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INTERNATIONAL ADVANCED LEVEL

PHYSICS

AS EXEMPLARS WITH COMMENTARIES

Pearson Edexcel International Advanced Subsidiary in Physics (XPH11)
First teaching September 2018
First examination from January 2019
First certification from August 2019

Pearson

Introduction

This booklet has been produced to support physics teachers delivering the new International Advanced Level Physics specification for first teaching in September 2018 and first assessment in January 2019.

This booklet looks at questions from the Sample Assessment Materials. It shows real student responses to these questions, and indicates how the examining team will follow the mark schemes to demonstrate how students would be awarded marks in these questions.

We have selected some responses to 7 questions, with mark schemes, from the sample assessment materials. A range of student responses with accompanying examiner commentaries on how the mark scheme has been applied then follow.

Other teaching and learning materials for this specification are available on the IAL Physics subject page here.

Question 1 - EXAMINER COMMENTARIES

This question requires a description of one of the 16 core practical experiments in the new IAS/IAL specification. Students should have undertaken all of these experiments, so examiners will be expecting them to be able to recall the details of how data was collected, and then used, to determine a value for the Young Modulus. There is more than one graphical method that can be used to determine the Young Modulus, but the majority of candidates opt to plot Stress against Strain (the second alternative on the mark scheme).

Exemplar 1: Question 1

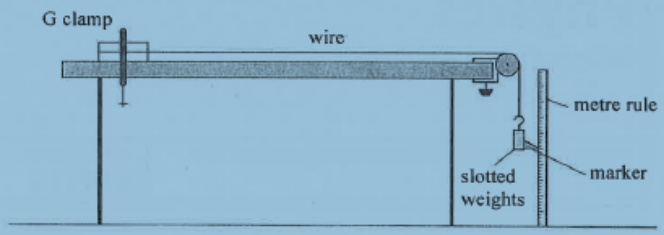
In the first couple of lines, there is reference to the measuring of the diameter using a micrometer screw gauge, so mark 1 is achieved here. Although in this case, the apparatus used to measure the diameter was not required for the mark scheme, it is always good practice to name the piece of apparatus being used for each measurement.

Although the candidate mentions calculating the cross sectional area of the wire, there is no explanation of how this is done, so mark 2 is not achieved.

The fact that this candidate goes on to state that they will plot stress against strain means that they are using the second alternative shown on the mark scheme, and this achieves mark 4. However, they do not achieve mark 3 as they have unfortunately given two different equations for stress, when one of them should be strain.

They have clearly stated that the Young Modulus is the gradient of the linear section of the graph, so score mark 5. As a result, this script scores a total of 3 marks (marks 1,4 and 5).

1 A student carried out an experiment to determine the Young modulus of a material in the form of a wire. The student set up the apparatus as shown.

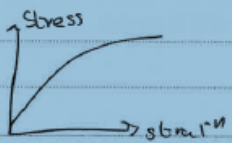


The initial length of the wire was measured. Slotted weights of known values were added to the hanger at the free end of the wire. Each time a weight was added, the new position of the marker was read from the metre rule and the extension calculated.

Describe a graphical method that the student should use to obtain a value for the Young modulus. State the additional measurement that would have to be taken.

(5)

The student should use a micrometer screw guage in order to measure the diameter of the wire at multiple points when different forces are applied. Use this value to calculate the cross-sectional area of the wire. Measure the orisinal length and extension of the wire using a meter ruler. Calculate, stress = force / area, force being the mass multiplied by 'g'. ~~Calculate~~, ~~str~~ calculate, Stress = extension / orisinal length. Plot a graph of stress against strain and the gradient of the linear portion is youngs modulus

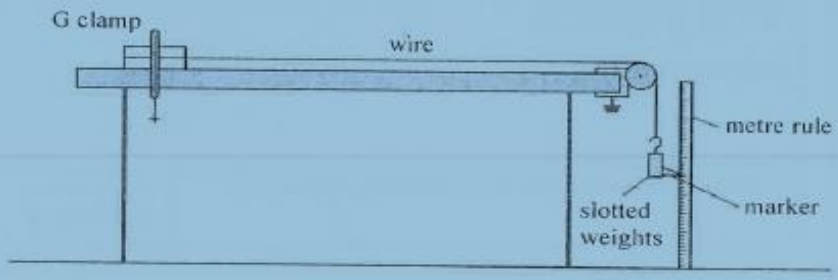


Exemplar 2: Question 1

This candidate is also using the stress-strain method. However, they have failed to recognise that the question requested a description of a graphical method. As such, they fail to score both mark 4 and mark 5 as no graph is suggested.

An instruction to "find the diameter" is not the same as to "measure the diameter" so mark 1 is not awarded. Additionally, if the measurement is a diameter, then there needs to be some link between this and the radius in order to achieve mark 2. This candidate has a diameter reading and then quotes πr^2 to calculate the cross sectional area, so does not score mark 2. If they had said "measure the diameter, divide it by 2 to get the radius r, then calculate cross sectional area using πr2" they would have scored both mark 1 and mark 2.
Mark 3 is the only one awarded to this script for the correct equations (in words), so it scores 1 mark overall.

1 A student carried out an experiment to determine the Young modulus of a material in the form of a wire. The student set up the apparatus as shown.



The initial length of the wire was measured. Slotted weights of known values were added to the hanger at the free end of the wire. Each time a weight was added, the new position of the marker was read from the metre rule and the extension calculated.

Describe a graphical method that the student should use to obtain a value for the Young modulus. State the additional measurement that would have to be taken.

To find young modulus you have to use the equation, young modulus = $\frac{\text{stress}}{\text{strain}}$, but first you have to calculate stress and strain. For stress, first find the cross-sectional area of the wire, first find the diameter using a micrometer screw gauge to find diameter then use πr^2 to find the cross-sectional area. Record the ~~weight~~ force added (weight added) and use equation, stress = $\frac{\text{Force}}{\text{cross-sectional area}}$, to find stress.

For strain, the original length of the wire is already known. For a known mass added, measure the extension using a metre rule. Then use the equation strain = $\frac{\text{extension}}{\text{original length}}$ to find the strain.

Now that you have the values of both stress and strain use the equation young modulus = $\frac{\text{stress}}{\text{strain}}$, to calculate the young modulus of the wire.

Exemplar 3: Question 1

This candidate has used the method which is the first alternative on the mark scheme.

They do not achieve mark 1, as there is no mention of measuring the diameter of the wire.

Mark 2 was awarded, as they have stated that they will plot force against extension (force was accepted as an alternative to applied weight).

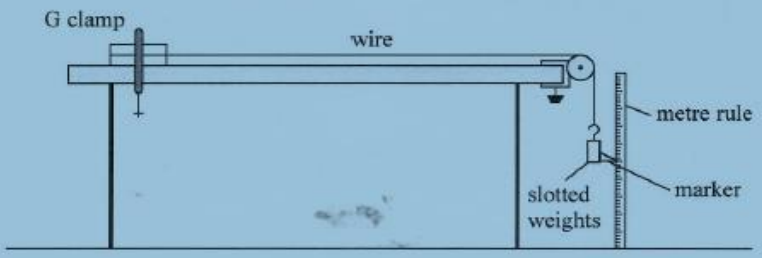
Mark 3 was also awarded, as the candidate clearly showed a graph which only had a linear section, and then stated that the Young Modulus was the gradient. This is a good example of how a sketch graph might assist with an answer.

There is no mention of how the cross sectional area is obtained, so mark 4 is not awarded.

Although the candidate has defined most of the terms in the equation, they have not explained what A is in the final line of their answer. Bear in mind, that the equations for stress and strain are given to students in the examinations, but only in symbol form. If these are to be used to explain an answer, detail needs to be given about what the symbols stand for.

Overall, achieves 2 marks (mark 2 and mark 3 via the first alternative on the mark scheme).

1 A student carried out an experiment to determine the Young modulus of a material in the form of a wire. The student set up the apparatus as shown.



The initial length of the wire was measured. Slotted weights of known values were added to the hanger at the free end of the wire. Each time a weight was added, the new position of the marker was read from the metre rule and the extension calculated.

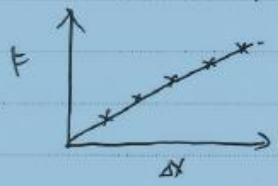
Describe a graphical method that the student should use to obtain a value for the Young modulus. State the additional measurement that would have to be taken.

$E = \frac{\sigma}{\varepsilon} = \frac{FX}{A\Delta X}$

cross section area of wire

plot a graph force against extension

use at least five groups of data



and then calculate the gradient

gradient $= \frac{F}{\Delta X}$

Therefore : E = gradient $\times \frac{X}{A}$

Mark scheme Question 1

Answer		Mark
Either		5
• Additional measurement: diameter of wire	(1)	
• Plot a graph of the applied weight on the y-axis against the extension on the x-axis	(1)	
• Calculate the gradient of linear region	(1)	
• Calculate the cross-sectional area of the wire using $\pi d^2/4$	(1)	
• E = gradient $\times \frac{\text{original lenth}}{\text{cross sectional area}}$	(1)	
Or		
• Additional measurement: diameter of wire	(1)	
• Calculate the cross-sectional area of the wire using $\pi d^2/4$	(1)	
• Calculate the stress for each applied force using force/area **and** the strain using $\frac{\text{extension}}{\text{original lenth}}$	(1)	
• Plot a graph of stress on the y-axis against strain on the x-axis	(1)	
• Gradient of linear region = E	(1)	

Question 2 - EXAMINER COMMENTARIES

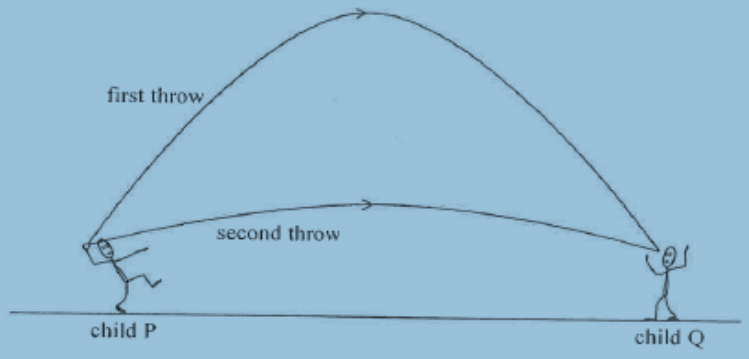
This question requires multiple steps in a calculation in order to achieve the correct answer. This is an example of the higher order mathematical skills expected from the new specification.

Exemplar 1: Question 2

This candidate has set out their working clearly, so that an examiner can see all of the steps in progression. The times for the throws are calculated separately, and then the difference between the two calculated times is expressed as a fully correct answer scoring all 4 marks.

2 Child P throws a ball towards child Q at a speed of 20 m s^{-1} at an angle of 75° to the horizontal.

While this ball is in the air, child P throws a second ball, also at a speed of 20 m s^{-1} at an angle of 15° to the horizontal. Both balls reach child Q at the same time.



Determine how long the child P should wait before throwing the second ball.

P 1st throw

~~20cos75~~ ~~20sin75~~

$s = ut + \frac{1}{2}at^2$

$0 = (20\sin 75)t + \frac{1}{2}(9.81)t^2$

$0 = 19.3t + 4.905t^2$

~~$t = 0$~~ or $t = 3.94$s

2nd throw

$s = ut + \frac{1}{2}at^2$

$0 = (20\sin 15)t + \frac{1}{2}(9.81)t^2$

$0 = 5.18t + 4.905t^2$

$t = 0$ or $t = 1.06$s

time difference = $3.94 - 1.06$

$= 2.88$s

Time between throws = ~~2.88 s~~ 2.88 s

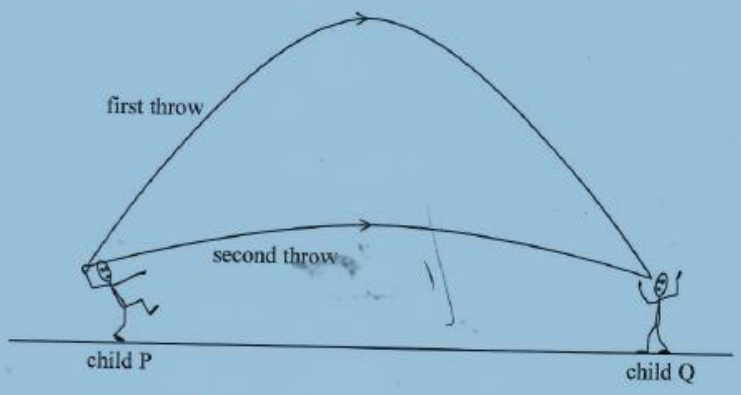
Exemplar 2: Question 2

This candidate has not been as clear with their working as Script 9. They have clearly used the correct equations of motion to achieve the correct times of flight for each ball, but have not clearly demonstrated the use of sin75 or sin15 in their working. We can only assume that they have used the correct angles as they have achieved the two times of 3.94 and 1.06 seconds. If a mistake had been made in the calculations, it would have been difficult to award mark 1, as it is not seen anywhere. The presence of a correct final answer means that marks 1, 2 and 3 are awarded.

However, this candidate has missed the unit off the answer, so cannot score mark 4, which means that they score 3 marks in total. Any candidate failing to apply a correct unit to their answer will fail to achieve the final marking point on calculation questions.

2 Child P throws a ball towards child Q at a speed of 20 m s^{-1} at an angle of 75° to the horizontal.

While this ball is in the air, child P throws a second ball, also at a speed of 20 m s^{-1} at an angle of 15° to the horizontal. Both balls reach child Q at the same time.



Determine how long the child P should wait before throwing the second ball.

~~20 x sin θ~~ $S = ut + \frac{1}{2}at^2$

$0 = 20\sin 75\, t + \frac{1}{2} \times (-9.8) t^2$

$19.32t - 4.9t^2 = 0$

$t = 3.943$

$0 = 5.18t - 4.9t^2$

$t = 1.06$

$t = 2.889$

Time between throws = 2.89

Mark scheme for Question 2

Answer		Mark
• Use of trig to determine the initial vertical velocity **Or** see 20cos 75 **Or** see 20cos15	(1)	4
• Use of equation(s) of motion to determine the time for either the first ball or the second ball	(1)	
• Use of $t_2 - t_1$ using candidate's values for t_1 and t_2	(1)	
• Time difference = 2.9 s	(1)	
Example of calculation If t_1 and t_2 represent the time for the balls to travel from child P to Q		
Equation for first ball		
$0 = (20\ \text{m s}^{-1} \times \sin 75)t_1 + (\frac{1}{2}gt_1^2)$		
$t_1 = 3.94$ s		
Equation for second ball		
$0 = (20\ \text{m s}^{-1} \times \sin 15)t_2 + (\frac{1}{2}gt_2^2)$		
$t_2 = 1.06$ s		
$t_1 - t_2 = 3.94\ \text{s} - 1.06\ \text{s} = 2.88$ s		

Question 3 (a) - EXAMINER COMMENTARIES

Free body force diagrams have been commonly seen on the previous specification, but remain a likely 2 or 3 mark question to appear on WPH11 papers. In this example, there were just 2 forces that needed to be labelled, which would lead to a resultant force acting on the yo-yo.

Exemplar 1: Question 3a

This candidate has drawn both of the forces expected to score the 2 marks, but has added in the components of tension in both the horizontal and vertical planes. This might have been acceptable if both of the components of T drawn had been dotted lines. In this case the Tsinθ is drawn as a solid line, so this candidate scores just 1 mark.

3 A yo-yo is a toy that consists of two connected discs on a piece of string.

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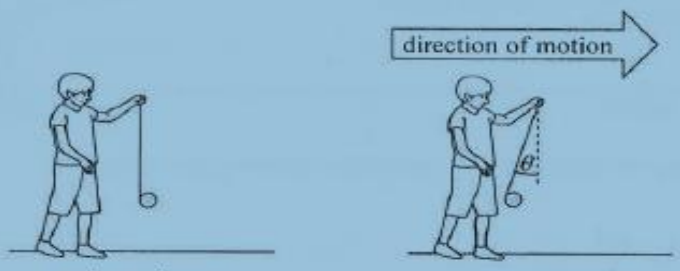
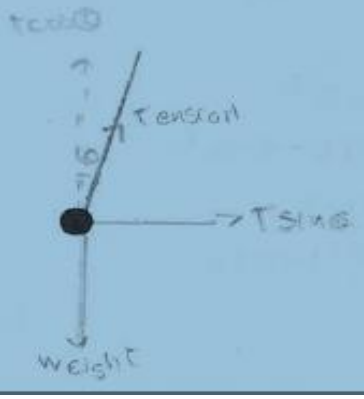
A child stands in a stationary train holding a yo-yo. The train accelerates and the string moves into the position shown, at an angle θ to the vertical.



(a) Draw the free-body force diagram for the yo-yo when the train is accelerating.

(2)



Exemplar 2: Question 3a

Ideally, lines of force would be drawn using a ruler. However, this candidate has scored both marks even though the lines are not completely straight. This is because it is completely clear which directions the weight and tension are acting. There are no additional forces drawn so all is correct.

3 A yo-yo is a toy that consists of two connected discs on a piece of string.

© homydesign/Shutterstock

A child stands in a stationary train holding a yo-yo. The train accelerates and the string moves into the position shown, at an angle θ to the vertical.

(a) Draw the free-body force diagram for the yo-yo when the train is accelerating.

Question 3 (b) - EXAMINER COMMENTARIES

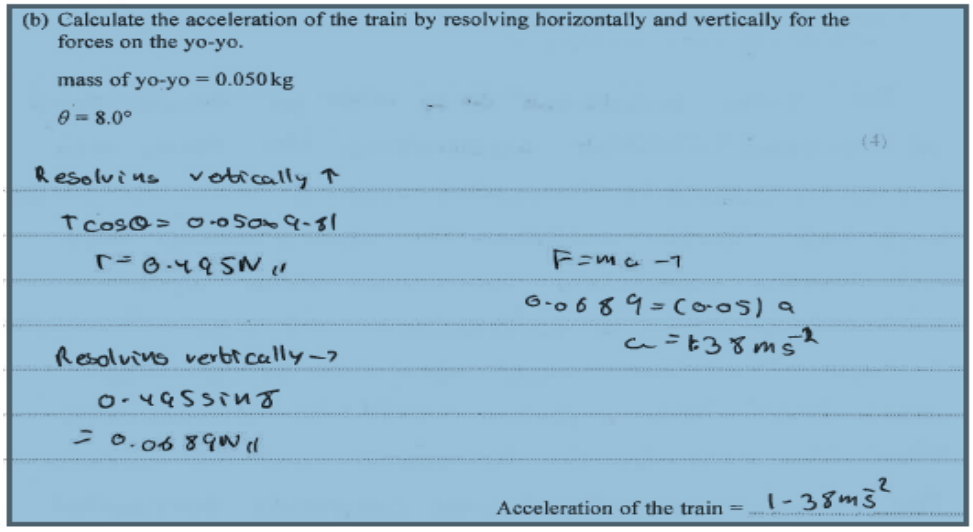
The traditional approach to this type of question would involve candidates resolving for the vertical and horizontal components of tension algebraically, as outlined in the first three marking points. However, there are many methods to achieving the same goal.

Exemplar 3: Question 3B

The first marking point is clear, having substituted the given values for m and g.
This response has split the second marking point into two stages. This was commonly seen. The candidate resolved horizontally (although this is labelled as "resolving vertically →") to calculate the horizontal resultant force, then performed a second calculation using F = ma.

The third marking point, for combining equations, was seen in the calculation of tension T from resolving vertically, which was then substituted into their horizontal force calculation.

A correct evaluation and unit, resulting in a mark of 4.


(b) Calculate the acceleration of the train by resolving horizontally and vertically for the forces on the yo-yo.

mass of yo-yo = 0.050 kg

$\theta = 8.0°$

(4)

Resolving vertically ↑

$T\cos\theta = 0.050 \times 9.81$

$T = 0.495\,N$ //

$F = ma$ –1

$0.0689 = (0.05)\,a$

$a = 1.38\,ms^{-2}$

Resolving vertically →

$0.495\sin\theta$

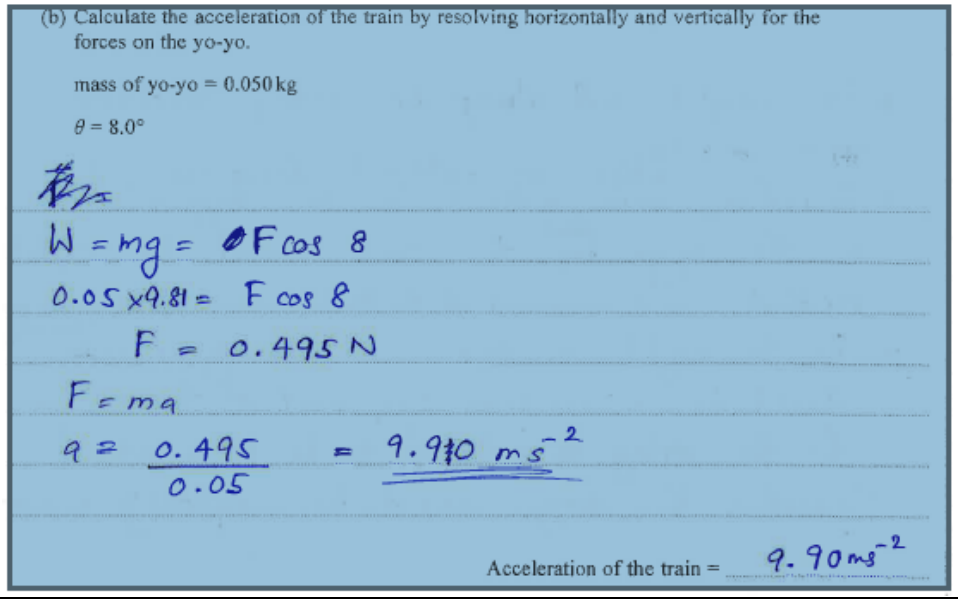
$= 0.0689\,N$ //

Acceleration of the train = $1.38\,ms^{-2}$

Exemplar 4: Question 3B

This candidate has a correct calculation for forces resolved vertically. However, there is a clear misunderstanding. The force calculated is the tension, however this student has misinterpreted this as the force causing the acceleration.

As such, the second and third marking points do not apply, so this response scored only the first marking point for a score of 1 mark.


(b) Calculate the acceleration of the train by resolving horizontally and vertically for the forces on the yo-yo.

mass of yo-yo = 0.050 kg

$\theta = 8.0°$

$W = mg = F\cos 8$

$0.05 \times 9.81 = F\cos 8$

$F = 0.495\,N$

$F = ma$

$a = \frac{0.495}{0.05} = 9.90\,ms^{-2}$

Acceleration of the train = $9.90\,ms^{-2}$

Question 3 (c) - EXAMINER COMMENTARIES
The extended open response questions have indicative content points that are generally hierarchical in building an argument. In this case, a candidate following the instructions given would attempt two arguments covering the directions stated. As such, the first three indicative content points build up the argument that the yo-yo string could never be completely vertical. Similarly, the final three indicative content points build up the argument that the yo-yo string could never be completely horizontal.

Candidates are awarded a up to four marks as determined by number of indicative content points they have included in their answer. The awarding of marks for indicative content points is consistent between this style of extended open response question.

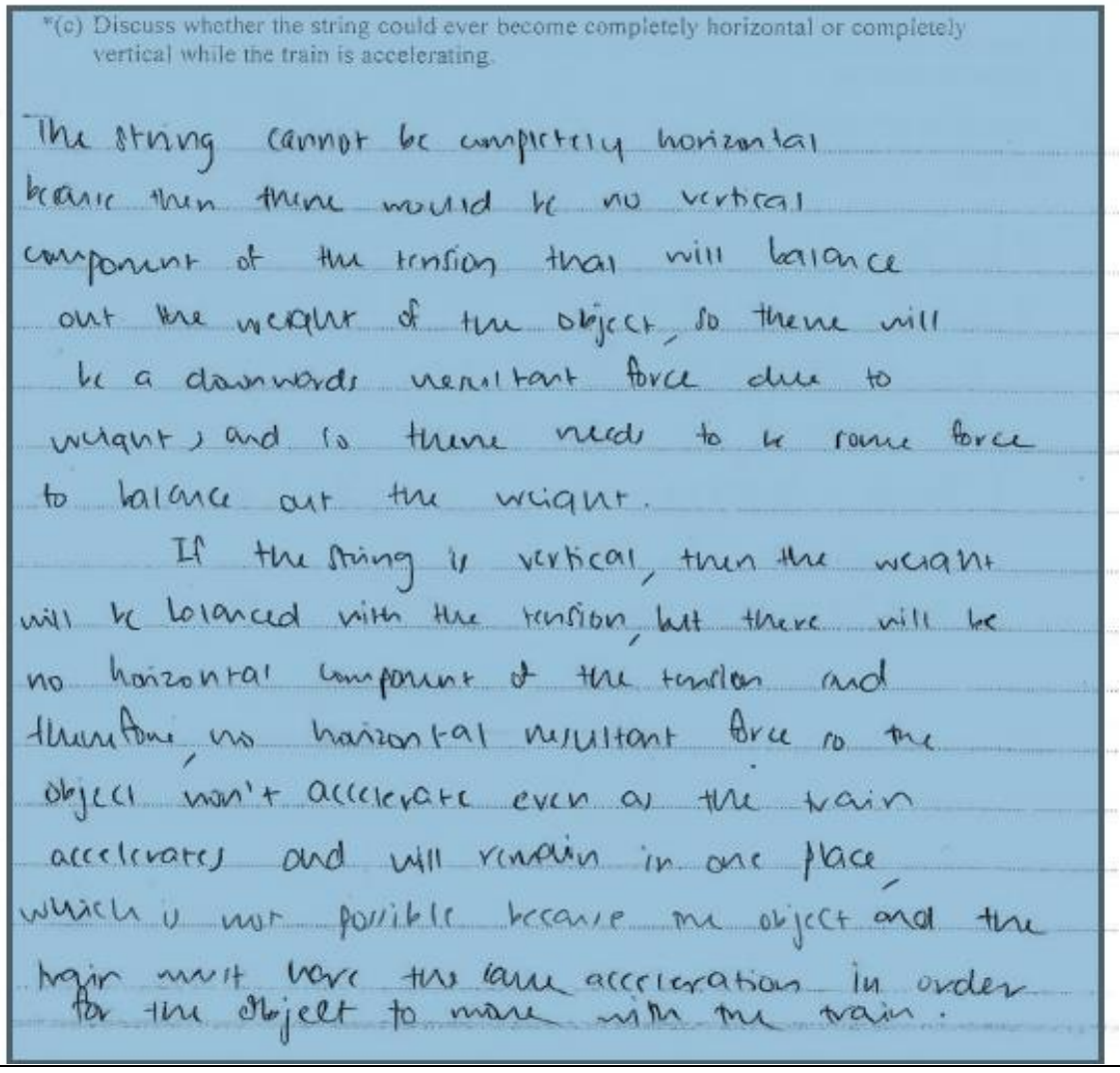
The manner in which the two marks for structure are awarded will vary by question. In this case, with two arguments to be made, the marks for structure and line of reasoning were awarded as one mark for each direction.

Exemplar 5: Question 3c

The first paragraph discusses the vertical forces, by reverse argument. The first four lines covers the final three indicative content points. The misuse of the word resultant in line 5 is countered by their explanation that this force needs to be "balanced out" by the vertical component of tension from the string.

The second paragraph also attempts a reverse argument, but clearly links this to the fact the object (yo-yo) must accelerate to move along with the train. This covers the first three indicative content points.

Having scored four marks for covering all six indicative content points, this candidate also showed clear lines of reason for both directions, scoring a further two marks, giving a total mark of 6.



*(c) Discuss whether the string could ever become completely horizontal or completely vertical while the train is accelerating.

The string cannot be completely horizontal because then there would be no vertical component of the tension that will balance out the weight of the object, so there will be a downwards resultant force due to weight, and so there needs to be some force to balance out the weight.

If the string is vertical, then the weight will be balanced with the tension, but there will be no horizontal component of the tension and therefore, no horizontal resultant force so the object won't accelerate even as the train accelerates and will remain in one place, which is not possible because the object and the train must have the same acceleration in order for the object to move with the train.

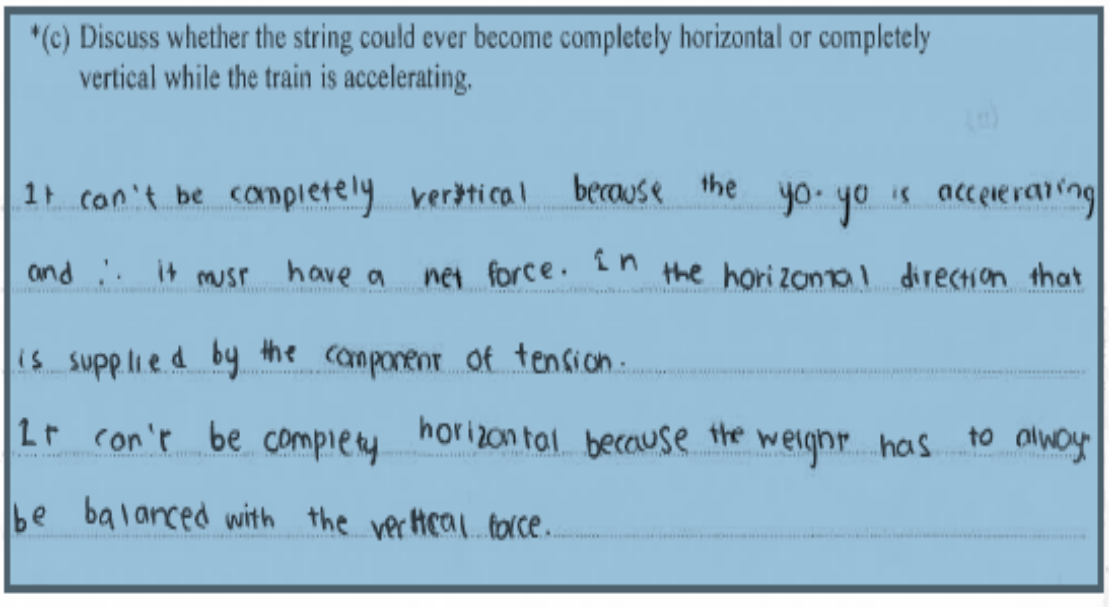
Exemplar 6: Question 3C

This candidate does write a brief, but convincing argument for both directions. However, by missing out key information it does not cover all six indicative content points.

The first three lines covers the first and third indicative content points. Ignoring the full stop in the line "It must have a net force. In the horizontal direction…" means at first glance that the second indicative content point could also be awarded. However, lack of clarity caused by the full stop and the lack of detail as to which component of tension, means that this higher-level idea was not communicated clearly enough.

The final two lines are very basic but do cover the ideas of the fourth and sixth indicative content points.

Having scored three marks for covering four of the six indicative content points, this candidate also showed clear lines of reason for their discussion of the horizontal forces, scoring a further one mark for structure and lines of reasoning, giving a total mark of 4.

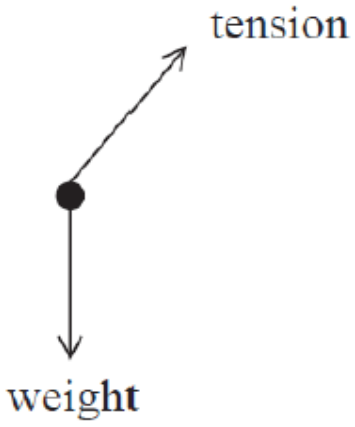


*(c) Discuss whether the string could ever become completely horizontal or completely vertical while the train is accelerating.

It can't be completely vertical because the yo-yo is accelerating and ∴ it must have a net force. In the horizontal direction that is supplied by the component of tension.

It can't be completely horizontal because the weight has to always be balanced with the vertical force.

Mark scheme for Question 3

Answer		Mark
• Weight/*W*/*mg* labelled • Tension/*T*  	(1) (1)	2
• $T\cos\theta = mg$ • $T\sin\theta = ma$ • Combining the two equations eg $\tan\theta = a/g$ • $a = 1.4\ \text{m s}^{-2}$ Example of calculation Resultant force in vertical direction $T\cos 8° = (0.050\ \text{kg} \times 9.81\ \text{N kg}^{-1})$ Resultant force in horizontal direction $T\sin 8° = (0.050\ \text{kg})a$ $\tan 8° = \frac{0.050\ \text{kg} \times a}{0.050\ \text{kg} \times 9.81\ \text{N kg}^{-1}}$ $a = 1.38\ \text{m s}^{-2}$	(1) (1) (1) (1)	4

Answer	Mark
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content. **Number of indicative marking points seen in answer / Number of marks awarded for indicative marking points** 6 / 4 54 / 3 3–2 / 2 1 / 1 0 / 0 The following table shows how the marks should be awarded for structure and lines of reasoning. **Number of marks awarded for structure of answer and sustained line of reasoning** Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout / 2 Answer is partially structured with some linkages and lines of reasoning / 1 Answer has no linkages between points and is unstructured / 0	6

Answer	Mark
Indicative content • For the yo-yo to accelerate with the train there must be a horizontal force acting on it • A horizontal force on the yo-yo is provided by the horizontal component of the tension in the string • The string could never be completely vertical because there must be a horizontal force • The yo-yo has a weight so there always has to be a vertical force acting on it • The tension in the string provides the vertical component of force • The string could never be completely horizontal because there must be a vertical force Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points, which is partially structured with some linkages and lines of reasoning, scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).	

Question 4 - EXAMINER COMMENTARIES

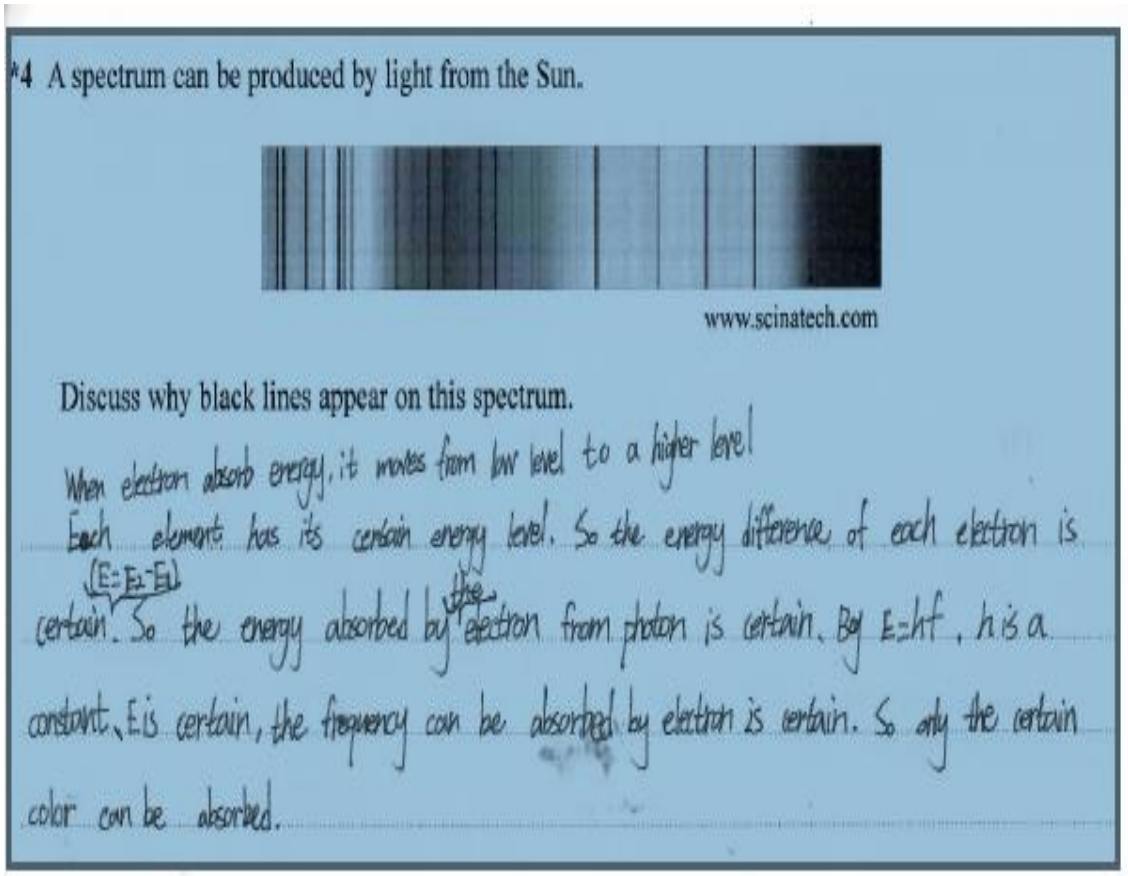
This is another extended open response question with hierarchical indicative content points that build up the answer. Unfortunately, in the sample scripts there were no examples of candidates who scored enough of the indicative content points to enable them to achieve two marks for structure and lines of reasoning.

Exemplar 1: Question 4

This candidate scores the third indicative content point in the very top line by talking about electrons moving from low level to a higher level. In the next line they state that there are only certain energy level(s) available, so they also achieve the fourth indicative content point. The third line scores the second indicative content point by stating that the electrons absorb the energy from photons (there is no need to see any mention of sunlight for this indicative marking point).

Overall, this script has indicative content points 2, 3 and 4. This scores 2 marks for indicative content. As these points are well linked, there is also 1 mark for structure and lines of reasoning. However, if only three indicative content marks are seen, it would not be possible to award a second mark for structure and lines of reasoning.

With 2 marks for indicative content and 1 mark for structure and lines of reasoning, the total score for this question is 3 marks.



Mark scheme for Question 4

Answer	Mark
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for indicative content.	6

Number of indicative marking points seen in answer	Number of marks awarded for indicative marking points
6	4
5–4	3
3–2	2
1	1
0	0

The following table shows how the marks should be awarded for structure and lines of reasoning.

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

Indicative content

- (the atoms) of gases in the atmosphere contain electrons
- electrons absorb photons from the sunlight
- electron moves to higher energy level
- the energy levels (of electrons) are discrete
  Or only certain energy levels are possible

- The energy of the photon must be equal to the difference in energy levels
  Or $hf = E2 - E1$

- There are only a limited number of energy differences and only a corresponding number of black lines

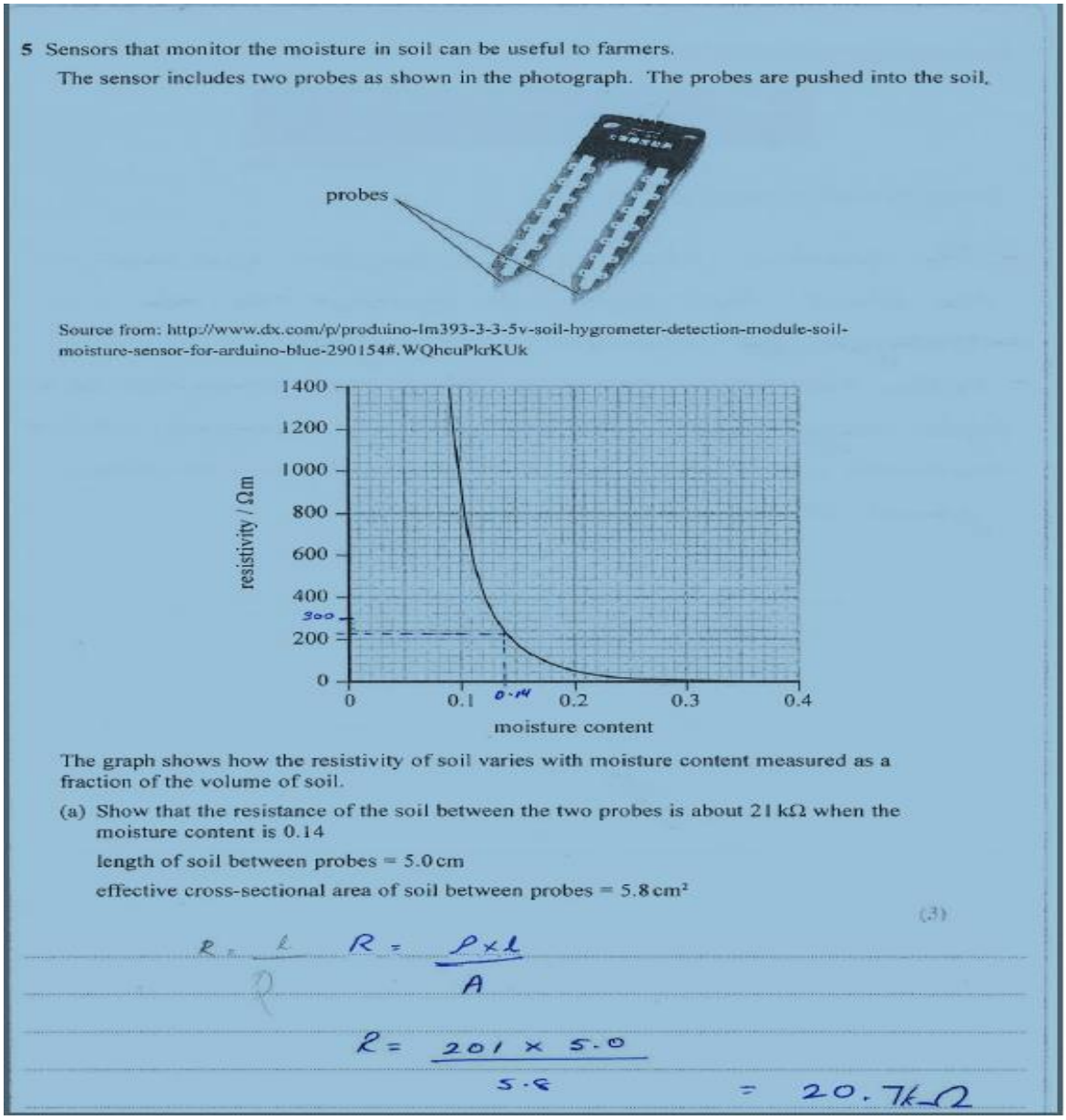
Question 5 (a) - EXAMINER COMMENTARIES

This question required candidates to read a value from a graph and then substitute it into a formula with given values in order to calculate a resistance value.

Before assessing the scripts for this part of the paper, it is worth noting that there are a couple of errors on the sample mark scheme for this question. Firstly, for marking point 1, the unit for the value read from the graph for resistivity should be Ωm rather than Wm (this is also incorrect in the example of calculation). In addition, the 3rd marking point should read "R = 20.7 (kΩ)". This is because a "show that" question should have an answer that is at least one more significant figure than the value given in the question, and does not require units (as they are added to the "show that" value in the question).

Exemplar 1: Question 5a

This candidate has misread the resistivity from the graph as being 201 Ωm instead of 240 Ωm so does not score the first marking point. They have used the resistivity equation correctly (remember, that "use of" on mark schemes implies that dimensionally correct numbers have been inserted for all terms) so score mark 2. The answer they have is correct, but as their working does not match this answer, they cannot be awarded mark 3. Candidates will know that the answer should be approximately 21 kΩ so an answer that does not match their calculation cannot be accepted.



5 Sensors that monitor the moisture in soil can be useful to farmers.

The sensor includes two probes as shown in the photograph. The probes are pushed into the soil.

Source from: http://www.dx.com/p/produino-lm393-3-3-5v-soil-hygrometer-detection-module-soil-moisture-sensor-for-arduino-blue-290154#.WQheuPkrKUk

The graph shows how the resistivity of soil varies with moisture content measured as a fraction of the volume of soil.

(a) Show that the resistance of the soil between the two probes is about 21 kΩ when the moisture content is 0.14

length of soil between probes = 5.0 cm

effective cross-sectional area of soil between probes = 5.8 cm²

(3)

$R = \frac{\rho}{A}$ $R = \frac{\rho \times l}{A}$

$R = \frac{201 \times 5.0}{5.8} = 20.7\text{k}\Omega$

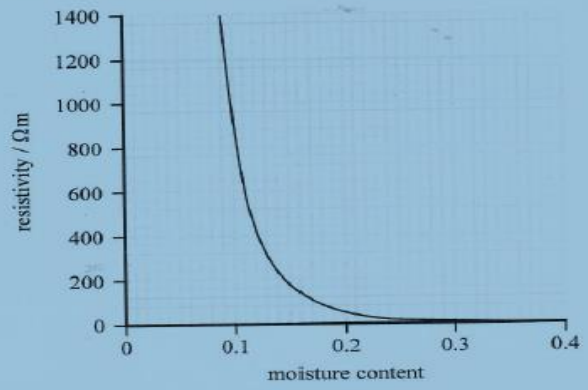
Exemplar 2: Question 5a

The working for this answer is all correct, as all of the numbers from the question and the graph have been correctly substituted. However, the answer is expressed as 20.6 kΩ so is not correct to at least one more significant figure than the value given in the question. The candidate has possibly rounded 20689 down rather than up. As a result, this candidate only scores marks 1 and 2.

5 Sensors that monitor the moisture in soil can be useful to farmers.

The sensor includes two probes as shown in the photograph. The probes are pushed into the soil.

Source from: http://www.dx.com/p/produino-lm393-3-3-5v-soil-hygrometer-detection-module-soil-moisture-sensor-for-arduino-blue-290154#.WQhcuPkrKUk



The graph shows how the resistivity of soil varies with moisture content measured as a fraction of the volume of soil.

(a) Show that the resistance of the soil between the two probes is about 21 kΩ when the moisture content is 0.14

length of soil between probes = 5.0 cm

effective cross-sectional area of soil between probes = 5.8 cm²

$R = \frac{\rho l}{A} = \frac{250 \times 5 \times 10^{-2}}{5.8 \times 10^{-4}} = 20.6 k\Omega$ (3 s.f.)

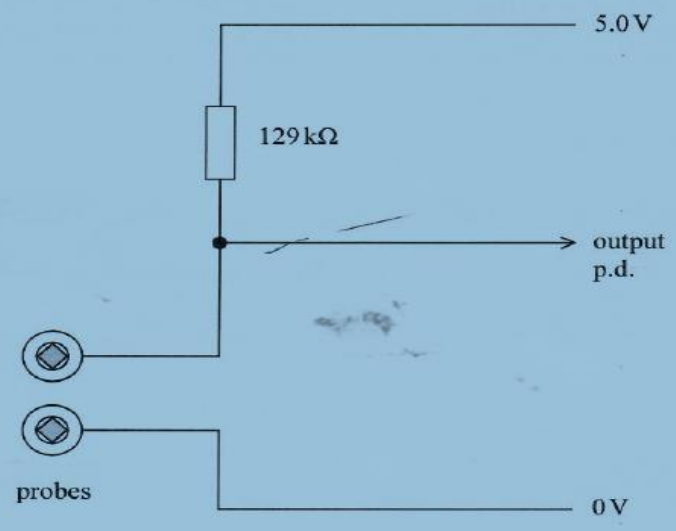
Question 5 (b) (i) - EXAMINER COMMENTARIES

This is a potential divider question which could be approached in a number of differing ways, although all of them required some use of $I = V/R$. Many of the calculations seen were completed in a combined equation rather than establishing the current first and then multiplying it by the resistance across the probes.

Exemplar 3: Question 5bi

A typical calculation, combining all of the working into one equation. Although similar to the example of calculation, the numbers on the top of the calculation are rearranged slightly but still lead to the same correct answer of 0.7 V for both marks.

(b) The sensor consists of a circuit that includes the probes and provides an output potential difference (p.d.) as shown. The output p.d. can be used to switch on a water supply.



(i) Calculate the output p.d. when the resistance of the soil between the probes is 21 kΩ

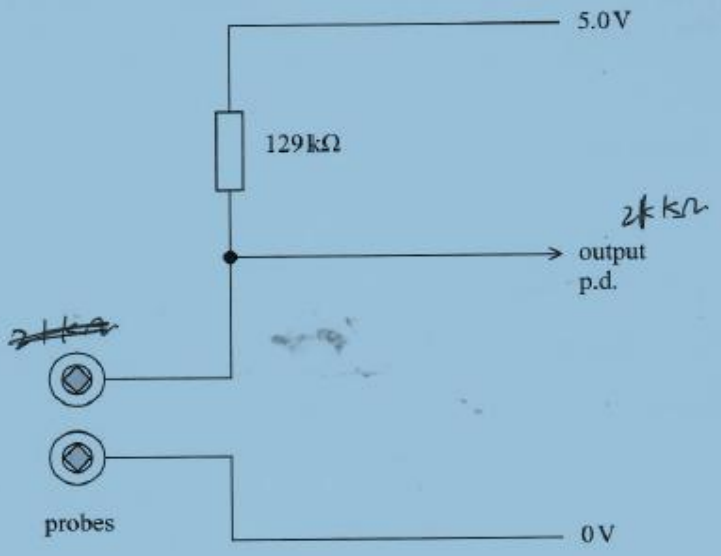
$V = \frac{5}{129 + 21} \times 21 = 0.70\text{V}$

Output p.d. = 0.70V

Exemplar 4: Question 5bi

This is a common response, where the candidate has assumed that the whole of the 5.0 V shown in the diagram is across the 129 kΩ resistor. Their calculation of 5/129 is a calculation to find current using $I = V/R$ so it scores mark 1. However, the answer is incorrect, so mark 2 is not awarded.

(b) The sensor consists of a circuit that includes the probes and provides an output potential difference (p.d.) as shown. The output p.d. can be used to switch on a water supply.



(i) Calculate the output p.d. when the resistance of the soil between the probes is 21 kΩ

$\frac{5}{129} = \frac{x}{21}$

$x = \frac{35}{43} V = 0.814 V$ (2.5 dp)

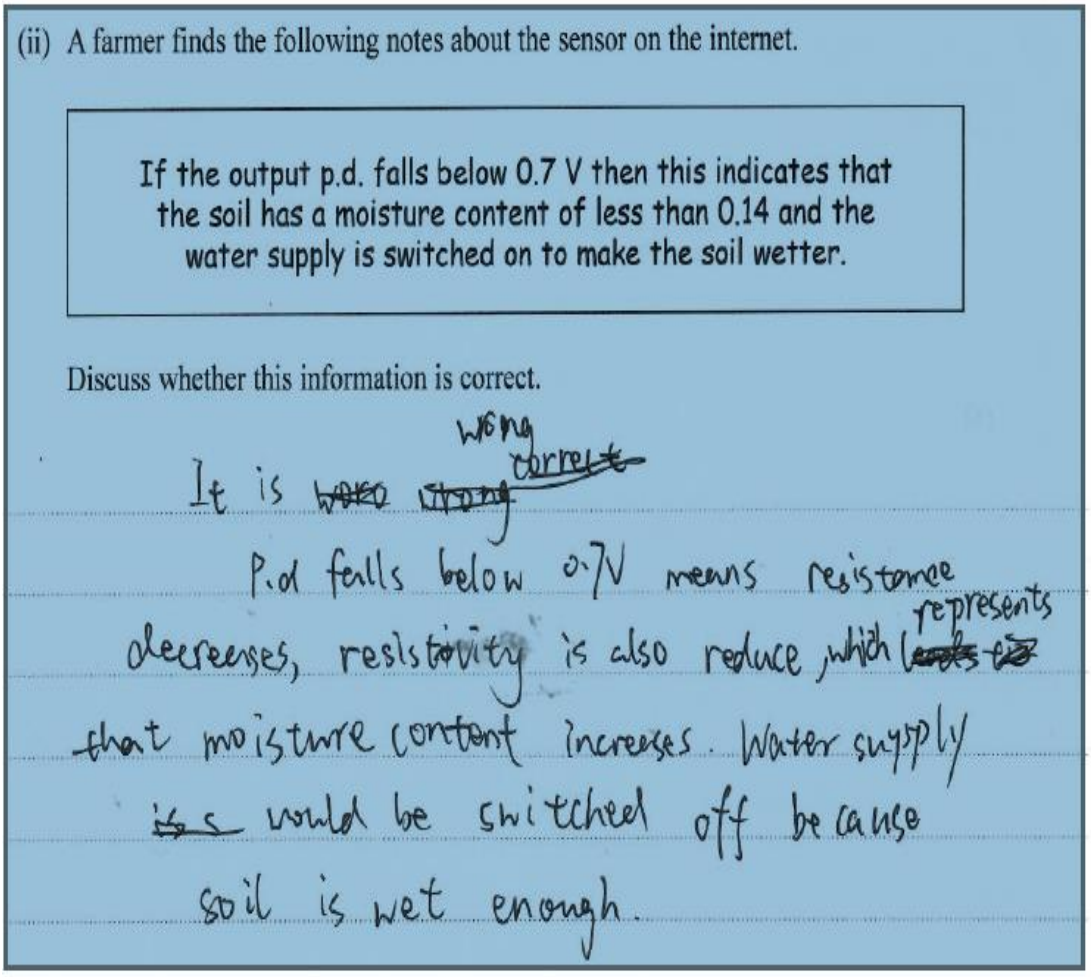
Output p.d. = 0.814 V

Question 5 (b) (ii) - EXAMINER COMMENTARIES

For the new IAS/IAL specification, more of the questions will involve assessing whether given information is correct or not. This is an example of such a question, where the final conclusion has to be backed up with evidence. Candidates are given a section of notes on how the output p.d. varies when the moisture content changes. In reality, the information given is incorrect, but students have to explain using appropriate Physics, why this is so.

Exemplar 5: Question 5bii

In this answer, the candidate has used a reverse argument to explain why the information is incorrect. At the start, there is a statement about the information being incorrect (It is wrong). The argument then follows that if the p.d. falls below 0.7V, that the resistivity would have decreased, meaning that the moisture would be higher (than 0.14), rather than lower. They have then followed this by stating the conditions under which the water supply would be switched off. As such, this script scores all 4 marks.



(ii) A farmer finds the following notes about the sensor on the internet.

> If the output p.d. falls below 0.7 V then this indicates that the soil has a moisture content of less than 0.14 and the water supply is switched on to make the soil wetter.

Discuss whether this information is correct.

It is ~~wrong~~ ~~strong~~ wrong ~~correct~~

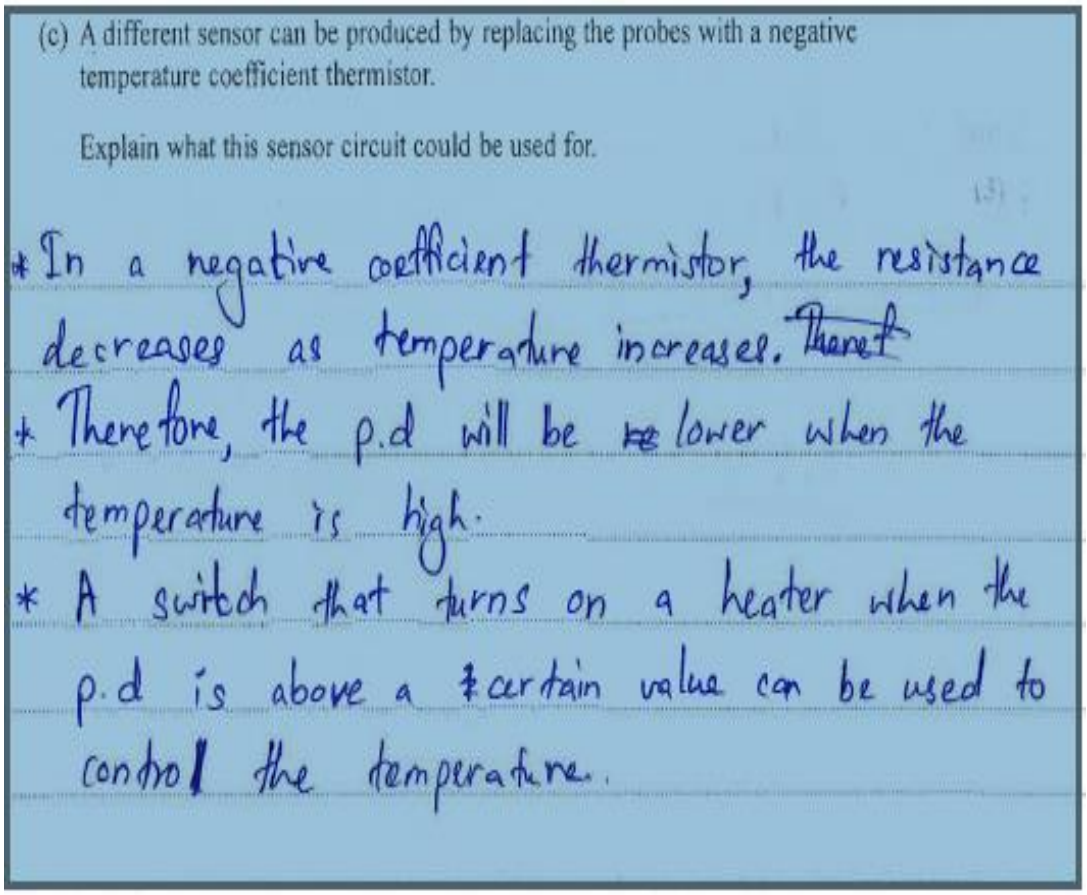
P.d falls below 0.7V means resistance decreases, resistivity is also reduce, which ~~looks~~ represents that moisture content increases. Water supply ~~is s~~ would be switched off because soil is wet enough.

Question 5 (c) - EXAMINER COMMENTARIES

This question introduces a thermistor with a negative temperature coefficient. As a result, it is important for candidates to explain how such a component behaves. Although this is clearly related to temperature changes, some of the candidates in the sample confused this with the previous part of the question, and attempted to describe a situation where hotter temperatures would be rectified by turning on a cold water supply. Unfortunately, as this question was no longer related to the moisture levels in the previous part, this was not suitable for accessing mark 3.

For all marking points, a converse argument was allowed in terms of what would happen if the temperature became too low.

Exemplar 6: Question 5c
This candidate has a clearly laid out and fully correct answer. In the first two lines they clearly state what happens to a ntc thermistor when the temperature increases (scoring mark 1). This is then linked to the fact that the output p.d. would be lower as a result (scoring mark 2). Finally, the candidate describes how a heater could be switched on if the temperature became too low. Although this is the converse argument, it links well with the description so scores mark 3, giving a total of 3 marks for this response.


(c) A different sensor can be produced by replacing the probes with a negative temperature coefficient thermistor.

Explain what this sensor circuit could be used for.

(3)

* In a negative coefficient thermistor, the resistance decreases as temperature increases. ~~There~~ f
* Therefore, the p.d will be ~~be~~ lower when the temperature is high.
* A switch that turns on a heater when the p.d is above a certain value can be used to control the temperature.

Mark scheme for Question 5

Answer		Mark
• Uses graph to find $\rho = 240$ Wm • Use of $R = \frac{\rho l}{A}$ • $R = 21$ kΩ Example of calculation: $R = \frac{240\text{Wm} \times 5.0 \times 10^{-2}\text{m}}{5.8 \times 10^{-4}\text{m}^2} = 20.7\,\text{k}\Omega$	(1) (1) (1)	3
• Use of $I = V/R$ • Output p.d. = 0.70 V Example of calculation: $V = \frac{21}{21+129} \times 5 = 0.70\,\text{V}$	(1) (1)	2
Either • As soil dries resistivity of soil increases • As soil dries R_{probe} increases (above 21k) • So as soil dries the p.d. becomes greater than 0.7 V • Incorrect information as this system will switch off water as soil gets drier **Or** • As soil gets wetter resistivity decreases • As soil has moisture more than 0.14 R_{probe} decreases (below 21 k) • As it gets wetter p.d. decreases below 0.7 V • Incorrect information as this system will switch on water as soil gets wetter	(1) (1) (1) (1) (1) (1) (1) (1)	4
• Negative coefficient: resistance decreases as temperature increases • Resistance decreases means output p.d. decreases • So sensor could switch on coolers **Or** open windows **Or** turn off heaters when temperature above a certain value	(1) (1) (1)	3

Question 6 (a) - EXAMINER COMMENTARIES

Every candidate completing the exemplar question paper made the same fundamental mistake.

All took the full resolution (0.1 mm) of a Vernier caliper to be the uncertainty. All then correctly worked out the percentage of that uncertainty (0.4%), though this was not a marking point. As such all scored 0 marks.

Unit 3: Section 3.3 and 3.5 of the IAL Physics specification state the following.

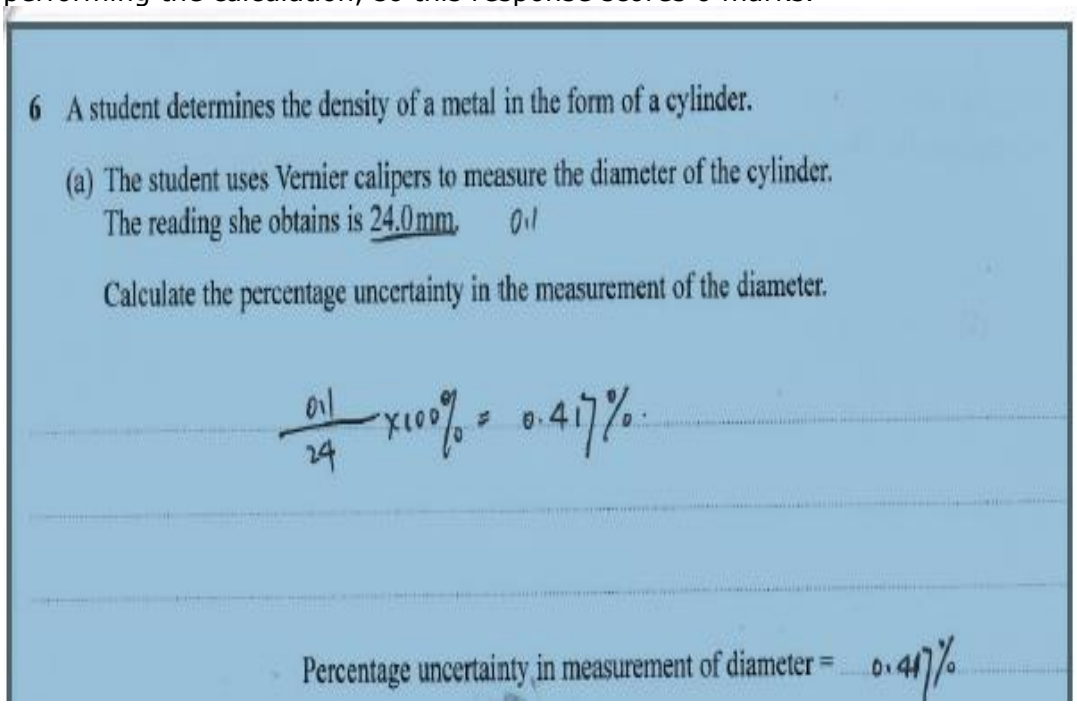
"the range and resolution of measuring instruments including Vernier calipers (0.1 mm) and micrometer screw gauge (0.01 mm)"

"determine the percentage uncertainty in measurements for a single reading using **half** the resolution of the instrument **and** from multiple readings using the **half** range"

As such, the correct uncertainty to use is half the resolution, 0.05 mm, or 0.2%

Exemplar 1: Question 6a

The questions stated the student is using Vernier calipers to take a single reading. This candidate has correctly identified 0.1mm as the resolution of Vernier calipers. However, this was not a marking point. The percentage calculation does not use an uncertainty of half the resolution, so the percentage uncertainty calculated is double the expected value. There is no mark for performing the calculation, so this response scores 0 marks.



6 A student determines the density of a metal in the form of a cylinder.

(a) The student uses Vernier calipers to measure the diameter of the cylinder.
The reading she obtains is 24.0 mm. 0.1

Calculate the percentage uncertainty in the measurement of the diameter.

$\frac{0.1}{24} \times 100\% = 0.417\%$

Percentage uncertainty in measurement of diameter = 0.417%

Question 6 (b) (i) and (ii) - EXAMINER COMMENTARIES

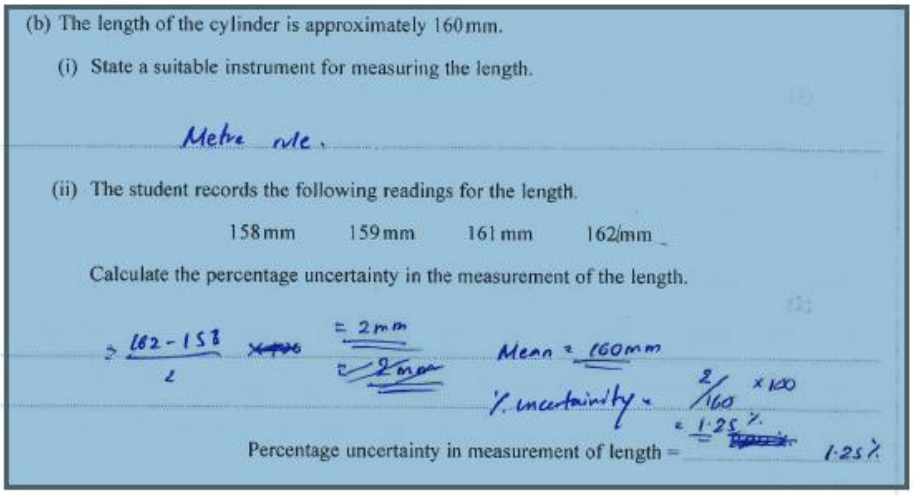
Part (i) simply asks for students to state a measuring instrument for measuring ***the*** length. Most candidates scored this mark. The others did give an instrument that would measure length, but not in enough detail to demonstrate it was suitable for measuring a length of 160 mm. For example, stating "ruler" would not be enough, as a typical 15 cm ruler could not measure this length.

Part (ii) requires candidates to use the guidance given in Unit 3: 3.5 of the IAL Physics specification "determine the percentage uncertainty in measurements… from multiple readings using the **half** range"

Exemplar 2: Question 6bi, ii

Part (i) This response has a clearly suitable instrument for 1 mark.

Part (ii) A clear calculation of half the range on the left, followed by a correct calculation of percentage uncertainty. The answer is given to 3 significant figures, which matches the original readings, though the uncertainty (2 mm) would be 1 s.f. The mark scheme does not specify the number of s.f. for this, so 2 marks are awarded.


(b) The length of the cylinder is approximately 160 mm.

(i) State a suitable instrument for measuring the length.

Metre rule.

(ii) The student records the following readings for the length.

158 mm 159 mm 161 mm 162 mm

Calculate the percentage uncertainty in the measurement of the length.

$= \frac{162 - 158}{2}$ ~~× 100~~ $= 2$ mm $= 2$ mm

Mean = 160 mm

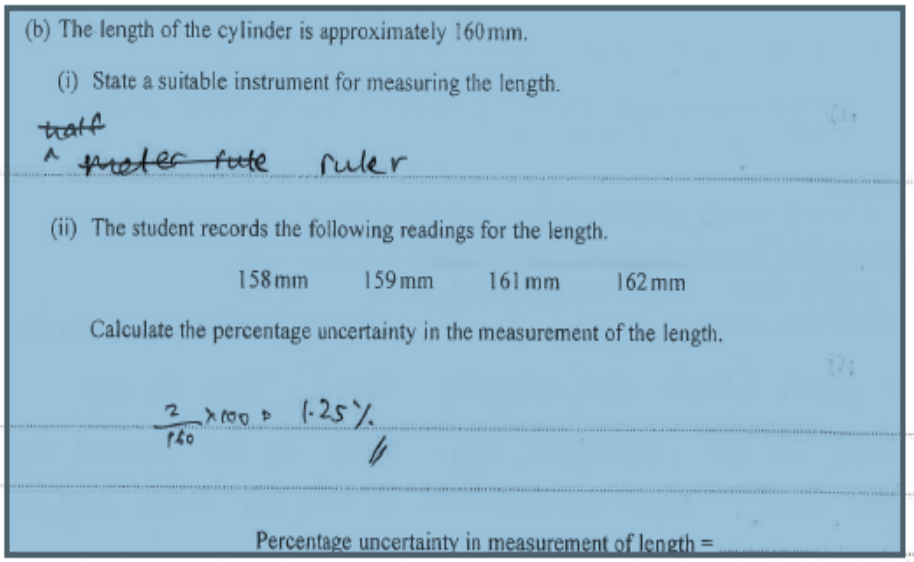
% uncertainty = $\frac{2}{160} \times 100$ = 1.25 %

Percentage uncertainty in measurement of length = 1.25 %

Exemplar 3: Question 6bi, ii

Part (i) This candidate fell afoul of the rule regarding crossed out work. Had the new word "ruler" not been written, the original answer would have scored the mark. However, ruler alone was not detailed enough to demonstrate a suitable instrument for measuring the specific length of 160 mm.

Part (ii) This response does not show the step for marking point one, but the value for half the range is seen (2 mm). This would be enough to be awarded marking point one, which is not relevant in this case as the correct answer scored both marks.


(b) The length of the cylinder is approximately 160 mm.

(i) State a suitable instrument for measuring the length.

~~half~~ ~~meter rule~~ ruler

(ii) The student records the following readings for the length.

158 mm 159 mm 161 mm 162 mm

Calculate the percentage uncertainty in the measurement of the length.

$\frac{2}{160} \times 100 = 1.25\%$

Percentage uncertainty in measurement of length =

Mark scheme for Question 6

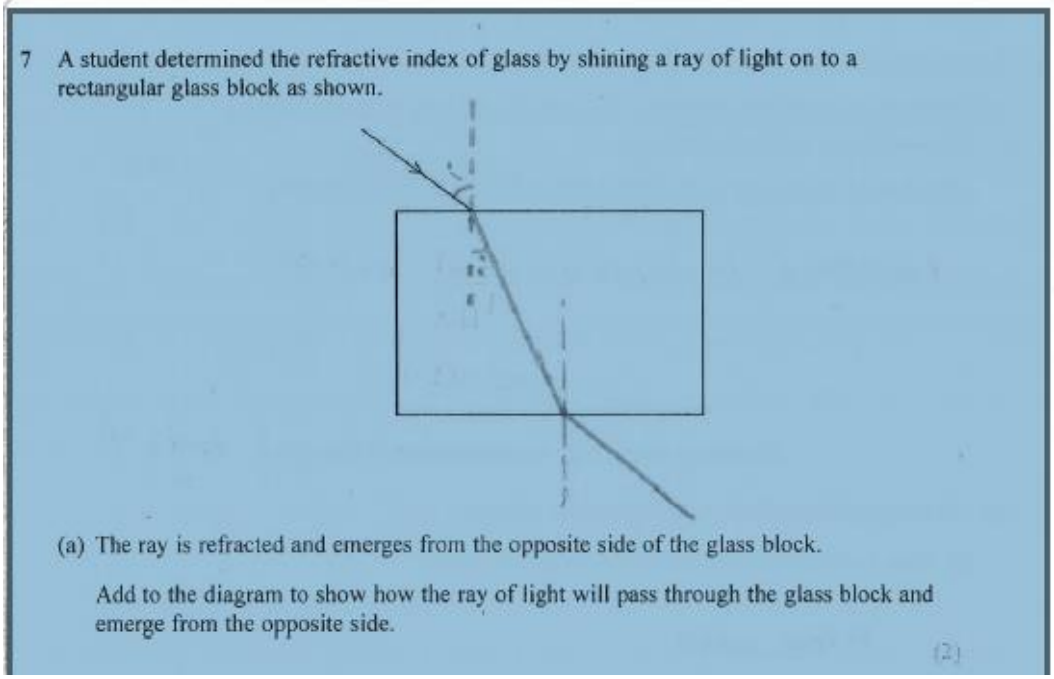
Answer		Mark
• Use of half resolution (0.05 mm) • Percentage uncertainty = 0.2% (Accept 0.21%) Example of calculation Uncertainty = (0.05/24) × 100 = 0.208 %	(1) (1)	2
Metre rule	(1)	1
• Use of half range (2 mm) • Percentage uncertainty = 1% (Accept 1.3%) Example of calculation Uncertainty = (2/160) × 100 = 1.25 %	(1) (1)	2

Question 7a - EXAMINER COMMENTARIES

This question asks candidates to draw the path of a ray undergoing refraction through a rectangular glass block. This is a common practical carried out at A-level and in earlier science courses. Here students were expected to recall the changes in direction of the ray and that the parallel sides of the block resulted in the emergent ray being parallel to the incident ray. The addition of normals is welcome, but in this case they are not a marking point. Most responses scored 2 marks.

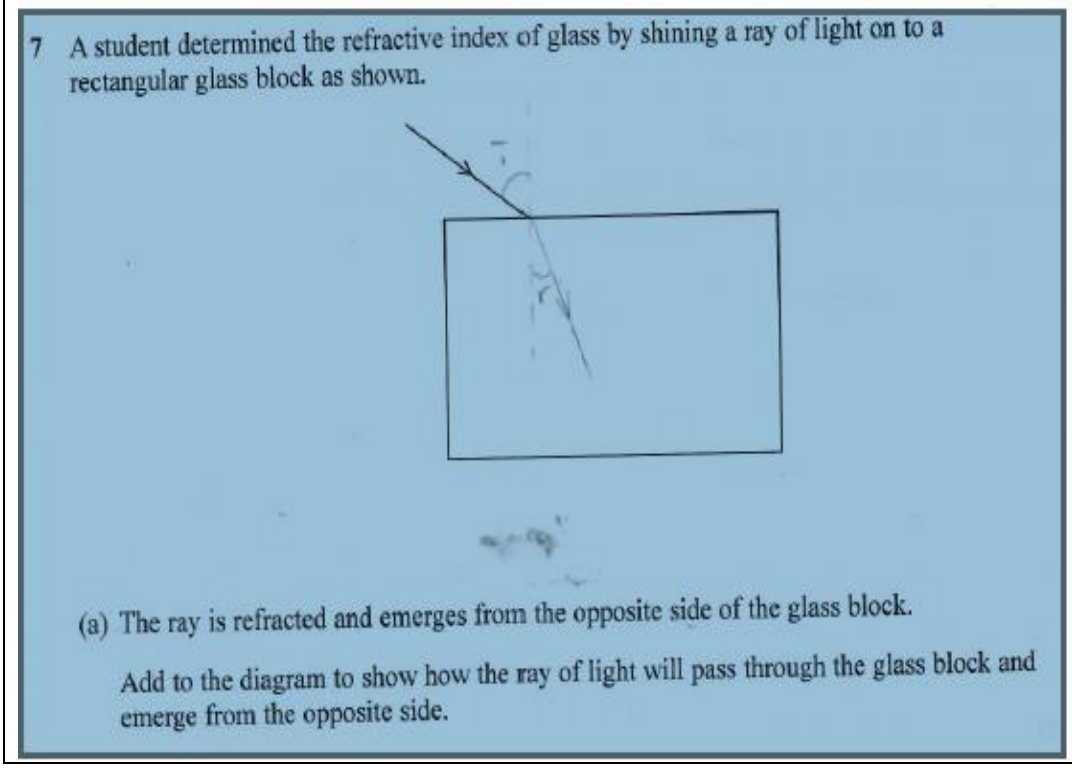
Exemplar 1: Question 7a

This is a clear diagram, draw with a ruler. The emergent ray was parallel by eye. This response scores 2 marks.



Exemplar 2: Question 7a

This candidate has only completed the first part of the instructions. They have shown how the light will pass through the block, by showing the refraction of the incident ray, but not how it will emerge. As such, is fails to meet the requirements of either marking point and scores 0.



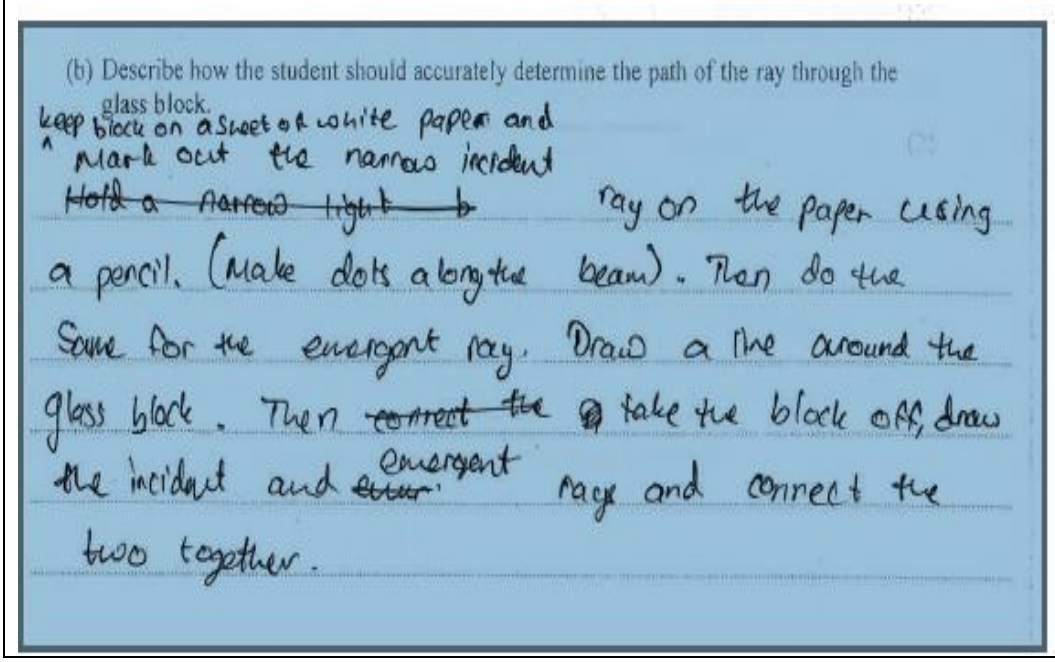
Question 7 (b) - EXAMINER COMMENTARIES

This question asks students to describe a practical process, but with only two marks available we expect to see some key detail for each of the marking points. It is clear that some responses assumed they were given the outline of the block and that the incident ray was already marked.

However, this is now 7 (a) (ii), so is not a follow-on question. As such, candidates were expected to describe those steps.

Exemplar 3: Question 7b

A clear description of marking out the incident and emergent rays using a pencil and dots along the beam, along with drawing around the block, so marking point one is met. The block is then removed, the rays drawn and connected together so marking point two can be awarded for a total of 2 marks.



(b) Describe how the student should accurately determine the path of the ray through the glass block.

keep block on a sheet of white paper and mark out the narrow incident ray on the paper using a pencil. (Make dots along the beam). Then do the same for the emergent ray. Draw a line around the glass block. Then take the block off, draw the incident and emergent rays and connect the two together.

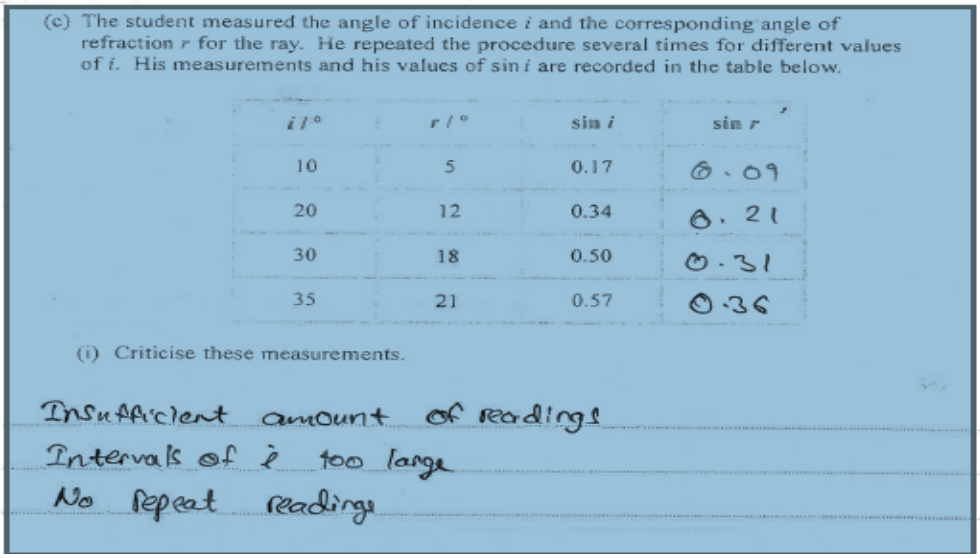
Question 7 (c) (i) - EXAMINER COMMENTARIES
Questions such as this have increasingly been answered by candidates using a "scatter-gun" approach. General criticisms, usually more statements than required, in an attempt to score marks. Many responses for this exemplar paper gave three criticisms.

Now, for this type of question, to avoid the repetition of a standard response we need to see more detail. For example:
"Range too small" is only true for values of *i*, as *r* has a range of 5 to 21
(which is greater than 4x)

"No repeat readings" was not enough detail, as the experiment discussed so far in question 7 does have a repeat reading (the rays for the second refraction were recorded), but these readings were not recorded/used.

Exemplar 4: Question 7ci

The first line scores marking point one. Reducing the intervals of *i* would give more readings is irrelevant – it is one method to correct the previous criticism. However, the idea of "no repeat readings" is not detailed enough for marking point three. So, 1 mark only.



(c) The student measured the angle of incidence *i* and the corresponding angle of refraction *r* for the ray. He repeated the procedure several times for different values of *i*. His measurements and his values of sin *i* are recorded in the table below.

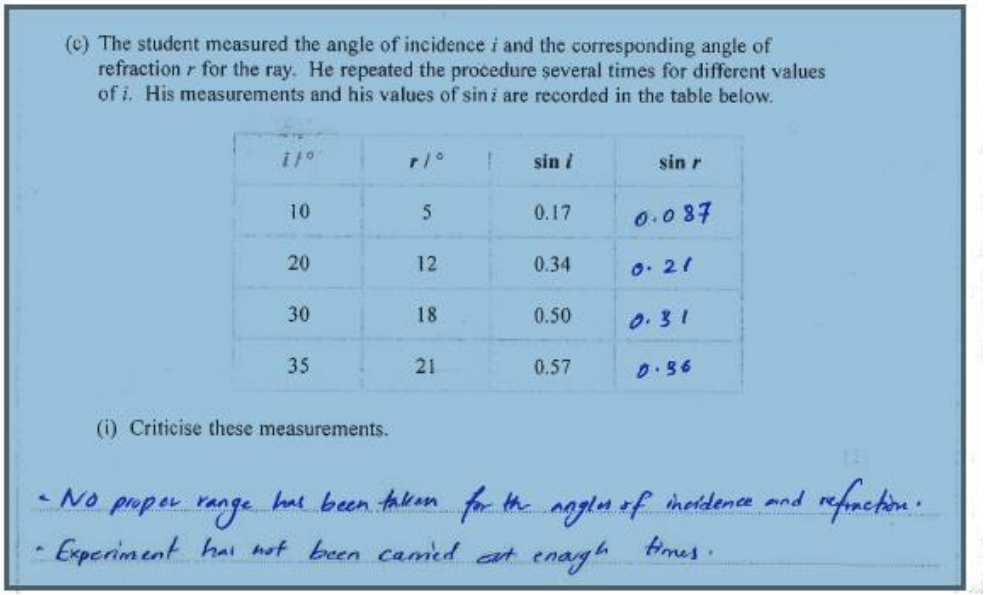
i / °	*r* / °	sin *i*	sin *r*
10	5	0.17	0.09
20	12	0.34	0.21
30	18	0.50	0.31
35	21	0.57	0.36

(i) Criticise these measurements.

Insufficient amount of readings
Intervals of *i* too large
No repeat readings

Exemplar 5: Question 7ci

This response leaves too much to be interpreted by the examiner. "No proper range" is not enough to mean the range is too small, it could be the range was the correct size, just in the incorrect position in the possible set of angles. Similarly, "Experiment has not been carried out enough times" could be interpreted as no repeats or no enough sets of data. So, 0 marks.



(c) The student measured the angle of incidence *i* and the corresponding angle of refraction *r* for the ray. He repeated the procedure several times for different values of *i*. His measurements and his values of sin *i* are recorded in the table below.

i / °	*r* / °	sin *i*	sin *r*
10	5	0.17	0.087
20	12	0.34	0.21
30	18	0.50	0.31
35	21	0.57	0.36

(i) Criticise these measurements.

- No proper range has been taken for the angles of incidence and refraction.
- Experiment has not been carried out enough times.

Question 7 (c) (ii) - EXAMINER COMMENTARIES

In unit 3, candidates are expected to complete calculations to the correct number of significant figures. This is clearly stated in Unit 3: 3.5 of the IAL Physics specification "perform calculations, using the correct number of significant figures". Some responses rounded the first calculation (sin 5°) to 1 s.f. so that the table had consistent decimal places, so were not awarded marking point one.

Marking point two requires correct labels on ***both*** axes without units, which are not relevant in this case. It was common to see sin i/° and sin r/° but the correct labels in this case would be sin (i/°) and sin (r/°).

The evidence for sensible scales remained as in the past, a scale that allows the full range of data to be plotted, with a sensible interval/step value (e.g. increasing in 1s, 2s and 5s but certainly not increasing in 3s, 4s, 7s etc.)

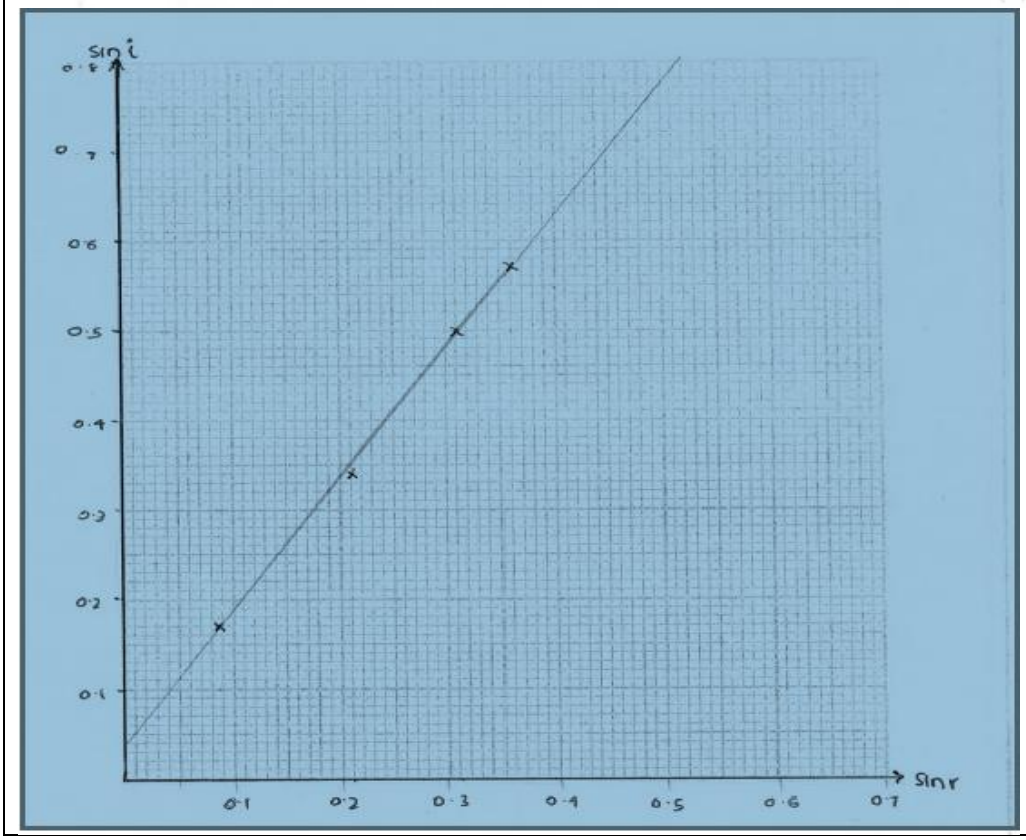
Plotting in this case was awarded two marks. This requires slight adjustment to the marking criteria seen in past examinations. Points are still expected to be within 1 mm of the correct position. As before, when two points are checked if either is 2 mm (1 small square) or both 1 mm out of position the mark is not awarded. If one point is 1 mm out, a second pair are checked.

In this case, with 2 marks available and only 4 plots to check, it was expected that any single point that was 2 mm out of position would result in a plotting mark not being awarded. It was not seen, but if two points had been 1 mm out, the same would apply.

Exemplar 6: Question 7cii

This response is a clear example of all six marking points. The values in the table are consistent to 2 s.f. Both axes are labelled correctly, with the scales increasing in 0.1 intervals on the 2 cm marks (so 0.5 per cm). The plots are to within 1 mm and there is a single straight line balancing the points. There is some evidence of overlap of a previous line that may have been erased, but there is no disjointed continuation of a line or changes in direction. 6 marks.

(ii) Use the data in the table to plot a graph of sin *i* on the *y*-axis against sin *r* on the *x*-axis on the grid provided. Use the right-hand column for your processed data.



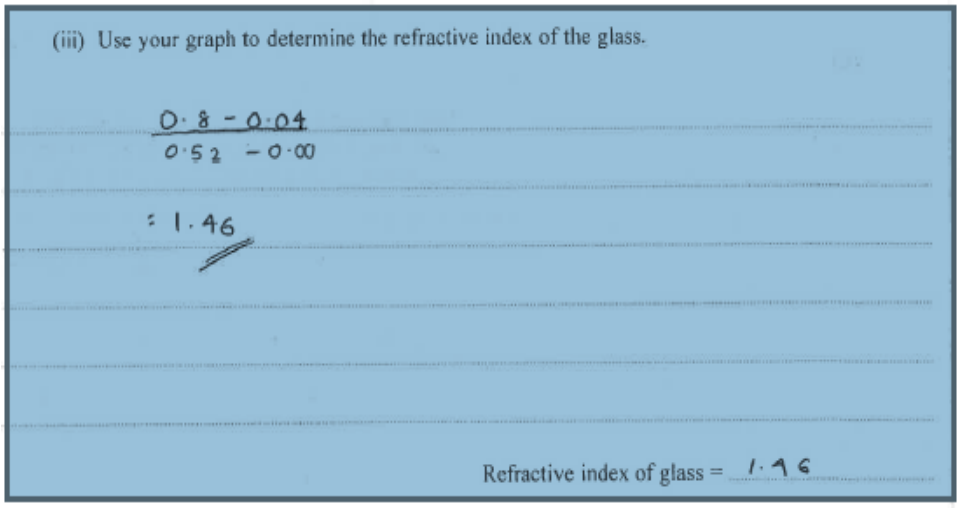
Question 7 (c) (iii) - EXAMINER COMMENTARIES

As in previous examination series, the calculation of a gradient should include values taken from the line of best fit, using a gradient triangle that includes at least half the drawn line. In many cases an actual triangle was not seen on the graph, but the values stated must still cover a suitable range. If the line of best fit does not pass through the origin (which in this case it should not), two pairs of values are expected.

Most candidates scored 3 marks. Common errors included using values from the table that were not on the line of best fit (so did not score marking point one) and calculated values that were out of range.

Exemplar 7: Question 7ciii

This example has two pairs of values which cover the entire range of the line of best fit. The value calculated is within range and to 3 s.f. So, all 3 marks.


(iii) Use your graph to determine the refractive index of the glass.

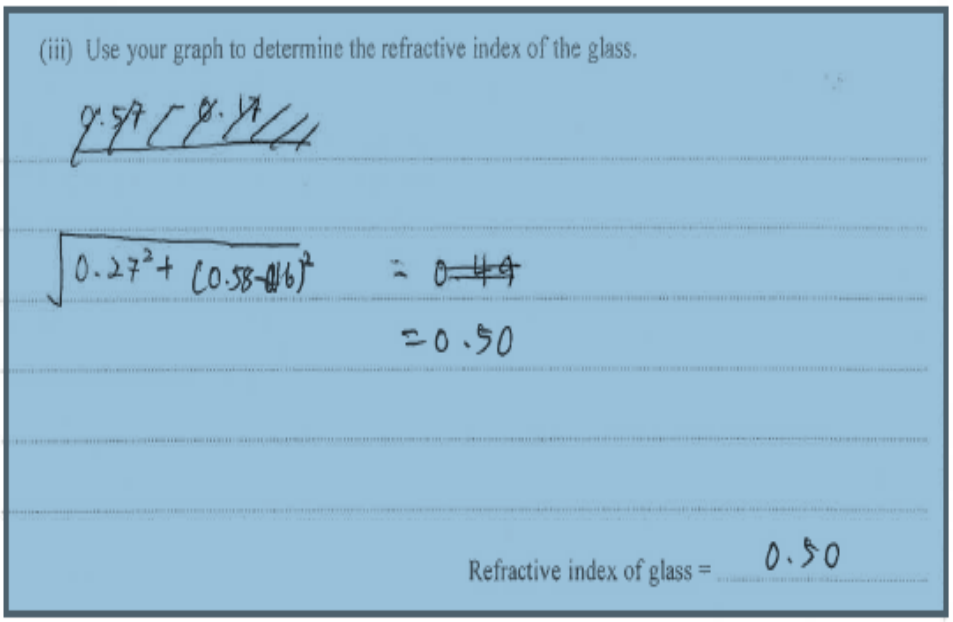
$\frac{0.8 - 0.04}{0.52 - 0.00}$

$= 1.46$

Refractive index of glass = 1.46

Exemplar 8: Question 7ciii

Although a triangle covering over half the line is drawn, the calculation attempted is no a gradient. Here Pythagoras Theorem is used to calculate the length of the line. The answer is given to 2 s.f. but it is not a value of refractive index. 0 marks.

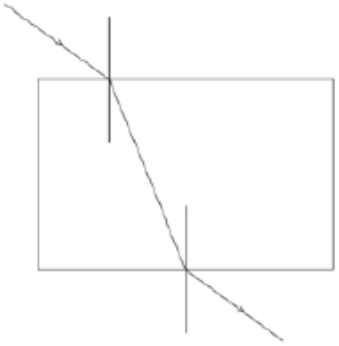

(iii) Use your graph to determine the refractive index of the glass.

$\sqrt{0.27^2 + (0.58 - 0.16)^2} = 0.49$

$= 0.50$

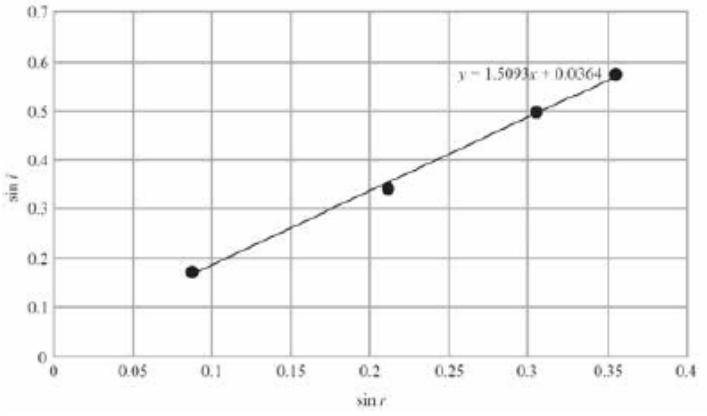
Refractive index of glass = 0.50

Mark scheme for Question 7

Answer		Mark
• Refraction towards the normal at the first boundary **and** refraction away from the normal at the second boundary • Emerging ray parallel to the incident ray 	(1) (1)	2
• Place block on white paper, trace round it and draw points on incident and emergent rays • Remove block, join up points and draw ray within block using a ruler	(1) (1)	2
Any 2 from • Too few sets of results **Or** only 4 sets of results • Range of values of *i* are too small • No evidence of use of readings as ray leaves the block	(1) (1) (1)	2

Answer		Mark
• Correct sin *r* values to two s.f. • Labels on axes with sin *i* along the y-axis • Sensible scales • Plotting • Line of best fit	(1) (1) (1) (2) (1)	6

i / °	*r* / °	sin *i*	sin *r*
10	5	0.17	0.087
20	12	0.34	0.21
30	18	0.50	0.31
35	21	0.57	0.36



• Use of large triangle to determine gradient • Refractive index = 1.5 • Value given to 2 or 3 sig fig Accept refractive index in the range 1.3 to 1.7	(1) (1) (1)	3