Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2017

Centre Number

Candidate Number

Physics

Assessment Unit AS 2
assessing
Module 2: Waves, Photons and Medical Physics

[AY121]

AY121

THURSDAY 8 JUNE, 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.
You must answer the questions in the spaces provided.
Do not write outside the boxed area on each page or on blank pages.
Complete in black ink only. **Do not write with a gel pen.**
Answer **all ten** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 75.
Quality of written communication will be assessed in Question **8(a)**.
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.

1 The Arecibo Telescope is able to detect faint emissions of radiation from far-off regions of the universe. Information extracted from these emissions allows astronomers to measure the distances to, and masses of, galaxies.

(a) (i) The Arecibo system detects radiation with frequencies in the range 50 MHz to 10 000 MHz. Calculate the corresponding range of wavelengths of this radiation.

Range of wavelengths = ____________ m to ____________ m [2]

(ii) To which region of the electromagnetic spectrum do the waves of frequency 10 000 MHz belong?

_________________________________ [1]

(b) **Fig. 1.1** shows how the relative intensity of the electric field of the radiation, I, varies with time, t.

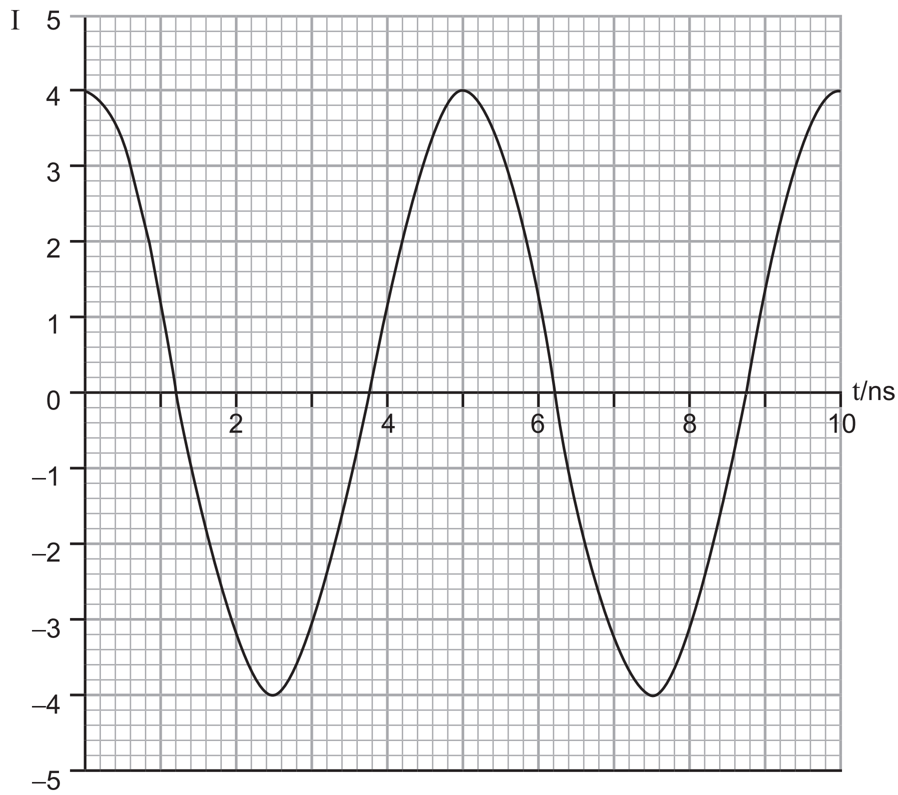

Fig. 1.1

(i) Use data from **Fig. 1.1** to find out if this wave could be detected by the Arecibo system. Explain your answer.

____

____ [2]

(ii) What percentage of its maximum is I when the time $t = 3\,\text{ns}$?

Percentage = ______________ % [2]

2 A student carried out an experiment to determine the refractive index of a material. A ray of light was directed at a rectangular block of the material and the student measured the angles labelled A and B in **Fig. 2.1**.

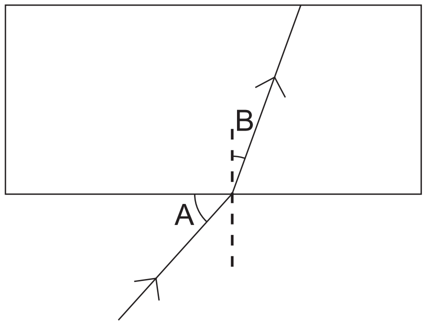

Fig. 2.1

(a) The value of the refractive index is to be determined **graphically**. Describe how the experiment should be continued and the results processed.

____

____

____

____

____

____

____ [3]

(b) Calculate the angle of refraction, B, that would result from a ray of light entering the rectangular block when angle A = 60°. The refractive index of the material is 1.36.

Angle B = ____________ ° [3]

3 A person with very poor eyesight could use a magnifying glass to read print on a page. **Fig. 3.1** shows one word before and after it has been magnified.

Physics Physics

Fig. 3.1

(a) What type of lens is used as a magnifying glass?

____ [1]

(b) (i) Take measurements from **Fig. 3.1** to calculate an accurate value for the magnification produced by the lens. Record your measurements and show your calculations clearly.

Magnification = ____________ [3]

(ii) The distance of the object from the lens was 8.0 cm when the magnified image in **Fig. 3.1** was viewed. Calculate the power of the lens in dioptres, D.

Power = ____________ D [3]

(c) Draw a ray diagram in **Fig. 3.2** to show how the lens in a magnifying glass causes magnification of an object. Show the position of the eye from which the image may be viewed. The points marked F are the principal foci of the lens.

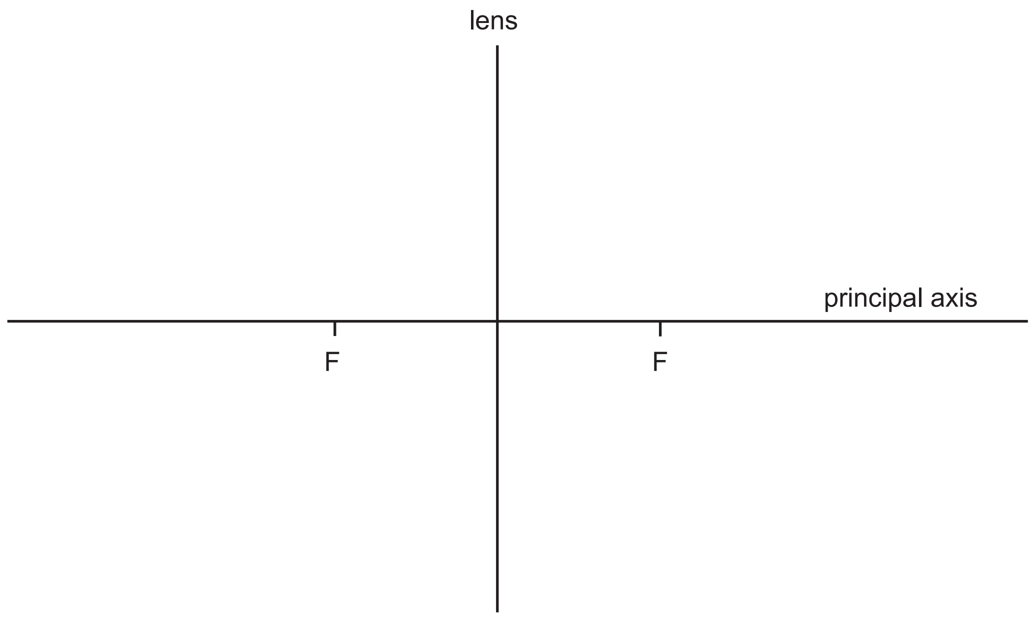

Fig. 3.2

[4]

4 In an experiment to measure the wavelength of laser light, the apparatus was set up as shown in **Fig. 4.1**.

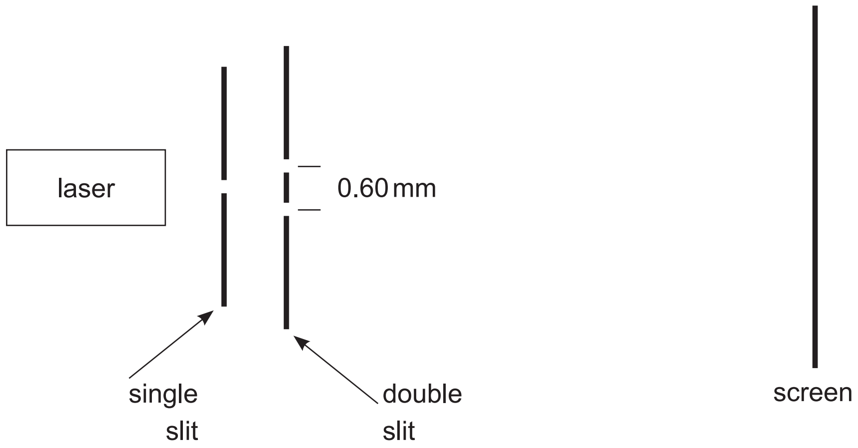

Fig. 4.1

(a) **(i)** What is the name of this experiment?

____ [1]

(ii) Which piece of apparatus in **Fig. 4.1** is not needed in this experiment? Explain why it is not needed.

____

____ [2]

(b) (i) In this experiment a pattern of equally spaced bright and dark fringes is observed on the screen. Describe how an accurate value for the fringe separation can be measured.

____

____

____ [1]

(ii) The fringe separation is measured to be 2.8 mm when the screen is 2.5 m from the double slit and the slit separation is 0.60 mm.

Calculate the wavelength of the laser light in nanometres.

Wavelength = ____________ nm [3]

(iii) Using the same laser, state one change that could be made to the apparatus to increase the fringe separation by 50%.

____ [1]

5 Longitudinal and transverse waves can both undergo diffraction.

(a) Explain what is meant by diffraction.

____

____ [2]

(b) Give an example of an observation that is caused by diffraction of

(i) a longitudinal wave.

____

____ [1]

(ii) a transverse wave.

____

____ [1]

(c) **Fig. 5.1** shows wavefronts of waves approaching a barrier. On **Fig. 5.1** shade in the part of the barrier that should be removed to allow the most noticeable diffraction to occur. Draw in the wavefronts of the waves after they have passed through the gap created.

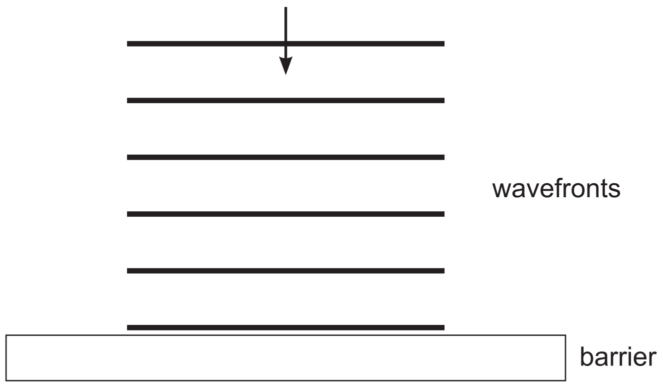

Fig. 5.1

[3]

6 **Fig. 6.1** shows the trace produced on the screen of a cathode ray oscilloscope due to a pure note. The note has a period of 0.008 s.

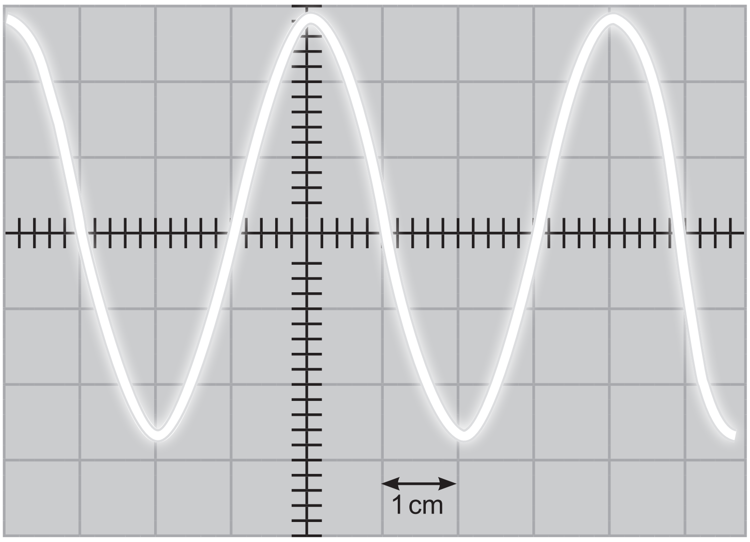

Fig. 6.1

(a) Calculate the value of the time base setting and state the appropriate unit.

Time base setting = ____________

Unit = ____________ [2]

(b) **Fig. 6.2** is a graph showing how the intensity response varies with frequency for an average human ear.

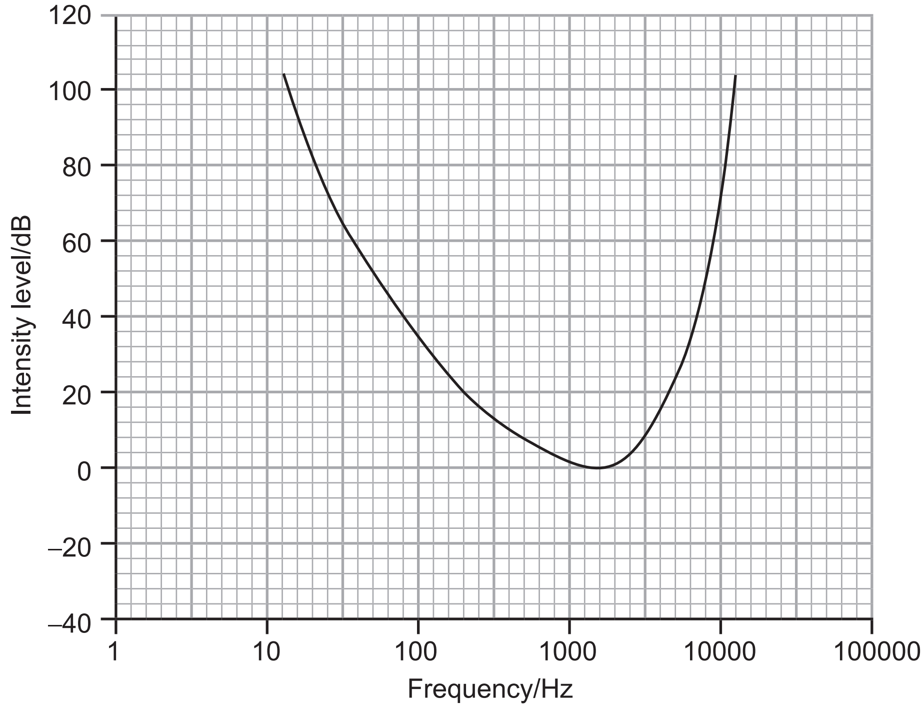

Fig. 6.2

(i) Will a note of 100 Hz at an intensity level of 20 dB be heard by a person with average hearing? Explain your answer. Draw lines on **Fig. 6.2** to support your explanation.

____

____

____ [2]

(ii) Calculate the sound intensity of the 100 Hz note when the intensity level is 20 dB.

Sound intensity = ________________ $W\,m^{-2}$ [3]

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(Questions continue overleaf)

7 **(a)** The following paragraph describes how a conventional X-ray photograph is taken in a hospital.

Radiation is aimed at the part of the body of the patient being examined. It passes through the body and an image is recorded on a photographic plate which is then viewed.

(i) Both conventional X-rays and CT scans use X-ray radiation. Describe the two distinct means by which X-rays are produced when electrons, that have been accelerated to high speed, strike a metal target in an X-ray tube.

____

____

____

____

____

____

____ [3]

(ii) State one way in which CT scanning differs from conventional X-ray photography, as described above.

____

____ [1]

(b) A CT scan is not suitable in all situations. Explain why alternative methods are used for the following patients.

(i) a patient with soft tissue damage.

____

____ [1]

(ii) a pregnant woman.

____

____ [1]

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

8 **(a)** Describe the photoelectric effect and use the photon model to explain what happens as the frequency and intensity of the radiation are changed.

[6]

Quality of written communication [2]

(b) **Fig. 8.1** is a graph which shows how the kinetic energy, *E*, of the electrons emitted due to the photoelectric effect varies with the frequency of the radiation, *f*. The threshold frequency is 6.7×10^{14} Hz.

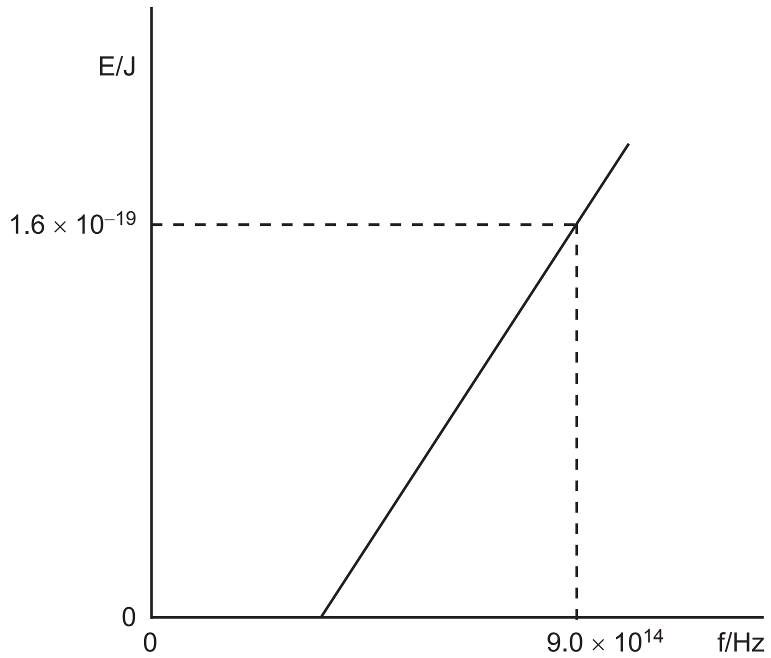

Fig. 8.1

Equation 8.1 describes the graph, where *h* is the Planck constant and ϕ is the work function.

$$E = hf - \phi \qquad \textbf{Equation 8.1}$$

Use the graph to find a value for *h*, the Planck constant.

h = ____________ J s [3]

[Turn over

9 **(a)** Elements are sometimes described as having unique "fingerprints" in reference to the set of frequencies of light they emit or absorb. Explain why this description is appropriate.

____

____

____ [2]

(b) Four electron energy levels of an element are shown in **Fig. 9.1**.

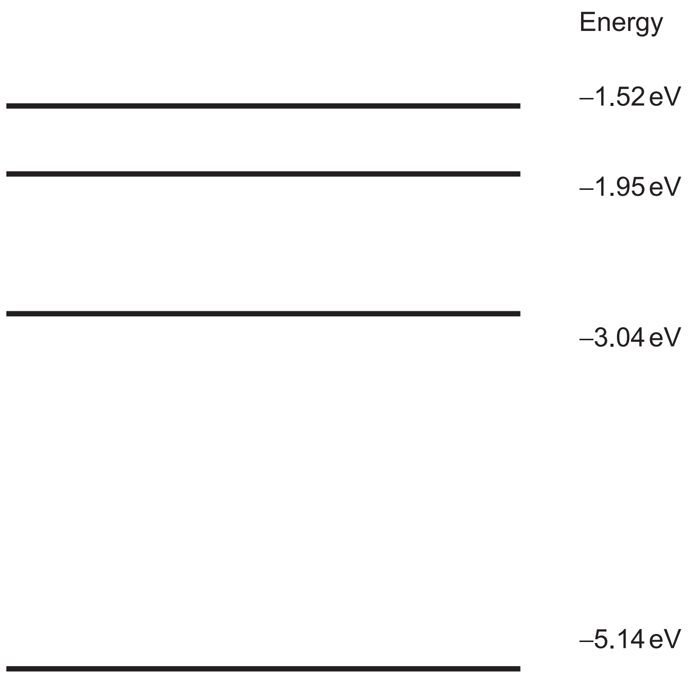

Fig. 9.1

(i) How many lines will there be in the emission spectrum associated with the energy levels shown in **Fig. 9.1**?

Number of lines = ____________ [1]

(ii) Calculate the maximum wavelength in this spectrum.

Maximum wavelength = ____________ m [4]

10 (a) **Table 10.1** shows some phenomena associated with waves and/or particles. Put a tick (✓) in the table if the phenomenon can be explained using the wave model and/or using the particle model. The first row of the table has been completed for you.

Table 10.1

	Can be explained using wave model	**Can be explained using particle model**
Diffraction	✓	
Interference		
Polarization		
Reflection		

[2]

(b) (i) Electron diffraction by a thin film of graphite is evidence that particles have a wave nature. Why are fast moving electrons diffracted by the graphite?

____

______________________________ [1]

(ii) For a particle moving at the speed of light, use the de Broglie equation and Planck's equation, E = hf, to derive Einstein's famous equation, $E = mc^2$.

[2]

THIS IS THE END OF THE QUESTION PAPER

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

Examiner Number

GCE (AS) 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	$= 10 \lg_{10} \dfrac{I}{I_0}$

Waves

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

Light

Lens formula	$\dfrac{1}{u} + \dfrac{1}{v} = \dfrac{1}{f}$
Magnification	$m = \dfrac{v}{u}$

Electricity

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

Particles and photons

de Broglie equation	$\lambda = \dfrac{h}{p}$