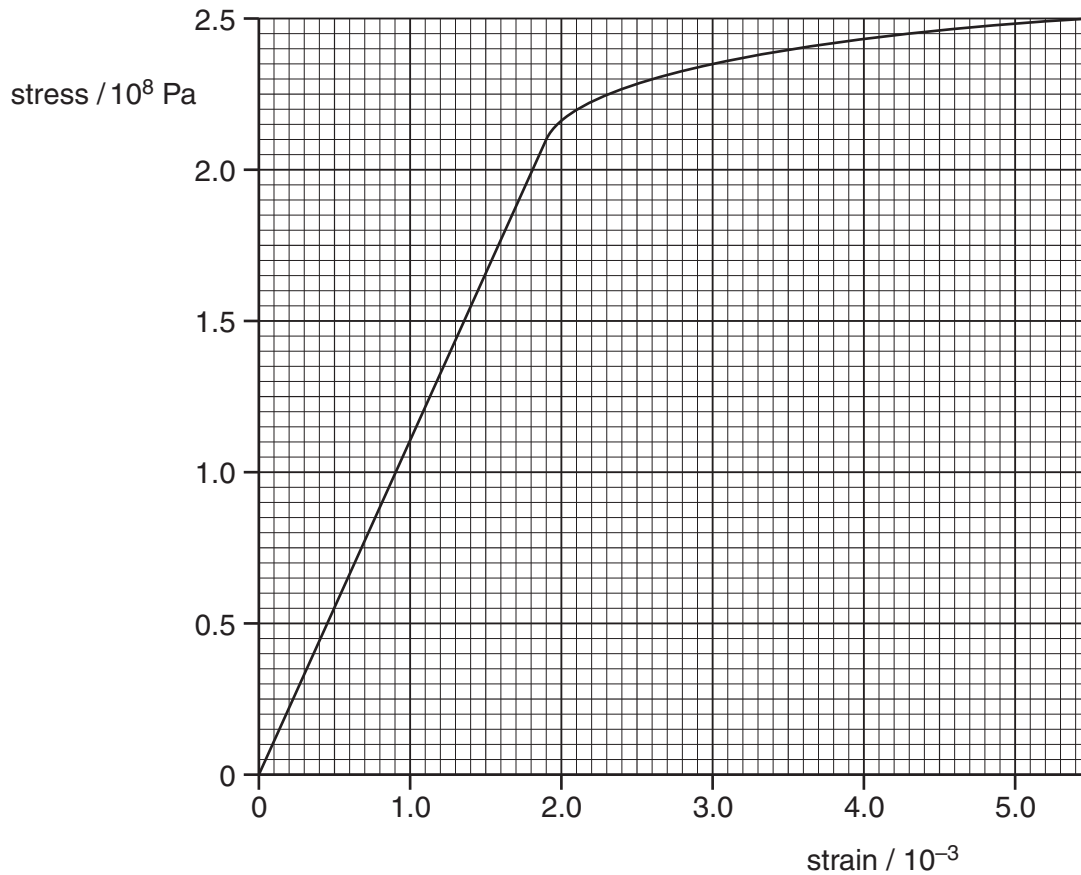


Fig. 5.1

- (i) Use Fig. 5.1 to determine the Young modulus of copper.

Young modulus = ... Pa [3]

- (ii) On Fig. 5.1, sketch a line to show the variation with stress of the strain of the rod as the stress is reduced from 2.5×10^6 Pa to zero. No further calculations are expected. [1]

- (b) The walls of the tyres on a car are made of a rubber compound. The variation with stress of the strain of a specimen of this rubber compound is shown in Fig. 5.2.

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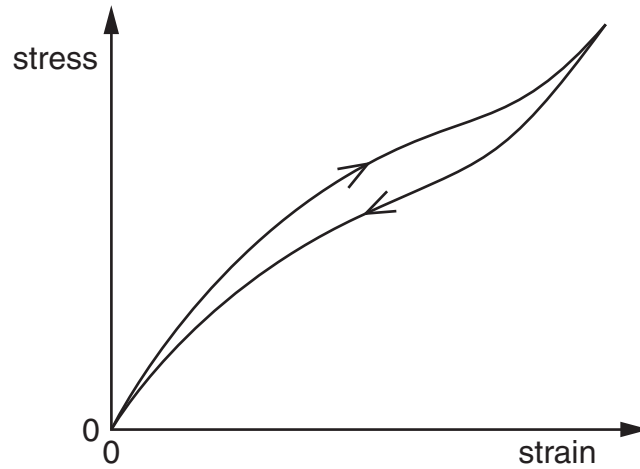


Fig. 5.2

As the car moves, the walls of the tyres bend and straighten continuously.

Use Fig. 5.2 to explain why the walls of the tyres become warm.

.....

.....

.....

.....[3]

- 6 (a) A metal wire of constant resistance is used in an electric heater. In order not to overload the circuit for the heater, the supply voltage to the heater is reduced from 230V to 220V.

Determine the percentage reduction in the power output of the heater.

reduction = ... % [2]

- (b) A uniform wire AB of length 100cm is connected between the terminals of a cell of e.m.f. 1.5V and negligible internal resistance, as shown in Fig. 6.1.

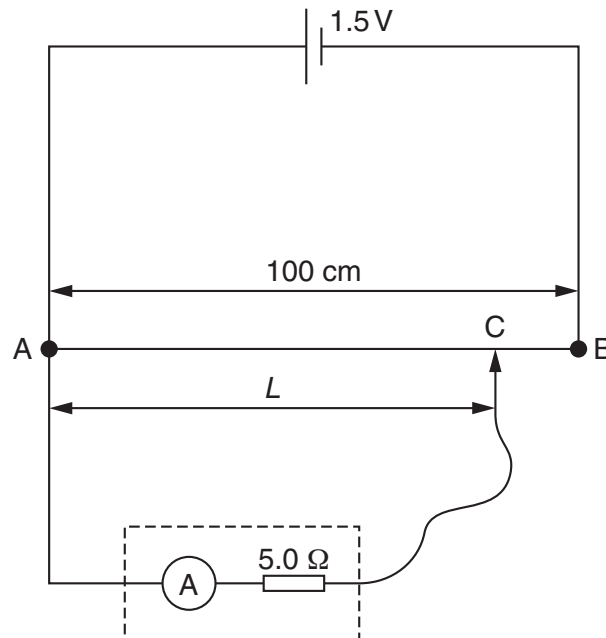


Fig. 6.1

An ammeter of internal resistance 5.0Ω is connected to end A of the wire and to a contact C that can be moved along the wire.

Determine the reading on the ammeter for the contact C placed

- (i) at A,

reading = ... A [1]

(ii) at B.

reading = ... A [1]

- (c) Using the circuit in (b), the ammeter reading I is recorded for different distances L of the contact C from end A of the wire. Some data points are shown on Fig. 6.2.

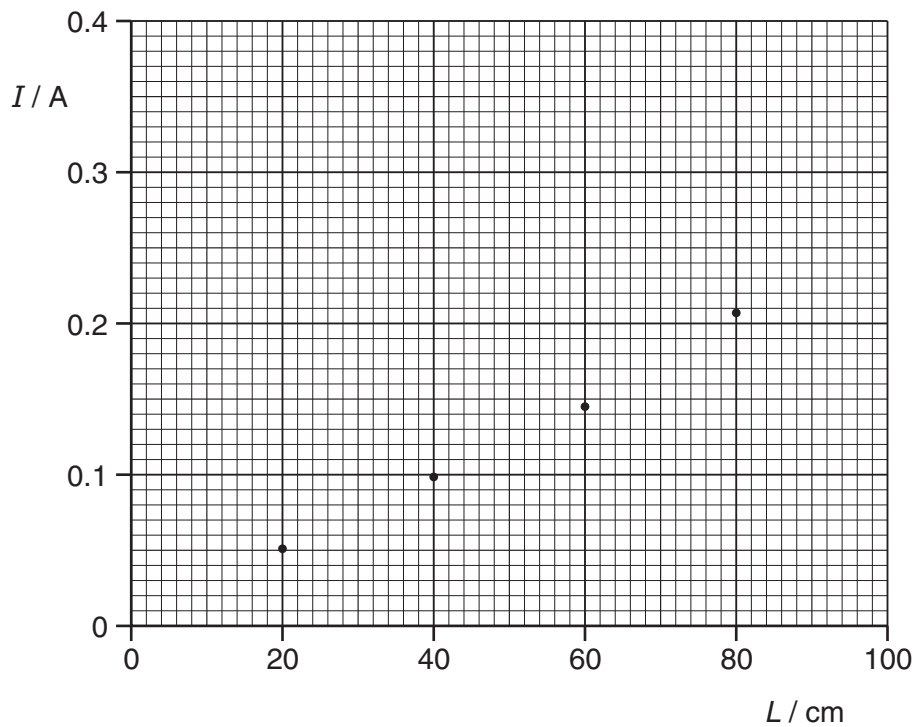


Fig. 6.2

- (i) Use your answers in (b) to plot data points on Fig. 6.2 corresponding to the contact C placed at end A and at end B of the wire. [1]
- (ii) Draw a line of best fit for all of the data points and hence determine the ammeter reading for contact C placed at the midpoint of the wire.

reading = ... A [1]

- (iii) Use your answer in (ii) to calculate the potential difference between A and the contact C for the contact placed at the midpoint of AB.

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potential difference = ... V [2]

- (d) Explain why, although the contact C is at the midpoint of wire AB, the answer in (c)(iii) is **not** numerically equal to one half of the e.m.f. of the cell.

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

- 7 (a) The radioactive decay of some nuclei gives rise to the emission of α -particles.
State

- (i) what is meant by an α -particle,

.....[1]

- (ii) two properties of α -particles.

1.

.....

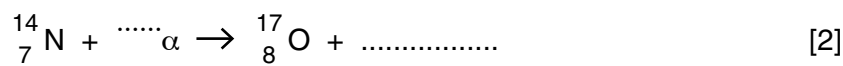
2.

.....

[2]

- (b) One possible nuclear reaction involves the bombardment of a stationary nitrogen-14 nucleus by an α -particle to form oxygen-17 and another particle.

- (i) Complete the nuclear equation for this reaction.



- (ii) The total mass-energy of the nitrogen-14 nucleus and the α -particle is less than that of the particles resulting from the reaction. This mass-energy difference is 1.1 MeV.

1. Suggest how it is possible for mass-energy to be conserved in this reaction.

.....

.....[1]

2. Calculate the speed of an α -particle having kinetic energy of 1.1 MeV.

speed = ... m s^{-1} [4]

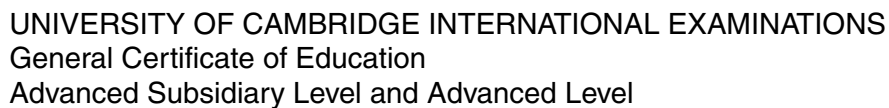
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Total	

This document consists of **17** printed pages and **3** 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,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
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 constant,	$u = 1.66 \times 10^{-27} \text{ kg}$
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.,	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
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,	$W = \frac{1}{2} QV$
resistors in series,	$R = R_1 + R_2 + \dots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \dots$
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.

For
Examiner's
Use

- 1** A digital voltmeter with a three-digit display is used to measure the potential difference across a resistor. The manufacturers of the meter state that its accuracy is $\pm 1\%$ and ± 1 digit. The reading on the voltmeter is 2.05 V.

(a) For this reading, calculate, to the nearest digit,

(i) a change of 1% in the voltmeter reading,

change = ... V [1]

(ii) the maximum possible value of the potential difference across the resistor.

maximum value = ... V [1]

(b) The reading on the voltmeter has high precision. State and explain why the reading may not be accurate.

.....

.....

.....[2]

- 2 (a) State the two conditions that must be satisfied for a body to be in equilibrium.

1.

.....

2.

.....

[2]

- (b) Three co-planar forces act on a body that is in equilibrium.

- (i) Describe how to draw a vector triangle to represent these forces.

.....

.....

.....

.....

.....

.....

..... [3]

- (ii) State how the triangle confirms that the forces are in equilibrium.

.....

..... [1]

- (c) A weight of 7.0 N hangs vertically by two strings AB and AC, as shown in Fig. 2.1.

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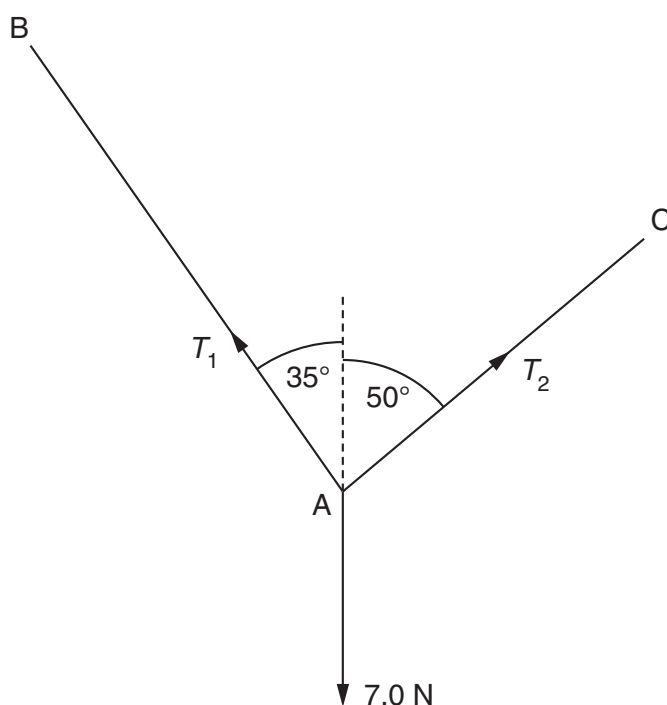


Fig. 2.1

For the weight to be in equilibrium, the tension in string AB is T_1 and in string AC it is T_2 .

On Fig. 2.1, draw a vector triangle to determine the magnitudes of T_1 and T_2 .

$$T_1 = \dots\dots\dots \text{ N}$$

$$T_2 = \dots\dots\dots \text{ N}$$

[3]

- (d) By reference to Fig. 2.1, suggest why the weight could not be supported with the strings AB and AC both horizontal.

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

- 3 A cyclist is moving up a slope that has a constant gradient. The cyclist takes 8.0 s to climb the slope.

The variation with time t of the speed v of the cyclist is shown in Fig. 3.1.

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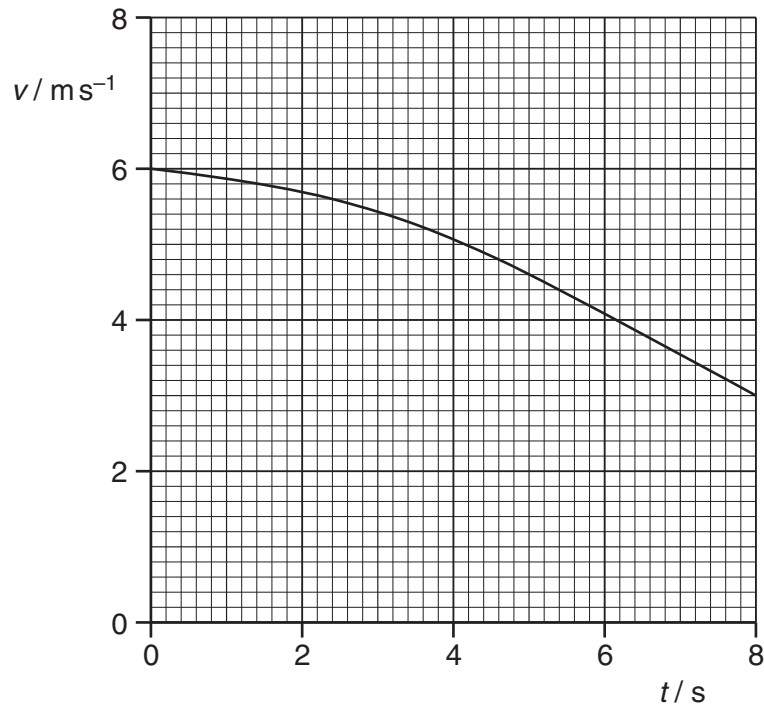


Fig. 3.1

- (a) Use Fig. 3.1 to determine the total distance moved up the slope.

distance = ... m [3]

- (b) The bicycle and cyclist have a combined mass of 92 kg.
The vertical height through which the cyclist moves is 1.3 m.

- (i) For the movement of the bicycle and cyclist between $t = 0$ and $t = 8.0$ s,

1. use Fig. 3.1 to calculate the change in kinetic energy,

change = ... J [2]

2. calculate the change in gravitational potential energy.

change = ... J [2]

- (ii) The cyclist pedals continuously so that the useful power delivered to the bicycle is 75 W.
Calculate the useful work done by the cyclist climbing up the slope.

work done = ... J [2]

(c) Some energy is used in overcoming frictional forces.

- (i) Use your answers in (b) to show that the total energy converted in overcoming frictional forces is approximately 670 J.

For
Examiner's
Use

[1]

- (ii) Determine the average magnitude of the frictional forces.

average force = ...N [1]

- (d) Suggest why the magnitude of the total resistive force would not be constant.

.....

[2]

4 (a) State the evidence for the assumption that

(i) there are significant forces of attraction between molecules in the solid state,

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

(ii) the forces of attraction between molecules in a gas are negligible.

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

(b) Explain, on the basis of the kinetic model of gases, the pressure exerted by a gas.

.....
.....
.....
.....
.....[4]

(c) Liquid nitrogen has a density of 810 kg m^{-3} . The density of nitrogen gas at room temperature and pressure is approximately 1.2 kg m^{-3} .
Suggest how these densities relate to the spacing of nitrogen molecules in the liquid and in the gaseous states.

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

- 5 (a) A source of sound has frequency f . Sound of wavelength λ is produced by the source.

(i) State

1. what is meant by the *frequency* of the source,

.....
[1]

2. the distance moved, in terms of λ , by a wavefront during n oscillations of the source.

distance = ...[1]

- (ii) Use your answers in (i) to deduce an expression for the speed v of the wave in terms of f and λ .

[2]

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

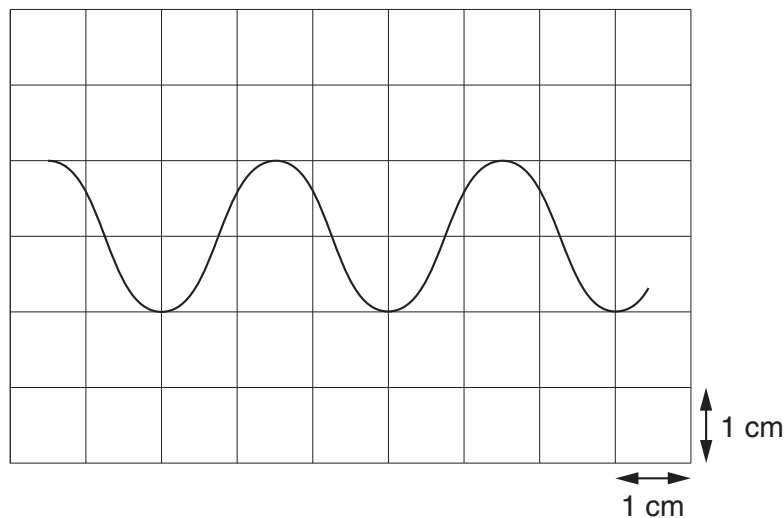


Fig. 5.1

The time-base setting of the c.r.o. is 2.0 ms cm^{-1} .

For
Examiner's
Use

- (i) Determine the frequency of the sound wave.

frequency = ...Hz [2]

- (ii) A second sound wave has the same frequency as that calculated in (i). The amplitude of the two waves is the same but the phase difference between them is 90° .

On Fig. 5.1, draw the waveform of this second wave. [1]

- 6 (a) (i) State what is meant by an *electric current*.

For
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Use

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

- (ii) Define *electric potential difference*.

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

- (b) The variation with potential difference V of the current I in a component Y and in a resistor R are shown in Fig. 6.1.

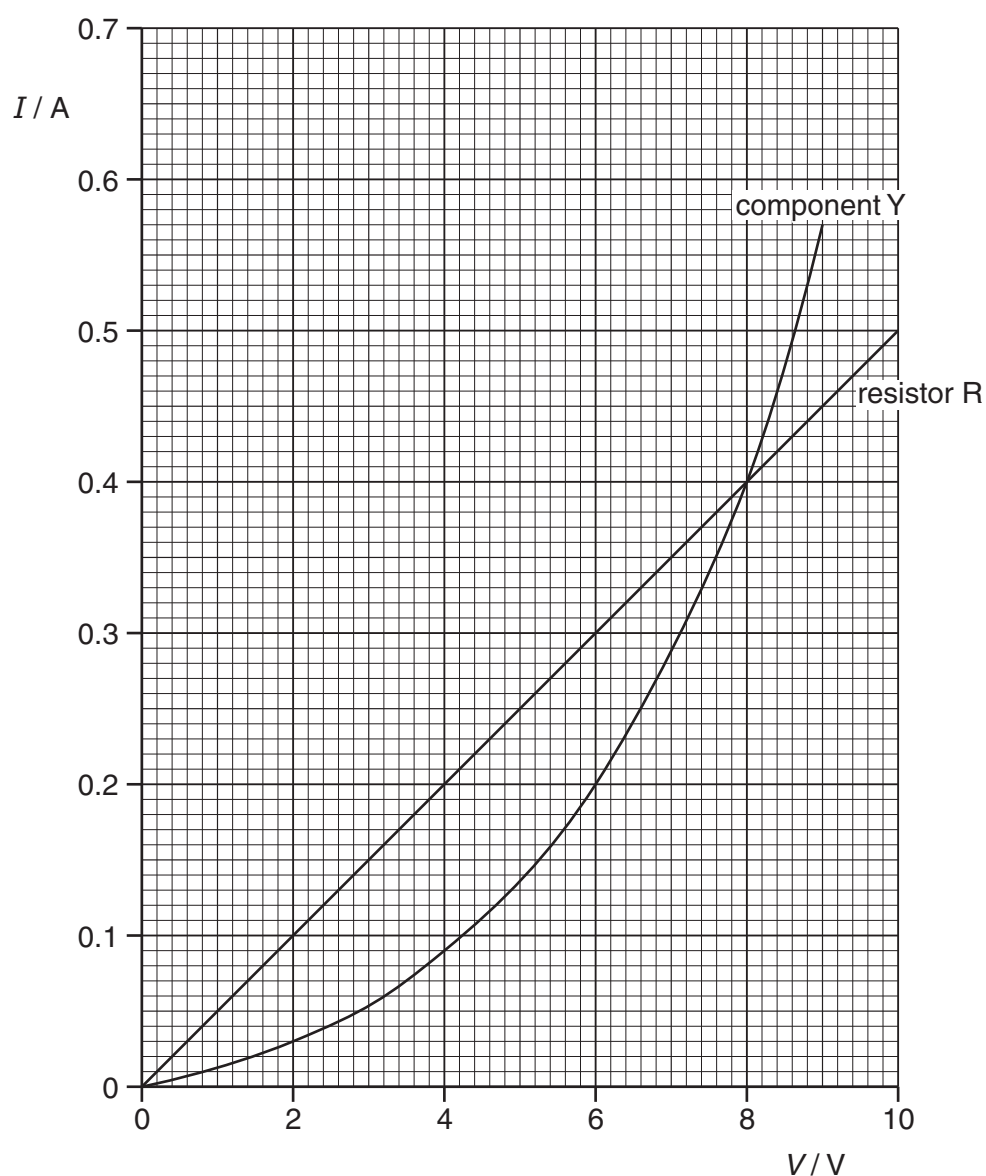


Fig. 6.1

Use Fig. 6.1 to explain how it can be deduced that resistor R has a constant resistance of $20\ \Omega$.

For
Examiner's
Use

.....

[2]

- (c) The component Y and the resistor R in (b) are connected in parallel as shown in Fig. 6.2.

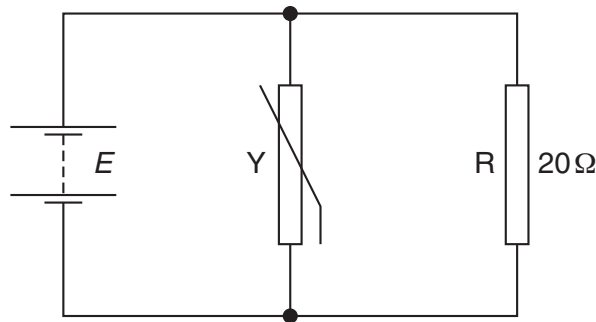


Fig. 6.2

A battery of e.m.f. E and negligible internal resistance is connected across the parallel combination.

Use data from Fig. 6.1 to determine

- (i) the current in the battery for an e.m.f. E of 6.0V ,

current = ...A [1]

- (ii) the total resistance of the circuit for an e.m.f. of 8.0V .

resistance = ... Ω [2]

(d) The circuit of Fig. 6.2 is now re-arranged as shown in Fig. 6.3.

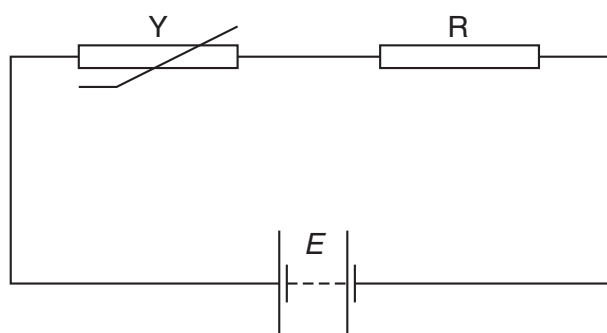


Fig. 6.3

The current in the circuit is 0.20 A.

(i) Use Fig. 6.1 to determine the e.m.f. E of the battery.

$E = \dots\dots\dots$ V [1]

(ii) Calculate the total power dissipated in component Y and resistor R .

power = $\dots\dots\dots$ W [2]

- 7 One property of α -particles is that they produce a high density of ionisation of air at atmospheric pressure. In this ionisation process, a neutral atom becomes an ion pair. The ion pair is a positively-charged particle and an electron.

(a) State

- (i) what is meant by an α -particle,

.....
[1]

- (ii) an approximate value for the range of α -particles in air at atmospheric pressure.

range = ... cm [1]

- (b) The energy required to produce an ion pair in air at atmospheric pressure is 31 eV.
 An α -particle has an initial kinetic energy of 8.5×10^{-13} J.

- (i) Show that 8.5×10^{-13} J is equivalent to 5.3 MeV.

[1]

- (ii) Calculate, to two significant figures, the number of ion pairs produced as the α -particle is stopped in air at atmospheric pressure.

number = ...[2]

- (iii) Using your answer in (a)(ii), estimate the average number of ion pairs produced per unit length of the track of the α -particle as it is brought to rest in air.

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number per unit length = ...[2]

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