Cambridge Assessment International Education

Cambridge International AS & A Level

MATHEMATICS **9709/52**

Paper 5 Probability and Statistics **March 2020**

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.

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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.

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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	${}^{38}C_r$ or ${}^{n}C_{34}$	**M1**	Either expression seen OE, no other terms, condone x1
	${}^{38}C_{34}$	**A1**	Correct unsimplified OE
	73815	**A1**	If M0, **SCB1** ${}^{38}C_{34}$ x *k, k* an integer
		3	

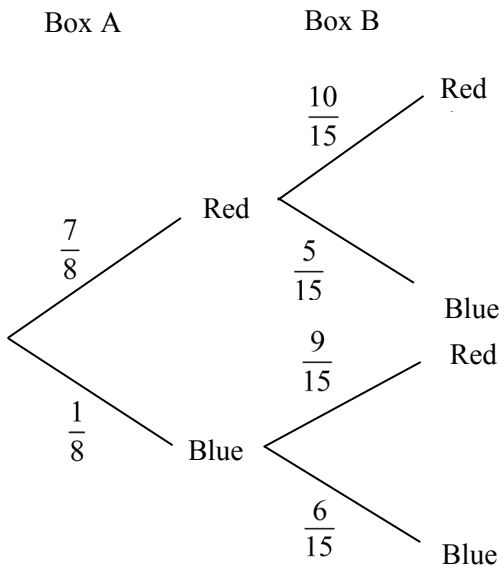
Question	Answer	Marks	Guidance
2(a)	$\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)^2+\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)^3+\left(\frac{1}{3}\right)\left(\frac{2}{3}\right)^4$	**M1**	One correct term with $0 < p < 1$
	$=\frac{4}{27}+\frac{8}{81}+\frac{16}{243}\left(=\frac{2432}{7776}\right)$	**A1**	Correct expression, accept unsimplified
	$=\frac{76}{243}$ or 0.313	**A1**	
		3	

Question	Answer	Marks	Guidance
2(b)	x | 0 | 1 | 2 | 3 P(x) | $\frac{8}{27}$ | $\frac{12}{27}$ | $\frac{6}{27}$ | $\frac{1}{27}$	**B1**	Probability distribution table with correct values of x, no additional values unless with probability of 0 stated, at least one non-zero probability included
	$P(0) = \left(\frac{2}{3}\right)^3$ $P(1) = \left(\frac{1}{3}\right)\left(\frac{2}{3}\right)^2 \times 3$ $P(2) = \left(\frac{2}{3}\right)\left(\frac{1}{3}\right)^2 \times 3$ $P(3) = \left(\frac{1}{3}\right)^3$	**B1** **B1**	1 correct probability seen (may not be in table) **or** 3 or 4 non-zero probabilities summing to 1 All probabilities correct
		3	
2(c)	$E(X) = \left[0 \times \frac{8}{27}\right] + 1 \times \frac{12}{27} + 2 \times \frac{6}{27} + 3 \times \frac{1}{27}$ $= \left[\frac{0}{27}\right] + \frac{12}{27} + \frac{12}{27} + \frac{3}{27}$	**M1**	Correct method from *their* probability distribution table with at least 3 terms, $0 \leqslant$ *their* P(x) $\leqslant 1$, accept unsimplified
	= 1	**A1**	
		2	

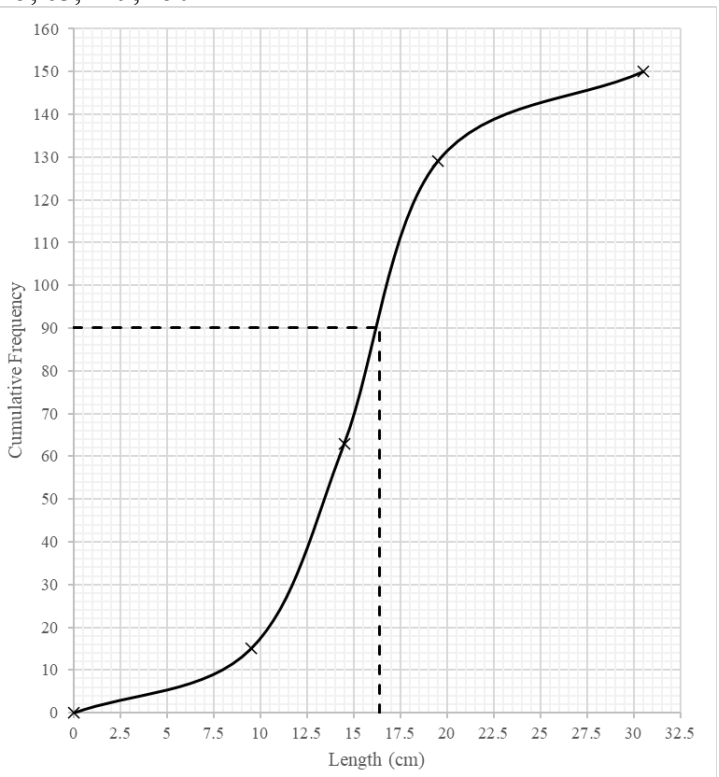
Question	Answer	Marks	Guidance
3(a)	$\mathrm{P}(X > 87) = \mathrm{P}\left(Z > \frac{87-82}{\sigma}\right) = 0.22$	**M1**	Using ± standardisation formula, not σ^2, not $\sqrt{\sigma}$, no continuity correction
	$\mathrm{P}\left(Z < \frac{5}{\sigma}\right) = 0.78$ $\left(\frac{5}{\sigma} =\right) 0.772$	**B1**	AWRT ±0.772 seen B0 for ±0.228
	$\sigma = 6.48$	**A1**	
		3	
3(b)	$\mathrm{P}\left(-\frac{4}{\sigma} < Z < \frac{4}{\sigma}\right) = \mathrm{P}(-0.6176 < Z < 0.6176)$	**M1**	Using ±4 used within a standardisation formula (SOI), allow σ^2, $\sqrt{\sigma}$ and continuity correction
		M1	Standardisation formula applied to **both** *their* ±4
	$\Phi = 0.7317$ Prob = $2\Phi - 1 = 2(0.7317) - 1$	**M1**	Correct area $2\Phi - 1$ oe linked to final solution
	= 0.463	**A1**	
		4	

Question	Answer	Marks	Guidance
4(a)	R ^ ^ ^ ^ ^ ^ ^ ^ ^ R $\frac{9!}{3!6!}$	**M1**	9! Alone on numerator, $3! \times k$ or $6! \times k$ on denominator
	= 84	**A1**	
		2	
4(b)	^ (B B B) ^ ^ ^ ^ ^	**M1**	$\frac{7!}{6!} \times k$ or $7k$ seen, k an integer > 0
	$\frac{7!}{6!} \times \frac{8 \times 7}{2}$	**M1**	$m \times n(n-1) or\ m \times {}^nC_2 or\ m \times {}^nP_2$, n=7, 8 or 9, m an integer > 0
		M1	n = 8 used in above expression
	= 196	**A1**	
	Alternative for question 4(b)		
	[Arrangements, blues together – Arrangements with blues together and reds together =] $\frac{9!}{2!6!} - \frac{8!}{6!}$	**M1**	9! Seen alone or as numerator with subtraction
	= [252 – 56]	**M1**	8! Seen alone or as numerator in a second term and no other terms
		M1	All terms divided by 6! x k, k an integer
	= 196	**A1**	
		4	

Question	Answer	Marks	Guidance
5(a)	$1 - P(6, 7, 8)$ $= 1 - ({}^8C_6\ 0.7^6 0.3^2 + {}^8C_7\ 0.7^7 0.3^1 + 0.7^8)$	**M1**	One term ${}^8C_x\ p^x (1-p)^{8-x}$, $0 < p < 1,\ x \neq 0$
	$= 1 - 0.55177$	**A1**	Correct unsimplified expression, or better
	$= 0.448$	**A1**	
	Alternative method for question 5(a)		
	$P(0, 1, 2, 3, 4, 5)$ $= 0.3^8 + {}^8C_1\ 0.7^1 0.3^7 + {}^8C_2\ 0.7^2 0.3^6 + {}^8C_3\ 0.7^3 0.3^5 +$ ${}^8C_4 0.7^4 0.3^4 + {}^8C_5\ 0.7^5 0.3^3$	**M1**	One term ${}^8C_x\ p^x (1-p)^{8-x}$, $0 < p < 1,\ x \neq 0$
		A1	Correct unsimplified expression, or better
	$= 0.448$	**A1**	
		3	
5(b)	Mean $= 120 \times 0.7 = 84$ Var $= 120 \times 0.7 \times 0.3 = 25.2$	**B1**	Correct mean and variance, allow unsimplified
	$P(\text{ more than } 75) = P\left(z > \frac{75.5 - 84}{\sqrt{25.2}}\right)$	**M1**	Substituting *their* μ and σ into the ±standardising formula (any number), not σ^2, not $\sqrt{\sigma}$
		M1	Using continuity correction 75.5 or 74.5
	$P(z > -1.693)$	**M1**	Appropriate area Φ, from final process, must be a probability
	$= 0.955$	**A1**	Allow $0.9545 < p \leqslant 0.955$
		5	

Question	Answer	Marks	Guidance
6(a)		**B1**	Both correct probs, box A
		B1	2 probs correct for box B
		B1	All correct probs for box B
		3	
6(b)	$\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{9}{15}$	**M1**	Two 2 factor terms added, correct or FT *their* **6(a)**.
	$=\frac{44}{120}\left[\frac{11}{30}\text{ or }0.367\right]$	**A1**	OE
		2	

Question	Answer	Marks	Guidance
6(c)	$\text{P(A blue } \vert \text{B blue)} = \frac{\text{P(A blue} \cap \text{ B blue)}}{\text{P(B blue)}}$ $= \frac{\frac{1}{8}\times\frac{6}{15}}{\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{6}{15}} = \frac{\frac{1}{20}}{\frac{41}{120}}$	**M1**	*their* $\frac{1}{8}\times\frac{6}{15}$ seen as numerator or denom of fraction
		M1	*their* $\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{6}{15}$ seen
		M1	*their* $\frac{7}{8}\times\frac{5}{15}+\frac{1}{8}\times\frac{6}{15}$ seen as denominator
	$= \frac{6}{41}$ or 0.146	**A1**	
		4	

Question	Answer	Marks	Guidance
7(a)	15, 63, 129, 150  	**B1**	Correct cumulative frequencies seen (may be on graph)
		B1	0 ⩽ Horizontal axis ⩽ 30, 0 ⩽ vertical axis ⩽ 150 Labels correct: length cm, cf
		M1	At least 3 points plotted at upper end points (e.g. allow 9, 9.5, 10) with a linear horizontal scale.
		A1	Linear vertical scale, all points at correct upper end points (9.5 etc.), curve drawn accurately, joined to (0,0) (condone (–0.5, 0))
		4	
7(b)	60% of 150 = 90	**M1**	90 seen or implied by use on graph
	Approx. 16.5 [cm]	**A1FT**	FT *their* increasing cumulative frequency graph, Use of graph must be seen. If no clear evidence of use of graph **SCB1FT** correct value from *their* graph
		2	

Question	Answer	Marks	Guidance
7(c)	Midpoints: 4.75, 12, 17, 25	**M1**	At least 3 correct midpoints used (39449.4375 implies M1)
	$\text{Var} = \dfrac{4.75^2 \times 15 + 12^2 \times 48 + 17^2 \times 66 + 25^2 \times 21}{150} - 15.295^2$	**M1**	Using midpoints ±0.5 in correct var formula, including subtraction of *their* μ^2.
	$= 29.1$	**A1**	
		3	