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Examiners' Report
June 2022

IAL Physics WPH13 01

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June 2022

Publications Code WPH13_01_2206_ER

Introduction

The Pearson Edexcel International AS-level paper WPH13, Practical Skills in Physics I, is worth 50 marks and consists of four questions, which enables candidates of all abilities to apply their knowledge and skills to a variety of styles of question.

Each question assesses the candidate's knowledge and understanding of the skills developed while completing practical investigations.

A candidate's understanding of the 8 core practical tasks will be assessed by the WPH11 and WPH12 papers. As such, the practical contexts met in the WPH13 paper will be less familiar but are similar to practical investigations candidates may complete during their AS Physics studies. The scenarios outlined will be related to content taught during the study of WPH11 and WPH12.

However, the focus of WPH13 is the assessment of the practical skills that the candidates have developed during the completion of the required core practical tasks and other experiments, as applied to the physics context described in the question.

Question 1 (a-c)

This three-part calculation question tests the candidate's understanding of standard measuring techniques and the ability to perform simple calculations. Most candidates completed these calculations successfully.

Q1(a)

The photographs show candidates the dimensions of multiple old coins.

Candidates should be well-practiced in the method of taking the total size of multiple objects to calculate an average size. In this case, the average diameter and thickness of the coins.

Once these dimension are determined, the candidates can calculate the average volume using standard maths equations.

Q1(b)

Using the value of volume from (a) and the mass given in (b), candidates were asked to perform a simple calculation.

Error carried forward was applied.

However, some candidates did not use the factor of 20 (applied the mass or the average volume).

Q1(c)

This question tests the candidate's ability to use percentage uncertainty to calculate the range of uncertainty of a value.

Candidates then needed to make a statement, based on this range and the value calculated in (b).

This example shows an ideal answer, with calculations that are well laid out.

(a) Determine the average volume of one of the coins.

(4)

Diameter of 10 coins = 30.0 cm

Diameter of 1 coin = $\frac{30}{10}$ = 3.0 cm

Thickness of 20 coins = 3.25 cm

Thickness of 1 coin = 0.1625 cm

$V = \pi r^2 h$ (where r = radius, h = thickness)

$= \pi (0.015)^2 (1.625 \times 10^{-3})$

$= 1.15 \times 10^{-6}$ m^3 (3 s.f.)

Average volume = 1.15×10^{-6} m^3

(b) The mass of the 20 coins shown is 196 g.

Determine the average density of the coins.

(2)

Mass of one coin = $\frac{196}{20}$ = 9.8 g = 9.8×10^{-3} kg

Density = $\frac{\text{mass}}{\text{volume}}$ = $\frac{9.8 \times 10^{-3}}{1.15 \times 10^{-6}}$ = 8520 kg m^{-3} (3 s.f.)

Average density = 8520 kg m^{-3}

(c) Determine whether the coins could be made from brass.

density of brass = 8550 kg m^{-3} ± 2%

(2)

Minimum value for density of brass = 0.98 × 8550

= 8379 kg m^{-3}

Maximum value for density of brass = 1.02 × 8550

= 8721 kg m^{-3}

As the range of values for the density of brass is 8379 kg m^{-3} to 8721 kg m^{-3}, and the average density of the coins is 8520 kg m^{-3}, the coins could be made from brass

ResultsPlus Examiner Comments

Q1(a)

This example shows a clear calculation of the average diameter and thickness, using all the coins shown in the photograph, so the first 2 marks are awarded.

To the right, there is a clearly laid out calculation of the volume of a cylinder, using those average values, so the 3rd mark is awarded.

The correct answer is given, along with the appropriate unit, achieving the final mark.

Q1(b)

The average mass of a single coin is calculated – this alone does not score marks.

Mass and volume are substituted into the density equation, so the 1st mark is awarded.

The answer is within the accepted range and the appropriate unit is given, so the 2nd mark is also awarded.

Q1(c)

Although only one boundary of the range of uncertainty is needed for the mark to be awarded, this candidate has calculated both, so the 1st mark is awarded.

A clear statement is made, linking the value from (b) to this range and a decision is made that the coins could be made from brass.

The conclusion mark is based on the value from (b) and the range calculated, so it was possible to be awarded this mark for a statement demonstrating the coins were not brass.

ResultsPlus
Examiner Tip

Candidates should show all steps in their working.

Candidates should also be writing the appropriate unit for all calculation answers.

Question 1 (d)

The question informs candidates that the surface of the coins is uneven. This was meant to guide candidates to consider using a displacement method to determine volume. However, we did accept the correct use of a micrometer screw gauge or vernier caliper as an acceptable alternative.

There was a clear issue with terminology. For example, the names of key pieces of equipment such as measuring cylinder.

Since the concept of density and how it can be determined links to a significant proportion of the WPH12 topic materials, it suggests that many candidates have not experienced the practical to determine the volume and density of an irregular shaped object.

This example gives a good description of the displacement method to determine the volume of an irregular shaped object.

(d) The surfaces of the coins are uneven, which introduces a systematic error.

Describe an alternative method the student could have used to determine the average volume of one of the coins, which would avoid this error.

Your description should include details of how any measuring equipment is used.

(4)

The student should pour a known amount of water or any other non-corrosive liquid in a measuring cylinder wide enough to fit the coins. The student ~~shot~~ should then carefully drop all 20 coins in the measuring cylinder without spilling any liquid. The liquid should've risen above the initial level. The new water level should be measured while ensuring their eye is at the same horizontal level as the water, to avoid any parallax errors. The initial amount of water should then be subtracted from the reading after dropping the coins. This would give the total volume for all the coins. This value should be divided by the number of coins dropped to give the average volume of one coin.

(Total for Question 1 = 12 marks)

ResultsPlus Examiner Comments

All the equipment used is named correctly and describes how it can be used to determine an accurate value.

This candidate has noted the requirement to determine the average volume.

It was common to see only a single coin used, which limited the available mark to 2.

ResultsPlus

Examiner Tip

Read the question carefully, your answer will need to meet all the criteria to be awarded full marks.

Question 2 (a)

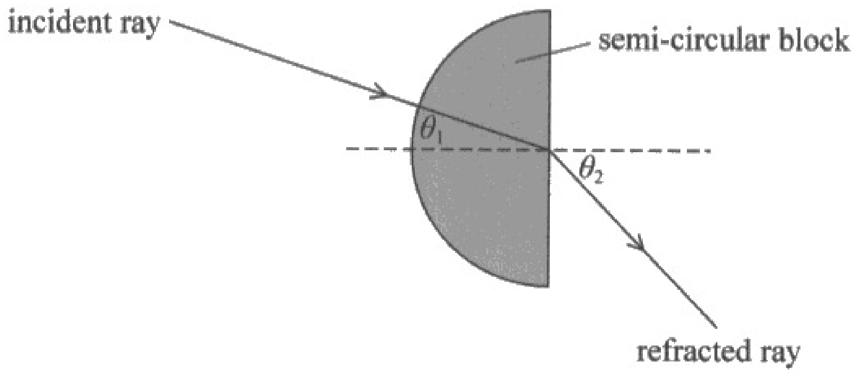
This question tests a standard skill, the recall of how we calculate uncertainty of a single value and how to calculate the percentage uncertainty. Both of these are found in Appendix 10 of the specification – Uncertainties and practical work.

This skill has been tested regularly in the past, so it should not be a surprise to candidates.

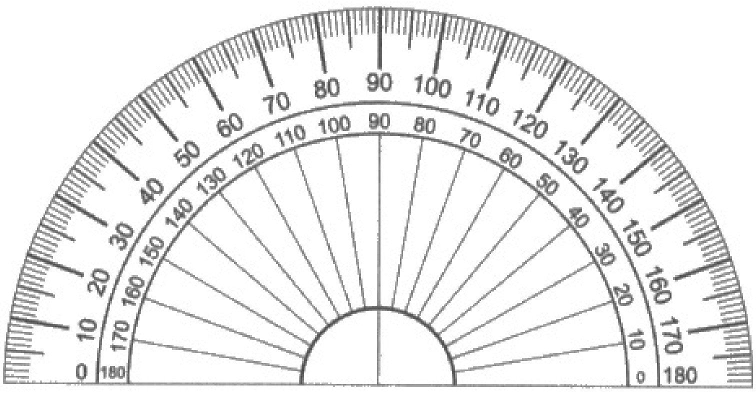
When using a protractor, the 0° line (the edge for this protractor) should be aligned with the marked ray (or alternatively the flat edge of the block). So, we can assume there is zero uncertainty for that value. Since a single angle is measured, the uncertainty in the angle would be half the resolution (0.5°).

It is possible the protractor could be used in a way that the normal or rays were not aligned to 0°, so the angle was determined by a difference in protractor measurements, so we did accept an uncertainty of 1°, but for a maximum of 2 marks.

2 A student directed a ray of light from air into a semi-circular block of transparent material as shown.



He varied the angle of incidence θ_1 and measured the corresponding angles of refraction θ_2. He used the protractor shown below.



(Source: PAL)

(a) When the measured value of θ_1 is 35°, the measured value of θ_2 is 62°.

Calculate the percentage uncertainty in each of these values.

(3)

resolution of protractor = 1

1/2 (1) = 0.5

$\frac{0.5}{35} \times 100 = 1.42857...$ $\frac{0.5}{62} \times 100 = 0.8064...$

Percentage uncertainty in θ_1 = 1.43 %

Percentage uncertainty in θ_2 = 0.81 %

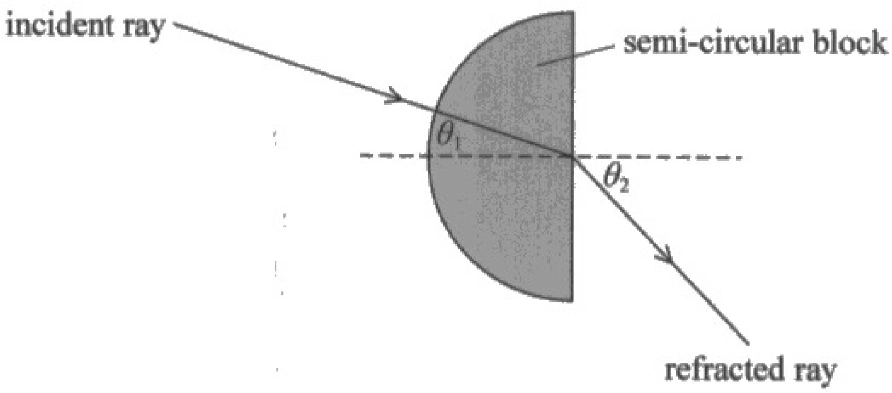
ResultsPlus
Examiner Comments

This example demonstrates the correct method for calculating the percentage uncertainty for both angles.

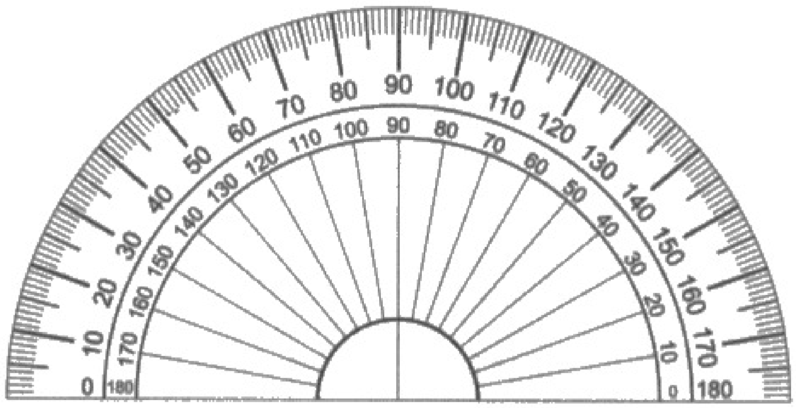
ResultsPlus
Examiner Tip

Although correct use of significant figures was not tested in this question, it would be acceptable to round these percentage uncertainties to 1 significant figure.

2 A student directed a ray of light from air into a semi-circular block of transparent material as shown.



He varied the angle of incidence θ_1 and measured the corresponding angles of refraction θ_2. He used the protractor shown below.



(Source: PAL)

(a) When the measured value of θ_1 is 35°, the measured value of θ_2 is 62°.

Calculate the percentage uncertainty in each of these values.

(3)

~~θ1~~ Percentage uncertainty of $\theta_1 = \frac{1}{35} \times 100\% = 2.86\%$

Percentage uncertainty of $\theta_2 = \frac{1}{62} \times 100\% = 1.613\%$

Percentage uncertainty in θ_1 = 2.86%

Percentage uncertainty in θ_2 = 1.613%

ResultsPlus
Examiner Comments

This example shows a correct calculation of percentage uncertainty, but for the wrong uncertainty in the angles.

ResultsPlus
Examiner Tip

Ensure you are familiar with all keywords and techniques described in Appendix 10 of the specification.

Question 2 (b)

Q2(b) assesses the candidates ability to use the data from a typical practical. In this case, the graph that demonstrates Snell's law.

Q2(b)(i)

Here candidates were asked to explain why the refractive index could be determined from the graph shown.

Most candidates correctly applied Snell's law, as given in the equation list.

Some candidates then mistakenly stated n_1 was the refractive index of air, as they were considering the practical where light is passing into a block.

Here the angle θ_1 is inside the block, so material 2 is the air. Substituting $n_2 = 1$ into the given equation would lead to $n \sin \theta_1 = \sin \theta_2$

This could then be compared to $y = mx + c$ or to the gradient $= \sin \theta_2 / \sin \theta_1$

However, those candidates who used $n_1 = 1$, were awarded 1 mark if they successfully argued that n = 1/gradient.

Candidates who referred to n = sin i / sin r (which is not the version of Snell's law described in the specification), generally did not link i to θ_1 or r to θ_2, so were unsuccessful in their explanation.

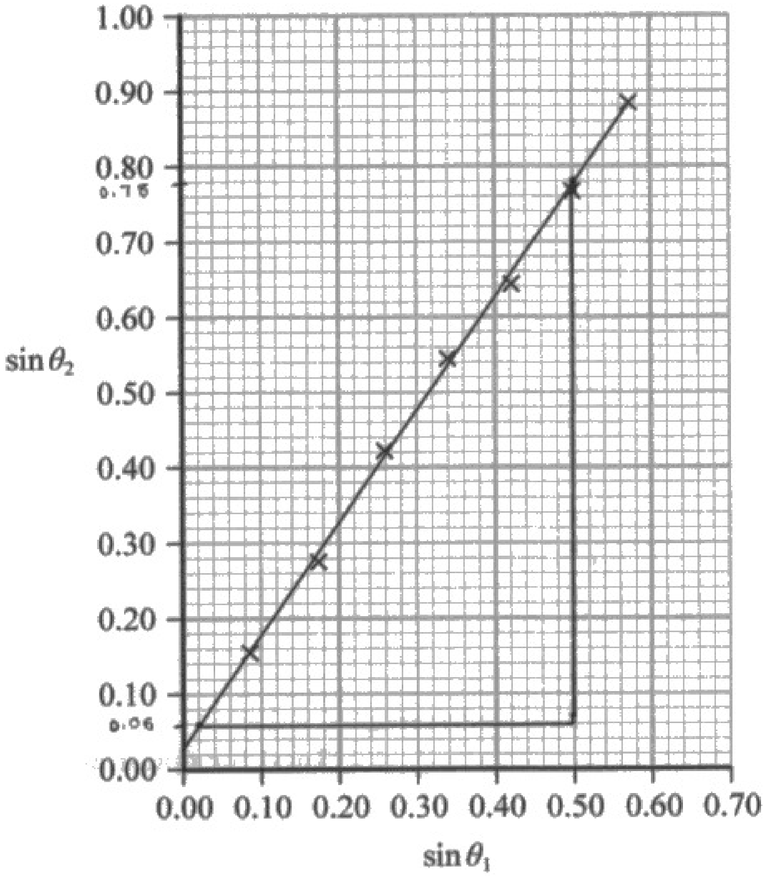
Q2(b)(ii)

Many candidates who were unsuccessful in (b)(i) still went on to correctly use the gradient to determine the value for the refractive index.

We did allow for error carried forward where candidates argued in (b)(i) that n = 1/gradient.

This example was awarded full marks.

(b) The student plotted a graph of $\sin\theta_2$ against $\sin\theta_1$ as shown.



(i) Explain why the gradient of this graph can be used to determine the refractive index of the transparent material.

(3)

$n_1 \sin\theta_1 = n_2 \sin\theta_2$, where $n_1 = 1$ (refractive index of air)

Therefore, $n_1 \sin\theta_1 = \sin\theta_2$.

$\sin\theta_2 = n \times \sin\theta_1$

$y = mx + c$ ($c = 0$) and the gradient is equal to the refractive index of the transparent material.

(ii) Determine the refractive index of the transparent material.

(2)

Refractive Index = Gradient $\left(\frac{y_2 - y_1}{x_2 - x_1}\right)$

$= \frac{(0.78 - 0.06)}{(0.50 - 0.02)} = 1.50$

Refractive index = 1.50

ResultsPlus
Examiner Comments

Note the clear layout of the explanation, with all steps shown in a logical progression.

The calculation shows all the values and working.

ResultsPlus
Examiner Tip

Take time to think about any explanation before you start to write.

Break down the marks, consider writing a rough plan on a blank space.

In this case what are the 3 key things you need to say, then write them in a logical progression.

Question 2 (c)

For this question, there was a clear split between candidates who had carried out this, or similar, experiments and those who were repeating "standard" causes of error.

(c) The line of best fit on the graph does not pass through the origin.

Describe a possible cause for this error, and how the student could reduce the effect of this error.

(2)

The normal was not drawn 90° to the surface of the material or the normal was not a straight level line resulting in the student measuring an ~~90~~ angle of refraction at 0° for the incident ray. ~~Parallax error can be reduced by~~ The student could use a set square to make sure the normal is perpendicular to the surface of the transparent material.

ResultsPlus
Examiner Comments

Here we have a good description of a cause of systematic error, the normal line not being perpendicular to the flat surface or was not straight. This is solved using a set square.

So, both marks (cause and method of reduction) were awarded.

ResultsPlus
Examiner Tip

It is common for some questions to have multiple parts to the instruction. Make sure your answer covers all parts.

(c) The line of best fit on the graph does not pass through the origin.

Describe a possible cause for this error, and how the student could reduce the effect of this error.

(2)

- it could be a zero error as the student when measuring the angle didn't place the protractor at the right place.
- the student can take more measurement to diffrent angl to ~~redu increase the~~ reduce the ~~effect~~ errors
- while measuring the angle the student didn't look from verticly downwards,

ResultsPlus
Examiner Comments

This response scored 1 mark, as it described a zero error in terms of zero of the protractor not being properly aligned.

However, the solution described seems to be more relevant to a random error, such as parallax error.

(c) The line of best fit on the graph does not pass through the origin.

Describe a possible cause for this error, and how the student could reduce the effect of this error.

(2)

The semicircular block of a transparent material could have moved, which caused the line not to pass through the origin, The student could have sticked the block on the table with a tape or a sticky material so it would not have moved.

ResultsPlus
Examiner Comments

Here is another 2 mark example. This is clearly a candidate who has carried out this, or a similar, experiment before.

The block moving is a common issue and taping it into position is a sensible method to prevent the block moving.

Another would be to mark the block (eg draw around it).

Question 3 (a)

Candidates should be well versed in determining the resistance of components using an ammeter and voltmeter method. This is a common experiment met during study of the WPH12 – Electric Circuits topic, and during the study of physics in earlier years.

Candidates should know the standard circuit symbols, including the symbol for an LDR. This is taught in physics courses prior to AS-level.

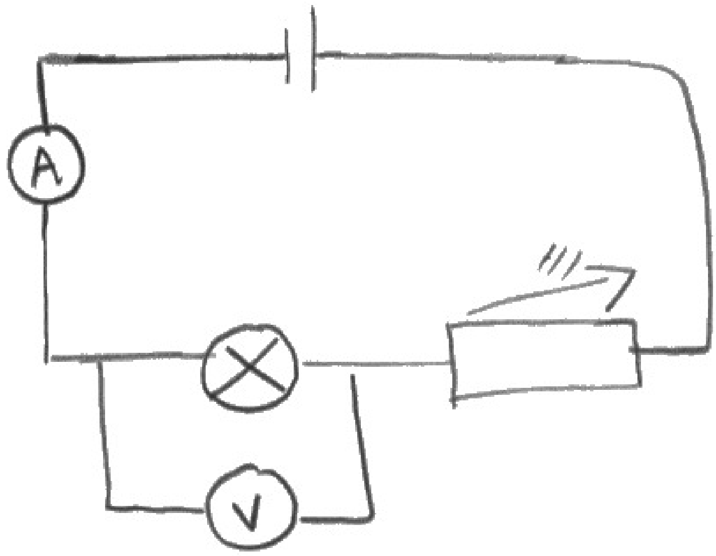
However, it was common for the LDR symbol to be incorrect. In this case, we allowed 1 mark for a circuit that could determine the resistance of the given component.

3 A student investigated the relationship between the resistance R of a light dependent resistor (LDR) and the light intensity I incident upon the LDR.

(a) The student determined R using a circuit that included an ammeter and a voltmeter.

Draw a circuit the student could have used.

(2)



ResultsPlus
Examiner Comments

Here is a typical circuit, where the LDR symbol was not used.

1 mark was awarded as the circuit would allow the candidate to determine the resistance of the filament bulb shown.

ResultsPlus
Examiner Tip

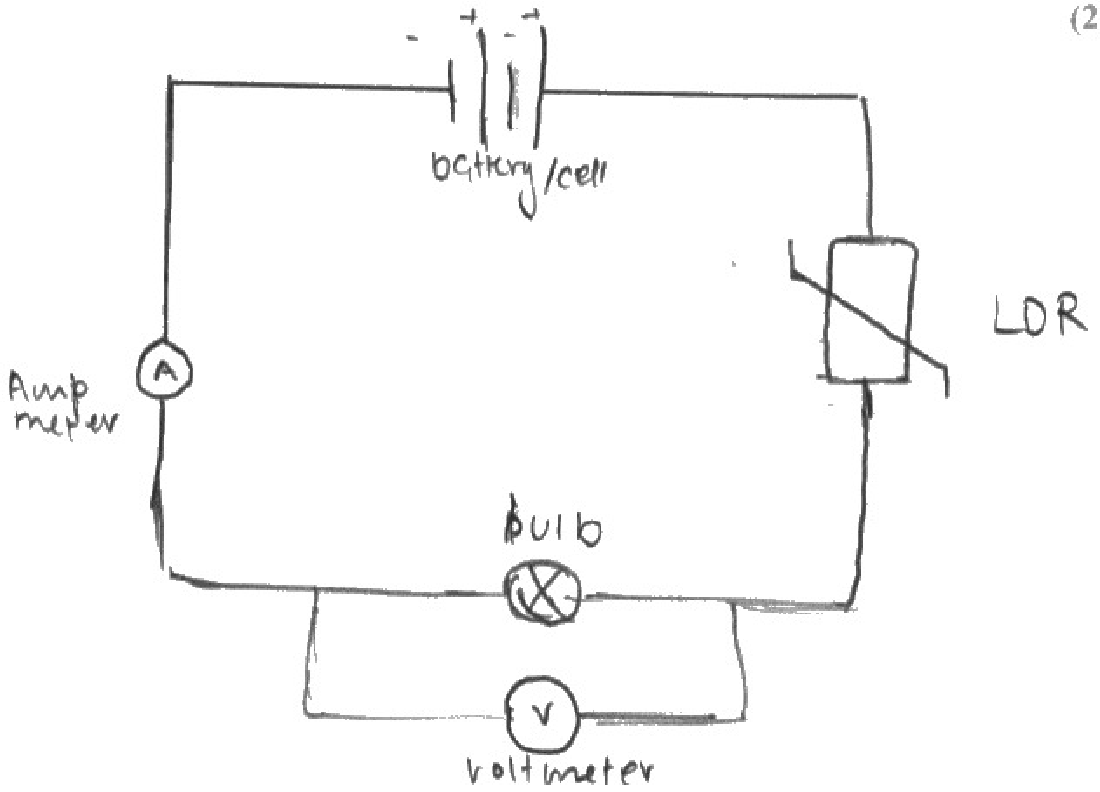
Learn the standard circuit symbol, for basic components and for all components listed in the specification.

3 A student investigated the relationship between the resistance R of a light dependent resistor (LDR) and the light intensity I incident upon the LDR.

(a) The student determined R using a circuit that included an ammeter and a voltmeter.

Draw a circuit the student could have used.

(2)



ResultsPlus
Examiner Comments

In this example, there is an LDR labelled (so we can ignore that the symbol is an incorrectly drawn thermistor).

However, this circuit would determine the resistance of the filament bulb, so only 1 mark was awarded.

ResultsPlus
Examiner Tip

Read the question carefully, so you follow all the instructions.

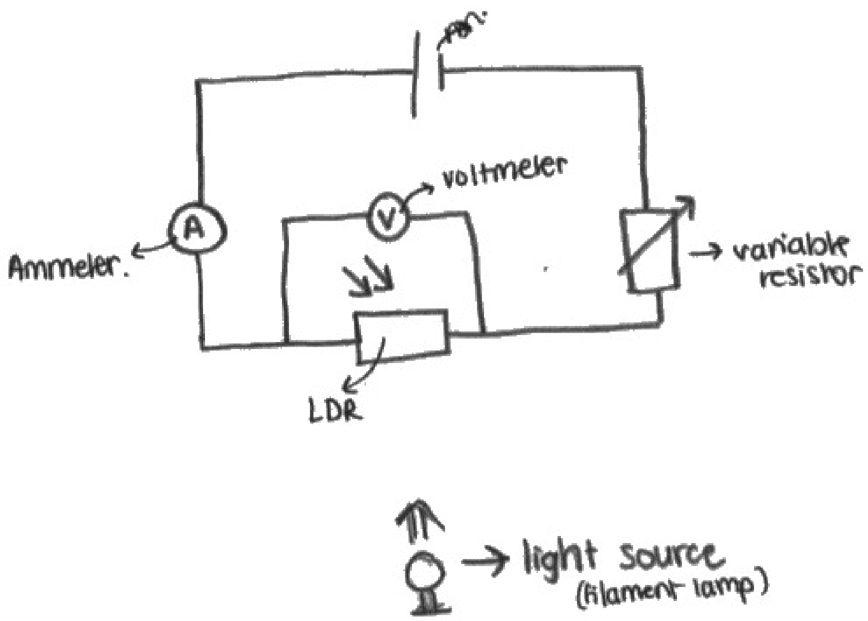
Here, candidates were asked to determine the resistance of the LDR, not the light bulb.

3 A student investigated the relationship between the resistance R of a light dependent resistor (LDR) and the light intensity I incident upon the LDR.

(a) The student determined R using a circuit that included an ammeter and a voltmeter.

Draw a circuit the student could have used.

(2)



ResultsPlus
Examiner Comments

This example labelled the component as the LDR, although we did accept the LDR symbol with or without the circle.

The voltmeter is correctly positioned to determine the resistance of the LDR.

Question 3 (b)

This question asked candidates to describe how to obtain accurate measurements.

However, many candidates incorrectly described the method to carry out the experiment. In some cases, their answer did include how the measurements were obtained, so some marks were still awarded.

(b) She varied I by varying the distance d between the LDR and a filament bulb.

Describe a method the student could have used to obtain accurate values for R and d.

(3)

$I = \frac{P}{A} = \frac{VI}{A}$

~~Me~~ The student can measure distance (d) using a metre ruler. Student can then vary the distance (d) to find ~~the~~ current and p.d across LDR. By varying d, we can get more values of ~~current~~ current and p.d, which would then allow us to find Resistances (R), V = IR ~~ε~~. Repeat experiment three more times using same set of values for d to get mean resistance for each value of d. The student can also carry out the expirement in a dark room to avoid external sources of light affecting final result.

ResultsPlus
Examiner Comments

This example goes beyond what is asked for in the question. Fortunately, while describing the experiment method, the candidate also covers the three marking points, so was awarded full marks.

(b) She varied I by varying the distance d between the LDR and a filament bulb.

Describe a method the student could have used to obtain accurate values for R and d.

(3)

For d, use a metre rule to measure d, and make sure to take readings from eye-level to prevent parallax error. Then, vary d and ~~calculate~~ measure the current and p.d from the ammeter and voltmeter, by also preventing parallax error by taking measurements from eye-level. ~~Then~~ Also, take 6 sets of measurements. Then, repeat for each d and calculate a mean for current and p.d. Then, calculate R by using $V = IR$, so $R = \frac{V}{I}$. Also, cover the equipment by a dark material or cloth to prevent background light.

ResultsPlus
Examiner Comments

This response also goes a little beyond the scope of the question that was asked (by describing the need to "take 6 sets of measurements").

However, all three marking points are clearly met.

ResultsPlus
Examiner Tip

Read the question carefully, so you do not spend excessive time on details that are not needed or relevant.

Question 3 (c)

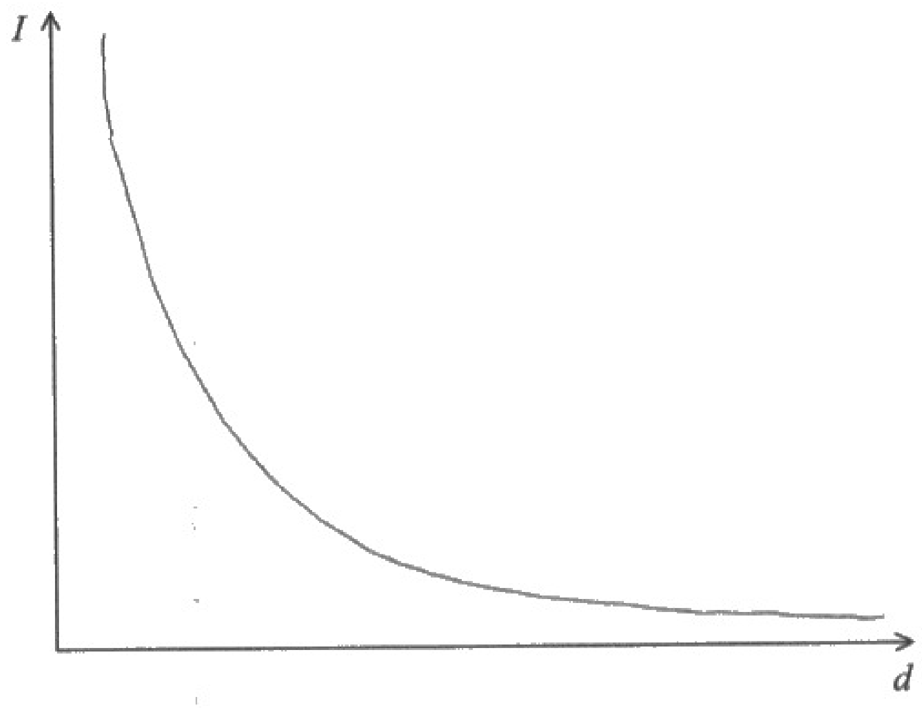
During their study of the WPH12 Waves topic, candidates should learn that the intensity of a light source reduces by an inverse squared relationship, as I = P/A and the area A is the surface area of a sphere.

So, here candidates were expected to sketch an inverse squared relationship, a downwards curve with decreasing gradient that is asymptotic along both the x and y axes.

It is clear from both Q3(c) and Q3(d) that many candidates were not aware of this relationship.

(c) Sketch the relationship between I and d on the axes below.

(2)



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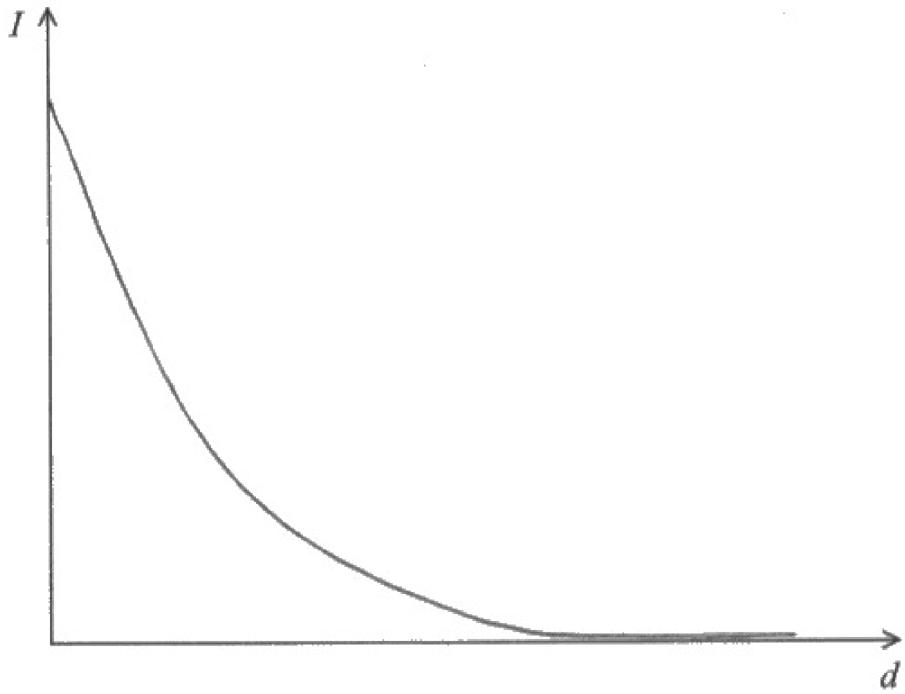
Examiner Comments

This example clearly shows an inverse squared relationship, so scores 2 marks.

(c) Sketch the relationship between I and d on the axes below.

(2)



ResultsPlus
Examiner Comments

This candidate clearly understands intensity reduces with an inverse squared relationship but does not realise that this means intensity at 0 distance would be infinite, which is based on the equation that candidates are expected to know.

Question 3 (d)

As discussed in Q3(c), candidates were generally not aware that the area to be used was the surface area of a sphere.

The need for candidates to know the equation for the surface area of a sphere is identified in Appendix 6 of the specification – Maths skills and exemplifications.

In a few cases, some candidates who did know the area was the surface area of a sphere did misinterpret d as the diameter of the sphere, not the distance from the filament bulb (hence, the radius of the sphere). In this case, we did allow the first 2 marking points.

Candidates who calculated an area, but not the surface area of a sphere, could still be awarded the 2nd marking point for substituting an area quantity into I = P / A.

(d) The student calculated the intensity of light incident on the LDR at each value of *d*.

The output power of the filament lamp was 9.0 W.

Calculate the intensity of the light incident on the LDR when *d* is 20 cm.

(3)

$I = \frac{P}{A}$

$= \frac{9.0}{4(\frac{20}{100})^2 \pi}$

$= 17.9 \ W m^{-2}$

Light intensity = 17.9 Wm^{-2}

ResultsPlus Examiner Comments

This example shows a fully described and correct answer, with the appropriate unit.

(d) The student calculated the intensity of light incident on the LDR at each value of *d*.

The output power of the filament lamp was 9.0 W.

Calculate the intensity of the light incident on the LDR when *d* is 20 cm.

(3)

when d = 20 cm, area of effect => $\pi \times (0.2)^2 = 0.126\ m^2$

$I = \frac{P}{A} = \frac{9}{0.126} = 71.4\ Wm^{-2}$

Light intensity = 71. Wm^{-2}

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Examiner Comments

In this example, the candidate has calculated the area of a circle. As such, only the 2nd mark is awarded.

(d) The student calculated the intensity of light incident on the LDR at each value of *d*.

The output power of the filament lamp was 9.0 W.

Calculate the intensity of the light incident on the LDR when *d* is 20 cm.

(3)

$I = \frac{P}{A} = \frac{9}{4\pi r^2} = \frac{9}{4\pi(0.1)^2}$

$= 71.6$

20cm → 0.2m

~~work = F×d~~

Light intensity = 71.6 W.m^{-2}

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Examiner Comments

Here the candidate has incorrectly assumed the radius is half the given d value.

However, the first 2 marks can still be awarded, as this is a calculation of the surface area of a sphere using a value determined from the question, which is then substituted into I = P / A.

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Examiner Tip

Double check what quantities (letters) stand for. Do not assume, as many of the letters we use for quantities are repeated (eg P is used for power and lens power, two very different quantities).

Question 3 (e)

Q3(e) was asked as two parts, to limit the lists of answers we have seen in previous series of WPH13.

However, it was marked as a whole.

Most candidates struggled to identify a control variable that was relevant to the question (or specific enough to be worth credit).

Many candidates named variables given earlier in the question that were clearly being changed, distance being a common example.

Very few candidates gave the most suitable control variable, background light level, suggesting limited practical experience of working with LDRs.

Despite the specification stating that candidates should be able to analyse potential divider circuits containing LDRs, it is clear that many candidates had only done so in a theoretical manner.

(e) (i) Identify one control variable in this investigation.

(1)

The amount of light incident on the LDR from sources other than the filament bulb.

(ii) State how this variable can be controlled.

(1)

Carry out the experiment in a dark/blacked out room so that ~~only~~ ~~the~~ the bulb is the only light source.

(Total for Question 3 = 12 marks)

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Examiner Comments

This example scored full marks.

There is a clear example of a control variable, and a statement for how this can be controlled.

Another good example.

(e) (i) Identify one control variable in this investigation.

(1)

Output power of the lamp

(ii) State how this variable can be controlled.

(1)

Make sure pd and current across the lamp is constant using voltmeter and ammeter.

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Examiner Comments

Many of the answers seen were too vague, eg power, voltage, current.

Without knowing more detail, eg current in the bulb, current could refer to the current in the LDR, which would be expected to change with LDR resistance.

ResultsPlus
Examiner Tip

Make sure that answers are specific to the question asked on the exam you are completing.

Avoid generic answers – learning from past exams is an important part of revision. However, in an exam you still need to answer the question that is asked, not an answer from the past.

Question 4 (a)

As the ball changes direction as it moves down the ramp, this question cannot be answered using the equations of linear motion.

As such, many of the attempts to answer this question did not succeed.

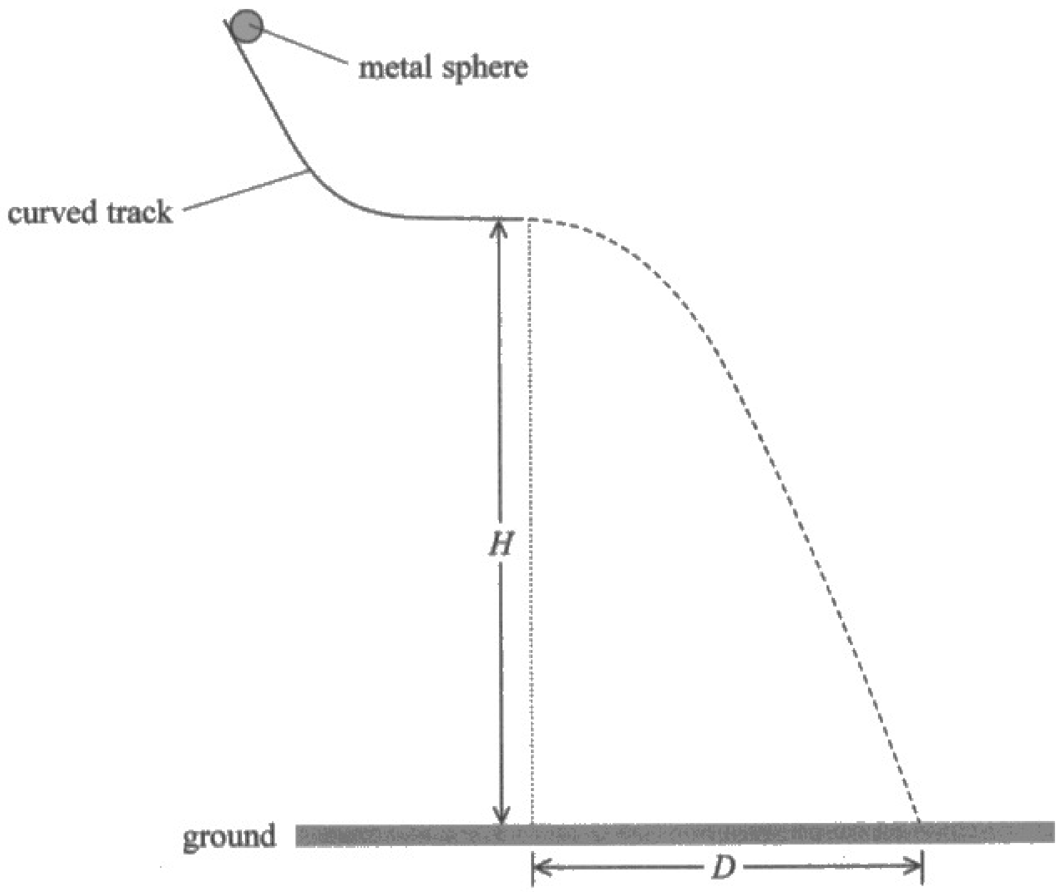
Some candidates did understand that conservation of energy can be used to explain this, but in many cases they did not complete their explanation.

The question asked why the speed would be the same, not the kinetic energy.

4 A student investigated the motion of a small metal sphere moving horizontally from the lower end of a rigid curved track.

The track was supported by a clamp stand. The student adjusted the position of the track so that the end of the track was a height H above the ground as shown.

She determined the horizontal distance D travelled by the sphere before it reached the ground, for different values of H.



(a) For each value of H, the student released the sphere from the same position on the track.

Explain why this ensured the sphere always reached the end of the track with the same horizontal speed.

(3)

Because it is travelling the same distance with the same acceleration so it's final velocity will always be same

$mgh = \frac{1}{2}mv^2$

So, if m, g and h are constant, v will also be constant.

ResultsPlus
Examiner Comments

This example clearly links the change of the gravitational potential energy store to the change in the kinetic energy store.

But it goes further to demonstrate the link between speed and position on the ramp by stating that all the other quantities are constant, so v must be constant.

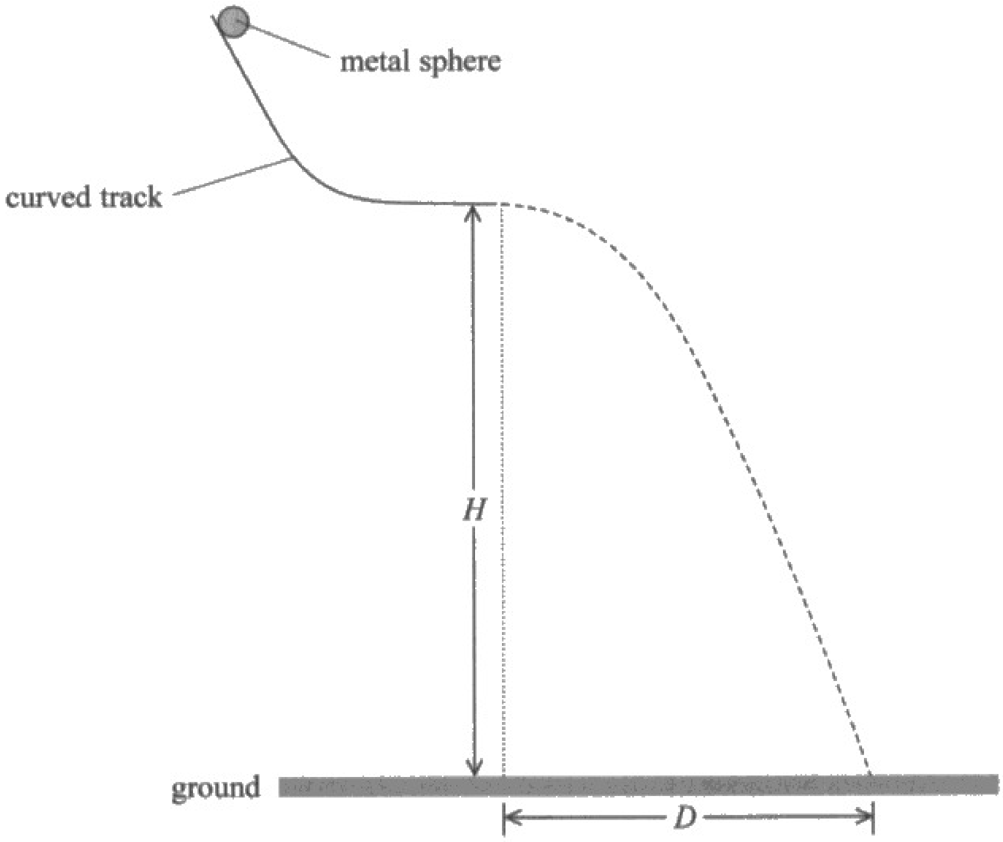
ResultsPlus
Examiner Tip

When demonstrating the relationship between two quantities, make sure you detail any other quantities that remain constant.

4 A student investigated the motion of a small metal sphere moving horizontally from the lower end of a rigid curved track.

The track was supported by a clamp stand. The student adjusted the position of the track so that the end of the track was a height *H* above the ground as shown.

She determined the horizontal distance *D* travelled by the sphere before it reached the ground, for different values of *H*.



(a) For each value of *H*, the student released the sphere from the same position on the track.

Explain why this ensured the sphere always reached the end of the track with the same horizontal speed.

(3)

Releasing it from the same position ensures that it will lose the same GPE when it reaches the end of the track and will gain the same KE. Plus, it would experience the same frictional force over the same time period ~~ar~~ and will accelerate at the same rate while crossing the same distance in the same time. So, the net force at a given moment will be the same ~~as~~ each time, which produces the same acceleration. Plus, the work done against friction will be identical.

ResultsPlus
Examiner Comments

This answer does link the change in the gravitation potential energy store to the change in the kinetic energy store. However, it does not then justify the speed being the same each time.

This answer then tried to argue distance, friction and acceleration are the same. We allowed 1 mark for this argument, for the final mark, if it was supported by equations.

ResultsPlus
Examiner Tip

This example shows an answer that was not planned before writing. The argument presented changes several times.

Consider your explanation before you start to write.

A minute spent thinking about a 3 mark answer, before writing, will be a more effective use of time than starting and then changing the direction of thinking many times in the same answer.

Question 4 (b)

The command word "criticise" is defined as "look at the merits and/or faults of the information presented".

This type of question has appeared in multiple previous WPH13 and WPH03 papers, so candidates should be well practiced in answering this.

In this example we have presented several faults, and most candidates suggested at least 1 that was relevant.

(b) The student derived the following equation for the relationship between D and H

$$D^2 = \frac{2v^2}{g}H$$

where v is the horizontal velocity of the sphere at the end of the track.

She recorded her results in a table.

H / m	D / m	D^2 / m^2
0.2	0.38	0.14
0.35	0.53	0.28
0.5	0.63	0.40
0.75	0.76	0.58
1	0.89	0.79
1.2	0.96	0.92

Criticise the recording of these results.

(2)

- There is no sign of repetition and obtaining mean
- The height H does not have constant decimal places

ResultsPlus Examiner Comments

This example is awarded the first mark for clearly identifying H as not being recorded to a consistent number of decimal places.

As the data produces a graph with minimal random error, the points are close to the line, suggesting repeats would not be necessary.

We allowed the idea of "no repeats" as at this stage, the candidates have not yet plotted the graph.

ResultsPlus Examiner Tip

Measurements should be recorded to the same number of decimal places as the resolution of the measuring device used.

Answers to calculations should be rounded to match the least number of significant figures in the original values.

This is why the mark scheme refers to decimal places, as these are all measured values.

Question 4 (c)

Every WPH13 exam has included a question where a graph is plotted, using given or calculated data, and an analysis of the graph gradient (or sometime y-axis intercept) produces a value for a constant in a given equation.

Here, candidates needed to calculate the values of D^2. As D values were recorded to 2 significant figures, D^2 should also be rounded to 2 significant figures.

As usual, candidates are told which quantities to plot on the x and y-axes and are given a full page of graph paper.

This time, candidates were given an equation and told this was equal to the gradient, as the use of y = mx + c to identify a quantity related to the gradient was tested earlier in the paper.

As such, candidates generally performed better on this question than in the past.

However, the usual issues with drawing graphs still appeared, including:

- incorrectly shown or missing units in axis labels.
- unsuitable scales.
- plots that are too large to be accurate to within 1 mm.
- lines of best fit that are unbalanced.

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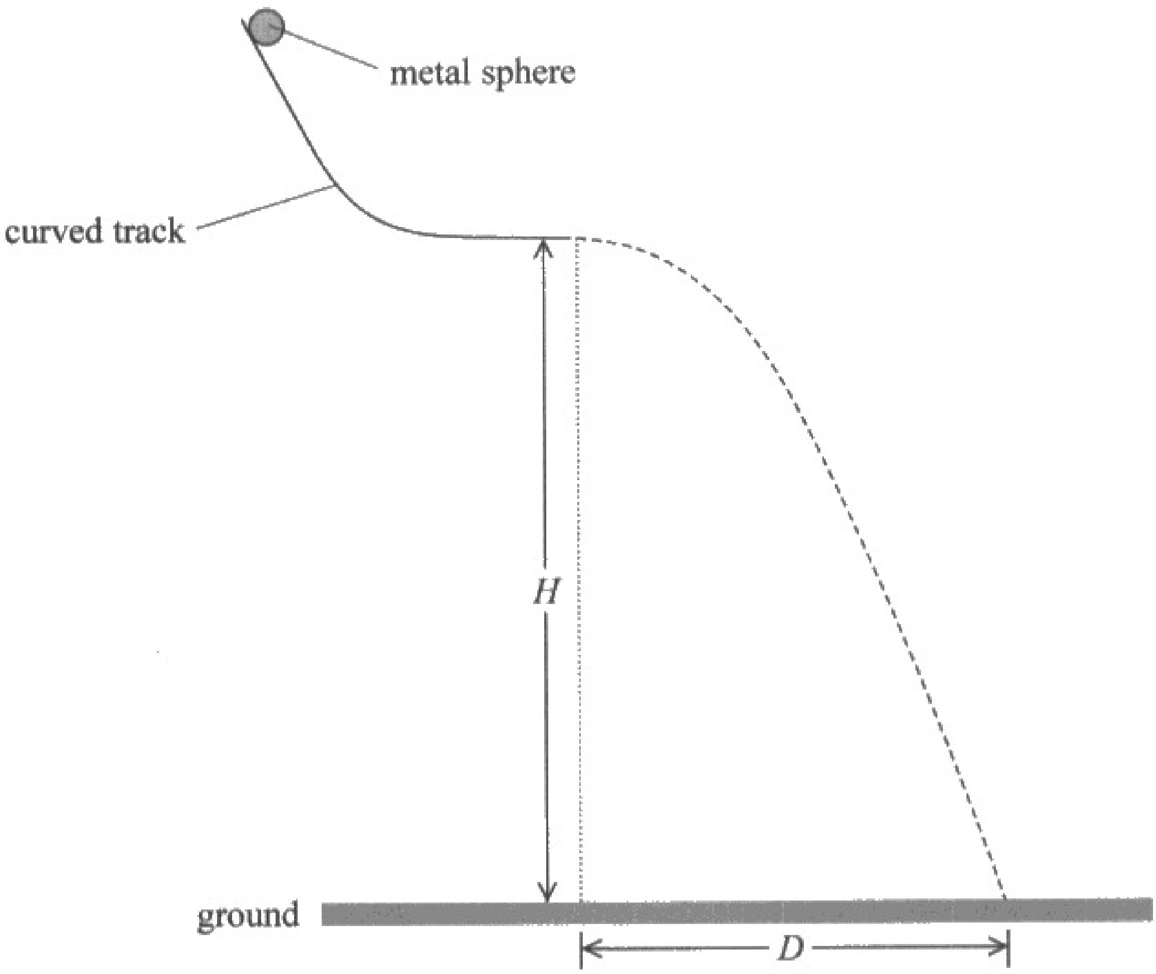

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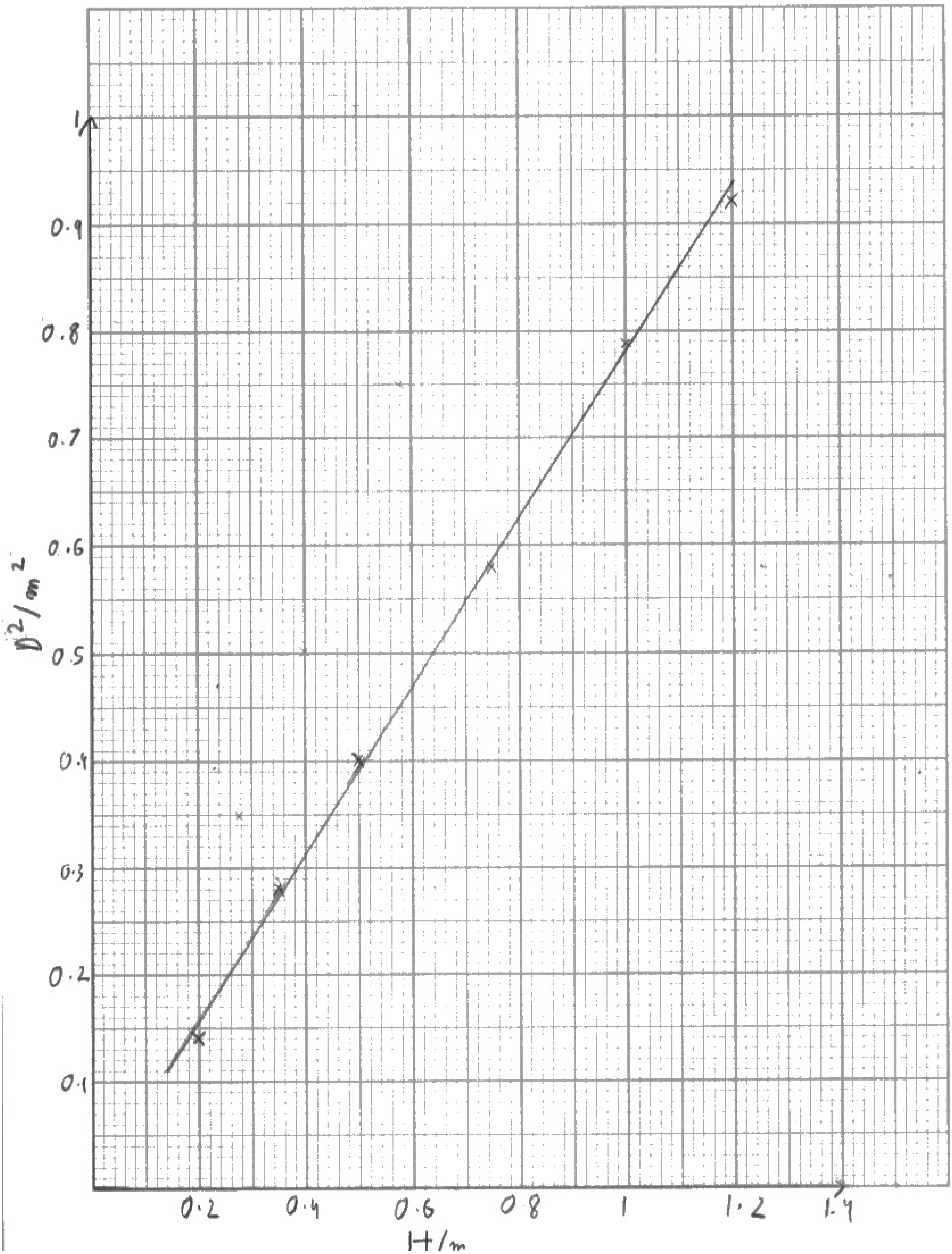
(c) (i) Plot a graph of D^2 on the y-axis against H on the x-axis. Use the additional column of the table for your processed data.

(6)



(ii) The gradient of the graph is equal to $\frac{2v^2}{g}$

Determine the value of v using your graph.

(3)

$m = \frac{0.86 - 0.31}{1.1 - 0.4}$ $\frac{D^2}{H} = \frac{2v^2}{g}$

$= 0.79$ $0.79 = \frac{2v^2}{9.81}$

$v = 1.97$

$v =$ 1.97 m s^{-1}

(iii) The student used a light gate and data logger to measure v. The measured value was 1.98 m s^{-1}.

Comment on the value of v determined using your graph.

(2)

$\frac{1.98 - 1.97}{1.98} \times 100$, percentage difference is small so its accurate

$= 0.5\%$

ResultsPlus Examiner Comments

In previous reports, the examples have included common issues.

This example shows the standard we expect of a graph drawn and gradient calculated:

- calculated data is correctly rounded to match the number of significant figures of the original values
- axis labels, including the unit preceded by /
- scales increasing in sensible increments on the 2cm lines (0.1 and 0.2 in this case)
- plots all within 1mm of the correct position
- a well-balanced and straight line of best fit, with points above and below the line at similar distances along the length
- a gradient calculated using over half the line drawn

ResultsPlus Examiner Tip

Take your time on the graph.

This 50 mark exam give you 80 minutes.

If we assume the general rule of "1 mark per minute" then WPH13 has the same 10 minutes of extra "checking" time as WPH11 and WPH12, plus an extra 20 minutes of time to plot the graph.

As plotting the graph alone is usually worth 6 marks (and 5 marks at a minimum) and the following gradient calculation is usually worth 3 marks, these questions alone could be worth 1 or 2 grades.

Therefore, it is worth practicing plotting graphs and calculating gradients, as part of your revision.

I have included this next example to show how small errors build up to a significant drop in the mark.

The drop of 5 marks from (c)(i) and (c)(ii) would be equivalent to a whole grade.

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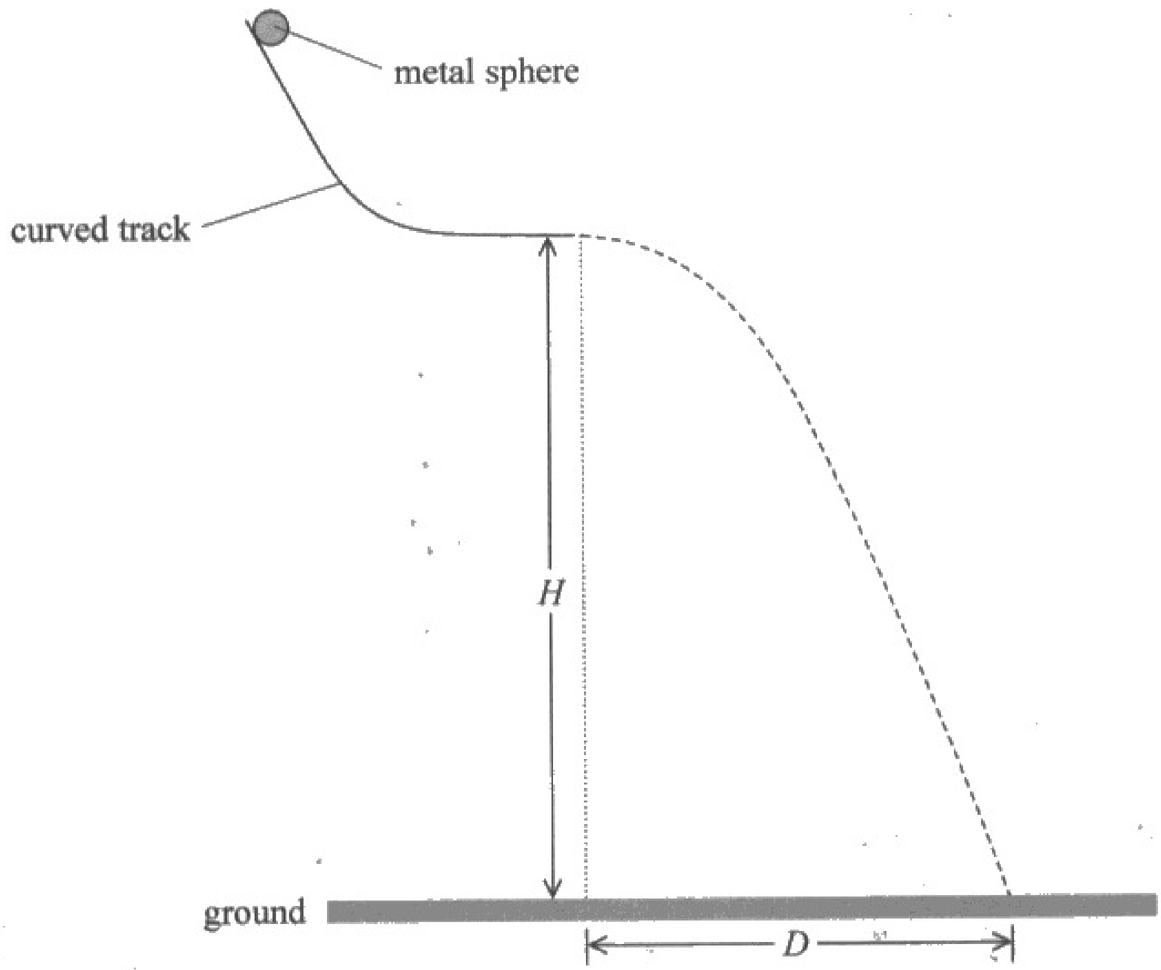

(b) The student derived the following equation for the relationship between D and H

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where v is the horizontal velocity of the sphere at the end of the track.

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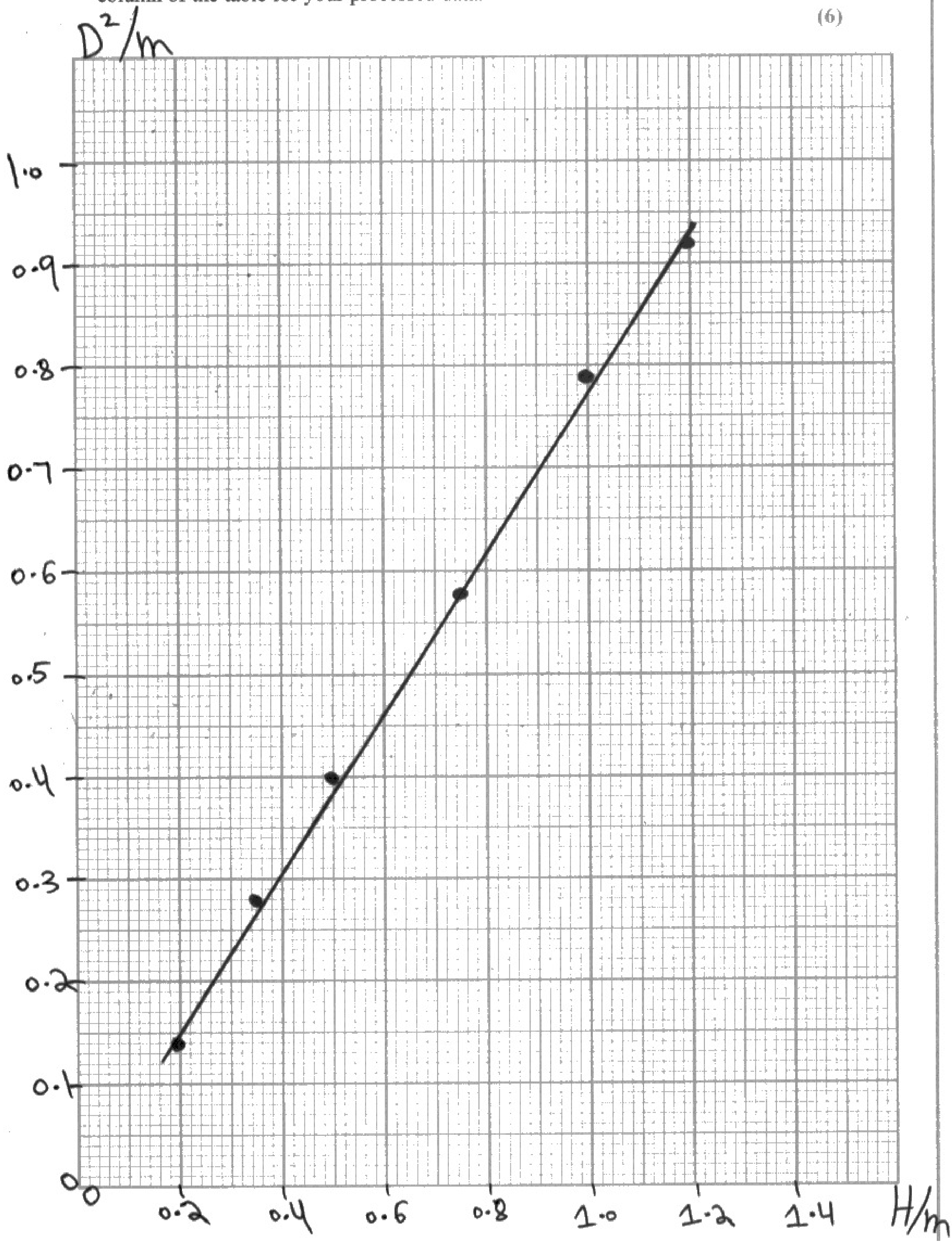
(c) (i) Plot a graph of D^2 on the y-axis against H on the x-axis. Use the additional column of the table for your processed data.

(6)



(ii) The gradient of the graph is equal to $\frac{2v^2}{g}$

Determine the value of v using your graph.

(3)

$D^2 = \frac{2v^2}{g} H$ (1.2, 0.92) H D^2

$0.92 = \frac{2v^2}{g}(1.2)$

$0.92g / 1.2 = 2v^2$

$v^2 = \frac{7.521}{2}$

$v = \sqrt{3.76}$

$v = 1.94$ m/s

$v =$ 1.94 m s^{-1}

(iii) The student used a light gate and data logger to measure v. The measured value was 1.98 m s^{-1}.

Comment on the value of v determined using your graph.

(2)

Light gate and data logger can measure more accurately as compared to graph but this value is also accurate as the percentage uncertainty is less. $\left(\frac{1.98-1.94}{1.94} \times 100 = 2.1\%\right)$

(Total for Question 4 = 16 marks)

ResultsPlus
Examiner Comments

Q4(c)(i)

There are several simple errors here – reducing the mark by 3:

- the candidate has correctly calculated D^2, but not squared the unit. So, even though this candidate has formatted the axis labels correctly (eg used /), that mark is not awarded.
- all the plots are at least 2 mm wide (one small square), as such none of the plots can be checked for accuracy to within 1 mm.

Q4(c)(ii)

- the line of best fit is not shown to pass through the origin. The candidate has ignored the instructions that the gradient is equal to the equation given and to use the graph. The candidate has gone back to the equation presented at the start of Q4(b) and used a pair of values from the table. So, the only mark that can be awarded is for the value being within the acceptable range.

Paper Summary

Based on their performance on this paper, candidates should:

- practice past papers. In this paper, there were questions that would be familiar to candidates who have revised using the earlier series of WPH03 and WPH13 papers, but some performances would suggest those candidates were unfamiliar with the standard practical skills outlined in the specification for Unit 3. Candidates who have not developed their skills during practical work in lessons would therefore be at a disadvantage.
- avoid generic statements. At all ability levels, there were some questions which candidates answered with generic and pre-learned responses, rather than being specific to the particular scenario as described in the question. Question 2(c) would be an example of this, where candidates gave generic causes of error, rather than those likely to occur when measuring an angle using a protractor.
- learn basic definitions and understand their meaning. Standard command words (such as "describe", "determine" and "comment on") proved a challenge to candidates at the lower end of the ability range.

Grade boundaries

Grade boundaries for this, and all other papers, can be found on the website on this link:

https://qualifications.pearson.com/en/support/support-topics/results-certification/grade-boundaries.html

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