Cambridge Assessment International Education

Cambridge International A Level

MATHEMATICS **9709/63**

Paper 6 Probability & Statistics 2 **May/June 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.

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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	$\frac{3}{2}\int_0^1 (x - x^3)\mathrm{d}x$	**M1**	Attempt to integrate $xf(x)$; ignore limits.
	$= \frac{3}{2}\left[\frac{x^2}{2} - \frac{x^4}{4}\right]_0^1$	**A1**	Correct integration and limits.
	$= \frac{3}{8}$	**A1**	
		3	

Question	Answer	Marks	Guidance
2(a)	180, 227	**B1**	One correct. Ignore incorrect numbers.
		B1	Both correct and no extra numbers seen. (Allow other correct use of list of digits).
		2	
2(b)	These numbers are not independent of the previous numbers OR Only a finite number of digits used	**B1**	Already used these numbers, so therefore not random. Does not include numbers not in the list, therefore not random (not random or biased needs a reason).
		1	

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Question	Answer	Marks	Guidance
3(a)	$z = 1.645$	**B1**	
	$z \times \frac{\sqrt{\frac{x}{100} \times (1 - \frac{x}{100})}}{100} = 0.07896$	**M1**	OE. Equation of correct form. Accept $p = x/100$. Any z. Allow missing factor of 2.
	$[x(100 - x) = 100^3 \times 0.07896^2 \div 1.645^2]$ $x^2 - 100x + 2304 = 0$	**A1**	Any correct (likely scalar multiple) three-term quadratic equation in x or p with simplified coefficients. Accept $p^2 - p + 0.2304 = 0$ or $p(1-p) = 0.2304$.
	$x = 36$ or 64	**A1**	
		4	
3(b)	$0.1^2 = 0.01$	**B1**	Accept either.
		1	

Question	Answer	Marks	Guidance
4	**Method 1: Based on mass**		
	Mean = $7 \times 65.2 = 456.4$	**B1**	
	Var = 7×3.6^2 [= 90.72]	**M1**	
	22 000/50 = 440 used in standardising equation	**M1**	
	$\frac{'440' - '456.4'}{\sqrt{'90.72'}}$ [= –1.722] no mixed methods	**M1**	For standardising with their values. No mixed methods.
	$\phi(-'1.722') = 1 - \phi('1.722')$	**M1**	For correct probability area consistent with their values.
	= 0.0425 or 0.0426	**A1**	Note: accept alt method using per day. $N(65.2, \frac{3.6^2}{7})$. No mixed methods.
	Method 2: Based on profit		
	Mean = $7 \times 65.2 \times 50 = 22\,820$	**B1**	
	Var = 7×3.6^2	**M1**	
	Var = $50^2 \times$ '90.72' [= 226 800]	**M1**	
	$\frac{22\,000 - '22\,820'}{\sqrt{'226800'}}$ [= –1.722] no mixed methods	**M1**	For standardising with their values. No mixed methods.
	$\phi(-'1.722') = 1 - \phi('1.722')$	**M1**	For correct probability area consistent with their values.
	= 0.0425 or 0.0426	**A1**	
		6	

Question	Answer	Marks	Guidance
5(a)	$\bar{x} = 1700/50 = 34$	**B1**	
	$\text{Est}(\sigma^2) = \frac{50}{49}\left(\frac{59050}{50} - 34^2\right)$ or $\frac{1}{49}\left(59050 - \frac{1700^2}{50}\right)$	**M1**	$\text{Est}(\sigma^2) = \frac{59050}{50} - 34^2$ biased scores M0.
	$= 25.5$ (3 sf) or $\frac{1250}{49}$	**A1**	$= 25$ scores A0.
		3	
5(b)	H_0: Population mean time = 32.4 H_1: Population mean time $\neq$ 32.4	**B1**	Not just 'mean' but allow just 'μ'.
	$\frac{34 - 32.4}{\frac{\sqrt{'25.5'}}{\sqrt{50}}}$	**M1**	Must have $\sqrt{50}$ and not 50. FT *their* mean and var. Can be implied.
	$= 2.24$ (3 sf)	**A1**	or $P(\bar{T} > 34) = 0.0125$. **SC** use of biased var (25) $z = 2.26$ or $p = 0.0119$, allow M1A1.
	'2.24' < 2.326	**M1**	Or $0.0125 > 0.01$ for a valid comparison.
	[Not reject H_0] Insufficient evidence that (mean) time has changed	**A1FT**	In context, not definite, e.g. not 'Time not changed'. No contradictions. Note: accept CV method $x_{cri} = 34.06$ for M1A1. Compares $34 < 34.06$ for M1, conclusion for A1. Condone $x = 32.34$ M1A1: compares $32.4 > 32.34$ for M1, conclusion for A1.
		5	**SC** for using a one-tail method. Award max 3/5 (B0 M1 A1 M1 A0).

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Question	Answer	Marks	Guidance
5(c)	Distribution of times in the population is normal	**B1**	Accept answers with no context here. Accept underlying distribution for population.
		1	

Question	Answer	Marks	Guidance
6(a)	$X \sim \text{Po}(2.5)$	**B1**	SOI.
	$e^{-2.5}(1 + 2.5 + \frac{2.5^2}{2} + \frac{2.5^3}{3!})$	**M1**	Any λ. Allow one end error.
	= 0.758 (3 sf)	**A1**	**SC** use of binomial B1 for 0.758. **SC** when no working is shown, $X \sim \text{Po}(2.5)$ seen scores B1, 0.758 seen also scores B1.
		3	
6(b)	$\text{E}(X) = \frac{5}{2}$ or 2.5 , $\text{Var}(X) = \frac{4999}{2000}$ or 2.4995	***B1**	Just an answer of 2.5 for the variance is not sufficient. However, 2.4995 is sufficient.
	These are almost equal	**DB1**	Condone 'equal'.
		2	

Question	Answer	Marks	Guidance
7(a)	$\frac{1}{2}\pi\left(\sqrt{\frac{2}{\pi}}\right)^2$	**M1**	
	= 1, which is the area under a PDF [and f(x) ≥ 0]	**A1**	Result and statement are both needed.
		2	
7(b)	$\cos^{-1}\left(\frac{\sqrt{\frac{1}{\pi}}}{\sqrt{\frac{2}{\pi}}}\right)=\frac{\pi}{4}$	**B1**	AG. Accept alternative approaches, e.g. using Pythagoras, tangent, or isosceles right-angle triangles. Answer should be convincingly obtained and all correct.
	Area of sector = $\frac{1}{4}$	**B1**	
	Area of triangle $AOB = \frac{1}{2}OA\times OB = \frac{1}{2}\times\sqrt{\frac{1}{\pi}}\times\sqrt{\frac{2}{\pi}-\frac{1}{\pi}}$ or Area of triangle $AOB = \frac{1}{2}OA\times OB\times\sin(AOB) = \frac{1}{2}\times\sqrt{\frac{1}{\pi}}\times\sqrt{\frac{2}{\pi}}\sin\frac{\pi}{4}$	**M1**	Accept alternative approaches. Note: AB = $\sqrt{0.7979^2-0.5642^2}$ [= 0.5642] Allow values to 3sf.
	$\frac{1}{2\pi}$ or 0.1592	**A1**	
	'$\frac{1}{4}$' – '$\frac{1}{2\pi}$' or '0.25' – '0.1592'	**M1**	Attempt area of sector – area of triangle AOB.
	= $\frac{1}{4}-\frac{1}{2\pi}$ or 0.0908 (3sf)	**A1**	

Question	Answer	Marks	Guidance
7(b)	**Alternative Method for Question Q7(b): Using integration**		
	Find equation of curve $x^2 + y^2 = \frac{2}{\pi}$	**M1**	
	$y = \sqrt{\frac{2}{\pi} - x^2}$	**A1**	
	Attempt to integrate (any limits)	**M1**	
	Use of correct limits $\sqrt{\frac{1}{\pi}}$ to $\sqrt{\frac{2}{\pi}}$	**B1**	
	Correct integration with correct limits	**A1**	
	$= \frac{1}{4} - \frac{1}{2\pi}$ or 0.0908 (3sf)	**A1**	Correct final answer.
		6	

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Question	Answer	Marks	Guidance
8(a)	H_0: Pop mean no. people = 3.03 or 1.01 (per 20 min) H_1: Pop mean no. people > 3.03 or 1.01 (per 20 min)	**B1**	These must not just be 'mean', but allow just 'λ' or 'μ'.
	Use of $P_O(3.03)$	**M1**	
	$= 1 - e^{-3.03}(1 + 3.03 + \frac{3.03^2}{2} + \frac{3.03^3}{3!} + \frac{3.03^4}{4!} + \frac{3.03^5}{5!})$ $= 1 - e^{-3.03}(1 + 3.03 + 4.5905 + 4.6364 + 3.5120 + 2.128)$ $= 1 - (0.04832 + 0.1464 + 0.2218 + 0.2240 + 0.1697 + 0.1028)$	**M1**	Allow incorrect λ. Allow one end error. Must see Poisson expression used.
	= 0.0870 (3sf) [0.0869727]	**A1**	Allow 0.087 .
	0.0870 > 0.05	**M1**	For a valid comparison.
	(Do not reject H_0) Insufficient evidence to believe (mean) number of people has increased	**A1FT**	Conclusion stated must be in context, not definite and include no contradictions (e.g. not 'mean number people has not increased').
		6	If only P(x = 6) award max 2/6 (single term not valid). **SC** No working B1 B2 M1 A1. Award maximum 5/6.

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Question	Answer	Marks	Guidance
8(b)	"0.0869727" – $e^{-3.03} \times \frac{3.03^6}{6!}$ or $0.869727 - e^{-3.03}(1.0748)$ or $0.869727 - 0.05193$ or $1 - e^{-3.03}(1 + 3.03 + \frac{3.03^2}{2} + \frac{3.03^3}{3!} + \frac{3.03^4}{4!} + \frac{3.03^5}{5!} + \frac{3.03^6}{6!})$	**M1**	OE. Must see Poisson expression (may be in part (a)).
	0.0350 or 0.0351	**A1**	Accept 0.035. **SC** no working seen, award B1 for 0.0350, 0.0351 or 0.035.
		2	
8(c)	Concluding that the (mean) number of people (using the path per 20 mins in the evening) has increased when it has not	**B1**	OE. Conclusion must be in context.
		1	
8(d)	A value for the true mean	**B1**	Allow without context for this mark.
	Number of people using the path per 20 mins in the evening.	**B1**	Condone equivalent comment on three randomly chosen 20-minute periods.
		2	

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