



Cambridge International AS & A Level

MATHEMATICS

9709/51

Paper 5 Probability & Statistics 1

October/November 2021

MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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This document consists of **12** printed pages.

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These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

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- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

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GENERIC MARKING PRINCIPLE 6:

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Mathematics Specific Marking Principles	
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3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

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The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

- M** Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.
- A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).
- B** Mark for a correct result or statement independent of method marks.
- DM or DB** When a part of a question has two or more ‘method’ steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
- FT** Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.
- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
 - For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
 - The total number of marks available for each question is shown at the bottom of the Marks column.
 - Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
 - Square brackets [] around text or numbers show extra information not needed for the mark to be awarded.

Abbreviations

AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
CAO	Correct Answer Only (emphasising that no ‘follow through’ from a previous error is allowed)
CWO	Correct Working Only
ISW	Ignore Subsequent Working
SOI	Seen Or Implied
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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Question	Answer	Marks	Guidance
1(a)	$\left(\frac{3}{4}\right)^6 \frac{1}{4}$	M1	$(1-p)^6 p, 0 < p < 1$
	$0.0445, \frac{729}{16384}$	A1	
		2	
1(b)	$\left(\frac{3}{4}\right)^9$	M1	$\left(\frac{3}{4}\right)^n \text{ or } p^n, 0 < p < 1, n = 8, 9, 10$
	$0.0751, \frac{19683}{262144}$	A1	
		2	

Question	Answer	Marks	Guidance
2(a)	$\left[\frac{\sum x}{40} - k = \frac{\sum (x-k)}{40} \right]$	M1	Forms an equation involving $\sum x$, $\sum (x-k)$ and k . Accept at a numeric stage with k .
	$\frac{40 \times 34}{40} - k = \frac{520}{40}$		
	$k [= 34 - 13] = 21$	A1	Evaluated.
		2	

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Question	Answer	Marks	Guidance
2(b)	$\text{Var} = \left[\frac{\sum (x-k)^2}{40} - \left(\frac{\sum (x-k)}{40} \right)^2 \right] = \frac{9640}{40} - \left(\frac{520}{40} \right)^2 = [241 - 13^2 =]$	M1	Values substituted into an appropriate variance formula, accept unsimplified.
	72	A1	
		2	

Question	Answer	Marks	Guidance
3	$\left[P(T B') = \frac{P(T \cap B')}{P(B')} \right]$	M1	$0.45 \times a + 0.35 \times b + 0.2[\times 1], a = 0.7, 0.3b = 0.4, 0.6$, seen anywhere.
	$P(B') = 0.45 \times 0.7 + 0.35 \times 0.4 + 0.2 \times 1$	A1	Correct, accept unsimplified.
	$\left[= 0.655, \frac{131}{200} \right]$		
	$P(T \cap B') = 0.35 \times 0.4 \left[= 0.14, \frac{7}{50} \right]$	M1	Seen as numerator or denominator of a fraction.
	$P(T B') = \frac{\text{their } 0.14}{\text{their } 0.655}$	M1	Values substituted into conditional probability formula correctly. Accept unsimplified. Denominator sum of 3 two-factor probabilities (condone omission of 1 from final factor). If clearly identified, condone from incomplete denominator.
	$0.214, \frac{28}{131}$	A1	If 0 marks awarded, SC B1 0.214 WWW.
		5	

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Question	Answer	Marks	Guidance																																
4(a)	<table><tr><td>x</td><td>-1</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>p</td><td>$\frac{1}{12} = 0.0833$</td><td>$\frac{2}{12} = 0.167$</td><td>$\frac{4}{12} = 0.333$</td><td>$\frac{3}{12} = 0.25$</td><td>$\frac{2}{12} = 0.167$</td></tr></table>	x	-1	0	1	2	3	p	$\frac{1}{12} = 0.0833$	$\frac{2}{12} = 0.167$	$\frac{4}{12} = 0.333$	$\frac{3}{12} = 0.25$	$\frac{2}{12} = 0.167$	B1	<table><tr><td></td><td>0</td><td>1</td><td>2</td><td>2</td></tr><tr><td>-1</td><td>-1</td><td>0</td><td>1</td><td>1</td></tr><tr><td>0</td><td>0</td><td>1</td><td>2</td><td>2</td></tr><tr><td>1</td><td>1</td><td>2</td><td>3</td><td>3</td></tr></table> Table with x values and at least one probability substituted, $0 < p < 1$. Condone any additional x values if probability stated as 0.		0	1	2	2	-1	-1	0	1	1	0	0	1	2	2	1	1	2	3	3
	x	-1	0	1	2	3																													
	p	$\frac{1}{12} = 0.0833$	$\frac{2}{12} = 0.167$	$\frac{4}{12} = 0.333$	$\frac{3}{12} = 0.25$	$\frac{2}{12} = 0.167$																													
		0	1	2	2																														
-1	-1	0	1	1																															
0	0	1	2	2																															
1	1	2	3	3																															
B1	2 correct identified probabilities.																																		
B1	All probabilities correct (accept to 3sf). SC if less than 2 correct probabilities: SC B1 4 or 5 probabilities summing to one.																																		
		3																																	
4(b)	$E(X) = -\frac{1}{12} + \frac{4}{12} + \frac{6}{12} + \frac{6}{12} \left[= \frac{15}{12} \right]$	M1	May be implied by use in Variance, accept unsimplified expression. Probabilities must sum to 1 ± 0.001 .																																
	$\text{Var}(X) = \frac{1}{12} + 0 + \frac{4}{12} + \frac{12}{12} + \frac{18}{12} - \left(\frac{15}{12} \right)^2$	M1	Appropriate variance formula using <i>their</i> $(E(X))^2$. FT accept probabilities not summing to 1. Condone $\frac{35}{12} - \left(\frac{15}{12} \right)^2$ or $\frac{35}{12} - \frac{25}{9}$ from correct table.																																
	$\left[\frac{35}{12} - \frac{25}{16} \right] \frac{65}{48}, 1.35$	A1	WWW																																
			3																																

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Question	Answer	Marks	Guidance
5(a)	$[8! =] 40\,320$	B1	Evaluated, exact value only.
		1	
5(b)	Method 1 $[{}^8R^{}S^{}]$		
	$7! \times {}^8C_2 \times 2$	M1	$7! \times k$ seen, k an integer > 1 .
		M1	$m \times n(n-1)$ or $m \times {}^nC_2$ or $m \times {}^nP_2$, $n = 7, 8$ or 9 , m an integer > 1 .
	282 240	A1	Exact value only. SC B1 for final answer 282 240 WWW.
	Method 2 [Total number of arrangements – Arrangements with R & S together]		
	$9! - 8! \times 2$	M1	$9! - k$, k an integer $< 362\,880$.
		M1	$m - 8! \times n$, m an integer $> 40\,320$, $n = 1, 2$.
	282 240	A1	Exact value only. SC B1 for final answer 282 240 WWW.
		3	
5(c)	${}^9C_5 [{}^4C_4]$	M1	${}^9C_x [{}^{9-x}C_{9-x}]$, $x = 4, 5$. Condone $\times 1$ for ${}^{9-x}C_{9-x}$. Condone use of P.
	126	A1	WWW
		2	

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Question	Answer	Marks	Guidance
5(d)	[Number of ways with Raman and Sanjay together on back row =] ${}^7C_3$ [Number of ways with Raman and Sanjay together on front row =] ${}^7C_2$	M1	${}^7C_x$ seen, $x = 3$ or 2 .
	[Total =] $35 + 21$	M1	Summing two correct scenarios.
	56	A1	Evaluated – may be seen used in probability. If M0 scored, SC B1 for 56 WWW.
	Probability = $\frac{\text{their } 56}{\text{their}(c)} = \frac{56}{126}, \frac{4}{9}, 0.444$	B1 FT	FT <i>their</i> 56 from adding 2 or more scenarios in numerator and <i>their</i> (c) or correct as denominator.
		4	

Question	Answer	Marks	Guidance																									
6(a)	<table><tr><td>Rebels</td><td></td><td></td><td>Sharks</td></tr><tr><td></td><td>6</td><td>6</td><td>8</td></tr><tr><td>9 8 5</td><td>7</td><td>1 2 4 5 5 6</td><td>8</td></tr><tr><td>9 6 5 4 3 2 2 0</td><td>8</td><td>3 3 4 5 6</td><td></td></tr><tr><td>9 5 3</td><td>9</td><td>2</td><td></td></tr><tr><td></td><td>2</td><td>10</td><td></td><td></td></tr></table>	Rebels			Sharks		6	6	8	9 8 5	7	1 2 4 5 5 6	8	9 6 5 4 3 2 2 0	8	3 3 4 5 6		9 5 3	9	2			2	10			B1	Correct stem, ignore extra values (not in reverse).
	Rebels			Sharks																								
		6	6	8																								
	9 8 5	7	1 2 4 5 5 6	8																								
	9 6 5 4 3 2 2 0	8	3 3 4 5 6																									
9 5 3	9	2																										
	2	10																										
		B1	Correct Rebels labelled on left, leaves in order from right to left and lined up vertically, no commas.																									
		B1	Correct Sharks labelled on same diagram, leaves in order and lined up vertically, no commas.																									
	Key: 8 7 2 means 78 kg for Rebels and 72 kg for Sharks	B1	Correct key for their diagram, need both teams identified and ‘kg’ stated at least once here or in leaf headings or title. SC If 2 separate diagrams drawn, SC B1 if both keys meet these criteria.																									
		4																										

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Question	Answer	Marks	Guidance
6(b)	Median = 84 (kg)	B1	
	[UQ = 93, LQ = 80] 93 – 80	M1	$95 \leq \text{UQ} \leq 89 - 79 \leq \text{LQ} \leq 82$
	[IQR =] 13 (kg)	A1	WWW
		3	
6(c)	Box and whisker with end points 75 and 102	B1	Whiskers drawn to correct end points not through box, not joining at top or bottom of box.
	Median and quartiles plotted as found in (b)	B1 FT	Quartiles and median plotted as box graph.
		2	
6(d)	e.g. Average weight of Rebels is higher than average weight of Sharks	B1	Acceptable answers refer to: Range, skew, central tendency within context. E.g. range of Rebels is greater B0 . Range of weights of the rebels is greater B1 . Simple value comparison insufficient.
		1	

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Question	Answer	Marks	Guidance
7(a)(i)	$P(X > 142) = P\left(Z > \frac{142 - 125}{24}\right)$	M1	Substitution of correct values into the $\pm$ Standardisation formula, allow continuity correction, not σ^2 , $\sqrt{\sigma}$.
	$[= P(Z > 0.7083) =] 1 - 0.7604$	M1	Appropriate numerical area Φ , from final process, must be probability, expect $p < 0.5$.
	0.2396	A1	$0.239 \leq p \leq 0.240$ to at least 3sf.
	<i>Their</i> $0.2396 \times 365 [= 87.454]$	M1	FT <i>their</i> 4sf (or better) probability.
	87 or 88	A1 FT	Final answer must be positive integer, no indication of approximation/rounding, only dependent on previous M mark. SC B1 FT for <i>their</i> 3sf probability $\times 365$ = integer value, condone 0.24 used.
		5	
7(a)(ii)	$P(0, 1) = 0.7604^{10} + {}^{10}C_1 \times 0.2396^1 \times 0.7604^9$ $[= 0.064628 + 0.20364]$	M1	One term: ${}^{10}C_x p^x (1 - p)^{10-x}$ for $0 < x < 10$, any p .
		A1 FT	Correct unsimplified expression using <i>their</i> probability to at least 3sf from (a)(i) or correct.
	0.268	A1	AWRT, WWW.
		3	
7(b)	$z = \pm 1.282$	B1	Correct value only, critical value.
	$\frac{t - 125}{24} = -1.282$	M1	Use of $\pm$ Standardisation formula with correct values substituted, allow continuity correction, σ^2 , $\sqrt{\sigma}$, to form an equation with a z -value and not probability.
	$t = 94.2$	A1	AWRT, condone AWRT 94.3. Not dependent on B mark.
		3	



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1(a)	$\frac{82}{180}, \frac{41}{90}, 0.456$	B1	
		1	
1(b)	$\left[P(M D) = \frac{P(M \cap D)}{P(D)} \right] = \frac{\frac{11}{180}}{\frac{20}{180} + \frac{11}{180}} \text{ or } \frac{0.6011}{0.1722}$	M1	<i>Their identified</i> $\frac{P(M \cap D)}{P(D)}$ <i>or from data table</i> $\frac{11}{20+11}$, accept unsimplified, condone $\times 180$.
	$\frac{11}{31}, 0.355$	A1	Final answer.
		2	

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Question	Answer	Marks	Guidance
1(c)	$P(F) = \frac{100}{180}, \frac{5}{9}, 0.5556$ OE $P(G) = \frac{82}{180}, \frac{41}{90}, 0.4556$ OE $P(F \cap G) = \frac{38}{180}, \frac{19}{90}, 0.2111$ OE $P(F) \times P(G) = \frac{100}{180} \times \frac{82}{180} = \frac{41}{162}, 0.2531$ OE $\left[\neq \frac{38}{180} \right]$ Not independent	M1	<i>Their</i> identified $P(F) \times \textit{their}$ identified $P(G)$ or correct seen, can be unsimplified.
		A1	$\frac{41}{162}, \frac{38}{180}, P(F \cap G)$ and $P(F) \times P(G)$ seen with correct conclusion, WWW. Values and labels must be seen.
	Alternative method for question 1(c)		
	$P(F \cap G) = \frac{38}{180}, \frac{19}{90}, 0.2111$ OE $P(G) = \frac{82}{180}, \frac{41}{90}, 0.4556$ OE $P(F G) = \frac{\frac{38}{180}}{\frac{82}{180}} = \frac{19}{41}, 0.4634$ OE $\neq P(F) = \frac{100}{180}, \frac{5}{9}, 0.5556$ OE Not independent	M1	$P(F G)$ (OE) unsimplified with <i>their</i> identified probs or correct
		A1	$\frac{19}{41}, \frac{100}{180}, P(F \cap G)$ and $P(F G)$ seen with correct conclusion WWW. Values and labels must be seen.
		2	

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Question	Answer	Marks	Guidance
2(a)	${}^{11}\text{C}_5 \times {}^4\text{C}_1$	M1	${}^{11}\text{C}_5 \times {}^4\text{C}_1$ condone ${}^{11}\text{P}_5 \times {}^4\text{P}_1$ no +, −, × or ÷.
	1848	A1	CAO as exact.
		2	
2(b)	Method 1 [Identifying scenarios]		
	[Neither selected =] ${}^{13}\text{C}_6$ [= 1716] [Only Jane selected =] ${}^{13}\text{C}_5$ [= 1287] [Only Kate selected =] ${}^{13}\text{C}_5$ [= 1287]	M1	Either ${}^{13}\text{C}_6$ seen alone or ${}^{13}\text{C}_5$ seen alone or × 2 (condone ${}^{13}\text{P}_n$, $n = 5, 6$).
	[Total =] $1716 + 1287 + 1287$	M1	Three correct scenarios only added, accept unsimplified (values may be incorrect).
	4290	A1	
	Method 2 [Total number of selections – selections with Jane and Kate both picked]		
	${}^{15}\text{C}_6 - {}^{13}\text{C}_4$ [= 5005 – 715]	M1	${}^{15}\text{C}_6 - k$, k a positive integer < 5005, condone ${}^{15}\text{P}_6$.
		M1	$m - {}^{13}\text{C}_4$, m integer > 715, condone $n - {}^{13}\text{P}_4$, $n > 17\ 160$.
	4290	A1	
		3	
			SC Where the condition of 2(a) is also applied in 2(b) , the final answer is 1512 SC M1 M1 A0 max. The method marks can be earned for the equivalent stages in each method. Method 1 ${}^4\text{C}_1 \times {}^9\text{C}_5 + {}^4\text{C}_1 \times {}^9\text{C}_4 \times 2$ Method 2 ${}^4\text{C}_1 \times {}^{11}\text{C}_5 - {}^4\text{C}_1 \times {}^9\text{C}_3$

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Question	Answer	Marks	Guidance
3(a)	For one yellow: YGG + GYG + GGY $\frac{5}{9} \times \frac{4}{8} \times \frac{3}{7} \times 3$	M1	$\frac{a}{9} \times \frac{b}{8} \times \frac{c}{7}, 0 < a, b, c \text{ integers} \leq 5$, for one arrangement.
		M1	<i>Their</i> three-factor probability $\times 3$, ${}^3C_1$, ${}^3C_2$ or ${}^3P_1$, (or repeated adding) no additional terms.
	$\left[\frac{180}{504} = \right] \frac{5}{14}$	A1	AG. Convincingly shown, including identifying possible scenarios, may be on tree diagram WWW.
		3	
	Alternative method for question 3(a)		
	$\frac{{}^5C_1 \times {}^4C_2}{{}^9C_3}$	M1	$\frac{{}^5C_1 \times {}^4C_2}{{}^9C_r}, r = 2, 3, 4$
		M1	$\frac{{}^5C_s \times {}^4C_t}{{}^9C_3}, s + t = 3$
	$\left[\frac{30}{84} = \right] \frac{5}{14}$	A1	AG. Convincingly shown, WWW.
		3	

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Question	Answer					Marks	Guidance
3(b)	X	0	1	2	3	B1	Table with correct X values and one correct probability inserted appropriately. Condone any additional X values if probability stated as 0.
	$P(X)$	$\frac{24}{504}$ $\left[= \frac{1}{21}, \right.$ $\left. 0.0476 \right]$	$\frac{180}{504}$ $\left[= \frac{5}{14}, \right.$ $\left. 0.357 \right]$	$\frac{240}{504}$ $\left[= \frac{10}{21}, \right.$ $\left. 0.476 \right]$	$\frac{60}{504}$ $\left[= \frac{5}{42}, \right.$ $\left. 0.119 \right]$	B1	Second identified correct probability, may not be in table.
						B1	All probabilities identified and correct . SC if less than 2 correct probabilities or X value(s) omitted: SC B1 3 or 4 probabilities summing to one.
						3	
3(c)	$[E(X) =] \frac{840}{504}, \frac{5}{3}, 1.67$					B1	OE Must be evaluated. SC B1 FT correct unsimplified expression from incorrect 3(b) using at least 3 probabilities, $0 < p < 1$.
						1	

Question	Answer	Marks	Guidance
4(a)	$\frac{9!}{3!}$	M1	$\frac{9!}{e!}, e = 2, 3$
	60 480	A1	
		2	

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Question	Answer	Marks	Guidance
4(b)	$\frac{7!}{3!} \times 2 \times 6$	M1	$\frac{7!}{3!} \times k$ seen, k an integer > 0 .
		M1	$\frac{m!}{n!} \times 2 \times q$ $7 \leq m \leq 9, 1 \leq n \leq 3, 1 \leq q \leq 8$ all integers.
		M1	$\frac{m!}{n!} \times p \times 6$ $7 \leq m \leq 9, 1 \leq n \leq 3, 1 \leq p \leq 2$ all integers. (Accept 3P2 for 6) If M0 M0 M0 awarded, SC M1 for $t \times 12$, t an integer ≥ 20 , $\frac{5!}{3!}$.
	10 080	A1	Exact value.
	Alternative method for question 4(b)		
	$\frac{{}^7P_2 \times 6! \times 2}{3!}$	M1	$\frac{6!}{3!} \times k$ seen, k an integer > 0 .
		M1	$\frac{m!}{n!} \times {}^7P_2 \times q$ $m = 6, 9, 1 \leq n \leq 3, 1 \leq q \leq 2$ all integers.
		M1	$\frac{m!}{n!} \times {}^7P_r \times 2$ $m = 6, 9, 1 \leq n \leq 3, 1 \leq r \leq 5$ all integers. If M0 M0 M0 awarded, SC M1 for $t \times 84$, t an integer ≥ 20 , $\frac{5!}{3!}$.
	10 080	A1	Exact value.

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Question	Answer	Marks	Guidance
4(b)	Alternative method for question 4(b)		
	$\frac{7!}{3!} \times 4P_2$	M1	$\frac{7!}{3!} \times k$ seen, k an integer > 0 .
		M1	$t \times {}^4P_2$ or 12, t an integer ≥ 20 , $\frac{5!}{3!}$.
		M1	$\frac{m!}{n!} \times 4P_2$ $7 \leq m \leq 9$, $1 \leq n \leq 3$ all integers.
	10 008	A1	Exact value.
		4	

Question	Answer	Marks	Guidance
5(a)	$[P(0, 1, 2) = {}^{10}C_0 0.16^0 0.84^{10} + {}^{10}C_1 0.16^1 0.84^9 + {}^{10}C_2 0.16^2 0.84^8$ $[= 0.17490 + 0.333145 + 0.28555]$	M1	One term: ${}^{10}C_x p^x (1-p)^{10-x}$ for $0 < x < 10$, any p .
		A1	Correct unsimplified expression, or better.
	0.794	A1	$0.7935 < p \leq 0.794$, mark at most accurate. If M0 scored, SC B1 for final answer 0.794.
		3	
5(b)	$(0.84)^7 0.16$	M1	$(1-p)^7 p$, $0 < p < 1$
	0.0472	A1	0.0472144 to at least 3sf.
		2	

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Question	Answer	Marks	Guidance
5(c)	$4 \times 0.0472 \times (1 - 0.0472)^3$	M1	$4 \times q(1 - q)^3$, $q = \text{their (b)}$ or correct.
	0.163	A1	$0.163 \leq p \leq 0.1634$, mark at most accurate from <i>their</i> probability to at least 3sf.
		2	

Question	Answer	Marks	Guidance
6(a)	$\left[P(X > 28.6) = \right] P\left(Z > \frac{28.6 - 32.2}{9.6} \right)$ $\left[= P(Z > -0.375) \right]$	M1	28.6, 32.2 and 9.6 substituted appropriately in $\pm$ Standardisation formula once, allow continuity correction of ± 0.05 , no σ^2 , $\sqrt{\sigma}$.
	$[\Phi(\text{their } 0.375) =] \text{ their } 0.6462$	M1	Appropriate numerical area, from final process, must be probability, expect > 0.5 .
	0.646	A1	AWRT
		3	
6(b)	$z = \pm 0.842$	B1	$0.841 < z \leq 0.842$ or $-0.842 \leq z < -0.841$ seen.
	$\frac{t - 32.2}{9.6} = 0.842$	M1	Substituting 32.2 and 9.6 into $\pm$ standardisation formula, no continuity correction, allow σ^2 , $\sqrt{\sigma}$, must be equated to a z-value.
	$t = 40.3$	A1	$40.28 \leq t \leq 40.3$ WWW
		3	

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Question	Answer	Marks	Guidance
6(c)	$P\left(-\frac{15}{9.6} < Z < \frac{15}{9.6}\right)$ $P(-1.5625 < Z < 1.5625)$	M1	Identifying at least one of $\frac{15}{9.6}$ and $-\frac{15}{9.6}$ as the appropriate z-values or substituting <i>their</i> (32.2 ± 15) into $\pm$ Standardisation formula once, no continuity correction, σ^2 nor $\sqrt{\sigma}$. Condone ± 1.563 for M1 .
	$\left[2 \Phi\left(\frac{15}{9.6}\right) - 1\right]$ $= 2 \times 0.9409 - 1$	A1	$p = 0.941$ AWRT SOI
		M1	Appropriate area $2\Phi - 1$ oe, (eg $1 - 2 \times 0.0591$, $2 \times (0.9409 - 0.5)$ or $0.9409 - 0.0591$), from final process, must be probability > 0.5 .
	0.882	A1	
		4	

Question	Answer	Marks	Guidance
7(a)	Cumulative frequency graph drawn	B1	Axes labelled ‘cumulative frequency’ (or cf) from 0 to at least 140 and ‘distance (or d) [in] m’ from 0 to at least 1600, linear scales with at least 3 values stated.
		B1	All plotted correctly at correct upper end points (200 etc.) curve drawn accurately joined to (0, 0) (straight line segments B0) but no daylight above 140. Cf scale no less than 2 cm = 20 children .
		2	

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Question	Answer	Marks	Guidance
7(b)	[UQ at 75% of 140 = 105, LQ at 25% of 140 = 35] [IQR:] 700 – 260	M1	Accept $660 \leq \text{UQ} \leq 720 - 240 \leq \text{LQ} \leq 290$. If values are outside our range, FT providing scales linear and increasing cf drawn.
	440	A1	Accept correct evaluation of $660 \leq \text{their UQ} \leq 720 - 240 \leq \text{their LQ} \leq 290$ with clear indication that graph has been used for at least one of 105 or 35.
		2	

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Question	Answer	Marks	Guidance														
7(c)	$\frac{[Mean =] 16 \times 100 + 30 \times 250 + 42 \times 400 + 34 \times 700 + 12 \times 1050 + 6 \times 1400}{140}$	B1	<table border="1"><tr><td>Frequencies</td><td>16</td><td>30</td><td>42</td><td>34</td><td>12</td><td>6</td></tr><tr><td>Mid-points</td><td>100</td><td>250</td><td>400</td><td>700</td><td>1050</td><td>1400</td></tr></table> 5 or 6 correct frequency values seen.	Frequencies	16	30	42	34	12	6	Mid-points	100	250	400	700	1050	1400
		Frequencies	16	30	42	34	12	6									
		Mid-points	100	250	400	700	1050	1400									
		B1	5 or 6 correct midpoint values seen.														
M1	Values substituted into mean formula using <i>their</i> midpoints which must be in the class – condone 1 data error. Accept $\frac{1600 + 7500 + 16\,800 + 23\,800 + 12\,600 + 8400}{140}$ or $\frac{70\,700}{140}$. Condone $\frac{70\,770}{140}$ for M1 .																
	505	A1	WWW														
	Variance = $\frac{16 \times 100^2 + 30 \times 250^2 + 42 \times 400^2 + 34 \times 700^2 + 12 \times 1050^2 + 6 \times 1400^2}{140}$ -505^2	M1	Values substituted into variance formula using (<i>their</i> mean) ² and <i>their</i> midpoints and <i>their</i> frequencies (including for denominator). Accept unsimplified. Condone 1 data error. Accept: $\left[\frac{160\,000 + 1\,875\,000 + 6\,720\,000 + 16\,660\,000 + 13\,230\,000 + 11\,760\,000}{140} \right]$ or $\frac{50\,405\,000}{140}$ or 360 035.7143] – [505 ² or 255 025] If formula stated accept 105 010 or 105 011 WWW.														
	S.d. = $\left[\sqrt{105\,010.7} \right] 324$	A1	WWW														
		6															



Cambridge International AS & A Level

MATHEMATICS

9709/53

Paper 5 Probability & Statistics 1

October/November 2021

MARK SCHEME

Maximum Mark: 50

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2021 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **13** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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Mathematics Specific Marking Principles	
1	Unless a particular method has been specified in the question, full marks may be awarded for any correct method. However, if a calculation is required then no marks will be awarded for a scale drawing.
2	Unless specified in the question, answers may be given as fractions, decimals or in standard form. Ignore superfluous zeros, provided that the degree of accuracy is not affected.
3	Allow alternative conventions for notation if used consistently throughout the paper, e.g. commas being used as decimal points.
4	Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored (isw).
5	Where a candidate has misread a number in the question and used that value consistently throughout, provided that number does not alter the difficulty or the method required, award all marks earned and deduct just 1 mark for the misread.
6	Recovery within working is allowed, e.g. a notation error in the working where the following line of working makes the candidate's intent clear.

Mark Scheme Notes

The following notes are intended to aid interpretation of mark schemes in general, but individual mark schemes may include marks awarded for specific reasons outside the scope of these notes.

Types of mark

- M** Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.
- A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).
- B** Mark for a correct result or statement independent of method marks.
- DM or DB** When a part of a question has two or more ‘method’ steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly, when there are several B marks allocated. The notation DM or DB is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
- FT** Implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only.
- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
 - For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures if rounded (1 decimal place for angles in degrees).
 - The total number of marks available for each question is shown at the bottom of the Marks column.
 - Wrong or missing units in an answer should not result in loss of marks unless the guidance indicates otherwise.
 - Square brackets [] around text or numbers show extra information not needed for the mark to be awarded.

Abbreviations

AEF/OE	Any Equivalent Form (of answer is equally acceptable) / Or Equivalent
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
CAO	Correct Answer Only (emphasising that no ‘follow through’ from a previous error is allowed)
CWO	Correct Working Only
ISW	Ignore Subsequent Working
SOI	Seen Or Implied
SC	Special Case (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)
WWW	Without Wrong Working
AWRT	Answer Which Rounds To

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Question	Answer	Marks	Guidance
1	$^{23}\text{C}_{17}$	M1	$^{23}\text{C}_x$ or $^y\text{C}_{17}$ or $^z\text{C}_6$, x , y or z are integers no $+$, $-$, $\times$ or $\div$.
	100947	A1	CAO
		2	

Question	Answer	Marks	Guidance																																																							
2(a)	<table><tr><td colspan="4">Lakeview</td><td></td><td colspan="6">Riverside</td></tr><tr><td>9</td><td>4</td><td>0</td><td>1</td><td>8</td><td>8</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>8</td><td>7</td><td>6</td><td>2</td><td>2</td><td>0</td><td>1</td><td>3</td><td>4</td><td>5</td><td>5</td></tr><tr><td></td><td>3</td><td>2</td><td>0</td><td>3</td><td>0</td><td>6</td><td>7</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td>1</td><td>4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr></table> Key: 6 2 3 means 26m for Lakeview and 23m for Riverside	Lakeview					Riverside						9	4	0	1	8	8						8	7	6	2	2	0	1	3	4	5	5		3	2	0	3	0	6	7						1	4								B1	Correct stem, ignore extra values.
	Lakeview					Riverside																																																				
	9	4	0	1	8	8																																																				
	8	7	6	2	2	0	1	3	4	5	5																																															
		3	2	0	3	0	6	7																																																		
		1	4																																																							
B1	Correct Lakeview labelled on left, leaves in order from right to left and lined up vertically, no commas.																																																									
B1	Correct Riverside labelled on same diagram, leaves in order and lined up vertically, no commas.																																																									
B1	Correct key for their diagram, need both teams identified and ‘m’ stated at least once here or in leaf headings or title. SC If 2 separate diagrams drawn: SC B1 if both keys meet these criteria.																																																									
		4																																																								
2(b)	UQ = 32, LQ = 19	M1	$(30 \leq \text{UQ} \leq 33) - (14 \leq \text{LQ} \leq 22)$																																																							
	IQR = 32 – 19 = 13	A1	WWW																																																							
		2																																																								

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Question	Answer	Marks	Guidance
3(a)	Cw: 5 5 10 10 20	M1	At least 4 frequency densities calculated (f/cw), accept unsimplified and class widths ± 1 of true values. May be implied by graph.
	Fd: 4.6 20.4 13.5 7.6 1.2	A1	All heights correct on graph NOT FT
		B1	Bar ends at 0, 5, 10, 20, 30, 50 clear intention not to draw at 4.5 or 5.5 etc.
		B1	Axes labelled: Frequency density (fd), time (t) and mins (or appropriate title). Linear scales between 0 and 20.4 or above on vertical axis, and 0 and 50 or above on the horizontal axis. (Axes may be reversed.)
		4	
3(b)	$\frac{2.5 \times 23 + 7.5 \times 102 + 15 \times 135 + 25 \times 76 + 40 \times 24}{360}$	M1	Uses at least 4 midpoint attempts (e.g. 2.5 ± 0.5) in correct formula, accept unsimplified expression, denominator either correct or <i>their</i> Σ frequencies .
	$\left[\frac{5707.5}{360} = \right] 15.9, 15\frac{41}{48}$	A1	Evaluated.
		2	

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Question	Answer	Marks	Guidance
4(a)	$P(X > 43.2) = P\left(Z > \frac{43.2 - 41.2}{3.6}\right) = P(Z > 0.5556)$	M1	Use of $\pm$ Standardisation formula once, allow continuity correction, not σ^2 , $\sqrt{\sigma}$.
	$1 - \Phi(0.5556) = 1 - 0.7108$	M1	Appropriate area Φ , from final process, must be probability.
	0.289	A1	AWRT
		3	
4(b)	Probability = $1 - \text{their (a)} = 1 - 0.2892 = 0.7108$	B1FT	$1 - \text{their (a)}$ or correct.
	$0.7108 \times 365 = 259.4$ 259, 260	B1FT	FT <i>their</i> 4SF (or better) probability, final answer must be positive integer.
		2	
4(c)	$z = \pm 1.645$	B1	CAO, critical z value.
	$\frac{t - 41.2}{3.6} = -1.645$	M1	Use of $\pm$ standardisation formula with μ , σ equated to a z -value, no continuity correction, allow σ^2 , $\sqrt{\sigma}$.
	$t = 35.3$	A1	
		3	

Question	Answer	Marks	Guidance
5(a)	${}^5P_2 \times {}^7P_4$ or $5 \times 4 \times 7 \times 6 \times 5 \times 4$	M1	${}^5P_x \times {}^7P_y$, $1 \leq x \leq 4$, $1 \leq y \leq 6$
	16 800	A1	
		2	

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Question	Answer	Marks	Guidance
5(b)	Method 1 [Identify scenarios]		
	With A and no 5: $8 \times {}^6P_4$ or $(1 \times 4 \times 6 \times 5 \times 4 \times 3) \times 2$ or $4C1 \times 2! \times 6P4 = 2880$	M1	One number of ways correct, accept unsimplified.
	With 5 and no A: ${}^4P_2 \times 4 \times {}^6P_3$ or $(4 \times 3 \times 1 \times 6 \times 5 \times 4) \times 4$ or $4P2 \times 6C3 \times 4! = 5760$	M1	Add 2 or 3 identified correct scenarios only, accept unsimplified.
	With A and 5: $8 \times 4 \times {}^6P_3$ or $(4 \times 1 \times 1 \times 6 \times 5 \times 4) \times 8$ or $4C1 \times 2! \times 6C3 \times 4! = 3840$		
	[Total =] 12 480	A1	CAO
	Method 2 [total number of codes – number of codes with no A or 5]		
	No A or 5 : $(4 \times 3) \times (6 \times 5 \times 4 \times 3) = 4320$	M1	${}^4P_2 \times {}^6P_4$ or ${}^4C_2 \times {}^6C_4$ seen, accept unsimplified.
	Required number = <i>their (a)</i> – <i>their</i> 4320	M1	<i>Their 5(a)</i> (or correct) – <i>their</i> (No A or 5) value.
	12 480	A1	
	Method 3 [subtracting double counting]		
	With A ${}^4P_1 \times {}^7P_4 \times 2$ or ${}^4C_1 \times 2 \times {}^7C_4 \times 4! = 6720$ With 5 ${}^5P_2 \times {}^6P_3 \times 4$ or ${}^5C_2 \times 2 \times {}^6C_3 \times 4! = 9600$ With A and 5 = ${}^4P_1 \times {}^6P_3 \times 8$ or $4C1 \times 2! \times 6C3 \times 4! \times 8 = 3840$	M1	One outcome correct, accept unsimplified.
	Required number = $6720 + 9600 - 3840$	M1	Adding ‘with a’ to ‘with 5’ and subtracting ‘A and 5’.
	12 480	A1	CAO
		3	

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Question	Answer	Marks	Guidance
5(c)	Method 1 – number of successful codes divided by total		
	$(1 \times) 3 \times {}^5P_2$	M1	$3 \times {}^5P_n, n = 2, 3$. Condone $3 \times {}^5C_2$, no + or –.
	Probability = $\frac{\text{their } 3 \times 5P2}{\text{their } 16\,800}$	M1	Probability = $\frac{\text{their } 60}{\text{their } 16\,800}$.
	$\frac{1}{280}, 0.00357$	A1	
	Method 2 – product of probabilities of each part of code		
	$\frac{1}{5} \times \frac{1}{4} \times \frac{1}{7} \times \frac{3}{6} \left(\times \frac{5}{5} \times \frac{4}{4} \right)$ or $\frac{1}{5} \times \frac{1}{4} \times \frac{3 \times 5P2}{7P4}$	M1	$\frac{1}{5} \times \frac{1}{4} \times k$ where $0 < k < 1$ for considering letters.
		M1	$t \times \frac{1}{7} \times \frac{3}{6}$ or $t \times \frac{3 \times 5P2}{7P4}$ where $0 < t < 1$.
	$\frac{1}{280}$	A1	CAO
		3	

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Question	Answer	Marks	Guidance
6(a)	$p + q + 0.65 = 1$	B1	Sum of probabilities = 1.
	$p + 2q + 0.15 = 0.55$	B1	Use given information.
	Solve 2 linear equations	M1	Either a single expression with one variable eliminated formed or two expressions with both variables on the same side seen with at least one variable value stated.
	$p = 0.3, \frac{3}{10}, q = 0.05, \frac{1}{20}$	A1	CAO, both WWW If M0 with correct answers SC B1 .
		4	
6(b)	$\text{Var}(X) = \text{their } 0.3 + 4 \times \text{their } 0.05 + 9 \times 0.05 - 0.55^2$	M1	Appropriate variance formula including $(E(X))^2$, accept unsimplified.
	$0.6475 \left[\frac{259}{400} \right]$	A1	CAO (must be exact).
		2	
6(c)	$1 - P(0, 1, 2) = 1 - ({}^{12}C_0 0.3^0 0.7^{12} + {}^{12}C_1 0.3^1 0.7^{11} + {}^{12}C_2 0.3^2 0.7^{10})$	M1	One correct term: ${}^{12}C_x p^x (1 - p)^{12-x}$ for $0 < x < 12$, $0 < p < 1$.
	$1 - (0.01384 + 0.07118 + 0.16779)$	A1FT	Correct unsimplified expression, or better in final answer. Unsimplified expression must be seen to FT <i>their p</i> from 6(a) or correct.
	0.747	A1	
		3	
6(d)	$(0.95)^8 \times 0.05 = 0.0332$ or $0.95^8 - 0.95^9 = 0.0332$	B1	Evaluated.
		1	

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Question	Answer	Marks	Guidance
7(a)	Probabilities: $\frac{x+1}{x+10}$, $\frac{9}{x+10}$, $\frac{x}{x+10}$, $\frac{10}{x+10}$	B1	One probability correct in correct position.
		B1	Another probability correct in correct position.
		B1	Other two probabilities correct in correct positions.
		3	
7(b)	$\frac{4}{10} \times \text{their } \frac{10}{x+10}$	M1	Method consistent with <i>their</i> tree diagram.
	$\frac{4}{x+10}$	A1	AG
		2	

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Question	Answer	Marks	Guidance
7(c)	$\frac{4}{x+10} = \frac{1}{6}$ $x+10=24, \quad x=14$	B1	Find value of x . Can be implied by correct probabilities in calculation.
	$P(\text{ARed} \text{BRed}) = P(\text{ARed} \cap \text{BRed}) \div P(\text{BRed})$ $\frac{\frac{6}{10} \times \text{their} \frac{x+1}{x+10}}{\frac{6}{10} \times \text{their} \frac{x+1}{x+10} + \frac{4}{10} \times \text{their} \frac{x}{x+10}} = \frac{\frac{6}{10} \times \frac{15}{24}}{\frac{6}{10} \times \frac{15}{24} + \frac{4}{10} \times \frac{14}{24}} = \frac{\frac{3}{8}}{\frac{73}{120}}$	B1 FT	$\frac{6}{10} \times \text{their} \frac{x+1}{x+10}$ as numerator or denominator of fraction.
		M1	$\frac{6}{10} \times \text{their} \frac{x+1}{x+10} + \frac{4}{10} \times \text{their} \frac{x}{x+10}$ seen anywhere.
		A1 FT	Seen as denominator of fraction.
	$\frac{45}{73}, 0.616[4\dots]$	A1	If B0 M0: SC B1 for $\frac{\frac{3}{8}}{\frac{73}{120}}$ or $\frac{0.375}{0.6083}$ SC B1 $\frac{45}{73}$ or 0.616.
		5	