Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME		
CENTRE NUMBER		CANDIDATE NUMBER

1953185037

PHYSICS **9702/21**

Paper 2 AS Structured Questions **May/June 2015**

1 hour

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,	$c = 3.00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
	$\left(\dfrac{1}{4\pi\varepsilon_0} = 8.99 \times 10^{9}\ \mathrm{m\,F^{-1}}\right)$
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 constant,	$u = 1.66 \times 10^{-27}\ \mathrm{kg}$
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.,	$v = v_0 \cos \omega t$ $v = \pm\, \omega \sqrt{(x_0^{\,2} - x^2)}$
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,	$W = \frac{1}{2}QV$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
alternating current/voltage,	$x = x_0 \sin \omega t$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

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

1 **(a)** Use the definition of power to show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[2]

(b) Use an expression for electrical power to determine the SI base units of potential difference.

units ....[2]

2 **(a)** Define *speed* and *velocity* and use these definitions to explain why one of these quantities is a scalar and the other is a vector.

speed: ....

velocity: ....

....

....
[2]

(b) A ball is released from rest and falls vertically. The ball hits the ground and rebounds vertically, as shown in Fig. 2.1.

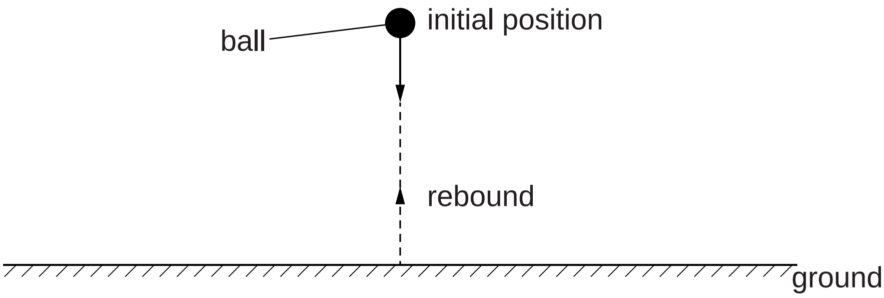

Fig. 2.1

The variation with time t of the velocity v of the ball is shown in Fig. 2.2.

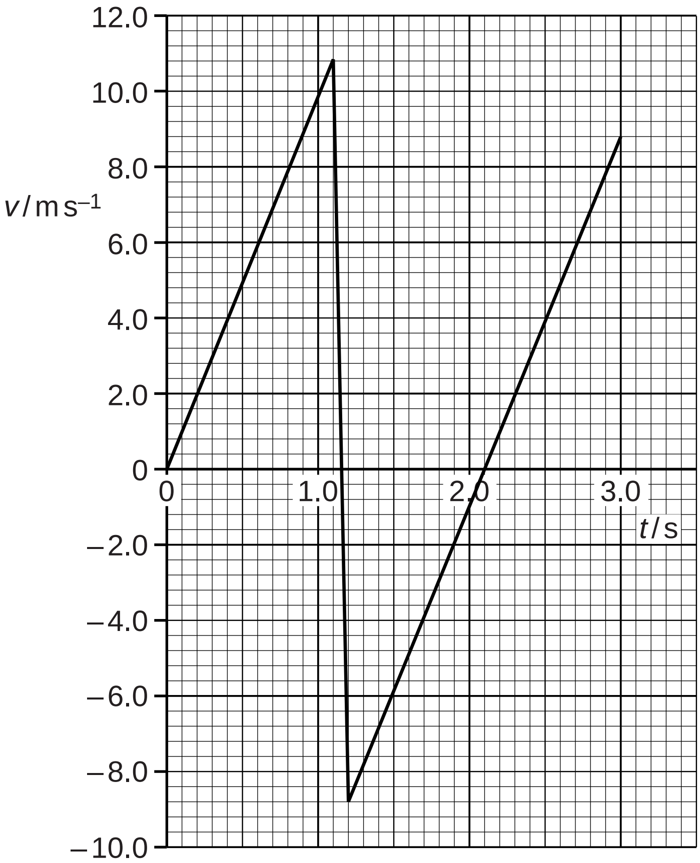

Fig. 2.2

Air resistance is negligible.

(i) Without calculation, use Fig. 2.2 to describe the variation with time t of the velocity of the ball from $t = 0$ to $t = 2.1$ s.

....

....

....

....

....

....[3]

(ii) Calculate the acceleration of the ball after it rebounds from the ground. Show your working.

acceleration = ... $m\,s^{-2}$ [3]

(iii) Calculate, for the ball, from $t = 0$ to $t = 2.1\,s$,

1. the distance moved,

distance = ... m [3]

2. the displacement from the initial position.

displacement = ... m [2]

(iv) On Fig. 2.3, sketch the variation with t of the speed of the ball.

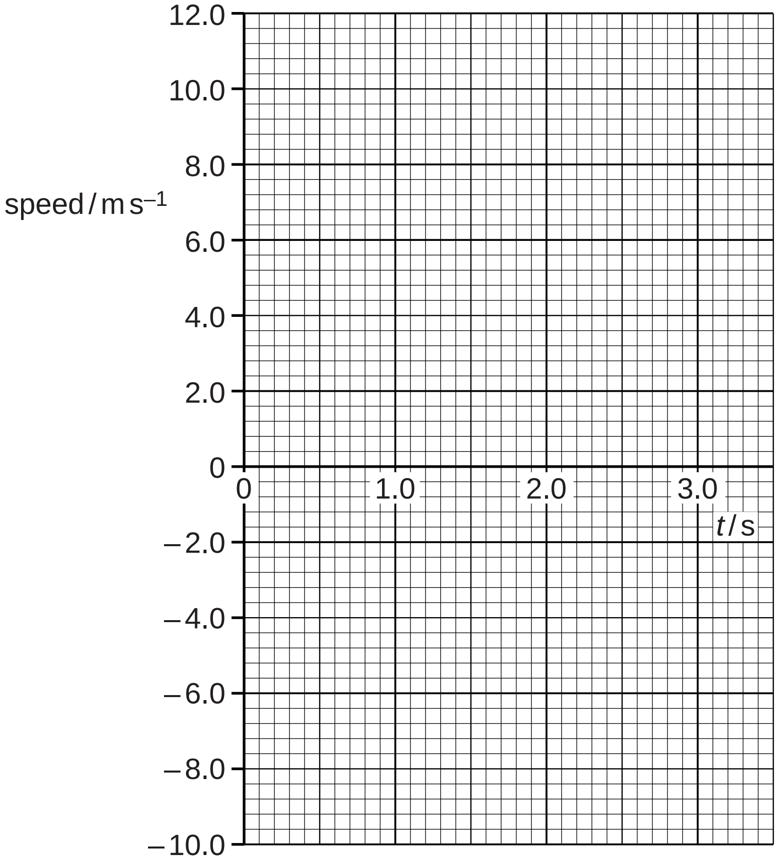

Fig. 2.3

[2]

3 Two balls X and Y are supported by long strings, as shown in Fig. 3.1.

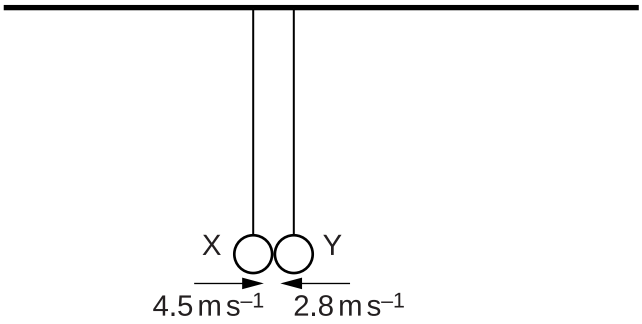

Fig. 3.1

The balls are each pulled back and pushed towards each other. When the balls collide at the position shown in Fig. 3.1, the strings are vertical. The balls rebound in opposite directions.

Fig. 3.2 shows data for X and Y during this collision.

ball	mass	velocity just before collision / m s^{-1}	velocity just after collision / m s^{-1}
X	50 g	+4.5	–1.8
Y	*M*	–2.8	+1.4

Fig. 3.2

The positive direction is horizontal and to the right.

(a) Use the conservation of linear momentum to determine the mass *M* of Y.

M = ... g [3]

(b) State and explain whether the collision is elastic.

....

....

....[1]

(c) Use Newton's second and third laws to explain why the magnitude of the change in momentum of each ball is the same.

....

....

....

....

....[3]

4 A spring is kept horizontal by attaching it to points A and B, as shown in Fig. 4.1.

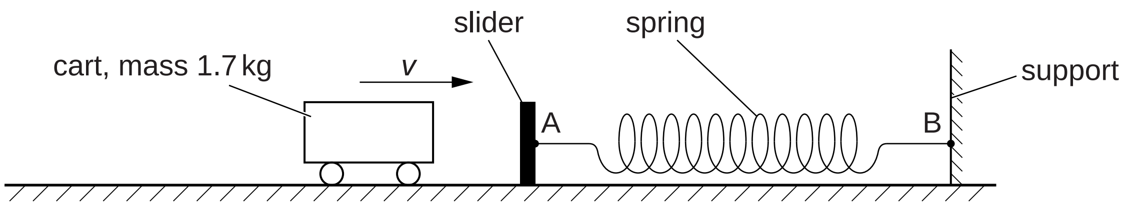

Fig. 4.1

Point A is on a movable slider and point B is on a fixed support. A cart of mass 1.7 kg has horizontal velocity v towards the slider. The cart collides with the slider. The spring is compressed as the cart comes to rest. The variation of compression x of the spring with force F exerted on the spring is shown in Fig. 4.2.

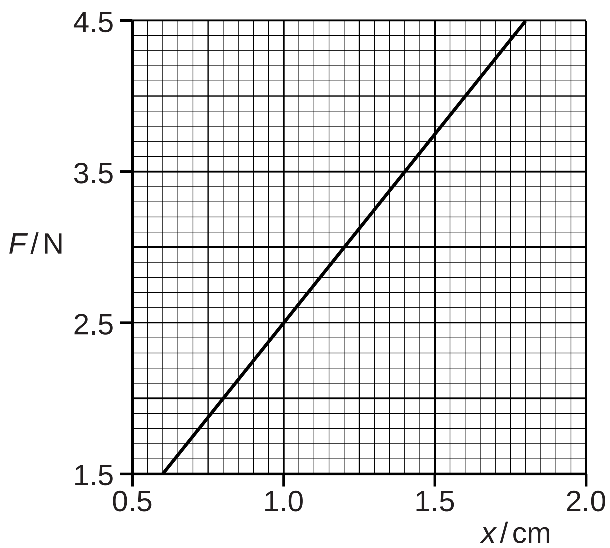

Fig. 4.2

Fig. 4.2 shows the compression of the spring for F = 1.5 N to F = 4.5 N. The cart comes to rest when F is 4.5 N.

(a) Use Fig. 4.2 to

(i) show that the compression of the spring obeys Hooke's law,

....

....

....[2]

(ii) determine the spring constant of the spring,

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

(iii) determine the elastic potential energy E_P stored in the spring due to the cart being brought to rest.

E_P = ... J [3]

(b) Calculate the speed v of the cart as it makes contact with the slider. Assume that all the kinetic energy of the cart is converted to the elastic potential energy of the spring.

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

5 The variation with potential difference (p.d.) V of current I for a semiconductor diode is shown in Fig. 5.1.

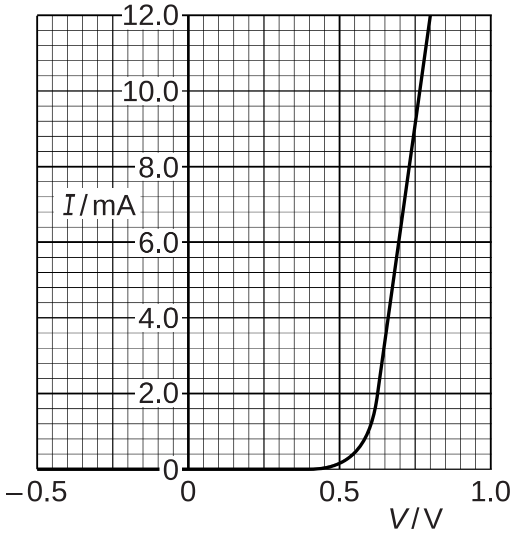

Fig. 5.1

(a) Use Fig. 5.1 to describe the variation of the resistance of the diode between V = –0.5 V and V = 0.8 V.

....

....

....

....[2]

(b) On Fig. 5.2, sketch the variation with p.d. V of current I for a filament lamp. Numerical values are not required.

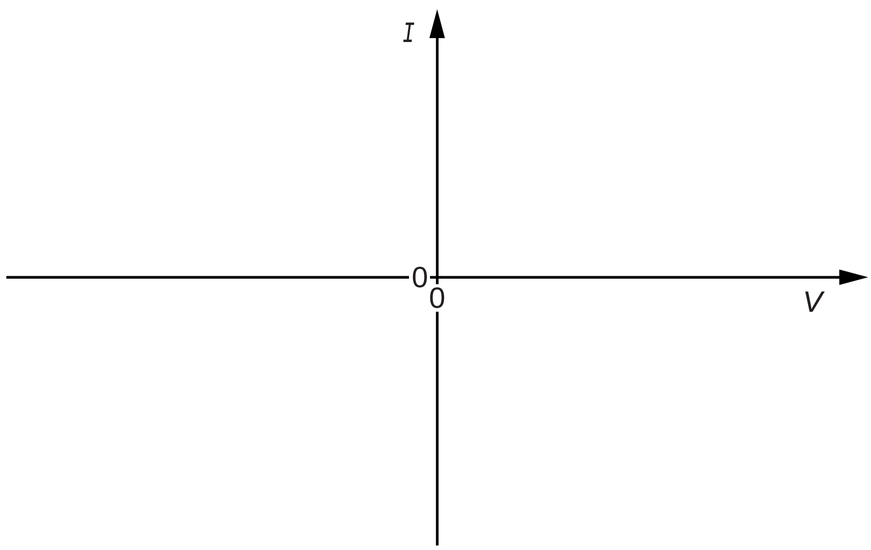

Fig. 5.2

[2]

(c) Fig. 5.3 shows a power supply of electromotive force (e.m.f.) 12 V and internal resistance 0.50 Ω connected to a filament lamp and switch.

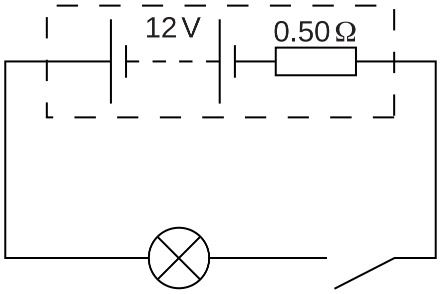

Fig. 5.3

The filament lamp has a power of 36 W when the p.d. across it is 12 V.

(i) Calculate the resistance of the lamp when the p.d. across it is 12 V.

resistance = ... Ω [1]

(ii) The switch is closed and the current in the lamp is 2.8 A. Calculate the resistance of the lamp.

resistance = ... Ω [3]

(d) Explain how the two values of resistance calculated in **(c)** provide evidence for the shape of the sketch you have drawn in **(b)**.

....

....[1]

6 **(a)** State what is meant by *diffraction* and by *interference*.

diffraction: ....

....

interference: ....

....
[3]

(b) Light from a source S_1 is incident on a diffraction grating, as illustrated in Fig. 6.1.

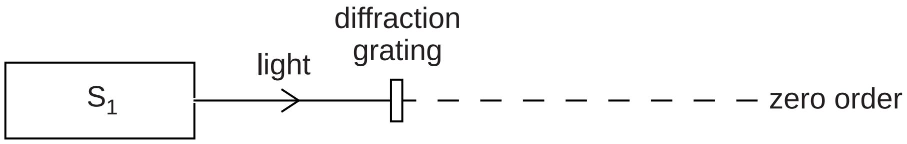

Fig. 6.1 (not to scale)

The light has a single frequency of 7.06×10^{14} Hz. The diffraction grating has 650 lines per millimetre.

Calculate the number of orders of diffracted light produced by the grating. Do not include the zero order.
Show your working.

number = ... [3]

(c) A second source S_2 is used in place of S_1. The light from S_2 has a single frequency lower than that of the light from S_1.

State and explain whether more orders are seen with the light from S_2.

....

....[1]

7 **(a)** Explain what is meant by an *electric field*.

....

....[1]

(b) A uniform electric field is produced between two vertical metal plates AB and CD, as shown in Fig. 7.1.

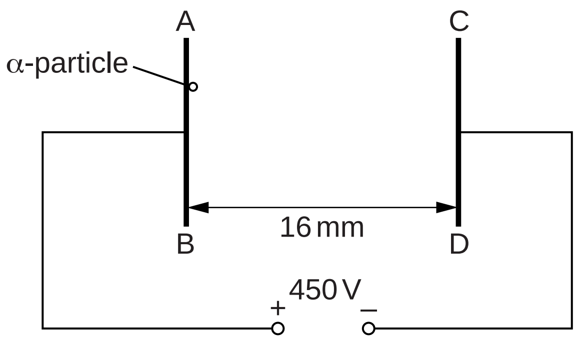

Fig. 7.1

The potential difference between the plates is 450 V and the separation of the plates is 16 mm.

An α-particle is accelerated from plate AB to plate CD.

(i) On Fig. 7.1, draw lines to represent the electric field between the plates. [2]

(ii) Calculate the electric field strength between the plates.

electric field strength = ... $\mathrm{V\,m^{-1}}$ [2]

(iii) Calculate the work done by the electric field on the α-particle as it moves from AB to CD.

work done = ... J [3]

Question 7 continues on page 16.

(iv) A β-particle moves from AB to CD. Calculate the ratio

$$\frac{\text{work done by the electric field on the } \alpha\text{-particle}}{\text{work done by the electric field on the } \beta\text{-particle}}.$$

Show your working.

ratio = ... [1]