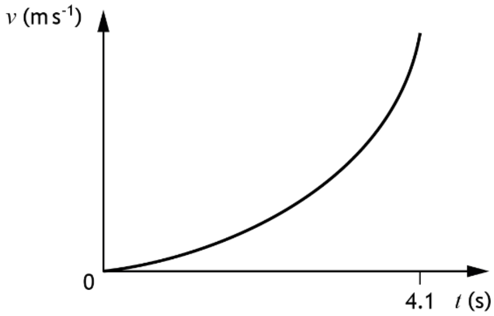
National
Qualifications
2022

2022 Physics

Advanced Higher

Finalised Marking Instructions

Marking Instructions for each question

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	$\left(v = 6.6t^2 + 2.2t\right)$ $a\left(=\frac{dv}{dt}\right) = 13.2t + 2.2$ **(1)** $a = (13.2 \times 4.1) + 2.2$ **(1)** $a = 56\ \text{ms}^{-2}$ **(1)**	3	Accept: 60, 56.3, 56.32
		(ii)	$\left(s = \int (6.6t^2 + 2.2t).dt\right)$ $s = \frac{6.6}{3}t^3 + \frac{2.2}{2}t^2\ (+c)$ **(1)** ($s = 0$ when $t = 0$, so $c = 0$) $s = \frac{6.6}{3} \times 4.1^3 + \frac{2.2}{2} \times 4.1^2$ **(1)** $s = 170$ m **(1)**	3	Accept: 200, 170.1 Solution with limits also acceptable $\left(s = \int_0^{4.1} (6.6t^2 + 2.2t).dt\right)$ $s = \left[\frac{6.6}{3}t^3 + \frac{2.2}{2}t^2\right]_0^{4.1}$ **(1)** $s = \left(\frac{6.6}{3} \times 4.1^3 + \frac{2.2}{2} \times 4.1^2\right)\ (-0)$ **(1)** $s = 170$ m **(1)**
	(b)			1	Single smooth curve with increasing gradient. Must start at the origin and extend to 4.1 s. Ignore any lines beyond t = 4.1 s

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	$\omega = \omega_0 + \alpha t$ **(1)** $0.52 = 0 + \alpha \times 18$ **(1)** $\alpha = 0.029$ rads^{-2} **(1)**	**3**	Accept 0.03, 0.0289, 0.02889
		(ii)	$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$ **(1)** $\theta = 0 \times 18 + 0.5 \times 0.029 \times 18^2$ **(1)** $\theta = 4.7$ rad **(1)**	**3**	Or consistent with (a)(i) Accept: 5, 4.70, 4.698 $\omega^2 = \omega_0^2 + 2\alpha\theta$ **(1)** $0.52^2 = 0^2 + 2 \times 0.029 \times \theta$ **(1)** $\theta = 4.7$ rad **(1)** Accept: 5, 4.66, 4.662 $\theta = \left(\frac{\omega_0 + \omega}{2}\right)t$ **(1)** $\theta = \left(\frac{0 + 0.52}{2}\right) \times 18$ **(1)** $\theta = 4.7$ rad **(1)** Accept: 5, 4.68, 4.680
	(b)	(i)	$v = r\omega$ **(1)** greater r same ω **(1)**	**2**	$v = \frac{d}{t}$ **(1)** greater d same t **(1)**
		(ii)	(Centripetal acceleration of Y is) greater **(1)** Student Y is a greater distance from the axis of rotation $a_r = r\omega^2$, ω is the same for X and Y. **(1)**	**2**	MUST JUSTIFY Accept as justification: $a_r = \frac{v^2}{r}$ both v and r increase but v is squared (so more significant) (1) Could be answered by calculation $a_t = r\alpha$ or $a = r\alpha$ is incorrect justification (0)

Question			Expected response	Max mark	Additional guidance
3.	(a)		$I_{(rod)} = \frac{1}{3}ml^2$ and $I_{(hoop)} = mr^2$ **(1), (1)** $I = \left(5 \times \frac{1}{3} \times 0.07 \times 0.14^2\right) + \left(0.38 \times 0.14^2\right)$ **(1)** $I = 9.7 \times 10^{-3}$ kgm^2	3	NON-STANDARD SHOW 1 for rod relationship 1 for hoop relationship $I_{(wheel)} = \left(5 \times \frac{1}{3}ml^2\right) + mr^2$ (1), (1) Final answer must be shown, otherwise max 2. May also be calculated separately but addition must be shown before the final answer.
	(b)	(i)	$\tau = Fr$ **(1)** $\tau = 1.2 \times 0.14$ **(1)** $\tau = 0.17$ Nm **(1)**	3	Accept: 0.2, 0.168, 0.1680
		(ii)	$\tau = I\alpha$ **(1)** $\tau = 9.7 \times 10^{-3} \times 16$ **(1)** $\left(\tau_F = \tau_A - \tau_U\right)$ $\tau_F = 0.17 - \left(9.7 \times 10^{-3} \times 16\right)$ **(1)** $\tau_F = 0.015$ Nm **(1)**	4	Or consistent with (b)(i) Accept: 0.01, 0.0148, 0.01480
	(c)		(The angular velocity increases so the required) centripetal force increases **(1)** until the friction is insufficient (to hold the stone in place) **(1)**	2	Accept: central force

Question			Expected response	Max mark	Additional guidance
4.	(a)		$E_P = -\frac{GMm}{r}$ **(1)** $E_P = -\frac{6.67\times10^{-11}\times6.0\times10^{24}\times2.30\times10^{3}}{(6.4\times10^{6}+3.12\times10^{5})}$ **(1)** $E_P = -1.4\times10^{11}$ J	2	SHOW Final answer must be shown otherwise MAX 1 $V = -\frac{GM}{r}$ and $E_p = Vm$ both relationships required for 1st mark all substitutions required for 2nd mark.
	(b)		$d = \bar{v}t$ **(1)** $2\pi\times(6.4\times10^{6}+3.12\times10^{5}) = \bar{v}\times90.7\times60$ **(1)** $\bar{v} = 7750$ ms^{-1} **(1)**	3	Accept: 7700, 7749, 7749.5 $\omega = \frac{2\pi}{T}$ and $v = r\omega$ (1) $v = (6.4\times10^{6}+3.12\times10^{5})\times\frac{2\pi}{(90.7\times60)}$ (1) $v = 7750$ ms^{-1} (1) OR $\frac{mv^2}{r} = \frac{GMm}{r^2}$ (1) $\frac{2.30\times10^{3}\times v^2}{3.12\times10^{5}+6.4\times10^{6}} = \frac{6.67\times10^{-11}\times6.0\times10^{24}\times2.3\times10^{3}}{(3.12\times10^{5}+6.4\times10^{6})^2}$ (1) $v = 7720$ ms^{-1} (1) Accept: 7700, 7722, 7721.7
	(c)		$(E_{\text{total}} = E_P + E_K)$ $E_{\text{total}} = E_P + \frac{1}{2}mv^2$ **(1)** $E_{\text{total}} = -1.4\times10^{11} + (0.5\times2.30\times10^{3}\times7750^2)$ **(1)** $E_{\text{total}} = -7.1\times10^{10}$ J **(1)**	3	Or consistent with (b) Accept: 7, 7.09, 7.093 $E_{\text{total}} = -\frac{GMm}{2r}$ **(1)** $E_{\text{total}} = -\frac{6.67\times10^{-11}\times6.0\times10^{24}\times2.30\times10^{3}}{2\times(6.4\times10^{6}+3.12\times10^{5})}$ **(1)** $E_{\text{total}} = -6.9\times10^{10}$ J **(1)** Accept: 7, 6.86, 6.857
	(d)		(low-altitude orbit satellites experience) greater drag/friction from the atmosphere (than high-altitude orbit satellites). or similar	1	Do not accept: drag or friction alone or arguments about gravitational field strength alone.

Question			Expected response	Max mark	Additional guidance
4.	(e)		$\left(r^3 = R^3\left(\frac{M_2}{3M_1}\right)\right)$ $r^3 = \left(3.84\times10^8\right)^3 \times \left(\frac{7.3\times10^{22}}{3\times6.0\times10^{24}}\right)$ **(1)** $r = 6.1\times10^7$ m **(1)**	2	Accept 6, 6.12, 6.124

Question			Expected response	Max mark	Additional guidance
5.	(a)		$r_{schwarzschild} = \frac{2GM}{c^2}$ **(1)** $r_{schwarzschild} = \frac{2 \times 6.67 \times 10^{-11} \times 2.19 \times 10^{31}}{\left(3.00 \times 10^{8}\right)^{2}}$ **(1)** $r_{schwarzschild} = 3.25 \times 10^{4}$ m **(1)**	**3**	Accept: 3.2, 3.246, 3.2461
	(b)		<u>Hydrogen fusion</u> stops/ceases.	**1**	
	(c)		$b = \frac{L}{4\pi d^2}$ **(1)** $L = 4\pi r^2 \sigma T^4$ **(1)** $5.0 \times 10^{-8} \times 4\pi\left(250 \times 365.25 \times 24 \times 60 \times 60 \times 3.00 \times 10^{8}\right)^{2}$ $= 4\pi\left(4.0 \times 10^{9}\right)^{2} \times 5.67 \times 10^{-8} \times T^4$ (1),**(1)** $T = 2.4 \times 10^{4}$ K **(1)**	**5**	Accept 2, 2.36, 2.357 If 365 used Accept: 2, 2.36, 2.356 250 ly conversion mark independent

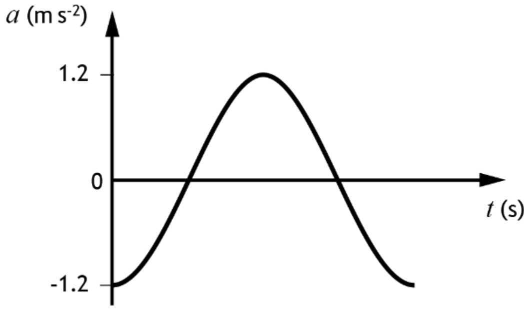
Question			Expected response	Max mark	Additional guidance
5.	(d)		**Award 3 marks** where the candidate has demonstrated a good understanding of the physics involved. They show a good comprehension of the physics of the situation and provide a logically correct answer to the question posed. This type 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
6.	(a)		It is not possible to know the (precise) momentum and position of a quantum particle simultaneously.	**1**	It is not possible to know the (precise) lifetime and associated energy change of a quantum particle simultaneously.
	(b)		The momentum of the alpha particle is known precisely therefore its position is not known precisely **(1)** there is a (small) probability that the particle could exist outside the nucleus (even although classically it does not have sufficient energy to escape). **(1)**	**2**	Second mark is dependent on the first mark being awarded. The lifetime of the alpha particle is known precisely therefore its energy is not known precisely **(1)** there is a (small) probability that the particle could escape from the nucleus (even although classically it does not have sufficient energy to escape). **(1)**
	(c)		$\Delta E \Delta t \geq \frac{h}{4\pi}$ **(1)** $\Delta E_{(\min)} \times 0.70 \times 10^{-6} = \frac{6.63 \times 10^{-34}}{4\pi}$ **(1)** $\Delta E_{(\min)} = 7.5 \times 10^{-29}$ J **(1)**	**3**	Accept: 8, 7.54, 7.537 Accept: $\Delta E_{\min} \Delta t = \frac{h}{4\pi}$ Do not accept as starting point: $\Delta E_{\min} \Delta t \geq \frac{h}{4\pi}$ $\Delta E \Delta t = \frac{h}{4\pi}$ Do not accept as final answer: $\Delta E_{\min} \geq 7.5 \times 10^{-29}$ J $\Delta E \geq 7.5 \times 10^{-29}$ J

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.

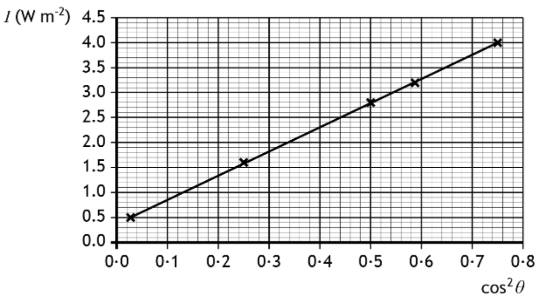
Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	$\lambda = \frac{h}{p}$ **(1)** $\lambda = \frac{6.63 \times 10^{-34}}{9.11 \times 10^{-31} \times 1.75 \times 10^{7}}$ **(1)** $\lambda = 4.16 \times 10^{-11}$ m **(1)**	3	Accept: 4.2, 4.159, 4.1587 Accept: $\lambda = \frac{h}{mv}$ (1)
		(ii) (A)	Yes, as 4.16×10^{-11} (m) < 2.6×10^{-10} (m) **OR** Yes, as the de Broglie wavelength is of the same magnitude as the diameter of the atom	1	Or consistent with (a)(i) Accept: Yes, as the de Broglie wavelength is smaller than the diameter of the atom
		(B)	mass three orders of magnitude greater (and velocity three orders of magnitude less) **(1)** de Broglie wavelength is similar to diameter of gold atom. **(1)**	2	Can show by calculation. 2nd mark is dependent on the 1st mark being awarded.
	(b)		A single value from 398 – 410 nm	1	

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$v_{(parallel)} = 1.38 \times 10^7 \text{ ms}^{-1}$	1	Accept: 1.4, 1.375, 1.3750
		(ii)	$v_{(perpendicular)} = 2.38 \times 10^7 \text{ ms}^{-1}$	1	Accept: 2.4, 2.382, 2.3816
	(b)	(i)	$F = qvB$ **(1)** $F = 1.60 \times 10^{-19} \times 2.38 \times 10^7 \times 23 \times 10^{-6}$ **(1)** $F = 8.8 \times 10^{-17}\text{N}$	2	SHOW Accept: $F = qvB\sin\theta$ $F = 1.60 \times 10^{-19} \times 2.75 \times 10^7 \times 23 \times 10^{-6} \times \sin 60.0$ Must have final answer, otherwise max 1.
		(ii) (A)	$F = \frac{mv^2}{r}$ **(1)** $8.8 \times 10^{-17} = \frac{1.673 \times 10^{-27} \times (2.38 \times 10^7)^2}{r}$ **(1)** $r = 1.1 \times 10^4 \text{ m}$ **(1)**	3	Or consistent with (a)(ii) Accept: 1, 1.08, 1.077 $r = \frac{mv}{qB}$ ok as starting point Accept: 1, 1.08, 1.082
		(ii) (B)	$v = r\omega$ and $\omega = \frac{2\pi}{T}$ **(1)** $\left(T = \frac{2\pi r}{v}\right)$ $T = \frac{2\pi \times 1.1 \times 10^4}{2.38 \times 10^7}$ **(1)** $T = 2.9 \times 10^{-3} \text{ s}$ **(1)**	3	Or consistent with (a)(ii) and (b)(ii)(A) Accept:3, 2.90, 2.904 Accept: $d = \bar{v}t$ and $d = 2\pi r$ as starting point $F = mr\omega^2$ and $\omega = \frac{2\pi}{T}$ (1) $8.8 \times 10^{-17} = \frac{1.673 \times 10^{-27} \times 1.1 \times 10^4 \times 4 \times \pi^2}{T^2}$ (1) $T = 2.9 \times 10^{-3} \text{ s}$ (1) Accept: 3, 2.87, 2.873
		(iii)	$d = vt$ **(1)** $d = 1.38 \times 10^7 \times 2.9 \times 10^{-3}$ **(1)** $d = 4.0 \times 10^4 \text{ m}$ **(1)**	3	Or consistent with (a)(i) and (b)(ii)(B) Accept: 4, 4.00, 4.002
	(c)		radius decreases **(1)** pitch decreases **(1)**	2	

Question			Expected response		Max mark	Additional guidance
10.	(a)		Displacement is proportional to and in the opposite direction to the acceleration/unbalanced force.		1	$F=-ky$ or equivalent.
	(b)		$y=A\cos\left(\sqrt{\frac{k}{m}}t\right)$ $\frac{dy}{dt}=-A\sqrt{\frac{k}{m}}\sin\left(\sqrt{\frac{k}{m}}t\right)$ $\frac{d^2y}{dt^2}=-A\frac{k}{m}\cos\left(\sqrt{\frac{k}{m}}t\right)$ $m\frac{d^2y}{dt^2}=-kA\cos\left(\sqrt{\frac{k}{m}}t\right)$ **OR** $m\frac{d^2y}{dt^2}=-ky$ $m\frac{d^2y}{dt^2}+ky=0$	 **(1)** **(1)**	2	NON-STANDARD SHOW 1 mark for <u>both differentiations</u> When first differentiation shown, it must be correct, otherwise 0 marks. Final relationship must be shown, otherwise max 1.
	(c)	(i)	$\omega=\sqrt{\frac{k}{m}}$ $\omega=\sqrt{\frac{24}{0.75}}$ $\omega=5.7$ rads^{-1}	**(1)** **(1)**	2	NON-STANDARD SHOW Final answer must be shown, otherwise max 1
		(ii)	$a=(-)\omega^2y$ $a_{(\max)}=(-)5.7^2\times0.038$ $a_{(\max)}=(-)1.2$ ms^{-2}	**(1)** **(1)** **(1)**	3	Accept:1, 1.23, 1.235 Accept: $a=(-)\omega^2A$
		(iii)			2	Or consistent with (c)(ii) If harmonic function shown: 1 for values of a_{max} 1 for shape (cos or -cos curve) Non-harmonic function (0) Can show damping if done correctly.

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	$E = kA^2$ **(1)** $(8.17 = k \times 12.6^2)$ $E_2 = \frac{8.17}{12.6^2} \times 6.3^2$ **(1)** $E_2 = 2.04$ mJ **(1)**	**3**	Accept: 2.0, 2.043, 2.0425 Accept: $\frac{E_1}{A_1^2} = \frac{E_2}{A_2^2}$ (1) $\frac{8.17}{12.6^2} = \frac{E_2}{6.3^2}$ (1) $E_2 = 2.04$ mJ (1)
	(a)	(ii)	$y = 6.3 \sin 2\pi(1.32t + 1.04x)$	**2**	1 for all numerical values 1 for change of sign
	(b)		$\phi = \frac{2\pi x}{\lambda}$ **(1)** $\phi = \frac{2\pi \times (3.6 - 2.0)}{4.0}$ **(1)** $\phi = \frac{4\pi}{5}$ rad **(1)**	**3**	Accept: 3, 2.5, 2.51, 2.513

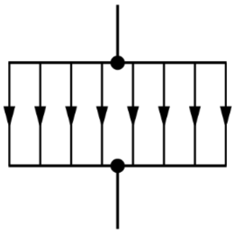
Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	$\Delta x = \frac{\lambda D}{d}$ **(1)** $\Delta x = \frac{633 \times 10^{-9} \times 2.42}{0.38 \times 10^{-3}}$ **(1)** $\Delta x = 4.0 \times 10^{-3}\,\text{m}$ **(1)**	**3**	Accept: 4, 4.03, 4.031
		(ii)	$\frac{\Delta(\Delta x)}{\Delta x} = \sqrt{\left(\frac{\Delta D}{D}\right)^2 + \left(\frac{\Delta d}{d}\right)^2}$ **(1)** $\frac{\Delta(\Delta x)}{4.0 \times 10^{-3}} = \sqrt{\left(\frac{0.02}{2.42}\right)^2 + \left(\frac{0.01}{0.38}\right)^2}$ **(1)** $\Delta(\Delta x) = 1.1 \times 10^{-4}\,\text{m}$ **(1)**	**3**	Or consistent with (a)(i) Suspend significant figures rule Accept: rule of three applied Accept calculations using percentages.
	(b)		$\Delta x = (3.90 \pm 0.03)$ mm	**1**	Suspend significant figures rule Accept uncertainty as a %
	(c)		(b) or 3.90 mm **(1)** As it has a smaller (absolute/fractional/percentage) uncertainty **(1)**	**2**	**MUST JUSTIFY** Or consistent with (a) and/or (b) Accept: It is more precise. (1) Smaller random/systematic/scale reading uncertainty is incorrect.
	(d)		(The fringe separation) decreases **(1)** λ decreases, d and D remain constant **(1)**	**2**	**MUST JUSTIFY** Accept: $\Delta x \propto \lambda$ for second mark

<table>
<tr><th colspan="3">Question</th><th>Expected response</th><th>Max mark</th><th>Additional guidance</th></tr>
<tr><td>13.</td><td>(a)</td><td></td><td>(The electric field vector) oscillates (or vibrates) in one plane only.</td><td>1</td><td>Do not accept:
direction instead of plane
or
travels instead of oscillates</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td><table><tr><th>I (W m^{-2})</th><th>$\cos^2\theta$</th></tr><tr><td>4.0</td><td>0.75</td></tr><tr><td>3.2</td><td>0.59</td></tr><tr><td>2.8</td><td>0.50</td></tr><tr><td>1.6</td><td>0.25</td></tr><tr><td>0.5</td><td>0.03</td></tr></table></td><td>1</td><td>Accept a range of 1 to 4 significant figures</td></tr>
<tr><td></td><td></td><td>(ii)</td><td>
</td><td>3</td><td>1 mark for labels including unit and suitable scales
1 mark for accurate plotting (±½ box tolerance and consistent with (b)(i))
1 mark for line of best fit

Non-linear scale(s) across the range of the data
– award 0 marks
Do not penalise for swapping the axes</td></tr>
<tr><td></td><td></td><td>(iii)</td><td>(1) for substitution into gradient relationship (may be implied)
(1) for answer</td><td>2</td><td>Must be consistent with candidate's line
Determine gradient
Must use two points on the line.</td></tr>
<tr><td></td><td></td><td>(iv)</td><td>(1) for value of $\cos^2\theta$ from graph
(1) for θ</td><td>2</td><td>Must be consistent with candidate's line

If using the equation of a straight line, must include y-axis intercept, otherwise 0 marks.</td></tr>
<tr><td></td><td></td><td>(v)</td><td>intercept of candidate's line with I axis</td><td>1</td><td>Must be consistent with candidate's line.</td></tr>
</table>

Question			Expected response	Max mark	Additional guidance
13.	(c)	(i)	Reduce the background light level **OR** Place a black cloth on the bench **OR** Repeat measurements (and take the mean)	**1**	Measurements of angle only not acceptable. 0 marks
		(ii)	Repeat measurements (and take the mean) **OR** Use a (light) meter that measures to more decimal places/finer graduations on scale	**1**	Measurements of angle only not acceptable. 0 marks

Question			Expected response	Max mark	Additional guidance
14.	(a)		$\frac{1}{2}mv^2 = QV$ **(1)** $0.5 \times 9.11 \times 10^{-31} \times (2.9 \times 10^7)^2 = 1.60 \times 10^{-19} \times V$ **(1)** $V = 2.4 \times 10^3$ V **(1)**	**3**	Accept:2, 2.39, 2.394 Accept negative value for ***Q***.
	(b)			**1**	Ignore end effects. Field lines must be straight/spaced uniformly. Field lines must start and end on the plates.
	(c)		The electrons travel with (constant) horizontal speed/velocity. **(1)** Electrons travel with (constant) vertical acceleration. **(1)**	**2**	No force in the horizontal direction **(1)** Unbalanced force in the vertical direction **(1)** Accept: Perpendicular to field in place of horizontal Parallel to field in place of vertical. Do not accept: Attracted to the top/positive plate without reference to unbalanced force for second mark
	(d)	(i)	$v^2 = u^2 + 2as$ **(1)** $(1.2 \times 10^7)^2 = 0^2 + 2 \times a \times 4.0 \times 10^{-3}$ **(1)** $a = 1.8 \times 10^{16}$ ms^{-2}	**2**	SHOW Final answer must be shown, otherwise MAX 1.
		(ii)	$(F = ma)$ $F = 9.11 \times 10^{-31} \times 1.8 \times 10^{16}$ **(1)** $F = QE$ and $E = \frac{V}{d}$ **(1)** $\left(F = \frac{QV}{d}\right)$ $9.11 \times 10^{-31} \times 1.8 \times 10^{16} = 1.60 \times 10^{-19} \times \frac{0.90 \times 10^3}{d}$ **(1)** $d = 8.8 \times 10^{-3}$ m **(1)**	**4**	Accept: 9, 8.78, 8.782

Question			Expected response	Max mark	Additional guidance
15.	(a)	(i)	$B = \frac{\mu_0 I}{2\pi r}$ **(1)** $B = \frac{4\pi \times 10^{-7} \times 1.8 \times 10^3}{2\pi \times 30.0}$ **(1)** $B = 1.2 \times 10^{-5}$ T **(1)**	**3**	Accept: 1, 1.20, 1.200
		(ii)	$F = IlB$ **(1)** $\frac{F}{l} = 1.8 \times 10^3 \times 1.2 \times 10^{-5}$ **(1)** $\frac{F}{l} = 2.2 \times 10^{-2}$ Nm^{-1} **(1)**	**3**	or consistent with (a)(i) Accept: 2, 2.16, 2.160 Where l is substituted as 1 accept final answer in N
	(b)		$\left(v_m = \frac{1}{\sqrt{\varepsilon_r \varepsilon_0 \mu_r \mu_0}} \right)$ $1.52 \times 10^8 = \frac{1}{\sqrt{\varepsilon_r \times 8.85 \times 10^{-12} \times 1.00 \times 4\pi \times 10^{-7}}}$ **(1)** $\varepsilon_r = 3.89$ **(1)**	**2**	Accept:3.9, 3.892, 3.8919 If unit given in final answer (1) max.

Question			Expected response	Max mark	Additional guidance
16.	(a)		Inductive reactance is the opposition (of an inductor) to changing current **(1)**	**1**	
	(b)	(i)	$\left(X_L = 2\pi fL,\ X_C = \frac{1}{2\pi fC}\right)$ $2\pi f_0 L = \frac{1}{2\pi f_0 C}$ **(1), (1)** $f_0 = \frac{1}{2\pi\sqrt{LC}}$	**2**	NON-STANDARD SHOW 1 mark for both relationships 1 mark for equating using f_0 If equated using f then maximum 1 mark Final relationship must be shown otherwise maximum 1 mark
		(ii)	$f_0 = \frac{1}{2\pi\sqrt{LC}}$ $160\times10^3 = \frac{1}{2\pi\sqrt{120\times10^{-6}\times C}}$ **(1), (1)** $C = 8.2\times10^{-9}$ F **(1)**	**3**	Accept: 8, 8.25, 8.246 1 mark for $f_0 = 160\times10^3$ (Hz)
	(c)	(i)	$\tau = RC$ **(1)** $250 = 125\times10^3\times C$ **(1)** $C = 2.0\times10^{-3}$ F **(1)**	**3**	Accept: 2, 2.00, 2.000
		(ii)	At 250 s, voltage = 4.4 V **(1)** $\frac{4.4}{12.0}$ **(1)** $(=0.37) = 37\%$	**2**	NON-STANDARD SHOW $37\%\times12 = 4.4$ (V) **(1)** 4.4 (V) gives a time of 250 s **(1)** Accept 4.44 (V) Do not accept: 4 (V)

[END OF MARKING INSTRUCTIONS]

General marking principles for Physics Advanced Higher

Always assign marks for each candidate response in line with these marking principles, the Physics: general marking principles (GMPs) (http://www.sqa.org.uk/files_ccc/Physicsgeneralmarkingprinciples.pdf) and the detailed marking instructions for this assessment.

(a) Always use positive marking. This means candidates accumulate marks for the demonstration of relevant skills, knowledge and understanding; marks are not deducted from a maximum on the basis of errors or omissions.

(b) 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.

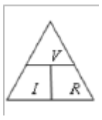
(c) Where a candidate incorrectly answers part of a question and carries the incorrect answer forward in the following part, award marks if the incorrect answer has then been used correctly in the subsequent part or 'follow-on'. (GMP 17)

(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 correctly conveys 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. (GMP 3)

(g) Award marks for the use of 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 responses that have up to two figures more or one figure less than the number in the data with the fewest significant figures. (GMP 10)

For example:

Data in question is given to 3 significant figures.

Correct final answer is 8.16 J.

Final answer 8.2 J or 8.158 J or 8.1576 J – award the final mark.

Final answer 8 J or 8.15761 J – do not award the final mark

(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 m**arks for a valid response to the question asked. Where candidates are asked 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.

(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