Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/52**

Paper 5 Probability and Statistics 1 **February/March 2023**

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 February/March 2023 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.

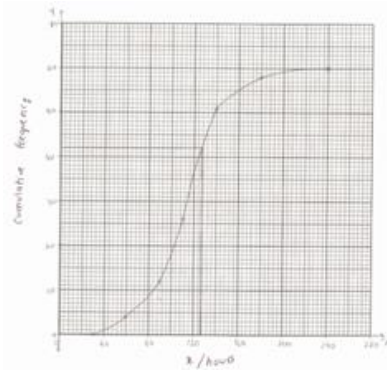
- A or B marks are given for correct work only (not for results obtained from incorrect working) unless follow through is allowed (see abbreviation FT above).
- For a numerical answer, allow the A or B mark if the answer is correct to 3 significant figures or would be correct to 3 significant figures 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(a)	<table><tr><td>Upper value</td><td>60</td><td>90</td><td>110</td><td>140</td><td>180</td><td>240</td></tr><tr><td>cf</td><td>4</td><td>12</td><td>26</td><td>51</td><td>58</td><td>60</td></tr></table>	**B1**	All cumulative frequencies stated. May be under data table, condone omission of 4. May be read accurately from graph, must include 4.
		**M1**	At least 5 points plotted at class upper end points, daylight rule tolerance. Linear cf scale $0 \leqslant \text{cf} \leqslant 60$, linear time scale $30 \leqslant \text{time} \leqslant 240$ with at least 3 values identified on each axis.
		A1	All points plotted correctly. Curve drawn (within tolerance), no ruled segments, and joined to $(30, 0)$. Axes labelled 'cumulative frequency' and 'hours [of sunshine]' (OE including appropriate title).
		3	
1(b)	[60 × 0.7 =] 42	**M1**	42 may be implied by clear use on graph.
	126	**A1 FT**	Must be clear evidence on graph of use of 42, e.g. an appropriate mark on either axis, appropriate mark on curve. FT from increasing cf graph only read at 42 only.
		2	

Question	Answer	Marks	Guidance
1(c)	Midpoints: 45, 75, 100, 125, 160, 210	**B1**	At least 5 correct mid-points seen, check by data table or used in formula.
	[Mean =] $\dfrac{4\times45+8\times75+14\times100+25\times125+7\times160+2\times210}{60}$ $\left[=\dfrac{6845}{60}\right]$	**M1**	Correct mean formula using their 6 midpoints (must be within class, not upper bound, lower bound), condone 1 data error If correct midpoints seen accept $\dfrac{180+600+1400+3125+1120+420}{60}$.
	= 114, $114\dfrac{1}{12}$	**A1**	Accept 114.1, 114.08[3…] If A1 not awarded, **SC B1** for 114, $114\dfrac{1}{12}$, 114.1 or 114.08[3…].
		3	

Question	Answer	Marks	Guidance
2(a)	$0.6(0.5)^3 + 0.4(0.5)^3\times3$	**B1**	Either $0.6(0.5)^3 + a$ or $b + 0.4(0.5)^3\times(3 \text{ or } {}^3C_1)$, $0 < a, b < 1$ seen.
		M1	$0.6(0.5)^3 + 0.4(0.5)^3\times d$ seen, $d = 1, 3$. Condone $0.075 + 0.05\times d$, $d = 1, 3$.
	= 0.225	**A1**	AG full supporting working required. Scenarios identified and linked to calculations.
		3	

Question	Answer	Marks	Guidance
2(b)	<table><tr><td>x</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>P($X = x$)</td><td>0.05</td><td>0.225</td><td>**0.375**</td><td>**0.275**</td><td>0.075</td></tr></table>	**B1**	Either [P(2) =] 0.375, $\frac{3}{8}$ or [P(3) =] 0.275, $\frac{11}{40}$ seen. Condone not in table if identified.
		B1 FT	Both values in table. FT P(2) + P(3) = 0.650 .
		2	
2(c)	Var(X) $= [1^2\times]0.225 + 2^2 \times \textit{their}\, 0.375 + 3^2 \times \textit{their}\, 0.275 + 4^2 \times 0.075 - 2.1^2$	**M1**	Appropriate variance formula from their probability distribution table with at least 4 terms, $0 < \textit{their}$ P(x) < 1. Condone 4.41 for 2.1^2. Condone mean clearly recalculated inaccurately. Or $0.225 + 4 \times \textit{their}\, 0.375 + 9 \times \textit{their}\, 0.275 + 16 \times 0.075 - 2.1^2$ Condone 2.1^2 for 4.41.
	$\left[5.4 - 2.1^2\right] = 0.99[0]$	**A1**	If M0 awarded **SC B1** for 0.99[0] WWW.
		2	

Question	Answer	Marks	Guidance
3(a)	**Method 1 for Question 3(a)**		
	[P(X > 17) = P(18, 19, 20) =] $^{20}C_{18}\left(0.8\right)^{18}\left(0.2\right)^{2}+{}^{20}C_{19}\left(0.8\right)^{19}\left(0.2\right)^{1}$ $+\ {}^{20}C_{20}\left(0.8\right)^{20}$ = 0.13691 + 0.05765 + 0.01153	**M1**	One term $^{20}C_x\left(p\right)^x\left(1-p\right)^{20-x},\ 0<p<1, 0<x<20$.
		A1	Correct expression, accept unsimplified, no terms omitted leading to final answer.
	0.206	**B1**	Mark the final answer at the most accurate value $0.206 \leqslant p \leqslant 0.2061$.
	Method 2 for Question 3(a)		
	[P(X > 17) = 1 – P(0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17) =] $1-(^{20}C_0\left(0.8\right)^0\left(0.2\right)^{20}+{}^{20}C_1\left(0.8\right)^1\left(0.2\right)^{19}$ $+\ {}^{20}C_2\left(0.8\right)^2\left(0.2\right)^{18}+\ldots+{}^{20}C_{16}\left(0.8\right)^{16}\left(0.2\right)^4$ $+{}^{20}C_{17}\left(0.8\right)^{17}\left(0.2\right)^3)$ $=1-(1.048\times10^{-14}+8.389\times10^{-13}$ $+3.188\times10^{11}+\ldots+0.2182+0.2054)$	**M1**	One term $^{20}C_x\left(p\right)^x\left(1-p\right)^{20-x},\ 0<p<1, 0<x<20$.
		A1	Correct expression, accept unsimplified, no terms omitted leading to final answer. If answer correct, condone omission of any 15 of the 16 middle terms.
	0.206	**B1**	Mark the final answer at the most accurate value $0.206 \leqslant p \leqslant 0.2061$. Condone omission of brackets.
		3	
3(b)	$\left[\left(0.8\right)^4\left(0.2\right)=\right]0.08192, \dfrac{256}{3125}$	**B1**	Accept $\dfrac{8192}{100000}$ OE.
		1	

Question	Answer	Marks	Guidance
3(c)	$(0.8)^5(0.2)^2\times 6$	**M1**	$(0.8)^5(0.2)^2\times k$ *or* $(0.8)^5(0.2)\times k\times 0.2$, $2\leqslant k\leqslant 7$.
	$=0.0786, \frac{8144}{78125}$	**A1**	$0.0786\leqslant p<0.07865$, $\frac{786432}{10000000}$. If A0 awarded, **SC B1** for correct answer WWW.
		2	

Question	Answer	Marks	Guidance
4	$(1-x)\times 0.7\times 0.9=0.36$	**M1**	$(1-x)\times a\times b=0.36,\ a=0.7\text{ or }0.3,\ b=0.9\text{ or }0.1$
		B1	$(1\text{-}x)\times 0.7\times 0.9=0.36$, $(1\text{-}x)\times 0.63=0.36$, $0.63-0.63x=0.36$ or $1-x=\frac{0.36}{0.63}$ seen. Condone recovery from omission of brackets.
	$x=\frac{3}{7}$	**A1**	Accept 0.428571 to at least 3 sf. Condone 0.4285 rounding to 0.429 . If M0 awarded, **SC B1** for $x=\frac{3}{7}$ or 0.428571 to at least 3 sf.
		3	

Question	Answer	Marks	Guidance
5	$P(A) = \frac{1}{2}$, $P(B) = \frac{8}{24} = \frac{1}{3}$,	**B1**	Both stated, accept unsimplified.
	$P(A \cap B) = \frac{1}{6}$	**M1**	Evidence that independence properties not used.
	$P(A) \times P(B) = \frac{1}{2} \times \frac{1}{3} = \frac{1}{6}$ so events are independent	**A1**	Evaluated and conclusion stated. $P(A) \times P(B)$ and $P(A \cap B)$ seen.
		3	

Question	Answer	Marks	Guidance
6(a)	$[P(X < 74) =] P\left(Z < \frac{74 - 62.3}{8.4}\right) \left[= P\left(Z < 1.393\right)\right]$	**M1**	Use of ± standardisation formula with 74, 62.3 and 8.4 substituted appropriately, not 8.4^2, not $\sqrt{8.4}$, no continuity correction.
	= 0.918	**A1**	$0.918 \leqslant p \leqslant 0.9185$.
		2	

Question	Answer	Marks	Guidance
6(b)	$[\text{P}(50 < X < 74) = \text{P}]\left(\frac{50-62.3}{8.4} < Z < \frac{74-62.3}{8.4}\right)$ $[\text{P}(-1.464 < Z < 1.393)]$	**M1**	Use of ± standardisation formula with both 74 (may be seen in 6(a) if *their* value seen) & 50, 62.3 and 8.4 substituted appropriately. Condone use of $8.4^2, \sqrt{8.4}$ and continuity correction ±0.5 (73.5 or 74.5 and 49.5 or 50.5).
	$[\Phi(1.464) + \Phi(1.393) - 1\ ]$ 0.9285 + 0.9182 – 1	**M1**	Calculating the appropriate probability area from stated Φ of *z*-values (leading to *their* final answer > 0.5) but not symmetrical values.
	= 0.847	**A1**	$0.8465 \leqslant p < 0.8475$. **SC B1** for $0.8465 \leqslant p < 0.8475$ if M0A0 awarded.
	$(0.8467)^4 = 0.514$	**B1 FT**	Accept $0.513 \leqslant p \leqslant 0.514$. FT (*their* 4-figure p)^4, $0 < p < 1$.
		4	
6(c)	$z_1 = \frac{36-\mu}{\sigma} = -0.739$ $z_2 = \frac{54-\mu}{\sigma} = 1.282$	**B1**	$-0.740 < z_1 < -0.738$ or $0.738 < z_1 < 0.740$.
		B1	$z_2 = \pm 1.282$ (critical value).
		M1	Use of the ±standardisation formula once with μ, σ and a *z*-value (not 0.23, 0.77, 0.90, 0.10, ±0.261, ±0.282…). Condone continuity correction ±0.5, not $\sigma^2, \sqrt{\sigma}$.
	Solve, obtaining values for μ and σ $\mu = 42.6, \quad \sigma = 8.91$	**M1**	Solve using the elimination method, substitution method or other appropriate approach to obtain values for both μ and σ.
		A1	$42.58 \leqslant \mu \leqslant 42.6$, $8.90 \leqslant \sigma \leqslant 8.91$.
		5	

Question	Answer	Marks	Guidance
7(a)	**Method 1: Arrangements with 3 Es together – arrangements with 3 Es together and 2 Ds together**		
	$\frac{7!}{2!}-6!$	**B1**	$\frac{7!}{2!}$ – *e*, *e* a positive integer (including 0).
		M1	*f* – 6!, *f* > 6!
		M1	$\frac{7!}{a!b!}-\frac{6!}{c!d!}$, *a*,*c* = 1, 2 and *b*,*d* = 1, 3.
	1800	**A1**	
	Method 2: Identified scenarios ^ EEE ^ ^ ^		
	$5!\times\frac{6\times5}{2}$	**B1**	5! × *j*, *j* a positive integer (*j* = 1 may be implied).
		M1	$\frac{k!}{m!}\times\frac{6\times5}{2}$, $\frac{k!}{m!}\times{}^{6}\mathrm{C}_{2}$, $\frac{k!}{m!}\times\frac{{}^{6}\mathrm{P}_{2}}{2}$ or $k!\times\frac{7\times6}{n}$, *k* a positive integer (*k* = 1 may be implied), *m* = 1, 2 *n* = 1, 2, 3.
		M1	$k!\times\frac{m\times(m-1)}{n}$ *k* a positive integer > 1, *m* = 10, 9, 8, 7, 6 and *n* = 1, 2.
	1800	**A1**	
		4	

Question	Answer	Marks	Guidance
7(b)	**First 2 marks: Method 1 – Number of arrangements with 2 Ds in one position with 4 letters in between – repeats allowed**		
	$7! \times 4 \times 2$	**M1**	$7! \times s$, s = positive integer > 1.
		M1	$t! \times 4 \times 2$, $t = 8, 7, 6$. Condone $t! \times 8$.
	First 2 marks: Method 2 – Picking 2Ds, arranging 4 letters from remaining letters between and then arranging terms		
	${}^{7}\mathrm{P}_{4} \times 4! \times 2!$	**M1**	${}^{7}\mathrm{P}_{4} \times a! \times b!$, $1 \leqslant a \leqslant 6$ and $b = 1, 2, 3$.
		M1	${}^{7}\mathrm{P}_{c} \times 4! \times 2!$, $c = 3, 4, 5$.
	First 2 marks: Method 3 – Identified scenarios involving Es between Ds		
	D ^ ^ ^ ^ D E E E = ${}^{4}\mathrm{C}_{4} \times 4! \times 4! \times 2! = 1152$ D E ^ ^ ^ D E E ^ = ${}^{4}\mathrm{C}_{3} \times 4! \times 4! \times 3 \times 2! = 13824$ D E E ^ ^ D E ^ ^ = ${}^{4}\mathrm{C}_{2} \times 4! \times 4! \times 3 \times 2! = 20736$ D E E E ^ D ^ ^ ^ = ${}^{4}\mathrm{C}_{1} \times 4! \times 4! \times 2! = 4608$	**M1**	1 identified scenario value correct.
		M1	4 appropriate scenarios added, no incorrect.

Question	Answer	Marks	Guidance
7(b)	**Final 3 marks for Methods 1, 2 and 3**		
	40320	**A1**	If A0 scored, **SC B1** for 40320 WWW.
	[Total number of arrangements =] $[9!=]$ 362880	**B1**	Accept unsimplified. May be seen as denominator of probability.
	Probability = $\frac{40320}{362880}=\frac{1}{9}$	**B1FT**	$\frac{their\ 40320}{their\ 362880}$, accept unsimplified. B1FT if *their* 40320 and *their* 362880 supported by work in this part. Condone *their* 362880 supported by calculation in **7(a)**.
		5	
7(c)	Scenarios D E _ _ _ $^4C_3$ 4 D E E _ _ $^4C_2$ 6 D E E E _ $^4C_1$ 4 D D E _ _ $^4C_2$ 6 D D E E _ $^4C_1$ 4 D D E E E $[^4C_0]$ 1	**B1**	1 correct unsimplified outcome/value for one identified scenario excluding DDEEE. Note: $^4C_1$ cannot be used for $^4C_3$.
		M1	Add values of 6 appropriate scenarios, no additional, incorrect or repeated scenarios. Accept unsimplified.
	[Total =] 25	**A1**	
		3	