

Please write clearly in block capitals.

Centre number

Candidate number

Surname \_\_\_\_\_

Forename(s) \_\_\_\_\_

Candidate signature \_\_\_\_\_

I declare this is my own work.

# A-level PHYSICS

## Paper 3 Section B Astrophysics

Time allowed: The total time for both sections of this paper is 2 hours. You are advised to spend approximately 50 minutes on this section.

### Materials

For this paper you must have:

- a pencil and a ruler
- a scientific calculator
- a Data and Formulae Booklet
- a protractor.

### Instructions

- Use **black ink** or **black ball-point pen**.
- **Fill** in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do **all** rough work in this book. Cross through any work you do not want to be marked.
- Show **all** your working.

### Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 35.
- You are expected to use a scientific calculator where appropriate.
- A Data and Formulae Booklet is provided as a loose insert.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
<b>TOTAL</b>	



**Section B**Answer **all** questions in this section.

- 0 1 . 1** Draw a ray diagram to show how a converging lens can cause spherical aberration. **[1 mark]**

\_\_\_\_\_ principal axis

- 0 1 . 2** Draw a **labelled** ray diagram for an astronomical refracting telescope in normal adjustment.

Show **three** non-axial rays passing through both lenses.  
Label the principal foci of the lenses.

**[3 marks]**

\_\_\_\_\_ principal axis



0 1 . 3

The James Lick telescope is an astronomical refracting telescope. When in normal adjustment, the distance between the lenses of the telescope is 17.4 m and the angular magnification is 750

Calculate the focal length of the eyepiece lens.

[2 marks]

focal length = \_\_\_\_\_ m

0 1 . 4

The James Lick telescope can be used to identify binary stars.

Two techniques are available using this telescope:

- using a processed image from a CCD, and
- direct observation using the naked eye.

Compare the use of a CCD with the use of the naked eye to observe binary stars with this telescope.

[3 marks]

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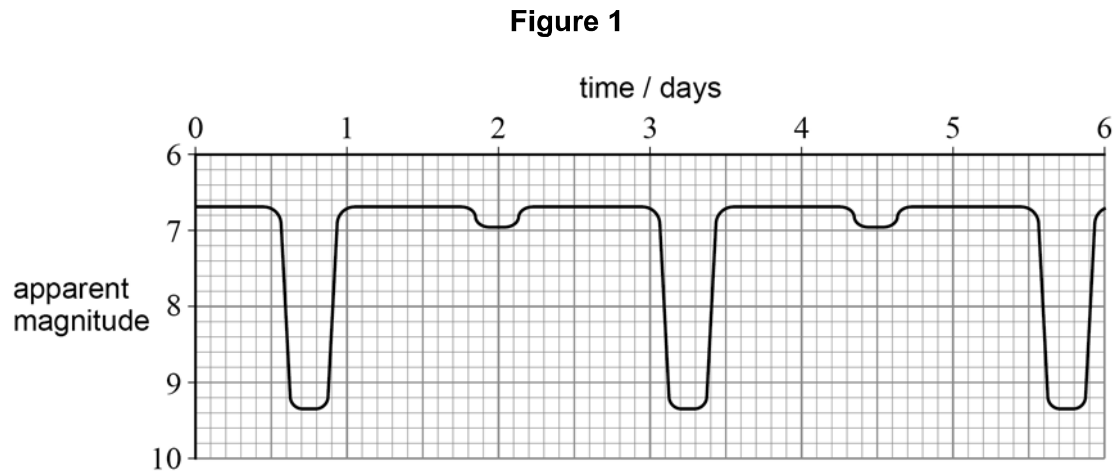


0 2

U Cephei is an eclipsing binary system consisting of two stars that orbit their common centre of mass.

The primary star is class B; the secondary star is class G.

**Figure 1** shows the variation of apparent magnitude of U Cephei with time as observed from Earth.



0 2 . 1

Explain the shape of the graph in **Figure 1**.

[2 marks]

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Question 2 continues on the next page

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A particular spectral line has a wavelength of 486.136 nm when measured from a source in the laboratory.  
This line is also present in the absorption spectrum of the primary star of U Cephei. When observed from Earth, the wavelength of the primary star's absorption line varies as shown in **Table 1**.

**Table 1**

	<b>Wavelength / nm</b>
maximum value	486.498
minimum value	485.672

**0 2 . 2** State why the average of the values in **Table 1** is different from the laboratory value. **[1 mark]**

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**0 2 . 3** Show that the orbital speed of the primary star is about 250 km s<sup>-1</sup>. **[3 marks]**



**0 2 . 4** Calculate the orbital radius of the primary star.

**[2 marks]**

orbital radius = \_\_\_\_\_ m

**0 2 . 5** Which absorption lines would be most prominent in the spectrum of the primary star?  
Tick (✓) **one** box.

**[1 mark]**

hydrogen

hydrogen and helium

ionised metals

neutral metals

**0 2 . 6** A different eclipsing binary star system is thought to consist of a white dwarf star and a neutron star.

Discuss how astronomers could confirm this.

**[2 marks]**

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**0 3**

3C 273 was the first quasar to be discovered.  
 IC 1101 is one of the largest galaxies known.  
**Table 2** shows some information about these objects.

**Table 2**

	<b>Absolute magnitude</b>	<b>Apparent magnitude</b>	<b>Distance / Mpc</b>
quasar 3C 273	<b>X</b>	12.8	760
galaxy IC 1101	-22.8	14.7	320

**0 3****1**

State the property of the quasar that led to its discovery.

**[1 mark]**


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**0 3****2**

Show that the absolute magnitude **X** of quasar 3C 273 is about  $-27$

**[2 marks]**



**0 3 . 3** Assume that the quasar and the galaxy are both viewed from the same distance.

Explain which would be the brighter object.

Go on to calculate the ratio  $\frac{\text{brightness of brighter object}}{\text{brightness of dimmer object}}$ .

**[3 marks]**

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ratio = \_\_\_\_\_

**0 3 . 4** The black hole at the centre of IC 1101 has a mass of  $7.1 \times 10^{11} M_{\text{S}}$   
where  $M_{\text{S}}$  is the mass of the Sun.

Calculate the average density within the event horizon of the black hole.

**[3 marks]**

average density = \_\_\_\_\_  $\text{kg m}^{-3}$

9

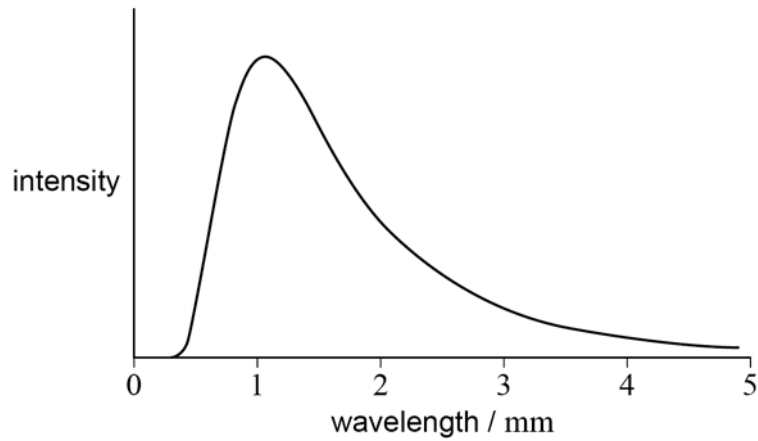
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0 4

In the middle of the 20th century, there were two competing theories of the Universe. In 1964, electromagnetic radiation was observed coming from **all** directions in space. **Figure 2** shows the distribution of this radiation as observed from Earth.

**Figure 2**



The graph provides evidence for one of these theories of the Universe.

Discuss the main features of this theory of the Universe.

In your answer, you should include:

- the main predictions and evidence for the theory, and
- a suitable calculation.

**[6 marks]**

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6

**END OF QUESTIONS**



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1 6



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