National
Qualifications
2015

2015 Physics

New Higher

Finalised Marking Instructions

General Marking Principles for Physics Higher

This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in the paper. These principles must be read in conjunction with the detailed marking instructions, which identify the key features required in candidate responses.

(a) Marks for each candidate response must <u>always</u> be assigned in line with these General Marking Principles and the Detailed Marking Instructions for this assessment.

(b) 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.

(c) If a specific 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.

(d) There are no half marks awarded.

(e) Where a wrong answer to part of a question is carried forward and the wrong answer is then used correctly in the following part, the candidate should be given credit for the subsequent part or 'follow on'.

(f) Unless a numerical question specifically requires evidence of working to be shown, full marks should be awarded for a correct final answer (including units if required) on its own

(g) Credit should be given where a diagram or sketch conveys correctly the response required by the question. It will usually require clear and correct labels (or the use of standard symbols).

(h) Marks are provided for knowledge of relevant formulae alone. When a candidate writes down several formulae and does not select the correct one to continue with, for example by substituting values, no mark can be awarded.

(i) Marks should be awarded 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.

(j) No marks should be awarded if a 'magic triangle' (eg 

) is the only statement in a candidate's response. To gain the mark, the correct relationship must be stated eg V = IR or $R = \frac{V}{I}$, etc.

(k) In rounding to an expected number of significant figures, the mark can be awarded for answers which have up to two figures more or one figure less than the number in the data with the fewest significant figures.

(l) The incorrect spelling of technical terms should usually be ignored and candidates should be awarded the relevant mark, provided that answers can be interpreted and understood without any doubt as to the meaning. Where there is ambiguity, the mark should not be awarded. Two specific examples of this would be when the candidate uses a term that might be interpreted as 'reflection', 'refraction' or 'diffraction' (eg 'defraction') or one that might be interpreted as either 'fission' or 'fusion' (eg 'fussion').

(m) Marks are awarded only for a valid response to the question asked. For example, in response to questions that ask candidates to:

- **identify**, **name**, **give**, or **state**, they need 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, eg 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 eg 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: marks will be awarded for any suggestions that are supported by knowledge and understanding of physics.
- **use your 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). They will be rewarded for the breadth and/or depth of their conceptual understanding.

(n) Marking in calculations

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 + Comment**
1. $V = IR$ $7{\cdot}5 = 1{\cdot}5R$ $R = 5{\cdot}0\ \Omega$	1 mark: formula 1 mark: substitution 1 mark: correct answer
2. $5{\cdot}0\ \Omega$	3 marks: correct answer
3. $5{\cdot}0$	2 marks: unit missing
4. $4{\cdot}0\ \Omega$	0 marks: no evidence, wrong answer
5. $\_\_\ \Omega$	0 marks: no working or final answer
6. $R = \frac{V}{I} = \frac{7{\cdot}5}{1{\cdot}5} = 4{\cdot}0\,\Omega$	2 marks: arithmetic error
7. $R = \frac{V}{I} = 4{\cdot}0\,\Omega$	1 mark: formula only
8. $R = \frac{V}{I} = \_\_\,\Omega$	1 mark: formula only
9. $R = \frac{V}{I} = \frac{7{\cdot}5}{1{\cdot}5} = \_\_\,\Omega$	2 marks: formula & subs, no final answer

10. $R = \frac{V}{I} = \frac{7 \cdot 5}{1 \cdot 5} = 4 \cdot 0$ — 2 marks: formula & subs, wrong answer

11. $R = \frac{V}{I} = \frac{1 \cdot 5}{7 \cdot 5} = 5 \cdot 0\,\Omega$ — 1 mark: formula but wrong substitution

12. $R = \frac{V}{I} = \frac{75}{1 \cdot 5} = 5 \cdot 0\,\Omega$ — 1 mark: formula but wrong substitution

13. $R = \frac{I}{V} = \frac{1 \cdot 5}{7 \cdot 5} = 5 \cdot 0\,\Omega$ — 0 marks: wrong formula

14. $V = IR$
$7 \cdot 5 = 1 \cdot 5 \times R$
$R = 0 \cdot 2\ \Omega$ — 2 marks: formula & subs, arithmetic error

15. $V = IR$
$R = \frac{I}{V} = \frac{1 \cdot 5}{7 \cdot 5} = 0 \cdot 2\,\Omega$ — 1 mark: formula correct but wrong rearrangement of symbols

Detailed Marking Instructions for each question

Section 1

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

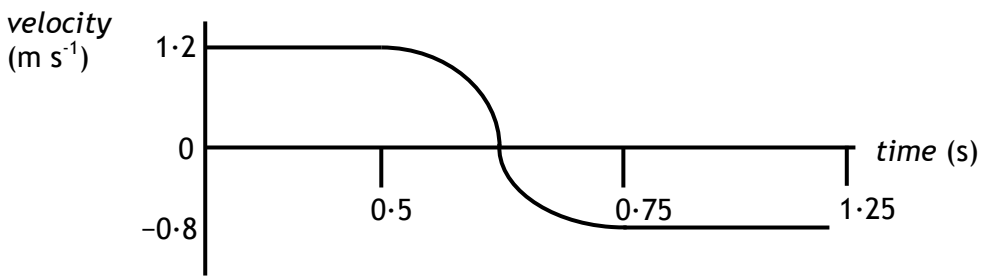
Section 2

Question			Answer	Max Mark	Additional Guidance
1.	(a)	(i)	**A** $v = 11{\cdot}6\ \text{m s}^{-1}$ **(1)**	1	Unit required – incorrect or missing unit award 0 Accept m/s No other value accepted.
			B $v_h = 11{\cdot}6\cos 40$ $= 8{\cdot}9\ \text{m s}^{-1}$ **(1)**	1	Or consistent with A Accept 8·886, 8·89, 9 but <u>not</u> 9·0 0 marks for mixing up B and C
			C $v_v = 11{\cdot}6\sin 40$ $= 7{\cdot}5\ \text{m s}^{-1}$ **(1)**	1	Or consistent with A Accept 7·456,7·46, 7 but <u>not</u> 7·0
		(ii)	**A** $s = ut + \frac{1}{2}at^2$ **(1)** $4{\cdot}7 = 0 + \frac{1}{2} \times 9{\cdot}8 \times t^2$ **(1)** $t = 0{\cdot}979$ (s) **(1)** Total Time = 0·98 + 0·76 = 1·7 s **(1)**	4	s and a must have the same sign $v^2 = u^2 + 2as$ $= 0 + 2 \times 9{\cdot}8 \times 4{\cdot}7$ $v = 9{\cdot}6$ $v = u + at$ $9{\cdot}6 = 0 + 9{\cdot}8t$ $t = 0{\cdot}979$ All formulae required to get final answer **(1)** Correct substitution into all **(1)** Answer of 0·979 **(1)** Watch for inappropriate intermediate rounding eg $t = 1$, treat as arithmetic error, max 3 marks Accept 2, 1·74, 1·739 but not 2·0 If $g = 9{\cdot}81$ or 10 then incorrect substitution, maximum 1 mark for formula NB No secs in physics!

Question			Answer	Max	Additional Guidance
			B $v = \frac{d}{t}$ **(1)** $8 \cdot 9 = \frac{d}{1 \cdot 7}$ **(1)** $d = 15\text{m}$ **(1)**	**3**	$s = ut + \frac{1}{2}at^2$ or $s = \frac{1}{2}(u+v)t$ **(1)** Or consistent with (a)(ii)(A) **and** (a)(i)(B) Accept 20, 15·1, 15·13 If t = 1·74 accept 15, 15·5, 15·49
	(b)		kinetic energy is less **(1)** (as θ increases) speed decreases **(1)**	**2**	This statement is required before any marks awarded. If there is wrong physics in the answer then award 0 marks Can be done by calculation but it must be clearly indicated which angle applies to which kinetic energy to access the second mark. Wrong substitution in calculation method – award 0 marks (wrong physics) Alternative: (total energy remains the same) The greater the angle the more energy used to lift the putt to a greater height before release **(1)** Less energy available to convert to E_k **(1)**

Question			Answer	Max Mark	Additional Guidance
2.	**(a)**		(Total momentum before = total momentum after) $m_x u_x + m_y u_y = m_x v_x + m_y v_y$ **(1)** $(0{\cdot}25 \times 1{\cdot}20) + (0{\cdot}45 \times -0{\cdot}60)$ $= (0{\cdot}25 \times -0{\cdot}80) + (0{\cdot}45 \times v_y)$ **(1)** $0{\cdot}30 - 0{\cdot}27 = -0{\cdot}20 + 0{\cdot}45 \times v_y$ $0{\cdot}45 \times v_y = 0{\cdot}23$ $v_y = 0{\cdot}51 \text{m s}^{-1}$ **(1)** *(to the right)*	**3**	If sign convention not applied then max (1) for formula. Answer must be consistent with sign convention in substitution line. 0·5, 0·511, 0·5111 Where candidates calculate the momentum of each trolley individually both before and after, no marks are awarded unless correct addition (including sign convention) and equating takes place.
	(b)	**(i)**	*impulse = area under graph* $\left(= \frac{1}{2} b \times h\right)$ **(1)** $= \frac{1}{2} \times 0{\cdot}25 \times 4{\cdot}0$ **(1)** = 0·50 N s **(1)** Accept 0·5, 0·500, 0·5000	**3**	Impulse = $mv - mu$ = (0·45 × 0·51) – (0·45 × −0·60) = 0·50 N s For alternative method accept: 0·5, 0·500, 0·4995 Accept kg m s^{-1}
		(ii)	0·50 kg m s^{-1} **(1)**	**1**	Or consistent with (i) Accept N s Accept 0·5

Question			Answer	Max Mark	Additional Guidance
		(iii)		**3**	



Constant velocity at correct values and signs before and after collision **(1)**

Velocity change from initial to final in 0·25 s. **(1)**

Shape of change of velocity correct ie initially gradual, increasing steepness then levelling out to constant velocity. **(1)**

The origin and at least one axis must be labelled with quantity or unit or both otherwise maximum 2 marks.

Question			Answer	Max Mark	Additional Guidance
3.	**(a)**		$F = \dfrac{GMm}{r^2}$ **(1)** $F = \dfrac{6\cdot67\times10^{-11}\times6\cdot42\times10^{23}\times5\cdot60\times10^{3}}{\left(3\cdot39\times10^{6}+3\cdot70\times10^{6}\right)^2}$ **(1)** $F = 4\cdot77\times10^{3}\ \text{N}$ **(1)**	**3**	Accept $4\cdot8$, $4\cdot770$, $4\cdot7704$
	(b)		$g = \dfrac{W}{m}$ **(1)** $g = \dfrac{4770}{5600}$ **(1)** $g = 0\cdot852\ \ \text{N kg}^{-1}$ **(1)**	**3**	Or consistent with (a) $F = ma$ is acceptable If candidate uses $g = \dfrac{GM}{r^2}$ and has already lost marks in (a) for not adding the radius to the height, do not penalise for a second time. (Gives $3\cdot13$) if r is consistent with (a). Accept m s^{-2}

Question			Answer	Max Mark	Additional Guidance
4.	**(a)**		photons of particular/some/ certain energies/frequencies are absorbed **(1)** in its/the Sun's (upper/outer) atmosphere/outer layers **(1)**	**2**	1st mark stands alone Particular/some/certain frequencies/wavelengths of light/radiation are absorbed **(1)** 'the atmosphere' is too vague Accept gases or suitable named gases in place of atmosphere but not elements or atoms on their own.
	(b)	**(i)**	light is redshifted/ shifted towards red **(1)** (as) the galaxies are moving away (from the Sun) **(1)**	**2**	accept: the wavelength (λ) has increased/ frequency (f) has decreased /lines have been redshifted Not 'blueshift'/becomes red/shifted to red – this is wrong physics, award 0 marks. Or further galaxies have greater recessional velocity Or equivalent
		(ii)	$z = \frac{\lambda_{observed} - \lambda_{rest}}{\lambda_{rest}}$ **(1)** $= \frac{450\times10^{-9} - 410\times10^{-9}}{410\times10^{-9}}$ **(1)** $= 0{\cdot}098$	**2**	Must start with the appropriate relationship Accept $\frac{450-410}{410}$ Award maximum of 1 mark if final answer is not $0{\cdot}098$
		(iii)	$z = \frac{v}{c}$ **(1)** $0{\cdot}098 = \frac{v}{3{\cdot}00\times10^{8}}$ **(1)** $(v = 2{\cdot}94 \times 10^{7}\ \text{m s}^{-1})$ $v = H_0 d$ **(1)** $2{\cdot}94 \times 10^{7} = 2{\cdot}3 \times 10^{-18} \times d$ **(1)** $d = 1{\cdot}3 \times 10^{25}\ \text{m}$ **(1)** $(1{\cdot}4 \times 10^{9}\ \text{ly})$	**5**	–anywhere Must use $0{\cdot}098$ otherwise incorrect substitution – max 2 marks –anywhere Accept 1×10^{25}, $1{\cdot}28 \times 10^{25}$, $1{\cdot}278 \times 10^{25}$ There is no need to convert to light years but if done must be correct otherwise max 4 marks.

Question			Answer	Max Mark	Additional Guidance
5.			Demonstrates no understanding 0 marks Demonstrates limited understanding 1 marks Demonstrates reasonable understanding 2 marks Demonstrates good understanding 3 marks This is an open-ended question. **1 mark:** The student has demonstrated a limited understanding of the physics involved. The student has made some statement(s) which is/are relevant to the situation, showing that at least a little of the physics within the problem is understood. **2 marks**: The student has demonstrated a reasonable understanding of the physics involved. The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated a good understanding of the physics involved. The student shows a good comprehension of the physics of the situation and has provided 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. This does not mean the answer has to be what might be termed an "excellent" answer or a "complete" one.	**3**	Open-ended question: a variety of physics arguments can be used to answer this question. Marks are awarded on the basis of whether the answer overall demonstrates "no", "limited", "reasonable" or "good" understanding.

Question			Answer	Max Mark	Additional Guidance
6.	**(a)**		Photon	**1**	
	(b)	**(i)**	$126\ \text{GeV} = 126 \times 10^{9} \times (1{\cdot}6 \times 10^{-19})$ **(1)** $= 2{\cdot}0 \times 10^{-8}\ (\text{J})$ $E = mc^2$ **(1)** $2{\cdot}0 \times 10^{-8} = m \times (3 \times 10^{8})^2$ **(1)** $m = 2{\cdot}2 \times 10^{-25}\ (\text{kg})$	**3**	If candidate does not show this line, either separately or in the formula, then max 2 marks may be awarded. –anywhere Alternative: $E = mc^2$ **(1)** $126 \times 10^{9} \times \left(1{\cdot}6 \times 10^{-19}\right) = m \times \left(3 \times 10^{8}\right)^2$ **(1)** $m = 2{\cdot}2 \times 10^{-25}\ (\text{kg})$ Max 2 marks if final answer not given
		(ii)	$(2{\cdot}2 \times 10^{-25} / 1{\cdot}673 \times 10^{-27} =) 130$ **(1)** (Higgs boson is) 2 orders of magnitude bigger **(1)**	**2**	**or** $10^{-25} / 10^{-27} = 100$ **or** $2{\cdot}2 \times 10^{-25} / 1{\cdot}67 \times 10^{-27} =$ **or** $2{\cdot}2 \times 10^{-25} / 1{\cdot}7 \times 10^{-27} =$ **or** $2{\cdot}24 \times 10^{-25} / 1{\cdot}673 \times 10^{-27} =$ etc Accept 100, 10^2, 132, 131·5, 134, 133·9, etc **(1)** If mass of neutron used treat as wrong physics – award 0 marks '2 bigger' on its own is worth 2 marks

Question			Answer	Max Mark	Additional Guidance
7.			Demonstrates no understanding 0 marks Demonstrates limited understanding 1 marks Demonstrates reasonable understanding 2 marks Demonstrates good understanding 3 marks This is an open-ended question. **1 mark:** The student has demonstrated a limited understanding of the physics involved. The student has made some statement(s) which is/are relevant to the situation, showing that at least a little of the physics within the problem is understood. **2 marks**: The student has demonstrated a reasonable understanding of the physics involved. The student makes some statement(s) which is/are relevant to the situation, showing that the problem is understood. **3 marks:** The maximum available mark would be awarded to a student who has demonstrated a good understanding of the physics involved. The student shows a good comprehension of the physics of the situation and has provided 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. This does not mean the answer has to be what might be termed an "excellent" answer or a "complete" one.	**3**	Open-ended question: a variety of physics arguments can be used to answer this question. Marks are awarded on the basis of whether the answer overall demonstrates "no", "limited", "reasonable" or "good" understanding.

Question			Answer	Max Mark	Additional Guidance
8.	**(a)**		The power per unit area (incident on a surface)	**1**	Accept power per square metre (m^2)
	(b)		$134 \times 0{\cdot}2^2 = 5{\cdot}4$ $60{\cdot}5 \times 0{\cdot}3^2 = 5{\cdot}4$ $33{\cdot}6 \times 0{\cdot}4^2 = 5{\cdot}4$ $21{\cdot}8 \times 0{\cdot}5^2 = 5{\cdot}5$ **(2)** Statement of $I \times d^2$ = constant **(1)**	**3**	If only 3 sets of data used correctly then maximum 2 marks. If 2 sets of data used correctly then maximum 1 mark (for relationship) If only 1 set of data used award 0 marks. Must be clear how the candidate has used the data to obtain the relationship. Ignore inappropriate averaging in this case. Accept straight line graph proof A sketch graph is not acceptable. 1 mark for all 4 points plotted correctly and best fit line 1 mark for correct axes including scales and labels ie I and $1/d^2$ (ignore units) 1 mark for statement of $I \times d^2$ = constant only if some or all data has been used $I \times d^2$ is equivalent to $I \propto 1/d^2$ Accept $I_1 d_1^{\,2} = I_2 d_2^{\,2}$
	(c)		$I \times d^2 = 5{\cdot}4$ **(1)** $I \times 0{\cdot}60^2 = 5{\cdot}4$ **(1)** $I = 15\ \text{W m}^{-2}$ **(1)**	**3**	Can use $I_1 d_1^{\,2} = I_2 d_2^{\,2}$ Watch for a variation in answers due to data used.

Question			Answer	Max Mark	Additional Guidance
	(d)		Smaller lamp **(1)** Will be more like a point source **(1)** **or** Black cloth on bench **(1)** to reduce reflections **(1)**	**2**	Accept Use a more precise instrument to reduce the (absolute) uncertainty. Must provide justification which is not wrong physics, otherwise 0 marks Do not accept 'repeat it' (since there is little variation in the calculated value of the constant/ spread of points from best fit line)
	(e)		$A = 4\pi r^2 = 4\pi \text{ x } 2^2 = 50{\cdot}265$ **(1)** $I = \frac{P}{A}$ **(1)** $I = 24/50{\cdot}265$ **(1)** $I = 0{\cdot}48 \text{ W m}^{-2}$ **(1)**	**4**	–anywhere Accept $0{\cdot}5$, $0{\cdot}477$, $0{\cdot}4775$

Question			Answer	Max Mark	Additional Guidance
9.	**(a)**	**(i)**	• Different frequencies/ colours have different refractive indices **(1)** **or** • Different frequencies/ colours are refracted through different angles **(1)**	**1**	Do NOT accept "bending" on its own but ignore it if follows 'refraction' Do not accept 'different amounts'. Not wavelength or speed on its own but ignore if reference made to frequency or colour. A correct answer followed by 'diffract' or 'defract', *0 marks*
		(ii)	$n = \frac{v_1}{v_2}$ **(1)** $1{\cdot}54 = \frac{3{\cdot}00 \times 10^8}{v_2}$ **(1)** $v_2 = 1{\cdot}95 \times 10^8\ \text{m s}^{-1}$ **(1)**	**3**	Accept 1·9, 1·948, 1·9481 Example of inappropriate intermediate rounding: $n = \frac{\sin\theta_1}{\sin\theta_2}$ $1{\cdot}54 = \frac{\sin 42}{\sin\theta_2}$ $\theta_2 = 25{\cdot}75^\circ = 26^\circ$ $\frac{v_1}{v_2} = \frac{\sin\theta_1}{\sin\theta_2}$ $\frac{3{\cdot}00\times10^8}{v_2} = \frac{\sin 42}{\sin 26}$ $v_2 = 2{\cdot}0\times10^8\ \text{m s}^{-1}$ (max 2 marks)

Question			Answer	Max Mark	Additional Guidance
	(b)	(i)	$v = f\lambda$ **(1)** $3{\cdot}00 \times 10^{8} = 4{\cdot}57 \times 10^{14} \times \lambda$ **(1)** $\lambda = 656{\cdot}5 \times 10^{-9}$ $m\lambda = d\sin\theta$ **(1)** $2 \times 656{\cdot}5 \times 10^{-9} = d \times \sin 19{\cdot}0$ **(1)** $d = 4{\cdot}03 \times 10^{-6}$ m **(1)**	**5**	–anywhere Inappropriate intermediate rounding eg 660, treat as arithmetic error max 4 marks –anywhere Accept 4·0, 4·033, 4·0327 If candidates go on to calculate 1/d then do not award the final mark for answer
		(ii)	• different colours have different λ **(1)** • $m\lambda = d\sin\theta$ **(1)** • (m and d are the same) • θ is different for different λ **(1)** **or** • different colours have different λ **(1)** • Path difference = $m\lambda$ **(1)** • (for the same m) • PD is different for different λ **(1)**	**3**	Any answer using different colours/wavelengths diffract/ refracts different amounts as the explanation is wrong physics, award 0 marks Any answer using wrong physics, award 0 marks. $2\lambda = d\sin\theta$ is ok Path difference = 2λ is ok Can be done by recalculation but must include the first statement else maximum 2 marks.

Question			Answer	Max Mark	Additional Guidance
10.	**(a)**	**(i)**	12·8 J (of energy) is gained by/supplied to 1 coulomb (of charge passing through the battery)	**1**	
		(ii)	$E=V+Ir$ and $V= IR$ **(1)** $E = I(R+r)$ $12{\cdot}8 = I(0{\cdot}050+6{\cdot}0 \times 10^{-3})$ **(1)** $I = 230$ A **(1)**	**3**	Both required for 1 mark If candidates start with this expression, it gets the formula mark $R_{\text{Total}} = 0{\cdot}050 + 6{\cdot}0 \times 10^{-3}$ $= 0{\cdot}056\ (\Omega)$ $I = E/R_T$ **(1)** $= 12{\cdot}8/0{\cdot}056$ **(1)** $= 230$ A **(1)** accept $I = V/R$ if sub correct accept 200, 229, 228·6 Or consistent with (a) (i)
		(iii)	(Wire of large diameter) has a low resistance **(1)** **or** to prevent overheating **(1)** **or** to prevent wires melting **(1)**	**1**	Not: motor requires large current, on its own Not: The wires will melt, on its own. eg wires melt (no justification) 0 marks, thin wires could melt due to large current 1 mark
	(b)	**(i)**	12·6 V	**1**	No tolerance
		(ii)	(gradient = $-r$) gradient= $(12 - 12{\cdot}5)/(60\text{-}10)$ **(1)** $= -0{\cdot}01$ (1) internal resistance = $0{\cdot}01\ \Omega$ **(1)**	**3**	Gradient = r is wrong physics, award 0 marks gradient formula or implied **(1)** calculating gradient **(1)** **or** $E = V + Ir$ **(1)** $12{\cdot}6 = 12 + 60r$ **(1)** $r = 0{\cdot}01\ \Omega$ **(1)** If using this method, they must use data from the line or points which lie on the line. Or consistent with (b) (i)

Question			Answer		Max Mark	Additional Guidance
		(iii)	(A)	$I = \frac{V}{R}$ **(1)** $= \frac{(15 - 11{\cdot}5)}{(0{\cdot}09 + 0{\cdot}45)}$ **(1)** $(0{\cdot}09 + 0{\cdot}45)$ $= 6{\cdot}5$ A **(1)**	3	Accept 6, 6·48, 6·481
			(B)	The e.m.f. of the battery increases **(1)** Difference between the two e.m.f.s decreases **(1)**	2	Independent marks Accept voltage or pd in place of emf or equivalent Apply ± rule

Question			Answer	Max Mark	Additional Guidance
11.	(a)		$C = \frac{Q}{V}$ **(1)** $64\times10^{-6} = \frac{Q}{2\cdot50\times10^{3}}$ **(1)** $Q = 0\cdot16(C)$	2	Must start with formula Maximum 1 mark if final answer not shown Note: $C = \frac{Q}{V}$ $64\times10^{-3} = \frac{Q}{2\cdot50}$ $Q = 0\cdot16$ Is awarded a maximum of 1 mark for the formula, as knowledge of units has not been shown. It is acceptable to work back to find the value of capacitance.
	(b)		$E = \frac{1}{2}QV$ **(1)** $E = \frac{1}{2}\times0\cdot16\times2\cdot50\times10^{3}$ **(1)** $E = 200\text{J}$ **(1)**	3	Alternative methods: $E = \frac{1}{2}CV^{2}$ **(1)** $= \frac{1}{2}\times64\times10^{-6}\times(2\cdot50\times10^{3})^{2}$ **(1)** = 200 J **(1)** **or** $E = \frac{1}{2}\frac{Q^{2}}{C}$ **(1)** $= \frac{1}{2}\frac{0\cdot16^{2}}{64\times10^{-6}}$ **(1)** = 200 J **(1)** Note: max 2 marks if not $\times 10^{-6}$, unless value shown as $0\cdot064 \times 10^{-3}$, which is acceptable or answer quoted as 200×10^{6} μJ or similar. (treat as unit error)
	(c)	(i)	$v = IR$ **(1)** $2\cdot50\times10^{3} = 35\cdot0\times R$ **(1)** $R = 71\cdot4\Omega$ **(1)**	3	Accept 71, 71·43, 71·429
		(ii)	The voltage decreases **(1)**	1	

Question			Answer		Max Mark	Additional Guidance
		(iii)	Smaller initial current Time to reach 0 A is longer	(1) (1)	2	Line must be a curve to award the second mark Line must tend towards the time axis to gain the second mark. Do not worry about areas under the lines being different.

Question			Answer	Max Mark	Additional Guidance
12.	**(a)**		Suitable scales with labels on axes (quantity and units) **(1)** [Allow for axes starting at zero or broken axes or an appropriate value eg 30°] Correct plotting of points **(1)** Smooth U shaped curve through these points. **(1)**	**3**	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 candidates plot θ against D Graphs of sine of angles are incorrect for (a) 0 marks but can still gain marks for rest of question.
	(b)		36° and 66°	**1**	both required for 1 mark Must be consistent with (a) Allow ± half box tolerance
	(c)		37°	**1**	Must be consistent with (a) Allow ± half box tolerance
	(d)		Correct substitution into equation using D_m from answer to (c) **(1)** Correct value for n (1·5 if using D_m equal to 37°) **(1)**	**2**	Must be consistent with (c)
	(e)		Repeat measurements **(1)** More measurements around/ close to a minimum or smaller 'steps' in angle **(1)**	**2**	Not: take more measurements Repeat the experiment more times Extend the range

[END OF MARKING INSTRUCTIONS]