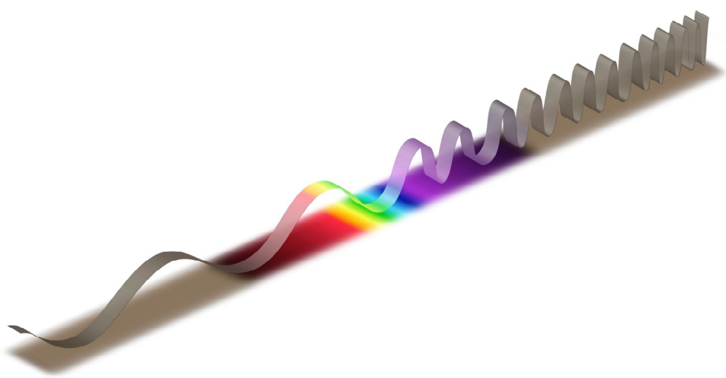
Cambridge Assessment International Education

Example Candidate Responses – Paper 5

Cambridge IGCSE™ / IGCSE (9-1) Physics 0625 / 0972

For examination from 2021



Cambridge Pathway

Contents

Introduction

The main aim of this booklet is to exemplify standards for those teaching Cambridge IGCSE™ / IGCSE (9-1) Physics 0625 / 0972, and to show how different levels of candidates' performance (high, middle and low) relate to the subject's curriculum and assessment objectives.

In this booklet, candidate responses have been chosen from the June 2021 series to exemplify a range of answers.

For each question, the response is annotated with a clear explanation of where and why marks were awarded or omitted. This is followed by examiner comments on how the answer could have been improved. In this way, it is possible for you to understand what candidates have done to gain their marks and what they could do to improve their answers. There is also a list of common mistakes candidates made in their answers for each question.

This document provides illustrative examples of candidate work with examiner commentary. These help teachers to assess the standard required to achieve marks beyond the guidance of the mark scheme. Therefore, in some circumstances, such as where exact answers are required, there will not be much comment

The questions and mark schemes used here are available to download from the School Support Hub. These files are:

0625 June 2021 Question Paper 51

0625 June 2021 Mark Scheme 51

Past exam resources and other teaching and learning resources are available on the School Support Hub:

www.cambridgeinternational.org/support

How to use this booklet

This booklet goes through the paper one question at a time, showing you the high-, middle- and low-level response for each question. The candidate answers are set in a table. In the left-hand column are the candidate answers, and in the right-hand column are the examiner comments.

Example Candidate Response – middle, continued	Examiner comments
(iii) Calculate $\frac{b}{a}$. $\frac{6.5}{3.5}$ $\frac{b}{a}$ = 1.86 [2]	Mark for (c)(i) = 1 out of 1 Mark for (c)(ii) = 1 out of 1 Mark for (c)(iii) = 2 out of 2
(d) State **one** precaution that you took in order to produce an accurate ray trace. ensure my eye was parralel to the pin board, ~~to avoid paralax error~~ [1] 5	5 The candidate needs to suggest a relevant precaution. Mark for (d) = 0 out of 1
(e) A student plans to test the suggestion that, in this experiment, $\frac{b}{a}$ is a constant for all possible values of *i*. List suitable values of *i* that the student could use. 40° and 20° 6 [2] **Tie your ray-trace sheet into this booklet between pages 8 and 9.**	6 The candidate suggests a range of values that is just wide enough. Mark for (e) = 0 out of 2

Answers are by real candidates in exam conditions. These show you the types of answers for each level. Discuss and analyse the answers with your learners in the classroom to improve their skills.

Examiner comments are alongside the answers. These explain where and why marks were awarded. This helps you to interpret the standard of Cambridge exams so you can help your learners to refine their exam technique.

How the candidate could have improved their answer

- **(b)** The candidate needed to place the pins further apart. The further apart the pins were the more accurately they could have been judged to be exactly in line. Candidates should be advised to place the pins as far apart as practical with the A4-sized ray-trace sheet. The minimum spacing allowed in this case was 5.0 cm. Candidates who tried to place their pins exactly 5 cm apart ran the risk of the distance being just under 5 cm, thus losing the mark.
- **(d)** The candidate needed to suggest an important precaution. Viewing the bases of the pins would have been a valid precaution as this overcomes the difficulty of trying to ensure that the pins are vertical. Ensuring that the pins are as far apart as practicable was another useful precau... of at least 5 cm apart was acceptable.
- **(e)** The candidate needed to suggest at least 4 extra an... a range as possible, but all under 90 degrees. This wou... sufficient number of results were required to draw a vali...

This section explains how the candidate could have improved each answer. This helps you to interpret the standard of Cambridge exams and helps your learners to refine their exam technique.

Common mistakes candidates made in this question

- **(b)** Common errors were:
  - placing the pins too close together (less than 5 cm) or trying to place them exactly 5 cm apart and actually placing them just under 5 cm apart
  - drawing the incident ray at 60 degrees instead of 3...
- (c... ...unit cm fo...
- (... ...recautio...
- (... ...al angles

Often candidates were not awarded marks because they misread or misinterpreted the questions.

Lists the common mistakes candidates made in answering each question. This will help your learners to avoid these mistakes and give them the best chance of achieving the available marks.

Question 1

Example Candidate Response – high

Examiner comments

1 In this experiment, you will investigate the period of a pendulum. Carry out the following instructions, referring to Fig. 1.1 and Fig. 1.2.

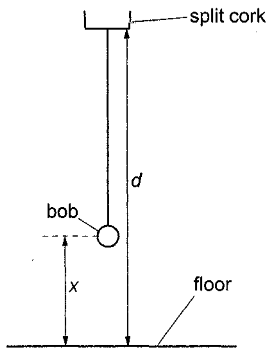


Fig. 1.1

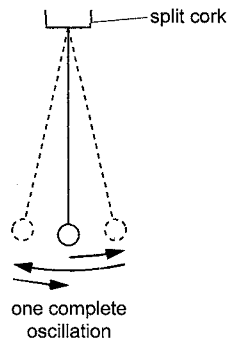


Fig. 1.2

A pendulum has been set up for you as shown in Fig. 1.1.

(a) Measure the distance *d* between the bottom of the split cork and the floor.

d = ...99 cm.... cm [1]

Mark for (a) = 1 out of 1

This distance *d* must remain constant throughout the experiment.

(b)
- Adjust the length of the pendulum until the distance *x*, measured from the centre of the bob to the floor, is 50.0 cm.
- Displace the bob slightly and release it so that it swings. Fig. 1.2 shows one complete oscillation of the pendulum.
- Measure, and record in Table 1.1, the time *t* for 10 complete oscillations.
- Calculate, and record in Table 1.1, the period *T* of the pendulum. The period is the time for one complete oscillation.
- Calculate, and record in Table 1.1, T^2. [2]

Mark for (b) = 2 out of 2

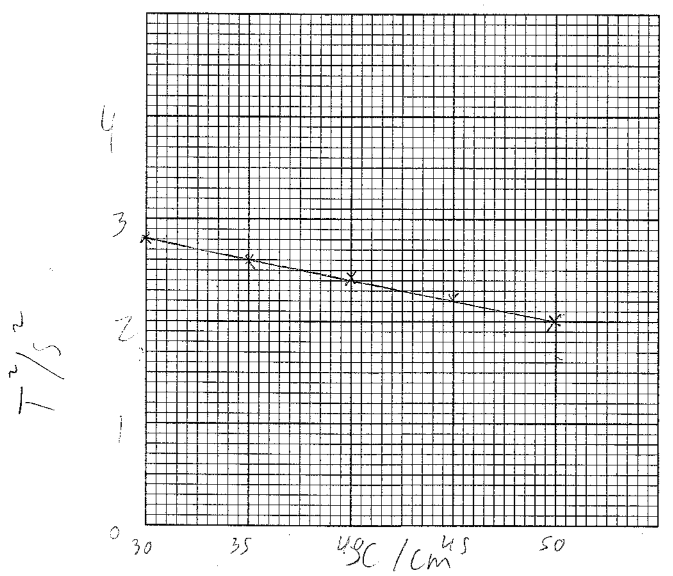
Table 1.1

x / cm	t / s	T / s	T^2 / s^2
50.0	~~13~~ 14.2	~~1.3~~ 1.42	~~1.69~~ 2.02
45.0	14.94	1.49	2.22
40.0	15.68	1.57	2.46
35.0	16.2	1.62	2.62
30.0	16.78	1.68	2.82

Example Candidate Response – high, continued

(c) Repeat the procedure in **(b)** using x = 45.0 cm, 40.0 cm, 35.0 cm and 30.0 cm. [3]

(d) Plot a graph of T^2/s^2 (y-axis) against x/cm (x-axis). You do **not** need to start your axes at the origin (0,0).



[4]

1

(e) Explain why timing 10 oscillations gives a more accurate result for the period T than timing one oscillation.

by timing 10 oscillations then dividing by 10 to get the time for one ~~we~~ we are effectively getting an average of 10 oscillations [1]

2

[Total: 11]

Examiner comments

Mark for (c) = 3 out of 3

1 The candidate accurately plots the points and adds an appropriate line of best fit. The axes are correctly labelled, but the candidate chooses a vertical scale that is too compressed.
Mark for (d) = 3 out of 4

2 The reason for the time for one oscillation likely being inaccurate is that the reaction time error in starting and stopping the stopwatch is significant in comparison with the time for one oscillation. When timing 10 oscillations, the reaction time error at the beginning and end of the time taken for 10 oscillations is a far smaller percentage of the time for 10 oscillations. The candidate needs to make this clear.
Mark for (e) = 0 out of 1

Total mark awarded = 9 out of 11

How the candidate could have improved their answer

- **(d)** A scale that produced plots occupying at least half the graph grid in both directions was required.
- **(e)** The reason why timing 10 oscillations would have given a more accurate result than timing one oscillation was that the reaction time error in starting and stopping the stopwatch would have been a smaller percentage of the time taken. The candidate needed to make this clear.

Example Candidate Response – middle

1 In this experiment, you will investigate the period of a pendulum. Carry out the following instructions, referring to Fig. 1.1 and Fig. 1.2.

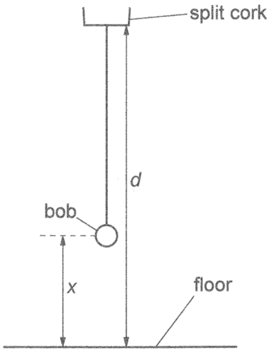


Fig. 1.1

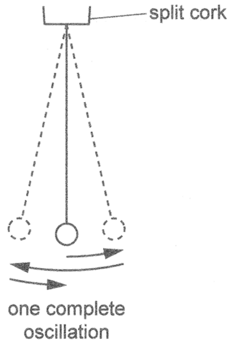


Fig. 1.2

A pendulum has been set up for you as shown in Fig. 1.1.

(a) Measure the distance *d* between the bottom of the split cork and the floor.

d = ...149...................... (1) cm [1]

This distance *d* must remain constant throughout the experiment.

(b)
- Adjust the length of the pendulum until the distance *x*, measured from the centre of the bob to the floor, is 50.0 cm.
- Displace the bob slightly and release it so that it swings. Fig. 1.2 shows one complete oscillation of the pendulum.
- Measure, and record in Table 1.1, the time *t* for 10 complete oscillations. (2)
- Calculate, and record in Table 1.1, the period *T* of the pendulum. The period is the time for one complete oscillation.
- Calculate, and record in Table 1.1, T^2. [2]

Table 1.1

x/cm	t/s	T/s	T^2/s^2
50.0	14.8	1.48	2.2
45.0	14.2	1.42	2.01
40.0	13	1.3	1.69
35.0	12.3	1.23	1.51
30.0	11.6	1.16	1.35

Examiner comments

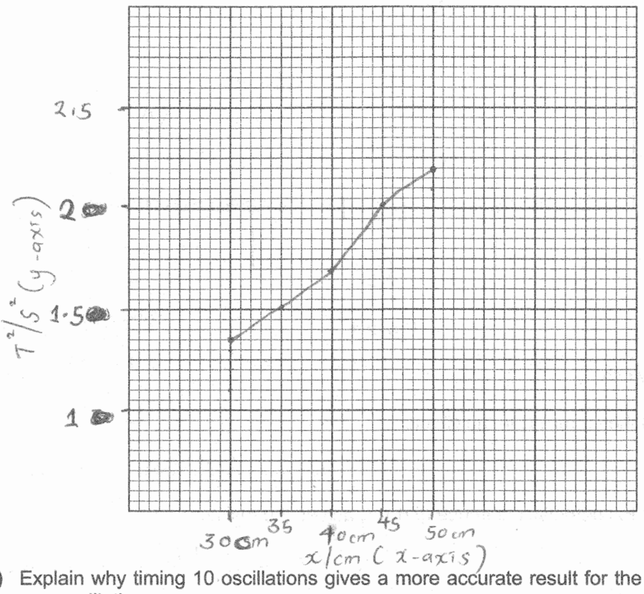
(1) The candidate records a value out of range.
Mark for (a) = 0 out of 1

(2) The candidate should obtain increasing values in the final column.
Additionally, the candidate does not record the initial value in the final column to 3 significant figures.
Mark for (b) = 2 out of 2

Example Candidate Response – middle, continued

(c) Repeat the procedure in **(b)** using x = 45.0 cm, 40.0 cm, 35.0 cm and 30.0 cm. [3]

(d) Plot a graph of T^2/s^2 (y-axis) against x/cm (x-axis). You do **not** need to start your axes at the origin (0,0).



3

[4]

(e) Explain why timing 10 oscillations gives a more accurate result for the period T than timing one oscillation.

Because it provides an average in which is more reliable than one oscillation [1]

4

[Total: 11]

Examiner comments

Mark for (c) = 1 out of 3

3 The candidate chooses a vertical scale that is too compressed and draws a series of straight lines joining each plot to the next, rather than one single best-fit straight line.
Mark for (d) = 2 out of 4

4 The reason for the time for one oscillation being likely to be inaccurate is that the reaction time error in starting and stopping the stopwatch is significant in comparison with the time for one oscillation.
Mark for (e) = 0 out of 1

Total mark awarded = 5 out of 11

How the candidate could have improved their answer

- **(b)(c)** The candidate needed to follow the instructions with care to obtain increasing values in the final column. In the last column, the first value should have been recorded as 2.19 in order to give all the values to 3 significant figures.
- **(d)** The axes were labelled correctly, and the points plotted accurately but the candidate chose a horizontal scale that was too compressed. A scale that produces plots that occupy at least half the graph grid in both directions was required. The candidate drew a series of straight lines joining each plot to the next when one single best-fit straight line was required.
- **(e)** The reason why timing 10 oscillations would have given a more accurate result than timing one oscillation was that the reaction time error in starting and stopping the stopwatch would have been a smaller percentage of the time taken. When recording the total time for 10 oscillations, the reaction time error at the beginning and end of the time taken is a much smaller percentage of the time taken for the 10 oscillations. The candidate needed to make this clear.

Example Candidate Response – low

1 In this experiment, you will investigate the period of a pendulum. Carry out the following instructions, referring to Fig. 1.1 and Fig. 1.2.

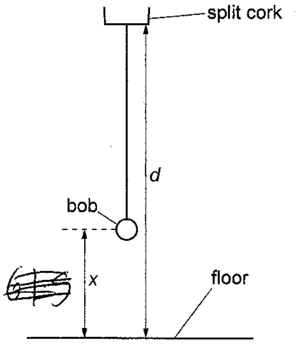


Fig. 1.1

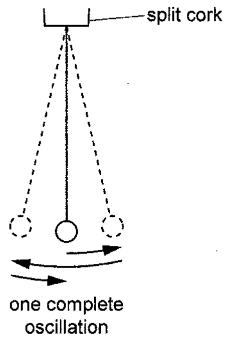


Fig. 1.2

A pendulum has been set up for you as shown in Fig. 1.1.

(a) Measure the distance *d* between the bottom of the split cork and the floor.

d = ...100.......... cm [1]

This distance *d* must remain constant throughout the experiment.

(b)
- Adjust the length of the pendulum until the distance *x*, measured from the centre of the bob to the floor, is 50.0 cm.
- Displace the bob slightly and release it so that it swings. Fig. 1.2 shows one complete oscillation of the pendulum.
- Measure, and record in Table 1.1, the time *t* for 10 complete oscillations.
- Calculate, and record in Table 1.1, the period *T* of the pendulum. The period is the time for one complete oscillation.
- Calculate, and record in Table 1.1, T^2. [2]

Table 1.1

x / cm	t / s	T / s	T^2 / s^2
50.0	14.46	1.46	9.2
45.0	14	1.4	11.7
40.0	12.97	13	11.7
35.0	11.95	1.195	10
30.0	10.7	1.07	10

10 . 13.46 − 10

Examiner comments

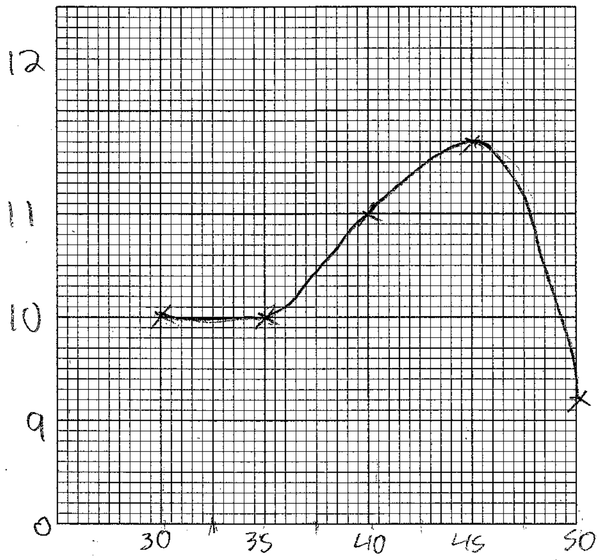
Mark for (a) = 1 out of 1

1 In the final column of Table 1.1, the candidate does not give values of *T* squared.
The values are not increasing, showing that the candidate may be using d values, as in the first column of the table, in place of the *x* values.
The candidate needs to use consistent significant figures in the final column.
Mark for (b) = 1 out of 2

Example Candidate Response – low, continued

(c) Repeat the procedure in **(b)** using x = 45.0 cm, 40.0 cm, 35.0 cm and 30.0 cm. [3]

(d) Plot a graph of T^2/s^2 (y-axis) against x/cm (x-axis). You do **not** need to start your axes at the origin (0,0).



2

[4]

(e) Explain why timing 10 oscillations gives a more accurate result for the period T than timing one oscillation.

You can get an average result which is more reliable than just using data from one oscillation [1]

3

[Total: 11]

Examiner comments

Mark for (c) = 0 out of 3

2 The candidate does not label the axes of the graph, or draw a best-fit straight line which, in this case, is difficult because the results are not as expected.
Mark for (d) = 2 out of 4

3 The candidate is incorrect. The reason for the time for one oscillation being likely to be inaccurate is that the reaction time error in starting and stopping the stopwatch is significant in comparison with the time for one oscillation.
Mark for (e) = 0 out of 1

Total mark awarded = 4 out of 11

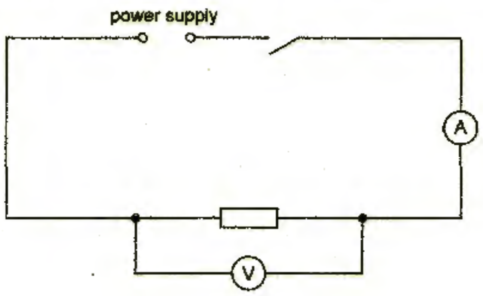
How the candidate could have improved their answer

- **(b)**, **(c)** In Table 1.1, the candidate recorded a value of t within range but made a mistake when dividing by 10 to obtain the period *T*. In the final column, the candidate did not give correct values for T^2.
- **(b)**, **(c)** The times recorded were not increasing. This suggested that the candidate had adjusted the length of the pendulum to equal the values of *x* in the table. The candidate needed to use a consistent number of significant figures for T^2.
- **(d)** The candidate needed to label the axes of the graph as given in the instruction. The candidate also needed to draw a best-fit straight line. In this case, the results were not as expected. The candidate could have circled the final plot to identify it as an anomalous result (not within the trend of the other plots) and then drawn a best-fit line appropriate for the remaining plots.

Common mistakes candidates made in this question

- **(b)**, **(c)** A common error was using an inconsistent number of significant figures when recording T^2.
- **(d)** A common error was for candidates to draw graphs with compressed scales (usually the vertical scale) such that the plotted points did not occupy at least one half of the graph grid. The question stated that the axes did not have to start at the origin (0,0) but this advice was not always heeded.
- **(e)** Many candidates suggested that the greater accuracy was due to 'taking an average' rather than realising that the reason for the time for one oscillation being less accurate was that the reaction time error in starting and stopping the stopwatch would be more significant when timing one oscillation compared with when timing 10 oscillations. When timing 10 oscillations, this reaction time error at the beginning and end of the oscillations would be a much smaller percentage of the time taken.

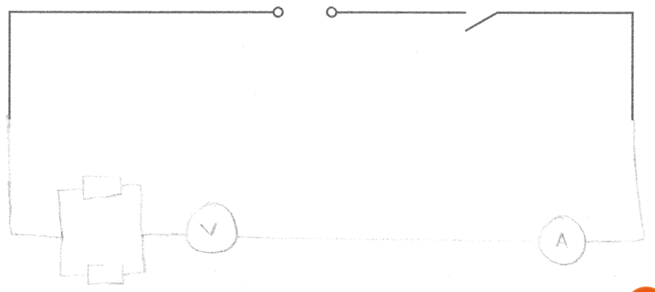
Question 2

Example Candidate Response – high	Examiner comments
2 In this experiment, you will investigate resistance. Carry out the following instructions, referring to Fig. 2.1. The circuit has been set up for you.	
 **Fig. 2.1**	
(a) Close the switch. **(i)** Record the current I_1 in the circuit. I_1 = 0.28A [1]	Mark for (a)(i) = 1 out of 1
(ii) Record the potential difference (p.d.) V_1 across the resistor. V_1 = 1.5V [1]	Mark for (a)(ii) = 1 out of 1
Open the switch. **(iii)** Calculate the resistance R_1 of the resistor using the equation $R_1 = \frac{V_1}{I_1}$. $R = \frac{1.5}{0.28}$ $R = 5.4\ \Omega$ R_1 = 5.4Ω [1]	Mark for (a)(iii) = 1 out of 1

Example Candidate Response – high, continued	Examiner comments
(b) Disconnect the voltmeter. Connect the second resistor provided in **series** with the first resistor. Connect the voltmeter across both resistors. Close the switch. • Record the current I_2 in the circuit. I_2 = 0.12 A • Record the potential difference (p.d.) V_2 across the resistors. V_2 = 1.7 V Open the switch. • Calculate the resistance R_S of the resistors in series using the equation $R_S = \frac{V_2}{I_2}$. $R_s = \frac{1.7}{0.12}$ $R = 14.2\ \Omega$ R_S = 14.2 Ω [2]	Mark for (b) = 2 out of 2
(c) Disconnect the voltmeter. Connect the second resistor in **parallel** with the first resistor. Connect the voltmeter across both resistors. Close the switch. • Record the current I_3 in the circuit. I_3 = 0.32 A • Record the potential difference (p.d.) V_3 across the resistors. V_3 = 0.30 V Open the switch. • Calculate the resistance R_P of the resistors in parallel using the equation $R_P = \frac{V_3}{I_3}$. $R_p = \frac{0.3}{0.32}$ $R_p = 0.94$ R_P = ~~0.4~~ 0.94 Ω	Mark for (c) = 2 out of 2

Example Candidate Response – high, continued

(d) Complete the circuit diagram to show the circuit you used in part **(c)**.



1

[2]

(e) Describe how you would extend part **(c)** of this experiment to investigate the relationship between the combined resistance of identical resistors connected in parallel and the number of resistors. You are **not** required to do this investigation.

More resistors can be added in ~~parallel with~~ parallel with the other resistors and the potential difference record as with the current. Feach time a resistor is added current and potential difference would be checked. [2]

2

[Total: 11]

Examiner comments

1 The candidate correctly draws two resistors in parallel and includes the ammeter in series but does not place the voltmeter in parallel with the resistors.
Mark for (d) = 1 out of 2

2 The candidate sensibly suggests adding more resistors in parallel but needs the extra detail of adding at least three more resistors, one at a time.
Mark for (e) = 1 out of 2

Total mark awarded = 9 out of 11

Example Candidate Response – middle	Examiner comments
2 In this experiment, you will investigate resistance.	
Carry out the following instructions, referring to Fig. 2.1. The circuit has been set up for you.	

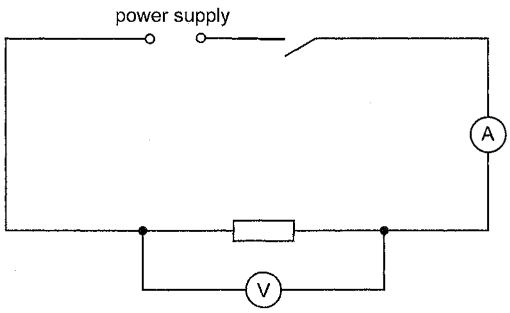


Fig. 2.1

(a) Close the switch.

(i) Record the current I_1 in the circuit.

I_1 = 0.30 [1]

(ii) Record the potential difference (p.d.) V_1 across the resistor.

V_1 = 1.44 [1]

Open the switch.

(iii) Calculate the resistance R_1 of the resistor using the equation $R_1 = \frac{V_1}{I_1}$.

$\frac{1.44}{0.30}$

R_1 = 4.8 [1]

Examiner comments

1 The candidate does not give the units but does give realistic readings with suitable precision.
Mark for (a)(i) = 1 out of 1

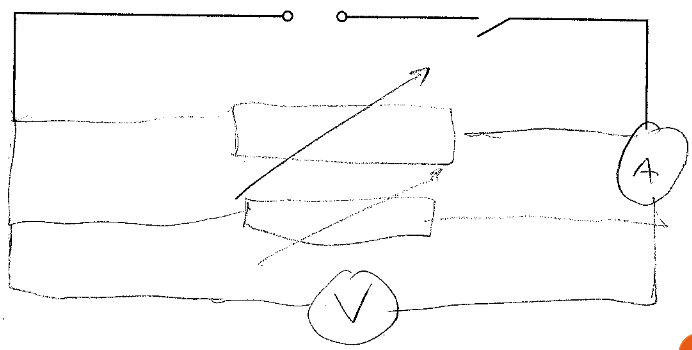
Mark for (a)(ii) = 1 out of 1

Mark for (a)(iii) = 1 out of 1

Example Candidate Response – middle, continued	Examiner comments
(b) Disconnect the voltmeter. Connect the second resistor provided in **series** with the first resistor. Connect the voltmeter across both resistors. Close the switch. • Record the current I_2 in the circuit. I_2 = ~~0.90~~ ~~0.98~~ 0.20 • Record the potential difference (p.d.) V_2 across the resistors. V_2 = ~~0.20~~ 0.98 Open the switch. • Calculate the resistance R_S of the resistors in series using the equation $R_S = \frac{V_2}{I_2}$. $\frac{0.98}{0.20}$ R_S = 4.9 (2) [2]	
	(2) The candidate omits the units at every stage and at this point there is a mark for correct units, A, V and Ω, given in (a) or (b) or both and not contradicted. Mark for (b) = 1 out of 2
(c) Disconnect the voltmeter. Connect the second resistor in **parallel** with the first resistor. Connect the voltmeter across both resistors. Close the switch. • Record the current I_3 in the circuit. I_3 = ~~2.16~~ 1.96 • Record the potential difference (p.d.) V_3 across the resistors. V_3 = 0.06 Open the switch. • Calculate the resistance R_P of the resistors in parallel using the equation $R_P = \frac{V_3}{I_3}$. ~~$\frac{2.16}{0.06}$~~ ~~$\frac{1.96}{0.06}$~~ $\frac{0.06}{1.96}$ R_P = 0.0625 [2]	Mark for (c) = 2 out of 2

Example Candidate Response – middle, continued

(d) Complete the circuit diagram to show the circuit you used in part **(c)**.



3

[2]

(e) Describe how you would extend part **(c)** of this experiment to investigate the relationship between the combined resistance of identical resistors connected in parallel and the number of resistors. You are **not** required to do this investigation.

To prove resista I would use the ammeter and voltemeter readings to show change in resistance after connection in series and paralal as compared to one resistor. The readings display changes that help come to a conclusion about resistance. [2]

[Total: 11]

4

Examiner comments

3 The candidate correctly draws two resistors in parallel and includes the ammeter in series but does not place the voltmeter in parallel with the resistors.
Mark for (d) = 1 out of 2

4 The candidate sensibly suggests adding more resistors in parallel but needs the extra detail of adding at least three more resistors, one at a time.
Mark for (e) = 0 out of 2

Total mark awarded = 7 out of 11

How the candidate could have improved their answer

- **(a)**, **(b)** The candidate gave realistic readings with suitable precision, however, the candidate omitted units at each stage. There was a mark for the correct units, A, V and Ω, given in **(a)** or **(b)** or both and not contradicted.
- **(e)** The candidate needed to describe the adding of at least another three resistors in parallel one at a time. There were many ways in which this could have been worded and the candidate would have been given credit for showing that they understood the practical principles and techniques involved.

Example Candidate Response – low

2 In this experiment, you will investigate resistance.

Carry out the following instructions, referring to Fig. 2.1. The circuit has been set up for you.

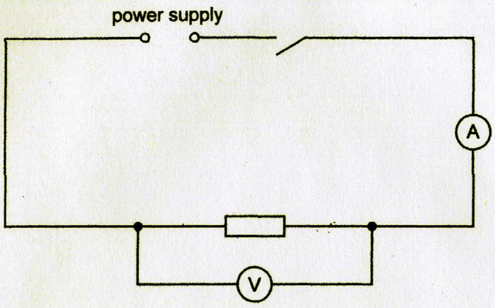


Fig. 2.1

(a) Close the switch.

(i) Record the current I_1 in the circuit.

I_1 = ~~0.23~~ 0.19 (1) [1]

(ii) Record the potential difference (p.d.) V_1 across the resistor.

V_1 = ~~[crossed out]~~ 0.91 [1]

Open the switch.

(iii) Calculate the resistance R_1 of the resistor using the equation $R_1 = \frac{V_1}{I_1}$.

$R_1 = \frac{0.91}{0.19} = 4.79$

R_1 = 4.79 [1]

Examiner comments

(1) The candidate does not give the units but does give realistic readings with suitable precision.
Mark for (a)(i) = 1 out of 1

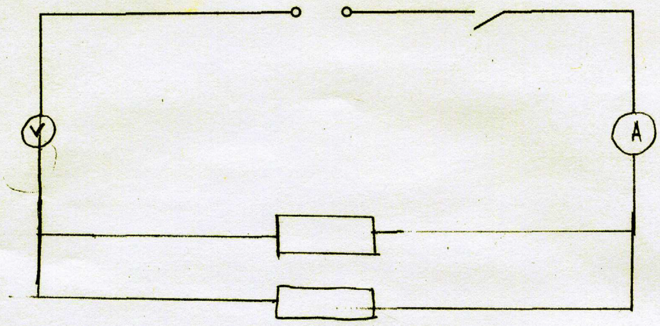
Mark for (a)(ii) = 1 out of 1

Mark for (a)(iii) = 1 out of 1

Example Candidate Response – low, continued	Examiner comments
(b) Disconnect the voltmeter. Connect the second resistor provided in **series** with the first resistor. Connect the voltmeter across both resistors. Close the switch. • Record the current I_2 in the circuit. I_2 = 0.10 • Record the potential difference (p.d.) V_2 across the resistors. V_2 = 0.80 Open the switch. • Calculate the resistance R_S of the resistors in series using the equation $R_S = \frac{V_2}{I_2}$. $\frac{0.8}{0.1}$ = R_S = 8 **2** [2]	**2** The candidate omits the units at every stage and, at this point, there is a mark for correct units, A, V and Ω, given in (a) or (b) or both and not contradicted. Mark for (b) = 1 out of 2
(c) Disconnect the voltmeter. Connect the second resistor in **parallel** with the first resistor. Connect the voltmeter across both resistors. Close the switch. • Record the current I_3 in the circuit. I_3 = ~~0.13~~ 0.11 • Record the potential difference (p.d.) V_3 across the resistors. V_3 = ~~0.36~~ 0.83 Open the switch. • Calculate the resistance R_P of the resistors in parallel using the equation $R_P = \frac{V_3}{I_3}$. ~~$\frac{0.36}{0.13}$~~ $\frac{0.83}{0.11}$ = R_P = 7.54 **3** [2]	**3** The candidate does not carry out the experiment in accordance with the instructions to obtain a current value greater than that in part (a). Correct procedure would also produce a resistance value less than that in part (a). Mark for (c) = 0 out of 2

Example Candidate Response – low, continued

(d) Complete the circuit diagram to show the circuit you used in part **(c)**.



4 [2]

(e) Describe how you would extend part **(c)** of this experiment to investigate the relationship between the combined resistance of identical resistors connected in parallel and the number of resistors. You are **not** required to do this investigation.

You can combine the identical resistors and che ...

5 [2]

[Total: 11]

Examiner comments

4 The candidate correctly places two resistors in parallel and the ammeter in series.
Mark for (d) = 1 out of 2

5 The candidate needs to describe adding at least another three resistors in parallel, one at a time.
Mark for (e) = 0 out of 2

Total mark awarded = 5 out of 11

How the candidate could have improved their answer

- **(a)**, **(b)** The candidate gave realistic readings with suitable precision, however, the candidate omitted units at each stage. There was a mark for the correct units, A, V and Ω, given in **(a)** or **(b)** or both and not contradicted.
- **(d)** The candidate needed to draw the voltmeter (without a line through it) in parallel with the resistors.
- **(e)** The candidate needed to describe the adding of at least another three resistors in parallel, one at a time. There were many ways in which this could have been worded. The candidate would have been given credit for showing that they understood the practical principles and techniques involved.

Common mistakes candidates made in this question

- **(d)** The most common error was to place the voltmeter in series with the other components instead of in parallel with the resistors.
- **(e)** Vague answers were common here. Many candidates correctly suggested adding another resistor, but few suggested adding at least three more resistors (to give a good range of results). Candidates also needed to make it clear that these resistors should be connected in parallel with a set of readings taken each time another resistor was added.

Question 3

Example Candidate Response – high	Examiner comments

3 In this experiment, you will investigate the refraction of light in the material of a transparent block.

Carry out the following instructions, using the separate ray-trace sheet provided. You may refer to Fig. 3.1 for guidance.

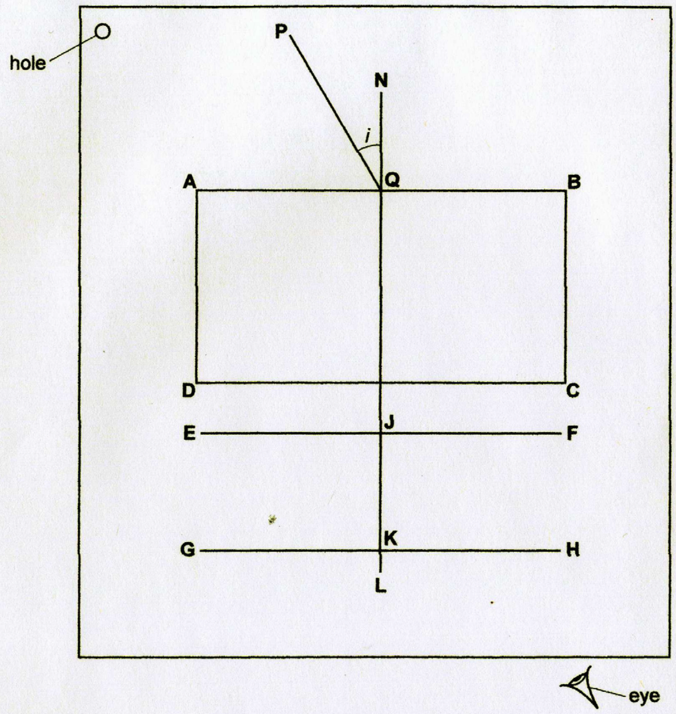
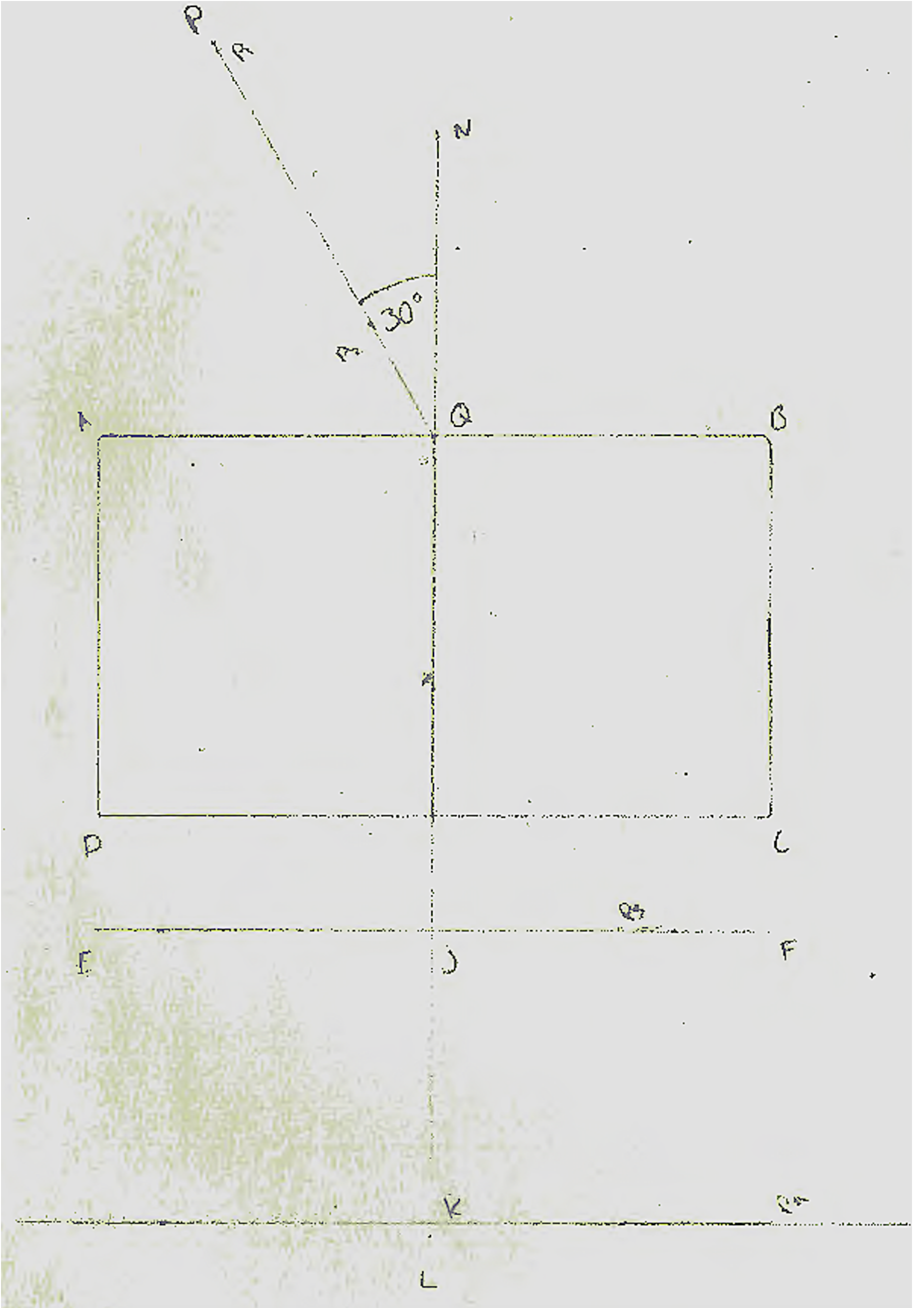


Fig. 3.1

(a)
- Place the transparent block, largest face down, on the ray-trace sheet supplied. The block should be approximately in the middle of the paper.
- Draw and label the outline of the block **ABCD**, as shown in Fig. 3.1.
- Remove the block and draw a normal at the centre of side **AB**. Continue the normal so that it passes through side **CD** of the block. Label the normal **NL**.
- Label the point **Q** where **NL** crosses **AB**.
- Draw a line **EF** parallel to **CD** and 2.0 cm below **CD**.
- Label the point **J** where **NL** crosses **EF**.
- Draw a line **GH** parallel to **CD** and 7.0 cm below **CD**.
- Label the point **K** where **NL** crosses **GH**.

Example Candidate Response – high, continued	Examiner comments
	Mark for (a) = 2 out of 2

Example Candidate Response – high, continued	Examiner comments
(b) • Draw the line **PQ** at an angle *i* = 30° to the normal as shown in Fig. 3.1. • Place the paper on the pin board. • Place two pins, P_1 and P_2, on line **PQ** at a suitable distance apart for this experiment. • Replace the block and look from the position of the eye shown in Fig. 3.1 to observe the images of P_1 and P_2 through side **CD** of the block. Adjust your line of sight until the images of P_1 and P_2 appear one behind the other. • Place a pin P_3 on line **EF** between your eye and the block so that the images of P_1 and P_2 seen through the block appear behind P_3. • Place a pin P_4 on line **GH** between your eye and the block so that P_3, and the images of P_1 and P_2 seen through the block, appear behind P_4. • Label the positions of P_1, P_2, P_3 and P_4. • Remove the pins. [2]	Mark for (b) = 2 out of 2
(c) **(i)** Measure and record the length *a* of the line from **J** to P_3. *a* = 3.2cm [1]	Mark for (c)(i) = 1 out of 1
(ii) Measure and record the length *b* of the line from **K** to P_4. *b* = 5.9cm [1]	Mark for (c)(ii) = 1 out of 1
(iii) Calculate $\frac{b}{a}$. $\frac{b}{a}$ = 1.84 [2]	Mark for (c)(iii) = 2 out of 2
(d) State **one** precaution that you took in order to produce an accurate ray trace. (1) Closed one eye: in order to see clearly [1]	(1) The candidate needs to suggest a relevant precaution. Mark for (d) = 0 out of 1
(e) A student plans to test the suggestion that, in this experiment, $\frac{b}{a}$ is a constant for all possible values of *i*. List suitable values of *i* that the student could use. (2) 30°, 45°, 60° [2]	(2) The candidate suggests a range of values that is just wide enough. Mark for (e) = 1 out of 2
	Total mark awarded = 9 out of 11

How the candidate could have improved their answer

- **(d)** The candidate needed to suggest an important precaution. Viewing the bases of the pins would have been a valid precaution as this overcomes the difficulty of trying to ensure that the pins are vertical. Ensuring that the pins are as far apart as practicable would have been another useful precaution. Due to the size of the ray-trace sheet, a suggestion of at least 5 cm apart was acceptable.
- **(e)** The candidate suggested a range of values that was just wide enough. However, at least 4 extra angles were required (in addition to the original 30 degrees).

Example Candidate Response – middle	Examiner comments

3 In this experiment, you will investigate the refraction of light in the material of a transparent block.

Carry out the following instructions, using the separate ray-trace sheet provided. You may refer to Fig. 3.1 for guidance.

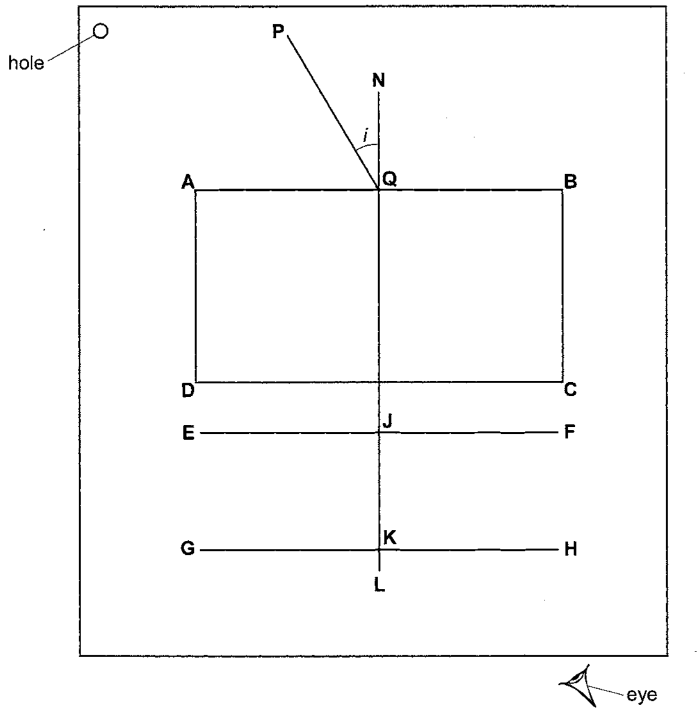
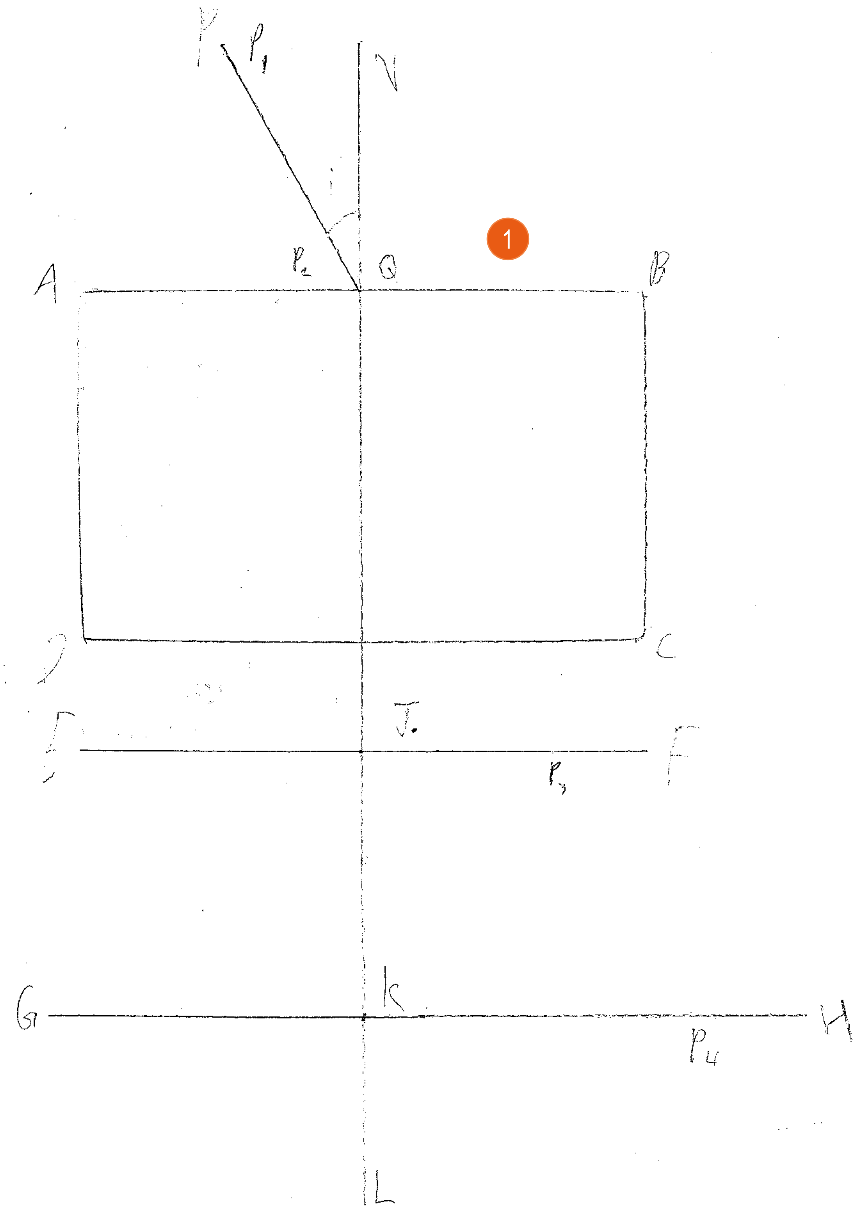


Fig. 3.1

(a)
- Place the transparent block, largest face down, on the ray-trace sheet supplied. The block should be approximately in the middle of the paper.
- Draw and label the outline of the block **ABCD**, as shown in Fig. 3.1.
- Remove the block and draw a normal at the centre of side **AB**. Continue the normal so that it passes through side **CD** of the block. Label the normal **NL**.
- Label the point **Q** where **NL** crosses **AB**.
- Draw a line **EF** parallel to **CD** and 2.0 cm below **CD**.
- Label the point **J** where **NL** crosses **EF**.
- Draw a line **GH** parallel to **CD** and 7.0 cm below **CD**.
- Label the point **K** where **NL** crosses **GH**.

Example Candidate Response – middle, continued	Examiner comments
	Mark for (a) = 2 out of 2 1 The candidate needs to place the pins further apart. Mark for (b) = 1 out of 2

Example Candidate Response – middle, continued	Examiner comments
(b) • Draw the line **PQ** at an angle *i* = 30° to the normal as shown in Fig. 3.1. • Place the paper on the pin board. • Place two pins, P_1 and P_2, on line **PQ** at a suitable distance apart for this experiment. • Replace the block and look from the position of the eye shown in Fig. 3.1 to observe the images of P_1 and P_2 through side **CD** of the block. Adjust your line of sight until the images of P_1 and P_2 appear one behind the other. • Place a pin P_3 on line **EF** between your eye and the block so that the images of P_1 and P_2 seen through the block appear behind P_3. • Place a pin P_4 on line **GH** between your eye and the block so that P_3, and the images of P_1 and P_2 seen through the block, appear behind P_4. • Label the positions of P_1, P_2, P_3 and P_4. • Remove the pins. [2]	
(c) (i) Measure and record the length *a* of the line from **J** to P_3. *a* = 3.5 cm [1]	Mark for (c)(i) = 1 out of 1
(ii) Measure and record the length *b* of the line from **K** to P_4. *b* = 6.5 cm [1]	Mark for (c)(ii) = 1 out of 1
(iii) Calculate $\frac{b}{a}$. $\frac{6.5}{3.5}$ $\frac{b}{a}$ = 1.86 [2]	Mark for (c)(iii) = 2 out of 2
(d) State **one** precaution that you took in order to produce an accurate ray trace. ensure my eye was parralel to the pin board, ~~to avoid paralax error~~ (2) [1]	(2) The candidate needs to suggest a relevant precaution. Mark for (d) = 0 out of 1
(e) A student plans to test the suggestion that, in this experiment, $\frac{b}{a}$ is a constant for all possible values of *i*. List suitable values of *i* that the student could use. 40° and 20° (3) [2] **Tie your ray-trace sheet into this booklet between pages 8 and 9.**	(3) The candidate suggests a range of values that is just wide enough. Mark for (e) = 0 out of 2 **Total mark awarded = 7 out of 11**

How the candidate could have improved their answer

- **(b)** The candidate needed to place the pins further apart. The further apart the pins were the more accurately they could have been judged to be exactly in line. Candidates should be advised to place the pins as far apart as practical with the A4-sized ray-trace sheet. The minimum spacing allowed in this case was 5.0 cm. Candidates who tried to place their pins exactly 5 cm apart ran the risk of the distance being just under 5 cm, thus losing the mark.
- **(d)** The candidate needed to suggest an important precaution. Viewing the bases of the pins would have been a valid precaution as this overcomes the difficulty of trying to ensure that the pins are vertical. Ensuring that the pins are as far apart as practicable was another useful precaution. Due to the size of the ray-trace sheet, a suggestion of at least 5 cm apart was acceptable.
- **(e)** The candidate needed to suggest at least 4 extra angles (in addition to the original 30 degrees) with as wide a range as possible, but all under 90 degrees. This would have indicated that the candidate understood that a sufficient number of results were required to draw a valid conclusion.

Example Candidate Response – low	Examiner comments

3 In this experiment, you will investigate the refraction of light in the material of a transparent block.

Carry out the following instructions, using the separate ray-trace sheet provided. You may refer to Fig. 3.1 for guidance.

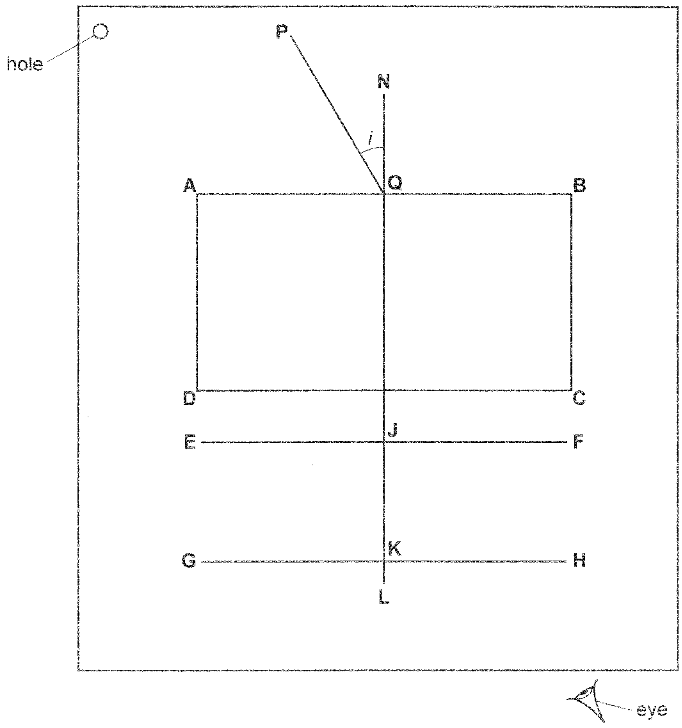
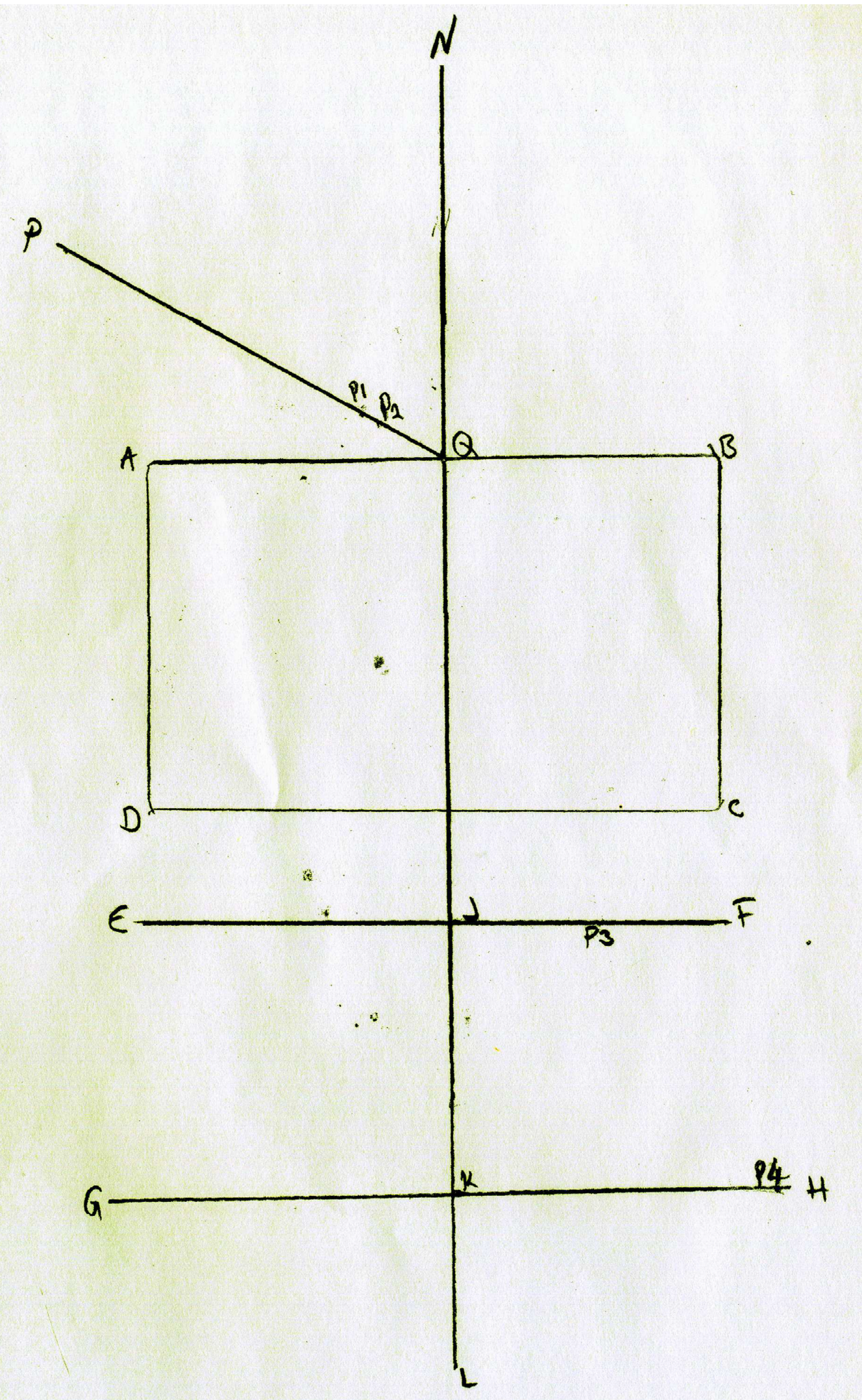


Fig. 3.1

(a)
- Place the transparent block, largest face down, on the ray-trace sheet supplied. The block should be approximately in the middle of the paper.
- Draw and label the outline of the block **ABCD**, as shown in Fig. 3.1.
- Remove the block and draw a normal at the centre of side **AB**. Continue the normal so that it passes through side **CD** of the block. Label the normal **NL**.
- Label the point **Q** where **NL** crosses **AB**.
- Draw a line **EF** parallel to **CD** and 2.0 cm below **CD**.
- Label the point **J** where **NL** crosses **EF**.
- Draw a line **GH** parallel to **CD** and 7.0 cm below **CD**.
- Label the point **K** where **NL** crosses **GH**.

Example Candidate Response – low, continued	Examiner comments
	Mark for (a) = 2 out of 2

Example Candidate Response – low, continued	Examiner comments
(b) • Draw the line **PQ** at an angle *i* = 30° to the normal as shown in Fig. 3.1. • Place the paper on the pin board. • Place two pins, P_1 and P_2, on line **PQ** at a suitable distance apart for this experiment. • Replace the block and look from the position of the eye shown in Fig. 3.1 to observe the images of P_1 and P_2 through side **CD** of the block. Adjust your line of sight until the images of P_1 and P_2 appear one behind the other. • Place a pin P_3 on line **EF** between your eye and the block so that the images of P_1 and P_2 seen through the block appear behind P_3. • Place a pin P_4 on line **GH** between your eye and the block so that P_3, and the images of P_1 and P_2 seen through the block, appear behind P_4. • Label the positions of P_1, P_2, P_3 and P_4. (1) • Remove the pins. [2]	(1) The candidate needs to place the pins much further apart. The candidate needs to draw the incident ray at 30 degrees to the normal. Mark for (b) = 0 out of 2
(c) (i) Measure and record the length *a* of the line from **J** to P_3. *a* = 2.7 cm [1]	Mark for (c)(i) = 1 out of 1
(ii) Measure and record the length *b* of the line from **K** to P_4. *b* = 6.9 cm [1]	Mark for (c)(ii) = 1 out of 1
(iii) Calculate $\frac{b}{a}$. $\frac{6.9}{2.7}$ $\frac{b}{a}$ = 2.185 [2]	Mark for (c)(iii) = 1 out of 2
(d) State **one** precaution that you took in order to produce an accurate ray trace. I tried to look at the pins at different positions. (2) [1]	(2) The candidate does not suggest an important precaution. Mark for (d) = 0 out of 1
(e) A student plans to test the suggestion that, in this experiment, $\frac{b}{a}$ is a constant for all possible values of *i*. List suitable values of *i* that the student could use. 6.4 and 4.8 (3) [2] **Tie your ray-trace sheet into this booklet between pages 8 and 9.**	(3) The candidate appears to suggest two additional values of b/a, in place of the list of suitable values for the angle of incidence. Mark for (e) = 0 out of 2 **Total mark awarded = 5 out of 11**

How the candidate could have improved their answer

- **(b)** The candidate needed to place the pins further apart. The further apart the pins were the more accurately they could have been judged to be exactly in line. Candidates should be advised to place the pins as far apart as practical with the A4-sized ray-trace sheet. The minimum spacing allowed in this case was 5 cm. Candidates who tried to place their pins exactly 5 cm apart ran the risk of the distance being just under 5 cm, thus losing the mark. The candidate also needed to draw the incident ray at 30 degrees to the normal. In this case, the candidate had drawn the ray at 30 degrees to the transparent block.
- **(c)(iii)** Although the candidate correctly calculated the ratio and realised that no unit was required, the value was outside the tolerance allowed. This was a mark for the overall quality and therefore relied upon correct work and accurate values throughout the experiment.
- **(d)** The candidate needed to suggest an important precaution. Viewing the bases of the pins would have been a valid precaution as this overcomes the difficulty of trying to ensure that the pins are vertical. Ensuring that the pins are as far apart as practicable was another useful precaution. Due to the size of the ray-trace sheet, a suggestion of at least 5 cm apart was acceptable.
- **(e)** The candidate needed to suggest at least 4 extra angles (in addition to the original 30 degrees) with as wide a range as possible, but all under 90 degrees. This would have indicated that the candidate understood that a sufficient number of results were required to draw a valid conclusion. In this case, the candidate appeared to misread the question and suggested two possible values for b/a. Candidates are advised to check their answers if they find they have time at the end of the examination. It is also important to check the question to ensure that it has been understood and answered appropriately. Candidates should also be advised not to change an answer unless they are sure that the change is necessary.

Common mistakes candidates made in this question

- **(b)** Common errors were:
  - placing the pins too close together (less than 5 cm) or trying to place them exactly 5 cm apart and actually placing them just under 5 cm apart
  - drawing the incident ray at 60 degrees instead of 30 degrees.
- **(c)(iii)** The most common error was giving the unit cm for the ratio.
- **(d)** Some candidates suggested inappropriate precautions such as using a darkened room (appropriate for a ray-box experiment but not this experiment).
- **(e)** Candidates had suggested too few additional angles or too narrow a range of angles, or both.

Question 4

Example Candidate Response – high	Examiner comments

4 A student investigates the rate of cooling, in air, of heated blocks made of different metals. The temperature of each block is increased by placing it in hot water.

Plan an experiment to investigate how the rate of cooling depends on the metal from which each block is made.

You are **not** required to carry out this experiment.

The following apparatus is available to the student:

cylindrical blocks of different metals, each with a hole for a thermometer, as shown in Fig. 4.1
a thermometer.

Other apparatus normally available in a school laboratory can also be used.

In your plan, you should:

- list any additional apparatus required
- explain briefly how you would carry out the investigation, including the measurements you would take
- state the key variables to be kept constant
- draw a suitable table, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)
- explain how you would use the results to reach a conclusion.

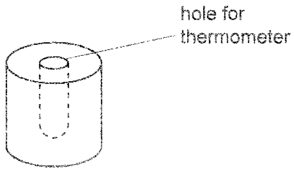


Fig. 4.1

Example Candidate Response – high, continued	Examiner comments
See handwritten response below	1 The candidate writes a clear and concise plan covering all the necessary points apart from suggesting a key variable to keep constant. **Total mark awarded = 6 out of 7**

The blocks of different metals should all be placed in water of 100~~80~~°C for 10 minutes.
The blocks would then be taken out of the water and onto a dry wooden surface, a thermometer would be placed in each block. ~~and~~
After the thermometers are placed start a timer for 10 minutes. ~~and record the temperature every 2 minutes of each block.~~

metal	Temp °C
A	
B	
C	

after 10 minutes record the temperature in a table like the on above. 1
The block with the lowest temperature after 10 minutes has the ~~lowest~~ highest rate of cooling in air and the one with the highest temperature has the lowest rate of cooling in air. [7]

How the candidate could have improved their answer

The candidate wrote a clear and concise plan that covered all the necessary points apart from suggesting a key variable to keep constant. The candidate did use the same time interval (10 minutes) throughout and this was a valid contribution to the method, but it was not explicitly stated as a key variable. Other possible key variables to keep constant included the starting temperature and the dimensions or mass of the blocks.

Example Candidate Response – middle	Examiner comments

4 A student investigates the rate of cooling, in air, of heated blocks made of different metals. The temperature of each block is increased by placing it in hot water.

Plan an experiment to investigate how the rate of cooling depends on the metal from which each block is made.

You are **not** required to carry out this experiment.

The following apparatus is available to the student:

cylindrical blocks of different metals, each with a hole for a thermometer, as shown in Fig. 4.1
a thermometer.

Other apparatus normally available in a school laboratory can also be used.

In your plan, you should:

- list any additional apparatus required
- explain briefly how you would carry out the investigation, including the measurements you would take
- state the key variables to be kept constant
- draw a suitable table, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)
- explain how you would use the results to reach a conclusion.

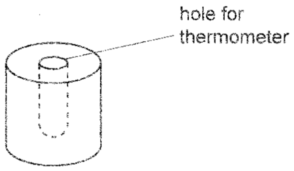


Fig. 4.1

Example Candidate Response – middle, continued

– A stopwatch should also be used to time the experiment. First of all, the heated ~~cy~~ blocks should have their temperature checked. The original temperature should be the same for all the metal blocks for better results. The metal blocks **(1)** should then be left ~~in~~ in open air for a controlled amount of time. Variables to be kept constant are: time, volume of cylindrical metal blocks and original temperature. At the onset of the experiment, place thermometers in all of the metal blocks. After the set amount of time read the new temperatures on the thermometer and calculate the change in temperature for each metal. The rate of cooling down would be calculated by dividing the change in temperature for each metal by the time taken for the experiment. The metal with the highest value can conclusively be deduced as the metal with [7] the highest cooling rate and ~~lowest~~ highest heating rate. The table of data would look like this: **(2)**

Type of Metal	Initial temp /C°	Final temp /C°	Change/C°	Rate of cooling /C°/s
Metal 1				
Metal 2				
Metal 3				
Metal 4				

Examiner comments

1 The candidate needs to explain that each block is placed in hot water to raise the temperature and then removed to allow cooling.

2 The candidate uses an incorrect unit symbol for temperature.

Total mark awarded = 5 out of 7

How the candidate could have improved their answer

The candidate needed to state clearly that each block must initially be immersed in the hot water and then removed to allow cooling to take place in the air. In the table, the candidate needed to use the correct unit symbol for temperature, °C and not C°.

Example Candidate Response – low

4 A student investigates the rate of cooling, in air, of heated blocks made of different metals. The temperature of each block is increased by placing it in hot water.

Plan an experiment to investigate how the rate of cooling depends on the metal from which each block is made. copper iron nickel nichrom

You are **not** required to carry out this experiment.

The following apparatus is available to the student:

cylindrical blocks of different metals, each with a hole for a thermometer, as shown in Fig. 4.1
a thermometer.

Other apparatus normally available in a school laboratory can also be used.

In your plan, you should:

- list any additional apparatus required
- explain briefly how you would carry out the investigation, including the measurements you would take
- state the key variables to be kept constant → size of metal ball, water temp
- draw a suitable table, with column headings, to show how you would display your readings (you are **not** required to enter any readings in the table)
- explain how you would use the results to reach a conclusion.

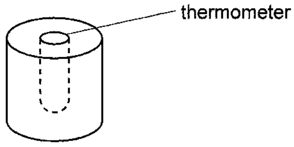


Fig. 4.1

Examiner comments

Example Candidate Response – low, continued

Investigating rate of cooling, in air, of heated blocks

I would first go into a room that has no external heater. I would then warm water to a ~~certai~~ temperature of ~~a~~ 100°. I would keep the ~~initial~~ temperature of warm water constant through out the experiment. Once the water is warm I would get a metal block and put it inside the beaker and wait for about 2 minutes for the temperature to rise fully. I would then put the thermometer in the hole and wait for the liquid in the capillary tube to rise fully before I record the temperature at time t=0 seconds. I would the record the temperature of the block after every 30 seconds until 180 second and write the temperature change in the table below. I would then use ~~dt~~ different metal blocks such as an iron block, copper block, nichrome block and an aluminium block and repeat the procedure keeping temperature of water constant and the mass of the block constant and ~~read~~ record the readings ~~on~~ in the table below. From the recorded readings, I would be able to see which metal lost most heat ~~x~~ in the 180 second and which one retained most heat [7]

Type of metal	0 sec	30 sec	60 sec	90 sec	120 sec	150 sec	180 sec

(t / s)

Examiner comments

Total mark awarded = 3 out of 7

How the candidate could have improved their answer

- The candidate described a cooling experiment but needed to include reference to having used a stopwatch or other suitable timing device. The candidate was required to explain that the blocks needed to be removed from the hot water to allow them to cool.
- The candidate also needed to construct a table with suitable columns and headings for the measurements taken.
- A clear conclusion was also needed. This could have involved either suggesting the plotting of a graph of temperature against time for each block or comparing temperature drops or times for the different metals. How this was expressed would have depended upon whether the candidate had used a fixed temperature drop or a fixed cooling time.

Common mistakes candidates made in this question

- Candidates described a cooling experiment but did not state the use of a stopwatch (or other suitable timing device).
- Candidates described immersing the blocks in hot water, but then did not describe removing the blocks from the hot water to start the cooling process.
- Candidates described pouring hot water into the hole in the block for the thermometer rather than immersing the block in hot water.
- Candidates wrote vague conclusions or gave no conclusion.
- The bullet points in the question were provided to help candidates organise their answers. Candidates should be encouraged to use these points to structure their responses. Successful candidates often wrote a concise account addressing the bullet points in order.

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