Rewarding Learning

Centre Number

| 71 | |
|---|---|

Candidate Number

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**ADVANCED SUBSIDIARY**
**General Certificate of Education**
**January 2012**

# Physics

## Assessment Unit AS 2

*assessing*

## Module 2: Waves, Photons and Medical Physics

**[AY121]**

AY121

**FRIDAY 20 JANUARY, MORNING**

**TIME**

1 hour 30 minutes.

**INSTRUCTIONS TO CANDIDATES**

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this question paper.

**INFORMATION FOR CANDIDATES**

The total mark for this paper is 75.
Quality of written communication will be assessed in question **2**.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.
You may use an electronic calculator.

| For Examiner's use only | |
|---|---|
| Question Number | Marks |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| 7 | |
| 8 | |
| 9 | |
| 10 | |
| Total Marks | |

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**1 (a) (i)** Waves may be categorised as either transverse or longitudinal. Describe how to distinguish between these two categories.

_____

_____

_____

_____ [2]

**(ii)** Complete **Table 1.1** below to indicate the category of the waves listed.

**Table 1.1**

| Wave | transverse or longitudinal |
|---|---|
| microwaves | |
| waves on a string | |
| waves in a resonance tube | |
| surface water waves | |

[2]

**(b)** Some waves may be polarised. Which category of wave may be polarised? Explain what is meant by polarisation.

_____

_____ [2]

**2 Where appropriate in this question you should answer in continuous prose. You will be assessed on the quality of your written communication.**

| Examiner Only | |
|---|---|
| Marks | Remark |

**(a)** State Snell's Law of refraction.

_____

_____

_____ [2]

**(b)** Describe an experiment to verify Snell's Law.

In your description you should:
**(i)** draw a labelled diagram of the apparatus you intend to use.
**(ii)** describe how the apparatus is used to obtain measurements.
**(iii)** explain how the measurements are used to verify Snell's Law.

**(i)** Labelled diagram

[1]

**(ii)** Description of how the apparatus is used to obtain measurements.

_____

_____

_____

_____

_____

_____

_____ [3]

| Examiner Only | |
|---|---|
| Marks | Remark |

**(iii)** Explanation of how the measurements are used to verify Snell's Law.

_____

_____

_____

_____

_____

_____ [2]

Quality of written communication [2]

**(c)** A ray of light is incident on the surface of a clear liquid in a beaker shown in **Fig. 2.1**. The refractive index from air to the liquid is 1.38.

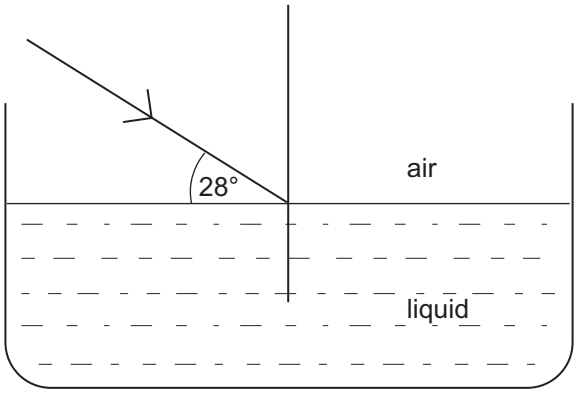


**Fig. 2.1**

Calculate the angle of refraction in the liquid.

Angle of refraction = _____ ° [2]

| Examiner Only | |
|---|---|
| Marks | Remark |

**3** **(a)** **Fig. 3.1** shows an object, O, placed in front of a lens, L. The axis of the lens is included. The lens forms a **real magnified** image.

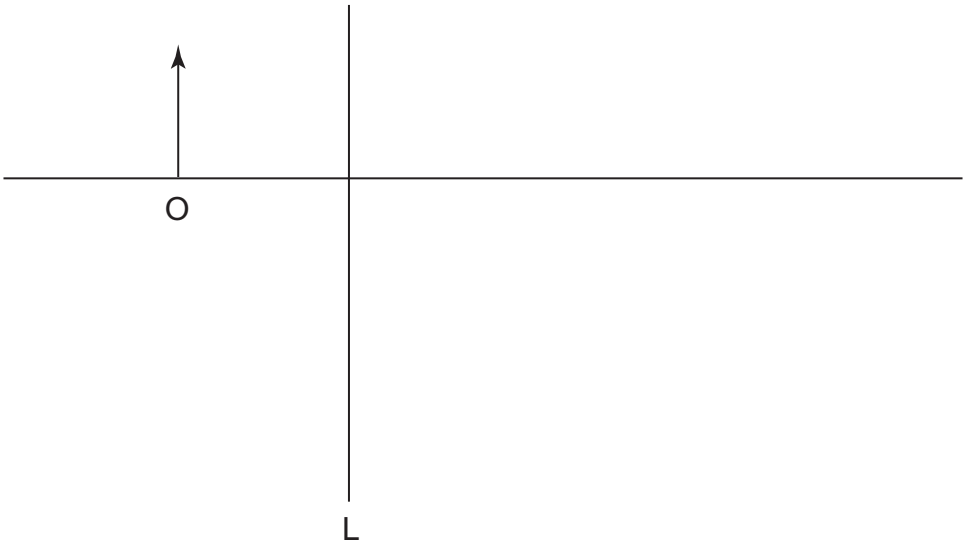


**Fig. 3.1**

**(i)** Name the type of lens that must be used.

_____ [1]

**(ii)** On **Fig. 3.1** draw a ray diagram to show the formation of a real magnified image. Label both the image I and a principal focus, F, for the lens. [4]

**(b)** A student has near point 1.8 m.

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**(i)** What type of lens is needed to allow the student to focus objects 25 cm from the eye? Calculate its focal length.

Type of lens = _____

Focal length = _____ cm [3]

**(ii)** Calculate the power of this lens and state its unit.

Lens power = _____ Unit _____ [2]

| Examiner Only | |
|---|---|
| Marks | Remark |

**4** **(a)** State the principle of superposition.

_____

_____

_____ [3]

**(b)** **Fig. 4.1** shows two waves of different amplitudes and frequencies.

The wave with the smaller amplitude has three times the frequency of the wave with the larger amplitude.

**(i)** Using the principle of superposition sketch the resultant wave shape on **Fig. 4.1**. [3]

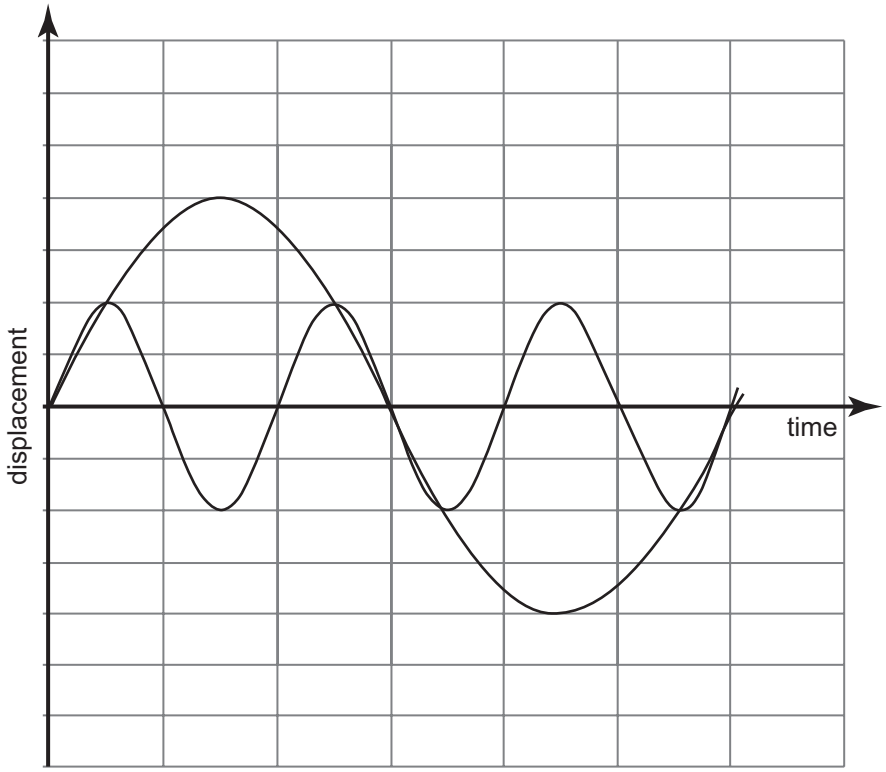


**Fig. 4.1**

The frequency of the wave with larger amplitude is $f_0$.

**(ii)** What is the frequency of the resultant wave? Tick the correct answer from the responses below.

$f_0$ ☐ $2f_0$ ☐ $3f_0$ ☐ $4f_0$ ☐ [1]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**5** Light from a single source is split in two by a double slit, as shown in **Fig. 5.1**, and the two beams overlap in the region beyond and illuminate a screen.


**Fig. 5.1**

**(a)** The two beams that emerge from $S_1$ and $S_2$ are said to be **coherent**.

**(i)** What is meant by **coherent**?

_____

_____ [1]

**(ii)** If, at certain points on the screen, the two waves show **total** destructive interference they must be coherent. What other two conditions must be met?

1. _____

2. _____ [2]

**(b) (i)** Use **Fig. 5.1** to explain what is meant by path difference.

Examiner Only

| Marks | Remark |
|---|---|
| | |

_____

_____ [1]

**(ii)** What will be observed on the screen at point **Z**, equidistant from each slit? You may assume that the light emerging from $S_1$ and $S_2$ is in phase.

_____ [1]

**(iii)** In terms of the path difference, what condition must be met for total destructive interference to occur at point **Y**?

_____ [1]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**6** The speed of sound in air may be measured by the resonance tube method.

**(a) (i)** Draw a labelled sketch of the apparatus to be used in this experiment.

[2]

**(ii)** Describe how the first position of resonance may be found.

_____

_____

_____ [3]

| Examiner Only | |
|---|---|
| Marks | Remark |

**(b)** In a resonance tube experiment a source of sound of unknown frequency is used and the frequency is measured using a cathode ray oscilloscope. **Fig. 6.1** shows the trace obtained on the screen of the oscilloscope with the time base set at $0.5\,\text{ms}\,\text{cm}^{-1}$.

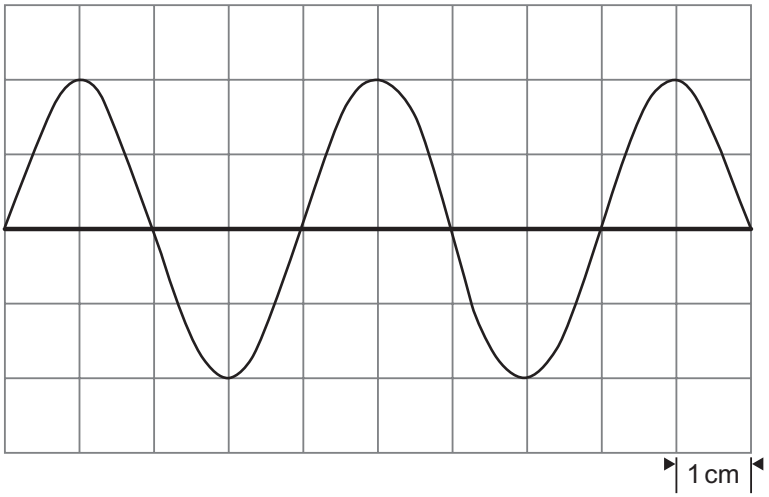


**Fig. 6.1**

**(i)** Calculate the frequency of the sound source.

Frequency = _____ Hz [2]

**(ii)** Taking the speed of sound in air to be $340\,\text{m}\,\text{s}^{-1}$, use this frequency to calculate the length of air column at first resonance position.

Length of air column = _____ m [2]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**7** X-rays have been used in medical diagnosis for over a century.

**(a) (i)** Describe briefly how an image of part of a patient is obtained using conventional x-ray imaging.

_____

_____

_____ [2]

**(ii)** More recently CT scans have become available. Explain how the equipment needed and the process for CT scans differs from conventional x-ray imaging.

_____

_____

_____

_____

_____

_____ [3]

**(b)** A patient with a previous fracture has had a steel pin inserted. He returns for a check-up scan. Explain why a CT scan would be preferable to an MRI scan.

_____

_____

_____ [1]

| Examiner Only | |
|---|---|
| Marks | Remark |

**8** **(a)** **(i)** What is meant by the **work function** of a metal?

_____

_____

_____ [1]

**(ii)** The longest wavelength of radiation which can cause photoelectric emission from a certain metal is 520 nm. Calculate the work function of this metal in electron volts.

Work function = _____ eV [2]

**(b)** One type of sodium street lamp is rated at 160 W input power. It is 70% efficient in converting this energy to light in the form of a stream of photons each of mean energy $3.38 \times 10^{-19}$ J.

Calculate the number of photons emitted per second by the lamp.

Photons emitted per second = _____ $s^{-1}$ [2]

| Examiner Only | |
|---|---|
| Marks | Remark |
| | |

**9** **Fig. 9.1** is a simplified diagram of some of the energy levels of an isolated hydrogen atom. The diagram is not to scale.

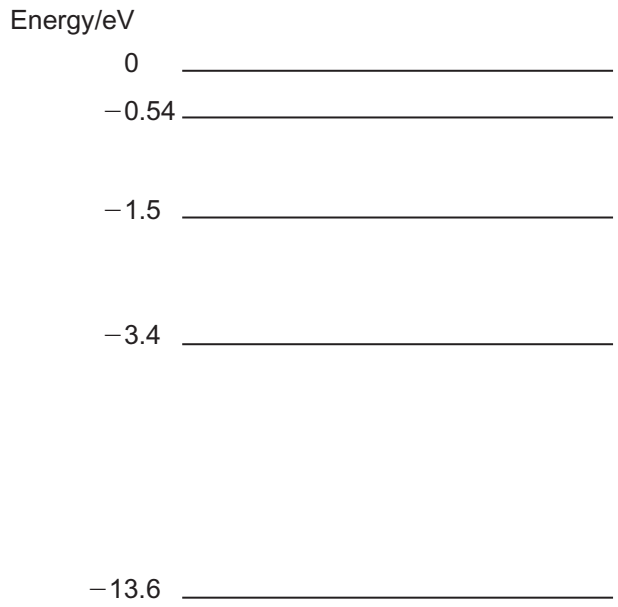


**Fig. 9.1**

**(a)** **(i)** What does the term ground state mean?

_____

_____ [1]

**(ii)** What is the energy level value of the ground state of the hydrogen atom?

_____ [1]

**(b)** **(i)** Calculate the longest wavelength of the radiation emitted when an electron makes an appropriate transition between two of the levels shown.

Wavelength = _____ μm [3]

**(ii)** On **Fig. 9.1** show clearly, with an arrow between the appropriate levels, the direction of the electron movement for this transition to occur. [1]

| Examiner Only | |
|---|---|
| Marks | Remark |

**10 (a)** With the aid of a labelled sketch describe briefly how the wave properties of electrons may be demonstrated.

_____

_____

_____ [4]

**(b)** In a cathode ray tube electrons are accelerated until they acquire a velocity of $4.20 \times 10^7 \, m\,s^{-1}$.

**(i)** Calculate the de Broglie wavelength of one of these electrons.

Wavelength = _____ m [2]

**(ii)** Explain how wave-particle duality is integral to the de Broglie equation.

_____

_____

_____ [2]

**THIS IS THE END OF THE QUESTION PAPER**

112606

**GCE (Advanced Subsidiary) Physics**

**Data and Formulae Sheet**

## Values of constants

| | |
|---|---|
| speed of light in a vacuum | $c = 3.00 \times 10^{8}$ m s$^{-1}$ |
| elementary charge | $e = 1.60 \times 10^{-19}$ C |
| the Planck constant | $h = 6.63 \times 10^{-34}$ J s |
| mass of electron | $m_e = 9.11 \times 10^{-31}$ kg |
| mass of proton | $m_p = 1.67 \times 10^{-27}$ kg |
| acceleration of free fall on the Earth's surface | $g = 9.81$ m s$^{-2}$ |
| electron volt | 1 eV $= 1.60 \times 10^{-19}$ J |

## Useful formulae

The following equations may be useful in answering some of the questions in the examination:

### Mechanics

| | |
|---|---|
| Conservation of energy | $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = Fs$ for a constant force |
| Hooke's Law | $F = kx$ (spring constant $k$) |

### Sound

| | |
|---|---|
| Sound intensity level/dB | $= 10 \lg_{10} \frac{I}{I_0}$ |

### Waves

| | |
|---|---|
| Two-source interference | $\lambda = \frac{ay}{d}$ |

### Light

| | |
|---|---|
| Lens formula | $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ |
| Magnification | $m = \frac{v}{u}$ |

### Electricity

| | |
|---|---|
| Terminal potential difference | $V = E - Ir$ (E.m.f. $E$; Internal Resistance $r$) |
| Potential divider | $V_{out} = \frac{R_1 V_{in}}{R_1 + R_2}$ |

### Particles and photons

| | |
|---|---|
| de Broglie equation | $\lambda = \frac{h}{p}$ |