Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2025

Centre Number

Candidate Number

Physics

Assessment Unit AS 2
assessing
Module 2: Waves, Photons and Astronomy

[SPH21]

SPH21

WEDNESDAY 21 MAY, AFTERNOON

TIME

1 hour 45 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 questions in black ink and use a dark HB pencil for drawings and graphs.
Do not write with a gel pen.
Answer **all ten** questions.

INFORMATION FOR CANDIDATES

The total mark for this paper is 100.
Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.
You may use a scientific calculator.
Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.

1 (a) Waves can be classified as transverse or longitudinal. What type of wave is a water wave?

_______________________________ [1]

(b) (i) A rectangular pool 15 m wide, 25 m long and 2 m deep contains 675 m^3 of water. If the water is at a constant depth, calculate the depth of water in the pool.

Depth of water = ____________________ m [2]

(ii) A wave is produced on the surface of the water which just reaches the top edge of the pool at its maximum displacement.

What name is given to the maximum displacement of the wave from its equilibrium position?

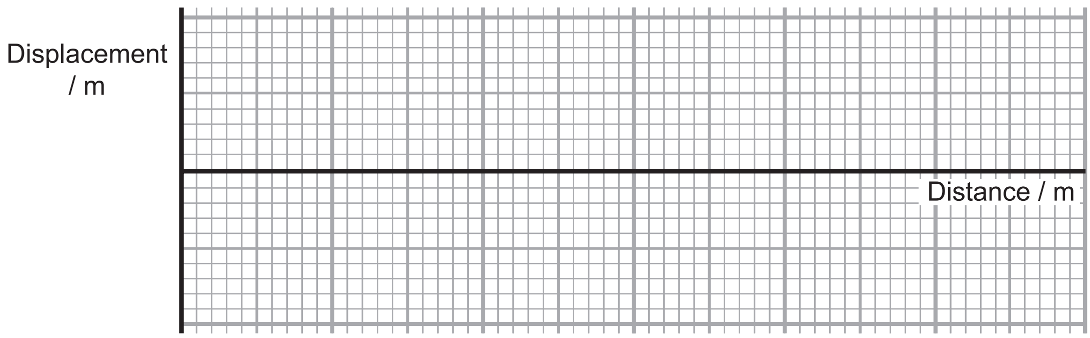
_______________________________ [1]

14726

(iii) When there is maximum displacement of the wave at each end of the 25 m length of the pool, there are four other crests visible in the water between the ends.

On the grid of **Fig. 1.1**, sketch a displacement–distance graph for **three** cycles of the wave. Label the axes with appropriate values.

Use the space above **Fig. 1.1** for any calculations needed.



[5]

Fig. 1.1

(c) The frequency of the wave is 4.5 Hz. Calculate the time it takes for a wavefront to travel the length of the pool.

Time = ____________________ s [4]

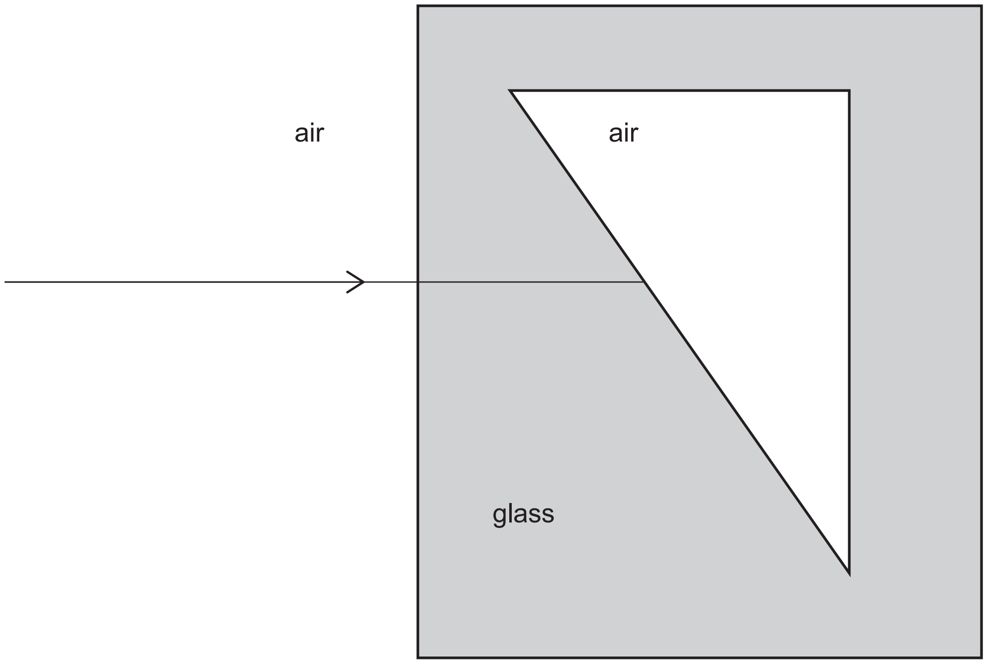
2 **(a)** What is meant by refraction?

____

____

____ [2]

(b) A ray of light is directed along the normal at a glass block which has a triangular space in the middle of it, as shown in **Fig. 2.1**. Draw the path of the ray as it passes through and out of the other side of the block assuming total internal reflection does not take place. Include a normal at each boundary.



[4]

Fig. 2.1

(c) The speed of light decreases by 35% when it enters the glass from the air. Calculate the refractive index of the glass.

Refractive index = ____________________ [3]

3 Describe a method to accurately determine the speed of sound in air using a resonance tube.

(a) Draw a labelled diagram of the apparatus required and how it is set up.

[3]

(b) Describe the method including the measurements taken.

____

____

____

____

____

____ [4]

(c) Describe how an accurate value for the speed of sound in air can be calculated from the results.

____

____

____

____

____ [2]

4 **Fig. 4.1** shows an endoscope being used to **view inside** the stomach of a patient.

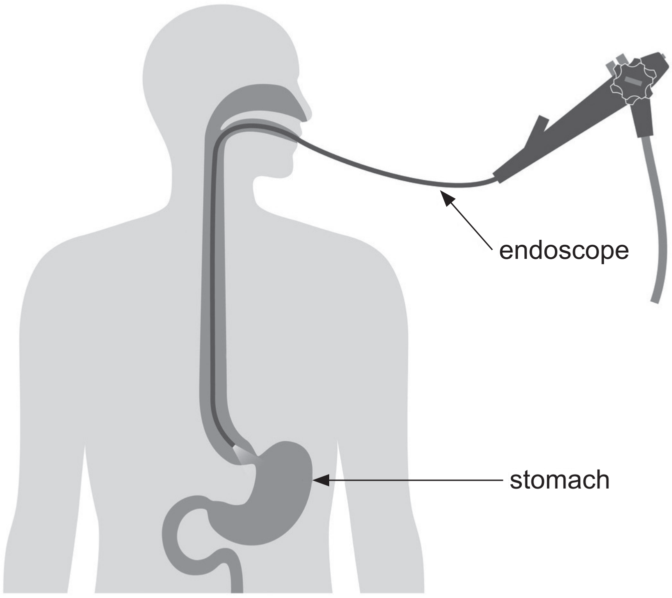


Fig. 4.1

(a) Describe the physical principles of optical fibres and how optical fibres are arranged when used in endoscopes.

____

____

____

____

____

____

____

____

____

____ [6]

(b) A type of glass has a refractive index of 1.46. Calculate the difference in the critical angle of light going from the glass towards air and the critical angle of light going from the same glass towards cladding of refractive index 1.43.

Difference in critical angle = ____________________ ° [6]

[Turn over

5 (a) Laser light is coherent and monochromatic. What is meant by each of these terms in the context of laser light?

Coherent:

____

____

Monochromatic:

____

____ [2]

(b) A laser emits light of wavelength 634 nm when an electron falls from an **energy level** of –20.66 eV to **energy level** B as shown in **Fig. 5.1**.

Fig. 5.1

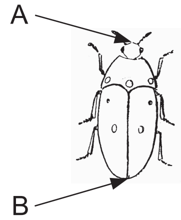
(i) Calculate the energy of energy level B, in eV.

Energy = ____________________ eV [6]

(ii) Another laser emits electromagnetic radiation of wavelength 157 nm.
State what region of the electromagnetic spectrum this radiation belongs to.

___________________________ [1]

6 A magnifying glass is used to view an insect. A full-scale diagram of the image that is seen when the insect is viewed through the magnifying glass is shown in **Fig. 6.1**.



Source: © Getty images

Fig. 6.1

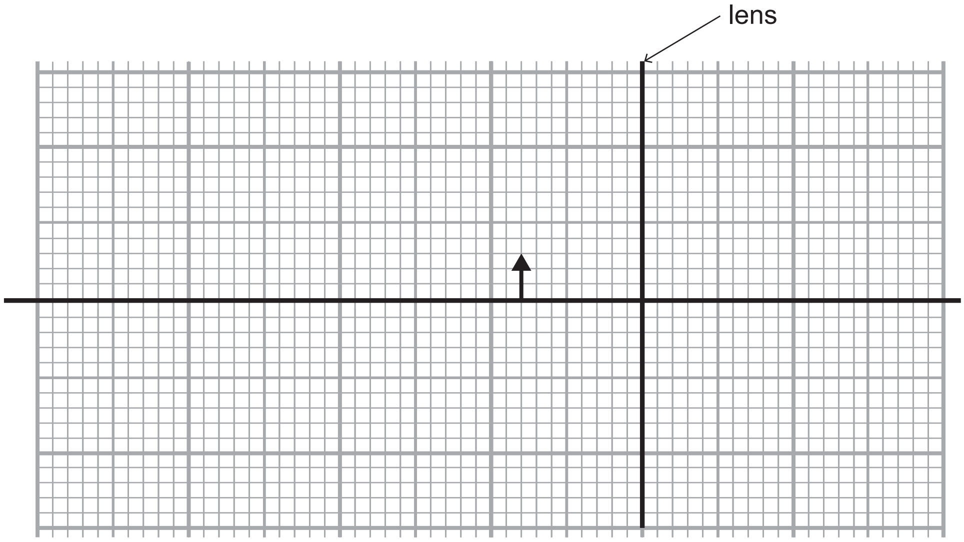
(a) (i) The actual length of the insect is 6 mm (measured between the points A and B as indicated on **Fig. 6.1**.) Calculate the magnification of the insect to one significant figure.

Magnification = ____________________ [2]

(ii) A converging lens is used in the magnifying glass. Sketch the shape of a converging lens.

[1]

(b) **(i)** Use the grid of **Fig. 6.2** to draw an accurate ray diagram showing how the lens magnifies the insect. The position of the lens has been drawn for you and the real, life-size insect is represented by the arrow.



[6]

Fig. 6.2

(ii) Measure the focal length f, of the lens directly from the full-scale ray diagram in **Fig. 6.2**.

f = __________ cm [1]

7 In a double slit experiment, a source of electromagnetic radiation is directed at the double slits. The separation between the slits is 0.40 mm and a screen is placed 0.80 m away from the slits. Maxima and minima are detected at different positions along the screen as shown in **Fig. 7.1**.

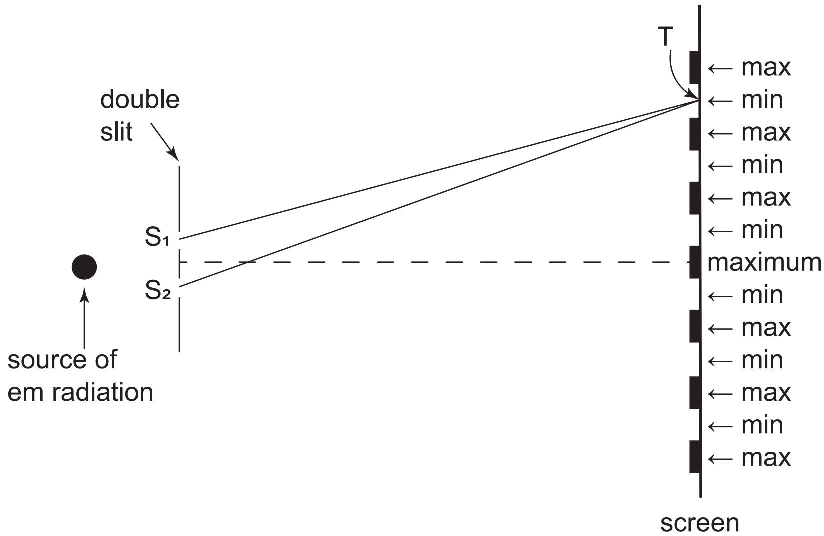


Fig. 7.1

(a) The distance from the centre of one minimum to the centre of the maximum beside it is 1.2 cm.

(i) Calculate the wavelength of the electromagnetic radiation.

Wavelength = ____________________ m [4]

(ii) Calculate the path difference between S_1 T and S_2 T as shown in **Fig. 7.1**.

Path difference = ____________________ m [3]

(b) The double slit is replaced with a diffraction grating. The spacing between the lines of the diffraction grating is 5.18×10^{-5} m.

(i) How many lines per millimetre are on the diffraction grating?

____________________ lines mm^{-1} [2]

(ii) Calculate the angle between central maximum and the third order maximum produced.

Angle = ____________________ ° [3]

[Turn over

8 **Fig. 8.1** represents a stationary wave on a stretched string at a frequency of 25 Hz. The diagram shows a time when each part of the string is at its **maximum displacement**.

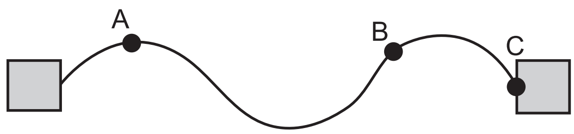


Fig. 8.1

(a) **(i)** On **Fig. 8.1**, draw an arrow at points A and B to indicate the direction in which they are about to move. [2]

(ii) State the phase difference between points A and C. Give the unit of the phase difference.

Phase difference = ____________________

Unit = ____________________ [2]

(b) (i) The length of the stretched string is 0.66 m. Calculate the wavelength of the wave.

Wavelength = ___________________ m [2]

(ii) The frequency is increased. At what frequency will resonance next occur?

Frequency = ___________________ Hz [3]

9 An image intensifier is used in night vision goggles. Photons from very low intensity visible light are collected through a lens, and then strike a photocathode causing the photoelectric effect.

The electrons produced are accelerated by a potential difference of 23 kV to increase their energy and they then hit a fluorescent screen which produces an image.

A simplified diagram of an image intensifier is shown in **Fig. 9.1**.

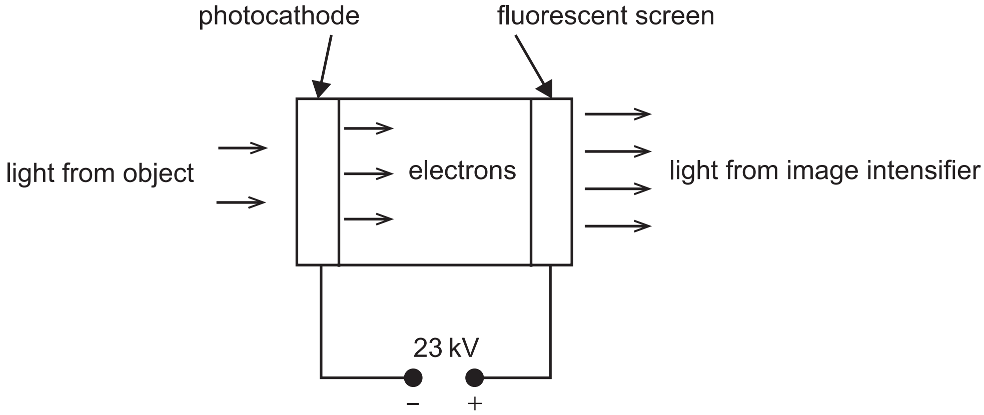


Fig. 9.1

(a) What is meant by the photoelectric effect?

____

____

____ [3]

(b) (i) The work function of the photocathode is 2.30×10^{-19} J. Light of frequency 3.72×10^{14} Hz is incident on the photocathode.

Calculate the maximum velocity of the emitted electrons.

Maximum velocity = ____________________ $m\,s^{-1}$ [6]

(ii) Calculate the kinetic energy gained by an electron released from the photocathode by the time it reaches the fluorescent screen.

Kinetic energy gained = ____________________ J [3]

[Turn over

10 **Fig. 10.1** shows two of the absorption lines in a spectrum of light from a distant galaxy and the same two lines from a light source on Earth.

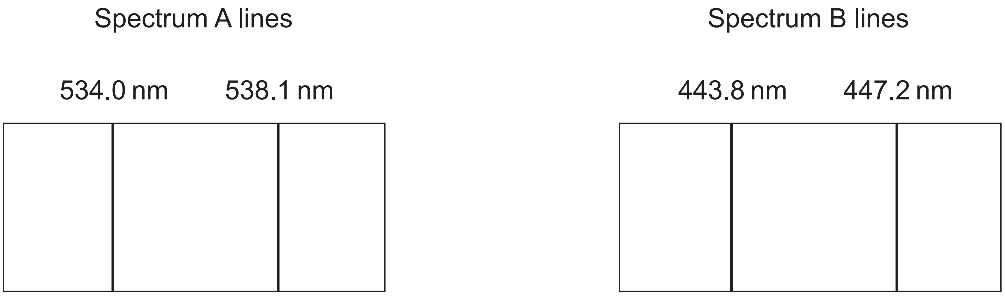


Fig. 10.1

(a) Which spectrum, A or B, is of light from the distant galaxy?
Explain your answer.

____

____

____ [2]

(b) Use **Fig. 10.1** to calculate a value for the velocity at which the galaxy is moving away from Earth.

Velocity = ____________________ $m\,s^{-1}$ [3]

THIS IS THE END OF THE QUESTION PAPER

BLANK PAGE

DO NOT WRITE ON THIS PAGE

BLANK PAGE

DO NOT WRITE ON THIS PAGE

14726

DO NOT WRITE ON THIS PAGE

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

Examiner Number

Rewarding Learning

ADVANCED SUBSIDIARY
General Certificate of Education

Physics

Assessment Units AS 1 and AS 2

[SPH11/SPH21]

DATA AND FORMULAE SHEET

Data and Formulae Sheet for AS 1 and AS 2

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
the Hubble constant	$H_0 \approx 2.4 \times 10^{-18}$ s^{-1}

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

Waves

two-source interference	$\lambda = \frac{ay}{d}$
diffraction grating	$d \sin\theta = n\lambda$

Light

lens equation $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

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

Einstein's equation $\frac{1}{2} m v_{max}^2 = hf - hf_0$

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

Astronomy

red shift $z = \frac{\Delta\lambda}{\lambda}$

recession speed $z = \frac{v}{c}$

Hubble's law $v = H_0 d$