
MATHEMATICS

9709/71

Paper 7

May/June 2017

MARK SCHEME

Maximum Mark: 50

Published

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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.
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Question	Answer	Marks	Guidance
1(i)	Poisson with $\lambda = 0.2$	B1	
	$1 - e^{-0.2} (1 + 0.2 + \frac{0.2^2}{2})$	M1	1 – Poisson P(0, 1, 2, 3) attempted, any λ , allow one end error
	= 0.00115 (3 sf)	A1	SR: using Bin, ans 0.00115: B1
	Total:	3	
1(ii)	n large ($n > 50$)	B1	
	$np = 0.2 < 5$ or p small	B1	
	Total:	2	
2	Assume sd still = 3.8	B1	or sd unchanged
	$H_0: \mu = 64.0$ $H_1: \mu < 64.0$	B1	
	$\frac{63.3 - 64.0}{\frac{3.8}{\sqrt{100}}}$	M1	Standardising with their values (no sd / var mixes) Must have $\sqrt{100}$
	= -1.842	A1	
	comp "1.842" with z -value "1.842" < 1.96	M1	comp +ve with +ve or -ve with -ve or comp Φ ("1.842") with 0.975 0.9672 < 0.975 OE
	No evidence that heights are shorter	A1FT	OE FT their z_{calc}
	Total:	6	

Question	Answer	Marks	Guidance
3(a)	$7.1 \pm z \times \sqrt{\frac{2.6}{75}}$	M1	Expression of correct form must be z (note MR var = 2.6 ² can score M1) seen
	$z = 1.751$	B1	
	6.77 to 7.43 (3 sfs)	A1	Must be an interval
	Total:	3	
3(b)	0.04^3	M1	Allow 0.08 ³ for M1
	$= 0.000064$	A1	
	Total:	2	
3(c)	e.g. Particular day or time of day	B1	Allow "Not random"
	Total:	1	
4(i)	Greater area where $x < 7.5$ than $x > 7.5$	B1	Allow Graph higher for $x < 7.5$ than for $x > 7.5$ or Graph decreasing or equiv expl'n
	Total:	1	
4(ii)	$\int_5^{10} \frac{k}{x^2} dx = 1$	M1	Attempt Integ $f(x) = 1$ ignore limits
	$k \left[-\frac{1}{x} \right]_5^{10} = 1$ $k \times \frac{1}{10} = 1$	A1	Correct integration and limits
	$k = 10$ AG	A1	No errors seen
	Total:	3	

Question	Answer	Marks	Guidance
4(iii)	$10 \int_5^{10} \frac{1}{x} dx$	M1	Attempt Integ $xf(x)$ ignore limits
	$= 10 [\ln x]_5^{10}$ $= 10(\ln 10 - \ln 5)$	M1	Correct integration and limits
	$= 10 \ln 2$ or 6.93 (3 sf)	A1	OE
	Total:	3	
4(iv)	$10 \int_5^{10} 1 dx - "6.93"2$	M1	Attempt (Integ $x^2f(x)$) – (E(x)) ² . No limits M0
	$= 1.95$ (accept 1.96)	A1	Use of 6.93 gives 1.97 A0
	Total:	2	
5(i)	$W \sim N(6210, 171.88)$	B2	seen or implied. B1 each parameter
	$\frac{6200 - "6210"}{\sqrt{"171.88"}} \quad (= -0.763)$	M1	Standardising with their values. No sd / var mix
	$1 - \Phi("0.763")$	M1	For area consistent with their mean
	$= 0.223$ (3 sfs)	A1	
	Total:	5	

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Question	Answer	Marks	Guidance
5(ii)	$E(C - 2B) = -50$	M1	“6210”–2(3130) (or $E(2B - C) = 50$)
	$\text{Var}(C - 2B) = "171.88" + 2^2 \times 12.1^2$ (= 757.52)	M1	
	$\frac{0 - (-50)}{\sqrt{"757.52"}}$ (= 1.817)	M1	Standardising with their values
	$\Phi("1.817")$	M1	For area consistent with their mean
	= 0.965 (3 sfs)	A1	
	Total:	5	
6(i)	mean = 6.6	B1	B1 for 6.6 (could be scored in iii)
	$P(X \leq 1) = e^{-6.6} (1 + 6.6) = 0.0103$	M1	Allow incorrect λ in both probs
	$P(X \leq 2) = e^{-6.6} (1 + 6.6 + \frac{6.6^2}{2}) = 0.0400$	M1A1	A1 for both values
	CR is $X \leq 1$	DA1	Dep on at least one M
	$P(\text{Type I error}) = P(X \leq 1) = 0.0103$	B1FT	FT their $P(X \leq 1)$
	Total:	6	
6(ii)	Wrongly concluding that (mean) no of (sports) injuries has decreased	B1	Must be in context
	Total:	1	

Question	Answer	Marks	Guidance
6(iii)	$H_0: \lambda = 6.6$ $H_1: \lambda < 6.6$	B1	Can be scored in (i). Allow μ or λ / 1.1 or 6.6 or $P(X \leq 2) = 0.0400 > 0.02$
	2 not in CR	M1	
	No evidence mean no. of injuries has decreased	A1FT	
	Total:	3	
6(iv)	$N(39.6, 39.6)$	B1	May be implied
	$\frac{29.5 - 39.6}{\sqrt{39.6}} \quad (= -1.605)$	M1	Allow with wrong or no cc
	$\Phi(-1.605) = 1 - \Phi(1.605)$	M1	For area consistent with their mean
	$= 0.0543$ (3 sfs)	A1	
	Total:	4	

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Question	Answer	Marks	Guidance
1	$\frac{0.801 \times (1 - 0.801)}{2000}$ (= 0.0000797)	M1	
	$0.801 \pm z \times \sqrt{0.0000797}$	M1	Allow any z-value
	$z = 1.96$	B1	
	0.784 to 0.818 (3 sf)	A1	As final answer. Must be an interval Allow 0.783 to 0.819
	Total:	4	
2(i)	$E(X) = 4.197$	B1	
	$\text{Var}(X) = 4.196$	B1	Both to 3dp or better
	Total:	4	
2(ii)	$E(X) \approx \text{Var}(X)$	B1	Condone =
2(iii)	$e^{-4.1968} \left(1 + 4.1968 + \frac{4.1968^2}{2} + \frac{4.1968^3}{3!} + \frac{4.1968^4}{4!} \right)$	M1	Any λ . Allow with one end error
	= 0.59(0) (3 sfs)	A1	Allow 0.591
	Total:	2	

Question	Answer	Marks	Guidance
3(i)	Est (μ) = 923/400 or 2.3075 or 2.31 (3 sf)	B1	
	Est(σ^2) = $\frac{400}{399} \left(\frac{3170}{400} - "2.3075"{}^2 \right)$ OE	M1	
	= 2.60696 or 2.61 (3 sf)	A1	(Note: Biased Var= 2.600 scores M0)
	Total:	3	
3(ii)	H ₀ : Pop mean (or μ) = "2.31" or "2310" H ₁ : Pop mean (or μ) > "2.31" or "2310"	B1 FT	
	$\pm \frac{2.6 - "2.310"}{\sqrt{2.60696 \div 50}} = 1.27$	M1 A1	Standardising using their values, Accept 1.28
	Comp 1.645 (OE)	M1	Valid comparison z values or areas
	No evidence that incomes in the region greater	A1 FT	OE FT their z. No contradictions (No FT for 2 tail test – max score B0 M1 A1 M1 for comp 1.96 A0) Note: Accept alternative CV method
	Total:	5	

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Question	Answer	Marks	Guidance
4(i)	$0.75^{20} + 20 \times 0.75^{19} \times 0.25 + {}^{20}C_2 \times 0.75^{18} \times 0.25^2$	M1	No end errors
	= 0.0913	A1	As final answer
	Total:	2	
4(ii)	H ₀ : Pop proportion=0.25 H ₁ : Pop proportion<0.25	B1	Allow p or π , not "proportion" (Accept anywhere in the question)
	$0.75^{25} + 25 \times 0.75^{24} \times 0.25$	M1	Must be B(25,0,25) No end errors
	= 0.00702	A1	
	comp 0.01	M1	Valid comparison
	There is evidence that the claim is not justified	A1 FT	OE. No contradictions
	Total:	5	

Question	Answer	Marks	Guidance
5(i)	$0.5 \times 1 \times h = 0.25$ $h = 0.5$ $\text{grad} = 0.5$	M1	$P(X < 2) = 4 \times P(X < 1)$ M1
	$f(x) = 0.5x$	A1	$P(X < 2) = 1$ A1 $a = 2$ A1
	$0.5 \times a \times 0.5a = 1$	M1	$0.5 \times 2 \times h' = 1$ M1 $h' = 1$
	$a = 2$	A1	$\text{grad} = 0.5$
	$P(X < 2) = 1$	A1	$f(x) = 0.5x$ A1
	Total:	5	
5(ii)	$\int_0^m 0.5x dx = 0.5$	M1	Attempt $\int f(x) dx = 0.5$ Ignore limits
	$= \left[\frac{x^2}{4} \right]_0^m = 0.5$	A1FT	Correct integration (ft $f(x)$) & limits = 0.5
	$m = \sqrt{2}$ or 1.41 (3 sf)	A1	or by similarity $m = \frac{1}{\sqrt{2}} \times 2$ M2 $= \sqrt{2}$ A1
	Total:	3	

Question	Answer	Marks	Guidance
6(i)	$e^{-2.4} \times \frac{2.4^2}{2!}$	M1	Allow incorrect λ
	= 0.261 (3 sfs)	A1	
	Total:	2	
6(ii)	N(60, 60)	B1	seen or implied
	$\frac{54.5-60}{\sqrt{60}}$ (= -0.710)	M1	allow with wrong or missing cc
	$1 - \phi(" -0.710") = \phi("0.710")$	M1	For area consistent with their working
	= 0.761 (3 sf)	A1	
	Total:	4	
6(iii)	$\lambda = 3.6 + 12 \div 7$ (= 186/35) (= 5.314)	M1	
	$e^{-5.314} \left(1 + 5.314 + \frac{5.314^2}{2} + \frac{5.314^3}{3!} \right)$	M1	Allow incorrect λ . Allow one end error.
	= 0.224 (3 sfs)	A1	
	Total:	3	

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Question	Answer	Marks	Guidance
7(a)	$E(X_1+X_2) = 2 \times 4.2 = 8.4$ $\text{Var}(X_1+X_2) = 2 \times 1.1^2 = 2.42$	B1	Both. Seen or implied (or sd = 1.56)
	$\frac{10-8.4}{\sqrt{2.42}} \quad (= 1.029)$	M1	Standardising with their mean and var (no sd / var mix)
	$1 - \phi("1.029")$	M1	For area consistent with their working
	$= 0.152 \text{ (3 sf)}$	A1	
	Total:	4	
7(b)	$E(X) = 20.5$	B1	
	$\text{Var}(X) = 105 + 0.5^2 \times 15 \quad (= 108.75)$	M1	correct expression oe
	$\frac{0-"20.5"}{\sqrt{108.75}} \quad (= -1.966)$	M1	correct standardisation using their E & V (no sd/var mix) ignore any attempted cc
	$\phi("-1.966") = 1 - \phi("1.966")$ $(= (1 - 0.9754))$	M1	For area consistent with their working
	$= 0.0246 \quad \text{or } 2.46\% \text{ (3 sf)}$	A1	Accept 0.0247
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1	573, 43 (or 043), 289	B1B1B1	Ignore incorrect numbers. But allow other correct use of table (i.e. 573, 650, 431)
	Total:	3	
2(i)	$z = 1.751$	B1	
	$\frac{103}{200} \pm z \sqrt{\frac{\frac{103}{200} \times (1 - \frac{103}{200})}{200}}$ oe	M1	all correct except for recognisable value of z , allow for one side only
	= 0.453 to 0.577 (3 sf) as final answer	A1	must be an interval
	Total:	3	
2(ii)	0.08 oe 8%, 8/100	B1	
3	$10 \times 0.46^2 (= 2.116)$ or $\frac{0.46}{\sqrt{10}}$	B1	SOI
	Total mass of ore $\sim N(70, 2.116)$ or $\sim N\left(7, \left(\frac{0.46}{\sqrt{10}}\right)^2\right)$	B1	
	$\pm \frac{71 - "70"}{\sqrt{"2.116"}}$ or $\pm \frac{7.1 - "7.0"}{0.46 / \sqrt{10}} (= 0.687)$	M1	correct, using their sd or $\sqrt{(\text{their var})}$ e.g. allow $\frac{71 - "70"}{4.6}$ for M1
	$1 - \phi("0.687")$	M1	for correct area consistent with their working
	= 0.246 (3 sf)	A1	
	Total:	5	

Question	Answer	Marks	Guidance
4(i)	$\bar{x} = 6.7/200 (= 67/2000 = 0.0335)$	B1	
	$s^2 = \frac{200}{199} \times \left(\frac{0.2312}{200} - "0.0335"{}^2 \right)$	M1	$s^2 = \frac{0.2312}{200} - 0.0335^2$ M0
	$= 0.0000339(2) = 27/796000$	A1	$= 0.00003375$ A0
	Total:	3	
4(ii)	H_0 : Pop mean level = 0.034 H_1 : Pop mean level $\neq$ 0.034	B1	not just "mean", but allow just " μ "
	$\frac{"030335" - 0.034}{\frac{\sqrt{"0.00003392"}}{\sqrt{200}}}$	M1	must have $\sqrt{200}$ $\frac{0.0335 - 0.034}{\frac{\sqrt{"0.00003375"}}{\sqrt{200}}}$ M1
	$= -1.21(4) \text{ (3 sfs)} (-1.22 \leftrightarrow -1.21)$	A1	$= -1.217 \text{ (3 sfs)}$ A1
	Comp with $z = -1.645$ (or $0.1124 > 0.05$)	M1	$0.112 > 0.05$ valid comparison z or areas
	No evidence that (mean) pollutant level has changed, accept H_0 (if correctly defined)	A1FT	correct conclusion no contradictions SR: One tail test: B0 , M1A1 as normal, M1 (comparison with 1.282 consistent signs) A0
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Question	Answer	Marks	Guidance
5(i)(a)	$X \sim N(42, 42)$	B1	stated or implied
	$\frac{39.5 - "42"}{\sqrt{"42"}} (= -0.386)$	M1	allow with wrong or no cc
	$1 - \phi("-0.386") = \phi("0.386")$	M1	correct area consistent with their working
	$= 0.65(0) \text{ (3 sf)}$	A1	
	Total:	4	
5(i)(b)	$42 > (\text{e.g. } 15) \text{ or mean is large}$	B1	$\lambda > 15$ or higher, $\lambda = \text{large}$ ignore subsequent work if not undermining what already written
	Total:	1	
5(ii)(a)	$Y \sim \text{Po}(1.2)$	B1	stated or implied
	$1 - e^{-1.2}(1 + 1.2 + \frac{1.2^2}{2})$	M1	allow any λ allow one end error
	$= 0.121 \text{ (3 sf)}$	A1	Using binomial: 0.119 SR B1
	Total:	3	
5(ii)(b)	$60 \times 0.02 = 1.2 < 5 \text{ or mean is small}$	B1FT	or large n small p FT Poisson only
	Total:	1	

Question	Answer	Marks	Guidance
6(i)	$k \int_0^1 (x - x^2) dx = 1$	M1	Attempt integ f(x) and "= 1", ignore limits
	$= k \left[\frac{x^2}{2} - \frac{x^3}{3} \right]_0^1 = 1$	A1	correct integration, limits 0 and 1
	$= k \left[\frac{1}{2} - \frac{1}{3} \right] = 1 \text{ or } \frac{k}{6} = 1$	A1	correctly obtained, no errors seen
	Total:	3	
6(ii)	$E(X) = 0.5$	B1	
	$6 \int_0^1 (x^3 - x^4) dx$	M1	Attempt integ $x^2 f(x)$, limits 0 to 1
	$(= 6 \left[\frac{1}{4} - \frac{1}{5} \right] = 0.3)$ "0.3" – "0.5" ²	M1	their int $x^2 f(x)$ – their $(E(X))^2$ dep +ve result
	$= 0.05 (= 1/20)$	A1	
	Total:	4	
6(iii)	$6 \int_{0.4}^1 (x - x^2) dx$	M1	ignore limits, eg M1 for $6 \int_{0.4}^2 (x - x^2) dx$
	$= 6 \left\{ \frac{1}{2} - \frac{1}{3} - \left(\frac{0.4^2}{2} - \frac{0.4^3}{3} \right) \right\}$	A1FT	subst correct limits into correct integration
	$= 0.648 (= 81/125)$	A1	condone incorrect "k" for A1
	Total:	3	

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Question	Answer	Marks	Guidance
7(i)	H_0 : Pop mean no. accidents = 5.64 H_1 : Pop mean no. accidents < 5.64	B1	or “= 0.47 (per month)” not just “mean”, but allow just “ λ ” or “ μ ”
	Use of $\lambda = 5.64$	B1	used in a Poisson calculation
	$= e^{-5.64} (1 + 5.64 + \frac{5.64^2}{2})$	M1	Allow incorrect λ in otherwise correct
	= 0.08(0)	A1	
	Comp with 0.05	M1	Valid comparison (Poisson only), no contradictions.
	No evidence to believe mean no. of accidents has decreased; accept H_0 (if correctly defined)	A1FT	Normal distribution: M0M0
	Total:	6	
7(ii)	Mean < 0.47 but conclude that this is not so	B1	(Mean) no. of accidents reduced , but conclude not reduced. Must be in context.
	Total:	1	
7(iii)	(Need greatest x such that $P(X \leq x) < 0.05$) $P(X \leq 1) = e^{-5.64} (1 + 5.64) = 0.024$ $P(X \leq 2) = 0.08$	B1	Both, could be seen in (i)
	Hence rejection region is $X \leq 1$	B1	Can be implied
	With $\lambda = 12 \times 0.05 = 0.6$, $1 - P(X \leq 1) = 1 - e^{-0.6}(1 + 0.6)$	M1	$\lambda=0.6$ and $1 - P(X \leq 1)$
	= 0.122 (3 sf)	A1	Normal scores 0
	Total:	4	