



General Certificate of Education
Advanced Subsidiary Examination
June 2011

Physics (Specifications A and B)

PHA3/B3/XTN

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 EMPA.

INSTRUCTIONS TO THE SUPERVISOR OF THE EXTERNALLY MARKED PRACTICAL ASSIGNMENT

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 Instructions to Supervisors (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 Part 1 and Part 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 on the front cover of the Section B Written Test that this requirement has been met.

Section A: Part 1 and Part 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 Part 1 or Part 2 of Section A, 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 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 any candidate is unable to perform any experiment, 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 candidates unable to proceed with the analysis of their experimental data.

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

Turn over ►

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 controlled conditions 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 by AQA.

Administration

Candidates must not bring any paper-based materials into any session or take any assessment materials away at the end of a session. Mobile phones or other communication devices 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 Advisor 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. In extreme circumstances, when such arrangements are not possible, the teacher can supply a candidate with class data. In this case, there will be no evidence for Part 1 or Part 2, so no marks can be awarded for Section A.

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

Details should be given on the *Supervisor's Report* (page 23) 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 these 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.

Once completed, each candidate's completed EMPA should be collated 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.

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

By the specified deadline centres should assemble and then despatch the following materials

- collated candidates' scripts, in candidate number order
- the *Supervisor's Report* (page 23 of these Instructions) if this is required by the Examiner.

Section A Part 1: Question 1

Candidates are to identify the SWG number of a wire and the type of material from which it is made.

Apparatus

- new D-type cell in holder capable of producing a steady output pd of at least 1.50 V, whilst supplying a current of 0.4 A, or stabilised variable voltage dc mains voltage supply, in series with switch marked S (this can be the on/off switch on the PSU) with the open (off) and closed (on) positions clearly marked
- dc voltmeter capable of reading pd's up to the emf of the dc supply in increments of 0.01 V or better; this meter can be a multimeter, set to suitable range, eg 2000 mV; leads should be connected to the inputs, terminating at crocodile clips labelled 'P' (to positive terminal) and 'Q' (to negative terminal)
- 2.2 Ω resistor, at least 2 W, tolerance **not greater** than 5%, eg Rapid 62-0235, mounted in such a way that candidates can connect crocodile clips to the legs in order to measure the pd across the resistor
- about 60 cm of 22 SWG constantan wire, free from kinks, fixed using 4 mm terminal posts (Rapid 17-0215) mounted on a half-metre ruler; suitable holes should be drilled through the median line of the ruler level with the 50 mm and 450 mm graduations, the wire should be labelled X, eg using a small sticky label close to one end
- connecting leads

Additional equipment

- micrometer screw gauge capable of reading to 0.01 mm
- about 20 cm of 22 SWG constantan wire

The micrometer screw gauge and the 20 cm of 22 SWG constantan wire should be placed on the bench.

Once the terminal posts have been attached to the half-metre ruler, the longer piece of constantan wire should be threaded through the holes in the posts so that the free ends at either end are roughly the same length. Pull the ends of the wire so that the wire goes into tension then screw down the terminal posts.

Assemble the circuit shown in **Figure 1** of the Section A Part 1 question paper/answer booklet so that the wire forms a series circuit with the 2.2 Ω resistor (note that the mounted constantan wire is joined to the rest of the circuit via the round terminal posts).

Ensure that the pd across the resistor can be measured by attaching the clips at the ends of the voltmeter leads to the exposed legs of the resistor.

Check that when switch S is closed the pd across the resistor is about 70% to 80% of the emf.

The candidates should be able to connect the voltmeter as shown in **Figure 2** of the Section A Part 1 question paper/answer booklet when the length of wire between clips P and Q is about 350 mm the pd shown on the voltmeter should be about 15% of the emf.

The examiners require no information for this question.

Supervisors should warn candidates that the 2.2 Ω resistor may get warm during the experiment and remind them to open switch S once they have completed their measurements.

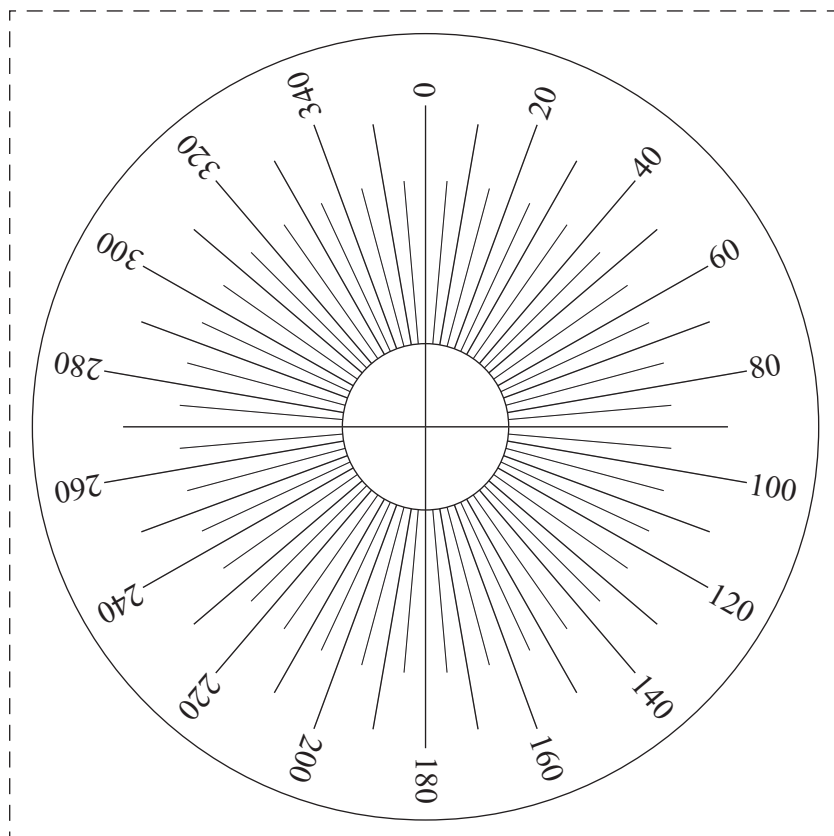
Section A Part 1: Question 2

Candidates are to determine the resistance of an unknown resistor using the circuit shown in **Figure 3** of their question paper / answer booklet.

Apparatus

- rotary 10 k Ω linear potentiometer, eg Rapid 65-0515, at least 0.2 W, fitted with pointer knob, eg Rapid 32-0175; this is to be fitted with connecting leads and joined to the assembly described below which involves the printed rotary scale
- one 2.2 k Ω resistor, metal film, at least 0.25 W, eg Rapid 62-0847; this is the fixed resistor in **Figure 3**
- one each of the following resistors, metal film, at least 0.25 W, Rapid references in brackets: 1 k Ω (62-0824), 2.7 k Ω (62-0852), 5.6 k Ω (62-0867), 15 k Ω (62-0907), 27 k Ω (62-0927), 39 k Ω (62-0408); attach these with Sellotape to a postcard, printing the value of each resistor alongside for the candidates to see
- one 9.1 k Ω resistor, carbon film, at least 0.25 W, eg Rapid 62-0884, the value of this resistor to be concealed from the candidate, eg using masking tape; this resistor should be labelled 'U'
- component holder (eg two mounted crocodile clips) into which the candidate will insert resistors; the clips are to be labelled 'C1' and 'C2'
- a dc supply with series switch labelled 'S'; the terminal pd is at the discretion of the centre (see below)
- voltmeter (moving coil centre zero analogue type) or millivoltmeter (digital multimeter set to a suitable range) capable of reading to ± 0.2 mV or better, with connecting leads attached; one of these is to be connected directly to the sweep arm of the potentiometer
- one copy of the scale below which can be photocopied
- a piece of hardboard or similar sheet material, 12 cm \times 12 cm on which the rotary scale and potentiometer are to be mounted

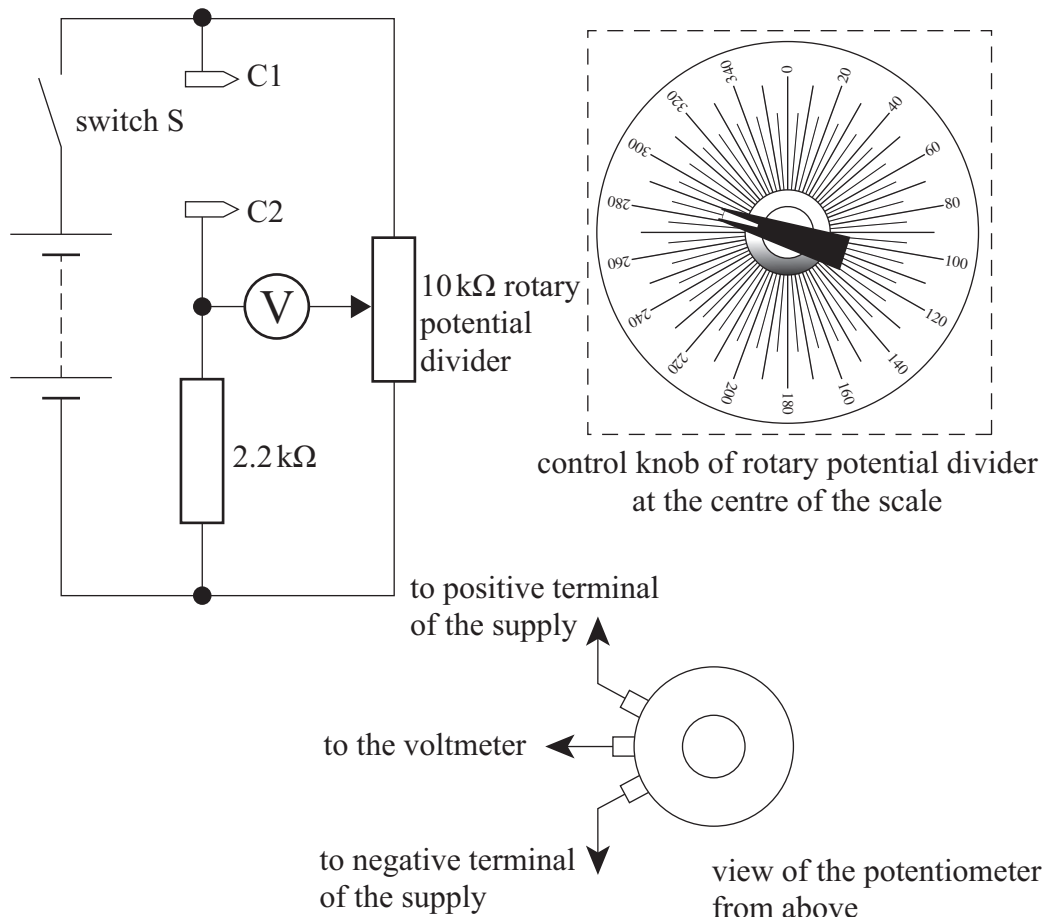
Duplicate without reduction or enlargement, sufficient copies of the template shown below, cutting out around the dotted lines.



Turn over ►

Fix the scale onto the square of hardboard and use Sellotape to ensure the edges are secure. Make a hole at the centre to accommodate the spindle of the potentiometer then secure this to the board using the locking nut supplied with the potentiometer. Cut down the spindle so that when the pointer knob is fitted this lies close to the surface of the scale.

Assemble the circuit shown in **Figure 3** of the question paper / answer booklet, reproduced below with the resistance of the resistors shown. Note the connections made to the potentiometer (called a 'rotary potential divider' in the question).



Connect the 1 kΩ resistor between C1 and C2 then close switch S. Ensure that the connections to the voltmeter are such that when the control knob is rotated fully anti-clockwise, the voltmeter shows a negative reading and when the control knob is rotated fully clockwise the reading becomes positive.

When the control knob is fully rotated anti-clockwise it is to the advantage of the candidates that the position of the pointer shows a small **positive** reading, eg less than 50°, against the scale.

Determine a terminal pd for the power supply that enables the meter to remain within full scale reading for either fully rotated position of the potentiometer.

When the 1 kΩ resistor is replaced with a resistor of greater resistance, the position of the pointer against the scale when the voltmeter reads zero will become more positive.

Ensure that resistor U is in plain view.

The examiners require no information for this question.

Section A Part 2

Candidates are to investigate the variation of potential difference along a piece of conductive paper of two different widths.

Apparatus

- a rectangle of conductive paper, length 300 mm, width 100 mm; rolls of conductive ('Teledeltos') paper are available from Philip Harris Ltd. (code B8A48252, roll dimensions 737 mm × 2 m, price £16.91)
- copper metal foil to produce two electrodes, each of width 10 mm, length 100 mm; copper metal foil can be obtained from Philip Harris Ltd. (copper metal foil (0.13 mm) B8A67131)
- rectangular piece of thin material on which to mount the conductive paper strip, of minimum length 300 mm, width 100 mm; the material should be such that the conductive paper can be glued to it, eg using paper glue, and the electrodes can be fixed to it using staples from a staple gun – suitable material could be sheet chipboard, notice-board ('Sundealla') or plywood
- a strip of paper tape, eg ticker tape, to be glued in place so that one edge lies along the centre line of the conductive paper, as shown in **Figure 4** of the Section A part 2 question paper / answer booklet

for the circuit:

- dc power supply; one, two, three or four 1.5 V D-type cell(s), in a holder, or regulated mains supply with emf in range up to 6.0 V is ideal
- digital voltmeter, capable of reading to 0.01 V or 0.001 V if used on 2000 mV full scale reading (most 3½ digit LCD multimeters will be suitable) – the meter should be capable of reading up to the emf of the supply; a probe should be connected to the positive terminal of meter, eg a multimeter test probe or small screwdriver connected via a crocodile clip to an insulated lead terminating at a 4 mm round plug
- one each of the following resistors, metal film, at least 0.25 W, Rapid references in brackets: 2.7 kΩ (62-0852), 3.9 kΩ (62-0854)
- two further connecting leads terminated at both ends with 4 mm round plugs

additionally:

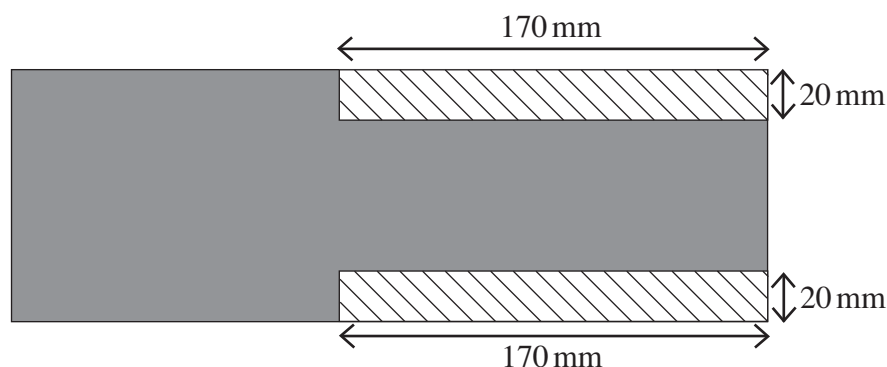
- 300 mm perspex ruler

tools required and additional materials for assembly:

- pencil and ruler to mark out conductive paper
- staple gun for construction
- scissors, sharp knife or scalpel for cutting conductive paper; use of cutting board recommended
- strong adhesive tape, eg Gaffer tape
- paper glue, eg Pritt Stick

Cut out a rectangle of conductive paper with dimensions 300 × 100 mm, then remove the areas (shown shaded in the diagram).

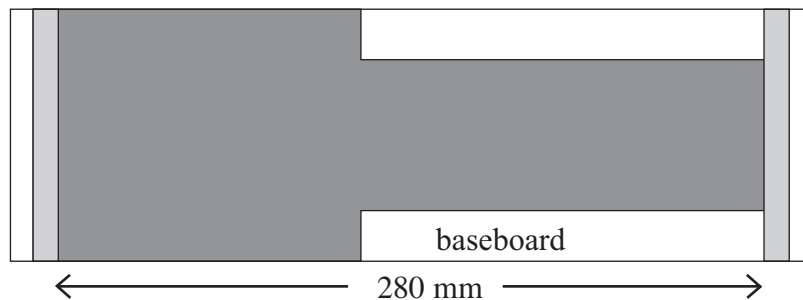
rectangle of conductive paper of size 300 mm by 100 mm



rectangles to be removed (shown shaded)
of dimensions 20 mm by 170 mm

Turn over ►

Position the conductive paper centrally on to the baseboard and glue down or use Sellotape to fix the conductive paper strip in place. Form the electrodes from the sheet of copper foil then position these so that they are flush with the edges of the paper and the exposed length of the conductive paper is 280 mm.

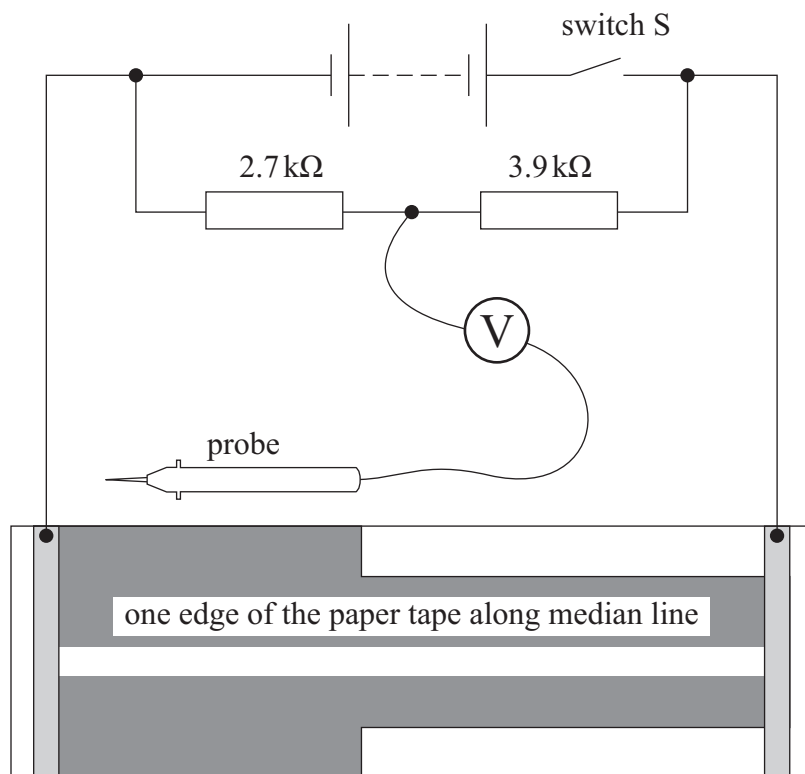


Fix the electrodes in position using staples or some other method to provide good electrical contact with the conductive paper.

It is suggested that the connecting leads between the electrodes and the external circuit are made by soldering stranded insulated wire to the exposed surface of the electrodes.

Finally glue a strip of paper tape so that one edge of this is aligned with the median line of the conductive paper.

Connect the external circuit as shown below.



The apparatus is now complete: details of testing given below.

Use the voltmeter to confirm that a potential gradient exists along the length of the conductive paper and not just between the copper electrodes. The voltmeter reading V , should be zero at a distance x from the left-hand electrode in the region $x = 140$ to 150 mm.

Candidates will be required to record V for x values starting at $x = 20$ mm and ending at $x = 260$ mm so contact resistances at the electrodes will not affect a candidate's ability to perform the experiment. Thus there is no necessity to produce apparatus for which $V = 0$ V when $x = 0$ mm, or $V = \text{emf of supply}$ when $x = 280$ mm.

Values of V should increase linearly along the median line of the conductive paper strip and the rate of increase of V with x should become greater where the width of the paper narrows, ie at $x = 120$ mm.

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 Part 1 should **not** be made available to them.

Turn over ►

Section A Part 1

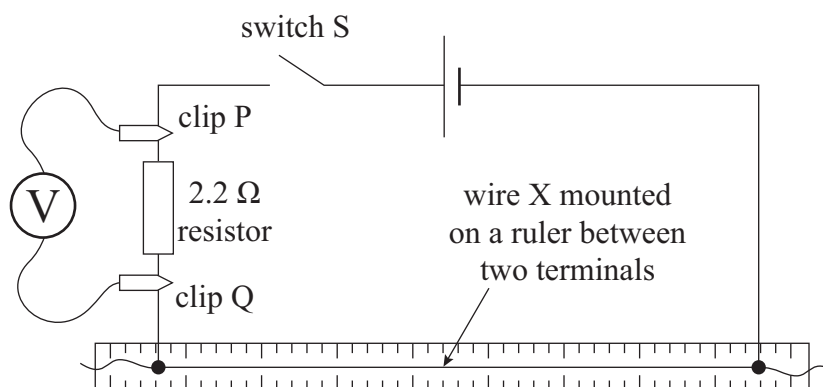
- 1 You are to identify the diameter of a wire and the material from which it is made.
- 1 (a) Wire is manufactured in certain diameters under a system known as the *English Standard Wire Gauge*, each diameter of wire being identified by a particular SWG number.
- Table 1** shows the diameter of wires with certain SWG numbers.

Table 1

SWG number	16	20	22	24	28	30
diameter / mm	1.626	0.914	0.711	0.559	0.376	0.315

- 1 (a) (i) You are provided with about 20 cm of loose wire.
Use the micrometer screw gauge to determine d , the diameter of this wire.
- 1 (a) (ii) Identify the SWG number of the wire you have been given. (2 marks)
- 1 (b) You are provided with a circuit that includes a wire X, mounted on a ruler between two terminals. The wire is connected in series with a $2.2\ \Omega$ resistor, a power supply and a switch S. Connect the voltmeter in parallel with the resistor by attaching the clips P and Q to the exposed legs of the resistor, as shown in **Figure 1**.

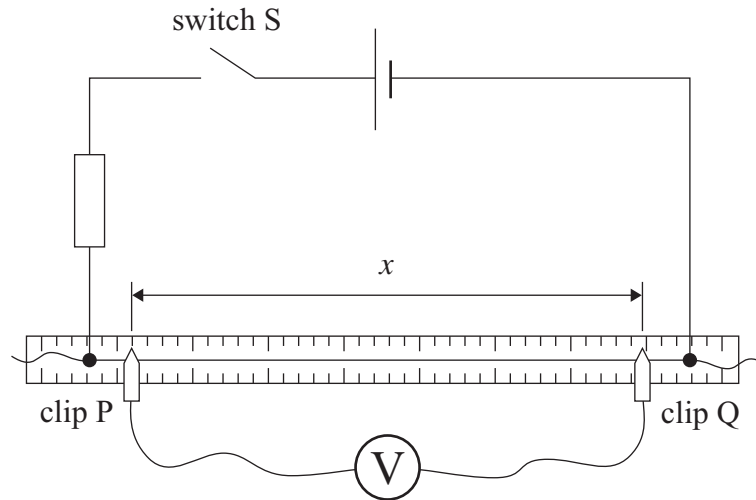
Figure 1



- 1 (b) (i) Close switch S, then read and record the voltmeter reading, V_1 .

Open switch S and disconnect the clips from the resistor, then reattach P and Q at points along the wire X close to each of the round terminals, as shown in **Figure 2**.

Figure 2



- 1 (b) (ii) Close switch S, then read and record the new voltmeter reading, V_2 .

Open switch S before moving on to the next part of the question.

- 1 (b) (iii) Use the ruler readings to determine the length, x , of wire between the clips P and Q.

- 1 (b) (iv) The resistance of the wire between P and Q is given by $2.2 \times \frac{V_2}{V_1}$.

Calculate the resistance of the wire between P and Q.

(2 marks)

- 1 (c) The uncertainty in V_1 and in V_2 is ± 10 mV.

- 1 (c) (i) Calculate the percentage uncertainty in V_1 .

- 1 (c) (ii) Calculate the percentage uncertainty in V_2 .

(2 marks)

- 1 (d) The percentage uncertainty in the resistance of the 2.2Ω resistor is 5%.

Calculate the percentage uncertainty in the resistance of the wire between P and Q.

(1 mark)

Question 1 continues on the next page

Turn over ►

- 1 (e) X is a wire of the same material and diameter as that you used in part (a). The material from which X has been made can be identified by measuring its resistance per unit length, ie the resistance of 1 metre of the wire. Use your answers to part (a) and part (b) and the information contained in **Table 2** to determine the material from which X has been made.

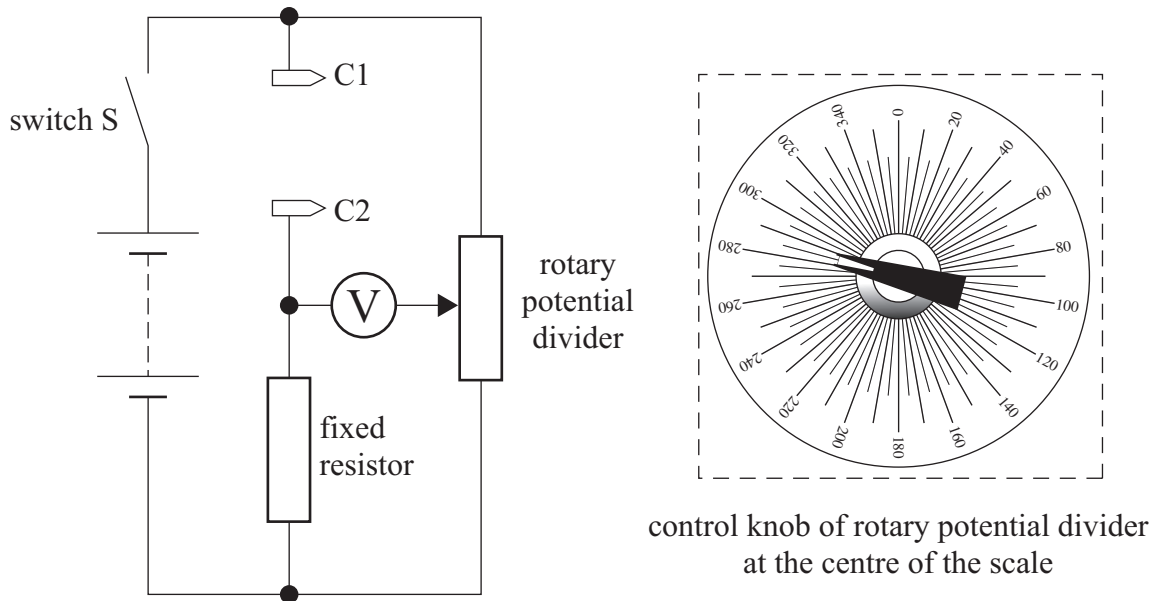
Table 2

SWG number	resistance per metre of wire / $\Omega \text{ m}^{-1}$				
	<i>tinned copper</i>	<i>manganin</i>	<i>constantan</i>	<i>chromel</i>	<i>nichrome</i>
16	0.00831	0.200	0.234	0.337	0.517
20	0.0263	0.633	0.747	1.07	1.64
22	0.0434	1.05	1.23	1.76	2.70
24	0.0703	1.69	2.00	2.85	4.37
28	0.155	3.74	4.41	6.30	9.66
30	0.221	5.33	6.29	8.98	13.8

(2 marks)

- 2 You are to determine the resistance of an unknown resistor using the circuit shown in **Figure 3**.

Figure 3



control knob of rotary potential divider
at the centre of the scale

You are provided with six resistors of known resistance.

Connect the $1\text{ k}\Omega$ resistor between clips C1 and C2 and close switch S.

Rotate the control knob of the rotary potential divider **fully** anti-clockwise. Check that the voltmeter shows a negative reading.

Slowly rotate the control knob in a clockwise direction until the voltmeter reading just starts to change.

- 2 (a) (i) Read and record the position, θ_0 of the control knob against the scale.
- 2 (a) (ii) Rotate the control knob further in a clockwise direction until the voltmeter reading becomes zero.
Read and record in **Table 3**, the new position, θ , of the control knob against the scale.

Question 2 continues on the next page

Turn over ►

- 2 (a) (iii) Remove the $1\text{ k}\Omega$ resistor from clips C1 and C2 then repeat the procedure in part (a)(ii) to read values of θ when each of the remaining resistors of known resistance R are connected, in turn, between clips C1 and C2. Record the values of θ for each of these resistors in **Table 3** then complete the right-hand column to show the corresponding values of $(\theta - \theta_0)$. When you have completed these readings remove the resistor from C1 and C2 and open switch S.

Table 3

$R/\text{k}\Omega$	$\theta/^\circ$	$(\theta - \theta_0)/^\circ$
1.0		
2.7		
5.6		
15.0		
27.0		
39.0		

(2 marks)

- 2 (b) Plot, on the grid provided, a graph with $(\theta - \theta_0)/^\circ$ on the vertical axis and $R/\text{k}\Omega$ on the horizontal axis.

(3 marks)

- 2 (c) You are provided with another resistor, U, of unknown resistance R_U . Connect U between clips C1 and C2 and close switch S.

- 2 (c) (i) Adjust the position of the control knob until the voltmeter reading becomes zero then read and record the position, θ_U , of the control knob against the scale.

- 2 (c) (ii) Showing your working clearly, use your graph to determine R_U .

(2 marks)

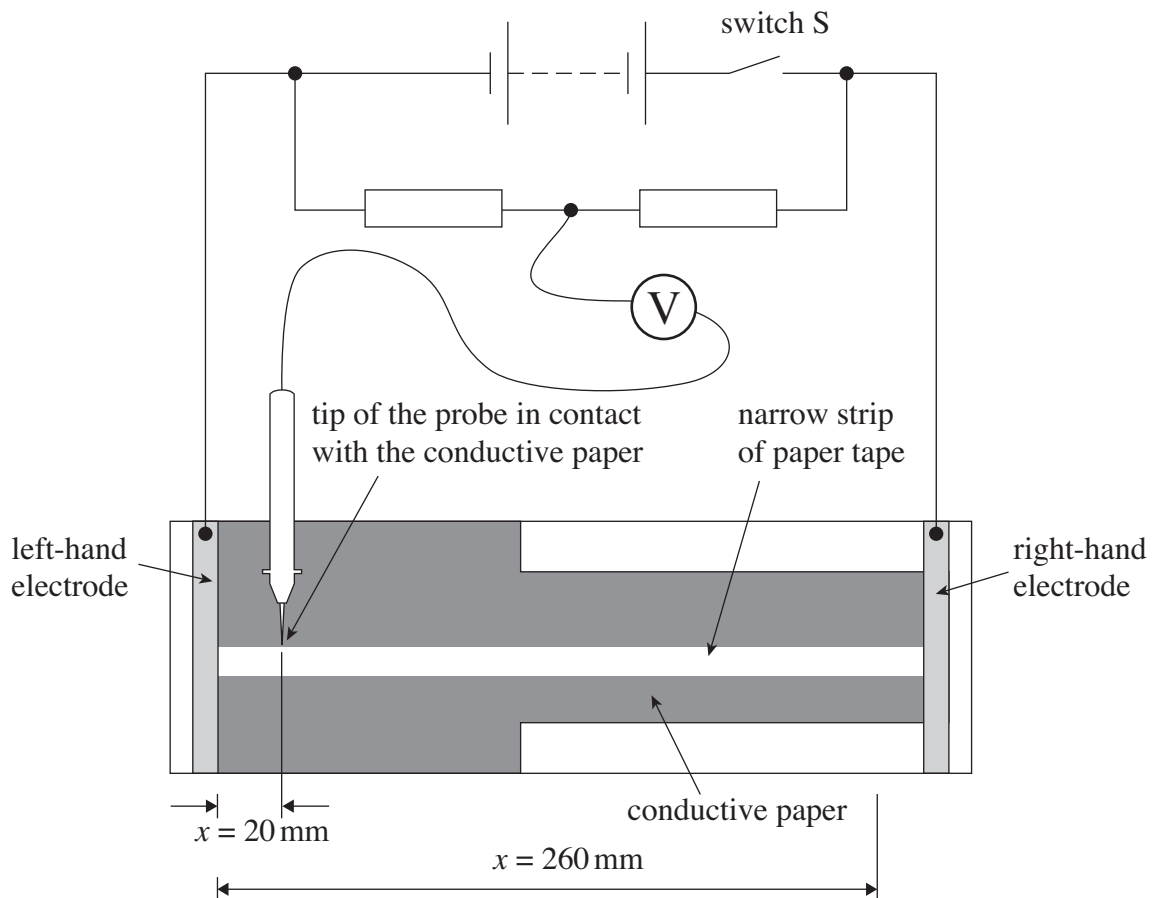
7

END OF SECTION A PART 1

Section A Part 2

- 1** In this experiment you are to investigate the variation of potential difference along a piece of conductive paper of two different widths.
A narrow strip of paper tape has been stuck to the conductive paper.
Make a faint pencil mark on this paper tape at a distance, $x = 20$ mm from the left-hand electrode.
- 1 (a)** Close switch S and place the tip of the probe in contact with the conductive paper next to the pencil mark as shown in **Figure 4**.

Figure 4



- 1 (a) (i)** Taking account of the sign shown on the meter, read and record V_{20} , the voltmeter reading when $x = 20$ mm.
- 1 (a) (ii)** Repeating the procedure as above and taking account of the sign shown on the meter, read and record V_{260} , the voltmeter reading when $x = 260$ mm.
- 1 (a) (iii)** Evaluate $\frac{V_{260}}{V_{20}}$.

(1 mark)

Question 1 continues on the next page

- 1 (b)** Using the same procedure as in part (a), investigate how V varies for values of x **between** 20 mm and 260 mm.
You should take sufficient readings so that when a graph is plotted of these data, you can establish clearly how V varies with x in both the wide and narrow parts of the conductive paper.
Open switch S when you have completed your measurements.

Record all your measurements and observations.

Note that the independent variable should be recorded in the **left-hand** column of your table.

(5 marks)

- 1 (c)** Using all your data from part (a) and part (b), plot a graph with V on the vertical axis and x on the horizontal axis.

(9 marks)

END OF SECTION A PART 2

Section B

1 (a) Use your graph to determine

1 (a) (i) V_0 , the voltmeter reading, where $x = 0$ mm,

1 (a) (ii) V_{280} , the voltmeter reading, where $x = 280$ mm,

1 (a) (iii) x_0 , the value of x in mm, when $V = 0$.

(2 marks)

1 (b) (i) Determine the gradient, G , of your graph, where $x = 200$ mm.

1 (b) (ii) Evaluate

$$\frac{G(280 - x_0)}{V_{280} - V_0}$$

(4 marks)

2 Suppose that you repeated the experiment using a supply with a lower emf.

2 (a) State the effect, if any, this change will have on

2 (a) (i) your value of G ,

2 (a) (ii) your value of $\frac{V_{260}}{V_{20}}$.

(2 marks)

2 (b) Explain the reasoning behind your answers to part (a).

(1 mark)

3 (a) State without explanation how you could determine from your graph the value of x at which the width of the conductive paper changes.

(1 mark)

3 (b) Student A claims that to reduce the uncertainty in the value of x at which the width of the conductive paper changes, it would be a good idea to take more readings around that point.

Student B says it is better to make sure that there are enough readings so that both straight line regions can be accurately plotted.

Explain which student has the better argument.

(2 marks)

6

3

3

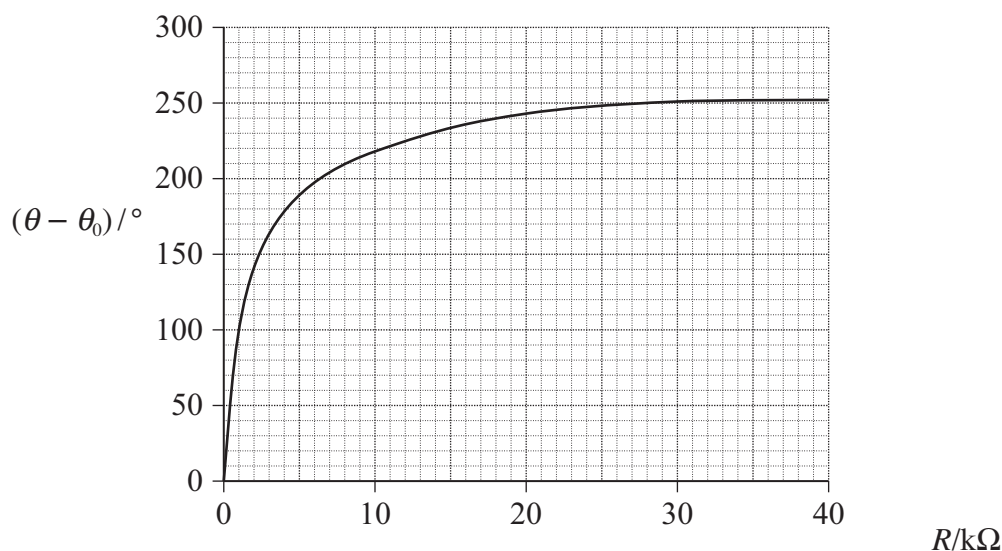
- 4 In Section A Part 1 you measured the diameter of a wire using a micrometer screw gauge.
- 4 (i) Suggest a possible source of random error in this measurement.
- 4 (ii) Describe and explain a procedure that can be followed that may reduce the effect of the source of random error you identified in part (i).
- 4 (iii) Suggest a procedure that can be followed that may reduce the effect of systematic error in the determination of the diameter.

(4 marks)

4

- 5 In Section A Part 1 you were asked to record the position, θ , of the control knob against a scale when the voltmeter read zero and then to plot a graph from which the resistance R_U , of an unknown resistor was determined.

A student who has carried out this experiment produces the graph shown in **Figure 5**.

Figure 5

The student estimates that the uncertainty in each reading of θ is $\pm 1.5^\circ$.

- 5 (i) State the uncertainty in the calculated values of $(\theta - \theta_0)$
- 5 (ii) Hence explain why the student would find it difficult to use **Figure 5** to make an accurate determination of R_U if the resistance was approximately $25 \text{ k}\Omega$.
You may add detail to **Figure 5** to illustrate your answer.

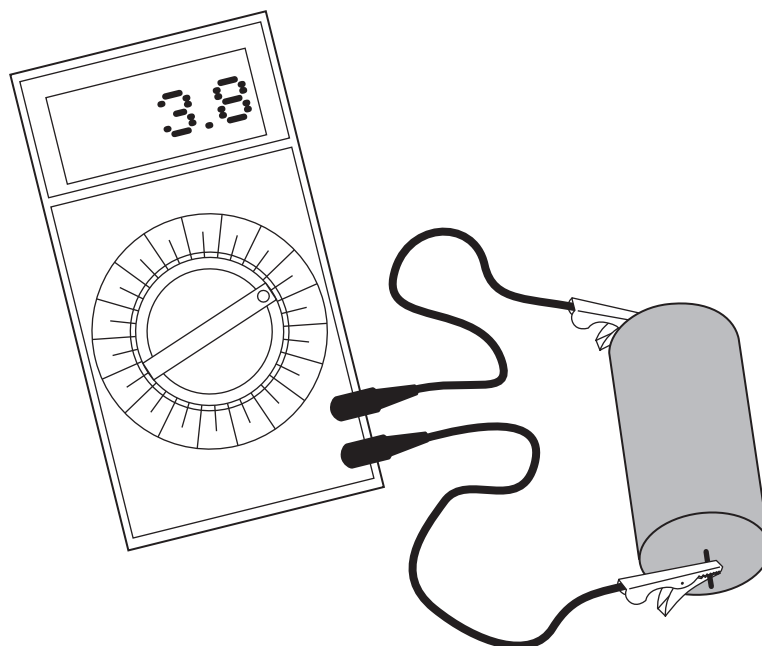
(3 marks)

3

- 6 Conducting putty is a material made by mixing silicone rubber with carbon powder. The putty can be easily formed into different shapes so the effect of these changes on the electrical resistance can be investigated.

A student forms a sample of the putty into a cylinder and connects the ends of the cylinder to a resistance meter which gives a direct reading of the resistance in Ω , as shown in **Figure 6**.

Figure 6



The student then forms the sample of putty into cylinders of different lengths, each time measuring the length L , and the resistance R .

The student's results for these different cylinders are shown in **Table 4**.

Table 4

L/cm	R/Ω	for use in answering part (a)
6.6	2.9	
10.6	7.6	
13.8	13.0	
17.8	21.6	
21.4	30.4	

Theory suggests that $R = kL^2$, where k is a constant.

- 6 (a) Show whether the data in **Table 4** confirm the theory.
You may use the right-hand column of **Table 4** to assist you with this question.
(3 marks)
- 6 (b) Estimate the length of the cylinder, the resistance of which is shown being measured in **Figure 6**.
(2 marks)

5

END OF SECTION B



**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.

There are no instructions printed on this page