Qualification Accredited

Oxford Cambridge and RSA

AS LEVEL

Examiners' report

PHYSICS A

H156

For first teaching in 2015

H156/02 Summer 2024 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Paper 2 series overview

This is the second paper of the AS Physics course.

To do well on this paper candidates need to have an in-depth knowledge and understanding of the subject content in Modules 3 and 4 as well as the foundation physics and practical skills in Modules 1 and 2.

A significant number of candidates could have gained more marks by stating definitions correctly and carefully answering the questions set showing all their working. It is important for all candidates to understand key command terms such as state, describe, define, etc.

For numerical questions, candidates should state the equation that is to be used and substitute the data before evaluating an answer.

It is worth reminding candidates that their scripts are scanned and then electronically marked by examiners. It is therefore important that answers are not written outside the space provided for the answers. The legibility of some candidates' work remains a concern.

There were two Levels of Response (LoR) questions which gave candidates the opportunity of demonstrating their knowledge and understanding of Physics. It is important that candidates' answers are structured and logical with clear explanations. In both questions, candidates did not demonstrate the in-depth understanding required for practical techniques and procedures. A number of candidates were also not aware of how to effectively analyse a graph both in terms of relating constants in a straight-line equation to the gradient and *y*-intercept or to determining uncertainties from using a worst acceptable line.

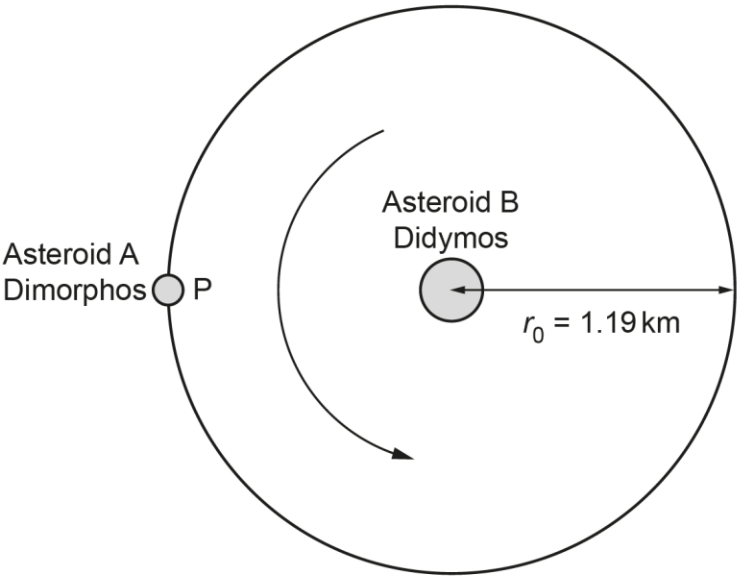
There are a number of questions which test candidates' knowledge and understanding of practical skills that candidates have developed throughout their physics course.

There were also several 'show' questions on the paper. These 'show' questions do require candidates to clearly indicate their method. The unknown should be the subject of any equation – credit is not given for using the 'show' value.

Candidates who did well on this paper generally:	Candidates who did less well on this paper generally:
• demonstrated good knowledge of definitions • wrote logical reasoned answers when answering explanation type questions • clearly demonstrated the working to numerical questions substituting in the appropriate numbers into stated equations • used technical terms correctly • demonstrated an understanding of practical skills.	• omitted detail when answering explanation type questions • omitted to show clear substitution of data into equations in calculation questions • did not use technical terms correctly • did not know definitions in sufficient detail • did not clearly explain their reasoning • omitted to explain practical procedures.

Question 1 (a)

1 In space, Asteroid A, called Dimorphos travels at constant speed in a circle around a larger Asteroid B, called Didymos. The diagram shows Asteroid A at position P.



The distance r_0 between Asteroid A and Asteroid B is 1.19 km.
The time T_0 for Asteroid A to travel once around Asteroid B is 4.29×10^4 s (11 hours 55 minutes).

(a) Calculate the average speed v, in m s^{-1}, of Asteroid A.

v = ... m s^{-1} **[2]**

The majority of candidates gained credit on this question. The two common errors were either not changing 1.19 km to 1190 m or incorrectly working out the circumference of a circle. Some candidates just use distance divided by time while others used the area of a circle.

Question 1 (b)

(b) Explain **one** similarity and **one** difference between the velocity of Asteroid A at P and its velocity six hours later.

similarity ....

....

difference ....

....

[2]

Most candidates understood that velocity was a vector quantity and there were many correct answers explaining the similarity in that the magnitude of the velocity was the same and the difference was the direction.

Lower scoring candidates often stated that the velocity was the same. This suggests that there was not the full understanding of the physical quantities speed and velocity.

Question 1 (c) (i)

(c) In 2022, the NASA DART mission impact caused Asteroid A to follow a different circular path round Asteroid B.

The new time T_N for Asteroid A to travel once around Asteroid B was reduced by 30 minutes.

(i) Show that the ratio

$$\frac{\text{new time to travel around Asteroid B } T_N}{\text{original time to travel around Asteroid B } T_0}$$

is approximately 0.958.

[1]

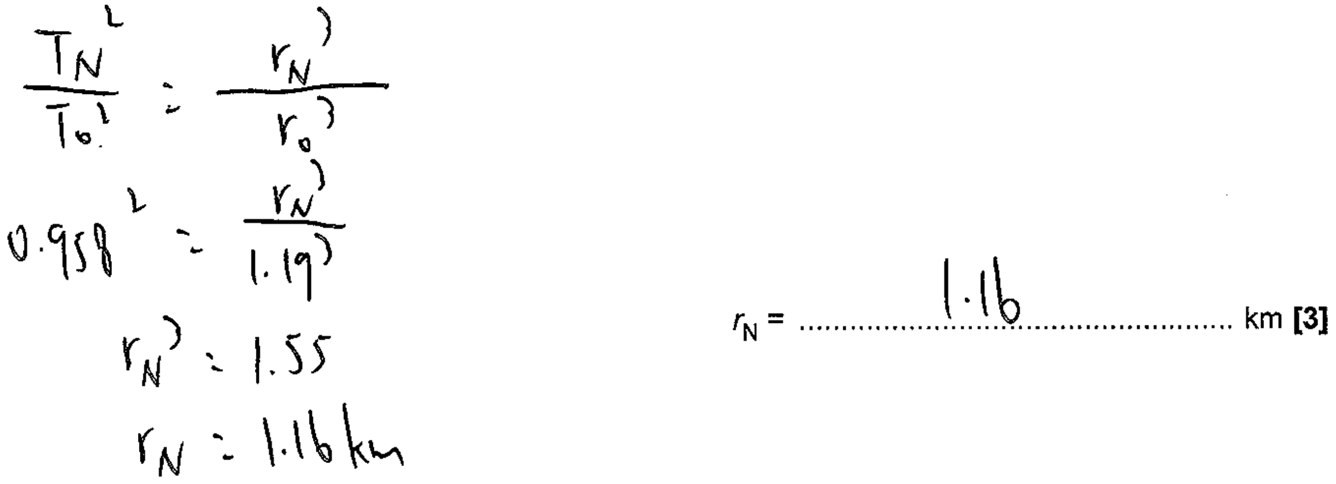
The majority of the candidates correctly showed the ratio. There were many different methods.

Assessment for learning

Candidates should practise answering ratio type questions.

Candidates should be able to determine the constant of proportionality.

Exemplar 1



The candidate has clearly demonstrated the use of the given proportional relationship. The working is logical and is correct mathematically at each stage. The candidate has helpfully included intermediate stages, e.g. $r_n^3 = 1.55$ before giving the correct answer.

Question 1 (c) (ii)

(ii) The relationship between the distance *r* from the centre of Asteroid B to the centre of Asteroid A and the time *T* for Asteroid A to travel around Asteroid B is

$r^3 \propto T^2$

Calculate the new distance r_N from the centre of Asteroid B to the centre of Asteroid A.
Give your answer in km and to **3** significant figures.

r_N = ... km **[3]**

The majority of the candidates found this question challenging. Many candidates did not use the answer from Question 1 (c) (i) but did correctly use ratios perhaps by calculating the constant of proportionality to work out the correct answer. A few candidates did not correctly round their answer to 3 significant figures or gave an answer with a power of ten error.

Question 2 (a)

2 In ice hockey, players use a stick to hit an object called a puck, across the surface of the ice.
Assume that the frictional force between the ice and the puck is negligible.
The mass of each puck is 0.16 kg.

(a) State Newton's second law of motion.

....

.... **[1]**

The majority of high scoring candidates stated that the net force is directly proportional to the rate of change of momentum. Some candidates gave the definition in symbols – this approach gained credit provided each symbol was identified.

Lower scoring candidates often gave the special case of Newton's second law (force = mass × acceleration) which did not gain credit.

Question 2 (b) (i)

(b) A player hits a single, stationary, puck. The stick is in contact with the puck for a time of 0.033 s and the puck moves at a velocity of 20 m s^{-1} across the ice.

Calculate:

(i) the impulse of the force applied to the puck. Include an appropriate unit.

impulse = ... unit .... **[2]**

This was generally well answered. Candidates who calculated the impulse correctly usually gave the correct unit. Both N s and kg m s^{-1} were given.

A significant minority of candidates calculated the force (97).

Question 2 (b) (ii)

(ii) the average force F that the stick exerts on the puck.

F = ... N **[1]**

The majority of candidates understood that impulse = change in momentum and correctly divided their answer to Question 2 (b) (i) by 0.033 s.

Question 2 (c) (i)

(c) A mass m is stuck on top of a second puck B. Puck B is stationary. The single puck travels across the surface of the ice towards B as shown in the diagram.

The single puck collides **elastically** head-on with B.

(i) Explain what is meant by a perfectly elastic collision.

....

.... **[1]**

Many candidates correctly stated that the kinetic energy in the collision is conserved. Where credit was not gained, it was invariably due to candidates stating that 'energy was conserved' without explicitly stating kinetic energy.

Question 2 (c) (ii)

(ii) After the collision B travels across the surface of the ice with a velocity of 8.0 m s^{-1}.
The velocity of the single puck after the collision is –12 m s^{-1}.
Determine *m*.

m = ... kg **[3]**

High scoring candidates generally scored well on this question. Most candidates attempted to determine *m* by using a conservation of momentum method. A small minority correctly used a conservation of kinetic energy method.

The common error for the conservation of momentum method was to have an incorrect sign.

A few candidates did not allow for the original mass of the puck.

Question 3*

3* In an experiment, a trapdoor and electromagnet are used to determine the acceleration of free fall of a ball.

The distance the ball falls is *h* and the time taken for the ball to fall is *t*.

The experiment is repeated for different values of *h*.

The table shows the results. Values of $\sqrt{h}$ have been included.

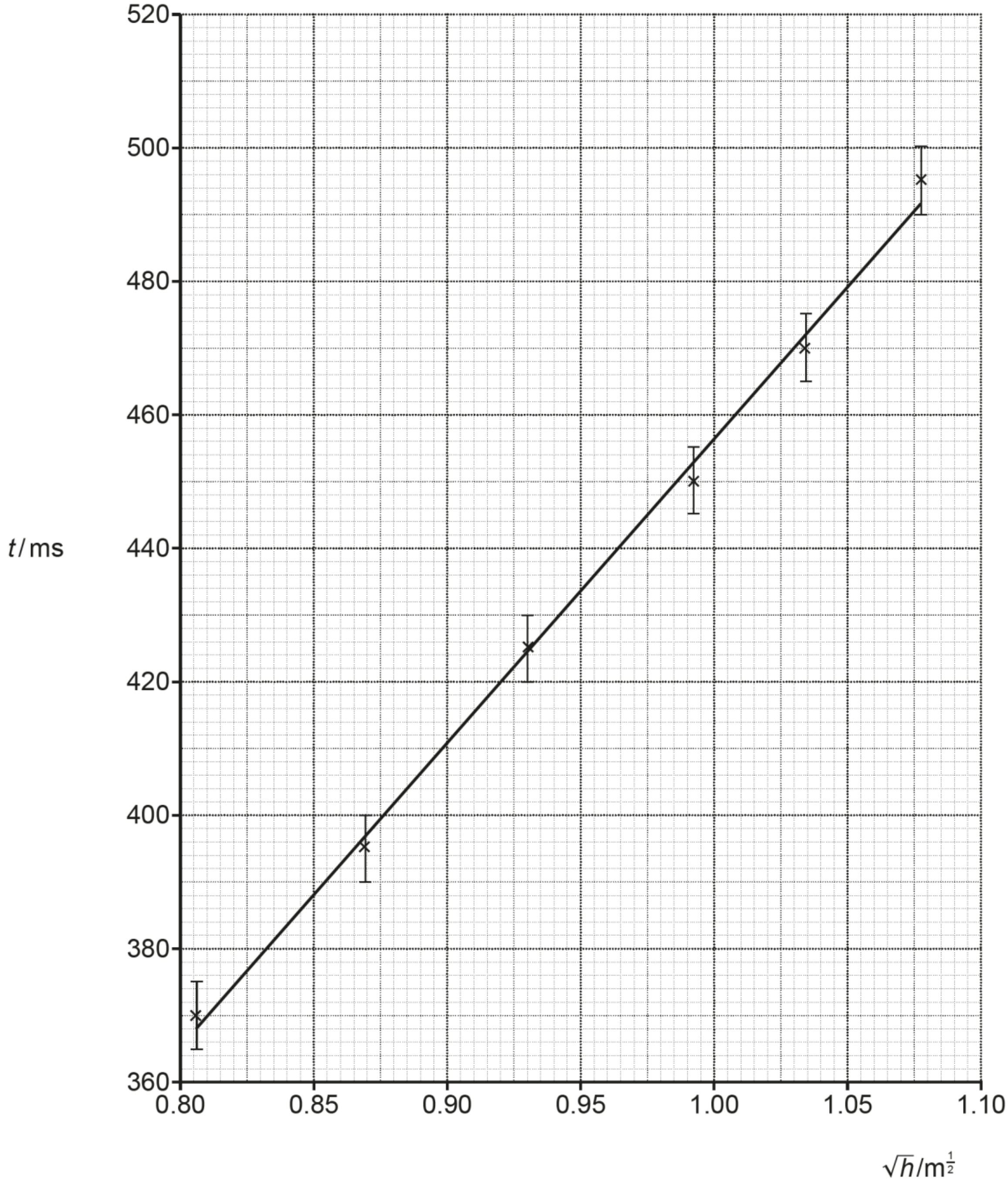
h / m	$\sqrt{h}$ / m$^{\frac{1}{2}}$	t / ms
0.650	0.806	370 ± 5
0.755	0.869	395 ± 5
0.865	0.930	425 ± 5
0.985	0.992	450 ± 5
1.070	1.034	470 ± 5
1.160	1.077	495 ± 5

It is suggested that the relationship between *t* and *h* is

$$t = \sqrt{\frac{2}{g}}\sqrt{h} + k$$

where *g* is the acceleration of free fall and *k* is a constant.

A graph of *t* / ms on the *y*-axis against $\sqrt{h}$ / m$^{\frac{1}{2}}$ on the *x*-axis is plotted.



- Describe how to measure *h* and *t*.
- Use the graph to determine *g*, including the percentage uncertainty.

[6]

This question was designed to test candidates' understanding of practical techniques both designing an experiment and analysing results.

High scoring candidates described measuring *h* using a metre rule or tape measure and allowed for the diameter of the ball. Many candidates were unable to explain the use of the electromagnet to release the ball. Some low scoring candidates suggested using a stopwatch. Since the time measurements were recorded to the nearest millisecond it was expected that candidates would describe how the electromagnet and light gate would connect to an electronic timer or datalogger.

For the analysis, candidates were expected to link the given equation to the equation of a straight line and thus identify how *g* was related to the gradient. The next logical step would then be to calculate the gradient. For this, it was expected that candidates would demonstrate substituting values from the line on the graph (not data points from the table) to determine the gradient and thus calculate a value of *g* with an appropriate unit.

To determine percentage uncertainty, candidate needed to draw the worst acceptable line. This should be either the steepest or shallowest line that passes within all the error bars. Candidates then needed to calculate the worst acceptable gradient. Candidates gained credit for either calculating the percentage uncertainty in *g* from twice the percentage uncertainty in the gradient or from calculating worst value of *g* and then determining the percentage uncertainty.

Assessment for learning

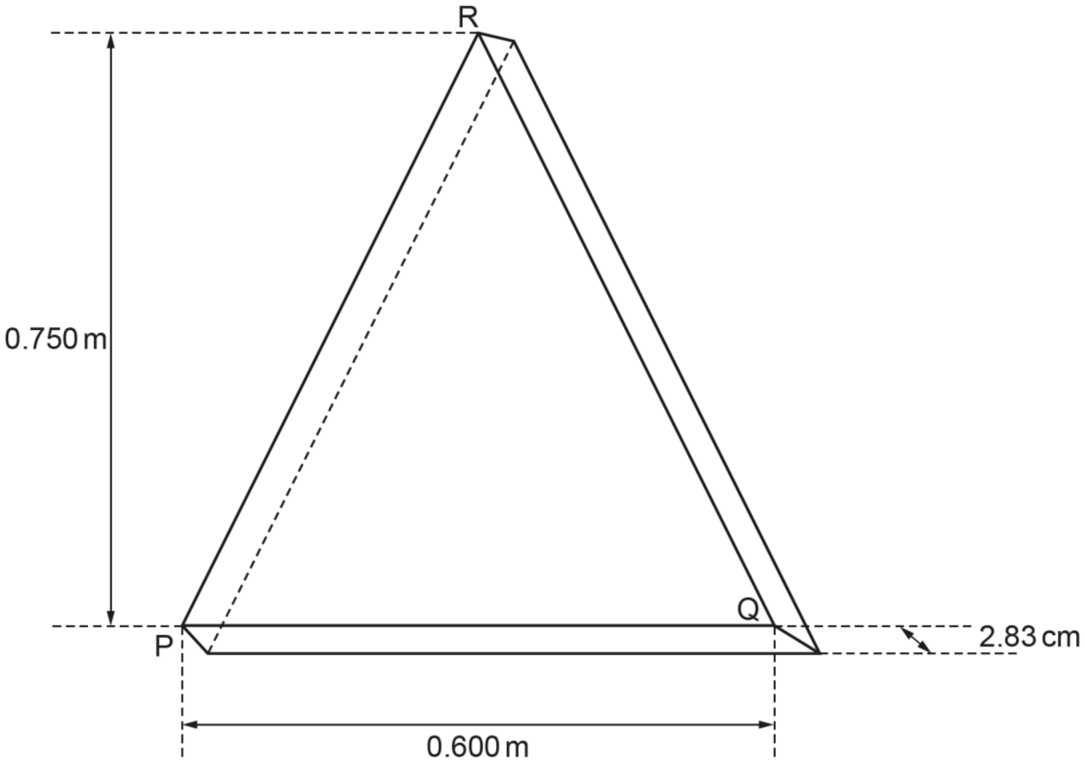
Candidates should have the opportunity to practise determining values for constants using the gradient and *y*-intercept of straight-line graphs.

Candidates should have the opportunity to practise drawing worst acceptable straight lines through error bars and understand the techniques to determine uncertainties in calculated constants using the worst acceptable gradient and/or *y*-intercept.

Question 4 (a) (i)

4 A solid uniform wooden isosceles prism has a mass of 3.98 kg. The corners of one of the triangular faces are P, Q and R.

Fig. 4.1 (not to scale)



A student determines the thickness of the prism to be 2.83 cm.

(a)
(i) Explain how to determine the thickness of the prism accurately in the laboratory.

....

....

.... **[2]**

Since the thickness was determined to be 2.83 cm, this was measuring the thickness to the nearest 0.1 mm. Thus, a ruler would not be an appropriate measuring instrument. The majority of the candidates suggested that calipers should be used.

The second mark was given for the determination of a mean value. It would be good experimental practice to take measurements of the thickness at different positions across the face of the prism. Often lower scoring candidates omitted this latter point.

Question 4 (a) (ii)

(ii) Calculate the density ρ of the wood.

ρ = ... $kg\,m^{-3}$ **[2]**

A significant minority of candidates found calculating the volume of the prism challenging. Some candidates did not allow for changing 'cm' to 'm' for the thickness.

Question 4 (b) (i)

(b)
(i) Explain what is meant by centre of gravity.

....

.... **[1]**

This definition was not clearly stated by the majority of candidates. Many candidates incorrectly referred to mass. It was expected that candidates would use the correct scientific term and refer to the weight (of the prism).

Examiners also did not credit answers where the term 'gravity' on its own was used. For example, 'the point where gravity is said to be acting' did not gain credit since it was not the correct scientific term and in effect was repeating the stem of the question.

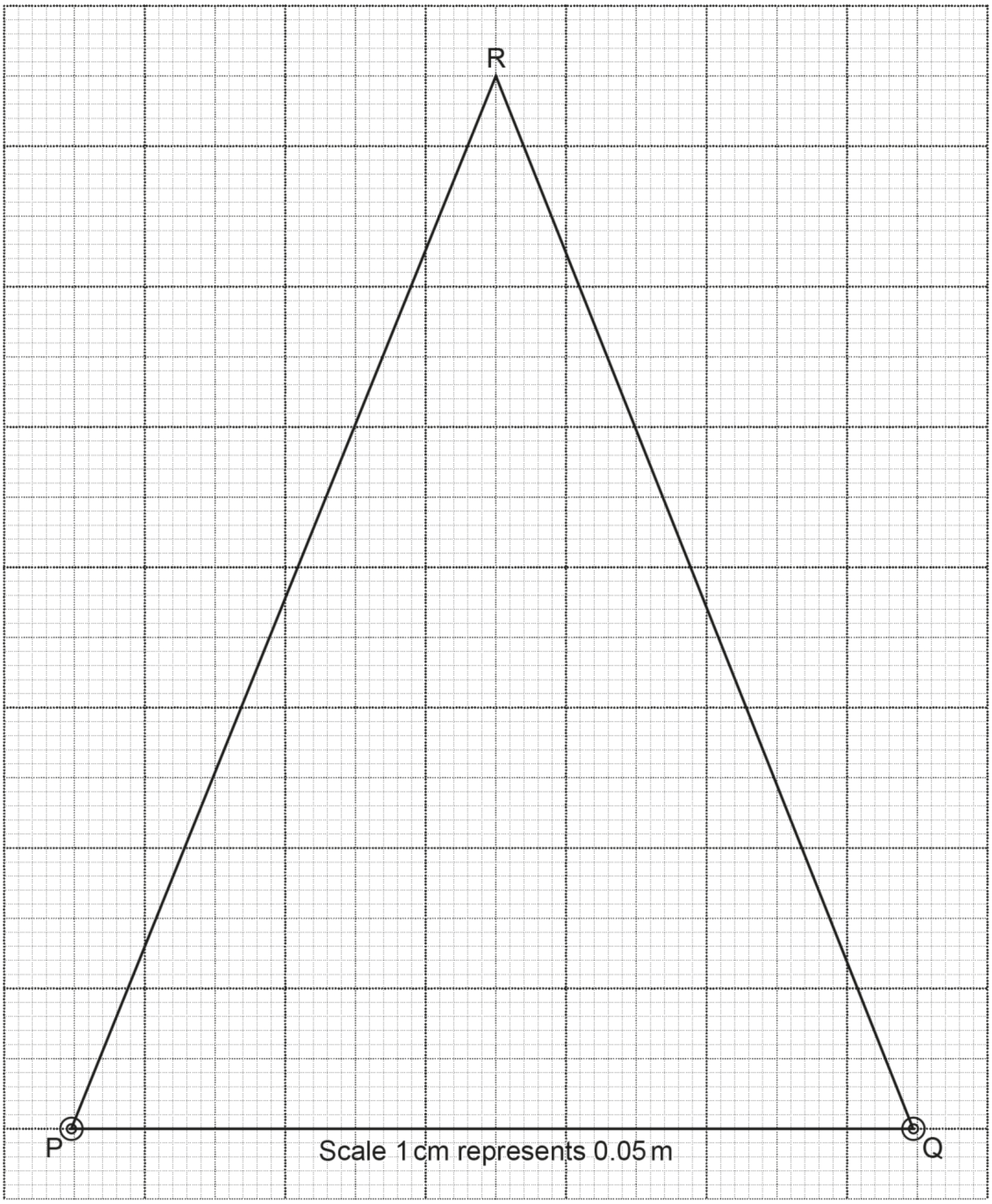
Misconception

Candidates appear not to understand the definitions and the difference between the two specification terms 'centre of mass' and 'centre of gravity' [specification reference 3.2.3d].

Question 4 (b) (ii)

(ii) **Fig. 4.2** shows a scale drawing of the triangular face.

Fig. 4.2



Show that the centre of gravity on the wooden prism is about 0.25 m perpendicularly from the edge of PQ.

In your answer, **draw lines** on **Fig. 4.2**, and label the position of the centre of gravity C on the scale drawing.

[3]

This question required candidates to show how they would obtain an answer. It appeared that many candidates incorrectly started with the answer and then marked on the diagram the position of the centre of gravity C.

The majority of the candidates understood that C would lie on a straight line from the mid-point of the horizontal surface to the apex of the triangle. Few candidates drew line from the mid-points of the other two sides to the opposite corners.

Few candidates used the scale to show that C was 0.25 m.

Question 4 (c) (i)

(c) The prism rests on a support along edge PQ. **Fig. 4.3** shows a top view and **Fig. 4.4** shows a side view.

Fig. 4.3 (not to scale) top view

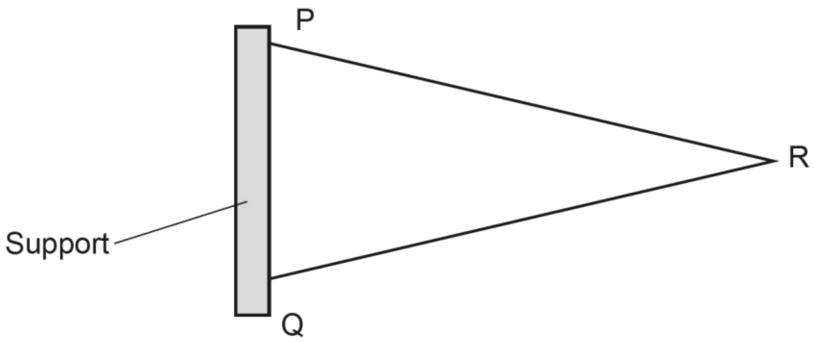
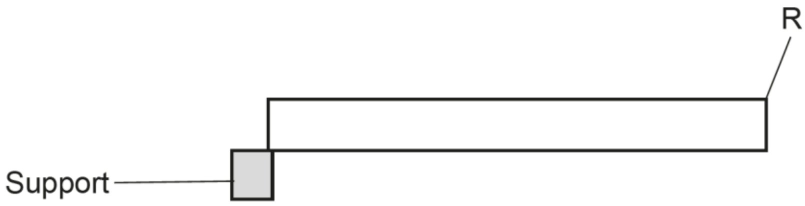


Fig. 4.4 (not to scale) side view



The student applies a force *F* at point R so that the prism is in equilibrium.

(i) State the **two** conditions for the equilibrium of the prism.

1 ....

....

2 ....

....

[3]

The majority of the candidates understood that resultant force was zero and that the resultant moment was also zero. Few candidates stated that the result force would be zero **in any direction** and the resultant moment would be zero **about any point**.

Question 4 (c) (ii)

(ii) Calculate the force *F*.

F = ... N **[3]**

The majority of the candidates correctly calculated the weight of the prism. It is expected that the value of *g* should be the value given on the data sheet.

Using the principle of moments was generally answered well by higher scoring candidates. A number of candidates incorrectly determined a distance of 0.50 m (0.75 – 0.25).

High scoring candidates usually showed clear working.

Assessment for learning

Candidates should practise answering calculation type questions.

Candidates should:

1. Write down the equation they are going to use
2. Substitute the data into the equation
3. Consider the units
4. Rearrange the equation
5. Evaluate the answer
6. Check that the answer is sensible.

OCR support

The Maths skills handbook: Physics has guidance on algebra, as well as a range of maths skills.

Question 5 (a) (i)

5 The table shows the speed and wavelength of yellow light in air.

Quantity	**Air**	**Glass**
Speed of light / m s^{-1}	3.00×10^8	....
Wavelength / nm	588	....
Frequency / THz	....	....

The refractive index at the air glass boundary is 1.52.

(a)
(i) Calculate the frequency, in THz, of yellow light in air.

Record your answer in the table.

[1]

Most candidates were able to calculate the frequency, however, many candidates did not allow for the table heading in THz.

Assessment for learning

Candidates should be able to record data in a table using the units given in the column headings.

Question 5 (a) (ii)

(ii) Complete the table for yellow light in glass.

[2]

Most candidates were able to calculate the speed of light in glass correctly. Lower scoring candidates often incorrectly believed that the frequency (as opposed to the wavelength) decreased in glass.

Misconception

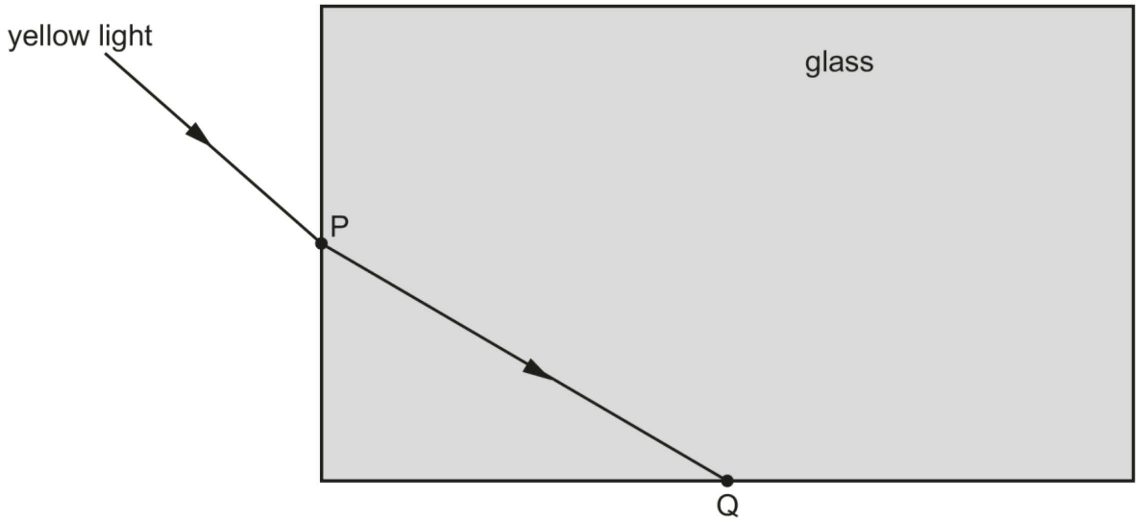
Many candidates did not fully understand effects of refraction on the quantities speed, frequency, and wavelength.

Question 5 (b) (i)

(b) A student uses a ray box to investigate the refraction of the yellow light in a rectangular glass block.

Fig. 5.1 shows the path the yellow light travels as it enters the block at point P and travels to point Q.

Fig. 5.1



(i) **Draw on Fig. 5.1** the angle of incidence *i* and the angle of refraction *r* at point P.
Label the angles *i* and *r*.

[1]

This was generally answered well with many candidates adding a labelled normal line. Some lower scoring candidates did not draw a normal and just marked the angles between the rays and the boundary of the two mediums.

Question 5 (b) (ii)

(ii) Describe how the student produces **Fig. 5.1** experimentally using a ray box.

....

....

....

....

....

.... **[4]**

This question was designed to give candidates the opportunity of describing a practical technique.

In this question, the basic set-up required a single slit and a yellow filter in the ray-box to produce the thin ray of yellow light. It is often easier to carry out this experiment in a darkened room.

Few candidates gave details of how the rays would be traced and the need to draw the outline of the glass block. High scoring candidates often included detail about placing small crosses on the rays and then using a rule joining them together and removing the block to join points P and Q.

Some candidates also discussed the drawing of the normal and using a protractor to measure the angles.

Assessment for learning

Students should have the opportunity of developing their practical skills so that they are able to describe methods and suggest improvements to obtain accurate data.

Question 5 (b) (iii)

(iii) The angle of incidence *i* is 49.9°.

Show that the angle of refraction *r* is approximately 30°.

[1]

To gain credit, candidates needed to show the correct substitution of the data into the correct equation and evaluate the answer.

Question 5 (b) (iv)

(iv) Show that total internal reflection occurs at point Q.

[3]

Candidates needed to determine the both the critical angle and the angle of incidence at point Q. Many candidates were able to calculate the critical angle.

Since this was a show question it was then expected that there would be an appropriate conclusion that since the angle of incidence (60°) was larger than the angle of incidence, total internal reflection would occur.

Some candidates showed mathematically that a refracted ray was not possible but did not link this with the criteria for total internal reflection.

Assessment for learning

Candidates should be able to state the conditions for total internal reflection and be able to apply these conditions to practical situations.

Question 5 (b) (v)

(v) **Draw on Fig. 5.1** the path of the light as it travels from point Q back into the air.

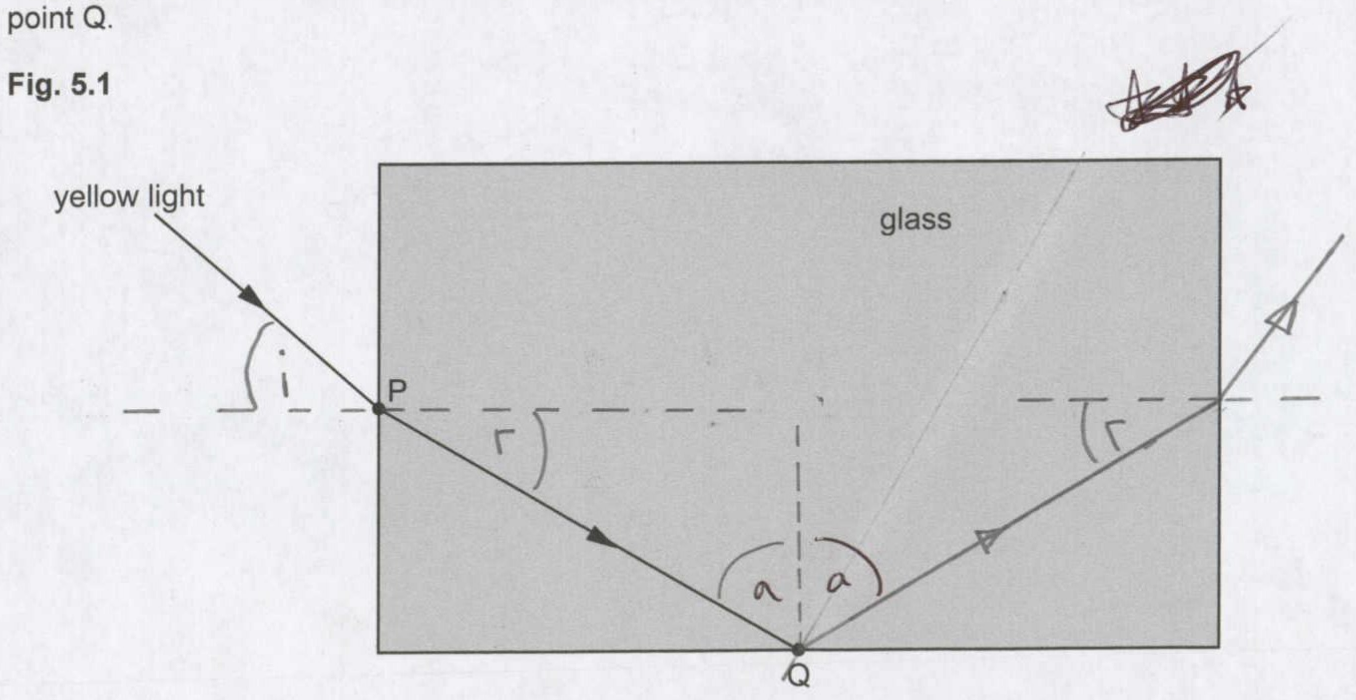
[1]

The majority of candidates did not realise that there should be a mirror image of the diagram. High scoring candidates answered this question well by adding appropriate lines to the diagram and adding where the angles were equal.

Exemplar 2

Fig. 5.1 shows the path the yellow light travels as it enters the block at point P and travels to point Q.

Fig. 5.1



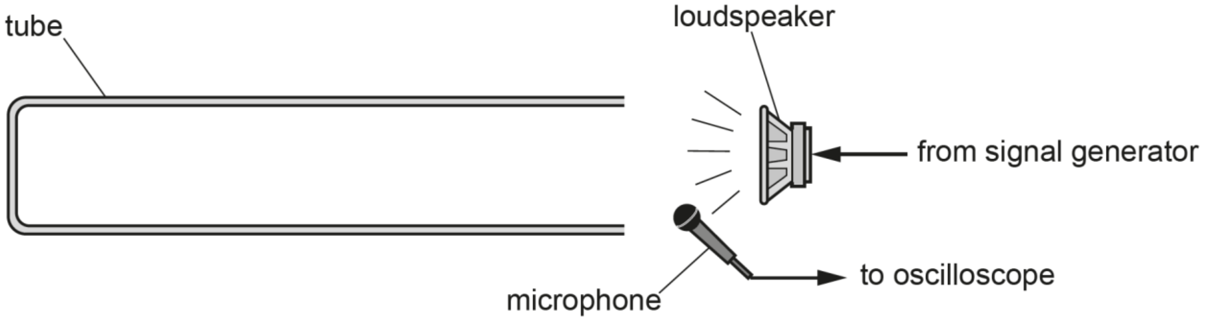
The candidate has clearly shown the answer with the normal lines aligned and labelled the angles so that it is clear which ones are equal.

This candidate has also clearly shown the angle of incidence and the angle of refraction for Question 5 (b) (i).

Question 6 (a)

6 A stationary sound wave is set up in a closed resonance tube as shown in **Fig. 6.1**.

Fig. 6.1

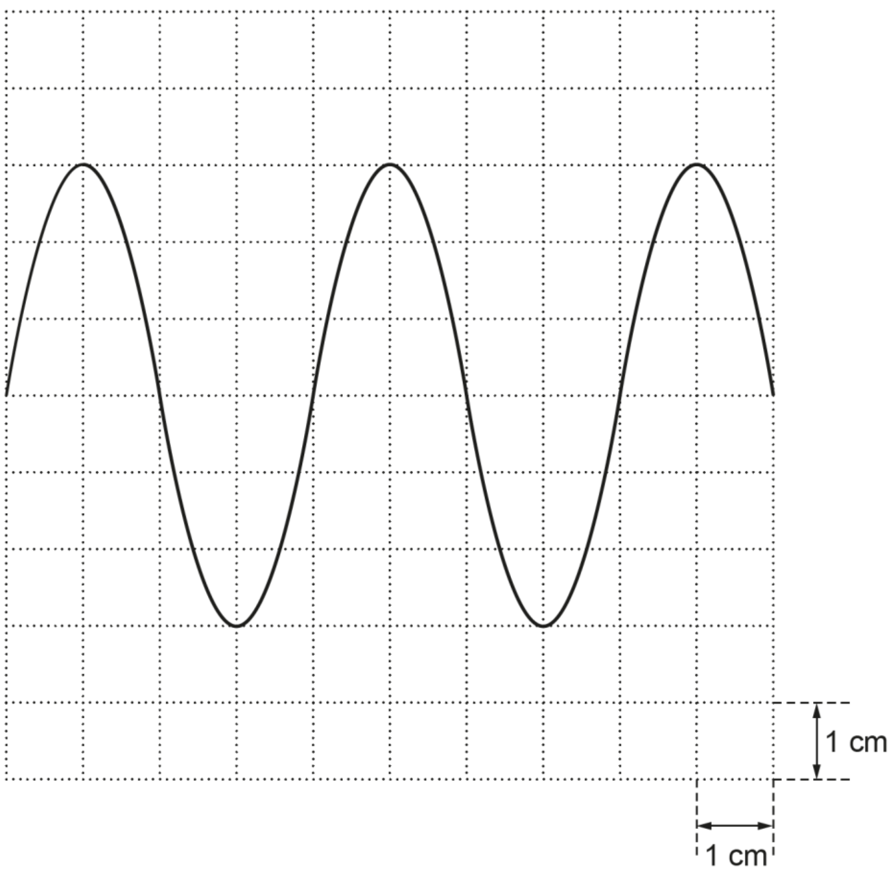


Sound is produced by a signal generator connected to a loudspeaker. The sound is detected by a microphone connected to an oscilloscope.

The time-base setting on the oscilloscope is $1\,\text{ms}\,\text{cm}^{-1}$.

The signal generator is adjusted until the fundamental mode of vibration is detected. **Fig. 6.2** shows the trace on the oscilloscope.

Fig. 6.2



(a) Use **Fig. 6.2** to determine the frequency f_0 of the fundamental mode of vibration.

f_0 = ... Hz **[2]**

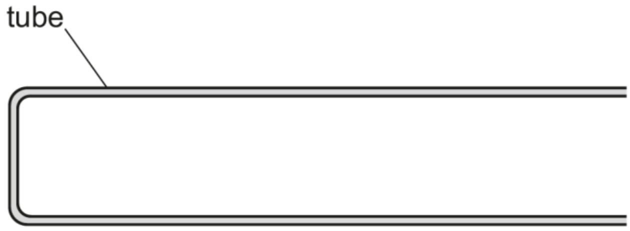
The majority of the candidates gained credit. Some lower scoring candidates did not interpret the trace correctly.

Question 6 (b)

(b) **Draw on Fig. 6.3** the stationary wave pattern for the fundamental mode of vibration.

Label on **Fig. 6.3** the positions, if any, of any nodes **N** and any antinodes **A**.

Fig. 6.3



[2]

Many candidates understood what was meant by an antinode and a node but did not understand that for the fundamental mode of vibration a node was formed at the closed end and one antinode was formed at the open end.

Question 6 (c)

(c) The frequency of the signal generator is increased until the next harmonic is displayed on the oscilloscope.

Calculate the frequency f_n of the next harmonic.

f_n = ... Hz **[1]**

This question was challenging. A value of 500 Hz was the common incorrect answer.

Other incorrect answers included candidates who thought that the frequencies decreased.

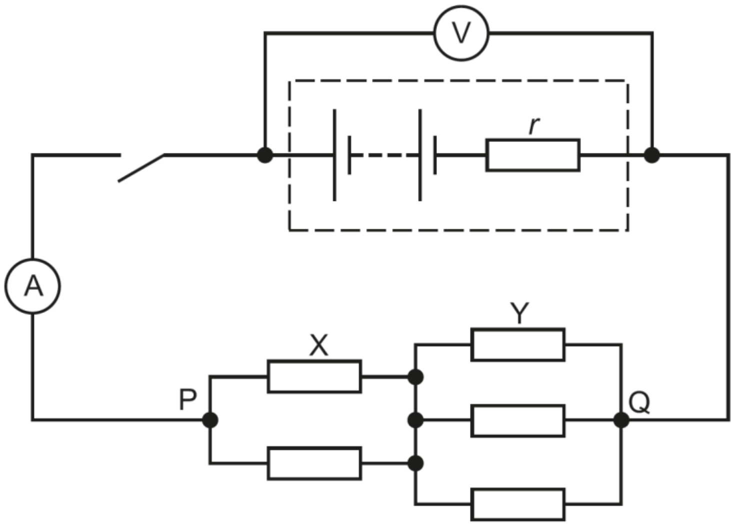
Misconception

Many candidates did not fully understand the formation of stationary waves in closed tubes and the effect on the harmonics.

Candidates should have the opportunity of drawing stationary waves in both open and closed tubes and determining the wavelength and frequency for each pattern.

Question 7 (a) (i)

7 A battery of electromotive force (e.m.f.) ε and internal resistance r is connected to five identical wire wound resistors in a circuit.



Each resistor between points P and Q has a resistance of 300 Ω. Two of the resistors are labelled X and Y as shown.

The table shows the ammeter and voltmeter readings when the switch is open and when the switch is closed.

Switch position	**Ammeter reading**	**Voltmeter reading**
open	0.0 mA	4.57 V
closed	18.0 mA	4.50 V

(a)
(i) Suggest why a student deduces that the e.m.f. ε of the battery has the value of 4.57 V.

....

.... **[1]**

There were many vague answers given. Candidates needed to state the reading of 4.57 V occurs when the current was zero. An open switch was not good enough.

Question 7 (a) (ii)

(ii) Show that the resistance *r* is approximately 3.9 Ω.

[1]

This was another show question where the method needed to be clearly stated. High scoring candidates stated the circuit equation, substituted the data and evaluated answer before rounding it to 3.9 Ω.

The majority of the candidates gained credit.

Exemplar 3

$$\varepsilon = V + Ir$$

$$4.57 = 4.50 + 18.0 \times 10^{-3} \times r$$

$$\frac{4.57 - 4.50}{18 \times 10^{-3}} = 3.889 \approx 3.9\,\Omega$$

The candidate has stated an equation, substituted in the data and evaluated the answer (3.889) which has then clearly been rounded to 3.9 Ω.

Question 7 (a) (iii)

(iii) Show that the total resistance of the resistors between P and Q is 250 Ω.

[1]

This question was well answered. There were two different routes for gaining credit. Candidates could either use the formulae for resistors in series and parallel or use the data given and use $R = V/I$.

Question 7 (b) (i)

(b) The switch is closed for 300 s.

Calculate:

(i) the energy *E* dissipated in *r*.

E = ... J **[1]**

Many candidates incorrectly calculated the total energy dissipated in the five 300 Ω resistors rather than *r*.

Question 7 (b) (ii)

(ii) the number of electrons *N* passing through *r*.

N = ... **[2]**

This question required candidates to determine the total charge flow and then divide this by the change on one electron.

Question 7 (b) (iii)

(iii) the ratio

$$\frac{\text{mean drift speed of electrons in resistor X}}{\text{mean drift speed of electrons in resistor Y}}.$$

ratio = ... **[2]**

Candidates needed to understand how the current in X and Y would be different and relate this to the $I=Anev$ equation.

Question 7 (c) (i)

(c) Resistor Y is removed from the circuit.

The switch is closed.

Complete the sentences to state the change, if any, in the meter readings.

Choose from **increases**, **decreases**, or **stays the same**.

(i) The ammeter reading

.... **[1]**

Candidates generally found this question challenging. They needed to understand that removing a resistor from a parallel combination, increased the total resistance of the circuit so that the current decreased.

Question 7 (c) (ii)

(ii) The voltmeter reading

.... **[1]**

This question was very challenging. Since the current has decreased, there would be less 'lost volts' across *r* so the voltmeter reading would increase. May candidates thought incorrectly that the voltmeter reading would remain the same.

Question 8*

8* In 1929, the Nobel prize was awarded to Louis de Broglie for his discovery of the wave nature of electrons.

Describe, with the aid of a suitable diagram:

- how an experiment can be safely conducted to demonstrate the wave nature of electrons
- how the observations indicate the wave nature of electrons
- how an estimate of the de Broglie wavelength of the electrons compares with an estimate of the de Broglie wavelength for a car travelling at a speed of 110 Km / h on a motorway.

[6]

Many candidates appeared not to understand an experiment to demonstrate the wave nature of electrons often drawing a diagram of a double slit and using a screen, in effect the Young slit experiment for light.

High scoring candidates often either stated an estimate of the de Broglie wavelength of electrons or used their knowledge and calculated a value for an estimated value of the accelerating potential difference.

Ther were some very good answers working out the de Broglie wavelength of a car. The best answers clearly showed the working.

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