National
Qualifications
2026

2026 Physics

Advanced Higher

Question Paper Finalised Marking Instructions

These marking instructions have been prepared by examination teams for use by Qualifications Scotland appointed markers when marking external course assessments.

Qualifications Scotland
Teisteanasan Alba

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) (Physics: general marking principles - National 3 to Advanced Higher (sqa.org.uk)) 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 16)

(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 1a)

(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 1c)

(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 20)

(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 2)

(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 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).

(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 22)

(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.

(I) Marking in calculations

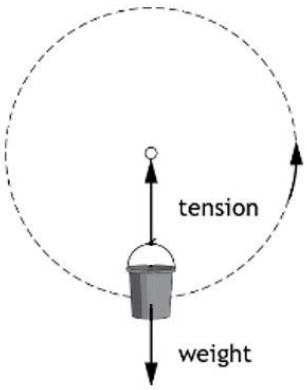
Example question

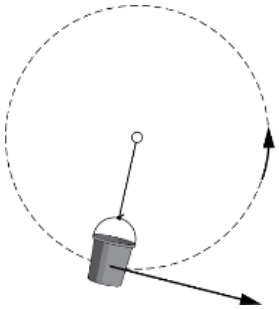
The current in a resistor is 1.5 amperes when the potential difference across it is 7.5 volts. Calculate the resistance of the resistor. (3 marks)

	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

Marking Instructions for each question

Question			Expected response	Max mark	Additional guidance
1.	(a)		$s = \left(\int v.dt\right) = \frac{8.13t^3}{3} + \frac{15.4t^2}{2}(+c)$ **(1)** $(\text{at } t = 0,\ s = 0 \therefore c = 0)$ $s = \frac{8.13\times(1.05)^3}{3} + \frac{15.4\times(1.05)^2}{2}$ **(1)** $s = 11.6 \text{ m}$ **(1)**	**3**	Accept: 12, 11.63, 11.626 $s = \left(\int_0^{1.05} \left(8.13t^2 + 15.4t\right) dt\right)$ $s = \left[\frac{8.13\times t^3}{3} + \frac{15.4\times t^2}{2}\right]_0^{1.05}$ **(1)** $s = \left(\frac{8.13\times(1.05)^3}{3} + \frac{15.4\times(1.05)^2}{2}\right) \ (-0)$ **(1)** $s = 11.6 \text{ m}$ **(1)**
	(b)		$a = \left(\frac{dv}{dt} =\right) 16.26t + 15.4$ **(1)** $a = 16.26\times 1.05 + 15.4$ **(1)** $a = 32.5 \text{ ms}^{-2}$ **(1)**	**3**	Accept: 32, 32.47, 32.473
	(c)		Q	**1**	

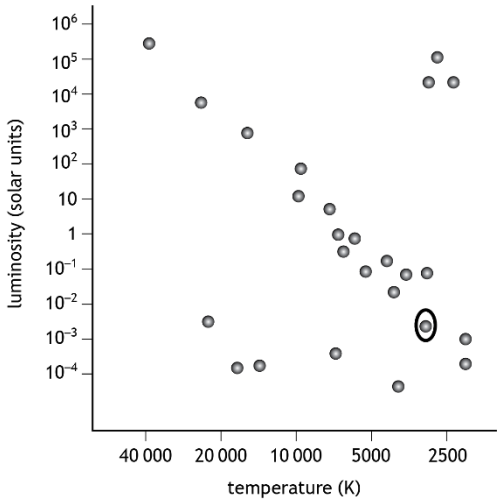
Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	$mg = mr\omega^2$ **(1,1)** $2.58 \times 9.8 = 2.58 \times 1.05 \times \omega^2$ **(1)** $\omega = 3.06 \text{ rads}^{-1}$	**3**	Not a standard SHOW question. **1 mark** for both relationships. **1 mark** for equating. Must show cancellation or substitution for m. Starting with $a_r = r\omega^2$ or $g = r\omega^2$ **0 marks**.
		(ii)	$\omega = \frac{d\theta}{dt}$ **(1)** $3.06 = \frac{\theta}{60}$ **(1)** rotations $= \left(\frac{\theta}{2\pi} =\right) \frac{3.06 \times 60}{2\pi} (= 29.2)$ **(1)** Complete rotations = 30 **(1)**	**4**	Alternative correct starting points are acceptable, eg $\omega = \frac{2\pi}{T}$ **(1)** $3.06 = \frac{2\pi}{T}$ **(1)** $\left(T = \frac{2\pi}{3.06}\right)$ rotations $= \frac{60}{\left(\frac{2\pi}{3.06}\right)}$ **(1)** Complete rotations = 30 **(1)**
	(b)	(i)		**2**	**1 mark** for each correctly labelled force. If any additional forces labelled incorrectly max **1 mark**. Weight and tension vectors must be touching the bucket. Accept 'mg' or 'gravitational force' for weight.
		(ii)	$T - mg = mr\omega^2$ **(1)** $T - (2.88 \times 9.8) = 2.88 \times 1.05 \times 3.61^2$ **(1)** $T = 67.6 \text{ N}$ **(1)**	**3**	Accept: 68, 67.63, 67.633

Question			Expected response	Max mark	Additional guidance
2.	(b)	(iii)		**1**	Tangent to circle. Perpendicular to the string and touching the bucket.

Question			Expected response	Max mark	Additional guidance
3.	(a)		$I_{rod} = \frac{1}{12} ml^2$ **(1)** $I_{total} = \frac{1}{12} \times 0.32 \times 0.36^2 + 4.7 \times 10^{-3}$ **(1)** $I = 8.2 \times 10^{-3}$ kgm^2 **(1)**	**3**	Accept: 8, 8.16, 8.156 Do not accept: $I_{rod} = \frac{1}{12} mr^2$
	(b)	(i)	$\omega = \omega_0 + \alpha t$ **(1)** $31 = (0+) \alpha \times 1.4$ **(1)** $\alpha = 22$ rads^{-2} **(1)**	**3**	Accept: 20, 22.1,22.14
		(ii)	$\tau = I\alpha$ **(1)** $\tau = 8.2 \times 10^{-3} \times 22$ **(1)** $\tau = 0.18$ Nm **(1)**	**3**	Accept: 0.2, 0.180, 0.1804 **OR** Consistent with (a) and/or (b)(i).
	(c)		(The unbalanced torque is) less (than). **(1)** The moment of inertia (of the cutting unit) is reduced (as the mass of the blade is smaller). **(1)**	**2**	JUSTIFY

Question			Expected response	Max mark	Additional guidance
4.	(a)	(i)	$\frac{GMm}{r^2} = mr\left(\frac{2\pi}{T}\right)^2$ **(1)** $\left(T^2 = \frac{4\pi^2}{GM}r^3\right)$ $T^2 = \left(\frac{4\pi^2}{6.67\times10^{-11}\times1.90\times10^{27}}\right)r^3$ **(1)** $T^2 = 3.12\times10^{-16}\times r^3$	**2**	SHOW question.
		(ii)	$\left(T^2 = 3.12\times10^{-16}\times r^3\right)$ $\left(3.55\times24\times60\times60\right)^2 = 3.12\times10^{-16}\times r^3$ **(1)** $r = 6.71\times10^8$ m **(1)**	**2**	Accept: 6.7, 6.706, 6.7057
	(b)	(i)	Work done in moving unit mass from infinity to that point.	**1**	
		(ii)	$V = -\frac{GM}{r}$ **(1)** $(\Delta V = V_G - V_C)$ $\Delta V = \left(-\frac{6.67\times10^{-11}\times1.90\times10^{27}}{1.07\times10^9}\right) - \left(-6.71\times10^7\right)$ $\Delta E = \Delta V m$ **(1)** $\Delta E = \left[\left(-\frac{6.67\times10^{-11}\times1.90\times10^{27}}{1.07\times10^9}\right) - \left(-6.71\times10^7\right)\right]\times5980$ **(1),(1)** $\Delta E = -3.07\times10^{11}$ J **(1)**	**5**	Accept: 3.1, 3.070, 3.0701. Alternative method: $E_G = V_G m$ **(1)** $V = -\frac{GM}{r}$ **(1)** $E_G = \left(-\frac{6.67\times10^{-11}\times1.90\times10^{27}}{1.07\times10^9}\right)\times5980$ $E_C = -6.71\times10^7\times5980$ $\Delta E = E_G - E_C$ $\Delta E = \left[\left(-\frac{6.67\times10^{-11}\times1.90\times10^{27}}{1.07\times10^9}\right)\times5980 - \left(-6.71\times10^7\times5980\right)\right]$ **(1),(1)** $\Delta E = -3.07\times10^{11}$ J **(1)** **1 mark** for $E = Vm$. **1 mark** for $V = -\frac{GM}{r}$. **1 mark** for all substitutions. **1 mark** for correct subtraction. **1 mark** for final answer.
	(c)		$\Delta E = (+)3.07\times10^{11}$ J	**1**	Or consistent with (b)(ii). Answer must be numerical.

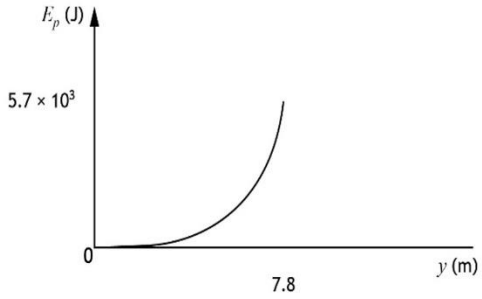
Question			Expected response	Max mark	Additional guidance
5.	(a)		It is not possible to distinguish between the effects (on an observer) of (constant) acceleration and a (uniform) gravitational field.	**1**	Effects must be implied. Do not accept: 'gravity'
	(b)		Clock Q. **(1)** It experiences the same effect as being in a stronger gravitational field (than clock P). **(1)** **OR** The astronaut is accelerating away from the point where clock Q was, and the light emitted from the clock is not accelerating. **(1)**	**2**	JUSTIFY. Any mention of clocks having different accelerations is wrong physics. **(max 1 mark)**. Accept a clear implication that the speed of light is constant in place of the light not accelerating.
	(c)	(i)	$r_{Schwarszchild} = \frac{2GM}{c^2}$ **(1)** $r_{Schwarszchild} = \frac{2 \times 6.67 \times 10^{-11} \times 6.54 \times 10^{31}}{\left(3.00 \times 10^{8}\right)^2}$ **(1)** $r_{Schwarszchild} = 9.69 \times 10^{4}\,\text{m}$ **(1)**	**3**	Accept: 9.7, 9.694,9.6937
		(ii)	The star can be observed. **(1)** Nothing from within the event horizon can be observed from outside the event horizon. **(1)**	**2**	Independent marks. Converse explanation is acceptable.

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	$\left(\frac{L}{L_{Sun}} = 10^{0.4(M_{Sun}-M)}\right)$ $\frac{L}{3.83\times10^{26}} = 10^{0.4(4.74-11.75)}$ **(1)** $L = 6.01\times10^{23}\ \text{W}$	**1**	SHOW
		(ii)	$b = \frac{L}{4\pi d^2}$ **(1)** $2.96\times10^{-11} = \frac{6.01\times10^{23}}{4\pi d^2}$ **(1)** $\left(d = \sqrt{\frac{6.01\times10^{23}}{4\pi\times2.96\times10^{-11}}}\right)$ $d = \frac{\sqrt{\frac{6.01\times10^{23}}{4\pi\times2.96\times10^{-11}}}}{\left(3.00\times10^{8}\times365.25\times24\times60\times60\right)}$ **(1)** $d = 4.25\,(\text{ly})$ **(1)**	**4**	Accept: 4.2, 4.246, 4.2458 Accept use of 365. Independent mark for conversion to light-years.
	(b)	(i)		**1**	
		(ii)	White dwarf	**1**	

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	$mvr = \frac{nh}{2\pi}$ and $\lambda = \frac{h}{p}$ and $p = mv$ **(1)** $mvr = \frac{n\lambda mv}{2\pi}$ **(1)** $2\pi r = n\lambda$	**2**	SHOW question. **1 mark** for all three relationships. **1 mark** for substitution of second and third relationships into first one.
		(ii)	Allowed electron orbit circumference is equal to a whole number of (de Broglie) wavelengths.	**1**	'Multiple number of wavelengths' is insufficient without an indication of the multiple being a positive integer. 'Wavelength multiplied by orbital number' is acceptable for an implication of whole numbers.
		(iii)	$(2\pi r = n\lambda)$ $2 \times \pi \times r = 3 \times 9.97 \times 10^{-10}$ **(1)** $r = 4.76 \times 10^{-10}$ m **(1)**	**2**	Accept: 4.8, 4.760, 4.7603
	(b)	(i)	$\left(E_t = -\frac{hcR}{n^2}\right)$ $E_t = -\frac{6.63 \times 10^{-34} \times 3.00 \times 10^8 \times 1.10 \times 10^7}{2^2}$ **(1)** $E_t = -5.47 \times 10^{-19}$ J **(1)**	**2**	Accept: 5.5, 5.470, 5.4700
		(ii)	Work has to be done to move an electron from the n = 2 orbit to the n = 3 orbit.	**1**	The energy in the n = 3 orbit is less negative. Accept justification by calculation and statement that energy in n = 3 orbit is less negative.

Question			Expected response	Max mark	Additional guidance
8.	(a)	(i)	$\lambda = \frac{h}{p}$ **(1)** $\left(\lambda = \frac{h}{\sqrt{2meV}}\right)$ $\lambda = \frac{6.63\times10^{-34}}{\sqrt{2\times9.11\times10^{-31}\times1.60\times10^{-19}V}}$ **(1)** $\lambda = \frac{1.228\times10^{-9}}{\sqrt{V}}$	**2**	SHOW
		(ii)	$\left(\lambda = \frac{1.228\times10^{-9}}{\sqrt{V}}\right)$ $\lambda = \frac{1.228\times10^{-9}}{\sqrt{150}}$ **(1)** $\lambda = 1.0\times10^{-10}$ (m) **(1)** (Wave-like,) as $1.0 \times 10^{-10} \approx 230 \times 10^{-12}$ **(1)** **OR** (Wave-like,) as the (lattice) spacing is of the same order of magnitude as the de Broglie wavelength.	**3**	$1.0 \times 10^{-10} < 230 \times 10^{-12}$ alone is insufficient for the final mark.
	(b)		Compton scattering. **OR** Photoelectric effect.	**1**	

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	Unbalanced force/acceleration (directly) proportional to and in the opposite direction to the displacement.	**1**	Accept: $F = -ky$ **or** equivalent. Accept answer in terms of displacement is (directly) proportional to the restoring force. Do not accept: force/acceleration is (directly) proportional to displacement without reference to direction
		(ii)	$(y = 7.8\sin(1{\cdot}7t))$ $v = \frac{dy}{dt} = 1.7 \times 7.8\cos(1.7t)$ **(1)** $v = 1.7 \times 7.8\cos(1.7 \times 0.72)$ **(1)** $v = 4.5\ \text{ms}^{-1}$ **(1)**	**3**	Accept: 5, 4.51, 4.507 Alternative method $v = \pm\omega\sqrt{A^2 - y^2}$ (1) $v = \pm 1.7\sqrt{7.8^2 - \left(7.8\sin\left(1.7 \times 0.72\right)\right)^2}$ (1) $v = 4.5\ \text{ms}^{-1}$ (1) Final answer must be positive or **MAX 2 marks**.
		(iii)	Less than **(1)** $v_{\max} = 13\ \text{ms}^{-1}$ **(1)**	**2**	MUST JUSTIFY. Or consistent with (a)(ii). Alternative method calculating the period. $T = \frac{2\pi}{\omega}$ $T = \frac{2\pi}{1.7}$ $T = 3.7\,\text{s}$ Justification in terms of maximum velocity at equilibrium position **and** bungee jumper not at equilibrium position.
	(b)	(i)	$E_p = \frac{1}{2}m\omega^2 y^2$ **(1)** $E_p = 0.5 \times 65 \times 1.7^2 \times 7.8^2$ **(1)** $E_p = 5.7 \times 10^3\,\text{J}$ **(1)**	**3**	Accept: 6, 5.71, 5.714 $v_{(\max)} = \omega A$ and $E_k = \frac{1}{2}mv^2$ (1) $E_k = 0.5 \times 65 \times (1.7 \times 7.8)^2$ (1) $E_p = E_k = 5.7 \times 10^3\ \text{J}$ (1)

Question			Expected response	Max mark	Additional guidance
9.	(b)	(ii)		**3**	Potential energy must start at 0 and increase else **0 marks**. Line must not extend beyond amplitude else **0 marks**. **1 mark** shape. **1 mark** for each numerical value. **OR** Consistent with b(i).

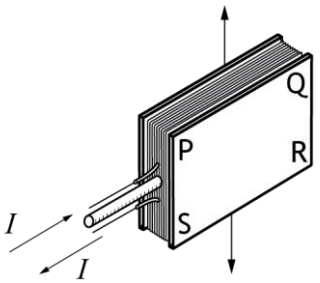
Question			Expected response	Max mark	Additional guidance
10.	(a)	(i)	(Division of) amplitude	**1**	
		(ii)	The light meets in phase (to give constructive interference). **(1)** The path difference between rays A and B is an odd number of half wavelengths. **(1)**	**2**	Independent marks.
		(iii)	$\Delta x = \frac{5.83\times10^{-3}}{19}$ **(1)** $\Delta x = \frac{\lambda l}{2d}$ **(1)** $\frac{5.83\times10^{-3}}{19} = \frac{589\times10^{-9}\times75\times10^{-3}}{2d}$ **(1)** $d = 7.2\times10^{-5}$ m **(1)**	**4**	Accept: 7, 7.20, 7.198 First mark independent.
		(iv)	(Measuring multiple fringes) will reduce the (fractional/percentage) uncertainty in Δx. **OR** Reduce the (fractional/percentage) uncertainty in d.	**1**	Do not accept reduces the scale reading uncertainty in the measurement. Response must specify the quantity in which the uncertainty is being reduced.
	(b)		Fringe separation will be less **(1)** d increases and λ & l remain constant. **(1)**	**2**	JUSTIFY Δx inversely proportional to d.

Question			Expected response	Max mark	Additional guidance
11.			**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
12.	(a)	(i)	(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
		(ii)	Use unpolarised light with Polaroid sheet/analyser (in front of lens). **(1)** (Observation of) light intensity change when the Polaroid sheet/ analyser/lens is rotated. **(1)**	**2**	Hold sunglasses to observe reflected light from sea water and rotate. **(1)** If the light intensity varies the sunglasses are polarising. **(1)** **OR** Compare the view seen when looking through polarising glasses against that seen when looking through the non-polarising glasses. **(1)** The view through the polarising glasses shows less glare reflected from the water surface. **(1)**
	(b)	(i)	$n = \tan i_p$ **(1)** $1.34 = \tan i_p$ **(1)** $i_p = 53.3°$ **(1)**	**3**	Accept: 53, 53.27, 53.267
		(ii)	Yes **(1)** 90 – 36.7 = 53.3° **(1)**	**2**	MUST JUSTIFY. Or consistent with (b)(i). 90 – 53.3 = 36.7°

Question			Expected response	Max mark	Additional guidance
13.	(a)		Electrical potential is the work done in moving unit positive charge from infinity to that point.	**1**	
	(b)	(i)	$V = \frac{Q}{4\pi\varepsilon_o r}$ **(1)** $V = \frac{1.60\times10^{-19}}{4\times\pi\times8.85\times10^{-12}\times4.76\times10^{-10}}$ $W = QV$ **(1)** $W = -1.60\times10^{-19}\times\left(\frac{1.60\times10^{-19}}{4\times\pi\times8.85\times10^{-12}\times4.76\times10^{-10}}\right)$ (1) for all substitutions $W = -4.84\times10^{-19}$ J	**3**	Not a standard SHOW question. Can start with $V = k\frac{Q}{r}$ and $k = 9\times10^9$
		(ii) (A)	$E = hf$ or $\Delta E = hf$ or $E_2 - E_1 = hf$ and $v = f\lambda$ **(1)** $-4.84\times10^{-19} - \left(-10.9\times10^{-19}\right) = 6.63\times10^{-34}\times\frac{3.00\times10^8}{\lambda}$ **(1)** $\lambda = 3.28\times10^{-7}$ m **(1)**	**3**	Accept: 3.3, 3.282, 3.2822 Accept: $E_2 - E_1 = \frac{hc}{\lambda}$ Accept subtraction in either order.
		(B)	(Greater kinetic energy in the) lower orbital radius. **(1)** $-2.42\times10^{-19} - (-4.84\times10^{-19}) = 2.42\times10^{-19}$ (J) - higher orbit $-5.44\times10^{-19} - (-10.9\times10^{-19}) = 5.46\times10^{-19}$ (J) - lower orbit **(1)**	**2**	JUSTIFY by calculation.
	(c)		$\left(M = \frac{v}{\lambda}\right)$ $M = \frac{3.00\times10^8}{656\times10^{-9}}$ **(1)** $M = 4.57\times10^{14}$ **(1)** $\left(N = \frac{1}{\lambda}\right)$ $N = \frac{1}{656\times10^{-9}}$ $N = 1.52\times10^6$ **(1)**	**3**	Accept: 4.6, 4.573, 4.5732 (for M) Accept: 1.5, 1.524, 1.5244 (for N) If units are included, they must be correct.

Question			Expected response	Max mark	Additional guidance
14.	(a)	(i)	$\left(\frac{16.58-13.48}{5}\right)$ $= 0.6$ s **(1)**	**1**	Suspend sig fig rule.
		(ii)	$\frac{\Delta W}{W} = \sqrt{\left(\left(\frac{\Delta X}{X}\right)^2 + \left(\frac{\Delta Y}{Y}\right)^2\right)}$ **(1)** $\frac{\Delta v_t}{2.01\times10^{-4}} = \sqrt{\left(\left(\frac{0.05}{3.00}\right)^2 + \left(\frac{0.6}{14.90}\right)^2\right)}$ **(1)** $\Delta v_t = 9\times10^{-6}$ ms^{-1} **(1)**	**3**	Or consistent with (a)(ii). Suspend sig fig rule.
		(iii)	(Reduce the random uncertainty by taking several) more measurements for <u>time</u> (for droplet to fall). **(1)**	**1**	Do not accept: 'repeat the experiment' alone
	(b)	(i)	$V = Ed$ **(1)** $322 = E\times27.5\times10^{-3}$ **(1)** $E = 1.17\times10^4$ Vm^{-1} **(1)**	**3**	Accept: 1.2, 1.171, 1.1709
		(ii)	$F = QE$ and $W = mg$ **(1)** $Q\times1.17\times10^4 = 9.58\times10^{-16}\times9.8$ **(1)** $Q = 8.0\times10^{-19}$ C **(1)**	**3**	Or consistent with (b)(i). Accept: 8, 8.02, 8.024
		(iii)	5	**1**	Or consistent with (b)(ii). Must be an integer.

Question			Expected response	Max mark	Additional guidance
15.	(a)	(i)	$F = IlB(\sin\theta)$ **(1)** $F = 0.56 \times 45 \times 10^{-3} \times 44 \times 10^{-3}$ **(1)** $F = 1.1 \times 10^{-3}$ N **(1)**	**3**	Accept: 1, 1.11, 1.109
		(ii)	$\tau = Fr$ **(1)** $\tau = 16 \times 2 \times 1.1 \times 10^{-3} \times \left(\frac{25 \times 10^{-3}}{2}\right)$ **(1,1)** $\tau = 4.4 \times 10^{-4}$ Nm **(1)**	**4**	Or consistent with (a)(i). Accept: 4, 4.40, 4.400 **1 mark** for full substitution that must show multiply by 2 and divide by 2. **1 mark** for multiplying by 16 anywhere. Accept use of: $\tau = BIAN$ **(1)** $\tau = 44 \times 10^{-3} \times 0.56 \times 45 \times 10^{-3} \times 25 \times 10^{-3} \times 16$ **(1,1)** $\tau = 4.4 \times 10^{-4}$ Nm **(1)** gives 4, 4.4, 4.44, 4.435
		(iii)	Current direction is parallel to the magnetic field.	**1**	
	(b)	(i)		**1**	Both arrows are required.
		(ii)	No (component of) force perpendicular to the axis of rotation.	**1**	The torque is zero.
	(c)		There is always a (component of) force perpendicular (to the axis of rotation).	**1**	Torque is never zero (when current in coil).

Question			Expected response	Max mark	Additional guidance
16.	(a)	(i)	$\tau = RC$ **(1)** $\tau = 1200 \times 2200 \times 10^{-6}$ **(1)** $(time = 5RC)$ $time = 5 \times 1200 \times 2200 \times 10^{-6}$ **(1)** $time = 13$ s **(1)**	**4**	Accept: 10, 13.2, 13.20
		(ii)	Increase value of resistance/ capacitance.	**1**	
	(b)		Increases (the magnitude of the inductance).	**1**	
	(c)	(i)	$E = \frac{1}{2} LI^2$ **(1)** $E = 0.5 \times 64 \times 10^{-3} \times (750 \times 10^{-3})^2$ **(1)** $E = 0.018$ J **(1)**	**3**	Accept: 0.02, 0.0180, 0.01800
		(ii) (A)	$\varepsilon = -L \frac{dI}{dt}$ **(1)** $\varepsilon = -64 \times 10^{-3} \times -1800$ **(1)** $\varepsilon = 120$ V **(1)**	**3**	Accept: 100, 115, 115.2
		(B)	The diode provides a path for the current to avoid damaging other circuit components.	**1**	Protect the components from excess current.

Question			Expected response	Max mark	Additional guidance
17.			**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]