Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
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7	
8	
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TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2011

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

Tuesday 24 May 2011 9.00 am to 10.15 am

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

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 21 marks in this section.

1 (a) Give the name of a particle that is a hadron.

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(1 mark)

1 (b) Pions are mesons.
Give a possible quark structure for a pion.

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(1 mark)

2 A nuclide of manganese ($^{52}_{25}$ Mn) undergoes beta$^+$ decay to form a nuclide of chromium (Cr).

2 (a) Complete the equation for this decay process.

$$^{52}_{25}\mathrm{Mn} \rightarrow {}^{\cdots\cdots}_{24}\mathrm{Cr} + {}^{\cdots\cdots}_{\cdots\cdots}\beta^+ + {}^{\cdots\cdots}_{\cdots\cdots}$$

(2 marks)

2 (b) State the name of the exchange particle involved in this beta+ decay.

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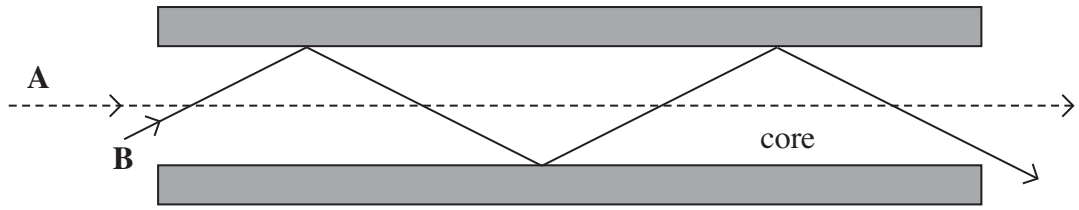
(1 mark)

3 **Figure 1** shows two rays of light **A** and **B** travelling through a straight optical fibre.

Figure 1



3 (a) Calculate the speed of light in the core of the optical fibre.

absolute refractive index of the core of the optical fibre = 1.6

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speed of light in the core ..... $m\,s^{-1}$

(2 marks)

3 (b) The overall length of the optical fibre is 0.80 km. As shown in **Figure 1**, ray **A** travels down the centre of the core of the optical fibre. The path of ray **B** has an overall length of 0.92 km as it travels through the core.

3 (b) (i) Ray **A** and ray **B** enter the fibre at the same instant.
Calculate the difference in time taken for ray **A** and ray **B** to travel through the core of the optical fibre.

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time difference ..... s

(2 marks)

Question 3 continues on the next page

3 (b) (ii) Explain how a graded-index optical fibre prevents this time difference occurring for rays such as **A** and **B** in **Figure 1**.

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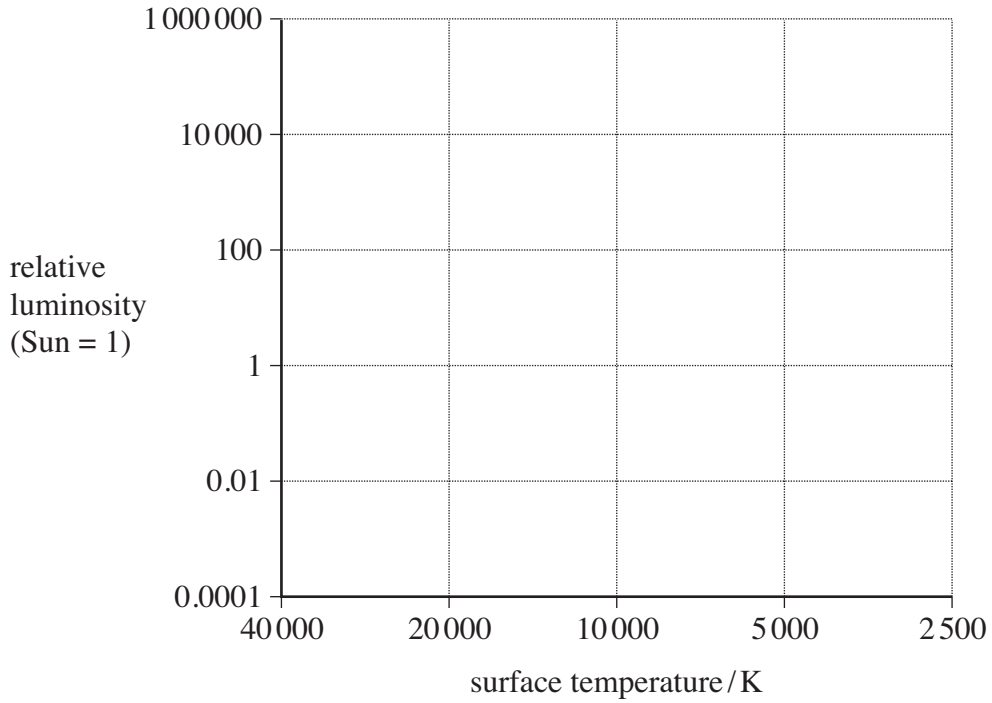
(2 marks)

4 **Figure 2** shows the grid for a Hertzsprung–Russell diagram.

Figure 2



4 (a) (i) On **Figure 2** mark the position of the Sun, label this S.

(1 mark)

4 (a) (ii) On **Figure 2** draw a line to indicate the position of the main sequence stars, label this M.

(1 mark)

4 (a) (iii) On **Figure 2** mark the position of an O-type star on the surface temperature axis, label this O.

(1 mark)

4 (b) In the future, the Sun is expected to change from a yellow dwarf star and to leave the main sequence.
State the next star type that the Sun is expected to become as it leaves the main sequence.

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(1 mark)

Turn over ▶

5 A girl is just able to hear sound from a point source when its intensity is $1.0 \times 10^{-12}\,W\,m^{-2}$.

5 (a) The girl is 455 m away from this point source of sound when she can just hear it.
Calculate the power of the sound emitted by the point source.
Give your answer to an appropriate number of significant figures.

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power of the sound ..... W

(3 marks)

5 (b) The girl's father cannot hear the sound until its intensity is $1.0 \times 10^{-6}\,W\,m^{-2}$.

5 (b) (i) Calculate the ratio

$$\frac{\text{amplitude of the sound wave just heard by the girl}}{\text{amplitude of the sound wave just heard by the father}}$$

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ratio .....

(2 marks)

5 (b) (ii) With age, the father's hearing has become less sensitive to loudness.
State **one** other change that will occur to the father's hearing as he ages.

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(1 mark)

21

Section B

Answer **all** questions in this section.

There are 49 marks in this section.

6 Two gamma rays may convert into a positron and an electron under certain circumstances.

6 (a) State the name of this process.

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(1 mark)

6 (b) (i) Explain why there is a minimum energy for this conversion to occur.

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(2 marks)

6 (b) (ii) In the production of the electron-positron pair, suggest what happens to the excess energy if the total gamma-ray energy is higher than the minimum value.

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(1 mark)

6 (c) Under different circumstances, particles other than a positron and an electron can be produced from two gamma rays.

State the names of **two** other particles that can be produced this way.

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(1 mark)

5

7 (a) Describe how a stationary wave is created on a stretched string.

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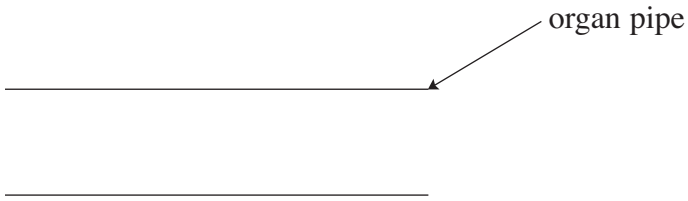
(2 marks)

7 (b) An organ pipe, open at both ends, is sounding its fundamental frequency (first harmonic).

7 (b) (i) Draw a diagram to show the stationary wave for the fundamental frequency (first harmonic) in the organ pipe.
Label the positions of any nodes (N) and antinodes (A).



(2 marks)

7 (b) (ii) One end of the organ pipe is closed to check its operation. The length of the organ pipe does not change.
State and explain the change in the fundamental frequency (first harmonic) emitted by the organ pipe when one end is closed.

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(2 marks)

7 (b) (iii) State which harmonics are missing in the organ pipe when one end is closed.

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(1 mark)

7 (c) The frequency of middle C on a piano is tuned to 262 Hz. The mass per unit length of a piano middle C string is 8.8×10^{-3} kg m^{-1} and it has a sounding length of 0.64 m.

Calculate the tension in the piano string.

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tension in the piano string ..... N

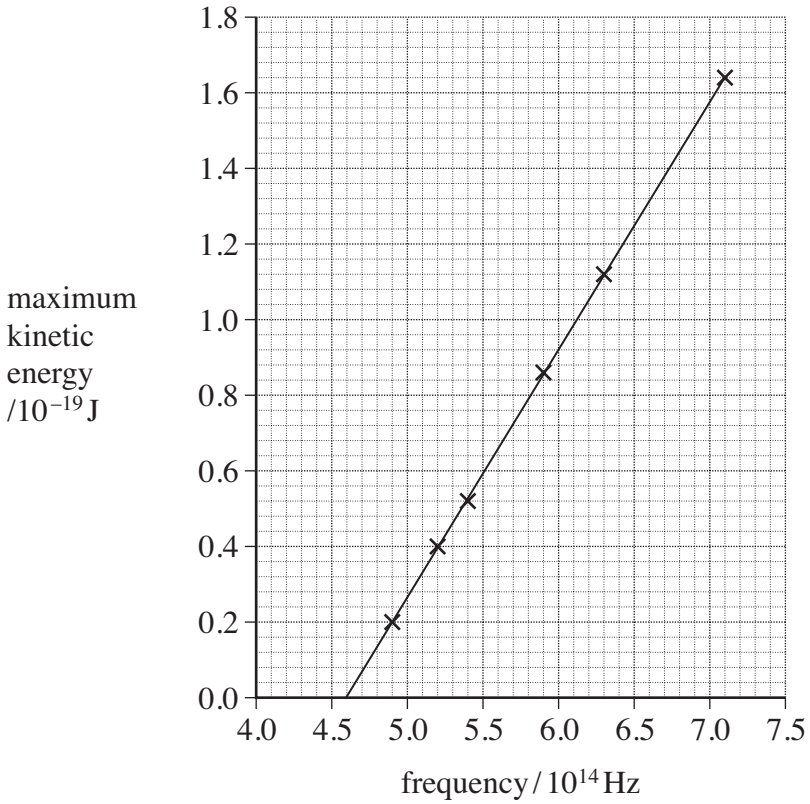
(3 marks)

10

Turn over for the next question

8 Light is incident on a metal surface in a vacuum. Electrons are ejected from the metal surface and the maximum kinetic energy of the ejected electrons is measured. **Figure 3** shows how the maximum kinetic energy of the ejected electrons varies with the frequency of the light incident on the metal surface.

Figure 3



8 (a) (i) Use **Figure 3** to show that the value of the Planck constant is approximately 7×10^{-34} J s.

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(3 marks)

8 (a) (ii) Use data from **Figure 3** to calculate the work function of the metal.

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work function .....J

(3 marks)

Question 8 continues on the next page

8 (b) **Figure 3** suggests that no electrons are ejected from the metal surface by light that has a frequency below a certain value.

Describe how Einstein's explanation of the photoelectric theory accounts for this.

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

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(6 marks)

12

Turn over for the next question

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9 (a) Explain what is meant by the luminosity of a star.

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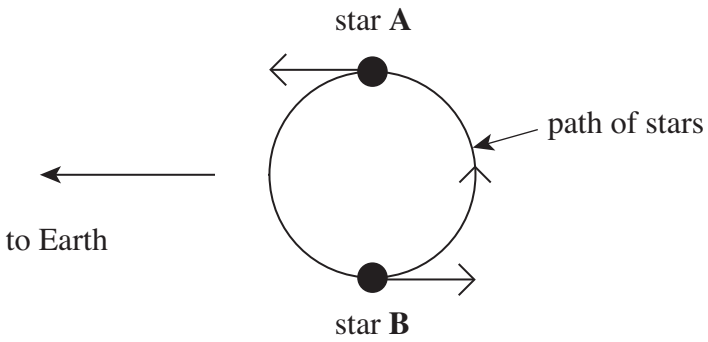
(1 mark)

9 (b) **Figure 4** shows a binary star system in which two stars of the same mass orbit their centre of mass. The Earth lies in the plane of orbit of the binary star system. The stars orbit at a constant orbital speed.

Figure 4



At the instant shown in **Figure 4**, star **A** has an apparent magnitude of 3.2 and star **B** has an apparent magnitude of 5.8.

State and explain which star radiates the most energy every second.

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(3 marks)

9 (c) The wavelength of a spectral line in the emission spectrum of star **A** is known to have a wavelength of 651.5 nm. When the light emitted by star **A** is observed on Earth, the wavelength of the spectral line varies between 651.3 nm and 651.7 nm.

9 (c) (i) Explain why the observed wavelength varies in this way.

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(3 marks)

9 (c) (ii) Calculate the orbital speed of star **A**.

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orbital speed ..... $m\,s^{-1}$

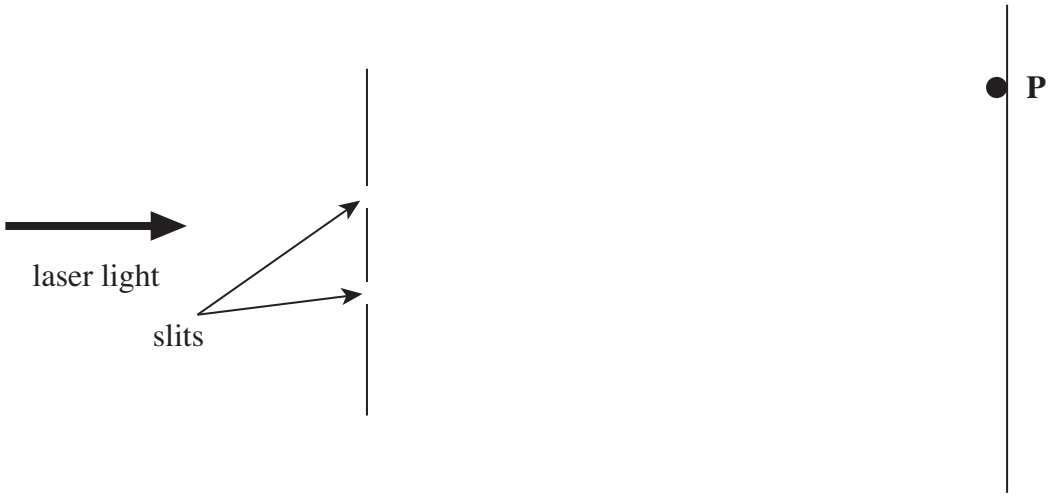
(3 marks)

10

10 (a) **Figure 5** shows a laser illuminating two slits leading to an interference pattern on a screen. A bright fringe is observed at **P**.

Use **Figure 5** to explain how the path difference between light from the two slits can lead to a bright fringe at **P**.
You may draw on the diagram to help your answer.

Figure 5



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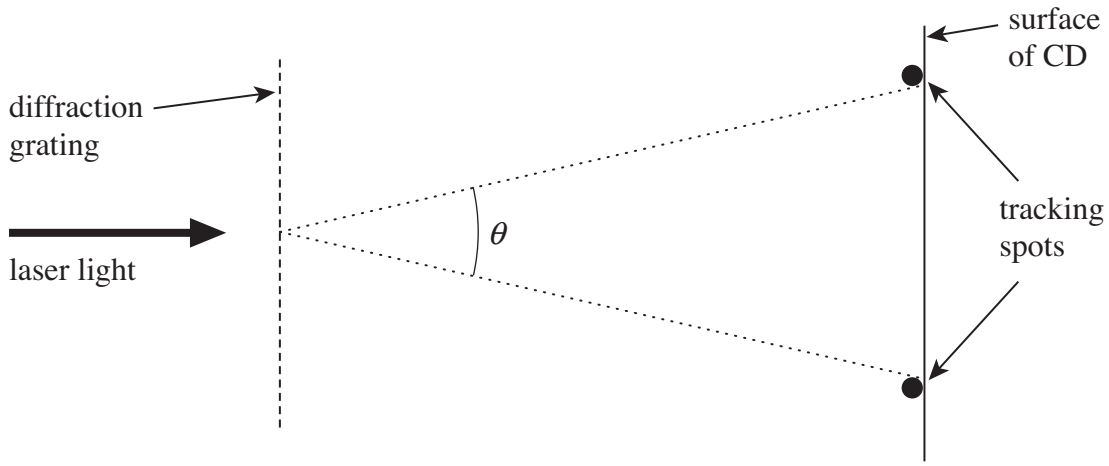
(3 marks)

10 (b) As part of the tracking system in a CD player a diffraction grating is used to produce tracking spots on each side of the CD track. The spots are first-order diffraction maxima. Laser light is used in this system.

Figure 6 shows sections of the diffraction grating and the surface of the CD.

Figure 6



The wavelength of the laser light in the tracking system is 780 nm. The angle θ between the tracking spots (shown on **Figure 6**) is 1.9°.
Calculate the required grating spacing of the diffraction grating.

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grating spacing ..... m

(3 marks)

10 (c) Suggest why the tracking system needed to read a DVD must read to a higher precision than that used to read a CD.

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(2 marks)

Question 10 continues on the next page

10 (d) In digital audio and video technology, compression techniques are used.

10 (d) (i) Name and explain **one** type of compression technique.

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(2 marks)

10 (d) (ii) State **two** advantages for consumers of the use of the compression technique.

advantage 1 .....

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advantage 2 .....

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(2 marks)

12

END OF QUESTIONS

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