| Surname | | Other Names | |
|---|---|---|---|
| Centre Number | | | Candidate Number | | | | | | | | | |
| Candidate Signature | | | | | | | | | | | | |

Leave blank

General Certificate of Education
June 2004
Advanced Subsidiary Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

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

Monday 14 June 2004 Afternoon 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 | | | |
| 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.

**Total for this section: *25 marks***

**1** The object in **Figure 1** is in equilibrium.

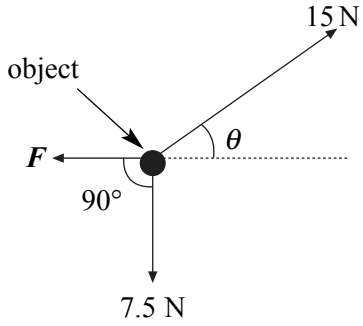



**Figure 1**

By resolving forces, calculate:

(a) the angle $\theta$;

Angle $\theta$ .....

*(2 marks)*

(b) the magnitude of the force $F$.

Magnitude of the force $F$ .....

*(1 mark)*

**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 $L$ | | |
|---|---|---|---|
| | $L_e$ | $L_\mu$ | $L_\tau$ |
| $e^-$ | 1 | | |
| $e^+$ | −1 | | |
| $\upsilon_e$ | 1 | | |
| $\overline{\upsilon}_e$ | −1 | | |
| $\mu^-$ | | 1 | |
| $\mu^+$ | | −1 | |
| $\upsilon_\mu$ | | 1 | |
| $\overline{\upsilon}_\mu$ | | −1 | |
| $\tau^-$ | | | 1 |
| $\tau^+$ | | | −1 |
| $\upsilon_\tau$ | | | 1 |
| $\overline{\upsilon}_\tau$ | | | −1 |

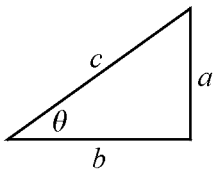
## Geometrical and Trigonometrical Relationships

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**

**2** **Figure 2** shows a spacecraft that initially moves at a constant velocity of 890 m s$^{-1}$ towards **A**.

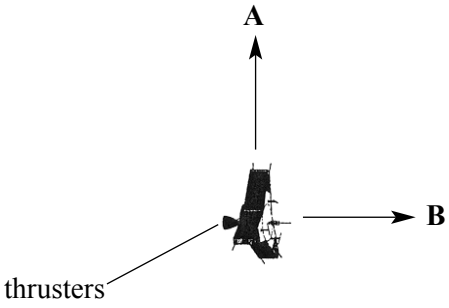



**Figure 2**

To change course, a sideways force is produced by firing thrusters. This increases the velocity towards **B** from 0 to 60 m s$^{-1}$ in 25 s.

(a) The spacecraft has a mass of $5.5 \times 10^4$ kg. Calculate:

(i) the acceleration of the spacecraft towards **B**;

Acceleration .....

*(1 mark)*

(ii) the force on the spacecraft produced by the thrusters.

Force on spacecraft .....

*(2 marks)*

(b) Calculate the magnitude of the resultant velocity after 25 s.

Magnitude of resultant velocity .....

*(2 marks)*

(c) Calculate the angle between the initial and final directions of travel.

Angle .....

*(1 mark)*

**3** A landscape gardener wanted to lift a uniform stone paving slab on a step. The gardener inserted the end of a long non-uniform metal bar under the slab and arranged the system as shown in **Figure 3**.

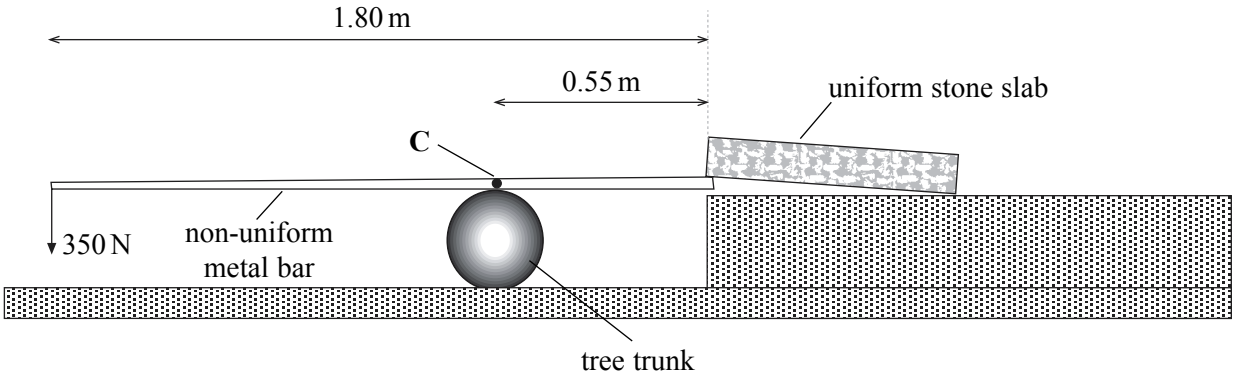



**Figure 3**

The tree trunk was positioned so that the metal bar was pivoted at its centre of mass, **C**. The gardener just managed to lift the end of the slab by exerting a downward force of 350 N on the end of the bar.

(a) Show on **Figure 3** all the other forces acting **on the metal bar** when it just lifted the end of the slab.

*(2 marks)*

(b) Calculate:

(i) the lifting force exerted on the edge of the slab;

Lifting force .....

*(3 marks)*

(ii) the weight of the uniform stone slab.

Weight .....

*(1 mark)*

**4** **Figure 4** shows the components that are to be connected in a circuit to investigate how the current *I* in a filament lamp varies with the potential difference *V* across it.

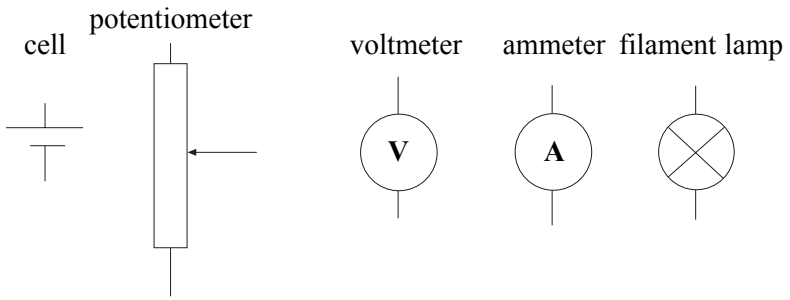



**Figure 4**

(a) Draw below, a circuit diagram to show how these components should be connected to obtain voltage and current data over the full range from 0 V to the maximum voltage available from the cell.

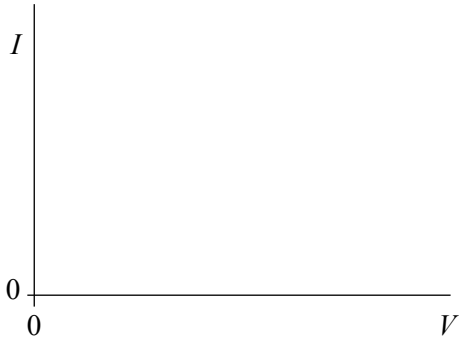
*(2 marks)*

(b) The lamp used is rated at 1.25 V, 0.3 W. Calculate the current in the lamp when it is working normally.

Current .....

*(1 mark)*

(c) Sketch on the axes below the shape of the graph of *I* against *V* that the results of the experiment should produce.




*(1 mark)*

**Turn over ▶**

**5** (a) Calculate the length of copper wire that has a diameter of $1.6 \times 10^{-3}$ m and a resistance of 25 Ω.

resistivity of copper = $1.7 \times 10^{-8}$ Ω m

Length of wire .....

*(3 marks)*

(b) The resistance of copper wire is **not** zero. Explain why this fact leads to the use of alternating current rather than direct current when transmitting electrical energy.

.....

.....

.....

.....

.....

.....

.....

*(3 marks)*

25

**TURN OVER FOR THE NEXT SECTION**

## SECTION B

Answer **all** questions in this section.

There are **50** marks in this section.

**Total for this question:** ***10 marks***

**6** **Figure 5** shows the principle of a hydroelectric pumped storage plant. During times when there is a low demand for electricity, the spare capacity of other power stations is used to pump water from the lake into the reservoir. The potential energy of the water is then converted into electricity when needed to satisfy peak demands.

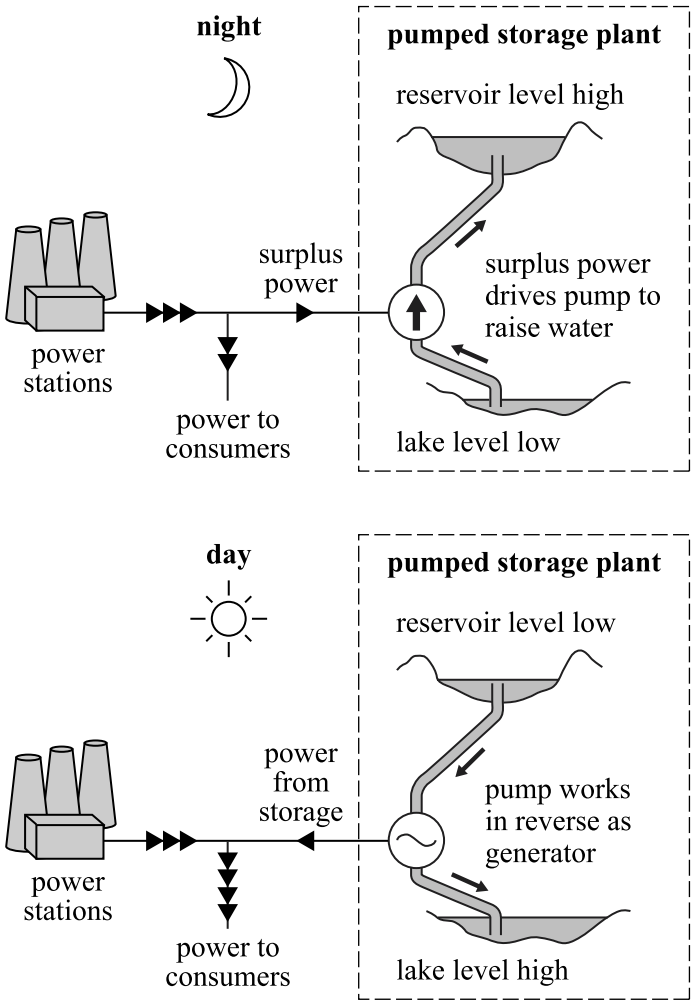



**Figure 5**

For this plant the water falls a mean distance of 370 m between the reservoir and the generator. The mass of water stored in the reservoir when it is full is $1.0 \times 10^{10}$ kg.

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

(a) (i) Show that the useful gravitational potential energy stored when the reservoir is full is about $4 \times 10^{13}$ J.

*(2 marks)*

(ii) Calculate the speed of the water as it reaches the generator assuming that no energy is lost as the water falls.

Speed of water .....

*(2 marks)*

(iii) The pumped storage plant has four 100 MW generators. Calculate the longest time, in hours, for which the stored energy alone could provide power at maximum output. Assume that all the stored gravitational potential energy can be converted into electrical energy.

Time .....

*(3 marks)*

(b) In practice not all the stored energy that is put into the system during the night can be retrieved as electrical energy during the day. State and explain how energy is lost in the system.

.....

.....

.....

.....

.....

.....

.....

*(3 marks)*

10

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

**7** The following data were obtained when two students performed an experiment to determine the acceleration of free fall. One student released a lump of lead the size of a tennis ball from a window in a tall building and the other measured the time for it to reach the ground.

| | | |
|---|---|---|
| distance fallen by the lump of lead | = | 35 m |
| time to reach the ground | = | 2.7 s |

(a) Calculate a value for the acceleration of free fall, *g*, from these observations.

*g* .....

*(2 marks)*

(b) State and explain the effect on the value of *g* obtained by the students if a tennis ball were used instead of the lump of lead.

.....

.....

.....

.....

.....

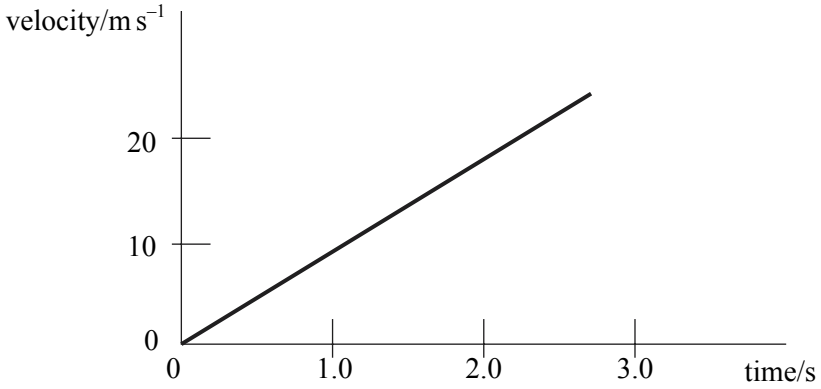
.....

.....

.....

*(3 marks)*

(c) The graph in **Figure 6** shows how the velocity changes with time for the lump of lead from the time of release until it hits the ground. Sketch on the same axes a graph to show how the velocity would change with time if a tennis ball were used by the students instead of the lump of lead.




*(2 marks)*

**Figure 6**

7

**TURN OVER FOR THE NEXT QUESTION**

**Total for this question: *10 marks***

**8** **Figure 7** shows how the resistance $R$ of two components **X** and **Y** varies with temperature $\theta$.

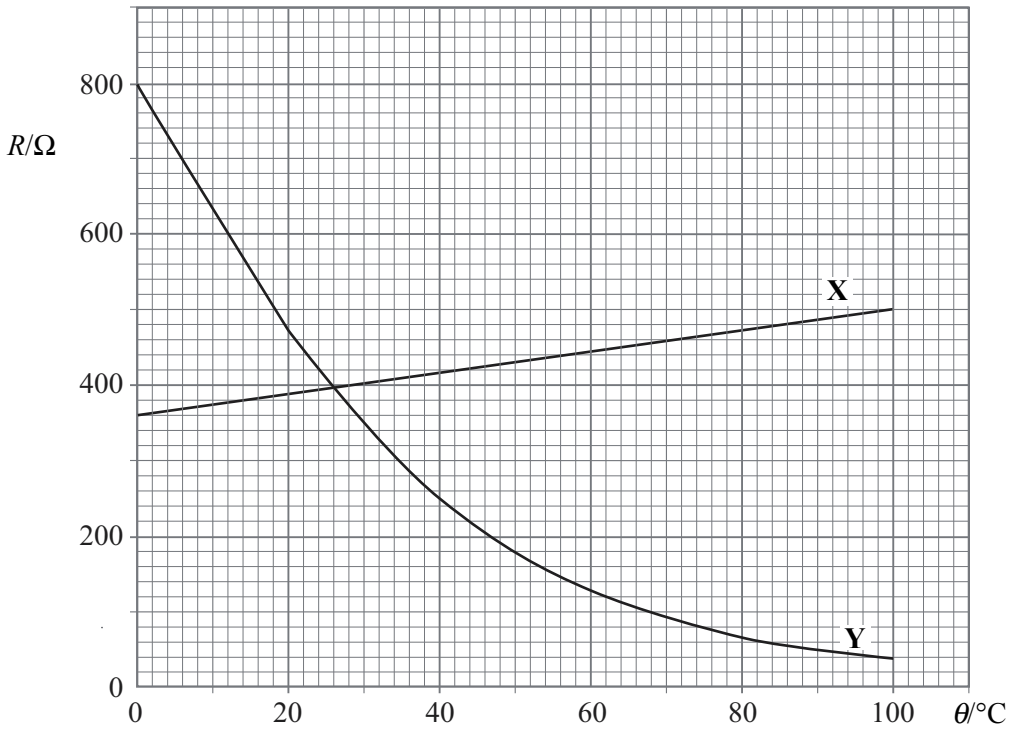



**Figure 7**

(a) (i) State whether **X** or **Y** is a resistor made of metal wire.

.....

*(1 mark)*

(ii) State the name of the other component.

Name of component .....

*(1 mark)*

(b) Explain in terms of the charge carriers why the resistance of component **X** increases when temperature increases whilst that of component **Y** decreases.

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

*(5 marks)*

(c) (i) In one experiment the components **X** and **Y** were connected in parallel and were found to carry the same current. State the temperature at which the experiment was performed.

Temperature .....

*(1 mark)*

(ii) In another experiment the components **X** and **Y** were connected in series to a 4.5 V supply that had negligible internal resistance. The experiment was carried out at a temperature of 70° C. Calculate the current in the circuit.

Current .....

*(2 marks)*

10

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

**9** **Figure 8** shows two circuits **X** and **Y** that were used by a student to test a battery of three identical cells. In circuit **X** there was no load resistor and in circuit **Y** a load resistor was connected. You can assume that the meters in the circuits were ideal. Their readings are shown on each diagram.

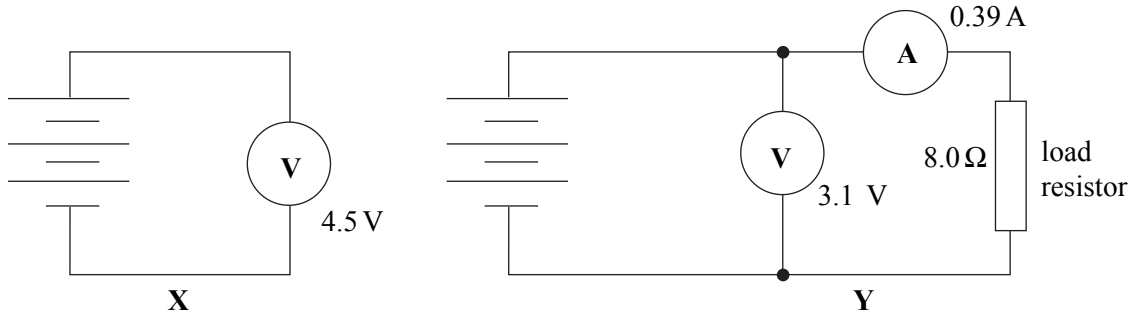



**Figure 8**

(a) (i) Explain what is meant by the *internal resistance* of a battery and why this explains the difference between the voltages recorded in the two circuits.

.....

.....

.....

.....

.....

.....

.....

*(3 marks)*

(ii) Calculate the internal resistance of **a single cell**.

Internal resistance .....

*(3 marks)*

(b) One of the cells in the battery is reversed. Determine the new reading:

(i) on the voltmeter in circuit **X**;

Voltmeter reading in **X** .....

*(1 mark)*

(ii) on the ammeter in circuit **Y**.

Ammeter reading in **Y** .....

*(2 marks)*

9

**Total for this question: *14 marks***

**10** **Figure 9** shows a variable linear resistor (a linear potentiometer) that is to be used as a position sensor. The output voltage to a computer interface depends on the position of the rigid bar **B**.

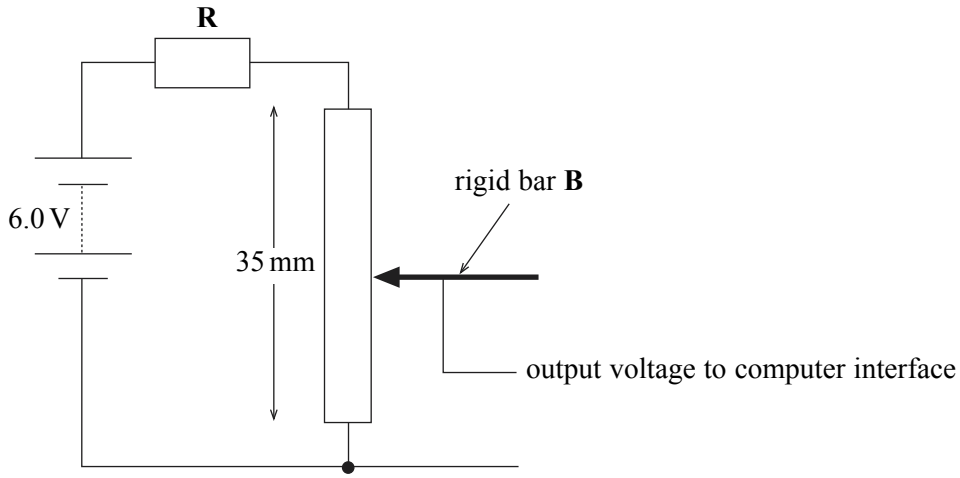



**Figure 9**

(a) The total resistance of the variable resistor is 150 Ω. The circuit designer makes the maximum voltage to the computer interface equal to 4.0 V. The 6.0 V supply has negligible internal resistance.

(i) Show that the value of the resistor **R** is 75 Ω.

*(2 marks)*

(ii) Calculate the total power dissipated in the circuit.

Total power dissipated .....

*(2 marks)*

(b) The computer is calibrated so that 0 V is represented as the binary number 0000 and 4.0 V as 1010.

(i) Calculate the smallest voltage change that the computer can record.

Smallest voltage change .....

*(1 mark)*

(ii) Calculate the smallest movement of the rigid bar **B** that can be detected by the computer.

Smallest movement .....

*(1 mark)*

(iii) Suggest **two** ways in which the system may be modified so that a smaller movement can be detected by the computer.

.....

.....

*(2 marks)*

(c) Other than the need for remote sensing, the use of data capture using sensors is essential or provides significant advantages over the manual collection of data. Give **two** experimental situations in which this is the case and explain why you suggest the use of data capture techniques.

Two of the 6 marks for this question are available for the quality of your written communication.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

*(6 marks)*

14

**END OF QUESTIONS**

**THERE ARE NO QUESTIONS PRINTED ON THIS PAGE**