Physics: general marking principles

National 3 — Advanced Higher

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General marking principles

These general marking principles will be used in the marking of examination papers in SQA qualifications in physics at National 5, Higher, and Advanced Higher levels. Please note, however, that specific marking instructions may contain some moderation of the principles in the light of particular issues relating to the examination papers.

The marking principles described in this document will be applied in the verification of assessment judgements relating to the relevant outcomes of unit assessments. Teachers and lecturers must use these general marking principles when marking candidate evidence.

Teachers and lecturers must adopt these general marking principles when marking prelim examinations and centre-devised or administered assessments for any SQA physics courses.

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Issue	Example	Instructions to markers
1 Standard 3-marker	**Question** The current in a resistor is 1.5 A when the potential difference across it is 7.5 V. Calculate the resistance of the resistor. (3) **Response** $V = IR$ or $I = \frac{V}{R}$ or $R = \frac{V}{I}$ $7.5 = 1.5 \times R$ $R = 5.0\ \Omega$	Award 1 mark for a selected appropriate relationship. (An appropriate relationship is one that could lead to the correct final answer.) Award 1 mark for correct substitution. Award 1 mark for the correct final answer. (To be correct, the final answer must include a unit where appropriate.) **Award 3 marks.**

Issue	Example	Instructions to markers
1a No working	**Question** The current in a resistor is 1.5 A when the potential difference across it is 7.5 V. Calculate the resistance of the resistor. (3)	
	Response 1 'R = 5.0 Ω' or '5.0 Ω' alone	Award 1 mark for an implied selected appropriate relationship. Award 1 mark for implied correct substitution. Award 1 mark for the correct final answer. **Award 3 marks.**
	Response 2 'R = 5.0' or 'R = 5.0 A' or '5.0 A'	Award 1 mark for an implied selected appropriate relationship. Award 1 mark for implied correct substitution. Do not award the mark for the final answer (incorrect/missing unit). **Award 2 marks.**
	Response 3 'R = 4.0 Ω' or 'R = Ω'	The given incorrect final answer implies an incorrect substitution. A selected appropriate relationship cannot be implied by an incorrect substitution. Do not award the mark for an appropriate relationship. Do not award the mark for substitution. **Award 0 marks.**

Issue	Example	Instructions to markers
1b Arithmetic error	**Question** The current in a resistor is 1.5 A when the potential difference across it is 7.5 V. Calculate the resistance of the resistor. (3) **Response 1** $V = IR$ $7.5 = 1.5 \times R$ $R = 4.0\ \Omega$ **Response 2** $V = IR$ $7.5 = 1.5 \times R$ $R = 4.0$ A	In a 'standard 3-marker', do not award the mark for the final answer if there is an arithmetic error in the candidate's working. Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer (incorrect value). **Award 2 marks.** Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer (incorrect value and incorrect unit). **Award 2 marks.**

Issue	Example	Instructions to markers
1b (continued)	**Response 3** $V = IR$ $R = 4.0\ \Omega$	Award 1 mark for a selected appropriate relationship. There is no evidence for implied correct substitution. Do not award the mark for substitution. Do not award the mark for the final answer. **Award 1 mark.**

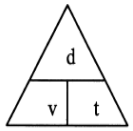
Issue	Example	Instructions to markers
1c Relationship only	**Question** The current in a resistor is 1.5 A when the potential difference across it is 7.5 V. Calculate the resistance of the resistor. (3) **Response 1** $V = IR$	Award 1 mark for a selected appropriate relationship. **Award 1 mark.**
	Response 2 $V = IR$ $P = I^2R$	Two relationships are quoted, but it is not clear which relationship has been selected. Do not award the mark for an appropriate relationship. **Award 0 marks.**

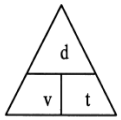
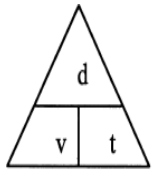
Issue	Example	Instructions to markers
1d Incorrect substitution	**Question** The current in a resistor is 1.5 A when the potential difference across it is 7.5 V. Calculate the resistance of the resistor. (3) **Response 1** $V = IR$ $7.5 = 1.55 \times R$ $R = 4.8\ \Omega$ **Response 2** $V = IR$ $7.5 = 1.55 \times R$ $R = 5.0\ \Omega$	Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution. (Incorrect value substituted for I.) The mark for the final answer is not accessible. **Award 1 mark.** Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution. (Incorrect value substituted for I.) The mark for the final answer is not accessible (despite a 'correct' final answer). **Award 1 mark.**

Issue	Example	Instructions to markers
1e Incorrect transposition	**Question** The current in a resistor is 1.5 A when the potential difference across it is 7.5 V. Calculate the resistance of the resistor. (3) **Response 1** $V = IR$ $7.5 = 1.5 \times R$ $R = \frac{1.5}{7.5} = 0.2\ \Omega$ **Response 2** $V = IR$ $R = \frac{I}{V}$ $R = \frac{7.5}{1.5} = 5.0\ \Omega$	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Incorrect transposition of the numbers. Do not award the mark for the final answer. **Award 2 marks.** Award 1 mark for a selected appropriate relationship. Incorrect transposition of the relationship. Do not award the mark for substitution. The mark for the final answer is not accessible (despite a 'correct' final answer). **Award 1 mark.**

Issue	Example	Instructions to markers
1f Omission	**Question** The current in a resistor is 1.5 A when the potential difference across it is 7.5 V. Calculate the resistance of the resistor. (3) **Response 1** $R = \frac{7.5}{1.5}$ $R = 5.0\ \Omega$ **Response 2** $R = \frac{7.5}{1.5}$ $R = 0.2\ \Omega$	Award marks where the omitted information can be clearly implied from the response. Note, this does not apply to 'show' questions in which the final answer is given. (Issue 22a) Award 1 mark for an implied selected appropriate relationship. Award 1 mark for correct substitution into the relationship. Award 1 mark for the correct final answer. **Award 3 marks.** Award 1 mark for an implied selected appropriate relationship. Award 1 mark for correct substitution into the relationship. Do not award the mark for the final answer. **Award 2 marks.**

Issue	Example	Instructions to markers
1f (continued)	**Response 3** $R = 0.2\ \Omega$	When substitution is not shown, a selected appropriate relationship cannot be implied by an incorrect final answer. The marks for substitution and final answer are not accessible. **Award 0 marks.**
	Response 4 $1.5 = 7.5 \times R$ $R = 0.2\ \Omega$	The selection of an incorrect relationship is implied by the substitution. The marks for substitution and final answer are not accessible. **Award 0 marks.**
	Response 5 $\frac{7.5}{1.5} = 0.2\ \Omega$	Award 1 mark for an implied selected appropriate relationship. Award 1 mark for correct substitution into the relationship. Do not award the mark for the final answer. **Award 2 marks.**

Issue	Example	Instructions to markers
2 Use of triangle relationship	**Question** A car travels at a constant speed of 25 m s^{-1}. Calculate the distance the car travels in 40 s. (3) **Response 1**  $d = 25 \times 40$ $d = 1000$ m	Ignore any 'magic' triangle written on the script. Start marking at the selected or implied relationship. Award 1 mark for a selected appropriate relationship implied by correct substitution. Award 1 mark for correct substitution. Award 1 mark for the correct final answer. **Award 3 marks.**

Issue	Example	Instructions to markers
2 (continued)	**Response 2**  $d = \frac{40}{25}$ $d = 1.6$ m **Response 3**  	The selection of an incorrect relationship is implied by the substitution. Do not award the mark for selection of an appropriate relationship. The marks for substitution and final answer are not accessible. **Award 0 marks.** Do not award the mark for selection of an appropriate relationship. The marks for substitution and final answer are not accessible. **Award 0 marks.**

Issue	Example	Instructions to markers
3 Squaring error (This also applies to powers other than 2)	**Question** Calculate the kinetic energy of a mass of 3.0 kg moving at 2.0 m s^{-1}. (3) **Response 1** $E_k = \frac{1}{2}mv^2$ $E_k = 0.5 \times 3.0 \times 2.0^2$ $E_k = 3.0$ J **Response 2** $E_k = \frac{1}{2}mv^2$ $E_k = 0.5 \times 3.0 \times 2.0$ $E_k = 3.0$ J	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution into the relationship. Do not award the mark for the final answer. **Award 2 marks.** Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution (squaring not shown). The mark for the final answer is not accessible. **Award 1 mark.**

Issue	Example	Instructions to markers
3 (continued)	**Response 3** $E_k = \frac{1}{2}mv^2$ $E_k = 0.5 \times 3.0 \times 2.0$ $E_k = 6.0$ J	Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution (squaring not shown). The mark for the final answer is not accessible (despite a 'correct' final answer). **Award 1 mark.**
	Response 4 $E_k = \frac{1}{2}mv^2$ $E_k = 0.5 \times 3.0 \times 4.0$ $E_k = 6.0$ J	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution into the relationship. (Squared value has been substituted correctly.) Award 1 mark for the correct final answer. **Award 3 marks.**

Issue	Example	Instructions to markers
4 Incorrect substitution of a physical constant	**Question** A ray of monochromatic light has a frequency of 4.57×10^{14} Hz. Calculate the wavelength of this light in air. (3) **Response** $v = f\lambda$ $2.00 \times 10^{8} = 4.57 \times 10^{14} \times \lambda$ $\lambda = 4.38 \times 10^{-7}$ m	Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution (incorrect substitution for v). The mark for the final answer is not accessible. **Award 1 mark.**
	Question Calculate the weight of a 5.0 kg mass on Earth. (3) **Response** $W = mg$ $W = 5.0 \times 9.81$ $W = 49$ N	Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution (incorrect substitution for g; the value given on the data sheet is 9.8). The mark for the final answer is not accessible (despite a 'correct' final answer). **Award 1 mark.**

Issue	Example	Instructions to markers
5 Unit conversion errors		Candidates are expected to be familiar with SI prefixes appropriate to their level, and to convert values between scientific notation form and SI prefix form. Note that the prefixes 'centi' and 'deci' are not SI prefixes.
5a Unit conversion error in substitution — SI prefixes	**Question** Calculate the wavelength in air of microwaves with frequency 65.0 GHz. (3) **Response 1** $v = f\lambda$ $3.00 \times 10^8 = 65.0 \times 10^6 \times \lambda$ $\lambda = 4.62$ mm **Response 2** $v = f\lambda$ $3.00 \times 10^8 = 65.0 \times 10^6 \times \lambda$ $\lambda = 4.62$ m	Award 1 mark for a selected appropriate relationship. Award 1 mark for appropriate substitution. Award 1 mark for correct final answer. (The unit is consistent with substitutions made.) **Award 3 marks.** Award 1 mark for a selected appropriate relationship. Award 1 mark for appropriate substitution. Do not award the mark for the final answer. (The unit is not consistent with substitutions made.) **Award 2 marks.**

Issue	Example	Instructions to markers
5b Unit conversion error in substitution — non-SI prefixes	**Question** Calculate the wavelength in air of microwaves with frequency 65.0 GHz. (3) **Response** $v = f\lambda$ $3.00 \times 10^8 = 65.0 \times 10^4 \times \lambda$ $\lambda = 4.62$ mm	Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution ('$\times 10^4$' does not correspond to an SI prefix). The mark for the final answer is not accessible. **Award 1 mark.**

Issue	Example	Instructions to markers
5c Unit conversion error in substitution — non-SI units	**Question** A car travels at an average speed of 8.0 m s^{-1} for 1.5 minutes. Calculate the distance travelled by the car. (3) **Response** $d = \bar{v}t$ $d = 8.0 \times 1.5$ $d = 12$ m	Depending on level, candidates are expected to be able to convert values given in non-SI units to SI units. Award 1 mark for a selected appropriate relationship. Award 1 mark for substitution (the distance and the time substituted). Do not award the mark for the final answer. **Award 2 marks.**

Issue	Example	Instructions to markers
5c (continued)	**Question** An alpha particle has kinetic energy of 4.85 MeV. Calculate the speed of the alpha particle. (4) **Response** $E_k = \frac{1}{2}mv^2$ $4.85 \times 10^6 = 0.5 \times 6.645 \times 10^{-27} \times v^2$ $v = 3.82 \times 10^{16}\ \text{m s}^{-1}$	Detailed marking instructions for questions involving more complex unit conversions may have marks allocated specifically for the conversion. In such cases, do not award the mark for substitution to a candidate not attempting the unit conversion, or attempting the conversion using wrong physics. Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution. (Unit conversion not attempted.) The mark for the final answer is not accessible. **Award 1 mark.**

Issue	Example	Instructions to markers
5d Unit conversion error in final answer	**Question** Calculate the wavelength of electromagnetic radiation with frequency 1.37×10^{12} Hz. (3) **Response** $v = f\lambda$ $3.00 \times 10^{8} = 1.37 \times 10^{12} \times \lambda$ $\lambda = 2.19 \times 10^{-4}$ m $\lambda = 21.9$ mm	In a 'standard 3-marker', award a maximum of 2 marks, assuming the candidate has selected an appropriate relationship(s), and substituted values correctly. Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer (despite a 'correct' final answer being shown in a previous line of the response). **Award 2 marks.**

Issue	Example	Instructions to markers
6 Significant figures in final answer	**Question** Calculate the kinetic energy of a ball with mass 0.950 kg travelling at 2.35 m s^{-1}. (3) **Response** $E_k = \frac{1}{2}mv^2$ $E_k = 0.5 \times 0.950 \times 2.35^2$ $E_k = 2.62$ J **If the final answer in the response is**: 3 J, 2.62319 J, 2.623188 J or 2.6231875 J	In a numerical question, the candidate should give the final answer to the same precision (number of significant figures) as the least precise data used in the calculation. When marking answers involving rounding to an expected number of significant figures, the mark for the final answer can be awarded for answers that have up to two figures more or one figure fewer than the data given to the fewest significant figures. Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Award 1 mark for the correct final answer. (2.6 J, 2.623 J, and 2.6232 J are also acceptable final answers.) **Award 3 marks.** Do not award the mark for the final answer. **Award a maximum of 2 marks.**

Issue	Example	Instructions to markers
6 (continued)	**Question** An unbalanced force of 4.0 N is applied to a 6.0 kg mass. Calculate the acceleration of the mass. (3) **Response** $F = ma$ $4.0 = 6.0 \times a$ $a = 0.66\dot{6}\ \text{m s}^{-2}$	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer. (Use of the recurrence dot implies an infinite number of significant figures.) **Award 2 marks.**
	Response $F = ma$ $4.0 = 6.0 \times a$ $a = 0.66...\ \text{m s}^{-2}$	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer. (Use of an ellipsis (…) implies an indeterminate number of significant figures.) **Award 2 marks.**

Issue	Example	Instructions to markers
7 Significant figures in intermediate calculations	**Question** In a ripple tank, a wave generator produces 9 waves in 27 seconds. The wavelength of the waves is 4.5×10^{-2} m. Determine the speed of the waves. (5) **Response** $f = \frac{N}{t}$ $f = \frac{9}{27}$ $f = 0.3$ $v = f\lambda$ $v = 0.3 \times 4.5 \times 10^{-2}$ $v = 1 \times 10^{-2}$ ms^{-1}	In numerical calculations involving intermediate stages, intermediate values should not be rounded. If a value rounded at an intermediate stage leads to a final answer that is not acceptable, this is treated as an arithmetic error (Issue 1b). Award 1 mark for a first selected appropriate relationship. Award 1 mark for first correct substitution. Award 1 mark for a second selected appropriate relationship. Award 1 mark for second correct substitution. Do not award the mark for the final answer (the rounded value for f at an intermediate stage has resulted in an unacceptable final answer). (The correct answer is 1.5×10^{-2}, with 2×10^{-2}, 1.50×10^{-2}, and 1.500×10^{-2} acceptable responses.) **Award 4 marks.**

Issue	Example	Instructions to markers
8 Rounding errors		If the digit immediately following the least significant digit is less than 5 then round down. If the digit immediately following the least significant digit is 5 or more then round up. Treat any incorrect rounding, whether it appears in the final answer or at an intermediate stage, as an arithmetic error. (Issue 1b)
	Question In a ripple tank, a wave generator produces 31 waves in 65 seconds. The wavelength of the waves is 4.5×10^{-2} m. Determine the speed of the waves. (5)	
	Response	
	$f = \frac{N}{t}$	Award 1 mark for the first selected appropriate relationship.
	$f = \frac{31}{65}$	Award 1 mark for first correct substitution.
	$f = 0.47$	
	$v = f\lambda$	Award 1 mark for the second selected appropriate relationship.
	$v = 0.47 \times 4.5 \times 10^{-2}$	Award 1 mark for second correct substitution.
	$v = 2.1 \times 10^{-2}$ ms^{-1}	Do not award the mark for the final answer. (The final answer is correct, but there is an incorrectly rounded value for f at an intermediate stage.) **Award 4 marks.**

Issue	Example	Instructions to markers
9 Vulgar fractions		Candidates should always give final answers in decimal notation with the appropriate number of significant figures. Exceptions to this would be a final answer expressing phase difference in terms of a fraction of π (eg $\frac{\pi}{2}$, $\frac{3\pi}{4}$) or the charge on a quark (eg $+\frac{2}{3}e$).
	Question Calculate the acceleration of a 2.0 kg mass when an unbalanced force of 1.0 N acts on it. (3)	
	Response $F = ma$ $1.0 = 2.0 \times a$ $a = \frac{1}{2}$ ms^{-2}	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer. (A final answer given as a vulgar fraction has an indeterminate number of significant figures.) **Award 2 marks.**

Issue	Example	Instructions to markers
10 Use of incorrect index notation	**Question** A car travels at a constant speed of 75 m s^{-1}. Calculate the distance it travels in 240 s. (3) **Response** $d = \bar{v}t$ $d = 75 \times 240$ $d = 1.8^4$ m or $d = 1.8\ 10^4$ m	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer. **Award 2 marks.**

Issue	Example	Instructions to markers
11 Superscript and subscript errors	**Question** A trolley of mass 0.75 kg is moving at 1.6 m s^{-1}. Calculate the kinetic energy of the trolley. (3) **Response** $E_k = \frac{1}{2}mv^2$ $E_k = 0.5 \times 0.75 \times 1.6_2$ $E_k = 0.96$ J	If a misaligned superscript or subscript makes the meaning of a relationship or a substituted value unclear, mark it as wrong physics. Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution. (It is unclear whether candidate means 1.62 or 1.6^2.) The mark for final answer is not accessible. **Award 1 mark.**

Issue	Example	Instructions to markers
11 (continued)	**Question** Air in a bicycle pump has a volume of 0.30 litres when is at a pressure of 1.5×10^5 Pa. Calculate the volume of the air when the pressure is increased to 2.0×10^5 Pa. (3) **Response** $p^1V^1 = p^2V^2$ $1.5 \times 10^5 \times 0.30 = 2.0 \times 10^5 \times V^2$ $V_2 = 0.23$ litres	Do not award the mark for the selection of an appropriate relationship. (It is unclear whether the candidate means p squared etc) The marks for substitution and final answer are not accessible. **Award 0 marks.**

Issue	Example	Instructions to markers
12 Multiple errors in final answer	Any combination of an arithmetic error, a significant figure, a vulgar fraction, incorrect index notation, and a unit error in the final answer.	If any, or all of the errors are present in the final answer, do not award the mark for the final answer. (The marks for selection of an appropriate relationship and correct substitution may still be awarded.)
13 Additional calculations beyond the required answer	**Question** A golf ball is struck with an initial vertical velocity of 9.9 m s^{-1}. Calculate the maximum height reached by the ball. **Response** $v^2 = u^2 + 2as$ $0 = 9.9^2 + 2 \times (-9.8) \times s$ $s = 5.0$ m maximum height $= 2 \times 5.0 = 10$ m	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Do not award the mark for the final answer. (The final answer continues beyond the required answer and is incorrect.) **Award 2 marks.**

Issue	Example	Instructions to markers
14 Application of a wrong physics principle	**Question** The bob of a simple pendulum has angular velocity 11 rad s^{-1}. The bob is released from its vertical amplitude of 0.16 m. Calculate the speed of the bob at its lowest position. (3) **Response** $v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times 9.8 \times 0.16$ $v = 1.8\ \text{m s}^{-1}$	Award 0 marks in part of a question if the candidate has applied a wrong physics principle or used a relationship that could not lead to the final answer. Although a candidate could obtain a numerically correct answer by selecting the equations of motion, award 0 marks as the selected relationship is not valid for the motion of a pendulum bob. (The bob does not travel in a straight line and its acceleration is not uniform). **Award 0 marks.**

Issue	Example	Instructions to markers
14 (continued)	**Question** A mass on the end of a string is moving in a circular path. Its angular velocity increases from 4 rad s^{-1} to 10 rad s^{-1} in a time of 6 s. Calculate the angular acceleration of the mass. (3) **Response** $a = \frac{v-u}{t}$ $a = \frac{10-4}{6}$ $a = 1\,\text{rad}\,\text{s}^{-2}$	Again, a candidate could obtain a numerically correct answer in a response using the equations of linear motion. However, award 0 marks, as the selected relationship is not valid for circular motion. **Award 0 marks.**

Issue	Example	Instructions to markers
15 Carry forward of a value obtained by wrong physics within part of a question	**Question** A child's spinning toy, with moment of inertia 2.5 kg m^2, is at rest. An unbalanced torque is applied, and the toy spins through 5.5 rad in 1.2 s. Determine the size of the unbalanced torque. (5)	Marking should not necessarily stop at the application of wrong physics. Independent marks may be accessible when allocated in the detailed marking instructions.

Issue	Example	Instructions to markers
15 (continued)	**Response** $s = ut + \frac{1}{2}at^2$ $5.5 = 0 + 0.5 \times a \times 1.2^2$ $a = \frac{5.5}{0.5 \times 1.2^2}$ $\tau = I\alpha$ $\tau = 2.5 \times \frac{5.5}{0.5 \times 1.2^2}$ $\tau = 19$ Nm	Do not award the mark for the first selected appropriate relationship. (The use of an equation of linear acceleration is wrong physics.) The mark for substitution is not accessible. Award 1 mark for a second selected appropriate relationship (allocated in the detailed marking instructions). The mark for second substitution and the mark for the final answer are not accessible. **Award 1 mark.**

Issue	Example	Instructions to markers
15 (continued)	**Question** A car of mass 400 kg travels at a steady speed. It travels 500 m in 25 s. Calculate its kinetic energy. (5) **Response** $v = \frac{s}{t}$ $v = \frac{500}{20}$ $E_k = \frac{1}{2}mv^2$ $E_k = 0.5 \times 400 \times \left(\frac{500}{20}\right)^2$ $E_k = 1 \times 10^5$ J	Award 1 mark for a first selected appropriate relationship. (Allocated in the detailed marking instructions.) Do not award the mark for first substitution. (Incorrect substitution for *t*.) Award 1 mark for a second selected appropriate relationship. (Allocated in the detailed marking instructions.) The mark for second substitution and the mark for a final answer are not accessible. **Award 2 marks.**

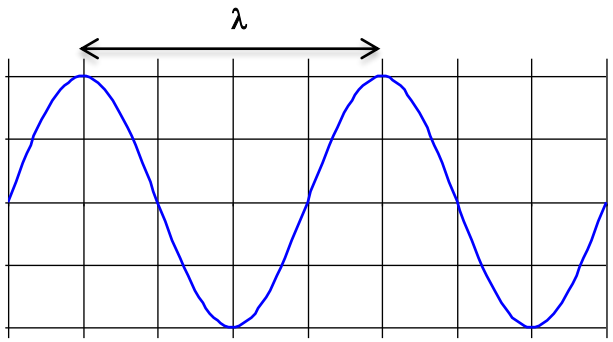
Issue	Example	Instructions to markers
16 Carry forward of an incorrect final answer from a previous part of a question	**Question** A car of mass 450 kg accelerates uniformly from rest to 15 m s^{-1} in 9.0 s. (a) Calculate the acceleration of the car. (3) (b) Calculate the unbalanced force acting on the car. (3) **Response** (a) $a = \frac{v-u}{t}$ $a = \frac{15-0}{5.0}$ $a = 3.0\ \text{m s}^{-2}$	If a candidate carries forward an incorrect final answer and uses it correctly in the next part of a question, full marks may be awarded for the subsequent part. The carry forward of an incorrect final answer from (a) correctly in (b) would be indicated with a wavy line under the final answer to (b). The exception to this is where one part of the question (possibly a 'show' question) gives the required numerical value or required relationship that is to be used in a subsequent part. In this case, the candidate must use the given value or relationship in the subsequent part. Award 1 mark for a selected appropriate relationship. Do not award the mark for correct substitution. The mark for the final answer is not accessible. **Award 1 mark.**

Issue	Example	Instructions to markers
16 (continued)	(b) $F = ma$ $F = 450 \times 3.0$ $F = 1400$ N	Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution (allowing incorrect final answer from (a) to be carried forward). Award 1 mark for final answer. **Award 3 marks.**

Issue	Example	Instructions to markers
17 Carry forward of an incorrect intermediate value (other than a final answer) from a previous part of a question	**Question** The International Space Station (ISS) orbits Earth at an altitude of 420 km. (a) Determine the gravitational field strength of Earth at this altitude. (3) (b) Calculate the gravitational potential at this altitude. (3)	An intermediate value other than a final answer, calculated incorrectly in a question and carried forward to a subsequent question, is marked as wrong physics in the subsequent question.

Issue	Example	Instructions to markers
17 (continued)	**Response** (a) $r = 4.20\times10^{5} + 6.0\times10^{6} = 6.42\times10^{6}$ $G\frac{Mm}{r^2} = mg$ $g = \frac{6.67\times10^{-11}\times6.0\times10^{24}}{\left(6.42\times10^{6}\right)^2}$ $g = 9.7$ Nkg^{-1}	Award 1 mark for the selected appropriate relationships. Do not award the mark for correct substitution (incorrect substitution for R_E and therefore r). The mark for the final answer is not accessible. **Award 1 mark.**
	Response (b) $V = -\frac{GM}{r}$ $V = -\frac{6.67\times10^{-11}\times6.0\times10^{24}}{6.42\times10^{7}}$ $V = -6.2\times10^{7}$ Jkg^{-1}	Award 1 mark for a selected appropriate relationship. Do not award the mark for correct substitution. (A carry forward of the incorrect value for r from the previous question is treated as an incorrect substitution.) The mark for the final answer is not accessible. **Award 1 mark.**

Issue	Example	Instructions to markers
18 Wrong experiment	**Question** Describe an experiment that demonstrates the interference of sound. **Response** Candidate describes an experiment that demonstrates the interference of light.	**Award 0 marks.**

Issue	Example	Instructions to markers
19 Solution by diagram	**Question** State what is meant by the wavelength of a transverse wave. (1) **Response**  	Award marks where a candidate has used an appropriately labelled diagram or sketch to convey correctly a response to the question. Take care when judging the accuracy of sketching. Wavelength indicated correctly using a labelled sketch. **Award 1 mark.**

Issue	Example	Instructions to markers
20 Use of non-standard symbols	**Question** A car is travelling at an average speed of 8 m s^{-1} for a time of 10 s. Calculate the distance it travels. (3) **Response** $S = \frac{D}{T}$ $8 = \frac{D}{10}$ $D = 80$ m	**Candidates are expected to select an appropriate relationship from the Relationships Sheet.** **Any exceptions to this will be specified in the detailed marking instructions.** The substitution of values for speed and time clarify that the candidate is using S for speed and T for time. Award 1 mark awarded for the relationship. Award 1 mark for correct substitution. Award 1 mark for the correct final answer. **Award 3 marks.**

Issue	Example	Instructions to markers
20 (continued)	**Question** The potential difference across a parallel plate capacitor is 9.0 V when the charge stored on its plates is 22 μC. Calculate the capacitance of the capacitor. (3) **Response** $C = FV$ $2.2 \times 10^{-5} = F \times 9.0$ $F = 2.4$ μF **Question** In a child's spinning toy, a thin cord is wound round an axle of radius 2.5 mm. The tension in the cord is 15 N. Calculate the torque applied to the toy. (3) **Response** $T = Fr$ $T = 15 \times 2.5 \times 10^{-3}$ $T = 38$ Nm	In this response, the use of C to represent charge is incorrect as C should represent capacitance. **Award 0 marks.** In this example, the use of T to represent torque in place of τ is not ambiguous as F is accepted as representing tension. Award 1 mark for a selected appropriate relationship. Award 1 mark for correct substitution. Award 1 mark for the correct final answer. **Award 3 marks.**

Issue	Example	Instructions to markers
20 (continued)	**Question** A child's spinning toy reaches an angular velocity of 25 rad s^{-1} from rest in a time of 3.0 s. Calculate the angular acceleration of the toy. (3) **Response** $a = \frac{\omega - \omega_0}{t}$ $a = \frac{25 - 0}{3.0}$ $a = 8.3 \text{ rad s}^{-2}$	In this example, the use of a to represent angular acceleration is incorrect as a represents the tangential acceleration of a point on the toy. **Award 0 marks.**

Issue	Example	Instructions to markers
21 Surplus answers		Where a question asks for a specific number of reasons, examples, points, etc and the candidate provides more than the required number of responses, then each incorrect response negates a correct response. **(This is commonly known as the +/- rule.)** Do not apply this principle to open-ended questions. Open-ended questions are marked holistically.
	Question State one detector of infrared radiation. (1) **Response** CCD and Geiger-Müller tube.	There is one correct and one incorrect answer. **Award 0 marks.**
	Question Name two particles that are classified as leptons in the Standard Model of fundamental particles. (2) **Response** Muon, gluon, and electron	There are two correct answers and one incorrect answer. **Award 1 mark.**

Issue	Example	Instructions to markers
22 Incorrect spelling		Accept incorrect spelling if the word is easily identified and used correctly. However, when the meaning of an incorrectly spelled word is unclear, do not award the mark(s). Take care to ensure that the incorrect spelling does not make the response ambiguous, leading to possible wrong physics. Notable examples are for questions requiring the response '**reflection**', '**refraction**', '**diffraction**', '**fission**' or '**fusion**'.
	Response 1 Candidate uses the words 'aceleration' and 'velosity'.	The meaning of the incorrectly spelled words is clear. These incorrect spellings are acceptable.
	Response 2 Candidate uses the words 'fussion', 'defraction' and 'rifraction'.	The meaning of the incorrectly spelled words is unclear**.** These incorrect spellings are not acceptable.

Issue	Example	Instructions to markers
23 'Show' questions	**Question** An object of mass m is dropped from a height h. Show that its maximum speed is given by $v = \sqrt{2gh}$ (2)	**In 'show' questions, candidates are required to demonstrate how a given numerical answer or relationship is determined.** Where the final numerical answer to a question is given, or the derivation of a given relationship required, then candidates must clearly and explicitly show all steps, including: (i) a statement of the relationship(s) selected from the Relationships Sheet (ii) substitution of data into the relationship, equating of relationships or algebraic manipulation, even those that might seem quite obvious (iii) a statement of the given final numerical answer or relationship

Issue	Example	Instructions to markers
23 (continued)	**Response** $E_k = \frac{1}{2}mv^2,\ E_p = mgh$ $E_k = E_p$ $\frac{1}{2}mv^2 = mgh$ $v = \sqrt{2gh}$ **Question** The mass of the water in a washing machine is 6.00 kg. Show that the minimum energy required to increase the temperature of the water from 15.0 °C to 40.0 °C is 627 000 J. (2) **Response 1** $E_h = 4180 \times 6.00 \times (40.0 - 15.0)$ $E_h = 627000$ J	Award 1 mark for both selected appropriate relationships. Award 1 mark for equating of relationships and statement of the given final answer. **Award 2 marks.** The response does not start with an appropriate relationship. The mark for substitution and statement of the given final answer is not accessible. **Award 0 marks.**

Issue	Example	Instructions to markers
23 (continued)	**Response 2** $E_h = cm\Delta T$ $E_h = 4180 \times 6.00 \times 25.0$ $E_h = 627000$ J	Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution and statement of the given final answer. Substituted values for ΔT (40.0 – 15.0) are not explicitly shown. **Award 1 mark.**
	Question Point A is 4.00 mm from a point charge of 2.40 nC. Show that the electrical potential at point A due to the charge is 5.40×10^3 V. (2)	
	Response $V = \frac{Q}{4\pi\varepsilon_0 r}$ $V = \frac{2.40 \times 10^{-9}}{4\pi\varepsilon_0 \times 4.00 \times 10^{-3}}$ $V = 5.40 \times 10^3$ V	Award 1 mark for a selected appropriate relationship. Do not award the mark for substitution and final answer (no attempt to substitute a value for ε_0). **Award 1 mark.**

Issue	Example	Instructions to markers
23 (continued)	**Question** The International Space Station (ISS) orbits Earth in an orbit of radius 6.82×10^6 m. Show that the weight of an astronaut of mass 75 kg on board the ISS is 650 N. (2) **Response** $F = \frac{GMm}{r^2}$ $F = \frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24} \times 75}{\left(6.82 \times 10^6\right)^2}$ $F = 645$ N	Award 1 mark for selected appropriate relationship. Do not award the mark for substitution and final answer, as the given final answer is not what the question asked the candidate to show. **Award 1 mark.**

Issue	Example	Instructions to markers
24 'Explain' questions		In 'explain' questions, candidates are required to answer using directly relevant and correct physics. In their responses, candidates are unlikely to use the same words as the marking instructions. It is possible that many will give responses that, while not incorrect, may not sufficiently answer the question. In such cases, take care not to award fewer marks than a response is worth. Moreover, avoid subconsciously 'filling in the gaps' in a candidate's response and awarding more marks than the response is worth.
	Question A satellite is in orbit around the Earth. Explain why the satellite follows a circular path, rather than falling to the surface of the Earth or moving off into space. (2)	
	Response 1 The weight of the satellite prevents it moving off into space, and the large horizontal velocity of the satellite causes a trajectory which has the same shape as the Earth.	Explanation uses correct and relevant physics. **Award 2 marks.**

Issue	Example	Instructions to markers
24 (continued)	**Response 2** The satellite is attracted to the Earth so it doesn't fly off into space, and has a large horizontal velocity.	Only the first part of the explanation uses sufficiently correct and relevant physics for a mark to be awarded. **Award 1 mark.**
	Response 3 Gravity pulls the satellite down so it doesn't fly off, and it is moving enough for it to continually fall over the horizon.	Neither part of the explanation uses sufficiently correct and relevant physics for a mark to be awarded. **Award 0 marks.**

<table>
<tr><th>Issue</th><th>Example</th><th>Instructions to markers</th></tr>
<tr><td>25 ‘Justify’ / ‘Must justify’ questions</td><td></td><td></td></tr>
<tr><td>25a ‘Justify’ questions</td><td></td><td>In ‘justify’ questions, candidates must make a statement and justify their statement using directly relevant and correct physics.

The mark for a correct statement is independent of the justification.

<table>
<tr><th>Response</th><th>Mark</th></tr>
<tr><td>Correct statement justified using correct physics</td><td>2</td></tr>
<tr><td>Correct statement with insufficient justification</td><td>1</td></tr>
<tr><td>Correct statement with attempted justification using incorrect physics</td><td>1</td></tr>
<tr><td>Correct statement with no attempted justification</td><td>1</td></tr>
<tr><td>Incorrect statement</td><td>0</td></tr>
</table>
</td></tr>
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Issue	Example	Instructions to markers
25a (continued)	**Question** A battery, a lamp, and an ammeter are connected in series. A second lamp is now connected in parallel with the original lamp. State what happens to the reading on the ammeter when the second lamp is connected. Justify your answer. (2) **Response 1** The reading on the ammeter increases because the resistance of the circuit has decreased. **Response 2** The reading on the ammeter increases because the resistance of the circuit has changed. **Response 3** The reading on the ammeter increases because the resistance of the circuit increases.	Correct statement. Correct and sufficient justification. **Award 2 marks.** Correct statement. Correct but insufficient justification. **Award 1 mark.** Correct statement. Incorrect justification. **Award 1 mark.**

Issue	Example	Instructions to markers
25a (continued)	**Response 4** The reading on the ammeter increases. **Response 5** The reading on the ammeter decreases because the resistance of the circuit decreases.	Correct statement. No justification attempted. **Award 1 mark.** Incorrect statement. **Award 0 marks.**

<table>
<tr><th>Issue</th><th>Example</th><th>Instructions to markers</th></tr>
<tr>
<td>25b ‘Must justify’ questions</td>
<td>Question
A battery, a lamp, and an ammeter are connected in series. A second lamp is now connected in parallel with the original lamp.
State what happens to the reading on the ammeter when the second lamp is connected.
You must justify your answer. (2)</td>
<td>In ‘must justify’ questions, candidates must make a statement and justify their statement using directly relevant and correct physics.

The mark for a correct statement is dependent on the justification based on relevant and correct physics.

<table>
<tr><th>Response</th><th>Mark</th></tr>
<tr><td>Correct statement justified using correct physics</td><td>2</td></tr>
<tr><td>Correct statement with insufficient justification</td><td>1</td></tr>
<tr><td>Correct statement with attempted justification using incorrect physics</td><td>0</td></tr>
<tr><td>Correct statement with no attempted justification</td><td>0</td></tr>
<tr><td>Incorrect statement</td><td>0</td></tr>
</table>
</td>
</tr>
</table>

Issue	Example	Instructions to markers
25b (continued)	**Response 1** The reading on the ammeter increases because the resistance of the circuit has decreased.	Correct statement. Correct and sufficient justification. **Award 2 marks.**
	Response 2 The reading on the ammeter increases because the resistance of the circuit has changed.	Correct statement. Correct but insufficient justification. **Award 1 mark.**
	Response 3 The reading on the ammeter increases because the resistance of the circuit increases.	Correct statement. Incorrect justification. **Award 0 marks.**
	Response 4 The reading on the ammeter increases.	Correct statement. No justification attempted. **Award 0 marks.**
	Response 5 The reading on the ammeter decreases because the resistance of the circuit decreases.	Incorrect statement. **Award 0 marks.**

Issue	Example	Instructions to markers
26 'State what is meant by …' questions		In 'state what is meant by …' questions, candidates must make a statement demonstrating their knowledge of a specific concept in physics. In their responses, candidates must ensure that the language they use is sufficiently precise to demonstrate knowledge at the required level. Course specification documents include wording appropriate for the description of a number of concepts, although there is no requirement for candidates to use these verbatim.
	Question State what is meant by the *Schwarzschild radius of a black hole*.	
	Response 1 It is the distance from the centre of the black hole (singularity) to its event horizon.	Correct statement, using precise language. **Award 1 mark.**

Issue	Example	Instructions to markers
26 (continued)	**Response 2** It is the distance from the point of no return to the centre of a black hole.	Language used not sufficiently precise. **Award 0 marks.**
	Response 3 It is the radius of a black hole.	Response re-uses key words given in the question. **Award 0 marks.**

Issue	Example	Instructions to markers
26 (continued)	**Question** State what is meant by *an EMF of 6.0 V*. **Response 1** It is the energy given to each coulomb of charge passing through an electrical source.	Statement not sufficiently precise. (No reference to the value *6.0*). **Award 0 marks.**
	Response 2 It is the reading on a voltmeter connected across the terminals of an open circuit cell with EMF 6.0 V.	Statement not sufficiently precise. (No reference to energy). **Award 0 marks.**
	Response 3 6.0 joules of energy is gained by unit charge passing through a cell with EMF 6.0 V.	Statement correct and precise. **Award 1 mark.**

Issue	Example	Instructions to markers
27 Open-ended questions		This type of question is identified by the phrase 'Use your knowledge …' or 'Using your knowledge …'. Mark open-ended questions **holistically**. Only award marks after reading and considering the candidate's response in its entirety. **Do not** use tally marks for each good point made. **Do not** apply the +/- rule (Issue 21). Avoid lists of expected responses in marking instructions, as these encourage an incorrect approach to marking open-ended questions. A variety of physics arguments can be used to answer open-ended questions. Award marks based on whether the response overall demonstrates: ♦ good understanding (**Award 3 marks**) ♦ reasonable understanding (**Award 2 marks**) ♦ limited understanding (**Award 1 mark**) ♦ no understanding (**Award 0 marks**) More detailed marking guidance is given in the detailed marking instructions for each question paper.

Issue	Example	Instructions to markers
28 Graph-plotting questions		In question papers, candidates may be required to select data from graphical formats or to present data graphically. Graphical data appearing in question papers may be in a variety of formats (scatter graph, line graph, H-R diagram etc), but candidates must present graphical data in scatter-graph format only. When presenting data in a scatter graph, candidates must: ♦ label each axis clearly with the name of the variable (or a recognised abbreviation/symbol) and a unit, where appropriate ♦ on each axis show a scale that is linear over the range of the data ♦ plot all data points accurately ♦ draw a line of best fit through the plot of data points that best expresses the relationship between the variables (the line of best fit may be either a single straight line or a single smooth curve) Award 1 mark for axes correctly labelled and scaled. Award 1 mark for all data points accurately plotted. Award 1 mark for an appropriate line of best fit.

History of changes

Version	Description of change	Authorised by	Date
2.0	Wording amended throughout the document. Additional information added throughout the existing sections of the document. Some sections of the document have been reordered from version 1.0. Information in version 1.0, relating to 'carry forward' within a question on the use of a dotted line in specific marking instructions has been removed, as these are no longer used. Section on 'Data marks' in version 1.0 has been removed, as these are no longer used. Alphanumeric identifiers renumbered throughout the document. Issues separated to each begin on a new page (apart from Issue 13). New section added covering 'incorrect substitution' (Issue 1d). Additional example added to the section covering 'incorrect substitution of a physical constant' (Issue 4) Section covering 'unit conversion error' restructured to cover unit conversion error in substitution — SI prefixes, unit conversion error in substitution — non-SI prefixes, unit conversion error in substitution — non-SI units, and unit conversion error in final answer (Issues 5a – 5d). Additional example on use of an ellipsis added to the section covering 'significant figures in final answers' (Issue 6). Example amended to use SI units in the section covering 'significant figures in intermediate calculations' (Issue 7). Example amended to use SI units in the section covering 'rounding errors' (Issue 8). New section added to cover 'superscript and subscript errors' (Issue 11).	Qualifications Manager	August 2022

Version	Description of change	Authorised by	Date
	New section added to cover ‘carry forward of a value obtained by wrong physics within part of a question’ (Issue 15). New section added to cover ‘carry forward of an incorrect intermediate value (other than a final answer) from a previous part of a question’ (Issue 17). Additional examples added to the section covering ‘use of non-standard symbols’ (Issue 20). Additional example added to the section covering ‘surplus answers’ (Issue 21). Additional examples added to the section covering ‘show questions’ (Issue 23). New section added to cover ‘explain questions’ (Issue 24). New section added to cover ‘justify questions’ (Issue 25a). New section added to cover ‘must justify questions’ (Issue 25b). New section added to cover ‘state what is meant by…’ questions (Issue 26). New section added to cover ‘graph-plotting questions’ (Issue 28).		