OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A

2823/01

Wave Properties

Friday **31 MAY 2002** 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 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	**8**	
2	**13**	
3	**10**	
4	**5**	
5	**9**	
TOTAL	**45**	

This question paper consists of 14 printed pages and 2 blank 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,	$n = \frac{1}{\sin C}$
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,	$= 10 \lg \left(\frac{I}{I_0}\right)$

1 Fig. 1.1 shows a laboratory experiment to determine the refractive index *n* for red light, from a laser, passing from air into a liquid.

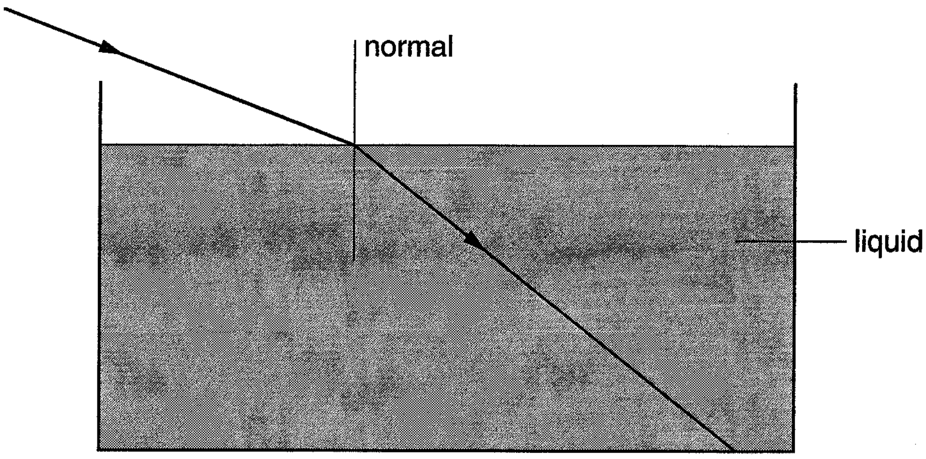

Fig. 1.1

(a) **(i)** Show on Fig. 1.1 the angle of incidence *i*, and the angle of refraction *r*. [2]

(ii) State how the refractive index *n* would be calculated from the measured values of *i* and *r*.

[1]

(b) The speed, frequency and wavelength of the light beam in air are *v*, *f* and λ respectively.

(i) By placing ticks (✓) in the appropriate boxes of Fig. 1.2 show which of these terms increase, decrease or stay the same when the light enters the liquid. [3]

	increase	decrease	stay the same
speed			
frequency			
wavelength			

Fig. 1.2

For Examiner's Use

(ii) State, for those that change, their new value in terms of v, f, λ and n.

[2]

[Total: 8]

[Turn over

For Examiner's Use

2 Fig. 2.1 shows a step index optic fibre with a ray of light striking the core/cladding boundary at angle of incidence θ.

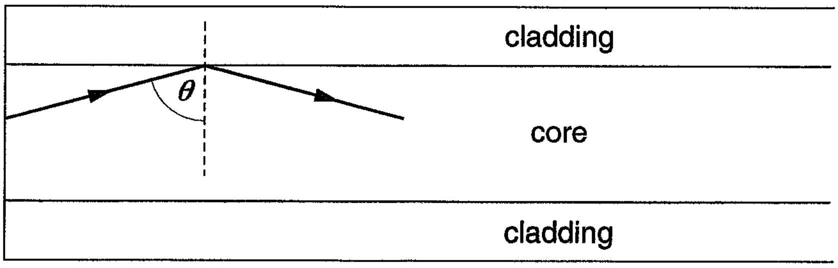

Fig. 2.1

(a) (i) State the name of the effect shown in Fig. 2.1.

.... [1]

(ii) State the conditions necessary for the ray in Fig. 2.1 to be completely reflected into the core.

....

....

.... [2]

(b) The optic fibre is 900 m long and the core of the fibre has a refractive index of 1.48.

(i) Calculate the speed of light in the core.

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

For Examiner's Use

(ii) Calculate the minimum time taken for light to travel along the core of the fibre.

time = ... s [2]

(iii) The ray following the path shown in Fig. 2.1 takes approximately 45 ns longer than the minimum time to travel along the fibre. Estimate, by calculation, the extra distance travelled by this ray.

distance = ... m [2]

(c) A microsecond pulse of monochromatic laser light has a square shaped intensity-time profile, as shown in Fig. 2.2a, and is sent into one end of the fibre.

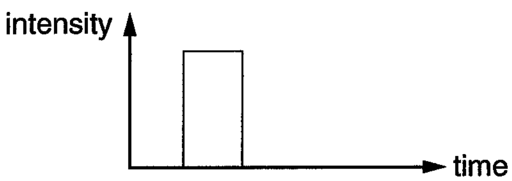

Fig. 2.2a

Fig. 2.2b

(i) Show on Fig. 2.2b how the pulse shape will have changed after passing through a long length of fibre. [2]

(ii) Explain why the pulse shape has changed.

....

....

....[2]

[Total: 13]

3 **(a)** Two coherent light wavetrains meet at a point and *interfere destructively*. Explain what this means and state two conditions that must be fulfilled before **totally destructive** interference can occur.

....

....

....

.... [3]

(b) Fig. 3.1 shows an experiment to demonstrate interference effects with microwaves. A transmitter, producing microwaves of wavelength λ, is placed in front of two slits separated by a distance a. A receiver is used to detect the strength of the resultant wave at different points in front of the slits.

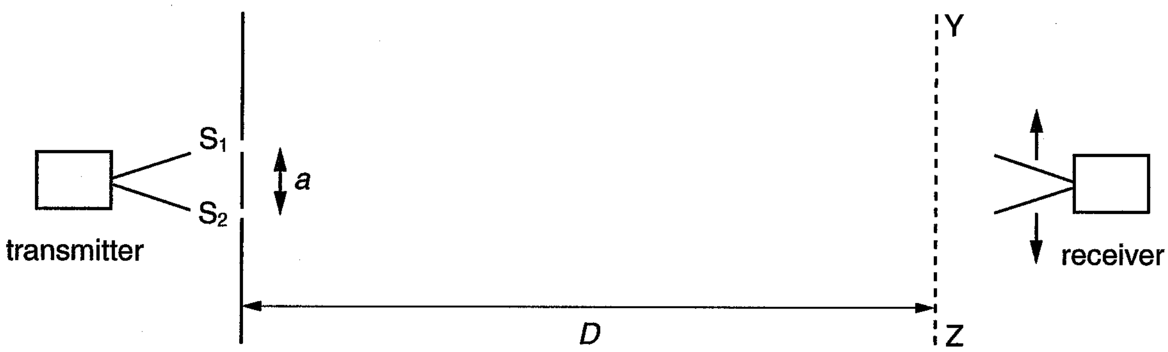

Fig. 3.1

(i) Explain, in terms of the path difference between the wavetrains emerging from the slits S_1 and S_2, why a series of interference maxima are produced along the line YZ.

....

....

....

....

.... [2]

(ii) Assuming that the interference of the microwaves is similar to double slit interference using light, state in terms of a, D and λ, an expression for the distance x between neighbouring minima on the line YZ.

....

.... [1]

For Examiner's Use

(iii) Use your answer to **(ii)** to predict how *x* would change if the distance *a* was doubled.

....

.... [2]

(c) Explain why it is necessary to use a barrier with two slits rather than two separate transmitters.

....

.... [2]

[Total: 10]

For Examiner's Use

4 (a) Draw a labelled diagram to show how plane water waves, in a ripple tank, are diffracted as they pass through a narrow rectangular slit.

[3]

For Examiner's Use

(b) Fig. 4.1 shows a piano being played on one side of a wall. Suggest why the person standing on the other side of the wall can hear the piano clearly even though she cannot directly see it.

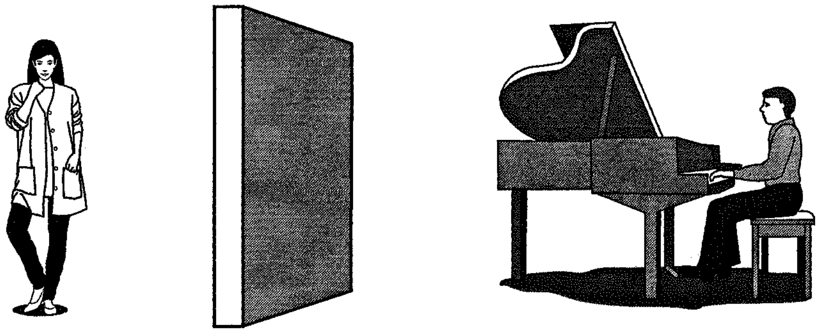

Fig. 4.1

....

....

.... [2]

[Total: 5]

For Examiner's Use

5 **(a)** A **transverse** wave pulse moves along a slinky coil. State how any single coil in the slinky will move as the pulse passes it.

....

....

....

....

....

.... [2]

(b) Fig 5.1 shows a large measuring cylinder. The air column in the cylinder can be made to produce a note by blowing horizontally across the top of the cylinder.

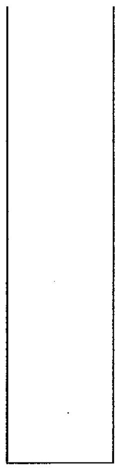

Fig. 5.1

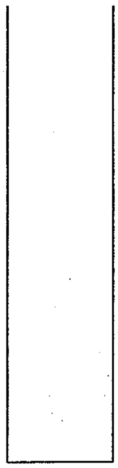

Fig. 5.2

(i) State the direction in which the particles in the air column move when the note is produced.

.... [1]

(ii) The air column in Fig. 5.1 is producing its lowest frequency note (the fundamental). Label on Fig. 5.1 the positions in the cylinder of a node, with the letter **N**, and an antinode with the letter **A**. [1]

(iii) The length of the air column is 0.40 m and the speed of sound in air is 320 m s^{-1}. Calculate the frequency of the lowest (fundamental) note.

frequency = ... Hz [3]

(iv) Label on Fig. 5.2 the positions of nodes (**N**) and antinodes (**A**) when a note of higher frequency is being produced. [2]

[Total: 9]

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