OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

PHYSICS A — 2826/01

Unifying Concepts in Physics

Monday **28 JANUARY 2002** Morning 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	21	
2	8	
3	17	
4	14	
TOTAL	60	

This question paper consists of 11 printed pages and 1 blank page.

[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,	$\epsilon_0 = 8.85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
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,	$N_A = 6.02 \times 10^{23}\ \mathrm{mol^{-1}}$
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, $s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

refractive index, $n = \frac{1}{\sin C}$

capacitors in series, $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

capacitors in parallel, $C = C_1 + C_2 + \ldots$

capacitor discharge, $x = x_0 e^{-t/CR}$

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

radioactive decay, $x = x_0 e^{-\lambda t}$

$t_{\frac{1}{2}} = \frac{0.693}{\lambda}$

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

relativity factor, $= \sqrt{\{1 - \frac{v^2}{c^2}\}}$

current, $I = nAve$

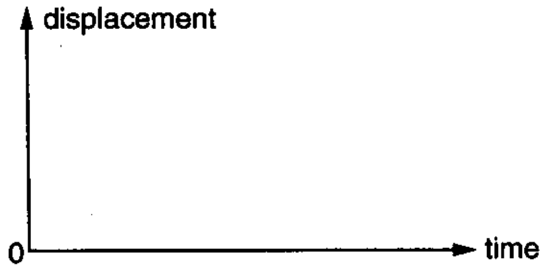
nuclear radius, $r = r_0 A^{1/3}$

sound intensity level, $= 10 \lg\left(\frac{I}{I_0}\right)$

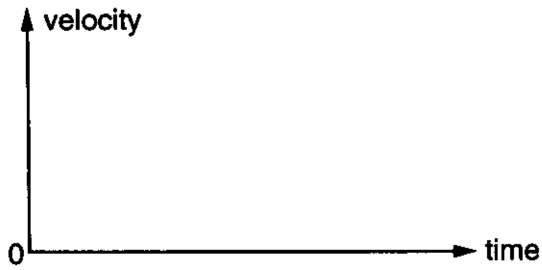
1 A brittle object, such as a china cup, breaks when it is dropped and hits a wooden floor that is distorted elastically a little at impact. Consider the physics of this event from the time the object is dropped until it is broken and stationary. You can assume that it does not bounce. Relate your answers to one another where appropriate.

(a) Using labelled sketch graphs show how the following vary with time:

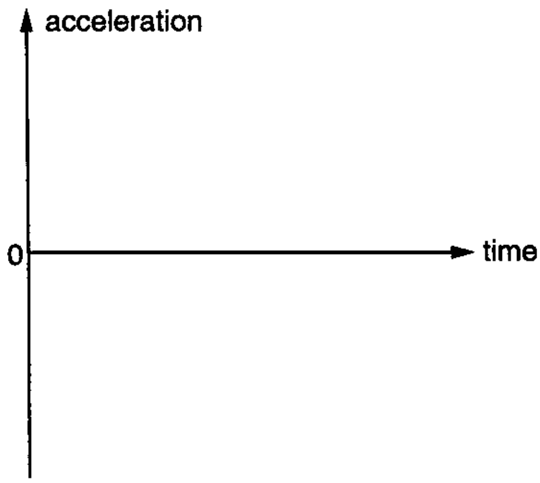
(i) the displacement from the point of release



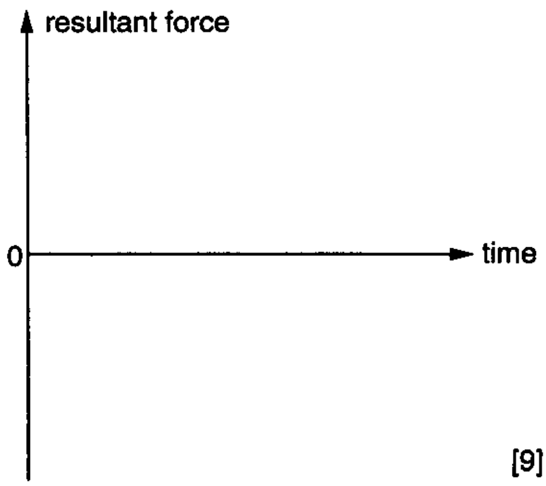
(ii) the velocity



(iii) the acceleration



(iv) the resultant force on the object.



[9]

(b) Describe for the falling and breaking of the cup, the application of

(i) the law of conservation of energy

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(ii) the law of conservation of momentum.

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[8]

(c) Explain, making use of answers already given, why the china cup breaks but a rubber ball falling the same distance would not.

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....[4]

[Total : 21]

2 A small domestic electric appliance, such as a toothbrush, runs off a 9 V rechargeable battery contained in its handle. In use, the appliance is removed from a charging unit and a small light in the handle goes out as it is removed. Mains power at 230 V is supplied to the charging unit. The arrangement, just as the appliance is being removed from the charging unit, is as shown in Fig. 2.1. There are no electrical connections between the handle and the charging unit.

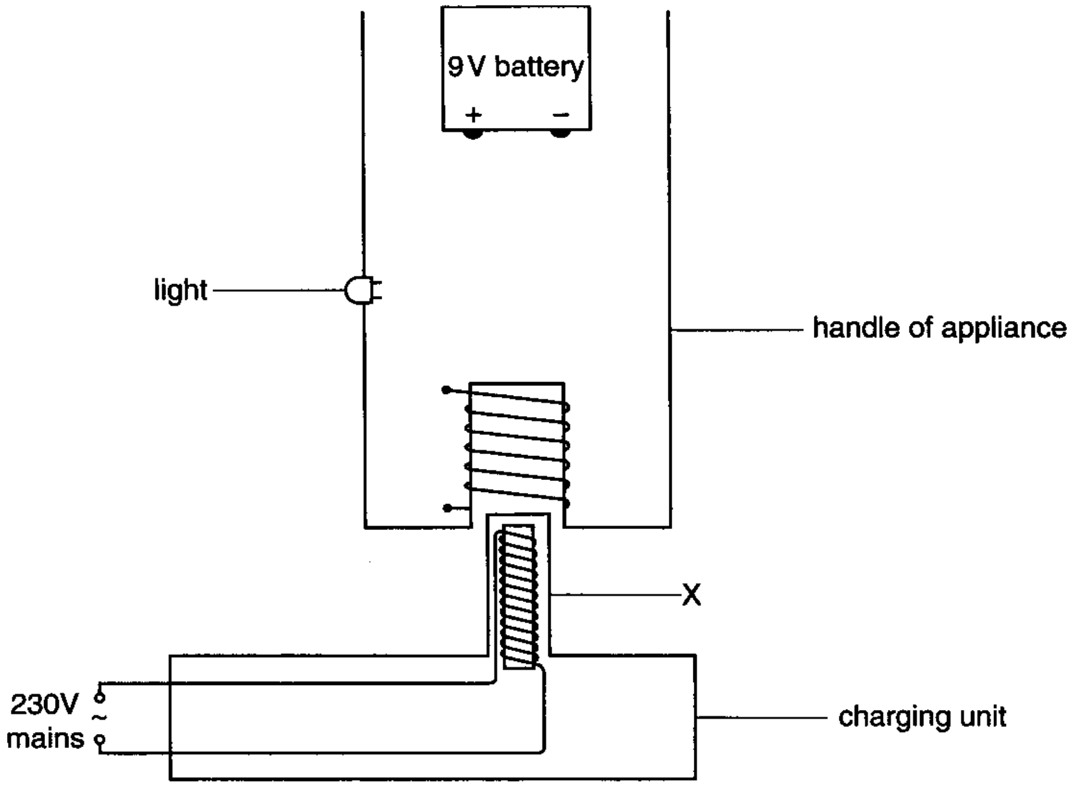

Fig. 2.1

(a) When the handle is lowered on to the charging unit, region X becomes a well-known electrical component. What is this component?

....[1]

(b) From the voltages given, name, and calculate an approximate value for, an important ratio for the component.

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....[2]

For Examiner's Use

(c) Complete Fig. 2.1 to show the electrical components and connections inside the handle. [3]

(d) Explain why the light dims and goes out as the appliance is removed.

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....[2]

[Total : 8]

For Examiner's Use

3 When dealing with exponential discharge of a capacitor through a resistor, it is normal to use an equation of the form

$$Q = Q_0 e^{-\frac{t}{CR}}.$$

When dealing with radioactive decay it is normal to use a similar equation

$$N = N_0 e^{-\lambda t}.$$

(a) State what the following symbols stand for in the equations.

Q .... N ....

Q_0 .... N_0 ....

C .... λ ....

R .... t ....

[4]

(b) **(i)** Show that the expression t/CR has no units

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(ii) State the SI unit of λ

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[4]

(c) A capacitor of capacitance 100 μF discharges through a resistor of resistance 200 kΩ.

Calculate

(i) the fraction of the original charge remaining on the capacitor after **five** time constants.

fraction = ...

(ii) the half life of the charge on the capacitor. By analogy with radioactive decay, half-life is the time for half of its original charge to have left the capacitor.

half-life = ... s

[5]

(d) Similarly, by analogy, it is possible to refer to a *time constant* for the radioactive decay of a nuclide.

(i) By comparing the equations for capacitor discharge and radioactive decay write down an expression for the time constant for radioactive decay in terms of λ.

(ii) Calculate

1. the time constant for a radioactive nuclide whose half-life is 850 s

time constant = ... s

2. the fraction of undecayed nuclei of this nuclide after **five** time constants.

fraction = ...

[4]

[Total : 17]

For Examiner's Use

4 (a) The A-level physics course deals with three force fields. Using definitions of these three fields state the physical quantity on which each force acts.

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(b) Discuss the similarities and the differences between the forces associated with each of the fields.

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For Examiner's Use

(c) Explain how it is known that there must be a different type of field within the nucleus of an atom.

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....[3]

[Total : 14]

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