



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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9702/23

May/June 2021

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

- 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.

- 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 ms^{-1} in a direction 35° east of north in still water, as shown in Fig. 1.1.

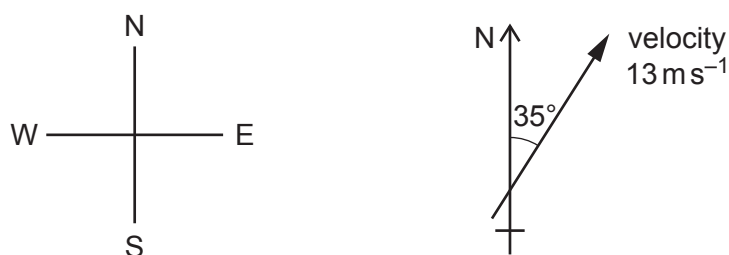


Fig. 1.1

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

north component of velocity = ms^{-1}

east component of velocity = ms^{-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 =° [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.

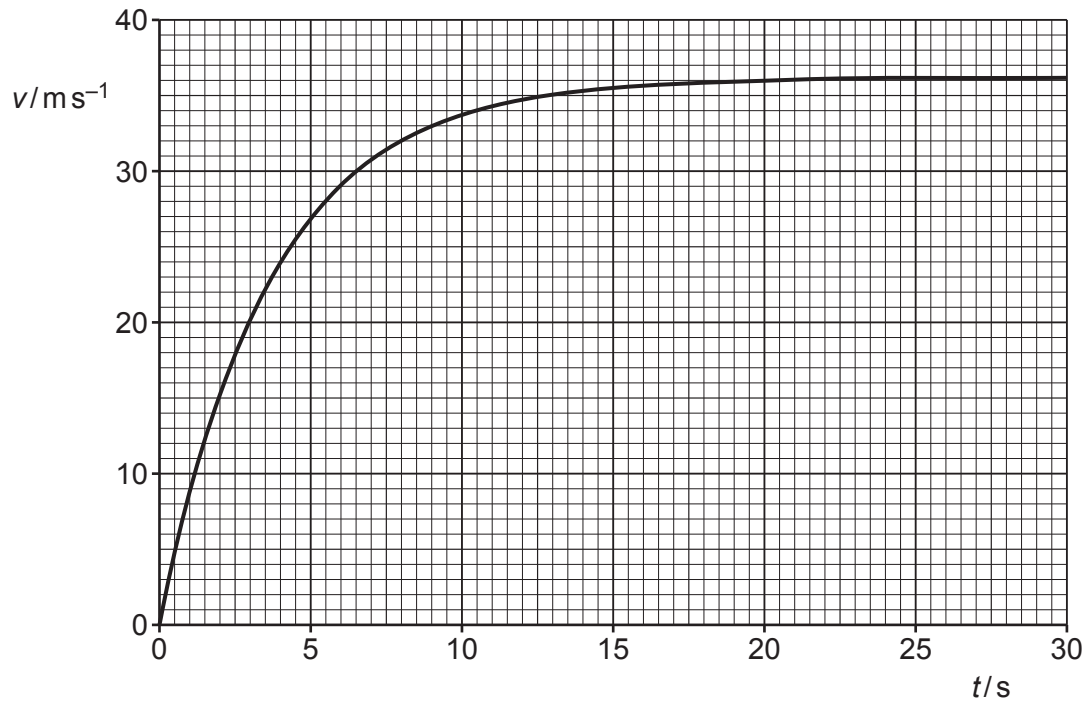


Fig. 2.1

- (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.

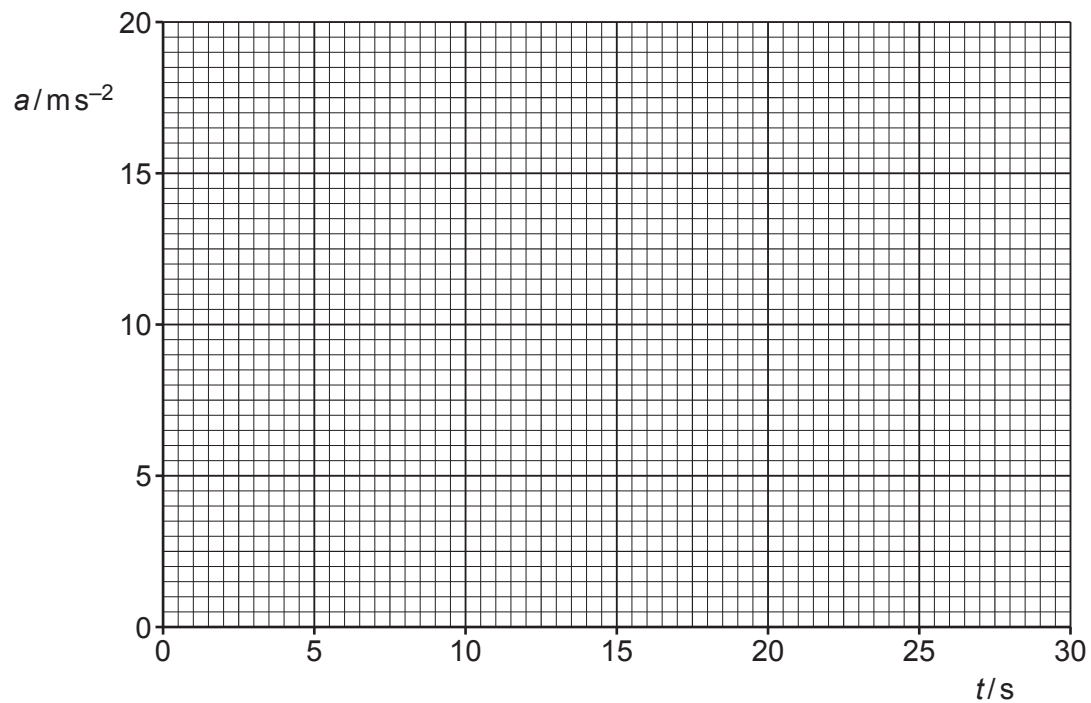


Fig. 2.2

[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.

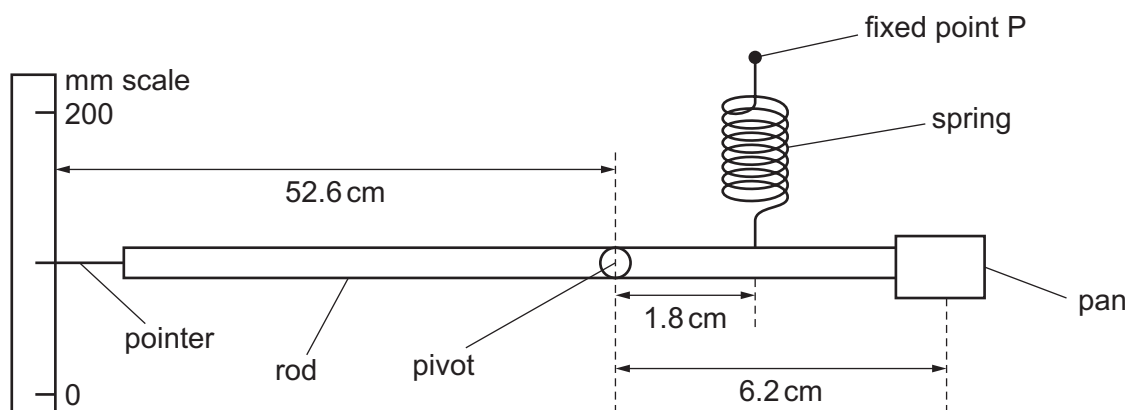


Fig. 3.1 (not to scale)

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.

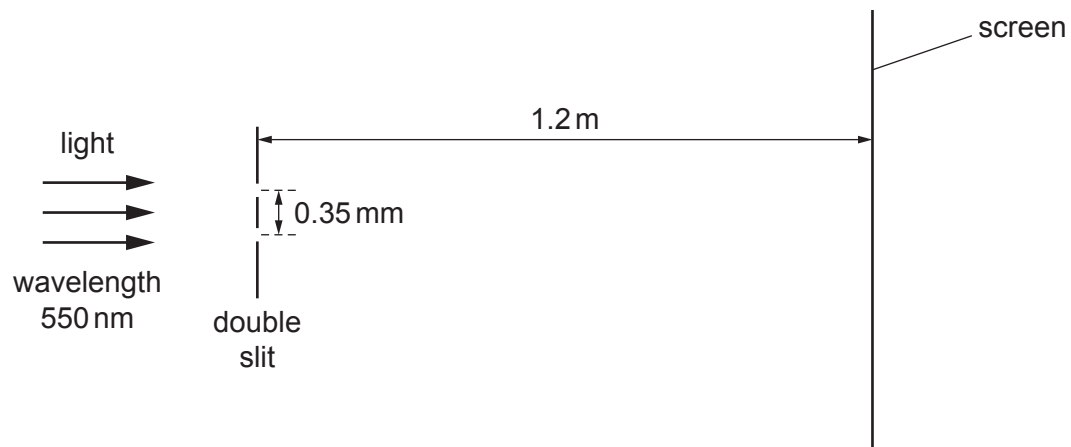


Fig. 4.1 (not to scale)

- (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.

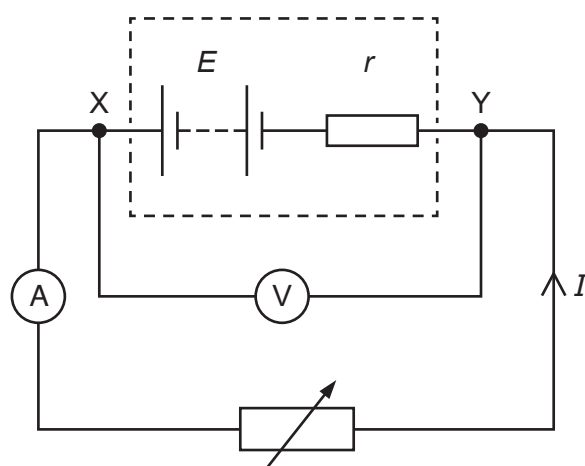


Fig. 5.1

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.

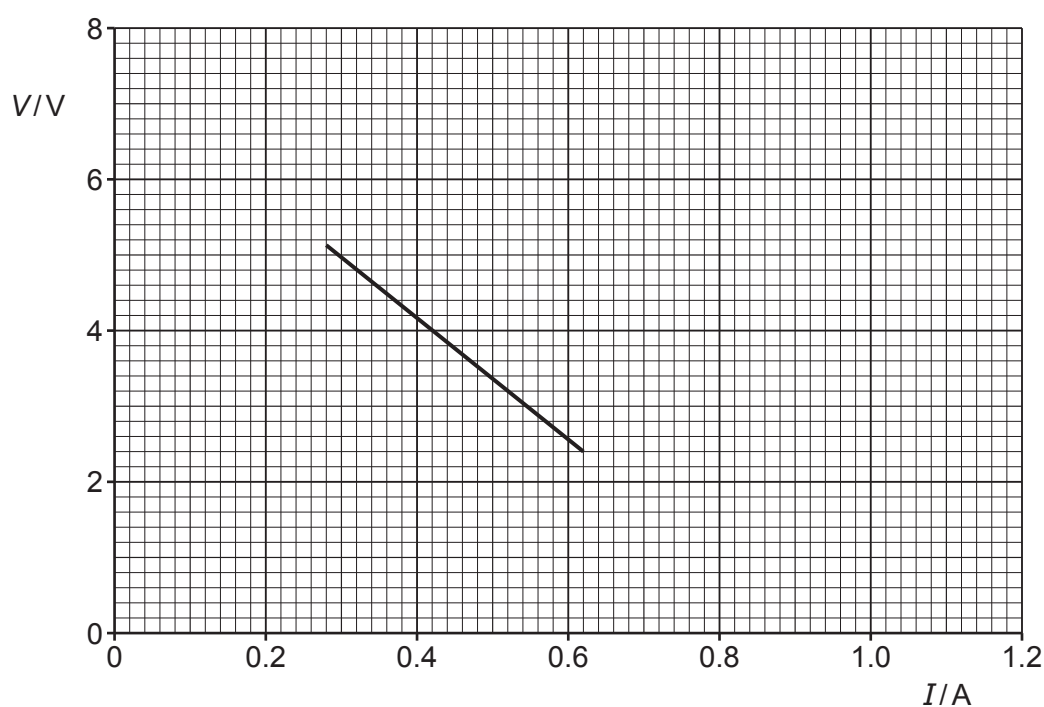


Fig. 5.2

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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