National
Qualifications
2019

2019 Physics

Advanced Higher

Finalised Marking Instructions

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

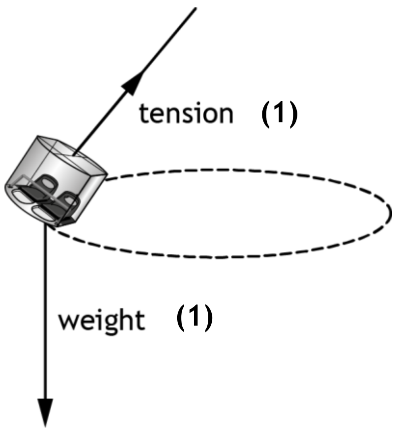
Question:

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

Marking instructions for each question

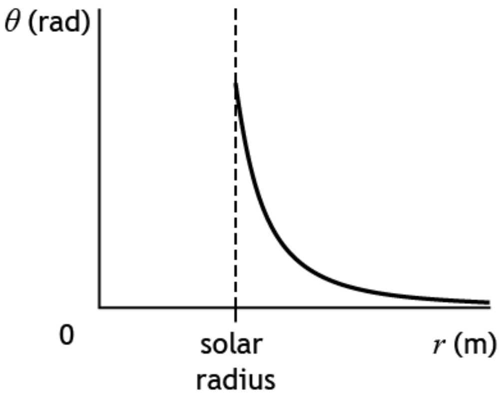
Question			Expected response	Max mark	Additional guidance
1.	(a)		$v = 4 \cdot 2t^2 + 1 \cdot 6t$ $a\left(= \frac{dv}{dt}\right) = 8 \cdot 4t + 1 \cdot 6$ **(1)** $24 = 8 \cdot 4t + 1 \cdot 6$ **(1)** $t = 2 \cdot 7 \text{ s}$ **(1)**	**3**	Accept: 3, 2·67, 2·667
	(b)		$s = \int (4 \cdot 2t^2 + 1 \cdot 6t).dt$ $s = \frac{4 \cdot 2t^3}{3} + \frac{1 \cdot 6t^2}{2} (+c)$ **(1)** (s=0 when t=0, so c=0) $s = \frac{4 \cdot 2 \times 2 \cdot 7^3}{3} + \frac{1 \cdot 6 \times 2 \cdot 7^2}{2}$ **(1)** $s = 33 \text{ m}$ **(1)**	**3**	Or consistent with (a) Accept: 30,33·4, 33·39 Solution with limits also acceptable $s = \int_0^{2 \cdot 7} \left(4 \cdot 2t^2 + 1 \cdot 6t\right). dt$ $s = \left[\frac{4 \cdot 2 \times t^3}{3} + \frac{1 \cdot 6 \times t^2}{2}\right]_0^{2 \cdot 7}$ **(1)** $s = \left(\frac{4 \cdot 2 \times 2 \cdot 7^3}{3} + \frac{1 \cdot 6 \times 2 \cdot 7^2}{2}\right)(-0)$ **(1)** $s = 33 \text{ m}$ **(1)**

Question			Expected response	Max mark	Additional guidance
2.	(a)	(i)	$F = \frac{mv^2}{r}$ **(1)** $F = \frac{380 \times 8 \cdot 8^2}{7 \cdot 6}$ **(1)** $F = 3900$ N **(1)**	**3**	Accept: 4000, 3870, 3872 $F = mr\omega^2$ and $\omega = \frac{v}{r}$ **(1)** $F = 380 \times 7 \cdot 6 \times \left(\frac{8 \cdot 8}{7 \cdot 6}\right)^2$ **(1)** $F = 3900$ N **(1)**
	(a)	(ii)	Towards the centre of the (horizontal) circle	**1**	Along the radius **(0)** Along the radius towards the centre **(1)**
	(b)	(i)		**2**	
	(b)	(ii)	(θ) decreases **(1)** (Horizontal component of) tension decreases **and** weight unchanged **(1)**	**2**	MUST JUSTIFY Accept: centripetal force decreases.

Question			Expected response	Max mark	Additional guidance
3.	(a)		$I = \frac{1}{3}ml^2$ **(1)** $I = \frac{1}{3} \times 63 \times 2{\cdot}1^2$ **(1)** $I = 93\ \text{kg m}^2$	2	SHOW QUESTION Final answer must be shown otherwise **(1 max)**
	(b)	(i)	Mass (is now distributed) closer to the axis of rotation	1	There must be some implication that the mass distribution/ gymnast/legs is closer to the axis.
		(ii)	$I_1\omega_1 = I_2\omega_2$ **(1)** $93 \times 7{\cdot}9 = 62 \times \omega_2$ **(1)** $\omega_2 = 12\ \text{rad s}^{-1}$ **(1)**	3	Accept 10, 11·9,11·85

Question			Expected response	Max mark	Additional guidance
4.			Demonstrates no understanding. **(0 marks)** Demonstrates limited understanding. **(1 marks)** 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.

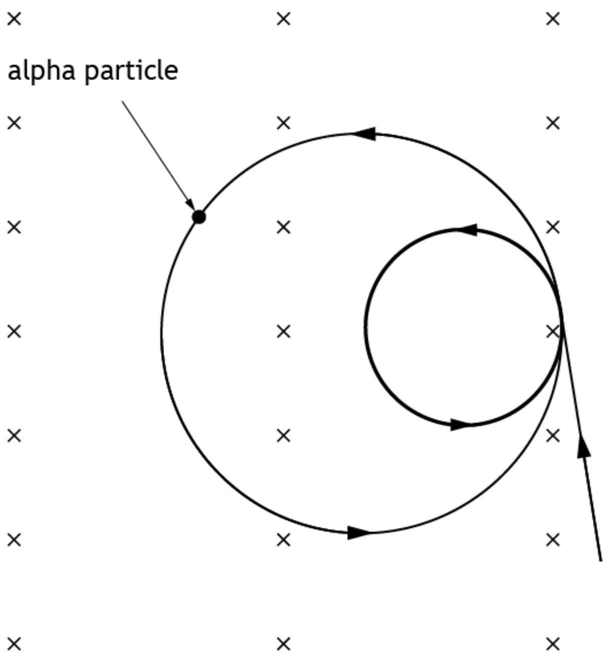
Question			Expected response	Max mark	Additional guidance
5.	(a)		(-)1·70×10⁹ joules (of energy) transferred in moving unit mass (or 1 kg) from infinity to that point	**1**	
	(b)		$V = -\frac{GM}{r}$ **(1)** $V = -\frac{6 \cdot 67 \times 10^{-11} \times 1 \cdot 90 \times 10^{27}}{1 \cdot 69 \times 10^{8}}$ **(1)** $V = -7 \cdot 50 \times 10^{8}\ \text{Jkg}^{-1}$ **(1)**	**3**	Accept: 7·5, 7·499, 7·4988
	(c)		$\Delta V = -7 \cdot 50 \times 10^{8} - (-1 \cdot 70 \times 10^{9})$ **(1)** $(\Delta)E_p = (\Delta)Vm$ **(1)** $(\Delta)E_p = (-7 \cdot 50 \times 10^{8} - (-1 \cdot 70 \times 10^{9})) \times 1 \cdot 6 \times 10^{3}$ **(1)** $(\Delta)E_p = 1 \cdot 5 \times 10^{12}\ \text{J}$ **(1)**	**4**	Or consistent with (b) Accept: 2, 1·52, 1·520 Alternative method: $E_p = Vm$ **(1)** $E_{p(B)} = -7 \cdot 50 \times 10^{8} \times 1 \cdot 6 \times 10^{3}$ $E_{p(A)} = -1 \cdot 70 \times 10^{9} \times 1 \cdot 6 \times 10^{3}$ **(1)** $(\Delta)E_p = (-7 \cdot 50 \times 10^{8} - (-1 \cdot 70 \times 10^{9})) \times 1 \cdot 6 \times 10^{3}$ **(1)** $(\Delta)E_p = 1 \cdot 5 \times 10^{12}\ \text{J}$ **(1)**

Question			Expected response	Max mark	Additional guidance
6.	(a)		It is not possible to distinguish between the effects (on a body) of(uniform) acceleration and a (uniform) gravitational field	**1**	Effects must be implied.
	(b)	(i)	P	**1**	
		(ii)	vertical straight line	**1**	
	(c)	(i)	$\theta = \frac{4GM}{rc^2}$ $0 \cdot 0487 = \frac{4 \times 6{\cdot}67 \times 10^{-11} \times M}{1{\cdot}54 \times 10^6 \times (3{\cdot}00 \times 10^8)^2}$ (1) $M = 2{\cdot}53 \times 10^{31}$ kg (1)	**2**	Accept: 2·5, 2·530, 2·5299
		(ii) (A)	$\theta = \frac{2r_{Schwarzschild}}{r}$ $\theta = \frac{2 \times 3{\cdot}0 \times 10^3}{6{\cdot}955 \times 10^8}$ **(1)** $\theta = 8{\cdot}6 \times 10^{-6}$ (rad) **(1)**	**2**	Accept: 9, 8·63, 8·627
		(ii) (B)		**2**	Shape of line as an inverse curve asymptotic to x-axis **(1)** An inverse curve starting from and continuing to the right of the vertical dotted line. **(1)**

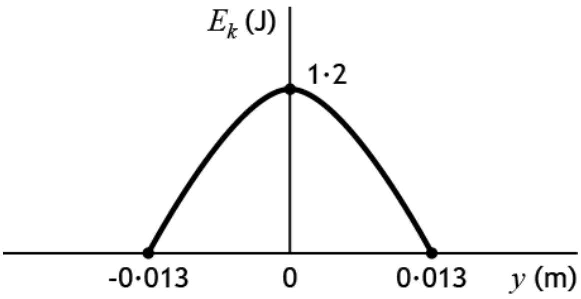
Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	(Star) D	**1**	
		(ii) A	Fusion (of hydrogen) (in core) stops	**1**	
		(ii) B	(Outward forces caused by) thermal pressure exceed gravitational forces.	**1**	Must compare thermal pressure and gravitational forces.
	(b)	(i)	$b = \frac{L}{4\pi r^2}$ **(1)** $1{\cdot}6 \times 10^{-7} = \frac{L}{4\pi \times (6{\cdot}1 \times 10^{18})^2}$ **(1)** $L = 7{\cdot}5 \times 10^{31}$ W **(1)**	**3**	Accept: 7, 7·48, 7·482
		(ii)	$L = 4\pi r^2 \sigma T^4$ **(1)** $7{\cdot}5 \times 10^{31} = 4\pi(8{\cdot}3 \times 10^{11})^2 \times 5{\cdot}67 \times 10^{-8} \times T^4$ **(1)** $T = 3500$ K **(1)**	**3**	Accept:4000, 3520, 3516 **OR** Consistent with (b)(i)
	(c)		Mass	**1**	

Question			Expected response	Max mark	Additional guidance
8.	(a)		$\Delta E \Delta t \geq \frac{h}{4\pi}$ or $\Delta E_{min} \Delta t = \frac{h}{4\pi}$ **(1)** $\Delta E \times 8 \cdot 5 \times 10^{-6} \geq \frac{6 \cdot 63 \times 10^{-34}}{4\pi}$ **(1)** $(\Delta E \geq 6 \cdot 2 \times 10^{-30}$ J) $\Delta E_{(min)} = (\pm) 6 \cdot 2 \times 10^{-30}$ J **(1)**	3	Accept: 6, 6·21, 6·207 $\Delta E_{min} \Delta t \geq \frac{h}{4\pi}$ not acceptable for first line
	(b)		particle energy (J) = $4 \cdot 1 \times 10^{9} \times 1 \cdot 6 \times 10^{-19}$ **(1)** energy = $(4 \cdot 1 \times 10^{9} \times 1 \cdot 6 \times 10^{-19}) \times \frac{10\,000}{60}$ **(1)** energy $= 1 \cdot 1 \times 10^{-7}$ (J) **(1)**	3	Accept: 1, 1·09, 1·093 Independent mark for 10 000 ÷ 60
	(c)		$\lambda = \frac{h}{p}$ **(1)** $\lambda = \frac{6 \cdot 63 \times 10^{-34}}{4 \cdot 87 \times 10^{-19}}$ **(1)** $\lambda = 1 \cdot 36 \times 10^{-15}$ m **(1)** λ is too small for interference/diffraction to be observed **(1)**	4	Accept: 1·4, 1·361, 1·3614

Question			Expected response	Max mark	Additional guidance
9.			Demonstrates no understanding. **(0 marks)** Demonstrates limited understanding. **(1 marks)** 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			Expected response	Max mark	Additional guidance
10.	(a)	(i) A	$F = qvB$ **(1)** $F = 3{\cdot}20 \times 10^{-19} \times 5{\cdot}0 \times 10^{6} \times 1{\cdot}7$ **(1)** $F = 2{\cdot}7 \times 10^{-12}$ N **(1)**	**3**	Accept: 3, 2·72, 2·720
		(i) B	$F = \frac{mv^2}{r}$ **(1)** $2{\cdot}7 \times 10^{-12} = \frac{6{\cdot}645 \times 10^{-27} \times \left(5{\cdot}0 \times 10^{6}\right)^2}{r}$ **(1)** $r = 6{\cdot}2 \times 10^{-2}$ m **(1)**	**3**	Or consistent with 10(a)(i)A Accept: 6, 6·15, 6·153 *If* $m = 6{\cdot}645 \times 10^{-27}$ not used then **(max 1)** Alternative method: $qvB = \frac{mv^2}{r}$ **(1)** $3{\cdot}20 \times 10^{-19} \times 5{\cdot}0 \times 10^{6} \times 1{\cdot}7 = \frac{6{\cdot}645 \times 10^{-27} \times \left(5{\cdot}0 \times 10^{6}\right)^2}{r}$ **(1)** $r = 6{\cdot}1 \times 10^{-2}$ m **(1)** Accept: 6, 6·11, 6·108
		(ii)		**3**	Independent marks smaller circle **(1)** direction of arrow **(1)** position of circle **(1)**

Question			Expected response	Max mark	Additional guidance
10.	(b)		(Component of) velocity perpendicular to the (magnetic) field produces circular motion/central force. **(1)** (Component of) velocity parallel to the (magnetic) field is constant/results in no (unbalanced) force/is unaffected by the magnetic field. **(1)**	**2**	Independent marks ‘Horizontal component’, ‘vertical component’ not acceptable
	(c)		(The observatory is at a high altitude,) bringing it closer to (the path of) the cosmic rays/reduces interaction of rays with the atmosphere. **(1)** (The location is closer to the South Pole,) where the Earth’s magnetic field is stronger/field lines are closer together/higher particle density **(1)**	**2**	Independent marks

Question			Expected response	Max mark	Additional guidance
11.	(a)	(i)	$\omega = 2\pi f$ **(1)** $\omega = 2\pi \times \frac{580}{60}$ **(1)** $\omega = 61\text{ rad s}^{-1}$	2	SHOW QUESTION Accept: $\omega = \frac{\theta}{t}$ or $\omega = \frac{d\theta}{dt}$ or $\omega = \frac{2\pi}{T}$ as a starting point
		(ii)	$E_k = \frac{1}{2}m\omega^2(A^2 - y^2)$ **(1)** maximum E_k at $y = 0$ $E_k = \frac{1}{2} \times 3{\cdot}67 \times 61^2 \times (0{\cdot}013^2 - 0^2)$ **(1)** $E_k = 1{\cdot}2\text{ J}$ **(1)**	3	$E_{k_{(max)}} = \frac{1}{2}m\omega^2 A^2$ acceptable Accept: 1, 1·15, 1·154
		(iii)		3	independent marks shape (inverted curve) **(1)** Line reaches, but does not exceed ± 0·013 on horizontal axis **(1)** Line reaches, but does not exceed 1·2 on vertical axis **(1)** **OR** consistent with (a)(ii)
	(b)	(i)	$9{\cdot}8\text{ ms}^{-2}$ DOWNWARDS	1	magnitude AND direction required
		(ii)	$a = -\omega^2 y$ **(1)** $(-)9{\cdot}8 = (-)61^2 \times y$ **(1)** $y = (-)2{\cdot}6 \times 10^{-3}\text{ m}$ **(1)**	3	**OR** consistent with (b)(i) Accept: 3, 2·63, 2·634

Question			Expected response	Max mark	Additional guidance
12.	(a)	(i)	(The incident wave reflects from the closed end) The <u>incident/transmitted</u> and <u>reflected</u> waves <u>interfere/superimposed</u>	**1**	
		(ii)	The sound will get quieter **(1)** The sound will then get louder again (when the frequency has doubled). **(1)**	**2**	2nd mark dependant on 1st mark
	(b)	(i)	$f = \frac{nv}{4L}$ $510 = \frac{11 \times v}{4 \times 2 \cdot 00}$ **(1)** $v = 370 \text{ m s}^{-1}$ **(1)**	**2**	Accept: 400, 371, 370·9
		(ii)	$\frac{\Delta W}{W} = \sqrt{\left(\frac{\Delta X}{X}\right)^2 + \left(\frac{\Delta Y}{Y}\right)^2 + \left(\frac{\Delta Z}{Z}\right)^2}$ **(1)** $\frac{\Delta L}{L} = \frac{0 \cdot 02}{2 \cdot 00}$ $\frac{\Delta f}{f} = \frac{10}{510}$ **(1 for both)** $\frac{\Delta v}{370} = \sqrt{\left(\frac{0 \cdot 02}{2 \cdot 00}\right)^2 + \left(\frac{10}{510}\right)^2}$ **(1)** $\Delta v = (\pm) 8 \text{ m s}^{-1}$ **(1)**	**4**	Speed used should be consistent with (b)(i) Use of percentage rather than fractional uncertainty is acceptable.

Question			Expected response	Max mark	Additional guidance
12.	(c)	(i)	Recognition that the gradient of the graph gives the speed of sound in air by using a relationship to calculate gradient, for example: $\left(v = \frac{"\Delta y"}{"\Delta x"}\right)$ **(1)** $v = \frac{(560 - 360)}{(1{\cdot}55 - 0{\cdot}95)}$ **(1)** $v = 330\ \text{m s}^{-1}$ **(1)**	**3**	Use of a single data point: award **(0 marks).** Both values used must be from the line, not plotted data points.
		(ii) (A)	Both methods are equally precise.	**1**	**OR** consistent with candidate's own calculations.
		(ii) (B)	The graphical method is more accurate.	**1**	**OR** consistent with candidate's own calculations.
		(iii)	Measurement of the frequency (consistently high) **OR** Measurement of the length (consistently high) **OR** Counting of resonant frequency (consistently low).	**1**	

Question			Expected response	Max mark	Additional guidance
13.	(a)	(i)	$\Delta x = \frac{43 \cdot 4 \times 10^{-3}}{14}$ **(1)** $\Delta x = \frac{\lambda D}{d}$ **(1)** $\frac{43 \cdot 4 \times 10^{-3}}{14} = \frac{550 \times 10^{-9} \times 2 \cdot 95}{d}$ **(1)** $d = 5 \cdot 2 \times 10^{-4}$ m **(1)**	**4**	The mark for substitution to determine Δx is independent Accept: 5, 5·23, 5·234
		(ii)	Measuring over multiple fringe separations reduces the uncertainty in Δx. **OR** Measuring over multiple fringe separations reduces the uncertainty in d.	**1**	Reducing absolute scale reading uncertainty in Δx **(0 marks)**
	(b)		The fringe separation will increase **(1)** λ has increased <u>and</u> d and D are unchanged **(1)**	**2**	MUST JUSTIFY Accept: λ has increased and $\Delta x \propto \lambda$ for second mark.
	(c)	(i)	*optical path difference* = *n*$\times$*geometrical path difference* **(1)** *optical path difference* = $1 \cdot 46 \times (2 \times 3 \cdot 39 \times 10^{-6})$ **(1)** *optical path difference*= $9 \cdot 90 \times 10^{-6}$ m **(1)**	**3**	Accept: 9·9, 9·899, 9·8988
		(ii)	*optical path difference* = $9 \cdot 90 \times 10^{-6} - 550 \times 10^{-9}$ *optical path difference* = $9 \cdot 35 \times 10^{-6}$ m **(1)**	**1**	**OR** consistent with (c)(i)

Question			Expected response	Max mark	Additional guidance
14.	(a)	(i)	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$ **(1)** $V = \dfrac{1{\cdot}3\times10^{-14}}{4\pi\times8{\cdot}85\times10^{-12}\times48\times10^{-3}}$ **(1)** $V = 2{\cdot}4\times10^{-3}\ \text{V}$	**2**	SHOW QUESTION $V = k\dfrac{Q}{r}$ **(1)** $V = 9\times10^{9}\times\dfrac{1{\cdot}3\times10^{-14}}{48\times10^{-3}}$ **(1)** $V = 2{\cdot}4\times10^{-3}\ \text{V}$ Final answer must be shown or max **(1 mark).**
		(ii)	$\left(V = \dfrac{Q}{4\pi\varepsilon_0 r}\right)$ $V_{(-)} = \dfrac{-1{\cdot}3\times10^{-14}}{4\pi\times8{\cdot}85\times10^{-12}\times52\times10^{-3}}$ **(1)** $(V_{(P)} = V_{(+)} + V_{(-)})$ $V_{(P)} = 2\cdot4\times10^{-3} + \dfrac{-1{\cdot}3\times10^{-14}}{4\pi\times8{\cdot}85\times10^{-12}\times52\times10^{-3}}$ **(1)** $V_{(P)} = 1{\cdot}5\times10^{-4}\ \text{V}$ **(1)**	**3**	Method using k as above acceptable. Accept: 2, 1·52, 1·520 (ϵ_0) Accept: 2, 1·50, 1·500 (k)
	(b)		The electrical potential (at the electrode) will increase. **(1)** As the electrical potential due to the positive charge will increase while the electrical potential due to the negative charge remains constant. **OR** As the distance from the positive charge to the electrode will decrease while the distance from the negative charge to the electrode remains constant. **(1)**	**2**	MUST JUSTIFY.

Question			Expected response	Max mark	Additional guidance
15.	(a)		Into the page.	**1**	
	(b)	(i)	$\left(F_{(E)} = QE, F_{(B)} = qvB\right)$ $EQ = qvB$ **(1) , (1)** $E = v\ B$ $V = Ed$ **(1)** $v = \frac{V}{Bd}$	**3**	SHOW QUESTION **(1 mark)** for both relationships, **(1 mark)** for equality of forces or fields Final line must appear or max **(2 marks)**
		(ii)	$v_d = \frac{V}{Bd}$ $v_d = \frac{3 \cdot 47 \times 10^{-6}}{1 \cdot 25 \times 3 \cdot 25 \times 10^{-2}}$ **(1)** $v_d = 8 \cdot 54 \times 10^{-5}$ ms^{-1} **(1)**	**2**	Accept: 8·5, 8·542, 8·5415
		(iii)	Because more charges have been separated (vertically) across the plate. **OR** More electrons gather on the bottom of the plate. **(1)** (The increased magnetic force) increases the electric force/potential difference/electric field strength (across the plate). **(1)**	**2**	Marks are independent.

Question			Expected response	Max mark	Additional guidance
16.	(a)	(i)	A series circuit containing a battery or cell, a resistor and capacitor in series. Voltmeter connection should be in parallel with the capacitor.	**1**	
		(ii)	63% of $6{\cdot}0(V)(= 3{\cdot}8V)$ **(1)** (From graph, $t = 0{\cdot}55\,\text{s}$ when $V = 3{\cdot}8\,\text{V}$) $t = 0{\cdot}55\,\text{s}$ **(1)**	**2**	(Considered) fully charged after 3 - 4 s **(1)** t= 0·6 → 0·8 **(1)**
		(iii)	$t = RC$ **(1)** $0{\cdot}55 = 2{\cdot}2 \times 10^3 \times C$ **(1)** $C = 2{\cdot}5 \times 10^{-4}$ F **(1)**	**3**	Or consistent with (a)(ii) Accept: $3, 2{\cdot}50, 2{\cdot}500$
	(b)	(i)	$\mathcal{E} = -L\frac{dI}{dt}$ **(1)** $-9{\cdot}0 = -L \times 95{\cdot}8$ **(1)** $L = 9{\cdot}4 \times 10^{-2}$ H **(1)**	**3**	Accept: $9, 9{\cdot}39, 9{\cdot}395$
		(ii)	The d.c. ammeter will display the greater current. **(1)** Since the a.c. current will generate reactance or impedance in the inductor **(1)**	**2**	MUST JUSTIFY

[END OF MARKING INSTRUCTIONS]