

Cambridge International AS & A Level

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PHYSICS

9702/21

Paper 2 AS Level Structured Questions

May/June 2021

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ ($\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1}$)
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion

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

$$v^2 = u^2 + 2as$$

work done on/by a gas

$$W = p\Delta V$$

gravitational potential

$$\phi = -\frac{Gm}{r}$$

hydrostatic pressure

$$p = \rho gh$$

pressure of an ideal gas

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

simple harmonic motion

$$a = -\omega^2 x$$

velocity of particle in s.h.m.

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

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

Doppler effect

$$f_o = \frac{f_s v}{v \pm v_s}$$

electric potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

capacitors in series

$$1/C = 1/C_1 + 1/C_2 + \dots$$

capacitors in parallel

$$C = C_1 + C_2 + \dots$$

energy of charged capacitor

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

electric current

$$I = Anvq$$

resistors in series

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

resistors in parallel

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

Hall voltage

$$V_H = \frac{BI}{ntq}$$

alternating current/voltage

$$x = x_0 \sin \omega t$$

radioactive decay

$$x = x_0 \exp(-\lambda t)$$

decay constant

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

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

- 1 (a) Define *density*.

.....
 [1]

- (b) Fig. 1.1 shows a solid pyramid with a square base.

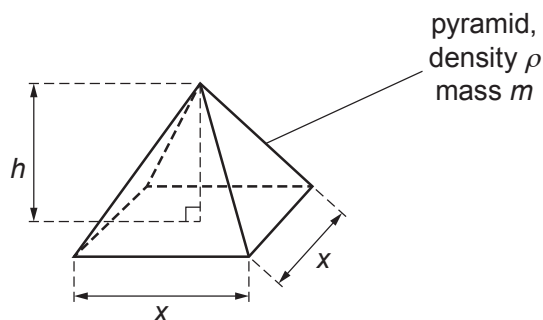


Fig. 1.1

The mass m of the pyramid is given by

$$m = \frac{1}{3}\rho hx^2$$

where ρ is the density of the material of the pyramid,
 h is the height, and
 x is the length of each side of the base.

Measurements are taken as shown in Table 1.1.

Table 1.1

quantity	measurement	percentage uncertainty
m	19.5g	$\pm 2\%$
x	4.0cm	$\pm 5\%$
h	4.8cm	$\pm 4\%$

- (i) Calculate the absolute uncertainty in length x .

absolute uncertainty = ... cm [1]

- (ii) The density ρ is calculated from the measurements in Table 1.1.

Determine the percentage uncertainty in the calculated value of ρ .

percentage uncertainty = ... % [2]

- (c) The square base of the pyramid in (b) rests on the horizontal surface of a bench.

Use data from Table 1.1 to calculate the average pressure of the pyramid on the surface of the bench. The uncertainty in your answer is not required.

pressure = ... Pa [3]

[Total: 7]

2 A person uses a trolley to move suitcases at an airport. The total mass of the trolley and suitcases is 72 kg.

(a) The person pushes the trolley and suitcases along a horizontal surface with a constant speed of 1.4 ms^{-1} and then releases the trolley. The released trolley moves in a straight line and comes to rest. Assume that a constant total resistive force of 18 N opposes the motion of the trolley and suitcases.

(i) Calculate the power required to overcome the total resistive force on the trolley and suitcases when they move with a constant speed of 1.4 ms^{-1} .

power = ... W [2]

(ii) Calculate the time taken for the trolley to come to rest after it is released.

time = ... s [3]

(b) At another place in the airport, the trolley and suitcases are on a slope, as shown in Fig. 2.1.

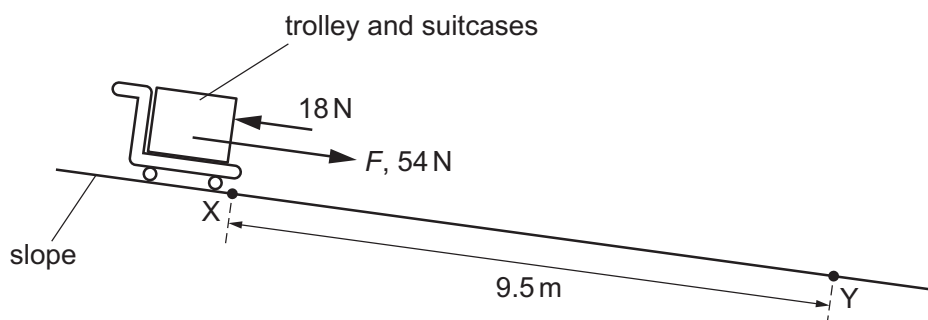


Fig. 2.1 (not to scale)

The person releases the trolley from rest at point X. The trolley moves down the slope in a straight line towards point Y. The distance along the slope between points X and Y is 9.5 m.

The component F of the weight of the trolley and suitcases that acts along the slope is 54 N. Assume that a constant total resistive force of 18 N opposes the motion of the trolley and suitcases.

- (i) Calculate the speed of the trolley at point Y.

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

- (ii) Calculate the work done by F for the movement of the trolley from X to Y.

work done = ... J [1]

- (iii) The trolley is released at point X at time $t = 0$.

On Fig. 2.2, sketch a graph to show the variation with time t of the work done by F for the movement of the trolley from X to Y.

Numerical values of the work done and t are not required.

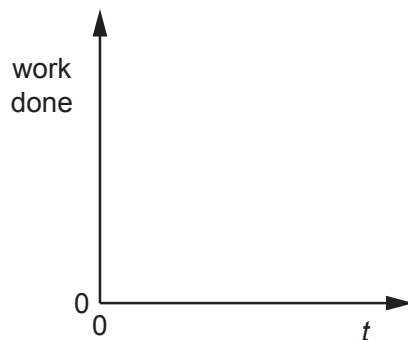


Fig. 2.2

[2]

- (c) The angle of the slope in (b) is constant. The frictional forces acting on the wheels of the moving trolley are also constant.

Explain why, in practice, it is incorrect to assume that the total resistive force opposing the motion of the trolley and suitcases is constant as the trolley moves between X and Y.

.....
 [1]

[Total: 12]

- 3 A pendulum consists of a solid sphere suspended by a string from a fixed point P, as shown in Fig. 3.1.

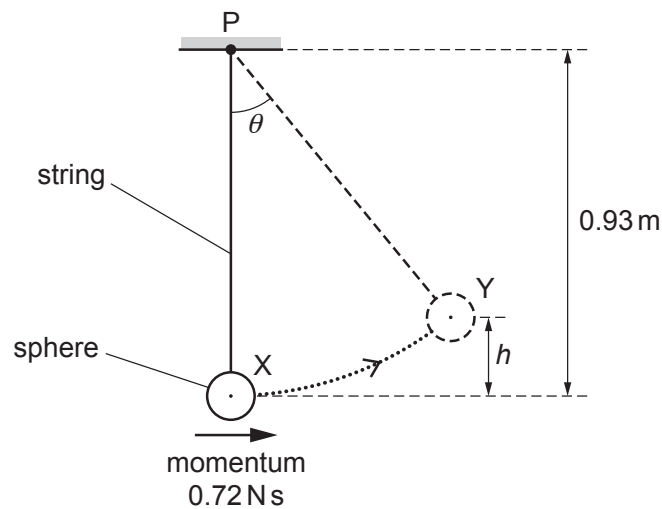


Fig. 3.1 (not to scale)

The sphere swings from side to side. At one instant the sphere is at its lowest position X, where it has kinetic energy 0.86 J and momentum 0.72 N s in a horizontal direction. A short time later the sphere is at position Y, where it is momentarily stationary at a maximum vertical height h above position X.

The string has a fixed length and negligible weight. Air resistance is also negligible.

- (a) On Fig. 3.1, draw a solid line to represent the displacement of the centre of the sphere at position Y from position X. [1]
- (b) Show that the mass of the sphere is 0.30 kg.

[3]

(c) Calculate height h .

$h = \dots\dots\dots$ m [2]

(d) The distance between point P and the centre of the sphere is 0.93 m. When the sphere is at position Y, the string is at an angle θ to the vertical.

Show that θ is 47° .

[1]

(e) For the sphere at position Y, calculate the moment of its weight about point P.

moment = $\dots\dots\dots$ Nm [2]

(f) State and explain whether the sphere is in equilibrium when it is stationary at position Y.

$\dots\dots\dots$
 $\dots\dots\dots$ [1]

[Total: 10]

- 4 (a) For a progressive wave, state what is meant by *wavelength*.

.....
 [1]

- (b) A light wave from a laser has a wavelength of 460 nm in a vacuum.

Calculate the period of the wave.

period = ... s [3]

- (c) The light from the laser is incident normally on a diffraction grating.

Describe the diffraction of the light waves at the grating.

.....

 [2]

- (d) A diffraction grating is used with different wavelengths of visible light. The angle θ of the **fourth**-order maximum from the zero-order (central) maximum is measured for each wavelength. The variation with wavelength λ of $\sin \theta$ is shown in Fig. 4.1.

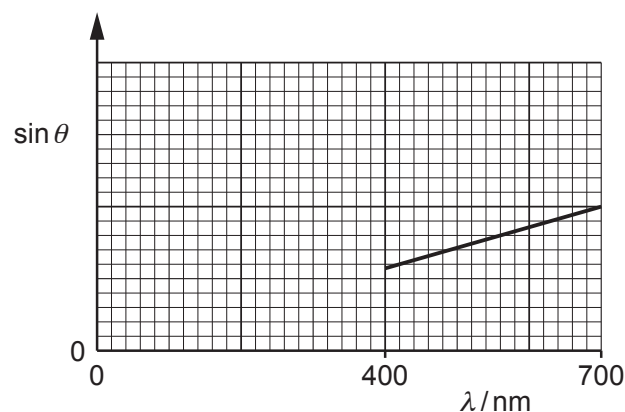


Fig. 4.1

- (i) The gradient of the graph is G .

Determine an expression, in terms of G , for the distance d between the centres of two adjacent slits in the diffraction grating.

$$d = \dots\dots\dots [2]$$

- (ii) On Fig. 4.1, sketch a graph to show the results that would be obtained for the **second-order** maxima. [2]

[Total: 10]

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

.....

 [2]

- (b) A battery has electromotive force (e.m.f.) 4.0 V and internal resistance $0.35\ \Omega$. The battery is connected to a uniform resistance wire XY and a fixed resistor of resistance R , as shown in Fig. 5.1.

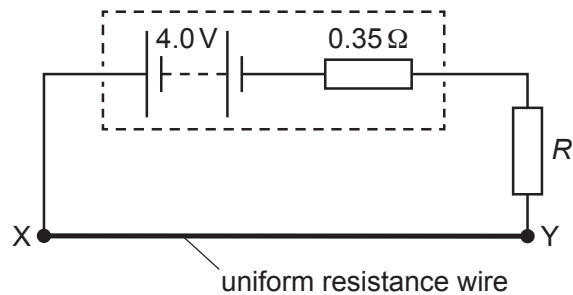


Fig. 5.1

Wire XY has resistance $0.90\ \Omega$. The potential difference across wire XY is 1.8 V .

Calculate:

- (i) the current in wire XY

current = ... A [1]

- (ii) the number of free electrons that pass a point in the battery in a time of 45 s

number = ... [2]

- (iii) resistance R .

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

(c) A cell of e.m.f. 1.2V is connected to the circuit in (b), as shown in Fig. 5.2.

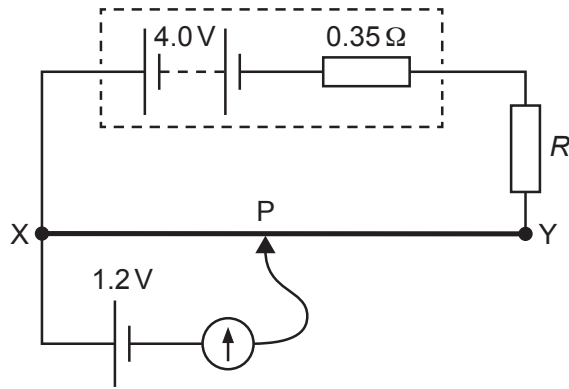


Fig. 5.2

The connection P is moved along the wire XY. The galvanometer reading is zero when distance XP is 0.30 m.

(i) Calculate the total length L of wire XY.

$L = \dots\dots\dots$ m [2]

(ii) The fixed resistor is replaced by a different fixed resistor of resistance greater than R .

State and explain the change, if any, that must be made to the position of P on wire XY so that the galvanometer reading is zero.

.....

 [2]

[Total: 11]

6 (a) A proton in a nucleus decays to form a neutron and a β^+ particle.

(i) State the name of another lepton that is produced in the decay.

..... [1]

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

..... [1]

(iii) State which of the three particles (proton, neutron or β^+ particle) has the largest ratio of charge to mass.

..... [1]

(iv) Use the quark model to show that the charge on the proton is $+e$, where e is the elementary charge.

[2]

(v) The quark composition of the proton is changed during the decay.

Describe the change to the quark composition.

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

(b) A nucleus X ($^{12}_6\text{X}$) and a nucleus Y ($^{16}_8\text{Y}$) are accelerated by the same uniform electric field.

(i) Determine the ratio

$$\frac{\text{electric force acting on nucleus X}}{\text{electric force acting on nucleus Y}}$$

ratio = ... [2]

(ii) Determine the ratio

$$\frac{\text{acceleration of nucleus X due to the field}}{\text{acceleration of nucleus Y due to the field}}$$

ratio = ... [1]

(iii) Nucleus X is at rest in the uniform electric field at time $t = 0$.

The field causes nucleus X to accelerate so that it moves through the field.

On Fig. 6.1, sketch the variation with time t of the acceleration a of nucleus X due to the field.

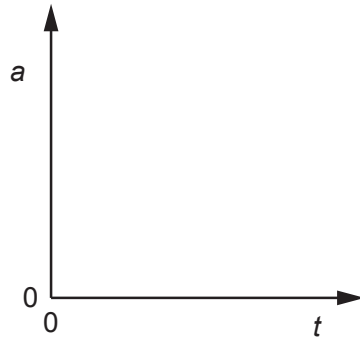


Fig. 6.1

[1]

[Total: 10]

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acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

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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) Complete Table 1.1 by stating whether each of the quantities is a vector or a scalar.

Table 1.1

quantity	vector or scalar
acceleration	
electrical resistance	
momentum	

[2]

- (b) State the conditions for an object to be in equilibrium.

.....

.....

.....

..... [2]

- (c) A floating solid cylinder is attached by a wire to the sea bed, as shown in Fig. 1.1.

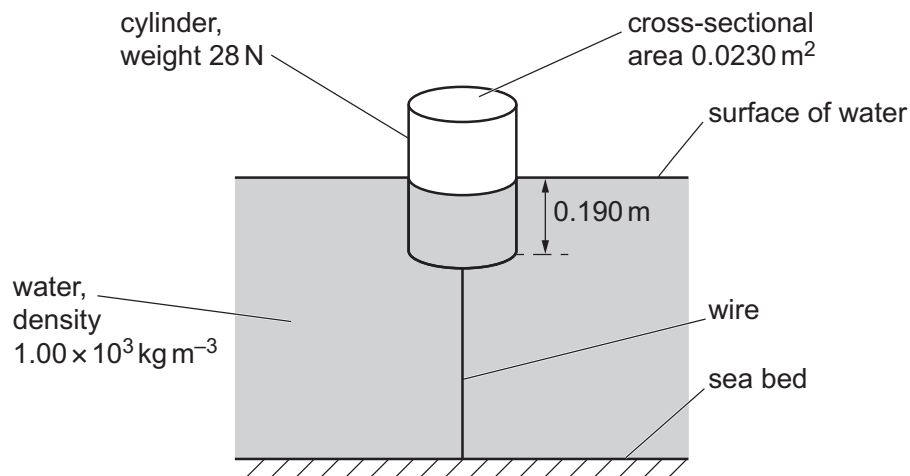


Fig. 1.1 (not to scale)

The density of the water is $1.00 \times 10^3 \text{ kg m}^{-3}$. The base of the cylinder is at a depth of 0.190 m below the surface of the water. The cylinder has a weight of 28 N and a cross-sectional area of 0.0230 m^2 .

The wire and the central axis of the cylinder are both vertical. The cylinder is in equilibrium.

- (i) Calculate, to three significant figures, the upthrust acting on the cylinder due to the water.

upthrust = ... N [2]

- (ii) Show that the tension T in the wire is 15 N.

[1]

- (iii) The wire has a cross-sectional area of 3.2 mm^2 .

Calculate the stress in the wire.

stress = ... Pa [2]

- (iv) The surface of the water gradually rises until it is level with the top face of the cylinder.

State and explain, qualitatively, the variation of the strain energy stored in the wire as the water surface rises.

.....

 [2]

[Total: 11]

- 2 A ball is thrown vertically downwards to the ground, as illustrated in Fig. 2.1.

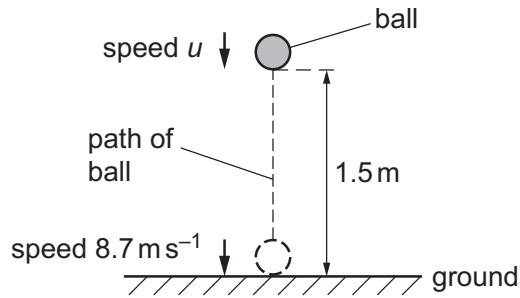


Fig. 2.1

The ball is thrown with speed u from a height of 1.5 m. The ball then hits the ground with speed 8.7 m s^{-1} . Assume that air resistance is negligible.

- (a) Calculate speed u .

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

- (b) State how Newton's third law applies to the collision between the ball and the ground.

.....

 [2]

- (c) The ball is in contact with the ground for a time of 0.091 s. The ball rebounds vertically and leaves the ground with speed 5.4 m s^{-1} . The mass of the ball is 0.059 kg.

- (i) Calculate the magnitude of the change in momentum of the ball during the collision.

$$\text{change in momentum} = \dots\dots\dots \text{ N s} \quad [2]$$

- (ii) Determine the magnitude of the average resultant force that acts on the ball during the collision.

average resultant force = ... N [1]

- (iii) Use your answer in (c)(ii) to calculate the magnitude of the average force exerted by the ground on the ball during the collision.

average force = ... N [2]

- (d) The ball was thrown downwards at time $t = 0$ and hits the ground at time $t = T$.

On Fig. 2.2, sketch a graph to show the variation of the speed of the ball with time t from $t = 0$ to $t = T$. Numerical values are not required.

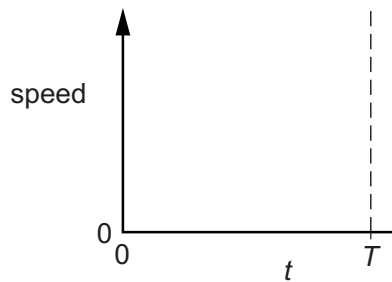


Fig. 2.2

[1]

- (e) In practice, air resistance is not negligible.

State and explain the variation, if any, with time t of the gradient of the graph in (d) when air resistance is not negligible.

.....

.....

.....

..... [2]

[Total: 12]

- 3 A child of weight 330 N is at point X at the top of a slide. The slide is at the edge of a swimming pool, as shown in Fig. 3.1.

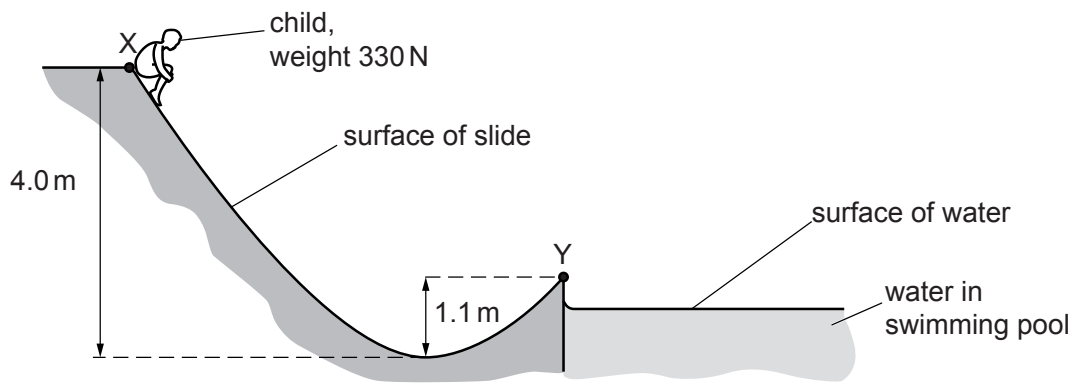


Fig. 3.1 (not to scale)

The child moves from rest to the lowest point of the slide that is a vertical distance of 4.0 m below X. The child continues moving towards point Y which is at the end of the slide and a vertical distance of 1.1 m above the lowest point. The kinetic energy of the child at Y is 540 J.

- (a) Calculate the difference in the gravitational potential energy of the child at points X and Y.

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

- (b) An average frictional force of 52 N acts on the child when moving from X to Y.

By considering changes of energy, determine the distance moved by the child from X to Y.

distance moved = ... m [2]

- (c) The child leaves the slide at point Y with a velocity that is at an angle of 41° to the horizontal. The path of the child through the air is shown in Fig. 3.2.

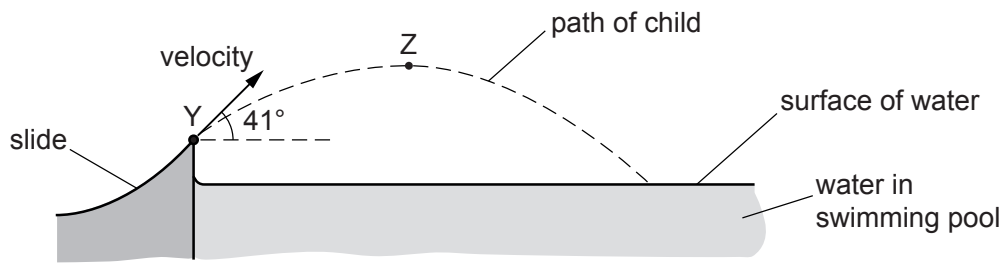


Fig. 3.2 (not to scale)

Point Z is the highest point on the path of the child through the air. Assume that air resistance is negligible.

Calculate the speed of the child at:

- (i) point Y

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

- (ii) point Z.

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

[Total: 8]

- 4 (a) For a progressive wave, state what is meant by its *period*.

.....
 [1]

- (b) State the principle of superposition.

.....

 [2]

- (c) Electromagnetic waves of wavelength 0.040 m are emitted in phase from two sources X and Y and travel in a vacuum. The arrangement of the sources is shown in Fig. 4.1.

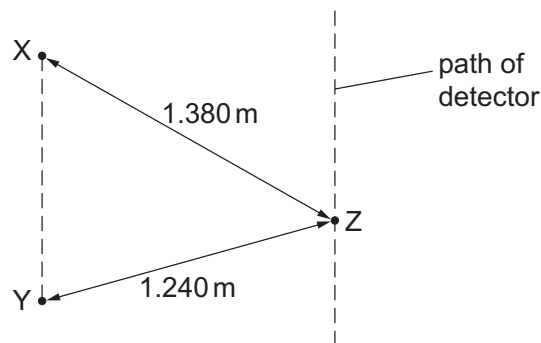


Fig. 4.1 (not to scale)

A detector moves along a path that is parallel to the line XY. A pattern of intensity maxima and minima is detected.

Distance XZ is 1.380 m and distance YZ is 1.240 m .

- (i) State the name of the region of the electromagnetic spectrum that contains the waves from X and Y.

..... [1]

- (ii) Calculate the period, in ps, of the waves.

period = ... ps [3]

- (iii) Show that the path difference at point Z between the waves from X and Y is 3.5λ , where λ is the wavelength of the waves.

[1]

- (iv) Calculate the phase difference between the waves at point Z.

phase difference = ...° [1]

- (v) The waves from X alone have the same amplitude at point Z as the waves from Y alone.

State the intensity of the waves at point Z.

..... [1]

- (vi) The frequencies of the waves from X and Y are both decreased to the same lower value. The waves stay within the same region of the electromagnetic spectrum.

Describe the effect of this change on the pattern of intensity maxima and minima along the path of the detector.

.....
 [1]

[Total: 11]

- 5 (a) Define the *ohm*.

.....
 [1]

- (b) A wire is made of metal of resistivity ρ . The length L of the wire is gradually increased. Assume that the volume V of the wire remains constant as its length is increased.

Show that the resistance R of the extending wire is proportional to L^2 .

[2]

- (c) 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. 5.1.

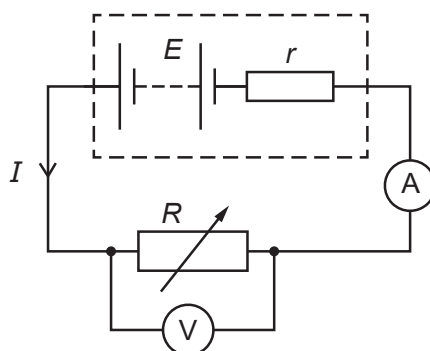


Fig. 5.1

An ammeter measures the current I in the circuit. A voltmeter measures the potential difference V across the variable resistor.

The resistance R is now varied to change the values of I and V .

The variation with I of V is shown in Fig. 5.2.

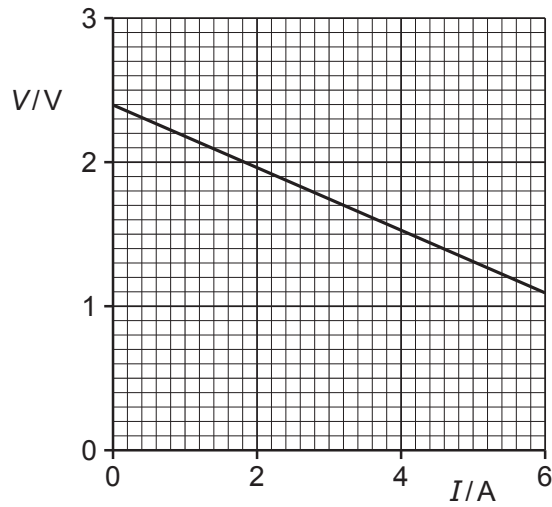


Fig. 5.2

- (i) Use Fig. 5.2 to state the e.m.f. E of the battery.

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

- (ii) Use Fig. 5.2 to determine the power dissipated in the variable resistor when there is a current of 5.0A.

power = $\dots\dots\dots$ W [3]

- (iii) State what is represented by the value of the gradient of the graph.

$\dots\dots\dots$ [1]

[Total: 8]

- 6 (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) An α -particle is made up of other particles. One of these particles is a proton.

State and explain whether a proton is a fundamental particle.

.....

..... [1]

- (c) A radioactive source produces a beam of α -particles in a vacuum. The average current produced by the beam is $6.9 \times 10^{-9} \text{ A}$.

Calculate the average number of α -particles passing a fixed point in the beam in a time of 1.0 minute.

number = ... [3]

- (d) The α -particles in the vacuum in (c) enter a uniform electric field. The α -particles enter the field with their velocity in the same direction as the field.

State and explain whether the magnitude of the acceleration of an α -particle due to the field decreases, increases or stays constant as the α -particle moves through the field.

.....

.....

..... [2]

- (e) A nucleus X is an isotope of a nucleus Y. The mass of nucleus X is greater than that of Y.

Both of the nuclei are in the same uniform electric field.

State and explain whether the magnitude of the electric force acting on nucleus X is greater than, less than or the same as that acting on nucleus Y.

.....

.....

..... [2]

[Total: 10]

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PHYSICS

9702/23

Paper 2 AS Level Structured Questions

May/June 2021

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 60.
- The number of marks for each question or part question is shown in brackets [].

This document has **16** pages. Any blank pages are indicated.

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ ($\frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ m F}^{-1}$)
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass unit	$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
gravitational potential	$\phi = -\frac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$
simple harmonic motion	$a = -\omega^2 x$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $v = \pm \omega \sqrt{(x_0^2 - x^2)}$
Doppler effect	$f_o = \frac{f_s v}{v \pm v_s}$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \dots$
capacitors in parallel	$C = C_1 + C_2 + \dots$
energy of charged capacitor	$W = \frac{1}{2} QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
Hall voltage	$V_H = \frac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

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

- 1 (a) A property of a vector quantity, that is not a property of a scalar quantity, is direction. For example, velocity has direction but speed does not.

- (i) State **two** other scalar quantities and **two** other vector quantities.

scalar quantities: and

vector quantities: and [2]

- (ii) State **two** properties that are possessed by both scalar and vector physical quantities.

1.

2. [2]

- (b) A ship at sea is travelling with a velocity of 13 m s^{-1} in a direction 35° east of north in still water, as shown in Fig. 1.1.

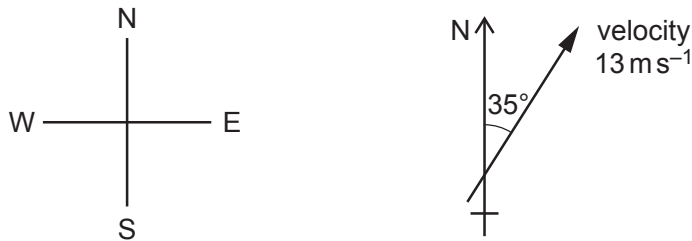


Fig. 1.1

- (i) Determine the magnitudes of the components of the velocity of the ship in the north and the east directions.

north component of velocity = ... m s^{-1}

east component of velocity = ... m s^{-1} [2]

- (ii) The ship now experiences a tidal current. The water in the sea moves with a velocity of 2.7 m s^{-1} to the west.

Calculate the resultant velocity component of the ship in the east direction.

resultant east component of velocity = ... m s^{-1} [1]

- (iii) Use your answers in (b)(i) and (b)(ii) to determine the magnitude of the resultant velocity of the ship.

magnitude of resultant velocity = ... m s^{-1} [2]

- (iv) Use your answers in (b)(i) and (b)(ii) to determine the angle between north and the resultant velocity of the ship.

angle = ... $^{\circ}$ [2]

[Total: 11]

- 2 (a) Define *acceleration*.

.....
 [1]

- (b) A stone falls vertically from the top of a cliff. Fig. 2.1 shows the variation with time t of the velocity v of the stone.

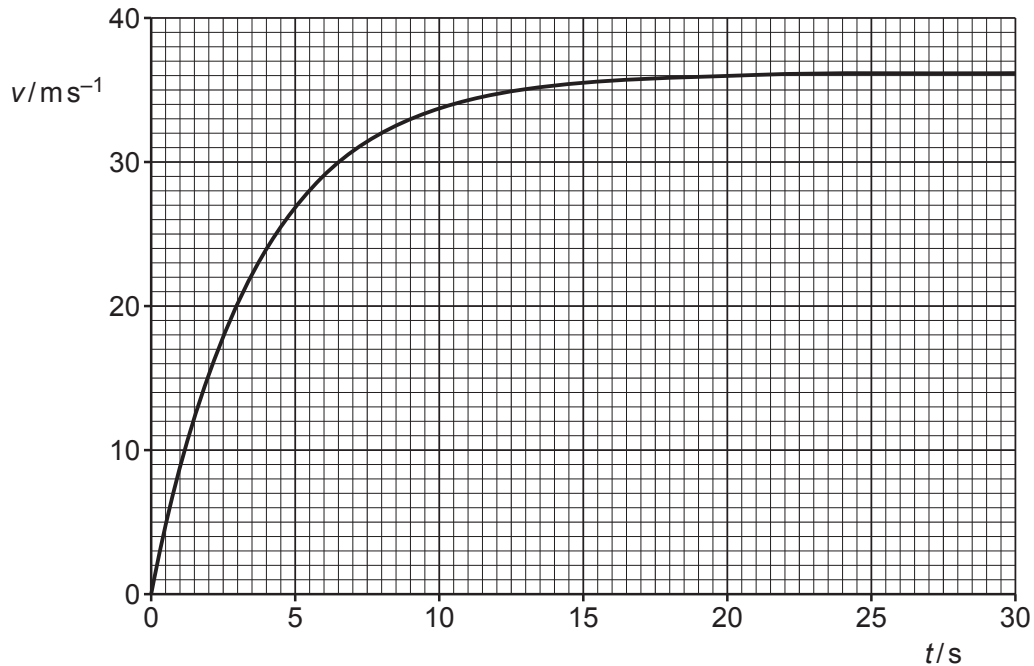


Fig. 2.1

- (i) Explain, with reference to forces acting on the stone, the shape of the curve in Fig. 2.1.

.....

 [3]

- (ii) Use Fig. 2.1 to determine the speed of the stone when the resultant force on it is zero.

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

- (iii) Use Fig. 2.1 to calculate the approximate height through which the stone falls between $t = 0$ and $t = 30$ s.

height = ... m [3]

- (iv) On Fig. 2.2, sketch the variation with t of the acceleration a of the stone between $t = 0$ and $t = 30$ s.

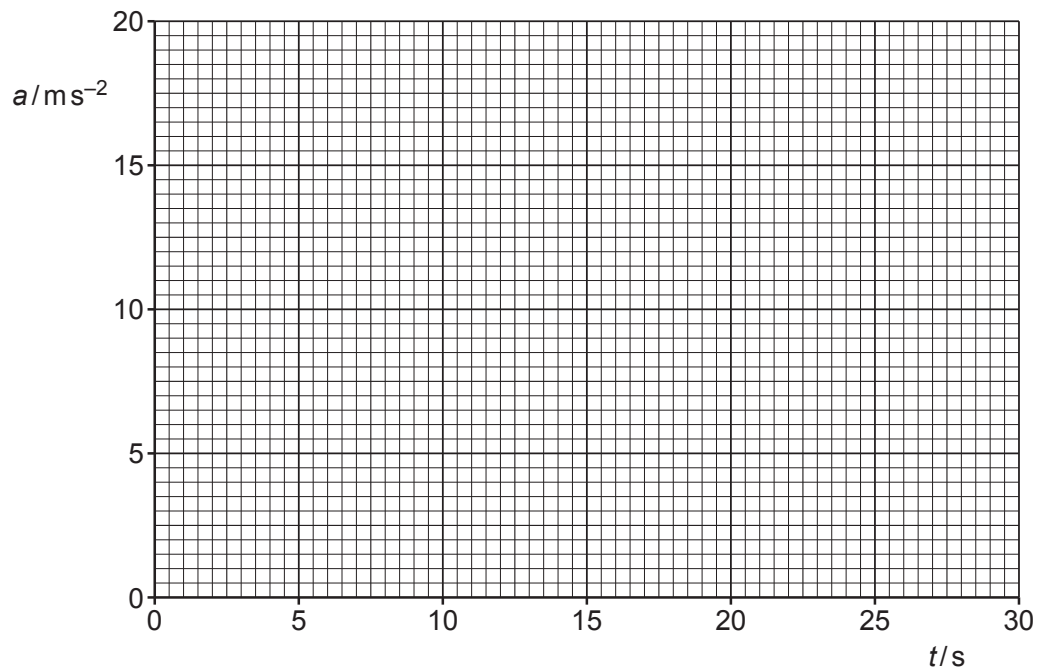


Fig. 2.2

[3]

[Total: 11]

- 3 (a) Define the *moment* of a force about a point.

.....

.....

..... [2]

- (b) Fig. 3.1 shows a type of balance that is used for measuring mass.

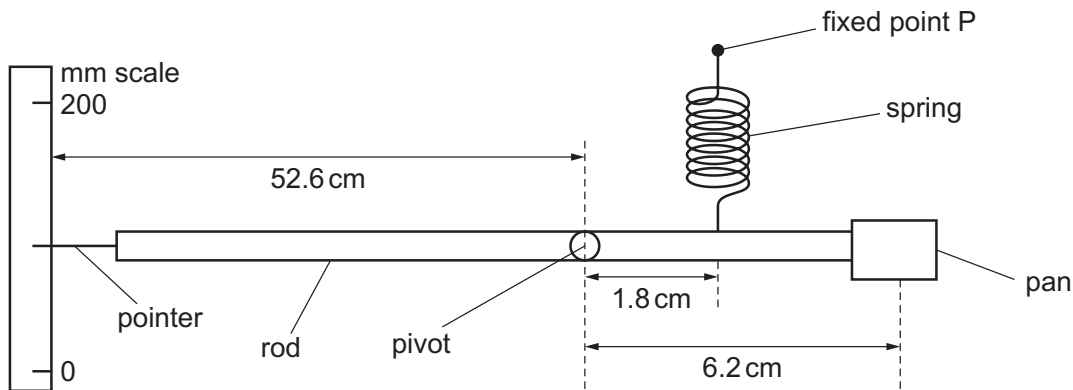


Fig. 3.1 (not to scale)

A rigid rod is pivoted about a point 6.2 cm from the centre of a pan which is attached to one end. The object being measured is placed on the centre of this pan.

A spring, attached to the rod 1.8 cm from the pivot, is attached at its other end to a fixed point P. The spring obeys Hooke's law over the full range of operation of the balance.

A pointer, on the other side of the pivot, is set against a millimetre scale which is a distance 52.6 cm from the pivot.

When the system is in equilibrium with no mass on the pan, the rod is horizontal and the pointer indicates a reading on the scale of 86 mm.

An object of mass 0.472 kg is now placed on the pan. As a result, the pointer moves to indicate a reading of 123 mm on the scale when the system is again in equilibrium.

- (i) Show that the increase in the length of the spring is approximately 1.3 mm.

[2]

- (ii) Calculate the magnitude of the moment about the pivot of the weight of the object.

moment = ... Nm [2]

- (iii) Use your answer in (b)(ii) to determine the increase in the tension in the spring due to the 0.472 kg mass.

increase in tension = ... N [2]

- (iv) Use the information in (b)(i) and your answer in (b)(iii) to determine the spring constant k of the spring. Give a unit with your answer.

k = ... unit [2]

[Total: 10]

- 4 (a) State the principle of superposition.

.....

 [2]

- (b) Two waves, with intensities I and $4I$, superpose. The waves have the same frequency.

Determine, in terms of I , the maximum possible intensity of the resulting wave.

maximum intensity = ... I [2]

- (c) Coherent light of wavelength 550 nm is incident normally on a double slit of slit separation 0.35 mm. A series of bright and dark fringes forms on a screen placed a distance of 1.2 m from the double slit, as shown in Fig. 4.1. The screen is parallel to the double slit.

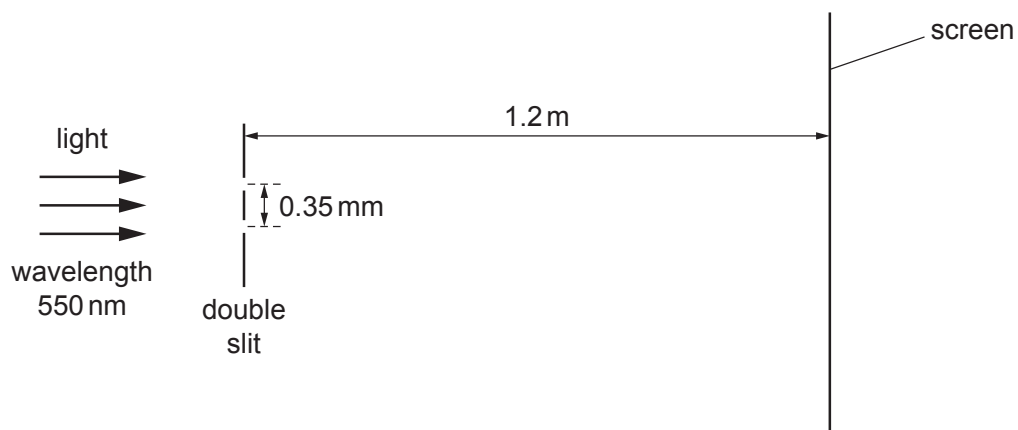


Fig. 4.1 (not to scale)

- (i) Determine the distance between the centres of adjacent bright fringes on the screen.

distance = ... m [3]

- (ii) The light of wavelength 550 nm is replaced with red light of a single frequency.

State and explain the change, if any, in the distance between the centres of adjacent bright fringes.

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

[Total: 8]

- 5 (a) Define the *electromotive force (e.m.f.)* of a source.

.....

 [2]

- (b) The circuit shown in Fig. 5.1 contains a battery of e.m.f. E that has internal resistance r , a variable resistor, a voltmeter and an ammeter.

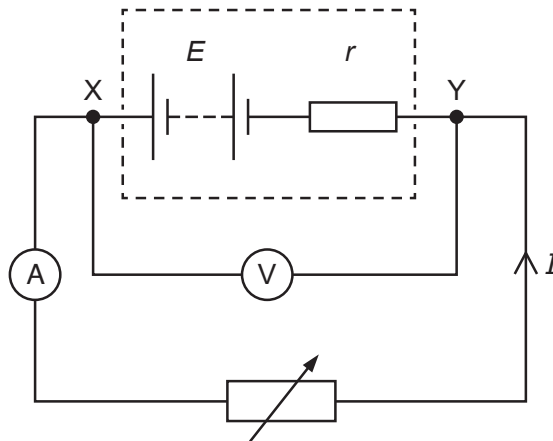


Fig. 5.1

Readings from the two meters are taken for different settings of the variable resistor. The variation with current I of the potential difference (p.d.) V across the terminals XY of the battery is shown in Fig. 5.2.

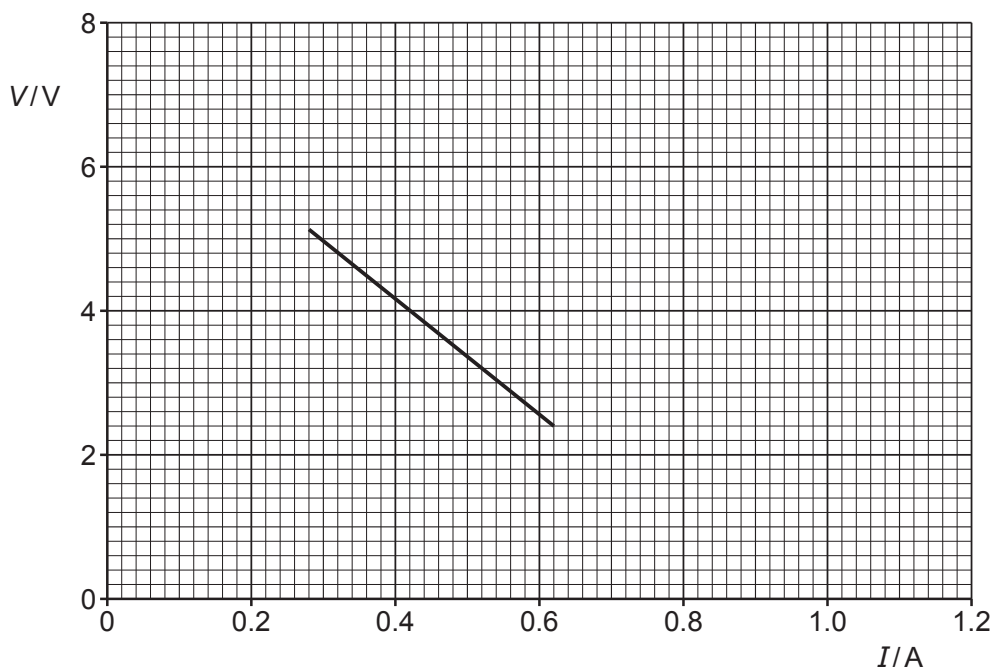


Fig. 5.2

Explain why V is not constant.

.....

.....

.....

..... [3]

(c) For the battery in (b), use Fig. 5.2 to determine:

(i) the e.m.f. E

$$E = \text{..... V [1]}$$

(ii) the maximum current that the battery can supply

$$\text{maximum current} = \text{..... A [1]}$$

(iii) the internal resistance r .

$$r = \text{..... } \Omega \text{ [2]}$$

(d) On Fig. 5.2, sketch a line to show a possible variation with I of V for a battery with a lower e.m.f. and a lower internal resistance than the battery in (b). Your line should extend over at least the same range of currents as the original line. [2]

[Total: 11]

6 (a) State the quark composition of:

(i) a proton

..... [1]

(ii) a neutron

..... [1]

(iii) an alpha-particle.

.....
 [2]

(b) In the alpha-particle scattering experiment, alpha-particles were directed at a thin gold foil.

State what may be inferred from:

(i) the observation that most alpha-particles pass through the foil

..... [1]

(ii) the observation that some alpha-particles are scattered through angles greater than 90°.

.....

 [2]

(c) A proton and an alpha-particle are moving in the same uniform electric field.

Determine the ratio

$$\frac{\text{acceleration of proton due to the electric field}}{\text{acceleration of alpha-particle due to the electric field}}$$

ratio = ... [2]

[Total: 9]

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