AQA

GCSE
Mathematics

8300/2 – Paper 2 Higher Tier

Mark scheme

June 2018

Version/Stage: 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 Assessment Writer.

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.

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.
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.

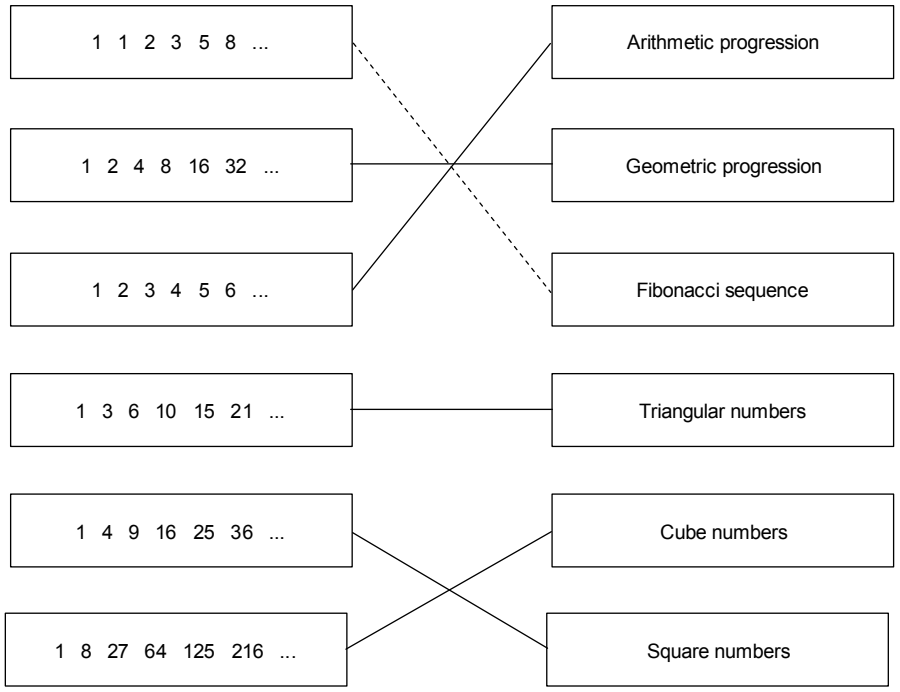
Premature approximation

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.

Question	Answer	Mark	Comments
1	segment	B1	
	Additional Guidance		
2	6×10^7	B1	
	Additional Guidance		
3	3 : 2	B1	
	Additional Guidance		
4	400%	B1	
	Additional Guidance		

Question	Answer	Mark	Comments
5	All 5 correct	B4	B3 for 4 correct B2 for 3 correct B1 for 1 or 2 correct
	Additional Guidance		
			B4
	Two connections from a LH box is choice so is incorrect for that box		
	Connections do not have to be straight lines		

Question	Answer	Mark	Comments
6	**Alternative method 1**		
	Any one of 60 000 ÷ 420 000 or 0.14… or 14.(…)% or $\frac{1}{7}$ or 480 000 ÷ 420 000 or 1.14… or 114.(…)% or $\frac{8}{7}$ or 420 000 ÷ 60 000 or 7 or 420 000 ÷ 480 000 or 0.875 or 87.5% or $\frac{7}{8}$ or 60 000 ÷ 540 000 or 0.11… or 11.(…)% or $\frac{1}{9}$ or 540 000 ÷ 60 000 or 9	M1	oe eg 60 000 : 420 000 or 1 : 7 or 480 000 : 420 000 or 8 : 7
	Any one of 60 000 ÷ 480 000 or 0.125 or 12.5% or $\frac{1}{8}$ or 540 000 ÷ 480 000 or 1.125 or 112.5% or $\frac{9}{8}$ or 480 000 ÷ 60 000 or 8 or 480 000 ÷ 540 000 or 0.88… or 0.89 or 88.(…)% or 89% or $\frac{8}{9}$	M1	must be a matching pair (could be different forms) to award M2 (see A1 for list of matching pairs) oe eg 60 000 : 480 000 or 1 : 8 or 540 000 : 480 000 or 9 : 8

Mark scheme continues on the next page

Question	Answer	Mark	Comments
6 cont	$\frac{1}{7}$ and $\frac{1}{8}$ and No or $\frac{8}{7}$ and $\frac{9}{8}$ and No or 0.14… and 0.125 and No or 14.(…)% and 12.5% and No or 1.14… and 1.125 and No or 114.(…)% and 112.5% and No or 7 and 8 and No or $\frac{7}{8}$ and $\frac{8}{9}$ and No or $\frac{1}{9}$ and $\frac{1}{8}$ and No or 9 and 8 and No or 0.11… and 0.125 and No or 11.(…)% and 12.5% and No or 0.875 and 0.88… or 0.89 and No or 87.5% and 88.(…)% or 89% and No	A1	oe eg 1 : 7 and 1 : 8 and No

Mark scheme continues on the next page

Question	Answer	Mark	Comments
6 cont	**Alternative method 2**		
	No and any one of $\frac{60\,000}{420\,000} \times 480\,000$ and [67200, 68640] or $\frac{60\,000}{480\,000} \times 540\,000$ and 67 500 or $\frac{60\,000}{480\,000} \times 420\,000$ and 52 500 or $\frac{60\,000}{540\,000} \times 480\,000$ and [52 800, 53 334] or $\frac{420\,000}{480\,000} \times 540\,000$ and 472 500 or $\frac{480\,000}{420\,000} \times 480\,000$ and [547 200, 548 640] or $\frac{480\,000}{540\,000} \times 480\,000$ and [422 400, 427 200] or $\frac{540\,000}{480\,000} \times 420\,000$ and 472 500	B3	oe B2 any one of the calculations B1 any one of the fractions oe for equivalent fractions, decimals and percentages see Alternative method 1

Additional guidance continues on the next page

Question	Answer	Mark	Comments

	Additional Guidance	
6 cont	In Alt 1, for M2 the matching pair do not have to be in comparable form eg 14.3% and $\frac{1}{8}$ and No	M1M1A0
	For comparable fractions, they must be in their lowest terms or have the same numerators or the same denominators for the A1 eg Alt 1 $\frac{60\,000}{420\,000}$ and $\frac{60\,000}{480\,000}$ and No	M1M1A1
	For comparable ratios, they must be in their lowest terms or have the same LH sides or the same RH sides for the A1 eg Alt 1 60 000 : 420 000 and 60 000 : 480 000 and No	M1M1A1
	If working with percentages, condone absence of % symbol eg Alt 1 14 and 12.5 and No	M1M1A1
	Both are increases of 60 000 and it is then over different amounts so cannot be the same percentage	M0M0A0

Question	Answer	Mark	Comments
7(a)	Two different probabilities from $\frac{15}{20}$ or 0.75 or 75% or $\frac{22}{30}$ or 0.73… or 73.(…)% or $\frac{17}{40}$ or 0.425 or 0.43 or 42.5% or 43% or $\frac{54}{90}$ or 0.6 or 60% or $\frac{37}{50}$ or 0.74 or 74% or $\frac{32}{60}$ or 0.53… or 53.(…)% or $\frac{39}{70}$ or 0.557… or 0.56 or 55.7…% or 56%	B2	oe B1 for one correct probability

Additional guidance continues on the next page

Question	Answer	Mark	Comments

	Additional Guidance	
7(a) cont	Accept $\frac{108}{180}$ as one of the probabilities	
	Mark the answer line if it has two answers ignoring any incorrect probabilities in the working lines	
	Ignore any incorrect cancelling or change of form (fraction, decimal or percentage)	
	If the answer line only has one answer, check the working lines for a second answer for B2. Ignore any extra probabilities, unless incorrect, in which case award B1 max eg Working lines $\frac{15}{20}$ Answer line $\frac{54}{90}$ eg Working lines $\frac{15}{20}$, $\frac{5}{15}$ Answer line $\frac{54}{90}$	B2 B1
	If the answer line is blank, check the working lines for answers for B1 or B2. Ignore any extra probabilities, unless incorrect, in which case award B1 max eg Working lines $\frac{15}{20}$, $\frac{22}{30}$, $\frac{54}{90}$ Answer line blank eg Working lines $\frac{15}{20}$, $\frac{5}{15}$, $\frac{54}{90}$ Answer line blank	B2 B1
	Probabilities must not be given as ratios	
	Do not accept the average of the given probabilities as answer	

Question	Answer	Mark	Comments
7(b)	**Alternative method 1 (ft their part (a))**		
	Their probability with the greater number of trials and valid reason eg More throws	B1ft	ft their two different probabilities from part (a) both probabilities must have a denominator based on throws
	Alternative method 2 (independent of part (a))		
	$\frac{54}{90}$ and valid reason eg Total throws	B1	oe
	Additional Guidance		
	Accept any unambiguous indication of their probability eg the day		
	Using ratios		B0
	Ignore any non-contradictory statements		
	60% and It's for all three days		B1
	$\frac{54}{90}$ and It takes into account more throws		B1
	$\frac{17}{40}$ (with $\frac{22}{30}$ also in (a)) and Because he threw it more on Wednesday		B1ft
	$\frac{54}{90}$ and Shows the overall probability		B1
	$\frac{54}{90}$ and Probability over total throws		B1
	$\frac{54}{90}$ (with Wednesday probability in (a)) and It's the average total days, not just Wednesdays		B1ft

Additional guidance continues on the next page

Question	Answer	Mark	Comments
7(b) cont	Correct ft probability or $\frac{54}{90}$ and It's more reliable	B0	
	$\frac{54}{90}$ and There's a lot of data	B0	
	Correct ft probability or $\frac{54}{90}$ and He may get better with more throws	B0	
	$\frac{54}{90}$ and He throws 90 times	B0	
	Correct ft probability or $\frac{54}{90}$ and More hits	B0	
8	**Alternative method 1**		
	22.5(0) and 4 or 27 and 8 or 31.5(0) and 12 or 36 and 16 or 40.5(0) and 20 or 45 and 24 or 30 : 16 or 45 : 24	M1	
	45 and 24 chosen	A1	eg 45 : 24 is the final ratio seen
	6	A1	

Mark scheme and additional guidance continues on the next page

Question	Answer	Mark	Comments

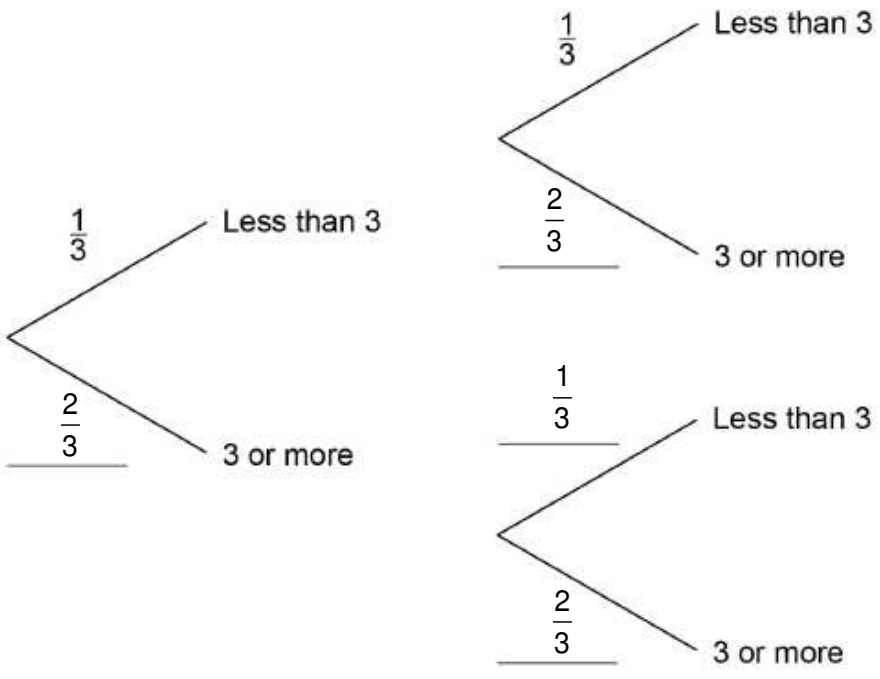
8 cont	**Alternative method 2**		
	$18 + 4.5x$ and $4x$ seen or $\frac{18 + 4.5x}{15} = \frac{4x}{8}$	M1	any letter oe sets up correct equation
	$8(18 + 4.5x) = 60x$ or $144 + 36x = 60x$ or $24x = 144$	M1dep	eliminates denominators oe
	6	A1	
	Additional Guidance		
	Answer 6 that is not from incorrect method		M1A1A1
	45 and 24 followed by eg 49.5(0) and 28 (answer not 6)		M1A0A0
	Equivalent ratio to 15 : 8 that is not 30 : 16 or 45 : 24 eg 60 : 32 (answer not 6)		M0A0A0
	Final calculation $\frac{15}{8} \times 24 = 45$ (answer not 6)		M1A1A0

Question	Answer	Mark	Comments
9(a)	8.35 and 8.45 in the correct order	B2	B1 8.35 on the left or 8.45 on the right or 8.45 and 8.35 in the wrong order accept $8.44\dot{9}$ for 8.45
	Additional Guidance		
	Do not accept 8.449… for $8.44\dot{9}$		
9(b)	41.75 and 42.25	B1ft	correct or ft their two different values from (a) their 8.35 must be in the range (8.3, 8.4] their 8.45 must be in the range (8.4, 8.5] correct order or ft order accept $42.24\dot{9}$ for 42.25
	Additional Guidance		
	(8.3, 8.4] does not include 8.3 but does include 8.4 (8.4, 8.5] does not include 8.4 but does include 8.5		
	Answer of 8.35 and 8.44 in part (a) leading to 41.75 and 42.2		B1ft
	Answer of 8 and 9 in part (a) leading to 40 and 45		B0ft

Question	Answer	Mark	Comments
10	**Alternative method 1**		
	$\frac{4}{3}\pi \times 30^3$ or $36\,000\pi$ or [112 757, 113 112] or $\frac{1}{2} \times \frac{4}{3}\pi \times 30^3$ or $18\,000\pi$ or [55 954, 56 839]	M1	oe allow 1.33… for $\frac{4}{3}$ allow 0.66… or 0.67 for $\frac{2}{3}$
	their [112 757, 113 112] ÷ 4000 or 9π or 28.(…) or their [55 954, 56 839] ÷ 4000 or $\frac{9\pi}{2}$ or [13.9, 14.21] or their [112 757, 113 112] ÷ (4000 × 60) or $\frac{3\pi}{20}$ or [0.46, 0.4713] or their [55 954, 56 839] ÷ (4000 × 60) or $\frac{3\pi}{40}$ or 0.23… or 0.24	M1dep	
	[13.9, 14.21] and Yes or 0.23… or 0.24 and Yes	A1	

Mark scheme and additional guidance continues on the next page

Question	Answer	Mark	Comments
10 cont	**Alternative method 2**		
	$\frac{4}{3}\pi \times 30^3$ or $36\,000\pi$ or [112 757, 113 112] or $\frac{1}{2} \times \frac{4}{3}\pi \times 30^3$ or $18\,000\pi$ or [55 954, 56 839]	M1	oe allow 1.33… for $\frac{4}{3}$ allow 0.66… or 0.67 for $\frac{2}{3}$
	4000 × 15 or 60 000	M1	
	[55 954, 56 839] and 60 000 and Yes	A1	
	Alternative method 3		
	$\frac{4}{3}\pi \times 30^3$ or $36\,000\pi$ or [112 757, 113 112] or $\frac{1}{2} \times \frac{4}{3}\pi \times 30^3$ or $18\,000\pi$ or [55 954, 56 839]	M1	oe allow 1.33… for $\frac{4}{3}$ allow 0.66… or 0.67 for $\frac{2}{3}$
	their [112 757, 113 112] ÷ 15 or 2400π or [7517, 7541] or their [55 954, 56 839] ÷ 15 or 1200π or [3730, 3790]	M1dep	
	[3730, 3790] and Yes	A1	
	Additional guidance		
	Do not award A1 if incorrect conversion of $\frac{1}{4}$ hour seen		

Question	Answer	Mark	Comments
11(a)	$\frac{1}{3}$ or $\frac{2}{6}$ or 0.33… or 33.(…)% on each top branch and $\frac{2}{3}$ or $\frac{4}{6}$ or 0.66… or 0.67 or 66.(…)% or 67% on each bottom branch	B1	accept any equivalent fraction, decimal or percentage
	Additional Guidance		
	Decimals must have at least 2 decimal places so do not accept 0.3 or 0.6 or 0.7		
	Only accept the percentages shown, do not accept 30% or 60%		
	Ignore working around the edge of the diagram		
		B1	

Question	Answer	Mark	Comments
11(b)	$\frac{1}{9}$ or 0.11… or 11.(…)%	B1	
	Additional Guidance		
	Ignore probability words such as 'unlikely' or 'evens'		
	Accept equivalent answers eg $\frac{2}{18}$, $\frac{3}{27}$, $0.\dot{1}$		
	Do not accept 0.1 or 10%		
11(c)	**Alternative method 1 Probabilities on branches in (a) all correct**		
	$\frac{1}{3} \times \frac{2}{3}$ or $\frac{2}{3} \times \frac{1}{3}$ or $\frac{2}{9}$	M1	oe accept 0.33… for $\frac{1}{3}$ accept 0.66… or 0.67 for $\frac{2}{3}$
	$\frac{4}{9}$ or 0.44… or 44.(…)%	A1	
	Alternative method 2 Probabilities on branches in (a) all correct		
	$1 - (\frac{1}{3} \times \frac{1}{3}) - (\frac{2}{3} \times \frac{2}{3})$	M1	oe accept 0.33… for $\frac{1}{3}$ accept 0.66… or 0.67 for $\frac{2}{3}$
	$\frac{4}{9}$ or 0.44… or 44.(…)%	A1	

Mark scheme continues on the next page

Question	Answer	Mark	Comments
11(c) cont	**Alternative method 3 Probabilities on branches in (a) not all correct**		
	$\frac{1}{3}$ × their $\frac{2}{3}$ where their $\frac{2}{3}$ must be for 2nd dice 3 or more or their $\frac{2}{3}$ × their $\frac{1}{3}$ where their $\frac{2}{3}$ must be for 1st dice 3 or more and their $\frac{1}{3}$ must be for 2nd dice less than 3	M1	oe accept 0.33… for $\frac{1}{3}$ accept 0.66… or 0.67 for $\frac{2}{3}$ their fractions must be between 0 and 1
	$\frac{4}{9}$ or 0.44… or 44.(…)%	A1ft	ft their fractions
	Alternative method 4 Probabilities on branches in (a) not all correct		
	$1 - (\frac{1}{3} \times \frac{1}{3}) - (\text{their } \frac{2}{3} \times \text{their } \frac{2}{3})$ where their $\frac{2}{3}$ must be for 1st dice 3 or more and their $\frac{2}{3}$ must be for 2nd dice 3 or more	M1	accept 0.33… for $\frac{1}{3}$ accept 0.66… or 0.67 for $\frac{2}{3}$ their fractions must be between 0 and 1
	$\frac{4}{9}$ or 0.44… or 44.(…)%	A1ft	ft their fractions

Additional guidance continues on the next page

Question	Answer	Mark	Comments

11(c) cont	**Additional Guidance**	
	If probabilities on branches in (a) are all $\frac{1}{3}$	M0A0
	Decimals must have at least 2 decimal places so do not accept 0.3 or 0.6 or 0.7	
	Ignore any incorrect cancelling or change of form (fraction, decimal or percentage)	
	$\frac{1}{3} \times \frac{2}{3} \times \frac{2}{3} \times \frac{1}{3}$	M0A0
	$\frac{1}{3} \times \frac{2}{3}$ and $\frac{1}{3} \times \frac{1}{3}$ without selecting $\frac{1}{3} \times \frac{2}{3}$ is choice	M0

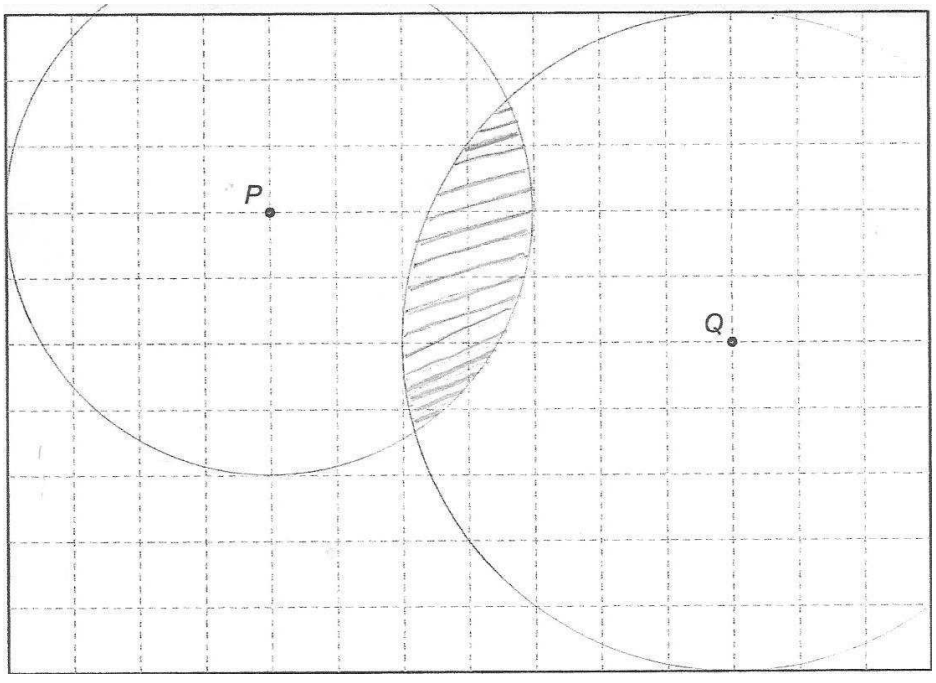
12(a)	$\frac{1}{2}$ or 0.5	B1	oe eg $\frac{4}{8}$ or $\frac{2}{4}$
	Additional Guidance		
	1 : 2 or 50%		B0
	$\frac{1}{2}x$		B0
	$y = 0.5x + 2$		B0
	$\frac{0.5}{1}$		B0
	Ignore units		

Question	Answer	Mark	Comments
12(b)	☐ The answer to part (a) is too big ☑ The answer to part (a) stays the same ☐ The answer to part (a) is too small	B1	
	Additional Guidance		

Question	Answer	Mark	Comments
13	**Alternative method 1**		
	Any correct factorisation of the numerator or the denominator	M1	eg $8(x^2 - 1)$ or $4(x + 1)$ or $2(4x^2 - 4)$ or $2(2x + 2)$ or $4(2x^2 - 2)$ or $(4x + 4)(2x - 2)$ or $(4x - 4)(2x + 2)$ or $(8x + 8)(x - 1)$ or $(8x - 8)(x + 1)$ or $-2(-4x^2 + 4)$ does not need to be seen in a fraction may be implied eg $\frac{2x^2 - 2}{x + 1}$ or $\frac{4x^2 - 4}{2x + 2}$
	Correct fraction with a common algebraic factor in the numerator and the denominator	A1	eg $\frac{8(x + 1)(x - 1)}{4(x + 1)}$ or $\frac{2(2x + 2)(2x - 2)}{2(2x + 2)}$ or $\frac{2(x + 1)(x - 1)}{(x + 1)}$ or $\frac{4(x + 1)(2x - 2)}{4(x + 1)}$ or $\frac{(4x + 4)(2x - 2)}{4x + 4}$
	$2x - 2$ or $a = 2$ and $b = -2$ with M1A1 scored	A1	

Mark scheme and additional guidance continues on the next page

Question	Answer	Mark	Comments
13 cont	**Alternative method 2**		
	$4ax^2 + 4ax + 4bx + 4b$	M1	oe expands $(ax + b)(4x + 4)$ to 4 terms with at least 3 terms correct
	Any 2 of $4a = 8$ $4b = -8$ $4a + 4b = 0$	A1	
	$a = 2$ and $b = -2$ and shows that third equation is satisfied with M1A1 scored	A1	
	Additional Guidance		
	M1 is implied by the first A1 eg $\frac{8(x+1)(x-1)}{4(x+1)}$		M1A1
	$1(8x^2 - 8)$ or $-1(8 - 8x^2)$ etc		M0
	$2x - 2$ without M1A1 scored		M0A0A0
	M1A1 scored and $2x - 2$ followed by attempt to solve $2x - 2 = 0$		M1A1A1
	M1A1 scored and $2x - 2$ followed by $2(x - 1)$		M1A1A1
	M1A1 scored followed by $2(x - 1)$ but $2x - 2$ not seen		M1A1A0

Question	Answer	Mark	Comments
14	Arc radius [3.8, 4.2] cm centre *P* or arc radius [4.8, 5.2] cm centre *Q*	M1	only need arcs within tolerance for the correct region ignore other lines M1 arc radius [3.8, 4.2] cm centre *Q* and arc radius [4.8, 5.2] cm centre *P* and correct ft region identified
	Arc radius [3.8, 4.2] cm centre *P* and arc radius [4.8, 5.2] cm centre *Q* and region identified	A1	only need arcs within tolerance for the correct region ignore other lines
	Additional Guidance		
	Arcs may go outside the rectangle		
	Allow any unambiguous indication of the region eg labelled R or appropriate shading		
	Do not accept highlighting the perimeter of the region for identification of the region		
			M1A1

Question	Answer	Mark	Comments
15	Men had more consistent scores than women	B1	
	Additional Guidance		
16(a)	2400 × 3.8 or $\frac{m}{3.8} = 2400$ or $\frac{m}{2400} = 3.8$	M1	oe equation allow mass for m allow any letter apart from v or d
	9120	A1	
	Additional Guidance		
16(b)	$\pi r^2 h = 3.8$ or $\pi \times 0.5^2 \times h$ or $0.25\pi h$ or [0.78, 0.79]h or $3.8 \div (\pi \times 0.5^2)$ or $3.8 \div 0.25\pi$ or $3.8 \div$ [0.78, 0.79]	M1	oe eg $\pi r^2 = \frac{3.8}{h}$
	[4.8, 4.841]	A1	
	Additional Guidance		
	$\pi\ 0.5^2\ h$		M1

Question	Answer	Mark	Comments
17(a)	[2.9, 3]	B1	
	Additional Guidance		
17(b)	[1.4, 1.6]	B1	
	Additional Guidance		
17(c)	$\frac{[4.55, 4.65] - 0}{3.5 - [1.5, 1.6]}$ or $\frac{[4.55, 4.65]}{[1.9, 2]}$ or $\frac{[4.55, 4.65] - 0}{[1.5, 1.6] - 3.5}$ or $\frac{[4.55, 4.65]}{[-2, -1.9]}$ or [–2.45, –2.275]	M1	oe
	[2.275, 2.45]	A1	
	Additional Guidance		
18	5 and 6 with no incorrect evaluation seen for 3^5 or 3^6 or 5 and 6 with no incorrect evaluation seen for $\sqrt[5]{300}$ or $\sqrt[6]{300}$	B1	5 and 6 in either order allow any evaluations truncated or rounded to 2 sf or 1 sf
	Additional Guidance		
	5 and 6 with either 3^5 or 3^6 evaluated incorrectly		B0
	3^5 or 3^6		B0
	243 and 729		B0
	$3^5 = 243$ Allow 240 or 200 (with no incorrect value seen) $3^6 = 729$ Allow 720 or 730 or 700 (with no incorrect value seen)		
	$\sqrt[5]{300} = 3.1(2\ldots)$ or 3.13 $\sqrt[6]{300} = 2.5(8\ldots)$ or 2.59 or 2.6		

Question	Answer	Mark	Comments
19	**Alternative method 1 Using one half of the isosceles triangle**		
	(base angle =) 35 or (top angle =) 55	B1	may be on diagram
	cos (their 35) = $\frac{6}{x}$ or sin (their 55) = $\frac{6}{x}$ or $6^2 + (6 \tan (\text{their } 35))^2$	M1	oe eg $\frac{\sin 90}{x} = \frac{\sin (\text{their } 55)}{6}$ any letter their 35 must be acute their 55 must be acute
	$\frac{6}{\cos (\text{their } 35)}$ or $\frac{6}{\sin (\text{their } 55)}$ or $\sqrt{6^2 + (6 \tan (\text{their } 35))^2}$ or 7.3(2…)	M1dep	oe
	[50.6, 50.65]	A1ft	ft B0M2 with evaluation of 36 + 2 × their 7.3(2…)

Mark scheme and additional guidance continues on the next page

Question	Answer	Mark	Comments
19 cont	**Alternative method 2 Using the isosceles triangle**		
	(base angle =) 35 or (top angle =) 110	B1	may be on diagram
	$\frac{x}{\sin(\text{their } 35)} = \frac{12}{\sin(\text{their } 110)}$ or $12^2 = x^2 + x^2 - 2 \times x \times x \times \cos(\text{their } 110)$ or $x^2 = x^2 + 12^2 - 2 \times x \times 12 \times \cos(\text{their } 35)$	M1	oe any letter their 35 must be acute their 110 cannot be 125
	$\frac{12}{\sin(\text{their } 110)} \times \sin(\text{their } 35)$ or $\sqrt{\frac{12^2}{2-2\cos(\text{their } 110)}}$ or $\frac{12^2}{2\times 12\times\cos(\text{their } 35)}$ or 7.3(2…)	M1dep	oe
	[50.6, 50.65]	A1ft	ft B0M2 with evaluation of 36 + 2 × their 7.3(2…)
	Additional Guidance		
	Allow B1 even if the angle is not subsequently used		
	Alt 2 Top angle 90		M0M0A0
	Answer [50.6, 50.65] (possibly from scale drawing)		B1M1M1A1

Question	Answer	Mark	Comments
20	$0.25\pi^2(30 - 20)^2(30 + 20)$ or $0.25\pi^2 \times 10^2 \times 50$	M1	oe allow use of π as [3.14, 3.142]
	[12 320, 12 340.21]	A1	may be implied
	12 300 or 1.23×10^4 with no value outside [12 320, 12 340.21] seen	A1	
	Additional Guidance		
	$0.25\pi^2(30 - 20)^2(30 + 20)$ 12 300		M1 A1(implied)A1
	12 300 with no incorrect working		M1A1A1
	12 300.0 is not to 3 significant figures		
	M1 gained followed by answer 12 300.0		M1A0A0
	Do not allow misreads eg $0.25\pi^2(30 + 20)^2(30 + 20)$		M0A0A0
	Brackets expanded correctly and values substituted		M1

Question	Answer	Mark	Comments
21(a)	**Alternative method 1**		
	$80^2 + 60^2 - 2 \times 80 \times 60 \times \cos 75$ or $6400 + 3600 - 9600 \cos 75$ or 7515.(…)	M1	oe
	$\sqrt{\text{their } 7515.(...)}$ or [86.6, 86.7] or 87	M1dep	
	[86.6, 86.7] and Liz or 87 and Liz	A1	accept 86 and Liz or 90 and Liz with full method seen
	Alternative method 2		
	$80^2 + 60^2 - 2 \times 80 \times 60 \times \cos 75$ or $6400 + 3600 - 9600 \cos 75$ or 7515.(…)	M1	oe
	$(80^2 =)$ 6400 and 7515.(…) and Liz	A2	
	Additional Guidance		
	$80^2 + 60^2 - 2 \times 80 \times 60 \times \cos 75$ seen followed by processing error can score up to M2 eg $80^2 + 60^2 - 2 \times 80 \times 60 \times \cos 75$ $= 6400 + 3600 - 9600 \cos 75$ $= 400 \cos 75 = 103.5$ $\sqrt{103.5}$		M1 M1depA0
	You may need to check on your calculator whether to award M1dep after first M1 with a processing error seen eg $80^2 + 60^2 - 2 \times 80 \times 60 \times \cos 75 = 3654$ (processing error) 60.4 (square root of 3654 is implied)		 M1 M1depA0
	Ignore any reasons given		
	Alt 2 not possible to score M1A1		
	Answer [86.6, 86.7] and Liz (possibly from scale drawing)		M1M1A1
	[86.6, 86.7] (possibly from scale drawing)		M1M1

Question	Answer	Mark	Comments
21(b)	**Alternative method 1 (answer Liz in (a))**		
	No change	B1	oe eg Liz will still arrive first or Liz will be there even earlier (than Tia)
	Alternative method 2 (answer Tia in (a))		
	Not possible to tell	B1ft	oe eg Liz might arrive before Tia or it depends on how much faster Liz walks or it could be either of them
	Alternative method 3 (answer they arrive at same time in (a))		
	Liz will arrive first	B1ft	oe eg Liz wins
	Alternative method 4 (neither Liz or Tia in (a))		
	If Liz had arrived first there would be no change and if Tia had arrived first it would not be possible to tell	B1ft	oe
	Additional Guidance		
	If correct decision is made, ignore non-contradictory further work		
	Alt 1 Liz will arrive earlier		B1
	Alt 1 No		B0
	Alt 2 Yes		B0
22	$x^2 + y^2 = 25$	B1	
	Additional Guidance		

Question	Answer	Mark	Comments
23	$\sqrt[3]{64}$ and $\sqrt[3]{343}$ or 4 and 7 or $\sqrt[3]{[5.3, 5.4]}$ or [1.74, 1.754411] or $\sqrt[3]{[0.18, 0.19]}$ or [0.56, 0.575]	M1	oe eg 4 : 7 or 7 : 4 or $\sqrt[3]{\frac{343}{64}}$ or $\frac{7}{4}$ or $\sqrt[3]{\frac{64}{343}}$ or $\frac{4}{7}$
	their 4^2 and their 7^2 or 16 and 49 or their $[1.74, 1.754411]^2$ or [3.02, 3.08] or their $[0.56, 0.575]^2$ or [0.31, 0.331]	M1dep	oe eg 16 : 49 or 49 : 16 or $\left(\text{their } \frac{7}{4}\right)^2$ or $\frac{49}{16}$ or $\left(\text{their } \frac{4}{7}\right)^2$ or $\frac{16}{49}$
	539	A1	

Additional Guidance	
4^3 and 7^3	M1
$64^{\frac{2}{3}}$ and $343^{\frac{2}{3}}$	M1M1
$\left(\frac{343}{64}\right)^{\frac{2}{3}}$ or $\left(\frac{64}{343}\right)^{\frac{2}{3}}$	M1M1
Answer 539 with evidence of rounding to 539 scores A0 eg1 176 × 3.06 = 538.56 Answer 539 eg2 176 × 3.06 = 539 (may have kept all digits on calculator)	M1M1A0 M1M1A1
$\left(\sqrt{176} \times \frac{7}{4}\right)^2$	M1M1
176 ÷ 16 = 11 and 11 × 49	M1M1
4 and 7 (and/or 4^2 and 7^2) but uses different method not involving 4 and 7	M1M0A0

Question	Answer	Mark	Comments
24	**Alternative method 1**		
	Any product of three valid dimensions that would give a volume < 34 000 or any product of three valid dimensions that would give a volume > 34 000	M1	eg 49.5 × 34.5 × 19.5 or 50.5 × 35.5 × 20.5 or 50 × 35 × 20 ignore any evaluations of products
	Any product of three valid dimensions that would give a volume < 34 000 and any product of three valid dimensions that would give a volume > 34 000	M1dep	eg 49.5 × 34.5 × 19.5 and 50.5 × 35.5 × 20.5 ignore any evaluations of products
	34 × 1000 or 34 000	M1	converts to cm^3
	their volume < 34 000 and their volume > 34 000 and 34 000 and ticks Cannot tell	A1	both volumes in cm^3 must see working for M3 answers for their volumes must be seen and be correct or rounded or truncated to at least 2 sf (unless 34 000 to 2 sf when must be to at least 3 sf)

Mark scheme continues on the next page

Question	Answer	Mark	Comments
24 cont	**Alternative method 2**		
	Any product of three valid dimensions that would give a volume < 34 000 or any product of three valid dimensions that would give a volume > 34 000	M1	eg 49.5 × 34.5 × 19.5 or 50.5 × 35.5 × 20.5 or 50 × 35 × 20 ignore any evaluations of products
	Any product of three valid dimensions that would give a volume < 34 000 and any product of three valid dimensions that would give a volume > 34 000	M1dep	eg 49.5 × 34.5 × 19.5 and 50.5 × 35.5 × 20.5 ignore any evaluations of products
	one of their volumes ÷ 1000	M1dep	dep on first M1 converts to litres
	their volume < 34 and their volume > 34 and ticks Cannot tell	A1	both volumes in litres must see working for M3 answers for their volumes must be seen and be correct or rounded or truncated to at least 2 sf (unless 34 000 to 2 sf when must be to at least 3 sf)

Additional guidance continues on the next page

Question	Answer	Mark	Comments

	Additional Guidance	
24 cont	There are an infinite number of sets of three valid dimensions Valid dimensions for 50 are [49.5, 50.5] for 35 are [34.5, 35.5] for 20 are [19.5, 20.5]	
	49.5 × 34.5 × 19.5 = 33 301.(…) or 33 000 or 33 300 49.6 × 34.6 × 19.6 = [33 636, 33 637] or 33 000 or 33 600 or 33 630 or 33 640 49.7 × 34.7 × 19.7 = 33 974.(…) or 33 000 or 33 900 or 33 970 49.8 × 34.8 × 19.8 = 34 314.(…) or 34 300 or 34 310 49.9 × 34.9 × 19.9 = 34 656.(…) or 34 600 or 34 700 or 34 650 or 34 660 50 × 35 × 20 = 35 000 50.1 × 35.1 × 20.1 = 35 346.(…) or 35 000 or 35 300 or 35 340 or 35 350 50.2 × 35.2 × 20.2 = 35 694.(…) or 35 000 or 36 000 or 35 600 or 35 700 or 35 690 50.3 × 35.3 × 20.3 = 36 044.(…) or 36 000 or 36 040 50.4 × 35.4 × 20.4 = [36 396, 36 397] or 36 000 or 36 300 or 36 400 or 36 390 50.5 × 35.5 × 20.5 = 36 751.(…) or 36 000 or 37 000 or 36 700 or 36 800 or 36 750	
	Three valid dimensions do not have to follow a pattern eg 49.6 × 35 × 20.4 (= 35 414.(…) or 35 000 or 35 400 or 35 410)	M1
	49.5 34.5 19.5 and 33 301 (answer implies multiplication signs)	M1
	49.5 34.5 19.5 (no answer so multiplication signs not implied)	M0
	33 301 but 49.5 34.5 19.5 not seen	M0
	Units do not have to be seen	

Question	Answer	Mark	Comments
25	$\frac{x}{x+35} = \frac{5}{12}$ or $\frac{35}{x+35} = \frac{7}{12}$ or $\frac{x}{35} = \frac{5}{7}$ or $x : 35 = 5 : 7$ or links $\frac{7}{12}$ to 35	M1	oe eg $x + 35 = 60$ or links $\frac{1}{12}$ to 5
	$12x - 5x = 175$ or $7x = 175$ or $420 - 245 = 7x$ or $(x =)$ 25 or $\frac{25}{60}$	M1dep	oe collects terms 25 may be seen in section labelled x on Venn diagram
	$(y =)$ 150 – 47 – 35 – their 25 or 43	M1dep	dep on M2 43 may be seen in section labelled y on Venn diagram
	$\frac{43}{150}$ or 0.286… or 0.287 or 0.29 or 28.6…% or 28.7% or 29%	A1	
	Additional Guidance		
	Accept $\frac{7}{12} = 35$	M1	
	Ignore any incorrect cancelling or change of form (fraction, decimal or percentage)		

Question	Answer	Mark	Comments
26	**Alternative method 1**		
	$4x^2 + 5x + 3 = x + 2$	M1	
	$4x^2 + 5x - x + 3 - 2$ (= 0) or $4x^2 + 4x + 1$ (= 0)	M1dep	oe collection of terms eg $4x^2 + 5x - x = 2 - 3$ or $4x^2 + 4x = -1$
	$(2x + 1)(2x + 1)$ (= 0) or $4\left(x + \frac{1}{2}\right)^2$ (= 0) or $\frac{-4 \pm \sqrt{4^2 - 4 \times 4 \times 1}}{2 \times 4}$ or $b^2 - 4ac = 4^2 - 4 \times 4 \times 1$ or D(iscriminant) = $4^2 - 4 \times 4 \times 1$	A1	oe eg $\left(x + \frac{1}{2}\right)^2$ (= 0) allow $b^2 - 4ac = 16 - 16$ or D(iscriminant) = 16 – 16
	$(x =) -\frac{1}{2}$ with no other solutions with M2A1 seen or states that as brackets are the same there is only one solution with M2A1 seen or $b^2 - 4ac = 4^2 - 4 \times 4 \times 1 = 0$ and states there is only one solution with M2A1 seen or D(iscriminant) = $4^2 - 4 \times 4 \times 1 = 0$ and states there is only one solution with M2A1 seen	A1	oe allow $b^2 - 4ac = 16 - 16 = 0$ and states there is only one solution with M2A1seen allow D(iscriminant) = 16 – 16 = 0 and states there is only one solution with M2A1seen

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Question	Answer	Mark	Comments
26 cont	**Alternative method 2**		
	$y = 4(y-2)^2 + 5(y-2) + 3$	M1	oe
	$4y^2 - 16y + 16 + 5y - 10 + 3 - y$ (= 0) or $4y^2 - 12y + 9$ (= 0)	M1dep	oe expansion and collection of terms eg $4y^2 - 16y + 5y - y = 10 - 16 - 3$ or $4y^2 - 12y = -9$
	$(2y-3)(2y-3)$ (= 0) or $4\left(y-\frac{3}{2}\right)^2$ (= 0) or $\frac{--12 \pm \sqrt{(-12)^2 - 4\times4\times9}}{2\times4}$ or $b^2 - 4ac = (-12)^2 - 4 \times 4 \times 9$ or D(iscriminant) = $(-12)^2 - 4 \times 4 \times 9$	A1	oe eg $\left(y-\frac{3}{2}\right)^2$ (= 0) allow $b^2 - 4ac = 144 - 144$ or allow D(iscriminant) = 144 – 144
	$(y =) \frac{3}{2}$ with no other solutions with M2A1 seen or states that as brackets are the same there is only one solution with M2A1 seen or $b^2 - 4ac = (-12)^2 - 4 \times 4 \times 9 = 0$ and states there is only one solution with M2A1 seen or D(iscriminant) = $(-12)^2 - 4 \times 4 \times 9 = 0$ and states there is only one solution with M2A1 seen	A1	oe allow $b^2 - 4ac = 144 - 144 = 0$ and states there is only one solution with M2A1seen allow D(iscriminant) = 144 – 144 = 0 and states there is only one solution with M2A1seen

Additional guidance continues on the next page

Question	Answer	Mark	Comments

	Additional Guidance	
26 cont	Alt 1 $(x=)-\frac{1}{2}$ with no working or Alt 2 $(y=)\frac{3}{2}$ with no working	M0M0A0A0
	Alt 1 Ignore any y-coordinate whether correct $\left(=\frac{3}{2}\right)$ or incorrect	
	Alt 2 Ignore any x-coordinate whether correct $\left(=-\frac{1}{2}\right)$ or incorrect	
	T & I leading to $x=-\frac{1}{2}$	M0M0A0A0
	To award M1dep you must see a correct expression with terms collected or a correct equation with terms collected	
	$4x^2 + 5x + 3 = x + 2$ $4x^2 + 1 = -4x$ (all x terms not collected on one side)	M1 M0dep
	$4x^2 + 5x + 3 = x + 2$ $4x^2 + 4x + 3 = 2$ (all constant terms not collected on one side)	M1 M0dep
	If using the discriminant to award A marks, you must see either $b^2 - 4ac$ or D(iscriminant) $b^2 - 4ac = 4^2 - 4 \times 4 \times 1$ can be implied eg $b + \sqrt{b^2 - 4ac}$ and $4 + \sqrt{4^2 - 4\times4\times1}$ scores first A1 For final A1 must see $b^2 - 4ac = 4^2 - 4 \times 4 \times 1 = 0$ and statement that there is only one solution with M2A1 seen	

Question	Answer	Mark	Comments
27	**Alternative method 1 Working with 2.75…..**		
	$10x = 27.5…$ or $100x = 275.5…$	M1	oe multiplication by a power of 10 eg $1000x = 2755.5…$ any letter
	$10x – x = 27.5… – 2.75…$ or $9x = 24.8$ with $10x = 27.5…$ seen or $100x – 10x = 275.5… – 27.5…$ or $90x = 248$ with $100x = 275.5…$ and $10x = 27.5…$ seen or $100x – x = 275.5… – 2.75…$ or $99x = 272.8$ with $100x = 275.5…$ seen	M1dep	oe subtraction to eliminate recurring digits eg $1000x – 10x = 2755.5… – 27.5…$ or $990x = 2728$ with $1000x = 2755.5…$ and $10x = 27.5…$ seen numbers must all be correct
	$x = 2.75…$ stated and M2 scored and $9x = 24.8$ and $x = \frac{24.8}{9} = \frac{124}{45}$ or $x = 2.75…$ stated and M2 scored and $90x = 248$ and $x = \frac{248}{90} = \frac{124}{45}$ or $x = 2.75…$ stated and M2 scored and $99x = 272.8$ and $x = \frac{272.8}{99} = \frac{124}{45}$	A1	oe eg $x = 2.75…$ stated and M2 scored and $990x = 2728$ and $x = \frac{2728}{990} = \frac{124}{45}$

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Question	Answer	Mark	Comments
27 cont	**Alternative method 2 Working with 0.75…..**		
	$10x = 7.5…$ or $100x = 75.5…$	M1	oe multiplication by a power of 10 eg $1000x = 755.5…$ any letter
	$10x – x = 7.5… – 0.75…$ or $9x = 6.8$ with $10x = 7.5…$ seen or $100x – 10x = 75.5… – 7.5…$ or $90x = 68$ with $100x = 75.5…$ and $10x = 7.5…$ seen or $100x – x = 75.5… – 0.75…$ or $99x = 74.8$ with $100x = 75.5…$ seen	M1dep	oe subtraction to eliminate recurring digits eg $1000x – 10x = 755.5… – 7.5…$ or $990x = 748$ with $1000x = 755.5…$ and $10x = 7.5…$ seen numbers must all be correct
	$x = 0.75…$ stated and M2 scored and $9x = 6.8$ and $x = \frac{6.8}{9}$ and $2\frac{6.8}{9} = \frac{124}{45}$ or $x = 0.75…$ stated and M2 scored and $90x = 68$ and $x = \frac{68}{90}$ and $2\frac{68}{90} = \frac{124}{45}$ or $x = 0.75…$ stated and M2 scored and $99x = 74.8$ and $x = \frac{74.8}{99}$ and $2\frac{74.8}{99} = \frac{124}{45}$	A1	oe eg $x = 0.75…$ stated and M2 scored and $990x = 748$ and $x = \frac{748}{990}$ and $2\frac{748}{990} = \frac{124}{45}$

Mark scheme continues on the next page

Question	Answer	Mark	Comments
27 cont	**Alternative method 3 Working with 0.05…..**		
	$10x = 0.5…$ or $100x = 5.5…$	M1	oe multiplication by a power of 10 eg $1000x = 55.55…$ any letter
	$10x – x = 0.5… – 0.05…$ or $9x = 0.5$ with $10x = 0.5…$ seen or $100x – 10x = 5.5… – 0.5…$ or $90x = 5$ with $100x = 5.5…$ and $10x = 0.5…$ seen or $100x – x = 5.5… – 0.05…$ or $99x = 5.5$ with $100x = 5.5…$ seen	M1dep	oe subtraction to eliminate recurring digits eg $1000x – 10x = 55.5… – 0.5…$ or $990x = 55$ with $1000x = 55.5…$ and $10x = 0.5…$ seen numbers must all be correct
	$x = 0.05…$ stated and M2 scored and $9x = 0.5$ and $x = \frac{0.5}{9}$ and $2.7 + \frac{0.5}{9} = \frac{124}{45}$ or $x = 0.05…$ stated and M2 scored and $90x = 5$ and $x = \frac{5}{90}$ and $2.7 + \frac{5}{90} = \frac{124}{45}$ or $x = 0.05…$ stated and M2 scored and $99x = 5.5$ and $x = \frac{5.5}{99}$ and $2.7 + \frac{5.5}{99} = \frac{124}{45}$	A1	oe eg $x = 0.05…$ stated and M2 scored and $990x = 55$ and $x = \frac{55}{990}$ and $2.7 + \frac{55}{990} = \frac{124}{45}$

Additional guidance continues on the next page

Question	Answer	Mark	Comments

27 cont	**Additional Guidance**	
	124 ÷ 45 = 2.75…	M0M0A0
	Alt 1 M1dep oe subtraction to eliminate recurring decimals includes $100x - 10x = 248$ with $100x = 275.5…$ and $10x = 27.5…$ seen or $90x = 275.5… - 27.5…$ with $100x = 275.5…$ and $10x = 27.5…$ seen (apply same principle in Alts 2 and 3)	
	Alt 2 equivalents for final part of A1 eg For $2\frac{68}{90} = \frac{124}{45}$ allow $2 + \frac{68}{90} = \frac{124}{45}$	
	Alt 3 equivalents for final part of A1 eg For $2.7 + \frac{5}{90} = \frac{124}{45}$ allow $2 + \frac{7}{10} + \frac{5}{90} = \frac{124}{45}$	

28(a)	$5 - 2x$	B1	may be implied
	$3(x - 1) + 7$ or $3x + 4$	M1	oe ignore incorrect expansion if $3(x - 1) + 7$ seen
	$9 + x$	A1	
	Additional Guidance		
	Working out $2f(x)$		B0
	Working out $g(x + 1)$		M0

Question	Answer	Mark	Comments
28(b)	**Alternative method 1**		
	$x - 7 = 3y$ or $y - 7 = 3x$	M1	allow $x - 7 = 3g$ or $g - 7 = 3x$
	$\frac{x-7}{3}$ or $\frac{y-7}{3}$	A1	oe allow $\frac{g-7}{3}$
	-1.4 or $-\frac{7}{5}$	A1	oe
	Alternative method 2		
	$3(2x) + 7$	M1	oe
	$x = 3(2x) + 7$ or $x = 6x + 7$	A1	oe equation
	-1.4 or $-\frac{7}{5}$	A1	oe
	Additional Guidance		
	Beware $-3x - 7 = 2x$ leading to -1.4		M0A0A0