OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A

2826/01

Unifying Concepts in Physics

Tuesday **20 JANUARY 2004** 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 provided 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	**10**	
2	**13**	
3	**14**	
4	**15**	
5	**8**	
TOTAL	**60**	

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

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,	$n = \dfrac{1}{\sin C}$
capacitors in series,	$\dfrac{1}{C} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \ldots$
capacitors in parallel,	$C = C_1 + C_2 + \ldots$
capacitor discharge,	$x = x_0 e^{-t/CR}$
pressure of an ideal gas,	$p = \frac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
radioactive decay,	$x = x_0\, e^{-\lambda t}$
	$t_{\frac{1}{2}} = \dfrac{0.693}{\lambda}$
critical density of matter in the Universe,	$\rho_0 = \dfrac{3{H_0}^2}{8\pi G}$
relativity factor,	$= \sqrt{(1 - \frac{v^2}{c^2})}$
current,	$I = nAve$
nuclear radius,	$r = r_0 A^{1/3}$
sound intensity level,	$= 10\lg\left(\dfrac{I}{I_0}\right)$

Answer **all** the questions.

1 In most homes, there are some measuring instruments. Estimate, showing your reasoning, the percentage accuracy with which the following may be measured. In each case state the domestic measuring instrument you have chosen.

(a) The mass of a pack of butter.

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....[2]

(b) The width of a living room.

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....[2]

(c) The time between going to bed and getting up the following morning.

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....[2]

(d) The angle between magnetic north and a route marked in a north-easterly direction on a map.

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....[2]

(e) The temperature difference between a freshly made cup of tea and room temperature.

....

....

....[2]

[Total: 10]

For Examiner's Use

2 Much of physics depends on finding out what will happen when something is done. In other words, for each effect there will need to be a cause.

(a) For each of the pairs of quantities in the table, decide which is cause and which is effect.

Complete the table by writing a word equation in the form $\frac{\text{cause}}{\text{effect}}$ = a third quantity.

Name this third quantity in each case.

quantity 1	quantity 2	$\frac{\text{cause}}{\text{effect}}$ = quantity 3
load on a spring	extension of spring	=
acceleration	force	=
electric current	electromotive force	=
applied stress	strain	=
charge on capacitor	potential difference across capacitor	=

[10]

(b) Why is the ratio cause/effect so useful?

....

....

....

....

..........[3]

[Total:13]

For Examiner's Use

3 A car is stopped by gradually increasing the braking force to a maximum and then reducing the force, at the same rate, to zero just as stopping occurs. In this way, a passenger in the car is subjected to the least possible jerk. The acceleration of the car during the 10 seconds braking time is given by the graph in Fig. 3.1.

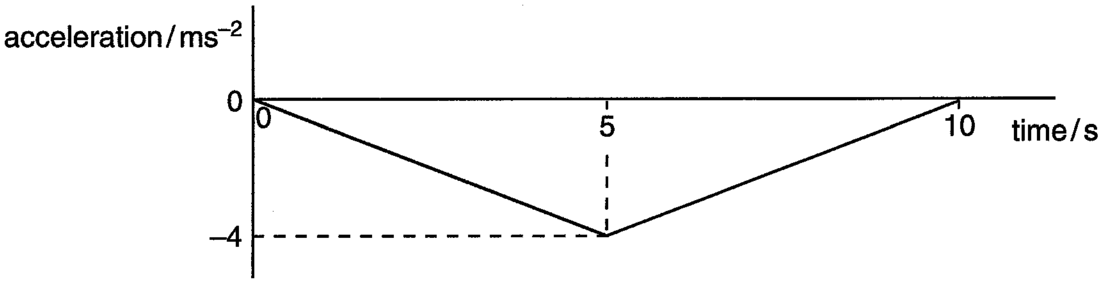

Fig. 3.1

(a) Why is the acceleration shown as negative?

....[1]

(b) Sketch on the axes of Fig. 3.2 a graph to show how the velocity of the car will change during the 10 seconds braking time. The car starts with a velocity of 20 m s^{-1}.

Fig. 3.2 [3]

Fig. 3.3

For Examiner's Use

(c) **(i)** What feature of a velocity-time graph gives the displacement?

....[1]

(ii) Sketch on the axes of Fig. 3.3 a displacement-time graph for the car for the 10 seconds braking time. [2]

(d) Estimate, showing your reasoning, the total stopping distance.

stopping distance = ... m [2]

(e) Suggest why this method of stopping involves less jerk for the passenger than a more usual method where the braking force is kept constant during deceleration. When do jerks occur for constant braking force?

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....[5]

[Total: 14]

4 **(a)** A boat of mass $m = 2000\,kg$ is moving with velocity $u = 6.0\,m\,s^{-1}$ towards a dock. The boat is stopped by a constant braking force $F = 300\,N$.

Complete the following table in order to calculate the time, t, and the distance, d, the boat takes to stop.

Starting from *force = mass × acceleration* and the appropriate equation of motion show that $Ft = mu$.	Starting from *force = mass × acceleration* and the appropriate equation of motion show that $Fd = \frac{1}{2}mu^2$.
Calculate the boat's initial momentum. momentum = ... N s	Calculate the boat's initial kinetic energy. kinetic energy = ... J
Calculate the time the boat takes to stop. time = ... s	Calculate the distance the boat takes to stop. distance = ... m

[8]

For Examiner's Use

(b) Momentum and kinetic energy are often used incorrectly when dealing with mechanical problems. Using the equations given in the third line of the table, explain

(i) why momentum must be a vector

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....

....[1]

(ii) the essential difference between momentum and kinetic energy, other than that one is a vector and the other one a scalar

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....[2]

(iii) why, when two bodies collide *inelastically*, conservation of momentum must still apply even though kinetic energy is reduced.

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....[4]

[Total: 15]

[Turn over

For Examiner's Use

5 Energy transformations from one form to another are a common feature of many frequently used devices. For example, a car starting a journey is transforming the chemical energy of its fuel into kinetic energy.

(a) Complete the table below to show different devices and their energy transformations.

device	energy at start	energy produced
car accelerating	chemical energy	kinetic energy
microphone		
		gravitational potential
	electrical	
		heat

[4]

(b) Making energy transformations is sometimes efficient and sometimes inefficient. In the example of the car only a small percentage of the chemical energy of the fuel becomes kinetic energy in the first 200 m of a journey.

Discuss the energy transformations in **(a)** in terms of their possible efficiency. As a conclusion to your discussion suggest which initial types of energy tend to provide the most efficient energy transformations and give an example of an energy transformation which is almost 100% efficient.

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....[4]

[Total: 8]

END OF QUESTION PAPER

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