

Cambridge International A Level

MATHEMATICS**9709/61**

Paper 6 Probability & Statistics 2

October/November 2024**MARK SCHEME**Maximum Mark: 50

Published

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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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GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

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- 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:

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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, non-integer 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 or sign 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 A or B 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
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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)	$z = 2.054$ or 2.055	B1	Accept 3 sf if nothing better seen (2.05 or 2.06).
	$1.42 \pm z \frac{0.35}{\sqrt{150}}$	M1	Must be a z value.
	1.36 to 1.48 [m] (3 sf)	A1	Correct working only. Must be an interval.
		3	
1(b)	No. CI is about mean, not individual values.	B1	Or similar. Need both.
		1	

Question	Answer	Marks	Guidance
2	$E(S_1 + S_2 + S_3 - L) = 16 \times 3 - 51$ [= -3]	B1	Oe, using $L - (S_1 + S_2 + S_3)$.
	$\text{Var}(S_1 + S_2 + S_3 - L) = 3 \times 0.4 + 0.9$ [= 2.1]	M1	
	$\frac{0 - (-3)}{\sqrt{2.1}}$ [= 2.070]	M1	For standardising with their values.
	$1 - \Phi('2.070')$	M1	For area consistent with their values.
	= 0.0192 (3 sf)	A1	
		5	

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Question	Answer	Marks	Guidance
3(a)	$\bar{t} = \frac{230}{75} [= 3.0666... \text{ or } 3.07 \text{ (3 sf)}] [\text{Or } 46/15]$	B1	
	$s^2 = \frac{75}{74} \left(\frac{930}{75} - \left(\frac{230}{75} \right)^2 \right) \text{ or } 1/74(930 - 230^2/75)$	M1	Use of correct formula.
	$= 3.0360... \text{ or } 3.04 \text{ (3 sf) or } = 337/111$	A1	
		3	
3(b)	$[\Phi^{-1}(1 - 0.234)] = 0.726$	B1	
	$\pm \frac{a - '3.0667'}{\sqrt{3.04/75}} = \pm '0.726'$	M1	Ft their 0.726 but must be a z value. Note using 0.766 is M0. Must have sqrt 75.
	$a = 3.21 \text{ (3 sf)}$	A1	CWO
		3	

Question	Answer	Marks	Guidance
4(a)	$\int_2^3 \left(\frac{a}{x^2} - \frac{18}{x^3} \right) dx = 1$	M1	Attempt integrate f(x), ignore limits and '= 1'.
	$\left[-\frac{a}{x} + \frac{9}{x^2} \right]_2^3 = 1$	A1	OE Correct integration and limits.
	$\left[-\frac{a}{3} + 1 + \frac{a}{2} - \frac{9}{4} \right] = 1 \quad a = \frac{27}{2} \text{ (AG)}$	A1	Must see correct substitution of limits. Correct working no errors seen.
		3	

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Question	Answer	Marks	Guidance
4(b)	$\int_2^3 \left(\frac{27}{2x} - \frac{18}{x^2} \right) dx$	M1	Attempt to integrate $xf(x)$, ignore limits.
	$\left[\frac{27}{2} \ln x + \frac{18}{x} \right]_2^3$ or $\left[\frac{27}{2} \ln 2x + \frac{18}{x} \right]_2^3$	A1	Correct integration and limits. OE e.g. using $\ln 2x$.
	$= \frac{27}{2} \ln 3 + 6 - \frac{27}{2} \ln 2 - 9 = \frac{27}{2} \ln \frac{3}{2} - 3$ AG	A1	Must see correct substitution of limits. Correct working no errors seen.
		3	

Question	Answer	Marks	Guidance
5(a)	Two-tailed because looking for difference	B1	
		1	

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Question	Answer	Marks	Guidance
5(b)	$H_0: \mu = 12.7$ $H_1: \mu \neq 12.7$	B1	No ft from part (a).
	$\frac{\frac{597.1}{50} - 12.7}{\frac{2.3}{\sqrt{50}}}$	M1	
	$= -2.330$ Accept -2.336 or -2.337	A1	or 0.00989 or 0.0099. or 0.0097 if area comparison used.
	$‘-2.330’ > -2.576$ or $‘2.330’ < 2.576$ or $‘0.00989’ > 0.005$ or $‘0.0097’ > 0.005$	M1	Accept 2.574 to 2.579. Or use of CV. $12.7 - 2.576 \times (2.3 / \sqrt{50}) = 11.862$ M1A1 . $11.942 > 11.862$ M1A1 .
	[Not reject H_0] There is insufficient evidence to suggest that μ is not 12.7	A1 FT	OE ft their z_{calc} . In context, not definite, e.g. not $‘\mu = 12.7’$. No contradictions. SC use of 1 tailed test can score B0M1A1M1 for comparison with 0.01 A0 max 3/5.
		5	

Question	Answer	Marks	Guidance
6(a)	$[\lambda = 2.7] 1 - e^{-2.7}(1 + 2.7 + \frac{2.7^2}{2})$ or $1 - e^{-2.7}(1 + 2.7 + 3.645)$ or $1 - (0.06721 + 0.1815 + 0.2450)$	M1	Any λ . Allow one end error. Must see expression.
	$= 0.506$ (3 sf)	A1	SC unsupported answer 0.506 scores B1 .
		2	

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Question	Answer	Marks	Guidance
6(b)	$\lambda = 1.95$	B1	
	$e^{-1.95}(1 + 1.95 + \frac{1.95^2}{2} + \frac{1.95^3}{3!})$ or $e^{-1.95}(1 + 1.95 + 1.90125 + 1.2358)$ or $0.1423 + 0.2774 + 0.2705 + 0.1758$	M1	Any λ . Allow one end error. Must see expression.
	$= 0.866$	A1	SC unsupported answer 0.866 scores B1B1 .
		3	
6(c)	$1 - e^{-2.1x} \geq 0.90$ or $1 - e^{-\lambda} \geq 0.90$	M1	OE Condone use of '=' throughout.
	$[e^{-2.1x} \leq 0.1]$ or $e^{-\lambda} \leq 0.1$ $-2.1x \leq \ln 0.1$ or $-\lambda \leq \ln 0.1$ [$\lambda \geq 2.3026, 2.3026/2.1$]	M1	Rearrange and attempt take logs of relevant form.
	1.096 or 10.96 accept 1.097 or 10.97	*A1	Seen.
	She must wait for at least 11 minutes	A1 dep	
			SC Use of trial and improvement. Use of $1 - e^{-\lambda}$ any numerical λ (not 2.1) ie one trial M1 . Use of enough trials to give an answer of 0.90 (2sf) M1 . $\lambda = 2.30$ i.e. 3sf accuracy AND 1.09... or 10.9 ... A1 . Then 11 A1 dep .
		4	

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Question	Answer	Marks	Guidance
7(a)	$\lambda = 6.6$	B1	
	$P(X \leq 2) = e^{-6.6}(1 + 6.6 + \frac{6.6^2}{2}) [= 0.0400] [< 0.05]$ or $e^{-6.6}(1 + 6.6 + 21.78)$ or $0.001360 + 0.008978 + 0.02963$	M1	Expression must be seen. No end errors. Allow use of 3.3 here.
	$P(X \leq 3) = e^{-6.6}(1 + 6.6 + \frac{6.6^2}{2} + \frac{6.6^3}{3!})$ or $0.0400 + e^{-6.6} \times \frac{6.6^3}{3!} = 0.105 [> 0.05]$	B1	Condone unsupported 0.105.
	$P(\text{Type I error}) = 0.0400$ (3 sf)	A1	Allow 0.040 or 0.04 AWRT SC unsupported ans of 0.0400 can score max B1B1B1 .
		4	
7(b)	$H_0: \lambda = 6.6, H_1: \lambda < 6.6$	B1	May be seen in part (a) and award B1 mark here. Accept μ or λ . Accept 3.3 or 6.6.
	$[P(X \leq 2) = 0.0400] \text{ ` } 0.04 \text{ ` } < 0.05$	M1	For comparing their $P(X \leq 2)$ any λ with 0.05.
	[Reject H_0] There is evidence to suggest that mean number of accidents has decreased	A1	In context, not definite. No contradictions. CWO.
		3	

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Question	Answer	Marks	Guidance
7(c)	$P(X > 2)$ attempted, with any λ	M1	
	$P(X > 2) = 1 - e^{-1.2}(1 + 1.2 + \frac{1.2^2}{2})$ or $= 1 - e^{-1.2}(1 + 1.2 + 0.72)$ or $= 1 - (0.3012 + 0.3614 + 0.2169)$	M1	Expression must be seen. Correct λ . No end errors.
	0.121 (3 sf) or 0.120	A1	SC unsupported answer scores B2 .
		3	
7(d)	$N(18, 18)$ seen or implied	B1	
	$\frac{10.5-18}{\sqrt{18}} [= -1.768]$	M1	Allow with no or incorrect continuity correction. Their 18.
	$P(X > '-1.768') = \Phi('1.768')$	M1	ft <i>their</i> standardised value. Area consistent with their values.
	= 0.961 or 0.962 (3 sf)	A1	
		4	

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Question	Answer	Marks	Guidance
1	$\lambda = 4.5$	B1	
	$1 - e^{-4.5}(1 + 4.5 + \frac{4.5^2}{2} + \frac{4.5^3}{3!}) = 1 - e^{-4.5}(1 + 4.5 + 10.125 + 15.1875)$ $= 1 - (0.011109 + 0.049999 + 0.11248 + 0.16872)$	M1	Expression must be seen or implied by correct figures. Any λ . Allow one end error. Accept fully correct Σ notation.
	0.658 (3 sf)	A1	SC unsupported 0.658 scores B1 B1 .
		3	

Question	Answer	Marks	Guidance
2(a)	254 [m]	B1	
		1	
2(b)	$263 = '254' + 1.96 \times \frac{\sigma}{\sqrt{50}}$ oe or $2 \times 1.96 \times \frac{\sigma}{\sqrt{50}} = 18$	M1	ft their '254' accept 1.96 or 1.645 for M1 .
	$[\sigma = \frac{9\sqrt{50}}{1.96} =]$. s.d. = 32.5 [m] (3 sf)	A1	
		2	
2(c)	No Because the sample mean is approximately normally distributed [for large n]	B1	Both needed. Or because of the Central Limit theorem. Or because n is large [accept ≥ 30 condone ≥ 50].
		1	

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Question	Answer	Marks	Guidance
3(a)	$H_0: p = 0.8$ $H_1: p > 0.8$	B1	
	[Assuming H_0 , $P(X \geq 23) = {}^{25}C_{23} \times 0.2^2 \times 0.8^{23} + {}^{25}C_{24} \times 0.2 \times 0.8^{24} + 0.8^{25}$ $= 0.070835 + 0.0236118 + 0.0037779$	M1	No end errors. Expression must be seen or supported by enough figures to be convinced B(25,0.8) used. Accept correct Σ notation.
	$= 0.0982$	A1	SC B1 for 0.0982 unsupported.
	$0.0982 < 0.1$	M1	Valid comparison their 0.0982 must be a tail probability.
	[There is evidence to reject H_0] There is sufficient evidence to suggest that p has increased	ftA1	No contradictions. In context, non-definite. Condone ‘there is sufficient evidence that the ‘claim’ is correct’ and condone ‘there is sufficient evidence that the number of employees (using the canteen) has increased’ Note: CR method will include $P(X \geq 23)$ so M1 A1 as above, and $P(X \geq 22) = 0.234 > 0.1$ with at least one probability comparison with 0.1 needed to find CR of 23,24,25 (so 23 in CR) M1 A1ft as above.
		5	
3(b)	Not suitable as model does not allow for more than 25 employees to use the canteen/Not suitable as uses a sample instead of all employees/Not suitable doesn’t include all employees /Not suitable as 30 is only just bigger than 25 should have used 30 OR Suitable as owner knows that not all employees use the canteen, or similar	B1	Need both (i.e. suitable or not suitable plus reason).
		1	

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Question	Answer	Marks	Guidance
4(a)	$\frac{36-35}{8.1 \div \sqrt{140}} [= 1.461]$	M1	Ignore inclusion of cc for M1 . Must have $\sqrt{140}$.
	$1 - \Phi('1.461')$	M1	For area consistent with their values.
	$= 0.0720$ (3 sf)	A1	Allow 0.072.
		3	
4(b)	$[\Phi^{-1}(0.986)] = 2.197$ to 2.198	B1	Seen. Note: 2.2 and nothing better seen scores B0
	$\pm \frac{a-35}{8.1 \div \sqrt{140}} = \pm '2.198'$	M1	Must be a z value.
	$a = 36.5$ (3 sf)	A1	CWO Note: use of 2.2 scores A1 so 2/3. But e.g. 2.196 gives 36.5 but scores B0 M1 A0 so 1/3
		3	

Question	Answer	Marks	Guidance
5(a)	$e^{-3.7} \left(\frac{3.7^3}{3!} + \frac{3.7^4}{4!} + \frac{3.7^5}{5!} \right) = e^{-3.7} (8.44217 + 7.80900 + 5.77866) = 0.20872 + 0.19307 + 0.14287$	M1	Expression must be seen or implied by correct figures. Any λ . Allow one end error. Accept fully correct Σ notation.
	$= 0.545$ (3 sf)	A1	SC 0.545 unsupported scores B1 .
		2	

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Question	Answer	Marks	Guidance
5(b)	$[\lambda] = 6.3$	B1	
	$e^{-6.3}(1 + 6.3 + \frac{6.3^2}{2!} + \frac{6.3^3}{3!}) = e^{-6.3}(1 + 6.3 + 19.845 + 41.6745) = 0.0018363 + 0.011569 + 0.0364415 + 0.076527$	M1	Expression must be seen or implied by correct figures. Any λ . Allow one end error. Accept fully correct Σ notation.
	$= 0.126$ (3 sf)	A1	SC 0.126 unsupported scores B1 B1
		3	
5(c)	$L \sim N(37, 37), O \sim N(26, 26)$	B1	SOI.
	$(O - L) \sim N(-11, 63)$	B1	For $N(\pm 11, \dots)$ SOI.
		M1	For var = 37+26 SOI.
	$\frac{0 - (-11)}{\sqrt{63}}$ [=1.386] or $\frac{0 + 0.5 - (-11)}{\sqrt{63}}$ [=1.449]	M1	Standardising with their values (wrong cc scores M1).
	$1 - \Phi(1.386)$ or $1 - \Phi(1.449)$	M1	For area consistent with their working.
	$= 0.0828$ or 0.0829 (3 sf) or $= 0.0737$ or 0.0736 (3 sf)	A1	
			SC ₁ 10 used twice $N(37,37), N(26,26)$ and use of $10O - 10L > 0$ Apply MR rules max B1 B1 M1 M1 M1 A0 (MR) SC ₂ $P(11)$ giving $N(11,11)$ scores B0 B1 M0 M1 M1 A0
		6	

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Question	Answer	Marks	Guidance
6(a)	Min and max times [to complete challenge]	B1	In context (e.g. min and max x scores B0).
		1	
6(b)	$\int_a^b \frac{1}{x^2} dx = 1$	M1	Attempt to integrate f(x) and =1, ignore limits.
	$\left[\left[-\frac{1}{x} \right]_a^b = 1 \right] -\frac{1}{b} + \frac{1}{a} = 1$	A1	For correct equation using correct limits into correct integration and = 1.
	$-a + b = ab$ or $b = a(b + 1)$	A1	Convincingly obtained. No errors seen. OE $\Rightarrow a = \frac{b}{b+1}$ AG .
		3	

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Question	Answer	Marks	Guidance
6(c)	$E(X) = \int_a^b \frac{1}{x} dx$	M1	Attempt to integrate $xf(x)$. Limits a and b or $b/(b+1)$ and b (condone a and 2 for M1) See SC for use of limits $2/3$ and 2
	$= \ln b - \ln a$ or $\ln b - \ln(b/(b+1))$	A1	Correct integration and limits substituted. Condone $\ln 2 - \ln a$.
	$[= \ln b - (\ln b - \ln(b+1))] = \ln b - \ln(b/(b+1)) = \ln 3$ $= \ln(b+1) = \ln 3$ or $b+1=3$ or $b^2+b=3b$ or $\frac{b}{\left(\frac{b}{b+1}\right)}=3$	A1	For correct equation in b only (i.e. using part (b)).
	$b=2$ (AG) $a = \frac{2}{3}$	A1	Both obtained correctly (Note: if $b=2$ not shown but used can score M1 A1, A1/A0 depending on where $b=2$ is introduced, A0)
			SC verification: using $b=2$ and $a=2/3$ then integrating $xf(x)$ from $2/3$ to 2 scores M1 A1 for integration and limits substituted, then A1 for showing $=\ln 3$ Final A0 (as verified not shown) max $\frac{3}{4}$.
		4	
6(d)	$\int_{\frac{2}{3}}^m \frac{1}{x^2} dx = 0.5$ or $\int_m^2 \frac{1}{x^2} dx = 0.5$	M1	Attempt to integrate $f(x)$ equated to 0.5 and correct limits stated.
	$\left[-\frac{1}{x}\right]_{\frac{2}{3}}^m = 0.5$ or $\left[-\frac{1}{x}\right]_m^2 = 0.5$	A1FT	Correct integration FT <i>their a</i> .
	$\left[-\frac{1}{m} + \frac{3}{2} = 0.5\right]$ or $\left[-\frac{1}{2} + \frac{1}{m} = 0.5\right]$ $m=1$	A1	
		3	

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Question	Answer	Marks	Guidance
7(a)	0.02 or 2%	B1	<0.02 B0
		1	
7(b)	$H_0: \mu = 2.3$ $H_1: \mu > 2.3$	B1	Accept ‘population mean’ for μ (not just mean) If not seen here, can be awarded if correctly seen in part (a)
	$s^2 = \frac{100}{99} \left(\frac{580}{100} - (2.38)^2 \right)$ or $1/99 (580 - 238^2/100)$	M1	Correct substitution in s^2 or $\sqrt{s^2}$ formula.
	$= 0.137 = 113/825$ or $s = 0.370$ (3 sf) and $\bar{x} = 238/100 [= 2.38]$	A1	$\bar{x}$ and s^2 (or s) correct. (SC biased estimate 0.1356 and $\bar{x} = 2.38$ scores B1).
	$\frac{2.38-2.3}{\sqrt{\frac{0.137}{100}}} [=2.161 \text{ or } 2.162]$	M1	
	$= 2.16$ (3 sf) OR 0.0153/0.0154 if area comparison used	A1	
	‘2.16’ > 2.054 (or 2.055) OR ‘0.0153 or 0.0154’ < 0.02	M1	Valid comparison.
	[There is evidence to reject H_0 .] There is sufficient evidence to suggest that the [mean] height [in scientist’s region] is greater than 2.3 [m] OR there is sufficient evidence to suggest that the scientist’s claim is justified.	A1FT	No contradictions. In context, non-definite. Accept CV method $x = 2.376 < 2.38$ or $x = 2.304 > 2.3$ M1 A1 for x and M1 A1ft for comparison and conclusion Two tail test can score B0 M1 A1 M1 A1 M1 (comparison with 0.01oe) A0ft max 5/7
		7	
7(c)	Not possible since H_0 was rejected.	B1FT	Need both. Accept No as H_0 was rejected. Follow through their conclusion in (b) . Condone a definite statement.
		1	

Cambridge International A Level

MATHEMATICS**9709/63**

Paper 6 Probability & Statistics 2

October/November 2024**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 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level components, and some Cambridge O Level components.

This document consists of **12** 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 descriptions 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.

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, non-integer 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 or sign 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 A or B 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.

PUBLISHED**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(a)	$z = 2.054$ or 2.055	B1	Accept 3 sf if nothing better seen (2.05 or 2.06).
	$1.42 \pm z \frac{0.35}{\sqrt{150}}$	M1	Must be a z value.
	1.36 to 1.48 [m] (3 sf)	A1	Correct working only. Must be an interval.
		3	
1(b)	No. CI is about mean, not individual values.	B1	Or similar. Need both.
		1	

Question	Answer	Marks	Guidance
2	$E(S_1 + S_2 + S_3 - L) = 16 \times 3 - 51$ [= -3]	B1	Oe, using $L - (S_1 + S_2 + S_3)$.
	$\text{Var}(S_1 + S_2 + S_3 - L) = 3 \times 0.4 + 0.9$ [= 2.1]	M1	
	$\frac{0 - (-3)}{\sqrt{2.1}}$ [= 2.070]	M1	For standardising with their values.
	$1 - \Phi('2.070')$	M1	For area consistent with their values.
	= 0.0192 (3 sf)	A1	
		5	

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Question	Answer	Marks	Guidance
3(a)	$\bar{t} = \frac{230}{75} [= 3.0666... \text{ or } 3.07 \text{ (3 sf)}] [\text{Or } 46/15]$	B1	
	$s^2 = \frac{75}{74} \left(\frac{930}{75} - \left(\frac{230}{75} \right)^2 \right) \text{ or } 1/74(930 - 230^2/75)$	M1	Use of correct formula.
	$= 3.0360... \text{ or } 3.04 \text{ (3 sf) or } = 337/111$	A1	
		3	
3(b)	$[\Phi^{-1}(1 - 0.234)] = 0.726$	B1	
	$\pm \frac{a - '3.0667'}{\sqrt{3.04/75}} = \pm '0.726'$	M1	Ft their 0.726 but must be a z value. Note using 0.766 is M0. Must have sqrt 75.
	$a = 3.21 \text{ (3 sf)}$	A1	CWO
		3	

Question	Answer	Marks	Guidance
4(a)	$\int_2^3 \left(\frac{a}{x^2} - \frac{18}{x^3} \right) dx = 1$	M1	Attempt integrate f(x), ignore limits and '= 1'.
	$\left[-\frac{a}{x} + \frac{9}{x^2} \right]_2^3 = 1$	A1	OE Correct integration and limits.
	$\left[-\frac{a}{3} + 1 + \frac{a}{2} - \frac{9}{4} \right] = 1 \quad a = \frac{27}{2} \text{ (AG)}$	A1	Must see correct substitution of limits. Correct working no errors seen.
		3	

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Question	Answer	Marks	Guidance
4(b)	$\int_2^3 \left(\frac{27}{2x} - \frac{18}{x^2} \right) dx$	M1	Attempt to integrate $xf(x)$, ignore limits.
	$\left[\frac{27}{2} \ln x + \frac{18}{x} \right]_2^3$ or $\left[\frac{27}{2} \ln 2x + \frac{18}{x} \right]_2^3$	A1	Correct integration and limits. OE e.g. using $\ln 2x$.
	$= \frac{27}{2} \ln 3 + 6 - \frac{27}{2} \ln 2 - 9 = \frac{27}{2} \ln \frac{3}{2} - 3$ AG	A1	Must see correct substitution of limits. Correct working no errors seen.
		3	

Question	Answer	Marks	Guidance
5(a)	Two-tailed because looking for difference	B1	
		1	

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Question	Answer	Marks	Guidance
5(b)	$H_0: \mu = 12.7$ $H_1: \mu \neq 12.7$	B1	No ft from part (a).
	$\frac{\frac{597.1}{50} - 12.7}{\frac{2.3}{\sqrt{50}}}$	M1	
	$= -2.330$ Accept -2.336 or -2.337	A1	or 0.00989 or 0.0099. or 0.0097 if area comparison used.
	$'-2.330' > -2.576$ or $'2.330' < 2.576$ or $'0.00989' > 0.005$ or $'0.0097' > 0.005$	M1	Accept 2.574 to 2.579. Or use of CV. $12.7 - 2.576 \times (2.3 / \sqrt{50}) = 11.862$ M1A1 . $11.942 > 11.862$ M1A1 .
	[Not reject H_0] There is insufficient evidence to suggest that μ is not 12.7	A1 FT	OE ft their z_{calc} . In context, not definite, e.g. not $'\mu = 12.7'$. No contradictions. SC use of 1 tailed test can score B0M1A1M1 for comparison with 0.01 A0 max 3/5.
		5	

Question	Answer	Marks	Guidance
6(a)	$[\lambda = 2.7] 1 - e^{-2.7}(1 + 2.7 + \frac{2.7^2}{2})$ or $1 - e^{-2.7}(1 + 2.7 + 3.645)$ or $1 - (0.06721 + 0.1815 + 0.2450)$	M1	Any λ . Allow one end error. Must see expression.
	$= 0.506$ (3 sf)	A1	SC unsupported answer 0.506 scores B1 .
		2	

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Question	Answer	Marks	Guidance
6(b)	$\lambda = 1.95$	B1	
	$e^{-1.95}(1 + 1.95 + \frac{1.95^2}{2} + \frac{1.95^3}{3!})$ or $e^{-1.95}(1 + 1.95 + 1.90125 + 1.2358)$ or $0.1423 + 0.2774 + 0.2705 + 0.1758$	M1	Any λ . Allow one end error. Must see expression.
	$= 0.866$	A1	SC unsupported answer 0.866 scores B1B1 .
		3	
6(c)	$1 - e^{-2.1x} \geq 0.90$ or $1 - e^{-\lambda} \geq 0.90$	M1	OE Condone use of '=' throughout.
	$[e^{-2.1x} \leq 0.1]$ or $e^{-\lambda} \leq 0.1$ $-2.1x \leq \ln 0.1$ or $-\lambda \leq \ln 0.1$ [$\lambda \geq 2.3026, 2.3026/2.1$]	M1	Rearrange and attempt take logs of relevant form.
	1.096 or 10.96 accept 1.097 or 10.97	*A1	Seen.
	She must wait for at least 11 minutes	A1 dep	
			SC Use of trial and improvement. Use of $1 - e^{-\lambda}$ any numerical λ (not 2.1) ie one trial M1 . Use of enough trials to give an answer of 0.90 (2sf) M1 . $\lambda = 2.30$ i.e. 3sf accuracy AND 1.09... or 10.9 ... A1 . Then 11 A1 dep .
		4	

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Question	Answer	Marks	Guidance
7(a)	$\lambda = 6.6$	B1	
	$P(X \leq 2) = e^{-6.6}(1 + 6.6 + \frac{6.6^2}{2}) [= 0.0400] [< 0.05]$ or $e^{-6.6}(1 + 6.6 + 21.78)$ or $0.001360 + 0.008978 + 0.02963$	M1	Expression must be seen. No end errors. Allow use of 3.3 here.
	$P(X \leq 3) = e^{-6.6}(1 + 6.6 + \frac{6.6^2}{2} + \frac{6.6^3}{3!})$ or $0.0400 + e^{-6.6} \times \frac{6.6^3}{3!} = 0.105 [> 0.05]$	B1	Condone unsupported 0.105.
	$P(\text{Type I error}) = 0.0400$ (3 sf)	A1	Allow 0.040 or 0.04 AWRT SC unsupported ans of 0.0400 can score max B1B1B1 .
		4	
7(b)	$H_0: \lambda = 6.6, H_1: \lambda < 6.6$	B1	May be seen in part (a) and award B1 mark here. Accept μ or λ . Accept 3.3 or 6.6.
	$[P(X \leq 2) = 0.0400] \text{ ` } 0.04 \text{ ` } < 0.05$	M1	For comparing their $P(X \leq 2)$ any λ with 0.05.
	[Reject H_0] There is evidence to suggest that mean number of accidents has decreased	A1	In context, not definite. No contradictions. CWO.
		3	

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Question	Answer	Marks	Guidance
7(c)	$P(X > 2)$ attempted, with any λ	M1	
	$P(X > 2) = 1 - e^{-1.2}(1 + 1.2 + \frac{1.2^2}{2})$ or $= 1 - e^{-1.2}(1 + 1.2 + 0.72)$ or $= 1 - (0.3012 + 0.3614 + 0.2169)$	M1	Expression must be seen. Correct λ . No end errors.
	0.121 (3 sf) or 0.120	A1	SC unsupported answer scores B2 .
		3	
7(d)	$N(18, 18)$ seen or implied	B1	
	$\frac{10.5-18}{\sqrt{18}} [= -1.768]$	M1	Allow with no or incorrect continuity correction. Their 18.
	$P(X > '-1.768') = \Phi('1.768')$	M1	ft <i>their</i> standardised value. Area consistent with their values.
	= 0.961 or 0.962 (3 sf)	A1	
		4	