Rewarding Learning

ADVANCED SUBSIDIARY
General Certificate of Education
January 2011

Centre Number

71	

Candidate Number

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

AY121

MONDAY 17 JANUARY, AFTERNOON

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)** Mechanical waves can be classified as longitudinal or transverse. Describe the difference between a longitudinal and a transverse wave in terms of the movement of the source that creates the disturbance.

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____ [2]

(b) **(i)** Light from a lamp is unpolarised. Explain what is meant by unpolarised.

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____ [1]

(ii) Give an example of a wave that cannot be polarised and explain why it cannot be polarised.

____

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____ [2]

2 Describe an experiment to determine an accurate value for the refractive index of glass using a rectangular glass block. Your answer should include:

- a diagram of the apparatus used,
- the measurements needed and the instruments used to take them,
- how the results are processed to obtain an accurate value for the refractive index of glass.

[6]

Quality of written communication [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

3 When an object is placed 32 cm in front of a converging lens, a virtual image is formed. The image is 2.7 times larger than the object. This is the magnification of the lens which is defined by **Equation 3.1**

$$\text{Magnification} = \frac{v}{u} \qquad \textbf{Equation 3.1}$$

(a) State the defect of vision that this lens could be used to correct in the human eye.

____ [1]

(b) (i) Calculate the power of the lens and state the units of power.

Power = ______________

Units of power = ______________ [4]

(ii) A person's near point when using this lens is 25 cm from the eye. What distance from the eye is the person's near point when unaided by this lens?

Distance to near point = ______________ cm [2]

4 **Fig. 4.1** shows a loudspeaker mounted near the open end of a tube of length 1.40 m. The loudspeaker is connected to a variable frequency a.c. supply. The frequency of the supply is gradually increased. The sound heard becomes very loud at several distinct frequencies.

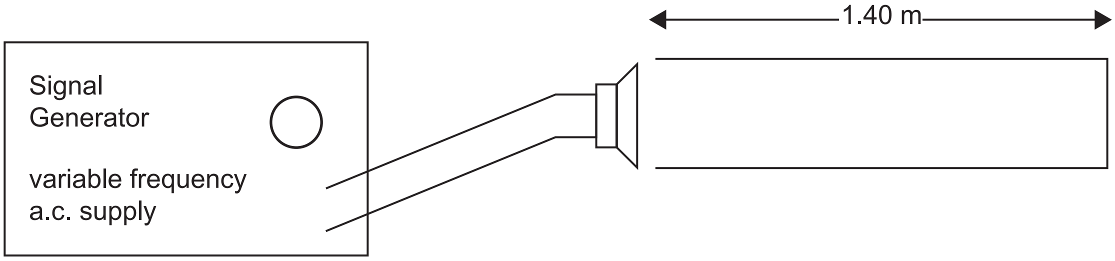

Fig. 4.1.

(a) **(i)** Describe how the standing waves that cause the loud sounds are formed.

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____ [3]

(ii) One such loud sound is heard when the frequency is 304 Hz. The speed of sound in air is 340 m s^{-1}. Calculate the wavelength of the sound wave.

Wavelength = _______________ m [1]

(iii) On **Fig. 4.1** sketch the standing wave formed in the tube at frequency 304 Hz. [2]

(b) The air in the tube is replaced with helium gas, in which the speed of sound is 965 m s^{-1}. Calculate the **minimum** frequency of sound that would be required to produce a standing wave in the same tube.

Frequency = _______________ Hz [2]

Examiner Only	
Marks	Remark

5 (a) Laser light is monochromatic. What is meant by monochromatic?

____

____ [1]

(b) **Fig. 5.1** is a sketch of an arrangement used to measure the wavelength of light from a laser. (Not to scale)

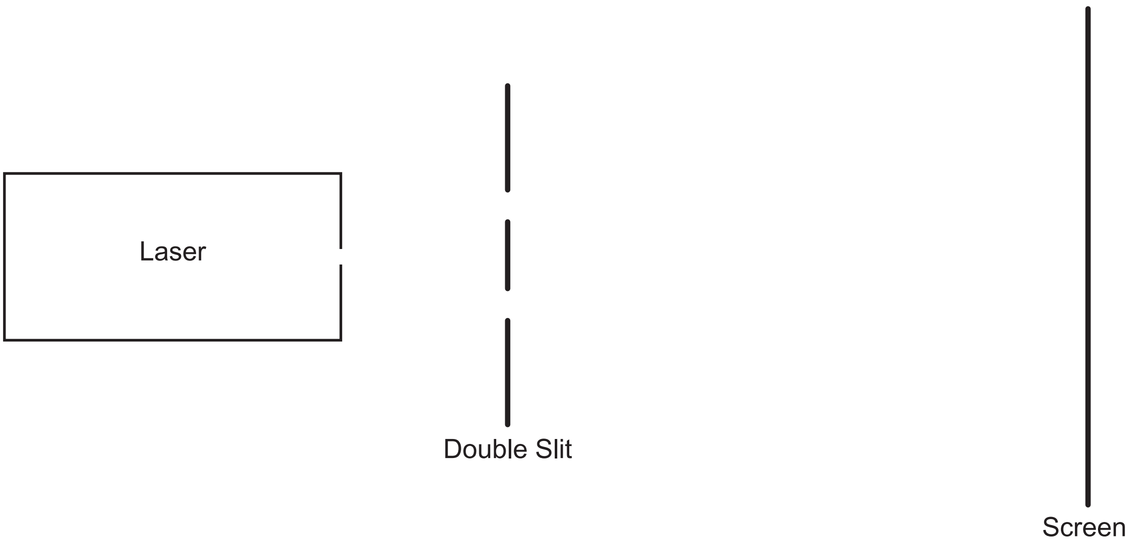

Fig. 5.1

(i) Describe the pattern that will be seen on the screen in **Fig. 5.1**.

____

____

____ [2]

Examiner Only	
Marks	Remark

(ii) The distance from the slits to the screen is 2.80 m. The centres of the slits are 0.24 mm apart. If the distance between the position of one maximum intensity and the next is 7.4 mm, calculate the wavelength of the laser light. Give your answer in nm.

Wavelength = _______________ nm [3]

(iii) State two ways in which the arrangement could be changed, using the same laser, so that the distance between positions of maximum intensity seen on the screen would be increased.

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____ [2]

6 **Fig. 6.1** shows the intensity response with frequency of a human ear. It is used as a measure of perceived loudness which matches the response of the human ear.

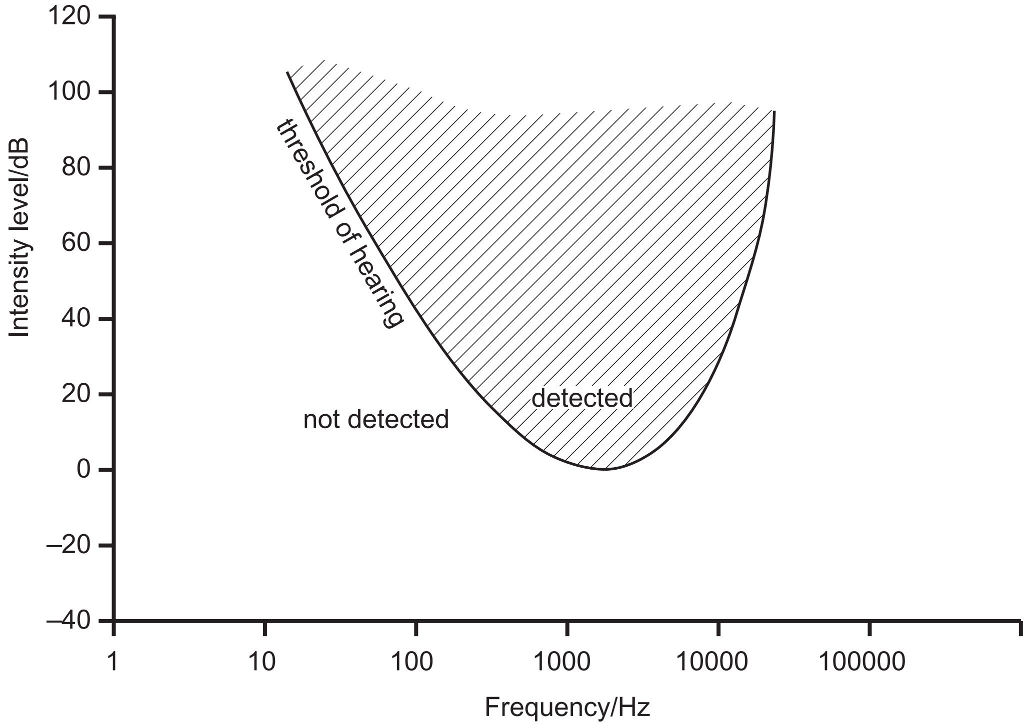

Fig. 6.1

(a) State the main feature of the scale which allows it to match the response of the ear.

____ [1]

(b) Dogs typically have a range of hearing from approximately 20 Hz to 50 kHz.

(i) State one similarity and one difference between the frequency range of a dog and a human.

Similarity:

____

Difference:

____ [2]

Examiner Only	
Marks	Remark

(ii) Using the intensity level/dB scale for a human ear, the intensity level corresponding to the threshold of hearing of a dog is –20 dB. Dogs' ears are most sensitive at a frequency of 5000 Hz. On the axes of **Fig. 6.1**, sketch a graph of the intensity response with frequency of a dog's ear. The curve should have a similar shape to that of the human ear in **Fig. 6.1**. [2]

(iii) Describe and explain the difference in how a sound of frequency 5000 Hz would be perceived by a human and a dog.

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____ [2]

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

7 (a) The main components of an MRI scanner are the scanner magnet, field gradient coils, rf transmitter, rf receiver and computer.

Describe briefly the function of the components listed below.

Field gradient coils

____

____

Computer

____

____ [2]

(b) Describe how the magnetic field of the scanner magnet is created. Explain how recent advances in technology have vastly reduced the cost of producing this magnetic field.

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____ [3]

(c) Outline three advantages of MRI compared to CT scanning.

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____ [3]

Examiner Only	
Marks	Remark

8 A UV (ultraviolet) lamp is shone onto a magnesium surface.

(a) **(i)** Show that, for UV light of wavelength 290 nm, the energy of each photon is 6.86×10^{-19} J.

[2]

(ii) The magnesium surface has an area of $1.6 \times 10^{-4}\,m^2$. The energy delivered to each square metre every second is 0.034 J. Calculate the number of photons that fall onto the surface each second.

Number of photons = _______________ s^{-1} [3]

(b) The frequency of the UV light remains constant and the energy of the incident photons is greater than the work function of the magnesium.

(i) State and explain the effect of increasing the intensity of the radiation on the rate of emission of photoelectrons from the magnesium surface.

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____ [2]

(ii) State the effect of increasing the intensity of the radiation on the kinetic energy of the emitted photoelectrons from the magnesium surface.

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____ [1]

9 Energy levels in atoms are described as being quantised.

Examiner Only	
Marks	Remark

(a) State the meaning of the word quantised.

____ [1]

(b) When electromagnetic radiation passes through hydrogen gas, some frequencies of radiation are absorbed. **Fig. 9.1** is a graph showing how the intensity of light transmitted through a sample of hydrogen gas depends on the frequency of the light.

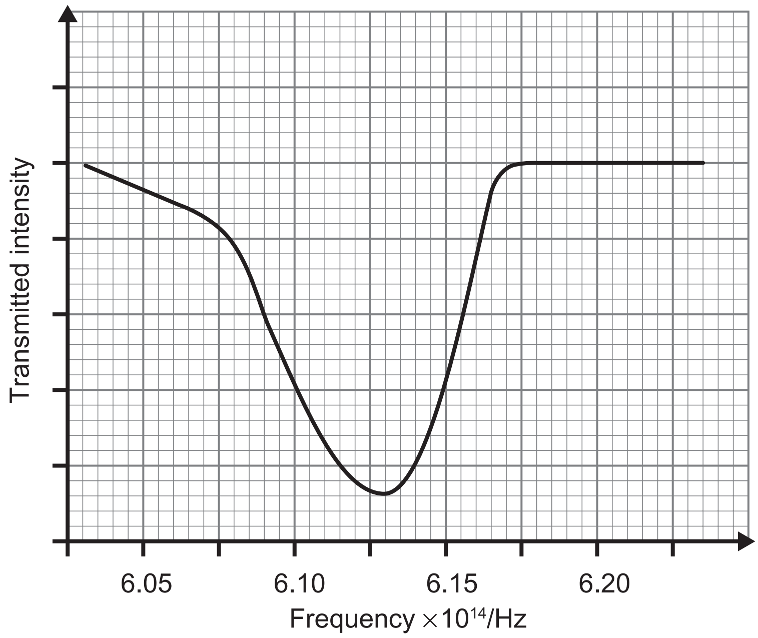

Fig. 9.1

(i) Calculate the energy of the photons associated with the maximum absorption shown in **Fig. 9.1**.

Energy of photons = _______________ J [2]

Examiner Only | Marks | Remark

(ii) **Fig. 9.2** shows part of the energy level diagram for hydrogen. Draw an arrow on **Fig. 9.2** to show the electron transition that occurs if the electron absorbs a photon of the energy calculated in **(b)(i)**.

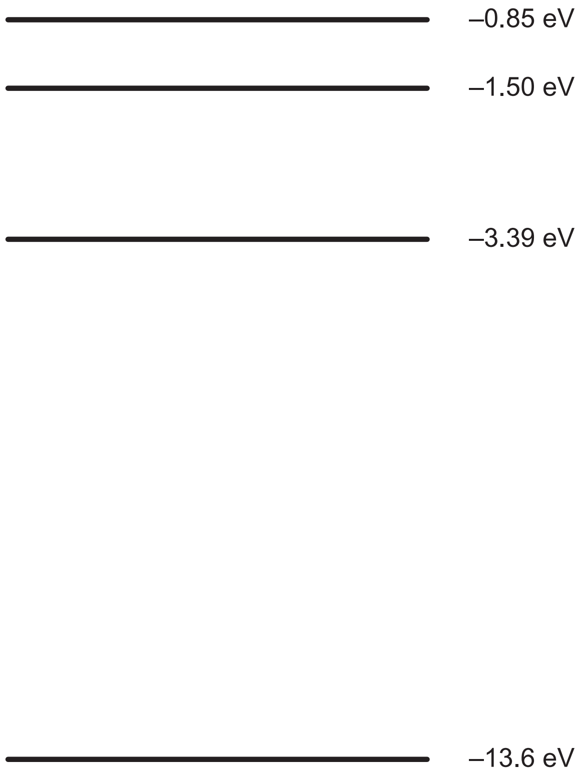

Fig. 9.2

[3]

(c) The term population inversion can be used in reference to the energy levels of electrons in atoms that emit laser light. Explain what the term population inversion means.

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____ [2]

Examiner Only	
Marks	Remark

10 Matter is described as having wave particle duality.

(a) Explain what this means and outline experimental evidence that confirms that matter has wave properties.

____ [3]

(b) **(i)** Describe how the de Broglie formula links the particle and the wave nature of matter together.

____ [2]

(ii) Calculate the de Broglie wavelength for an electron travelling at 8% of the speed of light.

de Broglie wavelength = ____________ m [3]

THIS IS THE END OF THE QUESTION PAPER

GCE (AS) Physics

Data and Formulae Sheet

Values of constants

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

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

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