



General Certificate of Education  
Advanced Subsidiary Examination  
June 2012

## Physics

## PHA3/B3/XTN

(Specifications A and B)

Unit 3 Investigative and Practical Skills in AS Physics  
Route X Externally Marked Practical Assignment (EMPA)

## Instructions to Supervisors Confidential

To be given immediately to the teacher(s) responsible for GCE Physics

Open on receipt

- These instructions are provided to enable centres to make appropriate arrangements for the Unit 3 Externally Marked Practical Assignment (EMPA)
- It is the responsibility of the Examinations Officer to ensure that these *Instructions to Supervisors* are given immediately to the Supervisor of the practical examination.

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## **INSTRUCTIONS TO THE SUPERVISOR OF THE EXTERNALLY MARKED PRACTICAL EXAMINATION**

### **General**

#### **Security/confidentiality**

The instructions and details of the EMPA materials are strictly confidential. In no circumstances should information concerning apparatus or materials be given before the examination to a candidate or other unauthorised person.

The EMPA supplied by AQA at AS and at A2 for a given academic year must only be used in that academic year. It may be used for practice in later academic years.

Using information for any purpose beyond that permitted in this document is potentially malpractice. Guidance on malpractice is contained in the JCQ document Suspected Malpractice in Examinations and Assessments: Policies and Procedures.

The Examinations Officer should give copies of the Teacher Notes (PHA3/B3/XTN and/or PHA6/B6/XTN) to the teacher entrusted with the preparation of the examination upon receipt.

#### **Material from AQA**

For each EMPA, AQA will provide:

- *Instructions to Supervisors*
- Section A Task 1 and Task 2 question paper/answer booklets
- Section B EMPA written test papers.

#### **Preparation/Centre responsibility**

This practical assessment should be carried out after candidates have acquired the necessary skills and after the appropriate sections of the specification have been taught so that candidates are familiar with any specialist apparatus involved.

The assessment must be carried out between the dates specified by AQA.

It is the responsibility of the centre to ensure that each of the specified practical activities works with the materials provided to the candidates.

**The assessment and management of risks are the responsibility of the centre.**

#### **Practical Skills Verification (PSV)**

Candidates must undertake the five practical activities specified, in order for them to demonstrate in the EMPA that they can use apparatus appropriate to the teaching of Physics at this level. In doing so, candidates will be familiar with the equipment and skills they will use in the EMPA. The teacher must confirm that this requirement has been met on the front cover of the Section B written paper.

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## Section A: Task 1 and Task 2

- Candidates should work individually and be supervised throughout. They should not discuss their work with other candidates at any stage.
- The work can be carried out in normal timetabled lessons and at a time convenient to the centre. Teachers will be in the best position to judge how many sessions are appropriate for candidates in their own centre.
- The candidates' work must be handed to the teacher at the end of each practical session and kept securely until the next stage of assessment.
- There is no specified time limit for these tasks, however candidates should be informed by the Supervisor of the expected timescale and timetable arrangements involved in carrying out the EMPA. Candidates must also be instructed that all readings must be entered in the question paper/answer booklet provided and all working must be shown. **Scrap paper must not be used.**

### Sharing equipment / working in groups

Candidates are to work individually. Where resources mean that equipment has to be shared, the teacher should ensure that the candidates complete the tasks individually. Where appropriate, spare sets of apparatus should be prepared to ensure that time is not lost due to any failure of equipment.

Centres may choose to provide sufficient sets of apparatus for the candidates to work on Section A in a circus format with some candidates completing the questions in reverse order. In such cases the changeover should be carefully supervised and the apparatus returned to its original state before being used again.

### Practical sessions

Before the start of the test the apparatus and materials for each candidate should be arranged, ready for use, on the bench. The apparatus should not be assembled unless a specific instruction to do so is made in these Instructions.

If a candidate is unable to perform any experiment, or is performing an experiment incorrectly, or is carrying out some unsafe procedure, the supervisor is expected to give the minimum help required to enable the candidate to proceed. In such instances the *Supervisor's Report* should be completed with the candidate's name and number, reporting to the Examiner the nature and extent of the assistance given. No help may be given to proceed with the analysis of their experimental data.

Any failure of equipment which, in the opinion of the Supervisor, may have disadvantaged any candidate should be detailed on the *Supervisor's Report*.

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## Section B: EMPA written test

- The Section B EMPA written test should be taken as soon as convenient after completion of Section A.
- This test must be carried out under supervision and must be completed in a single uninterrupted session.
- When carrying out the Section B EMPA written test, candidates should be provided with their completed copy of Section A Part 2 question paper/answer booklet.
- Supervisors should ensure that candidates understand that Section A Part 2 is for reference only and they must not make any written alterations to this previous work while undertaking Section B.
- The duration of the Section B EMPA written test is 1 hour 15 minutes except where candidates have been granted additional time or rest breaks.

### Administration

Candidates must not bring any paper-based materials into any session or take any assessment materials away at the end of a session. Electronic and communication devices, including mobile telephones, iPods, MP3 players are **not** allowed.

### Modifications

The equipment requirements for the experimental tasks are indicated in these Instructions. Centres are at liberty to make any reasonable minor modifications to the apparatus which may be required for the successful working of the experiment but it is advisable to discuss these with the Assessment Adviser or with AQA. A written explanation of any such modification must be given in the *Supervisor's Report*.

### Absent candidates

Candidates absent for any Part of Section A should be given an opportunity to carry out the practical exercises before attempting the Section B EMPA written test. No credit can be given for any analysis done when evidence of the relevant practical work is not provided.

### Redrafting

Candidates may make only one attempt at a particular EMPA and redrafting is **not** permitted at any stage during the EMPA.

### The Supervisor's Report

The *Supervisor's Report* provided in this document should be sent to the Examiner with the scripts. Details should be given on the *Supervisor's Report* if

- any part of the equipment provided differs significantly from that specified in these Instructions
- any help is given to candidates in the event of any failure of or difficulties with the equipment.

Supervisors must also include any numerical data that is specified in the Instructions. This may involve the Supervisor performing an experiment before the test and collecting certain data. Such data should be given to the uncertainty indicated. Note that the Examiners may rely heavily on such data in order to make a fair assessment of a candidate's work.

**Security of assignments**

Candidates' scripts and any other relevant materials, printed or otherwise, should be collected and removed to a secure location at the end of each session. Under no circumstances should candidates be allowed to remove question papers from the examination room.

Completed EMPAs are to be treated in the same manner as other completed scripts and should be kept under secure conditions before their despatch to the Examiner.

**Submission of materials to the AQA Examiner**

Once completed, each candidate's completed EMPA should be collated in candidate number order and in the following order

- Section A Part 1
- Section A Part 2
- Section B EMPA written test;

the assembled material should then be secured using a treasury tag. A copy of the Supervisor's Report should be sent with the scripts.

**Turn over ►**

**Section A Part 1, Question 1**

Candidates are to make measurements on a 10p coin.

**Apparatus required:**

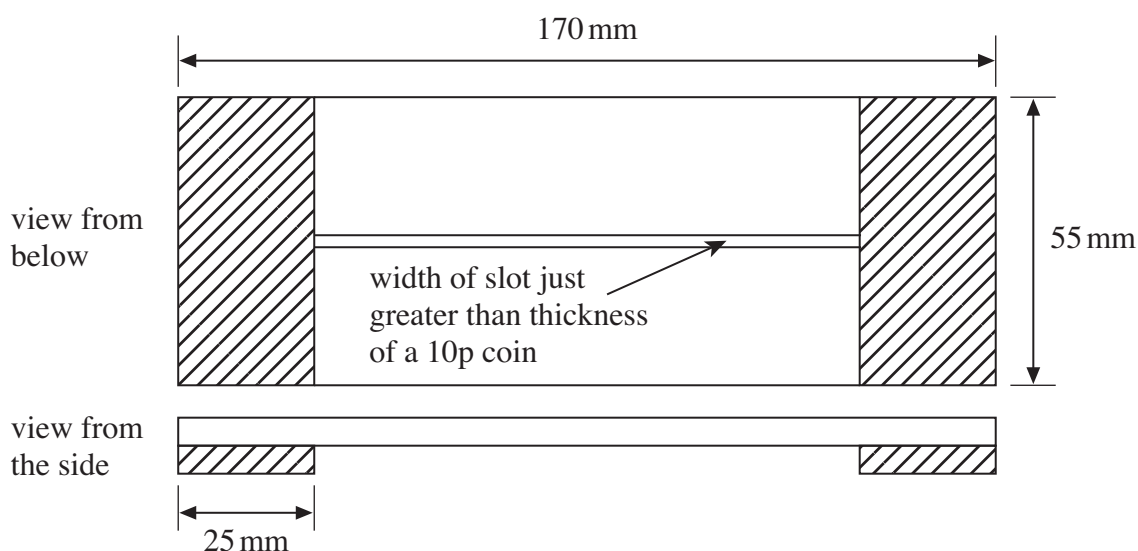
- micrometer screw gauge capable of reading to 0.01 mm
- 300 mm plastic ruler
- hand lens (or magnifying glass or bench magnifier)
- 10p coin; ensure that the rim of the coin is in good condition
- rectangle of carbon paper of dimensions 120 mm × 50 mm
- additional strip of wood of sufficient length and width to enable the candidate to press the coin down while rolling it along the length of the slot shown in the diagram below (approximate dimensions of this strip 150 mm × 30 mm)
- mdf, plywood or softwood (a discarded metre ruler is also suitable) of thickness 5 mm to 10 mm; two strips of length 170 mm and width 25 mm and two strips of length 55 mm and width 25 mm are required
- wood glue for construction

Candidates will place the carbon paper, inked side downwards, on their answer booklet and roll the coin over the top to leave an inked track showing the pattern of the ridges that appear along the rim of the coin.

To ensure that the coin is rolled in a straight line they are to be provided with a slot, into which the coin can be placed. The candidate is to roll the coin in the slot using the additional wooden strip held horizontally with sufficient downwards force for the coin ridges to mark the answer booklet through the carbon paper.

The slot is manufactured from the four strips of wood or mdf, as follows.

Lay the two longer strips side by side leaving a gap between them just wider than the thickness of the 10p coin; then glue the smaller pieces (shown hatched in the diagram below) into position, as shown.



Place all the equipment on the bench in clear view of the candidate. If the apparatus is to be used by another candidate following on, a fresh piece of carbon paper should be provided.

Supervisors may wish to draw the candidates' attention to the hand lens and explain how it may be used to assist in the measurement of the dimension  $s$ .

**The examiners require no information for this question.**

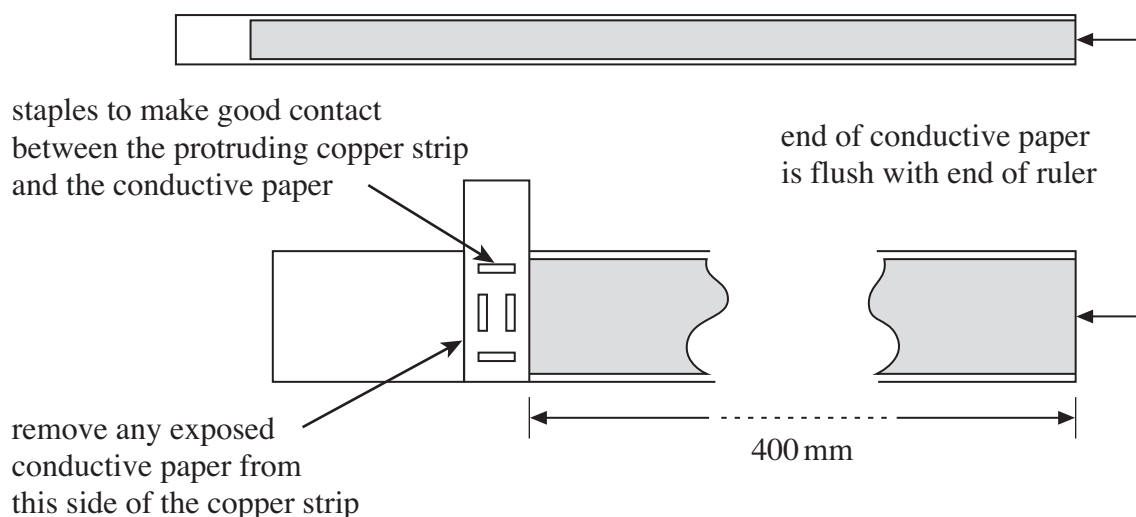
### Section A Part 1, Question 2

Candidates are to investigate the resistance of a variable resistor made from two rectangular pieces of conductive paper.

#### Apparatus required:

- two rectangular strips of conductive paper, width to be about 25 mm, length about 400 mm; rolls of conductive ('Teledeltos') paper are available from Philip Harris Ltd (code B8A48252, roll dimensions 737 mm  $\times$  2 m, price £16.91)
- two large bulldog clips, e.g. length about 6 cm
- mdf, plywood or softwood (a discarded metre ruler is also suitable) of thickness 5 mm to 10 mm; two strips of length 450 mm and width 25 mm are required.
- one 300 mm plastic ruler
- two rectangles of copper foil, suitable dimensions 1 cm  $\times$  5 cm; copper metal foil can be obtained from Philip Harris Ltd (copper metal foil (0.13 mm) B8A67131)
- two crocodile clips
- paper glue, e.g. *Pritt Stick*, and staple gun for construction
- 3½ digit LCD multi meter capable of reading resistance up to 100 k $\Omega$ ; most cheap multi meters (e.g. Rapid 85-0662) have a 200 k $\Omega$  setting, which will be ideal; leads should be connected to the inputs, terminating at crocodile clips to facilitate attachment to the copper foil electrodes

To construct the variable resistor, cut rectangular strips of conductive paper that are approximately the same width as the largest faces of the wooden strips. Ensuring one end is flush with the end of the strip, (see diagram below) use the paper glue to glue down a rectangular piece of conductive paper to the face of one of the strips. Place a rectangle of copper foil over the conductive paper, so that one end protrudes to enable connection, using a crocodile clip, to the external circuit. Adjust the position of the strip so that the exposed length of conductive paper between the edge of the strip and the end of the ruler is 400 mm then fix the copper strip in place using staples. Remove any conductive paper exposed between the edge of the strip and the closer end of the ruler.



Repeat this procedure exactly as before to produce the other part of the variable resistor.

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Place the parts of the variable resistor together so that the faces of the rectangles of conducting paper are in contact. Adjust the position until the contact area between the rectangles is such that the length of the contact area between the pieces of conducting paper is between 300 mm and 350 mm (this is dimension  $x$  in **Figure 3** in the question/answer booklet); then secure the arrangement using the bulldog clips.

Attach the multi meter and set this to read resistance. Sample results obtained during trials show that the resistance,  $R$ , of the resistor varies with dimension  $x$  as follows:

$x/\text{mm}$	$R/\text{k}\Omega$
300	39.0
250	45.7
200	54.7
150	61.4
100	68.7
50	74.7

At the start of the examination, candidates should find the apparatus arranged as described above and the multi meter should be set to the appropriate range.

Supervisors may remind the candidates that the read out of the multi meter (referred to as an ohm-meter in the question) is in  $\text{k}\Omega$ . Candidates should also be told what to expect if the meter shows an 'over range' reading.

**The examiners require no information for this question.**



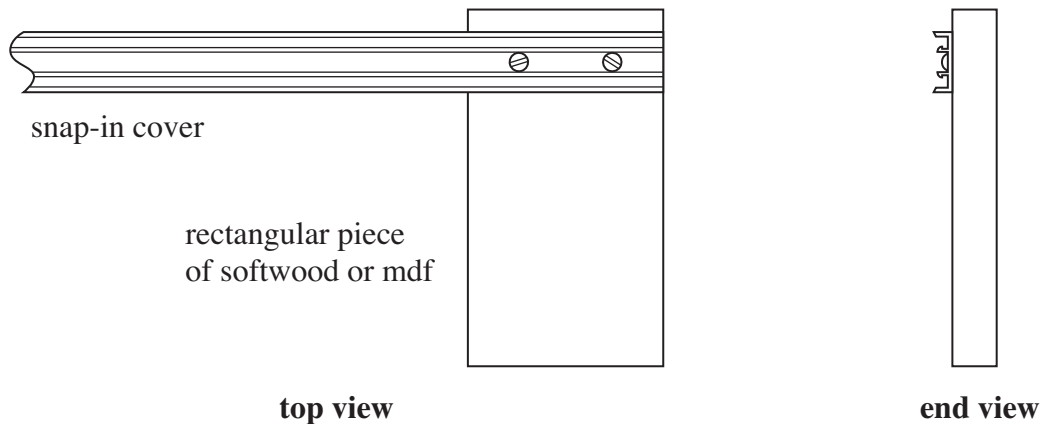
## Section A Part 2

Candidates are to investigate the trajectory of a ball bearing.

### Apparatus required:

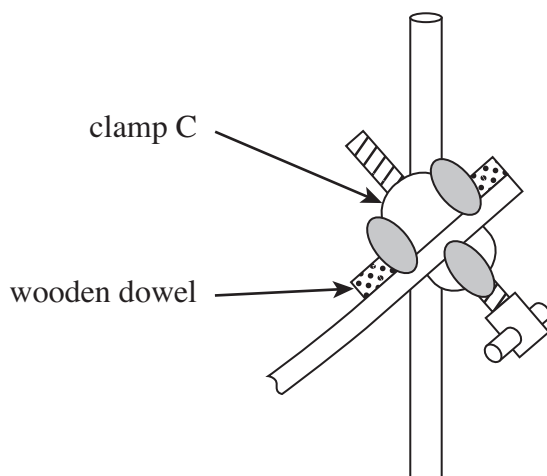
- 12 mm diameter steel sphere, e.g. Griffin Education XBX-480-030T
- A5-sized sheet of carbon paper
- masking tape with which candidates will fix the pieces of plain paper (see next item) to the floor
- pieces of plain paper which, in conjunction with the carbon paper, candidates will locate the position that the ball bearing strikes the floor; one piece of A4 photo copier paper, divided into eight rectangles of approximately 75 mm × 100 mm, will be sufficient for each candidate
- metre ruler
- plumb line with at least 1 metre of cord attached
- 80 cm of the snap-in cover to the (nominally) 16 mm square plastic cable conduit (B and Q sell this as 'mini trunking') to provide a smooth continuously curving track from which to launch the ball bearing
- retort stand fitted with boss and clamp
- retort stand fitted with boss into which is fitted a 6 inch nail or similar, mounted horizontally
- G-clamp
- rectangular piece of softwood or mdf, approximate dimensions 50 mm × 75 mm, thickness ≥ 8 mm, to be attached to lower end of track to facilitate securing this to the edge of the bench; the method of fixing is at the discretion of the centre although the use of 2 small pan head screws was found to be suitable (note that the head of the screw must not interfere with the transit of the ball bearing)
- about 75 mm of round wooden dowel of diameter 10 mm or 12 mm to ensure that the clamping of the raised end of the track does not introduce twisting in the track

Cut the snap-in cover to length and attach the rectangular piece of softwood or mdf as shown below. If screws are to be used two small pilot holes should be drilled beforehand.



Align the track so that it is flush with, and is perpendicular to, the edge of the bench. Use the G-clamp to secure the rectangle of softwood or mdf to the bench, as shown in **Figure 4** of the question/answer booklet. **Candidates will be instructed not to remove the G-clamp during the experiment.**

Place the dowel in the well of the track so that the end is aligned with the free end of the track, then attach the clamp (referred to as clamp C in the question paper/answer booklet) around the dowel and track, as in the enlarged view of **Figure 4** of the question paper/answer booklet, shown below.



Place the ball bearing on the track so that it is in contact with the wooden dowel and adjust the height of the clamp until the top of the ball bearing is between 350 mm and 400 mm above the bench. Before securing the clamp at this height, make any necessary adjustment to the clamp so that any twist in the track is removed and the transit of the ball bearing, when released, follows one smooth continuously curving path to the short horizontal section at the bench before describing a parabolic path to the floor.

Adjust the height of the nail in the other retort stand so that when this is placed on the floor, the upper surface of the nail is between 250 mm and 300 mm above the floor.

**Candidates will be instructed not to adjust the position of the clamped nail attached to this stand.**

Place the stand to which the clamped nail has been fixed, along with the rectangles of plain paper, the A5 piece of carbon paper, the plumb line, metre ruler and ball bearing on the bench in clear view for the candidate.

It is suggested that candidates are provided with some method of ensuring that some convenient barrier is placed in the path of the ball bearings so that these are easily recovered after falling to the floor. It is advisable that spare ball bearings are available in the event that any get lost during the experiment.

**The examiners require no information for this question.**

Note that when completing Section B of the test candidates should be provided with their completed copy of Section A Part 2, whereas candidates' copies of Section A part 1 should **not** be made available to them.



**PHYSICS**  
**(SPECIFICATIONS A AND B) PHA3/B3/XTN**  
**Unit 3**

**SUPERVISOR'S REPORT**

**When completed by the Supervisor, this Report must be attached firmly to the attendance list, or in the case of any problem affecting a particular candidate, it should be attached to the candidate's script, before despatch to the Examiner.**

**Information to be provided by the centre**

**Section A Part 1**

**Question 1** No information is required

**Question 2** No information is required

**Section A Part 2**

**Question 1** No information is required

Details of problems encountered by candidate..... candidate number .....

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Supervisor's Signature .....

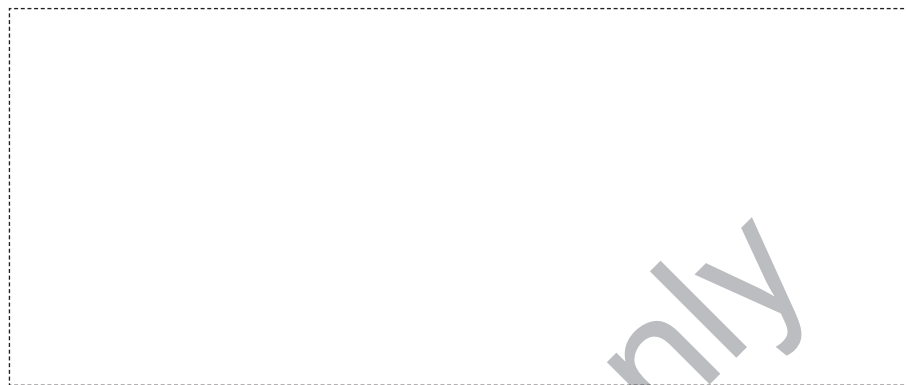
Centre Number .....

Date .....

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

## Section A Task 1

- 1** You are to make measurements on a 10p coin.
- 1 (a)** Use the micrometer screw gauge to determine  $d$ , the diameter of the 10p coin.
- 1 (b)** You have been provided with a piece of carbon paper, the dimensions of which are the same as the rectangular box, shown by the dotted outline below.  
Place the carbon paper over the rectangular box, with the inked side of the carbon paper facing downwards.

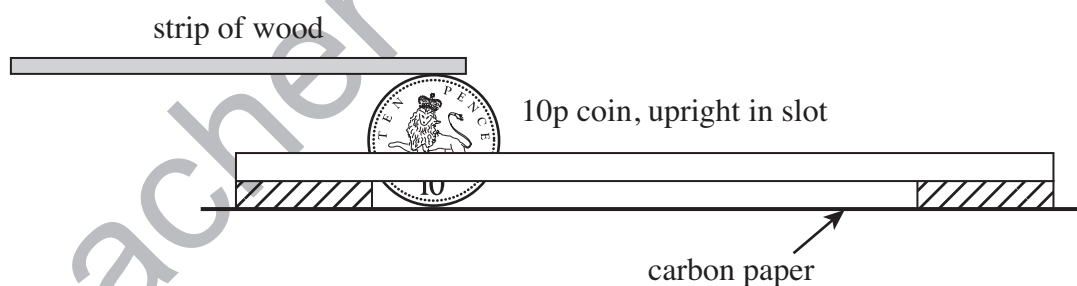


You have been provided with two strips of wood that have been joined together so that a narrow slot is formed between them. The width of the slot is just wider than the thickness of the 10p coin.

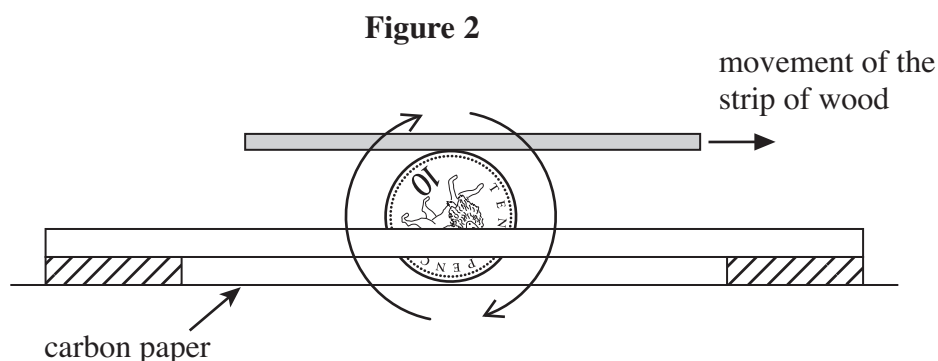
Position the slot over the carbon paper so that the direction of the slot is parallel to the longer edges of the paper.

Place the 10p coin in the slot at one end and hold the short strip of wood in contact with the rim of the coin, as shown in **Figure 1**.

**Figure 1**



Applying gentle downwards pressure to the strip of wood, push the coin along the slot so that it rotates without slipping, as shown in **Figure 2**.



When the carbon paper is removed, an imprint of the ridges around the rim of the coin is left on the page of your answer book.

You may move the slot and repeat the procedure until you have obtained a satisfactory result.

- 1 (b) (i) Use the 300 mm ruler to make suitable measurements to determine the separation,  $s$ , of the ridges on the coin.  
You may use the hand lens to assist you with making this measurement.
- 1 (b) (ii) Use your results for  $s$  and  $d$  to determine the number of ridges around the rim of the 10p coin.

Teacher use only

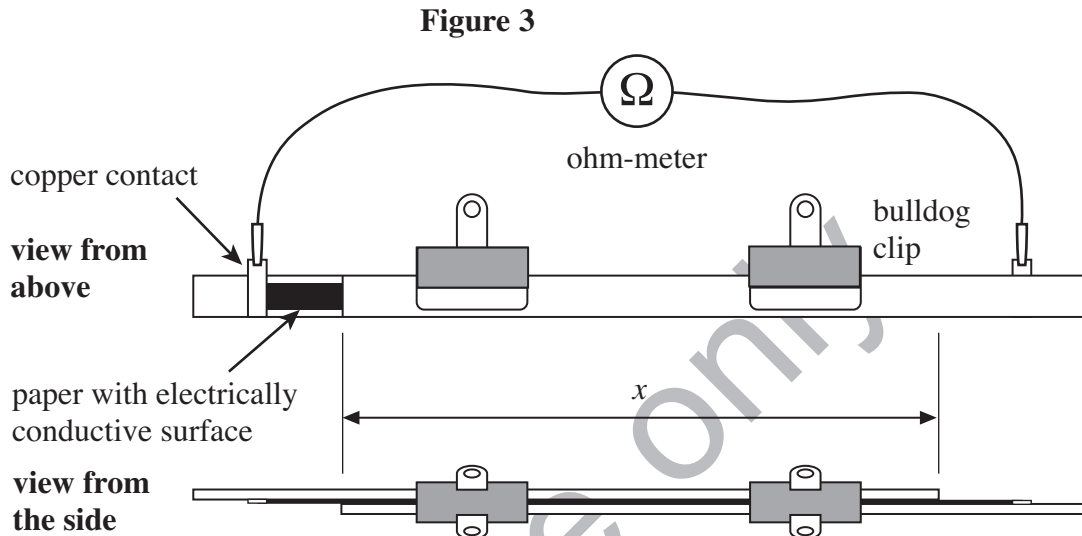
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- 2 You are provided with a resistor made from two rectangular pieces of paper that have electrically-conductive surfaces.

The pieces of paper have identical dimensions and are mounted on strips of wood. The conductive surfaces of the paper are in contact with each other. The strips are secured using bulldog clips.

The resistance is measured with an ohm-meter, connections to which are made through the copper contacts joined to one end of each of the pieces of paper.

Views of the resistor from above and from the side are shown in **Figure 3**.



The resistance of the resistor will be changed by altering  $x$ , the length of the conductive surfaces which are in contact.

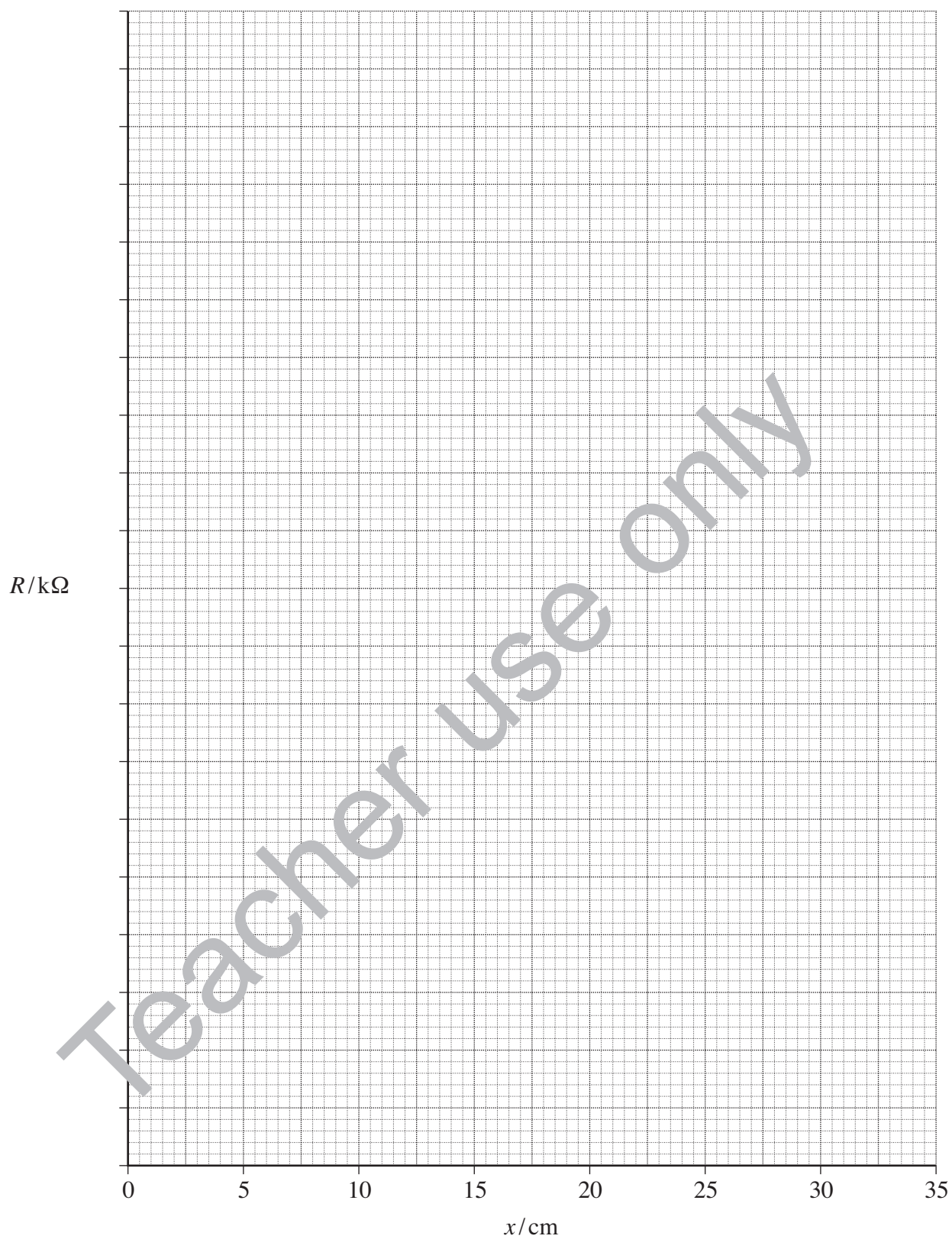
You are to investigate how  $R$ , the resistance of the resistor, depends on  $x$ .

- 2 (a) The resistor has already been assembled and the ohm-meter set to a suitable range. **Note that the ohm-meter shows the resistance in  $k\Omega$ .**
- 2 (a) (i) Measure  $x$  and read  $R$  from the ohm-meter.
- 2 (a) (ii) Remove the bulldog clips and rearrange the two parts of the resistor so that  $x$  is reduced. Reattach the bulldog clips then read  $R$  corresponding to the new value of  $x$ .
- 2 (a) (iii) Repeat the procedure until you have a total of six values of  $R$  and  $x$ . **The maximum value of  $x$  should not exceed 35.0 cm.**

Record all your data in the table below.

$x/\text{cm}$						
$R/k\Omega$						

- 2 (b) Adding a suitable vertical scale, plot, on the grid below, a graph to show how  $R$  varies with  $x$ .



Turn over ►

2 (c) (i) Circle the term below that best describes the relationship between  $R$  and  $x$  illustrated by your graph.

**directly proportional      linear      inversely proportional      none of these**

2 (c) (ii) Explain your answer to part (c)(i).

2 (d) Suppose that you were to repeat the experiment with a resistor constructed using two pieces of conductive paper of the same resistivity and length as in your experiment, but of **smaller width**.

2 (d) (i) State and explain the effect this change would produce on your measurement of  $R$  for a given value of  $x$ .

2 (d) (ii) State the effect, if any, this change would produce on the gradient of your graph.

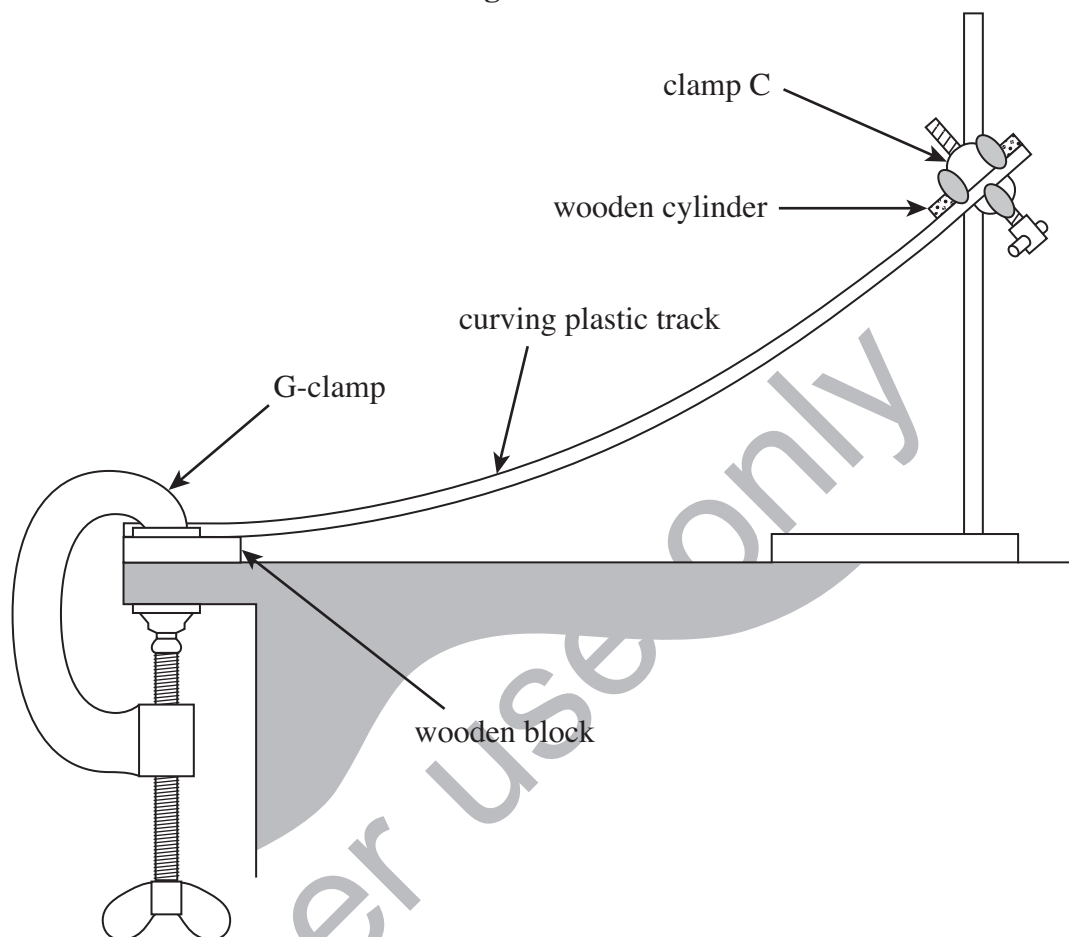
Teacher use only



## Section A Task 2

- 1 In this experiment you are to investigate the trajectory of a ball bearing.  
You are provided with the apparatus shown in **Figure 4**.

Figure 4



The lower end of a curving plastic track is attached to a wooden block; a G-clamp is used to fix this wooden block to the bench.

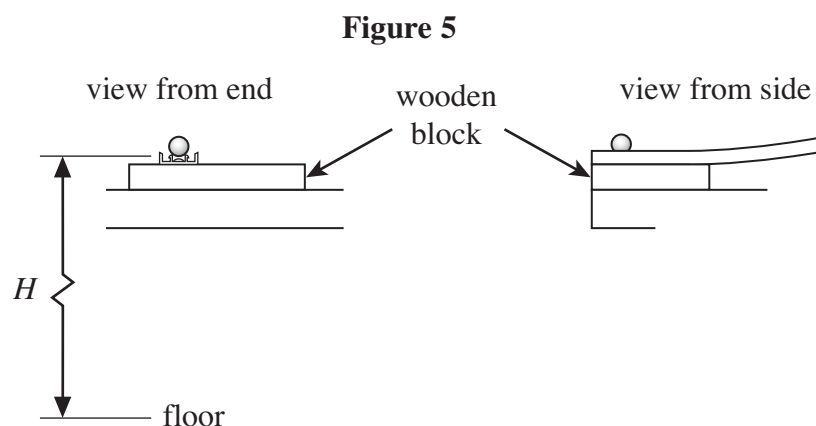
**Do not remove the G-clamp during the experiment.**

A short wooden cylinder has been placed inside the plastic track at the raised end of the track; a clamp, C, is used to keep this cylinder in place and support the raised end of the track.

**Do not remove clamp C from the raised end of the track during the experiment.**

Turn over ►

- 1 (a) Place a ball-bearing on the horizontal part of the plastic track as shown in **Figure 5**. **Note that the G-clamp is not shown in either of the views.**



- 1 (a) (i) Measure and record the vertical height,  $H$ , between the bottom of the ball bearing and the floor.

You are provided with an additional stand to which has been clamped a horizontal nail. **Do not adjust the height of the clamped nail at any stage.**

- 1 (a) (ii) Place this stand on the floor then measure and record the vertical height  $h$ , between the top of the nail and the floor.

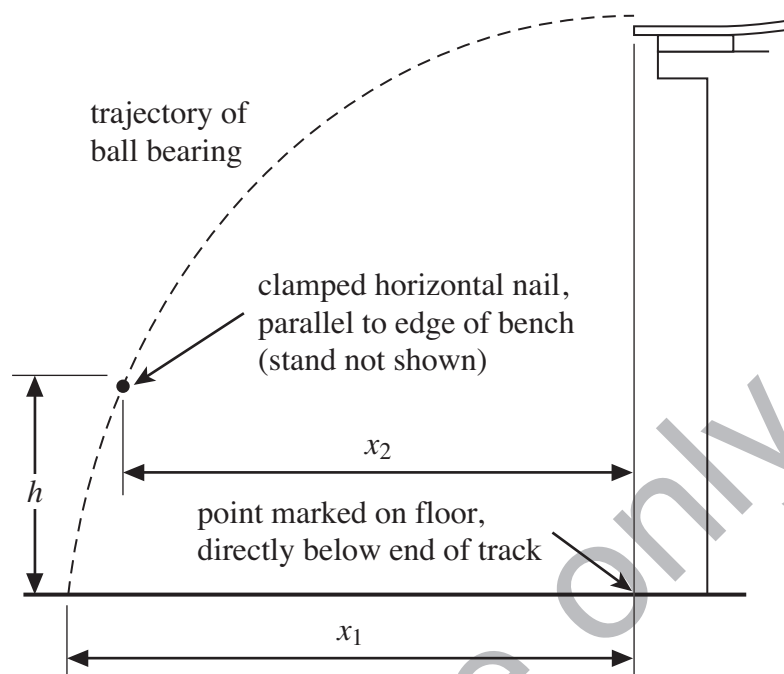
- 1 (b) Locate and mark the point on the floor directly below the end of the track. Place the ball bearing on the track so that it is in contact with the wooden cylinder. Release the ball bearing from rest and note where it lands. Place a piece of clean blank paper on the floor with the centre of the paper at the position where the ball bearing landed. Release the ball bearing as before to check that it lands near the centre of the paper. Secure the paper to the floor using masking tape.

You are provided with a piece of carbon paper; position this, carbon side down, over the paper. Release the ball bearing as before so that it lands on the carbon paper. The impact of the ball bearing will produce a mark on the paper below the carbon. Repeat the procedure to ensure that a consistent result is achieved.

1 (b) Record all your measurements and observations for part (b)(i), (b)(ii) and (b)(iii), on page 6 of this question paper/answer booklet.

1 (b) (i) Measure and record the horizontal distance,  $x_1$ , as shown in Figure 6.

Figure 6



1 (b) (ii) Place the stand to which the nail is attached on the floor so the nail is parallel to the edge of the bench, as shown in Figure 6. Ensuring that the height,  $h$ , of the top of the nail above the floor remains unchanged, adjust the position of the stand so that, after an identical release to that which gave the reading of  $x_1$ , the ball bearing hits the nail centrally.

Measure and record the horizontal distance,  $x_2$ , from the nail to the point you marked directly below the end of the track.

1 (b) (iii) Loosen the boss holding clamp C and reduce the height of the raised end of the curving plastic track above the bench by about 5 cm. Tighten up the boss to secure the track in this new position. Make any small adjustments that are necessary to clamp C to ensure that in this new position, the track forms a continuous smooth curve and is free from any twisting.

Using the same method as before, obtain further values of  $x_1$  and  $x_2$  for the new track positions.

Repeat the procedure until you have a total of **six sets** of readings for  $x_1$  and  $x_2$ .

Turn over ►

Measurements and observations.

- 1 (c) Plot, on the grid opposite, a graph with  $x_1$  on the vertical axis and  $x_2$  on the horizontal axis.

Teacher use only

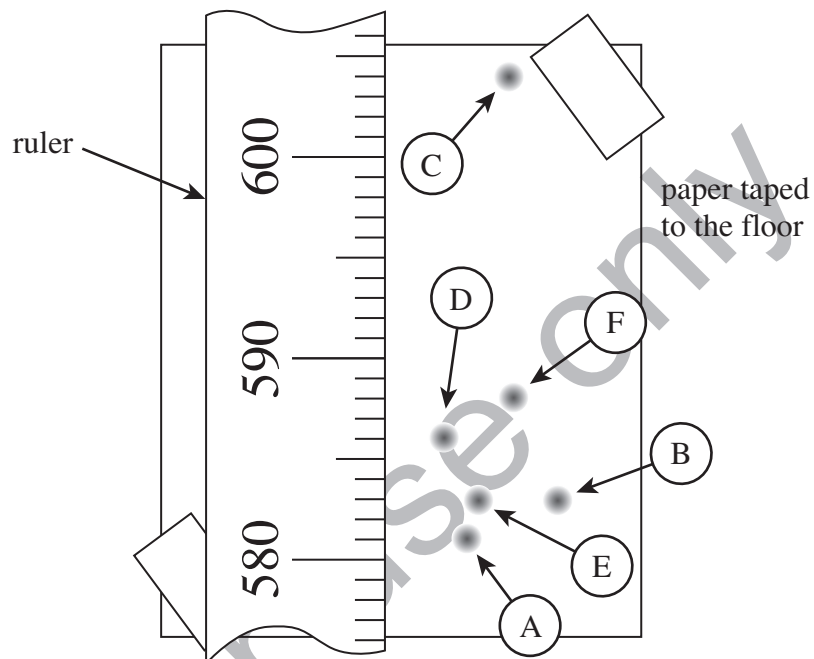
## Section B

1 (i) Determine the gradient,  $G$ , of your graph.

1 (ii) Calculate  $\frac{G^2(H-h)}{H}$ .

2 **Figure 7** shows the impact marks (labelled A to F) produced on a piece of paper, taped to the floor, as a student attempts to make a measurement of  $x_1$ .

**Figure 7**



The six marks were produced by successive impacts of the same ball bearing which was released, on each occasion, from the **same point** on the track and at the **same height** above the bench. The ruler shown in **Figure 7** was then placed over the piece of paper and the zero graduation of the ruler was positioned level with a point marked on the floor, directly below the end of the track.

- 2 (i) Explain how, in your experiment, you located the point on the floor, directly below the end of the track.
- 2 (ii) Suggest why impact mark C is isolated from the other five impact marks.
- 2 (iii) Using the information in **Figure 7**, state and explain the measurement of  $x_1$  that should be recorded by the student.
- 2 (iv) Calculate the uncertainty in the student's result for  $x_1$ . Show your working.

Teacher use only

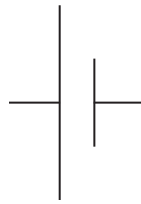
- 3 The electrically conductive surfaces of the paper you used in Section A Part 1 have a coating of paint containing a form of carbon (graphite) similar to that used in pencils.

Using a pencil as part of a circuit containing a single 1.5 V cell, a student designs an experiment to find out more about the electrical properties of graphite.

- 3 (a) Complete **Figure 8** to show the external circuit that the student should use to investigate the current – potential difference (pd) characteristic of the graphite used in the pencil.

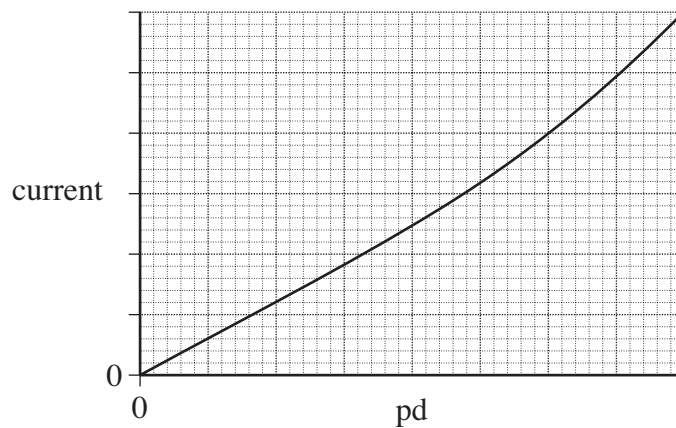
**Figure 8**

single 1.5 V cell



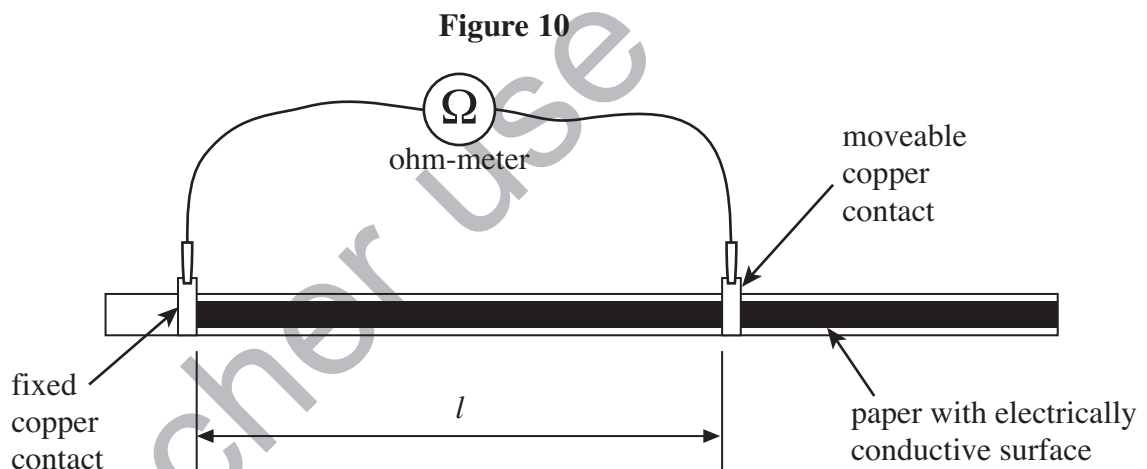
The experimental results are displayed in **Figure 9**.

**Figure 9**



- 3 (b) With reference to **Figure 9**, explain how the resistance of the graphite is affected by temperature.

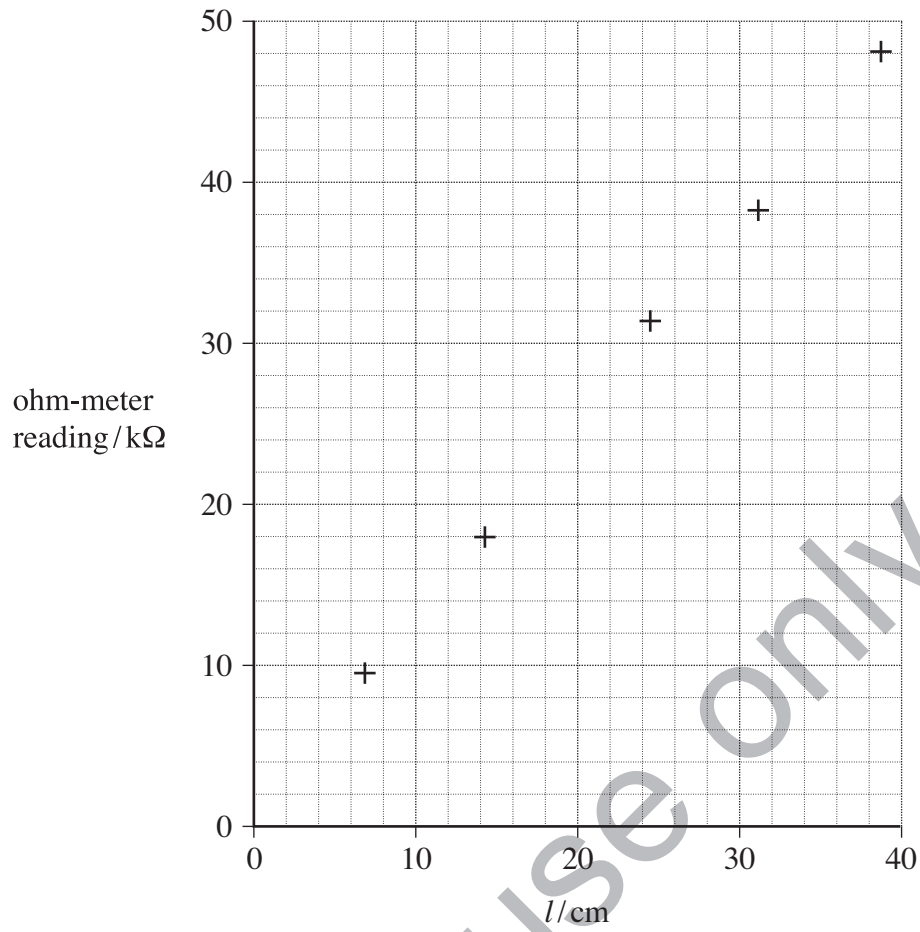
Using the equipment used in Section A Part 1, the student then carries out measurements on one strip of the paper with the electrically conductive surface. By using the moveable contact shown in **Figure 10**, the student investigates how  $l$ , the length of the strip, affects the ohm-meter reading.





The experimental results are displayed in **Figure 11**.

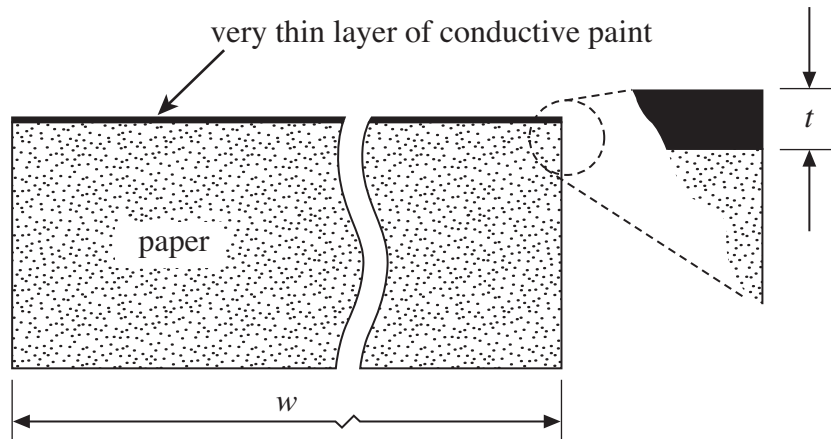
**Figure 11**



- 3 (c)** Use **Figure 11** to determine the resistance per metre of the strip. Show your working.

**Figure 12** shows a cross-sectional view of the strip; the conductive layer of graphite paint is of uniform thickness =  $t$  and the width of the paper strip =  $w$ .

**Figure 12**



- 3 (d) Show that  $\frac{R}{l} = \frac{\rho}{wt}$ , where  $\frac{R}{l}$  = resistance per unit length of the strip and  $\rho$  = resistivity of graphite.
- 3 (e) Describe how  $w$ , the width of the conductive paper strip, can be measured and explain how your procedure reduces uncertainty in the result.