

GCSE (9–1)

Mathematics

J560/06: Paper 6 (Higher tier)

General Certificate of Secondary Education

Mark Scheme for June 2019

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations used in the detailed Mark Scheme.

Annotation	Meaning
✓	Correct
✗	Incorrect
BOD	Benefit of doubt
FT	Follow through
ISW	Ignore subsequent working (after correct answer obtained), provided method has been completed
M0	Method mark awarded 0
M1	Method mark awarded 1
M2	Method mark awarded 2
A1	Accuracy mark awarded 1
B1	Independent mark awarded 1
B2	Independent mark awarded 2
MR	Misread
SC	Special case
^	Omission sign

These should be used whenever appropriate during your marking.

The **M**, **A**, **B**, etc annotations must be used on your scripts for responses that are not awarded either 0 or full marks.

It is vital that you annotate these scripts to show how the marks have been awarded.

Subject-Specific Marking Instructions

1. **M** marks are for using a correct method and are not lost for purely numerical errors.
A marks are for an accurate answer and depend on preceding **M** (method) marks. Therefore **M0 A1** cannot be awarded.
B marks are independent of **M** (method) marks and are for a correct final answer, a partially correct answer, or a correct intermediate stage.
SC marks are for special cases that are worthy of some credit.
2. Unless the answer and marks columns of the mark scheme specify **M** and **A** marks etc, or the mark scheme is 'banded', then if the correct answer is clearly given and is not from wrong working **full marks** should be awarded.

Do not award the marks if the answer was obtained from an incorrect method, ie incorrect working is seen and the correct answer clearly follows from it.
3. Where follow through (**FT**) is indicated in the mark scheme, marks can be awarded where the candidate's work follows correctly from a previous answer whether or not it was correct.

Figures or expressions that are being followed through are sometimes encompassed by single quotation marks after the word *their* for clarity, eg FT $180 \times (\text{their '37' + 16})$, or FT $300 - \sqrt{(\text{their '5^2 + 7^2'})}$. Answers to part questions which are being followed through are indicated by eg FT $3 \times \text{their (a)}$.

For questions with FT available you must ensure that you refer back to the relevant previous answer. You may find it easier to mark these questions candidate by candidate rather than question by question.
4. Where dependent (**dep**) marks are indicated in the mark scheme, you must check that the candidate has met all the criteria specified for the mark to be awarded.
5. The following abbreviations are commonly found in GCSE Mathematics mark schemes.
 - **cao** means **correct answer only**.
 - **figs 237**, for example, means any answer with only these digits. You should ignore leading or trailing zeros and any decimal point eg
 $237000, 2.37, 2.370, 0.00237$ would be acceptable but 23070 or 2374 would not.
 - **isw** means **ignore subsequent working** (after correct answer obtained).
 - **nfw** means **not from wrong working**.
 - **oe** means **or equivalent**.

- **rot** means **rounded or truncated**.
 - **seen** means that you should award the mark if that number/expression is seen anywhere in the answer space, including the answer line, even if it is not in the method leading to the final answer.
 - **soi** means **seen or implied**.
6. Make no deductions for wrong work after an acceptable answer unless the mark scheme says otherwise, indicated for example by the instruction 'mark final answer'.
7. As a general principle, if two or more methods are offered, mark only the method that leads to the answer on the answer line. If two (or more) answers are offered, mark the poorer (poorest).
8. When the data of a question is consistently misread in such a way as not to alter the nature or difficulty of the question, please follow the candidate's work and allow follow through for **A** and **B** marks. Deduct 1 mark from any **A** or **B** marks earned and record this by using the **MR** annotation. **M** marks are not deducted for misreads.
9. Unless the question asks for an answer to a specific degree of accuracy, always mark at the greatest number of significant figures even if this is rounded or truncated on the answer line. For example, an answer in the mark scheme is 15.75, which is seen in the working. The candidate then rounds or truncates this to 15.8, 15 or 16 on the answer line. Allow full marks for the 15.75.
10. If the correct answer is seen in the body and the answer given in the answer space is a clear transcription error allow full marks unless the mark scheme says 'mark final answer' or 'cao'. Place the annotation ✓ next to the correct answer.
- If the answer space is blank but the correct answer is seen in the body allow full marks. Place the annotation ✓ next to the correct answer.
- If the correct answer is seen in the working but a completely different answer is seen in the answer space, then accuracy marks for the answer are lost. Method marks would still be awarded. Use the **M0**, **M1**, **M2** annotations as appropriate and place the annotation ✗ next to the wrong answer.
11. Ranges of answers given in the mark scheme are always inclusive.
12. For methods not provided for in the mark scheme give as far as possible equivalent marks for equivalent work. If in doubt, consult your Team Leader.
13. Anything in the mark scheme which is in square brackets [...] is not required for the mark to be earned, but if present it must be correct.

MARK SCHEME

Question			Answer	Marks	Part marks and guidance	
1	a		5400 or 5401 or 5402 final answer	2	M1 for figs 35 ÷ figs 648, soi by figs 540[1...] or for 0.000 064 8 seen	
	b		Any reference to average/inexact weight oe [in packet weight or weight of a grain] or recognising that the number of grains of salt must be integer oe	1		Condone any mention of <ul style="list-style-type: none"> • average for variation and/or • size for weight Mark the best part if no contradiction or wrong statement See appendix

Question	Answer	Marks	Part marks and guidance
2	Poppy, Sesame, Pumpkin with correct comparable values shown	4	<p>B3 for all 3 quantities seen <u>correct in comparable form</u></p> <p>or</p> <p>B2 for 8.4×10^{-5} or 8.4×10^{-2} seen or seen <u>correct in comparable form</u>:</p> <ul style="list-style-type: none"> pumpkin with poppy eg implied by [250 poppy =] 0.075 or pumpkin with sesame eg implied by [250 sesame =] 0.91 <p>or</p> <p>B1 poppy and sesame seen <u>correct in comparable form</u> or [pumpkin =] 0.084 or 0.000 084 seen</p> <p>or [250 poppy =] 0.000 075 oe seen or [250 sesame =] 0.000 91 oe seen</p>

Condone weights as answer

Quantities given in the question (bold in table) need not be rewritten

Comparable forms include:

In kilograms:		
Pop	0.000 000 3	3×10^{-7}
Pum	0.000 084	8.4×10^{-5}
Ses	0.000 003 64	3.64×10^{-6}

In grams:		
Pop	0.000 3	3×10^{-4}
Pum	0.084	8.4×10^{-2}
Ses	0.003 64	3.64×10^{-3}

Must not be a mix of standard and ordinary form

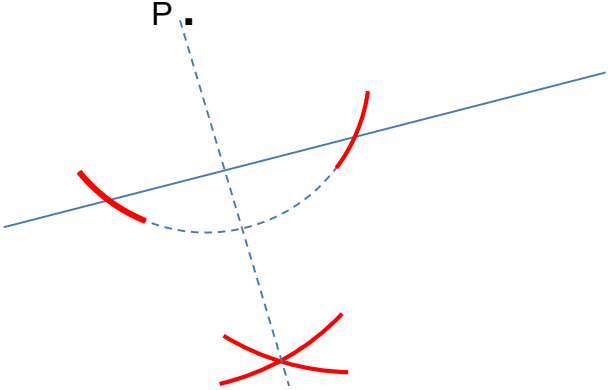
Accept consistent multiples for full marks. eg.
250 poppy = 0.075 and
250 sesame seeds = 0.91

May be all fractions with common denominator

Question		Answer	Marks	Part marks and guidance	
3	a	Correct answer based on angle or area/arc length	1	<p>The angle [for black]</p> <ul style="list-style-type: none"> • is too small oe or • is less than a fifth oe or • should be 72 oe <p>The area/arc length [for black]</p> <ul style="list-style-type: none"> • is too small oe or • is less than a fifth oe 	<p>Accept 26 to 30 for “the angle”</p> <p>Accept “not equal to” for “too small” or “less than”</p> <p>See appendix</p>
	b	Any comment recognising limitations in range of the vertical scale	1		<p>EG It does not start at zero or It starts at 113</p> <p>See appendix</p>
4		[expected profit is £] 80 with 200 and 120 seen	4	<p>B1 for [£] 200 or 20 000[p] AND M2 for $0.1 \times 400 \times 3$ soi 120 or M1 for 0.1×400 soi 40</p> <p><u>Alternative method</u> B1 for [£] 200 or 20 000[p] M1 for $\frac{their200-100}{3}$ [prizes] soi 33[.3...] M1 for 0.1×400 soi 40 A1 for she is giving away too many prizes oe</p> <p><u>Alternative method</u> B1 for [£] 200 or 20 000[p] M1 for $\frac{their200-100}{3}$ [prizes] soi 33[.3...] M1 for $\frac{their33[.3...]}{400}$ soi 0.08[3...] A1 for the probability of winning the game is too great oe</p>	<p>Apply scheme to consistent working in pence rather than £.</p>

Question	Answer	Marks	Part marks and guidance	
5			<p>3</p> <p>M2 for $\tan^{-1}\left(\frac{37}{20}\right)$ oe or M1 for $\tan[x =] \frac{37}{20}$ oe</p> <p>If M0 scored then SC1 for answers 28.4, 28 or angles that round to 28.4 if correct working seen.</p>	<p>Condone answer of 62 only if correct working seen</p> <p>Answers of 68.5 or 68.4(5..) [grads] or 1.08 or 1.07(5..) [rads] imply M2</p> <p>Alternative method After correct <u>method</u> for Pythagoras soi by 42.0 to 42.1 M2 for $\sin^{-1}\left(\frac{37}{\text{their } \sqrt{20^2+37^2}}\right)$ or $\cos^{-1}\left(\frac{20}{\text{their } \sqrt{20^2+37^2}}\right)$ or M1 for $\sin[x =] \frac{37}{\text{their } \sqrt{20^2+37^2}}$ or $\cos[x =] \frac{20}{\text{their } \sqrt{20^2+37^2}}$ or M0 for just Pythagoras reaching AC = 42.0 to 42.1 Do not condone answer of 62 following an interim answer seen that does not round to 61.6</p> <p>0 for scale drawing</p>

Question	Answer	Marks	Part marks and guidance
6	108 nfww	4	<p>B3 for $\frac{108}{300}$</p> <p>OR</p> <p>M3 for $(300 - \frac{23}{50} \times 300) \div 3 \times 2$ oe</p> <p>or</p> <p>M2 for $300 - \frac{23}{50} \times 300$ soi 162</p> <p>or</p> <p>M1 for $\frac{23}{50} \times 300$ oe soi 138</p> <p><u>Alternative method</u></p> <p>M1 for $[p(\text{white or red}) =] 1 - \frac{23}{50}$ soi $\frac{27}{50}$</p> <p>M1 for <i>their</i> $\frac{27}{[50]} \div 3 \times 2$ soi $\frac{18}{[50]}$</p> <p>M1 for <i>their</i> 18×6 or <i>their</i> $\frac{18}{50} \times 300$</p>

Question	Answer	Marks	Part marks and guidance	
7	Ruled perpendicular constructed with correct arcs (one pair intersecting AB)	2	<p>Condone dashed line B1 for correct arcs (one pair intersecting AB) only but no line or correct ruled line but no, or incomplete construction arcs</p> 	<p>Set protractor to 90° and check 88° to 92° at AB</p> <p>Correct construction arcs as shown (may be two pairs of arcs used to draw line through P) Ignore other arcs if correct arcs clearly used to construct line</p> <p>Condone perpendicular extending beyond AB but must pass through P and reach AB (no daylight)</p> <p>Alternative arcs. One centred on A length AP and one centred on B length BP meeting below AB (may also pass through P). Use overlay as check</p> <p>Candidates may use points on AB other than A and B for this construction. In such cases check radii of arcs using on-line ruler to judge.</p>

Question	Answer	Marks	Part marks and guidance	
8			<p>4</p> <p>B3 for $6x + 2$ as final answer or for $y = 6x + 2$ oe seen and then spoiled as final answer</p> <p>OR</p> <p>B2 for $y = 6x + k$ oe $0 < k < 7$ or for $y = mx + 2$, $m > 0$ and $m \neq 6$</p> <p>or</p> <p>B1 for gradient or $m = 6$ stated or for $y = 6x$ or for $[y =] 6x + k$ $k \neq 0$ or 7 oe or for $mx + 2$, $m > 0$ and $m \neq 6$</p> <p>B0 for $y = 6x + 7$ (as given)</p>	<p>Accept $y - 26 = 6(x - 4)$ as equivalent</p> <p>Do not allow other letters for x</p> <p><u>Alternative methods</u></p> <p>M1 for $6 \times 4 + 7$ soi 31 M1 for <i>their</i> $31 - 26$ soi 5 M1 for $7 - \text{their } 5$</p> <p>OR</p> <p>M1 for $[\pm]6 \times 4$ soi 24 or -24 M1 for $26 - \text{their } 24$ soi 2 M1 for $6x + \text{their } 2$</p>

Question			Answer	Marks	Part marks and guidance																																																	
9			<p>Correct solution is $x \leq -3$ from algebraic working</p> <p>No and number line shows $x \geq -3$ oe or No and draws the correct inequality on number line or No and “the arrow points the wrong way” oe</p>	<p>M3</p> <p>A1dep</p>	<p>M2 for $8x - 3x \leq -10 - 5$ or better, or for $5 + 10 \leq 3x - 8x$ or better or M1 for $8x - 3x$, or $3x - 8x$, or $[\pm]5x$, or $-10 - 5$, or $5+10$, or $[\pm]15$ seen</p> <p>A1 dep on M3</p> <p>After 0 scored, allow SC1 for number line shows $x \geq -3$ or “the arrow points the wrong way” oe but only if no incorrect working shown or correct substitution of a value $\neq -3$ and conclusion that inequality is false oe</p>	<p>For M2 and M1 condone incorrect inequality sign or “equals”.</p> <p><u>Alternative method</u> 3 trials for values of x where $x < -3$, $x = -3$ and $x > -3$ <u>and</u> correct conclusion can score full marks. Without the correct conclusion, maximum for this approach is SC1 for only the 3 correct trials (as described above)</p> <table><tr><th>x</th><th>$8x + 5$</th><th></th><th>$3x - 10$</th></tr><tr><td>-6</td><td>-43</td><td><</td><td>-28</td></tr><tr><td>-5</td><td>-35</td><td><</td><td>-25</td></tr><tr><td>-4</td><td>-27</td><td><</td><td>-22</td></tr><tr><td>-3</td><td>-19</td><td>=</td><td>-19</td></tr><tr><td>-2</td><td>-11</td><td>></td><td>-16</td></tr><tr><td>-1</td><td>-3</td><td>></td><td>-13</td></tr><tr><td>0</td><td>5</td><td>></td><td>-10</td></tr><tr><td>1</td><td>13</td><td>></td><td>-7</td></tr><tr><td>2</td><td>21</td><td>></td><td>-4</td></tr><tr><td>3</td><td>29</td><td>></td><td>-1</td></tr><tr><td>4</td><td>37</td><td>></td><td>2</td></tr></table>	x	$8x + 5$		$3x - 10$	-6	-43	<	-28	-5	-35	<	-25	-4	-27	<	-22	-3	-19	=	-19	-2	-11	>	-16	-1	-3	>	-13	0	5	>	-10	1	13	>	-7	2	21	>	-4	3	29	>	-1	4	37	>	2
x	$8x + 5$		$3x - 10$																																																			
-6	-43	<	-28																																																			
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-4	-27	<	-22																																																			
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1	13	>	-7																																																			
2	21	>	-4																																																			
3	29	>	-1																																																			
4	37	>	2																																																			

Question	Answer	Marks	Part marks and guidance	
10	<p>[0].88% [increase]</p> <p><u>Alternative method</u> The two answers are different oe dep on B5</p>	6	<p>B5 for 1.0088 or [0].0088 seen or B4 for 1.0088x where x is any letter or M4 for $k \times 1.04 \times [0].97 \div k$ oe or $(k \times 1.04 \times [0].97 - k) \div k$ oe or M3 for $k \times 1.04 \times [0].97$ oe or M2 for $k \times 1.04$ oe or $k \times [0].97$ oe or M1 for 1.04 or [0].97 or 4% of k found or 3% of k found</p> <p>If 0 scored then SC3 for figs 10088 or 88 seen</p> <p><u>Alternative method</u> B5 for correct answers to both $k \times 1.04 \times [0].97$ and $k \times 1.01$</p> <p>OR</p> <p>M3 for $k \times 1.04 \times [0].97$ oe or M2 for $k \times 1.04$ oe or $k \times [0].97$ oe or M1 for 1.04 or [0].97 or 4% of k found or 3% of k found</p> <p>and</p> <p>M1 for $k \times 1.01$ oe</p>	

accept [0].9% increase after 1.0088 found
For M marks, k is any seen starting value or a letter.

eg **M4** for $1.04 \times [0].97$ as k assumed to be 1.

eg **M3** for $104 \times [0].97$ as k assumed to be 100.

M2 or M1 may be embedded in an incorrect calculation, or in stages
eg **M2** for $k \times 1.4 \times [0].97$
eg **M1** for $k \times 1.4 \times [0].03$

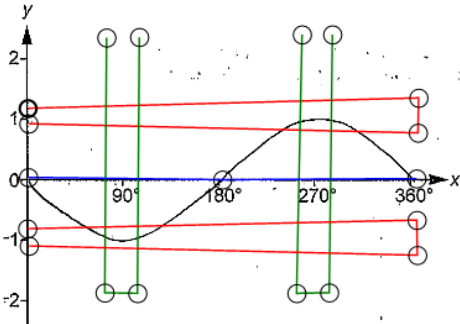
Alternative method
Answers to these calculations must be checked

Question			Answer	Marks	Part marks and guidance	
11	a	i	$2 \times 3^{11} \times 5$	1		Condone answers switched
			1771470	1		
		ii	$2^6 \times 3^{11} \times 5^6$	3	B1 for 3^{11} in answer and M1 for 2 and 5 identified as factors	Accept written in full without indices eg in factor tree
	b		21	3	M1 for 3^2 or $(3^2)^5$ or 3^{10} seen and M1 for 11 + <i>their</i> 10 soi after attempt at converting 9^5 to power of 3 Alternative method by trials: 3 marks for answer 21 but M0 for just converting to ordinary number and a wrong trial	M1M1 for answer 3^{21} eg M1M1 for $(3^2)^5 = 3^7$ and $3^{11} \times 3^7 = 3^{18}$

Question			Answer	Marks	Part marks and guidance	
12	a		(0)	2	B1 for at least 10 correct entries	
			1			
			2			
			3			
			4			
			5			
	b		125	4	B3 for $\frac{1000}{46656}$ oe isw wrong cancelling or for 0.0214(33...) oe as final answer OR B1FT for $\frac{10}{36}$ oe and M1 for <i>their</i> $\frac{10}{36} \times \text{their} \frac{10}{36} \times \text{their} \frac{10}{36}$	FT from their completed table in part (a) $\frac{10}{36} = \frac{5}{18} = 0.2777... \text{ to } 0.278$ Common mistake: B1 M0 for $3 \times \frac{10}{36}$
			5832			

Question	Answer	Marks	Part marks and guidance	
13	$\frac{(2x) + (2x + 2) + (2x + 4) + (2x + 6)}{4}$ $= \frac{8x + 12}{4}$ $= 2x + 3$ <p>which is an integer</p> <p>OR</p> $(2x) + (2x + 2) + (2x + 4) + (2x + 6)$ $= 8x + 12$ $= 4(2x + 3)$ <p>which is divisible by 4 oe</p>	4	<p>M1 for $2x$, $2x + 2$, $2x + 4$ and $2x + 6$ seen</p> <p>and</p> <p>M1 for adding their four terms in x, eg. $(2x) + (2x + 2) + (2x + 4) + (2x + 6)$</p> <p>and</p> <p>M1 for <i>their</i> $(8x + 12) \div 4$ or better, condoning lack of brackets, or for $4(2x + 3)$</p> <p>and</p> <p>A1dep (dep on M0M1M1 or M1M1M1) for correct algebraic mean for <i>their</i> four terms and conclusion eg. $2x + 3$ is an integer or $4(2x + 3)$ which is divisible by 4</p> <p>If 0 scored, allow SC1 for a numerical example with any 4 consecutive even integers with mean correctly calculated</p>	<p>Or equivalent algebraic representations of 4 consecutive even numbers. In this case, x does not need to be defined as being an integer.</p> <p>Using x, $x + 2$, $x + 4$, $x + 6$ oe does not score the first M mark unless x stated as even integer, but can score up to 3 marks for $(x) + (x + 2) + (x + 4) + (x + 6)$ <i>their</i> $(4x + 12) \div 4$ or better, or for $4(x + 3)$ and the relevant conclusion</p> <p>Using $x + 1$, $x + 3$, $x + 5$, $x + 7$ oe does not score the first M mark unless x stated as odd integer but can score up to 3 marks similar to above.</p>

Question	Answer	Marks	Part marks and guidance	
14	1250 nfww	5	<p>M4 for $[6x^2 =] 2 \times 625$</p> <p>or B4 for final answer 1244 to 1250.05</p> <p>OR</p> <p>M1 for $3x^2$ oe or 625</p> <p>and</p> <p>M1 for $3x^2 = 625$ oe</p> <p>and</p> <p>A1 for $[x =] \sqrt{\frac{625}{3}}$ or $\frac{25\sqrt{3}}{3}$ oe or 14.4 to 14.434 soi</p> <p>(14.4 to 14.434 seen implies M1M1A1)</p> <p>and</p> <p>M1 for $6 \times \text{their } x^2$</p> <p>If 0 scored,</p> <p>SC1 for starting from $x^2 = 25$ and final answer 150 or starting from $2x^2 = 25$ and final answer 75</p>	
			<p><u>Special cases:</u></p> <p>Starting from $3x^2 = 25$ oe soi</p> <p>M1M0 for $3x^2 = 25$</p> <p>A1 for $[x =] \sqrt{\frac{25}{3}}$ or $\frac{5\sqrt{3}}{3}$ oe or 2.88 to 2.89 soi</p> <p>(2.88 to 2.89 seen implies M1M0A1)</p> <p>M1 for $6 \times \text{their } x^2$ soi by 50</p> <p>Starting from $2x^2 = 625$ oe soi</p> <p>M1M0 for $2x^2 = 625$</p> <p>A1 for $[x =] \sqrt{\frac{625}{2}}$ or $\frac{25\sqrt{2}}{2}$ or 17.6 to 17.7 soi</p> <p>(17.6 to 17.7 seen implies M1M0A1)</p> <p>M1 for $6 \times \text{their } x^2$</p> <p>(1875 as final answer implies M1M0A1M1A0)</p> <p>Starting from $x^2 = 625$ oe soi</p> <p>M1M0 for $x^2 = 625$</p> <p>A0 (equation has been simplified and it is a more substantial error)</p> <p>M1 for $6 \times \text{their } x^2$</p> <p>(3750 as final answer implies M1M0A0M1A0)</p>	

Question	Answer	Marks	Part marks and guidance
15	$(5x + 2)(x + 1)$ oe using two pairs of brackets -0.4 oe and -1	2 1	M1 for any two factors that give two correct terms when expanded or partial factorisation such as $5x(x + 1) + 2(x + 1)$ or $x(5x + 2) + [1](5x + 2)$ Correct or FT <i>their</i> two factors Condone missing final bracket for up to full marks Up to full marks can be awarded for solving using non-integer factorisations such as $5(x + 0.4)(x + 1)$ oe NB Working backwards from the answers scores only the final mark eg. $(x + 0.4)(x + 1) = 0$ without seeing a factor of 5 or division by 5 leading to -0.4 and -1 Any other method, award B1 for both answers correct
16	Correct sketch of $y = -\sin x$ 	3	There must be at least one cycle to gain any marks. B1 for a positive or negative sine curve shape starting at (0, 0) and B1 for maximums at $(..., 1)$ and minimum at $(..., -1)$ and B1 for maximum only at $(270, ...)$ and minimum only at $(90, ...)$ eg B1B1B0 for $y = \sin x$ drawn B0B1B0 for $y = \pm \cos x$ drawn B1B1B0 for $y = \sin 2x$ drawn Before using overlay, check blue line is the x-axis All maximums and minimums within red on overlay Maximum and minimum within green on overlay

Question			Answer	Marks	Part marks and guidance
17	a		6.39 [pm] or 1839	4	<p>Condone 1839pm for full marks</p> <p>B3 for 39 or answer rounding to 39.1 or 3°39 to 3°39'6.07" or 6°39 to 6°39'6.07" or 219 or answer rounding to 219.1</p> <p>OR</p> <p>M1 for $[t =] \frac{3250}{890}$ oe soi by 3.65(...) and M1FT for $60 \times (\text{their time})$ soi or evidence from <i>their</i> answer by using calculator key</p> <p><u>Alternative method (converting speed to km/min)</u> M1 for $890 \div 60$ soi by $\frac{89}{6}$ or $14\frac{5}{6}$ oe or 14.8[3...] and M1FT for $[t =] 3250 \div \text{their } 14.8[3...]$</p> <p>eg $3\frac{58}{89}$ <i>their</i> time could be fraction or decimal and could be just the non-integer part (check using calculator)</p>

Question	Answer	Marks	Part marks and guidance	
b	3345 to 3350 nfw	4	<p>B1 for 42 seen</p> <p>AND</p> <p>M2 for $[x^2 =] 3250^2 + 4960^2 - 2 \times 3250 \times 4960 \cos \theta$ or soi by $[x^2 =] 11205110$ to 11205111</p> <p>or</p> <p>M1 for correct cosine rule with x^2 not as subject</p> <p><u>Alternative method (using horizontal/vertical components and Pythagoras)</u></p> <p>M3 for $\sqrt{(4960 \sin 57 - 3250 \sin 15)^2 + (3250 \cos 15 - 4960 \cos 57)^2}$</p> <p>or</p> <p>M2 for $4960 \sin 57 - 3250 \sin 15$ or $3250 \cos 15 - 4960 \cos 57$</p> <p>or</p> <p>M1 for two of $4960 \sin 57$, $3250 \sin 15$, $3250 \cos 15$ or $4960 \cos 57$</p>	
				<p>May be seen on sketch diagram</p> <p>For M2 or M1, θ is a number in the range $15 \leq \theta \leq 57$</p> <p>eg $\cos \theta = \frac{3250^2 + 4960^2 - x^2}{2 \times 3250 \times 4960}$</p> <p>Allow numerical values to imply relevant trig functions as below for M marks:</p> <ul style="list-style-type: none"> • $4960 \sin 57 = 4159$ to 4160 • $3250 \sin 15 = 841$ to 842 • $3250 \cos 15 = 3139$ to 3140 • $4960 \cos 57 = 2701$ to 2702 • $4960 \sin 57 - 3250 \sin 15 = 3317$ to 3319 • $3250 \cos 15 - 4960 \cos 57 = 437$ to 439 • $(4960 \sin 57 - 3250 \sin 15)^2 = 11\,002\,489$ to $11\,015\,761$ • $(3250 \cos 15 - 4960 \cos 57)^2 = 190\,969$ to $192\,721$

Question	Answer	Marks	Part marks and guidance	
18	8.74[...] nfww	4	<p>M3 for $[r =] \sqrt[3]{\frac{2100}{\pi}}$</p> <p>or</p> <p>M2 for $\pi r^3 = 2100$ oe</p> <p>M1 for $\frac{1}{3} \pi r^2(3r)$ oe</p> <p><u>Alternative method</u> using h</p> <p>M3 for $[h =] \sqrt[3]{\frac{56700}{\pi}}$ soi by 26.2[3...]</p> <p>or</p> <p>M2 for $\pi h^3 = 56700$ oe</p> <p>M1 for $\frac{1}{3} \pi \left(\frac{h}{3}\right)^2 h$ oe</p>	
19	a	4	<p>B2 for 29 or $\sqrt{29}$ or 5.38(5...) to 5.39</p> <p>or</p> <p>M1 for $2^2 + 5^2$ or $\sqrt{2^2 + 5^2}$ or $2^2 + (-5)^2$ or $\sqrt{2^2 + (-5)^2}$</p> <p>AND</p> <p>B1 for $x^2 + y^2 = k$ where k is a number > 0 or $x^2 + y^2 = r^2$</p>	<p>Accept answer of 8.7 after M3</p> <p>May be done in stages</p> <p>eg M3 for $\sqrt[3]{668. (...)}$</p> <p>eg. M2 for $3\pi r^3 = 6300$ or $\frac{1}{3} \pi r^2(3r) = 2100$ etc</p> <p>eg. M1 for πr^3</p> <p>eg. M1 for $\frac{1}{27} \pi h^3$</p>
	b	2	<p>M1 for $-\frac{2}{5}$ oe or -0.4 seen or use of $m_1 m_2 = -1$ with <i>their</i> radius gradient</p>	<p>M1 for $[y =] \frac{5}{2} x [+ c]$ oe</p> <p>Condone $-\frac{2}{5} x$ seen for M1</p>

Question	Answer	Marks	Part marks and guidance	
20 a	$1^4 - 1^2 - 9 = -9$ $2^4 - 2^2 - 9 = 3$ Sign change, solution between $x = 1$ and $x = 2$	3	<p>M2 for $1^4 - 1^2 - 9 = -9$ and $2^4 - 2^2 - 9 = 3$</p> <p>or</p> <p>M1 for $1^4 - 1^2 - 9$ or $2^4 - 2^2 - 9$ soi by -9 or 3</p> <p><u>Alternative method</u> After $x^4 - x^2 = 9$ seen M2 for $2^4 - 2^2 = 12$ and $1^4 - 1^2 = 0$ A1 for $12 > 9$ and $0 < 9$ so solution between $x = 1$ and $x = 2$ OR M1 for $2^4 - 2^2$ or $1^4 - 1^2$ soi by 12 or 0</p> <p><u>Alternative method</u> SC3 for using an iterative equation that converges to a value in the range 1.85 to 1.95 and concluding statement that $1 < 1.85$ to $1.95 < 2$ oe or SC2 for using an iterative equation that converges to a value in the range 1.85 to 1.95</p> <p><u>Alternative method</u> SC3 for using quadratic formula (see (b)) leading to a value in the range 1.88 to 1.89 and concluding statement that $1 < 1.88$ to $1.89 < 2$ oe or SC2 for using quadratic formula (see (b)) leading to a value in the range 1.88 to 1.89</p>	<p>Accept other values of x used between 1 and 2 (see table in part (b)). For full marks, the two values need to produce a sign change.</p> <p>Examples just sufficient for third mark include: sign change $-9 < 0 < 3$ $x = 1$ gives an answer < 0 and $x = 2$ gives an > 0</p> <p>Examples insufficient for third mark: so x lies between 1 and 2</p> <p>If candidates refer to their working in part (b) within part (a), award marks for any of the final 2 alternative methods.</p>

Question	Answer	Marks	Part marks and guidance
b	Two correct evaluations in the range 1.85 to 1.95, one which gives a positive value and the other giving a negative value 1.9	M3 and A1dep	<p>M2 for two correct evaluations between 1 and 2, one which gives a positive value and the other giving a negative value</p> <p>or</p> <p>M1 for one correct evaluation between 1 and 2</p> <p>Dependent on achieving at least M2</p> <p>OR</p> <p>SC1 for 1.9 with no worthwhile working</p> <p><u>Alternative method by iteration</u> M1 rearranges to a correct iterative formula (converging or diverging) M1 attempts first iteration (either substitution of $1 \leq x \leq 2$ seen or found to at least 2dp rot) M1 continues further iteration(s) to reach x in the range 1.85 to 1.95 A1 for 1.9</p> <p><u>Alternative method by quadratic formula</u> M2 for $[x^2 =] \frac{-(-1) \pm \sqrt{(-1)^2 - 4(1)(-9)}}{2(1)}$ soi by 3.54[1..] or M1 for this formula with at most two errors</p> <p>AND</p> <p>M1 for $x = \sqrt{\text{their } 3.54[1..]}$ soi by 1.88 to 1.89 A1 for 1.9</p>

Likely values: accept rot to 1 or more dp

x	$x^4 - x^2 - 9$
1.1	-8.7459
1.2	-8.3664
1.25	-8.12109...
1.3	-7.8339
1.4	-7.1184
1.5*	-6.1875
1.6	-5.0064
1.7	-3.5379
1.75*	-2.68359...
1.8	-1.7424
1.85	-0.70899...
1.875*	-0.1560...
1.9	0.4221
1.9375*	1.3379....
1.95	1.656506
2	3

Alternative iteration method notes
condone missing subscripts

eg **M1** for $x = \sqrt{\sqrt{9 + x^2}}$

and **M1** for $\sqrt{\sqrt{9 + 1^2}}$ or 1.77[8..]
or 1.78

If candidates **refer to or use their working** in part (a) within part (b), award up to full marks for part (b).

Question	Answer	Marks	Part marks and guidance	
21	2.625 nfww	4	<p>M3 for $2.1 \times \sqrt[3]{\frac{15.625}{8}}$ oe or $2.1 \div \sqrt[3]{\frac{8}{15.625}}$</p> <p>or</p> <p>M2 for $\sqrt[3]{\frac{15.625}{8}}$ soi by $\frac{5}{4}$ or 1.25 oe</p> <p>or $\sqrt[3]{\frac{8}{15.625}}$ soi by $\frac{4}{5}$ or 0.8 oe</p> <p>or</p> <p>M1 for $\frac{15.625}{8}$ soi by $\frac{125}{64}$ oe or 1.95(31...)</p> <p>or $\frac{8}{15.625}$ soi by $\frac{64}{125}$ oe or 0.512</p> <p>If 0 scored then SC1 for 4.1 to 4.11 as final answer</p>	

Accept 2.6, 2.62 or 2.63 as final answer after **M3**

May be done in stages, including rounding to at least 3 sig figs of intermediate steps

May see as length ratio, eg. **M2** for $\sqrt[3]{8} : \sqrt[3]{15.625}$ soi by 2 : 2.5 oe

May see as volume ratio, eg. **M1** for 8 : 15.625 oe
 May also be seen as part of wrong approach
 eg. $\frac{15.625}{8 \div 2.1}$ seen or done in stages scores **M1**

Question			Answer	Marks	Part marks and guidance	
22	a		17 150	1		
	b		$16\,807 \div 17\,150 = 0.98$	1	Condone: $17150 \times [0].98 = 16807$ $16807 \div [0].98 = 17150$	
	c		15 818 to 15 819	2	M1 for 17150×0.98^4 or <i>their</i> (a) $\times 0.98^4$ or for 16807×0.98^3 and A1FT from <i>their</i> (a) $\times 0.98^4$ correctly evaluated <u>Alternative methods using division</u> M1 for $16000 \div 0.98^4$ A1 for 17300 to 17350 is greater than 17150 OR M1 for $16000 \div 0.98^3$ A1 for 16900 to 17000 is greater than 16807	FT from <i>their</i> (a), and only if method shown Accept “[population in] 2018” for 17150 Accept “[population in] 2019” for 16807
	d		17 500 nfw	2	M1 for 17150×0.98^{-1} oe or <i>their</i> (a) $\times 0.98^{-1}$ oe or 16807×0.98^{-2} oe	NB: M1 for $0.98^{-1} = 1.02[04\dots]$ and $17150 \times 1.02[04\dots]$ but M0 for $17150 \times 1.02 = 17493$

Question 1b

A	Because it is a decimal and you can't have a decimal of a grain of salt.	1 Reference to requiring integer value
B	They might have rounded the 0.35kg up.	1 Equivalent to "figures not exact"
C	Some grains can be lighter or heavier than this.	1 "this" is "the average"?
D	The weight of each grain is an average.	1 True; mention of average
E	The weight given is an average weight.	1 True; mention of average
F	As it is an average amount of salt.	1 True; mention of average. Read amount for weight
G	Some grains of salt may be heavier.	1 Implies variation
H	It's an average	1 Minimum case
I	It's not exact	1 Minimum case
J	It's a decimal	1 Minimum case
K	Because it is hard to exactly measure that finite amount consistently.	0 It may be "hard to measure" but doesn't say they are not exact.
L	It's an estimate because in some packets there will be slightly more or less grains as they are too small to count.	0 Refers to the number of grains and does not reference the weight of a grain.
M	There could be a fraction of a grain of salt.	0 Implies number of grains can be non-integer.
N	They all weigh the same but could be different sizes	0 Choice One incorrect statement and one correct

Question 3a

A	The black section does not cover $\frac{1}{5}$ of the spinner	1 "covering" implies area
B	The angle is 28° . It should be 72° .	1
C	$\frac{1}{5}$ is 72° and the black section is less than this	1
D	The angle is only 28.	1 Implied comparison with correct angle BOD Minimum case
E	Because $30/360$ is $\frac{1}{12}$	1 comparing angle as fraction with common numerator with $\frac{1}{5}$ (which is given) ($\frac{3}{36}$ is not enough to compare)
F	Because $28/360 = 0.07[\dots]$ not 0.2	1 Correct comparison (but (26 to 30)/360 needed for evidence of working with angle)
G	The angle is 28° .	0 Does not say that it should be 72 or is too small
H	The sections are not of equal area	0
I	The sections are not of equal width	0
J	The black section is the smallest section	0
K	The spinner is unequal and some spaces are the same colour but different size	0
L	It's more like a tenth	0 No angle used to justify

Question 3b

A	The graph starts at 113	1 Recognises limitation in scale
B	The y-axis is only from 113 to 121	1 Recognises limitation in scale
C	Because you don't see anything below 113	1 Recognises limitation in scale
D	You can't read between the numbers on the scale	0 Does not recognise limitations in the range of the scale
E	It doesn't start from the bottom of the graph and the units go up in an unusual pattern.	0 Too vague.
F	It looks as though there has been a drastic increase in price when there hasn't.	0 Not explained why the scale causes this
G	There are lines joining the points.	0 Irrelevant
H	Because the cost varies throughout the month.	0 True but describing patterns
I	Because it would have fluctuated.	0 True but describing patterns
J	You don't see the bottom of the graph	0 Too vague

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