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ADVANCED SUBSIDIARY
General Certificate of Education
2012

Centre Number

71	

Candidate Number

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

AY121

MONDAY 18 JUNE, 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 **9(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	
7	
8	
9	
10	
Total Marks	

Examiner Only	
Marks	Remark

1 **(a)** A source of electromagnetic waves produces white light. Over what range of wavelengths does the white light extend?

Range of wavelengths = ____________ to ____________ nm [1]

(b) Tick the correct boxes in **Fig. 1.1** to show what happens to the frequency, energy per photon of the waves and the speed of the waves as the electromagnetic spectrum changes from UV rays to X-rays.

		Increases	**Decreases**	**Stays the same**
(i)	The frequency of the wave			
(ii)	The energy per photon of the wave			
(iii)	The speed of the wave			

[3]

Fig. 1.1

(c) The graph in **Fig. 1.2** shows a displacement (x) – time (t) graph for two waves, of the same type, travelling through the same medium.

Examiner Only	
Marks	Remark

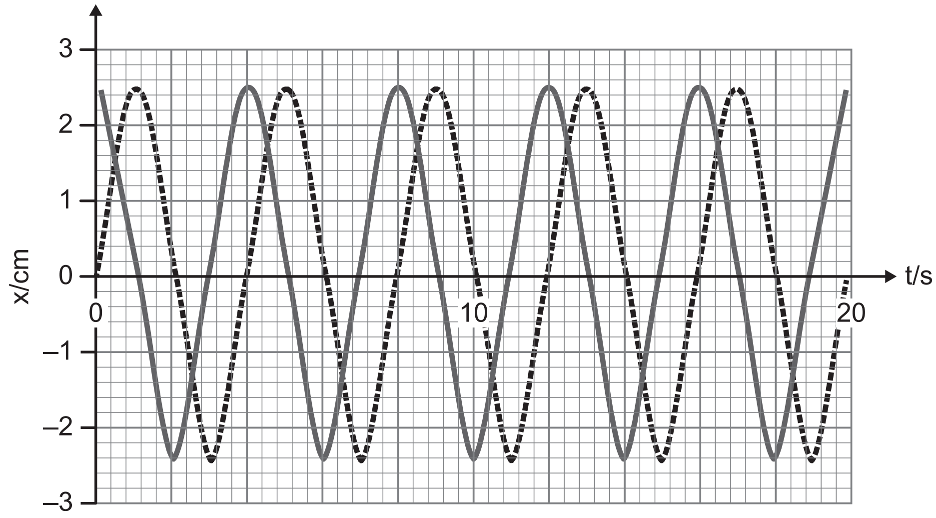

Fig. 1.2

(i) Name two features of the waves that are identical. State numerical values for them, giving units in each case.

Feature: ____________ Value: ____________ Unit: ____________

Feature: ____________ Value: ____________ Unit: ____________ [2]

(ii) Use the graph in **Fig. 1.2** to determine the phase difference between the two waves, stated in degrees.

Phase difference: ______________ ° [1]

Examiner Only

Marks	Remark

2 (a) (i) Under what conditions will a wave undergo refraction?

[2]

(ii) Under what conditions will a wave undergo total internal reflection?

[2]

(b) When surveying the structure of the earth, sound waves are transmitted through the ground and are refracted or reflected as they meet different boundaries between layers under the earth's surface.

Fig. 2.1 shows a beam of waves directed into two parallel layers of rock, A and B.

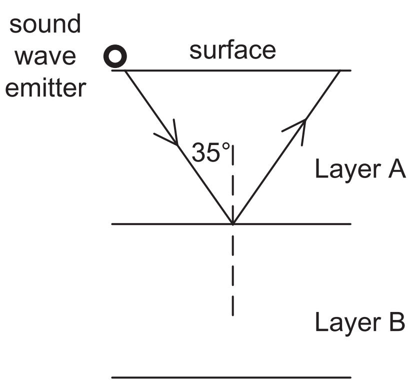

Fig. 2.1

The incident angle of the beam at the boundary is slowly increased from 0°. When it reaches an angle of 35° as shown in **Fig. 2.1**, a strong reflected signal is detected for the first time.

Examiner Only

Marks	Remark

(i) The reflected signal is detected at the surface 25 ms after being transmitted into layer A. Calculate the depth of layer A if the sound wave travels at a speed of 5000 $m s^{-1}$ through layer A.

Depth of layer A = ______________ m [3]

(ii) Given that the ratio of the velocity of the sound waves in the two layers is numerically equal to the refractive index between the two layers, see **Equation 2.1**, calculate the speed with which the wave would travel through layer B.

$${}_{A}n_{B} = \frac{\text{velocity of sound in A}}{\text{velocity of sound in B}}$$ **Equation 2.1**

Note that ${}_{A}n_{B}$ is the refractive index for sound moving from layer A into layer B.

Speed of wave = ______________ $m s^{-1}$ [2]

3 **(a)** The apparatus shown in **Fig. 3.1** is to be used to find a value for the focal length of a converging lens.

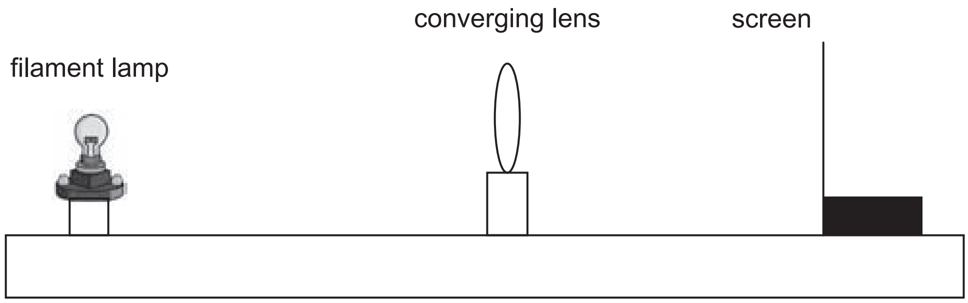

Fig. 3.1

(i) The lens formula is quoted on the Data and Formulae sheet. Mark clearly on **Fig. 3.1** what distances are represented by the letters u and v in the lens formula. [1]

(ii) Describe how, after obtaining a series of readings of u and v, a reliable value for the focal length of the lens can be determined.

____

____

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____

____

____ [3]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(b) A projector is used to magnify an object on a slide to become an image that is 250 times larger when viewed on a screen. The focal length of the projector lens is 4.00 cm.

(i) Show that the screen must be placed at a distance of 1004 cm from the lens to produce this image.

[3]

(ii) Calculate the distance from the slide to the lens. Give your answer to three significant figures.

Distance from slide to lens = ______________ cm [1]

Examiner Only

Marks	Remark

4 **(a)** A recent discovery in physics is acoustic levitation, where sound waves are used to suspend small objects a few centimetres above a surface. The simplest version of an acoustic levitator is shown in **Fig. 4.1**. It consists of a transducer that produces a sound wave and a reflector directly above it. The object to be suspended is located between the transducer and the reflector.

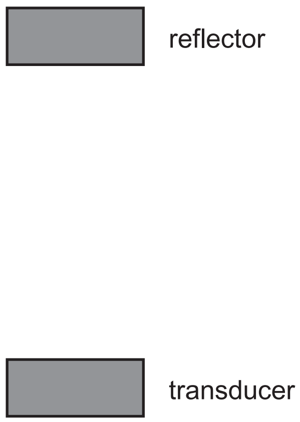

Fig. 4.1

(i) Explain why standing waves can be set up in the region between the transducer and the reflector.

____

____

______________________________________ [2]

(ii) The standing wave that is set up is similar to that in a pipe closed at one end. It has an antinode at the transducer and a node at the reflector.

On **Fig. 4.1** draw the standing wave that corresponds to the **second** mode of vibration (1st overtone) and label the positions of additional nodes (N) and antinodes (A). [2]

Examiner Only	
Marks	Remark

(b) In a low gravity situation, the particle being suspended will settle at the position of a node in the standing wave.

(i) The sound waves used in the levitator have frequency 13.5 kHz. If the speed of sound is 340 $m\,s^{-1}$, calculate the distance the reflector needs to be placed from the transducer for the standing wave in (a), the second mode of vibration, to be set up.

Distance between transducer and reflector = ____________ cm [2]

(ii) At what height above the transducer will the particle be suspended?

Height = ______________ cm [1]

5 Describe how Young's double slit experiment can be used to show that light waves interfere. Your answer should include:

- a labelled diagram showing how the apparatus should be set up,
- the value of a suitable distance from the slits to the screen,
- the value of a suitable slit separation that could be used,
- details of what is observed in the experiment,
- how the interference pattern can be explained.

[8]

Examiner Only

Marks	Remark

Examiner Only	
Marks	Remark

6 **(a)** Good quality loud speakers have different sized openings that allow sounds of different frequency to pass through.

(i) Why is it important that sound waves are diffracted when they pass through the opening of a speaker?

____

____ [1]

(ii) In one speaker system, the largest opening is 330 mm and the smallest opening is 110 mm. Which opening should be used for higher frequency sounds? Explain your answer in terms of diffraction.

____

____

____

____

____

____ [3]

(b) **(i)** What is meant by the intensity of a sound?

____

____ [1]

(ii) A music system can produce sound of intensity 1.8×10^{-5} W m^{-2}. If the amplifier is replaced with a more powerful one the intensity increases to 1.2×10^{-3} W m^{-2}. The lowest intensity the human ear can detect is 1.0×10^{-12} W m^{-2}.

By how many dB does the sound intensity level increase?

Increase in intensity level = ______________ dB [3]

Examiner Only	
Marks	Remark

7 (a) Ultrasound can be used in the diagnosis of some medical problems. **Fig. 7.1** shows an ultrasound scan of a human knee with suspected ligament damage.

Ultrasound image of a knee

Fig. 7.1

(i) What type of ultrasound scan has been used to produce this picture?

_______________________________ [1]

(ii) State a typical frequency of ultrasound used in medical diagnosis.

Frequency = ______________ Hz [1]

(b) Give two reasons why ultrasound was the imaging technique chosen in this case.

____

____

____

____ [2]

(c) State an example of a "coupling medium" and explain why it is required when carrying out an ultrasound scan.

____

____

____

____ [3]

Examiner Only	
Marks	Remark

8 **(a)** What name is given to the ejection of electrons from the surface of a metal when light shines on it?

______________________________ [1]

(b) A physicist is trying to eject electrons from the surface of a metal by shining light on it but none are ejected. How should the physicist change the light so that electrons are ejected? Explain why the change will result in electrons being ejected.

____

____

____

____

______________________________ [3]

(c) When the metal is illuminated with monochromatic light the ejected electrons do not all travel with the same speed. Explain why they have a range of speeds.

____

____

____

______________________________ [2]

Examiner Only	
Marks	Remark

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

9 **Table 9.1** gives the wavelengths of the first three lines in the visible spectrum of hydrogen.

Table 9.1

λ/nm	656	486	434
Photon energy/J	3.03×10^{-19}	4.09×10^{-19}	

(a) Calculate the photon energy, in joules, corresponding to the wavelength 434 nm in **Table 9.1** and complete the second row of the table.

[2]

(b) These photons are emitted when the electrons fall from a different excited state down to an energy level of -5.45×10^{-19} J.

Fig. 9.1 shows part of the energy level diagram for hydrogen. Draw three more lines to represent the energy levels of these excited states. Label the energy levels with their values, in joules.

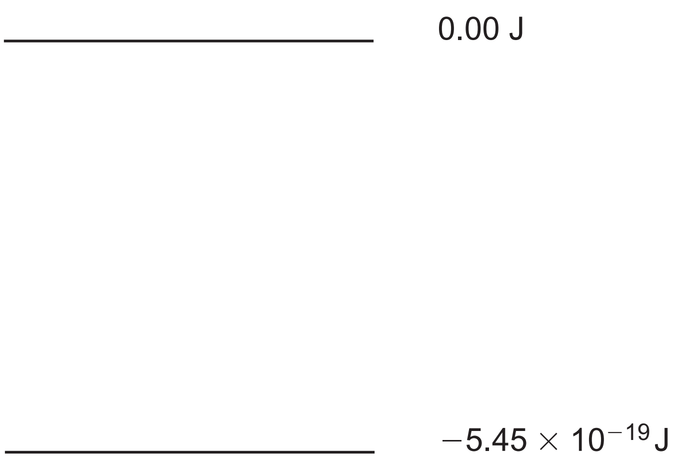

Fig. 9.1

[3]

(c) Give a simple explanation of laser action.

[3]

Quality of written communication [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

10 (a) Electron diffraction demonstrates an important concept in physics. What is the relevance of the observations from an electron diffraction experiment?

____

____ [1]

(b) In an electron scattering experiment the velocity (v) of the electrons was gradually increased and its de Broglie wavelength (λ) determined. The results were used to produce the graph in **Fig. 10.1**.

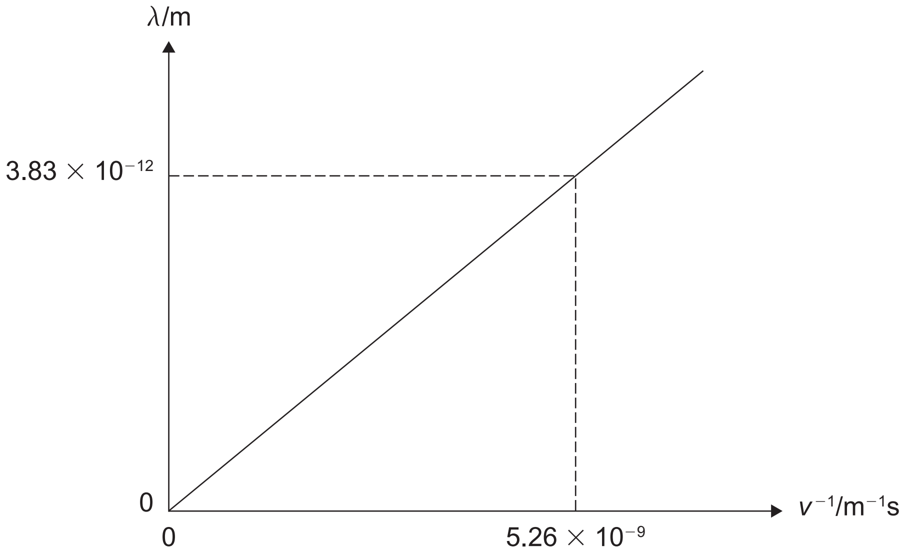

Fig. 10.1

Using the graph carry out calculations to prove that the particle involved in the scattering experiment to produce the graph in **Fig. 10.1** was an electron.

State how your calculations confirm the identity of the particle.

____

____ [4]

THIS IS THE END OF THE QUESTION PAPER

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 = 1.60×10^{-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 formula $\lambda = \frac{h}{p}$