Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
Section A	
B8	
B9	
B10	
B11	
B12	
TOTAL	

General Certificate of Education
Advanced Subsidiary Examination
January 2009

Physics B: Physics in Context PHYB2

Unit 2 Physics Keeps us Going

Module 1 Moving People, People Moving
Module 2 Energy and the Environment

Thursday 15 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 weightlifter lifts a weight of 1500 N through a height of 0.35 m in a time of 0.85 s. Calculate the mean power developed by the weightlifter.

power .... W

(2 marks)

2 In a diving event at the Olympic games, the centre of mass of a diver falls 10 m before reaching the water.

2 (a) Show that the diver's speed when she reaches the water is about 14 m s^{-1}.

Formula to be used

....

Substitution and answer

(2 marks)

2 (b) (i) On entering the water the vertical speed of the diver of mass 45 kg is reduced to zero in 0.54 s with uniform deceleration. Calculate the resultant force that produces this vertical deceleration.

force .... N

(2 marks)

2 (b) (ii) Describe **two** ways in which the decelerating force is exerted on the diver.

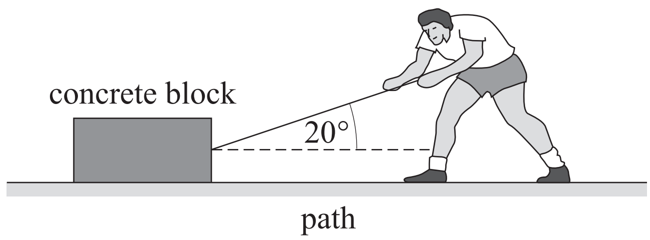
first way ....

second way...

(2 marks)

3 **Figure 1** shows a man participating in a 'strong man' competition. The event requires the man to haul a concrete block along a horizontal path for a distance of 15 m. The frictional force between the block and the path is 2800 N.

Figure 1



3 (a) The rope is inclined at an angle of 20° to the horizontal.
Calculate the minimum force that the man must exert on the rope to move the block.

force .... N
(1 mark)

3 (b) Calculate the minimum work that the man has to do to complete the event.

work done .... J
(1 mark)

Turn over ▸

4 The table below indicates some positions of a person carrying out a bungee jump from a high bridge.
Tick the appropriate box(es) to show the forms that the jumper's energy takes at the different stages of the jump.

Position \ Energy forms	kinetic energy	gravitational potential energy	elastic potential energy
at the instant the jumper steps off the bridge			
at the instant the elastic bungee rope just becomes taut			
at the instant the jumper reaches the lowest point of the jump			

(3 marks)

5 A solar panel fitted to a spacecraft has an area of one square metre. The spacecraft begins its journey to the Sun from a low Earth orbit where the solar panel receives energy at a rate of $1400\,\text{J}\,\text{s}^{-1}$.
Calculate the rate at which it will receive energy when it has travelled $\frac{1}{10}$ of the way to the Sun.

rate at which energy is received .... J s^{-1}
(2 marks)

6 The change in resistance with temperature of a thermistor is used in thermostats to control the central heating in houses. Explain why the resistance of a negative temperature coefficient (ntc) thermistor decreases as the temperature rises.

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(2 marks)

Areas outside the box will not be scanned for marking

7 The wire in an electric heater has a resistance of 75 Ω. It is 9.5 m long and has a cross-sectional area of $1.4 \times 10^{-7}\,\text{m}^2$.
Calculate the resistivity of the material from which the wire is made.
Give an appropriate unit for your answer.

resistivity ....
(3 marks)

20

Turn over for the next question

Turn over ▸

Areas outside the box will not be scanned for marking

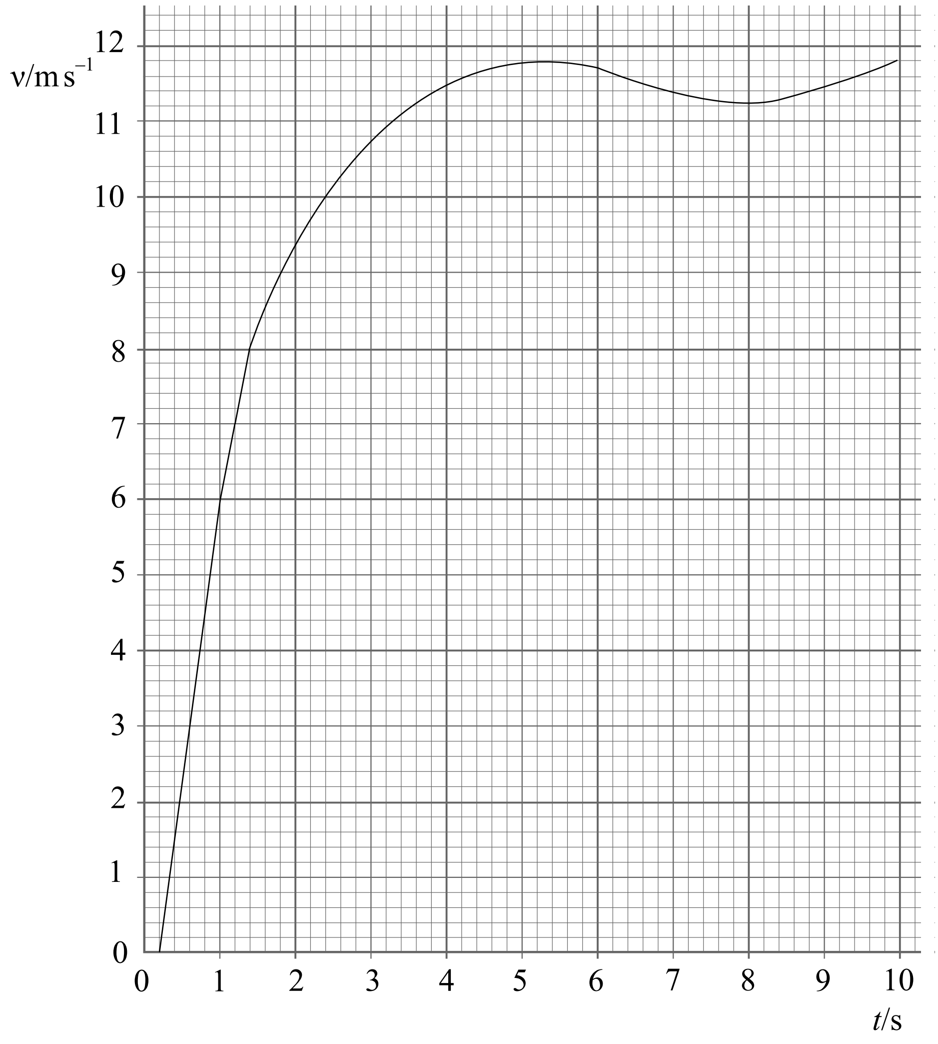
SECTION B

Answer **all** questions in this section.

There are 50 marks in this section.

8 **Figure 2** shows the variation of the speed, *v,* of a sprinter with time, *t,* from the time the starting pistol is fired until the sprinter reaches the finishing line during a 100 m sprint.

Figure 2



8 (a) Explain why the graph does not go through the origin.

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(1 mark)

Areas outside the box will not be scanned for marking

8 (b) Determine the acceleration of the sprinter 3.5 s after the start of the race.
Give an appropriate unit for your answer.

acceleration ....
(3 marks)

8 (c) What distance was covered in the first 2.0 s of the race?

distance ....
(4 marks)

8 (d) Describe briefly how the data for the sprinter's velocity–time graph shown in **Figure 2** could have been collected.

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(2 marks)

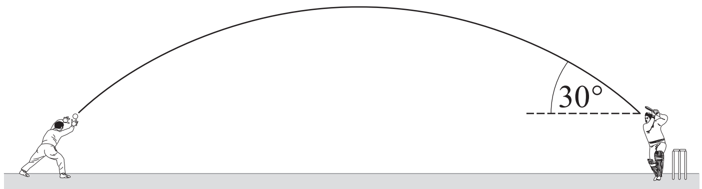
10

Turn over ▸

Areas outside the box will not be scanned for marking

9 **Figure 3** shows the flight of a cricket ball hit by a batsman at 30° to the horizontal at a speed of 22 m s^{-1}. The ball reached a fielder without bouncing and was caught at the same height as it was hit. The effect of air resistance on the cricket ball is negligible.

Figure 3



9 (a) (i) Calculate the vertical speed of the ball at the instant it left the bat.

vertical speed .... m s^{-1}
(1 mark)

9 (a) (ii) Show that the ball was in the air for about 2.2 s.

(3 marks)

9 (a) (iii) How far did the ball travel horizontally before it was caught?

distance .... m
(1 mark)

Areas outside the box will not be scanned for marking

9 (b) (i) A tennis ball is about the same size as a cricket ball but has a lower mass. By considering the energy changes that take place, explain why a tennis ball hit at the same speed and angle as the cricket ball would be unlikely to reach the fielder without bouncing.

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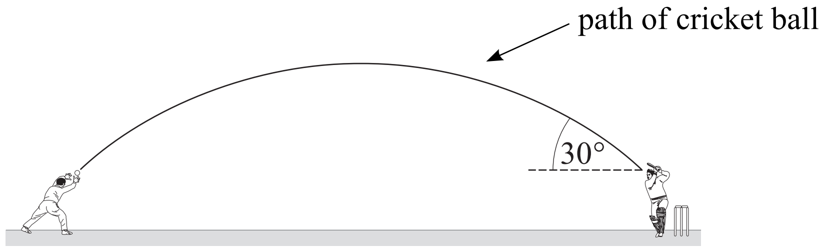
(3 marks)

9 (b) (ii) Draw on **Figure 4** the path you would expect a tennis ball to follow when hit at the same speed and angle as the cricket ball.

Figure 4



(2 marks)

10

10 A factory roof has an area of 600 m^2. It is made from corrugated iron sheets which have a thick coating of insulating material to reduce energy loss.
The *U*-value of the sheet is 0.45 $W\,m^{-2}\,K^{-1}$.

10 (a) The outside temperature is 5.0 °C and the temperature in the factory is 24 °C.
Calculate the rate at which energy is transferred through the roof.

rate of transfer of energy .... W
(3 marks)

10 (b) The electricity for heating, lighting and running the machinery in the factory comes from the National Grid at a cost of 11 p per kWh.
The roof could have been made of corrugated iron sheet with extra insulation that reduces the *U*-value to 0.19 $W\,m^{-2}\,K^{-1}$.
What would be the cost saving each day for the same temperature conditions as those in part (a)?
Give your answer in pence (p).

cost saving per day .... p
(2 marks)

10 (c) Other than insulating the walls and roof, discuss **three** ways of producing and efficiently using electricity to reduce the factory's carbon footprint.
In each case, explain why your suggestion would reduce carbon emissions.

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

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(6 marks)

11

11 To power a small village at peak times requires a mean power of 450 kW.
An engineer suggests two options for providing the power. The first is a wind turbine and the second is a bank of solar cells.

11 (a) (i) The efficiency of the wind turbine is 20%. Assuming a wind speed of 8.0 $m s^{-1}$ calculate the length of the blades of the turbine that would be needed.

density of air = 1.30 $kg m^{-3}$

length of blades .... m
(4 marks)

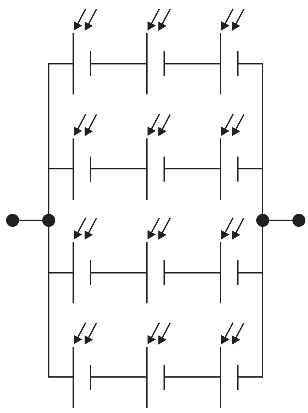
11 (a) (ii) A solar cell has an efficiency of 20%. The average intensity of the Sun's radiation is 210 $W m^{-2}$. Assuming that the Sun's radiation falls normally on the solar cells, calculate the area of solar cells that would provide a mean power output of 450 kW.

area .... m^2
(2 marks)

Areas outside the box will not be scanned for marking

11 (b) To provide a useful supply, a bank of solar cells consists of many cells connected in a series and parallel array. **Figure 5** shows the principle using a smaller number of cells than is used in practice.

Figure 5



11 (b) (i) What is the advantage of connecting the cells in series?

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(1 mark)

11 (b) (ii) Explain the advantage of connecting the cells in parallel.

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(2 marks)

Question 11 continues on the next page

Turn over ▸

11 (c) Even if both of the proposed supplies are installed and in working order there may still be no power available.
Explain why this could happen and what might be done to provide suitable back-up power.

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(2 marks)

11

12 The heater in a kettle, designed to operate from the 12 V battery in a car, has a power rating of 130 W.

12 (a) Calculate the current drawn from the battery by the kettle.

current .... A

(2 marks)

12 (b) The energy needed to raise the temperature of two cups of cold water to boiling point is 170 kJ.
Calculate the minimum time, in minutes, that it would take to raise the temperature of this water to its boiling point.

time .... minutes

(3 marks)

12 (c) The internal resistance of the battery affects the efficiency of the transfer of energy from the battery to the kettle.
Explain what causes internal resistance and why this affects the efficiency.

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(3 marks)

8

END OF QUESTIONS

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DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

General Certificate of Education
Advanced Subsidiary Examination
January 2009

Physics (B) Physics in Context **PHYB2**
Unit 2 Physics Keeps us Going

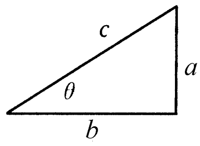
Data and Formulae Booklet

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_0	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^-, ν_e ; μ^-, ν_μ; τ^-, ν_τ	**+1**
antiparticles: e^+, $\overline{\nu_e}$; μ^+, $\overline{\nu_\mu}$; τ^+, $\overline{\nu_\tau}$	**−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	$= \frac{1}{2}\pi r^2 \rho v^3$