Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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10	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2013

Physics (B):Physics in Context PHYB1

Unit 1 Harmony and Structure in the Universe

Module 1 The World of Music
Module 2 From Quarks to Quasars

Friday 11 January 2013 1.30pm to 2.45pm

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

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen. Use pencil only for drawing.
- 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 paper is 70.
- 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.

Advice
- You are advised to spend about 20 minutes on **Section A** and about 55 minutes on **Section B**.

Section A

Answer **all** questions in this section.

There are 20 marks for this section.

1 A star may belong to one of the following classes:

O, B, A, F, G, K and M.

1 (a) State the class of star that has a surface temperature of more than 30 000 K.

....

(1 mark)

1 (b) State the colour of a class G star.

....

(1 mark)

2 The musical note, middle C, has a *frequency* of 260 Hz.

2 (a) Define the frequency of a musical note.

....

....

(1 mark)

2 (b) Calculate the frequency of the note two octaves lower than middle C.

frequency .... Hz

(2 marks)

Do not write outside the box

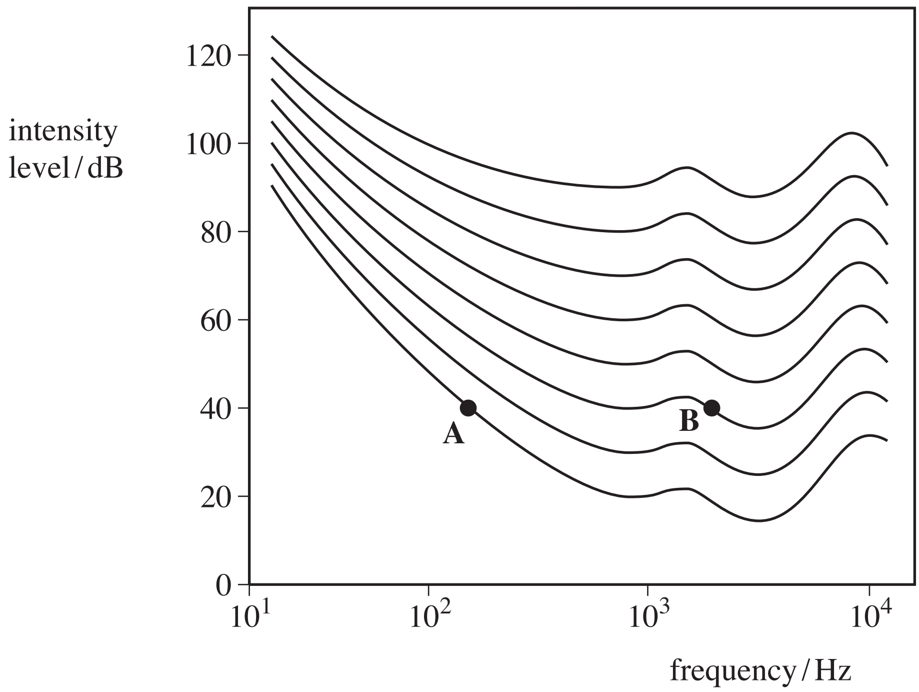
3 (a) State the range of frequencies detectable to a person with normal hearing.

lower limit .... Hz upper limit .... Hz

(1 mark)

3 (b) **Figure 1** shows a series of equal loudness curves for a person with normal hearing.

Figure 1



Sounds **A** and **B**, indicated in **Figure 1**, have the same intensity level of 40 dB. State and explain any difference in the loudness of the two sounds as perceived by a person with normal hearing.

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(2 marks)

Turn over ▶

Do not write outside the box

4 Mesons that contain a strange (or antistrange) quark are known as K-mesons or kaons. Mesons are a sub-group of a larger group of particles.

4 (a) (i) State the name of this larger group of particles.

....

(1 mark)

4 (a) (ii) Determine the charge on a kaon with a quark structure of $u\bar{s}$.

....

(1 mark)

4 (b) A proposed decay for this kaon is

$$u\bar{s} \longrightarrow \mu^{+} + \nu_{\mu}$$

4 (b) (i) Apply the law of conservation of strangeness to the proposed decay.

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....

....

(1 mark)

4 (b) (ii) Comment on whether or not this decay is possible.

....

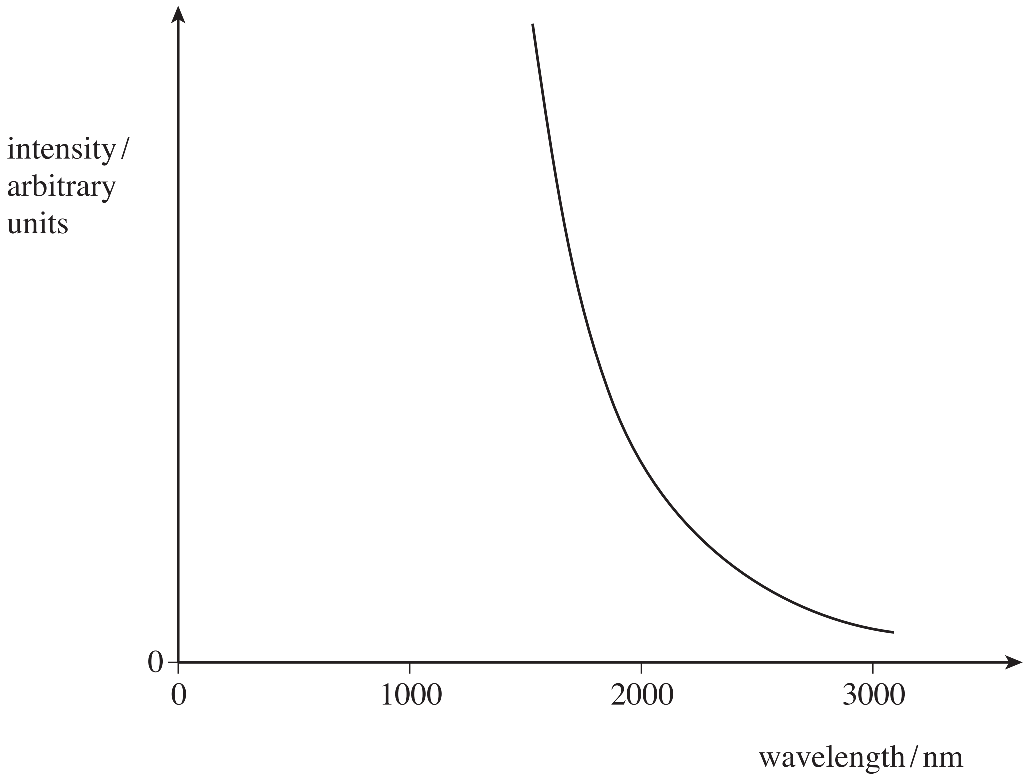
....

....

(1 mark)

5 **Figure 2** represents a theoretical relationship between the intensity and wavelength of emitted electromagnetic radiation for a black body. This theoretical relationship was proposed by scientists in the late nineteenth century.

Figure 2



5 (i) Experiments were carried out to test the theoretical relationship. The data collected did not fully support the theory. This was known as the ultraviolet catastrophe.
Show, by drawing on **Figure 2**, the relationship deduced from the experimental data.

(2 marks)

5 (ii) State the theory Planck proposed to resolve the ultraviolet catastrophe.

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(1 mark)

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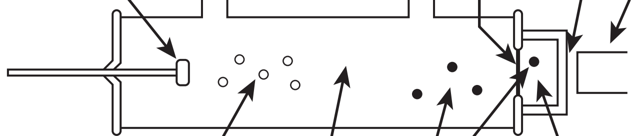
6 Rutherford bombarded nitrogen with alpha particles using the experimental arrangement shown in **Figure 3.**

Figure 3



The presence of a previously unknown particle **X** was detected using the fluorescent screen.

6 (i) Explain how Rutherford knew that a new particle was being detected using the fluorescent screen.

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(2 marks)

6 (ii) The nuclear equation below describes the bombardment of nitrogen with alpha particles. Complete the nuclear equation by adding the proton and nucleon numbers

$$^{\cdots}_{\cdots}\alpha \quad + \quad ^{14}_{7}N \longrightarrow \ ^{17}_{8}O \quad + \quad ^{\cdots}_{\cdots}X$$

(2 marks)

6 (iii) Identify particle **X**.

....

(1 mark)

20

Do not write outside the box

Section B

Answer **all** questions in this section.

There are 50 marks for this section.

7 (a) The Cosmic Background Explorer (COBE) satellite, launched in 1989, measured cosmic background radiation originating from an early stage in the Universe. The variation in intensity in this radiation shows a maximum value at a wavelength, λ_{max}, consistent with the emissions from a black body at a temperature of 2.7 K.

7 (a) (i) State the name of the region of the electromagnetic spectrum in which λ_{max} occurs for cosmic background radiation.

....
(1 mark)

7 (a) (ii) Calculate the wavelength, λ_{max}, at which the maximum intensity radiation is emitted by a black body at a temperature of 2.7 K.

wavelength .... m
(2 marks)

7 (a) (iii) Explain why cosmic background radiation of this wavelength is consistent with a hot, high-energy start to the Universe.

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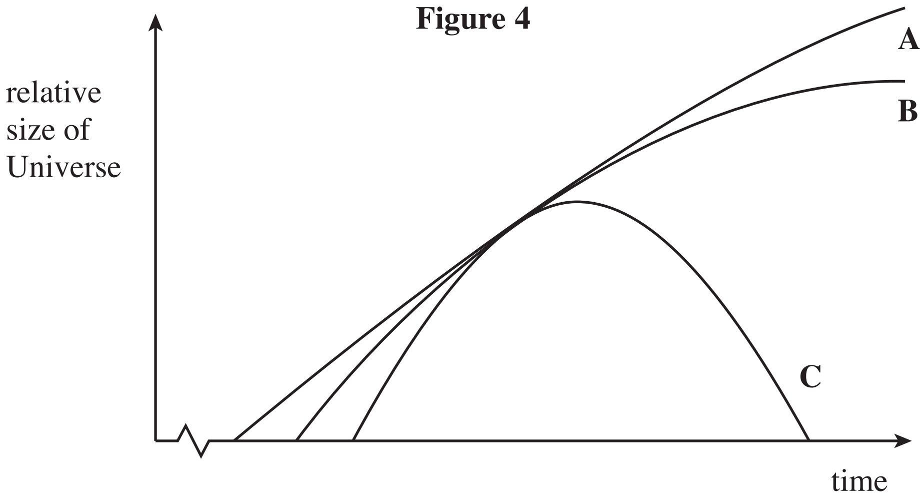
(3 marks)

Turn over ▶

7 (b) **Figure 4** illustrates the three possible fates of the Universe: **A**, **B**, and **C**.

Figure 4



7 (b) (i) On the time axis of **Figure 4**, mark with the letter **P** the position that corresponds to present time.

(1 mark)

7 (b) (ii) State the name of the model of the Universe illustrated by graph **C** in **Figure 4**.

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(1 mark)

Do not write outside the box

7 (b) (iii) Describe what is meant by *dark matter* and explain how the amount of dark matter in the Universe will contribute to determining the ultimate fate of the Universe.

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(3 marks)

7 (b) (iv) Describe how scientists have used their measurements of the mass in a galaxy and the orbital speeds of its stars to support the idea of the existence of dark matter.

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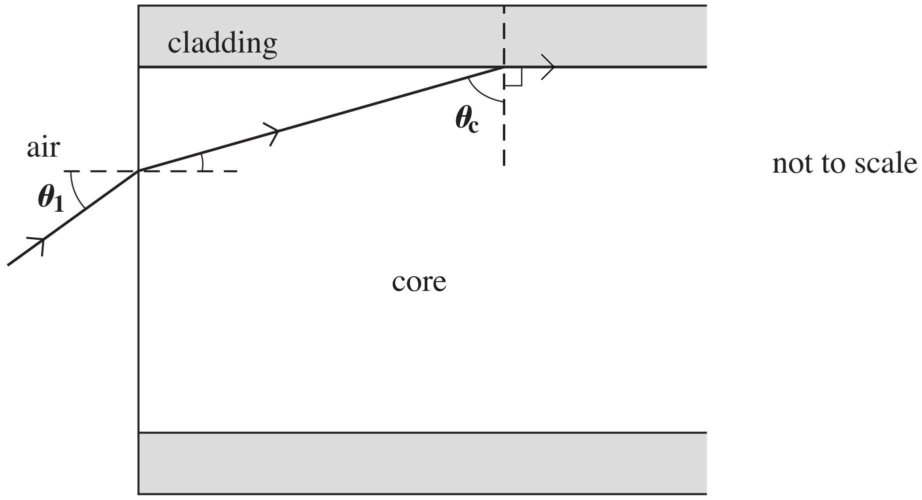
(2 marks)

13

Turn over for the next question

8 **Figure 5** shows a ray of light incident on an optical fibre at an angle of $\boldsymbol{\theta_1}$ and meeting the inner surface of the cladding at the critical angle, $\boldsymbol{\theta_c}$.

Figure 5



8 (a) (i) Calculate the refractive index of the cladding.

critical angle, $\boldsymbol{\theta_c}$ = 75.3°
refractive index of core = 1.52

refractive index of cladding ....

(2 marks)

Do not write outside the box

8 (a) (ii) Calculate the angle $\boldsymbol{\theta_1}$ at which a ray can enter the optical fibre from the air and meet the core-cladding boundary at the critical angle as shown in **Figure 5**.

refractive index of air = 1.00

angle ....degree

(3 marks)

8 (b) An engineer proposes to use another optical fibre with an identical core to the optical fibre in part (a) but with a cladding that has a refractive index closer to, but still less than, the refractive index of the core.

8 (b) (i) State and explain how the values of the critical angle $\boldsymbol{\theta_c}$ and the angle $\boldsymbol{\theta_1}$ for the optical fibre proposed by the engineer would compare to the values of $\boldsymbol{\theta_c}$ and $\boldsymbol{\theta_1}$ for the optical fibre in part (a).

$\boldsymbol{\theta_c}$ ....

....

$\boldsymbol{\theta_1}$ ....

....

(2 marks)

8 (b) (ii) State and explain the difference in the number of pulses per second that can be transmitted effectively in each fibre.

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(3 marks)

Turn over ▶

8 (c) In 1988 a consortium of telecommunication firms constructed the first transatlantic telephone cable to use optical fibres. The audio information was transmitted through the optical fibre using time division multiplexing (TDM).
Explain what is meant by time division multiplexing and go on to outline advantages of TDM.

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

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(6 marks)

16

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9 The wavelength of a line in the spectrum of hydrogen is 4.10×10^{-7} m when measured using a light source on Earth. When the light from a distant galaxy arrives at Earth the wavelength of this line in the hydrogen spectrum is observed to be 4.31×10^{-7} m.

9 (a) State the name of the effect that causes this observed change in wavelength.

....

(1 mark)

9 (b) Calculate the speed of the galaxy relative to the Earth.

speed of galaxy ....m s^{-1}

(3 marks)

9 (c) Calculate the distance between the galaxy and the Earth.
Give your answer in light years, ly.

Hubble constant = $65\,\text{km}\,\text{s}^{-1}\ \text{Mpc}^{-1}$

distance ....ly

(3 marks)

7

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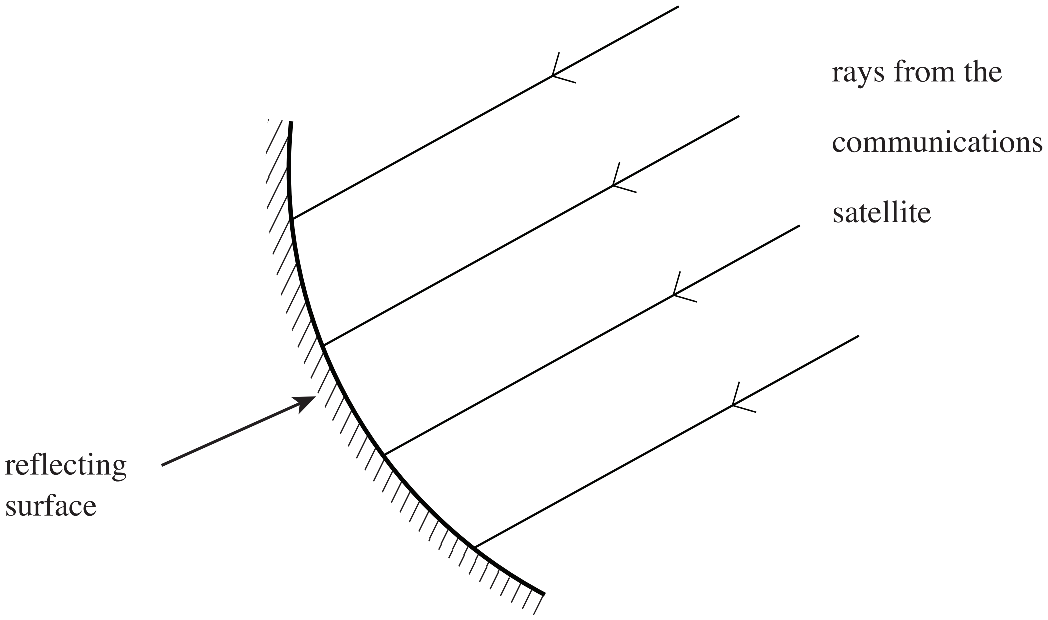
10 (a) **Figure 6** shows the reflecting surface of a dish used to receive television signals from a communications satellite.

Figure 6



10 (a) (i) Show on **Figure 6**, how the rays from the communications satellite reflect from the reflecting surface.

(1 mark)

10 (a) (ii) State and explain where the dipole should be placed in relation to the reflecting surface.

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(2 marks)

Do not write outside the box

10 (a) (iii) The maximum intensity of the signal incident on the dish is 2.0×10^{-8} W m^{-2}.
The circular aperture of the dish has a diameter of 0.50 m.

Calculate the maximum power collected by the dish.

maximum power ....W

(3 marks)

Question 10 continues on the next page

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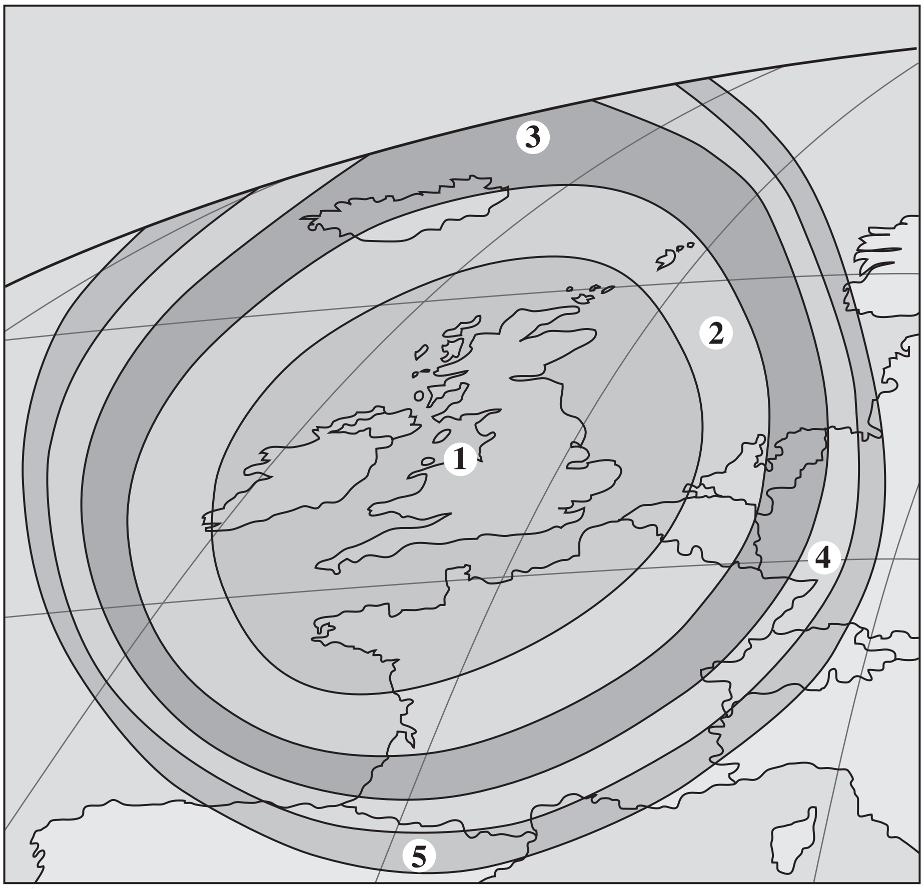
10 (b) The Astra 2D communications satellite is a geostationary satellite used to broadcast television signals to the British Isles. The footprint of the Astra 2D satellite is shown in **Figure 7**.

Figure 7



The table contains data on the diameter of satellite dish required in each region of the footprint to receive the minimum signal strength required for good television reception.

region of footprint	diameter of dish required / m
1	0.50
2	0.60
3	0.75
4	0.90
5	1.20

10 (b) Explain why the dish diameter required to receive the minimum signal strength in region **5** is greater than the dish diameter required in region **1**.

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(2 marks)

10 (c) Astra 2D transmits a signal frequency of 10.8 GHz. The diameter of its transmission dish is 2.10 m.
Calculate the angle subtended at the satellite between the centre of the signal's footprint and the position of its first minimum.

angle ....degree

(3 marks)

10 (d) State and explain how this satellite transmission system could be adjusted to allow more people across Europe to use a 0.50 m dish and receive adequate television reception.

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(3 marks)

14

END OF QUESTIONS

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