Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/21**

Paper 2 AS Level Structured Questions **May/June 2016**

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 **15** printed pages and **1** blank page.

DC (CW/FD) 108390/3

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[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(\frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\,\mathrm{m\,F^{-1}})$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass unit	$1\,\mathrm{u} = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$\phi = -\dfrac{Gm}{r}$
hydrostatic pressure	$p = \rho gh$
pressure of an ideal gas	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$f_o = \dfrac{f_s v}{v \pm v_s}$
electric potential	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
capacitors in series	$1/C = 1/C_1 + 1/C_2 + \ldots$
capacitors in parallel	$C = C_1 + C_2 + \ldots$
energy of charged capacitor	$W = \frac{1}{2}QV$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
Hall voltage	$V_H = \dfrac{BI}{ntq}$
alternating current/voltage	$x = x_0 \sin \omega t$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

[Turn over

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

1 **(a)** Make estimates of

(i) the mass, in kg, of a wooden metre rule,

mass = ... kg [1]

(ii) the volume, in cm^3, of a cricket ball or a tennis ball.

volume = ... cm^3 [1]

(b) A metal wire of length *L* has a circular cross-section of diameter *d*, as shown in Fig. 1.1.

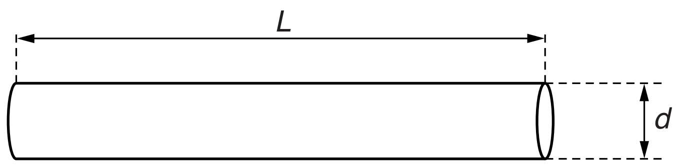

Fig. 1.1

The volume *V* of the wire is given by the expression

$$V = \frac{\pi d^2 L}{4}.$$

The diameter, length and mass *M* are measured to determine the density of the metal of the wire. The measured values are:

$d = 0.38 \pm 0.01\,\text{mm}$,
$L = 25.0 \pm 0.1\,\text{cm}$,
$M = 0.225 \pm 0.001\,\text{g}$.

Calculate the density of the metal, with its absolute uncertainty. Give your answer to an appropriate number of significant figures.

density = ... ± .... $kg\,m^{-3}$ [5]

[Total: 7]

2 A ball is thrown from a point P with an initial velocity u of $12\,\mathrm{m\,s^{-1}}$ at 50° to the horizontal, as illustrated in Fig. 2.1.

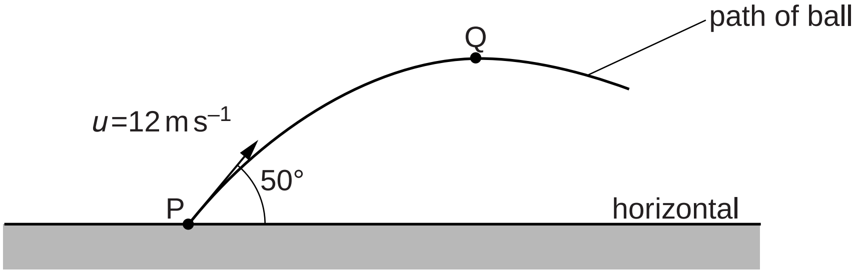

Fig. 2.1

The ball reaches maximum height at Q.

Air resistance is negligible.

(a) Calculate

(i) the horizontal component of u,

horizontal component = ... $\mathrm{m\,s^{-1}}$ [1]

(ii) the vertical component of u.

vertical component = ... $\mathrm{m\,s^{-1}}$ [1]

(b) Show that the maximum height reached by the ball is 4.3 m.

[2]

(c) Determine the magnitude of the displacement PQ.

displacement = ... m [4]

[Total: 8]

3 A ball of mass 150 g is at rest on a horizontal floor, as shown in Fig. 3.1.

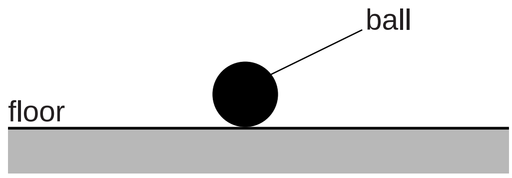

Fig. 3.1

(a) **(i)** Calculate the magnitude of the normal contact force from the floor acting on the ball.

force = ... N [1]

(ii) Explain your working in **(i)**.

....

....

....[1]

(b) The ball is now lifted above the floor and dropped so that it falls vertically, as illustrated in Fig. 3.2.

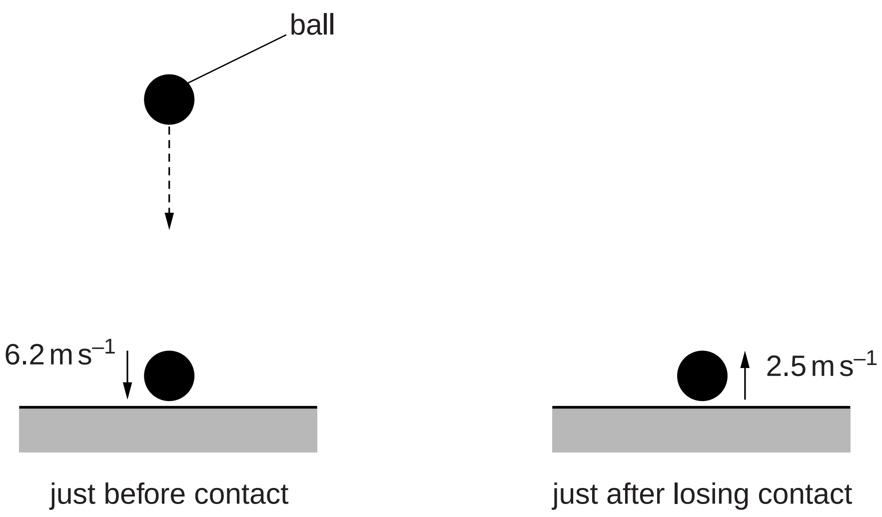

Fig. 3.2

Just before contact with the floor, the ball has velocity 6.2 $m\,s^{-1}$ downwards. The ball bounces from the floor and its velocity just after losing contact with the floor is 2.5 $m\,s^{-1}$ upwards. The ball is in contact with the floor for 0.12 s.

(i) State Newton's second law of motion.

....

....[1]

(ii) Calculate the average resultant force on the ball when it is in contact with the floor.

magnitude of force = ... N

direction of force ....
[3]

(iii) State and explain whether linear momentum is conserved during the collision of the ball with the floor.

....

....

....

....[2]

[Total: 8]

4 **(a)** State what is meant by *elastic potential energy*.

....

....[1]

(b) A spring is extended by applying a force. The variation with extension x of the force F is shown in Fig. 4.1 for the range of values of x from 20 cm to 40 cm.

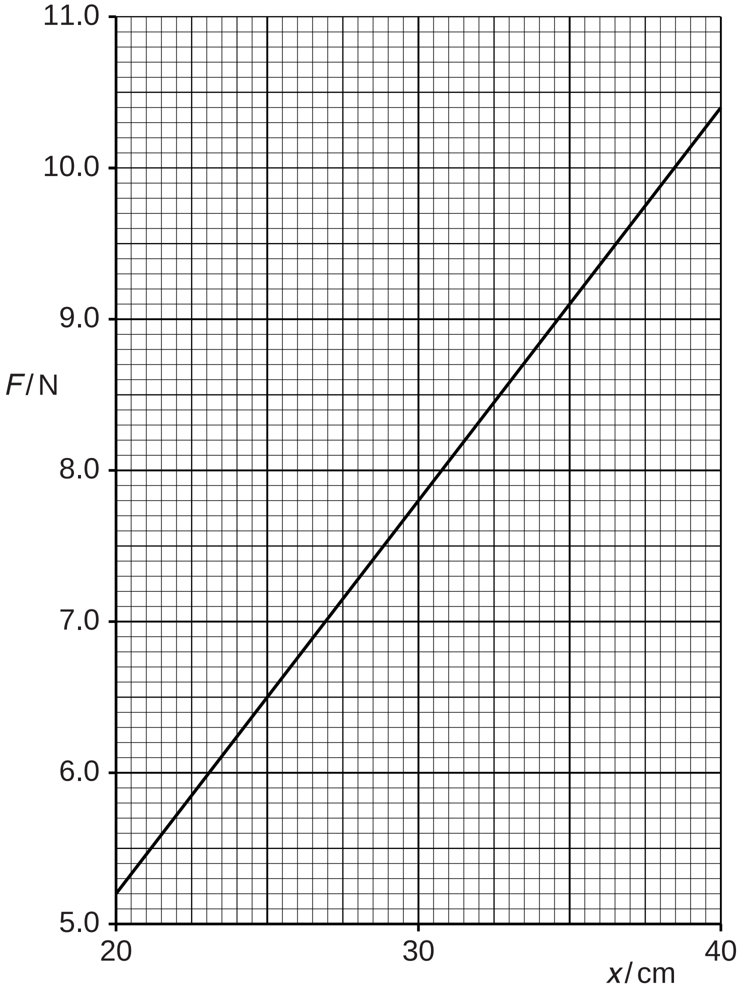

Fig. 4.1

(i) Use data from Fig. 4.1 to show that the spring obeys Hooke's law for this range of extensions.

....

....

....[2]

(ii) Use Fig. 4.1 to calculate

1. the spring constant,

spring constant = ... $N\,m^{-1}$ [2]

2. the work done extending the spring from x = 20 cm to x = 40 cm.

work done = ... J [3]

(c) A force is applied to the spring in **(b)** to give an extension of 50 cm.

State how you would check that the spring has not exceeded its elastic limit.

....

....[1]

[Total: 9]

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5 The variation with time *t* of the displacement *y* of a wave X, as it passes a point P, is shown in Fig. 5.1.

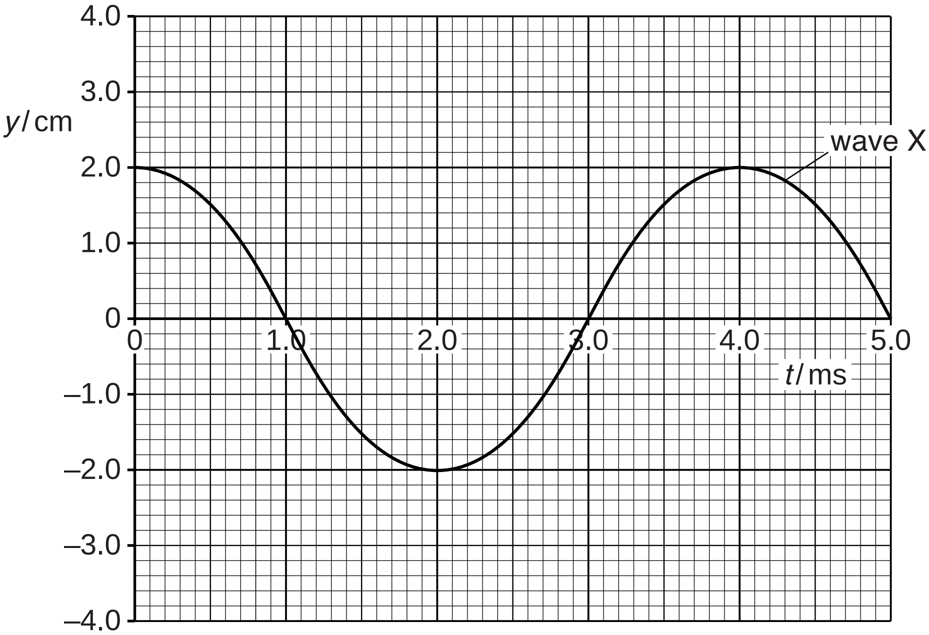

Fig. 5.1

The intensity of wave X is I.

(a) Use Fig. 5.1 to determine the frequency of wave X.

frequency = ... Hz [2]

(b) A second wave Z with the same frequency as wave X also passes point P.
Wave Z has intensity $2I$. The phase difference between the two waves is 90°.

On Fig. 5.1, sketch the variation with time *t* of the displacement *y* of wave Z.

Show your working.

[3]

(c) A double-slit interference experiment is used to determine the wavelength of light emitted from a laser, as shown in Fig. 5.2.

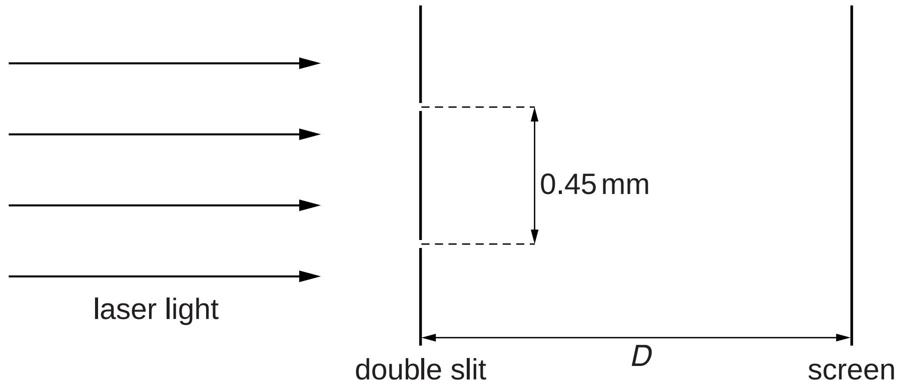

Fig. 5.2 (not to scale)

The separation of the slits is 0.45 mm. The fringes are viewed on a screen at a distance *D* from the double slit.

The fringe width *x* is measured for different distances *D*. The variation with *D* of *x* is shown in Fig. 5.3.

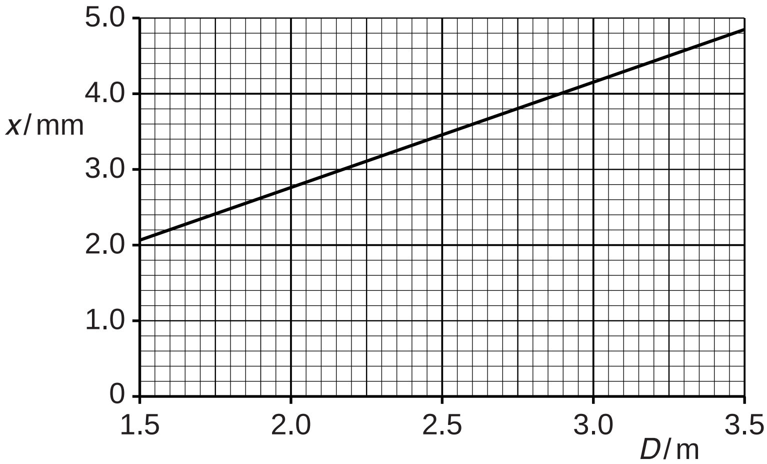

Fig. 5.3

(i) Use the gradient of the line in Fig. 5.3 to determine the wavelength, in nm, of the laser light.

wavelength = ... nm [4]

(ii) The separation of the slits is increased. State and explain the effects, if any, on the graph of Fig. 5.3.

....

....

....[2]

[Total: 11]

6 **(a)** Define the *coulomb*.

....[1]

(b) A resistor X is connected to a cell as shown in Fig. 6.1.

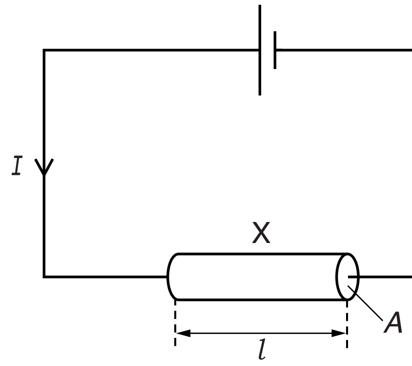

Fig. 6.1

The resistor is a wire of cross-sectional area A and length l. The current in the wire is I.

Show that the average drift speed v of the charge carriers in X is given by the equation

$$v = \frac{I}{nAe}$$

where e is the charge on a charge carrier and n is the number of charge carriers per unit volume in X.

[3]

(c) A 12V battery with negligible internal resistance is connected to two resistors Y and Z, as shown in Fig. 6.2.

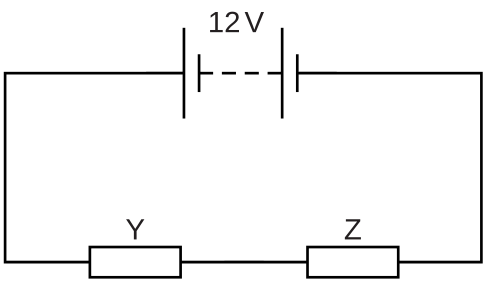

Fig. 6.2

The resistors are made from wires of the same material. The wire of Y has a diameter *d* and length l. The wire of Z has a diameter 2*d* and length $2l$.

(i) Determine the ratio

$$\frac{\text{average drift speed of the charge carriers in Y}}{\text{average drift speed of the charge carriers in Z}}\ .$$

ratio = ... [3]

(ii) Show that

$$\frac{\text{resistance of Y}}{\text{resistance of Z}} = 2.$$

[2]

(iii) Determine the potential difference across Y.

potential difference = ... V [2]

(iv) Determine the ratio

$$\frac{\text{power dissipated in Y}}{\text{power dissipated in Z}}\ .$$

ratio = ... [1]

[Total: 12]

7 **(a)** Give one example of

a hadron: ....

a lepton: ....
[1]

(b) Describe, in terms of the simple quark model,

(i) a proton,

....[1]

(ii) a neutron.

....[1]

(c) Beta particles may be emitted during the decay of an unstable nucleus of an atom. The emission of a beta particle is due to the decay of a neutron.

(i) Complete the following word equation for the particles produced in this reaction.

neutron → .... + ... + ... [1]

(ii) State the change in quark composition of the particles during this reaction.

....[1]

[Total: 5]