

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 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	$N(483.2, 537.92)$ or $N(483.2, 23.2^2)$ $\frac{436-483.2}{\sqrt{537.92}}$ or $\frac{436-483.2}{23.2}$ (= – 2.035) $\Phi(-2.035) = 1 - \Phi(2.035)$ = 0.021 or 2.1%	B1 M1 M1 A1 [4]	or $\frac{8.2}{\sqrt{8}}$ or $\frac{8.2^2}{8}$ seen or implied or $\frac{436-60.4}{8.2/\sqrt{8}}$ standardising (no mixed methods) Correct area consistent with their working
		[Total: 4]	
2	$\frac{70}{69} \times 2.70 = 2.73913$ $3.61 \pm z \sqrt{\frac{2.73913}{70}}$ $z = 1.96$ 3.22 to 4.00 (3 sf)	M1A1 M1 B1 A1 [5]	or $3.61 \pm z \sqrt{\frac{2.70}{69}}$ M2A1(implied) without $\frac{70}{69}$: $3.61 \pm z \sqrt{\frac{2.70}{70}}$ M0A0M1 $z = 1.96$ B1 3.23 to 3.99(4.00) (3 sf) A1 Answer must be an interval
		[Total: 5]	
3	$H_0: \mu = 250$ $H_1: \mu > 250$ $\frac{250.06-250}{0.2/\sqrt{40}}$ = 1.90 comp with $z = 1.645$ Claim is justified or There is evidence that claim is true	B1 M1 A1 M1 A1 $\checkmark$ [5]	Both hypotheses M1 for standardising, must have $\sqrt{40}$. Accept cv method For valid comparison “1.90” with 1.645 or area comparison or CVs Correct conclusion. No contradictions NB 2-tail test scores B0 M1 A1 M1 (use 1.96) A0
		[Total: 5]	
4 (i)	$B(3500, 0.001)$ Poisson with mean = 3.5 $n > 50$ and $np < 5$	B1 B1 B1 [3]	or $Po(3.5)$ Both. Or $n > 50$ and $\lambda < 5$ or $3.5 < 5$
(ii)	$e^{-3.5}(1 + 3.5 + \frac{3.5^2}{2} + \frac{3.5^3}{3!})$ = 0.537 (3 dp)	M1 A1 [2]	Allow any λ
		[Total: 5]	

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5	(i)	$0.25(1 + 4 + 9) - 1.5^2$ (=1.25 AG)	B1 [1]	
	(ii)	$\frac{1.4-1.5}{\sqrt{\frac{5}{300}}}$ (= -1.549) $\Phi(" -1.549 ") = 1 - \Phi(" 1.549 ")$ = 0.0607 (3 sf)	M1 M1 A1 [3]	$\frac{1.4-\frac{1}{600}-1.5}{\sqrt{\frac{5}{300}}}$ (= -1.523) $\Phi(" -1.523 ") = 1 - \Phi(" 1.523 ")$ = 0.0639 (3 sf)
	(iii)	Large sample or large n ($\bar{X}$ (approx) normally distr) or Central Limit Theorem	B1 [1]	
			[Total: 5]	
6	(i)	H_0 : Rate = 0.9 H_1 : Rate < 0.9 $1 - P(17, 18, 19, 20)$ $1 - ({}^{20}C_{17} \times 0.1^3 \times 0.9^{17} + {}^{20}C_{18} \times 0.1^2 \times 0.9^{18} + 20 \times 0.1 \times 0.9^{19} + 0.9^{20})$ = 0.133 (3 sf)	B1 M1 M1 A1 [4]	$p = 0.9$ $p < 0.9$ Use of B(20,0.1) Allow $1 - P(18, 19, 20)$ or $1 - P(16, 17, 18, 19, 20)$
	(ii)	Type II H_0 will not be rejected	B1 B1 [2]	or Stephan will conclude standard not fallen No contradictions
			[Total: 6]	

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7	(i)	$\int_1^a \frac{k}{x} dx = 1$ $k[\ln x]_1^a = 1$ $k \ln a = 1 \quad k = 1/\ln a$	M1 A1 A1 [3]	Int $f(x)$ & equate to 1. Ignore limits Correct integration and limits and = 1 AG
	(ii)	$\frac{1}{\ln a} \int_1^a 1 dx$ or $k \int_1^a 1 dx$ $= \frac{1}{\ln a} [x]_1^a$ or $k[x]_1^a$ $= \frac{1}{\ln a} (a - 1)$	M1 A1 A1 [3]	Int $xf(x)$. Ignore limits Correct integration and limits (condone missing k)
	(iii)	$\frac{1}{\ln a} \int_1^m \frac{1}{x} dx = 0.5$ $\frac{1}{\ln a} [\ln x]_1^m = 0.5$ $\frac{1}{\ln a} \ln m = 0.5$ $\ln m = 0.5 \ln a$ $m = \sqrt{a}$	M1 A1 A1 A1 [4]	Int $f(x)$ and equate to 0.5. Ignore limits Correct integration and limits (1 to m or m to a) (condone missing k) or $\ln m = \ln a^{0.5}$
			[Total: 10]	
8	(i)	V : cannot have neg value W : cannot have non-integer value	B1 B1 [2]	
	(ii)	(a) $e^{-\lambda} = p$ and $\lambda e^{-\lambda} = 2.5p$ (Hence $\lambda = 2.5$ AG)	B1 [1]	or equiv explanation
	(ii)	(b) $1 - e^{-2.5} (1 + 2.5 + \frac{2.5^2}{2})$ $= 0.456$ (3 sf)	M1 A1 [2]	Allow one end error
	(iii)	$\Phi^{-1}(0.5793) = -0.2$ $N(\mu, \mu)$ seen or implied $\frac{40.5 - \mu}{\sqrt{\mu}} = "-0.2"$ $\mu + "-0.2" \sqrt{\mu} - 40.5 = 0$ $\sqrt{\mu} = \frac{"0.2" \pm \sqrt{"0.2"^2 + 4 \times 40.5}}{2}$ (= 6.4647..) $\mu = 41.8$ (3 sf)	B1 M1 M1 M1 A1 [5]	Allow no cc or incorrect cc For solving quadratic in $\sqrt{\mu}$ (or μ) Ignore other answer for $\sqrt{\mu}$, but not for μ
			[Total: 10]	

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1	$\frac{\Sigma x}{8} = \frac{2006}{8} = 250.75$ or 251 (3 s.f.) ($\Sigma x^2 = 503274$) $\frac{8}{7} \left(\frac{503274}{8} - 250.75^2 \right)$ = 38.5 o.e. (accept 6.204 ²)	B1	Any equivalent form
		M1	For use of formula of correct form
		A1 [3]	cao (as final answer)
2	$(X + Y - Z) \sim N(8, \dots)$	B1	seen or implied
	$\mu = 8$ (or -8)	B1	– award at early stage
	$\text{Var}(X + Y - Z) = 2^2 + 1.5^2 + 1.8^2$ (= 9.49)	M1	For standardising (accept sd/var mixes, but variance must be a combination of at least 2 of X, Y, Z)
	$\frac{0-8}{\sqrt{9.49}}$ (= -2.597)	M1	For area consistent with their working
	$\Phi(-2.597) = 1 - \Phi(2.597)$ = 0.0047	A1 [5]	
3	H_0 : Pop mean (or μ or λ) = 50 (or 5)	B1	Not just “mean”
	H_1 : Pop mean (or μ or λ) $\neq$ 50 (or 5)	M1	For standardising with N(50,50) or N(5,5/ $\sqrt{10}$)
	$\frac{60.5-50}{\sqrt{50}}$ ($\pm$)	A1	Allow M1 with wrong or no continuity correction OR no $\sqrt{}$ (accept c.v method M1, A1 for 61.63 or 48.868)
	= ($\pm$)1.485 OR 0.0687 OR C.V	M1	For valid comparison (zs or areas or cv)
	1.485 < 1.645 or 0.0687 > 0.05 No evidence that mean changed	A1 $\sqrt{h}$ [5]	(S.R For cv comparison 61.63 only award final A1 if cc used)
			or if $H_1: \lambda > 50$, 1.485 < 1.96 M1 No evid mean changed A0 (i.e. if one-tail test, max B0 M1 A1 M1 A0)

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4	(i)	$\lambda = 4.5$ $1 - e^{-4.5} \left(1 + 4.5 + \frac{4.5^2}{2} \right)$ $= 0.826$ (3 s.f.)	B1 M1 A1 [3]	seen any λ . Allow one end error
	(ii)	$e^{-\lambda} = 0.523$ $(-\lambda = \ln 0.523)$ $\lambda = 0.648$ (3 s.f.)	B1 B1 [2]	
	(iii)	$e^{-\mu} \times \frac{\mu^3}{3!} = 24 \times e^{-\mu} \times \mu$ $\frac{\mu^2}{6} = 24$ $\mu = 12$	B1 M1 A1 [3]	For a simplified expression in μ^2 with $e^{-\mu}$ and μ cancelled and no factorials.
5	(i)	$p = \frac{184}{400}$ or 0.46 $z = 1.96$ $"0.46" \pm z \times \sqrt{\frac{"0.46"(1-"0.46")}{400}}$ $= 0.411$ to 0.509	B1 B1 M1 A1 [4]	Used Seen Using expression of correct form Must be an interval
	(ii)	0.5 within CI Claim not supported or not justified	B1 $\sqrt{h}$ [1]	Both needed. No contradictions. ft their (i)
	(iii)	$z \times \sqrt{\frac{"0.46"(1-"0.46")}{400}} = 0.05$ $z = 2.006$ $\Phi('2.006') = 0.9775$ $\alpha = '0.9775' - (1 - '0.9775')$ $= 95.5\%$	M1 A1 M1 A1 [4]	Allow M1 for $z \times \sqrt{\frac{"0.46"(1-"0.46")}{400}} = 0.1$ or $1 - 2(1 - '0.9775')$

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6	(i)	$k \int_0^4 (16t - t^3) dt = 1$ $k \left[8t^2 - \frac{t^4}{4} \right]_0^4 = 1$ $k(128 - 64) = 1 \text{ o.e.}$ $k \times 64 = 1$ $\left(k = \frac{1}{64} \right) \text{ AG}$	M1	Int $f(t) = 1$ ignore limits
			A1	correct integration with correct limits
			A1 [3]	must be convinced (AG)
	(ii)	$\frac{1}{64} \int_0^1 (16t - t^3) dt$ $= \frac{1}{64} \left[8t^2 - \frac{t^4}{4} \right]_0^1$ $= \frac{1}{64} \left[8 - \frac{1}{4} \right]$ $= \frac{31}{256} \text{ or } 0.121094$ $\left(\frac{31}{256} \right)^2 = 0.0147 \text{ (3 s.f.) o.e.}$	M1	Int $f(t)$ between 0 and 1 (accept 0 and a value < 1, 1 and 4)
			A1	correct integration and correct limits (ignore “k”)
			A1	
			B1 ^{ft} [4]	ft their “ $\frac{31}{256}$ ”
	iii	$\frac{1}{64} \int_0^4 (16t^2 - t^4) dt$ $= \frac{1}{64} \left[\frac{16t^3}{3} - \frac{t^5}{5} \right]_0^4$ $= \frac{1}{64} \left(\frac{1024}{3} - \frac{1024}{5} \right)$ $= \frac{32}{15} \text{ or } 2.13 \text{ (3 s.f.) o.e.}$	M1	Int $tf(t)$ ignore limits
			A1	correct integration and correct limits (ignore “k”)
			A1 [3]	

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7	(i)	2 nd More representative of all appointments or Lengths may vary during the day or 1 st does not include later appts so not representative	B1 B1 [2]	Any implication that times or conditions vary throughout day, e.g. doctors get tired
	(ii)	0.01 o.e. Concluding that times spent are too long when they are not.	B1 B1 [2]	Concluding that the mean time spent is more than 10mins when it is not. Must be in context.
	(iii)	H ₀ : Pop mean appt time (or μ) = 10 H ₁ : Pop mean appt time (or μ) > 10 $\frac{147-10}{\frac{3.4}{\sqrt{12}}} (\pm)$ = ($\pm$)2.292 or (0.0109 if area comparison done) “2.292” < 2.326 o.e. (No evidence to reject H ₀ .) No reason to believe appts are too long	B1 M1 A1 M1 A1 ^h [5]	Both correct. Allow μ , but not just “mean” Allow incorrect $\frac{147}{12}$ Must have $\sqrt{12}$ (accept totals method) For valid comparison Comp “2.292” with 2.326 Or 0.0109 with 0.01 Or 147/12 with 12.28 Dep 2.326, ft their “2.292” No contradictions
				$10 + 2.326 \times \frac{3.4}{\sqrt{12}}$ M1 = 12.28 A1 $\frac{147}{12} < 12.28$ M1
	(iv)	Normal population	B1 [1]	Must have “population” or equiv

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2	$ht = \frac{1}{2}$ seen $\frac{1}{2} \times m \times \left(\frac{m}{4} \times \frac{1}{2} \right) = \frac{1}{2}$ N.B. B1 M1 must be consistent $m = \sqrt{8}$ or $2\sqrt{2}$ or 2.83 (3 s.f.)	B1 M1 A1 [3]	or $y = \frac{1}{8}x$ $\frac{1}{2} \times m \times \left(\frac{1}{8}m \right) = \frac{1}{2}$ or $\frac{m^2}{16} = \frac{1}{2}$ o.e. Or Integrating linear function of form $y = kx$ with limits 0 and m or m and 4 and equated to 0.5
3	$p = 0.56$ $'0.56' \pm z \times \sqrt{\frac{0.56 \times 0.44}{100}}$ $z = 2.17$, or 2.169 or 2.171 0.452 to 0.668 (3 s.f.)	B1 M1 B1 A1 [4]	Used Equation of correct form condone just +ve or -ve Must be z Seen Must be an interval
4	$\bar{x} = 1.65$ $\text{est}(\sigma^2) = \frac{100}{99} \left(\frac{276.25}{100} - 1.65^2 \right)$ $= 0.040404... = 4/99$ $(\pm) \frac{1.65 - 1.6}{\sqrt{\frac{0.040404}{100}}}$ $= (\pm) 2.487/2.488$ accept 2.49 Or 0.0065/0.0064 if area comparison done comp with 1.96 There is evidence that μ is not 1.6	B1 B1 M1 A1 M1 A1 $\sqrt{6}$ [6]	Without $\frac{100}{99}$: $\frac{1.65 - 1.6}{\sqrt{\frac{0.04}{100}}}$ B1 B0 M1 $= 2.50$ A1 CV Method M1 must use 1.96 A1 for 1.639 or 1.6106 For valid comparison (z/z Signs consistent or area/area cv) Accept Reject H_0 No contradictions

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5	(i)	Longest lifetime	B1 [1]	Must be in context
	(ii)	$\int_1^a \frac{k}{x^2} dx = 1$ $k \left[-\frac{1}{x} \right]_1^a = 1$ $\left(k \left[-\frac{1}{a} + 1 \right] = 1 \right)$ $k \left[\frac{-1+a}{a} \right] = 1 \quad \text{or } k(-1 + a) = a$ $k = \frac{a}{a-1} \quad \text{AG}$	M1 A1 A1 [3]	Int $f(x)$ and equate to 1. Ignore limits Correct integral and limits Must be convinced (AG)
	(iii)	$\frac{5}{3} \int_1^{2.5} \frac{1}{x} dx \quad \text{or } k \int_1^{2.5} \frac{1}{x} dx$ $= \frac{5}{3} [\ln x]_1^{2.5} \quad \text{or } k [\ln x]_1^{2.5}$ $= \frac{5}{3} \ln 2.5 \quad \text{or } 1.53 \text{ (3 s.f.)}$	M1 A1 A1 [3]	Int $xf(x)$. Ignore limits Correct integral and limits (Accept “ k ” or “their k ”)
6	(i)	$H_0: p = 0.2$ $H_1: p < 0.2$ $P(0 \text{ or } 1 \text{ 5s in } 25 \mid H_0)$ $= 0.0274 \text{ (3 s.f.)}$ Comp with 0.025 No evidence (at 2.5% level) to support claim	B1 M1 A1 M1 A1 $\frac{1}{4}$ [5]	(Allow π) $0.8^{25} + 25 \times 0.8^{24} \times 0.2$ Use of B(25,1/5) and P(0) or P(1) or both – may be implied by “0.0274” Valid comparison No contradictions SR Use of Normal N(5,4) leading to $z = 1.75$ or 0.0401 B1* $H_0: \mu = 5$ $H_1: \mu < 5$ B1. Comparison $1.75 < 1.96$ or $0.0401 > 0.025$ B1* dep
	(ii)	Normal $\mu = 200, \sigma^2 = 160$ or $\sigma = \sqrt{160}$	B1 B1 [2]	
	(iii)	Concluding that the machine produces the right proportion of 5s, although it doesn't.	B1 [1]	Not concluding that the machine produces too few 5s although it does. Must be in context o.e. No contradictions

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7	(i)	Constant mean (or average) rate	B1 [1]	Constant mean per day (or week, etc.) o.e.
	(ii)	$e^{-\frac{4}{7}} \times \frac{\frac{4}{7}^2}{2!} \quad \text{or} \quad e^{-0.571} \times \frac{0.571^2}{2!}$ $= 0.0922 \text{ or } 0.0921 \text{ (3 s.f.)}$	M1 A1 [2]	Expression for P(2) allow any λ
	(iii)	$\lambda = \frac{40}{7} \text{ or } 5.71\dots$ $1 - e^{-\frac{40}{7}} \left(1 + \frac{40}{7} + \frac{\frac{40}{7}^2}{2!} + \frac{\frac{40}{7}^3}{3!} \right)$ $= 0.821 \text{ (3 s.f.)}$	B1 M1 A1 [3]	Allow any λ allow one end error
	(iv)	$\frac{24}{7} \text{ o.e. 3 s.f. or better seen}$ $e^{-\frac{4}{7}} \times e^{-\frac{24}{7}} \times \frac{\frac{24}{7}^5}{5!}$ $= 0.0723 \text{ (3 s.f.)}$	B1 M1 A1 [3]	M1 for P(0) $\times$ P(5) any consistent λ
8	(i)	$X + 2.5Y \sim N(127, 44.25)$ $(\pm) \frac{140 - "127"}{\sqrt{"44.25"}}$ $= \pm(1.954)$ $1 - \Phi("1.954")$ $= 0.0254/0.0253 \text{ (3 s.f.)}$	B1 B1 M1 M1 A1 [5]	B1 for 127 Allow at early stage ($57 + 2.5 \times 28$) B1 for 44.25 or 6.65 Allow at early stage ($13 + 2.5^2 \times 5$) May be implied by next line For standardising For area consistent with their working
	(ii)	$X - Y \sim N(29, 18)$ $\frac{20 - "29"}{\sqrt{"18"}} \quad (= -2.121)$ $1 - \Phi(" -2.121") = \Phi("2.121")$ $= 0.983 \text{ (3 s.f.)}$	B1 B1 M1 M1 A1 [5]	B1 for 29 Give at early stage ($57 - 28$) B1 for 18 Give at early stage ($13 + 5$) May be implied by next line For Standardising For area consistent with their working