Level 2 Certificate
FURTHER MATHEMATICS
8365/2

Paper 2 Calculator

Mark scheme

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Mark schemes are prepared by the Lead Assessment Writer and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all associates participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every associate understands and applies it in the same correct way. As preparation for standardisation each associate analyses a number of students' scripts. Alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

No student should be disadvantaged on the basis of their gender identity and/or how they refer to the gender identity of others in their exam responses.

A consistent use of 'they/them' as a singular and pronouns beyond 'she/her' or 'he/him' will be credited in exam responses in line with existing mark scheme criteria.

Further copies of this mark scheme are available from aqa.org.uk

Glossary for Mark Schemes

GCSE examinations are marked in such a way as to award positive achievement wherever possible. Thus, for GCSE Mathematics papers, marks are awarded under various categories.

If a student uses a method which is not explicitly covered by the mark scheme the same principles of marking should be applied. Credit should be given to any valid methods. Examiners should seek advice from their senior examiner if in any doubt.

M	Method marks are awarded for a correct method which could lead to a correct answer.
M dep	A method mark dependent on a previous method mark being awarded.
A	Accuracy marks are awarded when following on from a correct method. It is not necessary to always see the method. This can be implied.
B	Marks awarded independent of method.
B dep	A mark that can only be awarded if a previous independent mark has been awarded.
ft	Follow through marks. Marks awarded following a mistake in an earlier step.
SC	Special case. Marks awarded within the scheme for a common misinterpretation which has some mathematical worth.
oe	Or equivalent. Accept answers that are equivalent. eg accept 0.5 as well as $\frac{1}{2}$
[a, b]	Accept values between *a* and *b* inclusive.
3.14…	Accept answers which begin 3.14 eg 3.14, 3.142, 3.1416

Examiners should consistently apply the following principles.

Diagrams

Diagrams that have working on them should be treated like normal responses. If a diagram has been written on but the correct response is within the answer space, the work within the answer space should be marked. Working on diagrams that contradicts work within the answer space is not to be considered as choice but as working, and is not, therefore, penalised.

Responses which appear to come from incorrect methods

Whenever there is doubt as to whether a candidate has used an incorrect method to obtain an answer, as a general principle, the benefit of doubt must be given to the candidate. In cases where there is no doubt that the answer has come from incorrect working then the candidate should be penalised.

Questions which ask candidates to show working

Instructions on marking will be given but usually marks are not awarded to candidates who show no working.

Questions which do not ask candidates to show working

As a general principle, a correct response is awarded full marks.

Misread or miscopy

Candidates often copy values from a question incorrectly. If the examiner thinks that the candidate has made a genuine misread, then only the accuracy marks (A or B marks), up to a maximum of 2 marks are penalised. The method marks can still be awarded.

Further work

Once the correct answer has been seen, further working may be ignored unless it goes on to contradict the correct answer.

Choice

When a choice of answers and/or methods is given, mark each attempt. If both methods are valid then M marks can be awarded but any incorrect answer or method would result in marks being lost.

Work not replaced

Erased or crossed out work that is still legible should be marked.

Work replaced

Erased or crossed out work that has been replaced is not awarded marks.

Premature approximation

Rounding off too early can lead to inaccuracy in the final answer. This should be penalised by 1 mark unless instructed otherwise.

Continental notation

Accept a comma used instead of a decimal point (for example, in measurements or currency), provided that it is clear to the examiner that the candidate intended it to be a decimal point.

Q	Answer	Mark	Comments
1	$\frac{6\times5}{7\times5+25}$ or $\frac{30}{60}$	M1	oe eg $\frac{1}{2}$ or 0.5 may be seen in an equation or a list eg $\frac{20}{n+4}=\frac{1}{2}$
	20 = their $\frac{30}{60}\times(n+4)$	M1dep	oe linear equation eg $n+4=40$
	36	A1	accept $n=36$
	Additional Guidance		
	Allow n to be N or x etc		
	For 36 accept eg 36th		
	Answer nth term = 36		M2A0
	Answer $36n$		M2A0

Q	Answer	Mark	Comments
2	$(r =)\ \sqrt{144}$ or $(r =)\ 12$	M1	may be on diagram
	$\frac{1}{4} \times \pi \times \sqrt{144} \times \sqrt{144}$ or 36π or [113, 113.112] or $\frac{1}{2} \times \frac{5}{5+1} \times \sqrt{144} \times \sqrt{144}$ or 60	M1dep	oe area of $\frac{1}{4}$ circle eg $\frac{1}{4} \times \pi \times 12 \times 12$ or area of COD eg $\frac{1}{2} \times 10 \times 12$
	$\frac{1}{4} \times \pi \times \sqrt{144} \times \sqrt{144}$ $-\frac{1}{2} \times \frac{5}{5+1} \times \sqrt{144} \times \sqrt{144}$ or $36\pi - 60$	M1dep	oe full method
	[53, 53.112]	A1	SC2 [7637.7, 7648,13] or $5184\pi - 8640$
	Additional Guidance		
	Accept [3.14, 3.142] for π throughout		
	SC2 is from using a radius of 144		

Q	Answer	Mark	Comments
3	**Alternative method 1: substitutes (3, 1) into equation of line**		
	$6a + 1 = 25$ or $6a = 24$	M1	oe equation eg $2a \times 3 + 1 = 25$
	$(a =)$ 4	A1	implied by $2a = 8$ or $-2a = -8$ or $8x + y = 25$ oe equation of line
	-8	B1ft	ft M0A0 or M1A0 ft $-2 \times$ their a
	Alternative method 2: works out the y-intercept of line		
	(0, 25)	M1	oe eg y-intercept is 25
	$\frac{25-1}{0-3}$	M1dep	oe
	-8	A1	
	Additional Guidance		
	Alt 1 $2a + 1 = 25$ $a = 12$ Answer -24		M0A0 B1ft
	Alt 1 $6a = 24$ $a = 18$ Answer -36		M1A0 B1ft
	Answer $-8x$ or $-2a$		B0

Q	Answer	Mark	Comments
4	$0 \leqslant n^2 \leqslant 25$	B2	oe eg $n^2 \leqslant 25$ and $n^2 \geqslant 0$ B1 $n^2 \leqslant 25$ or $n^2 \geqslant 0$ SC1 $0 < n^2 < 25$ oe SC1 $0 \leqslant n \leqslant 25$ oe SC1 $0 \leqslant \text{f}(n) \leqslant 25$ oe
	Additional Guidance		
	B1 answers may be embedded eg1 $0 \leqslant n^2 < 25$ eg2 $-25 < n^2 \leqslant 25$		 B1 B1
	Accept equivalents throughout eg $25 \geqslant n^2 \geqslant 0$		B2
	B2 or B1 response in working with integer(s) on answer line is awarded B1 Condone integer(s) linked to n or n^2 eg1 $n^2 \leqslant 25$ in working Answer 1 2 3 4 5 eg2 $0 \leqslant n^2 \leqslant 25$ in working Answer $n^2 = 25$		 B1 B1
	Condone eg x used for n		
	$25 \leqslant n^2 \leqslant 25$ is choice		B0
	Accept interval notation throughout eg [0, 25)		B1

Q	Answer	Mark	Comments
5	$5x^4$ or $4px^3$	M1	oe eg $5 \times x^{5-1}$ or $4 \times px^{4-1}$
	$5(-1)^4 + 4p(-1)^3 = -3$ or $5 - 4p = -3$	M1dep	oe equation
	2	A1	
	Additional Guidance		
	M1 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts		
	$y = 5x^4 + 4px^3$ is awarded 1st M1 and may be awarded up to full marks with further correct working		
	Missing brackets must be recovered		

Q	Answer	Mark	Comments
6	x-coordinate of $C = 11$	B1	may be seen on diagram implied by C (11, …)
	y-coordinate of $C = 6$	B1	may be seen on diagram implied by C (…, 6)
	$y = \frac{6}{11}x$	B1ft	oe equation eg $11y = 6x + 0$ ft their non-zero coordinates of C
	Additional Guidance		
	C (11, 1) $y = \frac{1}{11}x$		B1B0B1ft
	C (3, 6) $y = \frac{6}{3}x$		B0B1B1ft
	C (6, 11) $y = \frac{11x}{6}$		B0B0B1ft
	C (11, 0) $y = 0$		B1B0B0ft
	C (0, 6) $y = 6$		B0B1B0ft
	Exact equations must be seen for the 3rd B1 eg1 C (11, 6) $y = \frac{6}{11}x$ Answer $y = 0.545x$ eg2 C (11, 6) Answer $y = 0.545x$ ($y = \frac{6}{11}x$ not seen)		B1B1B1 B1B1B0
	Condone eg C (9.5, 3) $y = \frac{3}{9.5}x$		B0B0B1ft

Q	Answer	Mark	Comments
7(a)	$5a + 1 = a$ or $2^{5a-a+1} = 1$ or $2^{5a-a+1} = 2^0$	M1	oe linear equation eg $4a = -1$ or oe index equation in the form $2^{f(a)} = 1$ or $2^{f(a)} = 2^0$
	$-\frac{1}{4}$ or -0.25	A1	oe value
	Additional Guidance		
	Only $\frac{2^{5a+1}}{2^a} = 1$		M0

Q	Answer	Mark	Comments
7(b)	3^{-7-c} or 3^{-6c} **or** $-7-c$ and $-6c$	M1	oe eg $\frac{1}{3^{7+c}}$ or $\frac{1}{3^{6c}}$ or $3^{-3\times 2c}$ implied by a correct equation equating powers of 3 eg $3^{-7} = 3^{-5c}$
	$-7-c = -6c$		oe linear equation eg $5c = 7$
	$\frac{7}{5}$ or 1.4	A1	oe value condone $\frac{-7}{-5}$
	Additional Guidance		
	$\frac{1}{3^7} \div 3^c$ needs further processing for M1		
	$\frac{1}{(3^3)^{2c}}$ needs further processing for M1		

Q	Answer	Mark	Comments
8	$4k^2 + 32k$ or $4k^2 - 4k + 9k - 9$ or $4k^2 + 5k - 9$	M1	may be seen in a full expansion eg … $- 4k^2 + 4k - 9k + 9$ may be seen in a grid
	$4k^2 + 32k - 4k^2 + 4k - 9k + 9$ or $4k^2 + 32k - (4k^2 - 4k + 9k - 9)$ or $4k^2 + 32k - 4k^2 - 5k + 9$ or $4k^2 + 32k - (4k^2 + 5k - 9)$	M1dep	correct 6-term expression and no errors or correct 5-term expression and no errors
	M2 awarded and $27k + 9$ and valid explanation involving 9 and $(3k + 1)$	A1	eg M2 awarded and $27k + 9 = 9(3k + 1)$ or M2 awarded and $\frac{27k + 9}{9} = 3k + 1$
	Additional Guidance		
	$4k^2 - 4k + 9k - 9$ followed by an error in simplifying to 3 terms eg $4k^2 - 4k + 9k - 9 = 4k^2 - 5k - 9$ ($- 5k$ is an error) Award 1st M1 but no further marks can be awarded		M1M0A0
	Do not award 2nd M1 if errors seen eg $4k(k + 8) = 4k^2 + 32k$ $(4k + 9)(k - 1) = 4k^2 + 4k - 9k - 9 = 4k^2 + 5k - 9$ ($+ 4k$ and $- 9k$ are errors) $4k^2 + 32k - 4k^2 - 5k + 9$ ('correct' 5-term expression with errors)		M1 M0A0
	Missing brackets cannot be recovered		
	For M marks accept eg $--9$ for $+9$		
	Valid explanations involving 9 and $(3k + 1)$ include eg1 $27k + 9$ when divided by 9 is $(3k + 1)$ eg2 $27k + 9$ has factors $(3k + 1)$ and 9		
	Incomplete explanations include eg1 $27k + 9$ which is divisible by 9 eg2 $27k + 9$ and $27k \div 9 = 3k$ and $9 \div 9 = 1$		
	Condone eg x used for k		

Q	Answer	Mark	Comments
9	$1 + p = 2p - \frac{1}{2}$	M1	oe equation eg $1^2 + p \times 1 = 2p - \frac{1}{2} \times 1$
	$\frac{3}{2}$ or 1.5	A1	oe value eg $1\frac{1}{2}$
	Additional Guidance		

Q	Answer	Mark	Comments
10	$4n^2 - 5$	B2	B1 $4n^2(\ldots)$
	Additional Guidance		
	Accept $4n^2 + -5$		B2
	Answer $a = 4 \quad b = -5$		B2
	Answer $a = 4 \quad b = 5$		B1
	Accept $\frac{8}{2}$ for 4		
	Condone eg $4n^2 + 0n - 5$		B2
	$4n^2 + 4n - 5$		B1
	Condone n being N or x etc for B2 or B1		
	$n = 4n^2 - 5$		B1
	$n = 4n^2$		B1

Q	Answer	Mark	Comments
11(a)	Valid common denominator with at least one numerator correct	M1	eg $\frac{9}{12w}$ and $\frac{2}{12w}$ or $\frac{18w}{24w^2}$ and $\frac{4w}{24w^2}$ implied by a correct single fraction not in simplest form eg $\frac{9+2}{12w}$ or $\frac{22}{24w}$ or $\frac{22w}{24w^2}$ for common denominator $4w$ or $6w$ both numerators must be correct
	$\frac{11}{12w}$	A1	accept $\frac{11}{12}w^{-1}$

Additional Guidance

$\frac{11}{12w}$ followed by incorrect further work	M1A0
$\frac{4.5}{6w} + \frac{1}{6w}$	M1
$\frac{5.5}{6w}$	A0
For M1 accept numerator(s) and/or denominator(s) seen as products eg $\frac{6w \times 3}{4w \times 6w}$ and $\frac{4w}{4w \times 6w}$	M1
$\frac{1}{w}\left(\frac{3}{4}+\frac{1}{6}\right)$ (does not score M1 at this stage)	
$\frac{1}{w}\left(\frac{9}{12}+\frac{2}{12}\right)$	M1
Omitting w in working with recovery to answer $\frac{11}{12w}$	M1A1
Omitting w in working with no or incorrect answer	M0A0

Q	Answer	Mark	Comments
11(b)	$(x-1)^8(2x+3)$	B2	B1 factorised expression with $(x-1)^8$ as one of the factors allow multiplication signs for B2 or B1
	Additional Guidance		
	Condone missing final bracket for B2 or B1 unless final factor is $(x-1)^8$ eg1 $(x-1)^8(2x+3$ eg2 $(2x+3)(x-1^8$		B2 B0
	Ignore expansion of a B2 or B1 response		
	$(x-1)^8(3+2x)$ etc		B2
	B2 response followed by further, incorrect work is B1 eg $(x-1)^8(2x+3)=5x(x-1)^8$		B1
	B1 response followed by further, incorrect work is B1 eg $(x-1)^8(3x+4)=7x(x-1)^8$		B1
	Ignore any attempt to 'solve'		
	$(x-1)^8(x-1)+(x-1)^8(x+4)$		B0
	$(x-1)^8(x-1)+(x+4)$		B0

Q	Answer	Mark	Comments
11(c)	$2(2y + 5)(2y - 5)$	B2	B1 $2(4y^2 - 25)$ or $(4y + 10)(2y - 5)$ or $(4y - 10)(2y + 5)$ or correct use of difference of two squares eg $8(y + 2.5)(y - 2.5)$ or $\frac{1}{2}(4y + 10)(4y - 10)$ or $(\sqrt{8}\,y + \sqrt{50})(\sqrt{8}\,y - \sqrt{50})$ or $(2\sqrt{2}\,y + 5\sqrt{2})(2\sqrt{2}\,y - 5\sqrt{2})$ allow multiplication signs for B2 or B1

Additional Guidance	
All B1 responses must be equivalent to $8y^2 - 50$	
Condone missing final bracket for B2 or B1	
Ignore expansion of a B2 or B1 response	
$2(5 + 2y)(2y - 5)$ etc	B2
$(10 + 4y)(2y - 5)$ etc	B1
B2 response followed by further, incorrect work is B1 eg $2(2y + 5)(2y - 5) = (4y + 10)(4y - 10)$	B1
B1 response followed by further, incorrect work is B1 eg $(4y + 10)(2y - 5) = 14y(2y - 5)$	B1
Ignore any attempt to 'solve'	

Q	Answer	Mark	Comments
12(a)	$\begin{pmatrix} 3 & 0 \\ 0 & 3 \end{pmatrix}$	B1	

Q	Answer	Mark	Comments
12(b)	$A'(0, -1)$ $B'(-1, -1)$ $C'(-1, 0)$	B3	B2 $\begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix}$ **or** any two of $A'(0, -1)$ $B'(-1, -1)$ $C'(-1, 0)$ **or** $\begin{pmatrix} 0 \\ -1 \end{pmatrix}$ and $\begin{pmatrix} -1 \\ -1 \end{pmatrix}$ and $\begin{pmatrix} -1 \\ 0 \end{pmatrix}$ B1 $\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$ **or** $\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}\begin{pmatrix} 1 \\ 0 \end{pmatrix}$ and $\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}\begin{pmatrix} 1 \\ -1 \end{pmatrix}$ and $\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}\begin{pmatrix} 0 \\ -1 \end{pmatrix}$ **or** any one of $A'(0, -1)$ $B'(-1, -1)$ $C'(-1, 0)$

The Additional Guidance for Question 12(b) is on the next page

	Additional Guidance	
12(b) cont	If answer line can only be awarded B1 or B0 check the working space to see if more marks can be awarded	
	No misreads	
	B1 awarded for products must have matrices in correct order but can be recovered for B2 or B3 eg $\begin{pmatrix}1\\0\end{pmatrix}\begin{pmatrix}0&1\\-1&0\end{pmatrix}$ and $\begin{pmatrix}1\\-1\end{pmatrix}\begin{pmatrix}0&1\\-1&0\end{pmatrix}$ and $\begin{pmatrix}0\\-1\end{pmatrix}\begin{pmatrix}0&1\\-1&0\end{pmatrix}$ is B0 but if recovered to $\begin{pmatrix}0\\-1\end{pmatrix}$ and $\begin{pmatrix}-1\\-1\end{pmatrix}$ and $\begin{pmatrix}-1\\0\end{pmatrix}$ award B2	
	$\begin{pmatrix}0\\-1\end{pmatrix}$ and $\begin{pmatrix}-1\\-1\end{pmatrix}$ and $\begin{pmatrix}-1\\0\end{pmatrix}$ may be seen as a single matrix eg $\begin{pmatrix}0&-1&-1\\-1&-1&0\end{pmatrix}$ or $\begin{pmatrix}-1&-1&0\\-1&0&-1\end{pmatrix}$	B2
	$\begin{pmatrix}0&1\\-1&0\end{pmatrix}\begin{pmatrix}1\\0\end{pmatrix}$ and $\begin{pmatrix}0&1\\-1&0\end{pmatrix}\begin{pmatrix}1\\-1\end{pmatrix}$ and $\begin{pmatrix}0&1\\-1&0\end{pmatrix}\begin{pmatrix}0\\-1\end{pmatrix}$ may be seen as a single matrix product eg $\begin{pmatrix}0&1\\-1&0\end{pmatrix}\begin{pmatrix}1&1&0\\0&-1&-1\end{pmatrix}$ or $\begin{pmatrix}0&1\\-1&0\end{pmatrix}\begin{pmatrix}0&1&1\\-1&-1&0\end{pmatrix}$	B1
	$\begin{pmatrix}0&1\\-1&0\end{pmatrix}\begin{pmatrix}1&0\\0&-1\end{pmatrix}$ may be seen embedded eg $\begin{pmatrix}0&1\\-1&0\end{pmatrix}\begin{pmatrix}1&0\\0&-1\end{pmatrix}\begin{pmatrix}1\\0\end{pmatrix}$	B1

Q	Answer	Mark	Comments
13	**Alternative method 1: eliminates fraction**		
	$x(5k^2-2)=3k^2$	M1	oe elimination of fraction eg $5xk^2-2x=3k^2$
	$5xk^2-3k^2=2x$	M1dep	oe expansion of bracket and collection of terms in k^2 eg $-2x=3k^2-5xk^2$
	$k^2(5x-3)=2x$	M1dep	oe full factorisation eg $-2x=k^2(3-5x)$ may be implied eg $k^2=\frac{2x}{5x-3}$ or $\sqrt{\frac{2x}{5x-3}}$
	$k=\sqrt{\frac{2x}{5x-3}}$	A1	oe with k the subject eg $k=\sqrt{\frac{-2x}{3-5x}}$ or $k=\frac{\sqrt{2x}}{\sqrt{5x-3}}$ or $\left(\frac{2x}{5x-3}\right)^{\frac{1}{2}}=k$
	Alternative method 2: takes reciprocal of both sides		
	$\frac{1}{x}=\frac{5k^2-2}{3k^2}$	M1	oe reciprocal of both sides eg $\frac{1}{x}=\frac{5k^2}{3k^2}-\frac{2}{3k^2}$
	$\frac{2}{3k^2}=\frac{5x-3}{3x}$	M1dep	oe collection of term in $\frac{1}{k^2}$ eg $\frac{2}{3k^2}=\frac{5}{3}-\frac{1}{x}$
	$\frac{3k^2}{2}=\frac{3x}{5x-3}$	M1dep	oe reciprocal of both sides may be implied eg $k^2=\frac{2x}{5x-3}$ or $\sqrt{\frac{2x}{5x-3}}$
	$k=\sqrt{\frac{2x}{5x-3}}$	A1	oe with k the subject eg $k=\sqrt{\frac{-2x}{3-5x}}$ or $k=\frac{\sqrt{2x}}{\sqrt{5x-3}}$ or $\left(\frac{2x}{5x-3}\right)^{\frac{1}{2}}=k$

The Additional Guidance for Question 13 is on the next page

	Additional Guidance	
	M1 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts	
	Condone one transcription error for A1 after correct answer seen	
	No miscopies for M marks	
	Condone eg $k=\sqrt{\frac{2x}{5x-3}}$ in working with $\sqrt{\frac{2x}{5x-3}}$ on answer line	M3A1
	For A1 accept eg $k=+\sqrt{\frac{2x}{5x-3}}$ or $k=\pm\frac{\sqrt{2x}}{\sqrt{5x-3}}$	
	Correct answer followed by incorrect further work eg $k=\sqrt{\frac{2x}{5x-3}}=\frac{2x}{5x-3}$	M3A0
	For M1 the terms may all be on one side of an equation but must be recovered to award further marks eg Alt 1 $x(5k^2-2)-3k^2=0$	M1
	Choose the alt that favours the student	

Q	Answer	Mark	Comments
14(a)	$(3w+2)^2 = w^2 + (2w+5)^2$ or $9w^2 + 12w + 4$ $= w^2 + 4w^2 + 20w + 25$	M1	oe Pythagoras' theorem eg $9w^2 + 6w + 6w + 4$ $= w^2 + 4w^2 + 10w + 10w + 25$ or $3w + 2 = \sqrt{w^2 + (2w+5)^2}$
	$9w^2 + 12w + 4$ $= w^2 + 4w^2 + 20w + 25$ and $4w^2 - 8w - 21 = 0$ with no errors	A1	oe with brackets expanded eg $9w^2 + 6w + 6w + 4$ $= w^2 + 4w^2 + 10w + 10w + 25$ and $4w^2 - 8w - 21 = 0$ with no errors allow $5w^2$ for $w^2 + 4w^2$
	Additional Guidance		
	$(3w+2)^2 = w^2 + (2w+5)^2$ $9w^2 + 6w + 6w + 4 = w^2 + 4w^2 + 10w + 10w + 10$ (error in expansion) $4w^2 - 8w - 21 = 0$	M1 A0	
	$9w^2 + 12w + 4 = w^2 + 4w^2 + 20w + 25$ $4w^2 - 8w - 21$ (omission of = 0)	M1 A0	
	Missing brackets must be recovered		

Q	Answer	Mark	Comments
14(b)	$(2w + 3)(2w - 7)$ or $\frac{--8 \pm \sqrt{(-8)^2 - 4 \times 4 \times -21}}{2 \times 4}$ or 3.5	M1	oe eg $1 \pm \sqrt{\frac{25}{4}}$ or $\frac{7}{2}$ in quadratic formula or completing the square allow $\pm$ to be $+$
	$\sin x = \frac{3.5}{3 \times 3.5 + 2}$ or $\cos x = \frac{2 \times 3.5 + 5}{3 \times 3.5 + 2}$ or $\tan x = \frac{3.5}{2 \times 3.5 + 5}$	M1dep	oe eg $\sin^{-1} \frac{7}{25}$ or $\sin^{-1} 0.28$ or $\cos^{-1} \frac{24}{25}$ or $\cos^{-1} 0.96$ or $\tan^{-1} \frac{7}{24}$ or $\tan^{-1}$ [0.29, 0.292]
	[16.17, 16.3] with no other solution	A1	accept 16 with no other solution with M2 awarded
	Additional Guidance		
	Up to M2 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts		
	In the quadratic formula -8^2 is M0 unless recovered		
	2nd M1 Using the sine rule or cosine rule must have sin x or cos x as the subject and a correct numerical expression or a correct value		
	$\sin x = \frac{3.5 \sin 90}{12.5}$ with no further correct working		M1M0
	Check 14(a) and diagram for working that may be valid in 14(b)		

Q	Answer	Mark	Comments
15(a)	**Alternative method 1: equates gradient to 0**		
	$1-\frac{9}{x^2}=0$ and $x=3$	B1	accept $9x^{-2}$ for $\frac{9}{x^2}$ ignore $x=-3$
	Alternative method 2: substitutes $x=3$ into gradient		
	$1-\frac{9}{3^2}=0$ or $1-\frac{9}{9}=0$	B1	may be seen in stages accept 9×3^{-2} for $\frac{9}{3^2}$
	Additional Guidance		
	Alt1 and alt 2 with errors in working is B0 eg Alt 1 $1-\frac{9}{x^2}=0$ $-1=\frac{9}{x^2}$ $x=3$		B0
	After B1 response ignore non-contradictory statements eg Alt 2 $1-\frac{9}{3^2}=0$ A turning point at (3, 0)		B1
	Alt 2 $\frac{9}{3^2}=1$ $1-1=0$		B1
	Alt 2 $\frac{9}{3^2}=1$ with no further correct work		B0
	Alt 1 $1-\frac{9}{x^2}=0$ $x=\pm3$		B1

Q	Answer	Mark	Comments
15(b)	$18x^{-3}$ with no other terms	M1	oe eg $-9 \times -2x^{-2-1}$ with no other terms
	M1 awarded and $18 \times 3^{-3} > 0$ and minimum or M1 awarded and $\frac{18}{27}$ and minimum	A1	oe eg $18x^{-3}$ with no other terms and this is positive when x is 3 and minimum or M1 awarded and $\frac{2}{3}$ and minimum allow [0.66, 0.67] for $\frac{18}{27}$ any evaluations of second derivative must be correct
	Additional Guidance		
	M1 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts		
	$\frac{dy}{dx} = 18x^{-3}$ with no other terms is awarded M1 and may be awarded A1 with further correct working		
	For A1 $x = 3$ must be used or stated eg $18x^{-3}$ is positive for all positive values of x and minimum		M1A0
	Only considering signs of $\frac{dy}{dx}$ either side of $x = 3$		M0A0
	Accept eg local min or minima for minimum		
	After differentiating to $18x^{-3}$ with no other terms, ignore further differentiation eg $18x^{-3}$ and $-54x^{-4}$		M1

Q	Answer	Mark	Comments
16	Correct expression for angle *BDC* eg $\frac{1}{2}x + 60$	M1	eg $180 - (x + 20) - [180 - (4x - 15)]$ or $3x - 35$ may be on the diagram implied by a correct equation
	Correct expression for angle *BCD* or angle *EBD* eg $180 - (4x - 15)$ or $180 - \left(\frac{1}{2}x + 60\right) - (x + 20)$	M1	eg $195 - 4x$ or $100 - \frac{3}{2}x$ may be on the diagram implied by a correct equation
	Equation from correct geometrical reasoning eg $\frac{1}{2}x + 60 + x + 20 + 180 - (4x - 15) = 180$	M1dep	eg $275 - \frac{5}{2}x = 180$ dep on M2
	38	A1	SC2 two different correct expressions for one of angle *BDC* or angle *BCD* or angle *EBD* SC2 two different correct expressions, one for angle *BCD*, one for angle *EBD*

The Additional Guidance for Question 16 is on the next page

	Additional Guidance	
16 cont	Up to M2 or SC2 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts	
	A correct expression with no indication of which angle it represents cannot be awarded M marks or SC marks eg $100 - \frac{3}{2}x$ not labelled as angle *BCD* or angle *EBD* in working or not shown in correct position on diagram (may be implied by a correct equation which will be awarded M3)	2nd M0
	Other equations which are awarded M3 include $4x - 15 + 100 - \frac{3}{2}x = 180$ or $\frac{1}{2}x + 60 + x + 20 = 4x - 15$ or $180 - (4x - 15) = 180 - \left(\frac{1}{2}x + 60\right) - (x + 20)$ or $195 - 4x = 100 - \frac{3}{2}x$	
	If an angle is written correctly, ignore any subsequent processing errors (3rd M1 may also be awarded) eg angle $BDC = \frac{1}{2}x + 60$ angle $BCD = 180 - (4x - 15) = 165 - 4x$ (should be $195 - 4x$) $\frac{1}{2}x + 60 + x + 20 + 165 - 4x = 180$	M1 M1 M1A0
	Missing brackets must be recovered	
	Ignore reasons	

Q	Answer	Mark	Comments
17	One correct equation in two variables with terms collected and simplified	M1	eg $14b + 7c = 0$ or $14a + 13c = -16$ or $a + 9b = 26$
	Two correct equations each in two variables with terms collected and simplified	M1dep	eg $14b + 7c = 0$ and $14b + 11c = -20$ or $14a + 13c = -16$ and $a + 9b = 26$
	Correct equation in one variable with terms collected and simplified	M1dep	eg $4c = -20$
	Correct equation in one variable with terms collected and simplified and any two of $a = 3.5$ $b = 2.5$ $c = -5$	A1	implied by final A1 oe values
	Correct equation in one variable with terms collected and simplified and $a = 3.5$ $b = 2.5$ $c = -5$	A1	oe values

The Additional Guidance for Question 17 is on the next page

<table>
<tr><td rowspan="8">17
cont</td><td colspan="2">Additional Guidance</td></tr>
<tr><td>Up to M2 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts</td><td></td></tr>
<tr><td>3rd M1 Do not award if the only correct equation is one of the values
eg only correct equation in one variable is $c = -5$</td><td>3rd M0</td></tr>
<tr><td>Some correct equations in two variables are
<table>
<tr><td>$14b - c = 40$</td><td>$14a + 9c = 4$</td><td>$6a - 2b = 16$</td></tr>
<tr><td>$14b + 3c = 20$</td><td>$14a - 7c = 84$</td><td>$7a + 7b = 42$</td></tr>
<tr><td>$14b + 7c = 0$</td><td>$14a + 13c = -16$</td><td>$a + 9b = 26$</td></tr>
<tr><td>$14b + 11c = -20$</td><td>$14a + 5c = 24$</td><td>$11a - 13b = 6$</td></tr>
</table>
All equations have equivalents</td><td></td></tr>
<tr><td>M3 can be implied if two variables are eliminated in one step
eg $4c = -20$ (from equation 2 – equation 1 – equation 3)</td><td>M3</td></tr>
<tr><td>Correct values only</td><td>Zero</td></tr>
<tr><td>Escalate any responses using a matrix method</td><td></td></tr>
</table>

Q	Answer	Mark	Comments
18	$(DM^2 =)\ 6^2 + 7^2$ or 85	M1	oe eg $(DM =)\ \sqrt{6^2 + 7^2}$ or [9.2, 9.22] may be seen on diagram
	$(BD^2 =)\ 14^2 + 8^2$ or 260	M1	oe eg $(BD =)\ \sqrt{14^2 + 8^2}$ or $2\sqrt{65}$ or [16.1, 16.125] may be seen on diagram
	$(BM^2 =)\ 6^2 + 8^2 + 7^2$ or $10^2 + 7^2$ or 149	M1	oe eg $(BM =)\ \sqrt{6^2 + 8^2 + 7^2}$ or $\sqrt{10^2 + 7^2}$ or [12.2, 12.21] may be seen on diagram
	their 260 = their 85 + their 149 $-$ $2 \times \sqrt{\text{their 85}} \times \sqrt{\text{their 149}}$ cos *BMD* or $\cos BMD = \dfrac{\text{their 85} + \text{their 149} - \text{their 260}}{2 \times \sqrt{\text{their 85}} \times \sqrt{\text{their 149}}}$	M1dep	oe cosine rule eg cos *BMD* = [−0.12, −0.11] or $\cos^{-1} \dfrac{\text{their 85} + \text{their 149} - \text{their 260}}{2 \times \sqrt{\text{their 85}} \times \sqrt{\text{their 149}}}$ dep on M3
	[96.3, 97]	A1	
	Additional Guidance		
	Up to M3 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts		
	4th M1 Accept any indication of *BMD* eg x or *M*		
	4th M1 $2\sqrt{65}^2$ must be recovered		

Q	Answer	Mark	Comments
19	$4 \times (2x)^3 - 7$ or $32x^3 - 7$	M1	oe expression for f($2x$) may be seen in an equation
	$6 \times (4x^3 - 7) + 8$ or $24x^3 - 34$	M1	oe expression for gf(x) may be seen in an equation
	$8x^3 = -27$ or $\sqrt[3]{\frac{-27}{8}}$	M1dep	oe correct equation of form $ax^3 = b$ eg $x^3 = -3.375$ or oe cube root eg $\sqrt[3]{-3.375}$ dep on M2
	$-\frac{3}{2}$ or -1.5 with no other solution	A1	oe value do not accept unprocessed cube roots
	Additional Guidance		
	f($2x$) and 2f(x) is 1st M0 unless f($2x$) chosen or used		
	gf(x) and fg(x) is 2nd M0 unless gf(x) chosen or used		
	Missing brackets must be recovered		

Q	Answer	Mark	Comments
20	$2-2x$	M1	oe eg $2x^0-2x^{2-1}$ may be implied eg $2-2\times 3$ or -4 or $-\frac{1}{2-2x}$
	Substitutes $x=3$ into $-\frac{1}{\text{their }(2-2x)}$	M1	oe eg $-1\div -4$ their $(2-2x)$ must be a linear expression in x
	(gradient of QR =) $\frac{1}{4}$ or 0.25	A1	oe value may be seen in an equation eg $y=\frac{1}{4}x+c$
	Substitutes $y=5$ into correct equation of QR	M1dep	eg $5-1=\frac{1}{4}(x-3)$ or $\frac{5-1}{x-3}=\frac{1}{4}$ or $5=\frac{1}{4}x+\frac{1}{4}$ dep on M2A1
	19	A1	implied by (19, 5)
	Additional Guidance		
	M1 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts		
	$y=2-2x$ is awarded 1st M1 and may be awarded up to full marks with further correct working		
	$2+2x$ $-\frac{1}{2+2\times 3}=-\frac{1}{8}$		M0 M1A0
	Escalate responses using similar triangles		

Q	Answer	Mark	Comments
21(a)	**Alternative method 1: works out $\sin\theta$**		
	$\sin\theta = -\frac{3}{5}$ or $\sin\theta = -\frac{3k}{5k}$ or $[-36.9, -36.8]$ or -37 or [216.8, 216.9] or 217	M1	oe eg $\sin\theta = -3k \div 5k$ or $\sin\theta = -3k \times \frac{1}{5k}$ or $\sin^{-1}-0.6$
	[323.1, 323.1301024] or 323 with no other value	A1	
	Alternative method 2: works out $\tan\theta$ or uses $\cos^{-1}$		
	$\tan\theta = -\frac{3}{4}$ or $360 - \cos^{-1} 0.8$	M1	oe eg $\tan\theta = -3 \times \frac{1}{4}$ or $\tan^{-1}-0.75$ or $360 -$ [36.8, 36.9]
	[323.1, 323.1301024] or 323 with no other value	A1	
	Additional Guidance		
	M1 may be awarded for correct work with no answer or incorrect answer, even if this is seen amongst multiple attempts		
	Accept any indication of θ eg x		
	Alt 1 $5\sin\theta = -3$ with no further correct working		M0
	Alt 1 $\cos\theta \times \tan\theta = -\frac{3}{5}$ with no further correct working		M0

Q	Answer	Mark	Comments
21(b)	90 and 270 and [82.8, 83] and [277, 277.2] with no other values in the range [0, 360]	B3	B2 four correct values with one other value in the range [0, 360] or three correct values with no other value in the range [0, 360] B1 four correct values with two other values in the range [0, 360] or three correct values with one other value in the range [0, 360] or two correct values with no other value in the range [0, 360]
	Additional Guidance		
	Ignore any values outside the range [0, 360]		
	If values are in the working lines and the answer line is blank, award marks from the working lines		
	If values are in the working lines but only some are listed on the answer line, award marks from the answer line		
	Embedded values B3 response becomes B2 B2 response becomes B1 B1 response becomes B0		