Surname		Other Names	
Centre Number			Candidate Number									
Candidate Signature												

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General Certificate of Education
June 2002
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION B) PHB2
Unit 2

Friday 31 May 2002 Afternoon Session

In addition to this paper you will require:
- a calculator;
- a ruler.

Time allowed: 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions in **Section A** and **Section B** in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.
- All working must be shown, otherwise you may lose marks.
- A *Formulae Sheet* is provided on page 3. Detach this perforated page at the start of the examination.

Information
- The maximum mark for this paper is 75.
- Mark allocations are shown in brackets.
- Marks are awarded for units in addition to correct numerical answers, and for the use of appropriate numbers of significant figures.
- You are expected to use a calculator where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.
- The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

Advice
- You are advised to spend about 30 minutes on **Section A** and about 1 hour on **Section B**.

For Examiner's Use			
Number	Mark	Number	Mark
A			
7			
8			
9			
10			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

Answer **all** questions in the spaces provided.

Total for this section: *25 marks*

1 Short pulses of sound are reflected from the wall of a building 18 m away from the sound source. The reflected pulses return to the source after 0.11 s.

(a) Calculate the speed of sound.

Speed of sound ..... *(3 marks)*

(b) The sound source now emits a continuous tone at a constant frequency. An observer, walking at a constant speed from the source to the wall, hears a regular rise and fall in the intensity of the sound. Explain how the **minima** of intensity occur.

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(3 marks)

2 The intensity of a sound is $1.9 \times 10^{-8}\,\mathrm{W\,m^{-2}}$ at a distance of 0.25 km from the source. Calculate the intensity of the sound at a distance of 0.75 km from the source.

Intensity of sound ..... *(3 marks)*

Detach this perforated page at the start of the examination.

Foundation Physics Mechanics Formulae

moment of force $= Fd$

$v = u + at$

$s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

$s = \frac{1}{2}(u + v)t$

for a spring, $F = k\ l$

energy stored in a spring $= \frac{1}{2}F\ l = \frac{1}{2}k(\ l)^2$

$T = \frac{1}{f}$

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

in series circuit, $R = R_1 + R_2 + R_3 + ...$

in parallel circuit, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$

output voltage across $R_1 = \left(\frac{R_1}{R_1 + R_2}\right) \times$ input voltage

Waves and Nuclear Physics Formulae

fringe spacing $= \frac{\lambda D}{d}$

single slit diffraction minimum $\sin\theta = \frac{\lambda}{b}$

diffraction grating $n\lambda = d\sin\theta$

Doppler shift $\frac{f}{f} = \frac{v}{c}$ for $v << c$

Hubble law $v = Hd$

radioactive decay $A = \lambda N$

Properties of Quarks

Type of quark	Charge	Baryon number
up u	$+\frac{2}{3}e$	$+\frac{1}{3}$
down d	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\overline{\text{u}}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\overline{\text{d}}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

Lepton Numbers

Particle	Lepton number L		
	L_e	L_μ	L_τ
e^-	1		
e^+	–1		
υ_e	1		
$\overline{\upsilon}_e$	–1		
μ^-		1	
μ^+		–1	
υ_μ		1	
$\overline{\upsilon}_\mu$		–1	
τ^-			1
τ^+			–1
υ_τ			1
$\overline{\upsilon}_\tau$			–1

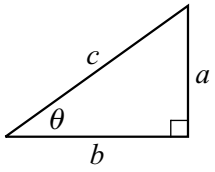
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\ r$

area of a circle $= \ r^2$

surface area of sphere $= 4\ r^2$

volume of sphere $= \frac{4}{3}\ r^3$



$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

$\tan\theta = \frac{a}{b}$

$c^2 = a^2 + b^2$

Turn over ►

NO QUESTIONS APPEAR ON THIS PAGE

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3 Polarization is a property of one type of wave.

(a) Circle below the type of wave that can be polarized.

transverse longitudinal

(1 mark)

(b) Give **one** example of the type of wave that can be polarized.

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(1 mark)

(c) Explain why some waves can be polarized but others cannot. Space is provided for sketches should you wish to include them in your answer.

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(3 marks)

Turn over ►

4 A radium-288 nuclide ($^{228}_{88}$Ra) is radioactive and decays by the emission of a β^- particle to form an isotope of actinium (Ac).

(a) Complete the equation for this decay.

$$^{228}_{88}\text{Ra} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{Ac} + {}^{\cdots\cdots}_{\cdots\cdots}\beta^- + \ldots\ldots$$

(3 marks)

(b) β^- decay is the result of a neutron within a nucleus decaying into a proton. Describe the change in the quark sub-structure that occurs during the decay.

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(1 mark)

5 A physicist, who is attempting to analyse a nuclear event, suggests that a π^- particle and a proton collided and were annihilated with the creation of a neutron, a π^+ particle, and a K^- particle.

π and K particles are mesons. The baryon and lepton numbers of both these mesons are zero.

(a) Write down the equation that represents this interaction.

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(1 mark)

(b) Show, in terms of the conservation of charge, baryon number and lepton number, that this transformation is permitted.

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(4 marks)

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6 Bone can be distinguished from soft tissue on a medical X-ray photograph of the human body.

Explain how the bones and soft tissues affect the X-rays to cause this effect.

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(2 marks)

25

TURN OVER FOR THE NEXT QUESTION

SECTION B

Answer **all** the questions in the spaces provided.

7 **Total for this question: *10 marks***

A Geiger-Müller tube and counter were used to detect β^- particles emitted by a source during a radioactivity experiment. **Figure 1** shows the **corrected** count rate detected by the counter plotted against time since the beginning of the experiment.

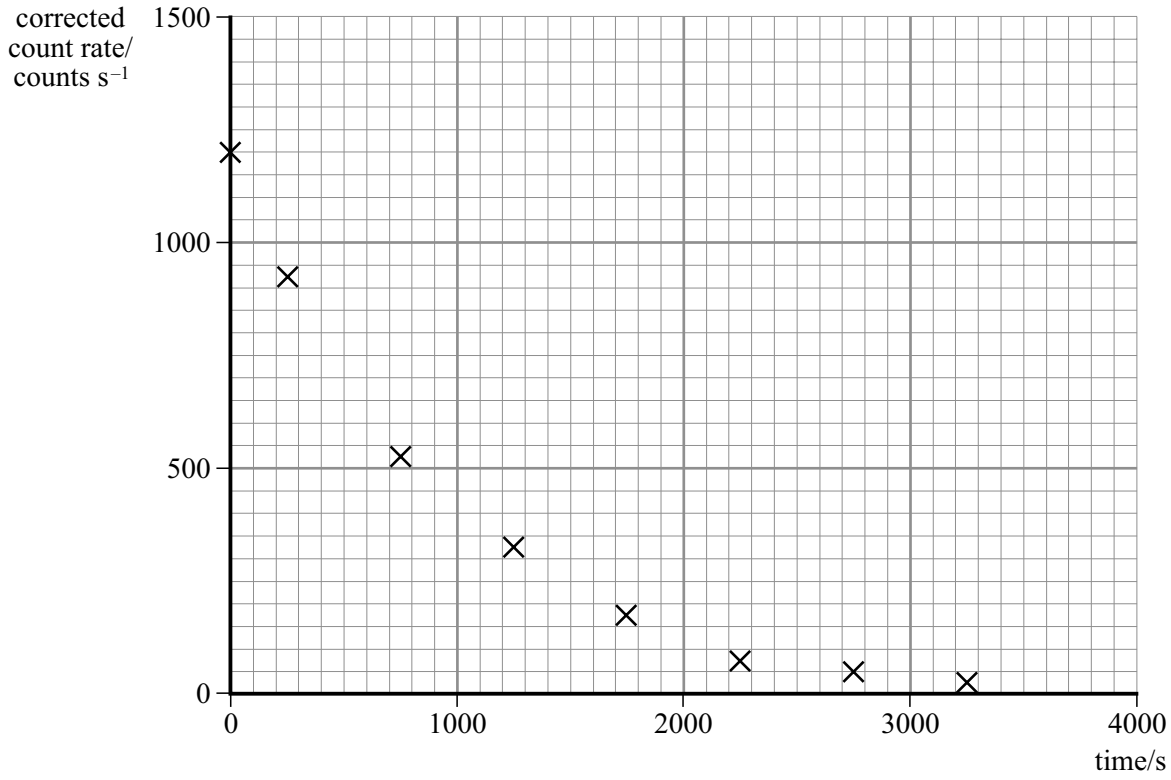

Figure 1

(a) Draw on the graph the curve that best fits these data.

Use the graph to determine the half-life of the radioactive source as accurately as you can.

Half-life ..... *(3 marks)*

(b) State why the count rate has to be corrected before it is plotted on the graph.

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(2 marks)

(c) Explain how the graph and your final answer for the half-life would change if the correction were **not** applied.

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(2 marks)

(d) Describe, giving reasons, how you would determine an accurate value for the correction.

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(3 marks)

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8 **Total for this question: *16 marks***

(a) Light arriving at the Earth from a distant galaxy is observed to be *red shifted*.

(i) Explain, in terms of spectral lines, what the term *red shift* means.

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(1 mark)

(ii) Explain how the red shift is consistent with the movement of distant astronomical objects away from us.

Two of the 6 marks in this question are for the quality of your written communication.

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(6 marks)

(b) The wavelength of a given line in the spectrum is 5.40×10^{-7} m when measured using a light source in a laboratory on Earth. When the light from the distant galaxy is used for the measurement, the wavelength is found to be 5.61×10^{-7} m.

(i) Show that this wavelength change corresponds to a frequency shift of about 2.1×10^{13} Hz.

speed of light in a vacuum, $c = 3.0 \times 10^{8}\,\text{m s}^{-1}$

Frequency shift ..... *(3 marks)*

(ii) Calculate the speed of the galaxy relative to Earth.

Galactic speed ..... *(3 marks)*

(iii) Estimate the distance, in m, between the galaxy and the Earth.

Hubble constant = $65\,\text{km s}^{-1}\,\text{Mpc}^{-1}$
1 pc (parsec) = 3×10^{16} m

Galactic distance ..... *(3 marks)*

16

9 **Total for this question: *12 marks***

(a) Laser light of wavelength 6.2×10^{-7} m falls on a single slit of width 0.15 mm.

(i) Calculate the angle, in degrees, between the central maximum and the first minimum in the diffraction pattern.

Angle ..... *(2 marks)*

(ii) Describe and explain how the appearance of the diffraction pattern will change when white light is used to illuminate the slit.

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(3 marks)

(b) The same laser as in part (a) is now used to illuminate a double slit that has a slit separation of 0.30 mm. Interference fringes are observed on a screen 5.0 m from the slits.

(i) Calculate the distance between a maximum and the next minimum of intensity on the screen.

Maximum-minimum separation ..... *(3 marks)*

(ii) Explain how the bright fringes in the pattern arise.

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(2 marks)

(iii) State the conditions necessary for the fringes to be visible.

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(2 marks)

12

10 **Total for this question: *12 marks***

(a) State:

(i) the typical frequency range of human hearing;

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(ii) the base bandwidth required for the transmission of music with the frequency range you have quoted in (a)(i);

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(iii) the minimum sampling rate required for the digital transmission of a signal with a base bandwidth of 6 kHz.

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(3 marks)

(b) Digital Audio Broadcasting (DAB) is a technique in which radio stations transmit programme material using digital rather than analogue signals. State **two** advantages that DAB has over analogue transmission.

Advantage 1 .....

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Advantage 2 .....

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(2 marks)

(c) **Figure 2** shows three radio stations **A**, **B** and **C** at three points on the Earth's surface.

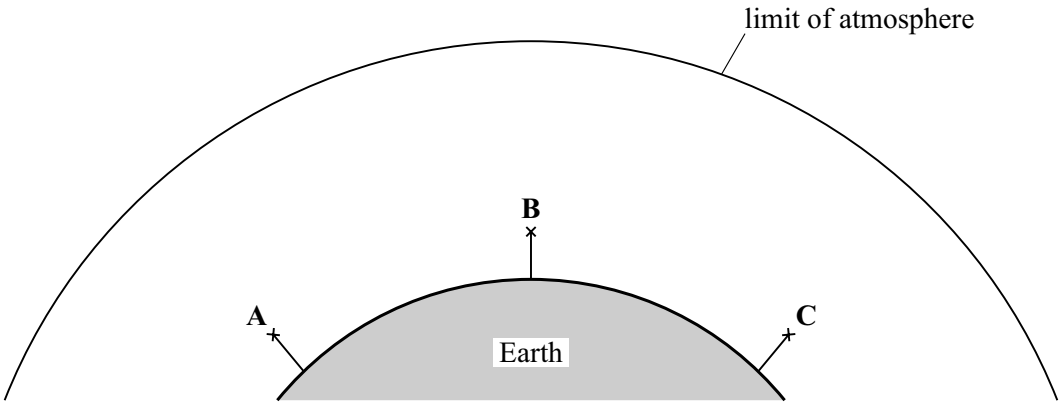

Figure 2

Station **A** transmits radio signals to **B** and **C**. Describe the various paths that can be taken by the radio waves in order to travel between stations. For each path, state whether it is suitable for long or short wavelengths, or for any wavelengths. You can sketch paths onto **Figure 2** if you wish in order to illustrate your answer.

Two of the 7 marks in this question are for the quality of your written communication.

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(7 marks)

12

END OF QUESTIONS

THERE ARE NO QUESTIONS PRINTED ON THIS PAGE