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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MS03 Statistics 3

Mark Scheme

2006 examination – June series

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting ensures that the mark scheme covers the candidates' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

Key To Mark Scheme And Abbreviations Used In Marking

M	mark is for method
m or dM	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 or F	follow through from previous incorrect result	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

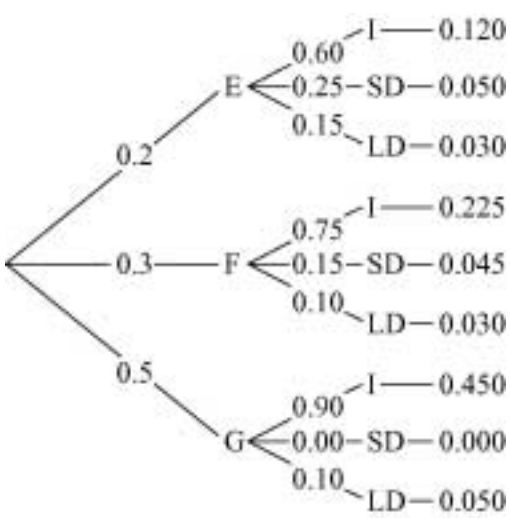
MS03

Q	Solution	Marks	Total	Comments
1(a)	$\hat{p} = \frac{209}{250} = 0.836$	B1		CAO
	95% CI $\Rightarrow z = 1.96$	B1		CAO
	CI for p:			
	$\hat{p} \pm z\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$	M1 M1		Variance term Use of: $\hat{p} \pm z \times \sqrt{(\text{Var}(\hat{p}))}$
	ie $0.836 \pm 1.96 \times \sqrt{\frac{0.836 \times 0.164}{250}}$	A1✓		✓ on $\hat{p}$ and z; not on n
	ie 0.836 ± 0.046			
	or (0.790, 0.882)	A1	6	AWRT; accept 0.79
(b)	Value of 0.8 (80%) **is within** CI	B1✓ ↑ dep		✓ on CI
	Council's clam **is supported** (at 5% level)	B1✓	2	✓ on CI
	Total		**8**	

MS03 (cont)

Q	Solution	Marks	Total	Comments
2(a)	$r = 0.819$ to 0.82	B3		AWFW
	or			
	$r = 0.81$ to 0.83	(B2)		AWFW
	or			
	$r = 0.8$ to 0.85	(B1)		AWFW
	Attempt at Σx Σx^2			989, 99321
	Σy Σy^2			1717, 296101
	Σxy			170956
	or			
	attempt at S_{xx} S_{yy} S_{xy}	(M1)		1508.9, 1292.1, 1144.7
	Attempt at a correct formula for r	(m1)		
	$r = 0.819$ to 0.82	(A1)	3	AWFW
(b)	H_0: $\rho = 0$	B1		Both
	H_1: $\rho > 0$			
	SL $\alpha = 0.01$ (1%)			
	SS $n = 10$			
	CV $r = 0.7155$	B1		AWFW 0.715 to 0.716
	Calculated r > Tabulated r	M1		Comparison
	Evidence (at 1% level) of a positive correlation between heart rate and systolic blood pressure	A1√	4	√ on r and CV
	Total		**7**	

MS03 (cont)

Q	Solution	Marks	Total	Comments
3				
(a)(i)	$P(G \cap I) = 0.5 \times 0.9 = 0.45$	B1	1	CAO; or equivalent
(ii)	$P(I) = (i) + P(E \cap I) + P(F \cap I)$	M1		3 possibilities
	$= 0.45 + (0.2 \times 0.6) + (0.3 \times 0.75)$	A1		≥ 1 correct **new** term
	$= 0.45 + 0.12 + 0.225 = 0.795$	A1	3	CAO; or equivalent
(iii)	$P(G \mid I) = \dfrac{P(G \cap I)}{P(I)}$	M1		Attempted use of Bayes' Theorem
	$= \dfrac{(i)}{(ii)} = \dfrac{0.45}{0.795} = 0.566$	m1 A1	3	AWRT; or equivalent
(b)	$P(E \mid SD) = \dfrac{P(E \cap SD)}{P(SD)}$	M1		Correct use of Bayes' Theorem
	$= \dfrac{0.2 \times 0.25}{(0.2 \times 0.25) + (0.3 \times 0.15)} =$	A1		Numerator (B1 if no Bayes' Theorem)
	$\dfrac{0.05}{0.05 + 0.045}$	A1		Denominator (B1 if no Bayes' Theorem)
	$= \dfrac{0.05}{0.095} = 0.526$	A1	4	AWRT; or equivalent
	Total		**11**	

MS03 (cont)

Q	Solution	Marks	Total	Comments
4(a)	$E(R) = (6 \times 0.1) + (7 \times 0.6) + (8 \times 0.3)$			
	$= 0.6 + 4.2 + 2.4 = 7.2$	B1		CAO
	$E(R^2) = (3.6 + 29.4 + 19.2) = 52.2$	B1		CAO
	$Var(R) = E(R^2) - (E(R))^2$	M1		Use of
	$= 52.2 - 51.84 = 0.36$	A1	4	CAO
(b)(i)	$E(T) = 7.2 + 10.9 = 18.1$	B1√		√ on $E(R)$
	$Cov(R, S) = \rho_{RS} \times \sqrt{Var(R) \times Var(S)}$	M1		Use of; or equivalent May be scored in (ii)
	$Var(T) = Var(R) + Var(S) + 2Cov(R, S)$	M1		Use of; or equivalent May be scored in (ii)
	$= 0.36 + 1.69 + 2 \times \frac{2}{3}\sqrt{0.36 \times 1.69}$			
	$= 0.36 + 1.69 + 1.04 = 3.09$	A1	4	CAO
(ii)	$E(D) = 10.9 - 7.2 = 3.7$	B1√		√ on $E(R)$
	$Var(D) = Var(S) + Var(R) - 2Cov(S, R)$			
	$= 1.69 + 0.36 - 2 \times \frac{2}{3}\sqrt{1.69 \times 0.36}$			
	$= 1.69 + 0.36 - 1.04 = 1.01$	B1	2	CAO
	Total		**10**	

MS03 (cont)

Q	Solution	Marks	Total	Comments
5	Letters/week ~ Po(12.25)			
(a)	Letters/4-week ~ N(49, 49)	B1		CAO; mean = variance = 49
	$P(42 \le X_P \le 54) = P(41.5 < X_N < 54.5)$	M1		Use of ±0.5
	$= P\left(\frac{41.5-49}{7} < Z < \frac{54.5-49}{7}\right)$	M1		Standardising (41.5, 42 or 42.5) or (53.5, 54 or 54.5) with C's μ and $\sqrt{\mu}$
	$= P(-1.07 < Z < 0.79)$			
	$= \Phi(0.79) - (1 - \Phi(1.07))$	m1		Area change
	$= 0.78524 - 1 + 0.85769$			
	$= 0.641$ to 0.644	A1	5	AWFW
(b)(i)	98% CI $\Rightarrow z = 2.3263$	B1		AWFW 2.32 to 2.33
	CI for λ/16-week: $\hat{\lambda} \pm z\sqrt{\hat{\lambda}}$	M1		Use of expression
	ie $248 \pm 2.3263 \times \sqrt{248}$			
	or $15.5 \pm 2.3263 \times \sqrt{\frac{15.5}{16}}$	A1√		√ on z
	ie 248 ± 36.6 or 15.5 ± 2.3	M1		Division by 16 somewhere
	or (13.2, 17.8)	A1	5	AWRT
(ii)	Value of 12.25 (196) **is below** CI	B1√		√ on CI; must use 12.25 (196)
	Rosa's belief **is supported**	↑ dep B1√		√ on CI
	Total		**12**	

MS03 (cont)

Q	Solution	Marks	Total	Comments
6(a)	$\mathrm{E}(X) = \sum x \times \mathrm{P}(X = x)$	M1		Use of
	$= \sum_{x=0}^{\infty} x \times \frac{\mathrm{e}^{-\lambda}\lambda^x}{x!} = \lambda \times \sum_{x=1}^{\infty} \frac{\mathrm{e}^{-\lambda}\lambda^{x-1}}{(x-1)!}$	M1		Factor of λ Cancelling of x (Ignore change in limits)
	$= \lambda \times \sum \mathrm{P}(X = x) = \lambda \times 1 = \lambda$	M1		AG; must be clear
	$\mathrm{G}(t) = \mathrm{e}^{\lambda t - \lambda}$ or $\mathrm{M}(t) = \mathrm{e}^{\lambda \mathrm{e}^t - \lambda}$	(B1)		Either CAO
	Alternative			
	$\mathrm{E}(X) = \left.\frac{\mathrm{d}\,\mathrm{G}(t)}{\mathrm{d}t}\right\|_1$ or $\left.\frac{\mathrm{d}\,\mathrm{M}(t)}{\mathrm{d}t}\right\|_0$	(M1)		Use of either
	$\left[\lambda \mathrm{e}^{\lambda t - \lambda}\right]_1$ or $\left[\lambda \mathrm{e}^t \mathrm{e}^{\lambda \mathrm{e}^t - \lambda}\right]_0 = \lambda$	(A1)	3	AG; correct derivation
(b)	$\mathrm{E}(X(X-1)) = \sum_{x=0}^{\infty} x(x-1) \times \frac{\mathrm{e}^{-\lambda}\lambda^x}{x!}$	M1		Use of
	$= \lambda^2 \times \sum_{x=2}^{\infty} \frac{\mathrm{e}^{-\lambda}\lambda^{x-2}}{(x-2)!}$	M1		Factor of λ^2 Cancelling of $x(x-1)$ (Ignore change in limits)
	$= \lambda^2 \times \sum \mathrm{P}(X = x) = \lambda^2 \times 1 = \lambda^2$	M1		AG; must justify
	$\mathrm{Var}(X) = \mathrm{E}(X^2) - (\mathrm{E}(X))^2$ $= \mathrm{E}(X(X-1)) + \mathrm{E}(X) - (\mathrm{E}(X))^2$	M1		
	$= \lambda^2 + \lambda - \lambda^2 = \lambda$	A1		AG; must be clear
	Alternative			
	$\mathrm{Var}(X) =$ $\left.\frac{\mathrm{d}^2\,\mathrm{G}(t)}{\mathrm{d}^2 t}\right\|_1 + \lambda - \lambda^2$ or $\left.\frac{\mathrm{d}^2\,\mathrm{M}(t)}{\mathrm{d}^2 t}\right\|_0 - \lambda^2$	(M2)		use of either
	$= \left[\lambda^2 \mathrm{e}^{\lambda t - \lambda}\right]_1 + \lambda - \lambda^2 = \lambda$	(A2)		AG; correct derivation
	or $= \left[\lambda \mathrm{e}^t \mathrm{e}^{\lambda \mathrm{e}^t - \lambda} + \lambda^2 \mathrm{e}^{2t} \mathrm{e}^{\lambda \mathrm{e}^t - \lambda}\right]_0 - \lambda^2 = \lambda$	(A1)	5	AG; correct derivation
	Total		**8**	

MS03 (cont)

Q	Solution	Marks	Total	Comments
7(a)	$\bar{y} = 1193$	B1	1	CAO
(b)	H_0: $\mu_Y - \mu_X = 200$	B1		200 is not necessary
	H_1: $\mu_Y - \mu_X > 200$	B1		200 is necessary
	SL $\alpha = 0.01$ (1%)			
	CV $z = 2.3263$	B1		AWFW 2.32 to 2.33
	$z = \dfrac{(\bar{y}-\bar{x})-200}{\sqrt{\dfrac{\sigma_Y^2}{n_Y}+\dfrac{\sigma_X^2}{n_X}}} = \dfrac{(1193-936)-200}{\sqrt{\dfrac{65^2}{10}+\dfrac{45^2}{20}}}$	M1 M1 A1√		Numerator; 200 is not necessary Denominator √ on (a)
	= 2.48 to 2.5	A1		AWFW
	Evidence (at 1% level) to support the claim	A1√	8	√ on z and CV
(c)(i)	CV $(\bar{y}-\bar{x})$: $200 + z$(denominator in (b))	M1		May be scored in (b)
	ie $200 + 2.3263 \times \sqrt{523.75}$			
	(= 253.24)	A1	2	AG; must justify
(ii)	Power = 1 – P(Type II error)	M1		Use of
	= 1 – P(accept H_0 | H_0 false)	M1		Use of; or equivalent
	$= 1 - P\left(Z < \dfrac{253.24-275}{\sqrt{523.75}}\right)$	M1		Standardising 253.24 using 275 and C's denominator in (b)
	= 1 – Φ(–0.95) = Φ(0.95)	m1		Area change
	= 0.83	A1	5	AWRT
(iii)	Probability of **accepting** that difference in mean weights **is more than 200** grams	B1		Not in context ⇒ max of 2
	when, in fact, **it is 275** grams	B1		
	is 0.83 (or 83%)	B1√	3	√ on (ii)
	Total		**19**	
	TOTAL		**75**	