National
Qualifications
2023

2023 Physics

Advanced Higher

Finalised Marking Instructions

Marking Instructions for each question

Question			Expected response	Max mark	Additional guidance
1.	(a)		$a\left(=\frac{dv}{dt}\right)=3\times0.0044t^2+2\times0.012t$ 1 $a=3\times0.0044\times8.0^2+2\times0.012\times8.0$ 1 $a=1.0\ \text{ms}^{-2}$ 1	**3**	Accept: 1, 1.04, 1.037
	(b)		$s\left(=\int v\,dt\right)=\frac{0.0044t^4}{4}+\frac{0.012t^3}{3}(+c)$ 1 (at $t=0$ $s=0$ $\therefore c=0$) $s=\frac{0.0044\times8.0^4}{4}+\frac{0.012\times8.0^3}{3}$ 1 $s=6.6$ m 1	**3**	Accept: 7, 6.55, 6.554 $\left(s=\int_0^{8.0}v.dt\right)$ $s=\left[\frac{0.0044t^4}{4}+\frac{0.012t^3}{3}\right]_0^{8.0}$ 1 $s=\left(\frac{0.0044\times8.0^4}{4}+\frac{0.012\times8.0^3}{3}\right)-0$ 1 $s=6.6$ m 1

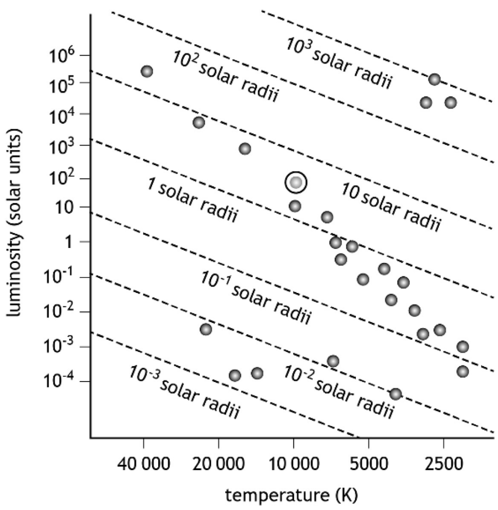
Question			Expected response	Max mark	Additional guidance
2.	(a)		$\omega = \frac{d\theta}{dt}$ or $\omega = \frac{\theta}{t}$ **1** $\omega = \frac{6.2 \times 2\pi}{60}$ **1** $\omega = 0.65$ rad s^{-1}	**2**	Non-standard SHOW Question Accept: $\omega = 2\pi f$ or $\omega = \frac{2\pi}{T}$
	(b)	(i)	$F = mr\omega^2$ **1** $F = 0.36 \times 10^{-3} \times 83 \times 10^{-3} \times 0.65^2$ **1** $F = 1.3 \times 10^{-5}$ N **1**	**3**	Accept: 1, 1.26, 1.262 $F = \frac{mv^2}{r}$ and $v = r\omega$ **1** all substitutions **1**
		(ii)	Towards the centre of the plate/circular path.	**1**	
	(c)		(for a given ω) the (required/needed) centripetal/central force is greater for the second pea since radius/distance from axis of rotation is greater **1** friction is insufficient to provide the required centripetal force **1**	**2**	Independent marks Any indication of second pea having centripetal force greater than friction (max 1)

Question			Expected response	Max mark	Additional guidance
3.	(a)		$I=\frac{1}{2}mr^2$ 1 $I=0.5\times0.82\times\left(150\times10^{-3}\right)^2$ 1 $I=9.2\times10^{-3}\ \text{kg m}^2$	**2**	SHOW question
	(b)	(i)	$I_{ring}=mr^2$ 1 $I_{table}\omega_{table}=\left(I_{table}+I_{ring}\right)\omega_2$ 1 $9.2\times10^{-3}\times12=$ $\left(9.2\times10^{-3}+75\times10^{-3}\times\left(130\times10^{-3}\right)^2\right)\omega_2$ 1 $\omega_2=11\ \text{rad s}^{-1}$ 1	**4**	Accept: 10, 10.5, 10.55 Indication of conservation of angular momentum – independent 1 mark
		(ii)	$E_k=\frac{1}{2}I\omega^2$ 1 $\left(\Delta E_k=\frac{1}{2}I_{table}\omega_{table}^2-\frac{1}{2}(I_{table}+I_{ring})\omega_2^2\right)$ $\Delta E_k=\left(0.5\times9.2\times10^{-3}\times12^2\right)-$ $\left(0.5\left(9.2\times10^{-3}+\left(75\times10^{-3}\times\left(130\times10^{-3}\right)^2\right)\right)\times11^2\right)$ 1,1 $\Delta E_k=0.029\ \text{J}$ 1	**4**	Or consistent with (b)(i) Accept: 0.03, 0.0291, 0.02912 1 for substitution into E_k before 1 for substitution into E_k after
		(iii)	(Work done against) friction between the ring and turntable.	**1**	Friction alone, 0 marks.

Question			Expected response	Max mark	Additional guidance
4	(a)		$V = -\frac{GM}{r}$ 1 $V = -\frac{6.67\times10^{-11}\times6.42\times10^{23}}{(3.39\times10^{6}+2.5\times10^{5})}$ 1 $V = -1.18\times10^{7}$ J kg^{-1}	2	SHOW question
	(b)		$\Delta V = -1.10\times10^{7} - (-1.18\times10^{7})$ 1 $(\Delta)E_p = (\Delta)Vm$ 1 $(\Delta)E_p = (-1.10\times10^{7} - (-1.18\times10^{7}))\times4.3\times10^{3}$ 1 $(\Delta)E_p = 3.4\times10^{9}$ J 1	4	Accept: 3, 3.44, 3.440 Alternative method: $E_p = Vm$ 1 $E_{p\ \text{low}} = -1.18\times10^{7}\times4.3\times10^{3}$ $E_{p\ \text{high}} = -1.10\times10^{7}\times4.3\times10^{3}$ 1 $(\Delta)E_p = (-1.10\times10^{7} - (-1.18\times10^{7}))\times4.3\times10^{3}$ 1 $(\Delta)E_p = 3.4\times10^{9}$ J 1
	(c)	(i)	$v_{esc} = \sqrt{\frac{2GM}{r}}$ 1 $v_{esc} = \sqrt{\frac{2\times6.67\times10^{-11}\times6.42\times10^{23}}{3.39\times10^{6}}}$ 1 $v_{esc} = 5.03\times10^{3}$ ms^{-1} 1	3	Accept: 5.0, 5.026, 5.0263
		(ii)	the orbit of the ERV is not at infinity **OR** the escape velocity enables an object to reach infinity	1	Allow arguments relating to the MAV being powered (continually) as it rises. the ERV is in the gravitational field of Mars **OR** the escape velocity enables an object to escape the gravitational field of Mars

Question			Expected response	Max mark	Additional guidance
4.	(c)	(iii)	$\frac{GMm}{r^2}=\frac{mv^2}{r}$ 1 $\frac{6.67\times10^{-11}\times6.42\times10^{23}\times4.3\times10^{3}}{\left(3.39\times10^{6}+5.0\times10^{5}\right)^2}$ $=\frac{4.3\times10^{3}\times v^2}{\left(3.39\times10^{6}+5.0\times10^{5}\right)}$ 1 $v=3.3\times10^{3}$ m s^{-1} 1	3	Accept: 3, 3.32, 3.318 Accept: $v=\sqrt{\frac{GM}{r}}$
		(iv)	Lower (tangential) velocity (makes docking easier).	1	Do not accept: arguments relating to friction with atmosphere or gravitational field strength.

Question			Expected response	Max mark	Additional guidance
5.			**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)		Proton-proton chain/p-p chain	1	
	(b)	(i)	$L = 4\pi r^2 \sigma T^4$ 1 $L = 4\pi \times \left(6.955\times10^8\right)^2 \times 5.67\times10^{-8} \times 5800^4$ 1 $L = 3.9\times10^{26}$ W 1	3	Accept: 4, 3.90, 3.900 If π = 3.14, accept 3.898
		(ii)	Blackbody	1	Accept: Uniform radius/spherical Uniform surface temperature
	(c)		Radius increases because (the forces due to) thermal pressure greater than gravitational force **1** Radius stops increasing when (the forces due to) thermal pressure balances gravitational forces. **1**	2	Ignore description of initial reduction in (core) radius and any fusion processes (in the core)
	(d)		$b = \frac{L}{4\pi d^2}$ 1 $b = \frac{5.46\times10^{27}}{4\pi\times(3.26\times24.7\times3.00\times10^8\times365.25\times24\times60\times60)^2}$ 1,1 $b = 7.48\times10^{-10}$ W m^{-2} 1	4	Accept: 7.5, 7.477, 7.4766 unit conversion from 24.7 parsecs is an independent mark Incorrect sub in unit conversion max 1 mark If 365 used, accept 7.5, 7.49, 7.487, 7.4868 Accept use of π = 3.14
	(e)			1	

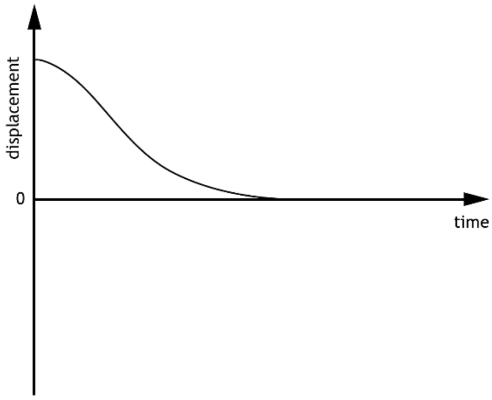
Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	It is not possible to know the (precise/exact) position and the momentum of a quantum particle simultaneously. 1	1	Accept 'energy and lifetime' The precise/exact position of a (quantum) particle and its momentum cannot be <u>known</u> simultaneously Do not accept: accurate in place of precise
		(ii)	$\Delta E \Delta t \geq \frac{h}{4\pi}$ 1 $\Delta E_{(\min)} \times 1.2 \times 10^{-13} = \frac{6.63 \times 10^{-34}}{4\pi}$ 1 $\Delta E_{(\min)} = 4.4 \times 10^{-22}\ \text{J}$ 1	3	Accept: 4, 4.40, 4.397 Accept: $\Delta E_{\min} \Delta t = \frac{h}{4\pi}$ Do not accept as starting point: $\Delta E_{\min} \Delta t \geq \frac{h}{4\pi}$ or $\Delta E \Delta t = \frac{h}{4\pi}$ Do not accept as final answer: $\Delta E_{\min} \geq 4.4 \times 10^{-22}\ \text{J}$ or $\Delta E \geq 4.4 \times 10^{-22}\ \text{J}$ Ignore ± in final answer
		(iii)	$(\Delta)E = h(\Delta)f$ 1 $4.4 \times 10^{-22} = 6.63 \times 10^{-34} \times (\Delta)f$ 1 $(\Delta)f = 6.6 \times 10^{11}\ \text{Hz}$ 1	3	Or consistent with (b)(ii) Accept: 7, 6.64, 6.637 Ignore ± in final answer
	(b)		$\Delta\lambda = \frac{c\Delta f}{f^2}$ $\Delta\lambda = \frac{3.00 \times 10^8 \times 6.6 \times 10^{11}}{(1.18 \times 10^{15})^2}$ 1 $\Delta\lambda = 1.4 \times 10^{-10}\ \text{m}$ 1	2	Or consistent with (a)(iii) Accept: 1, 1.42,1.422

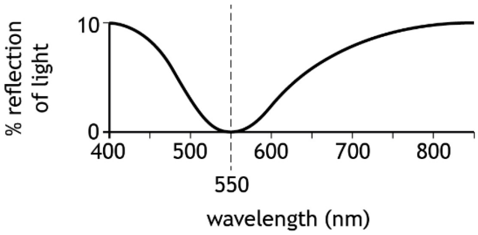
Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	$r=\dfrac{n^2h^2\varepsilon_o}{\pi m_e e^2}$ $r=\dfrac{1^2\times(6.63\times10^{-34})^2\times8.85\times10^{-12}}{\pi\times9.11\times10^{-31}\times((\text{-})1.60\times10^{-19})^2}$ 1 $r=5.31\times10^{-11}$ m 1	2	Accept: 5.3, 5.310, 5.3096 Accept use of π = 3.14
		(ii)	$\left.\begin{array}{l}\lambda=\dfrac{h}{p}\\ p=mv\\ mvr=\dfrac{nh}{2\pi}\end{array}\right\}$ 1 $\left(2\pi r=\dfrac{nh}{mv}=n\lambda\right)$ $(n\lambda=2\pi r)$ $1\times\lambda=2\times\pi\times5.31\times10^{-11}$ 1 $\lambda=3.34\times10^{-10}$ m 1	3	Or consistent with (a)(i) Accept: 3.3, 3.336, 3.3364 Accept: (When n = 1, $\lambda=2\pi r$) $\lambda=2\pi r$ 1 $\lambda=2\pi\times5.31\times10^{-11}$ 1 $\lambda=$ 3.34×10^{-10} m 1 Accept use of π = 3.14
	(b)	(i)	$(F_e=F_c)$ $\dfrac{Q_1Q_2}{4\pi\varepsilon_0 r^2}=\dfrac{mv^2}{r}$ 1,1 $v=\sqrt{\dfrac{Q_1Q_2}{4\pi\varepsilon_0 rm}}$	2	SHOW question 1 mark for both relationships 1 mark for equating Final line must be shown or max 1 mark

Question			Expected response	Max mark	Additional guidance
8.	(b)	(ii)	Speed is less. **1** since radius increases (by 4 times) and all other variables remain constant $v=\sqrt{\dfrac{Q_1Q_2}{4\pi\varepsilon_0 rm}}$ **1** **OR** $v^2\propto\dfrac{1}{r}$ **1** **OR** $v\propto\dfrac{1}{\sqrt{r}}$ **1**	**2**	JUSTIFY question Alternatively Speed is less. **1** In 2nd orbit (n = 2). This corresponds to 2 de Broglie wavelengths $\lambda\left(=\dfrac{h}{p}\right)=\dfrac{h}{mv}$ Wavelength is doubled, (velocity must be halved.) **1**

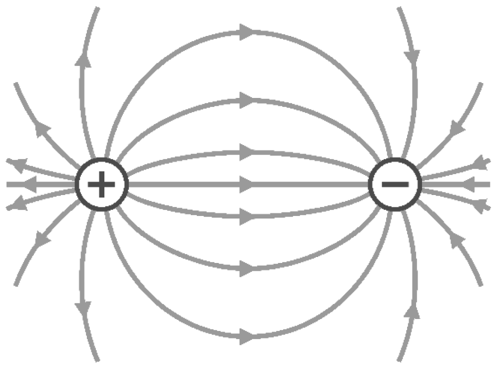
Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$r = \frac{mv}{qB}$ $1.50\times10^{-3} = \frac{9.11\times10^{-31}\times v}{1.60\times10^{-19}\times2.20\times10^{-2}}$ 1 $v = 5.80\times10^{6}\ \text{ms}^{-1}$ 1	**2**	Accept: 5.8, 5.796, 5.7958
		(ii)	Loses energy through radiation/to the liquid	**1**	Accept: velocity/speed decreases and m, q, B are unchanged **OR** accelerating charges radiate energy
		(iii)	(Ejected) electron follows a path with a much larger radius because it is moving faster. **1** Opposite curvature/direction/sense due to opposite charge. **1**	**2**	
	(b)		$E = (1.02\times10^{6} + 95.6 + 34.4 + 1.70\times10^{6})$ $\times1.60\times10^{-19}$ 1 $E = hf$ 1 $(1.02\times10^{6} + 95.6 + 34.4 + 1.70\times10^{6})$ $\times1.60\times10^{-19} = 6.63\times10^{-34}\times f$ 1 $f = 6.56\times10^{20}$ Hz 1	**4**	Accept: 6.6, 6.564, 6.5644 Initial kinetic energy of produced pair can be ignored: $E = (1.02\times10^{6} + 1.70\times10^{6})\times1.60\times10^{-19}$ 1 $E = hf$ 1 $(1.02\times10^{6} + 1.70\times10^{6})$ $\times1.60\times10^{-19} = 6.63\times10^{-34}\times f$ 1 $f = 6.56\times10^{20}$ Hz 1 Accept: 6.6, 6.564, 6.5641 Conversion can be demonstrated using $W = QV$

Question			Expected response	Max mark	Additional guidance
10.	(a)		(motion caused by) unbalanced force/acceleration (directly) proportional to and in the opposite direction to the displacement (of a particle).	**1**	Accept: $F = -ky$ or equivalent Accept answer in terms of displacement is (directly) proportional to the <u>restoring</u> force. Do not accept force is (directly) proportional to displacement without reference to direction.
	(b)	(i)	$\omega = 2\pi f$ (1) $\omega = 2\pi \times 55.1$ (1) $\omega = 346 \text{ rad s}^{-1}$	**2**	SHOW question Accept use of π = 3.14
		(ii)	$a = (-)\omega^2 y$ (1) $a_{(\max)} = (-)346^2 \times 8.24 \times 10^{-3}$ (1) $a_{(\max)} = (-)986 \text{ ms}^{-2}$ (1)	**3**	Accept: 990, 986.5, 986.46 Accept as starting point: $a = (-)\omega^2 A$ Accept determination of a using calculus methods
	(c)		$(F =) IlB = ma$ (1,1) $I \times 21.8 \times 1.10 = 0.177 \times 986$ (1) $I = 7.28$ A (1)	**4**	Or consistent with (b) Accept:7.3, 7.278, 7.2778 1 mark both relationships 1 mark equating
	(d)		$v = f\lambda$ (1) $v = 55.1 \times 6.00$ (1) $v = 331 \text{ ms}^{-1}$ (1)	**3**	Accept: 330, 330.6, 330.60
	(e)		$E = kA^2$ (1) $k = \frac{E}{(8.24 \times 10^{-3})^2} = \frac{0.25E}{A_2^2}$ (1) $A_2 = 4.12 \times 10^{-3}$ m (1)	**3**	Accept: 4.1, 4.120, 4.1200 $\frac{E_1}{A_1^2} = \frac{E_2}{A_2^2}$ (1) $\frac{E}{(8.24 \times 10^{-3})^2} = \frac{0.25E}{A_2^2}$ (1) $A_2 = 4.12 \times 10^{-3}$ m (1)

Question			Expected response	Max mark	Additional guidance
10.	(f)			**1**	Line must be a curve decreasing from maximum and reaching zero. Do not accept an exponential decay curve. Do not accept ¼ of cos curve. Line should not cross the x-axis.

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	π (rad)	**1**	Unit not required but, if given, must be correct.
		(ii)	π (rad)	**1**	Unit not required but, if given, must be correct.
	(b)		$d = \frac{\lambda}{4n}$ 1 $d = \frac{967 \times 10^{-9}}{4 \times 1.38}$ 1 $d = 1.75 \times 10^{-7}$ m 1	**3**	Accept: 1.8, 1.752, 1.7518
	(c)	(i)		**1**	Decrease from maximum (10%) at both ends of spectrum. Minimum (0%) at 550 nm.
		(ii)	(Reflected) red and violet light mix/combine (to give a purple tint).	**1**	Accept blue/indigo for violet. Suggestion of purple being single colour/wavelength (0 marks)

Question			Expected response	Max mark	Additional guidance
12.	(a)		(The electric field vector) oscillates (or vibrates) in one plane only.	**1**	Do not accept: travels instead of oscillates **OR** direction instead of plane **OR** axis instead of plane
	(b)		$n = \frac{\sin\theta_1}{\sin\theta_2}$ **1** $n = \frac{\sin i_p}{\sin(90 - i_p)}$ **1** $n = \frac{\sin i_p}{\cos i_p}$ **1** $n = \tan i_p$	**3**	Derive question If final line is missing then max 2. Alternative starting point: $n = \frac{\sin i}{\sin r}$ Must include a statement of Snell's law else zero marks
	(c)	(i)	$(n = \tan i_p)$ $1.33 = \tan i_p$ **1** $\theta = 90 - (\tan^{-1}(1.33))$ **1** $\theta = 36.9°$ **1**	**3**	Accept: 37, 36.94, 36.939
		(ii)	Transmission axis of the driver's sunglasses is perpendicular/not parallel to the plane of the polarised reflected light. (This absorbs/blocks the reflected plane polarised light.)	**1**	
	(d)		Light from a rainbow is (plane) polarised **1** The plane of the (plane) polarised light gradually changes (from vertical to horizontal.) **1**	**2**	Answer must be in terms of a gradual change. Digital change max 1.

Question			Expected response	Max mark	Additional guidance
13.	(a)		$V=\dfrac{Q}{4\pi\varepsilon_0 r}$ 1 $V_1=\dfrac{3.10\times10^{-20}}{4\pi\times8.85\times10^{-12}\times(1.33\times10^{-10}+2.10\times10^{-10})}$ 1 $V_2=\dfrac{-3.10\times10^{-20}}{4\pi\times8.85\times10^{-12}\times2.10\times10^{-10}}$ 1 $(V=V_1+V_2)$ $V=-0.515\text{ V}$ 1	**4**	Accept: 0.51, 0.5147, 0.51469 For 9×10^9: Accept: 0.52, 0.5152, 0.51516
	(b)			**2**	1 mark for arrow direction 1 mark for pattern that has no field lines crossing If no attempt at an attractive field pattern zero marks
	(c)	(i)	$F=QE$ **1** $F=3.10\times10^{-20}\times2550$ **1** $F=7.91\times10^{-17}\text{ N}$ **1**	**3**	Accept: 7.9, 7.905, 7.9050
		(ii) (A)	$\tau=Fr$ 1 $\tau=\left(7.91\times10^{-17}\times\dfrac{1.33\times10^{-10}}{2}\right)$ 1 $\tau_{resultant}=2\times\left(7.91\times10^{-17}\times\dfrac{1.33\times10^{-10}}{2}\right)$ 1 $\tau_{resultant}=1.05\times10^{-26}\text{ N m}$ 1	**4**	Or consistent with (c)(i) Accept: 1.1, 1.052, 1.0520
		(B)	Decrease **1** The component of the force (perpendicular to the radius) decreases (for the same electric field strength) **OR** The component of the radius (perpendicular to the field) decreases (for the same electric field strength) **1**	**2**	JUSTIFY

Question			Expected response	Max mark	Additional guidance
14.	(a)		$B=\frac{\mu_0 I}{2\pi r}$ 1 $27\times10^{-6}=\frac{\mu_0\times1.2}{2\pi\times0.010}$ 1 $\mu_0=1.4\times10^{-6}\ \text{Hm}^{-1}$	**2**	SHOW QUESTION
	(b)	(i)	$\text{Gradient}=19.4\times10^{-6}$ 1 $\left(B=\frac{\mu_0 I}{2\pi r}\right)$ $19.4\times10^{-6}=\frac{\mu_0}{2\pi\times0.010}$ 1 $\mu_0=1.2\times10^{-6}\ \text{Hm}^{-1}$ 1	**3**	Accept: 1, 1.22, 1.219 Or consistent with calculated gradient <u>using two points on the line</u>
		(ii)	The data are taken over a range	**1**	Accept calculation for part (a) only uses one data point Allow mention of graph plotting as this implies a range of values
		(iii)	$\frac{\Delta W}{W}=\sqrt{\left(\frac{\Delta X}{X}\right)^2+\left(\frac{\Delta Y}{Y}\right)^2+\left(\frac{\Delta Z}{Z}\right)^2}$ 1 $\frac{\Delta\mu_0}{1.2\times10^{-6}}=\sqrt{\left(\frac{0.6\times10^{-6}}{19.4\times10^{-6}}\right)^2+\left(\frac{0.0005}{0.010}\right)^2}$ 1 $\Delta\mu_0=7\times10^{-8}\ \text{Hm}^{-1}$ 1	**3**	Or consistent with (b)(i) Accept: 7.1, 7.06 Accept use of method involving the calculation of percentage uncertainties Suspend sig figs rule
		(iv)	<u>Measurement</u> of magnetic induction (too large) **OR** <u>Measurement</u> of current (too small)	**1**	Accept reference to the Earth's magnetic field/external magnetic field Any indication of direction must be correct

Question			Expected response	Max mark	Additional guidance
15.	(a)		Changing current produces a changing magnetic field (which induces a back EMF in the inductor).	**1**	
	(b)	(i)	$\tau = \frac{L}{R}$ $\tau = \frac{0.50}{2.2}$ 1 $\tau = 0.23$ s 1	**2**	Accept: 0.2, 0.227, 0.2273
		(ii)	$\varepsilon = -L\frac{dI}{dt}$ 1 $-3.2 = -0.50 \times \frac{dI}{dt}$ 1,1 $\frac{dI}{dt} = 6.4$ A s^{-1} 1	**4**	Accept: 6, 6.40, 6.400 Or consistent with (b) (i) 1 mark for value from graph 1 mark for substitutions For $\tau = 0.23$ accept a range of values for ε of -3.2 to -3.3 from the graph. If 63% is used accept ε = -3.33
	(c)		magnetic field collapses **OR** rapid change in current/large $\frac{dI}{dt}$ (induces a large back EMF of greater than 80 V)	**1**	
	(d)	(i)	$\left(T = \frac{1}{f}\right)$ $5 \times 0.23 = \frac{1}{f}$ 1 $f = 0.87$ Hz 1	**2**	Accept: 0.9, 0.870, 0.8696 Or consistent with (b) (i)
		(ii)	Frequency decreases 1 (Increase inductance) increases the time constant 1	**2**	MUST JUSTIFY Justification in terms of reactance zero marks.

Question			Expected response	Max mark	Additional guidance
16.			**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.

[END OF MARKING INSTRUCTIONS]

General marking principles for Physics Advanced 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.

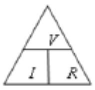
(d) Where a candidate answers part of a question incorrectly and carries the incorrect answer forward in the following part, award marks if the incorrect answer has then been used correctly in the subsequent part or 'follow-on'. (GMP 16)

(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)

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).

(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.

(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.	__ Ω	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.	$R = \frac{V}{I} =$ __ Ω	1 mark: relationship only
9.	$R = \frac{V}{I} = \frac{7.5}{1.5} =$ __ Ω	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