Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

For Examiner's Use	
Examiner's Initials	
Question	Mark
A1	
A2	
A3	
A4	
A5	
A6	
A7	
B8	
B9	
B10	
B11	
B12	
TOTAL	

AQA

General Certificate of Education
Advanced Subsidiary Examination
June 2009

Physics in Context (B) PHYB2

Unit 2 Physics Keeps Us Going

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

Friday 5 June 2009 9.00 am to 10.15 am

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 In parts (i) and (ii) circle the letter that corresponds to the correct answer.

1 (i) The resistance of a negative temperature coefficient (ntc) thermistor

A increases as temperature increases.
B is constant at temperatures below 0 °C.
C increases as temperature decreases.
D falls to zero when a critical temperature is reached. *(1 mark)*

1 (ii) The unit of potential difference can be expressed as

A $C\,s^{-1}$
B $J\,C^{-1}$
C $V\,A^{-1}$
D $J\,A^{-1}$ *(1 mark)*

2 A metal block cools by forced convection when air at a temperature of 10 °C is blown over it. The temperature of the metal block falls from 130 °C to 70 °C in 480 s.

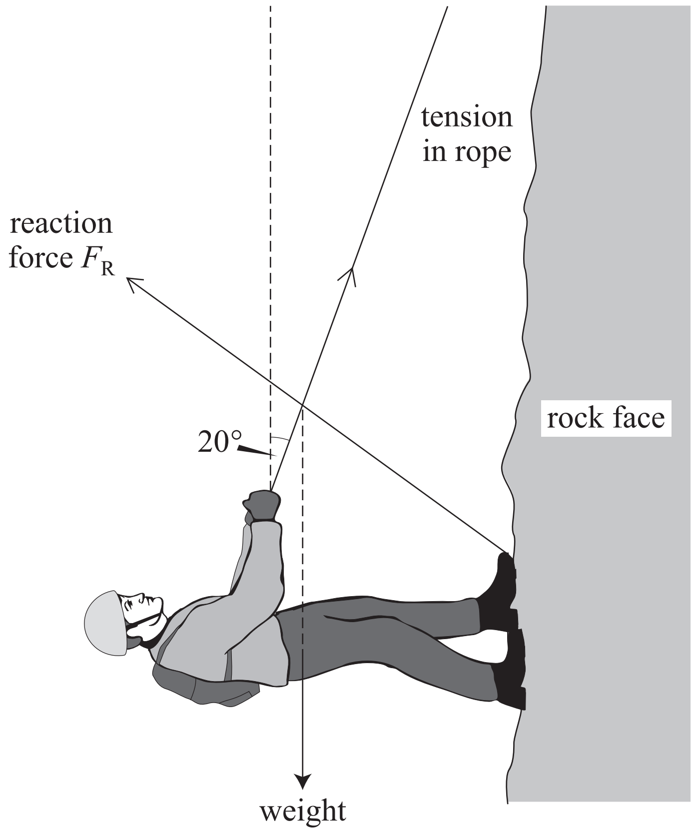
Calculate the temperature of the metal block after a further 480 s.

temperature ....°C
(2 marks)

Turn over ▸

3 **Figure 1** shows a rock climber abseiling down a rock face. At the instant shown the climber is stationary and in equilibrium. The forces acting on the climber are shown in **Figure 1**.

Figure 1



The tension in the rope is 610 N and it acts at 20° to the vertical.
The weight of the climber is 590 N.

Calculate the vertical component of the reaction force, F_R, between the feet of the climber and the rock.

vertical component .... N
(3 marks)

4 A light sensor is initially at a distance *d* from a light source of power *P*. The intensity is *I*. The power of the light source is increased to 3*P* and the distance is decreased to $\frac{d}{2}$.

Calculate, in terms of *I*, the new intensity of the light falling on the light sensor.

new intensity……………………………

(2 marks)

5 An iceberg formed from pure water floats in a large lake of pure water.

5 (i) State the principle of flotation.

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(1 mark)

5 (ii) State and explain the effect on the water level in the lake when the iceberg melts.

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(2 marks)

Turn over ▸

6 (i) State what is meant by a superconductor.

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(2 marks)

6 (ii) With reference to **two** uses for superconductors in today's world, explain the advantage of their use compared with conventional conductors such as copper.

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(3 marks)

7 An engineer constructs a turbine using blades of length 22 m. The efficiency of the turbine in converting the wind energy to electrical energy is 15%.

density of air = 1.3 kg m^{-3}

7 (i) The engineer assumes an average wind speed of 7.5 m s^{-1}.
Show that the average input power available from the wind is about 420 kW.

(2 marks)

7 (ii) Calculate the average output power available from the turbine.

average output power .... kW

(1 mark)

20

Turn over ▶

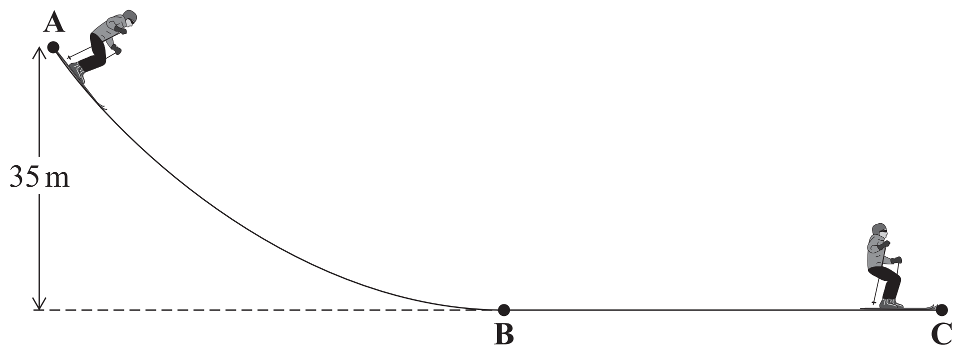
SECTION B

Answer **all** questions in this section.

There are 50 marks in this section.

8 **Figure 2** shows the path of a skier who descends a slope **AB**.

Figure 2



The skier starts from rest at **A** and eventually comes to rest again at **C** on the horizontal surface **BC**.

8 (a) (i) The slope **AB** has a vertical height of 35 m. The total mass of the skier is 65 kg. Show that the skier's loss in gravitational potential energy is about 20 kJ.

(1 mark)

8 (a) (ii) The kinetic energy of the skier at point **B** is 11 000 J. Show that the skier's speed at point **B** is about 18 m s^{-1}.

(2 marks)

Areas outside the box will not be scanned for marking

8 (a) (iii) The average retarding force acting on the skier is 140 N.
Calculate the distance travelled between **A** and **B.**

distance travelled .... m
(2 marks)

8 (a) (iv) Describe **two** ways in which the retarding force may arise.

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(3 marks)

8 (b) The skier decelerates uniformly between **B** and **C** at $2.8\,\mathrm{m\,s^{-2}}$.

8 (b) (i) Calculate the time taken to travel from **B** to **C**.

time .... s
(2 marks)

8 (b) (ii) Calculate the distance **BC**.

distance .... m
(2 marks)

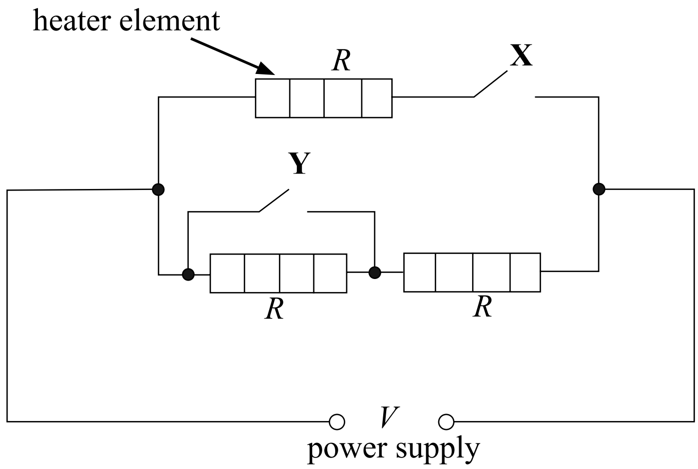
12

Turn over

Areas outside the box will not be scanned for marking

9 **Figure 3** shows the circuit for a small convector heater. Heater elements can be switched in and out of the circuit using switches **X** and **Y**. Each element has a resistance *R* and the power supply has an emf *V*.

Figure 3



9 (a) The table shows the possible combinations of open and closed switches. When a switch is closed, charge can flow through it.

Complete the table. Assume that the internal resistance of the power supply is negligible. The first row of the table has been done for you.

switch combination	**total resistance in circuit**
X open, **Y** closed	*R*
X closed, **Y** open	
X open, **Y** open	
X closed, **Y** closed	

(3 marks)

9 (b) State and explain which switch combination will dissipate least energy.

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(2 marks)

9 (c) Explain in terms of electron flow how thermal energy is produced in one of the heater elements when charge flows through it.

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(2 marks)

9 (d) The power supply for the heater is replaced with one that has a higher internal resistance.
Explain how this change will affect the thermal energy output of the heater for a given switch combination. State which switch combination will be affected most by the change.

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(3 marks)

9 (e) The resistance of each heater element is 68 Ω. Each one is made from 7.2 m of nichrome wire wound on a rod.

9 (e) (i) Calculate the radius of the nichrome wire.

resistivity of nichrome = $1.1 \times 10^{-6}\,\Omega\,\text{m}$

radius .... m

(2 marks)

9 (e) (ii) Suggest **two** properties that the rod must have to make it suitable in this application.

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(2 marks)

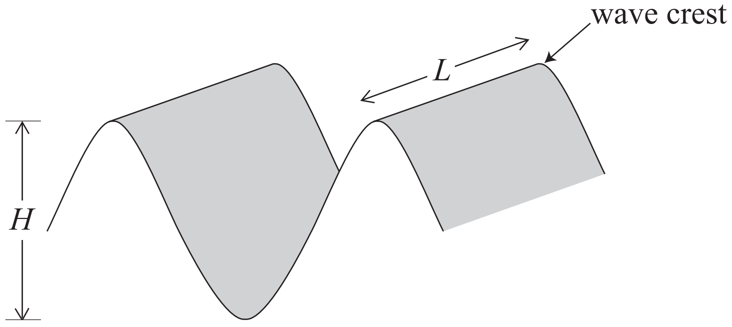
14

Turn over ▸

Areas outside the box will not be scanned for marking

10 **Figure 4** shows a sea wave of height *H* and crest length *L*.

Figure 4



The maximum power *P*, in kilowatts, available from this wave is given by

$$P = H^2 LT$$

where *T* is the time, in seconds, between the arrival of successive crests of the waves.

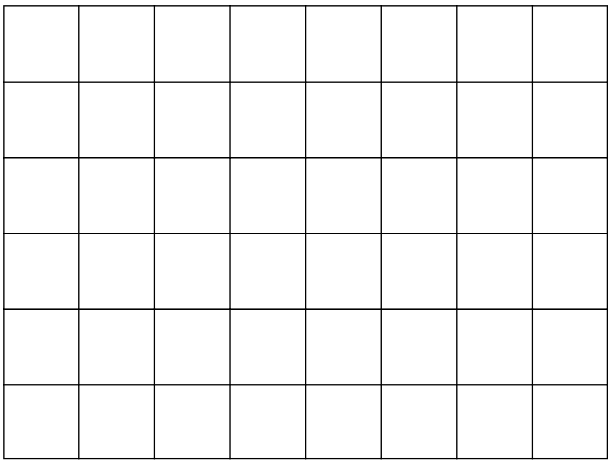
10 (a) A device known as a 'duck' is used to convert the energy of the sea wave into electrical energy. The duck accepts a wave of crest length 2.6 m.

Calculate the wave power available for conversion when the sea waves have a height *H* of 4.0 m and 5 waves arrive at the duck every minute.

wave power .... kW

(2 marks)

10 (b) Sketch on the axes below a graph showing how the power available varies with wave height.



(2 marks)

10 (c) Converting energy from water waves is one option for the generation of renewable energy. Outline why energy from water waves is renewable and the advantages and disadvantages of generating electrical energy from waves.

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

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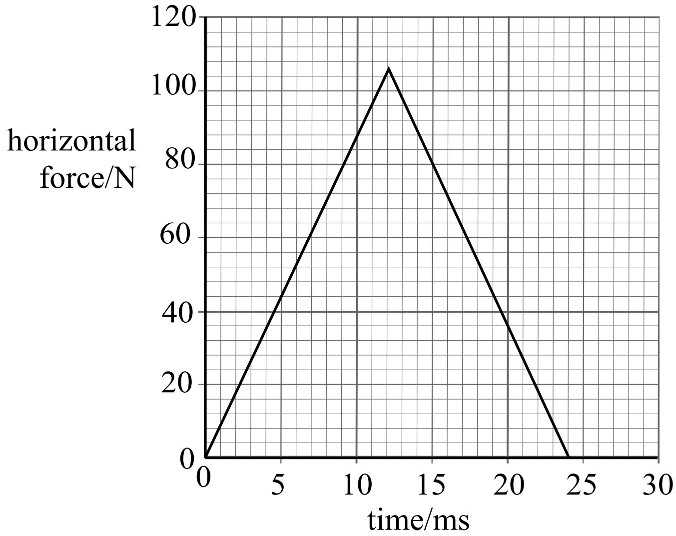
(6 marks)

10

Turn over for the next question

11 The graph shows the variation in the horizontal force acting on a tennis ball with time whilst the ball is being served.



11 (a) (i) Use the graph to show that the magnitude of the impulse that acts on the tennis ball is about 1.3 N s.

(2 marks)

11 (a) (ii) The mass of the tennis ball is 0.057 kg. Show that the impulse in part (a)(i) gives the ball a speed of about 20 m s^{-1} horizontally as the ball leaves the racquet. Assume that the ball had no horizontal speed before the impulse was applied.

(2 marks)

Areas outside the box will not be scanned for marking

11 (b) During flight the ball accelerates due to gravity. When it reaches the ground the vertical component of the velocity is $6.1\,\mathrm{m\,s^{-1}}$.
Calculate the speed and the angle between the direction of travel of the ball and the horizontal as it reaches the ground.
Assume that air resistance is negligible.

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

angle .... degree

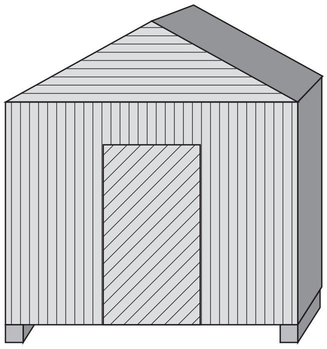
(3 marks)

7

Turn over for the next question

12 **Figure 5** shows a garden shed with no windows that is constructed from timber.

Figure 5



The shed has a total surface area (including the floor and roof) of 24 m^2. An electric heater rated at 2.5 kW is placed inside the shed. The outside air temperature is 3.0 °C.

U-value for the shed timber = 2.4 W m^{-2} K^{-1}

12 (a) (i) State the factors that determine the *U*-value of the timber used in constructing the shed.

....

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(2 marks)

12 (a) (ii) The interior of the shed reaches an equilibrium temperature when the rate at which energy is supplied by the heater is equal to the rate at which heat is lost from the shed. Estimate the equilibrium temperature of the interior of the shed.

equilibrium temperature ....

(3 marks)

12 (b) Suggest **two** reasons why the temperature inside the shed is likely to be different from your estimate in part (a)(ii).

First reason ....

....

Second reason ....

....

(2 marks)

7

END OF QUESTIONS

General Certificate of Education
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June 2009

Physics in Context (B) PHYB2

Unit 2 Physics Keeps Us Going

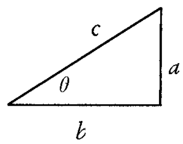
Data and Formulae Booklet

FUNDAMENTAL CONSTANTS AND OTHER NUMERICAL DATA

Quantity	*Symbol*	*Value*	*Units*
speed of light in vacuo	c	3.00×10^{8}	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_o	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^-, ν_e ; μ^-, ν_μ; τ^-, ν_τ	**+1**
antiparticles: $e^+, \overline{\nu_e}$; $\mu^+, \overline{\nu_\mu}$; $\tau^+, \overline{\nu_\tau}$	**−1**

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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	$v = H d$
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	$= \frac{1}{2}\pi r^2 \rho v^3$