OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE **2823/01**

PHYSICS A

Wave Properties

FRIDAY 11 JANUARY 2008 Afternoon

Time: 45 minutes

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

CUP/T31920

Candidate Forename | Candidate Surname

Centre Number | Candidate Number

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Do **not** write outside the box bordering each page.
- Write your answer to each question in the space provided.

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	**14**	
2	**11**	
3	**12**	
4	**8**	
TOTAL	**45**	

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

Answer **all** the questions.

1 **(a)** Define the *refractive index* of a transparent medium

(i) in terms of the speed of light

[1]

(ii) in terms of the angle of incidence *i* and angle of refraction *r*.

[1]

(b) Fig. 1.1 shows a ray of light in a glass, optic fibre of refractive index 1.46. The angle of incidence of the ray at the glass/air interface is 40°.

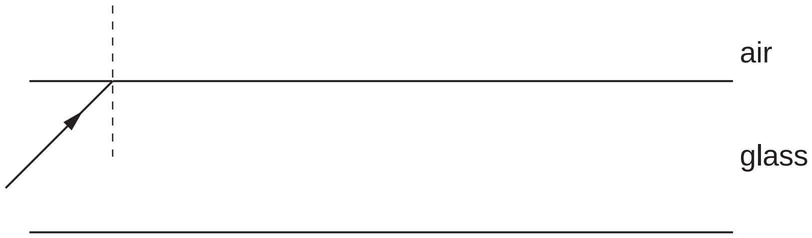

Fig. 1.1

(i) Calculate the angle of refraction of the ray.

angle of refraction = ... ° [3]

(ii) Show that the critical angle at the glass/air interface is 43°.

[2]

(iii) Describe the path followed by a ray of light that reaches the glass/air interface at an angle of incidence of 60°.

....

....

....[1]

(c)

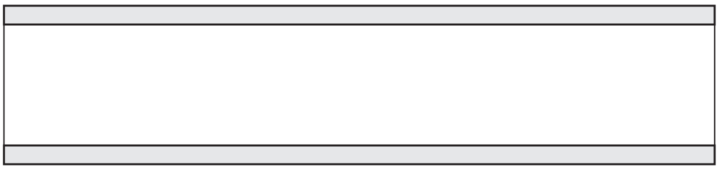

Fig. 1.2

Fig. 1.2 shows the glass fibre core, of refractive index 1.46, surrounded by transparent cladding of refractive index 1.40.

(i) Calculate the speed of light

1 in the glass core

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

2 in the cladding.

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

(ii) State and explain, without further calculations, how the critical angle for this core/cladding interface compares with the critical angle for the glass/air interface in **(b)**.

....

....

....

....[2]

(iii) Apart from any protection it provides for the core explain why the use of cladding may be an advantage for optic fibres used in telecommunications.

....

....

....

....[2]

[Total: 14]

2 **(a)** Complete the table below by writing, alongside the definition, the appropriate symbol of the travelling wave characteristic chosen from the following list:

period T, amplitude a, wavelength λ, frequency f, speed v

definition	symbol
number of cycles produced per unit time	
maximum displacement	
minimum distance between points on the wave moving in phase	
distance travelled by the wave per unit time	
time taken to complete one wave cycle	

[3]

(b) A wave source has a frequency of 125 Hz and an amplitude of 3.0 mm.

(i) Calculate the period of the wave.

period = ... s [1]

(ii) On the grid in Fig. 2.1, sketch a graph showing the variation with time t of the displacement x of the source. Assume x = 0 when t = 0 and draw at least one complete oscillation. Label this graph **A**. [3]

(iii) On Fig. 2.1 sketch a second oscillation of the same frequency and amplitude but with a phase difference of 90° to the original oscillation. Label this graph **B**. [2]

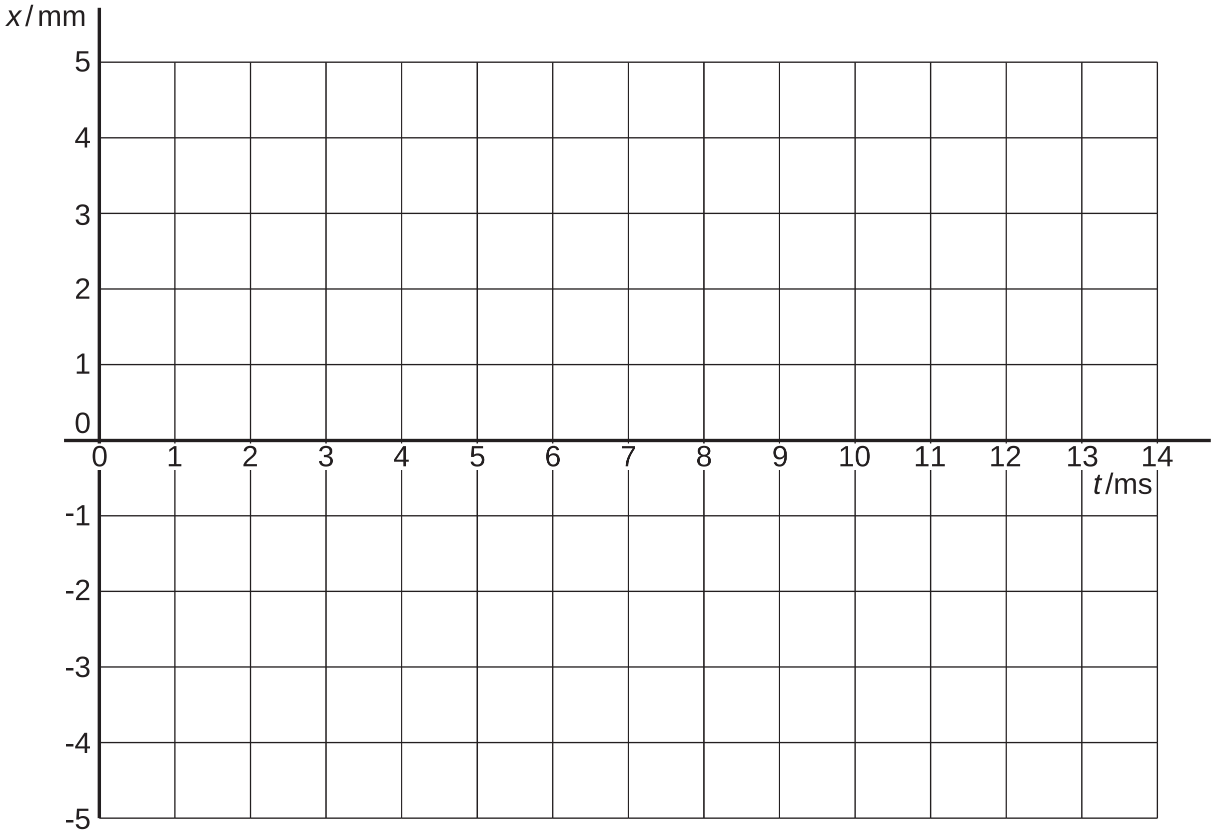

Fig. 2.1

(iv) The speed of the waves is 340 m s^{-1}. Determine their wavelength.

wavelength = ... m [2]

[Total: 11]

3 **(a)** With reference to the vibrations involved, state the difference between *transverse* and *longitudinal* waves. State an example of each.

....

....

....

example of a transverse wave: ....

example of a longitudinal wave: ....[3]

(b) State one similarity and one difference between *progressive* waves and *standing (stationary)* waves.

similarity: ....

....

difference: ....

....[2]

(c) Explain what is meant by

(i) a *node*

....

....[1]

(ii) an *antinode.*

....

....[1]

(d) The distance between a node and the neighbouring antinode in a standing wave formed on a stretched string is 0.12 m. Calculate the wavelength.

wavelength = ... m [1]

(e) Describe and explain how a standing wave can be formed using a suitable source of longitudinal waves. State the wave source and describe the arrangement using a labelled diagram. Label the position of a node (label as **N**) and an antinode (label as **A**).

....

....

....

....

....[4]

[Total: 12]

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

....

....

....[2]

(b) Fig. 4.1 shows an arrangement to produce an observable interference pattern. $\mathbf{S_1}$ and $\mathbf{S_2}$ are two coherent light sources separated by a distance of 0.20 mm. They are positioned 1.8 m in front of a screen.

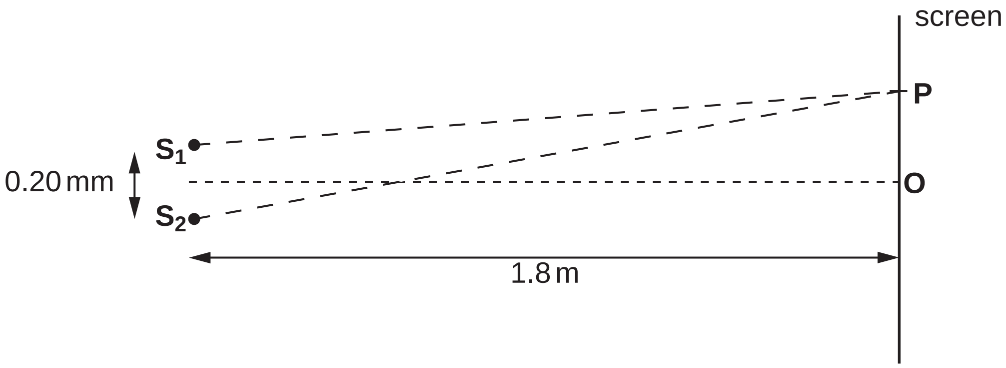

Fig. 4.1

(i) A series of bright images is formed on the screen. One image is at the centre of the interference pattern at **O** and another is at **P**. State, in terms of the wavelength λ, **two** possible values for the path difference between $\mathbf{S_2P}$ and $\mathbf{S_1P}$.

[1]

(ii) The wavelength of the light leaving $\mathbf{S_1}$ and $\mathbf{S_2}$ is 6.4×10^{-7} m. Calculate the distance between neighbouring bright images on the screen.

distance = ... m [3]

(iii) State and explain how the interference pattern changes when coherent wave sources of higher frequency are used, assuming that all other factors remain the same.

....

....

....

....[2]

[Total: 8]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE