

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/71

Paper 7, maximum raw mark 50

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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Mark Scheme Notes

Marks are of the following three types:

M Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

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.
- Note: B2 or A2 means that the candidate can earn 2 or 0.
B2/1/0 means that the candidate can earn anything from 0 to 2.

The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

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AEF	Any Equivalent Form (of answer is equally acceptable)
AG	Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)
CWO	Correct Working Only – often written by a ‘fortuitous’ answer
ISW	Ignore Subsequent Working
MR	Misread
PA	Premature Approximation (resulting in basically correct work that is insufficiently accurate)
SOS	See Other Solution (the candidate makes a better attempt at the same question)
SR	Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through ✓” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
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1 $\lambda = \frac{1}{30}$ $1 - e^{-\frac{1}{30}}$ $= 0.0328$ (3 s.f.)	B1 M1 M1 A1 [4]	o.e $1 - P(X=0)$ by Poisson, any λ allow 1 end error $1 - P(X=0)$ by Poisson, correct λ no end errors S.R. Binomial with final answer 0.0328 B2 Correct answer, no working scores B2
2 $z = 2.576$ $2 \times z \times \frac{0.17}{\sqrt{n}} = 0.2$ oe $n = \left(\frac{2 \times 0.17 \times 2.576}{0.2}\right)^2$ oe (= 19.2) Smallest n is 20	B1 M1 M1 A1 [4]	Seen (accept 2.574 to 2.579) Allow without '2 ×' OR with incorrect z Attempt to arrange equ of correct form (with correct z and '2×' into the form $n=$ or $\sqrt{n} =$
3 (i) est (μ) = 2866 or 2870 (3 s.f.) est (σ^2) = $\frac{1}{49} (410900000 - \frac{143300^2}{50})$ (= 4126.53) = 4130 (3 sf)	B1 M1 A1 [3]	Accept 143300/50 o.e. Correct subst in correct formula
(ii) H_0 : Pop mean (or μ) = 2850 H_1 : Pop mean (or μ) $\neq$ 2850 $\frac{\frac{143300}{50} - 2850}{\frac{\sqrt{4126.53}}{\sqrt{50}}}$ = 1.761 '1.761' < 1.96 No evidence mean distance changed	B1 M1 A1 M1 A1f [5]	Both. Not just 'mean' Allow '4126.53' without $\sqrt{\quad}$, but must have all $\sqrt{50}$ Or correct c.v. (2867.81) for alt method For valid comparison of z values, areas or c.v. Dep 1.96; ft their 1.761 If H_1 : $\mu > 2850$ and c.f. 1.645, max B0M1A1M1A0 (c.v. for 1 tail test 2864.94)
4 (i) $\lambda = 2.8$ $e^{-2.8} (1 + 2.8 + \frac{2.8^2}{2})$ = 0.469 (3 s.f.) or 0.47(0)	B1 M1 A1 [3]	seen any λ allow one end error As final answer
(ii) $e^{-0.7n} \geq 0.99$ or $e^{-\lambda} \geq 0.99$ $-0.7n \geq \ln 0.99$ or $-\lambda \geq \ln 0.99$ $n \leq 0.01436$ or $\lambda \leq 0.01005$ '0.01436' $\times$ 150 or '0.01005' $\times$ 150 $\div$ 0.7 Max period is 2.15 mins (3 sf)	M1 M1 A1 M1 A1 [5]	Allow '=' throughout Attempt ln both sides Can be implied. Accept 3 s.f. Note $e^{-(0.7/150)n} \geq 0.99$ scores 1 st and 3 rd M1 T & I leading to ans 2.2 mins, SC: B2

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5 (i) $\int_0^2 k(x-2)^2 dx = 1$ $\left(\left[\frac{k(x-2)^3}{3} \right]_0^2 = 1 \right)$ $k \left[0 - \left(-\frac{8}{3} \right) \right] = 1$ $k = \frac{3}{8}$ AG	M1 A1 [2]	Attempt to integrate $f(x)$ with correct limits and = 1 Must see this line or better, e.g. $k \times \frac{8}{3} = 1$
(ii) $\frac{3}{8} \int_d^2 (x-2)^2 dx = 0.2$ $\left(\frac{3}{8} \left[\frac{(x-2)^3}{3} \right]_d^2 = 0.2 \right)$ $\frac{3}{8} \left[0 - \frac{(d-2)^3}{3} \right] = 0.2$ oe $((d-2)^3 = -1.6)$ $d = 0.83(0)$ (3 s.f.)	M1 M1 A1 [3]	$\int f(x)dx$ with limits d and 2 or 0 and d, and = 0.2 or =0.8 Condone missing 'k' Reasonable attempt to integrate from a correct expression, with limits substituted to give expression in d^3. Condone missing 'k'
(iii) $\frac{3}{8} \int_0^2 x(x-2)^2 dx$ $\left(= \frac{3}{8} \int_0^2 x^3 - 4x^2 + 4xdx \right)$ $= \frac{3}{8} \left[\frac{x^4}{4} - \frac{4x^3}{3} + 2x^2 \right]_0^2$ $= \frac{1}{2}$	M1 A1 A1 [3]	Attempt integ $xf(x)$; ignore limits, condone missing k $\left(\frac{3}{8} \left[x \times \frac{(x-2)^3}{3} - \int \frac{(x-2)^3}{3} dx \right]_0^2 \right)$ $= \frac{3}{8} \left[x \times \frac{(x-2)^3}{3} - \frac{(x-2)^4}{12} \right]_0^2$ Correct integration & limits, condone missing k
6 (i) $P(\text{Type I}) = 1 - P(\geq 4 \text{ assuming } p = 0.7)$ $1 - ({}^6C_4 \times 0.7^4 \times 0.3^2 + {}^6C_5 \times 0.7^5 \times 0.3 + 0.7^6)$ $(= 1 - 0.744)$ $= 0.256$ (3 s.f.)	M1 M1 A1 [3]	or $P(\leq 3 \text{ assuming } p = 0.7)$ May be implied ${}^6C_3 \times 0.7^3 \times 0.3^3 + {}^6C_2 \times 0.7^2 \times 0.3^4 + {}^6C_1 \times 0.7 \times 0.3^5 + 0.3^6$ Allow one end error $= 0.256$ (3 s.f.) SR if zero scored allow B1 for use of B(6, 0.7) in any two or more terms
(ii) $P(\text{Type II}) = P(\geq 4 \text{ assuming } p = 0.35)$ $= {}^6C_4 \times 0.35^4 \times 0.65^2 + {}^6C_5 \times 0.35^5 \times 0.65 + 0.35^6$ $= 0.117$	M1 M1 A1 [3]	May be implied Allow one end error SR if zero scored allow B1 for use of B(6, 0.35) in any two or more terms
(iii) Type 1 They will reject Luigi's belief, although it might be true.	B1 B1 [2]	In context

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7 (i) $N(10.61, 0.1017)$ $\frac{11 - 10.61}{\sqrt{0.1017}} (= 1.223)$ $\Phi(1.223)$ $= 0.889$ (3 s.f.)	B1 M1 M1 A1 [4]	o.e. Stated or implied (accept in un-simplified form) Allow without $\sqrt{}$ For attempt to find correct area consistent with their working
(ii) $P(K - 1.2A > 0)$ $\text{Var} = 0.0576 + 1.2^2 \times 0.0441$ $(= 0.121104)$ $N(-0.324, 0.121104)$ $\frac{0 - (-0.324)}{\sqrt{0.121104}} (= 0.931)$ $1 - \Phi(0.931)$ $= 0.176$ (3 s.f.)	M1 B1 B1 M1 M1 A1 [6]	Or similar stated or implied o.e. May be implied (accept in un-simplified form) Allow without $\sqrt{}$ For attempt to find correct area consistent with their working

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1	$\text{Est}(\mu) = 1.8775 \text{ or } 1.88 \text{ (3 sf)}$ $\text{Est}(\sigma^2) = \frac{80}{79} \left(\frac{820.24}{80} - "1.8775"{}^2 \right)$ $= 6.81316 \text{ or } 6.81 \text{ (3 sf)}$ $z = 1.96$ $"1.8775" \pm z \times \sqrt{\frac{"6.81316"}{80}}$ $= 1.31 \text{ to } 2.45 \text{ (3 sf)}$	B1 M1 A1 B1 M1 A1	 	Accept 751/400 (not 150.2/80) Correct sub't'n in correct formula 1/79 (820.24 – 150.2 ² /80) Seen Must be an interval. NB use of biased var can still score A1.
	Total		[6]	
2	(i) Assume sd unchanged or sd = 10.4 H ₀ : Pop mean speed (or μ) = 62.3 H ₁ : Pop mean speed (or μ) < 62.3 $\frac{59.9 - 62.3}{\frac{10.4}{\sqrt{75}}}$ $= -1.999 \text{ or } -2.00 \text{ (allow + or -)}$ Compare – 2.054 or –2.055 No evidence that mean speed decreased	B1 B1 M1 A1 M1 A1 ft	 	Oe e.g. var unchanged Both. Not just “Mean . . .” Accept sd/var mixes, but must have $\sqrt{75}$ Correct z value (or correct critical value) Valid comparison of z's/areas/critical values No contradictions. Do not ft 2-tail test.
	(ii) Pop distribution unknown Yes	B1 B1	 	
3	(i) $\int_0^{10} \frac{1}{2500} (100t^3 - t^5) dt$ $\left(= \frac{1}{2500} \left[25t^4 - \frac{t^6}{6} \right]_0^{10} = \frac{100}{3} \right)$ $" \frac{100}{3} " \text{ or } \left(\frac{16}{3} \right)^2$ $= \frac{44}{9} \text{ or } 4.89 \text{ (3 sf)}$	M1 M1 A1	 	Attempt integ $t^2 f(t)$ For $E(T^2) - (E(T))^2$
	(ii) $\int_n^{10} \frac{1}{2500} (100t - t^3) dt$ $\frac{1}{2500} \left[50t^2 - \frac{t^4}{4} \right] = 0.1$ $\frac{1}{2500} \left[2500 - \left(50n^2 - \frac{n^4}{4} \right) \right] = 0.1$ $(n^4 - 200n^2 + 9000 = 0)$ $(n^2 = 68.3772, n = 8.27)$ $n = 8$	M1 M1 M1 M1 A1	 	Attempt integ $f(t)$, ignore limits Attempt integ $f(t)$, limits n to 10 or 0 to n Equated to 0.1 or 0.9. Not need to be matched 0.1/0.9 matched to correct limits and used Correct method of solution of a QE in n^2 Must be single ans only
3	Total		[8]	

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4	(i)			
	(a)	$e^{-2.1} \times \frac{2.1^3}{3!}$ alone = 0.189	M1 A1	2 Allow any λ . Allow sum of 3 or 4 rel products, e.g. P (3, 0)
	(b)	$e^{-1.2} \times \frac{1.2^3}{3!} \times e^{-0.9}$ $+ e^{-1.2} \times \frac{1.2^2}{2!} \times e^{-0.9} \times 0.9$ = 0.115	M1 M1 A1	
	(ii)	N (30, 30) $\frac{34.5-30}{\sqrt{30}}$ (= 0.8216) $1 - \Phi$ ("0.822") = 0.206 (3sf)	B1 M1 M1 A1	3 As final answer seen or implied standardising with their N (λ , λ) 4 Allow with no or incorrect cc or no $\sqrt$ Area consistent with their working
	Total			
5	(i)	E (X)= 3.5 $(1^2 + 2^2 + 3^2 + 4^2 + 5^2 + 6^2) \div 6 -$ "3.5" ² (= $\frac{35}{12}$ AG)	B1 B1	2 21/6 oe, must see correct expression and no incorrect working
	(ii)	Attempt P (X < 3) or 1 – P(X $\geq$ 3) N (3.5, $\frac{35}{12}$ /50) $\frac{3 - "3.5"}{\sqrt{\frac{35}{12}/50}}$ (= –2.070) Φ ("–2.070") = 1 – Φ ("2.070") = 0.0192 as final answer	M1 M1 M1 M1 A1	
	(iii)	Die is biased (towards lower numbers) Mean of 50 throws $\geq$ 3 (Allow > 3) or Equal nos of high and low scores or More high scores	B1 indep B1 indep	5 or $\frac{2.99 - "3.5"}{\sqrt{\frac{35}{12}/50}}$ (= –2.111) Φ ('–2.111') = 1 – Φ ('2.111') = 0.0174 or 0.0173 Consistent area As final answer or valid total method Allow with incorrect cc (e.g. 2.5) OR no $\sqrt$. Must have $\div 50$ Comment implying die is biased 2 Comment implying results of exp't do not indicate bias (or indicate bias towards higher numbers) Both must be in context
	Total			[9]

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6	(i)	$N(5100, 5 \times 45^2)$ or $N(5100, 10125)$ $\frac{5200 - 5100}{\sqrt{10125}} (= 0.994)$ $\Phi(0.994)$ $= 0.840$ (3 sf)	B1 M1 M1 A1	4	seen or implied standardising with their new mean and new var area consistent with their working with normal
	(ii)	Use of $E - 3L$ or similar $E(E - 3L) = -260$ $\text{Var}(E - 3L) = 52^2 + 9 \times 45^2$ or 20929 $\frac{0 - (-260)}{\sqrt{20929}} (= 1.797)$ $1 - \Phi(1.797)$ $= 0.0361$ (3 sf) or 0.0362	M1 B1 B1 M1 M1 A1	6	2800 – 3 x 1020 with a pos var with 45^2 and 52^2 combined consistent area, must clearly be ϕ P ($3L - E < 0$): similar scheme SR: use of $3E - L$, M1, 7380 B1, 26361 B1 stand 0 with these values M1, M0A0 max 4/6
Total				[10]	