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 2011

Physics A PHYA5/2A

Unit 5A Astrophysics
Section B

Monday 27 June 2011 9.00 am to 10.45 am

For this paper you must have:
- a calculator
- a ruler
- 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.

Do not write outside the box

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 the ray diagram for a Cassegrain telescope. Your diagram should show the paths of two rays, initially parallel to the principal axis, as far as the eyepiece.

(2 marks)

1 (b) A telescope design very similar to the Cassegrain was first proposed by James Gregory in 1663. His telescope design was also the first to include a parabolic primary reflector.

1 (b) (i) The use of a parabolic reflector overcomes the problem of *spherical aberration*. Draw a ray diagram to show how spherical aberration is caused by a concave spherical mirror.

(1 mark)

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1 (b) (ii) The first telescope constructed to this design had a primary mirror of diameter 0.15 m. Calculate the minimum angular separation which could be resolved by this telescope when observing point sources of light of wavelength 630 nm. State an appropriate unit.

answer = ...

(2 marks)

1 (b) (iii) The astronomer Edmund Halley claimed to have used this telescope to observe the Cassini division, a dark band in the rings of Saturn. Calculate the angle subtended by the width of this band at the Earth, and comment on whether Halley's claim is likely to be valid.

width of Cassini division = 4.8×10^3 km

distance from Earth to Saturn = 1.4×10^9 km

answer = ...

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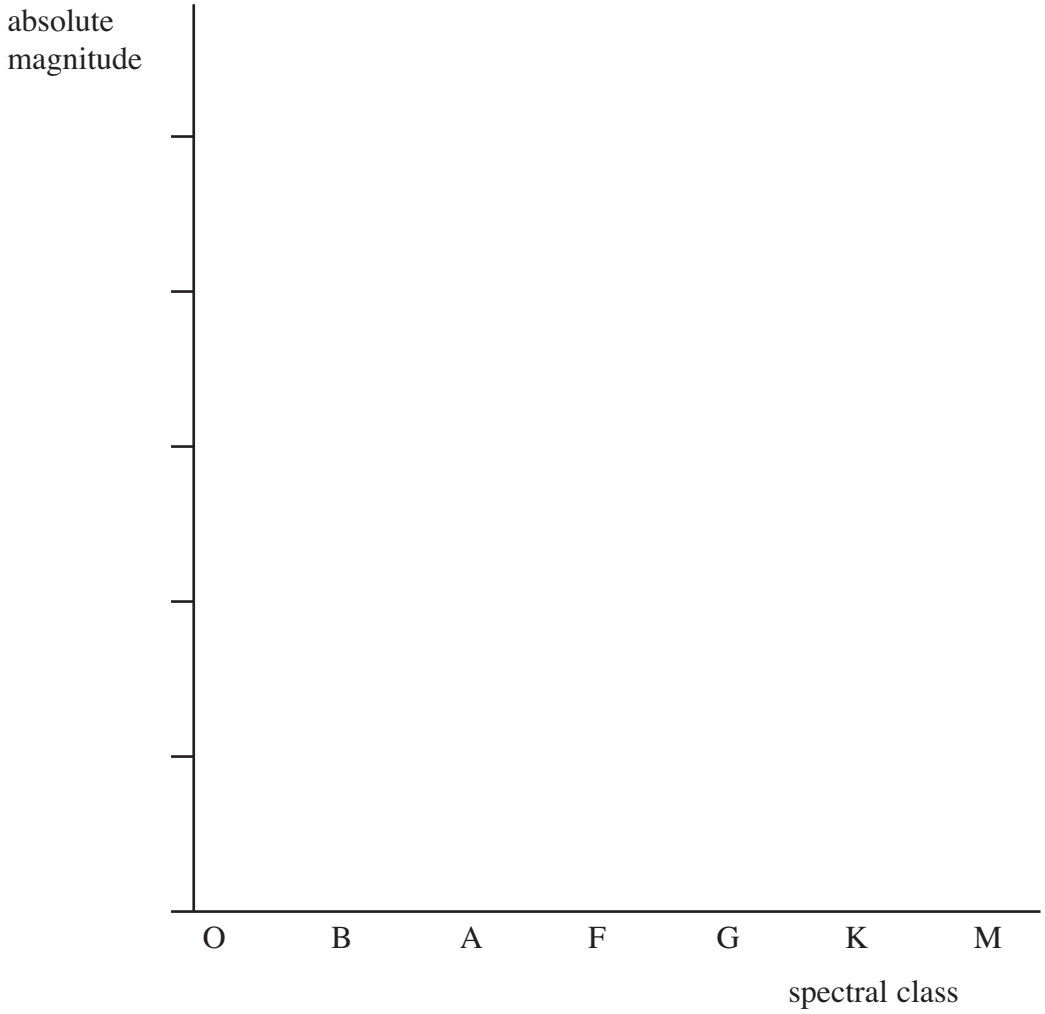
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(2 marks)

7

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2 (a) On the axes below draw the Hertzsprung-Russell (H-R) diagram, labelling the main sequence stars, giant stars and white dwarf stars. Complete the vertical axis by labelling a suitable absolute magnitude scale.



(3 marks)

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2 (b) Deneb is the brightest star in the constellation Cygnus.

2 (b) (i) The black-body radiation curve for Deneb shows a peak at a wavelength of 3.4×10^{-7} m. Calculate the black-body temperature of Deneb. Give your answer to an appropriate number of significant figures.

answer = ...K

(3 marks)

2 (b) (ii) The power output of Deneb is 70000 times greater than the Sun. Calculate the radius of Deneb.

surface temperature of the Sun = 5700 K

answer = ...m

(3 marks)

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2 (c) The spectrum of Deneb contains Hydrogen Balmer absorption lines. Describe how Hydrogen Balmer absorption lines are produced in the spectrum of a star.

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

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(6 marks)

15

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ANSWER IN THE SPACES PROVIDED

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3 The Antennae Galaxies are a pair of colliding galaxies in the constellation Corvus.

3 (a) Measurements of the *red shift* of radio signals from the galaxies suggest they are approximately 25 Mpc from the Earth.

3 (a) (i) Explain what is meant by red shift.

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(1 mark)

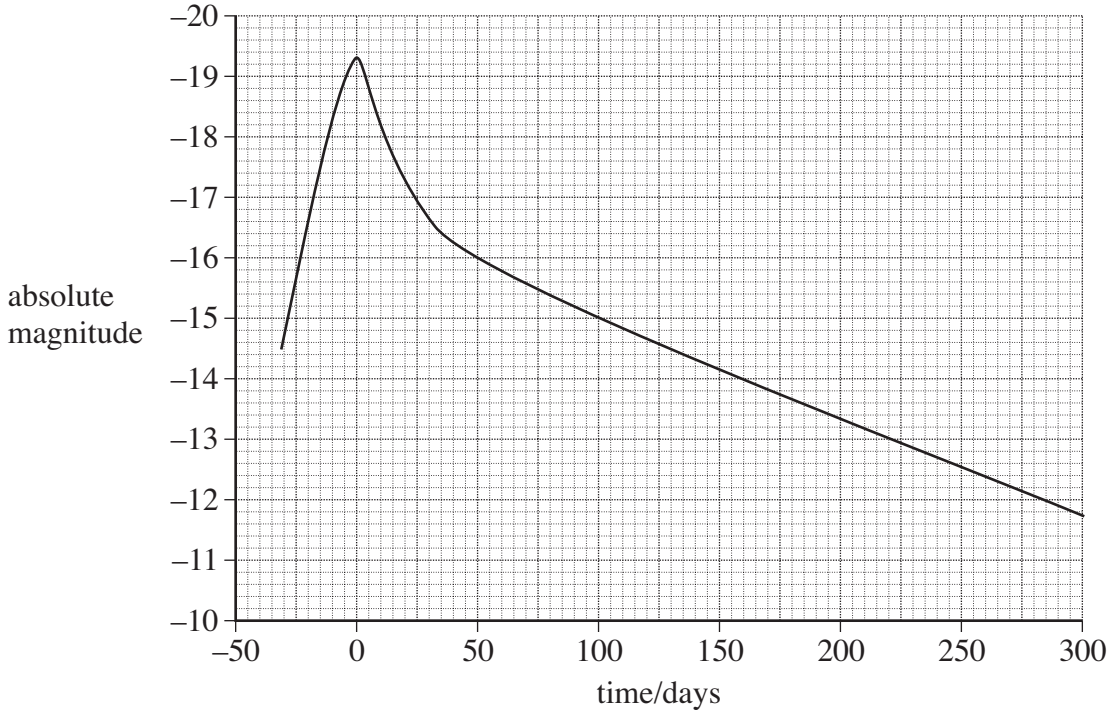
3 (a) (ii) Calculate the recessive velocity of the Antennae Galaxies.

answer = ...km s^{-1}

(2 marks)

3 (b) SN 2008sr was a type 1a supernova detected in the Antennae Galaxies. **Figure 1** is the light curve of a type 1a supernova.

Figure 1



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3 (b) (i) With reference to **Figure 1**, explain why type 1a supernovae can be used as standard candles to determine distances.

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(2 marks)

3 (b) (ii) The peak value for the apparent magnitude of this supernova was 12.9. Using this measurement and information from **Figure 1**, calculate the distance to the Antennae Galaxies in Mpc.

answer = ...Mpc

(2 marks)

3 (c) Why is it important for astronomers to have several independent methods of determining the distance to galaxies?

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(1 mark)

8

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4 Centaurus A is the nearest example of an active galactic nucleus. Many astronomers believe a supermassive black hole at the centre of such a galaxy produces a quasar as it consumes the material of its nearby stars.

4 (a) Explain what is meant by the event horizon of a black hole.

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(1 mark)

4 (b) (i) The mass of the black hole is 60 million times the mass of the Sun. Calculate the radius of its event horizon.

answer = ...m

(2 marks)

4 (b) (ii) Calculate the average density of the matter within its event horizon.

answer = ...kg m^{-3}

(2 marks)

END OF QUESTIONS

5

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