Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
Section A	
B6	
B7	
B8	
B9	
B10	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2009

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 13 January 2009 1.30 pm to 2.45 pm

For this paper you must have:
- a pencil and a ruler
- a calculator
- a Data and Formulae Booklet.

Time allowed
- 1 hour 15 minutes

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.

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 (a) Name **three** types (or *flavours*) of quark.

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(2 marks)

1 (b) By referring to the charges on quarks, explain why the neutron is uncharged.

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....

(2 marks)

2 (a) State the minimum frequency of ultrasound.

....

(1 mark)

2 (b) (i) Infrasound of wavelength 35 m travels at a speed of 330 m s^{-1} in air.
Calculate the frequency of this wave.

frequency .... Hz

(2 marks)

2 (b) (ii) Circle the object in the list below which would be most likely to diffract infrasounds.

insect bird elephant building

(1 mark)

3 (a) Explain how data are stored on compact discs (CDs) and digital versatile discs (DVDs).

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(2 marks)

3 (b) State the main difference between a CD and a DVD.

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(1 mark)

4 (a) For an optical fibre the refractive index of the core is 1.52 and the refractive index of the cladding is 1.49. Calculate the critical angle, in degrees, at the boundary between the core and cladding of the fibre.

critical angle .... degrees

(2 marks)

4 (b) Explain why the cladding is necessary for optical fibres.

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(2 marks)

Turn over ▸

5 (a) Explain what the role of exchange particles is believed to be.

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(2 marks)

5 (b) The graviton is thought to be an exchange particle.
Name the type of field that the graviton is believed to mediate.

....

(1 mark)

5 (c) Name **two** exchange particles which mediate the weak nuclear force.

....

....

(2 marks)

20

Turn over for the next section

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

SECTION B

Answer **all** questions in this section.

There are 50 marks in this section.

6 (a) Explain the difference between the loudness and the intensity of a sound.

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(2 marks)

6 (b) (i) What is meant by the threshold of hearing?

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(1 mark)

6 (b) (ii) Write down the value, in decibels, corresponding to the threshold of normal human hearing.

....

(1 mark)

6 (c) An observer measures the intensity of a sound wave at a distance of 1.5 metres from a source to be $2.0 \times 10^{-10}\,\mathrm{Wm^{-2}}$. The observer then moves to a position where the intensity is measured to be $2.5 \times 10^{-11}\,\mathrm{Wm^{-2}}$.

6 (c) (i) Calculate how far from the source the observer is when the intensity is measured to be $2.5 \times 10^{-11}\,\mathrm{Wm^{-2}}$.

distance from source .... m

(3 marks)

6 (c) (ii) Calculate the increase in the number of decibels which would be needed to restore the intensity measured by the observer in this new position to $2.0 \times 10^{-10}\,\mathrm{Wm^{-2}}$.

increase .... dB

(3 marks)

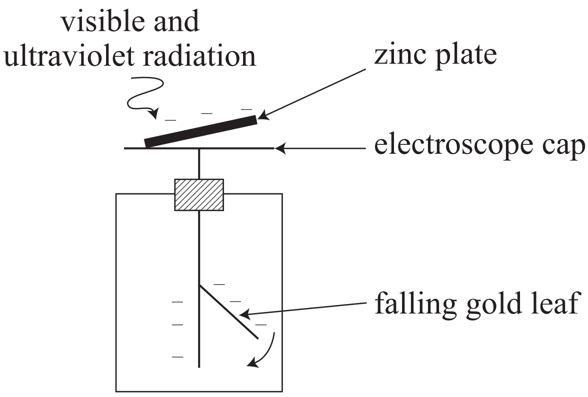
10

Turn over for the next question

Areas outside the box will not be scanned for marking

7 **Figure 1** shows the apparatus used to demonstrate the photoelectric effect. A clean zinc plate is placed on the cap of a gold leaf electroscope. The plate is then charged negatively and both visible and ultraviolet radiation are shone onto the plate. The gold leaf is seen to fall.

Figure 1



7 (a) Explain why the gold leaf falls.

....

....

....

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....

(2 marks)

7 (b) A clear sheet of glass, placed between the radiation sources and the zinc plate, absorbs some of the radiation.

7 (b) (i) Which type of radiation is absorbed?

....

(1 mark)

7 (b) (ii) Explain why this effect stops the gold leaf from falling further.

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(1 mark)

7 (c) The glass sheet is removed and the zinc plate is now charged positively. Again visible and ultraviolet radiation are shone onto the surface. Suggest why the gold leaf does not fall.

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(1 mark)

7 (d) Calculate the maximum speed of electrons emitted when radiation of wavelength 320 nm is shone onto a caesium plate.

work function of caesium = 3.04×10^{-19} J

maximum speed .... $m\,s^{-1}$

(4 marks)

9

Turn over ▸

8 (a) Explain why the discovery of cosmic microwave background radiation supports the Big Bang theory.

The quality of your written answer will be assessed in this question.

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(6 marks)

8 (b) Describe a *quasar*.

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(2 marks)

Areas outside the box will not be scanned for marking

8 (c) Calculate the distance from the Earth, in light years, of a galaxy moving with a recessional speed of $0.85c$, where c is the speed of electromagnetic waves in a vacuum.

Hubble constant = $71\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$

distance .... light years

(4 marks)

12

Turn over for the next question

Areas outside the box will not be scanned for marking

9 (a) The spectral classes of stars are O, B, A, F, G, K, M.

9 (a) (i) State the colour of the hottest star.

....

(1 mark)

9 (a) (ii) State the spectral class of the hottest star.

....

(1 mark)

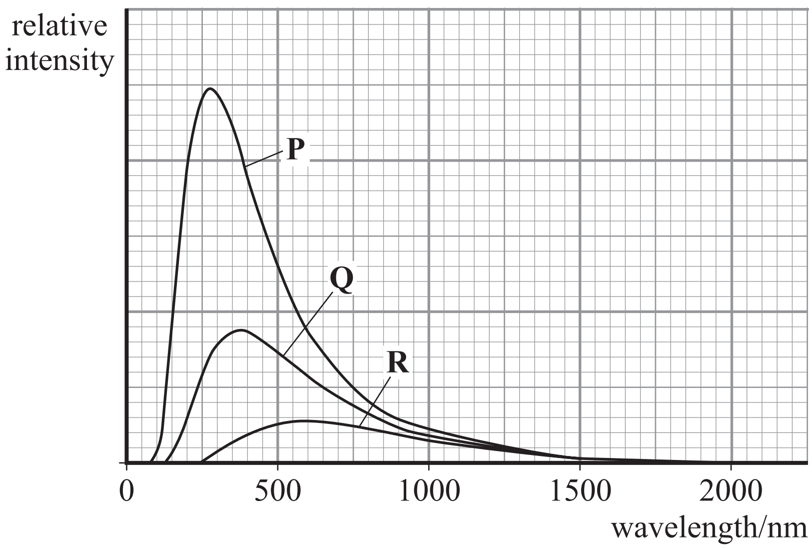
9 (a) (iii) State the spectral class of the Sun.

....

(1 mark)

9 (b) **Figure 2** shows the black body emission curves for three stars, **P**, **Q** and **R**.

Figure 2



9 (b) (i) Deduce the wavelength at which star **R** emits radiation of a maximum intensity.

wavelength .... nm

(1 mark)

9 (b) (ii) Calculate the surface temperature of this star.

surface temperature of **R** .... K

(2 marks)

9 (b) (iii) Although star **P** might be expected to appear brighter than star **Q** it will not necessarily be so.
Explain this statement.

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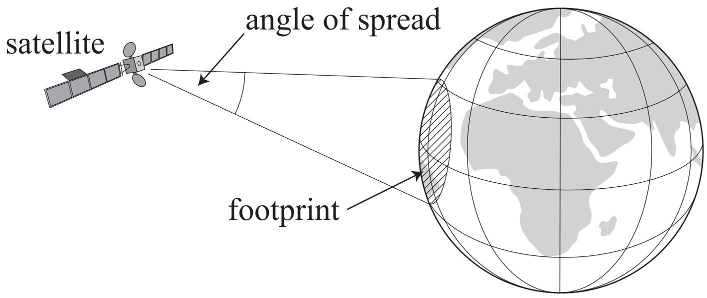
(3 marks)

9

Turn over for the next question

10 (a) **Figure 3** shows the footprint of a communications satellite in orbit around the Earth.

Figure 3



10 (a) (i) State the region of the electromagnetic spectrum that is used for satellite communication.

....

(1 mark)

10 (a) (ii) State **two** advantages of using the frequencies in this region of the electromagnetic spectrum.

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(2 marks)

10 (b) Explain why diffraction determines the size of a communication satellite's footprint.

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(2 marks)

10 (c) The down-link of a particular communication satellite has a wavelength of 0.076 m. The satellite's dish has a diameter of 1.80 m. Calculate the angle of spread, in degrees, for this satellite's footprint.

angle .... degrees
(3 marks)

10 (d) Explain why international agreement is needed for the use of communication satellites.

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(2 marks)

10

END OF QUESTIONS

Turn over for the next question

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Physics (B) Physics in Context PHYB1
Unit 1 Harmony and Structure in the Universe

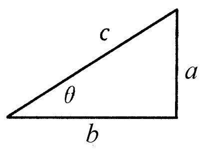
Data and Formulae Booklet

FUNDAMENTAL CONSTANTS AND OTHER NUMERICAL DATA

Quantity	*Symbol*	*Value*	*Units*
speed of light in vacuo	c	3.00×10^{8}	$\mathrm{m\,s^{-1}}$
Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$\mathrm{N\,m^{2}\,kg^{-2}}$
gravitational field strength	g	9.81	$\mathrm{N\,kg^{-1}}$
acceleration due to gravity	g	9.81	$\mathrm{m\,s^{-2}}$
electron rest mass	m_e	9.11×10^{-31}	kg
	m_e	5.5×10^{-4} u	
electron charge	e	-1.60×10^{-19}	C
proton rest mass	m_p	$1.67(3) \times 10^{-27}$	kg
	m_p	1.00728 u	
neutron rest mass	m_n	$1.67(5) \times 10^{-27}$	kg
	m_n	1.00867 u	
permeability of free space	ε_o	8.85×10^{-12}	$\mathrm{F\,m^{-1}}$
molar gas constant	R	8.31	$\mathrm{J\,K^{-1}\,mol^{-1}}$
Boltzmann constant	k	1.38×10^{-23}	$\mathrm{J\,K^{-1}}$
Avogadro constant	N_A	6.02×10^{23}	$\mathrm{mol^{-1}}$
Wien constant	α	2.90×10^{-3}	m K

GEOMETRICAL EQUATIONS

arc length	$r\theta$
circumference of circle	$2\pi r$
area of circle	πr^2
surface area of sphere	$4\pi r^2$
volume of sphere	$\frac{4}{3}\pi r^3$
surface area of cylinder	$2\pi rh$
volume of cylinder	$\pi r^2 h$



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

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

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

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

Unit Conversions

1 atomic mass unit (u)	1.661×10^{-27} kg
1 year (y)	3.15×10^{7} s
1 parsec (pc)	3.08×10^{16} m
1 parsec	3.26 ly
1 light year (ly)	9.45×10^{15} m

Particle Properties

Properties of quarks *antiquarks have opposite signs*

type	*charge*	*Baryon number*	*strangeness*
u	$+\frac{2}{3}e$	$+\frac{1}{3}$	0
d	$-\frac{1}{3}e$	$+\frac{1}{3}$	0
s	$-\frac{1}{3}e$	$+\frac{1}{3}$	-1

Properties of Leptons

	Lepton Number
particles: $e^-, \nu_e; \mu^-, \nu_\mu; \tau^-, \nu_\tau$	**+1**
antiparticles: $e^+, \overline{\nu_e}; \mu^+, \overline{\nu_\mu}; \tau^+, \overline{\nu_\tau}$	**−1**

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

Turn over ▸

AS FORMULAE

Waves

wave speed	$c = f\lambda$
period	$T = \frac{1}{f}$
intensity	$I = \frac{P}{A}$
stretched string frequency	$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$
beat frequency	$f = f_1 - f_2$
fringe spacing	$w = \frac{\lambda D}{s}$
diffraction grating	$n\lambda = d \sin\theta$
half beam width	$\sin\theta = \frac{\lambda}{a}$
refractive index of a substance	$n = \frac{c}{c_s}$
for two different substances of refractive index n_1 and n_2	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
critical angle	$\sin\theta_c = \frac{n_2}{n_1}$ for $n_1 > n_2$

Mechanics

speed or velocity	$v = \frac{\Delta s}{\Delta t}$
acceleration	$a = \frac{\Delta v}{\Delta t}$
equations of motion	$v = u + at$
	$s = \frac{(u+v)}{2}t$
	$v^2 = u^2 + 2as$
	$s = ut + \frac{1}{2}at^2$
force	$F = ma$
change in potential energy	$\Delta E_p = mg\Delta h$
kinetic energy	$E_k = \frac{1}{2}mv^2$
momentum	$p = mv$
impulse	$F\Delta t = \Delta(mv)$
spring stiffness	$k = \frac{F}{\Delta L}$
energy stored for $F \propto L$	$E = \frac{1}{2}F\Delta L$
work done	$W = Fs$
power	$P = \frac{\Delta W}{\Delta t} = Fv$
density	$\rho = \frac{m}{V}$

Quantum Physics and Astrophysics

photon energy	$E = hf$
Einstein equation	$hf = \varphi + E_{k(max)}$
line spectrum equation	$hf = E_1 - E_2$
de Broglie wavelength	$\lambda = \frac{h}{p} = \frac{h}{mv}$
Doppler shift for $v << c$	$\frac{\Delta f}{f} = -\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$
Wien's law	$\lambda_{max}T = 0.0029\ \text{m K}$
Hubble law	$v = Hd$
intensity for a point source	$I = \frac{P}{4\pi r^2}$

Electricity

current	$I = \frac{\Delta Q}{\Delta t}$
electromotive force (emf)	$\varepsilon = \frac{E}{Q}$
	$\varepsilon = IR + Ir$
resistance	$R = \frac{V}{I}$
resistors in series	$R = R_1 + R_2$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
resistivity	$\rho = \frac{RA}{L}$
power	$P = VI = I^2R = \frac{V^2}{R}$
potential divider formula	$V_o = \left(\frac{R_1}{R_1 + R_2}\right) \times V_i$
energy	$E = VIt$
efficiency	$\frac{\text{useful output power}}{\text{input power}}$

Energy production and transmission

rate of heat transfer by conduction	$= UA\,\Delta\theta$
maximum power for a wind turbine	$= \frac{1}{2}\pi r^2 \rho v^3$