Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
3	
4	
5	
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7	
8	
9	
10	
11	
12	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 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

Wednesday 12 January 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 for this section.

1 An electron has a speed of 8.4×10^5 m s^{-1}.

Calculate the de Broglie wavelength of this electron.

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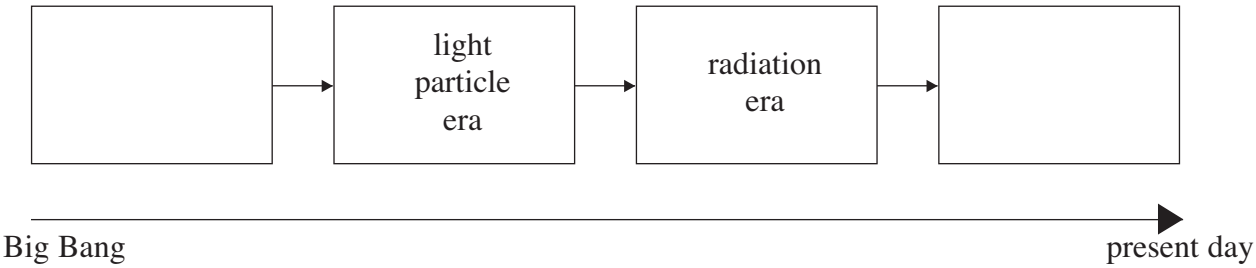
de Broglie wavelength ..... m

(2 marks)

2 In the development of the Universe since the Big Bang, a number of eras are thought to have occurred. The *radiation era* and the *light particle era* are two of these.

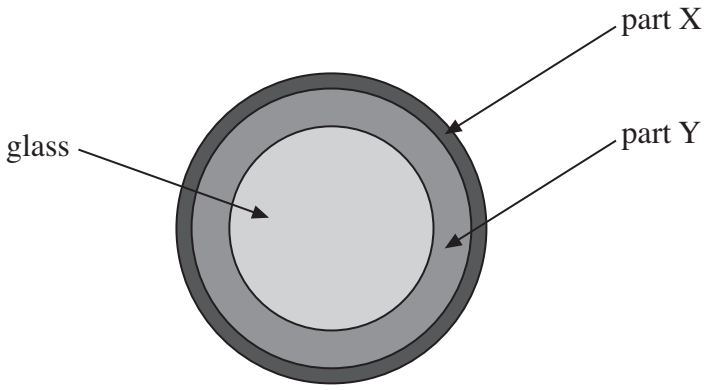
Complete the boxes below to give four eras in the order in which they occurred.



(2 marks)

3 **Figure 1** shows a cross-section through an optical fibre.

Figure 1



3 (a) Explain the purpose of part X.

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(1 mark)

3 (b) The critical angle for the optical fibre is to be 60° and the absolute refractive index for the glass in the core of the fibre is 1.6.
Calculate the required absolute refractive index for part Y.

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absolute refractive index for part Y .....

(3 marks)

3 (c) Explain why *dispersion* occurs in an optical fibre.

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(2 marks)

4 Describe the difference between the *apparent magnitude* and the *absolute magnitude* for a star.

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(3 marks)

5 State the type of interaction in which strangeness is

5 (i) conserved

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(1 mark)

5 (ii) not conserved.

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(1 mark)

6 (a) Label the boxes to show the analogue recording chain that a sound engineer will use to make a recording of the music produced by a rock band.

(2 marks)

6 (b) The sound engineer wishes to convert the analogue recording of the music into a digital file. The maximum frequency in the analogue recording of the music is 15 kHz.

Calculate the minimum sampling rate that the sound engineer must use.

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minimum sampling rate ..... kHz

(2 marks)

7 Explain the conclusions that astronomers have reached about the nature of galactic mass from their measurements of the orbital speeds of the stars in a galaxy.

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(2 marks)

21

Turn over for the next question

Section B

Answer **all** questions in this section.

There are 49 marks for this section.

8 During space missions to the Moon, radio signals to the SMART-1 spacecraft were sometimes transmitted by a satellite dish located in the UK.

8 (a) The satellite dish produced a footprint on the Moon's surface.

Use the data below to calculate the diameter of this footprint.

diameter of satellite dish = 35 m
average distance between the Earth's surface and the Moon's surface = 3.8×10^8 km
frequency of transmitted radio carrier wave = 8.5×10^9 Hz

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diameter of footprint ..... m

(4 marks)

8 (b) Explain why radio waves of frequency 600 kHz cannot be used for an Earth–Moon radio link.

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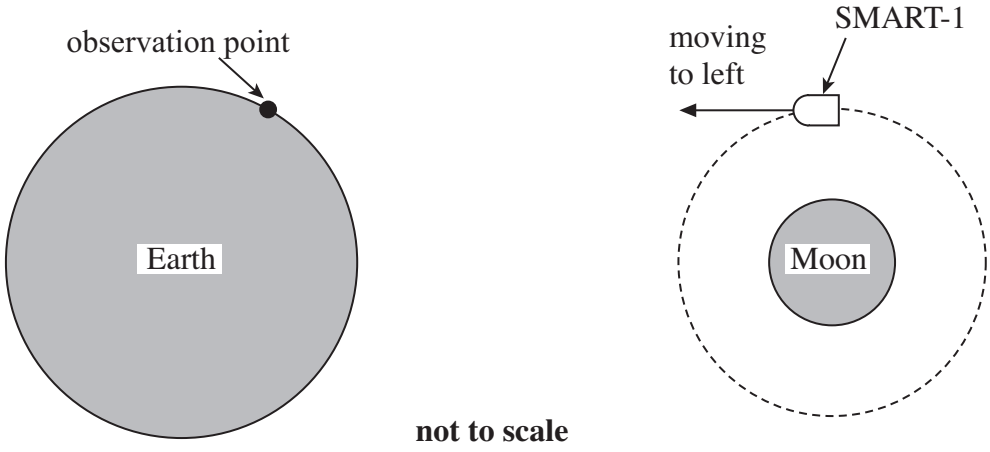
(2 marks)

8 (c) **Figure 2** shows that with SMART-1 orbiting the Moon, there is relative movement between SMART-1 and the Earth. SMART-1 transmits a radio carrier wave of frequency 3.400×10^{10} Hz back to the Earth.

Figure 2



not to scale

At the instant shown, the frequency of the radio carrier wave as observed from the Earth is shifted by 1.50×10^{5} Hz compared to the transmission frequency of 3.40×10^{10} Hz from SMART-1.

8 (c) (i) Explain how this effect arises.

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(2 marks)

8 (c) (ii) Calculate the speed of SMART-1 relative to the Earth at the instant shown in **Figure 2**. Give your answer to an appropriate number of significant figures.

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

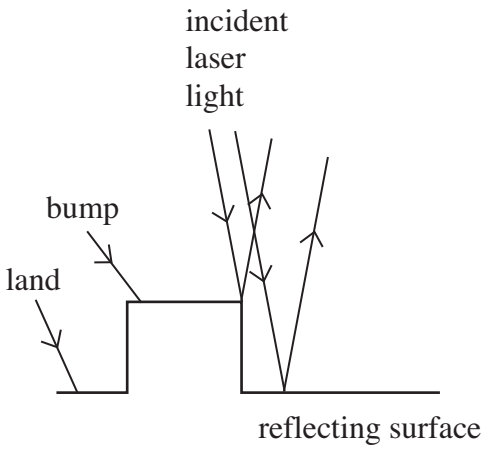
(4 marks)

12

9 **Figure 3** shows part of the profile of the track on a Compact Disc (CD). Laser light is incident normally (at an incident of 0°) on the CD. For clarity, **Figure 3**, shows the light incident at a small angle from the normal.

The two rays of laser light shown undergo reflections, one from the bump and the other from the land.
The two reflected rays are 180° out of phase and when they meet they interfere destructively and a zero is read.

Figure 3



9 (a) The minimum height difference between the bump and the land on the disc is 130 nm. Calculate the wavelength of the laser light when incident on the reflecting surface.

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wavelength ..... m

(2 marks)

9 (b) Reading a CD relies on the production of an observable interference pattern.
State **two** properties that the laser light must have in order to read the CD.

property 1 .....

property 2 .....

(2 marks)

9 (c) In the development of the Digital Versatile Disc (DVD) format, a number of changes were made to the CD format.

9 (c) (i) State **two** changes that were made to the CD format.

change 1 .....

.....

change 2 .....

.....

(2 marks)

9 (c) (ii) Discuss the improvement that these changes made for the user.

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(2 marks)

8

Turn over for the next question

10 In 1932, Chadwick produced neutrons by bombarding beryllium-9 ($^{9}_{4}\text{Be}$) with alpha particles.

10 (a) Complete the nuclear equation for this reaction

$$^{9}_{4}\text{Be} + \,^{\ }_{\ }\alpha \rightarrow \,^{\ }_{6}\text{C} + \,^{\ }_{\ }\text{n}$$

(3 marks)

10 (b) Some scientists initially thought that the neutrons Chadwick produced were a form of gamma radiation.

Describe the experiment that Chadwick carried out to show the existence of neutrons and go on to explain how he concluded that the new particles were neutrons.

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

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(6 marks)

10 (c) A neutron can decay in a reaction that produces a proton together with an electron and a third particle.

10 (c) (i) State the name of the third particle.

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(1 mark)

10 (c) (ii) State the class of particles to which the electron belongs.

.....

(1 mark)

10 (c) (iii) State the force that is responsible for the decay of the neutron.

.....

(1 mark)

12

Turn over for the next question

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11 (a) State what is meant by the *photoelectric effect*.

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(1 mark)

11 (b) Violet light of wavelength 380 nm is incident on a potassium surface.

11 (b) (i) Calculate the energy of a photon of this light.

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photon energy ..... J

(3 marks)

11 (b) (ii) Show that this photon can cause the photoelectric effect when incident on the potassium surface.

work function of potassium = 2.3 eV

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(2 marks)

11 (c) The potassium surface is now given a positive charge.
Explain why no photoelectric effect is observed.

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(2 marks)

8

12 **Figure 4** shows the apparatus used to determine the speed of sound in air. It consists of a balloon and two identical microphones, X and Y, connected to a computer via a data logger.

Figure 5 shows how the sound intensity at the microphones varies with time, just after the balloon was burst. The data logger was triggered by the arrival of the sound at microphone X.

Figure 4

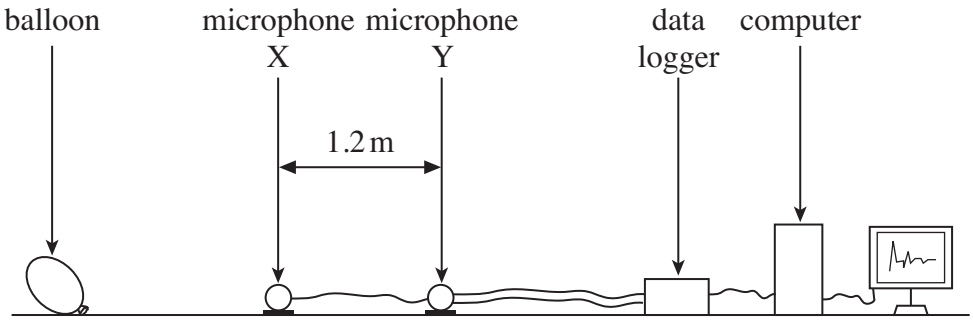

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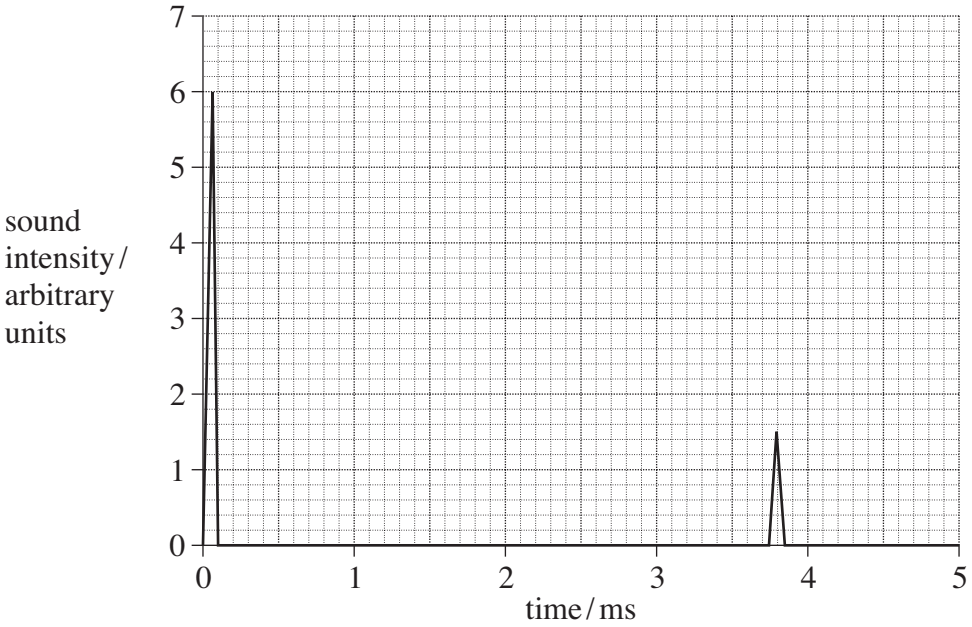
Figure 5



12 (a) X and Y are 1.2 m apart.
Using data from **Figure 5**, calculate the speed of sound in air.

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

(3 marks)

12 (b) (i) Use **Figure 5** to determine the sound intensity ratio

$$\frac{\text{sound intensity at microphone Y}}{\text{sound intensity at microphone X}}$$

sound intensity ratio .....

(2 marks)

12 (b) (ii) Estimate, in dB, the change in sound intensity level between microphone X and microphone Y.

change in sound intensity level ..... dB

(1 mark)

12 (b) (iii) Calculate the distance between the balloon and microphone X.

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distance between balloon and microphone X ..... m

(3 marks)

9

END OF QUESTIONS

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