



National  
Qualifications  
2019

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**2019 Physics**

**Higher - Paper 1 - Multiple Choice**

**Finalised Marking Instructions**

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Marking instructions for each question

Question	Answer	Mark
1.	E	1
2.	B	1
3.	D	1
4.	A	1
5.	B	1
6.	E	1
7.	B	1
8.	C	1
9.	B	1
10.	E	1
11.	D	1
12.	A	1
13.	A	1
14.	C	1
15.	E	1
16.	C	1
17.	C	1
18.	C	1
19.	D	1
20.	A	1
21.	B	1
22.	C	1
23.	D	1
24.	B	1
25.	E	1

[END OF MARKING INSTRUCTIONS]



National  
Qualifications  
2019

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**2019 Physics**  
**Higher - Paper 2**  
**Finalised Marking Instructions**

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## General marking principles for Physics Higher

**Marks for each candidate response must always be assigned in line with these marking principles, the Physics: general marking principles (GMPs) ([http://www.sqa.org.uk/files\\_ccc/Physicsgeneralmarkingprinciples.pdf](http://www.sqa.org.uk/files_ccc/Physicsgeneralmarkingprinciples.pdf)) and the detailed marking instructions for this assessment.**

- (a) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.
- (b) If a candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.
- (c) Where a wrong answer to part of a question is carried forward and the wrong answer is then used correctly in the following part, give the candidate credit for the subsequent part or 'follow-on'. (GMP 17)
- (d) Award full marks for a correct final answer (including units if required) on its own, unless a numerical question specifically requires evidence of working to be shown, eg in a 'show' question. (GMP 1)
- (e) Award marks where a diagram or sketch conveys correctly the response required by the question. Clear and correct labels (or the use of standard symbols) are usually required for marks to be awarded. (GMP 19)
- (f) Award marks for knowledge of relevant relationships alone. When a candidate writes down several relationships and does not select the correct one to continue with, for example by substituting values, do not award a mark.
- (g) Award marks for non-standard symbols where the symbols are defined and the relationship is correct, or where the substitution shows that the relationship used is correct. This must be clear and unambiguous. (GMP 22)

- (h) Do not award marks if a 'magic triangle' (eg ) is the only statement in a candidate's response. To gain the mark, the correct relationship must be stated, for example  $V = IR$  or  $R = \frac{V}{I}$  (GMP 6)

- (i) In rounding to an expected number of significant figures, award the mark for correct answers which have up to two figures more or one figure less than the number in the data with the fewest significant figures. (GMP 10)  
(Note: the use of a recurrence dot, eg  $0.\dot{6}$ , would imply an infinite number of significant figures and would therefore not be acceptable.)
- (j) Award marks where candidates have incorrectly spelled technical terms, provided that responses can be interpreted and understood without any doubt as to the meaning. Where there is ambiguity, do not award the mark. Two specific examples of this would be when the candidate uses a term that might be interpreted as 'reflection', 'refraction' or 'diffraction' (for example 'defraction'), or one that might be interpreted as either 'fission' or 'fusion' (for example 'fussion'). (GMP 25)

- (k) Only award marks for a valid response to the question asked. Where candidates are asked to:
- **identify, name, give, or state**, they must only name or present in brief form.
  - **describe**, they must provide a statement or structure of characteristics and/or features.
  - **explain**, they must relate cause and effect and/or make relationships between things clear.
  - **determine or calculate**, they must determine a number from given facts, figures or information.
  - **estimate**, they must determine an approximate value for something.
  - **justify**, they must give reasons to support their suggestions or conclusions. For example this might be by identifying an appropriate relationship and the effect of changing variables.
  - **show that**, they must use physics [and mathematics] to prove something, for example a given value - *all steps, including the stated answer, must be shown*.
  - **predict**, they must suggest what may happen based on available information.
  - **suggest**, they must apply their knowledge and understanding of physics to a new situation. A number of responses are acceptable: award marks for any suggestions that are supported by knowledge and understanding of physics.
  - **use their knowledge of physics or aspect of physics to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented (for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation). Candidates gain marks for the breadth and/or depth of their conceptual understanding.

### Standard three marker

The examples over the page set out how to apportion marks to answers requiring calculations. These are the 'standard three marker' type of questions.

Award full marks for a correct answer to a numerical question, even if the steps are not shown explicitly, **unless** it specifically requires evidence of working to be shown.

For some questions requiring numerical calculations, there may be alternative methods (eg alternative relationships) which would lead to a correct answer.

Sometimes, a question requires a calculation which does not fit into the 'standard three marker' type of response. In these cases, the detailed marking instructions will contain guidance for marking the question.

When marking partially correct answers, apportion individual marks as shown over the page.

**Example of a 'standard three marker' question**

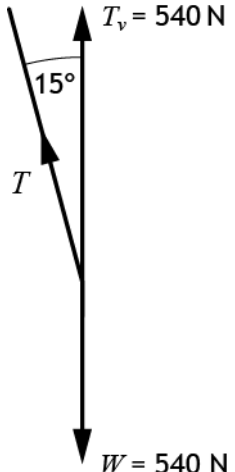
The current in a resistor is 1.5 amperes when the potential difference across it is 7.5 volts. Calculate the resistance of the resistor. (3 marks)

Candidate answer	Mark and comment
1. $V = IR$ $7.5 = 1.5 \times R$ $R = 5.0 \Omega$	1 mark: relationship 1 mark: substitution 1 mark: correct answer
2. $5.0 \Omega$	3 marks: correct answer
3. $5.0$	2 marks: unit missing
4. $4.0 \Omega$	0 marks: no evidence, wrong answer
5. $\_\_ \Omega$	0 marks: no working or final answer
6. $R = \frac{V}{I} = \frac{7.5}{1.5} = 4.0 \Omega$	2 marks: arithmetic error
7. $R = \frac{V}{I} = 4.0 \Omega$	1 mark: relationship only
8. $R = \frac{V}{I} = \_\_ \Omega$	1 mark: relationship only
9. $R = \frac{V}{I} = \frac{7.5}{1.5} = \_\_ \Omega$	2 marks: relationship and substitution, no final answer
10. $R = \frac{V}{I} = \frac{7.5}{1.5} = 4.0$	2 marks: relationship and substitution, wrong answer
11. $R = \frac{V}{I} = \frac{1.5}{7.5} = 5.0 \Omega$	1 mark: relationship but wrong substitution
12. $R = \frac{V}{I} = \frac{75}{1.5} = 5.0 \Omega$	1 mark: relationship but wrong substitution
13. $R = \frac{I}{V} = \frac{7.5}{1.5} = 5.0 \Omega$	0 marks: wrong relationship
14. $V = IR$ $7.5 = 1.5 \times R$ $R = 0.2 \Omega$	2 marks: relationship and substitution, arithmetic error
15. $V = IR$ $R = \frac{I}{V} = \frac{1.5}{7.5} = 0.2 \Omega$	1 mark: relationship only, wrong rearrangement of symbols

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	$v = u + at$ $-4.9 = 0 + a \times 0.50$ $a = -9.8 \text{ m s}^{-2}$	(1) (1)	<b>2</b> <b>SHOW QUESTION.</b>  Do not accept: $a = \frac{v}{t}$  Must show substitution for $u$ and must use the sign convention given in the question.  Alternative method: $a = \frac{\Delta v}{t}$ $= \frac{-4.9}{0.50}$ $= -9.8 \text{ m s}^{-2}$  Accept methods starting with  $a = \text{gradient}$  <b>OR</b>  $a = \frac{\Delta v}{\Delta t}$  <b>OR</b>  $a = \frac{y_2 - y_1}{x_2 - x_1}$

Question		Expected response	Max mark	Additional guidance
	(ii)	$s = ut + \frac{1}{2}at^2 \quad (1)$ $= 0 \times 0.50 + \frac{1}{2} \times (-)9.8 \times (0.50)^2 \quad (1)$ $= (-)1.2 \text{ m} \quad (1)$	3	<p>Accept: 1, 1.23, 1.225</p> <p>Sign convention must be consistent for all methods.</p> <p>Alternative methods:  <math>v</math> and <math>a</math> must have same sign  <math>v^2 = u^2 + 2as</math>  <math>((-)4.9)^2 = 0^2 + 2 \times (-)9.8 \times s</math>  <math>s = (-)1.2 \text{ m}</math></p> $s = \frac{1}{2}(u+v)t$ $s = \frac{1}{2}(0 + (-)4.90) \times 0.50$ $s = (-)1.2 \text{ m}$ <p><math>s = \text{area under the graph}</math></p> $s = \frac{1}{2} \times 0.5 \times (-)4.9$ $s = (-)1.2 \text{ m}$
(b)	(i)	$\Delta mv = mv - mu \quad (1)$ $= (0.0570 \times 4.0) - (0.0570 \times -4.9) \quad (1)$ $= 0.51 \text{ kg m s}^{-1} \quad (1)$	3	<p>Accept: 0.5, 0.507, 0.5073</p> <p>Accept:  <math>\Delta p = m\Delta v</math>  <math>Ft = mv - mu</math></p> <p>Do not accept:  <math>p = mv - mu - 0</math> marks</p> <p>Sign convention must be consistent within this part of the question.  <math>v</math> and <math>u</math> must have opposite signs.</p> $p = mv \quad (1)$ <p><b>all substitutions including</b>  subtraction <span style="float:right">(1)</span>  final answer <span style="float:right">(1)</span></p>

Question			Expected response	Max mark	Additional guidance
1.	(b)	(ii)	$Ft = mv - mu$ (1) $F \times 0.27 = 0.51$ (1) $F = 1.9 \text{ N}$ (1)	3	Or consistent with (b)(i) Accept: 2, 1.89, 1.889 Alternative method: Sign convention must be consistent for this method. $v$ and $u$ must have opposite signs. $v = u + at$ $4.0 = -4.9 + a \times 0.27$ $(a = 32.96296296 \text{ (m s}^{-2}\text{)})$ $F = ma$ $F = 0.0570 \times 32.96296296$ $F = 1.9 \text{ N}$ For this method accept 2, 1.88, 1.879 Both relationships (1) Both substitutions (1) Final answer (1)
		(c)	Same constant negative acceleration between 0 and 0.50 s and between 0.77 and 1.18 s (1) Constant positive acceleration between the two negative accelerations. Positive acceleration must be (clearly) greater than the negative acceleration (1)	2	Accept solid vertical lines If values are included on the acceleration axis, they must be correct (-9.8 and 33). If no positive acceleration is shown, maximum (1 mark) for a constant negative acceleration between 0 and 1.18 s.

Question		Expected response	Max mark	Additional guidance
2.	(a)	$W = mg$ (1) $= 55 \times 9.8$ (1) $= 540 \text{ N}$ (1)	3	Accept: 500, 539, 539.0  Accept: $F = mg$  Do not accept: $F = ma$ - 0 marks
	(b)	  $T_v = T \cos \theta$ (1) $540 = T \cos 15$ (1) $T = 560 \text{ N}$ (1)	3	Or consistent with (a)  Accept: 600, 559, 559.0  Accept: 600, 558, 558.0 for this value of $W$  Accept: $W = T \cos \theta$  Ignore any indication of direction given.
	(c)	(Tension) decreases (1)  (As the angle decreases) the cosine of the angle increases (1)  <b>OR</b>  the horizontal (component of the) force decreases  <b>OR</b>  shown by calculation with smaller angle	2	Look for this statement <b>first</b> - if incorrect or missing then <b>(0 marks)</b> .

Question	Expected response	Max mark	Additional guidance
3.	<p><b>Award 3 marks</b> where the candidate has demonstrated a good understanding of the physics involved. They show a good comprehension of the physics of the situation and provide a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.</p> <p><b>Award 2 marks</b> where the candidate has demonstrated a reasonable understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood the problem.</p> <p><b>Award 1 mark</b> where the candidate has demonstrated a limited understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood at least a little of the physics within the problem.</p> <p><b>Award 0 marks</b> where the candidate has not demonstrated an understanding of the physics involved. There is no evidence that they have recognised the area of physics involved, or they have not given any statement of a relevant physics principle. Award this mark also if the candidate merely restates</p>	3	<p>Candidates may use a variety of physics arguments to answer this question.</p> <p>Award marks based on candidates demonstrating overall good, reasonable, limited, or no understanding.</p>

Question		Expected response	Max mark	Additional guidance
4.	(a)	(distance = $6.4 \times 10^6 + 36.0 \times 10^6$ ) = $42.4 \times 10^6$ m	1	
	(b)	$F = G \frac{m_1 m_2}{r^2}$ (1) $57 = 6.67 \times 10^{-11} \times \frac{6.0 \times 10^{24} \times m_2}{(42.4 \times 10^6)^2}$ (1) $m_2 = 260$ kg (1)	3	Or consistent with (a) Accept: 300, 256, 256.1
	(c)	$W = mg$ (1) $57 = 260 \times g$ (1) $g = 0.22$ N kg <sup>-1</sup> (1)	3	Or consistent with (b) Accept: 0.2, 0.219, 0.2192 Accept: $F = mg$ Do not accept: $F = ma$ - (0 marks) Alternative method: $g = G \frac{M}{r^2}$ (1) $g = 6.67 \times 10^{-11} \times \frac{6.0 \times 10^{24}}{(42.4 \times 10^6)^2}$ (1) $g = 0.22$ N kg <sup>-1</sup> (1)
	(d)	Force is the same (1) $\frac{1}{4}$ the mass has an effect of quartering the force (1) $\frac{1}{2}$ the orbital height has an effect of quadrupling the force (1)	3	Look for this statement first - if incorrect or missing then 0 marks. Can justify by calculation Correct substitution of $\frac{1}{2}r$ and $\frac{1}{4}m$ or consistent with (a) and (b) (1) Correct final answer (1)

Question			Expected response	Max mark	Additional guidance
5.	(a)	(i)	Doppler (effect)	1	
		(ii)	$f_0 = f_s \left( \frac{v}{v \pm v_s} \right) \quad (1)$ $f_0 = 510 \left( \frac{340}{340 - 12} \right) \quad (1)$ $f_0 = 530 \text{ Hz} \quad (1)$	3	Accept: 500, 529, 528.7 Accept: $f_0 = f_s \left( \frac{v}{v - v_s} \right)$
	(b)		$\Delta f = \frac{2f v_{rbc} \cos \theta}{v}$ $286 = \frac{2 \times 3.70 \times 10^6 \times v_{rbc} \cos 60^\circ}{1540} \quad (1)$ $v_{rbc} = 0.119 \text{ ms}^{-1} \quad (1)$	2	Accept: 0.12, 0.1190, 0.11904

Question		Expected response	Max mark	Additional guidance
6.	(a)		2	Peak wavelength less (1)  Line added should always be above original line (1)
	(b)	$7700 \times 3.76 \times 10^{-7} = 2.9 \times 10^{-3}$ $8500 \times 3.42 \times 10^{-7} = 2.9 \times 10^{-3}$ $9600 \times 3.01 \times 10^{-7} = 2.9 \times 10^{-3}$ $12000 \times 2.42 \times 10^{-7} = 2.9 \times 10^{-3}$ <p style="text-align: right;">(2)</p> <p>therefore</p> $T \times \lambda_{peak} = 2.9 \times 10^{-3} \quad (1)$	3	All four calculations correct (2) Three correct calculations (1) < Three correct calculations (0)
				$7700 \times 3.76 \times 10^{-7} = 2.895 \times 10^{-3}$ $8500 \times 3.42 \times 10^{-7} = 2.907 \times 10^{-3}$ $9600 \times 3.01 \times 10^{-7} = 2.890 \times 10^{-3}$ $12000 \times 2.42 \times 10^{-7} = 2.904 \times 10^{-3}$ <p>therefore</p> $T \times \lambda_{peak} = 2.9 \times 10^{-3} \quad (1)$ <p>This 'conclusion' mark is only available if consistent with the calculations shown.</p> <p>For 'finding the constant' method, accept restatement of relationship for final mark.</p> <p>Alternative methods:</p> <p>Can calculate the temperatures or wavelengths using the relationship.</p> <p>Final mark is given for a statement that the calculated temperatures or wavelengths match values in the table.</p> <p>Graphical method:</p> <p>Graph drawn correctly (1)            Gradient calculated (1)            restatement of relationship (1)</p>

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	Fundamental particles are not composed of other particles.	1	Accept: Fundamental particles cannot be 'broken down' into other/smaller particles.  Fundamental particles cannot be 'broken down' any further.
		(ii)	Fermions	1	
	(b)		$\frac{2}{3}e + \frac{2}{3}e - \frac{1}{3}e + \frac{2}{3}e - \frac{2}{3}e$ (1)  $= 1e$ or $+1e$ or $e$ (1)	2	Accept: $\frac{2}{3} + \frac{2}{3} - \frac{1}{3} + \frac{2}{3} - \frac{2}{3}$  OR $2(\frac{2}{3}e) - \frac{1}{3}e + \frac{2}{3}e - \frac{2}{3}e$ (1)  $= 1e$ or $+1e$ or $e$ (1)
	(c)	(i)	Meson	1	
		(ii)	$t' = \frac{t}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$ (1)  $t' = \frac{8.0 \times 10^{-21}}{\sqrt{1 - \left(\frac{0.91c}{c}\right)^2}}$ (1)  $t' = 1.9 \times 10^{-20} \text{ s}$ (1)	3	Accept: 2, 1.93, 1.930
	(d)	(i)	$(4450 \times 10^6 \times 1.60 \times 10^{-19})$ $= 7.12 \times 10^{-10} \text{ (J)}$	1	A unit is not required but, if a unit is given, it must be correct.
		(ii)	$E = mc^2$ (1) $7.12 \times 10^{-10} = m \times (3.00 \times 10^8)^2$ (1) $m = 7.91 \times 10^{-27} \text{ kg}$ (1)	3	Or consistent with (d) (i) Accept: 7.9, 7.911, 7.9111

Question		Expected response	Max mark	Additional guidance
8.	(a)	(Nuclear) Fusion	1	
	(b)	Mass before $= 2 \times 3.3436 \times 10^{-27}$ $= 6.6872 \times 10^{-27}$ Mass after $= 5.0082 \times 10^{-27} + 1.6749 \times 10^{-27}$ $= 6.6831 \times 10^{-27}$ Mass lost $= 4.1 \times 10^{-30}$ (kg) (1)  $E = mc^2$ (1) $E = 4.1 \times 10^{-30} \times (3.00 \times 10^8)^2$ (1) $E = 3.69 \times 10^{-13}$ J (1)	4	Accept: 3.7, 3.690, 3.6900  Check for correct substitutions of values in calculation of mass “lost”. If values are incorrect, maximum (1 mark) for relationship.  $E = mc^2$ anywhere (1 mark)  If mass before and after not used to full 5 significant figures from table, then maximum (1 mark) for relationship.  Ignore inappropriate reference to mass defect.  Arithmetic mistake can be carried forward through the response.  Truncation error in mass before and/or mass after- maximum (1 mark) for relationship.
	(c)	$\frac{4.1 \times 10^{26}}{3.69 \times 10^{-13}}$ $= 1.1 \times 10^{39}$ (1)  (1)	2	Or consistent with (b) Accept: 1, 1.11, 1.111

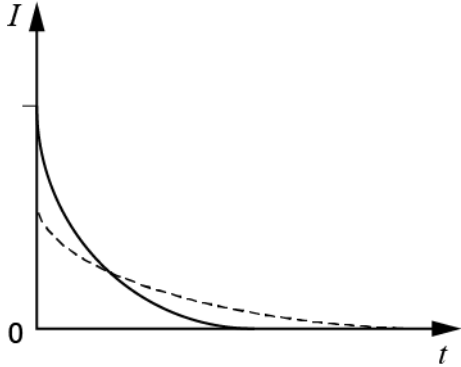
Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$E_2 - E_1 = hf$ $-2.976 \times 10^{-18} - (-3.290 \times 10^{-18}) \quad (1)$ $= 6.63 \times 10^{-34} \times f$ $(f = 4.736048265 \times 10^{14} \text{ Hz})$ $v = f\lambda \quad (1)$ <p>(for both relationships anywhere)</p> $3.00 \times 10^8 = 4.736048265 \times 10^{14} \times \lambda \quad (1)$ $\lambda = 6.33 \times 10^{-7} \text{ m} \quad (1)$	4	Accept: 6.3, 6.334, 6.3344  Accept: $(\Delta)E = hf$ with $v = f\lambda$  <b>OR</b>  $E_5 - E_3 = hf$ with $v = f\lambda$  for relationship mark anywhere  Note: $\Delta E = 3.14 \times 10^{-19} \text{ (J)}$  Accept: $3.290 \times 10^{-18} - 2.976 \times 10^{-18}$ $= 6.63 \times 10^{-34} \times f$ for energy substitution mark If $2.976 \times 10^{-18} - 3.290 \times 10^{-18}$ is shown for $\Delta E$ , maximum (1 mark) for both relationships.  Alternative method: $E_2 - E_1 = \frac{hc}{\lambda}$ <b>OR</b> $(\Delta)E = \frac{hc}{\lambda}$ Combined relationship (1) Substitution for $h$ and $\Delta E$ (1) Substitution for $c$ (1) Final answer (1)
		(ii)	$A = \pi r^2$ $= \pi \times (4.00 \times 10^{-4})^2 \quad (1)$ $I = \frac{P}{A} \quad (1)$ $9950 = \frac{P}{\pi \times (4.00 \times 10^{-4})^2} \quad (1)$ $P = 5.00 \times 10^{-3} \text{ W} \quad (1)$	4	Accept a range of 1 to 5 significant figures for <b>this question</b> . The use of 3.14 for $\pi$ is acceptable.  $I = \frac{P}{A} \text{ anywhere} - \quad (1)$ If no attempt to calculate area, maximum (1 mark) for relationship.

Question		Expected response	Max mark	Additional guidance
9.	(b)	<p>Obtain values of irradiance for different distances (1)</p> <p>Plot graph of <math>I</math> against <math>1/d^2</math> (1)</p> <p>Graph of <math>I</math> against <math>1/d^2</math> is a straight line <u>through the origin</u> (then this verifies the inverse square law of light) (1)</p>	3	<p>Look for this statement or equivalent first - if incorrect or missing then (0 marks).</p> <p>Alternative method:</p> <p>Obtain values of irradiance for different distances (1)</p> <p>Determine <math>I \times d^2</math> (1)</p> <p>Values of <math>Id^2</math> are a constant (then this verifies the inverse square law of light) (1)</p>

Question		Expected response	Max mark	Additional guidance	
10.	(a)	<p>Blue (light) (1)</p> <p>Shortest wavelength of light (1)</p> <p>Path difference is smaller/equals the wavelength so the spots are closer together</p> <p><b>OR</b></p> <p><math>\sin \theta</math> is proportional to <math>\lambda</math> (1)</p>	3	<p>Look for this statement first - if incorrect or missing then <b>(0 marks)</b>.</p> <p>Accept:  <math>d \sin \theta = m\lambda</math>  and shortest <math>\lambda</math> gives smallest <math>\sin \theta</math>  (which gives smallest <math>\theta</math>)</p> <p>Alternative methods:  Can be shown by calculation but it must be clear the candidate has used <b>appropriate</b> wavelengths.</p>	
	(b)	(i)	<p><math>m\lambda = d \sin \theta</math> (1)</p> <p><math>(1 \times) \lambda = 3 \cdot 3 \times 10^{-6} \times \sin 8 \cdot 9</math> (1)</p> <p><math>\lambda = 5 \cdot 1 \times 10^{-7} \text{ m (510 nm)}</math> (1)</p>	3	<p>Accept:  5, 5·11, 5·105</p> <p>Accept:  <math>\lambda = d \sin \theta</math> in this case</p>
		(ii)	Green	<p>1</p> <p>Or consistent with (b)(i) but <b>must be</b> red, green or blue.</p> <p>If <math>\lambda</math> in (b)(i) lies outside of range of red, green or blue this mark is not accessible.</p>	

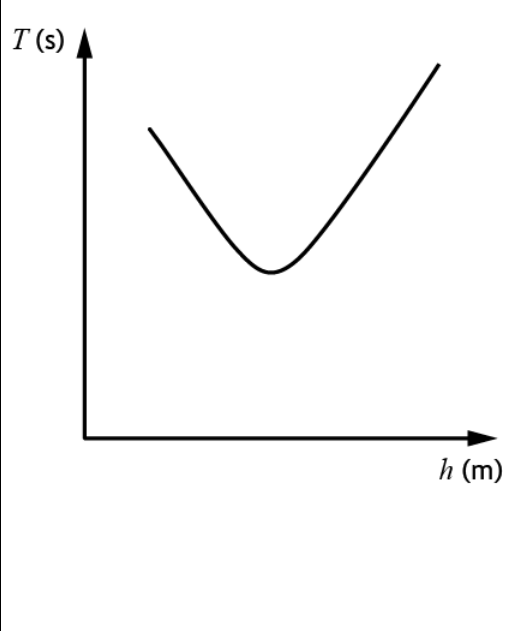
Question			Expected response	Max mark	Additional guidance
10.	(b)	(iii)	$(\sin \theta = \frac{m\lambda}{d} \text{ so if } d \text{ is greater then})$ angle $\theta$ will be smaller (1)  Smaller angle more difficult to measure accurately/greater <u>percentage</u> uncertainty. (1)	2	Accept: maxima are closer together (1)  Smaller distance between maxima more difficult to measure accurately/greater percentage uncertainty. (1)
11.	(a)		$n = \frac{\sin \theta_1}{\sin \theta_2}$ (1) $2.42 = \frac{\sin 49.0}{\sin \theta_2}$ (1) $\theta_2 = 18.2^\circ$ (1)	3	Accept: 18, 18.17, 18.172  Accept: $\frac{n_2}{n_1} = \frac{\sin \theta_1}{\sin \theta_2}$ (1) $\frac{2.42}{1} = \frac{\sin 49.0}{\sin \theta_2}$ (1) $\theta_2 = 18.2^\circ$ (1)
	(b)		$\sin \theta_c = \frac{1}{n}$ (1) $\sin \theta_c = \frac{1}{2.42}$ (1)  $\theta_c = 24.4^\circ$ (1)	3	Accept: 24, 24.41, 24.407
	(c)		more (sparkle) (1)  Critical angle for moissanite is smaller than for diamond (1)  (Total internal) reflection more likely (with moissanite). (1)	3	Look for this statement first - if incorrect or missing then (0 marks).  Critical angle for moissanite is smaller than for diamond can be shown by calculation.

Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	1.5 V	1	
		(ii)	$E = V + Ir$ (1) $1.5 = 1.3 + 0.88r$ (1) $r = 0.23 \Omega$ (1)	3	Accept: 0.2, 0.227, 0.2273  Alternative methods: $V = IR$ (1) $0.2 = 0.88 \times R$ (1) $R = 0.23 \Omega$ (1)  lost volts = $Ir$ (1) $0.2 = 0.88 \times R$ (1) $R = 0.23 \Omega$ (1)
		(iii)	(When the switch is closed) there is a current (in the circuit). (1)  Voltage (is dropped) across the internal resistance. (1)	2	<b>Independent marks</b>  Do not accept 'current increases' on its own.  'Lost volts' is not sufficient on its own
	(b)	(i)	$E = V + Ir$ and $V = IR$ (1)  <b>OR</b> $E = I(R+r)$ $9.0 = I(2.4 + 1.2)$ (1) $I = 2.5 \text{ A}$ (1)	3	Accept: 3, 2.50, 2.500  Both relationships (1)  Both substitutions (1)  Alternative method: $V = IR$ (1) $9.0 = I \times 3.6$ (1) $I = 2.5 \text{ A}$ (1)  For other alternative methods: All relationships (1) All substitutions (1) Correct final answer (1)
		(ii)	$P = I^2 R$ (1) $P = 2.5^2 \times 2.4$ (1) $P = 15 \text{ W}$ (1)	3	Or consistent with (b)(i) Accept 20, 15.0, 15.00  For alternative methods: All relationships (1) All substitutions (1) Correct final answer (1)

Question		Expected response	Max mark	Additional guidance
13.	(a)	$C = \frac{Q}{V} \quad (1)$ $47 \times 10^{-6} = \frac{Q}{6 \times 0} \quad (1)$ $Q = 2.8 \times 10^{-4} \text{ C} \quad (1)$	3	Accept: 3, 2.82, 2.820
	(b)	Lower initial current (1) Longer charging time (1) 	2	<b>Independent marks</b> Line crossing x-axis - maximum (1) Line crossing y-axis - maximum (1) Line must be a curve to award the second mark.  Line must tend towards the time axis to gain the second mark.  Do not accept: increasing curve - 0 marks straight line - 0 marks
	(c)	Increase the supply voltage	1	Must clearly indicate the supply voltage is increased/greater.  Accept: 'increase the voltage supplied to the circuit'. 'increase the voltage supplied to the capacitor'.  Do not accept: 'increase the voltage across the capacitor' on its own.  Do not accept any implication of power supply being replaced by another power supply.

Question		Expected response	Max mark	Additional guidance
13.	(d)	<p><b>Award 3 marks</b> where the candidate has demonstrated a good understanding of the physics involved. They show a good comprehension of the physics of the situation and provide a logically correct answer to the question posed. This type of response might include a statement of the principles involved, a relationship or an equation, and the application of these to respond to the problem. The answer does not need to be 'excellent' or 'complete' for the candidate to gain full marks.</p> <p><b>Award 2 marks</b> where the candidate has demonstrated a reasonable understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood the problem.</p> <p><b>Award 1 mark</b> where the candidate has demonstrated a limited understanding of the physics involved. They make some statement(s) that are relevant to the situation, showing that they have understood at least a little of the physics within the problem.</p> <p><b>Award 0 marks</b> where the candidate has not demonstrated an understanding of the physics involved. There is no evidence that they have recognised the area of physics involved, or they have not given any statement of a relevant physics principle. Award this mark also if the candidate merely restates the physics given in the question</p>	3	<p>Candidates may use a variety of physics arguments to answer this question.</p> <p>Award marks based on candidates demonstrating, overall, good, reasonable, limited or no understanding.</p>

Question		Expected response	Max mark	Additional guidance								
14.	(a)	<table border="1"> <thead> <tr> <th>Solid</th> <th>Category</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>insulator</td> </tr> <tr> <td>Y</td> <td>semiconductor</td> </tr> <tr> <td>Z</td> <td>conductor</td> </tr> </tbody> </table>	Solid	Category	X	insulator	Y	semiconductor	Z	conductor	1	Must have all 3 correct.
Solid	Category											
X	insulator											
Y	semiconductor											
Z	conductor											
	(b)	<p>The energy gap/band gap (between the valence and conduction bands) is small. (1)</p> <p>Some electrons have enough energy to move from the valence to the conduction band. (1)</p>	2	<p><b>Independent marks</b></p> <p>To access second mark, valence and conduction band must be included in answer. The direction the electrons move must be clear.</p> <p>Do not accept: 'valency' as a name for the valence band.</p>								
	(c)	Increases (conductivity).	1	Do not accept: 'reduces resistance' on its own.								
	(d)	$\left(\frac{2.3 \times 10^3}{1.7 \times 10^{-8}}\right) = 1.4 \times 10^{11} \quad (1)$ <p>Resistivity of silicon is 11 (orders of magnitude) greater (1)</p>	2	<p>Accept: <math>\left(\frac{10^3}{10^{-8}}\right) = 10^{11}</math></p> <p><b>OR</b></p> <p><math>(3 - (-8)) = 11 \quad (1)</math></p> <p>Accept: 11 greater on its own (2)</p> <p><b>OR</b></p> <p>Resistivity of copper is 11 (orders of magnitude) smaller. (2)</p>								

Question		Expected response	Max mark	Additional guidance	
15.	(a)	Measure the total time over a number of swings (1) Divide total time by number of swings (1)	2		
	(b)	(i)		3	Appropriate labels and units (1) Suitable scales (1) Plotting and curve of best fit (1)  Allow for axes starting at zero or broken axes or at an appropriate value.  Accuracy of plotting should be easily checkable with the scale chosen  If the origin is shown the scale must either be continuous or the axis must be 'broken'. Otherwise maximum (2 marks).  Do not penalise if the candidate plots $h$ against $T$ .
		(ii)	0.21 and 0.42 m	1	must be consistent with candidate's graph
		(iii) (A)	1.53 s	1	must be consistent with candidate's graph
		(B)	Use smaller increments around the 'turning point'. <b>OR</b> Take more measurements about the 'turning point'. <b>OR</b> Take more measurements over the whole range.	1	Accept: More readings around/close to turning point or smaller 'steps' in $h$ .  Do not accept: 'Repeat experiment' on its own.
	(c)	$T^2 h = \frac{4\pi^2 h^2}{g} + C$ $1.53^2 \times 0.30 = \frac{4 \times \pi^2 \times 0.30^2}{9.8} + C \quad (1)$ $C = 0.34 \quad (1)$	2	Accept: 0.3, 0.340, 0.3397  If candidate uses 3.14 for $\pi$ , accept 0.3401. Ignore any unit given.	

[END OF MARKING INSTRUCTIONS]