

MARK SCHEME for the May/June 2013 series

9709 MATHEMATICS

9709/71

Paper 7, maximum raw mark 50

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Note: “(3 sfs)” means “answer which rounds to ... to 3 sfs”. If correct ans seen to ≥ 3 sfs, ISW for later rounding. Penalise < 3 sfs only once in paper.

1	(i)	One of each is more likely $P(\text{one of each} = 0.5), P(HH) = 0.25$	B1 B1 [2]	or $P(TT) = 0.25$	
	(ii)	Choose Charlie only if H then T Throw again if T then H	B1 B1 [2]	or similar e.g. HH for A, HT for B, TT for C or vice versa	
2		H_0 : Pop mean = 17 H_1 : Pop mean $\neq 17$	B1	Both correct. Allow μ , but not just “mean”	
		$\frac{18.2 - 17}{\frac{2.4}{\sqrt{5}}}$	M1	Allow incorrect 18.2. Must have $\sqrt{5}$	$17 \pm 1.96 \frac{2.4}{\sqrt{5}}$ M1
		= 1.12 (3 sf)	A1		= (14.9, 19.1) A1
		‘1.12’ < 1.96 oe	M1	Comp ‘1.12’ with 1.96 or area ‘0.132’ with 0.025	‘14.9’ < 18.2 < ‘19.1’ M1
		Claim can be accepted	A1ft [5]	ft their ‘1.12’ If $H_1: \mu > 17$ and cf 1.645: can score max B0M1A1M1A1ft	
3		$\text{Var}(\text{total}) = 6(3.2^2 + 2.6^2) (+ 0)) (= 102)$ Total $\sim N(1528, 102)$	B1 B1	For mean (1528)oe and for variance (102) May be implied by use of $N(1528, 10.1^2)$	
		$\frac{1550 - 1528}{\sqrt{102}}$ (= 2.178)	M1	For standardising. No SD/Var mix	
		$1 - \Phi(2.178)$ = 0.0147 (3 sf)	M1 A1 [5]	For correct area consistent with working	
4	(i)	$\text{est}(\mu) = 2005/200 = (10.025)$ $\text{est}(\sigma^2) = \frac{1}{99} 20175 - \frac{2005^2}{200}$ = 0.376 (3 sf)	B1 M1 A1 [3]	Correct subst in correct formula	
	(ii)	$\frac{10 - 10.025}{\sqrt{\frac{0.376256}{50}}}$ (= -0.288) $1 - \Phi(0.288)$ = 0.387 (3 sf)	M1 M1 A1 [3]	Allow without $\sqrt{}$, but $\div \sqrt{50}$ essential (Use of ‘biased’ variance can still score fully in (ii))	

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(iii)	Yes; (assumed distr of $\bar{X}$ normal) although distr of X unknown	B1 B1 [2]	
5 (i)	B(520, 0.008) Po(4.16) $n = 500$ which is large, $np = 4.16$ which is < 5 or p small < 0.1	B1 B1B1 B1 [4]	Po: B1, $\lambda = 4.16$: B1 Both needed
(ii)	(a) $1 - e^{-4.16} \left(1 + 4.16 + \frac{4.16^2}{2} + \frac{4.16^3}{3!} \right)$ $= 0.597$ (3 sf)	M1 A1 [2]	$1 - P(0,1,2,3)$ any λ allow one end error
	(b) $e^{-4.16} \times \frac{4.16^n}{n!} > e^{-4.16} \times \frac{4.16^{n+1}}{(n+1)!}$ $1 > \frac{4.16}{n+1}$ $n > 3.16$ Smallest n is 4	M1 A1 A1 [3]	any λ or equiv equn without e and without factorials (Calculation of $P(0), P(1), \dots, P(5)$ scores M1 for at least 3 attempted, A1 all correct, A1 for $n = 4$)
6 (i)	$\frac{1}{2} \int_4^t \frac{1}{\sqrt{t}} dt = 0.9$ or $\frac{1}{2} \int_t^9 \frac{1}{\sqrt{t}} dt = 0.1$ $[\sqrt{t}]_4^t = 0.9$ or $[\sqrt{t}]_t^9 = 0.1$ $((\sqrt{t} - 2) = 0.9$ or $(3 - \sqrt{t}) = 0.1)$ $t = 8.41$ (mins) (3 sf)	M1 A1 A1 [3]	Attempt integ $f(t)$ with unknown limit and 0.9/0.1. Correct integration & limits = 0.9 or 0.1.
(ii)	$\frac{1}{2} \int_4^9 \frac{t}{\sqrt{t}} dt$ oe $\frac{1}{2} \left[\frac{t^{1.5}}{1.5} \right]_4^9$ oe $= \frac{19}{3}$ $\frac{1}{2} \int_4^9 \frac{t^2}{\sqrt{t}} dt$ oe $(= \frac{1}{2} \left[\frac{t^{2.5}}{2.5} \right]_4^9 = \frac{211}{5})$ $= \frac{211}{5} - \left(\frac{19}{3} \right)^2$ $= \frac{94}{45}$ or 2.09 (3 sf)	M1 A1 A1 M1 M1 A1 [6]	Attempt integ $tf(t)$. Ignore limits Correct integration & limits Attempt integ $t^2f(t)$. Ignore limits integ $t^2f(t) - (\text{integ } tf(t))^2$ attempted

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7	(i)	Conclude die is biased when it isn't or ${}^5C_3 \left(\frac{1}{6}\right)^3 \left(\frac{5}{6}\right)^2 + 5 \left(\frac{1}{6}\right)^4 \left(\frac{5}{6}\right) + \left(\frac{1}{6}\right)^5 + 5$ $= \frac{23}{648} \text{ or } 0.0355 \text{ (3 sf)}$	B1 M1 A1 [3]	In context $\text{or } 1 - \left({}^5C_2 \left(\frac{1}{6}\right)^2 \left(\frac{5}{6}\right)^3 + 5 \left(\frac{1}{6}\right) \left(\frac{5}{6}\right)^4 + \left(\frac{5}{6}\right)^5 \right)$ allow 1 end error
	(ii)	State or attempt $P(0, 1, 2)$ with $p = \frac{2}{3}$ ${}^5C_2 \left(\frac{2}{3}\right)^2 \left(\frac{1}{3}\right)^3 + 5 \left(\frac{2}{3}\right) \left(\frac{1}{3}\right)^4 + \left(\frac{1}{3}\right)^5$ $= \frac{17}{81} \text{ or } 0.210 \text{ (3 sf)}$	M1 M1 A1 [3]	Or $1 - P(3,4,5)$ Attempt at correct expression Allow 0.21
	(iii)	Est $\text{Var}(P_s) = \frac{0.625 \times (1 - 0.625)}{80}$ $\left(= \frac{3}{1024} \right)$ $z = 2.054 \text{ (or } 2.055)$ $0.625 \pm z \times \sqrt{\frac{3}{1024}}$ $= 0.514 \text{ to } 0.736 \text{ (3 sf)}$	M1 B1 M1 A1 [4]	Any z

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1	(i) Binomial $n = 400, \quad p = 0.012$	B1 B1 [2]	Both. Not $p = 1.2\%$ Or $B(400, 0.012)$: B1B1
	(ii) Poisson n large and mean = 4.8, which is < 5	B1 B1 [2]	n large, p small
	(iii) $1 - e^{-4.8} \left(1 + 4.8 + \frac{4.8^2}{2} \right)$ $= 0.857/0.858$	M1 A1 [2]	$P(X = 0, 1, 2)$; allow any λ ; allow one end error (Normal/Binomial in (ii) can score M1 only)
[Total: 6]			
2	(i) $\frac{2}{3} \int_1^2 x^2 dx$ $= \frac{2}{3} \left[\frac{x^3}{3} \right]_1^2$ $= \frac{14}{9}$ or 1.56 o.e.	M1 A1 A1 [3]	Attempt integ. $xf(x)$; ignore limits Correct integration and limits
	(ii) $\frac{2}{3} \int_1^{14} x dx$ $\left(= \frac{2}{3} \left[\frac{x^3}{3} \right]_1^{14} \right)$ $= \frac{115}{243}$ or 0.473 (3 s.f.)	M1 A1 [2]	Attempt integ. $f(x)$; with limits
	(iii) $\frac{115}{243} < \frac{1}{2}$ o.e. Hence mean $<$ median	M1 A1ft[2]	Comparison of prob. or values ft (i) or (ii)
[Total: 7]			

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3	(i)	$\frac{73.1-75.2}{\frac{5.7}{\sqrt{n}}} = -1.563$ $n = \{-1.563 \times 5.7 \div (-2.1)\}^2$ $n = 18$ Assume s.d. for the region is 5.7	M1 A1 A1 B1 [4]	For standardising (with $\sqrt{n}$) Any correct expression for n or $\sqrt{n}$. May be implied by ans.
	(ii)	H_0 : pop mean (or μ) = 75.2 H_0 : pop mean (or μ) < 75.2 1.563 comp 1.555 Evidence that plants shorter	B1 M1 A1 [3]	Both (could be stated in (i)) For comparison of z values / areas / x values CWO. No contradictions
[Total: 7]				
4	(i)	$\text{est}(\mu) = 9750/150 = (65)$ $\text{est}(\sigma^2) = \frac{1}{149} \left(647500 - \frac{9750^2}{150} \right)$ $= 92.3 \text{ (3 s.f.)}$	B1 M1 A1 [3]	Correct subst. in correct formula
	(ii)	$z = 2.326$ $'65' \pm z \times \frac{\sqrt{92.28188}}{\sqrt{150}}$ $= 63.2 \text{ to } 66.8 \text{ (3 s.f.)}$	B1 M1 A1 [3]	Any z (Use of 'biased' can still score here)
	(iii)	0.02^2 $= 0.0004 \text{ o.e.}$	M1 A1 [2]	Allow M1 for 0.02 seen
	[Total: 8]			

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5	(i) $6 \times 510 + 70 = (3130)$ $6 \times 12^2 + 4^2 = (880)$ $N(3130, 880)$ $\frac{3050-3130}{\sqrt{880}} \quad (= -2.697)$ $\frac{3150-3130}{\sqrt{880}} \quad (= 0.674)$ $\Phi('0.674') - (1 - \Phi('2.697'))$ $ (= 0.7499 - 0.0035)$ $= 0.746 \text{ (3 sf)}$	B1 B1 M1 M1 A1 [5]	
	(ii) $510 - 8 \times 70 = (-50)$ $12^2 + 8^2 \times 4^2 = (1168)$ $P - 8C \sim N(-50, 1168)$ $\frac{0 - (-50)}{\sqrt{1168}} \quad (= 1.463)$ $1 - \Phi('1.463')$ $= 0.0717 \text{ (3 s.f.)}$	B1 B1 M1 M1 A1 [5]	Both. With their mean and variance(≥ 0) Allow without $\sqrt{}$ Use of tables and attempt to find area consistent with their working o.e. +50; 510/8 -70; – (510/8 – 70) o.e. $(12/8)^2 + 4^2$ For standardising with attempt “P-8C” oe with their mean and variance(≥ 0). Allow without $\sqrt{}$ Use of tables and attempt to find area consistent with their working
[Total: 10]			

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6	(i)	H_0 : Pop mean (or λ or μ) is 5.3 H_1 : Pop mean (or λ or μ) is less than 5.3	B1	Both
		$P(X \leq 1) = e^{-5.3}(1 + 5.3)$		
		$P(X \leq 2) = e^{-5.3}(1 + 5.3 + \frac{5.3^2}{2})/P(X=2)$	M1	Both attempted
		$P(X \leq 1) = 0.0314$ or 0.0315 & $P(X \leq 2) = 0.102/ P(X=2)=0.7071$	A1	Both correct
		CR is 0 or 1 cases	A1	Dep. M1 and $P(X \leq 1) < 0.05 < P(X \leq 2)$
		No evidence mean has decreased	B1f [5]	ft their CR
		(ii)	Concluding mean has decreased when it hasn't '0.0314 or 0.0315'	B1
			B1ft[2]	ft their $P(X \leq 1)$, dep. < 0.05
	(iii)	(Po(18.4)) N(18.4, 18.4)	B1 B1ft	Stated or implied B1 for N(18.4, ..); B1f for var. = 18.4
		$\frac{20.5-18.4}{\sqrt{18.4}}$ (= 0.490)	M1	For standardising with or without cc.Allow without $\sqrt{}$
		$1 - \Phi('0.490')$	M1	Use of tables and attempt to find area consistent with their working
		= 0.312 (3 s.f.)	A1 [5]	
		[Total: 12]		

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1	(i)	9.3	B1	1	
	(ii)	27.9	B1	1	
	(iii)	E (S) = 17.4, E(T) = 19.4 E (S – T) = – 2.0, Var (S – T) = 37.2	M1 A1 B1ft	3	For subtracting their E[S] – E[T] can be non-numerical ft (i) & (ii) Adding (i) and (ii) ft non-negative answers only
[Total: 5]					
2		Assume shots independent OR prob of scoring constant H ₀ : P(score) = 0.82 H ₁ : P(score) > 0.82 $20 \times 0.82^{19} \times 0.18 + 0.82^{20}$ = 0.102 (3 sf) No evidence that improved	B1 B1 M1 A1 B1f	5	In context Both. Allow 'p' For use of Bin(20,0.82) and either P(19) and/or P(20) attempted Valid comparison seen (with 0.05 if H ₁ p ≠ 0.82) and correct conclusion ft numerical errors in 0.102 only Normal approx'n: B1 B1 (μ = 16.4 acceptable here) if earned, then: CR = 1.222 (from $\frac{18.5 - 20 \times 0.82}{\sqrt{20 \times 0.82 \times (1 - 0.82)}}$, need cc) comp z = 1.282 No evidence that improved SC 1 Same scheme for proportions
[Total: 5]					
3	(i)	$\bar{x} = 930/15 = (62)$ z = 1.751 $'62' \pm z \times \frac{12}{\sqrt{15}}$ = 56.6 to 67.4 (3 sf)	B1 B1 M1 A1	4	Any z Must be an interval
	(ii)	92% of such intervals will contain μ	B1	1	Accept P(This interval contains μ) = 0.92
	(iii)	Each possible sample of this size is equally likely	B1	1	Each member of pop equally likely to be chosen
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4	(i)	$e^{-2} \times 2 (\times) e^{-3} \times \frac{3^4}{4!}$	M1		Correct exp'n for P(1) with $\lambda=2$ OR P(4) with $\lambda=3$ Correct exp'n dep M1B1
		$e^{-5} \times \frac{5^4}{5!}$	B1		
		$\div$	M1		
		$\frac{162}{625}$ or 0.259 (3 sf)	A1	4	
	(ii)	$(e^{-2} \times \frac{2^r}{r!} = \frac{2}{3} e^{-2} \Rightarrow)$			
		$3 \times 2^r = 2 \times r! \text{ OR } 2^{r-1} = \frac{1}{3} \times r!$	B1		Legitimately shown
		$(\Rightarrow 3 \times 2^{r-1} = r!)$			
		$3 \times 2^3 = 24 \text{ OR } 3! = 24 \text{ seen}$	B1	2	Legitimately shown on either equation
[Total: 6]					
5	(i)	$\int_1^{\infty} \frac{k}{x^3} dx = 1$	M1		All correct, including limits and an attempt to integrate or $0 + \frac{k}{2} = 1$ or $\frac{k}{2} = 1$ AG must be convincing
		$\left[-\frac{k}{2x^2} \right]_1^{\infty} = 1$	A1	2	
		$0 - (-\frac{k}{2}) = 1$			
	(ii)	$\int_1^2 \frac{2}{x^3} dx$	M1		Attempt integ f(x); ignore limits Attempt integ xf(x); ignore limits Correct & correct limits
		$= \left[-\frac{1}{x^2} \right]_1^2$			
		$= \frac{3}{4}$	A1	2	
	(iii)	$\int_1^{\infty} \frac{2}{x^2} dx$	M1		Attempt integ xf(x); ignore limits Correct & correct limits
		$= \left[-\frac{2}{x} \right]_1^{\infty}$	A1		
		$= 2$	A1	3	
[Total: 7]					

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6	(i)	$\lambda (= 1.4 \times 2.5) = 3.5$ $1 - e^{-3.5}(1 + 3.5 + \frac{3.5^2}{2} + \frac{3.5^3}{3!})$ $= 0.463$ (3 sf)	B1 M1 A1	3	Any λ allow one end error
	(ii)	$(\lambda = 672 \times 1.4 = 940.8)$ $N(940.8, 940.8)$ $\frac{999.5 - 940.8}{\sqrt{940.8}} (= 1.914)$ $\Phi('1.914')$ $= 0.972$ (3 sf)	B1 M1 M1 A1	4	Seen or implied Allow with wrong or no cc . no sd/var mixes
[Total: 7]					
7	(i)	Assume sd unchanged or 4500 H_0 : Pop mean = 34600 H_1 : Pop mean > 34600 $\frac{35400 - 34600}{\frac{4500}{\sqrt{90}}}$ $= 1.687/1.686$ (1.69) cf 1.645 < 1.686 Evidence that mean wkly profit has increased	B1 B1 M1 A1 M1 A1 f	6	Both. Allow just μ , but not just “mean” Allow without $\sqrt{90}$ Valid comparison (or 0.0458/0.0459 < 0.05 or 35380 < 35400 or 34600 < 34620) If H_1 : $\neq$, and 1.96 used, max B1B0M1A1M1A1f No contradictions
	(ii)	Distr'n of X unknown. Yes	B1* B1* dep	2	Allow not Normal
	(iii)	0.05 or 5%	B1	1	
	(iv)	$\frac{a - 34600}{\frac{4500}{\sqrt{90}}} = 1.645$ $a = 35380$ $\frac{35380 - 36500}{\frac{4500}{\sqrt{90}}} (= -2.361)$ $1 - \Phi('2.361')$ $= 0.0091$	M1 A1 M1 M1 A1	6	Attempt to find cv must see (+) 1.645 allow without $\sqrt{90}$. If found in (i) award when used Standardising with their “ CV “ must use $\sqrt{90}$ Correct tail
[Total: 14]					