



Rewarding Learning

ADVANCED SUBSIDIARY (AS)
General Certificate of Education

Centre Number

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Candidate Number

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Physics

Assessment Unit AS 2

assessing

Module 2: Waves, Photons
and Astronomy



SPH21

[SPH21]

Assessment

TIME

1 hour 45 minutes.

Assessment Level of Control:

Tick the relevant box (✓)

Controlled Conditions	
Other	

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 eight** 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.

Your attention is drawn to the Data and Formulae Sheet which is inside this question paper.

You may use an electronic calculator.



- 1 (a) Table 1.1 shows typical wavelengths for three different regions of the electromagnetic spectrum. Insert each of the three values given into the appropriate space to complete the table.

Values: 2 cm, 1×10^{-8} m, 10 pm

Table 1.1

Region	γ -rays	Infrared	Microwave	Radio	Ultraviolet	X-rays
Typical Wavelength		0.1 mm		1 m		1×10^{-10} m

[3]

- (b) A beam of red light from a laser is incident upon a screen.

The energy of a single photon of light from the laser is 2.84×10^{-19} J.

- (i) Given that the average output power of the laser is 8 mW, how many photons strike the screen each second?

Number of photons per second = _____

[2]



(ii) Fill in the blank spaces in **Table 1.2** with the words **increases**, **decreases** or **stays the same**, to show the effect on the properties of the photons emitted by two other lasers, **compared to the photons from the 8 mW laser emitting red light**.

Table 1.2

Laser used	Energy in a single photon	Number of photons per second
10 mW laser emitting red light		
8 mW laser emitting green light		

[4]



(c) Matter and light can exhibit both wave-like behaviour and particle-like behaviour.

(i) Place a tick (✓) in each row of **Table 1.3** to correctly identify the type of behaviour exhibited in each of the experiments named in the first column.

Table 1.3

Experiment	Matter exhibiting wave-like behaviour	Light exhibiting wave-like behaviour	Light exhibiting particle-like behaviour
Photoelectric emission			
Electron beam diffraction			
Young's double slits			

[3]

(ii) Calculate the momentum of a photon from the laser emitting red light.

Momentum = _____ kg m s⁻¹

[3]





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[Turn over



24SPH2105

- 2 (a) A student is asked to carry out an experiment to determine the wavelength of light from a laser source using a double slit with a slit spacing of 0.4 mm.

What additional apparatus is needed to carry out the experiment?

Describe what two measurements the student should take and how an **accurate** value for the wavelength of light can be calculated from the measurements.

Measurement 1

Measurement 2

Calculations (identify any symbols used)

[6]



(b) The student carries out another experiment using a source that emits light which consists of two different wavelengths. The student knows that one wavelength is 400 nm but the second wavelength is unknown. To determine the unknown wavelength the student directs a beam from the light source onto a diffraction grating with 400 lines per mm.

(i) Calculate the spacing between adjacent lines on the diffraction grating.

Spacing = _____ m [2]

(ii) The student discovers that the third order maximum from the 400 nm light is at the same position on the screen as the second order maximum produced by the light of unknown wavelength. Calculate the unknown wavelength.

Wavelength = _____ m [3]

[Turn over



3 (a) An object **OA** is placed on the principal axis of a **converging** lens to produce a focused image on a screen.

(i) Draw the ray diagram on **Fig. 3.1** to show how the focused image of the object is produced on the screen. [4]

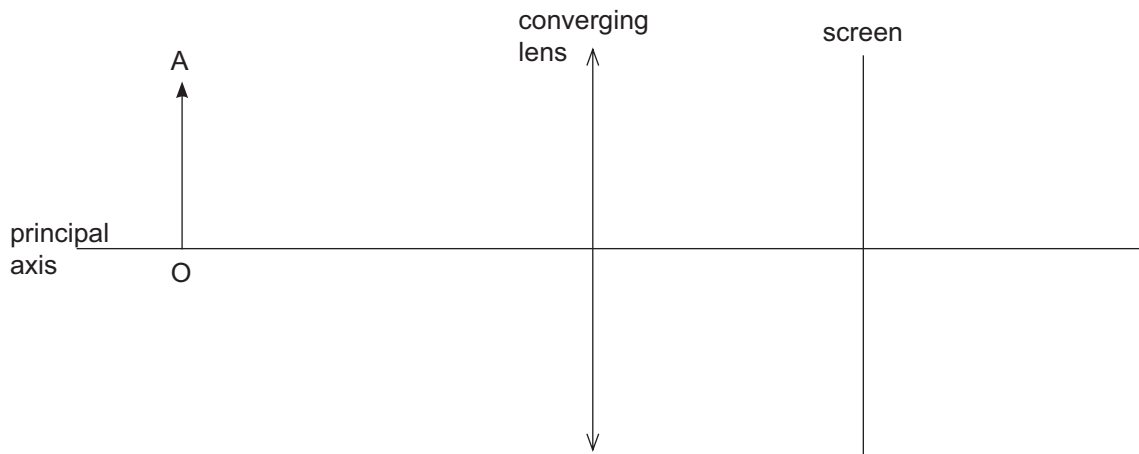


Fig. 3.1

(ii) State the three properties of the image produced on the screen in **Fig. 3.1**.

[2]

(iii) **Fig. 3.1** is a full scale diagram.

Label the principal focus **F** of the lens on **Fig. 3.1** and measure the focal length of the lens. Give your answer in millimetres.

Focal length = _____ mm

[3]



(b) A person has a far point of infinity and a near point of 75 cm.

(i) State the name of this defect of vision.

_____ [1]

(ii) Calculate the power of the lens needed to correct this defect of vision. Take the normal near point to be 25 cm.

Power = _____ D [5]

(iii) Calculate the furthest distance from the person of an object that can be focused while wearing the corrective lenses.

Distance = _____ m [2]

[Turn over



4 (a) State Snell's law.

[2]

(b) A student uses a ray box to direct a ray of light towards an equilateral triangular glass prism of refractive index 1.48 as shown in Fig. 4.1.

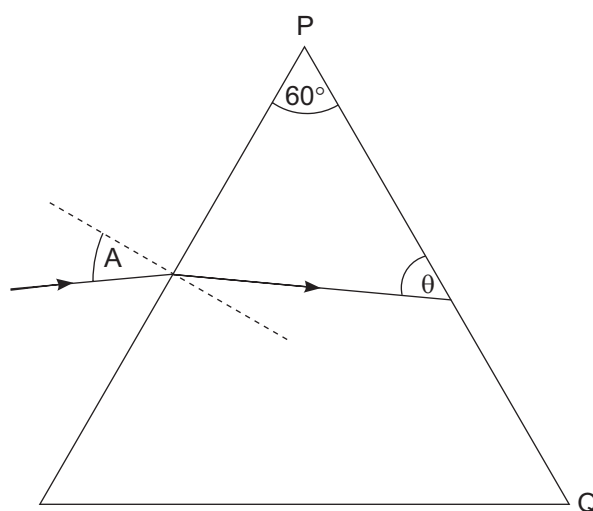


Fig. 4.1

(i) On Fig. 4.1 draw a normal where the ray meets the side PQ. Given that total internal reflection does not occur, sketch the path the ray will take after it exits the prism. [2]



(ii) Show, by calculation, that when angle A is 30° then the angle marked θ in Fig. 4.1 will be 50° to 2 significant figures.

[3]

(iii) Calculate the angle of refraction as the beam leaves the glass prism at PQ when angle A is 30° .

Angle of refraction = _____ $^\circ$

[3]



5 (a) An endoscope is a piece of scientific equipment often used in medical procedures. The endoscope consists of two bundles of optical fibres, a light source and lenses.

(i) State the purpose of each of the fibre optic bundles and the difference in their construction.

[3]

(ii) Some medical endoscopes have an additional instrumentation channel to allow minor surgical treatments to be carried out. Name one instrument that can be used through this instrumentation channel and state its purpose.

[2]



- (iii) Each step index optical fibre in the endoscope is made from two transparent materials, one of refractive index 1.52 and the other of refractive index 1.34. Which material should be used for the core and which should be used for the cladding? Explain why.

[2]

- (iv) Calculate the critical angle at the core/cladding boundary for the step index optical fibre described in part (iii).

Critical angle = _____ ° [4]

- (v) State an example of a non-medical use of an endoscope.

[1]

[Turn over



(b) A CT scanner can be used for medical imaging. State the type of radiation used and describe briefly how a CT scanner is used to produce a cross-sectional image of a patient.

[3]





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24SPH2115

- 6 (a) A signal generator is connected to an oscillator as shown in **Fig. 6.1**. The oscillator is attached to a string of length L , fixed at both ends. The output frequency of the signal is increased until a standing wave in the **third mode** of vibration is observed on the string.

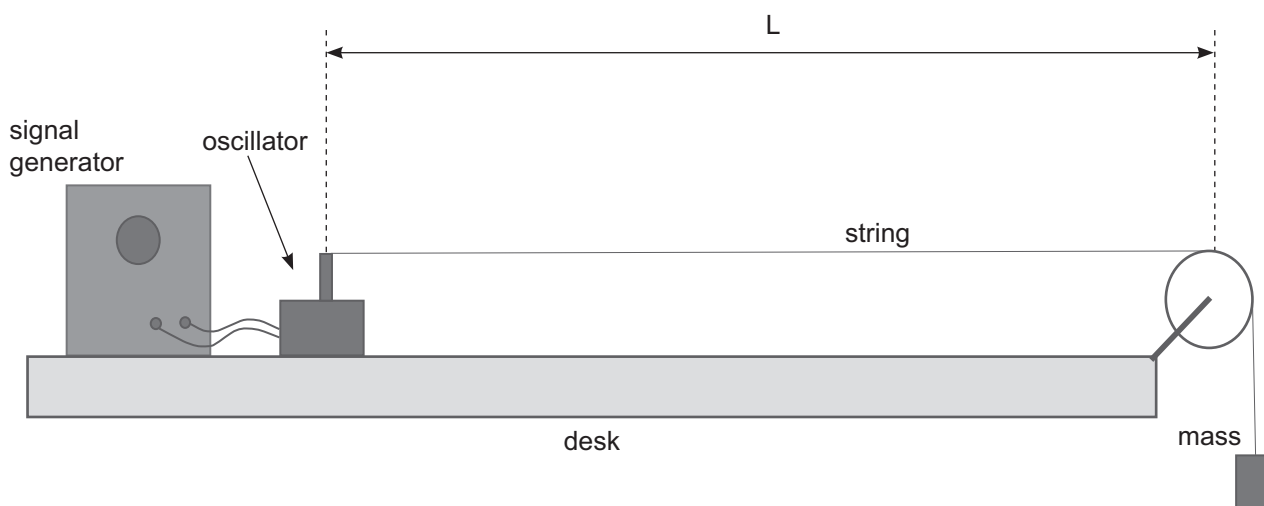


Fig. 6.1

- (i) On **Fig. 6.1** sketch the standing wave formed on the string in the third mode of vibration. Label the positions of all the antinodes A. [2]
- (ii) State the wavelength of the wave in terms of the length L of the string.

Wavelength = _____

[1]



- (b) The signal generator is now connected to a speaker which is placed next to the open end of a cylinder. The cylinder is closed at the other end, as shown in Fig. 6.2.

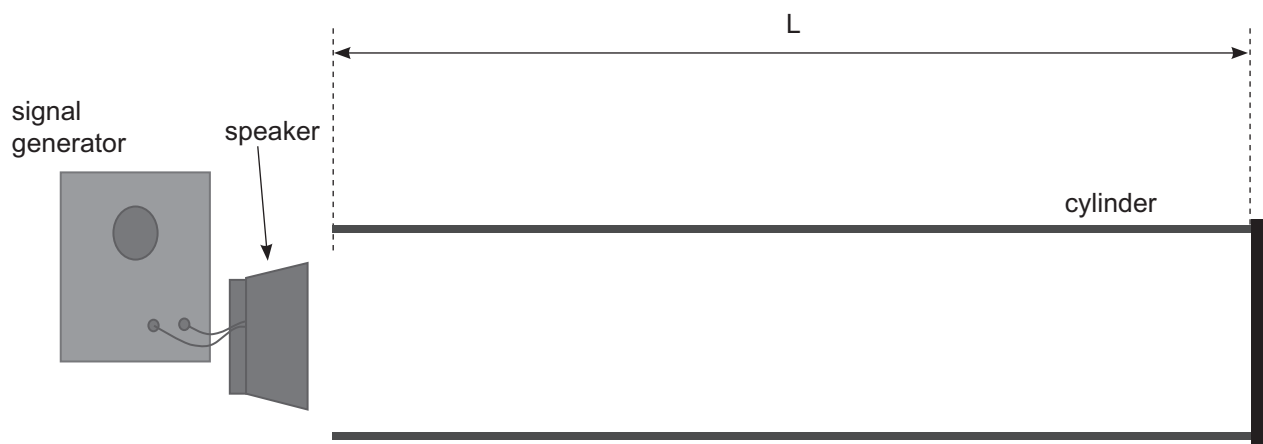


Fig. 6.2

A standing wave is produced in the air column inside the cylinder, also in the **third mode** of vibration, when the signal generator is set to a frequency of 650 Hz.

- (i) On Fig. 6.2 sketch the standing wave in the third mode of vibration formed in the cylinder. Label the positions of all the nodes N. [2]

- (ii) State the wavelength of the wave in terms of the length L of the cylinder.

Wavelength = _____ [1]

- (iii) If the speed of sound in air is 330 m s^{-1} calculate the length L of the cylinder.

Length = _____ m [2]

[Turn over



7 Modern electric cars are virtually silent.

(a) Explain why this could be considered a safety hazard.

[1]

(b) One adaptation is to introduce a speaker that produces a sound source of 280 Hz to mimic the sound of a conventional car engine.

Fig. 7.1 shows an electric car, with this speaker, travelling directly towards a microphone at a constant speed v .

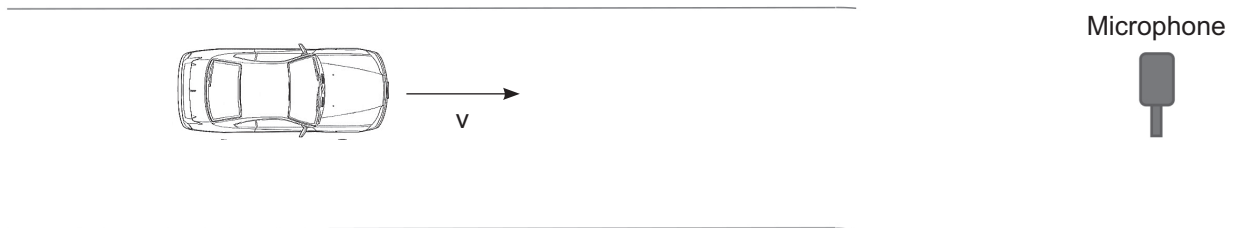


Fig. 7.1



- (i) The microphone records the frequency of the sound to be 300 Hz rather than 280 Hz. Explain this difference and state the scientific name given to this effect.

[2]

- (ii) If the speed of sound in air is 330 m s^{-1} , calculate the speed of the car. Give your answer in km h^{-1} .

Speed = _____ km h^{-1} [4]

[Turn over

12544



24SPH2119

(c) Hubble used a similar scientific technique, using light instead of sound, to measure the velocity of distant galaxies. From his results he was able to derive a relationship between the recessional velocity of a galaxy and its distance from Earth.

(i) Use the relationship Hubble discovered between the distance d of a galaxy from Earth and its recessional velocity v to sketch the graph of v against d in **Fig. 7.2**. [1]

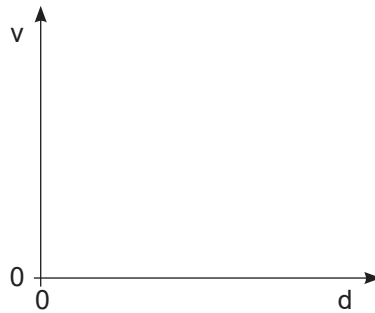


Fig. 7.2

(ii) State how the graph shown in **Fig. 7.2** provides evidence to support the big bang theory.

[2]



(iii) Describe how you could determine the Hubble constant from the graph.

[1]

(iv) Use the Hubble constant from your data sheet to calculate an estimate for the age of the Universe. Show clearly your working out.

Age of the Universe = _____ seconds

[2]



- 8 (a) The diagram in **Fig. 8.1** shows some of the energy levels for the electron of a hydrogen atom.

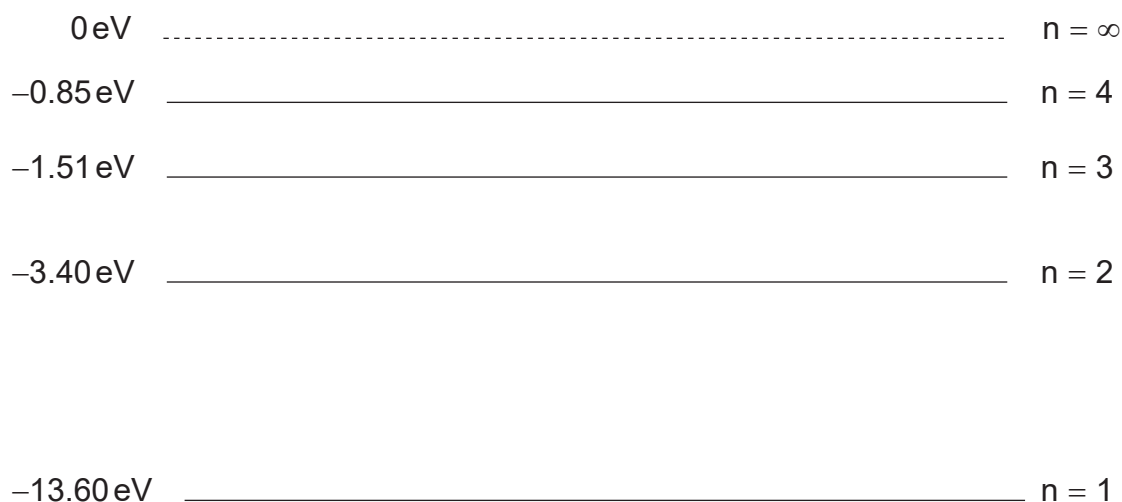


Fig. 8.1

- (i) Calculate the wavelength of a photon required to raise the electron from the ground state to the $n = 3$ energy level.

Wavelength = _____ m [4]

- (ii) Draw arrows on **Fig. 8.1** to show all the possible energy level transitions when the electron returns to the ground state from the $n = 3$ raised energy level. [2]



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Question Number	Marks
1	
2	
3	
4	
5	
6	
7	
8	
Total Marks	

Examiner Number

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