National
Qualifications
2018

2018 Physics

Advanced Higher

Finalised Marking Instructions

SQA

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General marking principles for Advanced Higher Physics

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

(a) Marks for each candidate response must **always** be assigned in line with these general marking principles and the detailed marking instructions for this assessment.

(b) Marking should always be positive. This means that, for each candidate response, marks are accumulated for the demonstration of relevant skills, knowledge and understanding: they are not deducted from a maximum on the basis of errors or omissions.

(c) If a specific candidate response does not seem to be covered by either the principles or detailed marking instructions, and you are uncertain how to assess it, you must seek guidance from your team leader.

(d) There are no half marks awarded.

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

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

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

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

(i) Marks should be awarded for non-standard symbols where the symbols are defined and the relationship is correct, or where the substitution shows that the relationship used is correct. This must be clear and unambiguous.

(j) Where a triangle type "relationship" is written down and then not used or used incorrectly, then any mark for a relationship should not be awarded.

(k) **Significant figures**
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
Candidates should not be credited for a final answer that includes:
- three or more figures too many
  or
- two or more figures too few, ie accept two more or one fewer

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

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

- **describe**, they must provide a statement or structure of characteristics and/or features;
- **determine** or **calculate**, they must determine a number from given facts, figures or information;
- **estimate**, they must determine an approximate value for something;
- **explain**, they must relate cause and effect and/or make relationships between things clear;
- **identify**, **name**, **give**, or **state**, they need only name or present in brief form;
- **justify**, they must give reasons to support their suggestions or conclusions, eg this might be by identifying an appropriate relationship and the effect of changing variables;
- **predict**, they must suggest what may happen based on available information;
- **show that**, they must use physics [and mathematics] to prove something eg a given value – *all steps, including the stated answer, must be shown*;
- **suggest**, they must apply their knowledge and understanding of physics to a new situation. A number of responses are acceptable: marks will be awarded for any suggestions that are supported by knowledge and understanding of physics;
- **use your knowledge of physics or aspect of physics to comment on**, they must apply their skills, knowledge and understanding to respond appropriately to the problem/situation presented (for example by making a statement of principle(s) involved and/or a relationship or equation, and applying these to respond to the problem/situation). They will be rewarded for the breadth and/or depth of their conceptual understanding.

(n) Marking in calculations

Question:

The current in a resistor is 1·5 amperes when the potential difference across it is 7·5 volts. Calculate the resistance of the resistor. (3 marks)

Candidate answer	**Mark + Comment**
1. $V = IR$	1 mark: formula
$7{\cdot}5 = 1{\cdot}5R$	1 mark: substitution
$R = 5{\cdot}0\ \Omega$	1 mark: correct answer
2. $5{\cdot}0\ \Omega$	3 marks: correct answer
3. $5{\cdot}0$	2 marks: unit missing
4. $4{\cdot}0\ \Omega$	0 marks: no evidence, wrong answer
5. $\_\_\ \Omega$	0 marks: no working or final answer
6. $R = \frac{V}{I} = \frac{7\cdot 5}{1\cdot 5} = 4\cdot 0\ \Omega$	2 marks: arithmetic error
7. $R = \frac{V}{I} = 4\cdot 0\ \Omega$	1 mark: formula only
8. $R = \frac{V}{I} = \_\_\ \Omega$	1 mark: formula only
9. $R = \frac{V}{I} = \frac{7\cdot 5}{1\cdot 5} = \_\_\ \Omega$	2 marks: formula & subs, no final answer
10. $R = \frac{V}{I} = \frac{7\cdot 5}{1\cdot 5} = 4\cdot 0$	2 marks: formula & subs, wrong answer
11. $R = \frac{V}{I} = \frac{1\cdot 5}{7\cdot 5} = 5\cdot 0\ \Omega$	1 mark: formula but wrong substitution
12. $R = \frac{V}{I} = \frac{75}{1\cdot 5} = 5\cdot 0\ \Omega$	1 mark: formula but wrong substitution
13. $R = \frac{I}{V} = \frac{7\cdot 5}{1\cdot 5} = 5\cdot 0\ \Omega$	0 marks: wrong formula
14. $V=IR$	2 marks: formula & subs, arithmetic error
$7{\cdot}5 = 1{\cdot}5 \times R$	
$R = 0{\cdot}2\ \Omega$	
15. $V=IR$	
$R = \frac{I}{V} = \frac{1\cdot 5}{7\cdot 5} = 0\cdot 2\ \Omega$	1 mark: formula correct but wrong rearrangement of symbols

Detailed marking instructions for each question

Question			Answer	Max mark	Additional guidance
1.	(a)		$v = 0 \cdot 0071t - 0 \cdot 00025t^2$ $a\left(=\frac{dv}{dt}\right) = 0 \cdot 0071 - 0 \cdot 0005t$ **(1)** $a = 0 \cdot 0071 - (0 \cdot 0005 \times 20 \cdot 0)$ **(1)** $a = -0 \cdot 0029$ ms^{-2} **(1)**	**3**	Accept -0·003
	(b)		$v = 0 \cdot 0071t - 0 \cdot 00025t^2$ $s\left(=\int_0^{20 \cdot 0} v.dt\right) = \left[\frac{0 \cdot 0071}{2}t^2 - \frac{0 \cdot 00025}{3}t^3\right]_0^{20 \cdot 0}$ **(1)** $s = (\frac{0 \cdot 0071}{2} \times 20 \cdot 0^2) - (\frac{0 \cdot 00025}{3} \times 20 \cdot 0^3) - 0$ **(1)** $s = 0 \cdot 75$ m **(1)**	**3**	Accept 0·8, 0·753, 0·7533 Constant of integration method acceptable

Question			Answer	Max mark	Additional guidance
2.	(a)	(i)	The car's direction/velocity is changing. **OR** Unbalanced/centripetal/central force acting on the car	**1**	
		(ii)	$a_{(r)} = \frac{v^2}{r}$ **(1)** $a_{(r)} = \frac{3 \cdot 5^2}{1 \cdot 8}$ **(1)** $a_{(r)} = 6 \cdot 8 \text{ m s}^{-2}$ **(1)**	**3**	Accept: 7, 6·81, 6·806 $a_r = r\omega^2$ **(1)** $a_r = 1 \cdot 8 \times \left(\frac{3 \cdot 5}{1 \cdot 8}\right)^2$ **(1)** $a_r = 6 \cdot 8 \text{ m s}^{-2}$ **(1)**
		(iii)	$F = \frac{mv^2}{r}$ $F = \frac{0 \cdot 431 \times 5 \cdot 5^2}{1 \cdot 8}$ **(1)** $F = 7 \cdot 2 \text{(N)}$ **(1)** Since 7·2(N)>6·4(N) **OR** There is insufficient friction and the car does not stay on the track. **(1)**	**3**	NOT A STANDARD 'SHOW' QUESTION Approach calculating minimum radius is acceptable.

Question			Answer	Max mark	Additional guidance
2.	(b)	(i)	$(F_{(centripetal)} = \frac{mv^2_{(max)}}{r}, W = mg)$ $\frac{mv^2_{(max)}}{r} = mg$ **(1), (1)** $\frac{v^2_{(max)}}{r} = g$ $v_{(max)} = \sqrt{gr}$	**2**	SHOW question both relationships **(1)** equating forces **(1)**
		(ii)	$v_{(max)} = \sqrt{gr}$ $v_{(max)} = \sqrt{9 \cdot 8 \times 0 \cdot 65}$ **(1)** $v_{(max)} = 2 \cdot 5 \text{ ms}^{-1}$ **(1)**	**2**	Accept: 3, 2·52, 2·524
		(iii)	The second car will not lose contact with the track. **(1)** A smaller centripetal force is supplied by a smaller weight. **(1)**	**2**	

Question			Answer	Max mark	Additional guidance
3.	(a)		$\omega = \omega_o + \alpha t$ **(1)** $\omega = 0 + (6 \cdot 7 \times 3 \cdot 9)$ **(1)** $\omega = 26 \text{ rads}^{-1}$	**2**	SHOW question If final answer not shown 1 mark max
	(b)		$E_{(k)} = \frac{1}{2} I \omega^2$ **(1)** $430 = \frac{1}{2} \times I \times 26^2$ **(1)** $I = 1 \cdot 3 \text{ kg m}^2$ **(1)**	**3**	Accept: 1, 1·27, 1·272
	(c)	(i)	$\theta = 14 \times 2\pi$ **(1)** $\omega^2 = \omega_o^2 + 2\alpha\theta$ **(1)** $0^2 = 26^2 + (2 \times \alpha \times 14 \times 2\pi)$ **(1)** $\alpha = -3 \cdot 8 \text{ rad s}^{-2}$ **(1)**	**4**	Accept: -4, -3·84, -3·842 Alternative method: $\theta = 14 \times 2\pi$ **(1)** $\omega = \omega_o + \alpha t$ AND $\theta = \omega_o t + \frac{1}{2}\alpha t^2$ **(1)** all substitutions correct **(1)** $\alpha =$ -3·8 rad s^{-2} **(1)**
		(ii)	$T = I\alpha$ **(1)** $T = 1 \cdot 3 \times (-)3 \cdot 8$ **(1)** $T = (-)4 \cdot 9 \text{ N m}$ **(1)**	**3**	Accept: 5, 4·94, 4·940 **OR** consistent with (b), (c)(i)

Question			Answer	Max mark	Additional guidance
4.	(a)	(i)	$(F_{centripetal} = F_{gravitational})$ **(1)** $mr\omega^2 = \frac{GMm}{r^2}$ **(1)** $\omega = \frac{2\pi}{T}$ *or* $\omega^2 = \left(\frac{2\pi}{T}\right)^2$ **(1)** $\frac{4\pi^2}{T^2} = \frac{GM}{r^3}$ $T^2 = \frac{4\pi^2}{GM}r^3$	3	SHOW question both relationships **(1)** equating **(1)** Alternative method acceptable $(F_{centripetal} = F_{gravitational})$ $\frac{mv^2}{r} = \frac{GMm}{r^2}$ **(1), (1)** $v = \frac{2\pi r}{T}$ or $v^2 = \left(\frac{2\pi r}{T}\right)^2$ **(1)** $\frac{4\pi^2}{T^2} = \frac{GM}{r^3}$ $T^2 = \frac{4\pi^2}{GM}r^3$
		(ii)	$T^2 = \frac{4\pi^2}{GM}r^3$ $\left\langle (197 \times 24 \times 60 \times 60)^2 = \frac{4\pi^2 \times (0 \cdot 63 \times 1 \cdot 5 \times 10^{11})^3}{6 \cdot 67 \times 10^{-11} \times M} \right\rangle$ **(1), (1)** $M = 1 \cdot 7 \times 10^{30}$ (kg) **(1)**	3	Accept: 2, 1·72,1·724 mark for converting AU to m independent. **(1)** complete substitution **(1)** final answer **(1)**
	(b)		$v = \sqrt{\frac{2GM}{r}}$ **(1)** $v = \sqrt{\frac{2 \times 6 \cdot 67 \times 10^{-11} \times 1 \cdot 7 \times 10^{30}}{1 \cdot 58 \times 10^{11}}}$ **(1)** $v = 3 \cdot 8 \times 10^4$ m s^{-1} **(1)**	3	**OR** consistent with (a)(ii) Accept 4, 3·79, 3·789

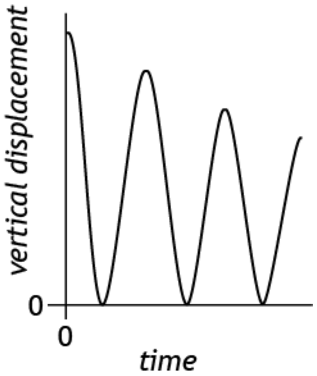
Question			Answer	Max mark	Additional guidance
5.	(a)		The Schwarzschild radius is the distance from the centre of a mass such that, the escape velocity at that distance would equal the speed of light. **OR** The Schwarzschild radius is the distance from the centre of a mass to the event horizon.	1	Responses in terms of black hole acceptable
	(b)	(i)	$r_{(Schwarzchild)} = \frac{2GM}{c^2}$ **(1)** $r_{(Schwarzchild)} = \frac{2 \times 6 \cdot 67 \times 10^{-11} \times 2 \cdot 0 \times 10^{30}}{(3 \cdot 00 \times 10^8)^2}$ **(1)** $r_{(Schwarzchild)} = 3 \cdot 0 \times 10^3 \text{ m}$ **(1)**	3	Accept: 3×10^3, $2 \cdot 96 \times 10^3$, $2 \cdot 964 \times 10^3$
		(ii)	(Radius of Sun is $6 \cdot 955 \times 10^8$ m) This is greater than the Schwarzschild radius (the Sun is not a black hole.) **(1)**	1	There MUST be a comparison of solar radius with the Sun's Schwarzschild radius.
	(c)		$\phi = 3\pi \frac{r_s}{a(1-e^2)}$ $\phi = 3\pi \frac{3000}{5 \cdot 805 \times 10^{10} \times (1 - 0 \cdot 206^2)}$ **(1)** Angular change after one year = $4 \times \phi$ **(1)** Angular change $= 2 \cdot 0 \times 10^{-6}$ rad **(1)**	3	**OR** consistent with (b)(i) Second mark independent Accept 2, 2·03, 2·035 If 3·14 used, accept 2·034

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

Question			Answer	Max mark	Additional guidance
7.	(a)	(i)	Neutrons are accelerated.	**1**	
		(ii)	$\lambda = \frac{h}{p}$ **(1)** $\lambda = \frac{6 \cdot 63 \times 10^{-34}}{1 \cdot 29 \times 10^{-23}}$ **(1)** $\lambda = 5 \cdot 14 \times 10^{-11}$ m **(1)**	**3**	Accept 5·1, 5·140, 5·1395
		(iii)	The precise/exact position of a particle and its momentum cannot both be known at the same instant. **(1)** **OR** If the (minimum) uncertainty in the position of a particle is reduced, the uncertainty in the momentum of the particle will increase (or vice-versa). **(1)**	**1**	
		(iv)	$\Delta p_x = p \times \frac{\%p}{100}$ $\Delta p_x = 1 \cdot 29 \times 10^{-23} \times \frac{3}{100}$ **(1)** $\Delta x_{\min} \Delta p_x = \frac{h}{4\pi}$ or $\Delta x \Delta p_x \geq \frac{h}{4\pi}$ **(1)** $\Delta x_{(\min)} = \frac{6 \cdot 63 \times 10^{-34}}{4\pi \times 1 \cdot 29 \times 10^{-23} \times 0 \cdot 03}$ **(1)** $\Delta x_{(\min)} = 1 \cdot 36 \times 10^{-10}$ m **(1)**	**4**	Accept 1·4, 1·363, 1·3633 $\Delta x_{\min} \geq 1 \cdot 36 \times 10^{-10}$ m do not award final mark
	(b)		The uncertainty in position will be (too) small. **(1)** Neutrons can be considered a particle/cannot be considered a wave, even on the length scale of the lattice spacing. **(1)**	**2**	Accept a de Broglie wavelength argument. A large uncertainty in p may result in a large uncertainty in the de Broglie wavelength. **(1)** This de Broglie wavelength may not be close to the lattice spacing. **(1)** Uncertainty in position less than gap between layers acceptable for both marks.

Question			Answer	Max mark	Additional guidance
8.	(a)	(i)	Main sequence	**1**	
		(ii)	X: helium (nucleus) **(1)** Z: positron **(1)**	**2**	Accept alpha particle Accept anti-electron Accept He, e^+, β^+ Do not accept 'Helium atom'
	(b)		Solar wind	**1**	Do not accept cosmic rays.
	(c)	(i)	$p = 1{\cdot}6726 \times 10^{-6} \times n \times v^2$ $0{\cdot}956 = 1{\cdot}6726 \times 10^{-6} \times n \times 602^2$ **(1)** $n = 1{\cdot}58$ (particles per cm^3) **(1)**	**2**	Correct unit conversions must be made. Accept 1·6, 1·577, 1·5771
		(ii) (A)	(As the particles are ejected in all directions they will) spread out (as they get further from the Sun).	**1**	Accept density decreases with radius/Sun acts as a point source/constant number of particles over a larger area.
		(ii) (B)	(The particles lose kinetic energy and) gain (gravitational) potential (energy) (as they move further from the Sun.) **OR** Work is done against the Sun's gravitational field (for the particles to move away).	**1**	Accept reduction in velocity due to gravitational force and statement of $E_K = \frac{1}{2}mv^2$ Lose speed on its own not sufficient
	(d)		The charged particles have a component (of velocity) parallel to the (magnetic) field which moves them forwards in that direction. (1) The component (of velocity) perpendicular: to the (magnetic) field causes a central force on the charged particle **OR** it moves in a circle. (1)	**2**	Independent marks

Question			Answer	Max mark	Additional guidance
9.	(a)	(i)	$\omega = \frac{d\theta}{dt}$ **(1)** $\omega = \frac{2\pi \times 1\cdot5}{2\cdot5}$ **(1)** $\omega = 3\cdot8 \text{ rad s}^{-1}$	**2**	SHOW question Accept $\omega = \frac{\theta}{t}$, $\omega = 2\pi f$ or $\omega = \frac{2\pi}{T}$ as a starting point. Final line must appear or max **(1 mark).**
		(ii)	$(x = -0\cdot2\cos(3\cdot8t))$ $\frac{\mathrm{d}x}{\mathrm{dt}} = -3\cdot8 \times (-0\cdot2\sin(3\cdot8t))$ $\frac{\mathrm{d}^2x}{\mathrm{dt}^2} = -3\cdot8^2 \times (-0\cdot2\cos(3\cdot8t))$ **(1)** $\frac{\mathrm{d}^2x}{\mathrm{dt}^2} = -3\cdot8^2 x$ **(1)** (Since the equation is in the form) $a = -\omega^2 y$ or $a = -\omega^2 x$ (, the horizontal displacement is consistent with SHM). **(1)**	**3**	NOT A STANDARD SHOW QUESTION First mark for BOTH differentiations correct Second mark for correct substitution of *x* back into second differential (including correct treatment of negatives). Numerical constant may be evaluated without penalty (14·44). Statement regarding significance of equation required for third mark.
		(iii)	$v = (\pm)\omega\sqrt{(A^2 - y^2)}$ **(1)** $v = (\pm)3\cdot8 \times \sqrt{(0\cdot2^2 - 0^2)}$ **(1)** $v = (\pm)0\cdot76 \text{ m s}^{-1}$ **(1)**	**3**	Accept $v_{(max)} = (\pm)\omega A$ Accept A=0·2m or A=-0·2m Accept $\frac{\mathrm{d}x}{\mathrm{dt}} = -3\cdot8 \times (-0\cdot2\sin(3\cdot8t))$ as a starting point. Accept 0·8, 0·760, 0·7600
		(iv)	$\frac{1}{2}(m)v^2 = (m)gh$ **(1)** $h = \frac{0\cdot5 \times 0\cdot76^2}{9\cdot8}$ **(1)** $h = 2\cdot9 \times 10^{-2} \text{ m}$ **(1)**	**3**	Allow $\frac{1}{2}(m)\omega^2 A^2 = (m)gh$ as starting point. $\frac{1}{2}(m)\omega^2 y^2 = (m)gh$ zero marks unless statement that $y = A$ Accept 3, 2·95, 2·947

Question			Answer	Max mark	Additional guidance
9.	(b)		The shape of the line should resemble a sinusoidal wave with values either all positive or all negative and the minimum vertical displacement consistent. **(1)** Peak height should show a steady decline with each oscillation / decreasing amplitude, as shown in the graph in the additional guidance notes. **(1)**	**2**	 Marks independent

Question			Answer	Max mark	Additional guidance
10.	(a)	(i)	$\phi = \frac{2\pi x}{\lambda}$ **(1)** $\phi = \frac{2\pi \times 4\cdot 25 \times 10^{-7}}{1\cdot 55 \times 10^{-6}}$ **(1)** $\phi = 1\cdot 72$ rad **(1)**	**3**	Accept 1·7, 1·723, 1·7228
		(ii)	(The electric field vectors will be in) <u>opposite</u> (directions at positions P and Q).	**1**	
	(b)	(i)	$v = f\lambda$ **(1)** $v = 1\cdot 31 \times 10^{14} \times 1\cdot 55 \times 10^{-6}$ **(1)** $v = 2\cdot 03 \times 10^{8}\ \text{m s}^{-1}$	**2**	SHOW question Both equation and substitution must be shown. Final line must also be shown.
		(ii)	$v_m = \frac{1}{\sqrt{\varepsilon_m \mu_m}}$ $2\cdot 03 \times 10^{8} = \frac{1}{\sqrt{\varepsilon_m \times 4\pi \times 10^{-7}}}$ **(1)** $\varepsilon_m = 1\cdot 93 \times 10^{-11}\ \text{F m}^{-1}$ **(1)**	**2**	Accept 1·9, 1·931, 1·9311

Question			Answer	Max mark	Additional guidance
11.	(a)		(Division of) amplitude	**1**	
	(b)		$\Delta x = \frac{9 \cdot 8 \times 10^{-4}}{20}$ **(1)** $\Delta x = \frac{\lambda l}{2d}$ **(1)** $d = \frac{589 \times 10^{-9} \times 75 \times 10^{-3} \times 20}{2 \times 9 \cdot 8 \times 10^{-4}}$ **(1)** $d = 4 \cdot 5 \times 10^{-4}$ m **(1)**	**4**	First mark independent Accept 5, 4·51, 4·508
	(c)		Reduces the uncertainty in the value of Δx or d obtained. **OR** Reduces the impact/significance of any uncertainty on the value obtained for Δx or d.	**1**	
	(d)		The wire expands/d increases **(1)** $\Delta x = \frac{\lambda l}{2d}$, (and since d increases) while l and λ remain constant, (Δx decreases). **OR** Since d increases and $\Delta x \propto 1/d$, Δx decreases. **(1)**	**2**	

Question			Answer	Max mark	Additional guidance
12.	(a)	(i)	The brightness (starts at a maximum and) decreases to (a minimum at) 90°. **(1)** The brightness then increases (from the minimum back to the maximum at 180°). **(1)**	**2**	Response must indicate a gradual change as the analyser rotates.
		(ii)	The brightness remains constant (throughout).	**1**	
	(b)	(i)	$n = \tan i_p$ **(1)** $i_p = \tan^{-1}(1\cdot33)$ **(1)** $i_p = 53\cdot1^{\circ}$ **(1)**	**3**	Accept 53, 53·06, 53·061
		(ii)	The polarising sunglasses will act as an analyser/ absorb/block (some of) the glare.	**1**	

Question			Answer	Max mark	Additional guidance
13.	(a)		Force per unit positive charge (at a point in an electric field)	**1**	
	(b)	(i)	$F_e = W \tan\theta$ **(1)** $F_e = 9\cdot80\times10^{-4}\times\tan 30$ **(1)** $F_e = 5\cdot66\times10^{-4}$ N	**2**	NOT A STANDARD SHOW QUESTION $\tan\theta = \frac{opposite}{adjacent}$ is an acceptable starting point
		(ii)	$F = \frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$ **(1)** $5\cdot66\times10^{-4} = \frac{(22\times10^{-9})^2}{4\pi\times8\cdot85\times10^{-12}r^2}$ **(1)** $r = 0\cdot088$ m **(1)**	**3**	Accept 0·09, 0·0877, 0·08769 Accept 0·08773 if 9×10^9 used.
		(iii)	$V = \frac{Q}{4\pi\varepsilon_o r}$ **(1)** $r = 0\cdot088$ (m) **(1)** $V = \frac{22\times10^{-9}}{4\times\pi\times8\cdot85\times10^{-12}\times0\cdot088}$ **(1)** $V_{total} = 2\times\frac{22\times10^{-9}}{4\times\pi\times8\cdot85\times10^{-12}\times0\cdot088}$ **(1)** $V_{total} = 4\cdot5\times10^3$ V **(1)**	**5**	Or consistent with (b)(ii) Accept : 4000, 4496

Question			Answer	Max mark	Additional guidance
14.	(a)		$B = 4\cdot2\times10^{-3}\times0\cdot22$ $= 9\cdot2\times10^{-4}$ T **(1)**	**1**	Accept 9, 9·24, 9·240
	(b)	(i)	$\frac{q}{m} = \frac{2V}{B^2r^2}$ $\frac{q}{m} = \frac{2\times5\cdot0\times10^3}{(9\cdot2\times10^{-4})^2\times0\cdot28^2}$ **(1)** $\frac{q}{m} = 1\cdot5\times10^{11}$ C kg^{-1} **(1)**	**2**	Accept 2, 1·51, 1·507 **OR** consistent with (a)
		(ii)	%Uncertainty in B & r is doubled **(1)** $\%\Delta(w) = \sqrt{(\%\Delta x^2 + \%\Delta y^2 + \%\Delta z^2)}$ **(1)** $\%\Delta(\frac{q}{m}) = \sqrt{(10^2 + 10^2 + 12^2)}$ **(1)** $\Delta(\frac{q}{m}) = 0\cdot3\times10^{11}$ C kg^{-1} **(1)**	**4**	Suspend sig fig rule
	(c)		B^2 and $1/r^2$ *(r^2 and $1/B^2$)* **OR** B and $1/r$ *(r and 1/B)* **OR** I and $1/r$ *(r and 1/I)* OR I^2 and $1/r^2$ *(r^2 and $1/I^2$)* **(1)**	**1**	Also accept constants correctly included on the axes

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

Question			Answer	Max mark	Additional guidance
15.	(a)		$t = RC$ **(1)** $\frac{10.0}{5} = R \times 32 \times 10^{-6}$ **(1)** $R = 6 \cdot 3 \times 10^{4}\,\Omega$ **(1)**	**3**	Accept 6, 6·25, 6·250
	(b)		$t = RC$ **(1)** $t_{\left(\frac{1}{2}\right)} = 0 \cdot 7 \times 80 \cdot 0 \times 32 \times 10^{-6}$ **(1)** $t_{\left(\frac{1}{2}\right)} = 1 \cdot 8 \times 10^{-3}\,\text{s}$	**2**	SHOW question
	(c)	(i)	$\varepsilon = -L\frac{dI}{dt}$ **(1)** $-4 \cdot 80 \times 10^{3} = -50 \cdot 3 \times 10^{-3} \times \frac{dI}{dt}$ **(1)** $\frac{dI}{dt} = 9 \cdot 54 \times 10^{4}\ \text{A}\,\text{s}^{-1}$ **(1)**	**3**	Accept 9·5, 9·543, 9·5427
		(ii)	(Additional) resistor will dissipate energy. **(1)** Inductor will store energy (and then deliver it to the patient). **(1)**	**2**	No energy loss/dissipation in inductor acceptable for second mark.

[END OF MARKING INSTRUCTIONS]