
INTERNATIONAL A-LEVEL MATHEMATICS

MA04

(9660/MA04) Unit S2 Statistics

Mark scheme

January 2020

Version: V1 Final Mark Scheme

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Key to mark scheme abbreviations

M	Mark is for method
m	Mark is dependent on one or more M marks and is for method
A	Mark is dependent on M or m marks and is for accuracy
B	Mark is independent of M or m marks and is for method and accuracy
E	Mark is for explanation
✓ or ft	Follow through from previous incorrect result
CAO	Correct answer only
CSO	Correct solution only
AWFW	Anything which falls within
AWRT	Anything which rounds to
ACF	Any correct form
AG	Answer given
SC	Special case
oe	Or equivalent
A2, 1	2 or 1 (or 0) accuracy marks
–x EE	Deduct x marks for each error
NMS	No method shown
PI	Possibly implied
SCA	Substantially correct approach
sf	Significant figure(s)
dp	Decimal place(s)

Q	Answer	Marks	Comments
1(a)	$E\left(\sum_{i=1}^3 X_i\right) = 8$	B1	
1(b)	$Var\left(\sum_{i=1}^3 X_i\right) = 4.5$	B1	
1(c)	$E(3X_1 - 4X_3) = 3 \times 2 - 4 \times 1$ $= 2$	M1 A1	$E(3X_1 - 4X_3) = 3a - 4b$ where a, b = 2, 5 or 1
1(d)	$Var(5X_1 - 2X_2) = 5^2 \times 3 + 2^2 \times 1$ $= 79$	M1 A1	$Var(5X_1 - 2X_2) = 5^2c + 2^2d$ c, d = 3, 1 or 0.5
	Total	6	

Q	Answer	Marks	Comments
2(a)	$\frac{1}{\lambda^2} = 400$ $\lambda = 0.05$	M1 A1	Do not award if -0.05 seen but not rejected
2(b)	Mean = $\frac{1}{\lambda} = 20$	B1ft	Follow through their λ
2(c)	$P(X > 25) = 1 - F(25)$ $= 1 - (1 - e^{-0.05 \times 25})$ $= 0.287$	M1 A1 A1	oe Attempts to find correct probability using cdf of exponential or integration of pdf AWRT, NMS 3/3
2(d)	$1 - e^{-0.05x} = 0.6$ $x = 18.3$	M1 A1	Forms equation using cdf of exponential or integration of pdf AWRT
	Total	8	

Q	Answer	Marks	Comments
3(a)	$Y \sim \text{Po}(1)$	B1	PI
	$P(X > 3) \approx P(Y > 3) = 1 - P(Y \leq 3)$	M1	Attempt at correct probability
	$= 0.019$	A1	AWRT
3(b)	n is large	B1	oe
	p is small	B1	oe
	Total	5	

Q	Answer	Marks	Comments
4(a)	$\bar{x} = 2.5$	B1	
	$s^2 = \frac{1}{20-1} \left(173 - \frac{50^2}{20} \right)$	M1	Attempt at variance formula Allow one slip Implied by correct answer
	$= 2.53$	A1	AWRT
	Because Mean \approx Variance	E1	Values and conclusion must be seen Allow “values of sample mean and variance are close”
4(b)	$P(X = 4) = \frac{e^{-2.5} \times 2.5^4}{4!}$	M1	Applies Poisson formula Implied by correct answer Condone using different value of λ
	$= 0.134$	A1	AWRT
	Total	6	

Q	Answer	Marks	Comments
5(a)	$H_0: p = 0.2$ or $H_0: p = 0.8$ $H_1: p < 0.2$ or $H_1: p > 0.8$ $X \sim B(15, 0.2)$ or $X \sim B(15, 0.8)$ $P(X \leq 1) = 0.1671$ or $P(X \geq 14) = 0.1671$ $0.1671 > 0.1$ Accept H_0 Evidence to suggest/support that the proportion of customers giving an “Excellent” rating has not increased	B1 M1 A1 M1 A1ft E1	Both hypotheses PI AWRT 0.17 Compares their probability with 0.1 Follow through their probability provided both M marks awarded Implied by correct conclusion in context Must be consistent with their conclusion on whether to accept H_0 or not or their probability if not explicitly stated
5(b)	Concluding that the proportion of customers giving an “Excellent” rating has not increased when it has	E1	oe
	Total	7	

Q	Answer	Marks	Comments
6(a)	$\frac{83 - \mu}{\sigma} = 1.6449$ $83 - \mu = 1.6449\sigma \text{ (AG)}$	M1 A1	Setting up formula with a z-value or $\Phi^{-1}(0.95)$ No errors seen 1.6449 must be seen before the final line
6(b)	1.4051 $\frac{10 - \mu}{\sigma} = \pm 1.4051$ $10 - \mu = -1.4051\sigma$ $\mu = 43.6 \text{ or } \sigma = 23.9$ $\mu = 43.6 \text{ and } \sigma = 23.9$	B1 M1 A1 M1 A1	Sight of anywhere in part (b) Oe, condone sign error for -1.4051 oe AWRT
6(c)	85 is within two standard deviations of the mean or Negative scores are within two standard deviations of the mean	E1	oe Allow non-zero probability (0.042) using normal distribution model of gaining a score higher than 85
	Total	8	

Q	Answer	Marks	Comments
7(a)	$H_0: \mu = 14$ $H_1: \mu \neq 14$	B1	Both hypotheses
	$\bar{X} \sim N\left(14, \frac{0.25^2}{25}\right)$	M1	Use of PI
	$z = \frac{13.892 - 14}{\frac{0.25}{\sqrt{25}}}$	M1	Attempts to find z Allow one slip
	$z = -2.16$	A1	AWRT Allow 2.16
	$z_{\text{crit}} = 2.3263$ or -2.3263	B1	Seen anywhere AWRT 2.33 Accept $P(Z < -2.16) = 0.015$
	Accept H_0	A1ft	Follow through their z and z_{crit} or their probability and 0.01 Implied by correct conclusion in context
	Evidence to suggest/support that the mean diameter of the pipes produced by machine A has not changed following the power cut	E1	Must be consistent with their conclusion on whether to accept H_0 or not or their z and z_{crit} (or their probability and 0.01) if not explicitly stated

Q	Answer	Marks	Comments
7(b)	$H_0: \mu = 14$ $H_1: \mu > 14$	B1	Both hypotheses
	dof $v = 8$	M1	PI
	$t = \frac{14.02 - 14}{\frac{0.04}{\sqrt{9}}}$	M1	Attempts to find t Allow one slip Condone $z =$
	$t = 1.5$	A1	Condone $z =$
	$t_{\text{crit}} = 1.397$	B1	Seen anywhere
	Reject H_0	A1ft	Follow through their t and t_{crit} (but not z_{crit}) Implied by correct conclusion in context
	Evidence to suggest/support that the mean diameter of the pipes produced by machine B is greater than 14 millimetres	E1	Must be consistent with their conclusion on whether to accept H_0 or not or their t and t_{crit} if not explicitly stated
	Total	14	

Q	Answer	Marks	Comments
8(a)	$\int_1^6 k(x^2 - 7x + 6) \, dx = 1$ $k \left[\frac{x^3}{3} - \frac{7x^2}{2} + 6x \right]_1^6 = 1$ $k \left[\left(\frac{6^3}{3} - \frac{7 \times 6^2}{2} + 6 \times 6 \right) - \left(\frac{1^3}{3} - \frac{7 \times 1^2}{2} + 6 \times 1 \right) \right] = 1$ $\Rightarrow k = -\frac{6}{125} \text{ (AG)}$	<p>M1</p> <p>M1</p> <p>A1</p>	<p>Sets integral over whole range equal to 1</p> <p>Correct integration</p> <p>Requires intermediate line after integration</p>
8(b)	$E(X) = \int_1^6 kx(x^2 - 7x + 6) \, dx$ $= k \left[\frac{x^4}{4} - \frac{7x^3}{3} + \frac{6x^2}{2} \right]_1^6$ $= k \left[\left(\frac{6^4}{4} - \frac{7 \times 6^3}{3} + \frac{6 \times 6^2}{2} \right) - \left(\frac{1^4}{4} - \frac{7 \times 1^3}{3} + \frac{1 \times 1^2}{2} \right) \right]$ $\Rightarrow E(X) = 3.5 \text{ (AG)}$	<p>M1</p> <p>M1</p> <p>A1</p>	<p>Identifies correct integral</p> <p>Correct integration</p> <p>Requires intermediate line after integration</p>
8(c)	$E(X^2) = \int_1^6 kx^2(x^2 - 7x + 6) \, dx$ $= k \left[\frac{x^5}{5} - \frac{7x^4}{4} + \frac{6x^3}{3} \right]_1^6$ $E(X^2) = 13.5$ $\text{Var}(X) = E(X^2) - (E(X))^2$ $= 13.5 - 3.5^2$ $= 1.25$	<p>M1</p> <p>M1</p> <p>A1</p> <p>M1</p> <p>A1</p>	<p>Identifies correct integral</p> <p>Correct integration</p> <p>PI</p> <p>Applies formula</p>
	Total	11	

Q	Answer	Marks	Comments
9(a)(i)	$\bar{X} \sim N\left(20, \frac{6.5536}{25}\right)$	B1	oe
9(a)(ii)	$P(\bar{X} > 21) = P\left(Z > \frac{21-20}{\sqrt{\frac{6.5536}{25}}}\right)$ $= 1 - \Phi(1.95)$ $= 1 - 0.97441$ $= 0.0254 \text{ to } 0.0256$	M1 M1 A1	 Standardises PI AWFW
9(b)(i)	$\sum_{i=1}^{25} X_i \sim N(500, 163.84)$	B1	oe
9(b)(ii)	$P\left(\sum_{i=1}^{25} X_i > 525\right) = P\left(Z > \frac{525-500}{\sqrt{163.84}}\right)$ $= 1 - \Phi(1.95)$ $= 1 - 0.97441$ $= 0.0254 \text{ to } 0.0256$	M1 M1 A1	 Standardises PI AWFW
9(c)	The probabilities are the same This is because a total height of 525 centimetres is the same as a mean height of 21 cm as $\frac{525}{25} = 21$	E1 E1	 oe oe
	Total	10	

Q	Answer	Marks	Comments
10(a)(i)	All the car owners in the town	E1	Must include 'all' or 'every'
10(a)(ii)	<p>A sample where each member of the population has an equal probability of being chosen</p> <p>or</p> <p>Each sample of the required size from the population has an equal probability of being chosen</p>	E1	oe
10(b)	average number of events in an interval	B1	oe
10(c)	<p>mean</p> <p>standard deviation</p>	<p>B1</p> <p>B1</p>	<p>Accept variance</p> <p>SC1 for μ and σ or μ and σ^2</p>
	Total	5	