Centre Number	Candidate Number	Name

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

PHYSICS **9702/02**

Paper 2

May/June 2003

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 in the spaces provided on the Question Paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.
The number of marks is given in brackets [ ] at the end of each question or part question.
You may lose marks if you do not show your working or if you do not use appropriate units.

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

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Total	

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Data

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

simple harmonic motion, $a = -\omega^2 x$

velocity of particle in s.h.m., $v = v_0 \cos \omega t$
$v = \pm \omega \sqrt{(x_0^2 - x^2)}$

resistors in series, $R = R_1 + R_2 + \ldots$

resistors in parallel, $1/R = 1/R_1 + 1/R_2 + \ldots$

electric potential, $V = \frac{Q}{4\pi\varepsilon_0 r}$

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, $W = \frac{1}{2}QV$

alternating current/voltage, $x = x_0 \sin \omega t$

hydrostatic pressure, $p = \rho g h$

pressure of an ideal gas, $P = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$

radioactive decay, $x = x_0 \exp(-\lambda t)$

decay constant, $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

critical density of matter in the Universe, $\rho_0 = \frac{3H_0^2}{8\pi G}$

equation of continuity, $Av = \text{constant}$

Bernoulli equation (simplified), $p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2$

Stokes' law, $F = 6\pi\eta rv$

Reynolds' number, $R_e = \frac{\rho v r}{\eta}$

drag force in turbulent flow, $F = \frac{1}{2}C\rho A v^2$

[Turn over

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

1 Complete Fig. 1.1 to show each quantity and its unit. [4]

quantity	*unit*
speed	ms-1
density	.....
.....	s-1
electric field strength	.....
.....	kgms-1

Fig.1.1

2 (a) (i) Define displacement.

.....

.....

(ii) Use your definition to explain how it is possible for a car to travel a certain distance and yet have zero displacement.

.....

.....

[3]

(b) A car starts from rest and travels upwards along a straight road inclined at an angle of 5.0° to the horizontal, as illustrated in Fig. 2.1.

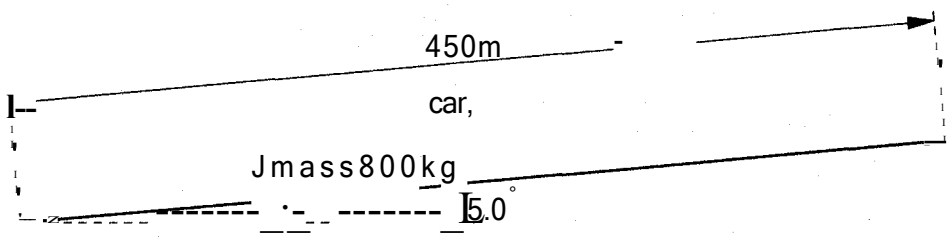

Fig. 2.1

For Examiner's Use

The length of the road is 450 m and the car has mass 800 kg. The speed of the car increases at a constant rate and is 28 m s-1 at the top of the slope.

(i) Determine, for this car travelling up the slope,

1. its acceleration,

acceleration = ... m s-2 [2]

2. the time taken to travel the length of the slope,

time taken= ..... s [2]

3. the gain in kinetic energy,

gain in kinetic energy = ... J [2]

[Turn over

4. the gain in gravitational potential energy.

gain in potential energy = ... J [3]

(ii) Use your answers in **(i)** to determine the useful output power of the car.

power = ... W [3]

(iii) Suggest one reason why the actual power output of the car engine is greater than that calculated in **(ii)**.

.....

..... [2]

3 **(a)** Fig. 3.1 shows the variation with tensile force of the extension of a copper wire.

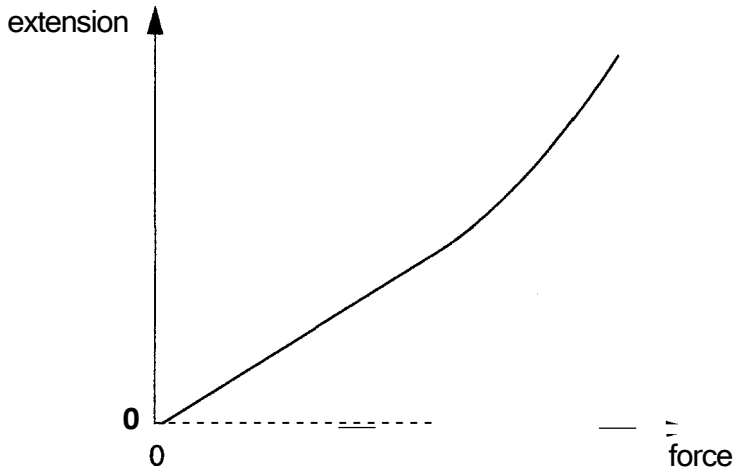

Fig. 3.1

(i) State whether copper is a ductile, brittle or polymeric material.

.....

(ii) **1.** On Fig. 3.1, mark with the letter L the point on the line beyond which Hooke's law does not apply.

2. State how the spring constant for the wire may be obtained from Fig. 3.1.

.....

.....

[3]

(b) A copper wire is fixed at one end and passes over a pulley. A mass hangs from the free end of the wire, as shown in Fig. 3.2.

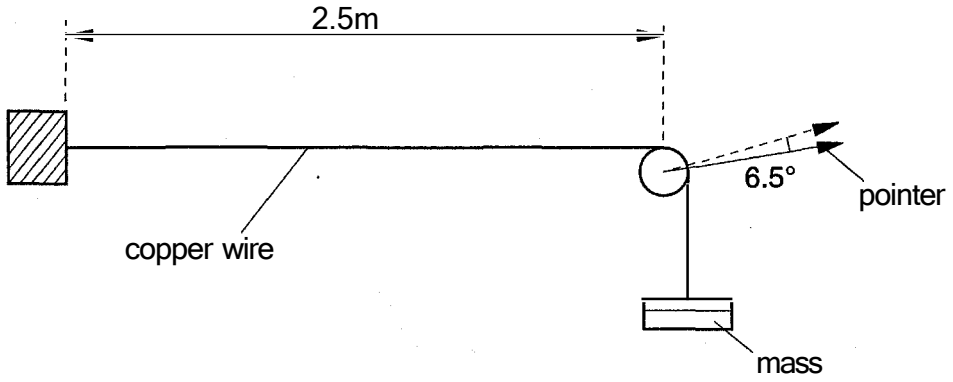

Fig.3.2

The length of wire between the fixed end and the pulley is 2.5 m. When the mass on the wire is increased by 6.0 kg, a pointer attached to the pulley rotates through an angle of 6.5°. The pulley, of diameter 3.0 cm, is rough so that the wire does not slide over it.

(i) For this increase in mass,

1. show that the wire extends by 0.17 cm,

2. calculate the increase in strain of the wire.

increase in strain = ...

[4]

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(ii) The area of cross-section of the wire is 7.9×10^{-7} m^2. Calculate the increase in stress produced by the increase in load.

increase in stress = ... Pa [3]

(iii) Use your answers to **(i) 2** and **(ii)** to determine the Young modulus of copper.

Young modulus = ... Pa [2]

(iv) Suggest how you could check that the elastic limit of the wire is not exceeded when the extra load is added.

.....

..... **[1]**

4 (a) State three conditions that must be satisfied in order that two waves may interfere.

1. .....

2. .....

3. ..... [3]

(b) The apparatus illustrated in Fig. 4.1 is used to demonstrate two-source interference using light.

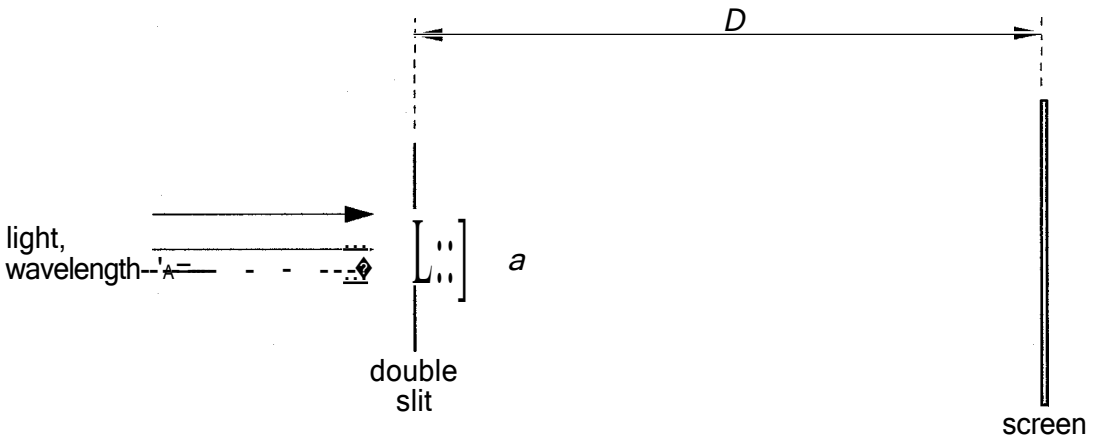

Fig. 4.1 (not to scale)

The separation of the two slits in the double slit arrangement is a and the interference fringes are viewed on a screen at a distance D from the double slit. When light of wavelength A is incident on the double slit, the separation of the bright fringes on the screen is x.

(i) 1. Suggest a suitable value for the separation a of the slits in the double slit.

.....

2. Write down an expression relating A, a, D and x.

.....

[2]

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(ii) Describe the effect, if any, on the separation and on the maximum brightness of the fringes when the following changes are made.

1. The distance D is increased to $2D$, keeping a and λ constant.

   separation: .....

   maximum brightness: .....

2. The wavelength λ is increased to 1.5λ, keeping a and D constant.

   separation: .....

   maximum brightness: .....

3. The intensity of the light incident on the double slit is increased, keeping λ, a and D constant.

   separation: .....

   maximum brightness: .....

[7]

[Turn over

5 A filament lamp operates normally at a potential difference (p.d.) of 6.0 V. The variation with p.d. V of the current I in the lamp is shown in Fig. 5.1.

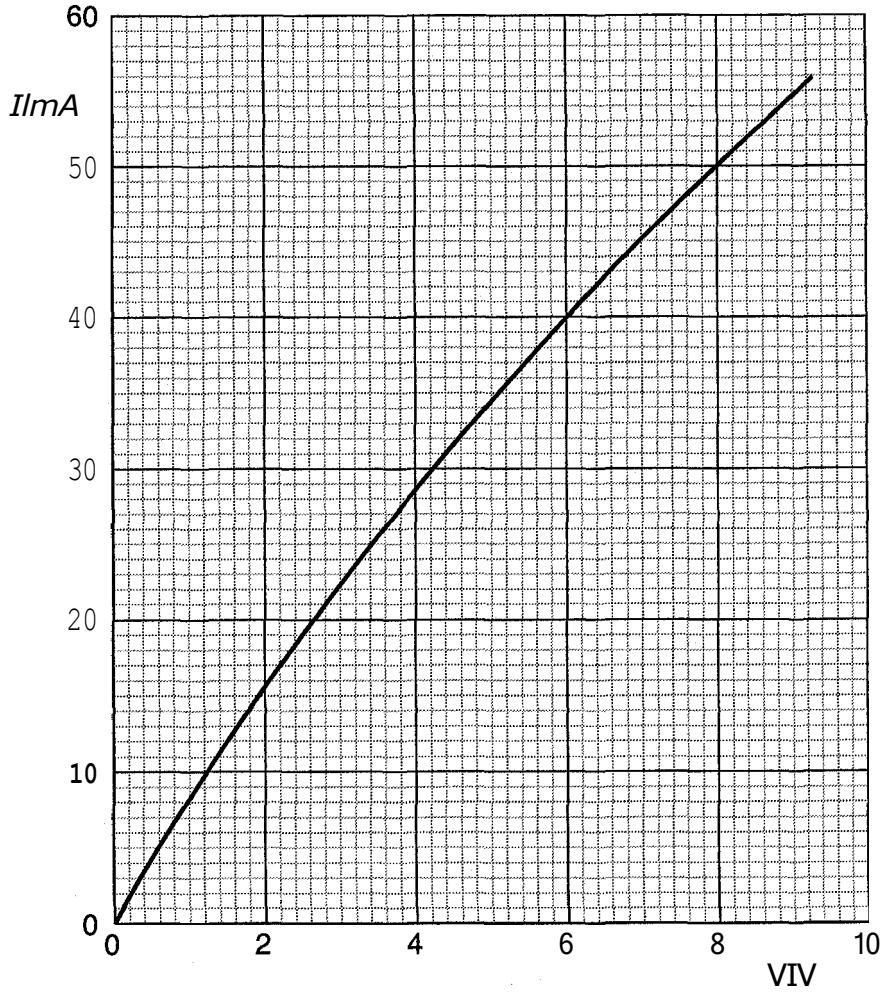

Fig.5.1

(a) Use Fig. 5.1 to determine, for this lamp,

(i) the resistance when it is operating at a p.d. of 6.0 V,

resistance = ... n

(ii) the change in resistance when the p.d. increases from 6.0 V to 8.0 V.

change in resistance = ... Ω
[4]

(b) The lamp is connected into the circuit of Fig. 5.2.

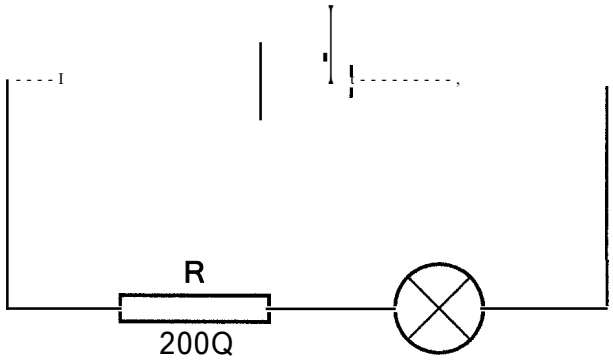

Fig.5.2

R is a fixed resistor of resistance 200 Ω. The battery has e.m.f. E and negligible internal resistance.

(i) On Fig. 5.1, draw a line to show the variation with p.d. **V** of the current **I** in the resistor **R**.

(ii) Determine the e.m.f. of the battery for the lamp to operate normally.

e.m.f. = ... V
[4]

6 **(a)** A student is provided with a freshly prepared sample of a radioactive material and the count rate *C* from the source is found to vary with time *t* as shown in Fig. 6.1 (a).

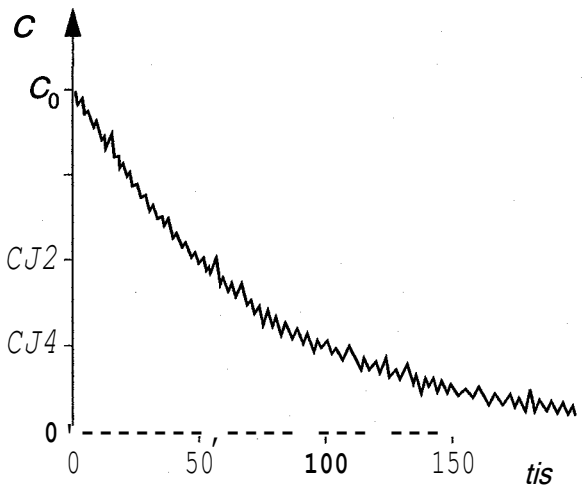

Fig. 6.1(a)

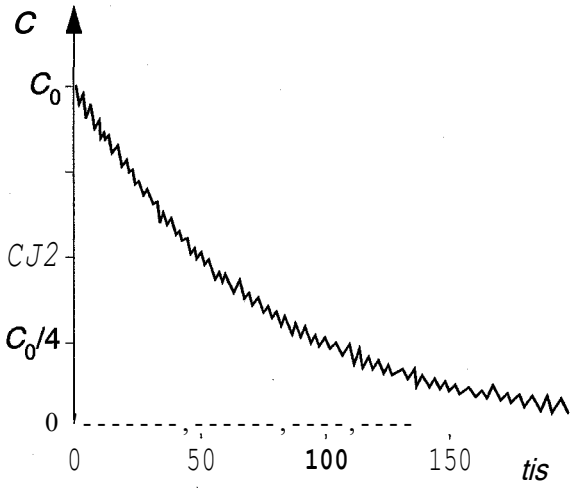

Fig. 6.1(b)

A second similar sample of the radioactive material is then prepared and the student repeats the experiment, but with the sample at a higher temperature. The variation with time of the count rate for the second sample is shown in Fig. 6.1 (b).

State the evidence that is provided by these two experiments for

(i) the random nature of radioactive decay,

.....

.....

(ii) the spontaneous nature of radioactive decay.

.....

.....

[2]

(b) The radioactive source in **(a)** is an isotope of radon ($^{220}_{86}$Rn) that emits a-radiation to become polonium (Po).

(i) State the number of neutrons in one nucleus of radon-220.

number = ... [1]

(ii) Write down a nuclear equation to represent the radioactive decay of a nucleus of radon.

$$^{220}_{86}\text{Rn} \rightarrow \text{Po} + \text{.....}$$

[3]

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