Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
A1	
A2	
A3	
A4	
A5	
B6	
B7	
B8	
B9	
B10	
B11	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
June 2009

Physics in Context (B) PHYB1

Unit 1 Harmony and Structure in the Universe

Module 1 The World of Music
Module 2 From Quarks to Quasars

Thursday 21 May 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. 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. 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.
- 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 specialist vocabulary where appropriate.

Advice
- You are advised to spend about 20 minutes on **Section A** and about 55 minutes on **Section B**.

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

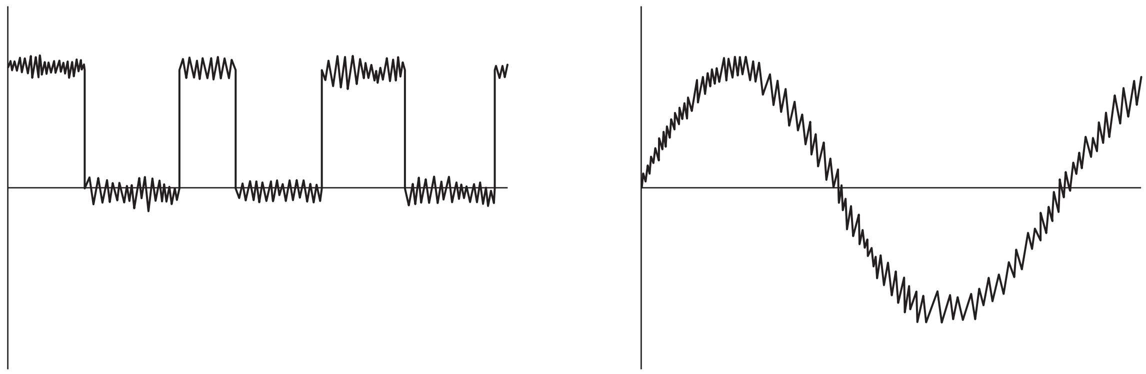
SECTION A

Answer **all** questions in this section.

There are 20 marks in this section.

1 **Figure 1** shows two signals **A** and **B**. Each signal is affected by noise.

Figure 1



Signal **A** Signal **B**

1 (a) Name the types of signal represented in **Figure 1**.

Signal **A** .... Signal **B**....................................... *(1 mark)*

1 (b) State and explain which signal could have the noise removed from it most effectively. For the other signal, explain the difficulty in removing noise from it.

....

....

....

....

....

(3 marks)

Turn over ▸

2 Complete the first column in the table to show which of the waves listed are transverse and which are longitudinal.
Complete the second column to show which waves can be polarised.

type of wave	**transverse or longitudinal**	**can be polarised (answer yes or no)**
light		
microwaves		
ultrasound		

(3 marks)

3 It is easy to download music files from the Internet.

Discuss the advantages and disadvantages, for musicians and the music industry, of downloading music in this way.

....

....

....

....

....

....

....

(3 marks)

4 A laser illuminates a pair of slits of separation 0.24 mm. The wavelength of light from the laser is 6.3×10^{-7} m. Interference fringes are observed on a screen 4.3 m from the slits.

4 (a) Calculate the fringe separation. Give an appropriate unit for your answer.

fringe separation ....

(3 marks)

Areas outside the box will not be scanned for marking

4 (b) State the conditions necessary for two light sources to be coherent.

....

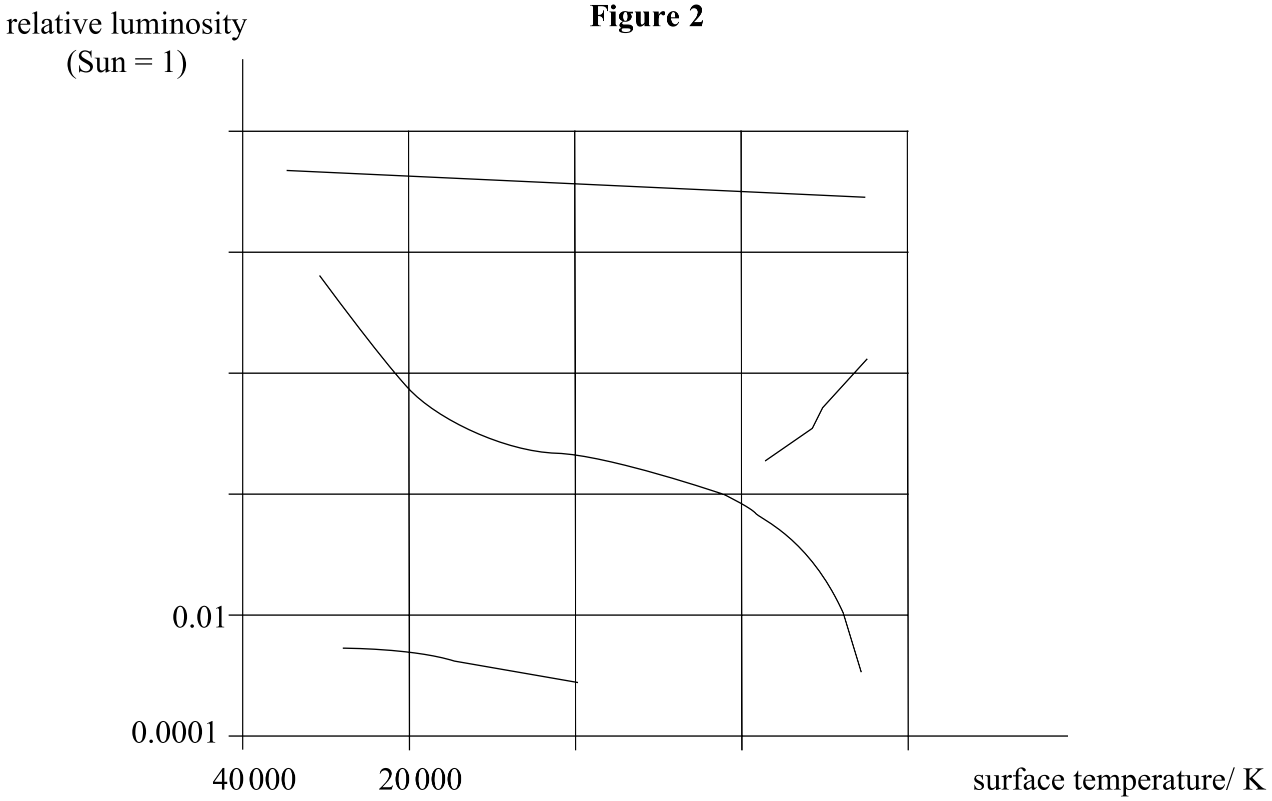
....

....

(2 marks)

5 **Figure 2** shows an incomplete Hertzsprung-Russell diagram.

Figure 2



5 (a) Complete all values on the scales on both axes of **Figure 2**.

(2 marks)

5 (b) Mark on **Figure 2** the positions of:

the Sun, label this **S**;

a red giant, label this **R**;

a white dwarf, label this **W**.

(3 marks)

20

Turn over ▸

Areas outside the box will not be scanned for marking

SECTION B

Answer **all** questions in this section.

There are 50 marks in this section.

6 (a) A violin string vibrates at a frequency of 660 Hz in its fundamental mode.

6 (a) (i) The dots show the positions of the two ends of this string. Sketch the fundamental mode of vibration between the dots.

(1 mark)

6 (a) (ii) The length of the string between the dots is 0.289 m. What is the wavelength of the standing wave?

wavelength .... m
(1 mark)

6 (a) (iii) Calculate the speed of the wave along the string.

speed...................................... m s^{-1}
(2 marks)

Areas outside the box will not be scanned for marking

6 (b) Another violin string is 0.330 m long and has a mass per unit length of 3.78×10^{-4} kg m^{-1}. It has a fundamental frequency of 656 Hz.

Calculate the tension in this string. Give your answer to an appropriate number of significant figures.

tension .... N

(3 marks)

6 (c) (i) The two strings in part(a) and part(b) are played at the same time with the violins close to each other.

Describe what would be heard and name this effect.

....

....

....

....

....

....

(3 marks)

6 (c) (ii) Explain how a violinist could tune a violin using this effect.

....

....

....

....

....

(2 marks)

12

Turn over ▸

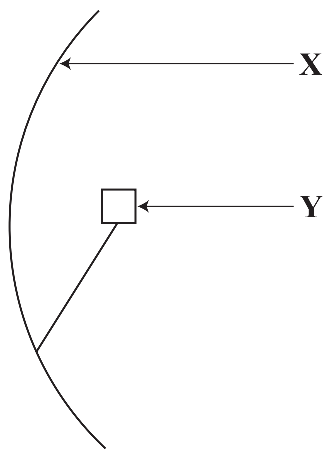
7 (a) Satellites use microwaves or uhf radio signals to send signals long distances around the Earth. Complete the table to show **two** further methods in which electromagnetic signals can be sent long distances around the Earth. For each method state the type of electromagnetic wave that is used.

transmission path	**appropriate type of wave**
satellite	microwave/uhf radio

(4 marks)

7 (b) **Figure 3** shows a satellite transmission dish.

Figure 3



7 (b) (i) Name the parts of the dish labelled **X** and **Y**.

X .... **Y** ....

(2 marks)

Areas outside the box will not be scanned for marking

7 (b) (ii) The dish transmits electromagnetic waves of frequency 1.25×10^{10} Hz and wavelength 2.4×10^{-2} m.

Explain why these waves are suitable for use in satellite communications.

....

....

....

....

(2 marks)

8

Turn over for the next question

Areas outside the box will not be scanned for marking

8 Describe how a compact disc (CD) is used to store data. Go on to explain how the data are read from the disc and how the data are processed to produce music.

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

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

(6 marks)

6

9 (a) A car travels towards an observer at a speed of $18\,\text{m s}^{-1}$. It emits a sound of frequency 2800 Hz.

Calculate the frequency of the sound heard by the observer.

speed of sound in air = $340\,\text{m s}^{-1}$

frequency heard.................................... Hz

(3 marks)

9 (b) (i) Explain how the red shift provides evidence to support the *Big Bang theory*.

....

....

....

....

(2 marks)

9 (b) (ii) In what way does the total mass of the Universe help to determine its ultimate fate?

....

....

....

....

(1 marks)

6

Turn over for the next question

10 (a) (i) Explain what is meant by an *exchange particle*.

....

....

....

....

(2 marks)

10 (a) (ii) Name the exchange particle that mediates the strong force.

....

(1 mark)

10 (a) (iii) The weak nuclear force acts over a much shorter distance than the strong force. Explain **two** differences between the relevant exchange particles that account for this.

....

....

....

....

(2 marks)

10 (b) The following equation shows the β^- decay of a free neutron.

$$ {}^{1}_{0}\mathrm{n} \rightarrow \mathbf{X} + {}^{0}_{-1}\beta + \mathbf{Y} $$

Identify each of the particles **X** and **Y**.

Show the appropriate nucleon and proton number for each of the particles.

X..

Y.. *(2 marks)*

Areas outside the box will not be scanned for marking

10 (c) For a decay to be possible each of baryon number, lepton number and charge must be conserved. Use these rules to show that the following decay is possible.

$$\mu^- \rightarrow e^- + \overline{\nu}_e + \nu_\mu$$

conservation of baryon number:

conservation of lepton number:

conservation of charge:

(3 marks)

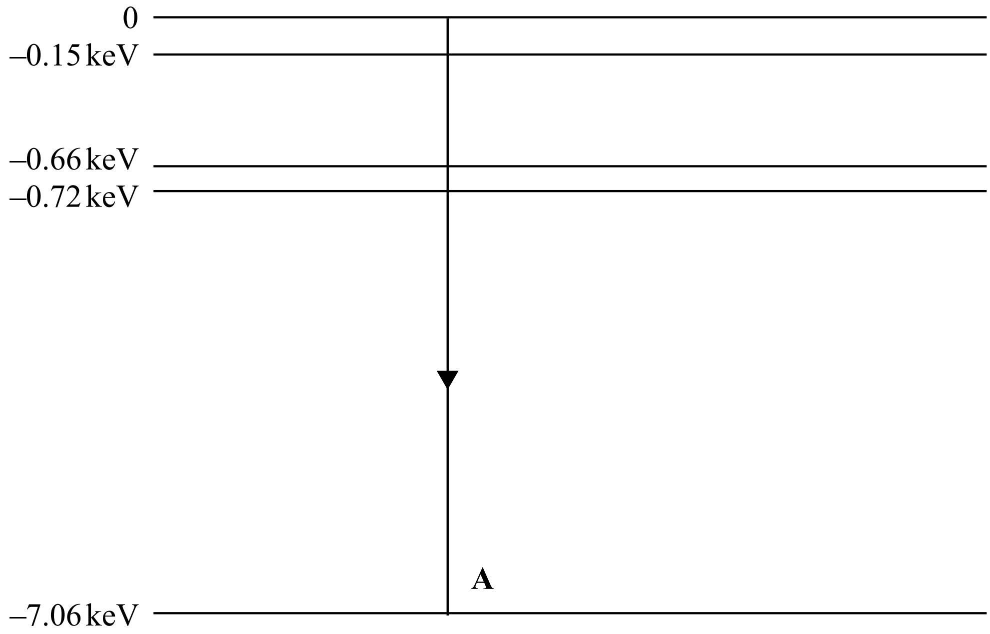
10

Turn over for the next question

11 (a) **Figure 4** shows some of the energy levels for an iron atom.

Figure 4

Not drawn to scale



11 (a) (i) Draw another arrow on **Figure 4** to represent the smallest energy change possible for an electron moving between two of the energy levels shown.
The electron energy change selected must result in energy being emitted from the atom.
Label this arrow **B**. *(1 mark)*

11 (a) (ii) In **Figure 4**, when the energy change labelled **A** occurs an X-ray photon is emitted.
Show that the frequency of the photon is approximately 2×10^{18} Hz.

(3 marks)

11 (b) (i) Radiation of frequency 2×10^{18} Hz has a wavelength of 1.5×10^{-10} m.
Calculate the speed of an electron that has a de Broglie wavelength of 1.5×10^{-10} m.

speed....................................... $m\,s^{-1}$
(2 marks)

11 (b) (ii) Explain why electrons of this wavelength would be suitable to investigate the structure of a metallic crystal.

....

....

....

....
(2 marks)

8

END OF QUESTIONS

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

General Certificate of Education
Advanced Subsidiary Examination
June 2009

Physics in Context (B) PHYB1

Unit 1 Harmony and Structure in the Universe

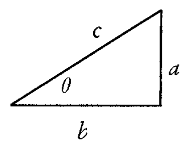
Data and Formulae Booklet

FUNDAMENTAL CONSTANTS AND OTHER NUMERICAL DATA

Quantity	*Symbol*	*Value*	*Units*
speed of light in vacuo	c	3.00×10^{8}	$m\ s^{-1}$
Planck constant	h	6.63×10^{-34}	J s
gravitational constant	G	6.67×10^{-11}	$N\ m^{2}\ kg^{-2}$
gravitational field strength	g	9.81	$N\ kg^{-1}$
acceleration due to gravity	g	9.81	$m\ s^{-2}$
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	
permittivity of free space	ε_0	8.85×10^{-12}	$F\ m^{-1}$
molar gas constant	R	8.31	$J\ K^{-1}\ mol^{-1}$
Boltzmann constant	k	1.38×10^{-23}	$J\ K^{-1}$
Avogadro constant	N_A	6.02×10^{23}	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

INSERT TO M/Jun09/PHYB1

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	$\lambda_{max} T = 0.0029$ m K
Hubble law	$v = H d$
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	$= \frac{1}{2}\pi r^2 \rho v^3$