Centre Number						Candidate Number				
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Other Names										
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For Examiner's Use	
Examiner's Initials	
Question	Mark
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TOTAL	

AQA

General Certificate of Education
Advanced Subsidiary Examination
June 2015

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 19 May 2015 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 scientific 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) Musical **concert pitch** has a frequency of 440 Hz.
A correctly tuned A-string on a guitar has a first harmonic (fundamental frequency) two octaves below concert pitch.

Determine the first harmonic of the correctly tuned A-string.

[1 mark]

frequency ..... Hz

1 (b) Describe how a note of frequency 440 Hz can be produced using the correctly tuned A-string of a guitar.

[1 mark]

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1 (c) Describe the effect heard when notes of frequency 440 Hz and 430 Hz of similar amplitude are sounded together.

[2 marks]

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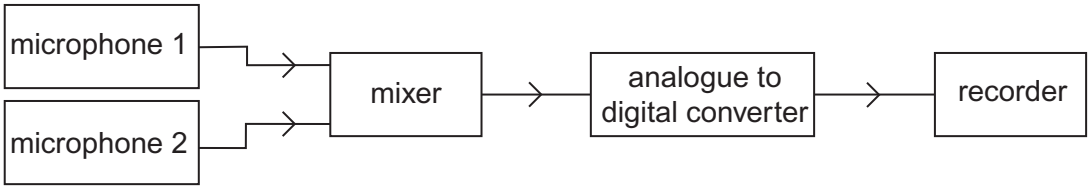
2 **Figure 1** shows a block diagram of an audio recording system.

Figure 1



2 (a) Explain the purpose of the mixer in this system.

[1 mark]

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2 (b) Suggest a type of recorder that may be used in this system.
Give **one** reason for your answer.

[2 marks]

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2 (c) Explain **one** advantage of including the analogue to digital converter in the system.

[2 marks]

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3 An optical fibre consists of a core, cladding and an outer sheath.

3 (a) State the purpose of the outer sheath in an optical fibre.

[1 mark]

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3 (b) For one fibre, the speed of monochromatic light in the core is 1.97×10^8 m s^{-1} and the speed in the cladding is 2.03×10^8 m s^{-1}.

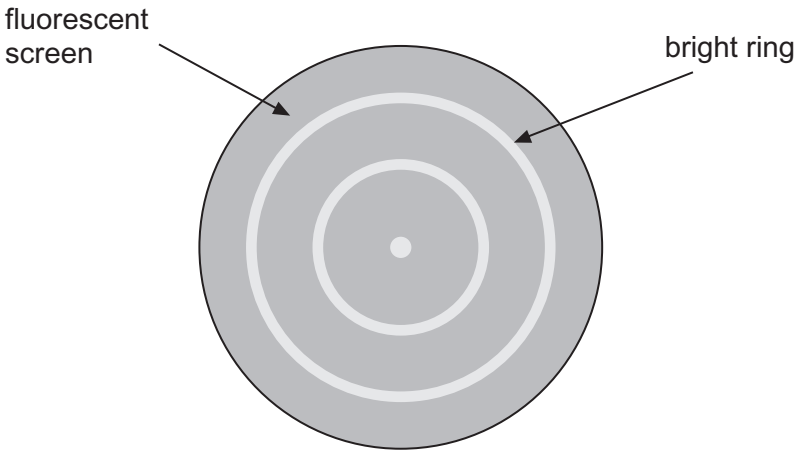
Calculate the critical angle for this light at the interface between the core and the cladding.

[2 marks]

critical angle ..... degrees

4 In an electron diffraction tube, high speed electrons are produced by an electron gun at one end of the tube. The electrons are incident on a thin slice of a polycrystalline material.
Figure 2 shows the pattern of bright rings that is formed on the fluorescent screen at the other end of the tube.

Figure 2



4 (a) Explain how the production of bright rings suggests that the electrons behave like waves.

[1 mark]

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4 (b) The electrons in the tube have a velocity of 3.5×10^7 m s^{-1}.

Calculate the de Broglie wavelength of the electrons.

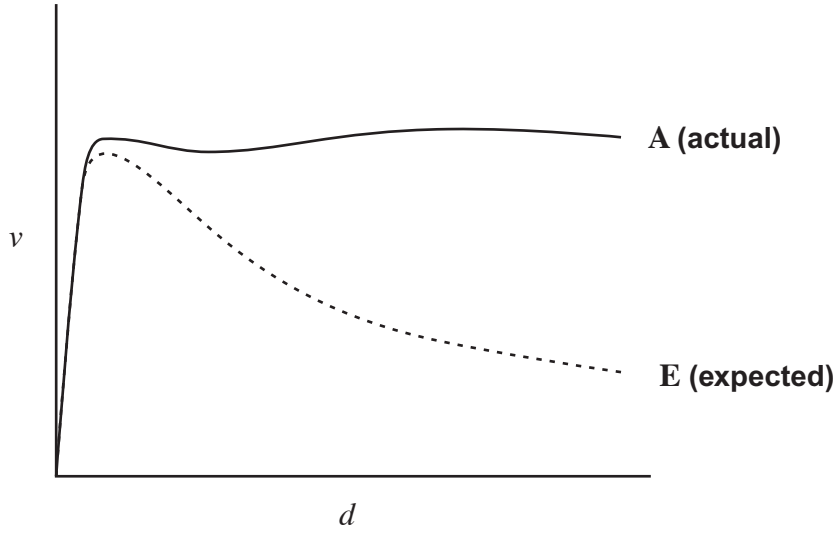
[2 marks]

de Broglie wavelength ..... m

Turn over ▶

5 Line **E** on **Figure 3** shows the **expected** relationship between the orbital velocity v of the stars in a spiral galaxy and the distance d of each star from the centre of the galaxy. Line **A** shows how the **actual** velocities vary with distance.

Figure 3



Explain what is thought to cause the difference between the two curves **A** and **E**.

[2 marks]

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6 Observations of the H-α line in the spectrum of a star indicate the presence of hydrogen. The H-α line has a wavelength of $656\ \text{nm}$ and is produced by a transition of electrons into the $-3.4\ \text{eV}$ energy level.

Calculate the energy level that the electron moves from when emitting a photon corresponding to a wavelength of $656\ \text{nm}$.
Give your answer in J.

[4 marks]

energy level ..... J

21

Turn over for the next question

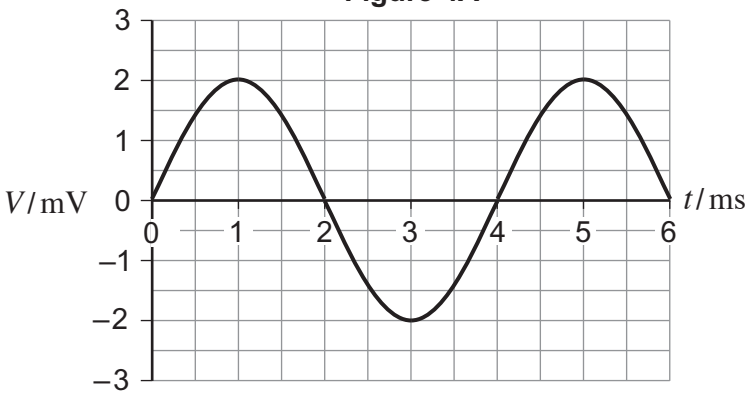
Section B

Answer **all** questions in this section.

There are **49** marks in this section.

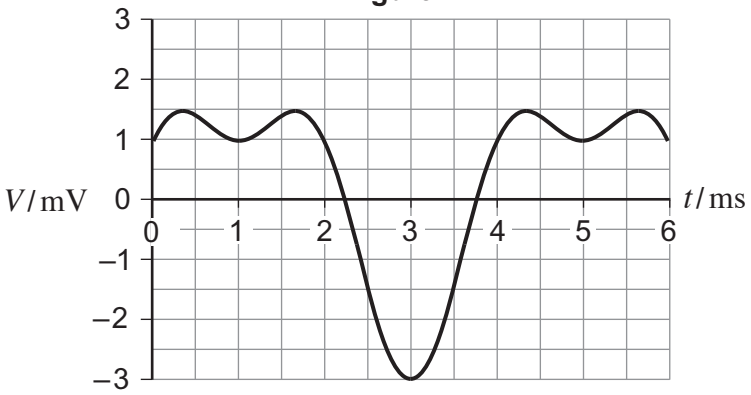
7 (a) A signal generator and loudspeaker produce a sound wave $\mathbf{W_1}$. A second similar system produces a sound wave $\mathbf{W_2}$.
Figure 4A shows the variation with time t of the voltage V generated by a microphone receiving $\mathbf{W_1}$.
Figure 4B shows the variation with time of the voltage generated by the microphone receiving the combination of $\mathbf{W_1}$ and $\mathbf{W_2}$.

Figure 4A



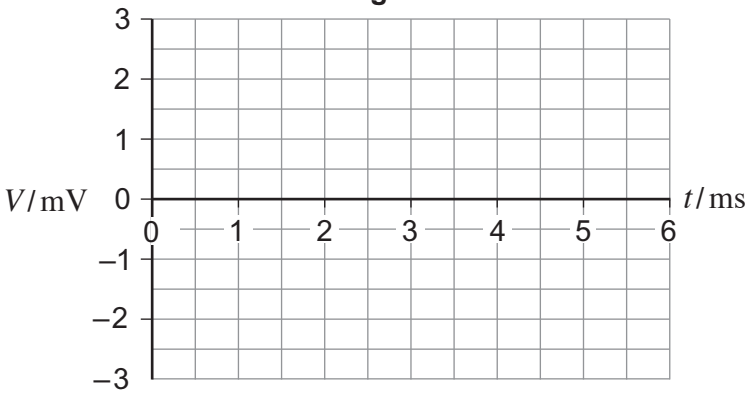
Only $\mathbf{W_1}$ received

Figure 4B



$\mathbf{W_1}$ and $\mathbf{W_2}$ received

Figure 4C



Only $\mathbf{W_2}$ received

7 (a) (i) Calculate the frequency of $\mathbf{W_1}$.

[1 mark]

frequency ..... Hz

7 (a) (ii) Draw on **Figure 4C** the variation with time of the voltage generated when the microphone receives $\mathbf{W_2}$ alone.

[3 marks]

7 (b) The power emitted by a point source of sound waves is $0.32\ \mathrm{W}$.

7 (b) (i) Calculate the average intensity of the source at a distance of $20\ \mathrm{m}$.
Give a suitable unit for your answer.

[2 marks]

intensity..... unit .....

7 (b) (ii) Calculate the change in intensity level in dB received by a detector moving from $20\ \mathrm{m}$ to $80\ \mathrm{m}$ away from the source.

[4 marks]

change in intensity level ..... dB

10

8 Discuss the ways in which radio communication can be used with and without the use of satellites to send information over a distance of several thousand kilometres.

For both communication methods, you should include discussion of:
- the frequency ranges and communication paths involved
- how the communication channel ensures maximum received signal strength throughout the day
- factors that limit the area in which a signal can be received.

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

[6 marks]

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6

Turn over for the next question

9 (a) Complete the following equation for beta minus (β^-) decay of strontium-90 ($^{90}_{38}Sr$) into an isotope of yttrium (Y).

[3 marks]

$$^{90}_{38}Sr \longrightarrow \ ^{.....}_{.....}Y \ + \ ^{.....}_{.....}\beta^- \ + \ ^{0}_{0} .....$$

9 (b) During β^- decay of a nucleus both the nucleon composition and the quark composition change.
State the change in quark composition.

[1 mark]

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9 (c) A positive kaon consists of an up quark and an antistrange quark ($u\,\bar{s}$). This kaon decays by strong and weak interactions into three pions. Two of the pions have quark compositions of ($u\,\bar{d}$). The third pion has a different quark composition.

9 (c) (i) Name the unique family of particles to which the kaon and pions belong.

[1 mark]

.....

9 (c) (ii) Tick the box corresponding to the charge of the third pion.

[1 mark]

positive ☐ negative ☐ neutral ☐

9 (c) (iii) Positive kaons have unusually long lifetimes.
Give a reason why you would expect this to be the case.

[1 mark]

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9 (c) (iv) Name the exchange particles which are involved in the strong and weak interactions of the kaon.

[1 mark]

strong interaction ..... weak interaction .....

8

10 (a) State what is meant by the Hubble constant.

[1 mark]

.....

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10 (b) The recessional velocity of a galaxy 8.0×10^8 ly from Earth is measured to be 1.8×10^4 km s^{-1}.

Show that this suggests a value for the Hubble constant of 73 km s^{-1} Mpc^{-1}.

[2 marks]

10 (c) (i) Using the value for the Hubble constant given in part **(b)**, estimate the age of the Universe.
Give your answer in years.

[3 marks]

age of the Universe ..... years

10 (c) (ii) State **one** assumption that must be made to justify the estimate made in part **(c)(i)**.

[1 mark]

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7

11 (a) State **two** pieces of evidence which enabled scientists to deduce that matter consists of atoms.

[2 marks]

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11 (b) Rutherford's alpha-particle scattering experiment resulted in the nuclear model of the atom replacing the 'plum pudding model'.

State and explain how **two** observations made in the experiment supported the nuclear model.

[4 marks]

1 .....

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2 .....

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11 (c) Deep inelastic scattering of electrons has revealed evidence for internal structure in protons.

11 (c) (i) State what happens to an electron that collides with an atom inelastically.

[1 mark]

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11 (c) (ii) Explain why electrons need to be accelerated to investigate the structure of protons.

[2 marks]

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11 (c) (iii) State an observation in electron scattering experiments that suggests that protons have internal structure.

[1 mark]

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10

Turn over for the next question

12 **Figure 5** shows an organ pipe that is closed at one end and open at the other. **Figure 6** shows a pipe that is open at both ends.

Figure 5

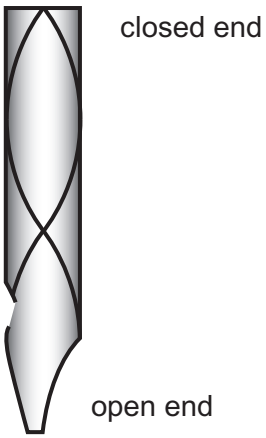
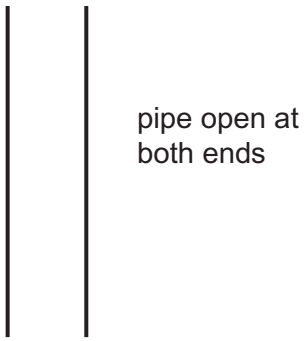


Figure 6



12 (a) (i) **Figure 5** shows one of the modes of vibration of standing waves that can be set up in the pipe.

Label on **Figure 5 one** node and **one** antinode.

[1 mark]

12 (a) (ii) Draw on **Figure 6** the mode of vibration of the standing wave when this pipe is emitting the lowest possible frequency.

[1 mark]

12 (b) The pipe in **Figure 6** emits a note of frequency $690\ \text{Hz}$ when the speed of sound in air is $345\ \text{m s}^{-1}$.

Deduce the distance between two adjacent antinodes of the standing wave that is set up in this pipe.

[2 marks]

distance between antinodes ..... m

12 (c) (i) Explain why the two pipes in **Figure 5** and **Figure 6** would sound different even if they were designed to have the same first harmonic (same fundamental frequency).

[2 marks]

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12 (c) (ii) Explain the difference between the intensity and the loudness of a musical note.

[2 marks]

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8

END OF QUESTIONS

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