New Specification

Rewarding Learning

Centre Number

71	

Candidate Number

ADVANCED SUBSIDIARY
General Certificate of Education
January 2009

Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons and Medical Physics

[AY121]

AY121

WEDNESDAY 28 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 **5**.
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	
Total Marks	

1 (a) (i) Waves may be categorised as either longitudinal or transverse. Complete **Table 1.1** below to indicate the category of the waves listed and a typical wavelength of each wave.

Examiner Only
Marks Remark

Table 1.1

Wave	Wave Category	Typical wavelength/m
Radio waves		
Visible light waves		

[2]

(ii) Sound waves have a speed in air of 340 m s^{-1}. The audio range of frequencies for the hearing of an elderly person may be taken as from 40 Hz to 12 kHz.

1. State the category of waves represented by sound waves.

Category = ________________ [1]

2. Calculate the maximum wavelength of the sound wave in this audio range.

Maximum wavelength = _________ m [2]

(iii) A tuning fork emits a continuous sound wave in air.
On **Fig. 1.1** below, sketch a graph to show the displacement *d* of a particle of air against the distance *x* from the tuning fork for at least two cycles of the pure sound emitted.
Label the axes of your graph and mark accurately the amplitude *a*, and the wavelength λ of the wave.

[3]

Fig. 1.1

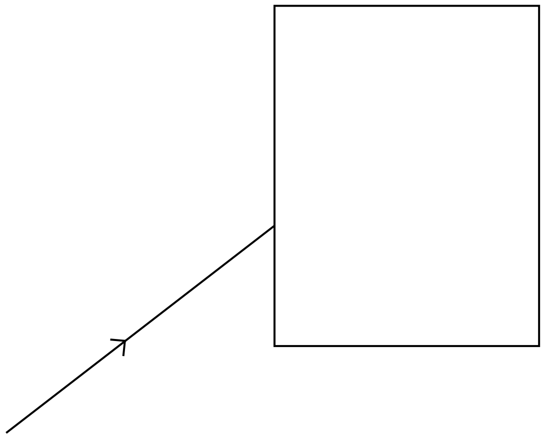
Examiner Only	
Marks	Remark

(b) A wave of frequency 50.0 Hz travels along a stretched string at $40.0\ \text{m s}^{-1}$. Calculate the phase difference between two points on the string which are 0.30 m apart.

Phase difference = _________ ° [4]

Examiner Only	
Marks	Remark

2 **(a)** **(i)** A ray of light is incident on one side of a rectangular glass block as shown in **Fig. 2.1**. On **Fig. 2.1**, sketch the path of the ray of light through the glass block and show how it emerges from the opposite side. Label clearly the angle of incidence *i* and the angle of refraction *r*, where the ray enters the glass block.



[3]

Fig. 2.1

(ii) Assume that an experiment has been carried out to provide a range of values of angles of incidence and the corresponding angles of refraction.
Explain how these results may be used to determine the refractive index of the glass by a graphical method.

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____

____

____ [3]

(b) A ray of light enters a medium of refractive index 1.39 at an angle θ as shown in **Fig. 2.2**. The ray is refracted inside the medium and travels to the upper surface where it is incident at the critical angle C of the medium.

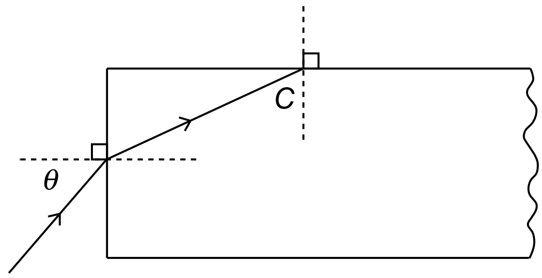


Fig. 2.2

(i) Describe what happens to the ray at the upper surface. What would occur if another ray met the upper surface at an angle greater than the critical angle?

____

____

____ [2]

(ii) Calculate the critical angle of the medium.

Critical angle = __________° [2]

(iii) Calculate the magnitude of the incident angle θ.

Angle θ = __________° [3]

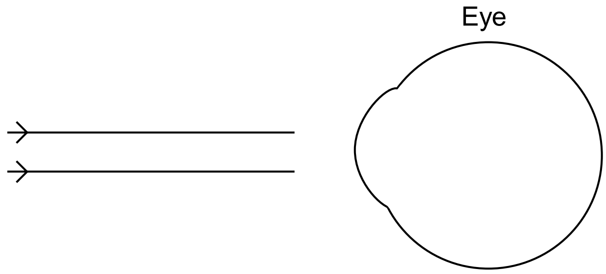
Examiner Only	
Marks	Remark

3 **(a)** **Fig. 3.1** shows an object OA placed on the principal axis of a lens. An upright, diminished, virtual image of this object is produced by the lens.
On **Fig. 3.1**, draw a suitable lens to produce this image.
On the diagram, label the type of lens drawn and mark clearly the focal points of the lens. Draw two rays from the point A of the object to locate the image and label it IB. Indicate the position of the eye to view the image.

[4]

Fig. 3.1

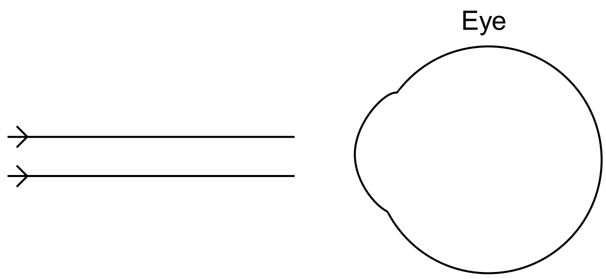
(b) **(i)** Complete **Fig. 3.2** to illustrate how rays from an object at infinity would be refracted by the eye of a person with the vision defect called myopia.



[1]

Fig. 3.2

(ii) Complete **Fig. 3.3** below to illustrate how this defect may be corrected using an appropriate lens.



[2]

Fig. 3.3

Examiner Only	
Marks	Remark

Examiner Only	
Marks	Remark

(iii) A person suffering from long sight can only see objects clearly at distances 35.0 cm to infinity from his eyes.
State the type of lens and calculate its focal length to correct his least distance of distinct vision to 25.0 cm.

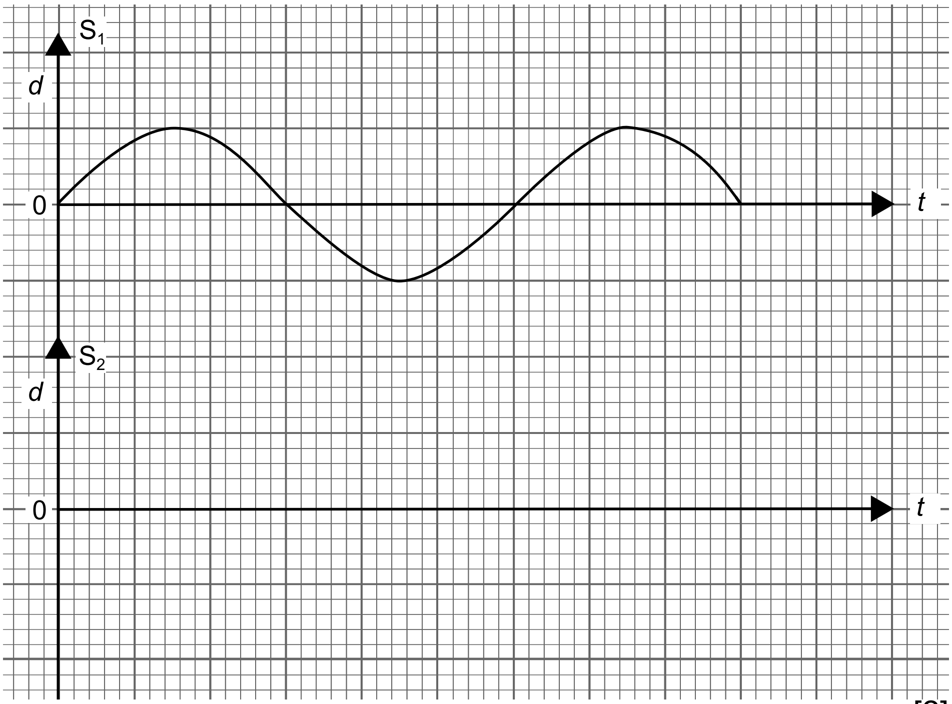
Type of lens = _______________ [1]

Focal length = _________ cm [2]

(iv) Find the power of this correcting lens.

Power = _________ D [2]

4 (a) (i) The upper graph in **Fig. 4.1** shows a progressive wave S_1. On the lower set of axes, sketch a graph for a second wave S_2 which, when superposed with S_1, gives complete **destructive** interference at the meeting point.



[2]

Fig. 4.1

(ii) Complete **constructive** interference between two waves is another case of the application of the principle of superposition. State the condition for complete constructive interference.

____

____ [1]

Examiner Only	
Marks	Remark

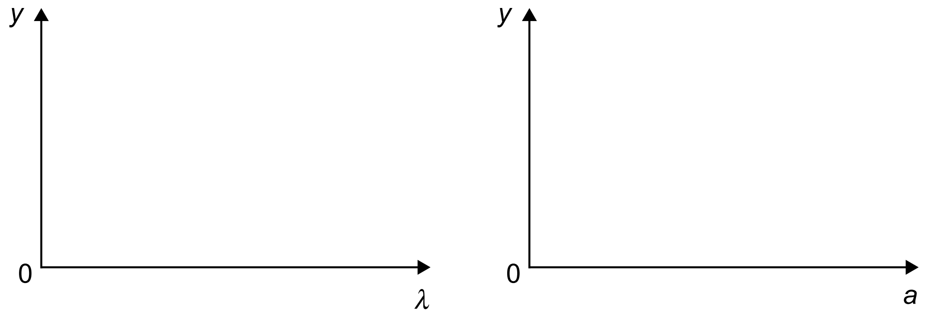
Examiner Only	
Marks	Remark

(b) (i) In a Young's slits interference experiment, y is the separation between two consecutive bright or dark fringes in the interference pattern obtained.
On **Fig. 4.2**, sketch graphs to show the relationship between y and

1. the wavelength λ of the light used,

2. the separation a of the slits.

In each instance, all quantities remain constant except the variables under consideration.



[4]

Fig. 4.2

(ii) A Young's slits experiment is carried out using light of wavelength 589 nm. An interference pattern is obtained on a screen which is 1.30 m from the slits.
The spacing between the centre of a dark fringe of the pattern and the centre of the adjacent bright fringe on the screen is 0.021 mm.
Calculate the separation of the slits.

Slit separation = __________ mm [3]

5 In parts (a) and (b)(ii) of this question you should answer in continuous prose. You will be assessed on the quality of your written communication.

Examiner Only	
Marks	Remark

(a) Describe the structure of the components of a flexible endoscope. The physical principles of optical fibres should not be described.

[4]

Examiner Only	
Marks	Remark

(b) (i) An ultrasonic A-scan uses a single pulse. State the typical time duration of such a pulse and state a typical frequency range used for the signal.

Time duration ________________ μs [1]

Frequency range __________ MHz to __________ MHz [1]

(ii) Describe an ultrasonic A-scan and indicate the information it yields.

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____ [3]

(iii) State the main difference between the information obtained from an ultrasonic B-scan compared to that of an A-scan.

____

____ [1]

Quality of written communication [2]

Examiner Only	
Marks	Remark

6 (a) (i) On **Fig. 6.1** sketch a graph to show the relationship between the energy E of a photon and its frequency f.

[1]

Fig. 6.1

(ii) Is it correct to state *the speed of a photon never varies, it is always constant*? Explain your answer.

____

____ [1]

(b) Explain qualitatively the meaning of the term **work function** of a metal surface.

____

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____ [2]

(c) An electron in an atom undergoes a transition from an energy level of –0.53 eV to a level of –3.39 eV. Calculate the frequency of this electromagnetic radiation.

Frequency = __________ Hz [4]

Examiner Only	
Marks	Remark

7 (a) Light is said to have a **wave–particle duality**. Name two experiments, one which illustrates light behaviour as a wave and the other as a particle. In each case state briefly the experimental evidence which supports the relevant classification of behaviour.

Wave

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Particle

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____

____ [4]

(b) An electron in the ground state in a hydrogen atom may be considered to move in a circular orbit of diameter 1.08×10^{-10} m. The wavelength associated with this electron is equal to the circumference of the orbit. Calculate the speed of the electron to satisfy this condition.

Speed = __________ m s^{-1} [4]

THIS IS THE END OF THE QUESTION PAPER

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

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