OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A

2823/01

Wave Properties

Friday **6 JUNE 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	6	
2	9	
3	6	
4	6	
5	14	
6	4	
TOTAL	45	

This question paper consists of 12 printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}\ \text{m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}\ \text{H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12}\ \text{F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19}\ \text{C}$
the Planck constant,	$h = 6.63 \times 10^{-34}\ \text{J s}$
unified atomic mass constant,	$u = 1.66 \times 10^{-27}\ \text{kg}$
rest mass of electron,	$m_e = 9.11 \times 10^{-31}\ \text{kg}$
rest mass of proton,	$m_p = 1.67 \times 10^{-27}\ \text{kg}$
molar gas constant,	$R = 8.31\ \text{J K}^{-1}\ \text{mol}^{-1}$
the Avogadro constant,	$N_A = 6.02 \times 10^{23}\ \text{mol}^{-1}$
gravitational constant,	$G = 6.67 \times 10^{-11}\ \text{N m}^{2}\ \text{kg}^{-2}$
acceleration of free fall,	$g = 9.81\ \text{m s}^{-2}$

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

[Turn over

For Examiner's Use

Answer **all** the questions.

1 **(a)** State the relationship between the angle of incidence ***i***, the angle of refraction ***r*** and the refractive index ***n*** for light travelling from one transparent medium to another in which the speed of light is less. Illustrate your answer with a labelled diagram showing the direction in which the light is travelling.

[3]

(b) The speed of light in free space ***c*** is $2.9979 \times 10^{8}\,m\,s^{-1}$. The refractive index of air is 1.0004. Calculate the speed of light in air.

speed of light in air = ... $m\,s^{-1}$ [3]

[Total: 6]

For Examiner's Use

2 **(a)** State **two** conditions necessary for total internal reflection of light to occur.

1. ....

....

2. ....

....[2]

(b) The refractive indices of glass and diamond are 1.50 and 2.42 respectively.

(i) Calculate the critical angle for

1. a glass/air interface

critical angle = ...°

2. a diamond/air interface.

critical angle = ...° [3]

(ii) Expensive rings contain diamond crystals which 'sparkle'. Cheaper rings made from glass crystals do not sparkle as much. Use your answers to **(i)** to explain this.

....

....[1]

(c) Figs. 2.1 and 2.2 show rays of light making an angle of incidence of 40° at a glass/air and diamond/air interface respectively. Continue the rays to show the path followed by each ray. There is no need to calculate any of the angles involved.

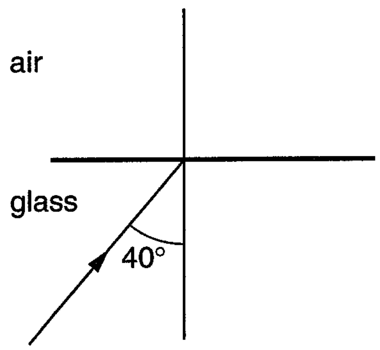

Fig. 2.1

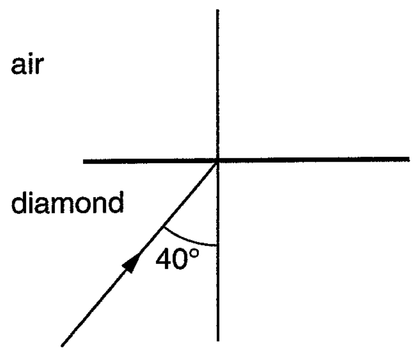

Fig. 2.2 [3]

[Total: 9]

[Turn over

For Examiner's Use

3 **(a)** The core of an optic fibre has a refractive index of 1.57.

(i) Calculate the minimum time taken for light to travel along a 500 m length of this fibre.

time = ... s [3]

(ii) Suggest why some light will take longer than this to travel along the fibre.

....

....

....[1]

(b) A common problem associated with the transmission of digital signals along optic fibres is known as *multipath dispersion.* State and explain how the problem of multipath dispersion may be minimised.

....

....

....[2]

[Total: 6]

For Examiner's Use

4 **(a)** Explain the meaning of the term *diffraction*.

....

....[1]

(b) Draw a labelled diagram to show how plane water waves, in a ripple tank, are diffracted as they pass through a rectangular slit whose width is about 10 times greater than the wavelength.

[3]

(c) Describe what effect, if any, is caused by gradually decreasing the slit width until it is about the same width as the wavelength.

....

....

....

....[2]

[Total: 6]

For Examiner's Use

5 **(a)** State what is meant by the *principle of superposition* of waves.

....

....

....[2]

(b) Fig. 5.1 shows an arrangement which can be used to determine the speed of sound in air.

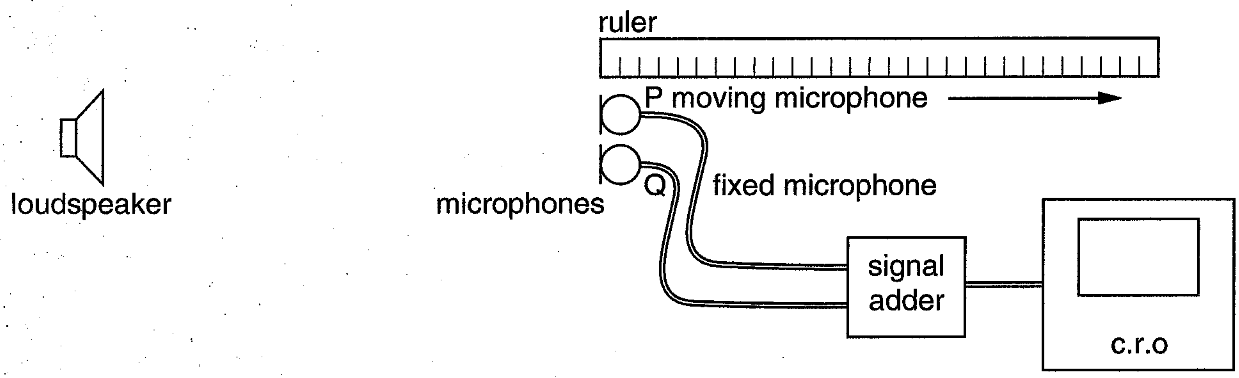

Fig. 5.1

The loudspeaker emits a sinusoidal sound wave. The electrical signals from the two microphones P and Q are added together in the electronic "signal adder" and the resultant signal is displayed on the cathode-ray oscilloscope (c.r.o.) screen. This process may be regarded as equivalent to the superposition of the waves.

Microphone Q **is fixed** and microphone P is **slowly moved** back along the edge of the ruler.

(i) Fig. 5.2 shows the appearance of the trace on the c.r.o. when both microphones are at the left hand end of the ruler i.e. the same distance from the loudspeaker.

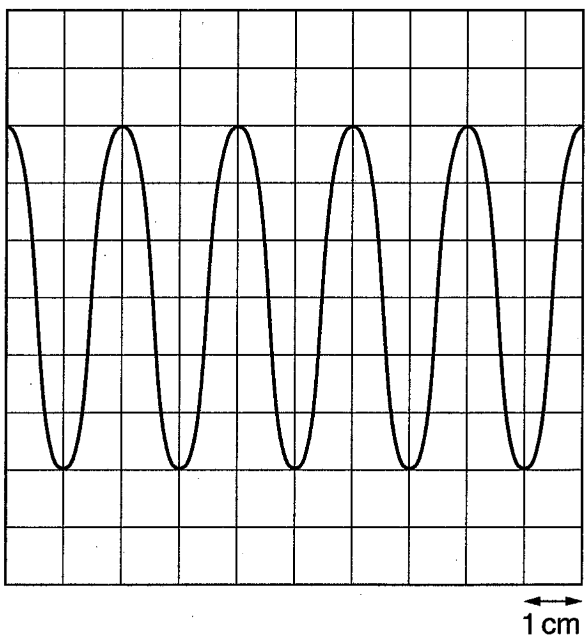

Fig. 5.2

The time-base setting of the c.r.o. is 0.2 ms/cm. Determine for the sound wave

1. the period

period = ... s [2]

2. the frequency.

frequency = ... Hz [2]

(ii) As P is moved slowly along the edge of the ruler, the amplitude of the trace is seen to decrease, then increase, then decrease and so on. Explain

1. why the amplitude is a maximum when P and Q are at the left hand of the ruler

....

....

....[2]

2. why the amplitude of the trace varies.

....

....

....

....[2]

[Turn over

(iii) The first **minimum** of the amplitude occurs when P is at a distance of 6.8 cm from the left hand end of the ruler. Determine

1. the wavelength of the sound

wavelength = ... m [2]

2. the speed of the sound in air.

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

[Total: 14]

For Examiner's Use

6 **(a)** Fig. 6.1 shows a string stretched between two points A and B.

Fig. 6.1

State how you would set up a standing wave on the string.

....

....[1]

(b) The standing wave vibrates in its fundamental mode i.e. the lowest frequency at which a standing wave can be formed. Draw this standing wave on Fig. 6.2.

Fig. 6.2 [1]

(c) Fig. 6.3 shows the appearance of another standing wave formed on the same string.

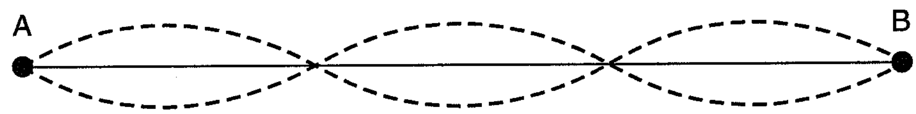

Fig. 6.3

The distance between A and B is 1.8 m. Use Fig. 6.3 to calculate

(i) the distance between neighbouring nodes

distance = ... m [1]

(ii) the wavelength of the standing wave.

wavelength = ... m [1]

[Total: 4]