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 2010

Physics A PHYA5/2A

Unit 5A Astrophysics
Section B

Tuesday 29 June 2010 1.30 pm to 3.15 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

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.

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 marks. You are advised to spend approximately 50 minutes on this section.

1 (a) Draw a ray diagram for an astronomical refracting telescope in normal adjustment. Your diagram should show the paths of **three** non-axial rays through both lenses. Label the principal foci of the two lenses.

(3 marks)

1 (b) An early form of this telescope was built by Johannes Hevelius. It was 3.7 m long and had an angular magnification of 50. Hevelius used it to help produce one of the earliest maps of the Moon's surface.

1 (b) (i) Calculate the focal lengths of the objective lens and eyepiece lens in an astronomical telescope of length 3.7 m and angular magnification 50.

focal length of objective lens = ... m

focal length of eyepiece lens = ... m

(2 marks)

1 (b) (ii) The Triesnecker Crater on the Moon has a diameter of 23 km. Calculate the angle subtended by the image of this crater when viewed through a telescope of angular magnification 50 on the Earth.

distance from Earth to Moon = 3.8×10^5 km

angle = ... rad

(2 marks)

1 (c) Early refracting telescopes suffered significantly from chromatic aberration. Draw a diagram to show how a single converging lens produces chromatic aberration.

(2 marks)

9

Turn over for the next question

2 Sirius is a binary system consisting of two stars, Sirius A and Sirius B, the properties of which are summarised below.

	Sirius A	**Sirius B**
absolute magnitude	1.4	11.2
apparent magnitude	–1.4	8.4
diameter / 10^3 km	2400	12
black-body temperature / K	10 000	25 000

2 (a) Calculate the distance to Sirius, giving an appropriate unit.

distance = ...

(3 marks)

2 (b) (i) Calculate the ratio

$$\frac{\text{power output of Sirius A}}{\text{power output of Sirius B}}$$

ratio = ...

(2 marks)

2 (b) (ii) Show that data in the table suggests that one star is about 8000 times brighter than the other.

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(2 marks)

2 (b) (iii) With reference to the spectra of the two stars, explain why the value in part **b (ii)** is much greater than the answer to part **b (i)**.

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(3 marks)

10

Turn over for the next question

3 The Chandra X-ray Observatory was launched into orbit in 1999. It is used to observe hot and turbulent regions of space.

3 (a) Explain why X-ray telescopes need to be in orbit.

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(1 mark)

3 (b) In 2000, the Chandra telescope was used to observe a *black hole* in Ursa Major.

3 (b) (i) Explain what is meant by a black hole.

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(1 mark)

3 (b) (ii) The black hole is believed to have a mass 7 times that of the Sun. Calculate the radius of its event horizon.

mass of the Sun = 2.0×10^{30} kg

radius = ... m

(2 marks)

3 (c) Chandra makes use of a charge coupled device (CCD) to detect the X-ray photons. Describe the processes involved in the detection of photons by a CCD.

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(3 marks)

7

4 (a) In 1997 a type 1a *supernova* was observed which contributed to the controversial conclusion that the expansion of the Universe is accelerating.

Explain why observations of supernovae led to the conclusion that the Universe is expanding at an accelerating rate and discuss why this conclusion is controversial.

The quality of your written communication will be assessed in this question.

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(6 marks)

Question 4 continues on the next page

4 (b) Measurements of the shift in the 21 cm H1 line in the spectrum of galaxy M84 suggests that it is receding at a velocity of 900 km s^{-1}.

4 (b) (i) Calculate the value of the red shift, z, for this galaxy.

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z = ...
(1 mark)

4 (b) (ii) Calculate the distance to this galaxy.

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distance = ... Mpc
(2 marks)

9

END OF QUESTIONS