Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/53**

Paper 5 Probability & Statistics 1 **October/November 2022**

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 2022 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

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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.

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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.

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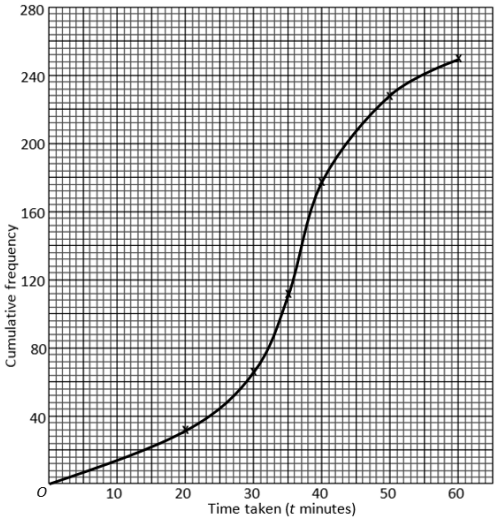
Abbreviations

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	$\sum x - 50\times 20 = 35\,;\ \sum x = 1035$ **or** $\bar{x} = \frac{35}{50} + 20 = \frac{1035}{50}$ [= 20.7]	**B1**	Correct value for $\sum x$ or $\bar{x}$.
	$\frac{25036}{50} - \left(\frac{\sum x}{50}\right)^2 = \frac{25036}{50} - \left(\frac{1035}{50}\right)^2$	**M1**	$\frac{25036}{50} - \left(their\left(\frac{\sum x}{50}\right)^2\right)$
	72.23	**A1**	Exact answer only **SC B1** for 72.23 with no substitution in formula.
		3	

Question	Answer	Marks	Guidance
2	Mean = $80\times 0.32 = 25.6$, $\text{var} = 80\times 0.32\times 0.68 = 17.408$	**B1**	25.6 and 17.4[08] seen, allow unsimplified. 4.172… implies correct variance.
	$P(X < 20) = P\left(Z < \frac{19.5 - 25.6}{\sqrt{17.408}}\right) = P(Z < -1.462)$	**M1**	Substituting *their* 25.6 and 17.408 into ±standardisation formula (any number for 19·5), not σ^2, $\sqrt{\sigma}$.
		M1	Using continuity correction 19·5 or 20·5 in *their* standardisation formula.
	$= [1 - \Phi(1.462)] = 1 - 0.9282$	**M1**	Appropriate area Φ, from final process, must be probability. (Expect final ans < 0·5). Note: the correct final answer may imply M1 from use of calculator.
	0.0718	**A1**	$0.0718 \leqslant p \leqslant 0.0719$
		5	

Question	Answer	Marks	Guidance
3(a)	Cumulative frequency graph  	**M1**	At least 3 points plotted accurately at class upper end points: (20,32), (30, 66), (35, 112), (40, 178), (50, 228), (60, 250). Linear cf scale $0 \leqslant cf \leqslant 250$ and linear time scale $0 \leqslant time \leqslant 60$ with at least 3 values identified on each.
		A1	All points plotted correct, curve drawn (within tolerance) and joined to (0,0). Axes labelled cumulative frequency (cf), time (t) and minutes (min or m) – or a suitable title. Axes can be the other way round.
		2	
3(b)	Line drawn from 150 on cf axis to meet graph at about t =38 minutes	**B1 FT**	Must be an increasing cf graph with correct upper bounds. Use of graph must be seen. Expect an answer in range $37 \leqslant t \leqslant 39$ for a correct graph
		1	

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Question	Answer	Marks	Guidance
3(c)	[Frequencies] [32] 34 46 66 50 22	**B1**	May be unsimplified and/or in variance calculation.
	[Midpoints] 10 25 32.5 37.5 45 55	**M1**	At least 5 correct midpoints seen , may be unsimplified.
	[Variance] = $\dfrac{32\times10^2+34\times25^2+46\times32.5^2+66\times37.5^2+50\times45^2+22\times55^2}{250}-34.4^2$ [= $\dfrac{333650}{250}-34.4^2=151.24$]	**M1**	Correct unsimplified Variance formula with *their* midpoints and *their* frequencies for var or sd. (− mean^2 included)
	[Sd =] 12.3	**A1**	Awrt WWW **SC B1** for 12.3 if second M1 not awarded.
		4	

Question	Answer	Marks	Guidance
4(a)	**Method 1: Scenarios identified**		
	[no of ways for score of 2 are] 222, 211, 212, 221, 122, 112, 121 [Total options = 64]	**B1**	7 correct scenarios identified, no incorrect.
	[So P(X = 2) =] $\frac{7}{4\times4\times4} = \frac{7}{64}$	**M1**	$\frac{a}{4\times4\times4}$, a = *their* number of correct identified scenarios > 4
		A1	Approach identified, WWW.
	Method 2: P(2 on all spinners) + P(2 on two spinners and 1 on one spinner) + P(2 on one spinner and 1 on two spinners)		
	$\left(\frac{1}{4}\right)^3 + {}^3C_2\left(\frac{1}{4}\times\frac{1}{4}\times\frac{1}{4}\right) + {}^3C_1\left(\frac{1}{4}\times\frac{1}{4}\times\frac{1}{4}\right)$	**B1**	$\left(\frac{1}{4}\right)^3 + {}^3C_2\left(or\ {}^3C_1\right)\left(\frac{1}{4}\times\frac{1}{4}\times\frac{1}{4}\right) + d$, $0 < d < 1$
		M1	$\left(\frac{1}{4}\right)^3 + e\left(\frac{1}{4}\right)^3 + f\left(\frac{1}{4}\right)^3$ $1 < e < 5$ and $1 < f < 5$
	[So P(X = 2) =] = $\frac{7}{64}$	**A1**	Approach identified, WWW.

Question	Answer	Marks	Guidance
	Method 3: P(1 or 2 on each spinner) – P(1 on all spinners)		
	$\left(\frac{1}{2}\right)^3 - \left(\frac{1}{4}\right)^3$	**B1**	$\left(\frac{1}{2}\right)^3 - b$ seen, $0 < b < 1$
		M1	$\left(\frac{1}{2}\right)^3 - c^3$, $0 < c < ½$
	[So P($X = 2$) =] $\frac{7}{64}$	**A1**	Approach identified, WWW.
		3	
4(b)	$P(X = 1) = \frac{1}{64}$	**B1**	P($X = 1$) or P($X = 4$) correct. Condone answers not in probability distribution table if clearly identified.
	$P(X = 4) = \left[1 - \frac{1}{64} - \frac{7}{64} - \frac{19}{64} = \right]\frac{37}{64}$	**B1 FT**	All 4 probabilities summing to 1.
		2	
4(c)	$P(Y = 6) = \left[\left(\frac{3}{4}\right)^5 \times \frac{1}{4} = \right] 0.0593, \frac{243}{4096}$	**B1**	Accept 0.059326… to 4 or more SF.
		1	

Question	Answer	Marks	Guidance
4(d)	$\left(\frac{3}{4}\right)^4$	**M1**	$\left(\frac{3}{4}\right)^g$, $g = 4, 5$ **or** p^4 where $0 < p < 1$
	$= \frac{81}{256}, 0.316$	**A1**	Accept 0.316406…to 4 or more SF.
	Alternative method for Question 4(d)		
	$P(Y > 4) = 1 - P(Y \leqslant 4) = 1 - \left(\frac{1}{4} + \frac{3}{4} \times \frac{1}{4} + \left(\frac{3}{4}\right)^2 \times \frac{1}{4} + \left(\frac{3}{4}\right)^3 \times \frac{1}{4}\right)$ $\left[= 1 - \frac{175}{256}\right]$	**M1**	Correct or $1 - \left(\frac{1}{4} + \frac{3}{4} \times \frac{1}{4} + \left(\frac{3}{4}\right)^2 \times \frac{1}{4} + \left(\frac{3}{4}\right)^3 \times \frac{1}{4} + \left(\frac{3}{4}\right)^4\right)$ **or** $1 - \left(p + qp + q^2p + q^3p\right)$ where $0 < p < 1$ and $q = 1 - p$
	$= \frac{81}{256}, 0.316$	**A1**	Accept 0.316406…to 4 or more SF.
		2	

Question	Answer	Marks	Guidance
5(a)	[P(0, 1, 2) =] $^{10}C_0\ 0.1^0\ 0.9^{10}\ +\ ^{10}C_1\ 0.1^1\ 0.9^9\ +\ ^{10}C_2\ 0.1^2\ 0.9^8$	**M1**	One term $^{10}C_x\ p^x\left(1-p\right)^{10-x}$, $0<p<1, x\neq 0$
	= 0.348678+0.38742+0.19371	**A1**	Correct expression, accept unsimplified.
	0.930	**B1**	$0.9298 \leqslant p \leqslant 0.9303$
	Alternative method for Question 5(a)		
	[1 – P(3, 4, 5, 6, 7, 8, 9, 10) = 1 – ($^{10}C_3\ 0.9^7\ 0.1^3\ +^{10}C_4\ 0.9^6\ 0.1^4\ +^{10}C_5\ 0.9^5\ 0.1^5\ +^{10}C_6\ 0.9^4\ 0.1^6\ +^{10}C_7\ 0.9^3\ 0.1^7\ +^{10}C_8\ 0.9^2\ 0.1^8\ +^{10}C_9\ 0.9^1\ 0.1^9\ +^{10}C_{10}\ 0.9^0\ 0.1^{10}$)	**M1**	One term $^{10}C_x\ p^x\left(1-p\right)^{10-x}$, $0<p<1, x\neq 0$
		A1	Correct expression, accept unsimplified.
	0.930	**B1**	$0.9298 \leqslant p \leqslant 0.9303$
		3	
5(b)	[P(X > 1.11) =]P($Z > \frac{1.11-1.04}{0.06}$) = P($Z$ > 1.167)	**M1**	1.11, 1.04 and 0.06 substituted into ±Standardisation formula, no continuity correction not 0.06^2 or $\sqrt{0.06}$
	= 1 – 0.8784	**M1**	1 – *their* 0.8784 as final answer, must be probability. (Expect final ans < 0·5).
	0.122	**A1**	$0.1216 \leqslant p \leqslant 0.122$ **SC M0 M1 B1** for 0.122 with no standardisation formula.
		3	

Question	Answer	Marks	Guidance
5(c)	$[P(X < w) = P(Z < \frac{w-1.04}{0.06}) = 0.81]$ $\frac{w-1.04}{0.06} = 0.878$	**B1**	$0.8775 < z \leqslant 0.878$ or $-0.878 \leqslant z < -0.8775$ seen.
		M1	1.04 and 0.06 substituted in ±standardisation formula, no continuity correction, not σ^2, $\sqrt{\sigma}$, equated to a z-value.
	$w = 1.09$	**A1**	$1.09 \leqslant w \leqslant 1.093$
		3	

Question	Answer	Marks	Guidance
6(a)	$\frac{9!}{2!2!}$	**M1**	$\frac{h!}{2! \times j!}$, $h = 7, 8, 9$; $j = 1, 2$
	90720	**A1**	
		2	
6(b)	**Arrangements with 5 letters between As + Arrangements with 6 letters between As + Arrangements with 7 letters between As**		
	With gap of 5: $\frac{7!}{2!} \times 3$ [= 7560]	**M1**	$\frac{7!}{2!} \times k$, k positive integer $1 < k < 7$
	With gap of 6: $\frac{7!}{2!} \times 2$ [= 5040] With gap of 7: $\frac{7!}{2!} \times 1$ [= 2520]	**M1**	Add their no of ways for 3 identified correct scenarios, no additional incorrect scenarios, accept unsimplified.
	[Total no = $\frac{7!}{2!} \times 6$ =] 15120	**A1**	
		3	

Question	Answer	Marks	Guidance
6(c)	**Method 1: Summing number of ways**		
	AT _ _ _ $2\times2\times{}^5C_3$ 40 A _ _ _ _ $2\times{}^5C_4$ 10 AATT _ ${}^5C_1$ 5 AAT _ _ $2\times{}^5C_2$ 20 AA _ _ _ ${}^5C_3$ 10 _ _ _ _ _ ${}^5C_5$ 1	**B1**	Correct no of ways for 4 correctly identified scenarios, accept unsimplified.
		M1	Add no of ways for 5 or 6 identified correct scenarios, no additional incorrect scenarios, no repeated scenarios, accept unsimplified.
	[Total no of ways not containing more Ts than As =] = 40+10+5+20+10+1 [=86]	**A1**	All correct and added
	Probability = $\frac{86}{{}^9C_5}$	**M1**	$\frac{\textit{their}\,86}{9C5\,\textit{or their identified total}}$ accept numerator unevaluated
	$\frac{86}{126}, \frac{43}{63}$, 0.683	**A1**	
	Method 2: Subtracting no of ways with more Ts from total		
	T _ _ _ _ $2\times{}^5C_4$ 10 TTA _ _ $2\times{}^5C_2$ 20 TT _ _ _ ${}^5C_3$ 10	**B1**	Correct no of ways for 2 correctly identified scenarios, no additional incorrect scenarios, no repeated scenarios, accept unsimplified, condone use of permutations
		M1	Add no of ways for 2 or 3 correct scenarios and subtract from their total no of ways All correct and subtracted
	Total no of ways with more Ts than As =40 ${}^9C_5 - 40 = 86$	**A1**	
	Probability = $\frac{86}{{}^9C_5}$	**M1**	$\frac{\textit{their}\,86}{9C5\,\textit{or their identified total}}$ accept numerator unevaluated

Question	Answer	Marks	Guidance
6(c)	$\frac{43}{63}$, 0.683	**A1**	
		5	

Question	Answer	Marks	Guidance
7(a)	[P(SR TR) + P(SW TR) =] $\frac{3}{8}\times\frac{2}{7}+\frac{5}{8}\times\frac{3}{7}$	**M1**	$\frac{3}{8}\times\frac{2}{7}+k$ or $l+\frac{5}{8}\times\frac{3}{7}$ $0 < k,l < 1$
	= $\frac{21}{56}, \frac{3}{8}$, 0.375	**A1**	**SC B1** for $\frac{3}{8}$ with no explanation.
		2	
7(b)	[RRWR, WRRR, WRWR] $\frac{3}{8}\times\frac{2}{7}\times\frac{5}{6}\times\frac{1}{5}+\frac{5}{8}\times\frac{3}{7}\times\frac{2}{6}\times\frac{1}{5}+\frac{5}{8}\times\frac{3}{7}\times\frac{4}{6}\times\frac{2}{5}$ $[=\frac{1}{56}+\frac{1}{56}+\frac{1}{14}]$	**M1**	$\frac{m}{8}\times\frac{n}{7}\times\frac{o}{6}\times\frac{q}{5}$ $1 \leqslant m,n,o,q \leqslant 5$, $m \neq n \neq o \neq q$
		A1	Probability for one scenario correct, accept unsimplified.
		M1	Adding probabilities for 3 correct scenarios and no incorrect.
	= $\frac{180}{1680}, \frac{3}{28}$, 0.107	**A1**	Or 0.1071428… to 4SF or better. **SC B1** for 3/28 with inadequate explanation.
		4	

Question	Answer	Marks	Guidance
7(c)	[P(S first disc R |T2) =] $\frac{\frac{30}{1680}}{\frac{3}{28}} = \frac{\frac{1}{56}}{\frac{3}{28}}$	**M1**	$\frac{\textit{their } P(RRWR) \textit{ or } \frac{3}{8}\times\frac{2}{7}\times\frac{5}{6}\times\frac{1}{5}}{\textit{their } 7(\mathbf{b}) - \textit{must be a prob or } \frac{3}{28}}$
	$\frac{1}{6}$, 0.167	**A1**	
		2	