THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A

Wave Properties

2823/01

Candidates answer on the question paper

OCR Supplied Materials:
None

Other Materials Required:
- Electronic calculator

Tuesday 13 January 2009
Afternoon

Duration: 45 minutes

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use 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.
- Write your answer to each question in the space provided, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

- The number of marks 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.
- This document consists of **12** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max**	**Mark**
1	**14**	
2	**10**	
3	**9**	
4	**12**	
TOTAL	**45**	

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

Answer **all** the questions.

1 Fig. 1.1 shows a ray of light passing from air into a liquid.

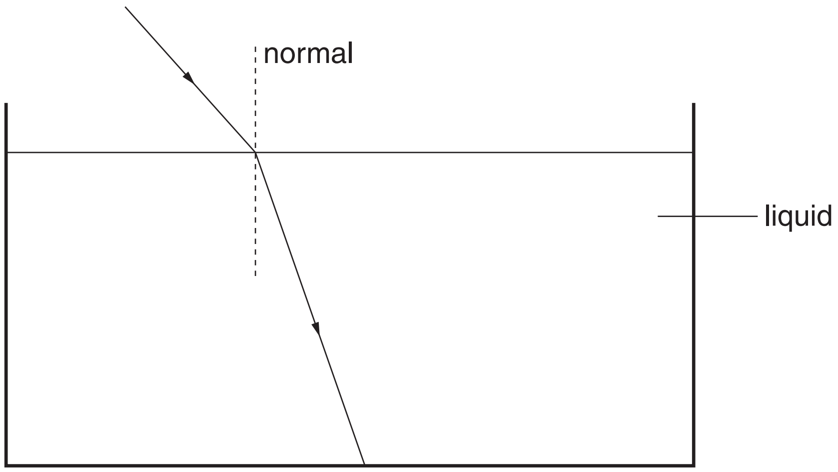

Fig. 1.1

(a) (i) Show on Fig. 1.1 the angle of incidence *i*, and the angle of refraction *r*. **[1]**

(ii) The refractive index of the liquid is 1.4. Calculate the angle of refraction for light incident at 30°.

angle of refraction = ... ° **[3]**

(iii) Without further calculation, state and explain how the angle of refraction changes when this liquid is replaced with water of refractive index 1.3. The angle of incidence is kept the same at 30°.

....

....

....

....

.... **[2]**

(b) **(i)** Calculate the speed of light in water of refractive index 1.3.

speed of light in water = ... $m\,s^{-1}$ **[2]**

(ii) The wavelength of the incident light in air is 5.2×10^{-7} m. Determine

1 the frequency of the incident light

frequency = ...Hz **[3]**

2 the wavelength of the light in water

wavelength = ... m **[2]**

3 the frequency of the light in water.

frequency = ...Hz **[1]**

[Total: 14]

2 **(a)** State the principle of superposition. Explain how this principle accounts for constructive and destructive interference.

....

....

....

....

....

.... **[4]**

(b) Fig. 2.1 shows a plan view of an experiment to demonstrate interference of microwaves. **T** is a transmitter placed near a steel plate. The transmitter emits microwaves in all directions. **D** is a microwave detector.

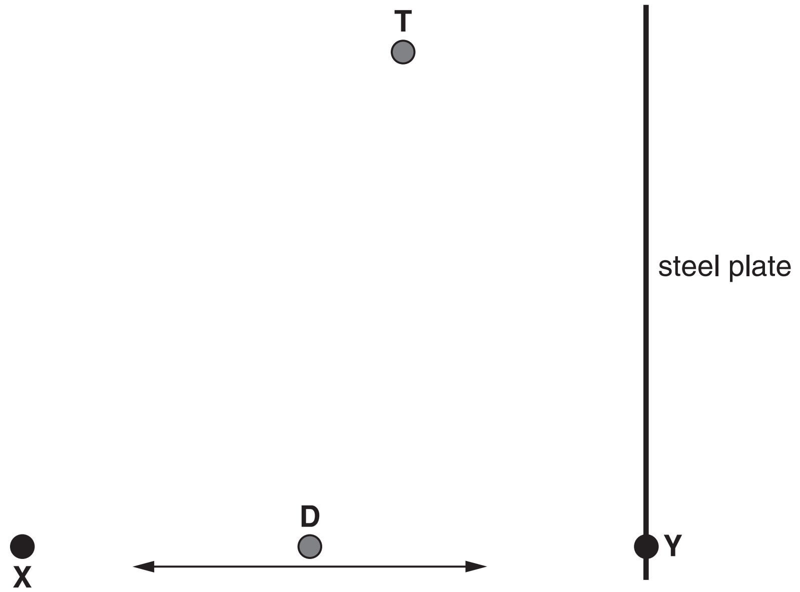

Fig. 2.1

(i) On Fig. 2.1 draw two paths taken by the microwaves that leave **T** and reach **D**. **[1]**

(ii) When **D** is moved between points **X** and **Y** a series of maximum and minimum signals is detected. By referring to the path difference between the two sets of waves arriving at **D** explain why these maxima and minima are formed.

....

....

....

.... **[2]**

(c) In a double-slit experiment using light of wavelength 6.4×10^{-7} m, an interference pattern is formed on a screen placed 1.8 m from the double slit. The distance between neighbouring dark lines in the interference pattern is 2.4 mm. Calculate the separation of the slits.

separation = ... m **[3]**

[Total: 10]

3 **(a)** **(i)** Draw a labelled diagram of an optic fibre composed of a core with surrounding cladding that could be used to transmit data.

[1]

(ii) Explain why the refractive index of the cladding must be less than that of the core.

....

....

.... **[1]**

(b) **(i)** An optic fibre has a core of refractive index 1.52. Calculate the value of the critical angle for this fibre without cladding.

critical angle = ... ° **[2]**

(ii) The speed of light is $1.974 \times 10^8\,\mathrm{m\,s^{-1}}$ in the core and $2.014 \times 10^8\,\mathrm{m\,s^{-1}}$ in the cladding. Calculate the critical angle at the core/cladding interface.

critical angle = ... ° **[2]**

(iii) Explain why it is advantageous to have a high value for the critical angle of an optic fibre when it is used to transmit data.

....

....

....

....

....

....

.... **[3]**

[Total: 9]

4 **(a)** A slinky spring can be used to demonstrate longitudinal or transverse waves. State how the individual coils of the slinky would move when transmitting

(i) a longitudinal wave

....

....

....

(ii) a transverse wave.

....

....

.... **[2]**

(b) State two differences and one similarity between progressive waves and standing (stationary) waves:

(i) differences

1. ....

....

2. ....

....

(ii) similarity ....

.... **[3]**

(c) Fig. 4.1 shows a tall hollow cylinder with one open end. A standing wave can be formed in the air column in the cylinder by holding a vibrating tuning fork near the top.

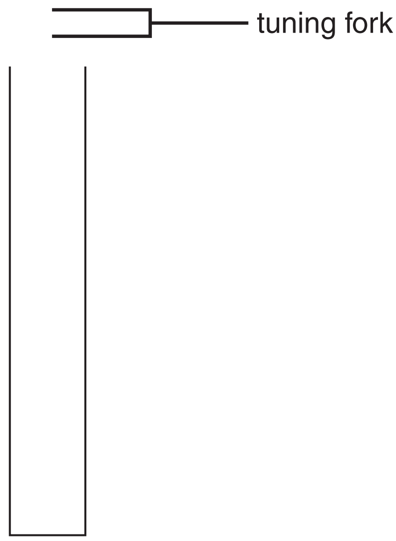

Fig. 4.1

(i) The air column in Fig. 4.1 is producing its lowest frequency note (fundamental). Label on Fig. 4.1 the positions in the cylinder of a node, with the letter **N**, and an antinode with the letter **A**. **[2]**

(ii) The length of the air column is 0.64 m and the speed of sound in air is 330 m s^{-1}. Calculate the frequency of this standing wave.

frequency = ...Hz **[3]**

(d) Fig. 4.2 shows a cylinder identical to that shown in Fig. 4.1 except that it has two open ends. A standing wave is again formed in the air column in the cylinder by another vibrating tuning fork. The standing wave is vibrating in its fundamental mode.

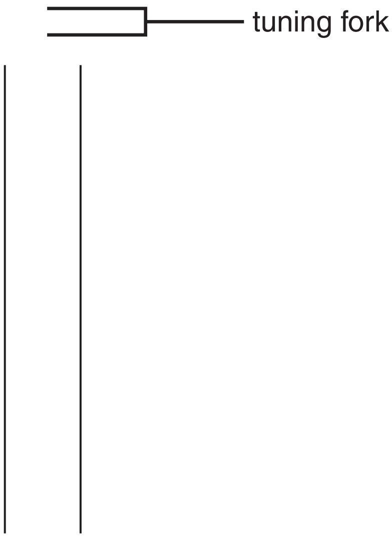

Fig. 4.2

(i) Mark the positions of a node **N** and antinodes **A** in the air column. **[1]**

(ii) Determine the frequency of this standing wave.

frequency = ...Hz **[1]**

[Total: 12]

END OF QUESTION PAPER