OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced Subsidiary GCE

# PHYSICS A

Wave Properties

2823/01

Friday 9 JUNE 2006 Morning 45 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler (cm/mm)

Candidate Name

Centre Number

Candidate Number

**TIME** 45 minutes

## INSTRUCTIONS TO CANDIDATES

- Write your name, Centre Number and Candidate number in the boxes above.
- Answer **all** the questions.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Pencil may be used for graphs and diagrams only.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT** WRITE IN THE AREA **OUTSIDE** THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.

## INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the 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 | 10 | |
| 2 | 8 | |
| 3 | 8 | |
| 4 | 9 | |
| 5 | 10 | |
| **TOTAL** | 45 | |

**This question paper consists of 12 printed pages.**



*712601401*

**[Turn over**

**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)** The refractive index $n$ of a transparent medium is defined by the equation

$$n = \frac{c_i}{c_r}.$$

State what is meant by

**(i)** $c_i$ ..........................................................................................................................

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**(ii)** $c_r$ ..........................................................................................................................

..........................................................................................................................[2]

**(b)** A ray of red laser light enters a transparent medium from air at an angle of incidence of 60°. The refractive index of the medium for this red light is 1.48.

**(i)** In the space below, sketch a ray diagram to show how the ray is refracted as it enters the medium. Label your diagram to show

- the normal at the point of entry
- the 60° angle of incidence
- the angle of refraction $r$.

[3]

**(ii)** Calculate the value of $r$.

$r$ = ................................ ° [2]

**(iii)** In air, the wavelength of the light is $6.48 \times 10^{-7}$ m and its frequency is $4.63 \times 10^{14}$ Hz. Determine the wavelength and frequency of this light in the **medium**.

wavelength = ........................................ m

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

[Total: 10]

2 **(a)** Fig. 2.1 shows three rays of light **X**, **Y** and **Z** leaving a point light source inside a glass block. Ray **Y** meets the glass/air interface at the critical angle ***C***.

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

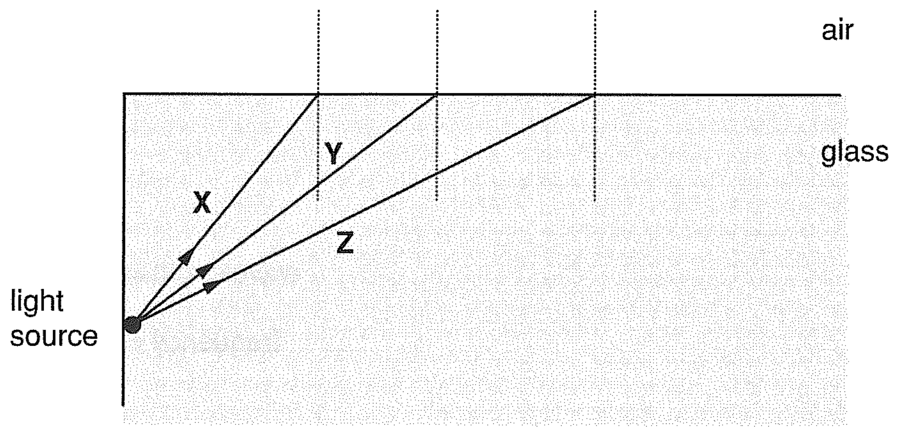


**Fig. 2.1**

**(ii)** On Fig. 2.1, continue rays **X**, **Y** and **Z** to show their paths after they meet the interface. [3]

**(iii)** The value of ***C*** is 44°. Calculate the refractive index *n* of the glass.

$n$ = ...................................[2]

**(b)** State and describe a practical application of the total internal reflection of light.

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[Total: 8]

**3** Fig. 3.1 shows part of a student's revision notes about 'Waves'. The notes contain several errors of physics.

WAVES
1. Longitudinal waves are caused by vibrations perpendicular to the direction of the waves.
2. No waves can travel through a vacuum, there must be a medium to carry them.
3. Waves carry the medium from one place to another.
4. Speed v is the distance travelled by the wave per unit time.
5. Frequency $f$ is the number of waves produced in unit time.
6. Wavelength $\lambda$ is the distance from a crest to a trough.

**Fig. 3.1**

Identify 4 incorrect statements of physics and state how each could be corrected.

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[Total: 8]

4 **(a)** Draw a labelled diagram to show the arrangement that you would use to produce, on a screen, a double-slit interference pattern for light.

[1]

In order to see the interference pattern clearly in a darkened room, suggest suitable values for

**(i)** the distance from the double-slit to the screen

distance = ........................................

**(ii)** the distance between the centres of the slits in the double-slit.

distance= ........................................

[2]

**(b)** Fig. 4.1 shows the light and dark fringes in a typical double-slit interference pattern. The diagram is drawn to full scale.

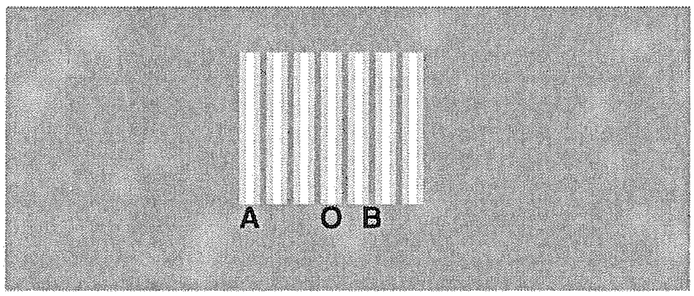


**Fig. 4.1**

**(i)** By taking measurements directly from Fig. 4.1, determine the fringe separation $x$.

$x$ = ............................mm [1]

**(ii)** Fringe **O** is the bright fringe at the centre of the pattern, **A** is a bright fringe and **B** is a dark fringe. For each of these fringes, state in terms of the wavelength $\lambda$, the value of the path difference for light coming from each slit.

fringe **O** path difference = ..............................................................................

fringe **A** path difference = ..............................................................................

fringe **B** path difference = ..............................................................................

[3]

**(c)** Use the formula for double-slit interference to explain how the fringe separation would change if blue light were used instead of red light.

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[Total: 9]

5 **(a)** State **two** differences between sound and light waves.

1. ..........................................................................................................................

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2. ..........................................................................................................................

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**(b)** The diffraction of waves can be demonstrated using a ripple tank.

**(i)** Describe how plane, transverse water waves can be produced in the ripple tank.

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**(ii)** Explain how the wavelength of the water waves can be increased.

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**(iii)** State how the speed of the water waves can be reduced.

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**(c)** Fig. 5.1 shows plane water waves in a ripple tank approaching a narrow gap.
On the diagram, draw the pattern of the wavefronts emerging from the gap. [2]

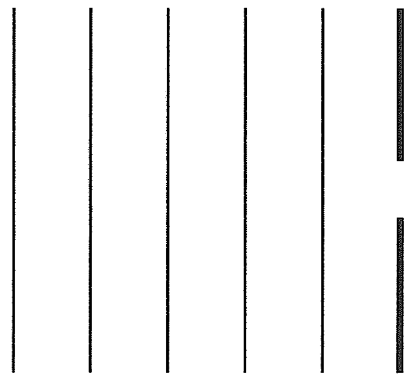

**Fig. 5.1**

**(d)** Explain why the diffraction of sound waves is much more likely to be noticeable than the diffraction of light.

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[Total: 10]

**END OF QUESTION PAPER**