

MARK SCHEME for the May/June 2011 question paper
for the guidance of teachers

9709 MATHEMATICS

9709/71

Paper 7, maximum raw mark 50

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B Mark for a correct result or statement independent of method marks.

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1	Poisson $\lambda = 1.2$ $1 - e^{-1.2}(1 + 1.2 + \frac{1.2^2}{2})$ $= 0.121$	B1 B1 M1 A1 [4]	1.2 seen 1 – Poisson P(0, 1, 2, 3) attempted, any λ , allow 1 end error SC: using Bin, ans 0.120: B1
2 (a)	$41.2 \pm z \times \sqrt{\frac{32.6}{50}}$ $z = 1.96$ [39.6, 42.8] (3 sfs)	M1 B1 A1 [3]	Allow any brackets or none, or < or “to” etc
(b)	$2 \times \frac{1}{16}$ or $\frac{1}{8}$ or 0.125 or 12.5% $\alpha = 87.5\%$	M1 A1 [2]	or 0.875
3 (i)	$\frac{85.7-85}{\frac{4.8}{\sqrt{n}}} (= 1.786)$ $n = \left(\frac{1.786 \times 4.8}{0.7}\right)^2$ $= 150$	M1 A1 A1 [3]	Correct equation in n
(ii)	$H_0: \mu = 85.0$ $H_1: \mu > 85.0$ $z = 1.645$ Evidence that μ increased	B1 M1 A1f [3]	Comparison 1.786 and 1.645 Allow 1.96 if $H_1: \mu \neq 85.0$ Correct conc. No contradictions. ft H_1
4 (a)	g: Area $\neq 1$ or > 1 h: pdf cannot be neg	B1 B1 [2]	
(b) (i)	$\int_{10}^{15} \frac{30}{x} dx$ $= [30 \ln x]_{10}^{15}$ $= 30(\ln 15 - \ln 10)$ $(= 30 \ln 1.5 \text{ AG})$	M1 A1 A1 [3]	Attempt integ $xf(x)$, ignore limits Correct integrand and limits or $30 \ln(15/10)$
(ii)	$\int_{10}^m \frac{30}{x^2} dx = 0.5$ $\left[-30x^{-1}\right]_{10}^m = 0.5$ $-\frac{30}{m} - \left(-\frac{30}{10}\right) = 0.5$ $m = 12$ $30 \ln 1.5$ $\int_{12}^{15} \frac{30}{x^2} dx$ '12' $= 0.0337$ (3 sfs)	M1 A1 A1 M1 A1 [5]	Integ $f(x) = 0.5$, limits 10 to unknown Correct integrand, limits and $= 0.5$

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5	(i) $W \sim N(2240, 848)$ $\frac{2200 - 2240}{\sqrt{848}} (= -1.374)$ $\Phi(-1.374) = 1 - \Phi(1.374) (= 0.0847)$ $\frac{2300 - 2240}{\sqrt{848}} (= 2.060)$ $\Phi(2.060) (= 0.9803)$ $\Phi(2.060) - (1 - \Phi(1.374))$ $= 0.896$ (3 sfs)	B2 M1A1 M1 A1 [6]	B1 each parameter Standardise either value and evaluate correctly Correct combination of Φ 's
	(ii) $X_1 - X_2 \sim N(0, 392)$ $\frac{20 - 0}{\sqrt{392}} (= 1.010)$ $(\Phi(1.010) = 0.8438)$ $P(X > 20) = 1 - \Phi(1.010) (= 0.1562)$ $2 \times P(X > 20)$ $= 0.312$ (3 sfs)	B1 M1 A1 M1 A1 [5]	May be implied
	(i) mean = 6.3 $P(X \leq 1) = e^{-6.3}(1 + 6.3) = 0.0134$ $P(X \leq 2) = e^{-6.3}(1 + 6.3 + \frac{6.3^2}{2}) = 0.0498$ CR is $X \leq 1$	B1 M1 M1A1 A1 [5]	B1 for 6.3 Allow incorrect λ in both probs A1 for both values
	(ii) $P(\text{Type I error}) = P(X \leq 1) = 0.0134$	B1 [1]	
	(iii) $H_0: \lambda = 6.3$ $H_1: \lambda < 6.3$ 3 not in CR No evidence mean no. of injuries has decreased	B1 M1 A1 [3]	Can be scored in (i). Accept $\lambda = 2.1$ (per month) or $P(X \leq 3) = 0.126 > 0.02$ Correct conclusion
	(iv) $N(25.2, 25.2)$ $\frac{19.5 - 25.2}{\sqrt{25.2}} (= -1.135)$ $\Phi(-1.135) = 1 - \Phi(1.135)$ $= 0.128$ (3 sfs)	B2 M1 M1 A1 [5]	B1 for N & $\mu = 25.2$. B1 for $\sigma^2 = 25.2$ May be implied Allow with wrong or no cc or no $\sqrt{}$ Correct area

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1	$E(T) = 9.6$ $\text{Var}(\text{wt of one bag}) = 0.0016$ $\text{Var}(T) = 3 \times 0.0016$ $\text{sd of } T = \sqrt{3 \times 0.0016} = 0.0693$	B1 M1 M1 A1 [4]	May be impl. by $\text{Var}(T) = 0.0048$ or 0.0144
[Total: 4]			
2	$\bar{X} \sim N(3, \frac{9}{60})$ $\frac{2.8-3}{\sqrt{\frac{9}{60}}} (= -1.033)$ $\Phi(-1.033) = 1 - \Phi(1.033)$ $= 0.151$	B2 M1 M1 A1 [5]	B1 for N & $\mu = 3$; (oe) B1 for $\frac{9}{60}$ or $\frac{3}{80}$ or 0.0375 (oe) (oe working with totals or proportions) With or without c.c. With cc of $-\frac{1}{120}$, $\Phi(-1.076) = 1 - \Phi(1.076) = 0.141$
[Total: 5]			
3	(i) Constant average rate of goals scored Goals random Goals indep	B1 B1 [2]	Any two given in context (SR score B1 for any two not in context) Not Goals scored singly (because this is inherent in the context so it's not a condition)
	(ii) $e^{-1.8}(\frac{1.8^3}{3!} + \frac{1.8^4}{4!} + \frac{1.8^5}{5!})$ $= 0.259$	M1 A1 [2]	Poisson probs, $\lambda = 1.8$. Allow 2, 6 included
	(iii) $1 - e^{-1.8}$ $(1 - e^{-1.8})^{10}$ $= 0.164$	M1 M1 A1 [3]	Any λ . Allow end errors.
[Total: 7]			
4	(i) $\bar{x} = 8.4$ $8.4 \pm z \frac{1.3}{\sqrt{15}}$ $z = 2.576$ [7.54, 9.26]	B1 M1 B1 A1 [4]	Accept 2.574 to 2.579 or equiv. Accept 7.53. Accept 9.27
	(ii) No because pop normal so $\bar{X}$ normally distr	B1 B1 [2]	SR If 'Yes' or no conclusion, but 2 correct statements score B1
	(iii) 8 within CI Claim justified	B1√ B1√ [2]	ft (i)
[Total: 8]			

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5	(i) Po(3.3) $e^{-3.3}(1 + 3.3 + \frac{3.3^2}{2})$ = 0.359	B1 M1 A1 [3]	seen or implied Poisson $P(0) + P(1) + P(2)$. Allow + $P(3)$ Allow wrong λ . Accept equiv method.
	(ii) $X \sim \text{Po}(36)$ $X \sim N(36, 36)$ $\frac{48.5 - 36}{\sqrt{36}}$ = 2.08(3) comp with 1.96 Evidence to support claim	B1 B1 M1 A1 M1 A1√ [6]	Allow with no or wrong cc or no √ 2.08(3) or 0.0186/0.0187 if area comparison Valid comparison Correct conclusion (ft their z)
[Total: 9]			
6	(i) $H_0: P(6) = \frac{1}{6}$ $H_1: P(6) > \frac{1}{6}$	B1 [1]	Condone undefined p
	(ii) $\left(\frac{5}{6}\right)^{10} + 10 \times \left(\frac{5}{6}\right)^9 \times \frac{1}{6} + \binom{10}{2} \times \left(\frac{5}{6}\right)^8 \times \frac{1}{6}^2 + \binom{10}{3} \times \left(\frac{5}{6}\right)^7 \times \left(\frac{1}{6}\right)^3$ $1 - \left(\left(\frac{5}{6}\right)^{10} + 10 \times \left(\frac{5}{6}\right)^9 \times \frac{1}{6} + \binom{10}{2} \times \left(\frac{5}{6}\right)^8 \times \left(\frac{1}{6}\right)^2 + \binom{10}{3} \times \left(\frac{5}{6}\right)^7 \times \left(\frac{1}{6}\right)^3\right)$ = 0.0697 (3 sfs)	M1 M1 A1 [3]	(1 –) $P(0,1,2,3)$ o.e. using $B(10,1/6)$ allow end errors Attempt at fully correct expression for $1 - P(0,1,2,3)$ o.e. Accept 0.0698
	(iii) Die biased towards a six but result < 4 so no evidence of bias	B1 [1]	or equiv. Must be in context
	(iv) $P(0, 1, 2 \text{ or } 3 \text{ sixes})$ $\left(\frac{1}{2}\right)^{10} + 10 \times \left(\frac{1}{2}\right)^9 \times \frac{1}{2} + \binom{10}{2} \times \left(\frac{1}{2}\right)^8 \times \left(\frac{1}{2}\right)^2 + \binom{10}{3} \times \left(\frac{1}{2}\right)^7 \times \left(\frac{1}{2}\right)^3$ = 0.172 or 11/64	B1 M1 A1 [3]	Stated or attempted. Can be implied Attempt at $P(0,1,2,3)$ with $p = 1/2$, allow end errors.
[Total: 8]			

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7	(i)	$\int_{-1}^1 k(1-x)dx = 1$ $(k[x - \frac{x^2}{2}]_{-1}^1 = 1)$ $2k = 1$ $(k = \frac{1}{2} \quad \text{AG})$	M1 A1 [2]	Attempt integ $f(x) = 1$ with correct limits
	(ii)	$(\int_{0.5}^1 \frac{1}{2}(1-x)dx = \frac{1}{2}[x - \frac{x^2}{2}]_{0.5}^1)$ $= \frac{1}{16} \text{ or } 0.0625$	B1 [1]	
	(iii)	$\int_{-1}^1 \frac{1}{2}(x-x^2)dx$ $= \frac{1}{2}[\frac{x^2}{2} - \frac{x^3}{3}]_{-1}^1$ $= -\frac{1}{3} \text{ or } -0.333$	M1 A1 A1 [3]	$\int xf(x)dx$ ignore limits Correct integrand and limits
	(iv)	$\int_{-1}^a \frac{1}{2}(1-x)dx = 0.25$ $(\frac{1}{2}[x - \frac{x^2}{2}]_{-1}^a = 0.25)$ $(\frac{1}{2}(a - \frac{a^2}{2} - (-1 - \frac{1}{2})) = 0.25)$ $a^2 - 2a - 2 = 0$ $a = 1 - \sqrt{3} \text{ or } -0.732$	M1 A1 A1 [3]	Correct limits (or integral from a to 1 = 0.75) any correct QE with “= 0”(or in completed square form $(a-1)^2 = 3$) Not $a = 1 \pm \sqrt{3}$; Not -0.732 or 2.732
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1	$(0.7 + 1.0) \times 2$ $= 3.4$ $e^{-3.4}(1 + 3.4 + 3.4^2 \div 2)$ $= 0.34(0)$ Alternative Method By Combinations		M1 A1 M1 A1 M2 A1 A1 [4]	Attempt combined mean Poisson P(0, 1, 2), any λ (Allow one end error) At least 4 correct $\lambda = 1.4, \lambda = 2$ All 6 correct combinations Correct answer
[Total: 4]				
2	(i)	$\frac{18 \times (1 - \frac{18}{70})}{70}$ (= 0.00272886..) $z = 1.645$ $\frac{18}{70} \pm z \times \sqrt{0.00272886}$ 0.171 to 0.343	M1 B1 M1 A1 [4]	Seen
	(ii)	Var (or sd) estimated or $N \sim B$ used	B1 [1]	
[Total: 5]				
3	(i)	$0.85^{30} + 30 \times 0.85^{29} \times 0.15 + {}^{30}C_2 \times 0.85^{28} \times 0.15^2$ $= 0.151$ > 0.04 No evidence decrease or Accept no decrease	M1 A1 M1 A1√ [4]	Allow just $0.85^{30} + 30 \times 0.85^{29} \times 0.15$ (Or critical region $X = 0$, or $X = 2$ Not in CR) Comp with 0.04 (can be implied by diagram) Correct Conclusion (ft) Use of $P(X = 2)$ only: max M0A0M1A1
	(ii)	(a) Not rejected H_0 (b) Has been decrease or π (or p) < 0.15	B1 [1] B1 [1]	Both independent marks Must be in context
[Total: 6]				
4	(i)	Po(4) $1 - e^{-4}(1 + 4 + \frac{4^2}{2!} + \frac{4^3}{3!})$ $= 1 - 0.43347..$ $= 0.567$ or 0.566	M1 A1 M1 A1 [4]	Use of Poisson, any mean Correct mean Allow one end error SC1: $\frac{3.5-4}{\sqrt{3.9984}}$ B1 SC2: Correct Bin method M1 ans 0.567 or 0.566 A1
	(ii)	$\lambda = \frac{n}{2500}$ $e^{-\frac{n}{2500}} < 0.01$ $-\frac{n}{2500} < \ln 0.01$ $n > 11512.9...$ Smallest $n = 11513$	$(\frac{2499}{2500})^n$ $(\frac{2499}{2500})^n < 0.01$ $n \times \ln(\frac{2499}{2500}) < \ln 0.01$ $n > 11510.6...$ Smallest $n = 11511$ A1 [3]	B1 M1 Correct exp'n < 0.01 . Allow ' = ' Allow by trial
[Total: 7]				

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5	(i)	$E(T) = 234, \text{Var}(T) = 15^2 + 8^2 = 289$	B1		
		$\frac{200-234}{\sqrt{289}} \quad (= -2.000)$	M1		
		$\Phi(“-2.000”) = 1 - \Phi(“2.000”)$	M1		
		$1 - 0.9772$ 2.28%	A1 [4]		
	(ii)	Require $P(D > 0)$ where $D = X - 4Y$	B1	For -16 or $+16$ or $\pm (184 - 4 \times 50)$ For 1249 or $15^2 + 4^2 \times 8^2$	
		$E(D) (= 184 - 4 \times 50) = -16$	B1		
		$\text{Var}(D) (= 15^2 + 4^2 \times 8^2) = 1249$	M1		
		$\frac{0 - (-16)}{\sqrt{1249}} \quad (= 0.453)$	M1		
		$1 - \Phi(“0.453”)$ $(= 1 - 0.6747)$ $= 0.325$	A1 [5]		
[Total: 9]					
6	(i)	$-k \int_2^3 (x^2 - 5x + 6)dx = 1$ $(-k(\frac{3^3}{3} - 5 \times \frac{3^2}{2} + 6 \times 3 - [\frac{2^3}{3} - 5 \times \frac{2^2}{2} + 6 \times 2])) = 1)$ $-k \times (-\frac{1}{6}) = 1$ or $k \times \frac{1}{6} = 1$ $(k = 6 \quad \mathbf{AG})$	M1	Integ = 1; ignore limits	$-6 \int_2^3 (x^2 - 5x + 6)dx$ ignore limits
			A1 [2]	Correctly obtain $-\frac{1}{6}$ or $\frac{1}{6}$ CWO No rounded decimals	Correctly obtain 1
	(ii)	$E(X) = 2.5$	B1	Condone 25000	
		$-6 \int_2^3 (x^4 - 5x^3 + 6x^2)dx \quad (= -6 \times (-1.05))$	M1*	Integ $x^2 f(x)$; ignore limits	
		$-“2.5”^2$	Dep M1*	Subtr μ^2 ,	
		$= 0.05$	A1 [4]	ISW	
	(iii)	$-6 \int_2^{2.2} (x^2 - 5x + 6)dx \quad (= 0.104)$	M1	Integ with limits 2, 2.2 or 2.2, 3	
		$1 - (1 - “0.104”)^4$ $= 0.355/0.356$	M1 A1 [3]	Or equivalent	
[Total: 9]					

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7	(i)	$\text{Var}(\bar{X}) = \frac{121}{200}$ or SD of $\bar{X} = \frac{11}{\sqrt{200}}$ $(\pm) \frac{354 - 352}{\frac{11}{\sqrt{200}}} (= \pm 2.571)$ $1 - \Phi("2.571")$ $(= 1 - 0.9949)$ $= 0.0051$	M1 A1 M1 A1 [4]	Or with cc attempted. Allow no $\sqrt{\quad}$ Must include 200 or $\sqrt{200}$ 2.57(1) or correct expression
	(ii)	(No) n is large, $\bar{X}$ (appr) norm distr or CLT applies	B1 B1 [2]	“No” must be seen or implied, but gains no marks by itself $n \geq 30$ (SR Both statements correct, but wrong or no conclusion scores B1)
	(iii)	H_0 : Pop mean = 352 H_1 : Pop mean $\neq$ 352 $\pm \frac{356 - 352}{\frac{11}{\sqrt{50}}} \pm (= 2.57(1))$ Comp with $z = \pm 1.96$ (signs consistent) Evidence that pop mean has changed	B1 M1 A1 B1 $\sqrt{\quad}$ [4]	Allow ' μ ' but not just 'mean' Must have $\sqrt{50}$ Correct statement or 2.57(1) Correct comparison, and correct conclusion, follow through one tail test
[Total: 10]				