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	
11	
TOTAL	

AQA

General Certificate of Education
Advanced Subsidiary Examination
June 2014

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 20 May 2014 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 (enclosed).

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 in this section.

1 The intensity of a sound at the threshold of hearing is $1.0 \times 10^{-12}\,\mathrm{W\,m^{-2}}$. This has a decibel value of $0\,\mathrm{dB}$.

1 (a) State what is meant by the threshold of hearing.

[1 mark]

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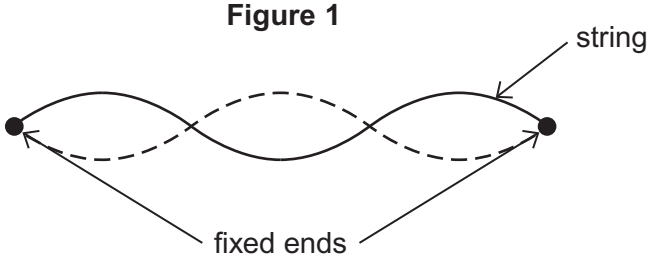
1 (b) A sound has a decibel value of $15\,\mathrm{dB}$. Calculate the intensity of this sound.

[3 marks]

intensity of sound ..... $\mathrm{W\,m^{-2}}$

2 **Figure 1** shows the third harmonic (second overtone) of a guitar string vibrating between two fixed ends. The length of the string is $0.645\,\mathrm{m}$. The frequency of this note is $1320\,\mathrm{Hz}$.

Figure 1



2 (a) Deduce the frequency of the fundamental (first harmonic) for this string.

[1 mark]

frequency ..... Hz

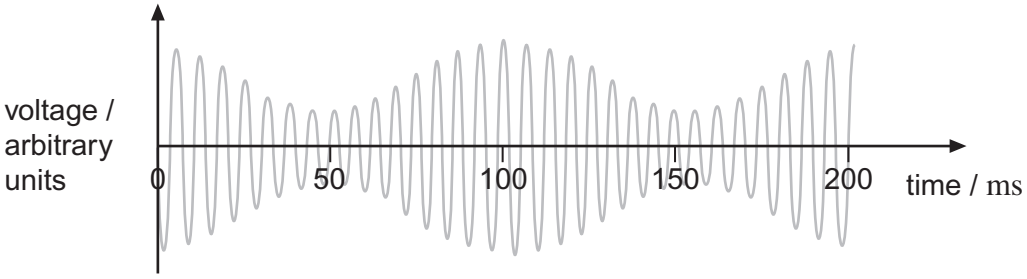
2 (b) Calculate the speed of the transverse wave along the string.

[3 marks]

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

3 **Figure 2** shows how the voltage generated in a radio receiving aerial varies with time when receiving a radio wave. The radio wave consists of a carrier wave that is amplitude modulated by a signal of fixed frequency.

Figure 2



3 (a) Calculate the frequency of the signal that modulates the carrier wave.

[2 marks]

frequency ..... Hz

3 (b) State an advantage of transmitting a signal using frequency modulation (FM) compared with using amplitude modulation (AM).

[1 mark]

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Turn over for the next question

4 Alpha particle scattering experiments carried out by Rutherford, Geiger and Marsden provided information about the structure of the atom. One conclusion established was that the atom is largely empty space.

4 (a) State **two** results of the experiment which suggested that this was the case.

[2 marks]

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4 (b) A hydrogen nucleus has a diameter of approximately $1.7 \times 10^{-15}\,\text{m}$ and a hydrogen atom has a diameter of approximately $1.1 \times 10^{-10}\,\text{m}$.

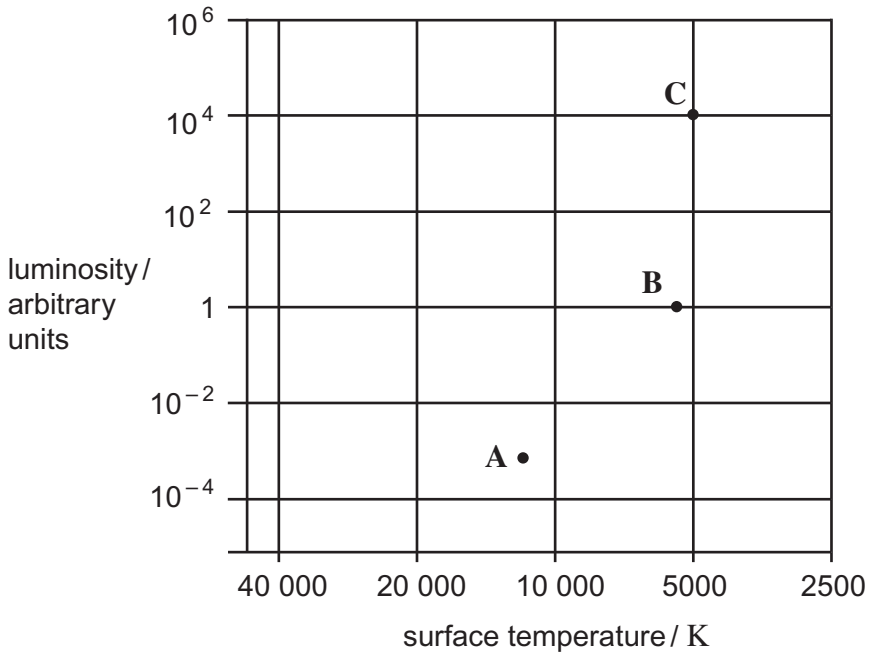
Calculate the ratio $\dfrac{\text{volume of hydrogen nucleus}}{\text{volume of hydrogen atom}}$

[3 marks]

ratio .....

5 **Figure 3** shows the grid used for a Hertzsprung-Russell diagram. The positions of three stars **A**, **B** and **C** are shown.

Figure 3



5 (a) Name a commonly used alternative label for the horizontal axis of a Hertzsprung-Russell diagram.

[1 mark]

.....

5 (b) Identify the star type of the stars **A**, **B** and **C**.

[3 marks]

A .....

B .....

C .....

20

Section B

Answer **all** questions in this section.

There are **50** marks in this section.

6 (a) Explain the difference between analogue and digital signals.

[1 mark]

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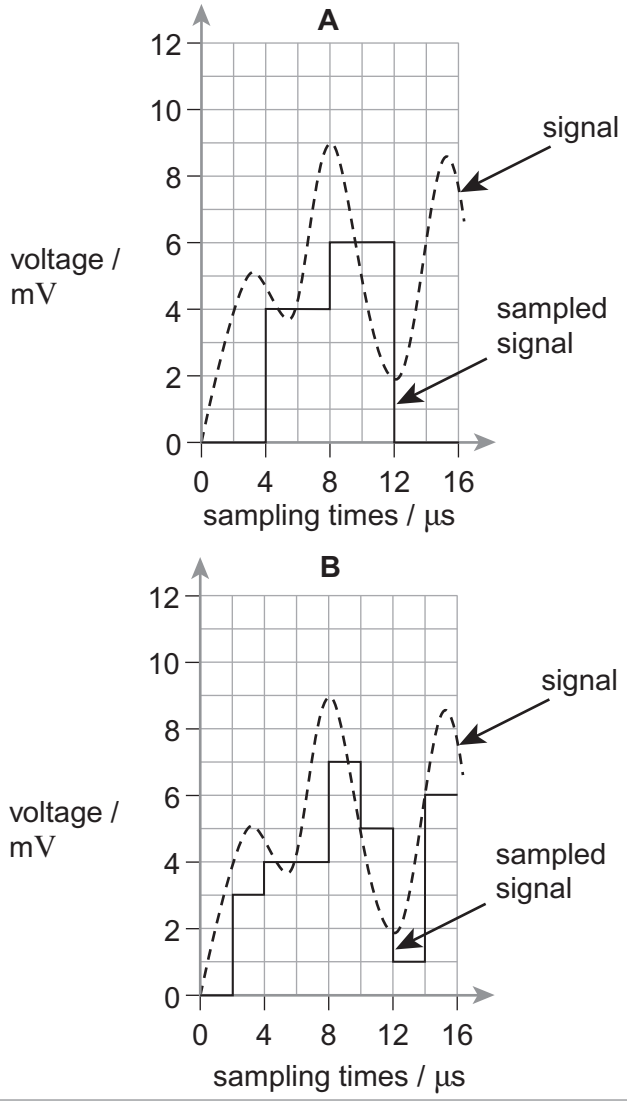
6 (b) **Figure 4** shows an analogue signal together with the sampled signal that results from sampling at different sampling rates and quantisation levels. **A** shows sampling at four levels (each separated by $2\,\text{mV}$) and taken at $4\,\mu\text{s}$ intervals. **B** shows sampling at eight levels (each separated by $1\,\text{mV}$) and at $2\,\mu\text{s}$ intervals.

Figure 4



6 (b) (i) Explain why the sampling used in **A** is described as 2-bit sampling while that used in **B** is described as 3-bit sampling.

[1 mark]

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6 (b) (ii) The next sample of each of **A** and **B** is taken at 16 μs.
State the sampled voltage at this time in each case.

[2 marks]

voltage in **A** ..... mV

voltage in **B** ..... mV

6 (b) (iii) State **one** advantage and **one** disadvantage of using a higher sampling frequency.

[2 marks]

Advantage .....

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Disadvantage .....

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Question 6 continues on the next page

6 (c) Digital audio and video data are commonly downloaded from websites. Explain why such information is transmitted using digital rather than analogue signals. Go on to discuss the factors which affect the quality of music that is regenerated and why MP3 and MP4 formats are commonly used.

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

[6 marks]

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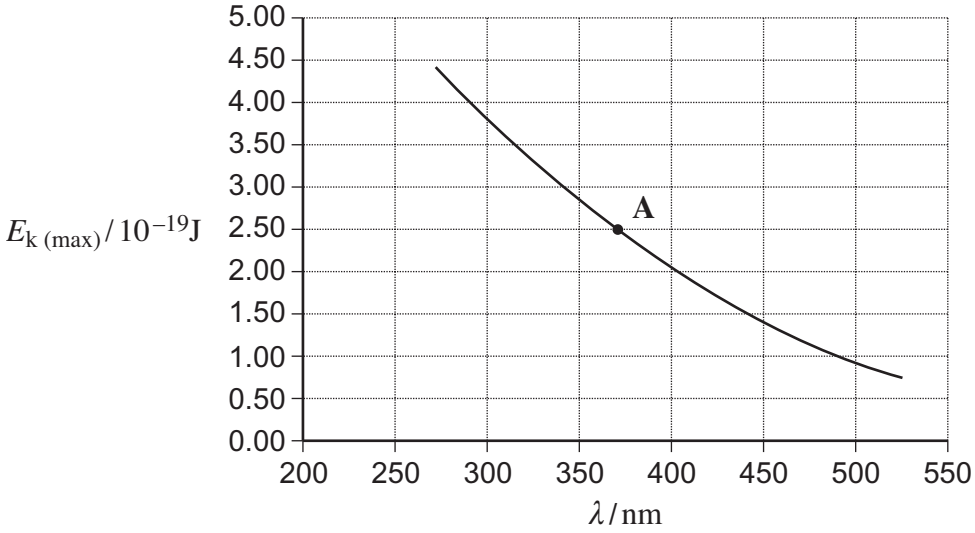
12

7 (a) Electromagnetic radiation of wavelength λ is incident on a metal surface in an evacuated container. **Figure 5** shows the variation of the maximum kinetic energy, $E_{k(max)}$, of the emitted electrons with λ for the metal surface.

Figure 5



Electrons are emitted with energies other than $E_{k(max)}$ for a given wavelength. Explain the origin of these electrons.

[2 marks]

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7 (b) Use point **A** on **Figure 5** to obtain a value for the work function of the metal.

[4 marks]

work function ..... J

6

8 **Figure 6** shows how the track on a compact disc (CD) spirals outwards from the centre. **Figure 7** shows a diffraction grating being used to produce three beams which enable the CD player to follow the track and read the data correctly. The central maximum beam must be centred on the pits and lands that make the track. The two first-order maxima must stay entirely on the land on either side of the track where they are reflected to a detector with equal intensity. The laser beam has a wavelength of $780\,\text{nm}$.

Figure 6

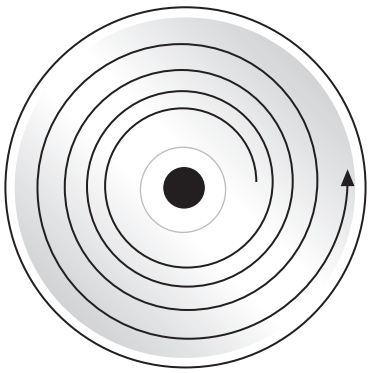
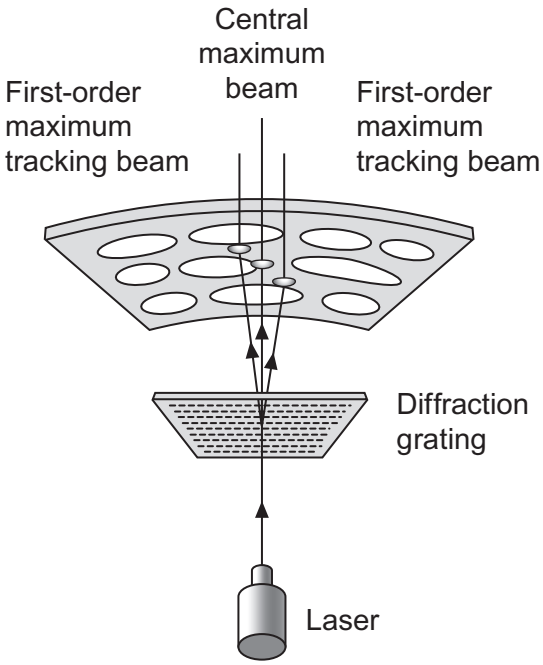


Figure 7



8 (a) Light of wavelength $780\,\text{nm}$ is incident on a diffraction grating having 40 lines per mm. Calculate the angle between the two first-order maxima.

[3 marks]

angle ..... degrees

8 (b) Explain why the pits should be $195\,\text{nm}$ deep.

[3 marks]

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8 (c) Explain how the reflected first-order beams ensure that the tracking is correct.

[2 marks]

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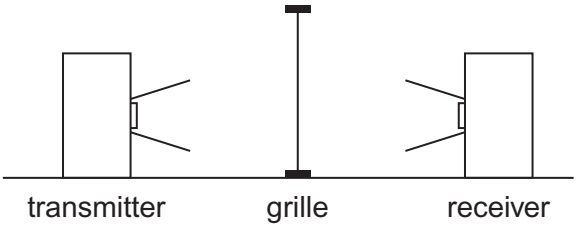
8

Turn over for the next question

9 **Figure 8** shows an experiment in which the electric field of the microwaves transmitted is vertically polarised. The microwaves are incident upon a metal grille consisting of parallel metal wires $1\,\text{cm}$ apart. The microwaves have a wavelength of approximately $3\,\text{cm}$. When the grille is in place the receiver detects no microwaves. When the grille is removed the receiver detects the maximum possible microwave signal for this separation of the transmitter and the receiver.

Figure 8



9 (a) State what is meant by polarisation.

[1 mark]

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9 (b) (i) Explain how the experiment indicates that the aerials in the transmitter and receiver are orientated so that they are aligned.

[1 mark]

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9 (b) (ii) State and explain the orientation of the wires in the grille in this experiment.

[3 marks]

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9 (c) Explain why it is **not** possible to polarise sound waves.

[2 marks]

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7

Turn over for the next question

10 (a) (i) State **one** similarity and **one** difference between a proton and an antiproton.

[2 marks]

Similarity .....

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Difference .....

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10 (a) (ii) Circle the correct quark structure of an antineutron.

[1 mark]

ddu $\bar{d}\bar{d}\bar{u}$ $\bar{d}\bar{u}$ $\bar{d}u$

10 (a) (iii) By analogy with the beta decay of a free neutron, suggest the decay products of a free antineutron.

[3 marks]

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10 (b) The delta ++ (Δ^{++}) particle is made up of three up quarks. It decays into a proton (p) and a positive pion (π^{+}).

10 (b) (i) What class of particle is Δ^{++}?

[1 mark]

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10 (b) (ii) Show that the decay $\Delta^{++} \rightarrow p + \pi^{+}$ obeys the laws of conservation of charge (Q), baryon number (B) and lepton number (L).

[3 marks]

Q:

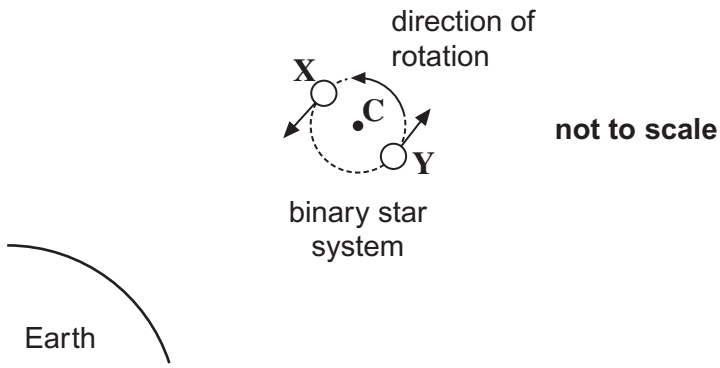
B:

L:

10

11 **Figure 9** shows the relative positions of the Earth and a binary star system. The binary star system is made up of two stars, **X** and **Y**, of equal mass which rotate about their common centre, **C**. The Earth is in the same plane as that in which the stars rotate.
A line in the spectrum emitted by the binary star system is seen to split periodically into two.

Figure 9



11 (a) Explain why the splitting occurs.

[2 marks]

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Turn over ▶

11 (b) One line with a wavelength of $654.6\,\text{nm}$ is seen to split into two lines having a minimum wavelength of $654.4\,\text{nm}$ and a maximum wavelength of $654.8\,\text{nm}$.
Assuming that **C** remains at a constant distance from the Earth, calculate in km s^{-1} the orbital speed of the stars.

[3 marks]

orbital speed ..... km s^{-1}

11 (c) The binary system is $27\,000\,\text{ly}$ from the Solar system.
Calculate its recessional speed in km s^{-1}.

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

[2 marks]

recessional speed ..... km s^{-1}

7

END OF QUESTIONS