National
Qualifications
2024

2024 Physics

Higher - Paper 1

Question Paper Finalised Marking Instructions

Marking Instructions for each question

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

[END OF MARKING INSTRUCTIONS]

National
Qualifications
2024

2024 Physics

Higher - Paper 2

Question Paper Finalised Marking Instructions

Marking instructions for each question

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i) (A)	$(u_h = u\cos\theta)$ $(u_h = 11.0 \times \cos 36.0)$ $u_h = 8.90\ \text{ms}^{-1}$	**1**	Accept: 8.9, 8.899, 8.8992
		(B)	$(u_v = u\sin\theta)$ $(u_v = 11.0 \times \sin 36.0)$ $u_v = 6.47\ \text{ms}^{-1}$	**1**	Accept: 6.5, 6.466, 6.4656
		(ii)	$s = \overline{v}t$ **(1)** $s = 8.90 \times 1.53$ **(1)** $s = 13.6\ \text{m}$ **(1)**	**3**	**OR** consistent with (a)(i)(A) Accept: 14, 13.62, 13.617 Accept: $s = vt$ **OR** $d = vt$ **OR** $d = \overline{v}t$ **OR** $s = \frac{1}{2}(u+v)t$ **OR** $s = ut + \frac{1}{2}at^2$
		(iii)	$s = ut + \frac{1}{2}at^2$ (1) $s = (6.47 \times 0.95) + (0.5 \times (-9.8) \times 0.95^2)$ (1) $h = 1.60 + ((6.47 \times 0.95) + (0.5 \times (-9.8) \times 0.95^2)) - 2.10$ (1) $h = 1.2\ \text{m}$ (1)	**4**	**OR** consistent with (a)(i)(B) Accept: 1, 1.22, 1.224 u and a must have opposite signs Alternative methods eg using $v^2 = u^2 + 2as$ and $v = u + at$ 1 mark for both relationships 1 mark for substitutions into both relationships 1 mark for calculation to find h 1 mark for final answer

Question			Expected response	Max mark	Additional guidance
1.	(b)	(i)	$f_o = f_s\left(\frac{v}{v \pm v_s}\right)$ **(1)** $f_o = 622 \times \left(\frac{3.40 \times 10^2}{3.40 \times 10^2 - 8.60}\right)$ **(1)** $f_o = 638$ Hz **(1)**	**3**	Accept: 640, 638.1, 638.14 Accept: $f_o = f_s\left(\frac{v}{v - v_s}\right)$
		(ii)	(The foam) increases the time of contact (with the handles) **(1)** The force (on the circuit board) is less **(1)**	**2**	INDEPENDENT MARKS Accept: time/duration of collision Accept: force on ball is less Accept: 'rate of change of momentum' for force

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	$F = mg\sin\theta$ **(1)** $F = (1650+1350)\times 9.8\times \sin 9.6$ **(1)** $F = 4900$ N **(1)**	3	Accept: 5000, 4903 Do not accept: $W = mg\sin\theta$ Accept: $W_{comp} = mg\sin\theta$ $W_{parallel} = mg\sin\theta$ $W_{down\ slope} = mg\sin\theta$ $W_{//} = mg\sin\theta$
		(ii)	$(1800+4900=)$ 6700 N	1	Must be consistent with (a)(i)
	(b)	(i)	$v = u + at$ **(1)** $9.5 = 4.0 + (a\times 250)$ **(1)** $a = 0.022$ ms^{-2}	2	SHOW question
		(ii)	$F = ma$ **(1)** $F = (1650+1350)\times 0.022$ **(1)** $\left(F_{forward} = ((1650+1350)\times 0.022)+6700\right)$ $F_{forward} = 6766$ N **(1)**	3	Or consistent with (a)(ii) Accept: 6800, 6770
		(iii)	The frictional force remains 1800 N/ constant	1	Accept: the slope does not change. **OR** mass does not change. **OR** air resistance does not change. Do not accept: acceleration is constant. **OR** friction/air resistance is negligible.
	(c)		$F = ma$ **(1)** $F = 1350\times 0.16$ **(1)** $\left(Tension = (1350\times 0.16)+1200\right)$ $Tension = 1400$ N **(1)**	3	Accept: 1000, 1420, 1416 $T = ma$ on its own - 0 marks

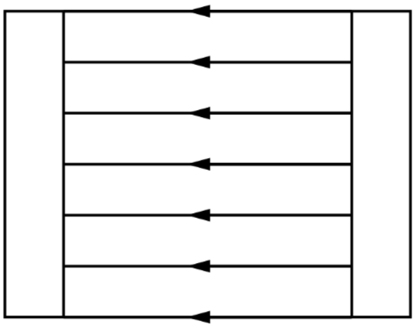
Question			Expected response	Max mark	Additional guidance
3.			**Award 3 marks** where the candidate has demonstrated a good understanding of the physics involved. They show a good comprehension of the physics of the situation and provide a logically correct answer to the question posed. This type of 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. **Award 2 marks** 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. **Award 1 mark** 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. **Award 0 marks** 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.	3	Candidates may use a variety of physics arguments to answer this question. Award marks based on candidates demonstrating overall good, reasonable, limited, or no understanding.

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)	$\left(\frac{6.0\times10^{24}}{5.3\times10^{11}}\right)=1.1\times10^{13}$ **(1)** (Mass of Earth is) 13 (orders of magnitude) greater **OR** (mass of) Didymos is 13 (orders of magnitude) smaller **(1)**	2	Accept: $\left(\frac{10^{24}}{10^{11}}\right)=10^{13}$ **OR** (24-11) = 13 **(1)** Do not accept: 'heavier' for 'greater' Accept: '13 greater' on its own **(2)** Do not accept: '13 <u>times</u> greater' on its own **(0)** Care should be taken where candidates answer by the reciprocal method – 2 marks are still available. $\left(\frac{5.3\times10^{11}}{6.0\times10^{24}}\right)=8.8\times10^{-14}$ **(1)** Comparison statement **(1)**
		(ii)	$F=G\frac{m_1m_2}{r^2}$ **(1)** $F=6.67\times10^{-11}\times\left(\frac{5.3\times10^{11}\times6.0\times10^{24}}{\left(1.1\times10^{10}\right)^2}\right)$ **(1)** $F=1.8\times10^{6}$ N **(1)**	3	Accept: 2, 1.75, 1.753
	(b)	(i)	$E_k=\frac{1}{2}mv^2$ **(1)** $E_k=\frac{1}{2}\times570\times\left(6.6\times10^{3}\right)^2$ **(1)** $E_k=1.2\times10^{10}$ J **(1)**	3	Accept: 1, 1.24, 1.241
		(ii)	Force-time graph with bell-shaped curve or equivalent triangle	1	

Question			Expected response	Max mark	Additional guidance
5.	(a)		$\left(\begin{array}{l} T=\frac{1}{f} \\ 3.5=\frac{1}{f} \end{array}\right)$ $v=f\lambda$ **(1)** $1.5=\frac{1}{3.5}\times\lambda$ **(1)** $\lambda=5.3$ m **(1)**	**3**	Accept: 5, 5.25, 5.250 Accept: $d=vt$ **(1)** $d=1.5\times 3.5$ **(1)** $d=5.3$ m **(1)** Accept: $s=\frac{1}{2}(u+v)t$ for this method
	(b)		(The star is moving) <u>away</u> (relative to the observer.) **(1)** The (observed) wavelength has increased. **(1)**	**2**	MUST JUSTIFY Accept: explanations about increased distance between wavefronts/students Accept: fewer wavefronts/students passing (the observer) per second **OR** observed frequency has decreased Do not accept: the (observed) wavelength is increasing Do not accept: Any answer that implies that the frequency/wavelength of the 'star' itself is changing.

Question			Expected response	Max mark	Additional guidance
5.	(c)	(i)	Statement of Olbers' paradox **(1)** Explanation of redshift of light to IR **OR** time delay argument **(1)**	**2**	INDEPENDENT MARKS Olbers' paradox states the darkness of the (night) sky disagrees with/is contrary to/conflicts with the idea of a non-expanding/static Universe **OR** If all stars/galaxies/celestial objects are (equally) bright at fixed distances from an observer on Earth, then we should see a bright night sky **OR** If the Universe had always existed the night sky would not be dark **OR** If the Universe is non-expanding / static/infinite the night sky would not be dark/would be bright **(1)** Many stars/galaxies/celestial objects are moving away from an observer on Earth and so the light from these objects is redshifted to the IR region of the EM spectrum and undetectable with the naked eye, leaving the sky dark. **OR** Many stars/galaxies/celestial objects are moving away from an observer on Earth and so the light from these objects has yet to reach an observer on Earth, leaving the sky dark. **OR** Light would have had sufficient time to reach the observer **(1)**

Question			Expected response	Max mark	Additional guidance
5.	(c)	(ii)	Cosmic Microwave Background Radiation	**1**	Do not accept: the abbreviation 'CMBR' on its own. Accept: Abundance of hydrogen and helium (in the Universe) **OR** the abundance of light elements (in the Universe) **OR** Hubble-Lemaître Law/Hubble's Law Do not accept: Redshift +/- rule applies (GMP 21)

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)		**1**	Direction must be correct. Field lines must be passably straight/spaced approximately uniformly. Field lines must start and end on the plates and be perpendicular. Minimum 3 approximately equally spaced lines that cover most of the vertical space between the plates (that is one near the top, one at the middle, and one near the bottom). Ignore end effects.
		(ii)	$E_k = \frac{1}{2}mv^2$ (1) $3.84 \times 10^{-16} = \frac{1}{2} \times 9.11 \times 10^{-31} \times v^2$ (1) $v = 2.90 \times 10^7 \text{ ms}^{-1}$ (1)	**3**	Accept: 2.9, 2.903, 2.9035
		(iii)	$v^2 = u^2 + 2as$ (1) $(2.90 \times 10^7)^2 = 0^2 + 2 \times a \times 45.0 \times 10^{-3}$ (1) $a = 9.34 \times 10^{15} \text{ ms}^{-2}$ (1)	**3**	Or consistent with (a)(ii) Accept: 9.3, 9.344, 9.3444 Alternative methods eg $W = Fd$ and $F = ma$ 1 for both relationships 1 for both substitutions 1 for final answer For this method accept: 9.4, 9.37, 9.367, 9.3670
	(b)		Out of page	**1**	

Question			Expected response	Max mark	Additional guidance
7.			**Award 3 marks** 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. **Award 2 marks** 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. **Award 1 mark** 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. **Award 0 marks** 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.	3	Candidates may use a variety of physics arguments to answer this question. Award marks based on candidates demonstrating overall good, reasonable, limited, or no understanding.

Question			Expected response	Max mark	Additional guidance
8.	(a)		$\frac{5.00}{0.350^2} = 40.8$ $\frac{10.00}{0.495^2} = 40.8$ **(2)** $\frac{15.00}{0.606^2} = 40.8$ $\frac{20.00}{0.700^2} = 40.8$ Therefore $\frac{L_2}{{d_2}^2} = \text{constant}$ **(1)**	**3**	If only 3 calculations completed correctly then maximum 2 marks. If only 2 calculations completed correctly then maximum 1 mark (for relationship). If only 1 calculation completed correctly, award 0 marks. Must be clear how the candidate has used the data to establish the relationship. Accept: $\frac{L}{d^2} = \text{constant}$ $\frac{L}{d^2} = k$ $\frac{L}{d^2} = 40.8$ Ignore inappropriate averaging in this case. The 'conclusion' mark is only available if consistent with the calculations shown. Graphical method: Graph drawn correctly **(1)** Line of best fit through origin **(1)** Statement of relationship. **(1)** A sketch graph is not acceptable.

Question			Expected response	Max mark	Additional guidance
8.	(b)		(Lamps can be considered as) point source(s of light.)	**1**	
	(c)	(i)	$\left(\bar{d} = \frac{(0.88 + 0.86 + 0.90 + 0.89 + 0.86)}{5}\right)$ $\bar{d} = 0.88$ m	**1**	Accept: 0.9, 0.878, 0.8780
		(ii)	$\left(\Delta R = \frac{R_{\max} - R_{\min}}{n}\right)$ $\Delta\bar{d} = \frac{0.90 - 0.86}{5}$ **(1)** $\Delta\bar{d} = (\pm)0.01$ **m** **(1)**	**2**	Accept: 0.008 Accept: $d = (0.88 \pm 0.01)$ m **OR** $\Delta R = (\pm)0.01$ m
		(iii)	$\left(\frac{L_{lamp}}{d^2} = \frac{L_{Sun}}{D^2}\right)$ $\frac{1.0\times10^2}{0.88^2} = \frac{L_{Sun}}{(1.5\times10^{11})^2}$ **(1)** $L_{Sun} = 2.9\times10^{24}$ W **(1)**	**2**	Or consistent with (c)(i) Accept: 3, 2.91, 2.905

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$E = hf$ **(1)** $E = 6.63\times10^{-34}\times1.25\times10^{15}$ **(1)** $E = 8.29\times10^{-19}$ J **(1)**	**3**	Accept: 8.3, 8.288, 8.2875
		(ii)	Energy of photons is greater than work function. **OR** Energy of photons is high enough. **OR** Frequency (of UV/photons/radiation) is greater than threshold frequency. **OR** Frequency (of UV/photons/radiation) is high enough. **(1)** The (photo)electrons are attracted to/move towards the (positive) wire mesh. **(1)**	**2**	Must have first statement otherwise 0 marks. Accept: for the first mark arguments about the threshold frequency being less than the photon frequency. For second mark Looking for an indication that the (photo)electrons are completing the circuit. Accept: The electrons are attracted/move to the positive terminal.
	(b)		(Current) increases **(1)** More photons incident (on the zinc plate per second) **(1)**	**2**	MUST JUSTIFY Accept: there are more (photo)electrons ejected (per second).
	(c)		Current is zero **(1)** No (photo)electrons reach wire mesh **(1)**	**2**	JUSTIFY Accept: (Current) decreases **(1)** Accept: Zinc plate positively charged **OR** (photo)electrons are attracted back to the zinc plate **OR** Fewer (photo)electrons reach wire mesh (per second) **(1)**

Question			Expected response	Max mark	Additional guidance
10.	(a)		$v = f\lambda$ **(1)** $3.40\times10^2 = 1700\times\lambda$ **(1)** $\lambda = 0.20$ m **(1)**	**3**	Accept: 0.2, 0.200, 0.2000
	(b)		**path difference** $= m\lambda$ **(1)** $(1.80-1.50) = m\times0.20$ **(1)** $m = 1.5$ **(1)** **destructive (interference)** **(1)**	**4**	Or consistent with (a) Accept: $m = \frac{3}{2}$ in this case. Accept: path difference $= (m+\frac{1}{2})\lambda$ **(1)** $(1.80-1.50) = (m+\frac{1}{2})\times0.20$ **(1)** $m = 1$ **(1)** destructive (interference) **(1)** Using either relationship, if m is not an integer multiple of ½ then final mark is not accessible.
	(c)		(The amplitude) increases. **(1)** (Destructive) interference no longer takes place. **(1)**	**2**	JUSTIFY Must be consistent with conclusion from (b) Accept: louder Second mark can be justified by diagram.

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	6	**1**	
		(ii)	E_3 to E_0	**1**	Accept: $E_3 \rightarrow E_0$ Between E_3 and E_0 Direction must be correct. Do not accept: $E_3 - E_0$ 'E_3 and E_0' on its own Between E_0 and E_3

Question			Expected response	Max mark	Additional guidance
11.	(b)	(i)	$E_2 - E_1 = hf$ $-1.36\times10^{-19} - \left(-5.45\times10^{-19}\right) = 6.63\times10^{-34}\times f$ (1) $v = f\lambda$ (1) (**for both relationships** anywhere) $3.00\times10^{8} = \left(\dfrac{-1.36\times10^{-19} - \left(-5.45\times10^{-19}\right)}{6.63\times10^{-34}}\right)\times\lambda$ (1) $\lambda = 4.86\times10^{-7}$ m (1)	***4***	Accept: 4.9, 4.863, 4.8631 1 mark for both relationships (anywhere) 1 mark for substitution into 1st relationship 1 mark for substitution into 2nd relationship 1 mark for final answer Accept: $E_3 - E_1 = hf$ Do not accept: $E_1 - E_3 = hf$ Accept: $5.45\times10^{-19} - 1.36\times10^{-19} = 6.63\times10^{-34}\times f$ for 1st substitution mark Note: $\varDelta E = 4.09\times10^{-19}$ (J) Accept: $(\varDelta)E = hf$ and $v = f\lambda$ If $1{\cdot}36\times10^{-19} - 5{\cdot}45\times10^{-19}$ is shown for $\varDelta E$, maximum 1 mark for correct relationships. Alternative methods: $(\varDelta)E = \dfrac{hc}{\lambda}$ **OR** $E_2 - E_1 = \dfrac{hc}{\lambda}$ Combined relationship **(1)** Substitution for h and ΔE **(1)** Substitution for c **(1)** Final answer **(1)**
		(ii)	(emitted photon is) blue-green **(1)**	**1**	Must be consistent with (b)(i)

Question			Expected response	Max mark	Additional guidance
11.	(c)		(For the red line) more electrons are making this transition (per second). **(1)** (Therefore), there are more photons (per second) emitted (of that specific energy and so produce a brighter line). **(1)**	**2**	**INDEPENDENT MARKS** Do not accept greater brightness due to greater frequency/energy of the photons. 'More electrons release more photons' on its own – MAX 1 mark

Question			Expected response	Max mark	Additional guidance
12.	(a)		Plot a graph of $\sin\theta_i$ against $\sin\theta_r$ **(1)** Calculate gradient of graph **(1)**	**2**	Accept: $\sin i$ and $\sin r$ Accept: gradient of graph is n Accept reciprocal method: Plot a graph of $\sin\theta_r$ against $\sin\theta_i$ **(1)** Calculate inverse of gradient of graph **(1)** Do not accept: Calculating n for each angle of incidence and averaging (as this is an example of invalid averaging)
	(b)		$\sin\theta_c = \frac{1}{n}$ **(1)** $\sin\theta_c = \frac{1}{1.50}$ **(1)** $\theta_c = 41.8°$ **(1)**	**3**	Accept: 42, 41.81, 41.810
	(c)		<u>Total</u> internal reflection **(1)** 50° reflected angle shown on diagram **(1)**	**2**	Must be consistent with (b) Ray must be passably straight. Any change in direction at curved Perspex-air boundary MAX 1 mark. If answer for (b) is greater than 50°, MAX 1 mark for a ray that refracts away from the normal.

Question			Expected response	Max mark	Additional guidance
13.	(a)		(An alternating current) <u>changes direction</u> and (instantaneous) <u>value with time.</u>	**1**	Accept: 'magnitude' for 'value'
	(b)		$V_{rms} = \frac{V_{peak}}{\sqrt{2}}$ **(1)** $V_{rms} = \frac{(3 \times 5.0)}{\sqrt{2}}$ **(1)** $V_{rms} = 11$ **V** **(1)**	**3**	Accept: 10, 10.6, 10.61
	(c)		$T = \frac{1}{f}$ **(1)** $T = \frac{1}{250}$ **(1)** $(T = 4.0 \times 10^{-3}\ \text{s})$ $(\lambda = 4\ \text{div})$ Timebase setting = $\left(\frac{4.0 \times 10^{-3}}{4} = 1.0 \times 10^{-3} = \right)$ 1 (ms/div) **(1)**	**3**	Accept: 1 ms **OR** 1.0×10^{-3} s in this instance

Question			Expected response	Max mark	Additional guidance
14.	(a)	(i)	3.8 Ω	**1**	Accept: 3.7 - 3.8
		(ii)	$\left(gradient = E\right)$ $gradient = \frac{0-(-3.8)}{0.20-0}$ **(1)** $E = 19$ V **(1)**	**2**	Or consistent with (a)(i) substitution of any valid pair of points from line into gradient formula **(1)** value for E **(1)** For any value for E stated on its own, without any working, accept a value within the range: 18.5 – 20 V Alternative methods: $\left(R = \left(\frac{1}{I} \times E\right) - r\right)$ $11.4 = 0.8 \times E - 3.8$ (1) $E = 19$ V (1) **OR** $\left(R = \frac{E}{I} - r\right)$ $11.4 = \frac{E}{1.25} - 3.8$ (1) $E = 19$ V (1) If using this method, must use data from the line and value of r consistent with (a)(i) Do not accept: Any implication that $gradient \neq E$, eg $gradient = \frac{E}{I}$, **(0)**

Question			Expected response	Max mark	Additional guidance
14.	(a)	(iii)	$\left(I_{sc} = \frac{1}{x \text{ intercept}}\right)$ $I_{sc} = \frac{1}{0.20}$ **(1)** $I_{sc} = 5.0$ A **(1)**	**2**	Accept: 5, 5.00, 5.000 Alternative method: $\left(R = \frac{E}{I} - r\right)$ (I_{sc} **occurs when** $R = 0\,\Omega$) $0 = \frac{19}{I_{sc}} - 3.8$ **(1)** $I_{sc} = 5.0$ A **(1)** **OR** $(E = Ir)$ **OR** $(V = IR)$ $19 = I \times 3.8$ **(1)** $I = 5.0$ A **(1)** OR consistent with (a)(i) and/or (a)(ii)
	(b)		Same **(1)** $\left(I_{SC} = \frac{E}{r}\right)$ E and r are unchanged. **(1)**	**2**	JUSTIFY Short circuit current is not affected by load resistance/external resistance/R **OR** When a battery is short circuited the only resistance in the circuit is r (for the same E). **(1)**

Question			Expected response	Max mark	Additional guidance
15.	(a)		$\frac{1}{R_T}=\frac{1}{R_1}+\frac{1}{R_2}+\cdots$ **(1)** $\frac{1}{R_T}=\frac{1}{220}+\cdots+\frac{1}{220}$ **(1)** $R_T=22\ \Omega$ **(1)**	**3**	Accept: 20, 22.0, 22.00 If incorrect relationship used eg $R_T=\frac{1}{R_1}+\frac{1}{R_2}+\cdots$ then 0 marks Alternative method: $R_T=\frac{R}{n}$ **(1)** $R_T=\frac{220}{10}$ **(1)** $R_T=22\ \Omega$ **(1)**
	(b)	(i)	Photovoltaic (effect)	**1**	
		(ii)	Electrons gain/absorb energy from photons/light **(1)** Electrons move from <u>valence band</u> to <u>conduction band</u> **(1)** Electrons move towards n-type (semiconductor producing a potential difference). **(1)**	**3**	Look for reference to both conduction and valence band first, otherwise (0) marks. Bands must be named correctly, eg do not accept 'valency' or 'conductive'. Third statement is dependent on second statement.

Question			Expected response	Max mark	Additional guidance
16.	(a)	(i)	Axes appropriately labelled (quantity and units) and axes linearly scaled **(1)** [Allow for axes starting at zero or broken axes or an appropriate value] Data points plotted accurately **(1)** Appropriate line of best-fit **(1)**	**3**	If the origin is shown the scale must either be continuous, or the axis must be 'broken'. Otherwise, maximum 2 marks. If non-linear scale is used over the range of the data on either axis eg values from the table are used as the scale points, (0) marks. Do not penalise if candidates plot e against F. Accuracy of plotting should be easily checkable with the scale chosen. An appropriate scale to allow the accuracy of plotting to be checked must be linear over the range of the data.

Question			Expected response	Max mark	Additional guidance
16.	(a)	(ii)	$(gradient = k)$ $gradient = \frac{5.9-2.6}{24\times10^{-3}-10\times10^{-3}}$ **(1)** $k = 240\ \text{Nm}^{-1}$ **(1)**	2	**<u>Must be</u>** consistent with (a)(i). If relationship to calculate gradient is stated incorrectly (0) marks, eg $\frac{y^2-y^1}{x^2-x^1}$ Tolerance required depending upon best fit line drawn by the candidate. If candidates use values from the table, these points must lie on **<u>their line</u>**. If ($\times10^{-3}$) is not accounted for in the final answer, maximum 1 mark unless this being omitted is consistent with the graph drawn in (a)(i). If the candidate has drawn a straight line through the origin, then any point on the line can be used to calculate the spring constant using $F = ke$ If the line drawn (or extrapolated line) does NOT pass through the origin, the gradient of the line must be used and not one single point selected, otherwise 0 marks. If the candidate uses a broken scale on either axis, or does not start their scale at zero, they must use the gradient in their calculation of k, otherwise 0 marks. If candidate has plotted e against F, then any implication of k = gradient, 0 marks, as in this case: $k = \frac{1}{gradient}$

Question			Expected response	Max mark	Additional guidance
16.	(a)	(iii)	Repeat the measurements and calculate the mean **OR** Use a greater range of masses/forces	**1**	Accept: 'Average' for 'mean' Accept: use smaller increments Do not accept: 'Repeat the **<u>experiment</u>** and take the mean' on its own. **OR** 'Take more measurements' on its own. **OR** Answers addressing precision of measuring instruments. **OR** Answers addressing a systematic uncertainty.
	(b)		$E_e = \frac{ke^2}{2}$ $E_e = \frac{240 \times (22 \times 10^{-3})^2}{2}$ **(1)** $E_e = 5.8 \times 10^{-2}$ J **(1)**	**2**	Must be consistent with (a)(ii)

[END OF 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 this 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 always be assigned in line with these marking principles, the Physics: general marking principles (GMPs) (Physics: general marking principles - National 3 to Advanced Higher (sqa.org.uk)) 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) Where a candidate answers part of a question incorrectly and carries the incorrect answer forward in the following part, award marks if the incorrect answer has then been used correctly in the subsequent part or 'follow-on'. (GMP 16)

(e) 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 20)

(f) 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)

(g) Award marks 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). (GMP 19)

(h) Marks are allocated for knowledge of relevant relationships alone. Do not award a mark when a candidate writes down several relationships and does not select the correct one to continue with, for example by substituting values. (GMP 1c)

(i) 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 2)

(j) In rounding to an expected number of significant figures, award the mark for responses that have up to two figures more or one figure less than the number in the data with the fewest significant figures. (GMP 6)

(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.)

(k) 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, 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*, eg 'defraction'
- that might be interpreted as either *fission* or *fusion*, eg 'fussion'

The spelling of these words is similar, but the words have totally different meanings. If the spelling (or handwriting) in an answer makes it difficult for you to interpret a candidate's intention, then do not award the mark. (GMP 22)

(l) 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. 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 are given credit 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) that would lead to a correct answer.

Sometimes, a question requires a calculation that 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.

(l) Marking in calculations

Example 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)

	Example response	Mark and comment
1.	$V = IR$ $7.5 = 1.5R$ $R = 5.0\ \Omega$	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.	$R = \frac{I}{V} = \frac{1.5}{7.5} = 5.0\ \Omega$	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 correct but wrong rearrangement of symbols