

Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
TOTAL	



General Certificate of Education
Advanced Level Examination
June 2015

Physics A

PHYA5/2AR

Unit 5A Astrophysics
Section B

Thursday 18 June 2015 9.00 am to 10.45 am

For this paper you must have:

- a calculator
- a pencil and a ruler
- a Data and Formulae Booklet (enclosed).

Time allowed

- The total time for both sections of this paper is 1 hour 45 minutes.
You are advised to spend approximately 50 minutes on this section.

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.
- 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 section is 35.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
 - use good English
 - organise information clearly
 - use specialist vocabulary where appropriate.



Section B

The maximum mark for this section is 35. You are advised to spend approximately 50 minutes on this section.

- 1 (a)** **Table 1** summarises some of the properties of Vesta, one of the largest objects in the asteroid belt between Mars and Jupiter.

Table 1

Diameter / m	Distance from the Sun / AU	
	smallest	largest
5.4×10^5	2.15	2.57

- 1 (a) (i)** Calculate the largest possible distance, in m, between the Earth and Vesta.

[2 marks]

distance = m

- 1 (a) (ii)** Show that when Vesta is at a distance of 1.73×10^{11} m from Earth, the angle subtended by Vesta to an observer on Earth is about 3×10^{-6} radian.

[2 marks]

1 (b) Observations of Vesta have been made by the Infrared Telescope Facility (IRTF) in Hawaii.

1 (b) (i) Draw a ray diagram for a Cassegrain telescope.

[2 marks]

1 (b) (ii) The IRTF includes a camera capable of detecting infrared radiation with wavelengths in the range $1.0\ \mu\text{m}$ to $5.0\ \mu\text{m}$.

The smallest angle the telescope can resolve is 3.3×10^{-7} radian.

Calculate the diameter of the objective of the telescope.
Give your answer to a suitable number of significant figures.

[2 marks]

diameter of objective = m

Question 1 continues on the next page

Turn over ►



- 1 (c)** Discuss the level of detail the IRTF would be able to detect on the surface of Vesta, when Vesta is 1.73×10^{11} m from Earth.

[2 marks]

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10



Turn over for the next question

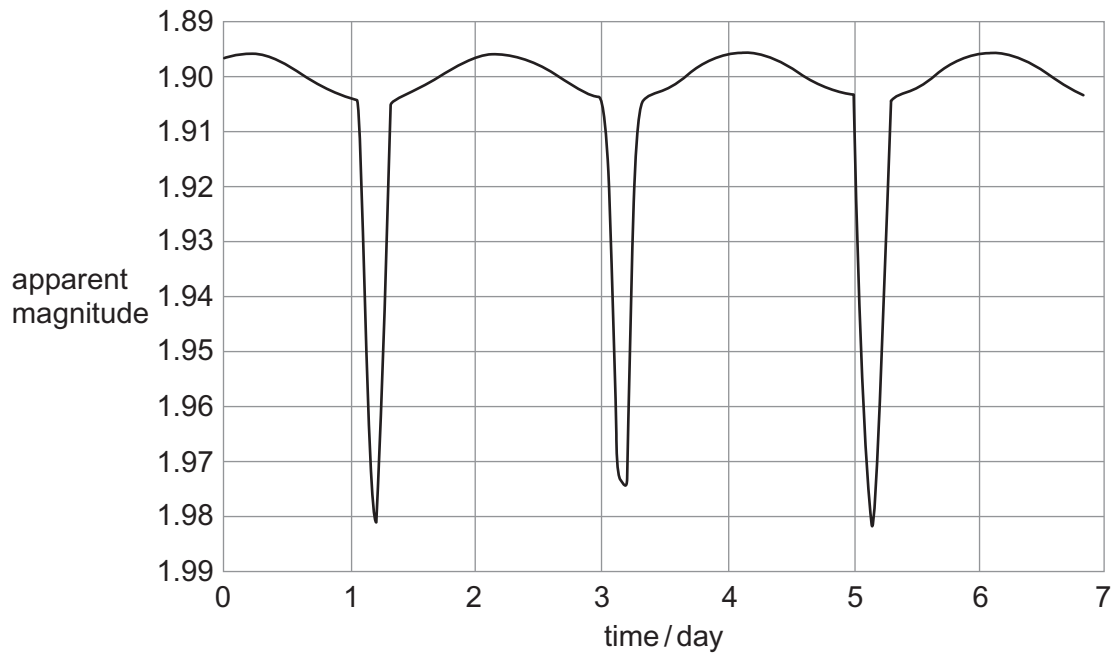
**DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED**

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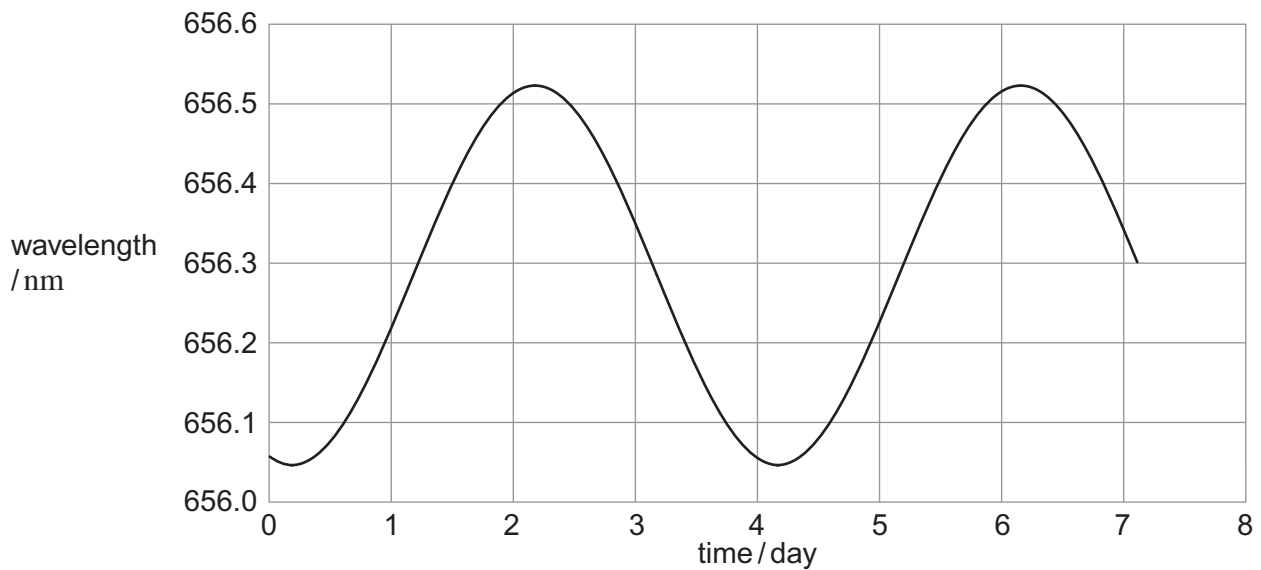
- 2 Menkalinan is an eclipsing binary star system in the constellation of Auriga. **Figure 1** shows the variation in apparent magnitude with time (light curve) for Menkalinan.

Figure 1



Analysis of the spectrum of one of the stars shows a periodic variation in wavelength. **Figure 2** shows the results for one of the spectral lines in the Hydrogen Balmer series. The wavelength for this line as measured for a source in a laboratory on the Earth is 656.28 nm.

Figure 2



The quality of your written communication will be assessed in your answer.

[illegible]

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2 (b) The black body temperature of each star is approximately 9200 K.

Explain why a Hydrogen Balmer line was chosen for the analysis of wavelength variation.

[2 marks]

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2 (c) The distance from the Earth to Menkalinan is 7.7×10^{17} m.

Calculate the value of the absolute magnitude of Menkalinan when it appears dimmest.

[3 marks]

absolute magnitude =

11

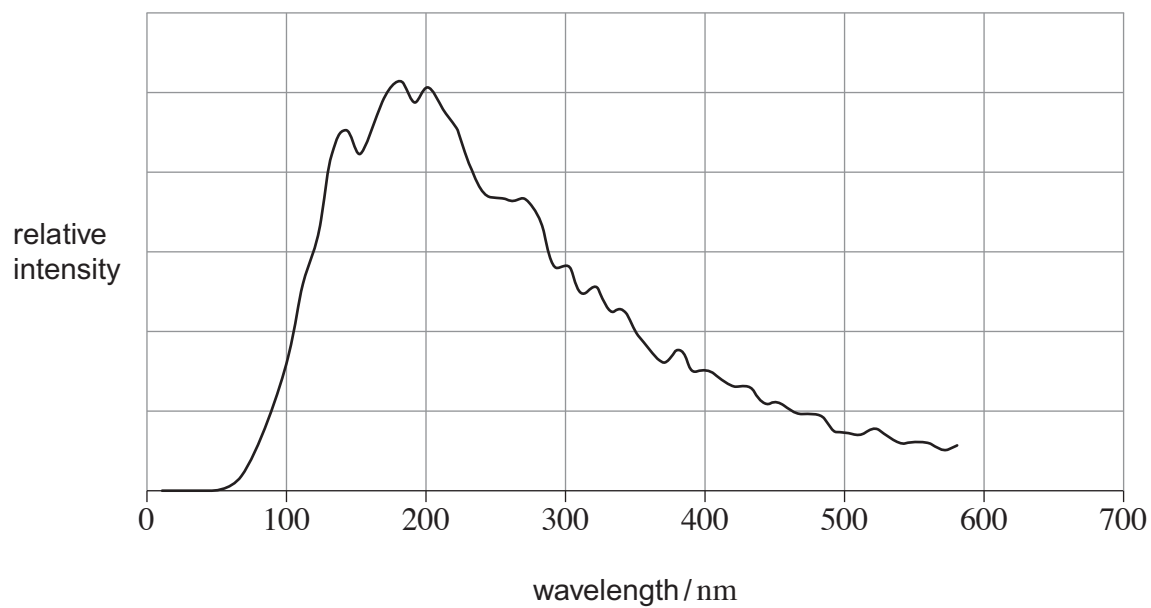
Turn over for the next question

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3 **Figure 3** shows the variation of intensity with wavelength for the star 40 Eridani B.

Figure 3



3 (a) (i) Calculate the black body temperature of 40 Eridani B.

State an appropriate unit for your answer.

[3 marks]

temperature = unit



3 (a) (ii) 40 Eridani B has a total power output of $4.2 \times 10^{24} \text{ W}$.

Calculate its radius.

[2 marks]

radius = m

3 (b) (i) Which of the following regions of the Hertzsprung-Russell diagram does 40 Eridani B belong to?

Tick (✓) the correct answer.

[1 mark]

main sequence	
dwarf star	
giant star	

3 (b) (ii) Give reasons for your answer to part (b)(i).

[2 marks]

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Turn over for the next question

Turn over ►



4 NGC 3842 is a galaxy which contains one of the biggest black holes ever discovered.

4 (a) State what is meant by a black hole.

[1 mark]

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4 (b) The mass of the black hole in NGC 3842 is believed to be 1.0×10^{10} times greater than that of the Sun.

Calculate the radius of its event horizon.

[2 marks]

radius = m

4 (c) NGC 3842 is 3.3×10^8 light years from the Earth, and is receding at a velocity of $6.3 \times 10^6 \text{ m s}^{-1}$.

Estimate, using these data, an age in seconds for the Universe.

[3 marks]

age of Universe = s

END OF QUESTIONS

