New Specification

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ADVANCED SUBSIDIARY (AS)
General Certificate of Education
2017

Centre Number

Candidate Number

Physics

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

SPH21

[SPH21]

THURSDAY 8 JUNE, 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 in black ink only. **Do not write with a gel pen.**
Answer **all seven** 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 In the laboratory a certain line in the calcium spectrum has a wavelength of 396.9 nm. When the calcium spectrum from another distant galaxy was observed the same line is red shifted to a wavelength of 398.3 nm.

(a) (i) Explain why there is this change in the wavelength of the same spectral line.

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____

____ [1]

(ii) Explain how cosmological red shift differs from Doppler red shift.

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____ [2]

(b) (i) Calculate the cosmological red shift parameter, z, for the spectral line of calcium from the other galaxy.

z = ____________ [2]

(ii) Use your value of z to calculate the recession speed of the other galaxy.

Speed = ________________ $m\,s^{-1}$ [2]

(iii) Estimate how far the other galaxy is away from Earth in mega light years.
[1 mega light year (Mly) = 9.46×10^{18} km.]

Distance = _______________ Mly [3]

(c) Use the value for the Hubble constant, H_0, in the Data and Formulae Sheet to obtain a value for the age of the Universe in billions of years (giga years).

Age = _______________ billion years [3]

2 Potassium has a work function of 2.29 eV.

(a) Calculate the maximum wavelength of electromagnetic radiation that would cause photoelectric emission if incident on a clean potassium surface.

Wavelength = ______________ m [4]

(b) A photon of energy 8.69×10^{-19} J is incident on a clean potassium surface. Calculate the maximum velocity with which an electron can be emitted.

Maximum velocity = ______________ $m\,s^{-1}$ [4]

(c) Explain why the velocity of other emitted electrons will be less than this maximum value.

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____ [2]

3 **(a)** **(i)** Photoelectric emission can only be fully explained by the photon model. State which observations relating to photoelectric emission can only be explained by the photon model and not by the wave model.

[2]

(ii) What observation associated with photoelectric emission could be successfully explained by the wave model?

[1]

(b) Describe an experiment to observe electron diffraction. Your answer should include detail of the apparatus used and a description of what is observed. State the significance of the observations.

[8]

(c) Calculate the de Broglie wavelength, in nanometres, of an electron that has a velocity of $2.50 \times 10^6\,\mathrm{m\,s^{-1}}$.

Wavelength = _______________ nm [4]

4 An experiment is performed to determine the refractive index of the material of a rectangular transparent block. The results of the experiment are used to plot a graph of sin r against sin i as shown in **Fig. 4.1**.
N.B. r is the angle of refraction and i is the angle of incidence.

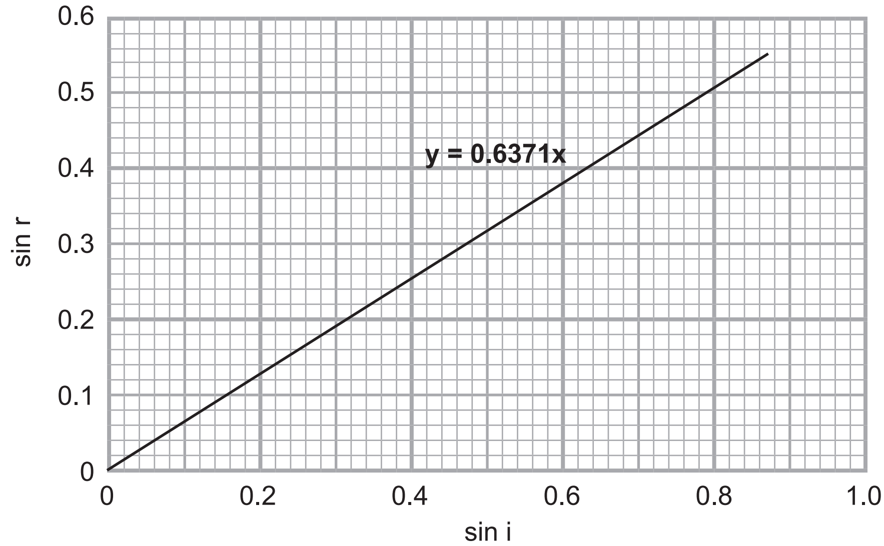

Fig. 4.1

(a) Outline the experimental procedure that would enable results to be taken so that the graph shown in **Fig. 4.1** can be drawn.

[4]

(b) **(i)** Use data from **Fig. 4.1** to determine the refractive index of the material from which the transparent block was made.

Refractive index = _______________ [2]

(ii) Determine the critical angle for the material.

Critical angle = _______________ ° [3]

(iii) Determine the speed of visible light during its passage through the material from which the transparent block was made.

Speed = _______________ $m\,s^{-1}$ [3]

[Turn over

(c) (i) Complete **Fig. 4.2** by labelling the structures of the optical fibre, and complete the passage of the ray through the fibre.

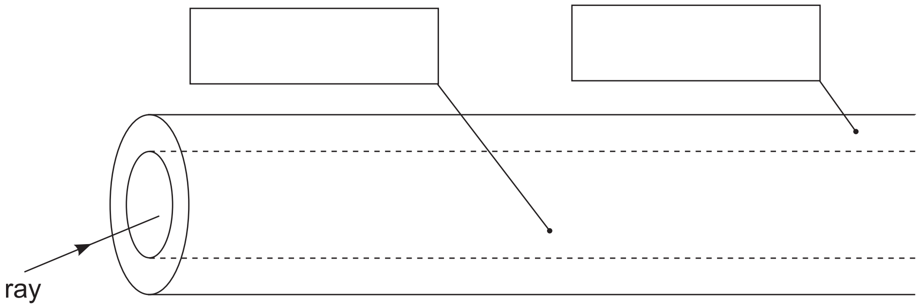

Fig. 4.2

[4]

(ii) Describe how optical fibres are used in a flexible endoscope.

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____ [3]

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(Questions continue overleaf)

5 **(a)** **(i)** **Fig. 5.1** shows a 3.0 cm high object, OA, placed 300 cm from a converging lens, L. On the grid of **Fig. 5.1**, complete the scale diagram to determine the focal length of the converging lens if a real image, 2.0 cm high is formed.

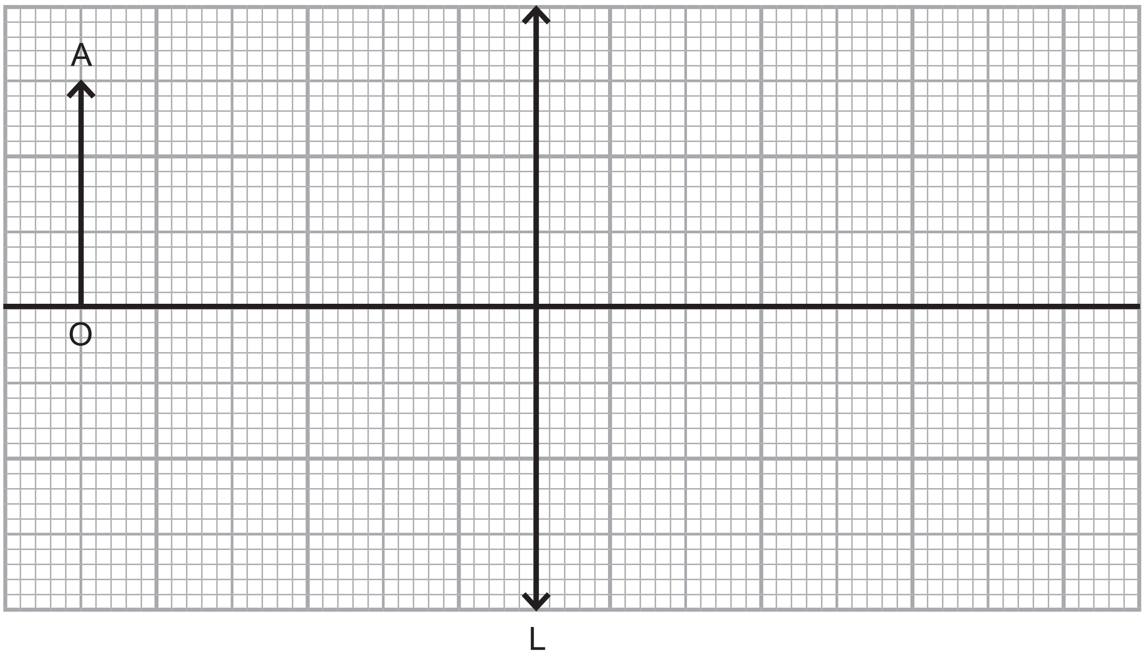

Fig. 5.1

Focal length = _______________ cm [6]

(ii) Determine the magnification for the situation described.

Magnification = _______________ [2]

(b) (i) When used as a magnifying glass a lens of focal length 16 cm can produce an upright (erect) image with a magnification of 2.2. How far is the object from the lens when this magnification is achieved?

Position _______________ cm [4]

(ii) Calculate the power of this lens in dioptres, D.

Power = _______________ D [2]

(c) (i) Name the condition affecting a person's vision if he requires spectacles with a lens of power –2.2 D.

____

____ [1]

(ii) What is the cause of this condition?

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____ [1]

(iii) What effect does this condition have on his vision?

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____ [1]

(iv) Explain how the **correcting lens** improves his vision.

____

____ [1]

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(Questions continue overleaf)

6 **(a)** Explain why a standing wave can be established in a pipe closed at one end.

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____ [2]

(b) **Figs. 6.1** and **6.2** show two pipes of the same length, closed at one end. A speaker, attached to a signal generator, is placed at the open end of each pipe. The frequency of the note emitted by the speaker is varied to produce resonance.

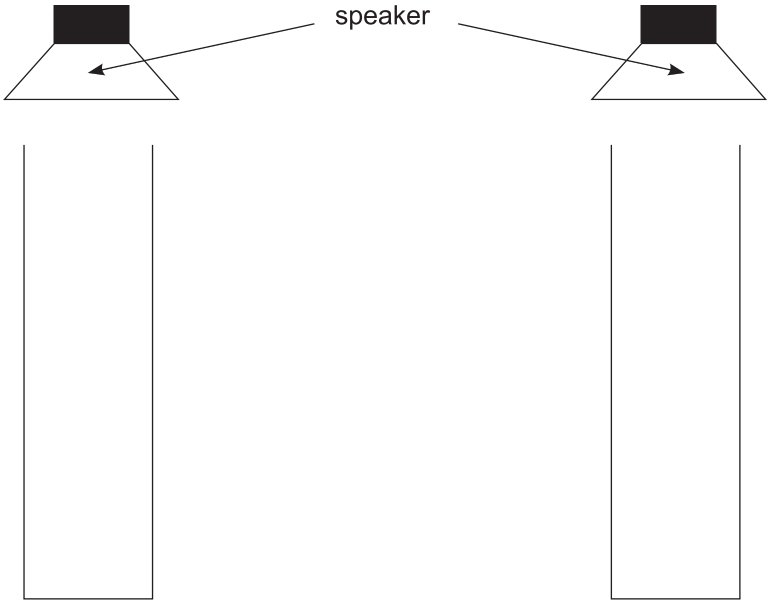

Fig. 6.1 **Fig. 6.2**

(i) On **Fig. 6.1**, draw the graphical representation of the first mode of vibration of the standing wave in the pipe. [2]

(ii) On **Fig. 6.2**, draw the graphical representation of the fourth mode of vibration of the standing wave in the pipe. [1]

(c) Explain the difference between a 'node' and an 'antinode' in this context.

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____ [2]

(d) The pipes are 0.68 m long and the speed of sound in air is 330 m s^{-1}.
Determine the frequency of the note emitted in each pipe.

Frequency (1st mode of vibration) = ________________ Hz

Frequency (4th mode of vibration) = ________________ Hz [4]

7 **(a)** In the Young's slits interference experiment, light rays from two slits (s_1 and s_2) meet on a screen to produce an interference pattern.

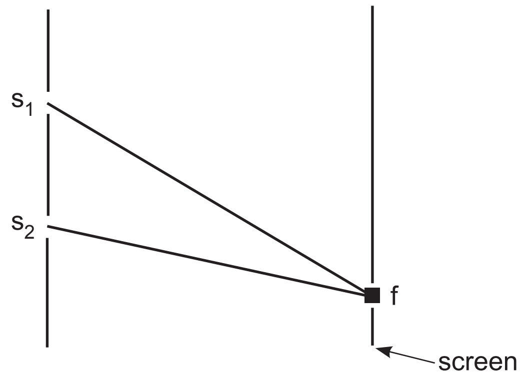

Fig. 7.1

Use the twin concepts of coherence and path difference to explain how constructive interference could occur at position f on the screen on **Fig. 7.1**.

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____ [3]

(b) In a Young's slits interference experiment to determine the wavelength of laser light the slits are measured to be 0.58 mm wide and they are 1.24 mm apart. The distance between the first bright fringe and the sixth bright fringe on interference pattern produced was 9.29 mm. The screen on which the interference pattern was formed was 3.74 m from the laser and the laser was 10 cm from the slits. The wavelength can be calculated using the equation

$$\lambda = \frac{ay}{d}$$

(i) Identify the magnitude of the quantities a, y and d:

a = ________________

y = ________________

d = ________________ [3]

(ii) Calculate the wavelength of the laser light.

Wavelength = ________________ m [1]

[Turn over

(c) Another technique for determining the wavelength of monochromatic light is to use a diffraction grating. **Fig. 7.2** illustrates the effect of the diffraction grating on incident monochromatic light. n = 0, 1, 2 represent the direction of different orders of diffraction maxima.

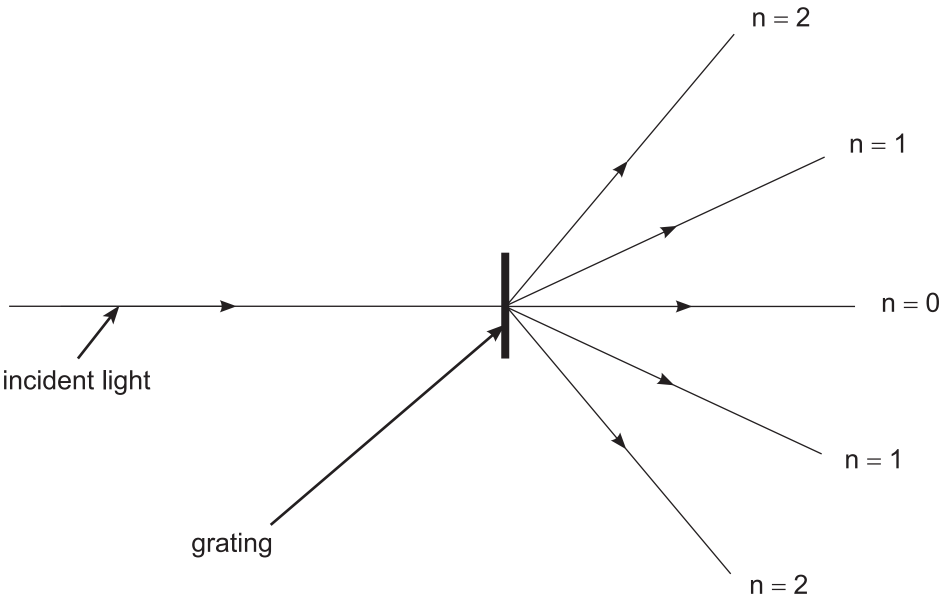

Fig. 7.2

The diffraction grating has 300 lines per millimetre and the angle between the two second orders is 40.2°.

(i) Determine the wavelength of the incident light.

Wavelength = _______________ m [4]

(ii) Determine the highest order of diffraction fringes that it is possible to observe using this diffraction grating with this wavelength of light.

Highest n = _______________ [3]

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Question Number	**Marks**
1	
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