H

National
Qualifications
RESOURCE

2021 Physics
Section 1

Higher

Finalised Marking Instructions

Marking instructions for each question

Question	Answer	Mark
1.	B	**1**
2.	E	**1**
3.	A	**1**
4.	A	**1**
5.	A	**1**
6.	C	**1**
7.	C	**1**
8.	D	**1**
9.	C	**1**
10.	B	**1**
11.	D	**1**
12.	B	**1**
13.	B	**1**
14.	D	**1**
15.	E	**1**
16.	B	**1**
17.	E	**1**
18.	D	**1**
19.	A	**1**
20.	D	**1**
21.	D	**1**
22.	C	**1**
23.	A	**1**
24.	C	**1**
25.	D	**1**

[END OF MARKING INSTRUCTIONS]

The following table provides information on each question including: Course content being assessed, Skills assessed (see Physics Understanding Standards materials for a definition of each code); Maximum Mark; A-type marks.

Question	Part	Course content	Skills assessed	Maximum mark	A-type marks
1		Our dynamic Universe - motion-equations and graphs	K3	1	
2		Our dynamic Universe - motion-equations and graphs	K1	1	
3		Our dynamic Universe - motion-equations and graphs	K3	1	
4		Our dynamic Universe - forces, energy, and power	K3	1	1
5		Our dynamic Universe - forces, energy, and power	S6	1	
6		Our dynamic Universe - forces, energy, and power	K3	1	
7		Our dynamic Universe - collisions, explosions, and impulse	K3	1	
8		Our dynamic Universe - skills	S4	1	
9		Our dynamic Universe - special relativity	K1	1	
10		Our dynamic Universe - special relativity	K3	1	
11		Our dynamic Universe - expanding Universe	K3	1	1
12		Our dynamic Universe - expanding Universe	K1	1	
13		Particles and waves - forces on charged particles	S6	1	1
14		Particles and waves - Standard Model	K1	1	
15		Particles and waves - Standard Model	S4	1	1
16		Particles and waves - nuclear reactions	K3	1	
17		Particles and waves - wave-particle duality	S5	1	
18		Particles and waves - interference	K3	1	1
19		Particles and waves - refraction of light	K3	1	
20		Particles and waves - refraction of light	S6	1	1
21		Electricity - current, potential difference, power, and resistance	K3	1	
22		Electricity - current, potential difference, power, and resistance	K3	1	
23		Electricity - capacitors	K1	1	
24		Electricity - capacitors	K3	1	
25		Electricity - capacitors	S6	1	

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2021 Physics
Section 2

Higher

Finalised Marking Instructions

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General marking principles for Physics Higher

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

(a) 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.

(b) If a 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.

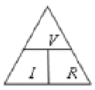
(c) Where a wrong answer to part of a question is carried forward and the wrong answer is then used correctly in the following part, give the candidate credit for the subsequent part or 'follow-on'. (GMP 17)

(d) Award full marks for a correct final answer (including units if required) on its own, unless a numerical question specifically requires evidence of working to be shown, eg in a 'show' question. (GMP 1)

(e) Award marks where a diagram or sketch conveys correctly 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.

(g) 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 22)

(h) Do not award marks if a 'magic triangle' (eg) 

is the only statement in a candidate's response. To gain the mark, the correct relationship must be stated, for example $V = IR$ or $R = \frac{V}{I}$ (GMP 6)

(i) In rounding to an expected number of significant figures, award the mark for correct answers which have up to two figures more or one figure less than the number in the data with the fewest significant figures. (GMP 10)
(Note: the use of a recurrence dot, eg $0{\cdot}\dot{6}$, would imply an infinite number of significant figures and would therefore not be acceptable.)

(j) Award marks where candidates have incorrectly spelled technical terms, provided that responses can be interpreted and understood without any doubt as to the meaning. Where there is ambiguity, do not award the mark. Two specific examples of this would be when the candidate uses a term that might be interpreted as 'reflection', 'refraction' or 'diffraction' (for example 'defraction'), or one that might be interpreted as either 'fission' or 'fusion' (for example 'fussion'). (GMP 25)

(k) Only award marks for a valid response to the question asked. Where candidates are asked to:

- **identify**, **name**, **give**, or **state**, they must 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 gain marks for the breadth and/or depth of their conceptual understanding.

Standard three marker
The examples over the page set out how to apportion marks to answers requiring calculations. These are the 'standard three marker' type of questions.

Award full marks for a correct answer to a numerical question, even if the steps are not shown explicitly, **unless** it specifically requires evidence of working to be shown.

For some questions requiring numerical calculations, there may be alternative methods (eg alternative relationships) which would lead to a correct answer.

Sometimes, a question requires a calculation which does not fit into the 'standard three marker' type of response. In these cases, the detailed marking instructions will contain guidance for marking the question.

When marking partially correct answers, apportion individual marks as shown over the page.

Example of a 'standard three marker' 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 and comment**
1.	$V = IR$ $7{\cdot}5 = 1{\cdot}5 \times R$ $R = 5{\cdot}0\ \Omega$	1 mark: relationship 1 mark: substitution 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: relationship only
8.	$R = \frac{V}{I} = \_\_\ \Omega$	1 mark: relationship only
9.	$R = \frac{V}{I} = \frac{7{\cdot}5}{1{\cdot}5} = \_\_\ \Omega$	2 marks: relationship and substitution, no final answer
10.	$R = \frac{V}{I} = \frac{7{\cdot}5}{1{\cdot}5} = 4{\cdot}0$	2 marks: relationship and substitution, wrong answer
11.	$R = \frac{V}{I} = \frac{1{\cdot}5}{7{\cdot}5} = 5{\cdot}0\ \Omega$	1 mark: relationship but wrong substitution
12.	$R = \frac{V}{I} = \frac{75}{1{\cdot}5} = 5{\cdot}0\ \Omega$	1 mark: relationship but wrong substitution
13.	$R = \frac{I}{V} = \frac{7{\cdot}5}{1{\cdot}5} = 5{\cdot}0\ \Omega$	0 marks: wrong relationship
14.	$V = IR$ $7{\cdot}5 = 1{\cdot}5 \times R$ $R = 0{\cdot}2\ \Omega$	2 marks: relationship and substitution, arithmetic error
15.	$V = IR$ $R = \frac{I}{V} = \frac{1{\cdot}5}{7{\cdot}5} = 0{\cdot}2\ \Omega$	1 mark: relationship only, wrong rearrangement of symbols

Marking instructions for each question

Question			Expected response	Max mark	Additional guidance
1.	(a)	(i)	$(v_h = 16\cdot0\cos 42\cdot0)$ $v_h = 11\cdot9$ m s^{-1}	**1**	Accept:12, 11·89, 11·890
		(ii)	$(v_v = 16\cdot0\sin 42\cdot0)$ $v_v = 10\cdot7$ m s^{-1}	**1**	Accept: 11, 10·71, 10·706
	(b)		$v = u + at$ **(1)** $0 = 10\cdot7 + (-9\cdot8)t$ **(1)** $t = 1\cdot1$ s **(1)**	**3**	Or consistent with (a)(ii) u and a must have opposite signs Accept: 1, 1·09, 1·092 For alternative methods: 1 mark for **all** relationships 1 mark for **all** substitutions 1 mark for final answer
	(c)		$s = vt$ **(1)** $s = 11\cdot9 \times (1\cdot1 + 1\cdot40)$ **(1)** $s = 29\cdot8$ m **(1)**	**3**	Or consistent with (a)(i) and (b) Accept: 29·75, 29·750 Also accept 30
	(d)		Greater **(1)** The skier has a greater speed/ velocity as they land. **(1)**	**2**	Potential energy at take-off is transferred/converted to kinetic energy.

Question			Expected response	Max mark	Additional guidance
2.	(a)		$F = ma$ **(1)** $1{\cdot}15\times10^5 = (9{\cdot}75\times10^4 + 3{\cdot}56\times10^4)\times a$ **(1)** $(F = ma)$ $F = 3{\cdot}56\times10^4 \times \left(\frac{1{\cdot}15\times10^5}{1{\cdot}331\times10^5}\right)$ **(1)** $F = 3{\cdot}08\times10^4$ N **(1)**	**4**	Accept 3·1, 3·076, 3·0759 $F = ma$ anywhere, 1 mark
	(b)	(i)	$f_0 = f_s\left(\frac{v}{v \pm v_S}\right)$ **(1)** $531 = 511\left(\frac{340}{340 - v_S}\right)$ **(1)** $v_S = 13$ m s^{-1} **(1)**	**3**	Accept $f_0 = f_s\left(\frac{v}{v - v_S}\right)$ Accept 10, 12·8, 12·81
		(ii)	Not correct/incorrect **(1)** The passenger and engine are travelling at the same velocity. **(1)**	**2**	MUST JUSTIFY Accept: The passenger is travelling at the same speed and in the same direction as the whistle/engine. The distance between the whistle/engine and passenger remains constant.

Question			Expected response	Max mark	Additional guidance
3.	(a)		$v^2 = u^2 + 2as$ **(1)** $v^2 = 0^2 + 2\times(-)9\cdot8\times(-)1\cdot27$ **(1)** $v = 5\cdot0\ \text{m s}^{-1}$ **(1)**	**3**	Accept: 5, 4·99, 4·989 a and s **must** have the same sign, otherwise max 1 mark. For alternative methods: 1 mark for **all** relationships 1 mark for **all** substitutions 1 mark for final answer eg $E_p = mgh$ $E_p = 1\cdot59\times10^{-2}\times9\cdot8\times1\cdot27$ $E_k = \frac{1}{2}mv^2$ $\left(1\cdot59\times10^{-2}\times9\cdot8\times1\cdot27\right) = \frac{1}{2}\times1\cdot59\times10^{-2}\times v^2$ $v = 5\cdot0\ \text{ms}^{-1}$
	(b)		$Ft = mv - mu$ **(1)** $0\cdot14 = \left(1\cdot59\times10^{-2}\times v\right) - \left(1\cdot59\times10^{-2}\times -5\cdot0\right)$ **(1)** $v = 3\cdot8\ \text{m s}^{-1}$ **(1)**	**3**	**Or** consistent with (a) Accept: 4, 3·81, 3·805 Ft and u must have opposite signs otherwise max 1 mark. Accept: $\Delta p = mv - mu$ $p = mv$ Do not accept $p = mv - mu$
	(c)		Kinetic energy is greater before (the collision) than after. **OR** Kinetic energy is lost (during the collision)	**1**	Do not accept E_k before not equal to E_k after. Do not accept E_k is not conserved.
	(d)		(Softer material would) increase the time of contact **(1)** and decrease the (maximum/ average) force **(1)**	**2**	Independent marks

Question			Expected response	Max mark	Additional guidance
4.			**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
5.	(a)		$F = G\frac{m_1 m_2}{r^2}$ **(1)** $1{\cdot}59\times10^{39} = 6{\cdot}67\times10^{-11}\times\frac{3{\cdot}18\times10^{30}\times2{\cdot}27\times10^{30}}{r^2}$ **(1)** $r = 5{\cdot}50\times10^{5}$ m **(1)**	**3**	Accept: 5·5, 5·503, 5·5029
	(b)	(i)	Waves <u>meet</u> 180°/completely/totally/exactly out of phase **OR** Crest <u>meets</u> trough **OR** Path difference = $\left(m+\frac{1}{2}\right)\lambda$	**1**	Can be shown by appropriate diagram
		(ii)	$\left(\frac{4\cdot0\times10^{-18}}{4\cdot0\times10^{3}}=\right)10^{-21}$ **(1)** (change in length is) <u>21</u> orders of magnitude <u>smaller</u> **(1)**	**2**	Accept $\left(\frac{10^{-18}}{10^{3}}=\right)10^{-21}$ **OR** (-18-3) = -21 **(1)** Accept 21 <u>smaller</u> on its own **(2)** Do not accept 21 <u>times</u> smaller on its own (0) Accept $\left(\frac{10^{3}}{10^{-18}}=\right)10^{21}$ **OR** 3-(-18) = 21 **(1)** Accept: the length of the arm is 21 orders of magnitude greater than the change in length. **(1)**

Question			Expected response	Max mark	Additional guidance
6.	(a)	(i)	$E_2 - E_1 = hf$ **(1)** $(-0{\cdot}871\times10^{-19} - (-5{\cdot}45\times10^{-19}) = 6{\cdot}63\times10^{-34}\times f$ **(1)** $f = 6{\cdot}91\times10^{14}$ Hz **(1)**	**3**	Accept: 6·9, 6·906, 6·9065 Accept: $E_1 - E_4 = -hf$ $E_4 - E_1 = hf$ $(\Delta)E = hf$ for relationship mark anywhere Accept: $(5{\cdot}45\times10^{-19} - 0{\cdot}871\times10^{-19}) = 6{\cdot}63\times10^{-34}\times f$ If $(0{\cdot}871\times10^{-19} - 5{\cdot}45\times10^{-19})$ shown for substitution, maximum 1 mark for relationship
		(ii)	$v = f\lambda$ **(1)** $3{\cdot}00\times10^{8} = 6{\cdot}91\times10^{14}\times\lambda$ **(1)** $\lambda = 4{\cdot}34\times10^{-7}$ m **(1)**	**3**	Or consistent with (a)(i) Accept: 4·3, 4·342, 4·3415
		(iii)	Blue-violet	**1**	Or consistent with (a)(ii)
	(b)		$z = \frac{v}{c}$ **(1)** $z = \frac{4{\cdot}51\times10^{6}}{3{\cdot}00\times10^{8}}$ **(1)** $z = 0{\cdot}0150$ **(1)**	**3**	Accept: 0·015, 0·01503, 0·015033
	(c)		Redshift is evidence that the Universe is expanding **(1)** Expanding Universe is evidence supporting the Big Bang theory **(1)**	**2**	Accept: Redshift is evidence that the galaxies are moving away from each other.

Question			Expected response	Max mark	Additional guidance
7.	(a)	(i)	To ensure the (accelerating) force on the hydrogen ion is in the same direction. **OR** To ensure the hydrogen ions accelerate in the same direction. **OR** To ensure that the direction of the electric field is correct when the hydrogen ions pass across the gaps.	1	Response must make some implication of 'same direction'.
		(ii)	As the speed of hydrogen ions increases, they travel further in the same time.	1	Accept: So that the hydrogen ions are at the ends of the tubes when the field changes polarity. **OR** So that a constant frequency AC supply can be used.
	(b)		$l' = l\sqrt{1-\left(\frac{v}{c}\right)^2}$ **(1)** $l' = 13\sqrt{1-\left(\frac{0{\cdot}50c}{c}\right)^2}$ **(1)** $l' = 11$ m **(1)**	3	Accept: 10, 11·3, 11·26 Alternative substitutions: $l' = 13\sqrt{1-(0{\cdot}50)^2}$ $l' = 13\sqrt{1-\left(\frac{0\cdot50\times3\cdot00\times10^8}{3\cdot00\times10^8}\right)^2}$
	(c)	(i)	A (composite) particle made of a quark-antiquark pair.	1	Do not accept: made of two quarks
		(ii)	Into the page	1	
	(d)	(i)	W boson **OR** Z boson	1	
		(ii)	4·20 GeV = 4·20 × 10^9 × 1·60 × 10^{-19} **(1)** $E = mc^2$ **(1)** $(4\cdot20\times10^9\times\ 1\cdot60\times10^{-19}) = m\times(3\cdot00\times10^8)^2$ **(1)** $m = 7\cdot47\times10^{-27}$ kg **(1)**	4	Accept: 7·5, 7·467, 7·4667 Relationship anywhere 1 mark.

Question			Expected response	Max mark	Additional guidance
8.	(a)		The frequency of the UV is greater than the threshold frequency, whereas the frequency of white light is less than the threshold frequency. **OR** The energy of a photon of UV is greater than the work function, whereas the energy of a photon of white light is less than the work function.	**1**	Response must refer to both UV and white light.
	(b)	(i)	$1{\cdot}1 \times 10^{-19}$ J	**1**	
		(ii)	$W = QV$ **(1)** $W = 1{\cdot}60 \times 10^{-19} \times 12{\cdot}0$ **(1)** $W = 1{\cdot}92 \times 10^{-18}$ J	**2**	SHOW
		(iii)	$E_k = 1{\cdot}1 \times 10^{-19} + 1{\cdot}92 \times 10^{-18}$ **(1)** $E_k = \frac{1}{2}mv^2$ **(1)** $\left(1{\cdot}1 \times 10^{-19} + 1{\cdot}92 \times 10^{-18}\right) = \frac{1}{2} \times 9{\cdot}11 \times 10^{-31} \times v^2$ **(1)** $v = 2{\cdot}11 \times 10^{6}$ m s^{-1} **(1)**	**4**	Or consistent with (b)(i) Accept: 2·1, 2·111, 2·1111 Relationship anywhere 1 mark

Question			Expected response	Max mark	Additional guidance
9.	(a)	(i)	$F = 19{\cdot}5\sin 14{\cdot}0$ **(1)** $F_R = (2 \times 19{\cdot}5\sin 14{\cdot}0) = 9{\cdot}43$ N **(1)** **OR** $F_R = 2 \times 19{\cdot}5\sin 14{\cdot}0$ **(1)** $F_R = 9{\cdot}43$ N **(1)**	**2**	Accept: 9·4, 9·435, 9·4350 Or by scale diagram: 1 for suitable scale diagram 1 for correct answer
		(ii)	No resultant force in this direction/ the sideways direction **OR** Unbalanced force in this direction/ the sideways direction is 0 N **OR** The components of the force at 90° to the direction of the movement are equal and opposite/balanced. **(1)**	**1**	Accept reference to horizontal forces/left and right direction, since the diagram orientation makes it clear which forces are being referred to. Do not accept: 'the forces are balanced' alone
	(b)	(i)	$I = \frac{P}{A}$ **(1)** $11800 = \frac{P}{1{\cdot}24 \times 10^{-5}}$ **(1)** $P = \frac{E}{t}$ **(1)** $(11800 \times 1{\cdot}24 \times 10^{-5}) = \frac{2{\cdot}10}{t}$ **(1)** $t = 14{\cdot}4$ s **(1)**	**5**	Accept: 14, 14·35, 14·352 $I = \frac{P}{A}$ anywhere, 1 mark $P = \frac{E}{t}$ anywhere, 1 mark
		(ii)	$6{\cdot}3 \times 0{\cdot}30^2 = 0{\cdot}57$ $3{\cdot}5 \times 0{\cdot}40^2 = 0{\cdot}56$ $2{\cdot}3 \times 0{\cdot}50^2 = 0{\cdot}58$ $1{\cdot}6 \times 0{\cdot}60^2 = 0{\cdot}58$ **(2)** Statement of $I \times d^2$ = constant, so LED is a point source **(1)**	**3**	All four calculations correct (2) Three calculations correct (1) <Three calculations correct (0) This conclusion mark is only available if consistent with the calculations shown. Graphical method: Graph drawn correctly (1) Best fit line through origin (1) Statement of $I \propto \frac{1}{d^2}$, so LED is a point source (1)
		(iii) (A)	A semiconductor that has (specific) impurities added	**1**	

Question			Expected response	Max mark	Additional guidance
		(B)		3	Any answer using recombination of holes and electrons **on its own**, with no reference to band theory, is worth 0 marks Any wrong physics eg holes move up (from valence band to conduction band)- 0 marks
			(Voltage applied causes) electrons to move from the conduction band of the n-type (semiconductor) towards the conduction band of the p-type (semiconductor). **(1)**		To access this mark, the direction the electrons move must be clear.
			Electrons 'fall' from the conduction band into the valence band (on either side of the junction) **(1)**		To access this mark, valence and conduction bands must be included in the answer. Do not accept: 'valency' as a name for the valence band or 'conductive' as a name for the conduction band.
			Photons are emitted. **(1)**		This mark is dependent upon having at least one of the first two statements.

Question				Expected response	Max mark	Additional guidance
10.	(a)	(i)	(A)	13·9°	**1**	Do not accept:14
			(B)	$\left(\Delta R = \frac{R_{max} - R_{min}}{n}\right)$ $\Delta R = \frac{14\cdot5 - 13\cdot0}{5}$ **(1)** $\Delta R = 0\cdot3°$ **(1)**	**2**	
		(ii)		$m\lambda = d\sin\theta$ **(1)** $2 \times \lambda = 4\cdot00 \times 10^{-6} \sin 13\cdot9$ **(1)** $\lambda = 4\cdot80 \times 10^{-7}\,\text{m}$ **(1)**	**3**	Or consistent with (a)(i)(A) Accept: 4·8, 4·805, 4·8046
		(iii)		Percentage (scale reading) uncertainty in the angle is smaller **(1)**	**1**	Accept: fractional uncertainty in place of percentage uncertainty Must be percentage or fractional uncertainty not just scale reading uncertainty or uncertainty alone.
	(b)			The path difference (at the central maximum) for each wavelength/ frequency/colour will be zero **(1)**	**1**	Must answer in terms of path difference.

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)	$n = \dfrac{\sin\theta_1}{\sin\theta_2}$ **(1)** $n = \dfrac{\sin 47 \cdot 0}{\sin 31 \cdot 0}$ **(1)** $n = 1 \cdot 42$ **(1)**	**3**	Also accept 1·4, 1·420, 1·4200
		(ii)	(frequency is the) same	**1**	
	(b)		Ray drawn at smaller angle of refraction	**1**	Ignore any emergent rays Ray must be passably straight.
	(c)		green light has a higher/larger/ greater frequency (1) so the refractive index is greater (and the ray refracts more/at a smaller angle) (1)	**2**	Any mention of a greater angle of refraction or no change in the angle of refraction – 0 marks

Question			Expected response	Max mark	Additional guidance
13.	(a)		(An alternating current) changes direction and (instantaneous) value with time.	**1**	
	(b)	(i)	$(V_{peak} = 5{\cdot}0 \times 3)$ $V_{peak} = 15$ V	**1**	
		(ii)	$\left(T = 1{\cdot}0 \times 10^{-3} \times 4 = 4{\cdot}0 \times 10^{-3}\ \text{s}\right)$ $f = \frac{1}{T}$ (1) $f = \frac{1}{4{\cdot}0 \times 10^{-3}}$ (1) $f = 250\text{Hz}$ (1)	**3**	
	(c)		Same frequency and peak voltage **(1)** Trace shows 'half-wave rectification' **(1)**	**2**	Positive or negative half of the cycle accepted.

Question			Expected response	Max mark	Additional guidance
14.	(a)		Adjust variable resistor and take readings of V and I. **(1)** Plot a graph of V against I. **(1)** Gradient of graph = -r. **(1)**	**3**	Measure open circuit voltage E/measure the voltage E when the switch is open. (1) Close the switch and take a reading of V and I. (1) Calculate r using $E = V + Ir$. (1)
	(b)	(i)	1·5 J of energy is supplied to/gained by each coulomb (of charge passing through the cell).	**1**	
		(ii)	$E = V + Ir$ and $V = IR$ **(1)** $6 \cdot 0 = \left(0 \cdot 20R + \left(0 \cdot 20 \times 2 \cdot 0\right)\right)$ **(1)** $R = 28\ \Omega$ **(1)** $(R_v = 28 - 20)$ $R_v = 8 \cdot 0\ \Omega$ **(1)**	**4**	Accept: $E = I\left(R + r\right)$ Accept: 8, 8·00, 8·000
	(c)		Increases **(1)** Current is less **(1)** Lost volts (Ir) decreases **(1)**	**3**	Look for this statement first – if incorrect or missing then (0 marks).

Question			Expected response	Max mark	Additional guidance
15.	(a)		The frictional force/drag acting on the ball bearing increases (as its speed increases). **(1)** The frictional force/drag and weight become balanced. **(1)**	2	
	(b)	(i)	Appropriate labels and units **(1)** Suitable scales **(1)** Correct plotting of points and appropriate line of best fit **(1)**	3	Allow for axes starting at zero or broken axes or at an appropriate value. Accuracy of plotting should be easily checkable with the scale chosen. Do not penalise if the candidate plots d^2 against v_t.
		(ii)	There is a non-zero y-intercept/ The line of best fit does not go through the origin	1	
		(iii)	$m=\frac{y_2-y_1}{x_2-x_1}$ **(1)** Correctly calculated gradient **(1)**	2	**Must** be consistent with graph drawn for (i). Candidates are asked to calculate the gradient of **their graph.** Unit not required but if a unit is given it must be correct. Tolerance required depending upon line of best fit drawn by the candidate.
		(iv)	$m=\frac{375g}{\eta}$ **(1)** Correctly calculated viscosity consistent with b(iii), including correct unit. **(1)**	2	

[END OF MARKING INSTRUCTIONS]

The following table provides information on each question including: Course content being assessed, Skills assessed (see Physics Understanding Standards materials for a definition of each code); Maximum Mark; A-type marks.

Question	Part	Course content	Skills assessed	Maximum mark	A-type marks
1	(a)(i)	Our dynamic Universe - gravitation	K3	1	
	(a)(ii)	Our dynamic Universe - gravitation	K3	1	
	(b)	Our dynamic Universe - motion-equations and graphs	K3	3	
	(c)	Our dynamic Universe - motion-equations and graphs	K3	3	2
	(d)	Our dynamic Universe - forces, energy, and power	K2	2	
2	(a)	Our dynamic Universe - forces, energy, and power	K3	4	
	(b)(i)	Our dynamic Universe - expanding Universe	K3	3	
	(b)(ii)	Our dynamic Universe - expanding Universe	S6	2	2
3	(a)	Our dynamic Universe - motion-equations and graphs	K3	3	
	(b)	Our dynamic Universe - collisions, explosions, and impulse	K3	3	
	(c)	Our dynamic Universe - collisions, explosions, and impulse	K2	1	
	(d)	Our dynamic Universe - collisions, explosions, and impulse	K2	2	
4		Our dynamic Universe - expanding Universe	K2	3	2
5	(a)	Our dynamic Universe - gravitation	K3	3	
	(b)(i)	Particles and waves - interference	K2	1	
	(b)(ii)	Particles and waves - Standard Model	S4	2	1
6	(a)(i)	Particles and waves - spectra	K3	3	
	(a)(ii)	Particles and waves - spectra	K3	3	
	(a)(iii)	Particles and waves - spectra	S2	1	
	(b)	Our dynamic Universe - expanding Universe	K3	3	
	(c)	Our dynamic Universe - expanding Universe	K2	2	1
7	(a)(i)	Particles and waves - forces on charged particles	K2	1	1
	(a)(ii)	Particles and waves - forces on charged particles	S6	1	1
	(b)	Our dynamic Universe - special relativity	K3	3	
	(c)(i)	Particles and waves - Standard Model	K1	1	
	(c)(ii)	Particles and waves - forces on charged particles	S6	1	
	(d)(i)	Particles and waves - Standard Model	K1	1	
	(d)(ii)	Particles and waves - nuclear reactions	S4	1	1
			K3	3	2
8	(a)	Particles and waves - wave-particle duality	K2	1	1
	(b)(i)	Particles and waves - wave-particle duality	S4	1	
	(b)(ii)	Particles and waves - forces on charged particles	K3	2	
	(b)(iii)	Particles and waves - forces on charged particles	K3	4	3

9	(a)(i)	Our dynamic Universe - forces, energy, and power	K3	2	1
	(a)(ii)	Our dynamic Universe - forces, energy, and power	K2	1	1
	(b)(i)	Particles and waves - inverse square law	K3	5	3
	(b)(ii)	Particles and waves - inverse square law	S4	2	
			S6	1	1
	(b)(iii)(A)	Electricity - semiconductors and p-n junctions	K1	1	
	(b)(iii)(B)	Electricity - semiconductors and p-n junctions	K2	3	3
10	(a)(i)(A)	Uncertainties	S4	1	
	(a)(i)(B)	Uncertainties	K3	2	
	(a)(ii)	Particles and waves - interference	K3	3	
	(a)(iii)	Uncertainties	S7	1	1
	(b)	Particles and waves - interference	K2	1	1
11		Particles and waves - spectra	K2	3	2
12	(a)(i)	Particles and waves - refraction of light	K3	3	
	(a)(ii)	Particles and waves - refraction of light	K1	1	
	(b)	Particles and waves - refraction of light	S3	1	
	(c)	Particles and waves - refraction of light	K2	2	2
13	(a)	Electricity - monitoring and measuring AC	K1	1	
	(b)(i)	Electricity - monitoring and measuring AC	S4	1	
	(b)(ii)	Electricity - monitoring and measuring AC	S4	3	
	(c)	Electricity - monitoring and measuring AC	S5	2	1
14	(a)	Electricity - electrical sources and internal resistance	S1	3	1
	(b)(i)	Electricity - electrical sources and internal resistance	K1	1	
	(b)(ii)	Electricity - electrical sources and internal resistance	K3	4	1
	(c)	Electricity - electrical sources and internal resistance	K2	3	2
15	(a)	Our dynamic Universe - forces, energy, and power	K2	2	1
	(b)(i)	Unfamiliar content - skills	S3	3	
	(b)(ii)	Unfamiliar content - skills	S6	1	
	(b)(iii)	Unfamiliar content - skills	S4	2	
	(b)(iv)	Unfamiliar content - skills	S4	2	2