AQA

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.

| For Examiner's Use | |
|---|---|
| Question | Mark |
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| **TOTAL** | |

**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.

## 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]**



**9**

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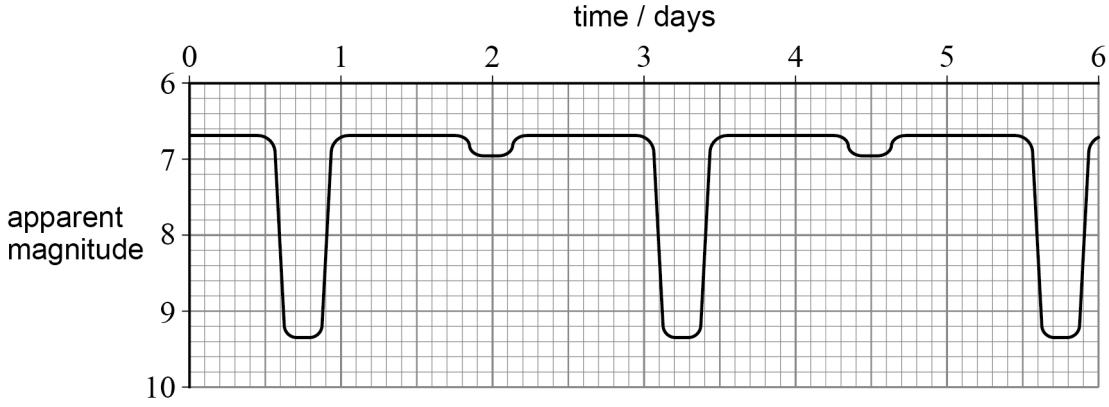
**ANSWER IN THE SPACES PROVIDED**

**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.

**Figure 1**




**0 2 . 1** Explain the shape of the graph in **Figure 1**.

**[2 marks]**

**Question 2 continues on the next page**

A particular spectral line has a wavelength of $486.136\ \text{nm}$ 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]**

**0 2 . 3** Show that the orbital speed of the primary star is about $250\ \text{km s}^{-1}$.

**[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]**



**11**

**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**

| | **Absolute magnitude** | **Apparent magnitude** | **Distance / Mpc** |
|---|---|---|---|
| quasar 3C 273 | **X** | 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]**

**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]**

ratio = _____

**0 3 . 4** 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.

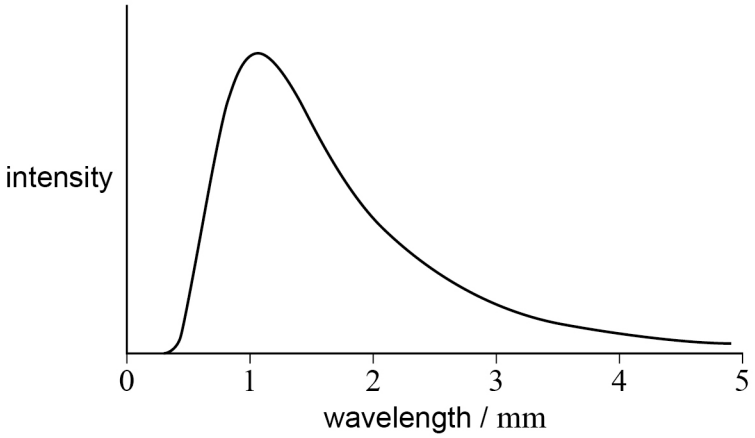
**[3 marks]**

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

9

**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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**END OF QUESTIONS**

6

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