OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A

2823/01

Wave Properties

Thursday **16 JANUARY 2003** Afternoon 45 minutes

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

Candidate Name	Centre Number	Candidate Number

TIME 45 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	12	
2	14	
3	12	
4	7	
TOTAL	45	

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

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

For Examiner's Use

Answer **all** the questions.

1 **(a)** Define the refractive index for light passing from air into glass. Identify any symbols you use.

[2]

(b) A block of glass has a refractive index of 1.54.

(i) Determine the speed of light in the glass block.

speed of light = ... m s^{-1} [2]

(ii) Calculate the critical angle for the glass/air interface.

critical angle = ... ° [2]

For Examiner's Use

(c) Fig. 1.1 shows a ray of light passing from air into a rectangular glass block of refractive index 1.54.

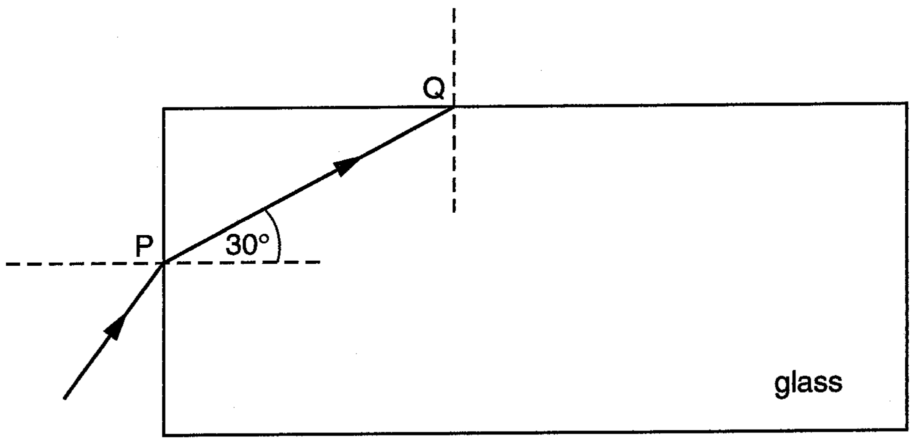

Fig. 1.1

(i) The angle of refraction in the glass is 30°. Calculate the angle of incidence, in the air, at the point P.

angle of incidence at P = ...° [3]

(ii) Determine the angle of incidence of the ray in the glass at the point Q.

angle of incidence at Q = ...° [1]

(iii) On Fig. 1.1, sketch the path followed by the ray when it leaves Q. Explain your sketch.

....

....[2]

[Total: 12]

2 **(a)** All waves are either longitudinal or transverse. State **one** example of each.

longitudinal ....

transverse ....[2]

(b) Define

(i) the frequency of a wave

....[1]

(ii) the period of a wave.

....[1]

(c) Fig. 2.1 shows the variation of displacement with position at a particular instant for a progressive sound wave travelling in air.

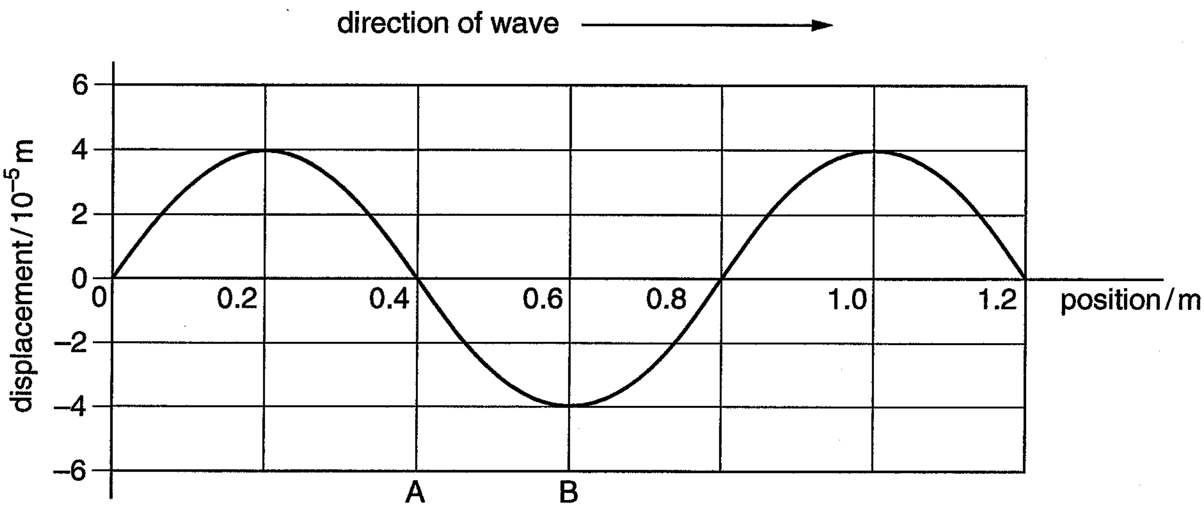

Fig. 2.1

(i) State the amplitude of the sound wave shown in Fig. 2.1

amplitude = ... m [1]

(ii) Describe the motion of an air particle at position A as one full cycle of the wave passes.

....

....

....

....

....[3]

(iii) State **one** way in which the motion of an air particle at position B is similar to, and **one** way in which it is different from, the motion of an air particle at A as the wave passes.

similarity ....

....

difference ....

....[2]

(iv) Use Fig. 2.1 to determine the wavelength of the sound wave.

wavelength = ... m [1]

(v) The speed of the sound wave is 340 m s^{-1}. Calculate the frequency of the sound.

frequency = ... Hz [3]

[Total: 14]

For Examiner's Use

3 (a) Fig. 3.1 shows a laboratory microwave transmitter T positioned directly opposite a microwave detector D which is connected to a meter.

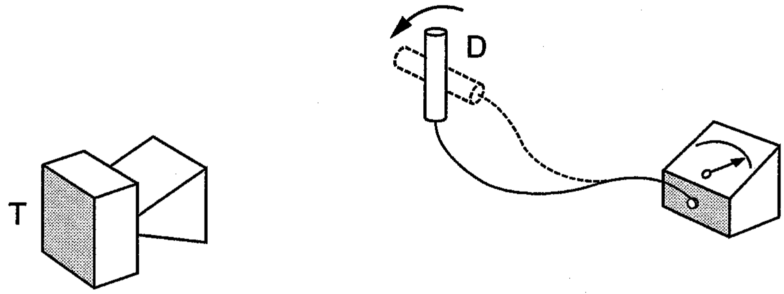

Fig. 3.1

Initially the meter shows a maximum reading. When the detector is rotated through 90°, in a vertical plane as shown, the meter reading falls to zero.

(i) Explain why the meter reading falls.

....

....

....[2]

(ii) Predict what would happen to the meter reading if the detector were rotated through a further 90°.

....[1]

(iii) State what the observations tell you about the nature of microwaves.

....[1]

For Examiner's Use

(b) Fig. 3.2 is a plan view of the same arrangement shown in Fig. 3.1 with the addition of a metal plate **M** placed in front of the transmitter. The plate **M** contains a double slit.

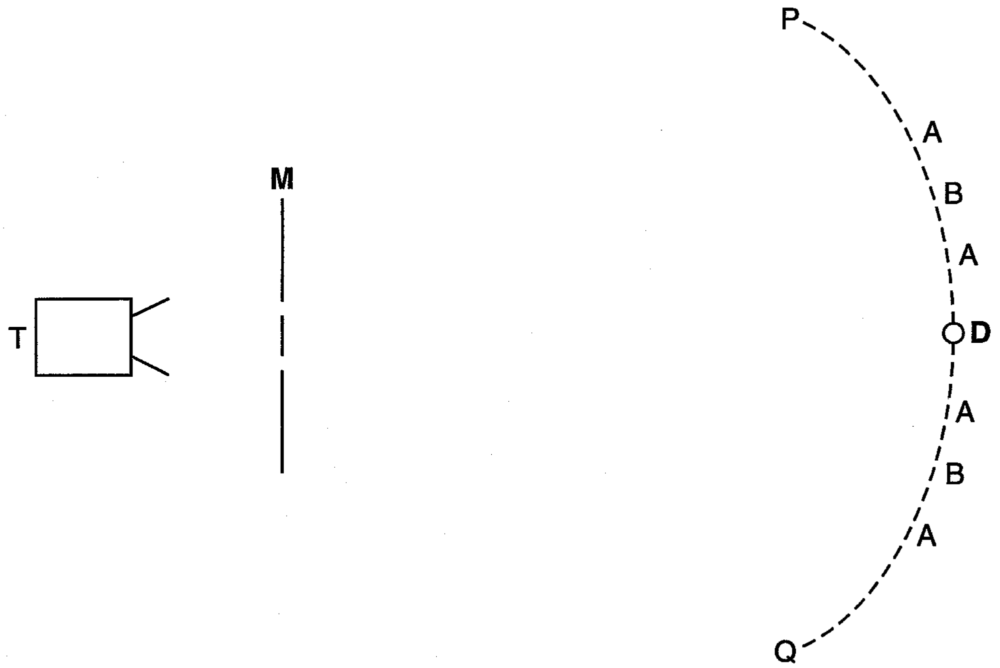

Fig. 3.2

When the detector **D** is placed in the position shown, the meter reading is a maximum, but as it moves along the horizontal arc PQ the reading passes through a sequence of low and high readings at positions A and B respectively.

(i) State the name of the phenomenon that accounts for this.

....[1]

(ii) Explain why the meter reading is a maximum when the detector is in the position shown (i.e. directly opposite the centre of the double slit).

....

....

....[2]

(iii) Explain

1. why the meter reading is low at positions A

....

....

2. why the meter reading is high at positions B.

....

....[3]

For Examiner's Use

(iv) Suggest, with reasons, how the total number of low and high readings along the arc PQ changes when the separation between the slits in M is **reduced**.

....

....

....[2]

[Total: 12]

4 **(a)** Standing waves have nodes and antinodes. State what is meant by

(i) a node

....[1]

(ii) an antinode.

....

....[2]

For Examiner's Use

(b) Using a labelled sketch to illustrate your answer, describe an experiment to demonstrate how a standing wave can be produced in an air column.

In your answer
- state whether the wave is transverse or longitudinal
- mark on your diagram the position of a node (label this N) and an antinode (label this A).

....

....

....

....

....

....

....

....

....

....

....

.... [4]

[Total: 7]