Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
January 2006
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION B) **PHB1**
Unit 1 Foundation Physics

Thursday 12 January 2006 9.00 am to 10.30 am

For this paper you must have:
- a calculator
- a pencil and a ruler
- a protractor

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.
- Answer the questions in **Section A** and **Section B** in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.
- A *Formulae Sheet* is provided on page 3. Detach this perforated page at the start of the examination.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- You are reminded of the need for good English and clear presentation in your answers. Questions 7(b) and 10(c) should be answered in continuous prose. Quality of Written Communication will be assessed in these answers.

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

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

SECTION A

Answer **all** questions in this section.

There are 25 marks in this section.

1 Complete the following table by stating whether the quantity is a vector or a scalar and by giving the full name of its unit.

Quantity	Vector or Scalar	S.I. Unit
force	vector	newton
displacement		
kinetic energy		
power		

(3 marks)

2 Calculate the number of free electrons per unit volume in a metal wire of cross-sectional area $8.0 \times 10^{-8}\ m^2$ carrying a current of 2.4 A with an electron drift velocity of $2.2 \times 10^{-3}\ m\ s^{-1}$.

electron charge, $e = -1.6 \times 10^{-19}\ C$

number of free electrons per unit volume .....

(3 marks)

Detach this perforated page at the start of the examination.

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

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

Foundation Physics Electricity Formulae

$I = nAvq$

terminal p.d. $= E - Ir$

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

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

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

Waves and Nuclear Physics Formulae

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

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

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

Doppler shift $\frac{\Delta f}{f} = \frac{v}{c}$ 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

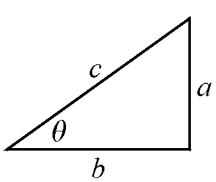
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

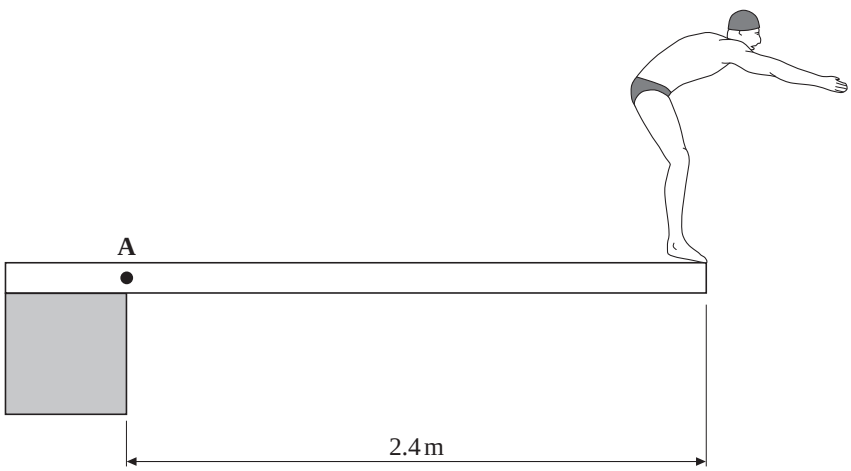
$\tan\theta = \frac{a}{b}$

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

There are no questions on this page

3 **Figure 1** shows a swimmer standing at the end of a diving board above a swimming pool. The mass of the swimmer is 72 kg and the horizontal distance between point **A** and his centre of mass is 2.4 m.

Figure 1



(a) Calculate the moment of the swimmer's weight about point **A**.

gravitational field strength of the Earth, $g = 9.8\,N\,kg^{-1}$

moment .....

(2 marks)

(b) The swimmer dives in and his centre of mass falls through 3.2 m before he reaches the water. Calculate the swimmer's vertical speed as he enters the water. Neglect air resistance.

gravitational field strength of the Earth, $g = 9.8\,N\,kg^{-1}$

speed .....

(3 marks)

4 (a) Define the electrical resistance of a component.

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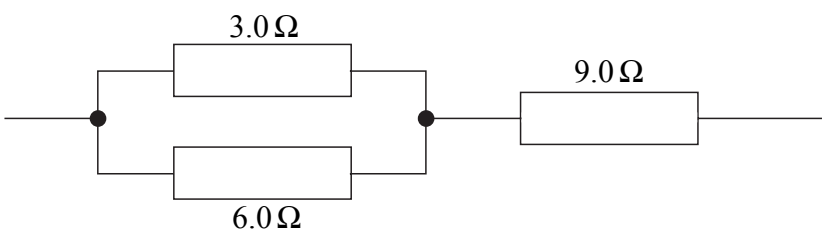
(2 marks)

(b) Calculate the total resistance of the arrangement of resistors in **Figure 2**.

Figure 2



total resistance .....

(3 marks)

(c) (i) Calculate the current in the 3.0 Ω resistor in **Figure 2** when the current in the 9.0 Ω resistor is 2.4 A.

current in the 3.0 Ω resistor .....

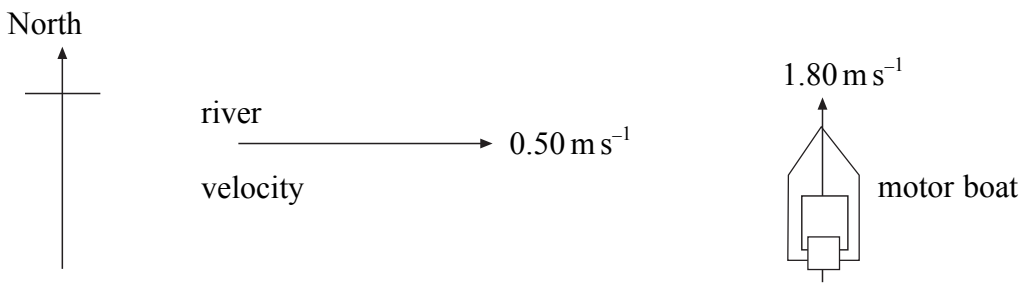
(ii) Calculate the total power dissipated by the arrangement of resistors in **Figure 2** when the current in the 9.0 Ω resistor is 2.4 A.

total power .....

(4 marks)

5 **Figure 3** shows a river which flows from West to East at a constant velocity of $0.50\,m\,s^{-1}$. A small motor boat leaves the south bank heading due North at $1.80\,m\,s^{-1}$. Find, by scale drawing or otherwise, the resultant velocity of the boat.

Figure 3



speed .....

direction .....

(5 marks)

25

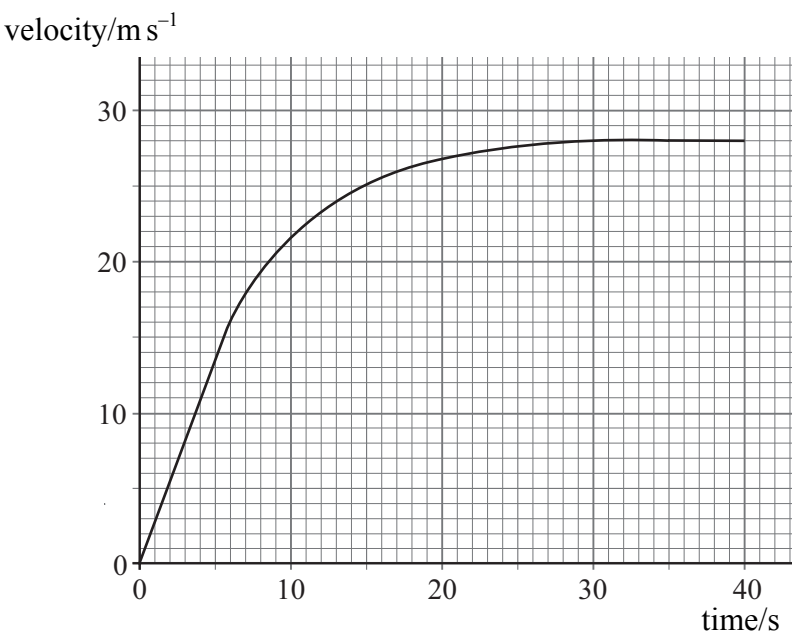
SECTION B

Answer **all** questions in this section.

There are 50 marks in this section.

6 **Figure 4** shows how the velocity of a motor car increases with time as it accelerates from rest along a straight horizontal road.

Figure 4



(a) The acceleration is approximately constant for the first five seconds of the motion. Show that, over the first five seconds of the motion, the acceleration is approximately 2.7 m s^{-2}.

(3 marks)

(b) Throughout the motion shown in **Figure 4** there is a constant driving force of 2.0 kN acting on the car.

(i) Calculate the mass of the car and its contents.

mass .....

(ii) What is the magnitude of the resistive force acting on the car after 40 s?

resistive force .....

(3 marks)

(c) Find the distance travelled by the car during the first 40 s of the motion.

distance .....

(3 marks)

9

7 Climate change and increasing global demand for oil and other fossil fuels has led to the development of ways of using renewable sources of energy to generate electricity.

(a) In the United Kingdom, wind turbines are the most widely used form of renewable energy technology.

On average, over a 24-hour period a wind turbine is rotated by $3.0 \times 10^9\ m^3$ of moving air at a wind speed of $8.5\ m\ s^{-1}$.

(i) Calculate the total kinetic energy of this moving air.

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

total kinetic energy .....

(ii) The wind turbine converts 45 % of this kinetic energy into electrical energy. Calculate the average power output of the wind turbine.

average power output .....

(6 marks)

(b) It has been suggested that tides and waves could also be used to generate electricity for the National Grid. Write about the feasibility of this suggestion, giving both advantages and disadvantages to the power industry and to the environment.

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

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(7 marks)

13

8 (a) Define the *electromotive force (emf)* of an electrical power supply.

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(2 marks)

(b) Explain why, when a battery is supplying a current to a circuit, the voltage measured between its terminals is less than its emf.

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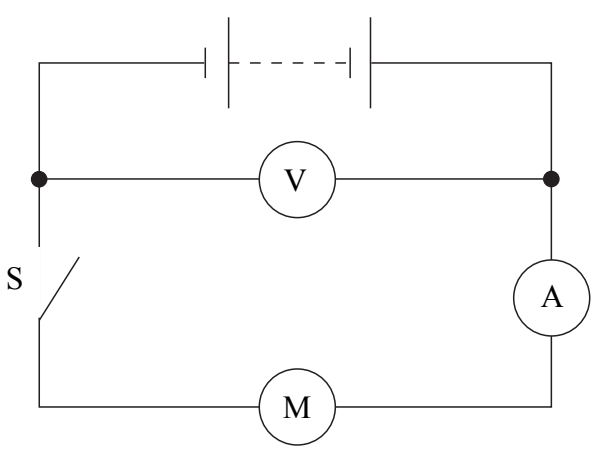
(2 marks)

(c) In the circuit shown in **Figure 5** the voltmeter has a very high resistance and the resistance of the ammeter is negligible. The motor M is being tested using a battery with an emf of 9.00 V.

Figure 5



(i) State the reading on the voltmeter when the switch S is open.

voltmeter reading .....

(ii) When S is closed and the motor is allowed to run freely the voltmeter reading is 8.41 V and the ammeter reads 0.82 A. Calculate the internal resistance of the battery.

internal resistance .....

(iii) Explain why the ammeter reading is greater than 0.82 A when the motor does work by lifting a load.

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(5 marks)

9

Turn over for the next question

9 A simple pendulum was made by attaching a small mass to a 1.20 m length of thin string. The pendulum was displaced 10.0 cm sideways and released to swing in a vertical plane. The amplitude of the motion was then observed and recorded after each oscillation. **Figure 6** shows some of the results from the experiment.

Figure 6

Oscillation	0	1	2	3	4	5	6
Amplitude/cm	10.0	8.4	7.1	5.9	5.0	4.2	3.5

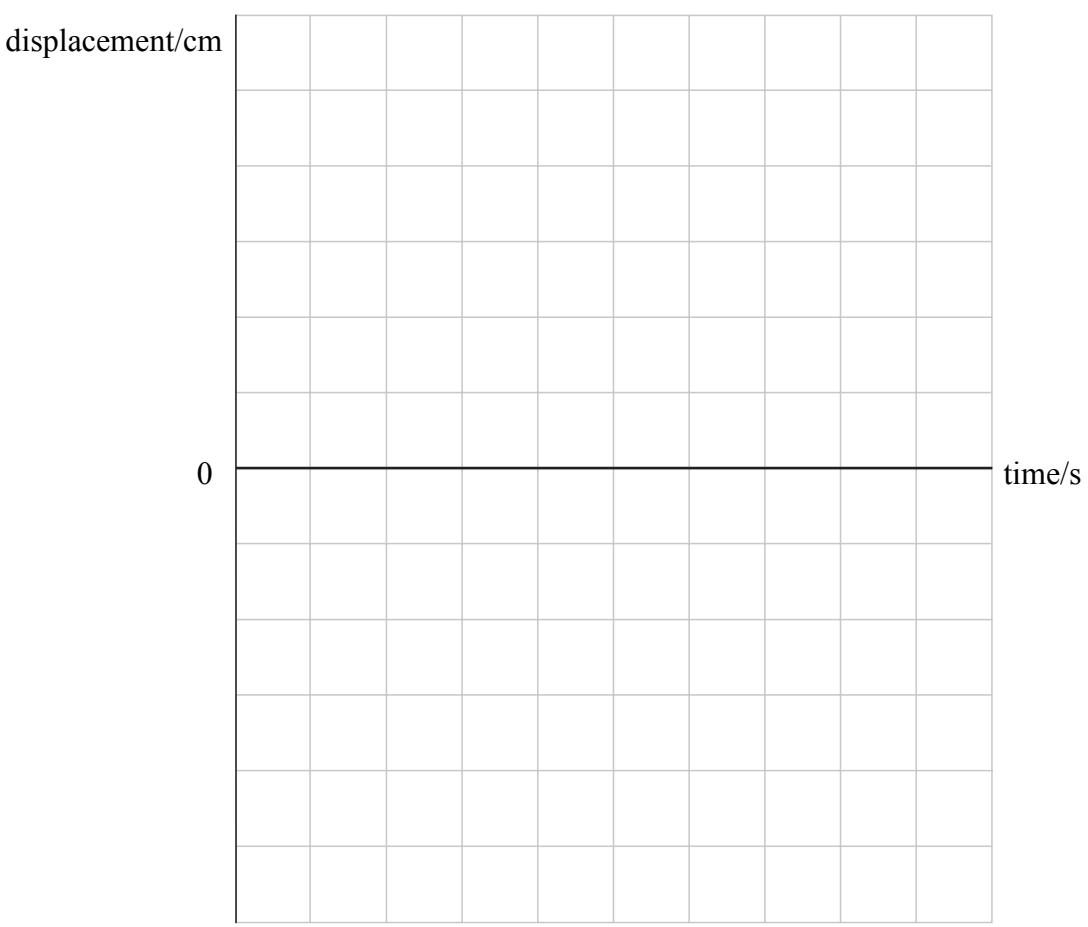
(a) The time for 6 oscillations was 13.2 s. Calculate the periodic time of the oscillations.

periodic time .....

(1 mark)

(b) On the axes in **Figure 7**, carefully sketch a graph of displacement against time for the first two oscillations of the pendulum. Mark the scale on each axis.

Figure 7



(4 marks)

(c) State the effect on the motion of the pendulum when

(i) a shorter string is used,

.....

(ii) a greater mass of the same size is used.

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(2 marks)

7

Turn over for the next question

10 Data are often captured as *analogue* signals and then converted into *digital* form for storing and processing.

(a) (i) Explain, with the aid of sketch graphs, the difference between analogue data and digital data.

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(ii) Give **one** example of a sensor for which the output is an analogue voltage and state what physical quantity it can be used to monitor.

sensor .....

physical quantity .....

(5 marks)

(b) Automatic data-logging can be used for taking a number of measurements over a period of time. Suggest **one** advantage and **one** disadvantage of using an automatic data-logging system rather than taking readings manually.

advantage .....

disadvantage .....

(2 marks)

(c) Describe an experiment in which data collection using an automatic data-logging system is preferable to one in which a human observer takes and records the measurements.

Two of the 5 marks for this question are available for the quality of your written communication.

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(5 marks)

END OF QUESTIONS

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