OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE UNIT **2823/01**

PHYSICS A

Wave Properties

FRIDAY 8 JUNE 2007 Morning

Time: 45 minutes

Additional materials: Electronic calculator

CUP/T30938

Candidate Name

Centre Number

Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate Number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is 45.
- 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	13	
3	6	
4	9	
5	6	
TOTAL	45	

This document consists of **11** printed pages and **1** blank page.

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 **(a)** Define the following terms associated with waves.

(i) frequency f

....

....[1]

(ii) wavelength λ

....

....[1]

(b) Use the definitions in **(a)** to deduce an equation for the speed v of a wave in terms of λ and f.

[3]

(c) **(i)** The speed of sound in air is about $340\,\text{m}\,\text{s}^{-1}$ while light travels at a speed of $3.0 \times 10^8\,\text{m s}^{-1}$. Calculate the time interval between seeing a flash of lightning, 1.0 km away, and hearing the sound of thunder caused by the lightning.

time interval = ... s [3]

(ii) Describe how observers may estimate their distance away from the point of a flash of lightning.

....

....

....[1]

(d) State two differences, other than their speeds, between sound and light waves.

....

....

....[2]

[Total: 11]

2 Fig. 2.1 shows a ray of light entering a semi-circular glass block and reaching the glass/air interface at the mid-point **M** of the straight face.

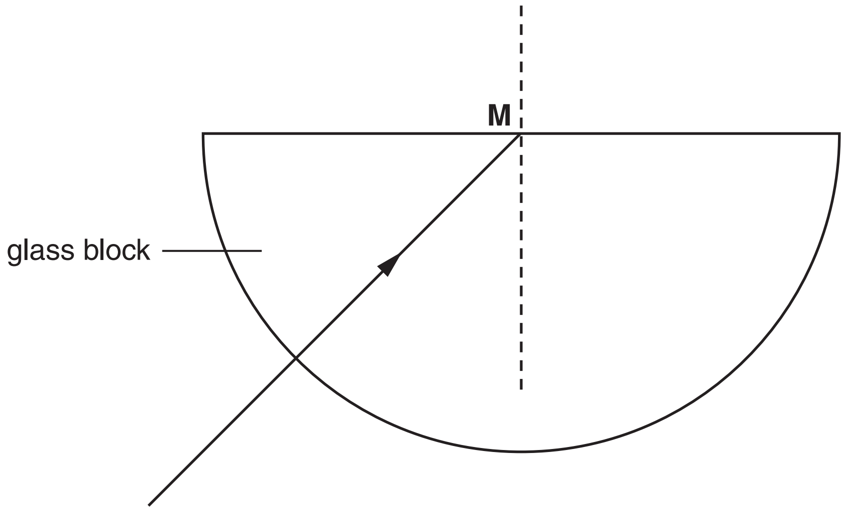

Fig. 2.1

(a) The ray of light meets the glass/air interface with an angle of incidence equal to the critical angle *C*.

(i) Label the angle *C* on Fig. 2.1. [1]

(ii) Show on Fig. 2.1 the path followed by the ray when it leaves the glass/air interface. [1]

(iii) State the angle of incidence for the ray of light as it enters the curved surface of the block.

angle = ...° [1]

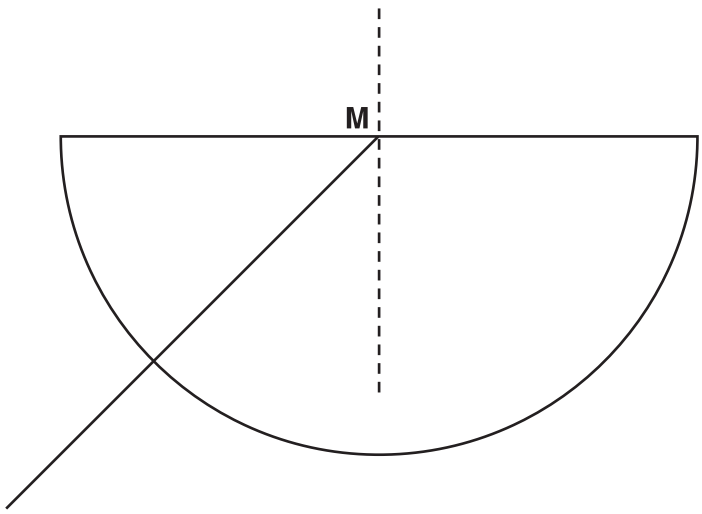

Fig. 2.2

(b) Fig. 2.2 shows the same ray of light as in Fig. 2.1.

On Fig. 2.2 draw two more rays that enter the curved surface and reach the midpoint **M** of the straight face at an angle of incidence

(i) less than *C* – label this ray **1**

(ii) greater than *C* – label this ray **2**.

Show the path followed by ray **1** after reaching the point M – again label this ray **1**.
Show the path followed by ray **2** after reaching the point M – again label this ray **2**. [2]

(c) The refractive index of the glass block is 1.54. Calculate

(i) the value of the critical angle *C*

C = ...° [2]

(ii) the speed of light in the glass

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

(iii) the angle of refraction corresponding to an angle of incidence, in the glass at **M**, of 30°.

angle of refraction = ...° [3]

[Total: 13]

3 Optic fibres are used in telecommunications to transmit signals. A single pulse of light is to be sent down a long optic fibre. The shape of the light pulse entering the fibre is shown in Fig. 3.1a.

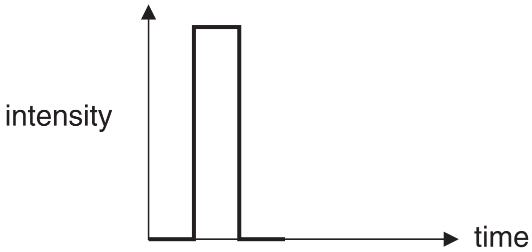

Fig. 3.1a

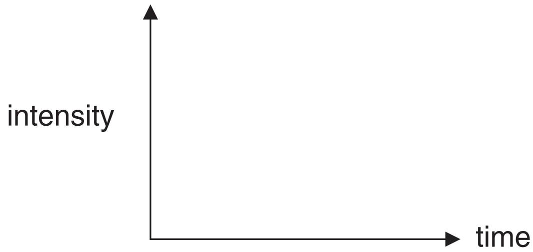

Fig. 3.1b

(a) Sketch on Fig. 3.1b the shape of the pulse after travelling through the optic fibre. [1]

(b) The shape of the pulse has changed.

(i) State the term used to describe the cause of this change of shape.

....[1]

(ii) Explain why the pulse shape has changed.

....

....

....

....[2]

(c) State and explain how an optic fibre could be designed to minimise the change in shape of the pulse.

....

....

....

....[2]

[Total: 6]

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4 **(a)** A detector is moved in front of two identical coherent wave sources and detects regions of constructive and destructive interference. Explain the terms

(i) *coherence*

....

....[1]

(ii) *path difference*.

....

....[1]

(b) Fig. 4.1 shows two identical monochromatic light sources $\mathbf{S_1}$ and $\mathbf{S_2}$ placed in front of a screen. The sources emit light in phase with each other.

Fig. 4.1

(i) State, in terms of the path difference of the waves, the conditions necessary to produce

1 constructive interference at point **P** on the screen

....

....[1]

2 destructive interference at point **Q** on the screen.

....

....[1]

(ii) The light sources $\mathbf{S_1}$ and $\mathbf{S_2}$ are 0.50 mm apart. They each emit light of wavelength 4.86×10^{-7} m. An interference pattern is produced on the screen placed 2.00 m from the sources. Calculate the distance between two neighbouring bright fringes on the screen.

distance = ... m [3]

(iii) Suggest how the appearance of the interference pattern would change if coherent **white** light sources were used instead of the monochromatic sources.

....

....

....[2]

[Total: 9]

Turn over for question 5

5 A phenomenon associated with microwave ovens is the uneven heating of food. An internet website gives the following explanation and the illustration shown in Fig. 5.1.

'Microwaves of a fixed frequency are emitted in all directions from a source within the oven. The waves reflect off the metal walls so that the microwave radiation reaching any particular point arrives both directly and by reflection. The waves interfere and set up standing waves. This produces the pattern of hot and cold zones observed in food heated in the oven.'

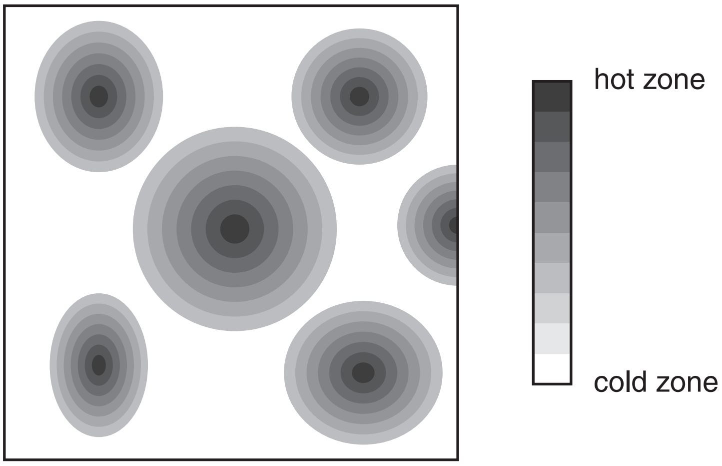

Fig. 5.1

(a) State how the reflected microwaves set up standing (stationary) waves in the oven.

....

....

....

....[2]

(b) Mark on Fig. 5.1 the positions of two antinodes – label these as **A**. [1]

(c) The frequency of the microwaves is 2.45×10^9 Hz. Calculate the wavelength of the microwaves.

wavelength = ... m [3]

[Total: 6]

END OF QUESTION PAPER