

Commentary on candidate responses

The marking issues identified in this document are based on examples that were noted during Quality Assurance and Appeals procedures in Spring/Autumn 2021.

Question	Candidate response	Max mark	Mark awarded	Commentary
1(b)	A	3	0	In the second line, the candidate has introduced the integral sign, indicating the intention to integrate the associated function, but appears to have already integrated the given velocity function. This is wrong physics.
2(a)(i)	A	3	1	The candidate has selected an appropriate relationship, but has substituted a value for ω rather than v . This is an incorrect substitution.
	B	3	2	The candidate has selected an appropriate relationship, substituted correct values, but has given an incorrect unit in the final answer. The correct abbreviation for 'radians' is 'rad', and not 'rads'.
	C	3	3	The candidate has used capital letters as abbreviations for variables in the selected relationship, and the symbol used for angular velocity appears more like ' W ' than ' ω '. Given that, in this example , there is no ambiguity as to the meaning of the abbreviations, this is not treated as wrong physics. The candidate has selected an appropriate relationship, correctly substituted values and given a correct final answer.
2(a)(ii)	A	4	0	The candidate has not selected an appropriate relationship, appearing to use abbreviations for both angular and linear variables. In this example, both s and a represent linear quantities related to the context in which the question is set. In examples involving angular motion, there is often potential ambiguity as to the meaning of unclear abbreviations. Stated relationships must therefore be clear and correct in the use of accepted abbreviations for angular and linear variables. Following the selection of an inappropriate or incorrect relationship, an acceptable correct relationship cannot be implied by 'correct' substitutions, as is the case for this response.
	B	4	2	The candidate has selected an appropriate relationship, correctly substituted values (the decimal point in 0.5 is there but is difficult to see) but appears to have rounded at an

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				intermediate stage to obtain the value for θ of 68 radians. The candidate has not given an acceptable final answer, and so the mark for this is not awarded. In addition, the candidate has not explicitly indicated a division by 2π , and so this mark is also not awarded.
	C	4	2	The candidate has selected an appropriate relationship but has not correctly substituted values (t^2 should be 5.5^2 , rather than 5.5). Following the statement of an incorrect substitution, correct substitutions cannot be implied by subsequent working. The candidate has explicitly shown the division by 2π , and so is awarded this independent mark.
2(a)(iii)	A	2	0	The candidate's use of ' \uparrow ' and ' \downarrow ' are not accepted as alternatives to 'increases' or 'decreases'.
	B	2	2	The candidate's statement referring to 'rotations' rather than 'revolutions' is acceptable. The justification is correct.
	C	2	1	The candidate has made a correct statement, but the justification does not go beyond information given in the question.
2(b)	A	2	0	The candidate has made an incorrect statement. Although correct, the justification is not consistent with the statement. In a 'Justify' or 'Must Justify' type question, 0 marks are awarded if the statement is incorrect, irrespective of the quality of the justification.
	B	2	2	The candidate has made a correct statement and justification. The 'axle of the wheel' is equivalent to 'the axis of rotation of the wheel'.
	C	2	1	The candidate has made a correct statement, but the justification refers to 'the centre of the circle' rather than 'the axis of rotation'.
	D	2	1	The candidate has made a correct statement, but the justification refers to 'the centre of the wheel' rather than 'the axis of rotation'.
3(a)	A	2	0	The candidate has not selected an appropriate relationship. The candidate's use of ' a ', rather than ' α ' would suggest linear acceleration rather than angular acceleration, which is incorrect. In many parts of the course, including rotational dynamics, there is the potential for

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				ambiguity if candidates do not use clear and correct abbreviations for variables. The selection of an incorrect or ambiguous relationship means that, in most questions, subsequent marks are not accessible. In addition, in a 'show' question, candidates must state the given final answer, including the unit. The candidate has omitted a unit in their statement of the final answer.
	B	2	1	The candidate has selected an appropriate relationship, and correctly substituted values. However, the candidate has not stated the given final answer, and so is awarded 1 mark.
	C	2	0	The candidate has not stated an appropriate relationship, and so, in a 'show' question, is awarded 0 marks.
3(b)(iii)	A	2	1	The candidate has made a correct statement. The justification is not incorrect but is insufficient for the second mark to be awarded.
	B	2	2	The candidate has made a correct statement and has shown a correct calculation in justification. This is an acceptable alternative method of justification.
	C	2	0	The candidate has made a correct statement, but the justification contains wrong physics ($l=mr$, rather than $l=mr^2$). In a 'Must Justify' question, 0 marks are awarded if the justification is incorrect, even if the statement is correct.
4(a)(i)	A	1	0	The candidate's statement is not sufficiently precise, as 'gravitational force' is not specified.
	B	1	0	The candidate's statement is not sufficiently precise, as 'gravitational force' is not specified.
	C	1	1	The statement 'force of gravity' and 'kilogram of mass' are acceptable alternatives for 'gravitational force' and 'unit mass', and so the candidate's statement is acceptable.
4(b)	A	2	2	The candidate has made a correct statement, and the 'smaller force of gravity acts' justification is acceptable as equivalent to 'weaker gravitational field'.
	B	2	1	The candidate has made a correct statement, but the justification is neither at an appropriate level or sufficiently precise.

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4(c)	A	4	2	The candidate has selected an appropriate relationship and has correctly converted AU to metres but has incorrectly substituted into the relationship. ($G = 6.67 \times 10^{11}$ rather than 6.67×10^{-11}).
	B	4	1	The candidate has selected a correct relationship, but the substitution is incorrect. The conversion from AU to metres is incorrect and as no working is shown this cannot be treated as an arithmetic mistake.
	C	4	3	The candidate has selected an appropriate relationship and has correctly substituted values. The candidate has rounded the value of r and converted this to metres at an intermediate stage, which has resulted in an unacceptable final answer. In such circumstances, the rounding at an intermediate stage is treated as an arithmetic error, and the mark for the final answer is not awarded.
6(b)(i)	A	3	0	The candidate has not selected an appropriate relationship ($L = 4\pi r^2 \sigma T^4$ rather than $L = 4\pi r \sigma T^4$). Having stated an unacceptable relationship, an acceptable relationship cannot be implied by subsequent 'correct' substitutions.
	B	3	1	The candidate has stated an acceptable relationship but has not correctly substituted values ($\sigma = 5.67 \times 10^{-8}$ rather than 5.7×10^{-8}). In addition, the candidate has not clearly shown the squaring of the substituted value for r .
6(c)(i)	A	4	1	The candidate has selected an appropriate relationship, but has not correctly substituted a value for T . Since there is no indication that the candidate used a value of 3.5 days, the independent mark for selecting data from the graph cannot be awarded.
	B	4	3	The candidate has selected an appropriate relationship and correctly substituted values. They have inappropriately rounded their converted value of T at an intermediate stage, resulting in an unacceptable final answer.

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7(b)(i)	A	2	1	The candidate has selected an appropriate relationship but has incorrectly substituted the value for m . In addition, in a 'show' question, candidates must state the given final answer, which this candidate has not done correctly.
	B	2	0	The candidate has not selected an appropriate relationship ($mvr = \frac{nh}{2\pi}$), and so is awarded 0 marks. In a 'show' question, an appropriate relationship must be explicitly stated, and cannot be implied by subsequent 'correct' substitution.
	C	2	1	The candidate has selected an appropriate relationship but has not explicitly shown all substitutions (the value for h is not explicitly substituted into the relationship). A correct substitution cannot be implied by subsequently stating the given final answer.
7(c)	A	2	1	The candidate has correctly substituted values into the given relationship and calculated a final answer but omitted an acceptable unit. The mark for the final answer is not awarded.
	B	2	0	Although appearing to give an acceptable final answer, the candidate has not correctly substituted values into the given relationship ($\frac{1}{n_f^2} - \frac{1}{n_i^2}$) should be $\left(\frac{1}{2^2} - \frac{1}{6^2}\right)$ rather than $\left(\frac{1}{6^2} - \frac{1}{2^2}\right)$.
8(a)	A	1	1	The candidate has answered in terms of the waveform passing through a potential barrier. This is an acceptable approach.
	B	1	1	The candidate has answered in terms of the uncertainty in energy due to the Uncertainty Principle. This is an acceptable approach.
8(b)	A	3	2	The candidate has selected an appropriate relationship and correctly substituted values. The statement below the calculated value clarifies the minimum value. The calculated value for Δp_x is, however, incorrect (the unit should be kg m s^{-1} rather than kg m s^{-2}).
	B	3	2	The candidate has selected an appropriate relationship, correctly substituted values and

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				calculated an acceptable value for Δp but has not clarified the value of Δp_{min} .
	C	3	2	The candidate has selected an appropriate relationship. The unit in the final answer, however, is not consistent with the substitution of 54×10^{-12} for 54 fm and so the mark for the final answer is not awarded. The unit kg km s^{-1} in the final answer would have been consistent with the candidate's substitution.
8(c)(ii)	A	2	0	The candidate has substituted some values into the given relationship but has not substituted a value for ϵ_0 . The candidate's final answer is not acceptable, and so a correct substitution of ϵ_0 cannot be implied.
	B	2	0	The candidate has not correctly substituted into the given relationship. 9×10^9 is an acceptable substitution for $\frac{1}{4\pi\epsilon_0}$, but the constant in this case is $\frac{1}{2\pi\epsilon_0}$.
	C	2	0	The candidate has not correctly substituted into the given relationship. The calculation of the mass of an alpha particle by summing the masses of two protons and two neutrons is wrong physics. The correct mass of an alpha particle is given in the Data Sheet.
9(a)	A	1	0	The candidate's statement does not give the directional relationship between the force acting on a particle moving with SHM and its displacement.
	B	1	1	The candidate's statement is acceptable.
	C	1	1	Despite clumsy language, the candidate's statement is acceptable.
	D	1	0	The candidate's statement does not give the proportionality relationship between the force acting on a particle moving with SHM and its displacement. The word 'equivalent' does not imply proportionality.
9(c)(i)	A	3	0	The candidate has not selected an appropriate relationship. The relationship $F = -ky$ must be explicitly stated.
	B	3	2	The candidate has selected appropriate relationships and has correctly substituted values. The candidate has not, however,

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				stated the given final answer, either in terms of value or unit.
9(d)	A	2	0	The candidate's drawing shows a sine wave and reducing amplitude but does not show a minimum of two cycles as required.
	B	2	0	The candidate's drawing shows a reducing amplitude but does not show either a sine wave or a minimum of two cycles as required.
	C	2	1	The candidate's drawing shows a sine wave, and a minimum of two cycles as required. The amplitude appears to be reducing but increases from the third to the fourth half cycle.
	D	2	2	The candidate's drawing shows a sine wave, a reducing amplitude, and a minimum of two cycles as required.
9(e)	A	2	1	The candidate has answered in terms of angular velocity rather than angular frequency. This is acceptable. The candidate has made a correct statement and has implied that ω depends on k and m only, but has not stated that k and m are unchanged, and so the justification is not sufficient.
	B	2	0	The candidate has made an incorrect statement, and so 0 marks are awarded.
10(a)	A	1	0	The candidate's explanation is incorrect. The rays reflected from the glass interfere destructively with the rays reflected from the zinc oxide coating.
	B	1	0	The candidate's explanation is not acceptable. The candidate has made no mention of the <u>energy</u> transmitted into the glass.
10(d)(ii)	A	3	0	The candidate has selected an incorrect relationship ($EA^2 = k$ rather than $E = kA^2$). Following an incorrect statement, a correct relationship cannot be implied by 'correct' substitution.
	B	3	2	The candidate has selected an appropriate relationship and correctly substituted values. (The decimal point between the 1 and the 6 is indistinct). The final answer, however, is incorrect and this mark is not awarded.
	C	3	2	The candidate has neither stated an appropriate relationship nor shown the substitution of values. Both steps, however,

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				are implied by the acceptable final answer, even without a unit. The lack of unit means that the mark for the final answer is not awarded.
11(b)(i)	A	1	0	The refracted ray drawn by the candidate is not straight and suggests that the ray is changing direction inside the Perspex.
	B	1	1	The refracted ray drawn by the candidate appears to be at 90° to the reflected ray.
	C	1	1	The refracted ray drawn by the candidate does not appear to be at 90° to the reflected ray but the candidate has indicated their intention by the inclusion of a right-angle quadrant in the appropriate place.
11(c)	A	2	0	The candidate has indicated sudden, rather than gradual changes in brightness.
13(b)	A	3	0	The candidate has not selected an appropriate relationship ($V = \frac{Q}{4\pi\epsilon_0 r^2}$ rather than $V = \frac{Q}{4\pi\epsilon_0 r}$). Following the selection of an inappropriate relationship, an appropriate relationship cannot be implied by subsequent 'correct' substitutions.
	B	3	3	The candidate has selected an appropriate relationship, correctly substituted values and given an acceptable final answer. In the context of the question, the use of the non-standard symbol 'd', rather than 'r' in the candidate's stated relationship is not ambiguous, and therefore acceptable.
13(c)	A	4	2	The candidate has selected an appropriate relationship and has correctly substituted values when calculating the work done in moving the charge from infinity to position X and to position Y. The subsequent subtraction, however, is incorrect ((19.2 – 57.5) rather than (57.5 – 19.2)). Following that statement of an incorrect substitution, correct substitutions cannot be implied by a correct final answer.
14(c)	A	1	1	The candidate's statement implies that the proton travels in opposite directions.

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	B	1	0	The candidate's statement states that the protons change direction but does not specify opposite directions.
	C	1	0	The candidate's statement refers to a 'photon' rather than a proton.
15(a)(i)	A	1	0	The candidate's statement correctly describes the changing magnetic field but does not reference changing current as required.
15(a)(ii)	A	4	2	The candidate has selected both an appropriate relationship and data on initial rate of change of current from the graph. The substitution of values into the relationship, however, is incorrect ($\varepsilon = 4$ rather than $\varepsilon = -4$).
	B	4	1	The candidate has correctly selected data on the initial rate of change of current from the graph. The candidate, however, has not selected an appropriate relationship ($\varepsilon = L \frac{dI}{dt}$ rather than $\varepsilon = -L \frac{dI}{dt}$). Following the statement of an inappropriate relationship, an appropriate relationship cannot be implied by 'correct' substitutions.
	C	4	4	The candidate has selected both an appropriate relationship and data on the initial rate of change of current from the graph. The substitution of values into the relationship is not incorrect, as the negative signs may have been cancelled. (It is worth noting that in a 'show' question, the explicit substitution of -4, would be required.) The candidate has given the correct final answer.
15(b)	A	2	1	The line drawn by the candidate consists of a straight line and a curve, which is incorrect. The candidate has, however, shown the correct value of I_{\max} .
	B	2	1	The curve drawn by the candidate shows a shorter time to I_{\max} , but shows an incorrect value of I_{\max} .
	C	2	1	The curve drawn by the candidate shows a correct value of I_{\max} , but shows a longer time to I_{\max} .