Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
June 2007
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION B) **PHB2**
Unit 2 Waves and Nuclear Physics

Friday 8 June 2007 9.00 am to 10.30 am

For this paper you must have:
- a calculator
- a ruler
- a formulae sheet insert.

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**.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.
- A *Formulae Sheet* is provided as a loose insert to this question paper.

Information
- The maximum mark for this paper is 75.
- Four of these marks will be awarded for using good English, organising information clearly and using specialist vocabulary where appropriate.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- Questions 7(b) and 10 should be answered in continuous prose. In these questions you may be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

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

For Examiner's Use			
Question	Mark	Question	Mark
A		6	
		7	
		8	
		9	
		10	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

J U N 0 7 P H B 2 0 1

PHB2

SECTION A

Answer **all** questions in this section.

There are **25** marks in this section.

1 A diffraction grating has 6.0×10^5 lines per metre. Light from a hydrogen discharge tube is diffracted by the grating.

(a) Calculate the angle of the first order diffraction maximum for light of wavelength 6.6×10^{-7} m.

angle ....

(3 marks)

(b) Calculate the highest order that will be visible for light of wavelength 6.6×10^{-7} m.

highest order ....

(2 marks)

2 (a) Describe the difference between longitudinal and transverse waves.

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(2 marks)

(b) (i) Light from a lamp is unpolarised. Explain how this light is different from light that has been passed through a polarising filter.

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(ii) Name an example of a wave that cannot be polarised and explain why.

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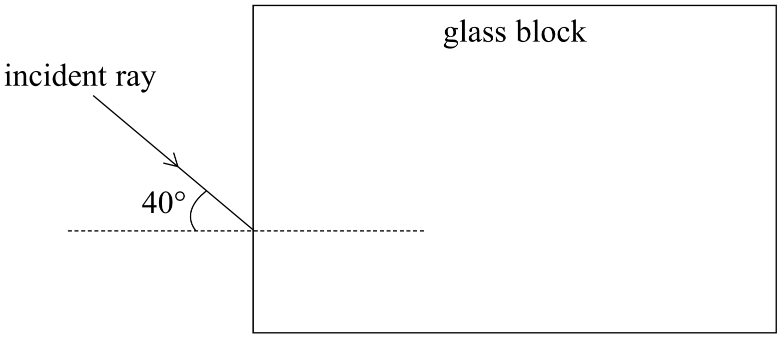
(3 marks)

Turn over for the next question

3 (a) In **Figure 1**, a ray of monochromatic light is incident in air on a glass block at an angle of incidence of 40°. The critical angle for the glass is 42°. Without attempting any calculations, complete the ray diagram to show the passage of light through the block.

Figure 1



(3 marks)

(b) The monochromatic light source in part (a) is replaced with a white light source. The ray will change in appearance between entering and leaving the block. State and explain a difference that may be observed.

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(2 marks)

4 (a) (i) State the quark structure of a neutron.

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(ii) State the quark structure of a proton.

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(2 marks)

(b) Write the equation to show the decay of a neutron into a proton. Indicate the proton and nucleon number for all of the particles involved.

(3 marks)

5 (a) Potassium-40 is a radioactive element emitting beta particles. On the axes below, sketch a typical beta particle emission spectrum for an element such as potassium-40.

(2 marks)

(b) (i) Explain how the spectrum gives evidence for the existence of neutrinos.

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(ii) State **two** characteristics of neutrinos.

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(3 marks)

25

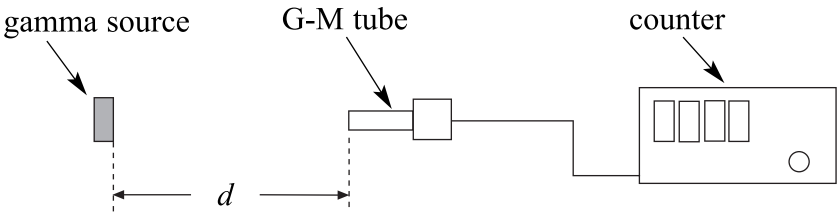
SECTION B

Answer **all** questions in this section.

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

6 **Figure 2** shows some of the apparatus used to measure the count rate from a gamma source.

Figure 2



The count rate is measured for different distances, d. The results are given in the table below.

d / cm	count rate / s^{-1}
20	87
40	23
80	5.9

(a) By performing suitable calculations assess whether or not the data in the table are consistent with an inverse square law.

conclusion ....

(3 marks)

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(b) (i) State **two** reasons why measurements of the count rates in the table may be unreliable.

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(ii) Describe **two** ways of improving the reliability of the measurements of count rates. For each technique, explain why it improves the reliability.

Technique 1 ....

Explanation 1 ....

....

Technique 2 ....

Explanation 2 ....

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(6 marks)

(c) Explain why gamma radiation is expected to follow the inverse square law.

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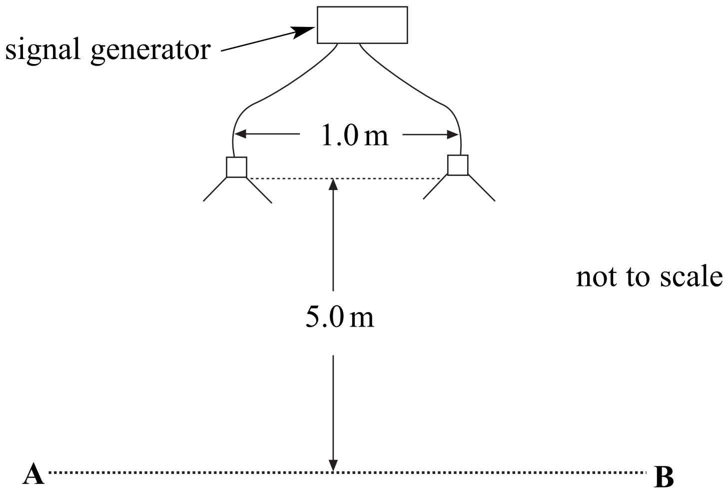
(2 marks)

11

Turn over for the next question

7 (a) **Figure 3** shows two loudspeakers emitting identical sound waves of wavelength 0.15 m. The loudspeakers are 1.0 m apart. A regular rise and fall in sound intensity can be detected by an observer moving from **A** to **B** in the area where the two sound waves from the loudspeakers overlap.

Figure 3



Calculate the separation of two adjacent positions of maximum sound intensity in the interference pattern between **A** and **B**.

separation ....
(3 marks)

(b) **Figures 4** and **5** each show situations in which waves from two sources overlap.
In **Figure 4**, two lamps, emitting white light with a range of wavelengths of 4.5×10^{-7} m to 7.0×10^{-7} m, are separated by 1.0 m.
In **Figure 5**, two loudspeakers, connected to the same signal generator, are separated by 1.0 m. The wavelength of the sound from each speaker is 0.15 m.

Figure 4

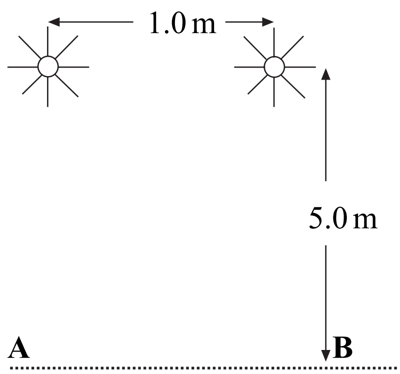
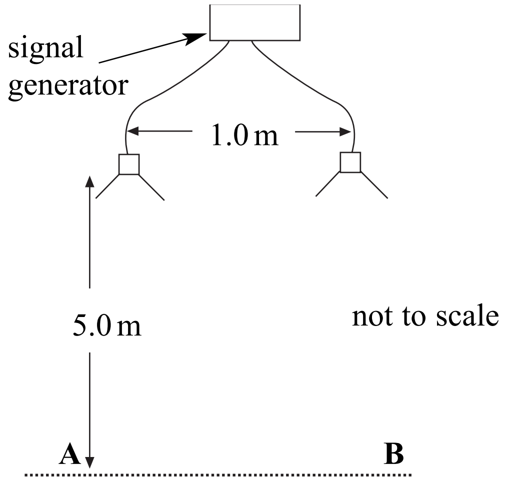


Figure 5



In **Figure 4** an observer moves between **A** and **B** and does not see interference maxima and minima.

In **Figure 5** an observer moves between **A** and **B** and does hear interference maxima and minima.

Explain why interference is detected with the sound (**Figure 5**) but not with the light (**Figure 4**).

Two of the 7 marks are available for the quality of your written communication.

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(7 marks)

8 (a) Explain how a standing wave is formed.

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(4 marks)

(b) **Figure 6** shows a loudspeaker, emitting a sound of single frequency, positioned in front of a wall. A standing (stationary) wave is produced between the loudspeaker and the wall. A microphone, connected to an oscilloscope, is used to detect positions of maximum amplitude (labelled **M**) on the standing sound wave. Places marked **M** are antinodes on the standing wave. The microphone and oscilloscope are not shown on the diagram.

Figure 6

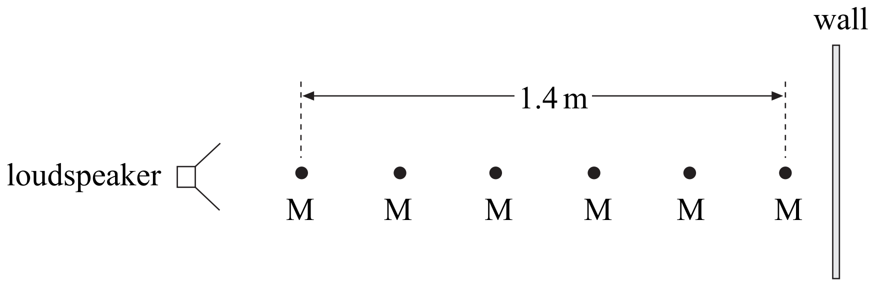
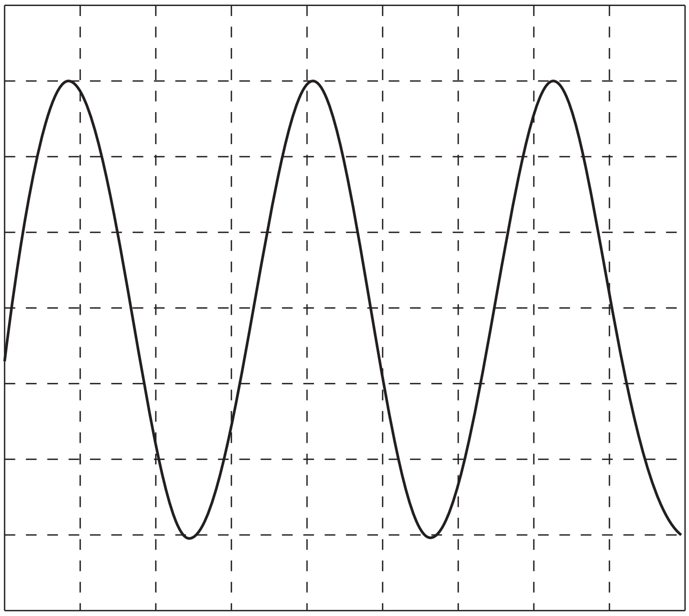


Figure 7 shows the oscilloscope trace observed when the microphone is in one of the positions labelled **M**. Each grid square measures 1 cm by 1 cm. The time-base of the oscilloscope is set to 2 cm per ms.

Figure 7



(i) Use data from **Figure 7** to show that the frequency of the sound is approximately 630 Hz.

(ii) Use data from **Figure 6** to find the wavelength of the sound.

wavelength ....

(iii) Calculate the speed of sound in air.

speed ....

(8 marks)

12

9 (a) Show that a galaxy at a distance of 3.7×10^{24} m from the Earth will be receding from the Earth at a speed of approximately $7.8 \times 10^{6}\ \mathrm{m\,s^{-1}}$.

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

1 parsec $= 3.1 \times 10^{16}$ m

(4 marks)

(b) A galaxy is receding from the Earth at a speed of $7.8 \times 10^{6}\ \mathrm{m\,s^{-1}}$. It emits light of frequency 7.3×10^{14} Hz.

(i) Calculate the observed frequency of that light when it is measured on Earth.

speed of light, $c = 3.0 \times 10^{8}\ \mathrm{m\,s^{-1}}$

frequency ....

(ii) Calculate the wavelength of this light as observed on Earth.

wavelength ....

(5 marks)

9

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10 Explain how *optical fibres* and *time division multiplexing* can be used in the transmission of telephone calls. Your account should include explanations of how these techniques improve the transmission of the telephone calls.

Two of the 8 marks are available for the quality of your written communication.

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(8 marks)

8

END OF QUESTIONS

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PHYSICS (SPECIFICATION B) **PHB2**
Unit 2 Waves and Nuclear Physics

Formulae Sheet

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 $= \frac{1}{2}F\Delta l = \frac{1}{2}k(\Delta l)^2$

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

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

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

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

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

Waves and Nuclear Physics Formulae

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

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

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

Doppler shift $\dfrac{\Delta f}{f} = \dfrac{v}{c}$ 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		
ν_e	1		
$\overline{\nu}_e$	–1		
μ^-		1	
μ^+		–1	
ν_μ		1	
$\overline{\nu}_\mu$		–1	
τ^-			1
τ^+			–1
ν_τ			1
$\overline{\nu}_\tau$			–1

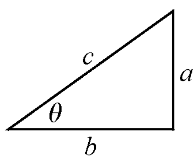
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

This insert page should **not** be sent to the examiner