UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

PHYSICS **9702/21**

Paper 2 AS Structured Questions

May/June 2012

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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
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.

For Examiner's Use	
1	
2	
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Total	

This document consists of **14** printed pages and **2** blank pages.

DC (SJF/SW) 42132/3

UNIVERSITY *of* CAMBRIDGE
International Examinations

[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 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,	$\lambda = \dfrac{0.693}{t_{\frac{1}{2}}}$

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

For Examiner's Use

1 **(a)** **(i)** State the SI base units of volume.

base units of volume ....m^3........ [1]

(ii) Show that the SI base units of pressure are kg m^{-1} s^{-2}.

Pressure = $\frac{\text{Force}}{\text{Area}} = \frac{\text{Kgms}^{-2}}{m^2} = \text{Kgm}^{-1}\text{s}^{-2}$

[1]

(b) The volume V of liquid that flows through a pipe in time t is given by the equation

$$\frac{V}{t} = \frac{\pi P r^4}{8Cl}$$

where P is the pressure difference between the ends of the pipe of radius r and length l. The constant C depends on the frictional effects of the liquid.

Determine the base units of C.

$\frac{V}{t} = \frac{\pi P r^4}{8CL}$ $\quad C = \frac{\pi P r^4 t}{8VL}$

Units = $\frac{\text{Kgm}^{-1}\text{s}^{-2} \times m^4 \times s}{m^3 \times m} = \text{Kgm}^{-1}\text{s}^{-1}$

base units of C ....$\text{Kgm}^{-1}\text{s}^{-1}$........ [3]

For Examiner's Use

2 A ball is thrown vertically down towards the ground with an initial velocity of $4.23\,\mathrm{m\,s^{-1}}$. The ball falls for a time of 1.51 s before hitting the ground. Air resistance is negligible.

(a) (i) Show that the downwards velocity of the ball when it hits the ground is $19.0\,\mathrm{m\,s^{-1}}$.

$v = u + at$

$= 4.23 + 9.81 \times 1.51 \Rightarrow 19.043$

$\approx 19.0\ \mathrm{ms^{-1}}$ (2sf)

4.23 ↓ t = 1.51s, v = ?

[2]

(ii) Calculate, to three significant figures, the distance the ball falls to the ground.

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

$= 4.23 \times 1.51 + \frac{1}{2} \times 9.81 \times 1.51^2$

$= 17.645 \approx 17.6$

distance = 17.6 m [2]

(b) The ball makes contact with the ground for 12.5 ms and rebounds with an upwards velocity of $18.6\,\mathrm{m\,s^{-1}}$. The mass of the ball is 46.5 g.

(i) Calculate the average force acting on the ball on impact with the ground.

$F = \frac{\text{change in momentum}}{\text{time}} = \frac{mv_2 - mv_1}{t} = \frac{46.5\times10^{-3}(18.6 - (-19))}{12.5\times10^{-3}} = 139.87\ \mathrm{N} \approx 140\ \mathrm{N}$ (2sf)

magnitude of force = 140 N N

direction of force Upwards

[4]

(ii) Use conservation of energy to determine the maximum height the ball reaches after it hits the ground.

$mgh = \frac{1}{2}mv^2$

$h = \frac{1}{2} \times \frac{v^2}{g}$

$h = \frac{1}{2} \times \frac{18.6^2}{9.81}$

$= 17.63$

height = 17.6 m [2]

(c) State and explain whether the collision the ball makes with the ground is elastic or inelastic.

The collison is inelastic because momentum is not the same before & after as speed before impact & after are diffrent.

[1]

3 One end of a spring is fixed to a support. A mass is attached to the other end of the spring. The arrangement is shown in Fig. 3.1.

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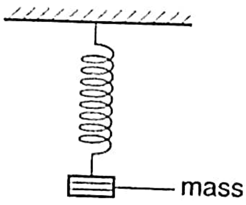

Fig. 3.1

(a) The mass is in equilibrium. Explain, by reference to the forces acting on the mass, what is meant by equilibrium.

It means the overall (Resultant) force on the mass will be 0, the weight will equal the upward force due to the spring .... [2]

(b) The mass is pulled down and then released at time $t = 0$. The mass oscillates up and down. The variation with t of the displacement of the mass d is shown in Fig. 3.2.

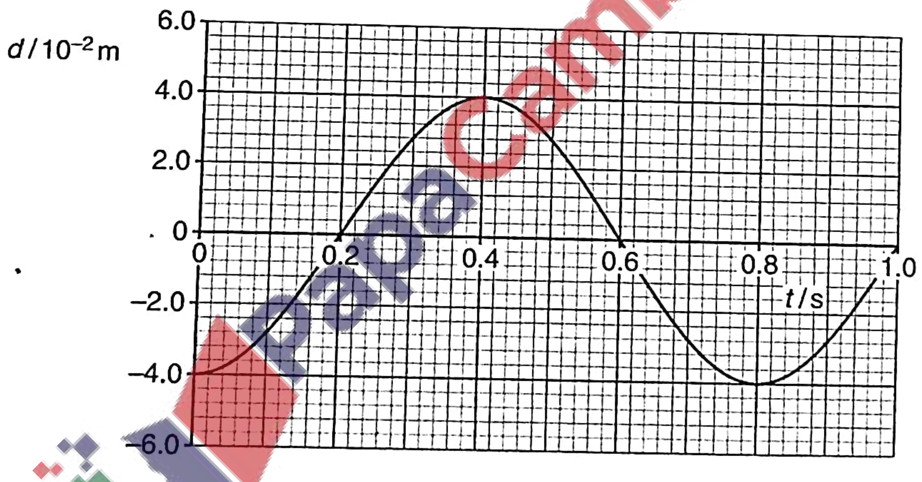

Fig. 3.2

Use Fig. 3.2 to state a time, one in each case, when

(i) the mass is at maximum speed,

Eq

time = ...0·2...... s [1]

(ii) the elástic potential energy stored in the spring is a maximum,

at $\frac{1}{2}mv^2 = 0$

time = ...0...... s [1]

(iii) the mass is in equilibrium.

KE = max = 0·2

time = ...0·2...... s [1]

(c) The arrangement shown in Fig. 3.3 is used to determine the length l of a spring when different masses M are attached to the spring.

For Examiner's Use

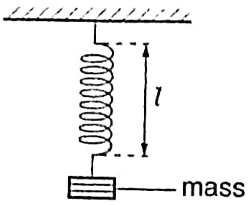

Fig. 3.3

The variation with mass M of l is shown in Fig. 3.4.

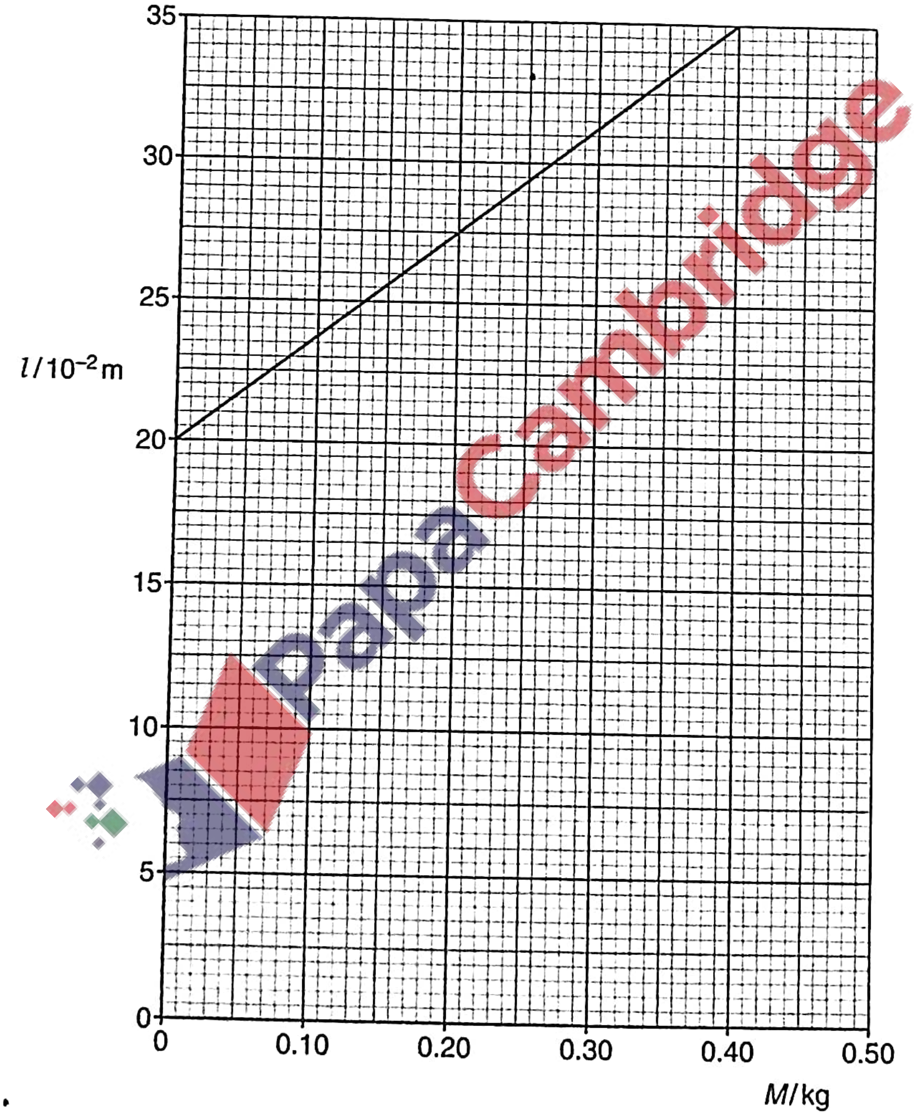

Fig. 3.4

For Examiner's Use

(i) State and explain whether the spring obeys Hooke's law.

Yes it obeys Hooke's law as the graph is a straight line, Hookes law states Force is proportional to ~~mass~~ extension (Hence true) [2]

(ii) Show that the force constant of the spring is 26 N m^{-1}.

@ $F = 0.40 \times 9.81$ $L = 35 \times 10^{-2}$ m

$\therefore$ extension $= 35 \times 10^{-2} - 20 \times 10^{-2}$
$= 15 \times 10^{-2}$

$F = Kx$

$\left(\frac{(N)}{(m)}\right) \frac{0.40 \times 9.81}{15 \times 10^{-2}} = K$ $\therefore K = 26.16$

≈ 26 Nm^{-1}

[2]

(iii) A mass of 0.40 kg is attached to the spring. Calculate the energy stored in the spring.

$\frac{1}{2}kx^2 = \frac{1}{2} \times 26.16 \times (15 \times 10^{-2})^2 = 0.2943$

≈ 0.294

$\therefore E = 0.29$ (2SF)

energy = 0.29 J [3]

4 (a) The output of a heater is 2.5 kW when connected to a 220 V supply.

For Examiner's Use

(i) Calculate the resistance of the heater.

$P = \frac{V^2}{R}$ $2500 = \frac{220^2}{R}$

$R = \frac{220^2}{2500} = 19.36$

$\approx$ 19 (2sf)

resistance = ...19........ Ω [2]

(ii) The heater is made from a wire of cross-sectional area 2.0×10^{-7} m^2 and resistivity 1.1×10^{-6} Ω m.

Use your answer in (i) to calculate the length of the wire.

$R = \frac{\rho L}{A}$ $L = \frac{19.36 \times 2 \times 10^{-7}}{1.1 \times 10^{-6}} = 3.52$ m

≈ 3.5 (2sf)

length = ...3.5........ m [3]

(b) The supply voltage is changed to 110 V.

(i) Calculate the power output of the heater at this voltage, assuming there is no change in the resistance of the wire.

$P \propto V^2$

$\therefore P = \frac{1}{4} \times 2500 = 625$ W

power = ...625........ W [1]

(ii) State and explain quantitatively **one** way that the wire of the heater could be changed to give the same power as in (a).

~~The area must be~~ cross sectional area must be increased 4 times as much as $P \propto 1/R$ & $P \propto V^2$ so to compensate area must increase. [2]

For Examiner's Use

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

Kirchhoff's second law states sum of EMF in the circuit is equal to the sum of potential difference in the circuit .... [1]

(ii) Kirchhoff's second law is linked to the conservation of a certain quantity. State this quantity.

Energy. .... [1]

(b) The circuit shown in Fig. 5.1 is used to compare potential differences.

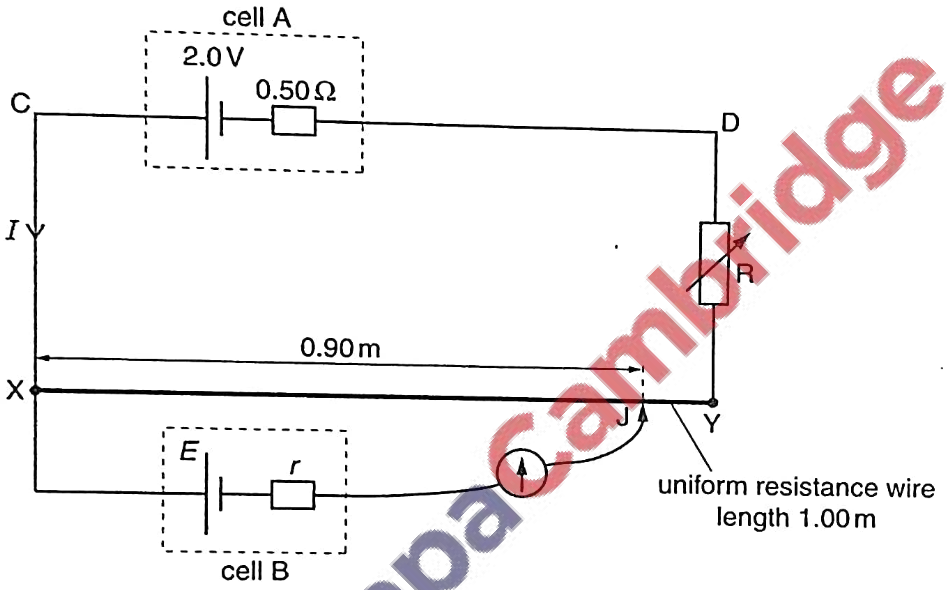

Fig. 5.1

The uniform resistance wire XY has length 1.00m and resistance 4.0Ω. Cell A has e.m.f. 2.0V and internal resistance 0.50Ω. The current through cell A is I. Cell B has e.m.f. E and internal resistance r.

The current through cell B is made zero when the movable connection J is adjusted so that the length of XJ is 0.90m. The variable resistor R has resistance 2.5Ω.

(i) Apply Kirchhoff's second law to the circuit CXYDC to determine the current I.

$2 = I \times R$

$2 = I\ (0.50 + 2.5 + 4)$

$I = 0.2857$

≈ 0.286

$I =$ ..... 0.29 ..... A [2]

(ii) Calculate the potential difference across the length of wire XJ.

Resistance of 0.9m wire = $\frac{0.9}{1} \times 4$ = 3.6Ω

V = IR = 0.2857 × 3.6 = 1.02852 V

≈ 1.03

potential difference = 1.03 V [2]

(iii) Use your answer in (ii) to state the value of *E*.

when 1.03 = 1.03 current = 0

E = 1.03 V [1]

(iv) State why the value of the internal resistance of cell B is not required for the determination of *E*.

As current = 0, V = IR, so

V = 0 [1]

6 (a) A laser is used to produce an interference pattern on a screen, as shown in Fig. 6.1.

For Examiner's Use

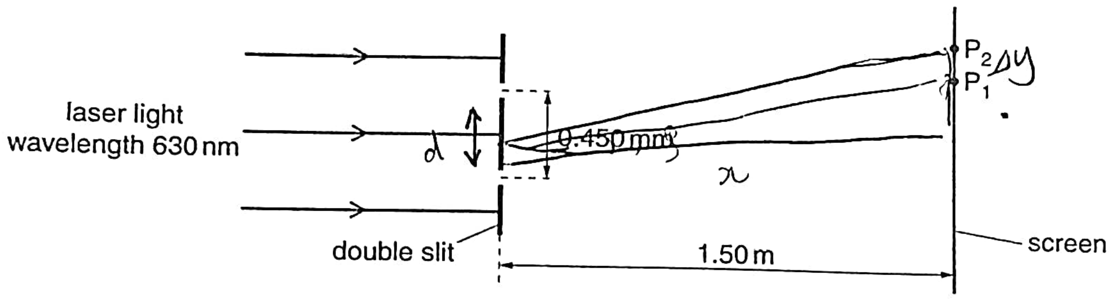

Fig. 6.1 (not to scale)

The laser emits light of wavelength 630 nm. The slit separation is 0.450 mm. The distance between the slits and the screen is 1.50 m. A maximum is formed at P_1 and a minimum is formed at P_2.
Interference fringes are observed only when the light from the slits is coherent.

(i) Explain what is meant by *coherence*.

Coherence means two or more waves having the same phase difference

.... [2]

(ii) Explain how an interference maximum is formed at P_1.

As phase difference = ~~...~~ λ

.... [1]

(iii) Explain how an interference minimum is formed at P_2.

As phase diffrence = $1\frac{1}{2}\lambda$

.... [1]

(iv) Calculate the fringe separation.

$$\Delta y = \frac{x\lambda}{d} = \frac{1.50 \times 630 \times 10^{-9}}{0.450 \times 10^{-3}}$$

$$= 0.0021$$

fringe separation = 0.0021 m [3]

(b) State the effects, if any, on the fringes when the amplitude of the waves incident on the double slits is increased.

For Examiner's Use

Since Amplitude is proportional to the square of intensity, increasing Amplitude will ~~change~~ increase the brightness of the bright fringes but wouldn't change fringe seperation. ($A \propto I$)

[3]

For Examiner's Use

7 (a) The spontaneous decay of polonium is shown by the nuclear equation

$$^{210}_{84}\text{Po} \rightarrow {}^{206}_{82}\text{Pb} + \text{X}.$$

(i) State the composition of the nucleus of X.

Helium nucleus → 2proton & 2nuetrons.

.... [1]

(ii) The nuclei X are emitted as radiation. State two properties of this radiation.

1. It is highly ionising in air

....

2. Is a particle that is positively charged that can be stopped by few cm of air.

[2]

(b) The mass of the polonium (Po) nucleus is greater than the combined mass of the nuclei of lead (Pb) and X. Use a conservation law to explain qualitatively how this decay is possible.

Even though mass differs, the total mass & energy before the ~~radiation~~ α particle is emitted & after remains constant. the mass is changed to energy that is released as gamma rays. [3]