



General Certificate of Education  
Advanced Subsidiary Examination  
June 2013

## 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*.

Turn over ►

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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 Task 2 question paper/answer booklet.
- Supervisors should ensure that candidates understand that Section A Task 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 and 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 Task 1
- Section A Task 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.

**For Section A Task 1, Question 1**

Candidates are to trace the path of a ray of light passing through a semicircular transparent block.

**Apparatus required:**

- semicircular transparent block, acrylic or glass
- plane mirror glued to a block of wood so that the reflective surface lies in a vertical plane, the mirror will be placed in contact with the diameter of the semicircular block
- 300 mm plastic ruler
- protractor, precision  $1^\circ$  or  $0.5^\circ$
- suitable white light source, eg ray box fitted with cylindrical convex lens and slit to produce a narrow parallel beam of white light
- photocopies of page 10 of these instructions

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, remove any marked diagrams used by the previous candidate.

**Please do not forward the candidates' marked diagrams to the examiner with the scripts; these should be securely disposed of by the centre.**

**Examiners require no information for this question.**

**For Section A Task 1, Question 2**

Candidates are to measure the transit time for water waves for three different depths of water.

**Apparatus required:**

- shallow polypropylene tray, eg 'Gratnells' type of dimensions  $427 \text{ mm} \times 312 \text{ mm} \times 75 \text{ mm}$ , any colour; these are available from Philip Harris
- digital stopwatch capable of reading to 0.1 s or 0.01 s
- jug (or beaker) to hold about 300 ml of water
- larger container(s) to hold sufficient water for the experiment
- paper towels to mop up spills

**For preparation:**

- measuring cylinder to establish the volume of water equivalent to "one measure" (see below)

Fill the tray to a depth of about 5 mm. Determine the volume of water in the tray using the measuring cylinder then transfer 50% of the water to the jug. Mark the level of the water in the jug using an indelible pen or with a label as "one measure" (for the specified tray the volume of one measure will be about 300 ml). Once calibrated, empty the jug and place this together with the other apparatus on the bench.

If the apparatus is to be used by another candidate following on, empty the tray of water, mop up any spills, and check that the container has sufficient water for the next candidate.

**If both experiments are to be undertaken in the same laboratory, the Supervisor should ensure that lighting conditions are such that the surface water waves are clearly visible.**

**Examiners require no information for this question.**

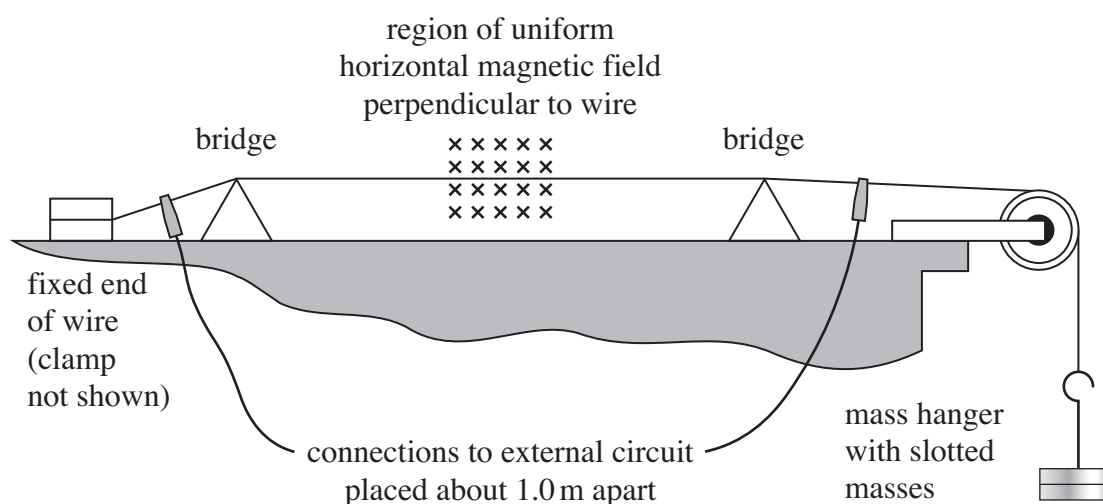
### For Section A Task 2

Candidates are to investigate transverse stationary waves on a wire undergoing forced vibration at the fundamental frequency.

#### Apparatus required for each candidate:

- 50 Hz continuously variable ac voltage supply to provide sinusoidal current of about 0.5 A, fitted with suitable connecting wires to attach to the ends of the constantan wire about 1.0 m apart (an equivalent arrangement using a stepped voltage supply with potentiometer may be used as a substitute)
- about 1.5 m 28 SWG constantan wire with a small loop tied at one end to attach hanger for slotted masses
- two Magnadur (slab) magnets, 50 mm × 19 mm × 6 mm and mild steel yoke (to hold slab magnets) as per Westminster Electromagnetism kit, to provide horizontal uniform magnetic field (check that the opposing faces of the magnets are of opposite polarity)
- micrometer screw gauge capable of reading to 0.01 mm (see note on page 8)
- metre ruler and set square
- two bridges, eg glass prisms or wooden bridges to define vibrating section of wire: candidates should be able to vary this distance between 0.20 m and 0.80 m.
- two small blocks of wood and G-clamp to secure fixed end of wire
- pulley, supported in a suitable fashion to enable the slotted masses to hang freely as shown in the diagram
- mass hanger and slotted masses to provide a total mass that can vary from 100 g to 450 g in 50 g steps, eg hanger of mass 100 g and slotted masses of values  $1 \times 50$  g and  $3 \times 100$  g (to provide maximum mass of 450 g)

The apparatus is shown below.



There is no insistence that the fixed end should be at the left-hand end of the arrangement as presented to the candidate. Note that each set will need to be set up parallel with, and close to, the edge of the bench, with the pulley overhanging the end of the bench. Ensure that the sections of the wire between bridge and fixed end, and between bridge and pulley, are not too steeply inclined, to enable ease of movement of the bridges.

Prior to the examination, the output of the power supply should be adjusted so that when the length of the vibrating section is about 0.5 m, the wire oscillates in fundamental mode with amplitude between 1 cm and 2 cm at the mid-point. The variable voltage control should then be taped over.

Turn over ►

**Note about provision of micrometer screw gauges.**

If the number of micrometer screw gauges available is limited the supervisor may ask the candidates to share instruments but must ensure that when transfer takes place, the screw gauge is reset. There is no insistence that the measurement with the micrometer (part (a) in the question) should be made by the candidates at the beginning of the experiment.

Centres may supply digital micrometers if the use of these is standard practice but examiners should be informed of this using the Supervisor's Report (page 9 of these Instructions).

Candidates must be familiar with the use of the analogue micrometer screw gauge.

**Examiners require the following information for this question.**

The typical mass, to 0.01 g of 1.000 m ( $\pm 0.005$  m) of the wire used by the candidates.

Information regarding the type of micrometer screw gauge used by the candidates.





**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 Task 1**

**Question 1 and Question 2** No information is required

**Section A Task 2**

**Question 1** The **typical** mass, to 0.01 g, of 1.000 m ( $\pm 0.005$  m) of the wire used by the candidates.

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The type of micrometer screw gauge used by the candidates  
(please tick appropriate box)

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

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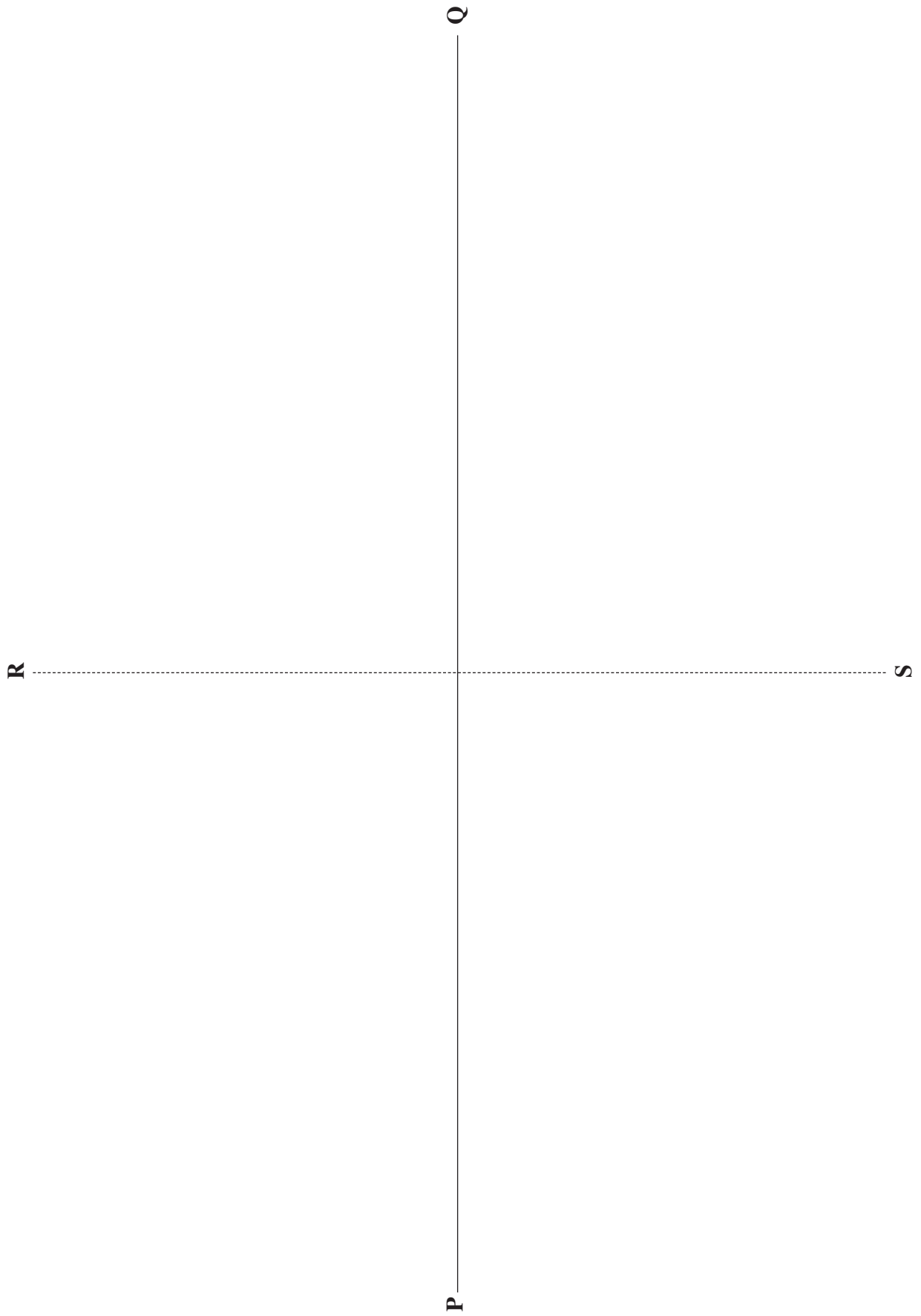
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Supervisor's Signature ..... Centre Number .....

Date .....

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



### SECTION A TASK 1

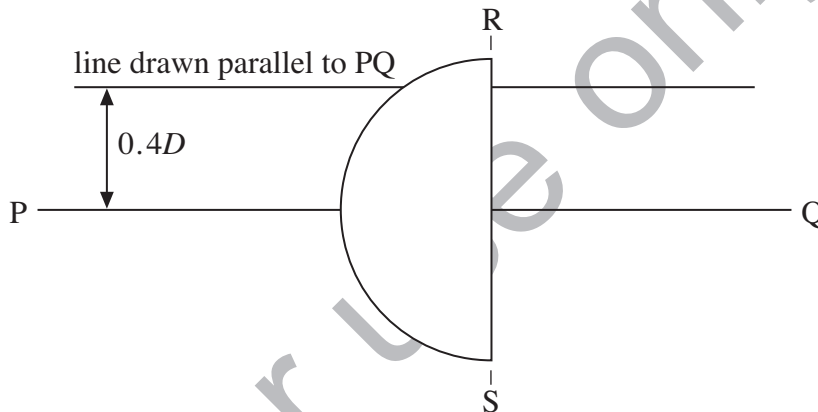
Follow the instructions given below.

Give the information required in the spaces provided.

No description of the experiments is required.

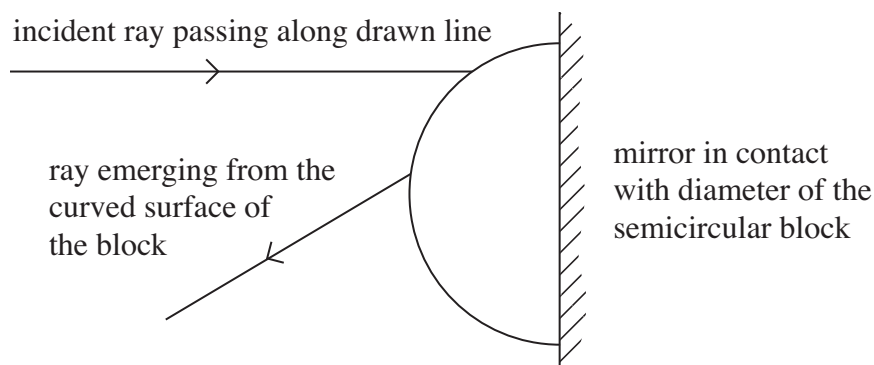
- 1** You are to trace the path of a light ray passing through a semicircular transparent block.
- 1 (a)** Measure and record the diameter,  $D$ , of the semicircular block.
- 1 (b)** You are provided with a sheet of paper, on which there is a solid line, PQ, and a dashed line, RS. Place this sheet on the table with P to your left.
- 1 (b) (i)** Draw a line across the sheet parallel to PQ and  $0.4D$  above it, as shown in **Figure 1**.

**Figure 1**



- 1 (b) (ii)** Place the block on the sheet so that the diameter of the block is aligned with RS and the mid-point of the diameter of the block is where PQ and RS meet, as shown in **Figure 1**.  
Mark the outline of the semicircular block on the paper.  
Place the plane mirror with the reflective surface along the line RS, in contact with the diameter of the block.
- 1 (b) (iii)** Use the ray box to direct a ray of light along the line you drew in part (i) so that the ray emerges from the curved surface of the block, as shown in **Figure 2**.

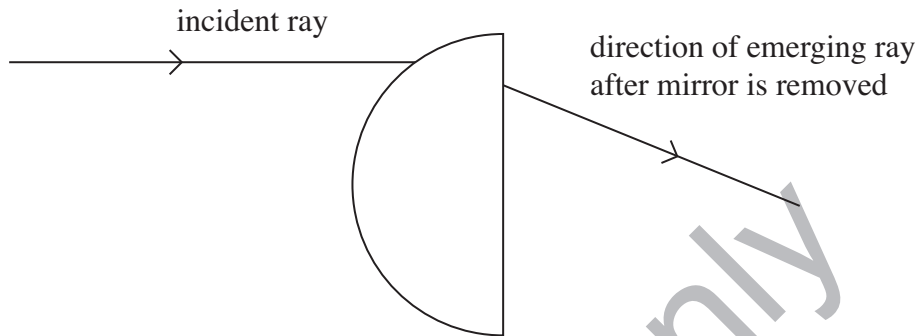
**Figure 2**



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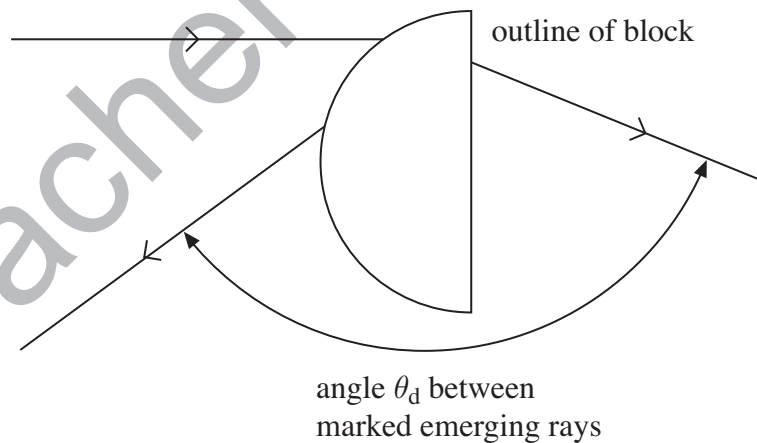
- 1 (b) (iv) Mark on the sheet of paper the direction of the ray emerging from the curved surface of the block.
- 1 (c) With the block and the ray box in the same positions, remove the plane mirror so that the ray now emerges from the diameter of the block, as shown in **Figure 3**.

Figure 3



- 1 (c) (i) Mark on the sheet the direction of the ray emerging from the diameter of the block.
- 1 (c) (ii) Remove the block. Measure and record the angle,  $\theta_d$ , defined in **Figure 4**.

Figure 4



- 1 (c) (iii) **Figure 5** shows how  $\theta_d$ , varies with  $n$ , the refractive index of the block. Showing your method on **Figure 5**, determine  $n$  for your block.
- 1 (d) **Table 1** shows the steps involved in performing the experimental procedure to determine  $\theta_d$ .

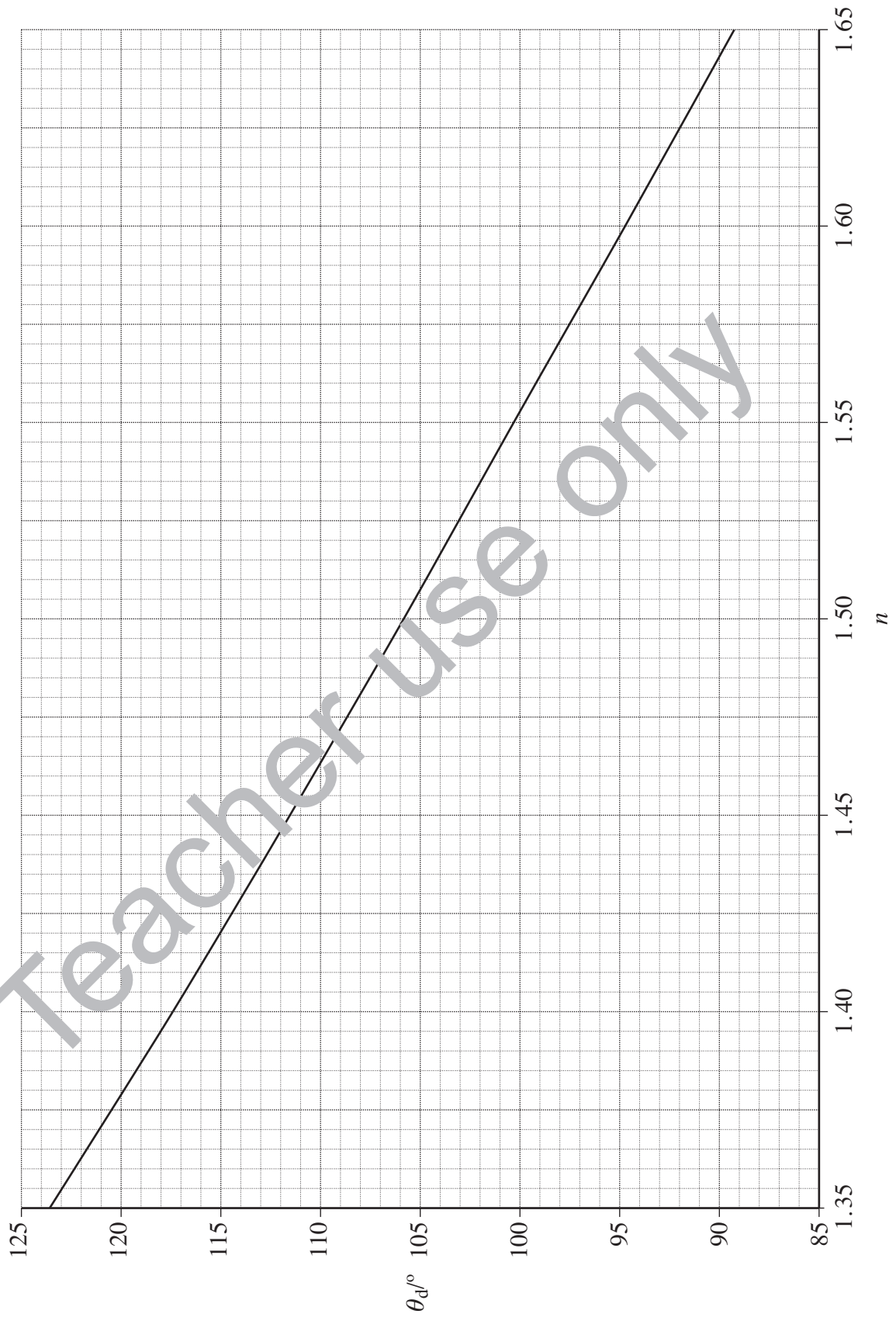
**Table 1**

step	question	procedure
A	(a)	measuring $D$ , the diameter of the semicircular block
B	(b)(i)	drawing the direction of the line parallel to PQ
C	(b)(ii)	positioning the block in the specified position
D	(b)(iii)	aligning the light ray with the line marked parallel to PQ
E	(b)(iv) and (c)(i)	marking the direction of the rays emerging from the block
F	(c)(ii)	measuring the angle $\theta_d$

State and explain which of the steps, A to F, contributed most to the uncertainty in your result for  $\theta_d$ .

- 1 (e) Describe with the aid of a sketch how you positioned the protractor before measuring  $\theta_d$ .

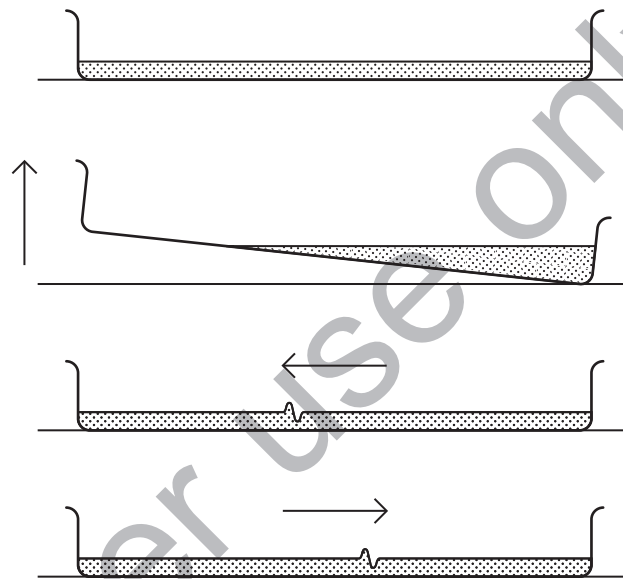
Figure 5



Teacher Use Only

- 2 You are to measure the transit time for water waves for three different depths of water.
- 2 (a) A container has been marked to show when it holds **one measure** of water. Fill the container with water up to this mark then carefully pour this into the shallow tray. Repeat the process so that the tray contains **two measures** of water.
- 2 (a) (i) Carefully lift one end of the tray about 2 cm above the bench then let it fall back. This will cause a plane wave to travel along the surface of the water, as shown in **Figure 6**.

Figure 6



2 (a) (ii) Make suitable measurements to determine  $T$ , the time for the water wave to travel **from one end of the tray to the other** when  $m$ , the number of measures of water in the tray is 2.

2 (a) (iii) Repeat the procedure for  $m = 3$  and for  $m = 4$ .

Record your measurements below.

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

2 (b) A teacher suggests that for this experiment,

$$T\sqrt{m} = k$$

where  $k$  is a constant.

2 (b) (i) By performing suitable calculations with your data from part (a), state and explain whether you think the teacher's theory is correct.

Teacher use only



- 2 (b) (ii) The teacher's theory is based on the assumption that  $m$  is directly proportional to the depth of the water in the tray.  
For the tray that you used, explain whether you think the teacher's assumption is valid.

Teacher use only

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### SECTION A TASK 2

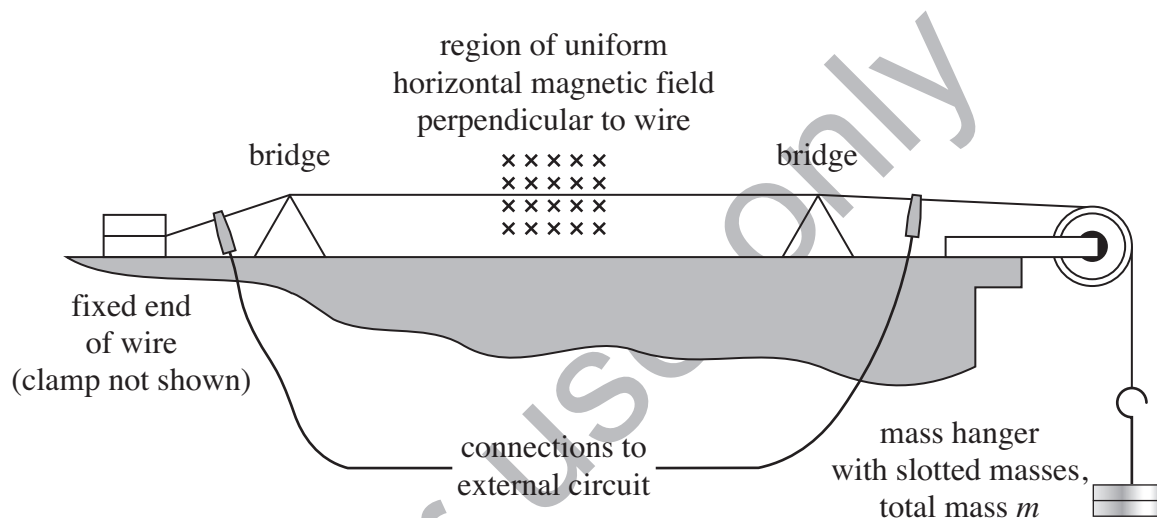
Follow the instructions given below.

Give the information required in the spaces provided.

No description of the experiment is required.

- 1** In this experiment you are required to investigate transverse stationary waves on a wire. You are provided with the arrangement shown in **Figure 7**.

**Figure 7**



When an alternating current passes along the wire, the wire vibrates because it is in tension and the magnetic field exerts an alternating force on it. Stationary waves are formed on the wire if the length of the vibrating section is adjusted suitably by moving the bridges.

- 1 (a)** Use the micrometer screw gauge to determine the diameter,  $d$ , of the wire.

- 1 (b) Place sufficient slotted masses on the hanger so that the **total** mass,  $m$ , supported by the wire is 0.100 kg.  
Adjust the separation of the bridges so that the length of the wire,  $l$ , between them is approximately 0.20 m.  
**Turn on** the ac power supply.  
Keeping the horizontal magnetic field at the centre of the vibrating section of the wire, **increase**  $l$  by moving the bridges apart until the wire is seen to vibrate at the fundamental frequency.  
Record your measurements of  $m$  **in kilograms** and  $l$  **in metres** then repeat the procedure for **five larger** values of  $m$ .  
When you have completed your measurements, **turn off** the ac power supply.
- Record your measurements below.  
Note that the independent variable should be recorded in the **left-hand** column of your table.  
Leave space in your table for an extra column for the data you will be required to plot on your graph (see part (c) below).
- 1 (c) Plot, on the grid opposite, a graph with  $l$  on the vertical axis and  $\sqrt{m}$  on the horizontal axis.

Teacher use only

**SECTION B**

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

Time allowed is 1 hour 15 minutes.

You will need to refer to the work you did in Section A Task 2 when answering these questions.

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

**1 (a) (ii)** Calculate the mass per unit length of the wire,  $\mu$ , given by

$$\mu = \frac{g}{(2fG)^2},$$

where  $g = 9.81 \text{ N kg}^{-1}$  and  $f = 50 \text{ Hz}$ .

Teacher use only

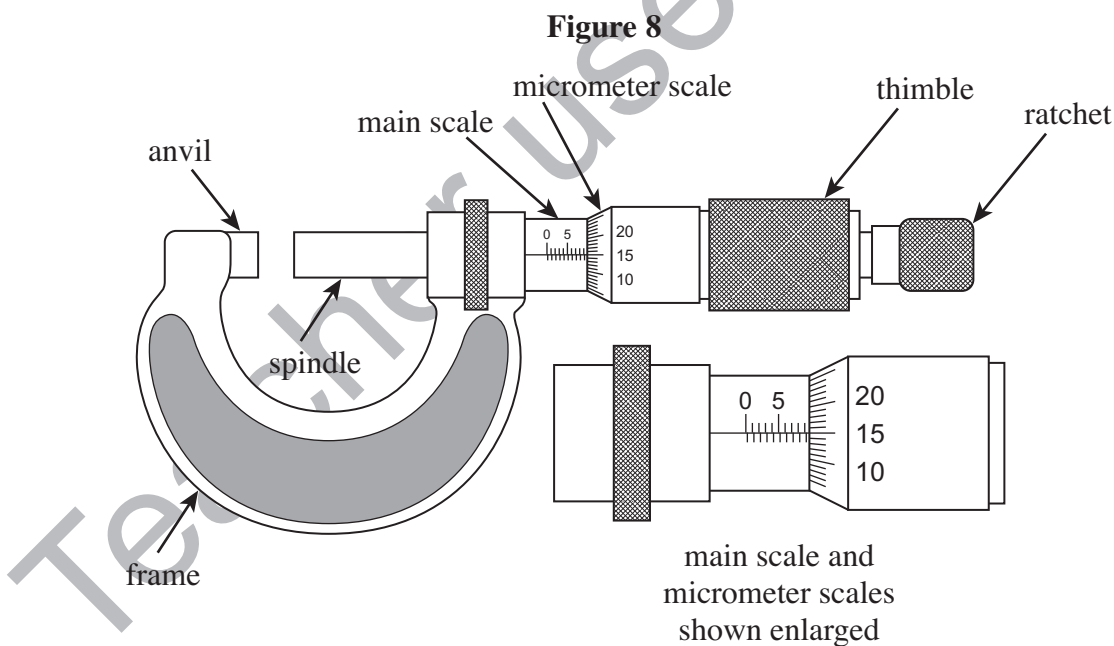
- 1 (b) Wire is manufactured in certain diameters under a system known as the *English Standard Wire Gauge*, each diameter of wire being identified by a particular SWG number.

**Table 2** shows the diameter of wires with certain SWG numbers.

**Table 2**

SWG number	22	24	26	28	30	32	34
diameter/mm	0.711	0.559	0.457	0.376	0.315	0.274	0.234

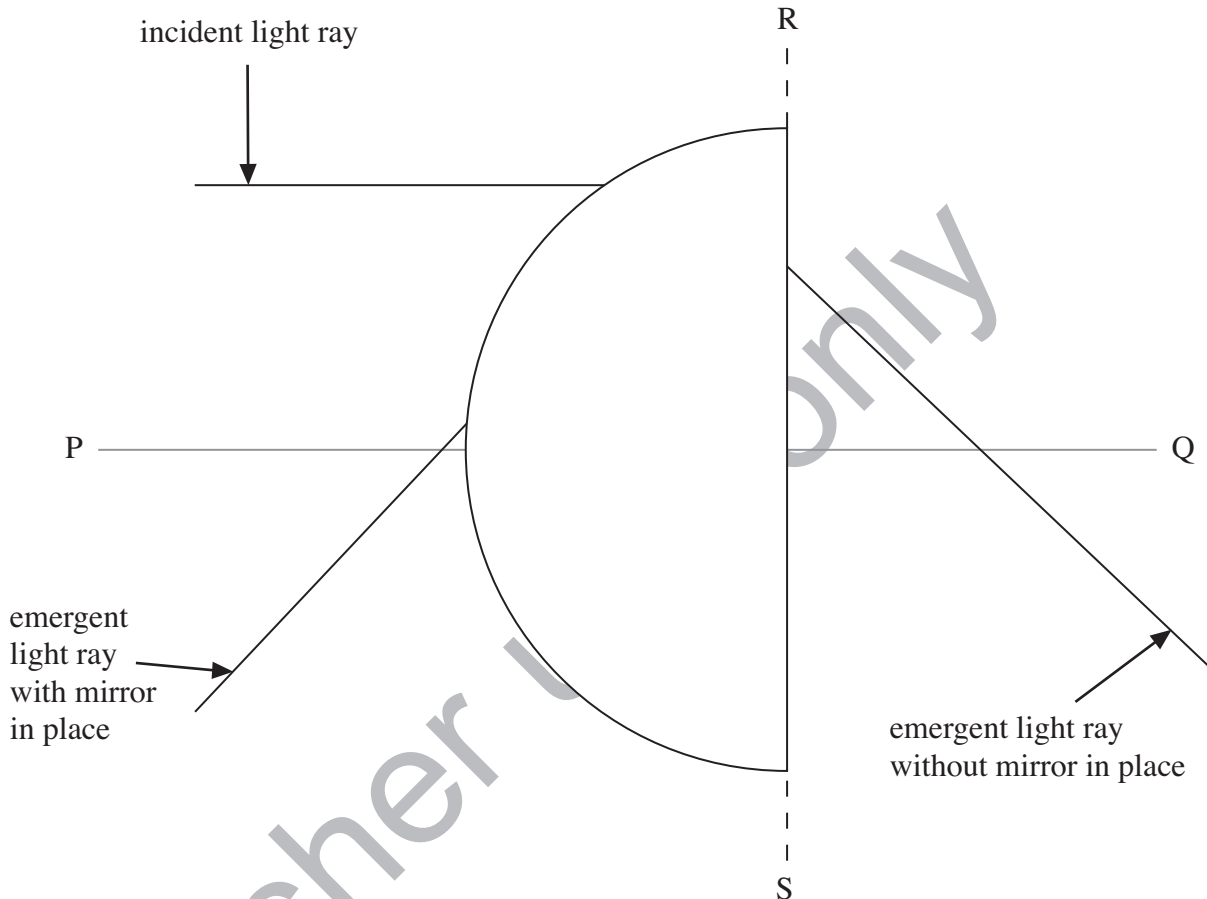
- 1 (b) (i) Using your result from part (a) of Section A Task 2, identify the SWG of the wire you were given.
- 1 (b) (ii) State and explain the effect, if any, on your graph, if the experiment were repeated with a wire made of the same material but with a lower SWG number.
- 1 (c) In part (a) of Section A Task 2 you used a micrometer screw gauge to measure the diameter of a wire. A micrometer screw gauge is shown in **Figure 8**.



- 1 (c) (i) What is the precision of the **main scale** on the micrometer screw gauge?
- 1 (c) (ii) Why is it important to close the gap between the anvil and the spindle of the micrometer using the ratchet and not the thimble?
- 1 (c) (iii) State a procedure to detect a possible systematic error in the micrometer readings.
- 1 (c) (iv) State any procedure you used to reduce the effect of random errors on your result for the diameter of the wire.

- 2 In Section A Task 1 you traced the paths of light rays passing through a semicircular transparent block and determined the refractive index of the block. A student performs this experiment and produces a diagram, seen approximately to full scale in **Figure 9**, showing lines PQ and RS, the outline of the block and the paths of the incident and emergent light rays.

**Figure 9**



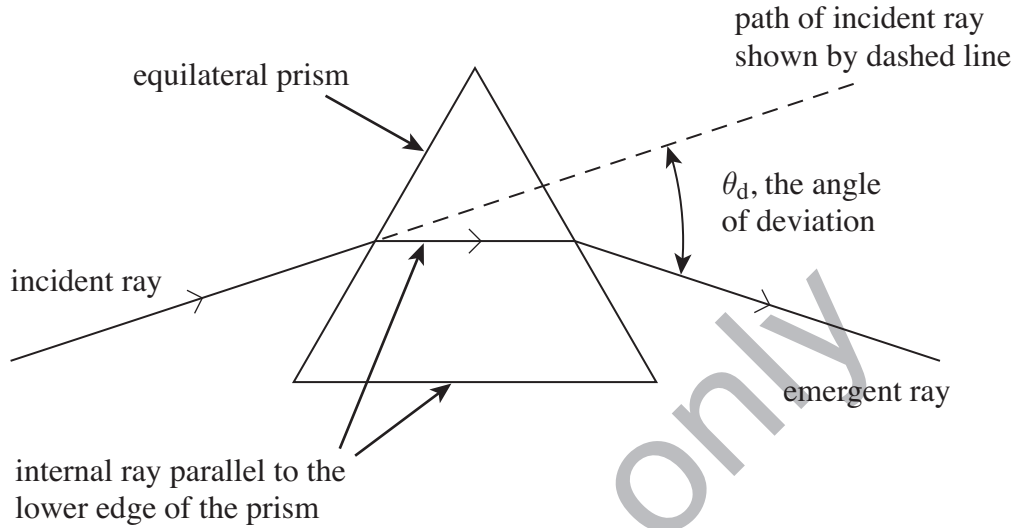
- 2 (a) **Figure 9** can be used to determine the refractive index of the block by a different method from that you used in Section A Task 1.
- 2 (a) (i) Complete **Figure 9** by showing the paths of the light rays within the block that lead to the formation of **both** emergent rays.
- 2 (a) (ii) Explain, by adding further detail to **Figure 9**, how you would determine another experimental value of the refractive index of the block. Make clear the calculations you would carry out.

- 2 (b) If both methods are used with the **same ray diagram** to calculate the refractive index of the block, explain why the result obtained using the method you used in Section A Task 1 is likely to provide the more accurate result.

Teacher use only

- 3 In a different experiment to that you performed in Section A Task 1, a student directs a ray of light on to an equilateral prism and adjusts the position of the prism until the internal ray is parallel to the lower edge of the prism, as shown in **Figure 10**.

**Figure 10**



- 3 (a) Outline a simple test that the student could perform **without moving the prism**, to check that the internal ray is parallel to the lower edge of the prism. You may wish to use a sketch to illustrate your answer.



- 3 (b) The student measures  $\theta_d$  to be  $40^\circ$  using a protractor with a precision of  $2^\circ$ . Calculate the percentage uncertainty in the student's result for  $\theta_d$ .
- 3 (c) The student discovers that  $\theta_d$ , the angle of deviation between the emergent ray and the path of the incident ray is related to  $n$ , the refractive index of the prism by

$$n = \sqrt{3} \sin\left(\frac{\theta_d}{2}\right) + \cos\left(\frac{\theta_d}{2}\right).$$

Using  $\theta_d = 40^\circ$  the student correctly calculates  $n = 1.53$ . Knowing that the true value of  $\theta_d$  could lie anywhere between  $38^\circ$  and  $42^\circ$ , the student then calculates the smallest and largest possible values for  $n$ .

- 3 (c) (i) Calculate the student's result for the smallest possible value for  $n$ , which occurs when  $\theta_d = 38^\circ$ .
- 3 (c) (ii) Calculate the student's result for the largest possible value for  $n$ , which occurs when  $\theta_d = 42^\circ$ .
- 3 (c) (iii) Calculate the percentage uncertainty in the student's result for  $n$ .

Teacher use only