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

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

5083540412

PHYSICS **9702/02**

Paper 2 AS Structured Questions **October/November 2007**

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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7	
Total	

This document consists of **15** printed pages and **1** blank page.

SP (NF/CGW) T19292/2

UNIVERSITY *of* CAMBRIDGE
International Examinations

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,	$\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
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,	$p = \frac{1}{3}\dfrac{Nm}{V}<c^2>$
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.

1 **(a)** Distinguish between systematic errors and random errors.

systematic errors ....

....

random errors ....

.... [2]

(b) A cylinder of length L has a circular cross-section of radius R, as shown in Fig. 1.1.

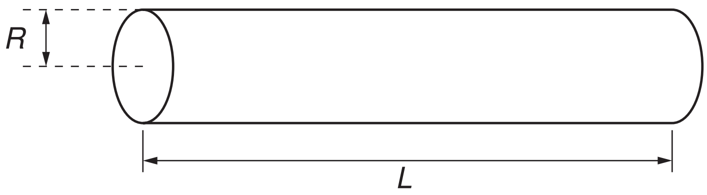

Fig. 1.1

The volume V of the cylinder is given by the expression

$$V = \pi R^2 L.$$

The volume and length of the cylinder are measured as

$V = 15.0 \pm 0.5\,\text{cm}^3$
$L = 20.0 \pm 0.1\,\text{cm}.$

Calculate the radius of the cylinder, with its uncertainty.

radius = ... ± .... cm [5]

2 A girl G is riding a bicycle at a constant velocity of $3.5\,\mathrm{m\,s^{-1}}$. At time $t = 0$, she passes a boy B sitting on a bicycle that is stationary, as illustrated in Fig. 2.1.

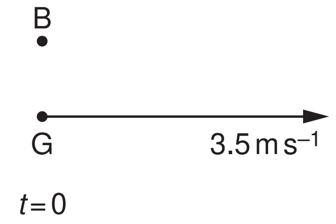

Fig. 2.1

At time $t = 0$, the boy sets off to catch up with the girl. He accelerates uniformly from time $t = 0$ until he reaches a speed of $5.6\,\mathrm{m\,s^{-1}}$ in a time of 5.0 s. He then continues at a constant speed of $5.6\,\mathrm{m\,s^{-1}}$. At time $t = T$, the boy catches up with the girl.
T is measured in seconds.

(a) State, in terms of T, the distance moved by the girl before the boy catches up with her.

distance = ... m [1]

(b) For the boy, determine

(i) the distance moved during his acceleration,

distance = ... m [2]

(ii) the distance moved during the time that he is moving at constant speed.
Give your answer in terms of T.

distance = ... m [1]

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(c) Use your answers in **(a)** and **(b)** to determine the time T taken for the boy to catch up with the girl.

T = ... s [2]

(d) The boy and the bicycle have a combined mass of 67 kg.

(i) Calculate the force required to cause the acceleration of the boy.

force = ... N [3]

(ii) At a speed of $4.5\,\mathrm{m\,s^{-1}}$, the total resistive force acting on the boy and bicycle is 23 N.
Determine the output power of the boy's legs at this speed.

power = ... W [2]

For Examiner's Use

3 **(a)** **(i)** Define potential energy.

....

.... [1]

(ii) Distinguish between *gravitational* potential energy and *elastic* potential energy.

gravitational potential energy ....

....

elastic potential energy ....

.... [2]

(b) A small sphere of mass 51 g is suspended by a light inextensible string from a fixed point P.
The centre of the sphere is 61 cm vertically below point P, as shown in Fig. 3.1.

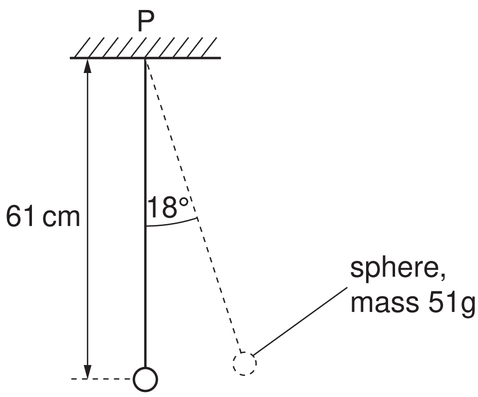

Fig. 3.1

The sphere is moved to one side, keeping the string taut, so that the string makes an angle of 18° with the vertical. Calculate

(i) the gain in gravitational potential energy of the sphere,

gain = ……………………….. J [2]

(ii) the moment of the weight of the sphere about point P.

moment = ... N m [2]

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4 A sample of material in the form of a cylindrical rod has length L and uniform area of cross-section A. The rod undergoes an increasing tensile stress until it breaks.
Fig. 4.1 shows the variation with stress of the strain in the rod.

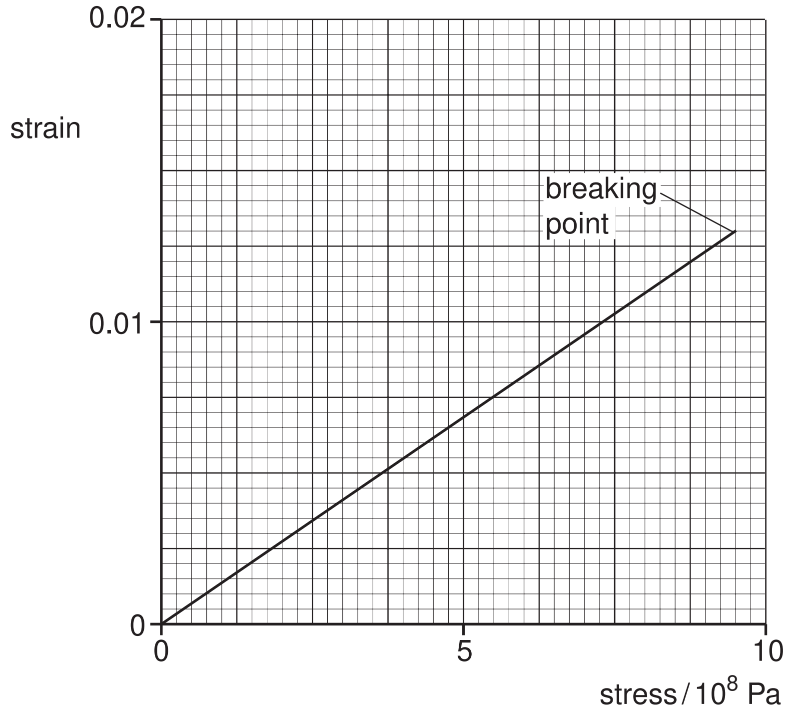

Fig. 4.1

(a) State whether the material of the rod is ductile, brittle or polymeric.

.... [1]

(b) Determine the Young modulus of the material of the rod.

Young modulus = ... Pa [2]

(c) A second cylindrical rod of the same material has a spherical bubble in it, as illustrated in Fig. 4.2.

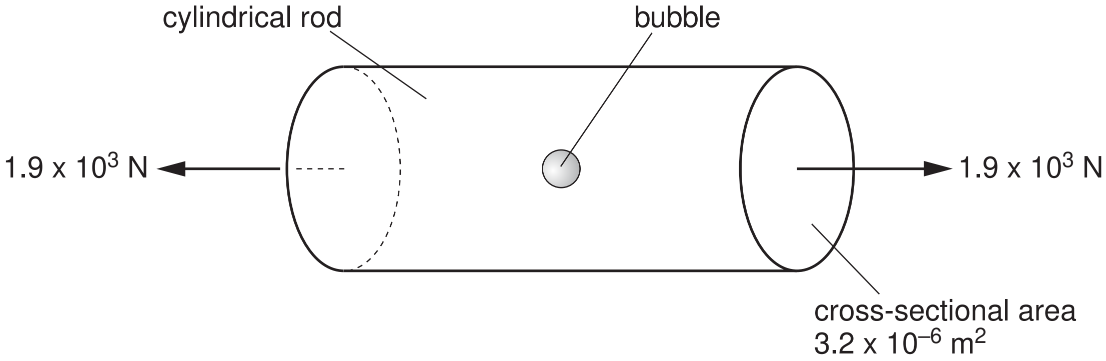

Fig. 4.2

The rod has an area of cross-section of $3.2 \times 10^{-6}\,m^2$ and is stretched by forces of magnitude $1.9 \times 10^3\,N$.
By reference to Fig. 4.1, calculate the maximum area of cross-section of the bubble such that the rod does not break.

area = ... m^2 [3]

(d) A straight rod of the same material is bent as shown in Fig. 4.3.

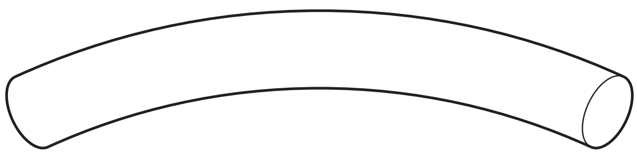

Fig. 4.3

Suggest why a thin rod can bend more than a thick rod without breaking.

....

....

.... [2]

5 **(a)** Fig. 5.1 shows the variation with time t of the displacement y of a wave W as it passes a point P. The wave has intensity I.

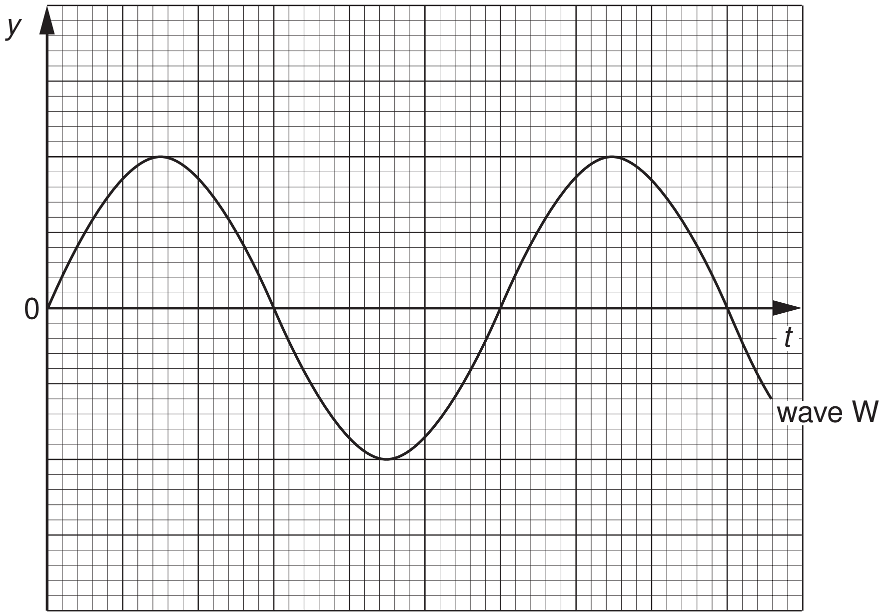

Fig. 5.1

A second wave X of the same frequency as wave W also passes point P.
This wave has intensity $\frac{1}{2}I$. The phase difference between the two waves is 60°.
On Fig. 5.1, sketch the variation with time t of the displacement y of wave X. [3]

(b) In a double-slit interference experiment using light of wavelength 540 nm, the separation of the slits is 0.700 mm. The fringes are viewed on a screen at a distance of 2.75 m from the double slit, as illustrated in Fig. 5.2 (not to scale).

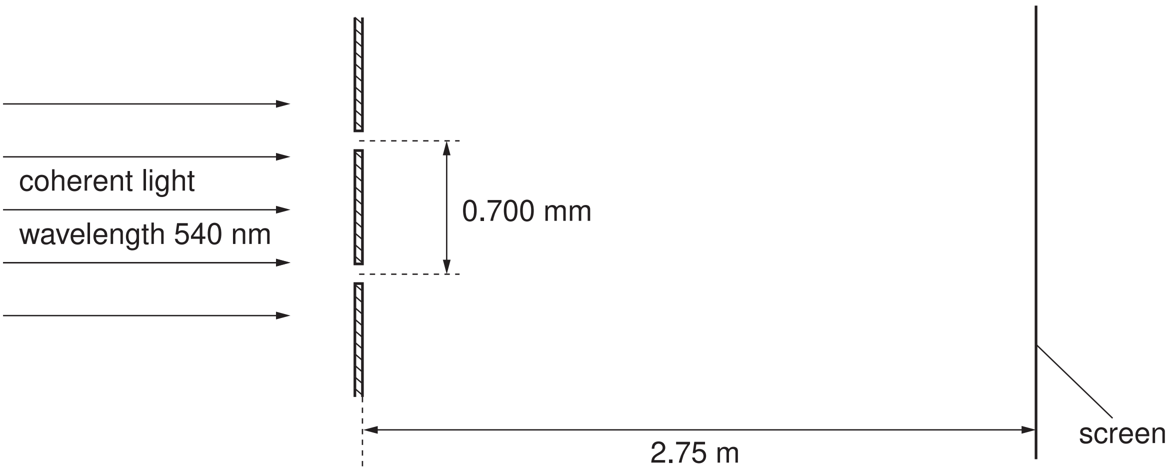

Fig. 5.2

Calculate the separation of the fringes observed on the screen.

separation = ... mm [3]

(c) State the effect, if any, on the appearance of the fringes observed on the screen when the following changes are made, separately, to the double-slit arrangement in **(b).**

(i) The width of each slit is increased but the separation remains constant.

....

....

....

.... [3]

(ii) The separation of the slits is increased.

....

....

.... [2]

6 An electric shower unit is to be fitted in a house. The shower is rated as 10.5 kW, 230 V. The shower unit is connected to the 230 V mains supply by a cable of length 16 m, as shown in Fig. 6.1.

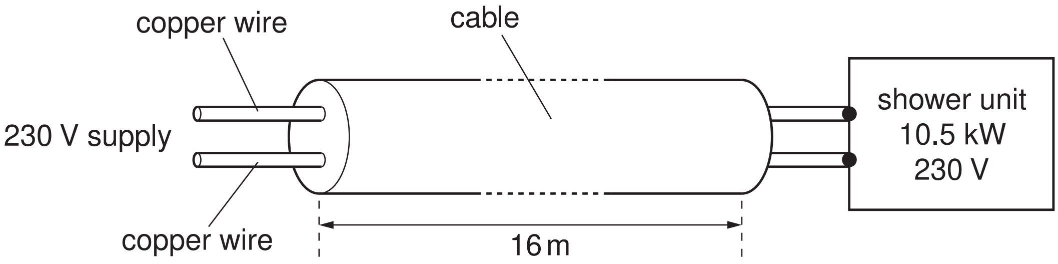

Fig. 6.1

(a) Show that, for normal operation of the shower unit, the current is approximately 46 A.

[2]

(b) The resistance of the two wires in the cable causes the potential difference across the shower unit to be reduced. The potential difference across the shower unit must not be less than 225 V.
The wires in the cable are made of copper of resistivity $1.8 \times 10^{-8}\ \Omega\,m$.
Assuming that the current in the wires is 46 A, calculate

(i) the maximum resistance of the cable,

resistance = ... Ω [3]

(ii) the minimum area of cross-section of each wire in the cable.

area = ... m^2 [3]

(c) Connecting the shower unit to the mains supply by means of a cable having wires with too small a cross-sectional area would significantly reduce the power output of the shower unit.

(i) Assuming that the shower is operating at 210 V, rather than 230 V, and that its resistance is unchanged, determine the ratio

$$\frac{\text{power dissipated by shower unit at 210 V}}{\text{power dissipated by shower unit at 230 V}}.$$

ratio = ... [2]

(ii) Suggest and explain one further disadvantage of using wires of small cross-sectional area in the cable.

....

....

.... [2]

7 **(a)** Evidence for the nuclear atom was provided by the α-particle scattering experiment. State the results of this experiment.

....

....

....

.... [2]

(b) Give estimates for the diameter of

(i) an atom,

....[1]

(ii) a nucleus.

....[1]