Surname		Other Names	
Centre Number						Candidate Number				
Candidate Signature										

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General Certificate of Education
January 2002
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION B) PHB1
Unit 1

Monday 14 January 2002 Morning Session

In addition to this paper you will require:
- a calculator;
- a ruler.

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 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.
- All working must be shown, otherwise you may lose marks.
- 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.
- Mark allocations are shown in brackets.
- Marks are awarded for units in addition to correct numerical answers, and for the use of appropriate numbers of significant figures.
- You are expected to use a calculator where appropriate.
- You will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary, where appropriate.
- The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

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			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

SECTION A

Answer **all** questions in the spaces provided.

Total for this section: *25 marks*

1 (a) (i) State what happens to the electrical resistance of a metal when it becomes superconducting.

.....

(1 mark)

(ii) State the necessary condition for this to happen.

.....

(1 mark)

(b) State **one** application of a superconducting material.

.....

(1 mark)

2 **Figure 1** shows a graph of potential difference against current for a thermistor.

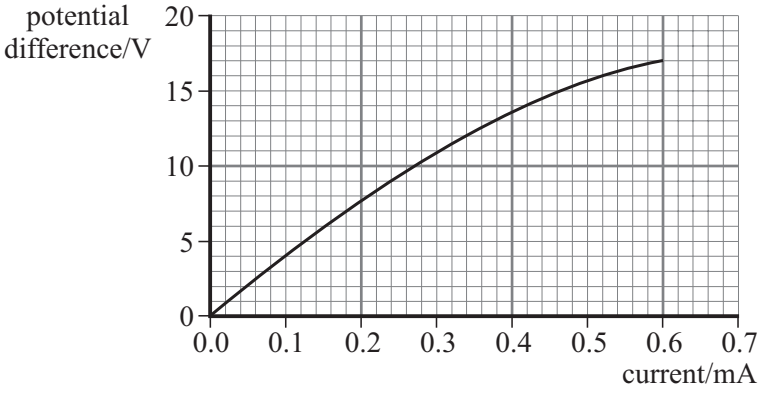


Figure 1

(a) Sketch an experimental arrangement that you could use to collect the data for this graph.

(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		
υ_e	1		
$\overline{\upsilon}_e$	–1		
μ^-		1	
μ^+		–1	
υ_μ		1	
$\overline{\upsilon}_\mu$		–1	
τ^-			1
τ^+			–1
υ_τ			1
$\overline{\upsilon}_\tau$			–1

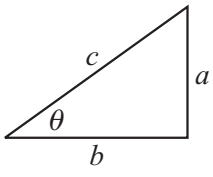
Geometrical and Trigonometrical Relationships

circumference of circle $= 2\pi r$

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

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

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



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

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

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

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

Turn over ►

NO QUESTIONS APPEAR ON THIS PAGE

(b) The thermistor is connected in parallel with a 2.0 kΩ resistor. The current in the resistor is 6.0 mA.

(i) Calculate the potential difference across the thermistor.

Potential difference = ...
(2 marks)

(ii) Use the graph to calculate the power dissipated in the thermistor.

Power dissipated in thermistor = ...
(3 marks)

(c) Describe and explain what happens to the resistance of the thermistor as its temperature increases.

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(2 marks)

3 (a) State the principle of moments.

.....

.....

.....
(3 marks)

Turn over ►

(b) **Figure 2** shows a horizontal beam pivoted close to one end. The beam is supported by a spring and is loaded with weights of 2.0 N and 5.0 N as shown. All dimensions are marked on the diagram **and are measured from the pivot.**

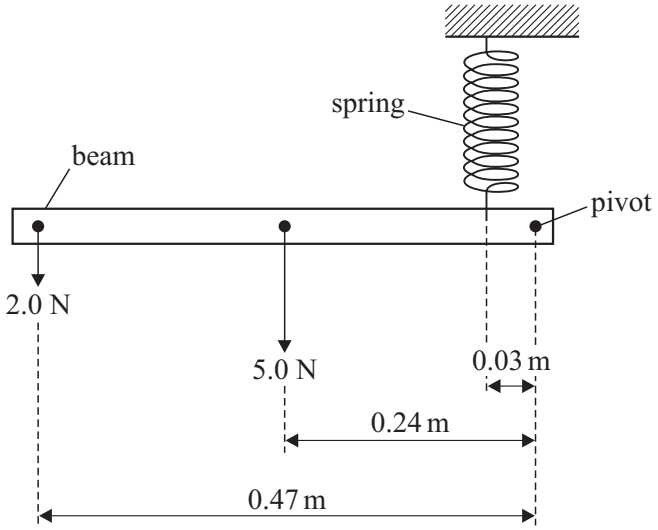

Figure 2

By taking moments about the pivot, calculate the tension in the spring when the beam is horizontal.

Tension = ...

(3 marks)

4 **Figure 3** shows three ropes attached to a ring. The ropes and the ring all lie in a horizontal plane and are in equilibrium. The tension in rope **A** is shown in **Figure 3**.

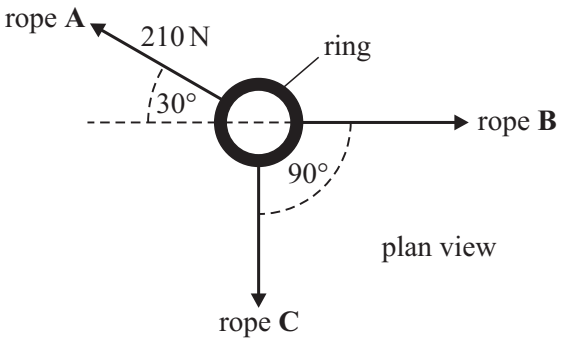

Figure 3

Calculate the tension in ropes **B** and **C**.

Tension in rope **B** = ...

Tension in rope **C** = ...
(3 marks)

5 **Figure 4** shows a lorry of mass 1.2×10^3 kg parked on a platform used to weigh vehicles. The lorry compresses the spring that supports the platform by 0.030 m.

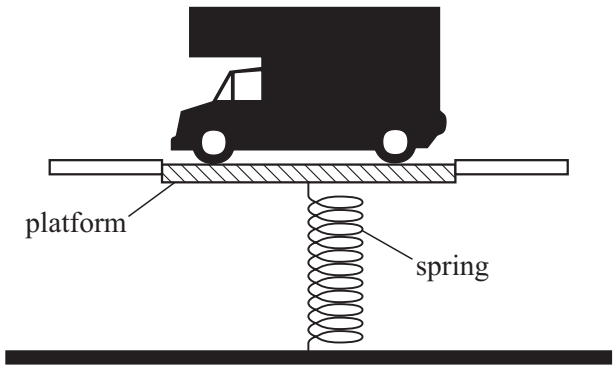

Figure 4

Calculate the energy stored in the spring.

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

Energy stored = ...
(3 marks)

25

Turn over ►

SECTION B

Answer **all** questions in the spaces provided.

6 **Total for this question: *6 marks***

Figure 5 shows a circuit that is part of a television set. **Figure 6** shows the waveform produced by the circuit.

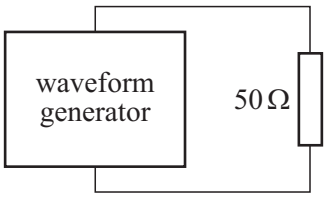

Figure 5

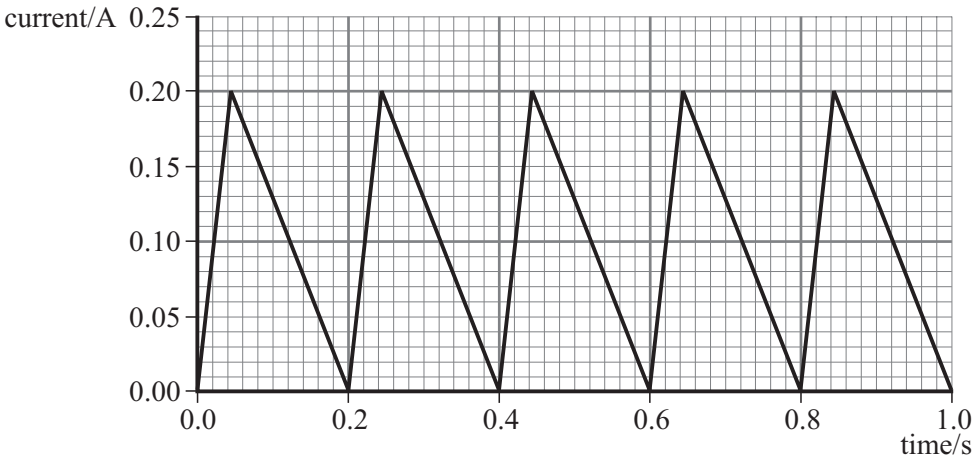

Figure 6

(a) Calculate the quantity of charge that flows through the resistor every second.

Charge = ...

(3 marks)

(b) An analogue-to-digital converter (ADC) is connected across the resistor as shown in **Figure 7**. The conversion calibration graph for this device is shown in **Figure 8**.

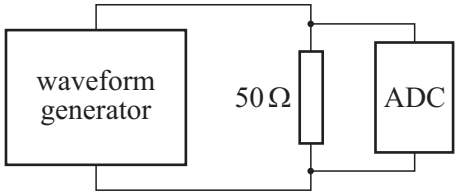

Figure 7

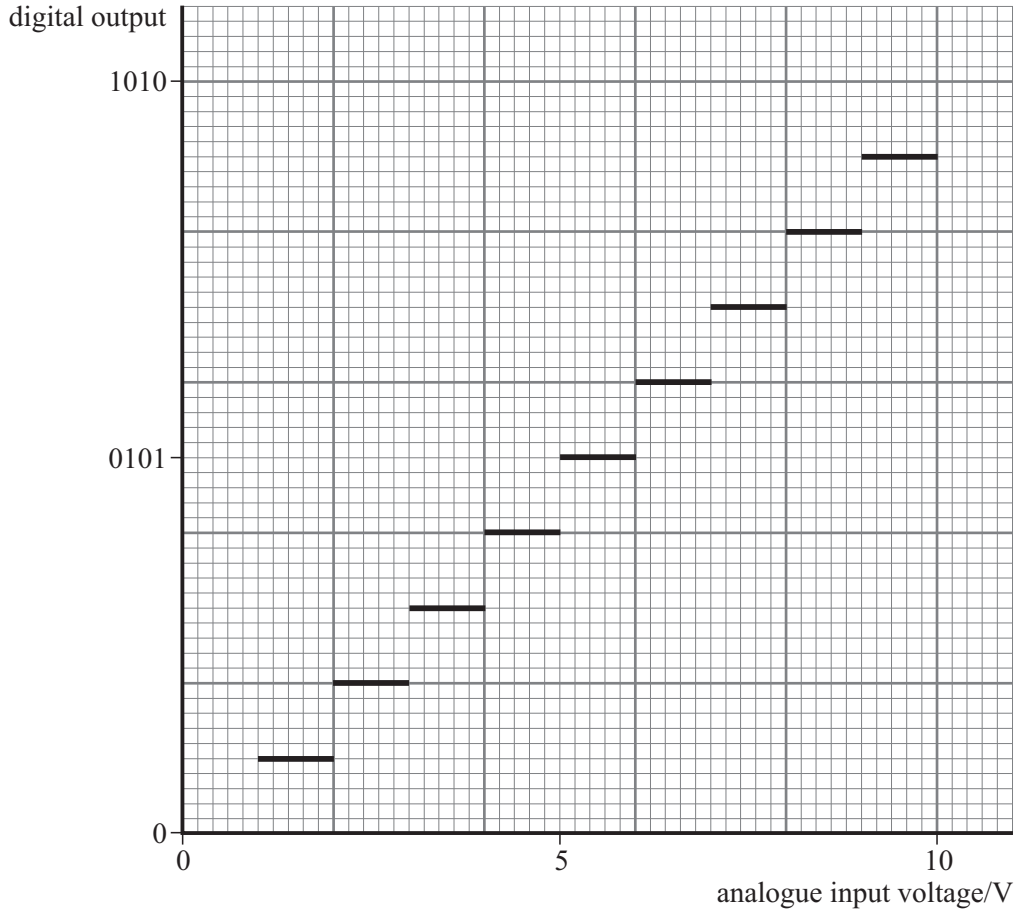

Figure 8

Determine the digital output that the converter will give when the time is 0.060 s.

Digital output = ...

(3 marks)

6

Turn over ►

7 **Total for this question: *16 marks***

A passenger aircraft has a mass of 3.2×10^5 kg when fully laden. It is powered by four jet engines each producing a maximum thrust of 270 kN.

(a) (i) Calculate the total force of the engines acting on the aircraft.

Force = ...
(1 mark)

(ii) Show that the initial acceleration of the aircraft with the engines set to full thrust is about $3.4\,\text{m s}^{-2}$. Ignore any frictional forces.

(2 marks)

(b) The aircraft starts from rest at the beginning of its take-off and has a take-off speed of $90\,\text{m s}^{-1}$.

(i) Calculate the time taken for the aircraft to reach its take-off speed if frictional forces are ignored.

Time taken = ...
(2 marks)

(ii) Frictional forces reduce the actual acceleration of the aircraft to $2.0\,\text{m s}^{-2}$. Calculate the mean total frictional force acting against the aircraft during the time taken to reach its take-off speed.

Frictional force = ...
(2 marks)

(c) Calculate the minimum runway length required by this aircraft for take-off when the acceleration is $2.0\,m\,s^{-2}$.

Minimum runway length = ...

(2 marks)

(d) The cruising speed of the aircraft in level flight with the engines at maximum thrust is a constant $260\,m\,s^{-1}$. The pilot adjusts the thrust so that the **horizontal** acceleration is always $2.0\,m\,s^{-2}$.

Calculate the time taken from take-off for the aircraft to reach its cruising speed.

Time taken = ...

(2 marks)

(e) When it is at cruising speed, the aircraft travels at a constant velocity and at a constant height. Explain, in terms of the horizontal and vertical forces acting on the aircraft, how this is achieved. Two of the 5 marks in this question are available for the quality of your written communication.

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(5 marks)

16

8 **Total for this question: *11 marks***

A manufacturer asks you to design the heating element in a car rear-window de-mister. The design brief calls for an output of 48 W at a potential difference of 12 V. **Figure 9** shows where the eight elements will be on the car window before electrical connections are made to them.

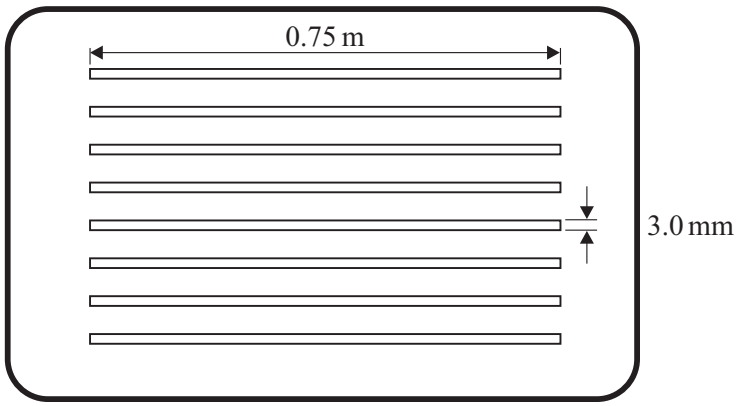

Figure 9

(a) Calculate the current supplied by the power supply.

Current = ...
(1 mark)

(b) One design possibility is for the eight elements to be connected in parallel.

(i) Calculate the current in each element in this parallel arrangement.

Current = ...
(1 mark)

(ii) Calculate the resistance required for each element.

Resistance = ...
(2 marks)

(c) Another design possibility is to have the eight elements connected in series.

(i) Calculate the current in each element in this series arrangement.

Current = ...
(1 mark)

(ii) Calculate the resistance required for each element.

Resistance = ...
(2 marks)

(d) State **one** disadvantage of the series design compared to the parallel arrangement.

.....

.....
(1 mark)

(e) The series design is adopted. Each element is to have a rectangular cross-section of 0.12 mm by 3.0 mm. The length of each element is to be 0.75 m.

(i) State the units of resistivity.

.....
(1 mark)

(ii) Calculate the resistivity of the material from which the element must be made.

Resistivity = ...
(2 marks)

11

9 **Total for this question: *17 marks***

A farmer living on a remote Scottish farm wishes to provide the farm with an electrical supply independent of the mains electricity. He opts for a combination of solar energy and tidal energy with each type of energy contributing half of his total needs.

(a) The farmer estimates that he will consume energy at an average rate of 4.9 kW. Calculate the number of joules of energy he requires per day.

Energy required per day = ...
(1 mark)

(b) The tidal contribution to his energy comes from a sea loch that is filled twice per day by the tide. The farmer intends to build a barrage across this loch and to use the outgoing tide to drive turbines that will generate electrical energy. The surface area of water retained by the barrage is 55 000 m^2 and the average difference between high and low tide water levels is 1.2 m.

(i) Show that about 7.3 $\times$ 10^7 kg of water moves through the turbines with each tide.

density of the seawater = 1100 $kg\,m^{-3}$

(1 mark)

(ii) Calculate the gravitational potential energy made available by this water flow each tide.

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

Gravitational potential energy = ...
(2 marks)

(iii) The generator can transform 25% of this energy into an electrical form. Calculate the total electrical energy that this system will output every day given that the loch will be filled twice during this time.

Energy output per day = ...
(1 mark)

(c) The specifications for the solar panels are shown in **Figure 10**.

Operating current = 4.6 A

Operating voltage at the operating current = 17 V

Open-circuit voltage = 21 V

Figure 10

(i) Explain why the open-circuit voltage and the operating voltage are not the same.

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(3 marks)

(ii) The panels produce $0.25\,\text{kW}\,\text{m}^{-2}$.

Estimate the average time per day during which the solar panels will produce energy.

.....

(1 mark)

(iii) Estimate the total area of solar panels that will be needed in order to generate half the energy needs of the farm.

Area of solar panels = ...

(2 marks)

Turn over ►

(d) A third option for the farmer is for him to obtain his energy from the wind.

Compare the advantages and disadvantages of solar-based and wind-based energy sources for the farmer's needs. Two of the 6 marks in this question are available for the quality of your written communication.

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(6 marks)

17

END OF QUESTIONS