

General Certificate of Education  
June 2003  
Advanced Level Examination



**PHYSICS (SPECIFICATION B)  
Unit 6 Exercise 1**

**PHB6/1**

to be conducted between 1 March 2003 and 22 May 2003

**In addition to this paper you will require:**

- an 8-page answer book;
- A4 graph paper;
- a calculator;
- a ruler.

Time allowed: 1 hour 30 minutes

**Instructions**

- Use blue or black ink or ball-point pen.
- Write the information required on the front of the answer book. The *Examining Body* for this unit is AQA. The *Paper Reference* is PHB6/1.
- Answer **all** questions. A separate sheet of graph paper is required.
- *Formulae Sheets* are provided on pages 3 and 4. Detach this perforated page at the start of the examination.
- Show all your working. Do all rough work in the answer book. Cross through any work you do not want marked.

**Information**

- The maximum mark for this paper is 39.
- Mark allocations are shown in brackets.
- 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**

- Before commencing the first part of any question, read the question through completely.
- Ensure that **all** measurements taken, including repeated readings, gradients, derived quantities, etc., are recorded to an appropriate number of significant figures with due regard to the accuracy of measurement.
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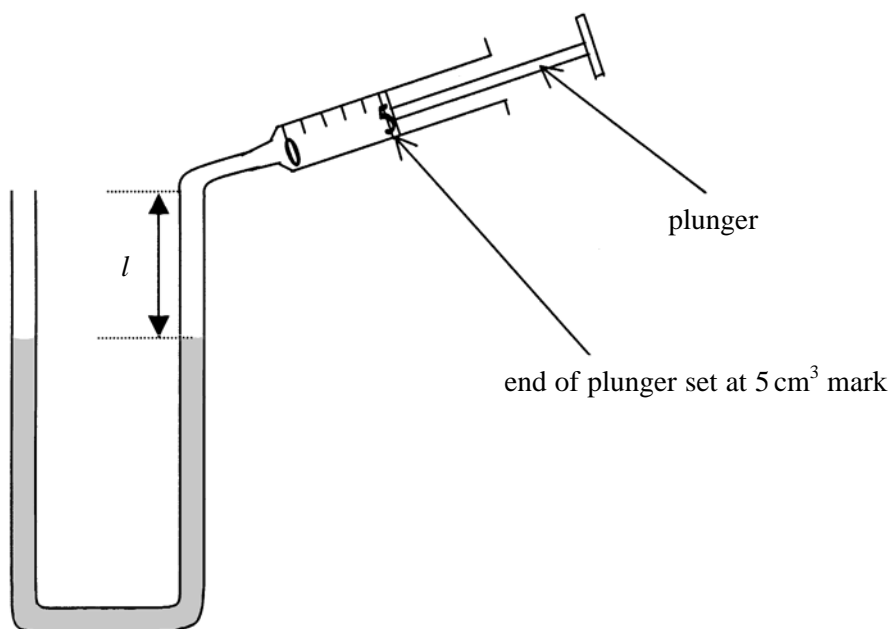
Answer **all** questions.

- 1 You are going to investigate the relationship between the pressure and the volume of some air trapped in a syringe connected to one arm of a U-tube.

You have been provided with a short length of glass tubing of the same internal diameter as that used in the U-tube.

- (a) (i) Measure and record the internal diameter of the short length of tube to the nearest mm. (2 marks)
- (ii) Calculate the cross sectional area,  $A$ , of the inside of the tube in  $\text{cm}^2$ . (2 marks)

You have been provided with the apparatus shown in **Figure 1**, with the plunger of the syringe set at the  $5 \text{ cm}^3$  mark. The liquid level is the same vertical height on each side of the U-tube.



**Figure 1**

$l$  is the length of the air column trapped in the right hand side of the U-tube.

- (b) Ignoring the volume of air in the tubing connecting the syringe to the right hand side of the U-tube, calculate and record in  $\text{cm}^3$  the **total** volume,  $V$ , of air trapped in the syringe and in the right hand side of the U-tube. (2 marks)

You are now going to adjust the syringe in order to obtain a series of values of volumes of trapped air and the difference in the heights of liquid exerting a pressure on the air.

- (c) (i) With a marker pen, mark the level of the liquid on each side of the U-tube. Explain how you decided where to mark the liquid level. (1 mark)
- (ii) By adjusting the position of the syringe plunger mark a series of corresponding positions of the liquid levels in each side of the U-tube. You should use the full range of graduated plunger positions. Explain how you ensured that the positions correspond to each other. (1 mark)

Detach this perforated page at the start of the examination.

### Foundation Physics Mechanics Formulae

$$\text{moment of force} = Fd$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \frac{1}{2}(u + v)t$$

$$\text{for a spring, } F = k\Delta l$$

$$\text{energy stored in a spring} = \frac{1}{2}F\Delta l = \frac{1}{2}k(\Delta l)^2$$

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

### Foundation Physics Electricity Formulae

$$I = nAvq$$

$$\text{terminal p.d.} = E - Ir$$

$$\text{in series circuit, } R = R_1 + R_2 + R_3 + \dots$$

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

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

### Waves and Nuclear Physics Formulae

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

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

$$\text{diffraction grating } n\lambda = d \sin \theta$$

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

$$\text{Hubble law } v = Hd$$

$$\text{radioactive decay } A = \lambda N$$

### Properties of Quarks

Type of quark	Charge	Baryon number
up u	$+\frac{2}{3}e$	$+\frac{1}{3}$
down d	$-\frac{1}{3}e$	$+\frac{1}{3}$
$\bar{u}$	$-\frac{2}{3}e$	$-\frac{1}{3}$
$\bar{d}$	$+\frac{1}{3}e$	$-\frac{1}{3}$

### Lepton Numbers

Particle	Lepton number $L$		
	$L_e$	$L_\mu$	$L_\tau$
$e^-$	1		
$e^+$	-1		
$\nu_e$	1		
$\bar{\nu}_e$	-1		
$\mu^-$		1	
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$\bar{\nu}_\mu$		-1	
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$\tau^+$			-1
$\nu_\tau$			1
$\bar{\nu}_\tau$			-1

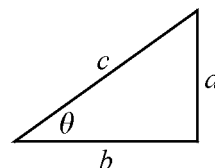
### Geometrical and Trigonometrical Relationships

$$\text{circumference of circle} = 2\pi r$$

$$\text{area of a circle} = \pi r^2$$

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

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



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

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

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

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

Detach this perforated page at the start of the examination.

### Circular Motion and Oscillations

$$v = r\omega$$

$$a = -(2\pi f)^2 x$$

$$x = A \cos 2\pi ft$$

$$\text{maximum } a = (2\pi f)^2 A$$

$$\text{maximum } v = 2\pi f A$$

$$\text{for a mass-spring system, } T = 2\pi \sqrt{\frac{m}{k}}$$

$$\text{for a simple pendulum, } T = 2\pi \sqrt{\frac{l}{g}}$$

### Fields and their Applications

$$\text{uniform electric field strength, } E = \frac{V}{d} = \frac{F}{Q}$$

$$\text{for a radial field, } E = \frac{kQ}{r^2}$$

$$k = \frac{1}{4\pi\epsilon_0}$$

$$g = \frac{F}{m}$$

$$g = \frac{GM}{r^2}$$

$$\text{for point masses, } \Delta E_p = GM_1 M_2 \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$

$$\text{for point charges, } \Delta E_p = kQ_1 Q_2 \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$$

$$\text{for a straight wire, } F = BIl$$

$$\text{for a moving charge, } F = BQv$$

$$\phi = BA$$

$$\text{induced emf} = \frac{\Delta(N\phi)}{t}$$

$$E = mc^2$$

### Temperature and Molecular Kinetic Theory

$$T/\text{K} = \frac{(pV)_T}{(pV)_{tr}} \times 273.16$$

$$pV = \frac{1}{3} Nm \langle c^2 \rangle$$

$$\text{energy of a molecule} = \frac{3}{2} kT$$

### Heating and Working

$$\Delta U = Q + W$$

$$Q = mc\Delta\theta$$

$$Q = ml$$

$$P = Fv$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{power input}}$$

$$\text{work done on gas} = p\Delta V$$

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$$\text{stress} = \frac{F}{A}$$

$$\text{strain} = \frac{\Delta l}{l}$$

$$\text{Young modulus} = \frac{\text{stress}}{\text{strain}}$$

### Capacitance and Exponential Change

$$\text{in series, } \frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\text{in parallel, } C = C_1 + C_2$$

$$\text{energy stored by capacitor} = \frac{1}{2} QV$$

$$\text{parallel plate capacitance, } C = \frac{\epsilon_0 \epsilon_r A}{d}$$

$$Q = Q_0 e^{-t/RC}$$

$$\text{time constant} = RC$$

$$\text{time to halve} = 0.69 RC$$

$$N = N_0 e^{-\lambda t}$$

$$A = A_0 e^{-\lambda t}$$

$$\text{half-life, } t_{\frac{1}{2}} = \frac{0.69}{\lambda}$$

### Momentum and Quantum Phenomena

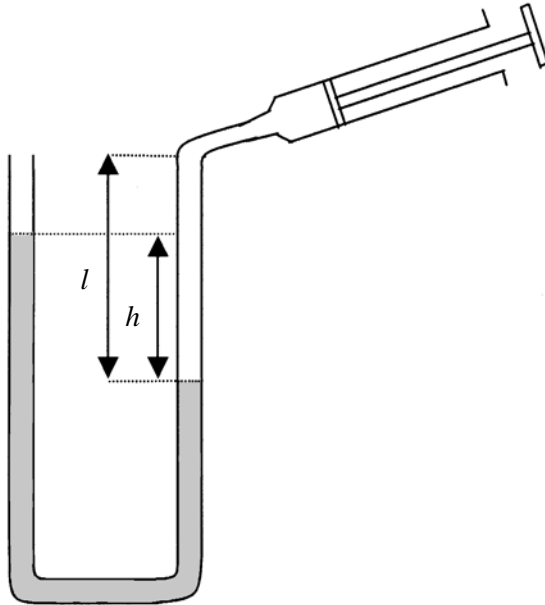
$$Ft = \Delta(mv)$$

$$E = hf$$

$$hf = \Phi + E_{k(\text{max})}$$

$$hf = E_2 - E_1$$

- (d) (i) Measure and record in a table a series of lengths  $l$  and the heights  $h$  corresponding to the different liquid levels in the tube as shown in **Figure 2**.



**Figure 2**

Values of  $h$  with the liquid levels as shown on the diagram should be recorded as positive whilst those when the levels are reversed should be recorded as negative. (9 marks)

- (ii) Draw and complete a second table to include corresponding values of  $h$ ,  $V$  and  $\frac{1}{V}$  /cm<sup>-3</sup>. (4 marks)
- (e) Plot the graph of  $h$  against  $\frac{1}{V}$ . Draw the best straight line through your plotted points. (5 marks)

- (f) The quantities  $h$  and  $V$  are related by the equation:

$$P + h = \frac{k}{V}$$

where  $P$  is the height of liquid that corresponds to atmospheric pressure and  $k$  is a constant.

- (i) Determine a value for  $k$ . (3 marks)
- (ii) Give a consistent unit for  $k$ . (1 mark)
- (iii) Determine a value for  $P$ . (3 marks)
- (g) Suggest **two** factors that you would expect  $k$  to depend upon. Explain your reasoning. Two of the 6 marks in the question are available for the quality of your written communication. (6 marks)

General Certificate of Education  
June 2003  
Advanced Level Examination



**PHYSICS (SPECIFICATION B)**  
**Unit 6 Exercise 2**

**PHB6/2**

Thursday 22 May 2003 Morning Session

**In addition to this paper you will require:**

- an 8-page answer book;
- a calculator;
- a ruler.

Time allowed: 1 hour 30 minutes

**Instructions**

- Use blue or black ink or ball-point pen.
- Write the information required on the front of the answer book. The *Examining Body* for this unit is AQA. The *Paper Reference* is PHB6/2.
- Answer **all** questions.
- *Formulae Sheets* are provided on pages 3 and 4. Detach this perforated page at the start of the examination.
- There are two questions in this paper. 45 minutes are allowed for Question 1 and 45 minutes for Question 2.
- All working must be shown. Do all rough work in the answer book. Cross through any work you do not want marked.

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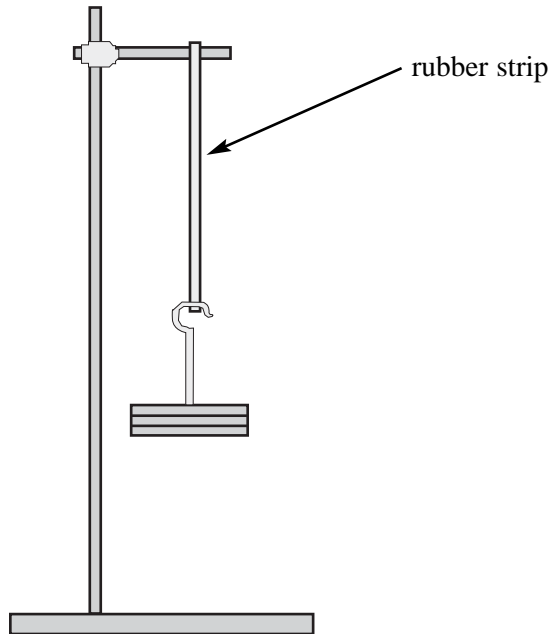
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Answer **all** questions.

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**Total for this question: 20 marks**

- 1 You are to investigate the oscillations of a loaded rubber strip shown in **Figure 1**.



**Figure 1**

The mass can be made to undergo three modes of oscillation: swinging, bouncing vertically up and down and twisting.

- (a) With a 300 g mass suspended from the rubber strip, measure the period for each mode of oscillation. In order to do this you should either displace the mass by a few centimetres horizontally or vertically or twist it by half a turn from the rest position.

In each case you should make it clear how you measured the period of oscillation. *(6 marks)*

- (b) (i) From your observations in part (a) compare the damping involved in the three modes of oscillation. *(1 mark)*
- (ii) Discuss the energy changes which occur when the mass is made to oscillate vertically up and down. *(2 marks)*
- (iii) Explain **two** causes for the damping when the mass oscillates vertically up and down. *(3 marks)*

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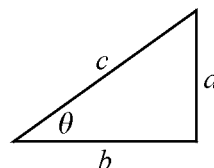
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$$\text{half-life, } t_{\frac{1}{2}} = \frac{0.69}{\lambda}$$

### Momentum and Quantum Phenomena

$$Ft = \Delta(mv)$$

$$E = hf$$

$$hf = \Phi + E_{k(\text{max})}$$

$$hf = E_2 - E_1$$

- (c) It is suggested that the period of oscillation,  $T$ , of the mass when it oscillates in the twisting mode is related to the suspended mass,  $m$ , by the equation:

$$T = cm^n$$

where  $c$  and  $n$  are constants.

Describe clearly how you would obtain and use data to investigate whether this relationship holds for masses between 100 g and 600 g.

You should explain how you would expect to use your data in order to obtain values for the constants  $c$  and  $n$ .

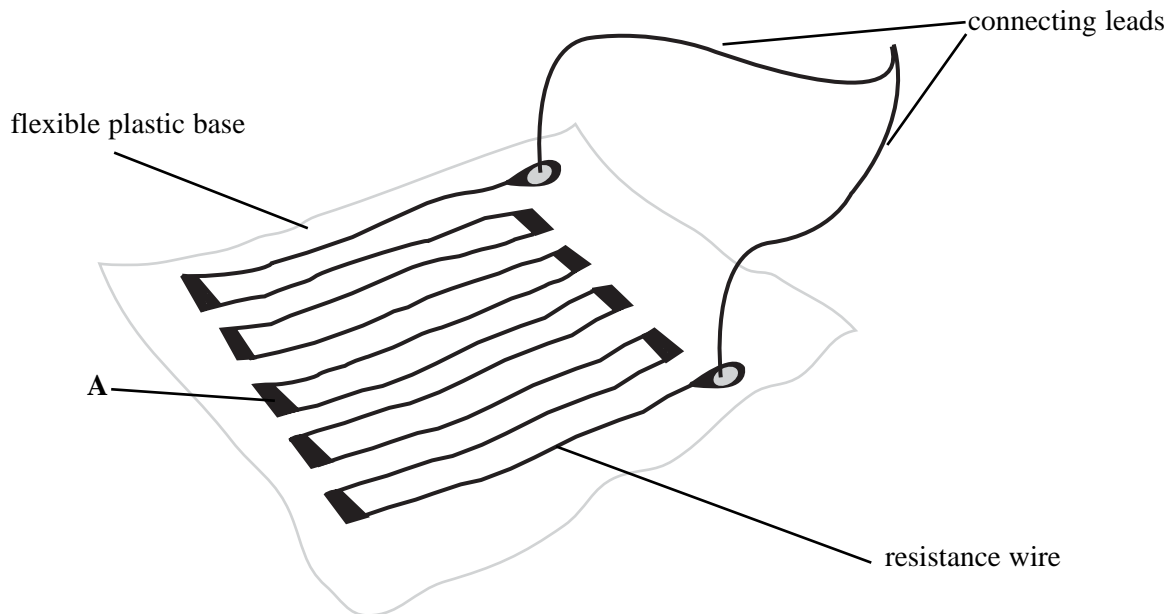
Two of the 8 marks in this question are available for the quality of your written communication.  
(8 marks)

**TURN OVER FOR QUESTION 2**

**Total for this question: 19 marks**

- 2 You are going to use a strain gauge to investigate the strain in a plastic ruler when it is bent into an arc.

**Figure 2** shows a strain gauge, made from a length of resistance wire. The gauge is attached firmly to the object to be deformed. When the object is stretched the wire is also stretched and so it becomes longer and thinner increasing its resistance.

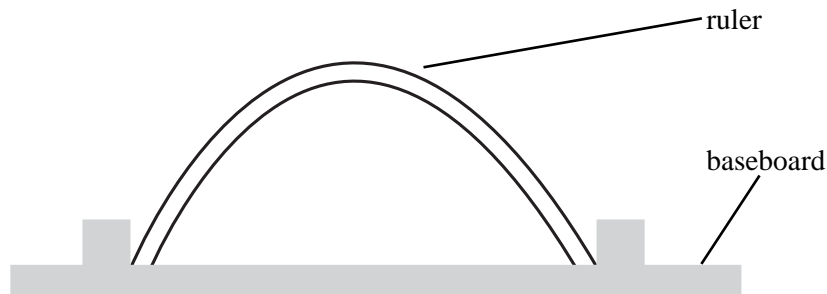


**Figure 2**

A strain gauge has been attached to the top surface of a 30 cm ruler.

- Connect the ohmmeter to the contacts of the strain gauge and record the resistance,  $R$ , of the unstretched wire, when the ruler lies on a flat surface. (1 mark)
- Using the baseboard provided, bend the ruler into arcs, as shown in **Figure 3**. Record the **two** different values for the resistance of the gauge.

**You may wish to reconsider the number of significant figures of your recorded value for the reading obtained in (a) in view of the measurements made here.** (4 marks)



**Figure 3**

- 
- (c) (i) Explain why the values of resistance you measured in part (b) are different from the value in part (a). *(2 marks)*
- (ii) Calculate a mean value for the fractional change in the resistance,  $\frac{\Delta R}{R}$ , of the wire when the ruler is bent as shown in **Figure 3**. *(1 mark)*
- (d) The strain is,  $\mathcal{E}$ , related to the fractional change in resistance by the equation:

$$\mathcal{E} = 2.1 \frac{\Delta R}{R}$$

- (i) Using the ruler and hand lens provided, estimate the length of the wire in the strain gauge. You should ignore the thicker portions of the wire, labelled **A**, in **Figure 2**. *(2 marks)*
- (ii) Estimate the absolute error in the extension of the wire. *(4 marks)*
- (e) In order to continuously monitor varying strains that occur in machines, strain gauges may be connected as one of the two resistors in a potential divider circuit. In this way the potential difference across the gauge can be monitored remotely.
- (i) Sketch a suitable circuit to use with the strain gauge provided. Suggest suitable values for the circuit components. *(2 marks)*
- (ii) Using the values you have suggested in part (e)(i), calculate the change in voltage that corresponds to your answer to part (c)(ii). Explain whether or not a voltmeter you might find in a school or college laboratory would be sensitive enough to record this change in voltage. *(3 marks)*

**END OF QUESTIONS**

General Certificate of Education  
June 2003  
Advanced Level Examination



**PHYSICS (SPECIFICATION B)**

**PHB6/TN**

## **Instructions to Supervisors**

### **STRICTLY CONFIDENTIAL**

**It is the responsibility of the Examinations Officer to ensure that these Instructions to Supervisors are given immediately to the Supervisor of the practical exercises.**

**These Instructions are strictly confidential and must be kept in safe custody by the Examinations Officer or by the Supervisor. They should be given to the Invigilator for the duration of the actual assessment and afterwards returned to the Examinations Officer. The Invigilator must ensure that when the Instructions are not in use, they are returned and kept in safe custody. Additional copies of these Instructions cannot be supplied by AQA.**

**Please note that these Instructions have the relevant questions from the papers, PHB6/1 and PHB6/2, printed after each set of apparatus and materials in the document, so that the Supervisor can consider any appropriate modifications. No copies of the relevant question paper should be given to the Supervisor at any time leading up to the examination.**

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□

The full copy of this paper can be obtained by ordering PHB6 from AQA Publications

Tel: 0161 953 1170

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## INSTRUCTIONS TO THE SUPERVISOR OF THE PRACTICAL EXERCISES

### General

- 1 The instructions and details of materials contained in this document are for the use of the Supervisor **and are strictly confidential**. After use, these Instructions must be kept in safe custody by the Examinations Officer until after the issue of results (in March or August as appropriate).
- 2 **The Supervisor has now been granted access to the question papers for both Exercise 1 (PHB/1) and Exercise 2 (PHB/2) as part of these Instructions. All the relevant questions are printed to enable the Supervisor to carry out the experimental parts of the Exercises in order to ensure that the apparatus and materials obtained are satisfactory and to seek advice from AQA if there are any problems. The Instructions must be returned to safe custody at the earliest possible moment after the Supervisor has ensured that all is in order.**
- 3 Candidates are allowed 1 hour 30 minutes for each of Exercises 1 and 2.
- 4 Exercise 1 (PHB6/1) is undertaken at a time suited to the circumstances of the centre, but under examination conditions. It is preferred that all candidates at a given centre undertake Exercise 1 at the same time.
- 5 About two weeks before candidates at a particular centre undertake Exercise 1, each candidate should be given a copy of the Preliminary Material (Information for Candidates) (PHB6/PM). This gives details of the general subject area of this assessment. The information is given to all candidates so that those undertaking the assessment early are not disadvantaged.
- 6 Exercise 2 (PHB6/2) is a timetabled practical examination and should be undertaken on the stipulated day. In a centre with a large number of candidates, it may be necessary for two or more examination sessions to be organised for Exercise 2. Candidates waiting for their session must be fully invigilated in a separate room throughout the period from the time of the first session until they enter the examination room. Candidates completing their session before the published starting time for the examination must similarly be invigilated.
- 7 For Exercise 2, centres may provide sufficient sets of apparatus for half their candidates to work on Question 1, while the other half work on question 2. Under strict supervision, the groups of candidates change over after 45 minutes. It will be necessary to allow a short period of time whilst the change over takes place. During this time the apparatus should be returned to its original state, ready for use by the next group of candidates. A similar short delay for the same purpose will be needed in centres running two or more sessions.
- 8 The exercises are **not** open-book examinations - candidates must **not** have access to textbooks, course notes, etc. However, the question papers for both Exercises include the AS and A2 Formulae Sheets.
- 9 AQA will provide question papers, A4 graph paper and answer books for the exercises. All other materials required for the assessments must be provided by the centre.
- 10 A suitable laboratory, or laboratories, must be reserved for the practical exercises. Enough apparatus and materials must be prepared to ensure that in the case of failure of a set of apparatus, a substitute is available so that the candidate does not lose time. Unauthorised persons not involved in the preparation for the examination must not be allowed to enter. Candidates must not be admitted until the specified time for commencement of the examination. The examination room must be cleared of candidates immediately after the examination.

- 
- 11 The apparatus and materials for each candidate must be arranged neatly, and ready to use, on the laboratory bench. No attempt should be made to connect together any parts or to wire up any electrical circuits except when specifically stated in these Instructions.
  - 12 Clear instruction must be given by the Supervisor to all candidates at the beginning of each examination concerning the organisation of the examination in the laboratory and the amount of time allowed for the examination. Candidates must also be instructed that all readings must be entered in the answer book provided and all working must be shown. **Scrap paper must not be used.**
  - 13 If a candidate is unable to perform any experiment, or is performing an experiment incorrectly, the Supervisor is expected to give the minimum help required to enable the candidate to proceed. In this instance, a note bearing the candidate's name and number must be attached to the candidate's script reporting to the Examiner the extent of the help given. Any failure in the apparatus should also be reported to the Examiner. **No help should be given with the analysis of the experimental data.**

It is not the wish of the Examiner that a candidate should waste time because of, for example, an incorrect electrical connection. The Examiner wishes to test the candidate's ability to perform an experiment and carry out the subsequent analysis.

- 14 Candidates' scripts **and** the question papers should be collected at the end of each exercise. Under no circumstances should candidates be permitted to remove question papers from the examination room. Note that candidates will require separate sheets of A4 graph paper which should be secured to the script for the appropriate exercise using a treasury tag.
- 15 Used question papers must be returned to the safe custody of the Examinations Officer, by whom they should be retained until after the issue of results.
- 16 **Candidates' scripts for Exercise 1 must be stored securely until the stipulated date for Exercise 2. Scripts for the two exercises should be collated and sent together to the Examiner.**
- 17 If a candidate is absent on the stipulated date for Exercise 2, their script for Exercise 1 should still be sent to the Examiner. The flexibility in the timing for Exercise 1 should make it possible for all candidates to be given an opportunity to undertake Exercise 1.
- 18 The Supervisor is required to report details concerning the experiment, apparatus or materials to the Examiner on the *Supervisor's Report* located at the end of this document. **This Supervisor's Report must be attached to the topmost script before despatch to the Examiner.**

Details must be given on the *Supervisor's Report* if the apparatus or materials provided differ from that detailed in this document. Where specific information or data about apparatus or materials is requested in these Instructions, it is important that it is given accurately. In some cases it may represent the only means available to the Examiner of assessing the accuracy of a candidate's work.

Centres may make copies of this *Supervisor's Report* for attachment to individual scripts if necessary. If all the information cannot easily be included on the *Supervisor's Report*, separate sheets of paper, bearing the candidates' names and numbers, can be attached to the relevant candidates' scripts.

In case of difficulty the Supervisor should telephone the Senior Subject Officer for A Level Physics, David Baker, at AQA (Manchester Office), telephone number 0161 953 1180, or email [dbaker@aqa.org.uk](mailto:dbaker@aqa.org.uk).

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**PHB6/1 – Exercise 1**

Candidates will be required to investigate the relationship between pressure and volume of air trapped in a syringe connected to one arm of a U-tube.

**Apparatus and materials**

- (a) 10 ml syringe – calibrated in 1 ml divisions;
- (b) two 50 cm lengths of 5 mm diameter bore glass tubing;
- (c) 5-10 cm length of 5 mm diameter bore glass tubing;
- (d) approximately 15 cm length of clear acrylic tubing cut into shorter lengths to make airtight joints between the two glass tubes and between the glass tube and the syringe. The distance between the glass tube and the syringe should be as small as practicable;
- (e) retort stand;
- (f) two bosses and clamps;
- (g) supply of 15 cm<sup>3</sup> coloured water, e.g. containing a little fluorescein. Sufficient coloured water should be supplied to allow a full range of syringe plunger positions without water leaving tube;
- (h) 300 mm ruler;
- (i) marker pen suitable for clearly marking glass;
- (j) cleaning fluid to remove pen imprints from glass tubing.

The U-tube is to be provided assembled so that the plunger in the syringe is on the 5 ml mark and the liquid is at the same level in each of the tubes. Fine adjustments of the liquid levels may be achieved by slightly raising or lowering the arms of the U-tube.

The scale on the syringe should be relabelled “cm<sup>3</sup>”.



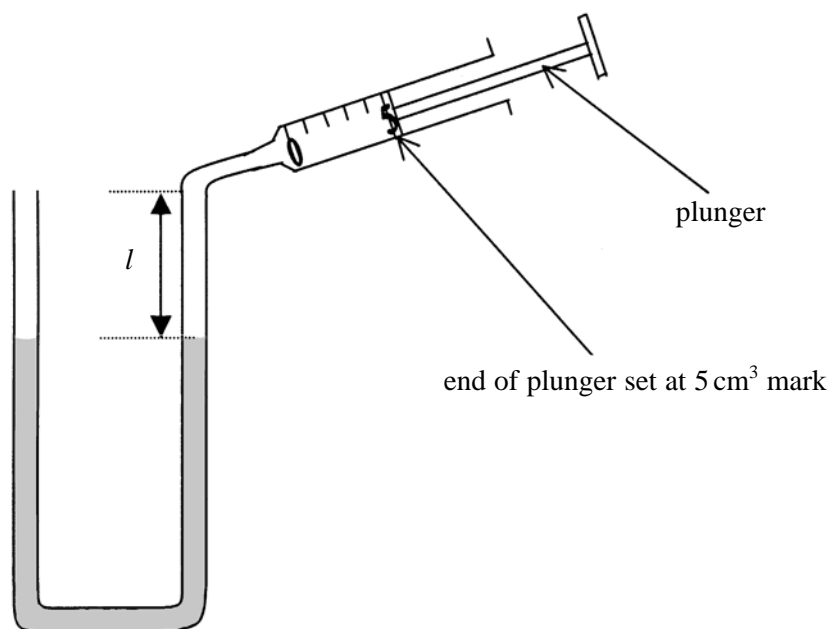
Answer **all** questions.

- 1 You are going to investigate the relationship between the pressure and the volume of some air trapped in a syringe connected to one arm of a U-tube.

You have been provided with a short length of glass tubing of the same internal diameter as that used in the U-tube.

- (a) (i) Measure and record the internal diameter of the short length of tube to the nearest mm. (2 marks)
- (ii) Calculate the cross sectional area,  $A$ , of the inside of the tube in  $\text{cm}^2$ . (2 marks)

You have been provided with the apparatus shown in **Figure 1**, with the plunger of the syringe set at the  $5 \text{ cm}^3$  mark. The liquid level is the same vertical height on each side of the U-tube.



**Figure 1**

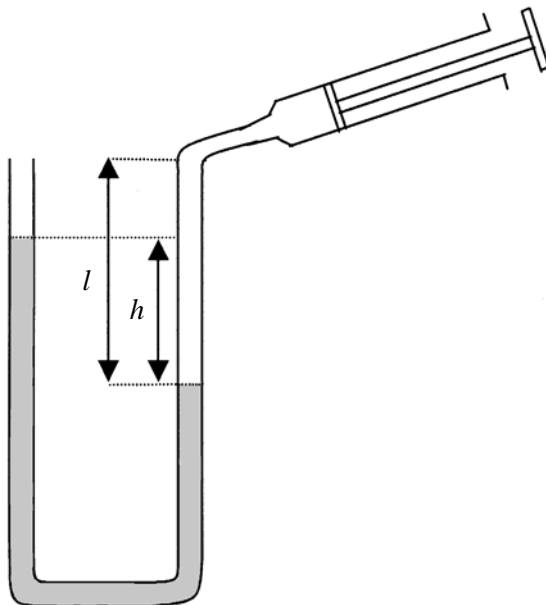
$l$  is the length of the air column trapped in the right hand side of the U-tube.

- (b) Ignoring the volume of air in the tubing connecting the syringe to the right hand side of the U-tube, calculate and record in  $\text{cm}^3$  the **total** volume,  $V$ , of air trapped in the syringe the right hand side on of the U-tube. (2 marks)

You are now going to adjust the syringe in order to obtain a series of values of volumes of trapped air and the difference in the heights of liquid exerting a pressure on the air.

- (c) (i) With a marker pen, mark the level of the liquid on each side of the U-tube. Explain how you decided where to mark the liquid level. (1 mark)
- (ii) By adjusting the position of the syringe plunger mark a series of corresponding positions of the liquid levels in each side of the U-tube. You should use the full range of graduated plunger positions. Explain how you ensured that the positions correspond to each other. (1 mark)

- (d) (i) Measure and record in a table a series of lengths  $l$  and the heights  $h$  corresponding to the different liquid levels in the tube as shown in **Figure 2**.



**Figure 2**

Values of  $h$  with the liquid levels as shown on the diagram should be recorded as positive whilst those when the levels are reversed should be recorded as negative. (9 marks)

- (ii) Draw and complete a second table to include corresponding values of  $h$ ,  $V$  and  $\frac{1}{V} / \text{cm}^{-3}$ . (4 marks)
- (e) Plot the graph of  $h$  against  $\frac{1}{V}$ . Draw the best straight line through your plotted points. (5 marks)
- (f) The quantities  $h$  and  $V$  are related by the equation:
- $$P + h = \frac{k}{V}$$
- where  $P$  is the height of liquid that corresponds to atmospheric pressure and  $k$  is a constant.
- (i) Determine a value for  $k$ . (3 marks)
- (ii) Give a consistent unit for  $k$ . (1 mark)
- (iii) Determine a value for  $P$ . (3 marks)
- (g) Suggest **two** factors that you would expect  $k$  to depend upon. Explain your reasoning. Two of the 6 marks in this question are available for the quality of your written communication. (6 marks)

**PHB6/2 – Exercise 2****Question 1**

Candidates will investigate the oscillations of a mass suspended from a rubber strip as the mass undergoes three different modes of oscillation.

**Apparatus and materials**

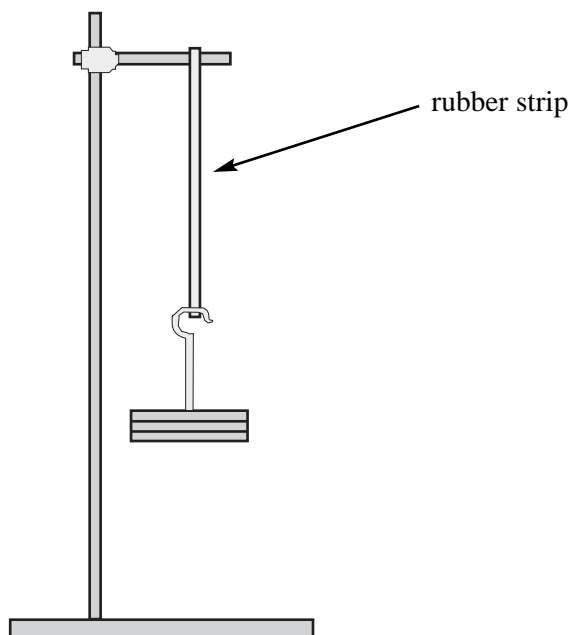
- (a) rubber band number 69 (e.g. from Viking Direct: Bursom Industrial Park, Tollwell Road, Leicester LE4 1BR or Quality Office Supplies: Anchor Lane, Cosely, Bilston, West Mids WV 14 9NE);
- (b) 100 g mass hanger;
- (c) two 100 g slotted masses;
- (d) stopwatch or stopclock with sensitivity of 0.1 s or better;
- (e) retort stand, boss and clamp.

The rubber band is cut to provide a rubber strip of unstretched length approximately 20 cm. It should be suspended from the clamp high enough to allow vertical oscillations to occur without touching the bench.

The band should be knotted so that it is not twisted.

Total for this question: 20 marks

- 1 You are to investigate the oscillations of a loaded rubber strip shown in **Figure 1**.



**Figure 1**

The mass can be made to undergo three modes of oscillation: swinging, bouncing vertically up and down and twisting.

- (a) With a 300 g mass suspended from the rubber strip, measure the period for each mode of oscillation. In order to do this you should either displace the mass by a few centimetres horizontally or vertically or twist it by half a turn from the rest position.

In each case you should make it clear how you measured the period of oscillation. (6 marks)

- (b) (i) From your observations in part (a) compare the damping involved in the three modes of oscillation. (1 mark)
- (ii) Discuss the energy changes which occur when the mass is made to oscillate vertically up and down. (2 marks)
- (iii) Explain **two** causes for the damping when the mass oscillates vertically up and down. (3 marks)

- (c) It is suggested that the period of oscillation,  $T$ , of the mass when it oscillates in the twisting mode is related to the suspended mass,  $m$ , by the equation:

$$T = cm^n$$

where  $c$  and  $n$  are constants.

Describe clearly how you would obtain and use data to investigate whether this relationship holds for masses between 100 g and 600 g.

You should explain how you would expect to use your data in order to obtain values for the constants  $c$  and  $n$ .

Two of the 8 marks in this question are available for the quality of your written communication.

*(8 marks)*

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**Question 2**

Candidates will investigate how the resistance of a strain gauge changes with strain when attached to a plastic ruler.

**Apparatus and materials**

- (a) “shatterproof” 30 cm ruler;
- (b) 30 cm ruler;
- (c) strain gauge of nominal unstressed resistance  $120\ \Omega$  (Rapid Electronics type 11 steel gauge 78-1105);
- (d) rectangular piece of hardboard or plywood of approximate dimensions  $5\ \text{cm} \times 25\ \text{cm}$  to act as baseboard;
- (e) two  $1\ \text{cm} \times 1\ \text{cm} \times 5\ \text{cm}$  wooden “spacers”;
- (f) two crocodile clips;
- (g) digital ohmmeter with a nominal resolution of  $0.1\ \Omega$  at  $120\ \Omega$ ;
- (h) two leads;
- (i) hand lens;
- (j) supply of epoxy resin glue or pressure sensitive (cyanoacrylate series) adhesive commonly known as super glue;
- (k) supply of wood glue;
- (l) small quantity of solder;
- (m) small quantity of insulating or masking tape;
- (n) safety glasses or goggles.

The spacers should be stuck laterally on the baseboard at a separation of 20 cm.

The strain gauge should be stuck symmetrically over the 15 cm mark in the central region of the top of the ruler. The axis of the gauge should be parallel to the edges of the ruler.

*Careful attention should be paid to paragraphs 3 and 4 – Strain Gauge Installation – of the Rapid Electronics datasheet DSM5/JETSET/CTH supplied with the gauges.*

A small blob of solder should be applied to each of the terminals of the strain gauge in order to facilitate an easy contact with the crocodile clips. The terminals should be taped to the ruler with insulating or masking tape in order to protect them from easily breaking.

The ohmmeter should be provided with the leads connected to the appropriate terminals and adjusted to give a reading of 4 s.f. when connected to the strain gauge.

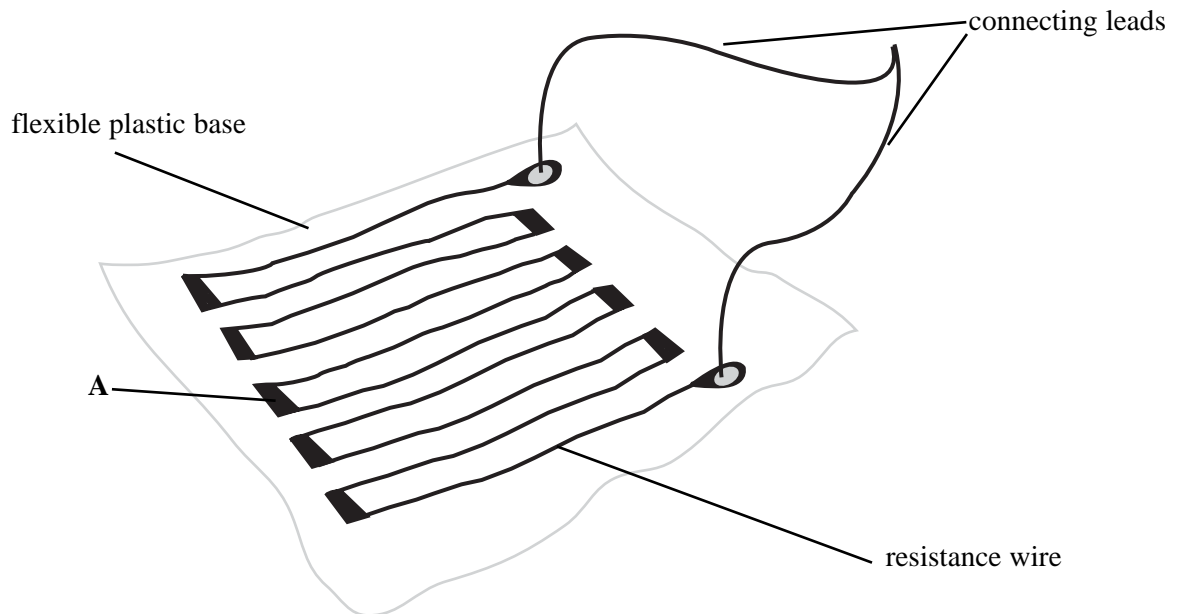
The strain ruler should be laid out flat on the bench with the strain gauge on its top surface.

**It is essential that the ruler is “shatter proof” not simply “shatter resistant”. Centres are advised to check the curvature produced when the ruler is bent between the spacers does not shatter the ruler (before the strain gauge has been attached). This should be done with the top surface in both convex and concave curvature.**

Total for this question: 19 marks

- 2 You are going to use a strain gauge to investigate the strain in a plastic ruler when it is bent into an arc.

**Figure 2** shows a strain gauge, made from a length of resistance wire. The gauge is attached firmly to the object to be deformed. When the object is stretched the wire is also stretched and so it becomes longer and thinner increasing its resistance.

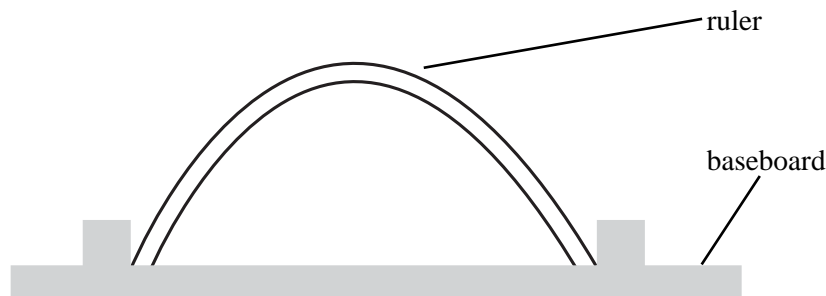


**Figure 2**

A strain gauge has been attached to the top surface of a 30 cm ruler.

- Connect the ohmmeter to the contacts of the strain gauge and record the resistance,  $R$ , of the unstretched wire, when the ruler lies on a flat surface. (1 mark)
- Using the baseboard provided, bend the ruler into arcs, as shown in **Figure 3**. Record the **two** different values for the resistance of the gauge.

**You may wish to reconsider the number of significant figures of your recorded value for the reading obtained in (a) in view of the measurements made here.** (4 marks)



**Figure 3**



- 
- (c) (i) Explain why the values of resistance you measured in part (b) are different from the value in part (a). *(2 marks)*
- (ii) Calculate a mean value for the fractional change in the resistance,  $\frac{\Delta R}{R}$ , of the wire when the ruler is bent as shown in **Figure 3**. *(1 mark)*
- (d) The strain,  $\mathcal{E}$ , is related to the fractional change in resistance by the equation:

$$\mathcal{E} = 2.1 \frac{\Delta R}{R}$$

- (i) Using the ruler and hand lens provided, estimate the length of the wire in the strain gauge. You should ignore the thicker portions of the wire, labelled **A**, in **Figure 2**. *(2 marks)*
- (ii) Estimate the absolute error in the extension of the wire. *(4 marks)*
- (e) In order to continuously monitor varying strains that occur in machines, strain gauges may be connected as one of the two resistors in a potential divider circuit. In this way the potential difference across the gauge can be monitored remotely.
- (i) Sketch a suitable circuit to use with the strain gauge provided. Suggest suitable values for the circuit components. *(2 marks)*
- (ii) Using the values you have suggested in part (e)(i), calculate the change in voltage that corresponds to your answer to part (c)(ii). Explain whether or not a voltmeter you might find in a school or college laboratory would be sensitive enough to record this change in voltage. *(3 marks)*

**END OF QUESTIONS**

General Certificate of Education  
June 2003  
Advanced Level Examination

**PHYSICS (SPECIFICATION B)  
UNIT 6**

**PHB6/TN**

**SUPERVISORS REPORT**

Your attention is drawn to paragraph 18 on p.3.

When completed by the Supervisor, this Report must be firmly attached to the topmost script before dispatch to the Examiner.

Supervisor's Signature.....

Centre Number .....

Date .....

Centres may make copies of this Supervisor's Report for attachment to individual scripts where necessary