

General Certificate of Education

Mathematics 6360

MS2A Statistics 2A

Mark Scheme

2007 examination - January 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.

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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							
В	mark is independent of M or m marks and is for method and accuracy							
E	mark is for explanation							
$\sqrt{\text{or ft or F}}$	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.

Jan 07

MS2A

Q	Solution	Marks	Total	Comments
1(a)(i)	$X \sim \text{Po}(0.70)$			
	$P(X < 3) = P(X \le 2)$			
	= 0.966	B1	1	0.9659
	- 0.700	D1	1	0.5025
(ii)	$Y \sim \text{Po}(1.30)$			
	$P(Y=2) = \frac{e^{-1.30} (1.30)^2}{21} = 0.230$	M1A1	2	
	2:	1411711	2	
(b)	$T \sim \text{Po}(2.0)$	M1		
	$P(T \ge 4) = 1 - P(T \le 3)$	M1		
	=1-0.8571	1711		
	= 0.143	A1	3	0.1429
	Total		6	
2	$\overline{x} = 65.375$	B1		_ 2426 (_2 11.7)
	$s = 3.662 \ (s^2 = 13.4)$	B1		$\sigma = 3.426 \left(\sigma^2 = 11.7\right)$
	000/ CI			
	99% CI t ₇ = 3.499	B1		
	7 – 3.173			
	$65.375 \pm \frac{3.662}{\sqrt{8}} \times 3.499$			65 275 + 3.426 , 2.400
	$\frac{03.373 \pm \frac{1}{\sqrt{8}} \times 3.499}{\sqrt{8}}$	M1		$65.375 \pm \frac{3.426}{\sqrt{7}} \times 3.499$
	65.055 1 4.500			
	$=65.375 \pm 4.530$			(60.0 (60.0 (60.0)
	=(60.8,69.9)	A1F	5	(60.8 – 60.9, 69.90 – 69.91)
3	$\overline{x} = 83.5$	B1	5	
		Di		
	$s^2 = \frac{1}{99}(15321) = 154.76$			
	s = 12.4	B1		(12.44)
	$H_0: \mu = 85.9$			
	$H_1: \mu \neq 85.9$	B1		
	Under H_0 , $\bar{X} \sim N \left(85.9, \frac{(12.44^2)}{100} \right)$			
	100			
	$z_{\text{crit}} = \pm 1.96$	B1		
	$z = \frac{83.5 - 85.9}{12.44/10} = -1.929$	M1A1		
	accept H ₀ , reject the claim	A1F		
	Insufficient evidence to suggest that the			
	mean has changed from 85.9 at the 5%	D45		
	level of significance. Total	E1F	8 8	
	1 Otal	O		

Q Solution Marks Total Comments 4(a) $\sum p = 1$ $k = 1 - (0.40 + 0.25 + 0.18 + 0.12)$ $k = 0.05$ B1 1 (b)(i) $E(X) = \sum_{all x} x P(X = x) = 3.17$ B1 1 (ii) $Var(X) = \sum_{all x} x^2 P(X = x) - \mu^2$ M1 $\sum x^2 P(X = x)$ attempted $= 11.53 - 10.0489$ M1 $\sum x^2 P(X = x) - \left[E(X)\right]^2$ $= 1.4811$ A1 3 AWFW $1.48 - 1.49$ (c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ M1 1 $= 3.34$ M1 1 their $Var(X) \times 4$ $= 4 \times 1.48$ $= 5.92$ Standard deviation $= 2.43$ m1A1 3 $$ Note: if separate table used for Y : $E(Y^2) = 17.08$ $E(Y)^2 = 11.16$	MS2A (cont)			
$k = 1 - (0.40 + 0.25 + 0.18 + 0.12) \\ k = 0.05$ B1 1 (b)(i) $E(X) = \sum_{\text{all } x} x P(X = x) = 3.17$ B1 1 (ii) $Var(X) = \sum_{\text{all } x} x^2 P(X = x) - \mu^2$ M1 $= 11.53 - 10.0489 \\ = 1.4811 \\ = 1.48$ A1 3 $E(Y) = 2E(Y) - 3 \\ = 2 \times 3.17 - 3 \\ = 3.34$ M1 1 (ii) $Var(Y) = 4Var(X) \\ = 4 \times 1.48 \\ = 5.92$ Standard deviation = 2.43 M1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Q	Solution	Marks	Total	Comments
(b)(i) $E(X) = \sum_{\text{all } x} X P(X = x) = 3.17$ B1 1 (ii) $Var(X) = \sum_{\text{all } x} X^2 P(X = x) - \mu^2$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 3.17$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 3.17$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 3.17 = 3.14$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 1.48 = 3.14$ A1 3 AWFW 1.48 – 1.49 (c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ M1 $= 3.34$ Their Var(X) × 4 $= 3.34$ M1 $= 3.34$ M1 $= 3.34$ M1 $= 3.34$ Their Var(X) × 4 $= 3.34$ M1 $= 3.34$ M2 M1 $= 3.34$ M2	4(a)	$\sum p = 1$			
(b)(i) $E(X) = \sum_{\text{all } x} X P(X = x) = 3.17$ B1 1 (ii) $Var(X) = \sum_{\text{all } x} X^2 P(X = x) - \mu^2$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 3.17$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 3.17$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 3.17 = 3.14$ M1 $\sum_{\text{all } x} X^2 P(X = x) = 1.48 = 3.14$ A1 3 AWFW 1.48 – 1.49 (c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ M1 $= 3.34$ Their Var(X) × 4 $= 3.34$ M1 $= 3.34$ M1 $= 3.34$ M1 $= 3.34$ Their Var(X) × 4 $= 3.34$ M1 $= 3.34$ M2 M1 $= 3.34$ M2		k = 1 - (0.40 + 0.25 + 0.18 + 0.12)			
(ii) $Var(X) = \sum_{\text{all } x} X^2 P(X = x) - \mu^2$ M1 $\sum_{\text{cl} (X)} x^2 P(X = x) \text{ attempted}$ $\sum_{\text{cl} (X)} x^2 P(X = x) \text{ attempted}$ $\sum_{\text{cl} (X)} x^2 P(X = x) \text{ attempted}$ $\sum_{\text{cl} (X)} x^2 P(X = x) - \left[E(X) \right]^2$ AWFW 1.48 - 1.49 (c) (i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ $= 3.34$ M1 1 $\sum_{\text{cl} (X)} x^2 P(X = x) - \left[E(X) \right]^2$ AWFW 1.48 - 1.49 (ii) $Var(Y) = 4 Var(X)$ $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 m1A1 3 $\sqrt{}$ Note: if separate table used for Y : $E(Y^2) = 17.08$			B1	1	
(ii) $Var(X) = \sum_{\text{all } x} X^2 P(X = x) - \mu^2$ M1 $\sum_{\text{cl} (X)} x^2 P(X = x) \text{ attempted}$ $\sum_{\text{cl} (X)} x^2 P(X = x) \text{ attempted}$ $\sum_{\text{cl} (X)} x^2 P(X = x) \text{ attempted}$ $\sum_{\text{cl} (X)} x^2 P(X = x) - \left[E(X) \right]^2$ AWFW 1.48 - 1.49 (c) (i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ $= 3.34$ M1 1 $\sum_{\text{cl} (X)} x^2 P(X = x) - \left[E(X) \right]^2$ AWFW 1.48 - 1.49 (ii) $Var(Y) = 4 Var(X)$ $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 m1A1 3 $\sqrt{}$ Note: if separate table used for Y : $E(Y^2) = 17.08$					
(ii) $Var(X) = \sum_{\text{all } x} x^2 P(X = x) - \mu^2$ M1 $\sum x^2 P(X = x) \text{ attempted}$ $= 11.53 - 10.0489$ $= 1.4811$ $= 1.48$ A1 3 AWFW 1.48 - 1.49 (c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ $= 3.34$ M1 1 $Var(Y) = 4Var(X)$ $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $\sum x^2 P(X = x) \text{ attempted}$ $\sum x^2 P(X = x) \text{ attempted}$ $\sum x^2 P(X = x) - \left[E(X)\right]^2$ AWFW 1.48 - 1.49 (ii) $Var(Y) = 4Var(X)$ $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $\sum x^2 P(X = x) \text{ attempted}$ $\sum x^2 P(X = x) - \left[E(X)\right]^2$ $\sum x^2 P(X = x) - \left[E(X)\right]$ $\sum x^2 P$	(b)(i)	$E(X) = \sum x P(X = x) = 3.17$	B1	1	
		all x			
	(ii)	$\operatorname{Var}(X) = \sum_{x} x^2 P(X = x) - \mu^2$	M1		$\sum r^2 P(X = r)$ attempted
Co(i) $= 1.4811$ $= 1.48$ A1 3 AWFW 1.48 - 1.49 (c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ $= 3.34$ M1 1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 m1A1 3 $\sqrt{Note: if separate table used for } Y: E(Y^2) = 17.08$	()	$\lim_{x \to \infty} \int_{\mathbb{R}^n} \int_{\mathbb{R}^n}$			
Co(i) $= 1.4811$ $= 1.48$ A1 3 AWFW 1.48 - 1.49 (c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ $= 3.34$ M1 1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 m1A1 3 $\sqrt{Note: if separate table used for } Y: E(Y^2) = 17.08$		11.52 10.0400	3.61		$\sum v^2 \mathbf{p}(\mathbf{V}-\mathbf{v}) \left[\mathbf{F}(\mathbf{V})^2 \right]^2$
(c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ $= 3.34$ M1 1 War $(Y) = 4Var(X)$ $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 3 AWFW 1.48 - 1.49 M1 1 their $Var(X) \times 4$ $Var(X) \times 4$ Their $Var(X) \times 4$			MI		$\sum x P(X = x) - \lfloor E(X) \rfloor$
(c)(i) $E(Y) = 2E(Y) - 3$ $= 2 \times 3.17 - 3$ $= 3.34$ M1 1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 1 their $Var(X) \times 4$ $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 3 $$ Note: if separate table used for Y : $E(Y^2) = 17.08$			Δ1	3	AWFW 1 48 – 1 49
$= 2 \times 3.17 - 3$ $= 3.34$ M1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $= 4 \times 1.48$ $= 5.92$ Note: if separate table used for Y: $E(Y^2) = 17.08$		- 1.40	711	3	71W1 W 1.40 1.47
$= 2 \times 3.17 - 3$ $= 3.34$ M1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 M1 $= 4 \times 1.48$ $= 5.92$ Note: if separate table used for Y: $E(Y^2) = 17.08$	(c)(i)	E(Y) = 2E(Y) - 3			
(ii) $Var(Y) = 4Var(X)$ $= 4 \times 1.48$ = 5.92 Standard deviation = 2.43 M1 their $Var(X) \times 4$ m1A1 3 $Note: if separate table used for Y:E(Y^2) = 17.08$		$=2\times3.17-3$	M1	1	
$= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 $m1A1$ 3 Note: if separate table used for Y: $E(Y^2) = 17.08$			1411	1	
$= 4 \times 1.48$ $= 5.92$ Standard deviation = 2.43 $m1A1$ 3 Note: if separate table used for Y: $E(Y^2) = 17.08$					
Standard deviation = 2.43 $m1A1$ 3 $\sqrt{}$ Note: if separate table used for Y: $E(Y^2) = 17.08$	(ii)	$\operatorname{Var}(Y) = 4\operatorname{Var}(X)$	M1		their $Var(X) \times 4$
Standard deviation = 2.43 $m1A1$ 3 $\sqrt{}$ Note: if separate table used for Y: $E(Y^2) = 17.08$		$=4\times1.48$			
Note: if separate table used for Y: $E(Y^2) = 17.08$					
$E(Y^2) = 17.08$		Standard deviation $= 2.43$	m1A1	3	•
					_
$\left[E(Y)\right]^2 = 11.16$					$\mathrm{E}(Y^2) = 17.08$
					$\left[\left[E(Y) \right]^2 = 11.16 \right]$
Total 9		Total		9	

Q Q	Solution	Marks	Total	Comments	
5(a)	$H_0: \mu = 30$				
	$H_1: \mu > 30$	B1			
	$\overline{x} = 33.5$ and $s = 4.25$ ($s^2 = 18.06$)	B1B1		$\sigma = 4.03 \left(\sigma^2 = 16.24\right)$	
	Under H_0 $\overline{X} \sim N \left(30, \frac{\left(4.25^2 \right)}{10} \right)$				
	$t = \frac{33.5 - 30}{4.25 / \sqrt{10}} = 2.60$	M1A1		$\frac{33.5 - 30}{4.03 / \sqrt{9}}$	
				(2.60-2.61)	
	$t_{\rm crit} = 2.821$	B1		Critical value for \overline{x} :	
				$30 + 2.821 \times \frac{4.25}{\sqrt{10}} = 33.79$	
	do not reject H_0				
	Insufficient evidence at the 1% level of significance that Jasmine's teacher is				
	underestimating the time that it takes to complete the homework assignments	E1F	7	on <i>t</i> -test used	
(b)	Times are Normally distributed	B1	1		
	Total		8		

Q Q	Solution	Marks	Total	Comments
6(a)	10 TO			
	0.6 0.5 0.1 0.1 5ne (nmq)	B1 B1 B1	3	curve line axes
(b)	$P(T \ge 1) = \frac{1}{2} \times \frac{7}{8} \times 2 = \frac{7}{8}$	M1A1	2	oe
(c)(i)	For $1 \le t \le 3$			
	$\int_{1}^{t} \frac{1}{16} (t+5) dt = \left[\frac{1}{32} t^{2} + \frac{5}{16} t \right]_{1}^{t}$	M1A1		
	$F(1) = \frac{1}{8}$	B1		
	$F(t) = \frac{1}{8} + \frac{1}{32}t^2 + \frac{5}{16}t - \frac{11}{32}$			
	$\Gamma(t) = \frac{1}{8} + \frac{1}{32}t + \frac{1}{16}t - \frac{1}{32}$	M1		Use of:
				$F(t) = F(1) + \int_{1}^{t} \frac{1}{16}(t+5)dt$
	$F(t) = \frac{1}{32} (t^2 + 10t - 7)$ Alternative: $\int \frac{1}{16} (t+5) dt$	A1	5	AG
	$= \frac{1}{16} \left(\frac{1}{2} t^2 + 5t + c \right)$	(M1A1) (B1)		
	$\Rightarrow c = -3.5$	(M1)		
	$F(1) = \frac{1}{8}$ $\Rightarrow c = -3.5$ $F(t) = \frac{1}{32} (t^2 + 10t - 7)$	(A1)	(5)	
(ii)	$\frac{1}{32} \left(m^2 + 10m - 7 \right) = 0.5$	M1		
	$m^2 + 10m - 23 = 0$	A1		
	$m = \frac{-10 \pm \sqrt{192}}{2} = -5 \pm \sqrt{48}$	m1		or any valid method
	$=-5\pm4\sqrt{3}$ ($m>0$)			
	$m = 4\sqrt{3} - 5 = 1.93$	A1	4	(1.9282)
	Total		14	

Q Q	,	So	lution		Marks	Total	Comments
7(a)	H · No a			the	Marks	10001	Comments
	H ₀ : No association between the performances at KS3 and GCE				B1		
	F						
	O_i	E_{i}	$O_i - E_i$	X^2			
		•					
	60	63.55	-3.55	0.1983	M1		E_i
	55 40	44.64 46.81	10.36 -6.81	2.4043 0.9907	1411		E_i
	10	10.01	0.01	0.5507	M1		$O_i - E_i$
	55	51.25	3.75	0.2744			
	32	36.00 37.75	-4.00 0.25	0.4444	M1		$O_i - E_i$ $(O_i - E_i)^2 / E_i$
	36	37.73	0.23	0.0017			
	47	46.33	0.67	0.0097	M1		\sum
	31	32.54 34.13	-1.54 0.87	0.0733			
	33	34.13	0.87	0.0222			
	43	43.87	-0.87	0.0173			
	26 38	30.82	-4.82 5.69	0.7527			
	38	32.31	3.09	1.0005			
	$X^2 = 6.1897$			$X^2 = 6.1897$	A1		AWFW 6.05 – 6.40
	$v = 3 \times 2 = 6 \implies \chi^2_{90\%} = 10.645$				B1		
				B1F		on their ν	
	Do not reject H ₀						
	No evidence to suggest an association between KS3 results and GCE grades at						
		KS3 result l of signifi		E grades at	E1	9	
(b)							
	KS3 gain grade A's at GCE than expected.				E1	1	
	Total					10	
				TOTAL		60	