
MATHEMATICS

9709/71

Paper 7

May/June 2016

MARK SCHEME

Maximum Mark: 50

Published

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Mark Scheme Notes

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A Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

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

- When a part of a question has two or more ‘method’ steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.

- The symbol ∇ implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously ‘correct’ answers or results obtained from incorrect working.

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ISW	Ignore Subsequent Working
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SOS	See Other Solution (the candidate makes a better attempt at the same question)
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Note: ‘(3 sfs)’ means ‘answer which rounds to ... to 3 sfs’. If correct ans seen to > 3sfs, ISW for later rounding.
 Penalise < 3 sfs only once in paper.

1	$B(200, \frac{1}{6}) \rightarrow N(\frac{100}{3}, \frac{250}{9})$ $\frac{25.5 - \frac{100}{3}}{\sqrt{\frac{250}{9}}}$ $= -1.486$ comp ‘1.486’ with 1.282 Evidence to reject H_0 There is some evidence that $p < \frac{1}{6}$ or, e.g. It is likely that $p < \frac{1}{6}$ oe	B1 M1 A1 M1 A1 ft [5]	seen or implied allow with wrong or no cc (Accept alternative correct methods) or comp (‘1.486’) with 0.1 No contradictions
2	(i) Each employee has an equal chance of being chosen (ii) Est $(\mu) = 4$ Est $(\sigma^2) = \frac{10}{9}(\frac{199.22}{10} - 4^2)$ $= 4.36$ (3 sf) (iii) Distances travelled by all employees at the firm	B1 [1] B1 M1 A1 [3] B1 [1]	oe sub in correct formula attempted working may not be seen oe
3	(i) $((0.5672 + 0.6528) \div 2)$ $= 0.61$ (ii) ‘0.61’ + $z \sqrt{\frac{0.61 \times (1 - 0.61)}{350}} = 0.6528$ $z = 0.0428 \times \sqrt{\frac{700}{0.61 \times (1 - 0.61)}}$ oe $= 2.321$ 98% confidence	B1 [1] M1 M1 A1 A1 ft [4]	 oe correct rearrangement of correct equn, ft ‘0.61’ ft their z (dep on both Ms)

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4	(i)	$H_0: \mu = 12.5$ $H_1: \mu \neq 12.5$ $\frac{13.5-12.5}{4.2/\sqrt{50}}$ $= 1.68(4)$ $'1.684' < 1.96$ No evidence that mean time has changed	B1 M1 A1 M1 A1 ft [5]	allow 4.2 ÷ 50 comp 1.96 allow comp 1.645 if $H_1: \mu > 12.5$ or comp 1 – ('1.684') with 0.025 No contradictions ft their 1.684, but not comp 1.645
	(ii)	0.05	B1 [1]	
5	(i)	$T \sim N(6 \times 2.4, 6 \times 0.3^2)$ $(= N(14.4, 0.54))$ $\frac{16-'14.4'}{\sqrt{0.54}}$ (= 2.177) $1 - ('2.177')$ $= 0.0147$ (3 sf)	M1 M1 M1 A1 [4]	seen or implied ft their E and Var; allow without $\sqrt{\quad}$ (Accept alternative method $N(2.4, (0.3^2)/6)$) correct area consistent with their working
	(ii)	$D = X_1 - 1.1X_2$ $E(D) = -0.24$ $\text{Var}(D) = 0.3^2 + 1.1^2 \times 0.3^2 (= 0.1989)$ $\frac{0-(-0.24)}{\sqrt{0.1989}}$ (= 0.538) ('0.538') $= 0.705$ (3 sf)	B1 M1 M1 M1 A1 [5]	ft their E and Var; allow without $\sqrt{\quad}$ correct area consistent with their working
6	(i)	2m	B1 [1]	allow without units
	(ii)	$k \int_0^2 x^2(2-x)dx = 1$ $k \left[\frac{2x^3}{3} - \frac{x^4}{4} \right]_0^2$ $k \times \left[\frac{16}{3} - 4 \right] = 1$ or $k \times \frac{4}{3} = 1$ oe $k = \frac{3}{4}$ AG	M1 A1 A1 [3]	attempt integ $f(x)$ and '=' 1'. Ignore limits correct integration and limits No errors seen
	(iii)	$\frac{3}{4} \int_0^2 x^3(2-x)dx$ $= \frac{3}{4} \times \left[\frac{2x^4}{4} - \frac{x^5}{5} \right]_0^2$ 1.2m oe	M1 A1 A1 [3]	attempt integ $xf(x)$, condone missing k correct integration and limits, condone missing k allow without units

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(iv)	$\frac{3}{4} \int_0^1 x^2(2-x)dx$ $(= \frac{3}{4} \times (\frac{2}{3} - \frac{1}{4}))$ $= \frac{5}{16}$ or 0.3125 oe	M1	attempt integ $f(x)$, 0 to 1, condone missing k
	$400 \times \frac{5}{16} = 125$	A1 A1 ft [3]	ft their $\frac{5}{16}$
7 (a) (i)	0.01×80 and 0.015×60 $(1 - e^{-0.8}) \times (1 - e^{-0.9})$ $= 0.327$ (3 sf)	M1 M1 A1 [3]	$(1 - e^{-\lambda}) \times (1 - e^{-\mu})$ any λ, μ ($\lambda \neq \mu$) allow one end error
	(ii) $\lambda = 0.02 \times 40 + 0.015 \times 60$	M1	or their $0.8 + 0.9$
	$e^{-1.7} \times (1 + 1.7 + \frac{1.7^2}{2})$ $= 0.757$ (3 sf)	M1 A1 [3]	
	(b) $e^{-\lambda} \times \lambda = p$ and $e^{-\lambda} \times \frac{\lambda^2}{2} = 1.5p$	M1	or $e^{-\lambda} \times \frac{\lambda^2}{2} = 1.5 \times e^{-\lambda} \times \lambda$ seen or implied
	$\lambda = 3$	A1	
	$p = e^{-3} \times 3$ $= 0.149$ (3 sf)	M1 A1 [4]	their λ

[Total for paper 50]

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1	$\frac{6.2}{\sqrt{50}}$ or $\frac{6.2^2}{50}$ $\frac{51-53}{6.2 \div \sqrt{50}} (= -2.281)$ $P(z > -2.281) = \phi(2.281)$ $= 0.989$ (3 sf)	B1 M1 M1 A1 [4]	seen or implied allow without $\div \sqrt{50}$ for finding correct area consistent with working as final answer
2 (i)	Conclude less than 90% satisfied when this is not true oe	B11	In context
(ii)	$1 - (0.9^{15} + 15 \times 0.9^{14} \times 0.1 + {}^{15}C_2 \times 0.9^{13} \times 0.1^2 + {}^{15}C_3 \times 0.9^{12} \times 0.1^3)$ $= 0.0556$ (3 sf) or 0.0555	M1 M1 A1 [3]	Attempt $(1 - P(X = 15, 14, 13, 12))$ allow 1 end error Attempt fully correct expression
3 (i)	Pop too big or takes too long oe or testing destroys articles oe	B1 [1]	or too expensive oe or pop inaccessible oe
(ii) (a)	$z = 1.96$ $65.7 \pm z \times \frac{\sqrt{15}}{10}$ $= 64.9$ to 66.5 (3 sf)	B1 M1 A1 [3]	seen Expression of correct form (must be 'z' must be 65.7) Must be an interval
(b)	CI does not include 64.7 Probably has affected (or increased) mean bounce ht.	B1 $\frac{1}{2}$ [1]	allow 64.7 not within CI both needed. ft their CI ft 65.7/64.7 mix
4	$H_0: \lambda$ (or μ) = 42 $H_1: \lambda$ (or μ) $\neq$ 42 $Po(42) \sim N(42, 42)$ stated or implied $\frac{53.5-42}{\sqrt{42}}$ $= 1.77(4)$ (or 0.038 for area comparison) comp 1.96 No evidence that mean has changed	B1 B1 $\frac{1}{2}$ M1 A1 M1 A1 $\frac{1}{2}$ [6]	Or pop weekly mean = 2.1 etc. allow 'population mean' not just 'mean' ft their '42' (Accept alt method $N(2.1, 2.1/20)$) allow with wrong or no cc. Accept alt method using $N(2.1, 2.1/20)$ with or without cc Valid comp z or $1 -$ ('1.774') with 0.025 seen allow comp 1.645 if $H_1: \lambda$ (or μ) > 42 No contradictions. No ft for $H_1: \lambda$ (or μ) > 42 Note – accept other valid methods(e.g. cv method)

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5	(i)	$T \sim N(520, 70)$ $\frac{530-520}{\sqrt{70}} (= 1.195)$ ('1.195') $= 0.884$ (3 sf)	B1 B1 M1 M1 A1 [5]	for N(520,..) or N(500,..) if standardising with 510 for Var = 70 seen or implied ft their E and Var; allow without $\sqrt{}$ finding correct area consistent with working CWO
	(ii)	$E(T) = -10$ $\text{Var}(T) = 50 + 4.1^2 \times 20 (= 386.2)$ $\frac{0-(-10)}{\sqrt{386.2}} (= 0.509)$ $1 - ('0.509')$ $= 0.305$ (3 sf)	B1 B1 M1 M1 A1 [5]	or +10 for $T < 0$ Seen or implied ft their E and Var; allow without $\sqrt{}$ finding correct area consistent with working CWO
6	(i)	$\lambda = 6.8$ $e^{-6.8} \times \frac{6.8^5}{5!}$ $= 0.135$ (3 sf)	B1 M1 A1 [3]	any λ
	(ii) (a)	$e^{-3.4} (1 + 3.4 + \frac{3.4^2}{2} + \frac{3.4^3}{3!} + \frac{3.4^4}{4!})$ $= 0.744$ (3 sf)	M1 A1 [2]	any λ , allow one end-error
	(b)	$'0.744' + e^{-3.4} \times \frac{3.4^5}{5!}$ $= 0.87(0)$ (3 sf) or 0.871	M1 A1 [2]	or complete method, any λ , allow one end-error
	(iii)	$P(X \leq 6) = '0.870' + e^{-3.4} \times \frac{3.4^6}{6!}$ $= 0.94$ Need 6 hair driers	M1 A1 A1 [3]	or complete method, any λ fully correct un-simplified expression or better dep M1A1 with numerical justification (0.94 or better)
7	(a)	0.3 or $1 - 0.6$ or 0.4 or 0.2 seen 0.8	M1 A1 [2]	
	(b) (i)	$k \int_0^{1.5} (2.25 - x^2) dx = 1$ $k \left[2.25x - \frac{x^3}{3} \right]_0^{1.5} = 1$ $k \times [3.375 - 1.125] = 1$ or $k \times \frac{9}{4} = 1$ oe $k = \frac{4}{9}$ AG	M1 A1 A1 [3]	attempt integ $f(x)$ and ' $= 1$ '. Ignore limits correct integration and limits No errors seen

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(ii)	$\frac{4}{9} \int_0^{1.5} (2.25x - x^3) dx$ $= \frac{4}{9} \left[2.25 \frac{x^2}{2} - \frac{x^4}{4} \right]_0^{1.5}$ $= 0.5625 \text{ or } 0.563$ Mean no. of hours = 56.25 or 56.3 56 hrs 15 mins	M1 A1 A1 A1 $\frac{1}{4}$ [4]	attempt integ $x f(x)$, ignore limits, condone missing k correct integration and limits, condone missing k ft their 0.5625
(iii)	Max x is 1.5, less than 2.9 or $150 < 290$	B1 [1]	Needs numerical justification
(iv)	any a such that $2.9 \leq a \leq 5$	B1 [1]	
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1	$192.4 \pm z \sqrt{\frac{43.6}{150}}$ $z = 2.326$ to 2.329 191 to 194 (3 sf)	M1 B1 A1 [3]	Allow $\frac{43.6}{\sqrt{150}}$ Allow one side for M1 Condone $\sqrt{(43.6/149)}$ oe CWO
2	H_0 : Pop mean yield = 8.2 H_1 : Pop mean yield > 8.2 $(\pm) \frac{8.7-8.2}{1.2/\sqrt{16}}$ $= (\pm) 1.667$ Comp $z = 1.645$ Or Area comparison 0.0475-0.0478) Reject H_0 Evidence that mean yield has increased	B1 M1 A1 M1 A1 [5]	or $\mu = 8.2$ (not just “mean”) $\mu > 8.2$ Allow without $\sqrt{}$ sign (Allow cc) Or comp $1 - \Phi(1.667)$ with 0.05 Valid Comparison z-values (same sign) or areas No Contradictions No follow through for 2 tail test
3 (i)	Use of Poisson Mean = 2.4 $1 - e^{-2.4}(1 + 2.4 + \frac{2.4^2}{2})$ $= 0.43(0)$ (3 sf)	B1 B1 M1 A1 [4]	Allow any λ (Allow one end error) Final answer SR Use of binomial: B1 for ans 0.431 (3 sf)
(ii)	$240 > 50$ or $n > 50$ $240 \times 0.01 = 2.4 < 5$ or $np < 5$ or $p < 0.1$	B1 B1 [2]	SR n large, p small: B1
4 (i)	H_0 : Pop mean = 2.5 (or 7.5) H_0 : Pop mean < 2.5 (or 7.5) $\lambda = 7.5$ $P(X \leq 2) = e^{-7.5}(1 + 7.5 + \frac{7.5^2}{2}) = 0.0203$ $P(X \leq 3) = 0.0203 + e^{-7.5} \times \frac{7.5^3}{3!} = 0.0591$ CR is $X \leq 2$ Reject H_0 Evidence that no of sightings fewer	B1 M1 A1 A1 A1 [5]	or $\lambda = 2.5$ (Not just “mean”) Allow μ or $\lambda < 2.5$ Either $P(X \leq 2)$ or $P(X \leq 3)$, allow any λ Both Correct Clear statement Follow through their CR/their $P(X \leq 2)$
(ii)	$P(\text{Type I}) = 0.0203$ (3 sf)	B1 [1]	ft their $P(X \leq 2)$
(iii)	H_0 was rejected oe	B1 [1]	or Type II is $P(\text{not reject } H_0)$ oe
5 (i)	$k \int_5^{10} (10t - t^2) dt = 1$ $k \left[5t^2 - \frac{t^3}{3} \right]_5^{10} = 1$ $k(500 - \frac{1000}{3} - (125 - \frac{125}{3})) = 1$ $k \times \frac{250}{3} = 1$ $(k = \frac{3}{250} \text{ AG})$	M1 A1 A1 [3]	Attempt to integrate, ignore limits Correct integral and limits No errors seen; No inexact decimals seen

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Qu	Answer	Marks	Notes
(ii)	$\frac{3}{250} \int_5^{10} (10t^2 - t^3) dt$ $= \frac{3}{250} \left[\frac{10t^3}{3} - \frac{t^4}{4} \right]_5^{10}$ $= \frac{3}{250} \left(\frac{10000}{3} - \frac{10000}{4} - \left(\frac{1250}{3} - \frac{625}{4} \right) \right)$ $= 6.875 \text{ or } 55/8$	M1 A1 A1 [3]	Attempt to integrate, ignore limits Correct integral and limit. Condone missing k Allow 6.88
(iii)	$P(T < E(T)) = \frac{3}{250} \left[5t^2 - \frac{t^3}{3} \right]_5^{6.875}$ $= 0.5361$ “0.5361” – 0.5 P(T between E(T) & median) = 0.0361	M1* DM1* A1 [3]	ft their E(T) allow 0.036 Alternative Method Integrate f(t) limits 5 and m equated to 0.5 M1* Integrate f(t) limits their 6.736 (provided between 5 and 10) and their 6.875 DM1 Allow without "minutes"
(iv)	10 (minutes)	B1 [1]	
6 (i)	$\lambda = 3.9$ $e^{-3.9} \times \frac{3.9^4}{4!}$ $= 0.195$	B1 M1 A1 [3]	M1 allow any λ SR Combination method B1 for $\lambda = 1.6$ AND $\lambda = 2.3$ used in combination method (at least 3 combinations) M1 All correctly combined and added
(ii)	$\bar{X} \sim N(1.6, \frac{1.6}{75})$	B1 B1 [2]	B1 for N(1.6, ...) stated B1 for Var = $\frac{1.6}{75}$ stated SR, not stated but all implied in (iii): B1
(iii)	$\frac{1.7-1.6}{\sqrt{\frac{1.6}{75}}} (= 0.685)$ $1 - \Phi(“0.685”)$ $= 0.247 \text{ (3 sf)}$	M1 M1 A1 [3]	For standardising (using their values or correct values). Ignore cc Correct area consistent with their working Accept use of 1/2n correction leading to 0.233. NB Use of Poisson sum Po(120) and N(120,120) with $\mu = 127.5$ leads to 0.247, or 0.233 with cc
(iv)	X not normally distr. So CLT needed	B1 [1]	Not “it”

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Qu	Answer	Marks	Notes
7 (i)	$E(T) = 20.8$ $\text{Var}(T) = 20 \times 0.03^2 + 0.01^2 (= 0.0181)$ $\frac{20.6 - 20.8}{\sqrt{0.0181}} (= -1.487)$ $1 - \Phi("1.487")$ $= 0.0684 \text{ to } 0.686$	B1 B1 M1 M1 A1 [5]	or $\sqrt{(20 \times 0.03^2 + 0.01^2)} = 0.135 \text{ (3sf)}$ For standardising (σ must come from combination) Area consistent with their working Any answer within range
(ii)	$E(D) = 0$ $\text{Var}(D) = 2 \times 0.0181 (= 0.0362)$ $\frac{0.02 - 0}{\sqrt{0.0362}} (= 0.105)$ $\Phi("0.105") = 0.5418 \text{ or } 1 - \Phi(0.015)$ $= 0.4582$ $\Phi("0.105") - (1 - \Phi("0.105"))$ $(= 0.5418 - 0.4582)$ $= 0.0836/0.0837$	B1 M1 A1 M1 A1 [5]	Both (Seen or implied) Allow without $\sqrt{}$ Allow to 3sf or $1 - 2(1 - \Phi("0.105"))$ $(= 1 - 2 \times 0.4582)$