Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2014

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

THURSDAY 19 JUNE, MORNING

AY121

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 six** 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 **(5)(c)**.
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	
Total Marks	

Examiner Only	
Marks	Remark

1 **(a)** There is a wide range of electromagnetic waves forming a continuous spectrum. They are classified as transverse waves.

(i) What is the meaning of the term 'wave' as used here?

_____

_____ [1]

(ii) Why are electromagnetic waves classified as transverse waves and not as longitudinal waves?

_____

_____

_____ [2]

(b) The wavelengths of some electromagnetic waves are listed in **Table 1.1** below. Assume the waves to be travelling in a vacuum.

(i) State the region of the spectrum which you would associate with each.

Table 1.1

Wavelength	Region
3.2 cm	
470 nm	
560 pm	

[3]

(ii) From the list in **Table 1.1**, choose the wave of **lowest frequency** and calculate its frequency.

Examiner Only

Marks	Remark

Frequency _____ Hz [3]

(c) A beam of visible light has been **polarised**.

(i) What is meant by the term 'polarised' waves?

_____

_____ [1]

(ii) Describe how you would demonstrate that the beam of visible light is polarised.

_____

_____

_____ [2]

(d) Surface water waves can also be classified as transverse waves. State one **difference** between electromagnetic waves and other transverse waves.

_____

_____ [1]

Examiner Only	
Marks	Remark

2 **(a)** A student carried out an experiment to verify Snell's law of refraction. She did so by directing a ray of light at the surface of a rectangular perspex block at various angles of incidence *i* and measuring the corresponding angles of refraction *r* within the block. She used these results to plot a graph from which the law could be verified.

(i) On **Fig. 2.1**, label the axes and sketch the graph that was obtained.

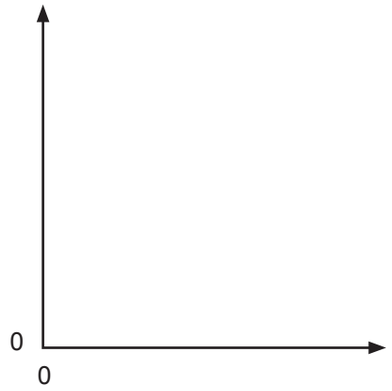

Fig. 2.1

[2]

(ii) State how the student could have obtained the refractive index of the perspex block from the graph in **Fig. 2.1**.

_____

_____ [1]

Examiner Only	
Marks	Remark

(b) A ray of light **R** is directed normally at one side of a transparent triangular prism as shown in **Fig. 2.2**.

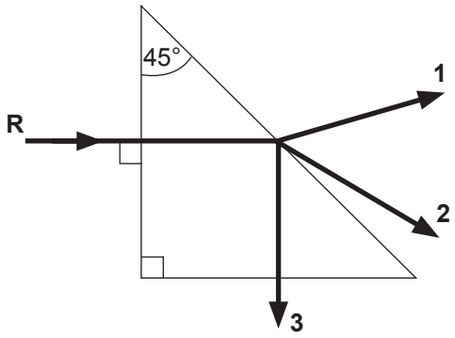

Fig. 2.2

(i) The material of the prism has a refractive index of 1.37. Calculate the critical angle for the material.

Critical angle = _____ ° [2]

(ii) Use your value of critical angle to determine if the ray will emerge along path **1**, path **2** or path **3** as shown in **Fig. 2.2**, and explain your choice.

Ray will emerge along path **1** ☐ path **2** ☐ path **3** ☐

Explanation: _____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

3 **(a)** Define the principal focus of a converging lens.

_____

_____ [2]

(b) **Fig. 3.1** shows a converging lens, its principal axis and principal foci, F. This lens is used to produce a **real**, **inverted** and **magnified** image IB, such as that produced by an overhead projector. The image IB is shown.

(i) On **Fig. 3.1**, complete the ray diagram by drawing two rays from the image to locate the object. Label the object OA.

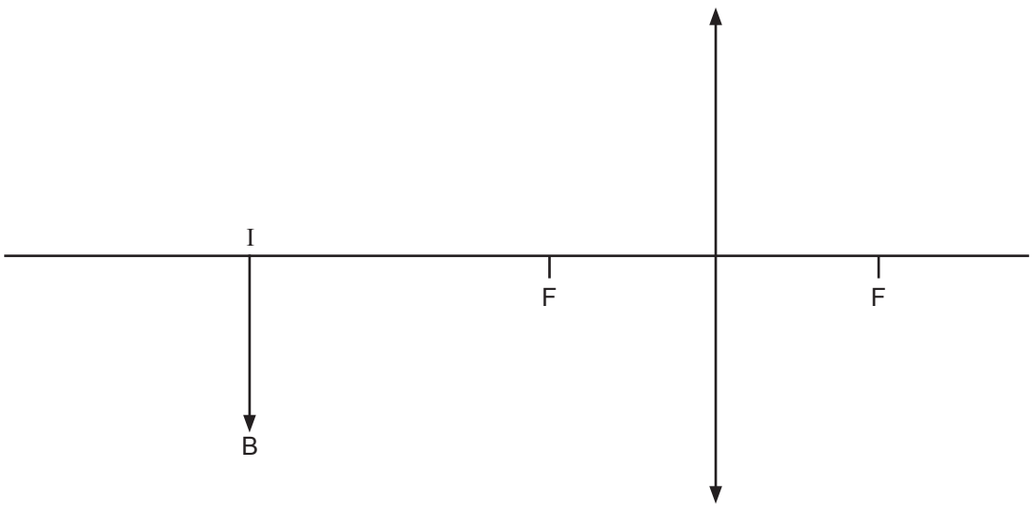

Fig. 3.1

[4]

(ii) The position of the object is now altered in order to obtain a new image which is **real**, **inverted** and **diminished**, such as that produced in a camera. Describe the new position of the object, in relation to the lens and principal focus.

_____

_____

_____ [2]

(c) A converging lens has a focal length of 300 mm. An object of height 30 mm is placed 240 mm from the lens.

Examiner Only	
Marks	Remark

(i) Calculate the distance of the image from the lens.

Image distance = _____ mm [2]

(ii) Calculate the height of the image.

Image height = _____ mm [2]

(iii) Describe the nature of the image formed.

_____

_____ [2]

(iv) Calculate the power of this converging lens. Include the unit.

Power = _____

Unit = _____ [2]

Examiner Only	
Marks	Remark

4 A student wishes to determine the speed of sound in air by the resonance tube method.

(a) Draw a labelled sketch of the apparatus required to carry out this experiment.

[2]

(b) What procedure should the student follow to ensure that the **first** position of resonance has been found?

_____

_____

_____

_____

_____

_____ [3]

(c) Describe the measurements the student should take, and how these are analysed, to obtain a reliable value for the speed of sound in air.

Examiner Only

Marks	Remark

_____

_____

_____

_____

_____ [3]

(d) A standing wave has been set up in the resonance tube. Name the physical principle involved and describe how the standing wave is formed in the tube.

_____

_____

_____

_____ [3]

Examiner Only	
Marks	Remark

5 Where appropriate in this question you should answer in continuous prose. You will be assessed on the quality of your written communication in part (c).

The human ear responds to sounds over a range of frequencies and sound intensities.

(a) (i) On **Fig. 5.1**, sketch a graph to show the variation with frequency f of the minimum audible intensity I_{min} for a normal human ear.

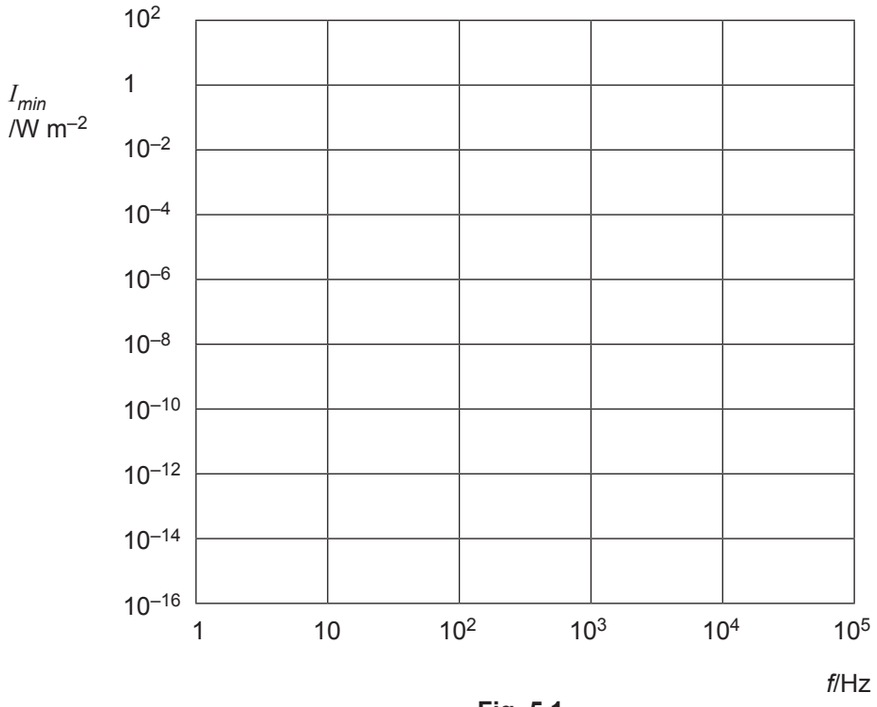

Fig. 5.1

[3]

(ii) The frequency scale of **Fig. 5.1** is logarithmic. Why is such a scale necessary on this graph?

_____

_____ [1]

(b) The threshold of feeling is the intensity level at which the sensation of hearing changes to one of discomfort or pain, and can be taken to be 110 dB.

Examiner Only	
Marks	Remark

(i) Show that this intensity level corresponds to a sound intensity of 0.1 W m^{-2}. ($I_0 = 1 \times 10^{-12}$ W m^{-2})

[1]

(ii) In order to prevent permanent hearing damage, a member of ground crew at an airport must wear ear defenders while refuelling aircraft. Engine sound intensities close to the aircraft are measured to be 0.1 W m^{-2}, the threshold of feeling. The effect of the ear defenders is to absorb 95 % of the sound intensity. By determining the intensity level with the ear defenders in place, calculate the **reduction** in intensity level for the wearer.

Reduction in intensity level = _____ dB [3]

(c) Ultrasound cannot be detected by the human ear but it can be used for internal imaging of the human body. One type of ultrasound scan is an A-scan. In the space below, briefly describe an A-scan by commenting on the physical principle involved, on the frequency of the ultrasound used, on the resulting display and on how the display is interpreted by the operator.

Examiner Only	
Marks	Remark

_____

_____

_____

_____

_____

_____

_____ [4]

Quality of written communication [2]

BLANK PAGE

(Questions continue overleaf)

Examiner Only	
Marks	Remark

6 **(a)** When an electric current is passed through a discharge tube of low pressure hydrogen gas, light is produced. If this light is viewed using a diffraction grating, a spectrum is observed. A simplified diagram of part of the resulting spectrum is shown in **Fig. 6.1** below. It is comprised of coloured lines on a dark background.

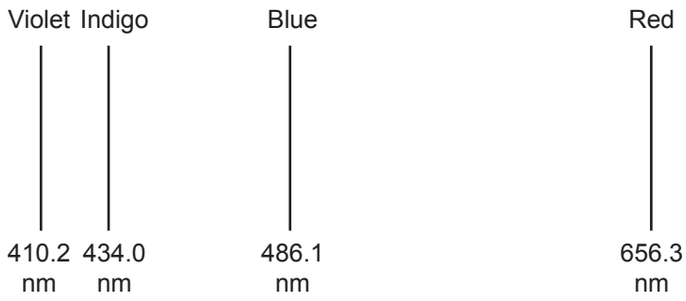

Fig. 6.1

(i) Explain how the formation of this spectrum provides evidence for energy levels within hydrogen atoms.

_____

_____

_____

_____

_____ [3]

(ii) Calculate the difference between energy levels in hydrogen that gives rise to the red line of wavelength 656.3 nm in the spectrum. Your answer should be given in eV.

Energy difference = _____ eV [3]

Examiner Only	
Marks	Remark

(b) When light of a certain wavelength is incident on the clean surface of a piece of zinc metal, electrons are emitted from the surface.

(i) What is this effect called?

_____ [1]

(ii) It is observed that when light of a longer wavelength is used to illuminate the metal surface, no electrons are emitted. Explain why electrons are no longer emitted.

_____

_____

_____

_____ [3]

(c) One of the emitted electrons has a de Broglie wavelength of 1.23 nm.

(i) State the meaning of a de Broglie wavelength.

_____

_____ [1]

(ii) Calculate the velocity with which the electron is moving.

Velocity = _____ $m\,s^{-1}$ [2]

THIS IS THE END OF THE QUESTION PAPER

184104

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	$\lambda = \frac{h}{p}$

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	$\lambda = \frac{h}{p}$