OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

PHYSICS A — 2826/01

Unifying Concepts in Physics

Thursday **20 JANUARY 2005** Morning 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler (cm/mm)

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	11	
2	17	
3	17	
4	15	
TOTAL	60	

This question paper consists of 12 printed pages.

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,	$\rho_0 = \dfrac{3H_0^2}{8\pi G}$
relativity factor,	$= \sqrt{(1 - \dfrac{v^2}{c^2})}$
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 The four sketch graphs in Fig. 1.1, plotted against time, show changes which occur in a small fraction of a second and which result in almost vertical lines on the graphs. Three of these sketch graphs are possible for ordinary objects and one of them is impossible.

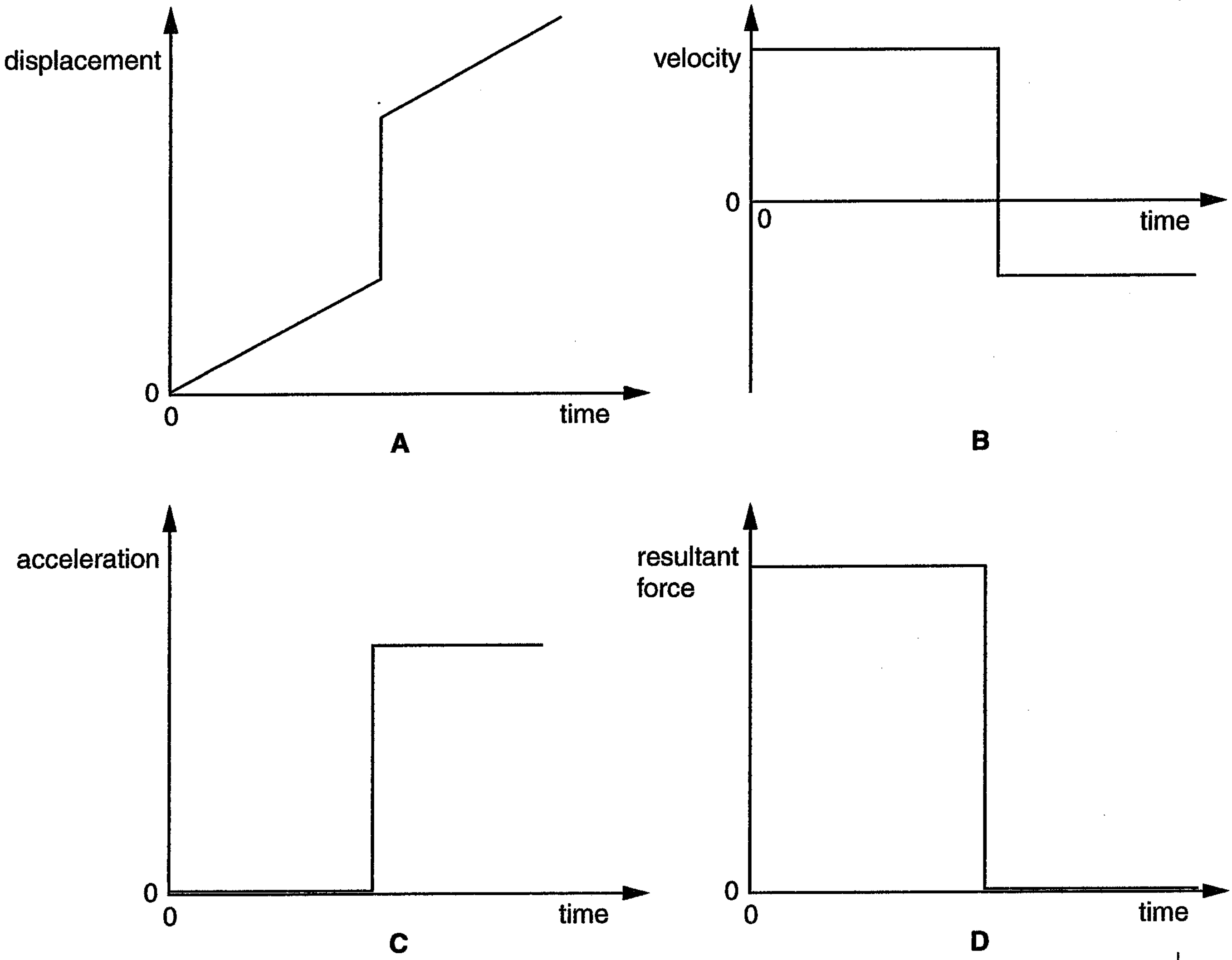

Fig. 1.1

(a) Identify the impossible graph, giving a reason for your selection.

Impossible graph is .... [1]

Reason why it is impossible ....

....[1]

For Examiner's Use

(b) Describe **three** everyday situations, one for each, which illustrate how the remaining graphs can arise. State to which graph each description refers.

graph letter ....

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....[3]

graph letter ....

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....[3]

graph letter ....

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....[3]

[Total: 11]

For Examiner's Use

2 Flow occurs in many different aspects of physics. For example, flow of electrons is an electric current, heat flow takes place as a result of a temperature gradient and flow of water or gas along a pipe is a common experience. The dimensions of the material through which flow occurs, together with the properties of the material and the cause of flow, determine the amount of flow which takes place.

(a) Why is one pipe necessary for the supply of gas to a house but two cables are necessary for the supply of electricity?

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....[3]

(b) The amount of heat energy flowing per unit time through the wall of a room is given by

$$\frac{Q}{t} = kA\left(\frac{\theta_2 - \theta_1}{d}\right)$$

where Q is the quantity of heat energy which flows in time t,
k is called the thermal conductivity,
A is the surface area of the wall,
d is the thickness of the wall
and θ_2 and θ_1 are the inside and outside temperatures respectively.

(i) Deduce the SI unit of k, the thermal conductivity.

unit of k .... [3]

(ii) Calculate the rate at which heat energy is lost through the wall of the room under the following conditions.

$k = 0.35$ in SI units
$A = 12.0\,m^2$
$\theta_2 = 22.0\,°C$
$\theta_1 = 8.0\,°C$
$d = 0.10\,m$

rate at which heat energy is lost $\left(\frac{Q}{t}\right)$ = ... W [2]

For Examiner's Use

(c) **(i)** Write a corresponding equation to that in **(b)** for charge flow per unit time, $\frac{Q}{t}$ through a wire, in terms of

the potential difference across the wire V
the resistivity of the material of which the wire is made ρ
and the length l and area of cross-section A of the wire.

[2]

(ii) Compare the equations in **(c)(i)** and **(b)**.

1 State which thermal property corresponds with V in the electrical case.

....[1]

2 State which thermal property corresponds with ρ in the electrical case.

....[1]

(d) **(i)** Flow of gas through a pipe follows the same pattern as for electron flow and heat flow. Suggest an equation for gas flow. State the meaning of any symbols you introduce.

[3]

(ii) 160 cm^3 of gas flow per second through a pipe of internal diameter 15 mm. How much gas will flow per second through a pipe of internal diameter 22 mm under the same conditions?

volume per second = ... cm^3 s^{-1} [2]

[Total:17]

[Turn over

3 Fig 3.1 shows a **full-scale** cross-section of the electric field in the region of a positively charged circular metal rod and a U-shaped metal frame. The potential difference between the rod and the frame is 600 V with the frame earthed at 0 V. Also shown on the diagram are dotted lines showing where the potential is 500 V, 400 V, 300 V, 200 V and 100 V.

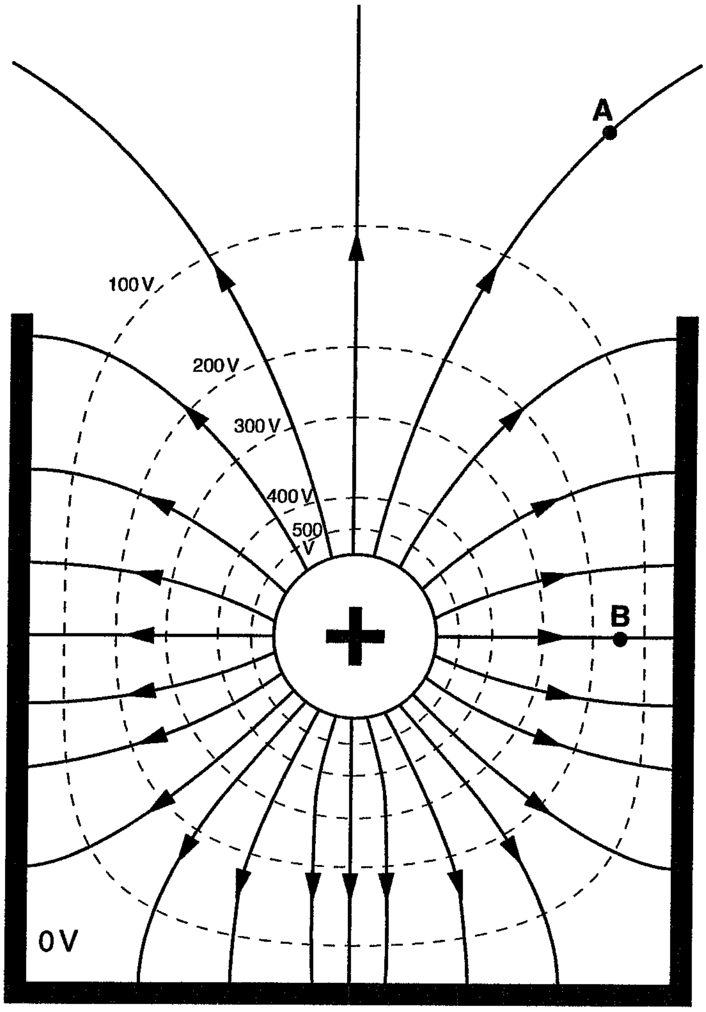

Fig. 3.1

(a) Define *electric field strength* at a point in an electric field.

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....[1]

(b) Draw on Fig. 3.1 at point **A** an arrow to show the direction of the force exerted by the field on a small positive charge placed at **A**. [1]

For Examiner's Use

(c) Is the charge on the inside of the earthed frame positive, negative or zero? Explain your answer.

....[1]

(d) Draw a line on Fig. 3.1 linking all the points where the potential is 250 V. [1]

(e) **(i)** By taking readings and measurements from Fig. 3.1, calculate the electric field strength at **B**, where the field may be considered to be uniform. Give the unit of electric field strength.

electric field strength = ... unit .... [4]

(ii) Calculate the magnitude and direction of the force on an electron at **B**.

force = ... N in a direction .... [3]

(f) Sketch a plan showing how magnets could be arranged in order to create a magnetic field of similar shape to the electric field inside the frame. Show the polarity on each magnet you suggest using.

[3]

(g) Give **two** reasons why a gravitational field of this shape is impossible, whatever size field is considered.

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....

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....[3]

[Total: 17]

For Examiner's Use

4 The electromagnetic spectrum covers a very wide range of wavelengths, frequencies and photon energies.

(a) **(i)** State the names and wavelengths for the shortest and longest electromagnetic waves.

shortest: name .... wavelength ....m

longest: name .... wavelength ....m
[4]

(ii) Calculate the ratio

$$\frac{\text{longest wavelength}}{\text{shortest wavelength}}$$

ratio = ... [1]

(iii) Two notes in sound which are an octave apart have a wavelength ratio of 2. When the notes are **three** octaves apart, the wavelength ratio is 8 since $8 = 2^3$. By how many octaves does your answer to **(ii)** correspond?

number of octaves .... [2]

(iv) Calculate the maximum energy of a photon in the electromagnetic spectrum, using a value of wavelength which you have given in **(i)**.

photon energy .... J [2]

For Examiner's Use

(b) State **two** properties of electromagnetic waves which **do not** change across the whole of the spectrum.
Discuss **two** features of electromagnetic waves, other than just wavelength and frequency, which **do** change across the spectrum.

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....[6]

[Total: 15]

END OF QUESTION PAPER