Surname		Other Names	
Centre Number						Candidate Number				
Candidate Signature										

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General Certificate of Education
January 2002
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION B) PHB2
Unit 2

Monday 14 January 2002 Morning 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			
6			
7			
8			
9			
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 (a) A musical note has a frequency of 512 Hz. Calculate the wavelength of the note.

the speed of sound = $330\,m\,s^{-1}$

Wavelength = ...

(2 marks)

(b) (i) Suggest why a doorway might cause such a note to diffract significantly.

.....

.....

.....

(1 mark)

(ii) A normal room doorway of width 0.81 m acts as an aperture for diffraction of sound. Calculate the angle to the straight through direction at which the note in (a) would give the first minimum.

Angle = ...

(3 marks)

2 (a) (i) Explain what is meant by *background radiation*.

.....

.....

.....

(2 marks)

(ii) Name a source of background radiation.

.....

(1 mark)

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, $F = k\Delta l$

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

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

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 $\frac{\Delta f}{f} = \frac{v}{c}$ 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

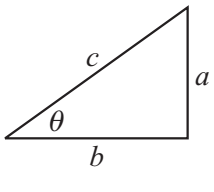
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

area of a circle $= \pi r^2$

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

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



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

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

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

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

Turn over ►

(b) State the meaning of each of the terms in the equation $A = \lambda N$

A .....

.....

λ .....

.....

N .....

.....

(3 marks)

3 (a) Draw a labelled diagram to illustrate the main features of the apparatus used in the scattering experiment that provided evidence for the existence of a positively charged nucleus.

(3 marks)

(b) Explain how the outcome of this experiment supports the model of atoms having a **small positively charged** nucleus.

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(2 marks)

TURN OVER FOR THE NEXT QUESTION

4 The Doppler effect equation may be written as:

$$\frac{\Delta f}{f} = \frac{v}{c}$$

(a) State in words the condition needed for this equation to be valid.

.....

(1 mark)

(b) (i) A radar "speed trap", using electromagnetic radiation, registers a car's fractional change in frequency as 7.3×10^{-8}.

Calculate the speed of the car.

speed of electromagnetic radiation, $c = 3.0 \times 10^{8}\,\text{m s}^{-1}$

Speed of car = ...

(2 marks)

(ii) The original frequency of the radar waves is 34 GHz.

Calculate the frequency shift corresponding to the fractional frequency change of 7.3×10^{-8}.

Frequency shift = ...

(2 marks)

5 A negative pion (π^-) is a meson with a charge of -1e.

State and explain the structure of the π^- in terms of up and down quarks.

.....

.....

.....

(3 marks)

25

SECTION B

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

6 **Total for this section: *12 marks***

(a) Beta decay may be described by the equation:

$$d \rightarrow u + e^{-} + \bar{\nu}_e$$

In terms of conservation of charge, lepton number and baryon number, show that it is possible for this decay to occur.

charge .....

lepton number .....

baryon number .....

(3 marks)

(b) Describe an experiment that you would perform in order to show that the radiation from a particular source consisted only of beta particles.

You should include:

- a labelled diagram of the apparatus;
- a statement of the measurements that you would take;
- an explanation of how you would interpret your observations.

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

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(6 marks)

Turn over ►

(c) **Figure 1** shows an energy spectrum for the radiation emitted by a beta source.

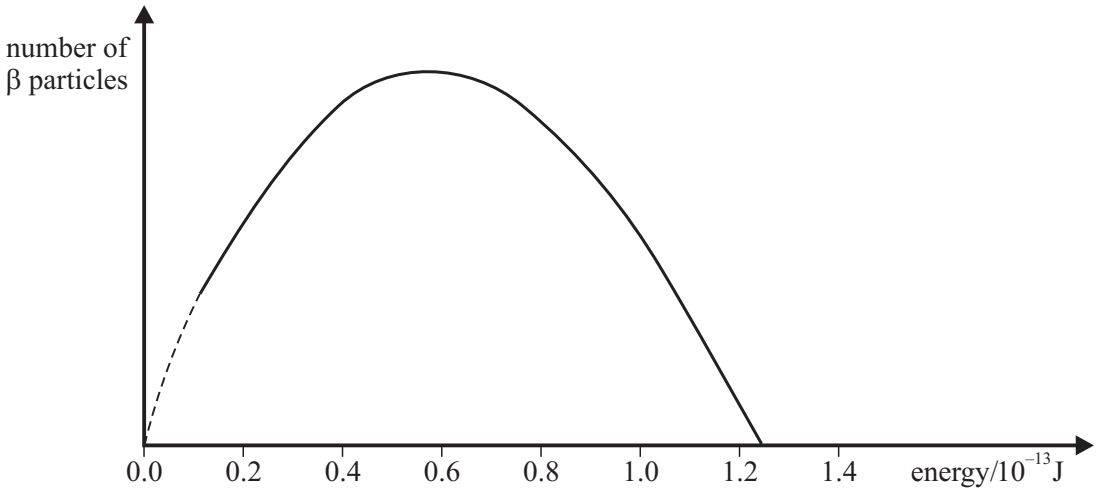

Figure 1

(i) Write down the maximum β particle energy.

.....

(1 mark)

(ii) Negative beta particles emitted by a single source arise as the result of identical energy changes in the nucleus. Explain how **Figure 1** suggests that a second particle (the anti-neutrino) must be emitted in addition to the beta particle.

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(2 marks)

12

7 **Total for this question: *13 marks***

The equation for the speed, v, of a transverse wave along a stretched string is:

$$v = \sqrt{\frac{T}{\mu}}$$

where T is the tension in the string and μ is the mass per unit length of the string.

(a) State the quantities that would need to be measured in order to calculate a single value for the speed of the wave using the equation. Name a suitable measuring instrument for each quantity.

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(4 marks)

(b) The apparatus shown in **Figure 2** could be used to measure a value for v.

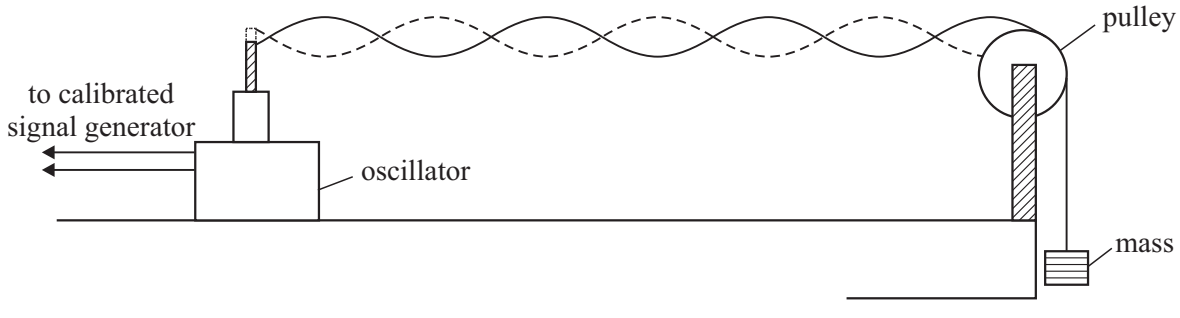

Figure 2

Explain how this apparatus may be used to calculate an accurate value of the speed of the transverse wave along the string.

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(4 marks)

Turn over ►

(c) With the signal generator in **Figure 2** set at 152 Hz, 10 loops fit the vibrating length of the string exactly. The string is of length 2.0 m and the mass on the end of it is 0.72 kg.

the Earth's gravitational field strength, $g = 9.8\,\text{N kg}^{-1}$

Calculate the mass of the string.

Mass = ...

(5 marks)

13

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

Figure 3 is an arrangement for analysing the light emitted by a source.

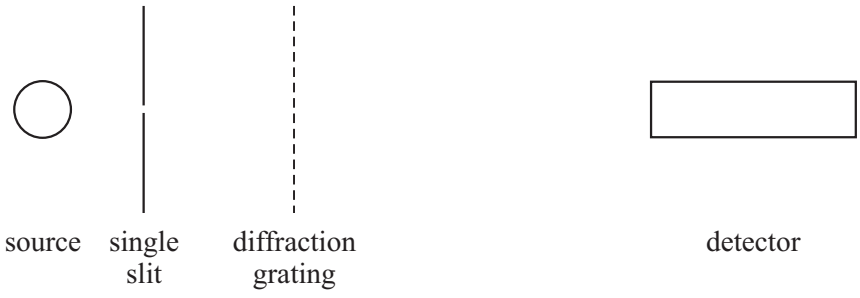

Figure 3

(a) Suggest a light source that would emit a continuous spectrum.

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(1 mark)

(b) The light source emits a range of wavelengths from 500 nm to 700 nm. The light is incident on a diffraction grating that has 10 000 lines per metre.

(i) Calculate the angle from the straight through direction at which the first order maximum for the 500 nm wavelength is formed.

Angle = ...
(3 marks)

(ii) Calculate the angular width of the first order spectrum.

Angular width .....
(1 mark)

(iii) The detector is positioned 2.0 m from the grating. Calculate the distance between the extreme ends of the first order spectrum in this position.

Distance = ...
(1 mark)

(c) The single slit is initially illuminated by light from a point source that is 0.02 m from the slit.

State and explain how the intensity of light incident on the single slit changes when the light source is moved to a position 0.05 m from the slit.

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(4 marks)

10

9 **Total for this question: *15 marks***

Figure 4 is a block diagram showing part of a telephone system.

Figure 4

(a) The output of the microphone is an *analogue* signal of *bandwidth* 3.4 kHz.

(i) Explain the meaning of the following words:

analogue .....

.....

bandwidth .....

.....

(3 marks)

(ii) Compare the bandwidth of the output of the microphone with the typical range of human hearing. Comment on any differences in these values.

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(3 marks)

(b) **Figure 5** shows the signal from the microphone.

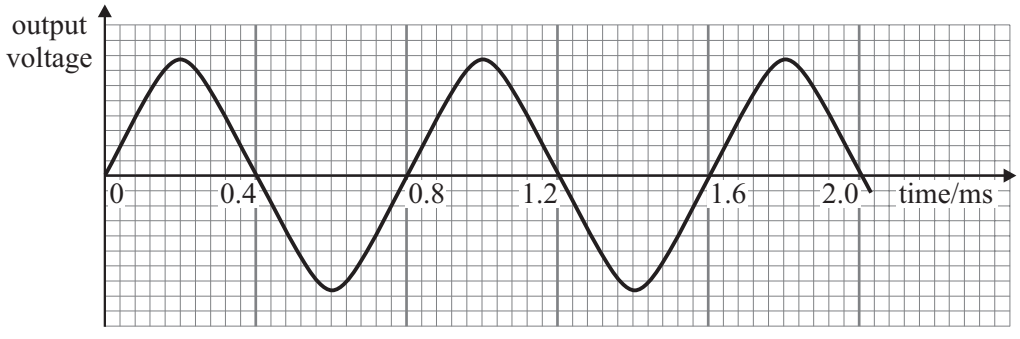

Figure 5

(i) Calculate the frequency of this signal.

Frequency = ...

(2 marks)

(ii) State the minimum sampling rate needed to allow effective transmission of this signal.

.....

(1 mark)

(iii) Explain how time division multiplexing may be used to send many audio signals "simultaneously" along a transmission medium. You may draw a labelled diagram to help your explanation. Two of the 6 marks in this question are available for the quality of your written communication.

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(6 marks)

END OF QUESTIONS

15