GCSE
MATHEMATICS
8300/3H

Higher Tier Paper 3 Calculator

Mark scheme

June 2021

Version: 1.0 Final



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.

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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.
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.
ft	Follow through marks. Marks awarded for correct working following a mistake in an earlier step.
SC	Special case. Marks awarded for a common misinterpretation which has some mathematical worth.
M dep	A method mark dependent on a previous method mark being awarded.
B dep	A mark that can only be awarded if a previous independent mark has been awarded.
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.
[a, b)	Accept values $a \leq$ value $< b$
3.14…	Accept answers which begin 3.14 eg 3.14, 3.142, 3.1416
Use of brackets	It is not necessary to see the bracketed work to award the marks.

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

Questions which ask students to show working

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

Questions which do not ask students to show working

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

Misread or miscopy

Students often copy values from a question incorrectly. If the examiner thinks that the student 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 student intended it to be a decimal point.

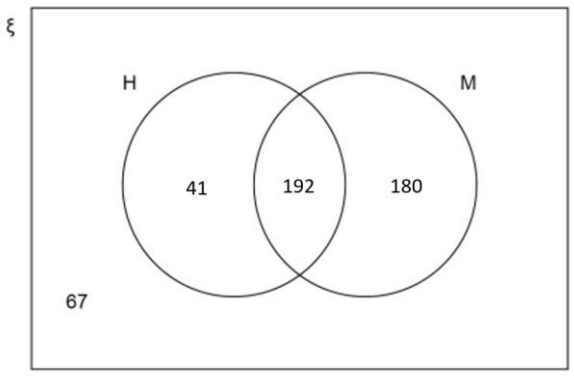
Q	Answer	Mark	Comments
1	$b = \sqrt{a} + 3$	B1	

Q	Answer	Mark	Comments
2	$0.\dot{5}$	B1	

Q	Answer	Mark	Comments
3	$\left(0, -\frac{2}{3}\right)$	B1	

Q	Answer	Mark	Comments
4	$(x + 8)(x – 8)$	B1	

Q	Answer	Mark	Comments
5	6 × 10 – (12 + 7 + 15 + 3) or 60 – 37 or 23	M1	implied by two numbers with a total of 23 eg –11 and 34
	Two positive numbers with a total of 23	A1	
	Two positive numbers which make the range of the list 19	B1	eg a and 22, where $3 \leqslant a \leqslant 22$
	Additional Guidance		
	2 and 21 is the only fully correct answer		M1A1B1
	11.5 and 11.5		M1A1B0
	1 and 22		M1A1B0
	0 and 23		M1A0B0

Q	Answer	Mark	Comments
6	480 × 0.4 or 192	M1	oe implied by 2400
	480 × $\frac{3}{8}$ or 180	M1	oe implied by 1440
	480 – their 192 – their 180 – 67 or 41	M1	oe implied by 287
	their 192 × 12.5 + their 180 × 8 + their 41 × 7 or 2400 + 1440 + 287	M1	
	4127	A1	
	Additional Guidance		
	Method marks may be awarded for correct work seen on Venn diagram or in working, with no or incorrect answer, even if this is seen amongst multiple attempts		
	For the 4th method mark, incorrectly placed values from their Venn diagram may be used or values connected to the correct category eg if house only and museum only values transposed on the Venn diagram accept their 192 × 12.5 + their 41 × 8 + their 180 × 7  		
	40% of 413 = 165, $\frac{3}{8}$ of 165 = 62, 413 – 62 – 165 = 186 165 × 12.50 + 62 × 8 + 186 × 7 = 3860.50		M0M0M1M1A0
	H = 154.875, H&M = 165.2 480 – 67 – 154.875 – 165.2		M0M0M1

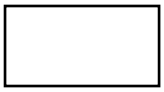
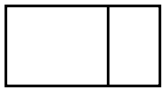
Q	Answer	Mark	Comments
7	270 ÷ (2.6 + 1) or 270 ÷ 3.6 or 75 or $\frac{2.6}{(2.6+1)}$ or $\frac{2.6}{3.6}$ or 0.72(…) or 2.6 – 1 or 1.6	M1	oe
	their 75 × 2.6 or 270 – their 75 or 195 or 270 × their 0.72(…) or their 75 × (2.6 – 1) or their 75 × their 1.6 or $\frac{\text{their } 1.6}{(2.6+1)}$ or 0.44(…)	M1dep	oe
	120	A1	
	Additional Guidance		
	195 and 75		M1M1
	270 ÷ 2.6		M0

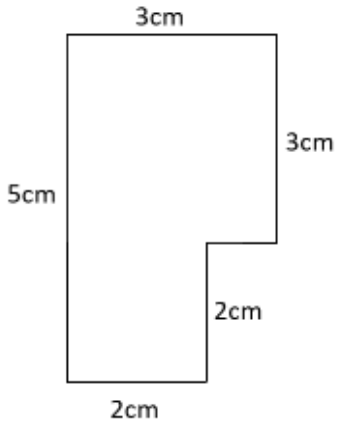
Q	Answer	Mark	Comments
8	**Alternative method 1**		
	198 × 0.45 or 89.1	M1	
	their 89.1 ÷ 6.25	M1	their 89.1 must come from a division or multiplication using 198 and 0.45 only
	14.256 or 14.26 or 14.3	A1	SC1 556.875 or 556.88 or 556.9 or 70.4
	Alternative method 2		
	198 ÷ 6.25 or 31.68	M1	
	their 31.68 × 0.45	M1	their 31.68 must come from a division or multiplication using 198 and 6.25 only
	14.256 or 14.26 or 14.3	A1	SC1 556.875 or 556.88 or 556.9 or 70.4
	Alternative method 3		
	0.45 ÷ 6.25 or 0.072	M1	
	198 × their 0.072	M1dep	
	14.256 or 14.26 or 14.3	A1	SC1 556.875 or 556.88 or 556.9 or 70.4
	Alternative method 4		
	6.25 ÷ 0.45 or $13.\dot{8}$ or 13.8(…) or 13.9	M1	
	198 ÷ their $13.\dot{8}$	M1dep	
	14.256 or 14.26 or 14.3	A1	SC1 556.875 or 556.88 or 556.9 or 70.4

Additional guidance for this question is on the next page

	Additional Guidance	
8 cont	198 × 0.45 ÷ 6.25 oe	M1M1
	198 × 0.45 × 6.25 (which gives 556.875)	M1M0
	198 ÷ 0.45 ÷ 6.25 (which gives 70.4)	M0M1
	198 ÷ 0.45 × 6.25 (which gives 2750)	M0M0
	Do not allow 6.25^2 for 6.25 eg 198 ÷ 6.25 ÷ 6.25	M0
	Ignore rounding or truncation after correct answer seen	

Q	Answer	Mark	Comments
9	(x =) 4 × 2 or (x =) 8 or area of top right rectangle is 12 × 2 or 12 ÷ 4 × their 8 or 24 or area of bottom left rectangle is 56 ÷ 2 or 4 × 56 ÷ their 8 or 28	M1	may be on diagram implied by length of bottom left or bottom right vertical section is 7
	Area of top right rectangle is 12 × 2 or 12 ÷ 4 × their 8 or 24 and area of bottom left rectangle is 56 ÷ 2 or 4 × 56 ÷ their 8 or 28 or Total area is (4 + their 8) × (12 ÷ 4 + 56 ÷ their 8) or 12 × 10 or 120	M1dep	may be on diagram
	(Total shaded area is) 52	A1	implied by 52 : 68
	13 : 17 or 1 : $\frac{17}{13}$ or $\frac{13}{17}$: 1	B1ft	ft simplification of their ratio or conversion into the form 1 : n or n : 1 with M2A0 or M1M0A0 scored
	Additional Guidance		
	If their ratio cannot be simplified by dividing by a common factor they can only score B1ft by converting into the form 1 : n or n : 1		
	$\frac{52}{120}$: $\frac{68}{120}$		M1M1A1B0
	68 : 52 simplified to 17 : 13		M1M1A0B1ft
	13 cm^2 : 17 cm^2		M1M1A1B0
	For B1, accept values as decimals rounded or truncated to 2 dp or better eg 1 : 1.31 or 0.76 : 1		B1

Q	Answer	Mark	Comments
10(a)	Rectangle with horizontal sides 3 cm and vertical sides 2 cm	B1	accept internal vertical line 1 cm from the right, but no other internal lines
	Additional Guidance		
	 or  with dimensions 3 cm and 2 cm		B1
	Do not accept other internal lines		
	Mark intention		

Q	Answer	Mark	Comments
10(b)		B1	any orientation
	Additional Guidance		
	Do not accept internal lines		
	Do not accept a reflection		
	Mark intention		

Q	Answer	Mark	Comments
11	23 or 29	B1	implied by correct answer
	$\frac{23}{125}$ (× 100) or $\frac{29}{125}$ (× 100) or $\frac{\text{their number}}{125}$ (× 100) or their number = $\frac{125x}{100}$	M1	oe their number can be any integer value
	18.4 or 23.2 or correct evaluation of their number as a percentage of 125	A1ft	ft B0M1 oe their number must be an integer [20, 30] or any prime number

Additional Guidance	
18.4 or 23.2	B1M1A1
18.4 and 23.2	B1M1A1
23 or 29 must be clearly indicated as their prime number	
Any integer [20, 30] used can score B0M1A1ft eg 25 ÷ 125 × 100 with answer 20	B0M1A1ft
Any prime number used can score B0M1A1ft eg 7 ÷ 125 × 100 with answer 5.6	B0M1A1ft
24% of 125 is 30 with answer 24	B0M1A1ft
29% of 125 is 36.25 (36.25 is not an integer)	B1M0A0ft
28% of 125 is 35 with answer 28 (35 is an integer out of range)	B0M1A0ft
28% of 125 is 35 scores M1 (35 is an integer)	
25% of 125 is 31.25 scores M0 (31.25 is not an integer)	

Q	Answer	Mark	Comments
12	360 ÷ 15 or 24 or (15 – 2) × 180 or 2340	M1	oe may be seen on diagram
	156	A1	

Q	Answer	Mark	Comments
13	**Alternative method 1**		
	4 × 26 × 15 or 1560	M1	
	$\pi \times (26 \div 2)^2 \times 15 (\div 2)$ or $\pi \times 13^2 \times 15 (\div 2)$ or $2535\pi (\div 2)$ or $\pi \times (26 \div 2)^2 \div 2 (\times 15)$ or $\pi \times 13^2 \div 2 (\times 15)$ or $\frac{169\pi}{2} (\times 15)$ or $84.5\pi (\times 15)$ or [265.3, 265.5] (× 15) or [7959.9, 7965] (÷ 2)	M1	oe accept [3.14, 3.142] for π
	$\frac{2535\pi}{2}$ or 1267.5π or [3979.95, 3982.5]	M1dep	dep on previous mark
	[5539, 5543]	A1	
	Alternative method 2		
	4 × 26 or 104	M1	
	$\pi \times (26 \div 2)^2 \div 2$ or $\pi \times 13^2 \div 2$ or $\frac{169\pi}{2}$ or [265.3, 265.5]	M1	accept [3.14, 3.142] for π
	(their 104 + their $\frac{169\pi}{2}$) × 15 or [369.3, 369.5] × 15	M1dep	dep on M1M1
	[5539, 5543]	A1	

Q	Answer	Mark	Comments
14	**Alternative method 1**		
	13.2 × 0.9 or 11.88	M1	oe
	13.2(0) ÷ 1.1 or 12	M1	oe
	11.88 and 12 and No	A1	
	Alternative method 2		
	1.1 or 0.9 seen	M1	
	1.1 × 0.9 or 0.99	M1dep	
	0.99 and No	A1	oe 1% decrease and No
	Alternative method 3		
	13.2 × 0.9 or 11.88	M1	
	their 11.88 × 1.1 or 13.068	M1dep	
	13.068 and No	A1	accept 13.07 or 13.06
	Additional Guidance		
	12 × 1.1 = 13.20, 13.2 × 0.9 = 11.88 and No		M1M1A1
	13.2 × 1.1 = 14.52, 14.52 × 0.9 = 13.068 and No		M0M0A0

Q	Answer	Mark	Comments
15	$0.5k + 7k - 0.15 + 2.5k = 1$	M1	oe eg $10k - 0.15 = 1$
	$k = 0.115$	A1	oe
	0.655	A1ft	oe eg $\frac{131}{200}$ or 65.5% ft their 0.115 to 3 dp or better with M1 scored if their 0.115 and their answer are both in the range (0, 1)
	Additional Guidance		
	Accept working in percentages		
	$10k - 0.15 = 1$, $10k = 0.85$, $k = 0.085$, answer 0.445		M1A0A1ft
	$10k + 0.15 = 1$, $10k = 0.85$, $k = 0.085$, answer 0.445		M0A0A0

Q	Answer	Mark	Comments
16	(Gradient of PQ =) $\frac{14-8}{2-6}$ or $\frac{8-14}{6-2}$ or –1.5 or $\frac{-3}{2}$ or (gradient of QR =) $\frac{8-5}{6-2}$ or $\frac{5-8}{2-6}$ or 0.75 or $\frac{3}{4}$ or $\frac{-3}{-4}$	M1	oe
	(Gradient of PQ =) –1.5 or $\frac{-3}{2}$ and (gradient of QR =) 0.75 or $\frac{3}{4}$ or $\frac{-3}{-4}$	M1dep	oe
	No and –1.5 × 0.75 ≠ –1 or No and –1.5 × 0.75 = –1.125	A1ft	oe eg No and $\frac{-3}{2} \times \frac{3}{4} = -\frac{9}{8}$ ft their two gradients with M1 scored accept No and –1.5 is not the negative reciprocal of 0.75
	Additional Guidance		
	Accept $-\frac{3}{2}$ or $\frac{3}{-2}$ for $\frac{-3}{2}$		
	Gradient of PQ = $\frac{-3}{2}$, gradient of QR = $\frac{4}{3}$, No and $\frac{-3}{2} \times \frac{4}{3} = -2$		M1M0A1ft
	Answers involving Pythagoras' theorem or scale drawing		M0M0A0

Q	Answer	Mark	Comments
17	$-\frac{7}{2}$	B1	

Q	Answer	Mark	Comments
18	w	B1	

Q	Answer	Mark	Comments
19	$2\sqrt{11}$	B1	

Q	Answer	Mark	Comments
20	$b = 2c$ or $b = 16$ or $\frac{a}{b} \times \frac{b}{c} = 3c \times 2$	M1	oe eg $\frac{a}{2c} = 3c$ or $\frac{a}{16} = 3c$
	$(a =) 6c^2$ or $3 \times 8 \times 2 \times 8$ or 24×16 or 6×8^2 or 6×64	M1dep	oe
	384	A1	
	Additional Guidance		
	$\frac{b}{8} = 2$	M0	
	$\frac{a}{b} = 24$	M0	

Q	Answer	Mark	Comments
21	(Class widths are) 5, 5, 10, 30	M1	
	18 ÷ 5 or 3.6 or 23 ÷ 5 or 4.6 or 17 ÷ 10 or 1.7 or 21 ÷ 30 or 0.7	M1	implied by correct bar
	Any three of 18 ÷ 5 or 3.6 and 23 ÷ 5 or 4.6 and 17 ÷ 10 or 1.7 and 21 ÷ 30 or 0.7	M1dep	implied by correct bars
	All bars correct	A1	$\pm \frac{1}{2}$ square
	Additional Guidance		
	Four correct frequency density values imply first M1		

Q	Answer	Mark	Comments
22	$\frac{2n}{3n+1}$	B3	oe eg $\frac{2n}{2n+(n+1)}$ B2 any two correct nth terms from $2n$ or $n+1$ or $3n+1$ B1 any one correct nth term from $2n$ or $n+1$ or $3n+1$
	Additional Guidance		
	May be seen in a fraction or added eg $2n + (n + 1)$		B2
	Do not accept $2n$ embedded in an incorrect expression eg $2n – 2$		B0

Q	Answer	Mark	Comments
23(a)	(2, 256)	B1	

Q	Answer	Mark	Comments
23(b)	–1	B1	accept (–1, $\frac{1}{16}$)
	Additional Guidance		
	$16^{-1} = \frac{1}{16}$		B0

Q	Answer	Mark	Comments
24	Any correct pair of values	B1	eg $a = 9 \;\; b = \frac{1}{2}$ $a = 27 \;\; b = \frac{1}{3}$ $a = 81 \;\; b = \frac{1}{4}$
	Additional Guidance		
	$a = 9 \;\; b = \frac{1}{3}$		B0
	$a = 3 \;\; b = \frac{1}{1}$		B0
	$a = 3 \;\; b = 1$		B0

Q	Answer	Mark	Comments
25	**Alternative method 1 – multiplies $(x – 3)(x + 2)$ first**		
	$x^2 – 3x + 2x – 6$ or $x^2 – x – 6$	M1	four terms with at least three correct implied by $x^2 – x \pm k$ where k is a non-zero constant
	$x^3 – 3x^2 + 2x^2 – 6x + 5x^2 – 15x + 10x – 30$ or $x^3 – x^2 – 6x + 5x^2 – 5x – 30$	M1dep	full expansion with correct multiplication of their 3 or 4 terms by x and 5
	$x^3 + 4x^2 – 11x – 30$	A1	
	Alternative method 2 – multiplies $(x – 3)(x + 5)$ first		
	$x^2 – 3x + 5x – 15$ or $x^2 + 2x – 15$	M1	four terms with at least three correct implied by $x^2 + 2x \pm k$ where k is a non-zero constant
	$x^3 – 3x^2 + 5x^2 – 15x + 2x^2 – 6x + 10x – 30$ or $x^3 + 2x^2 – 15x + 2x^2 + 4x – 30$	M1dep	full expansion with correct multiplication of their 3 or 4 terms by x and 2
	$x^3 + 4x^2 – 11x – 30$	A1	
	Alternative method 3 – multiplies $(x + 2)(x + 5)$ first		
	$x^2 + 2x + 5x + 10$ or $x^2 + 7x + 10$	M1	four terms with at least three correct implied by $x^2 + 7x \pm k$ where k is a non-zero constant
	$x^3 + 2x^2 + 5x^2 + 10x – 3x^2 – 6x – 15x – 30$ or $x^3 + 7x^2 + 10x – 3x^2 – 21x – 30$	M1dep	full expansion with correct multiplication of their 3 or 4 terms by x and –3
	$x^3 + 4x^2 – 11x – 30$	A1	
	Additional Guidance		
	Do not ignore further incorrect simplification or attempt to solve after correct answer seen		

Q	Answer	Mark	Comments
26	**Alternative method 1**		
	$4.5 \div 2$ or 2.25	M1	
	$\sqrt{\text{their } 2.25}$ or 1.5	M1dep	
	$1 : 1.5$ or $1 : 1\frac{1}{2}$ or $1 : \frac{3}{2}$	A1	
	Alternative method 2		
	$\sqrt{2} : \sqrt{4.5}$	M1	
	$1 : \frac{\sqrt{\text{their } 4.5}}{\sqrt{\text{their } 2}}$	M1dep	
	$1 : 1.5$ or $1 : 1\frac{1}{2}$ or $1 : \frac{3}{2}$	A1	
	Alternative method 3		
	$\sqrt{4} : \sqrt{9}$	M1	
	$2 : 3$	M1dep	
	$1 : 1.5$ or $1 : 1\frac{1}{2}$ or $1 : \frac{3}{2}$	A1	
	Alternative method 4		
	$2 \div 4.5$ or $\frac{4}{9}$ or $0.\dot{4}$	M1	accept 0.44 or better
	$\sqrt{\text{their } \frac{4}{9}}$ or $\frac{2}{3}$ or $0.\dot{6}$ and $\frac{2}{3} : 1$	M1dep	accept 0.66 or better
	$1 : 1.5$ or $1 : 1\frac{1}{2}$ or $1 : \frac{3}{2}$	A1	
	Additional Guidance		
	$1 : 1.5$ on answer line with no evidence of incorrect method		M1M1A1

Q	Answer	Mark	Comments
27(a)	**Alternative method 1: *DH* + *HX***		
	$HE = \mathbf{a} - \mathbf{b}$	M1	implied by $HX = \frac{1}{4}\mathbf{a} - \frac{1}{4}\mathbf{b}$
	$(\mathbf{b} + \frac{1}{4}(\mathbf{a} - \mathbf{b}) =) \mathbf{b} + \frac{1}{4}\mathbf{a} - \frac{1}{4}\mathbf{b}$ $= \frac{1}{4}\mathbf{a} + \frac{3}{4}\mathbf{b}$	A1	
	Alternative method 2: *DE* + *EX*		
	$EH = \mathbf{b} - \mathbf{a}$	M1	implied by $EX = \frac{3}{4}\mathbf{b} - \frac{3}{4}\mathbf{a}$
	$(\mathbf{a} + \frac{3}{4}(\mathbf{b} - \mathbf{a}) =) \mathbf{a} + \frac{3}{4}\mathbf{b} - \frac{3}{4}\mathbf{a}$ $= \frac{1}{4}\mathbf{a} + \frac{3}{4}\mathbf{b}$	A1	

Q	Answer	Mark	Comments
27(b)	**Alternative method 1: *DF* from *DE* + *EF* = *DE* + $\frac{1}{4}$*EG***		
	(*EG* =) $-\mathbf{a} + 9\mathbf{b}$ or (*EF* =) $-\frac{1}{4}\mathbf{a} + \frac{9}{4}\mathbf{b}$	M1	oe
	(*EF* =) $-\frac{1}{4}\mathbf{a} + \frac{9}{4}\mathbf{b}$ and (*DF* =) $\mathbf{a} - \frac{1}{4}\mathbf{a} + \frac{9}{4}\mathbf{b}$	M1	oe
	(*DF* =) $\frac{3}{4}\mathbf{a} + \frac{9}{4}\mathbf{b}$	A1	
	(*DF* =) $3(\frac{1}{4}\mathbf{a} + \frac{3}{4}\mathbf{b})$ and Yes	A1	oe using a different correct scalar multiple for *DF* and *DX*

Mark scheme for Question 27(b) continues on next page

Q	Answer	Mark	Comments
27(b) cont	**Alternative method 2: *DF* from *DG* + *GF* = *DG* + $\frac{3}{4}$*GE***		
	(*GE* =) $-9\mathbf{b} + \mathbf{a}$ or (*GF* =) $-\frac{27}{4}\mathbf{b} + \frac{3}{4}\mathbf{a}$	M1	oe
	(*GF* =) $-\frac{27}{4}\mathbf{b} + \frac{3}{4}\mathbf{a}$ and (*DF* =) $9\mathbf{b} - \frac{27}{4}\mathbf{b} + \frac{3}{4}\mathbf{a}$	M1	oe
	(*DF* =) $\frac{3}{4}\mathbf{a} + \frac{9}{4}\mathbf{b}$	A1	
	(*DF* =) $3(\frac{1}{4}\mathbf{a} + \frac{3}{4}\mathbf{b})$ and Yes	A1	oe using a different correct scalar multiple for *DF* and *DX*

Mark scheme for Question 27(b) continues on next page

Q	Answer	Mark	Comments
27(b) cont	**Alternative method 3: *XF* from *XE* + *EF* = $\frac{3}{4}$*HE* + $\frac{1}{4}$*EG***		
	$(XE =)\ \frac{3}{4}\mathbf{a} - \frac{3}{4}\mathbf{b}$ or $(EF =) -\frac{1}{4}\mathbf{a} + \frac{9}{4}\mathbf{b}$	M1	oe
	$(XF =)\ \frac{3}{4}\mathbf{a} - \frac{3}{4}\mathbf{b} - \frac{1}{4}\mathbf{a} + \frac{9}{4}\mathbf{b}$	M1	oe
	$(XF =)\ \frac{2}{4}\mathbf{a} + \frac{6}{4}\mathbf{b}$ or $(XF =)\ \frac{1}{2}\mathbf{a} + \frac{3}{2}\mathbf{b}$	A1	
	$(XF =)\ 2(\frac{1}{4}\mathbf{a} + \frac{3}{4}\mathbf{b})$ and Yes	A1	oe using a different correct scalar multiple for *XF* and *DX*

Mark scheme for Question 27(b) continues on next page

Q	Answer	Mark	Comments
27(b) cont	**Alternative method 4: *XF* from *XH* + *HG* + *GF* = $\frac{1}{4}$*EH* + *HG* + $\frac{3}{4}$*GE***		
	$(XH =) = -\frac{1}{4}\mathbf{a} + \frac{1}{4}\mathbf{b}$ or $(GF =) -\frac{27}{4}\mathbf{b} + \frac{3}{4}\mathbf{a}$	M1	oe
	$(XF =) -\frac{1}{4}\mathbf{a} + \frac{1}{4}\mathbf{b} + 8\mathbf{b} - \frac{27}{4}\mathbf{b} + \frac{3}{4}\mathbf{a}$	M1	oe
	$(XF =) \frac{2}{4}\mathbf{a} + \frac{6}{4}\mathbf{b}$ or $(XF =) \frac{1}{2}\mathbf{a} + \frac{3}{2}\mathbf{b}$	A1	
	$(XF =) 2(\frac{1}{4}\mathbf{a} + \frac{3}{4}\mathbf{b})$ and Yes	A1	oe using a different correct scalar multiple for *XF* and *DX*
	Additional Guidance		
	Method marks may be awarded for correct work seen on diagram or in working, with no or incorrect answer, even if this is seen amongst multiple attempts		

Q	Answer	Mark	Comments
28	4.715 or 4.725 or 157.5 or 158.5	B1	accept $4.724\dot{9}$ or 4.7249… accept $158.4\dot{9}$ or 158.49…
	their 4.725 ÷ their 157.5	M1	their 4.725 must be (4.72, 4.725] their 157.5 must be [157.5, 158)
	0.03 and correct working	A1	oe eg $\frac{3}{100}$
	Additional Guidance		
	Answer 0.03 with no correct working		B0M0A0
	4.7249 exact value with no continuation dots seen		B0

Q	Answer	Mark	Comments
29	**Alternative method 1**		
	OBD and *OCD* are right angles and *BOC* (obtuse) = 180 – x	M1	may be on diagram
	BAC = 90 – $\frac{x}{2}$	M1dep	oe may be on diagram
	BOC (reflex) = 180 + x and *ABO* + *ACO* = 360 – (90 – $\frac{x}{2}$ + 180 + x) or 90 – $\frac{x}{2}$ and *ABO* = $\frac{1}{2}(90 - \frac{x}{2})$ = 45 – $\frac{x}{4}$ with M2 scored	A1	oe 360 – 90 + $\frac{x}{2}$ – 180 – x
	All reasons given tangent meets the radius at 90° angles in a quadrilateral add up to 360° angle at the circumference is half the angle at the centre angles around a point add to 360°	A1	

Mark scheme for Question 29 continues on next page

Q	Answer	Mark	Comments
29 cont	**Alternative method 2**		
	OBD and *OCD* are right angles and *BOC* (obtuse) = 180 – x	M1	may be on diagram
	BAC = 90 – $\frac{x}{2}$	M1dep	oe may be on diagram
	BOC (reflex) = 180 + x and *BAD* = $\frac{1}{2}(90 - \frac{x}{2})$ or $45 - \frac{x}{4}$ and *ABO* = $180 - (45 - \frac{x}{4}) - (90 + \frac{x}{2})$ $= 45 - \frac{x}{4}$ with M2 scored	A1	
	All reasons given tangent meets the radius at 90° angles in a quadrilateral add up to 360° angle at the circumference is half the angle at the centre angles in a triangle add up to 180°	A1	

Mark scheme for Question 29 continues on next page

Q	Answer	Mark	Comments
29 cont	**Alternative method 3**		
	OBD and *OCD* are right angles and *BOC* (obtuse) = 180 – x	M1	may be on diagram
	BAC = 90 – $\frac{x}{2}$	M1dep	oe may be on diagram
	ABC = $\frac{1}{2}$ [180 – (90 – $\frac{x}{2}$)] = 45 + $\frac{x}{4}$ and *OBC* = $\frac{1}{2}$ [180 – (180 – x)] = $\frac{x}{2}$ and *ABO* = 45 + $\frac{x}{4}$ – $\frac{x}{2}$ = 45 – $\frac{x}{4}$ with M2 scored	A1	
	All reasons given tangent meets the radius at 90° angles in a quadrilateral add up to 360° angle at the circumference is half the angle at the centre angles in a triangle add up to 180° (base angles in an) isosceles triangle (are equal)	A1	

Mark scheme for Question 29 continues on next page

Q	Answer	Mark	Comments
29 cont	**Alternative method 4**		
	OBD is a right angle and $BDO = \frac{x}{2}$	M1	may be on diagram
	$BOD = 90 - \frac{x}{2}$	M1dep	may be on diagram
	$OAB + ABO = 90 - \frac{x}{2}$ and $ABO = 45 - \frac{x}{4}$ with M2 scored	A1	
	All reasons given tangent meets the radius at 90° the diagram is symmetrical oe angles in a triangle add up to 180° exterior angle of a triangle is equal to the sum of the opposite interior angles *OA* and *OB* are radii, so triangle *ABO* is isosceles (base angles in an) isosceles triangle (are equal)	A1	
	Additional Guidance		
	Using a value for x		M0M0A0A0

Q	Answer	Mark	Comments
30(a)	(r_2 =) 5.84(3…)	B1	
	(r_3 =) 6.39(5…) or 6.4(0)	B1ft	ft their 5.84(3…) to 2 dp or better
	Additional Guidance		
	eg r_2 = 6.39(5…) and r_3 = 6.11(3…)		B0B1ft

Q	Answer	Mark	Comments
30(b)	6.2	B1	
	Additional Guidance		
	6.20		B0