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PHYSICS

9702/21

Paper 2 AS Level Structured Questions

October/November 2017

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Write in dark blue or black pen.

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

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

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

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

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

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

This document consists of **16** printed pages.

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) The drag force F_D acting on a sphere moving through a fluid is given by the expression

$$F_D = K\rho v^2$$

where K is a constant,
 ρ is the density of the fluid
 and v is the speed of the sphere.

Determine the SI base units of K .

base units [3]

- (b) A ball of weight 1.5 N falls vertically from rest in air. The drag force F_D acting on the ball is given by the expression in (a). The ball reaches a constant (terminal) speed of 33 m s^{-1} .

Assume that the upthrust acting on the ball is negligible and that the density of the air is uniform.

For the instant when the ball is travelling at a speed of 25 m s^{-1} , determine

- (i) the drag force F_D on the ball,

$$F_D = \dots\dots\dots \text{ N [2]}$$

- (ii) the acceleration of the ball.

$$\text{acceleration} = \dots\dots\dots \text{ m s}^{-2} [2]$$

- (c) Describe the acceleration of the ball in (b) as its speed changes from zero to 33 ms^{-1} .

.....

.....

.....

.....[3]

[Total: 10]

- 2 The variation with time t of the velocity v of two cars P and Q is shown in Fig. 2.1.

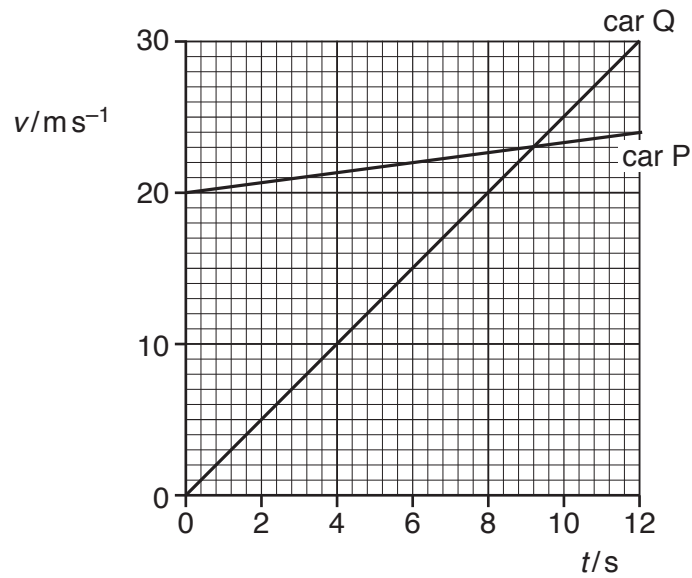


Fig. 2.1

The cars travel in the same direction along a straight road.
Car P passes car Q at time $t = 0$.

- (a) The speed limit for cars on the road is 100 km h^{-1} . State and explain whether car Q exceeds the speed limit.

.....[1]

- (b) Calculate the acceleration of car P.

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

- (c) Determine the distance between the two cars at time $t = 12\text{ s}$.

distance = ... m [3]

- (d) From time $t = 12\text{ s}$, the velocity of each car remains constant at its value at $t = 12\text{ s}$.

Determine the time t at which car Q passes car P.

$t =$ s [2]

[Total: 8]

3 (a) State the difference between a stationary wave and a progressive wave in terms of

(i) the energy transfer along the wave,

.....
[1]

(ii) the phase of two adjacent vibrating particles.

.....
[1]

(b) A tube is open at both ends. A loudspeaker, emitting sound of a single frequency, is placed near one end of the tube, as shown in Fig. 3.1.

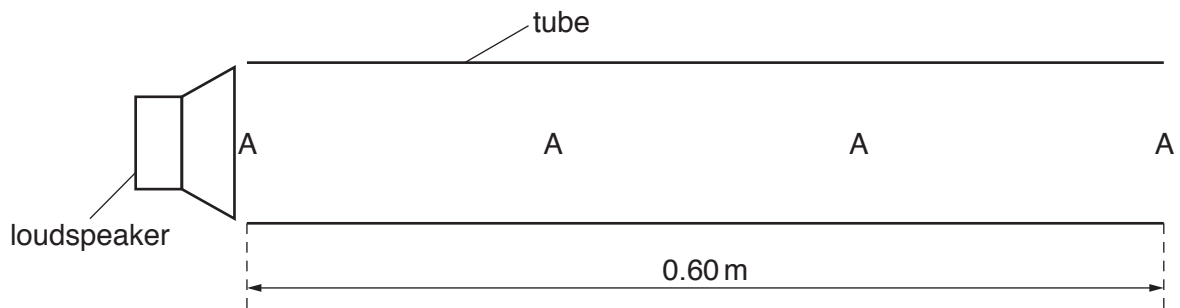


Fig. 3.1

The speed of the sound in the tube is 340 m s^{-1} . The length of the tube is 0.60 m. A stationary wave is formed with an antinode A at each end of the tube and two antinodes inside the tube.

(i) State what is meant by an *antinode* of the stationary wave.

.....
[1]

(ii) State the distance between a node and an adjacent antinode.

distance = ... m [1]

(iii) Determine, for the sound in the tube,

1. the wavelength,

wavelength = ... m [1]

2. the frequency.

frequency = ... Hz [2]

- (iv) Determine the minimum frequency of the sound from the loudspeaker that produces a stationary wave in the tube.

minimum frequency = ... Hz [2]

[Total: 9]

4 (a) Define *strain*.

.....
[1]

(b) A wire is designed to ensure that its strain does not exceed 4.0×10^{-4} when a force of 8.0 kN is applied. The Young modulus of the metal of the wire is 2.1×10^{11} Pa. It may be assumed that the wire obeys Hooke's law.

For a force of 8.0 kN, calculate, for the wire,

(i) the maximum stress,

maximum stress = ... Pa [2]

(ii) the minimum cross-sectional area.

minimum cross-sectional area = ... m^2 [2]

[Total: 5]

- 5 Three cells of electromotive forces (e.m.f.) E_1 , E_2 and E_3 are connected into a circuit, as shown in Fig. 5.1.

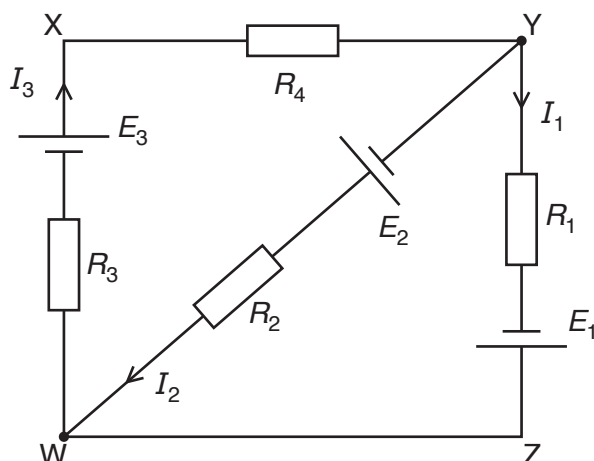


Fig. 5.1

The circuit contains resistors of resistances R_1 , R_2 , R_3 and R_4 . The currents in the different parts of the circuit are I_1 , I_2 and I_3 . The cells have negligible internal resistance.

Use Kirchhoff's laws to state an equation relating

- (a) I_1 , I_2 and I_3 ,

.....[1]

- (b) E_1 , E_3 , R_1 , R_3 , R_4 , I_1 and I_3 in loop WXYZW,

.....
[1]

- (c) E_1 , E_2 , R_1 , R_2 , I_1 and I_2 in loop YZWY.

.....
[1]

[Total: 3]

- 6 (a) Define *electric field strength*.

.....
 [1]

- (b) Two parallel metal plates in a vacuum are separated by a distance of 15 mm, as shown in Fig. 6.1.

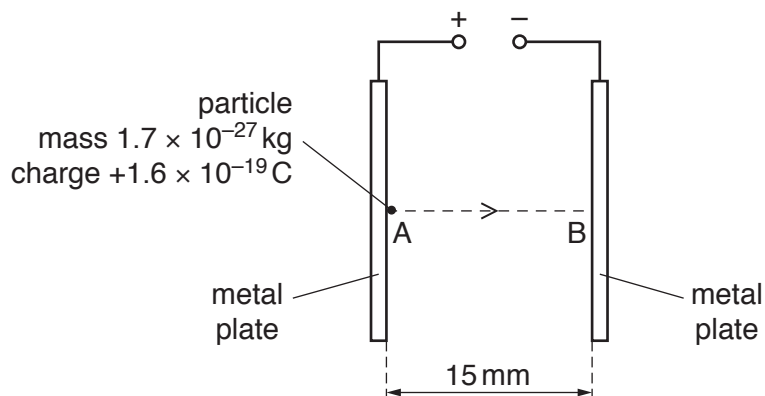


Fig. 6.1

A uniform electric field is produced between the plates by applying a potential difference between them.

A particle of mass $1.7 \times 10^{-27} \text{ kg}$ and charge $+1.6 \times 10^{-19} \text{ C}$ is initially at rest at point A on one plate. The particle is moved by the electric field to point B on the other plate. The particle reaches point B with kinetic energy $2.4 \times 10^{-16} \text{ J}$.

- (i) Calculate the speed of the particle at point B.

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

- (ii) State the work done by the electric field to move the particle from A to B.

work done = ... J [1]

- (iii) Use your answer in (ii) to determine the force on the particle.

force = ... N [2]

- (iv) Determine the potential difference between the plates.

potential difference = ... V [3]

- (v) On Fig. 6.2, sketch a graph to show the variation of the kinetic energy of the particle with the distance x from point A along the line AB.
Numerical values for the kinetic energy are not required.

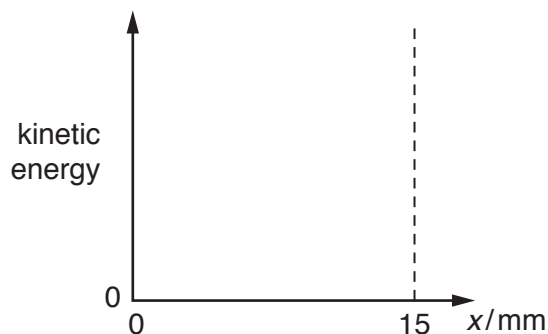


Fig. 6.2

[1]

[Total: 10]

- 7 (a) Define the *ohm*.

.....[1]

- (b) Wires are used to connect a battery of negligible internal resistance to a lamp, as shown in Fig. 7.1.

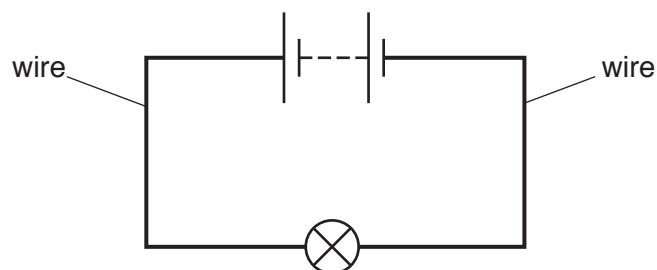


Fig. 7.1

The lamp is at its normal operating temperature. Some data for the filament wire of the lamp and for the connecting wires of the circuit are shown in Fig. 7.2.

	filament wire	connecting wires
diameter	d	$14d$
total length	L	$7.0L$
resistivity of metal (at normal operating temperature)	ρ	0.028ρ

Fig. 7.2

- (i) Show that

$$\frac{\text{resistance of filament wire}}{\text{total resistance of connecting wires}} = 1000.$$

[2]

- (ii) Use the information in (i) to explain qualitatively why the power dissipated in the filament wire of the lamp is greater than the total power dissipated in the connecting wires.

.....

[1]

- (iii) The lamp is rated as 12V, 6.0W. Use the information in (i) to determine the total resistance of the connecting wires.

total resistance of connecting wires = ... Ω [3]

- (iv) The diameter of the connecting wires is decreased. The total length of the connecting wires and the resistivity of the metal of the connecting wires remain the same.

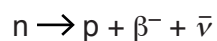
State and explain the change, if any, that occurs to the resistance of the filament wire of the lamp.

.....

[3]

[Total: 10]

- 8 A neutron within a nucleus decays to produce a proton, a β^- particle and an (electron) antineutrino.



- (a) Use the quark composition of the neutron to show that the neutron has no charge.

[3]

- (b) Complete Fig. 8.1 by giving appropriate values of the charge and the mass of the proton, the β^- particle and the (electron) antineutrino.

	proton	β^- particle	antineutrino
charge			
mass			

Fig. 8.1

[2]

[Total: 5]

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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** One end of a wire is connected to a fixed point. A load is attached to the other end so that the wire hangs vertically.

The diameter d of the wire and the load F are measured as

$$d = 0.40 \pm 0.02 \text{ mm},$$

$$F = 25.0 \pm 0.5 \text{ N}.$$

- (a)** For the measurement of the diameter of the wire, state

- (i)** the name of a suitable measuring instrument,

.....[1]

- (ii)** how random errors may be reduced when using the instrument in **(i)**.

.....

.....

.....[2]

- (b)** The stress σ in the wire is calculated by using the expression

$$\sigma = \frac{4F}{\pi d^2}.$$

- (i)** Show that the value of σ is $1.99 \times 10^8 \text{ N m}^{-2}$.

[1]

- (ii)** Determine the percentage uncertainty in σ .

percentage uncertainty = ...% [2]

- (iii) Use the information in **(b)(i)** and your answer in **(b)(ii)** to determine the value of σ , with its absolute uncertainty, to an appropriate number of significant figures.

$$\sigma = \dots\dots\dots \pm \dots\dots\dots \text{Nm}^{-2} \text{ [2]}$$

[Total: 8]

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- 2 (a) Define the *moment* of a force.

.....
[1]

- (b) A thin disc of radius r is supported at its centre O by a pin. The disc is supported so that it is vertical. Three forces act in the plane of the disc, as shown in Fig. 2.1.

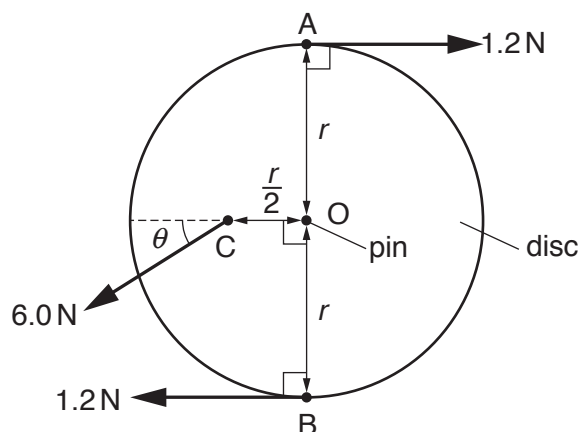


Fig. 2.1

Two horizontal and opposite forces, each of magnitude 1.2 N, act at points A and B on the edge of the disc. A force of 6.0 N, at an angle θ below the horizontal, acts on the midpoint C of a radial line of the disc, as shown in Fig. 2.1. The disc has negligible weight and is in equilibrium.

- (i) State an expression, in terms of r , for the torque of the couple due to the forces at A and B acting on the disc.

.....[1]

- (ii) Friction between the disc and the pin is negligible.
 Determine the angle θ .

$$\theta = \text{.....}^\circ [2]$$

- (iii) State the magnitude of the force of the pin on the disc.

$$\text{force} = \text{.....} \text{ N } [1]$$

[Total: 5]

- 3 A spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially held so that the spring has zero extension, as shown in Fig. 3.1.

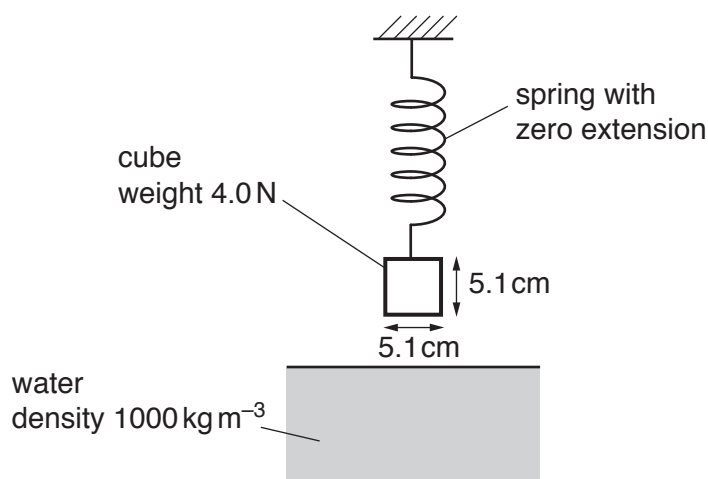


Fig. 3.1

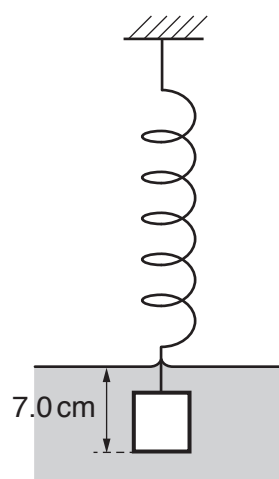


Fig. 3.2

The cube has weight 4.0 N and sides of length 5.1 cm. The cube is released and sinks into water as the spring extends. The cube reaches equilibrium with its base at a depth of 7.0 cm below the water surface, as shown in Fig. 3.2. The density of the water is 1000 kg m⁻³.

- (a) Calculate the difference in the pressure exerted by the water on the bottom face and on the top face of the cube.

difference in pressure = ... Pa [2]

- (b) Use your answer in (a) to show that the upthrust on the cube is 1.3 N.

[2]

- (c) Calculate the force exerted on the spring by the cube when it is in equilibrium in the water.

force = ... N [1]

- (d) The spring obeys Hooke's law and has a spring constant of 30 N m^{-1} .

Determine the initial height above the water surface of the base of the cube before it was released.

height above surface = ... cm [3]

- (e) The cube in the water is released from the spring.

- (i) Determine the initial acceleration of the cube.

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

- (ii) Describe and explain the variation, if any, of the acceleration of the cube as it sinks in the water.

.....

 [2]

[Total: 12]

- 4 (a) State the conditions required for the formation of a stationary wave.

.....

.....

.....

.....[2]

- (b) A horizontal string is stretched between two fixed points X and Y. The string is made to vibrate vertically so that a stationary wave is formed. At one instant, each particle of the string is at its maximum displacement, as shown in Fig. 4.1.

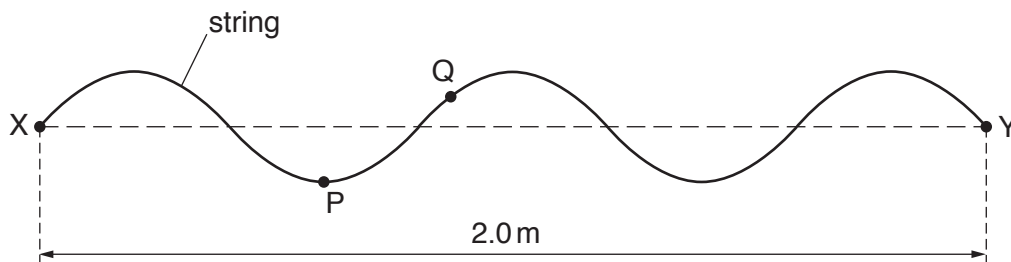


Fig. 4.1

P and Q are two particles of the string. The string vibrates with a frequency of 40 Hz. Distance XY is 2.0 m.

- (i) State the number of antinodes in the stationary wave.

number = ...[1]

- (ii) Determine the minimum time taken for the particle P to travel from its lowest point to its highest point.

time taken = ... s [2]

- (iii) State the phase difference, with its unit, between the vibrations of particle P and of particle Q.

phase difference = ...[1]

- (iv) Determine the speed of a progressive wave along the string.

speed = ...ms⁻¹ [2]

[Total: 8]

- 5 (a) Define the *coulomb*.

.....[1]

- (b) Two vertical metal plates in a vacuum have a separation of 4.0 cm. A potential difference of $2.0 \times 10^2 \text{ V}$ is applied between the plates. Fig. 5.1 shows a side view of this arrangement.

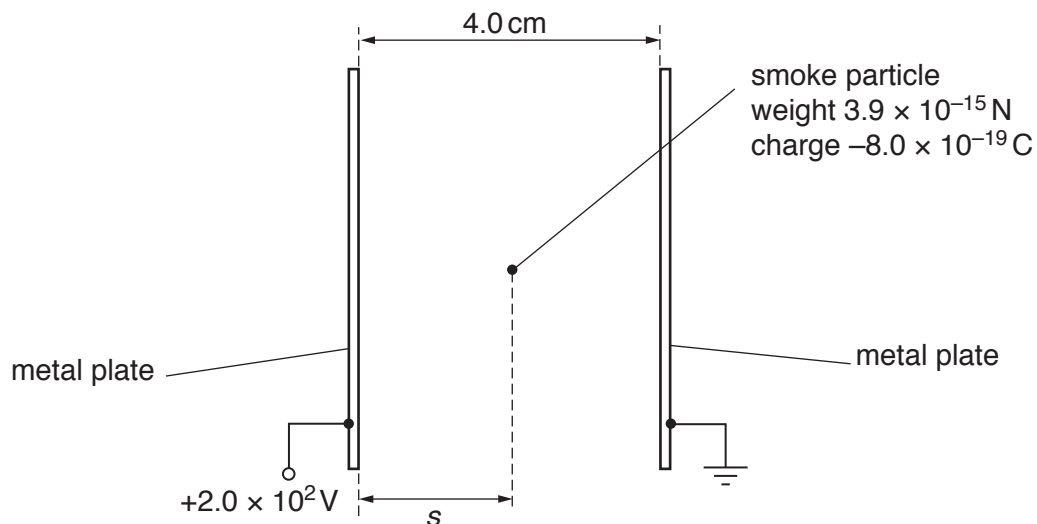


Fig. 5.1

A smoke particle is in the uniform electric field between the plates. The particle has weight $3.9 \times 10^{-15} \text{ N}$ and charge $-8.0 \times 10^{-19} \text{ C}$.

- (i) Show that the electric force acting on the particle is $4.0 \times 10^{-15} \text{ N}$.

[2]

- (ii) On Fig. 5.1, draw labelled arrows to show the directions of the two forces acting on the smoke particle.

[1]

- (iii) The resultant force acting on the particle is F .

Determine

1. the magnitude of F ,

magnitude = ... N

2. the angle of F to the horizontal.

angle = ...°
[3]

- (c) The electric field in (b) is switched on at time $t = 0$ when the particle is at a horizontal displacement $s = 2.0$ cm from the left-hand plate. At time $t = 0$ the horizontal velocity of the particle is zero. The particle is then moved by the electric field until it hits a plate at time $t = T$.

On Fig. 5.2, sketch the variation with time t of the horizontal displacement s of the particle from the left-hand plate.

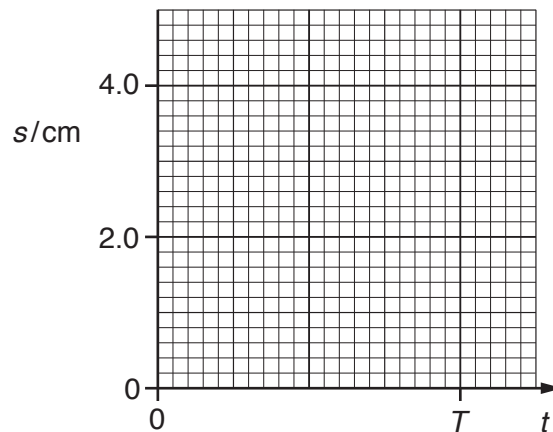


Fig. 5.2

[2]

[Total: 9]

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

.....[1]

- (b) A metal wire has length L and cross-sectional area A , as shown in Fig. 6.1.

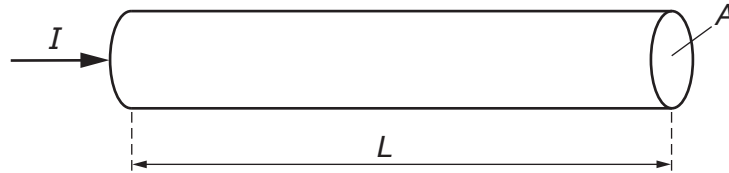


Fig. 6.1

I is the current in the wire,
 n is the number of free electrons per unit volume in the wire,
 v is the average drift speed of a free electron and
 e is the charge on an electron.

- (i) State, in terms of A , e , L and n , an expression for the total charge of the free electrons in the wire.

.....[1]

- (ii) Use your answer in (i) to show that the current I is given by the equation

$$I = nAve.$$

[2]

- (c) A metal wire in a circuit is damaged. The resistivity of the metal is unchanged but the cross-sectional area of the wire is reduced over a length of 3.0 mm, as shown in Fig. 6.2.

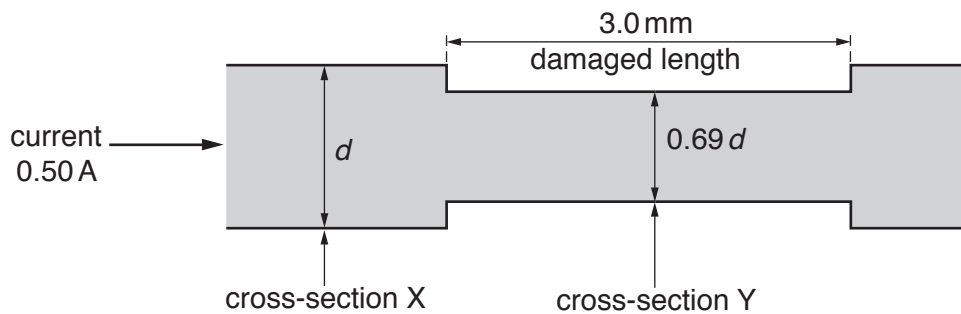


Fig. 6.2

The wire has diameter d at cross-section X and diameter $0.69d$ at cross-section Y.
 The current in the wire is 0.50 A.

- (i) Determine the ratio

$$\frac{\text{average drift speed of free electrons at cross-section Y}}{\text{average drift speed of free electrons at cross-section X}}$$

ratio = ... [2]

- (ii) The main part of the wire with cross-section X has a resistance per unit length of $1.7 \times 10^{-2} \Omega \text{ m}^{-1}$.

For the damaged length of the wire, calculate

1. the resistance per unit length,

resistance per unit length = ... $\Omega \text{ m}^{-1}$ [2]

2. the power dissipated.

power = ... W [2]

- (iii) The diameter of the damaged length of the wire is further decreased. Assume that the current in the wire remains constant.

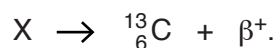
State and explain qualitatively the change, if any, to the power dissipated in the damaged length of the wire.

.....

 [2]

[Total: 12]

- 7 A stationary nucleus X decays by emitting a β^+ particle to form a nucleus of carbon-13 ($^{13}_6\text{C}$). An incomplete equation to represent this decay is



- (a) State the name of the class (group) of particles that includes β^+ .

.....[1]

- (b) For nucleus X, state the number of

protons, ...

neutrons.[1]

- (c) The carbon-13 nucleus has a mass of $2.2 \times 10^{-26}\text{kg}$. Its kinetic energy as a result of the decay process is 0.80MeV .

Calculate the speed of this nucleus.

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

- (d) Explain why the sum of the kinetic energies of the carbon-13 nucleus and the β^+ particle cannot be equal to the total energy released by the decay process.

.....
[1]

[Total: 6]

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CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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PHYSICS

9702/23

Paper 2 AS Level Structured Questions

October/November 2017

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

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

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

.....
[1]

- (ii) Show that the SI base units of power are $\text{kg m}^2 \text{s}^{-3}$.

[1]

- (b) All bodies radiate energy. The power P radiated by a body is given by

$$P = kAT^4$$

where T is the thermodynamic temperature of the body,
 A is the surface area of the body
 and k is a constant.

- (i) Determine the SI base units of k .

base units[2]

- (ii) On Fig. 1.1, sketch the variation with T^2 of P . The quantity A remains constant.

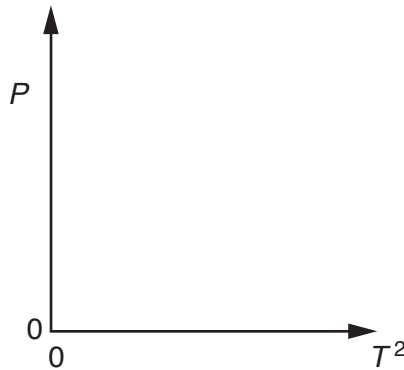


Fig. 1.1

[1]

[Total: 5]

- 2 A liquid of density ρ fills a container to a depth h , as shown in Fig. 2.1.

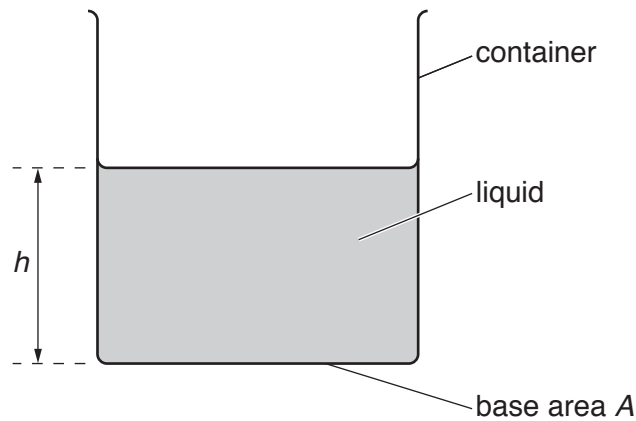


Fig. 2.1

The base of the container has area A .

- (a) Derive, from the definitions of pressure and density, the equation

$$p = \rho gh$$

where p is the pressure exerted by the liquid on the base of the container and g is the acceleration of free fall.

[3]

- (b) A small solid sphere falls with constant velocity through the liquid.

- (i) State

1. the names of the three forces acting on the sphere,

.....

.....

2. a word equation that relates the magnitudes of these forces.

.....

[2]

- (ii) State and explain the changes in energy that occur as the sphere falls.

.....

.....

.....

.....[2]

- (c) The liquid in the container is liquid L. Liquid M is now added to the container. The two liquids do not mix. The total depth of the liquids is 0.17 m.

Fig. 2.2 shows how the pressure p inside the liquids varies with height x above the base of the container.

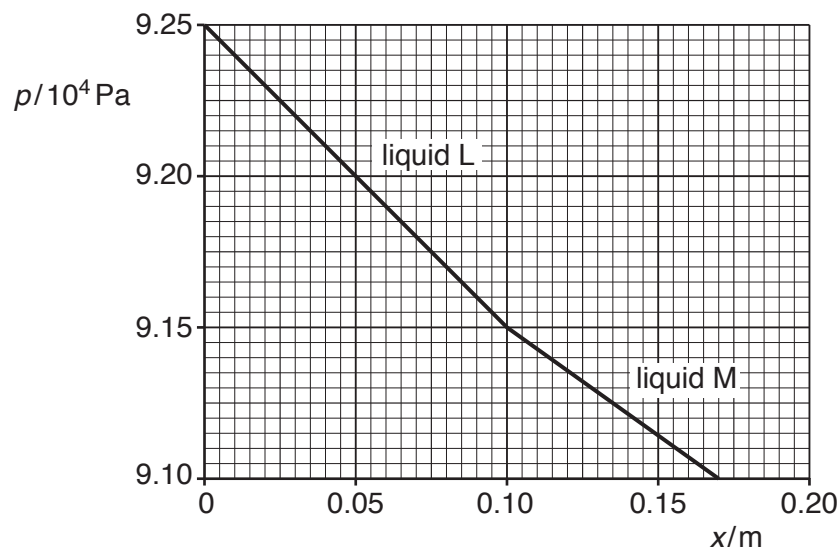


Fig. 2.2

Use Fig. 2.2 to

- (i) state the value of atmospheric pressure,

atmospheric pressure = ... Pa [1]

- (ii) determine the density of liquid M.

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

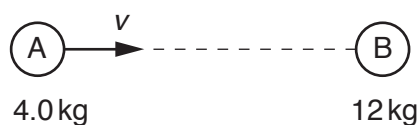
[Total: 10]

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

.....

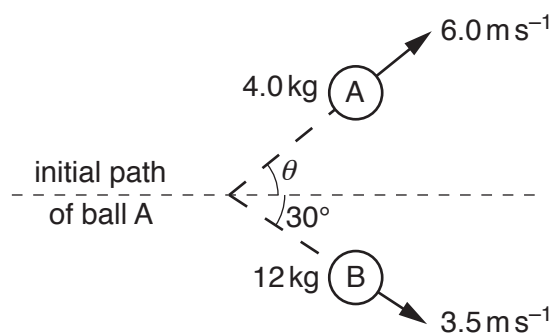
 [2]

- (b) Ball A moves with speed v along a horizontal frictionless surface towards a stationary ball B, as shown in Fig. 3.1.



before collision

Fig. 3.1



after collision

Fig. 3.2 (not to scale)

Ball A has mass 4.0 kg and ball B has mass 12 kg .

The balls collide and then move apart as shown in Fig. 3.2.

Ball A has velocity 6.0 ms^{-1} at an angle of θ to the direction of its initial path.

Ball B has velocity 3.5 ms^{-1} at an angle of 30° to the direction of the initial path of ball A.

- (i) By considering the components of momentum at right-angles to the direction of the initial path of ball A, calculate θ .

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

- (ii) Use your answer in (i) to show that the initial speed v of ball A is 12 m s^{-1} .
Explain your working.

[2]

- (iii) By calculation of kinetic energies, state and explain whether the collision is elastic or inelastic.

.....
.....[3]

[Total: 10]

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

.....
[1]

- (b) A car horn emits a sound wave of frequency 800 Hz. A microphone and a cathode-ray oscilloscope (c.r.o.) are used to analyse the sound wave. The waveform displayed on the c.r.o. screen is shown in Fig. 4.1.

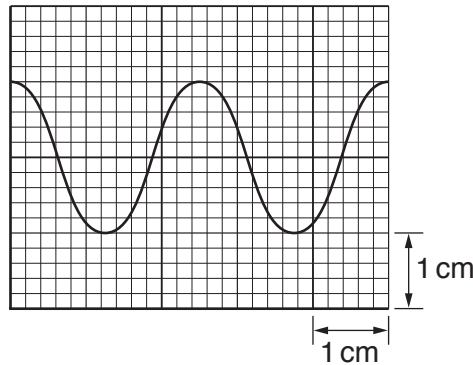


Fig. 4.1

Determine the time-base setting, in s cm^{-1} , of the c.r.o.

time-base setting = ... s cm^{-1} [3]

- (c) The intensity I of the sound at a distance r from the car horn in (b) is given by the expression

$$I = \frac{k}{r^2}$$

where k is a constant.

Fig. 4.2 shows the car in (b) on a road.

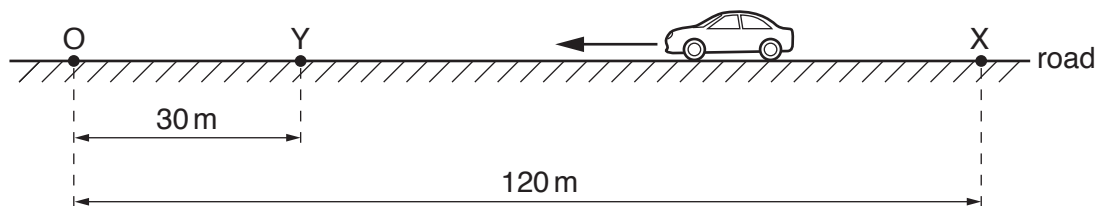


Fig. 4.2

An observer stands at point O. Initially the car is parked at point X which is 120 m away from point O. The car then moves directly towards the observer and stops at point Y, a distance of 30 m away from O.

The car horn continuously emits sound when the car is moving between points X and Y.

- (i) The sound wave at point O has amplitude A_X when the car is at X and has amplitude A_Y when the car is at Y.

Calculate the ratio $\frac{A_Y}{A_X}$.

ratio = ... [3]

- (ii) When the car is parked at X, the frequency of the sound from the horn that is detected by the observer is 800 Hz. As the car moves from X to Y, the maximum change in the detected frequency is 16 Hz. The speed of the sound in air is 330 m s^{-1} .

Determine, to two significant figures,

1. the minimum wavelength of the sound detected by the observer,

wavelength = ... m [2]

2. the maximum speed of the car.

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

[Total: 11]

- 5 (a) Define *electric field strength*.

.....
[1]

- (b) Two parallel metal plates in a vacuum are separated by 0.045 m. A potential difference V is applied between the plates, as shown in Fig. 5.1.

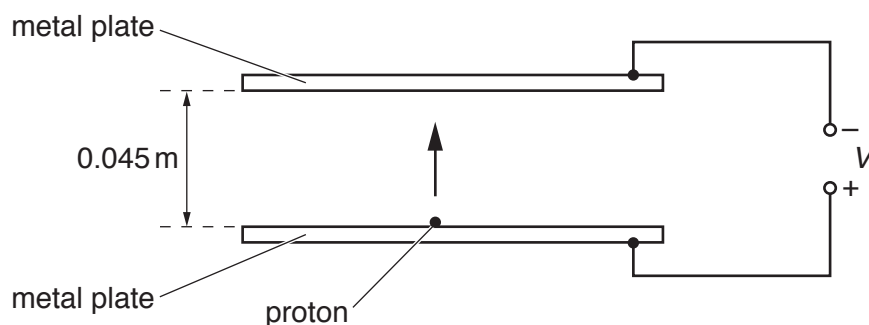


Fig. 5.1

A proton is initially at rest on the surface of the positive plate. The proton in the uniform electric field takes a time of 1.5×10^{-7} s to reach the negative plate.

- (i) Show that the acceleration of the proton is $4.0 \times 10^{12} \text{ m s}^{-2}$.

[2]

- (ii) Calculate the electric force on the proton.

force = ... N [1]

(iii) Use your answer in (ii) to determine

1. the electric field strength,

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

2. the potential difference V between the plates.

$V =$ V [2]

(c) An α particle is now accelerated between the two metal plates in (b) by the electric field.

Calculate the ratio

$$\frac{\text{acceleration of } \alpha \text{ particle}}{\text{acceleration of proton}} .$$

ratio = ... [2]

[Total: 10]

6 A filament lamp is rated as 30 W, 120 V. A potential difference of 120 V is applied across the lamp.

(a) For the filament wire of the lamp, calculate

(i) the current,

current = ... A [2]

(ii) the number of electrons passing a point in 3.0 hours.

number = ... [2]

(b) Show that the resistance of the filament wire is $480\ \Omega$.

[2]

(c) The filament wire has an uncoiled length of 580 mm and is made of metal. The metal has resistivity $6.1 \times 10^{-7}\ \Omega\text{ m}$ at the operating temperature of the lamp.

Calculate the diameter of the wire.

diameter = ... m [3]

(d) The potential difference across the lamp is now reduced. State and explain the effect, if any, on the resistance of the filament wire.

.....
 [1]

[Total: 10]

- 7 (a) A nucleus X decays by emitting a β^+ particle to form a new nucleus, ${}^{23}_{11}\text{Na}$.

State the number of nucleons and the number of neutrons in nucleus X.

number of nucleons = ...

number of neutrons = ...

[2]

- (b) State one similarity and one difference between a β^+ particle and a β^- particle.

similarity:

difference:

[2]

[Total: 4]

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