



**Surname** \_\_\_\_\_

**Other Names** \_\_\_\_\_

**Centre Number** \_\_\_\_\_

**Candidate Number** \_\_\_\_\_

**Candidate Signature** \_\_\_\_\_

**I declare this is my own work.**

## **A-level PHYSICS**

**Paper 3**

**Section B    Astrophysics**

**7408/3BA**

**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.**

**At the top of the page, write your surname and other names, your centre number, your candidate number and add your signature.**

**[Turn over]**



**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.
- Answer ALL questions.
- You must answer the questions in the spaces provided. Do not write 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.

**DO NOT TURN OVER UNTIL TOLD TO DO SO**



**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
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**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]**

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**principal  
axis**

**[Turn over]**



0	1	.	3
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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



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**[Turn over]**



0	1	.	4
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**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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**[Turn over]**

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<b>9</b>

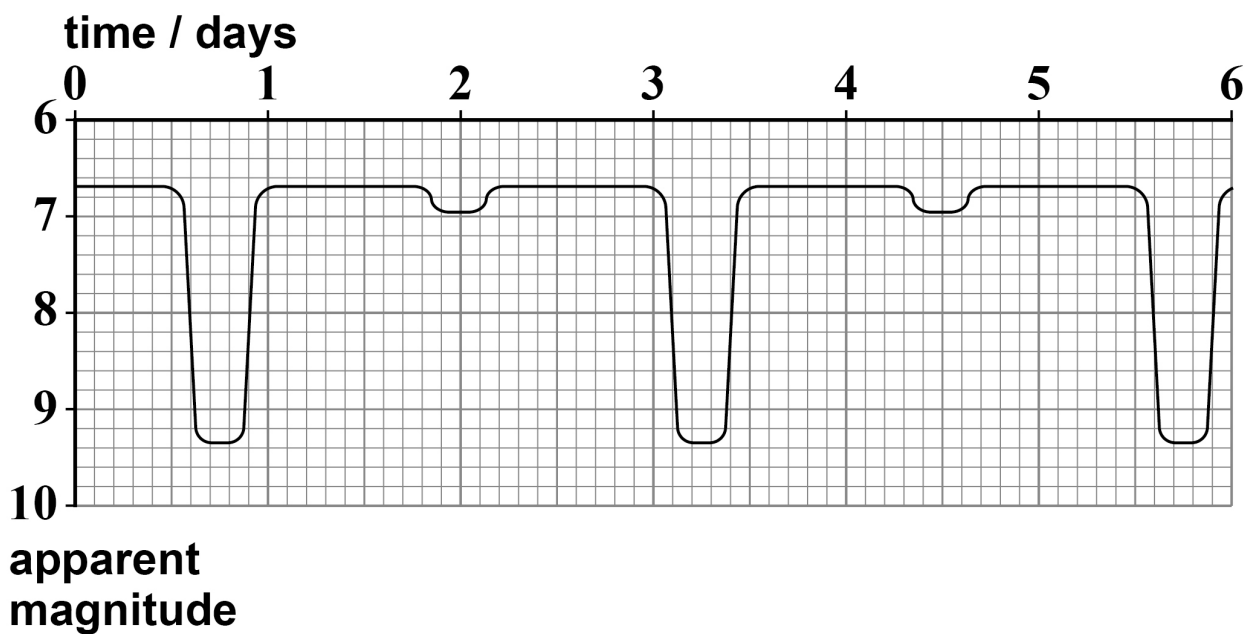


02

**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.**

**FIGURE 1**



0	2	.	1
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**Explain the shape of the graph in FIGURE 1, on the opposite page. [2 marks]**

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**[Turn over]**



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**

	Wavelength / nm
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
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**Show that the orbital speed of the primary star is about  $250 \text{ km s}^{-1}$ . [3 marks]**

**[Turn over]**



0	2	.	4
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Calculate the orbital radius of the primary star.  
[2 marks]

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



0	2	.	5
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**Which absorption lines would be most prominent in the spectrum of the primary star? [1 mark]**

**Tick (✓) ONE box.**

☐

**hydrogen**

☐

**hydrogen and helium**

☐

**ionised metals**

☐

**neutral metals**

**[Turn over]**



0	2	.	6
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**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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11





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**[Turn over]**



03

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>
<b>quasar 3C 273</b>	<b>X</b>	<b>12.8</b>	<b>760</b>
<b>galaxy IC 1101</b>	<b>−22.8</b>	<b>14.7</b>	<b>320</b>

03.1

State the property of the quasar that led to its discovery. [1 mark]

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0	3	.	2
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**Show that the absolute magnitude  $X$  of quasar 3C 273 is about  $-27$  [2 marks]**

**[Turn over]**



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

Explain which would be the brighter object. [3 marks]

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

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



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The black hole at the centre of IC 1101 has a mass of  $7.1 \times 10^{11} M_S$  where  $M_S$  is the mass of the Sun.

Calculate the average density within the event horizon of the black hole. [3 marks]

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

[Turn over]

9



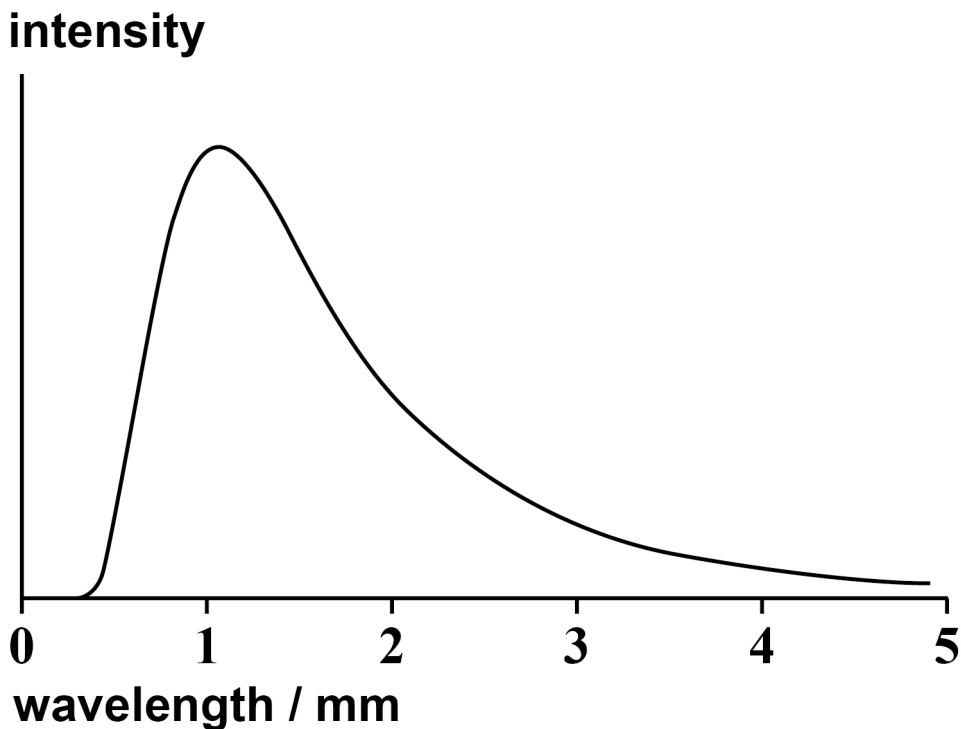
0	4
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In the middle of the 20th century, there were two competing theories of the Universe.

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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**[Turn over]**



[illegible]



[illegible]

**[Turn over]**



[illegible]

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**END OF QUESTIONS**

      
**6**



**Additional page, if required.**

**Write the question numbers in the left-hand margin.**

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**Additional page, if required.**

**Write the question numbers in the left-hand margin.**

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

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**IB/M/MW/Jun22/7408/3BA/E2**

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2 2 6 A 7 4 0 8 / 3 B A