Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

PHYSICS **9702/04**

Paper 4 A2 Core

October/November 2006

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.

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	
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Total	

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

SPA (SJF3679/CG) S98414/2

UNIVERSITY of CAMBRIDGE International Examinations

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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,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
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,	$\phi = -\frac{Gm}{r}$
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,	$V = \frac{Q}{4\pi\epsilon_0 r}$
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,	$p = \frac{1}{3}\frac{Nm}{V}<c^2>$
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,	$F = Ar\eta v$
Reynolds' number,	$R_e = \frac{\rho v r}{\eta}$
drag force in turbulent flow,	$F = Br^2\rho v^2$

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

1 The definitions of electric potential and of gravitational potential at a point have some similarity.

(a) State one similarity between these two definitions.

....

.... [1]

(b) Explain why values of gravitational potential are always negative whereas values of electric potential may be positive or negative.

....

....

....

....

.... [4]

2 A mercury-in-glass thermometer is to be used to measure the temperature of some oil.

The oil has mass 32.0 g and specific heat capacity 1.40 J g^{-1} K^{-1}. The actual temperature of the oil is 54.0 °C.

The bulb of the thermometer has mass 12.0 g and an average specific heat capacity of 0.180 J g^{-1} K^{-1}. Before immersing the bulb in the oil, the thermometer reads 19.0 °C.

The thermometer bulb is placed in the oil and the steady reading on the thermometer is taken.

(a) Determine

(i) the steady temperature recorded on the thermometer,

temperature = ... °C [3]

(ii) the ratio

$$\frac{\text{change in temperature of oil}}{\text{initial temperature of oil}}.$$

ratio = ... [1]

(b) Suggest, with an explanation, a type of thermometer that would be likely to give a smaller value for the ratio calculated in **(a)(ii)**.

....

....

.... [2]

(c) The mercury-in-glass thermometer is used to measure the boiling point of a liquid. Suggest why the measured value of the boiling point will **not** be affected by the thermal energy absorbed by the thermometer bulb.

....

....

....

.... [2]

3 Two vertical springs, each having spring constant k, support a mass. The lower spring is attached to an oscillator as shown in Fig. 3.1.

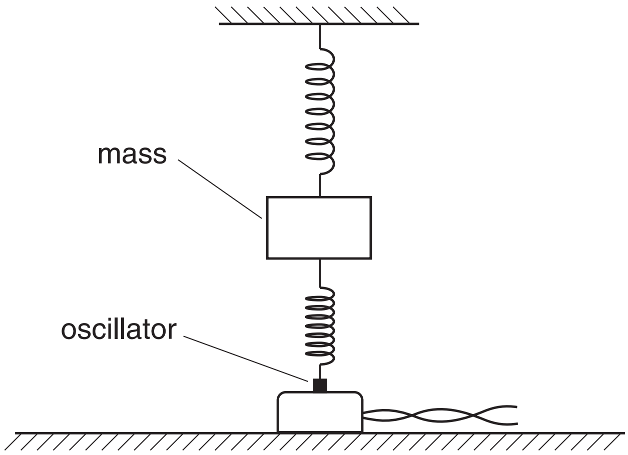

Fig. 3.1

The oscillator is switched off. The mass is displaced vertically and then released so that it vibrates. During these vibrations, the springs are always extended. The vertical acceleration a of the mass m is given by the expression

$$ma = -2kx,$$

where x is the vertical displacement of the mass from its equilibrium position.

(a) Show that, for a mass of 240 g and springs with spring constant $3.0\,\text{N cm}^{-1}$, the frequency of vibration of the mass is approximately 8 Hz.

[4]

(b) The oscillator is switched on and the frequency f of vibration is gradually increased. The amplitude of vibration of the oscillator is constant.

Fig. 3.2 shows the variation with f of the amplitude A of vibration of the mass.

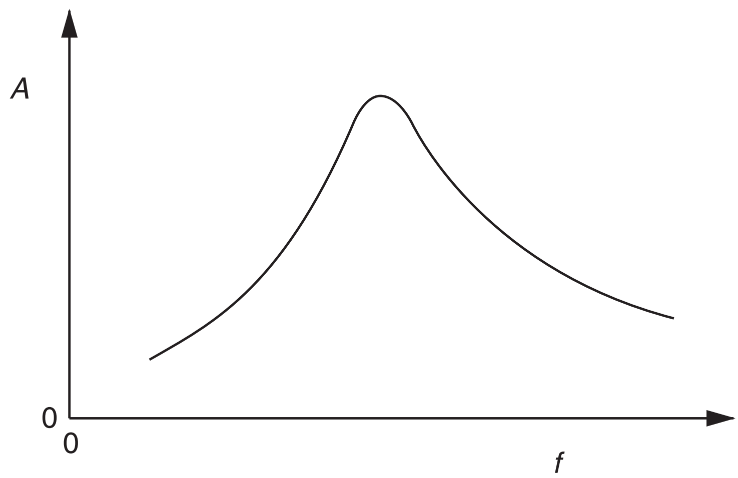

Fig. 3.2

State

(i) the name of the phenomenon illustrated in Fig. 3.2,

.... [1]

(ii) the frequency f_0 at which maximum amplitude occurs.

frequency = ... Hz [1]

(c) Suggest and explain how the apparatus in Fig. 3.1 could be modified to make the peak on Fig. 3.2 flatter, without significantly changing the frequency f_0 at which the peak occurs.

....

....

....

.... [3]

For Examiner's Use

4 A rocket is launched from the surface of the Earth.

Fig. 4.1 gives data for the speed of the rocket at two heights above the Earth's surface, after the rocket engine has been switched off.

height / m	speed / m s^{-1}
$h_1 = 19.9 \times 10^6$	$v_1 = 5370$
$h_2 = 22.7 \times 10^6$	$v_2 = 5090$

Fig. 4.1

The Earth may be assumed to be a uniform sphere of radius $R = 6.38 \times 10^6$ m, with its mass M concentrated at its centre. The rocket, after the engine has been switched off, has mass m.

(a) Write down an expression in terms of

(i) G, M, m, h_1, h_2 and R for the change in gravitational potential energy of the rocket,

.... [1]

(ii) m, v_1 and v_2 for the change in kinetic energy of the rocket.

.... [1]

(b) Using the expressions in **(a)**, determine a value for the mass M of the Earth.

M = ... kg [3]

5 A metal disc is swinging freely between the poles of an electromagnet, as shown in Fig. 5.1.

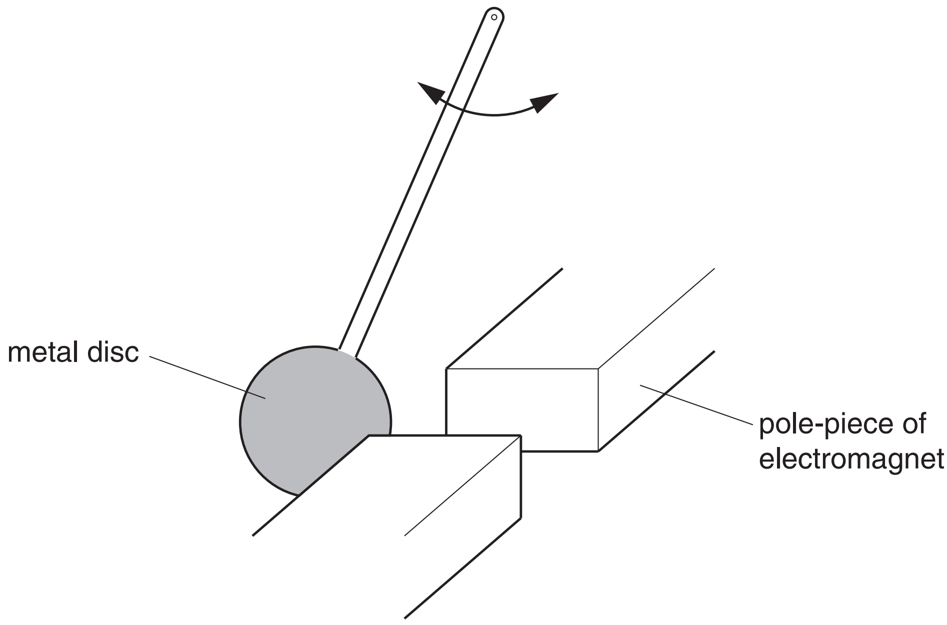

Fig. 5.1

When the electromagnet is switched on, the disc comes to rest after a few oscillations.

(a) (i) State Faraday's law of electromagnetic induction and use the law to explain why an e.m.f. is induced in the disc.

....

....

....

.... [2]

(ii) Explain why eddy currents are induced in the metal disc.

....

....

.... [2]

(b) Use energy principles to explain why the disc comes to rest after a few oscillations.

....

....

....

.... [3]

6 An alternating supply of frequency 50 Hz and having an output of 6.0 V r.m.s. is to be rectified so as to provide direct current for a resistor R. The circuit of Fig. 6.1 is used.

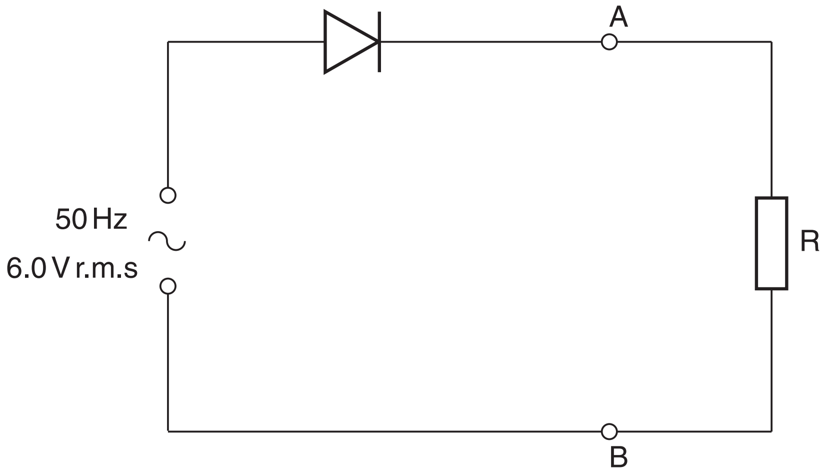

Fig. 6.1

The diode is ideal. The Y-plates of a cathode-ray oscilloscope (c.r.o.) are connected between points A and B.

(a) **(i)** Calculate the maximum potential difference across the diode during one cycle.

potential difference = ... V [2]

(ii) State the potential difference across R when the diode has maximum potential difference across it. Give a reason for your answer.

....

.... [1]

(b) The Y-plate sensitivity of the c.r.o. is set at 2.0 V cm^{-1} and the time-base at 5.0 ms cm^{-1}.

On Fig. 6.2, draw the waveform that is seen on the screen of the c.r.o. [3]

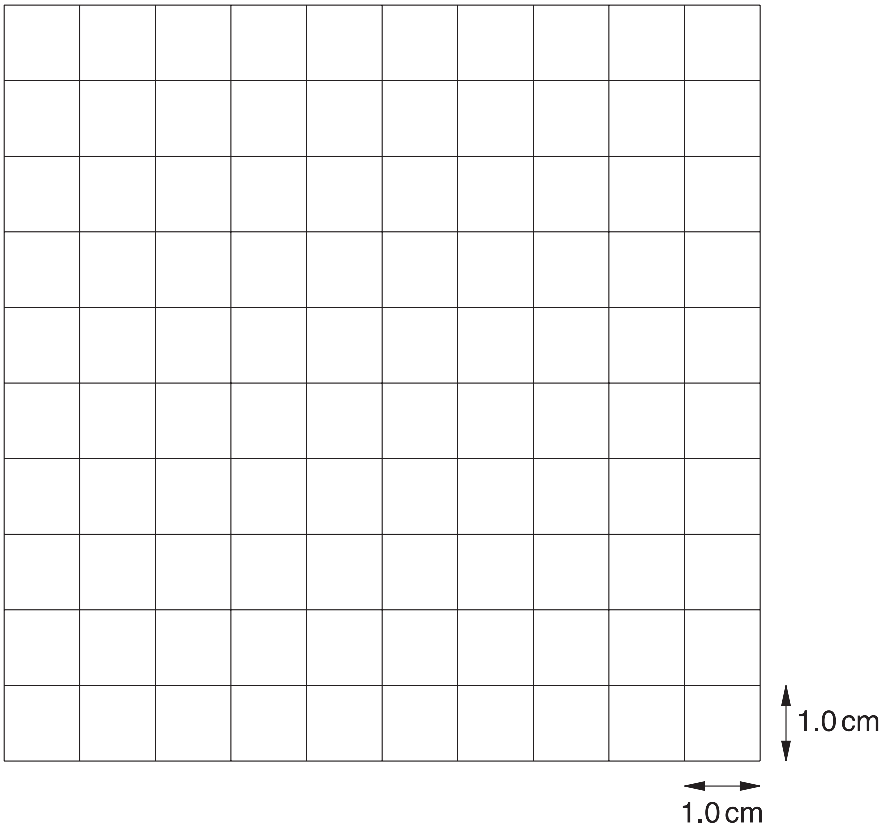

Fig. 6.2

(c) A capacitor of capacitance 180 μF is connected into the circuit to provide smoothing of the potential difference across the resistor R.

(i) On Fig. 6.1, show the position of the capacitor in the circuit. [1]

(ii) Calculate the energy stored in the fully-charged capacitor.

energy = ... J [3]

(iii) During discharge, the potential difference across the capacitor falls to 0.43 V_0, where V_0 is the maximum potential difference across the capacitor.

Calculate the fraction of the total energy that remains in the capacitor after the discharge.

fraction = ... [2]

For Examiner's Use

7 The photoelectric effect may be summarised in terms of the word equation

photon energy = work function energy + maximum kinetic energy of emitted electrons.

(a) Explain

(i) what is meant by a *photon*,

....

....

.... [2]

(ii) why most electrons are emitted with kinetic energy less than the maximum.

....

....

.... [2]

(b) Light of constant intensity is incident on a metal surface, causing electrons to be emitted.

State and explain why the rate of emission of electrons changes as the frequency of the incident light is increased.

....

....

.... [2]

For Examiner's Use

8 Uranium-234 is radioactive and emits α-particles at what appears to be a constant rate.

A sample of Uranium-234 of mass 2.65 μg is found to have an activity of 604 Bq.

(a) Calculate, for this sample of Uranium-234,

(i) the number of nuclei,

number = ... [2]

(ii) the decay constant,

decay constant = ... s^{-1} [2]

(iii) the half-life in years.

half-life = ... years [2]

For Examiner's Use

(b) Suggest why the activity of the Uranium-234 appears to be constant.

....

.... [1]

(c) Suggest why a measurement of the mass and the activity of a radioactive isotope is not an accurate means of determining its half-life if the half-life is approximately one hour.

....

.... [1]

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