OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

PHYSICS A — 2823/01

Wave Properties

Monday **14 JANUARY 2002** Morning 1 hour

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

Candidate Name	Centre Number	Candidate Number

TIME 1 hour

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	16	
2	5	
3	17	
4	7	
5	10	
6	5	
TOTAL	60	

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,	$n = \dfrac{1}{\sin C}$
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,	$= 10 \lg \left(\dfrac{I}{I_0}\right)$

[Turn over

For Examiner's Use

Answer **all** the questions.

1 **(a)** State the two laws of refraction.

1. ....

....

2. ....

.... [2]

(b) Fig. 1.1 shows a ray of light entering a glass prism.
speed of light in the glass = $2.0 \times 10^8\,m\,s^{-1}$
speed of light in air = $3.0 \times 10^8\,m\,s^{-1}$

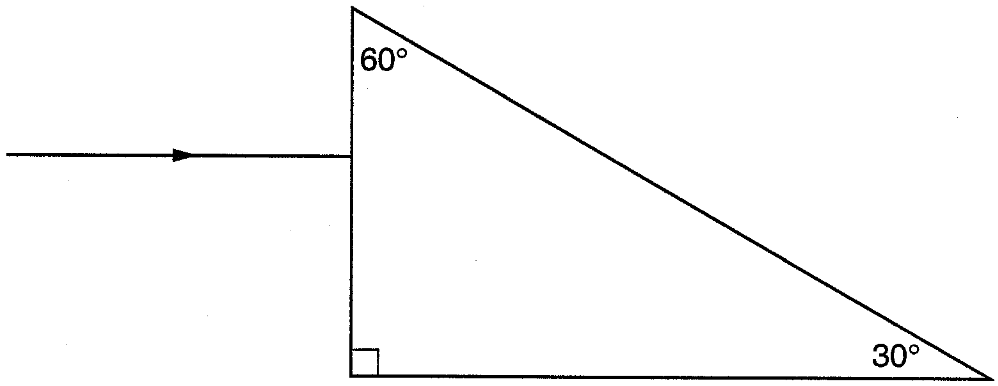

Fig. 1.1

(i) Calculate the refractive index of the prism's glass

refractive index = ... [2]

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

critical angle = ... [2]

(iii) By drawing on Fig. 1.1 show the path of the ray inside the prism. [2]

(iv) Deduce the angle of incidence of the ray at the bottom surface.

angle of incidence = ... [1]

(v) Calculate the angle of refraction as the ray finally emerges from the prism.

angle of refraction = ... [3]

[Turn over

For Examiner's Use

(c) Figs 1.2a and 1.2b show a device for detecting the level of acid in a car battery. It consists of a rod, of square cross-section, made of the same glass as in **(b)**. The end of the rod has the shape of a right-angled prism.

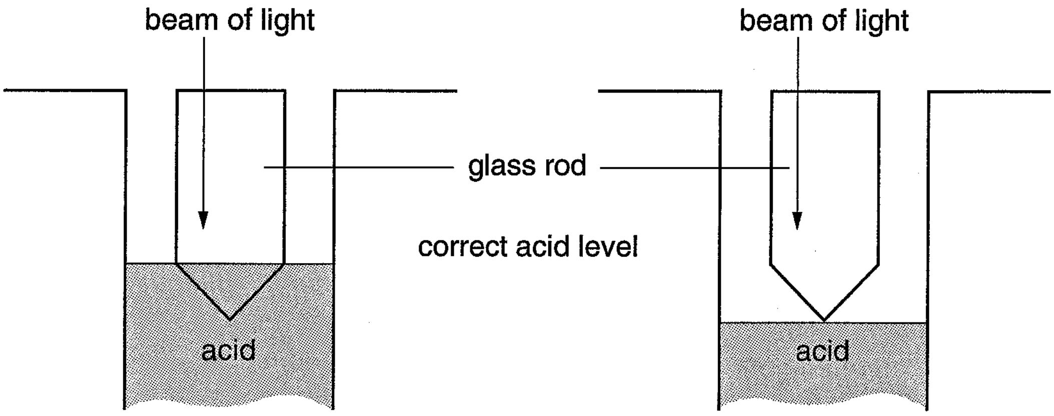

Fig. 1.2a **Fig. 1.2b**

When the acid in the battery is at its correct level, the end of the glass rod is just fully submerged i.e. to the level shown in Fig. 1.2a. When the acid level is too low the end of the rod is in air; this is the state shown in Fig. 1.2b.

(i) When a beam of light is directed down one half of the rod (as shown) a strong beam is observed emerging upwards from the other half when the acid level is too low. Explain why this happens.

....

....

....

.... [2]

(ii) When the acid level is correct the emerging beam disappears. Suggest why.

....

....

.... [2]

[Total: 16]

For Examiner's Use

2 **(a)** Explain what is meant by *multipath dispersion* in an optic fibre.

....

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....

.... [3]

(b) Fig. 2.1 shows an optic fibre used for data transmission.

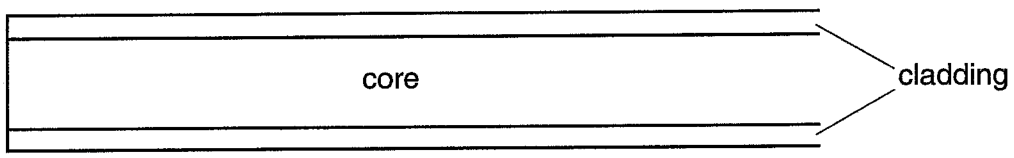

Fig. 2.1

The refractive index of the core is only slightly greater than that of the cladding so that the critical angle for the core-cladding surface is approximately 88°. Early types of optic fibres had no cladding and had much lower values of the critical angle. Explain how an increase of critical angle improves the quality of the data pulses received through the optic fibre.

....

....

....

.... [2]

[Total: 5]

For Examiner's Use

3 (a) Fig. 3.1 shows, at a given instant, the shape of a stretched rope along which a transverse wave is travelling from left to right. The letters V, W, X, Y and Z identify five particles on the rope.

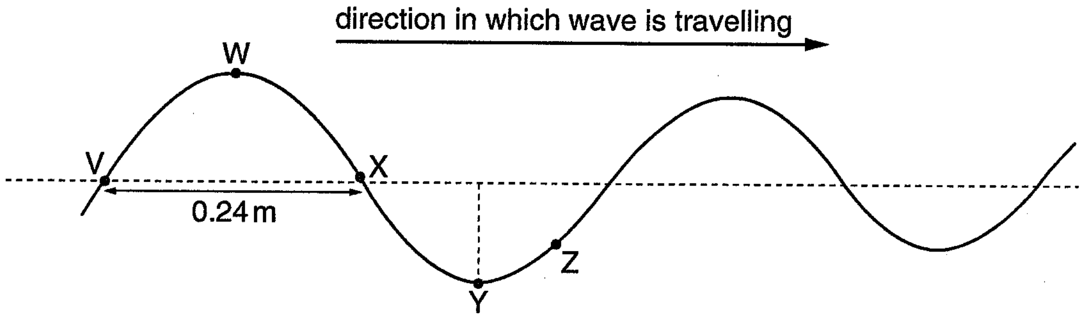

Fig. 3.1

(i) On Fig. 3.1 sketch the shape of the rope a short time later. [1]

(ii) On Fig. 3.1 draw arrows to show the directions in which the particles X and Z are moving during this short time. [2]

(iii) The distance between V and X is 0.24 m (as shown). The frequency of the wave is 3.6 Hz. Calculate the speed of the wave.

wave speed = ... $m\,s^{-1}$ [3]

(iv) The frequency is doubled to 7.2 Hz. Determine the changes, if any, in

1. the wave speed

....

....

2. the wavelength.

....

.... [3]

For Examiner's Use

(b) Fig. 3.2 shows, at a given instant, the shape of the stretched rope on which a **stationary** wave has been produced.

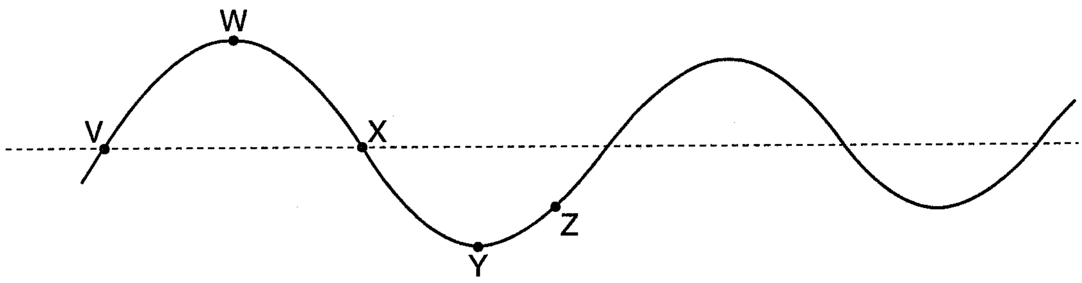

Fig. 3.2

(i) Briefly explain how a stationary wave may be formed on the rope.

....

....

.... [2]

(ii) State the phase difference between the oscillations of the following pairs of particles on this stationary wave.

1. W and Y

....

2. Y and Z

.... [2]

(iii) For a stationary wave, state what is meant by

1. a node

....

2. an antinode.

.... [2]

(iv) State which of the particles on Fig. 3.2 are

1. at a node

....

2. at an antinode.

.... [2]

[Total: 17]

For Examiner's Use

4 (a) (i) State the meaning of *plane polarisation* of light waves.

....

.... [1]

(ii) Explain why sound waves cannot be *plane-polarised.*

....

....

.... [2]

(b) Fig. 4.1 shows an experiment in which a student observes a parallel beam of plane-polarised light passing through a Polaroid filter.

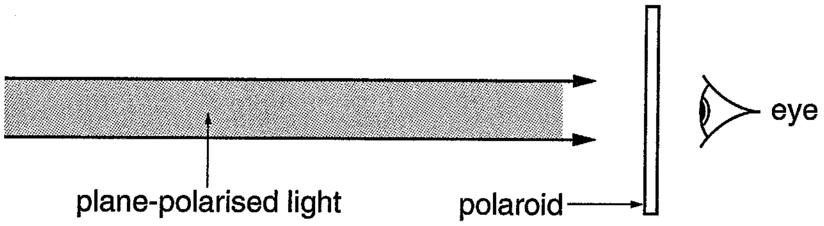

Fig. 4.1

Fig. 4.2 shows how the intensity of the light reaching the student will vary as the Polaroid filter is rotated through 360° in its own plane. Suggest why there is a series of maxima and minima.

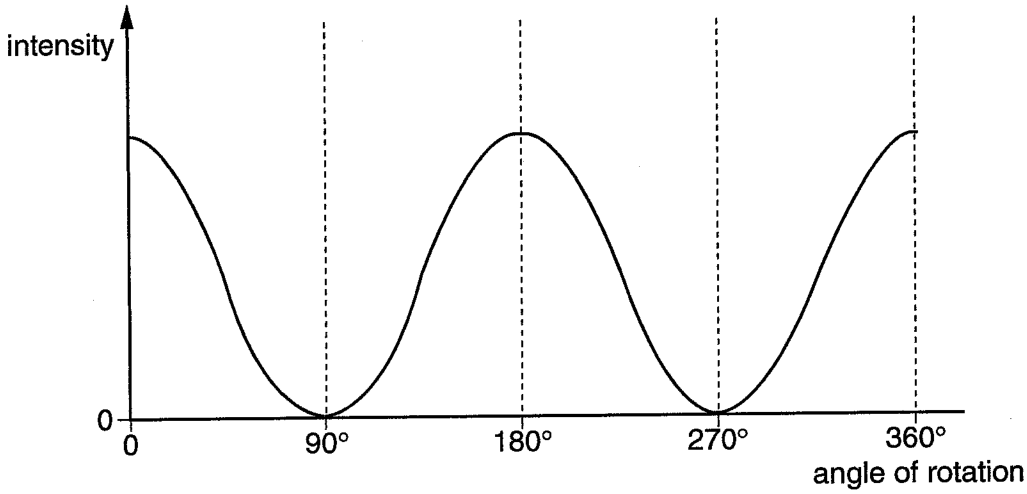

Fig. 4.2

....

....

....

....

.... [2]

(c) State an example of plane-polarisation that does **not** involve visible light and state how the polarised wave may be detected.

....

....

....

....

....

.... [2]

[Total: 7]

For Examiner's Use

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

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.... [2]

(b) In an experiment to produce an observable interference pattern, two monochromatic light sources, S_1 and S_2, are placed in front of a screen, as shown in Fig. 5.1.

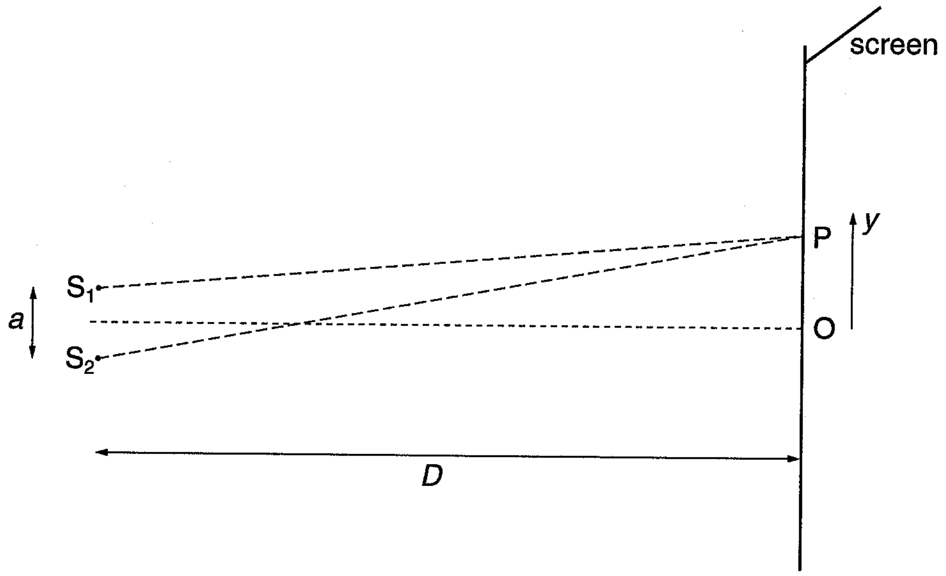

Fig. 5.1

(i) In order to produce a clear interference pattern on the screen the light sources must be *coherent*. State what is meant by *coherence*.

....

....

.... [2]

(ii) The point P is the first position of *minimum* intensity moving up from the central point of maximum intensity O. State, in terms of the wavelength λ, the magnitude of the path difference between S_1P and S_2P.

.... [1]

(iii) When $D = 1.5$ m and light of wavelength 6.4×10^{-7} m is incident on the double slit, the distance between P and O is 4.0 mm. Calculate the slit separation *a*.

a = ... m [3]

(iv) Sketch on the axes of Fig. 5.2 the variation of the intensity of the light on the screen with distance *y* from O. [2]

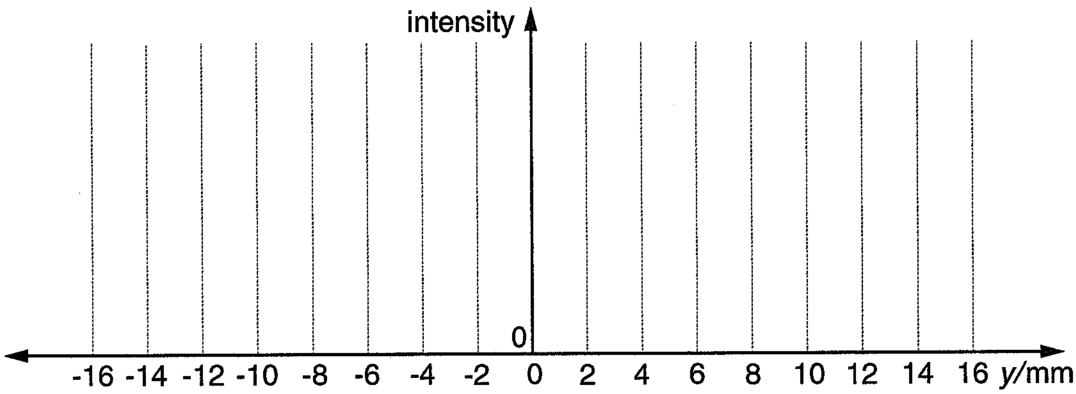

Fig. 5.2

[Total: 10]

For Examiner's Use

6 **(a)** State what is meant by the diffraction of waves.

....

....

....

....

.... [2]

(b) Fig. 6.1 shows water ripples approaching a gap in a barrier. In **(i)** the gap is narrow and in **(ii)** the gap is wide.

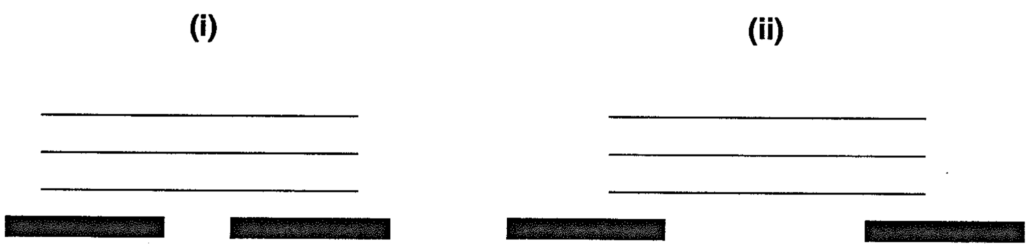

Fig. 6.1

On Fig. 6.1 draw the appearance of the ripples after they have passed through the gap. [3]

[Total: 5]

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