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

Monday 17 June 2024 Morning

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.

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Section B

Answer **all** questions in this section.

0 1 A student uses a refracting telescope in normal adjustment to make observations of Jupiter.
The telescope has an angular magnification of 75

0 1 . 1 The eyepiece has a focal length of 22 mm.

Determine the distance between the eyepiece and the objective lens.

[2 marks]

distance = _____ m

0 1 . 2 When viewed through the telescope, the image of Jupiter subtends an angle of 1.7×10^{-2} rad.

Calculate, in km, the distance between the Earth and Jupiter.

mean radius of Jupiter = 7.0×10^{4} km

[2 marks]

distance = _____ km

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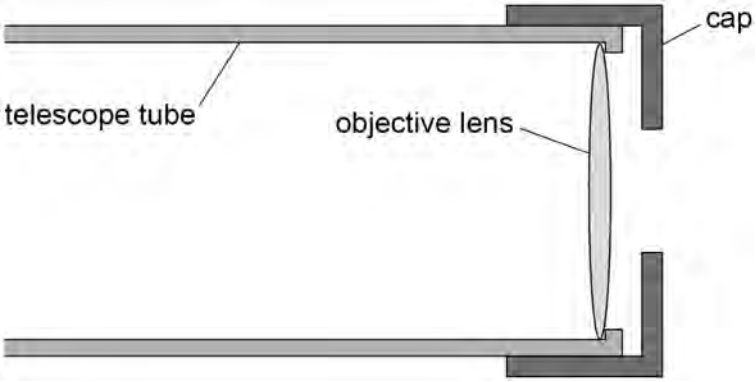
The student places a cap over one end of the telescope. The cap has a circular hole in its centre.
Figure 1 shows the end of the telescope, the objective lens and the cap.

Figure 1



0 1 . 3 State and explain the effect that the addition of the cap has on the chromatic aberration caused by the lens.

[3 marks]

0 1 . 4 Explain **two** other effects that the addition of the cap has on the image of Jupiter.

[4 marks]

1

2

11

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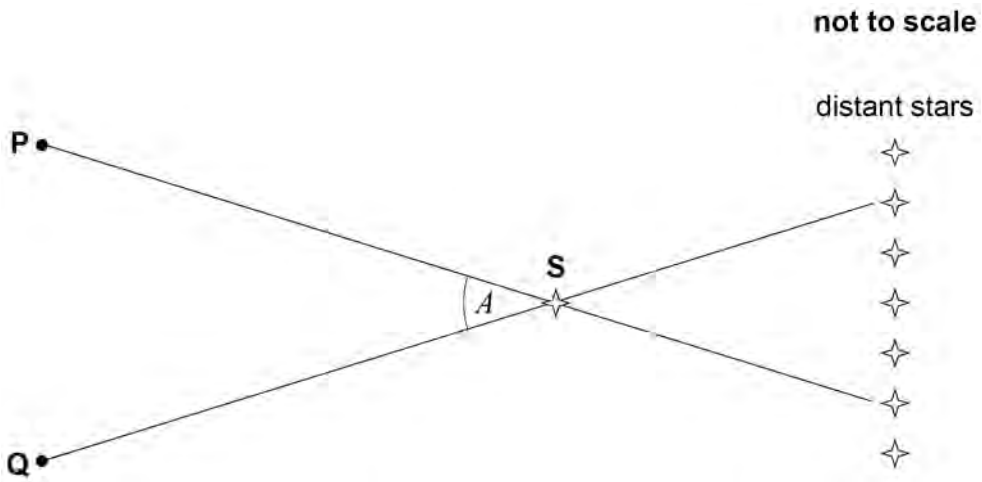
0 2 The apparent change in position of a nearby star relative to distant stars is due to an effect known as parallax.

Figure 2 shows how parallax arises. As the Earth moves from point **P** to point **Q**, an observer on the Earth sees the position of a nearby star **S** change in relation to distant stars.

Figure 2



Angle A is the parallax angle. This angle can be used to determine the distance to a nearby star, provided that the relative motion between the star and the Sun is negligible between observations.

0 2 . 1 The distance from the Sun to **S** is 79 ly.
The Earth takes 6 months to move from point **P** to point **Q**.

Calculate, in degrees, angle A.

[2 marks]

$A =$ _____ °

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0 2 . 2 Parallax is used to determine the distance to a different star. Observations of the star produce the following data:

distance determined using parallax = 0.40 pc
apparent magnitude = 13.5
absolute magnitude = 16.7

An astronomer suggests that the star moved significantly relative to the Sun between the two parallax observations.

Discuss whether this suggestion is valid.

[4 marks]

6

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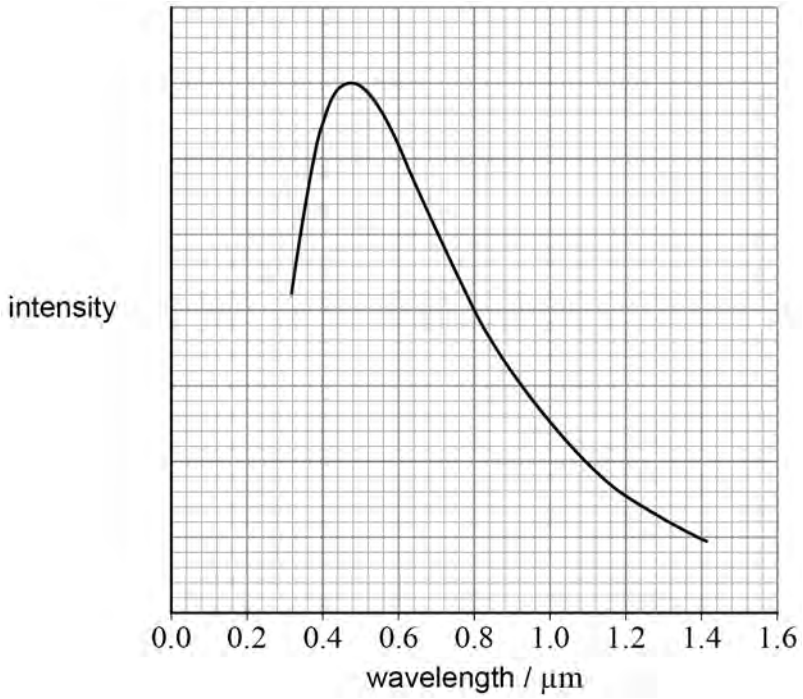
0 3 . 1 **Figure 3** shows the variation of intensity with wavelength for a star.

Figure 3



Show that **Figure 3** is consistent with a black-body temperature of about 6.0×10^3 K.

[2 marks]

0 3 . 2 The radius of the star is 9.6×10^6 m.

Calculate the power output of the star.

[2 marks]

power output = _____ W

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0 3 . 3 Which row gives the type and spectral class of the star?

Tick (✓) **one** box.

[1 mark]

Type of star	Spectral class	
white dwarf	F	
main sequence	G	
red giant	K	
main sequence	F	
red giant	G	
white dwarf	K	

0 3 . 4 The light from the star passes through an interstellar dust cloud before reaching Earth. The reduction in intensity when light passes through a dust cloud is assumed to be inversely proportional to the wavelength of the light.

An astronomer on the Earth estimates the black-body temperature of the star.

Discuss the effect that the dust cloud has on this estimate.

[2 marks]

7

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ANSWER IN THE SPACES PROVIDED

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0 4 The Earth is in the galaxy known as the Milky Way. The Andromeda Galaxy is one of the closest galaxies to the Milky Way.

0 4 . 1 The Andromeda Galaxy approaches the Milky Way at a speed of $110\ \text{km s}^{-1}$.
The distance between the galaxies is $770\ \text{kpc}$.

Discuss whether these data can be used to estimate an age for the Universe.

[2 marks]

0 4 . 2 There is a supermassive black hole at the centre of the Andromeda Galaxy. The mass of this black hole is 1.60×10^8 solar masses.

Calculate the radius of the event horizon of this black hole.
State an appropriate unit for your answer.

[3 marks]

radius = _____

unit = _____

Question 4 continues on the next page

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0 4 . 3 Scientists predict that a quasar will be produced as the Milky Way and the Andromeda Galaxy merge.

Explain what is meant by a quasar.
Go on to suggest why a quasar may be produced as galaxies merge.

In your answer you should:

- describe the typical properties of a quasar
- explain how observations of quasars provide evidence for these properties
- suggest the process of quasar formation that is likely when two galaxies merge.

[6 marks]

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END OF QUESTIONS

11

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