A

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

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

[Turn over]

JUN227408 3BA01

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.

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

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 $17.4\ \text{m}$ 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

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]

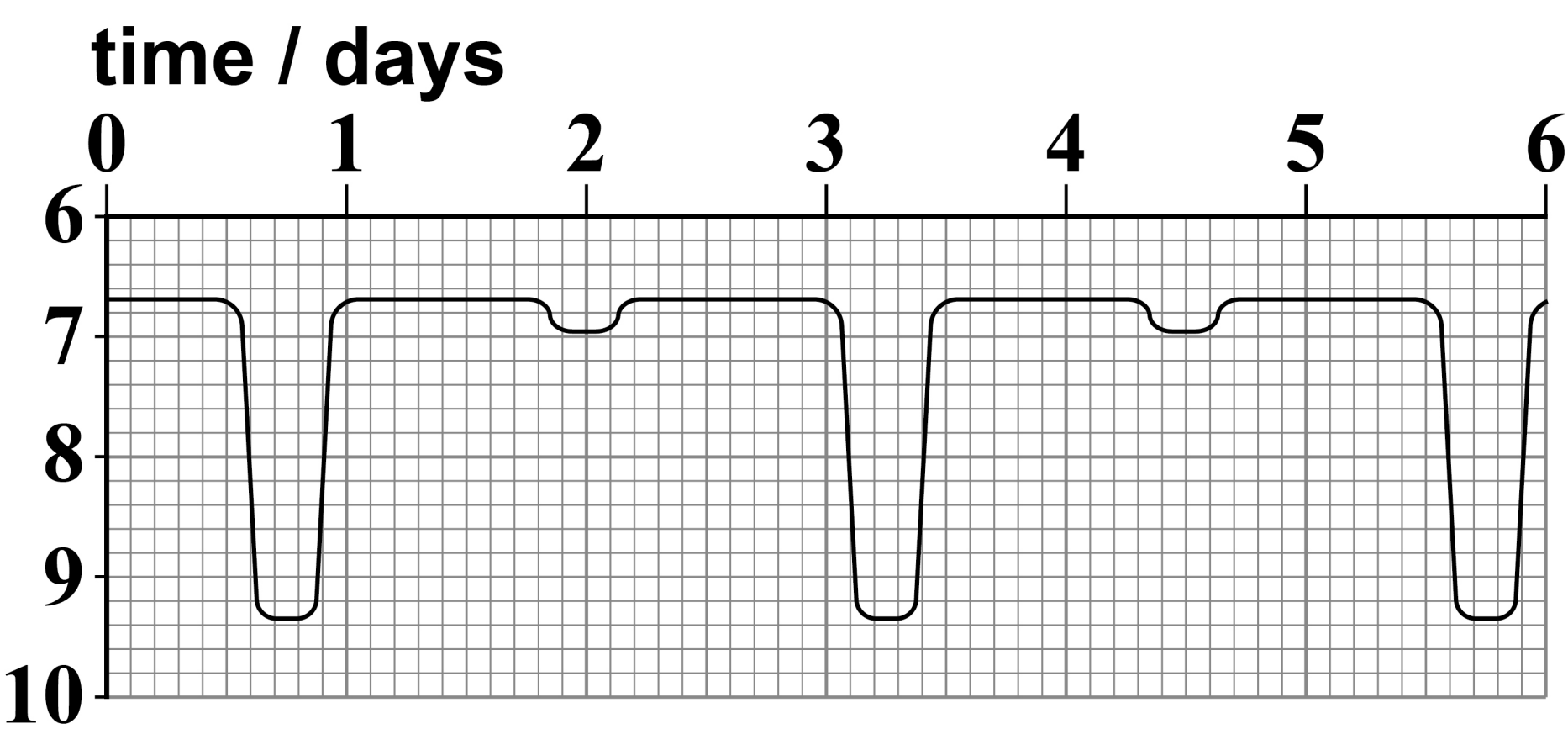
[Turn over]

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, on the opposite page.
[2 marks]

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]

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

[Turn over]

0 2 . 5

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**

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]

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]

[Turn over]

0 3 . 2

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

BLANK PAGE

[Turn over]

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 = _____

[Turn over]

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 = _____ kg m^{-3}

9

0 4

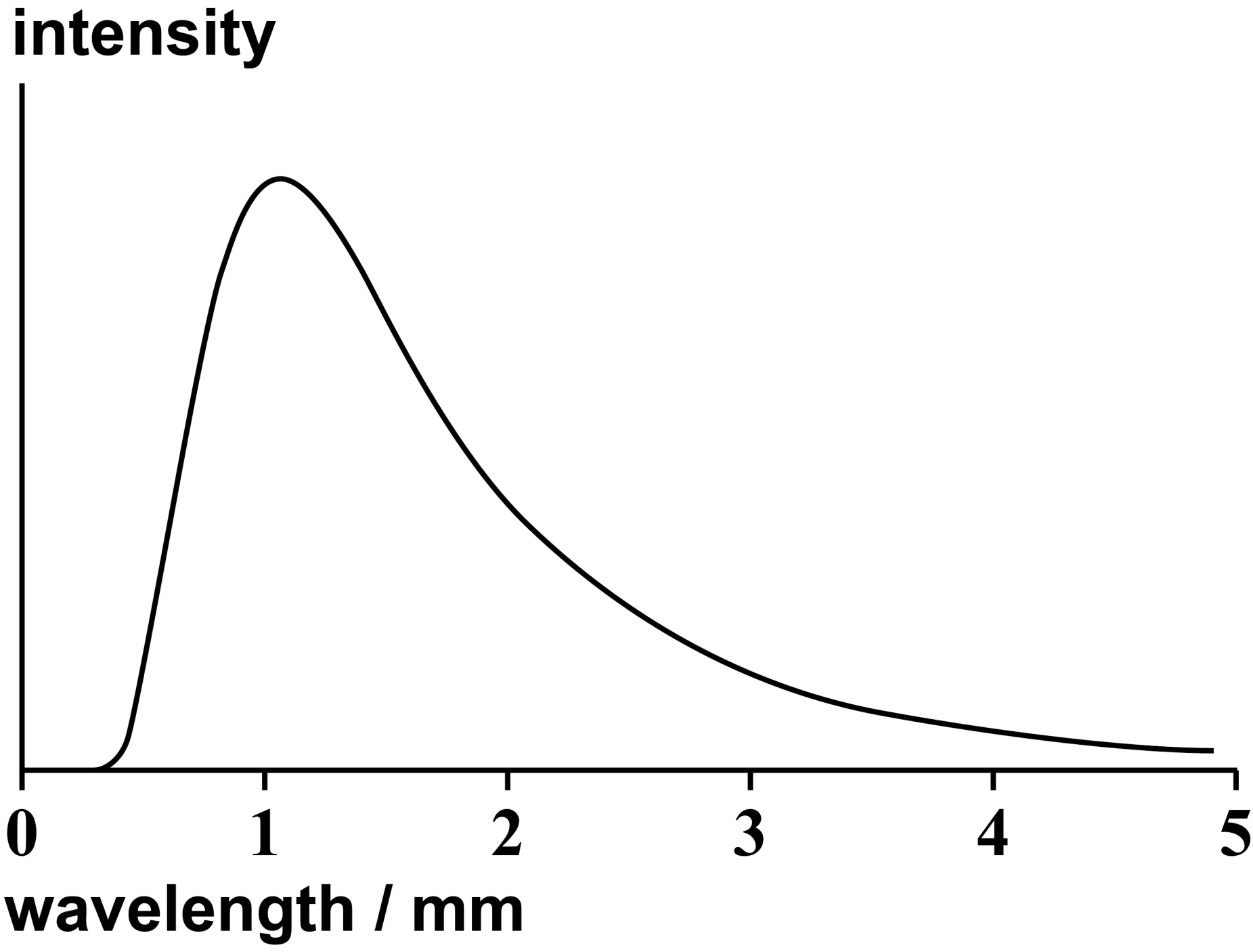
In the middle of the 20th century, there were two competing theories of the Universe.

In 1964, electromagnetic radiation was observed coming from all directions in space.

FIGURE 2, on page 26, shows the distribution of this radiation as observed from Earth.

[Turn over]

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]

[Turn over]

END OF QUESTIONS

6

Additional page, if required.

Write the question numbers in the left-hand margin.

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	
TOTAL	

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