OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A

2826/01

Unifying Concepts in Physics

Friday **21 JUNE 2002** Afternoon 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	22	
2	18	
3	10	
4	10	
TOTAL	**60**	

This question paper consists of 12 printed pages.

Registered Charity Number: 1066969

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, $p = \frac{1}{3}\frac{Nm}{V}<c^2>$

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

For Examiner's Use

1 Conservation laws are used a great deal in physics for solving problems.

(a) State the meaning of *conservation* in this context.

....

....

....[2]

(b) (i) Name any **three** conservation laws.

1. Conservation of ....

2. Conservation of ....

3. Conservation of ....

[3]

(ii) For each of the laws you have named in **(i)**, describe a situation where it is useful to apply the law.

1. ....

....

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2. ....

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3. ....

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[6]

(iii) For **one** of the laws you have stated, describe a situation where that conservation law seems not to apply. Explain why this is apparently so.

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....[3]

(c) Certain laws which do not mention conservation in their definitions are, in fact, conservation laws. Some of these laws are

Lenz's law of electromagnetic induction,
Kirchhoff's first law,
Kirchhoff's second law.

From this list choose **two** laws and

(i) state each law,

(ii) explain how it is applied in suitable circumstances,

(iii) explain why it can be considered to be a conservation law.

First law chosen:

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....[4]

second law chosen.

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....[4]

[Total : 22]

For Examiner's Use

2 Nowadays, manufacturers are giving considerable thought to making vehicles more energy efficient. One way of doing this is to fit a flywheel on a vehicle. The flywheel is a solid cylinder which can store kinetic energy when it is rotating. When the vehicle slows down its kinetic energy is used to increase the rotational speed of the flywheel. This stored energy is used later to accelerate the vehicle. A similar arrangement is used in some toy cars to make them travel further after being pushed.

In order to investigate the practicalities of flywheel energy storage it is necessary to use some equations from the physics of rotation.

Fig. 2.1 shows a cylindrical flywheel of length l, radius r and mass m spinning about its central axis with frequency of rotation f.

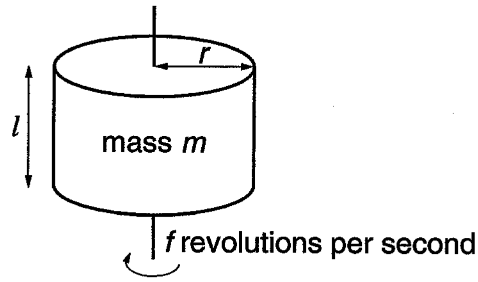

Fig. 2.1

The kinetic energy of this flywheel is given by the equation kinetic energy = $2\pi^2 f^2 I$

where I is called the moment of inertia and is given by $I = \frac{1}{2}mr^2$

Some details of three flywheels are given in Fig. 2.2. Assume that all the flywheels are made of steel of density 7800 kg m^{-3}.

	bus flywheel	car flywheel	toy car flywheel
length l/m	0.40		0.008
radius r/m	0.20		0.015
volume V/m^3	0.050		5.7×10^{-6}
mass m/kg	390		0.044
maximum frequency of rotation f/s^{-1}	200	200	
moment of inertia I	7.8		5.0×10^{-6}
maximum kinetic energy stored/J			0.50

Fig. 2.2

(a) Deduce the SI unit for moment of inertia.

....

....[2]

(b) Calculate the maximum kinetic energy able to be stored by the bus flywheel.

kinetic energy .... J [2]

(c) **(i)** With the figures given for the size of a flywheel suitable for a bus, suggest a suitable length and a suitable radius for a flywheel for a car. Enter these values in the table, Fig. 2.2. [1]

(ii) Calculate the maximum energy which can be stored by your suggested car flywheel. Show how you calculated this value in the space below and enter your answer in the table.

[4]

(d) Calculate the frequency of rotation necessary for the flywheel of the toy car in order that the energy stored is 0.50 J.

frequency = ... revolutions per second [3]

[Turn over

For Examiner's Use

(e) Explain,

(i) why a flywheel system is likely to be more commercially successful for a town bus than for a car

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....[2]

(ii) why it is advantageous to enclose the flywheel in a strong, evacuated container

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....[2]

(iii) how the amount of energy stored can be increased without altering the volume or the maximum rate of rotation.

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....[2]

[Total : 18]

For Examiner's Use

3 Energy is a term which is used in all branches of physics. It has been suggested that in reality all types of energy could be considered as being combinations of kinetic energy and potential energy.

(a) Explain, without the use of equations, what is meant by the terms

(i) energy

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(ii) kinetic energy

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(iii) gravitational potential energy.

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[4]

(b) Explain how sound energy can be regarded as part kinetic energy and part potential energy.

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....[2]

For Examiner's Use

(c) Name **two** other types of energy and describe each in terms of kinetic and potential energies.

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....[4]

[Total : 10]

For Examiner's Use

4 **(a)** Starting from the definition of electric field strength show that the unit of electric field strength is the same as the unit of potential gradient.

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....[3]

(b) **(i)** A copper wire of length 3.4 m has a potential difference across it of 12 V. Calculate the electric field strength in the copper. You can assume that the field in the copper is uniform and has the same value as it would have if there were a 12 V potential difference across 3.4 m in a vacuum.

electric field strength = ... [1]

(ii) Calculate, for a free electron in the copper wire

1. the force on the electron

force = ... N [2]

2. the acceleration of the electron.

acceleration = ... $m\,s^{-2}$ [2]

(c) If an electron were accelerated from rest with the acceleration in **(b)** through a distance of 3.4 m in a vacuum, its average speed would be about $1 \times 10^6\,m\,s^{-1}$. However, the average speed of the electrons along this wire (the drift speed) is less than $1 \times 10^{-3}\,m\,s^{-1}$. Explain why there is such a large difference between these values.

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....[2]

[Total : 10]