CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/61 Paper 6, maximum raw mark 50

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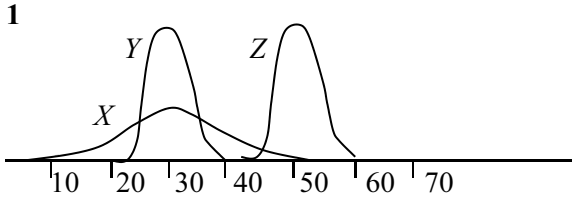
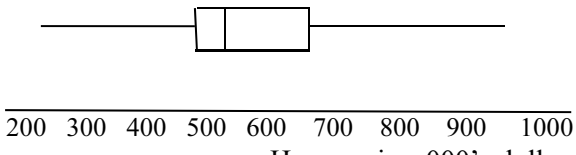
1		B1 B1 B1ft	**3**	X mean at 30, roughly from 10 to 50 or 15 – 45 Y same mean as X but higher and thinner Z same shape as Y but mean at 50 ft wrong Y
2	either 55/90 (11/18) or 95/160 (19/32) seen P(M and 18 – 60) = 0.6 × 55/90 = 0.367 (11 / 30) P(18 – 60) = 0.6 × 55/90 + 0.4 × 95/160 (= 29/48 or 0.604) $P(M \mid 18-60) = \frac{P(M \cap 18-60)}{P(18-60)}$ = 88/145 (0.607)	B1 M1 M1 A1 A1	**5**	oe 0.6 mult by 55/90 seen as num / denom of a fraction Summing 2 two-factor products seen anywhere Correct unsimplified answer seen as num/denom of a fraction Correct answer
3	$\Sigma(x-5) = 116 - 18 \times 5 = 26$ $\frac{\Sigma(x-5)^2}{18} - \left(\frac{26}{18}\right)^2 = \frac{967}{18} - \left(\frac{58}{9}\right)^2$ $\Sigma(x-5)^2 = 257$ OR coded mean = 58/9 – 5 = 1.444 $\Sigma(x-5) = 1.444 \times 18 = 26$ $\Sigma(x-5)^2 = \Sigma x^2 - 10\Sigma x + 25 \times 18$ = 967 – 1160 + 450 = 257	M1 A1 M1 M1 A1 M1 A1 M1 A1 A1	**5**	Obtaining Σx and subtracting 18 × 5 Correct answer Subst in correct var formula all coded vals Subst in correct var formula all uncoded Correct answer Subtracting 5 from true mean and mult by 18 Correct answer Expanding $\Sigma(x-5)^2$ 3 terms needed Any 2 terms correct Correct answer
4	**(i)** 	B1 B1 B1 B1	**4**	Linear scale or 5 values shown and labels or in heading, need thousands of dollars, Correct median Correct quartiles Correct end points of whiskers not through box
	(ii) 1.5 × 170 = 255 Expensive houses above 690 + 170 × 1.5 = 945 i.e. 957 and 986 thousands of dollars	M1 A1	**2**	Mult their IQ range by 1.5 Correct answers from correct wkg need thousands of dollars
	(iii) doesn't show all the data items	B1	**1**	Need to see 'individual items' oe

5	**(i)**	$z = -1.406$	B1	Rounding to ± 1.41 seen
		$\frac{c-14.2}{3.6} = -1.406$	M1	Standardising allow sq rt no cc
		$c = 9.14$	A1 **3**	Correct answer
	(ii)	$P\left(\frac{15-14.2}{3.6}\right) < z < \left(\frac{16-14.2}{3.6}\right)$	M1	2 attempts at standardising no cc no sq rt
		$= \Phi(0.5) - \Phi(0.222)$ $= 0.6915 - 0.5879$	M1	Subt two Φs (indep mark)
		$= 0.1036$	A1	Needn't be entirely accurate, rounding to 0.10
		P(at least 2) = 1 – P(0, 1)	M1	Binomial term with ${}_7C_r p^r(1-p)^{7-r}$ seen $r \neq 0$ any $p < 1$
		$= 1 - (0.8964)^7 - (0.8964)^6(0.1036){}_7C_1$ $= 1 - 0.8413$	M1	1 – P(0), 1 – P(1), 1 – P(0, 1) seen their p
		$= 0.159$	A1 **6**	Correct answer accept 3sf rounding to 0.16
6	**(i)**	M R O		
		3 1 2 = 7C3 × 5C1 × 8C2 = 4900	M1	Summing more than one 3term option involving combs (can be added)
		3 2 1 = 7C3 × 5C2 × 8C1 = 2800	M1	Mult 3 combs only (indep)
		2 2 2 = 7C2 × 5C2 × 8C2 = 5880	A1	1 option correct unsimplified
		Total = 13580	A1 **4**	Correct answer
	(ii)	4 groups in 4! ways 3 mountain in 3! ways	M1	4! seen mult by something
		2 ordinary in 2! ways	M1	Mult by 3! for racing or 2! for ordinary
		4! × 3! × 2 = 288	A1 **3**	Correct answer
	(iii)	e.g. s O x x x x O s s s Ordinary in 2!	M1	2! or 4! seen mult
		Rest of bikes in 4! Bikes and spaces 5 groups in 5 ways	M1	Mult by 5 (ssssb)
		2! × 4! × 5 = 240	A1 **3**	Correct answer

7 **(i)**	if throw H then smallest score is 2 P(T, 1) = 1/2 × 1/4 = 1/8 **AG**	B1 B1 **2**	Or equivalent
(ii)	P(3) from two dice = 2/16 seen P(H, 3) = 1/2 × 2/16 = 2/32 P(T, 3) = 1/2 × 1/4 = 1/8 So P(3) = 6/32 = 3/16 **AG**	B1 M1 A1 A1 **4**	From (1, 2) and (2, 1) Summing P(H, 3) and P(T, 3) One correct Correct answer must see clear reasoning
(iii)			
(iv)	P($Q \cap R$) = 0 or 'if you throw a tail you can't get a 7' Yes they are exclusive	M1 A1dep **2**	Stating P($Q \cap R$) = 0 or implying by words Dep on previous M

X	1	2	3	4	5	6	7	8
Prob		5/32		7/32		3/32		

B1 One correct prob
B1 A second correct prob
B1 **3** A third correct prob

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1		$P(x < -2.4) = P\left(z < \frac{-2.4-1.5}{3.2}\right)$	M1		Standardising no cc can have sq
		$= P(z < -1.219)$ $= 1 - 0.8886$	M1		Correct area, i.e. < 0.5
		$= 0.111$	A1	**[3]**	Correct answer rounding to 0.111
2	**(i)**	$P(C \cap < 50) = 0.35 \times 0.2 = 0.07$	B1	**[1]**	
	(ii)	$P(C \mid < 50) = \frac{P(C \cap < 50)}{P(< 50)}$	M1	**[4]**	Summing three 2-factor products seen anywhere (can omit the 1)
		$= \frac{0.35 \times 0.2}{0.25 \times 0.3 + 0.35 \times 0.2 + 0.4(\times 1)}$	A1		0.545 (unsimplified) seen as num or denom of a fraction
		$= \frac{0.07}{0.545}$	M1		Attempt at $P(C \cap < 50)$ as 2-factor prod only seen as num or denom of a fraction
		$= 0.128$ (14/109)	A1		Correct answer
3	**(i)**	$z = 0.878$	B1		± 0.878, 0.88, rounding to 0.88 seen
		$\frac{190-160}{\sigma} = 0.878$	M1		(190 – 160)/σ = something
		$\sigma = 34.2$	A1	**[3]**	Correct answer
	(ii)	P(at least 1) = 1 – P(0)	M1		Using 1 – P(0), 1 – P(0, 1), P(1,2 … 12) or P(2, … 12) with $p = 0.19$ or 0.81, terms must be evaluated to get the M1
		$= 1 - (0.81)^{12} = 0.920$	A1	**[2]**	Correct answer accept 0.92
4	**(i)**	number = 1.5 × 50 = 75 (AG)	B1	**[1]**	Must see 1.5 × 50
	(ii)	freqs are 10, 25, 50, 75, 30 (15, 15)	M1 A1		Attempt at freqs not fd Correct freqs
		Mean = (10 × 125 + 25 × 162.5 + 50 × 187.5 + 75 × 225 + 30 × 300)/190	M1		attempt at mid points not cw or ucb or lcb
		= 40562.5/190 = 213 (213.48 …)	A1		correct mean
		$sd^2 = 10 \times 125^2 + 25 \times 162.5^2 + 50 \times 187.5^2 + 75 \times 225^2 + 30 \times 300^2)/190 - (213.48 \ldots)^2$	M1		subst their Σfx^2 in correct variance formula
		sd = 46.5 or 46.6	A1	**[6]**	
	(iii)	have used the mid-point of each interval and not the raw data	B1	**[1]**	

5	**(i)**	$P(4, 5, 6) = (0.22)^4(0.78)^4 8C4 + (0.22)^5(0.78)^3 8C5 + (0.22)^6(0.78)^2 8C6$	M1 M1		Bin term with ${}_8C_r\, p^r\, (1-p)^{8-r}$ seen $r \neq 0$ any $p < 1$ Summing 2 or 3 bin probs $p = 0.22$, $n = 8$
		$= 0.0763$	A1	**[3]**	Correct answer
	(ii)	prob = 0.13 mean = $300 \times 0.13 = 39$ var = $300 \times 0.13 \times 0.87 = 33.93$	B1 B1ft		Correct prob can be implied Correct unsimplified np and npq ft wrong 0.13
		$P(30 < x < 50) = P\left(\frac{30.5 - 39}{\sqrt{33.93}} < z < \frac{49.5 - 39}{\sqrt{33.93}}\right)$	M1 M1		Standardising a value need sq rt Cont correction 30.5 / 31.5 or 48.5/49.5 only
		$= P(-1.4592 < z < 1.8026)$ $= \Phi(1.8026) + \Phi(1.4592) - 1$ $= 0.9643 + 0.9278 - 1 = 0.892$	M1 A1	 **[6]**	Correct area $\Phi_1 + \Phi_2 - 1$ oe Rounding to correct answer SC $P(31,..49) = 300C31(0.13)^{31}(0.87)^{269}$ + … +300C49 etc.) B1B1
6	**(i)**	1663200	B1	**[1]**	
	(ii)	M xxxxxxxxx M	M1		9! or 9P9 seen
		Number of ways = $\frac{9!}{3!2!} = 30240$	A1	**[2]**	Correct answer
	(iii)	4 vowels together = $8! \times 4/2!2!$ $= 40320$	M1 M1		8!/2!2! seen mult by something 4 oe 4!/3! or 4C1 etc. seen mult by something
		$1663200 - 40320 = 1622880$	B1	**[3]**	Correct answer SC 7!/2!2! × 8P4 or 7! × 8P4/3! Or 7!/2!2! × 8P4/3! M1
	(iv)	Exactly 2 Es 4C2 = 6 Exactly 3 Es 4C1 = 4 Total = 10 ways	M1 B1 A1	 **[3]**	Summing 2 options One option correct Correct answer
		OR 5C2 = 10	M2 A1		M1 for k5C2 Correct ans

7	**(i)**	options (3, 4, 4,) or (4, 3, 4) or (4, 4, 3) Probs (4/10 × 6/9 × 5/8) ×3C1 = 360/720 = ½ AG	M1 M1 A1	**[3]**	Summing three 3-factor options oe 10 × 9 × 8 seen in denom Correct answer
		OR $\frac{{}_6C_2 \times {}_4C_1}{{}_{10}C_3} = \frac{1}{2}$ AG	M1 M1 A1		One of 6C2 or 4C1 seen in num 10C3 in denom Correct answer
	(ii)		B1	**[4]**	9, 10, 11, 12 only seen
		P(3, 3, 3) = 4/10 × 3/9 × 2/8 = 24/720 (1/30) P(3, 3, 4) = 4/10 × 3/9 × 6/8 × 3C1 = 216/720 (3/10) P(4, 4, 4) = 6/10 × 5/9 × 4/8 = 120/720(1/6)	B1 B1 B1		One correct prob other than P(11), with or without replacement Another correct prob Σ all 4 probs = 1
	(iii)	P(R) = 0.5 P(S) = 0.4 P($R \cap S$) = 120/720 P($R \cap S$) = 120/720 ≠ P(R) × P(S) Not indep	B1 M1 A1ft	**[3]**	P($R \cap S$) = 120/720 (1/6) Numerical attempt to compare P(R and S) with P(R) × P(S) provided P($R \cap S$) ≠ 1/5 Correct conclusion ft wrong P($R \cap S$) ≠ 1/5, P(S) correct
	(iv)	P($R \cap S$) ≠ 0 or there is an overlap between R and S (34,4) Not exclusive Σxf/Σf	B1ft	**[1]**	Correct answer following correct reasoning ft wrong non zero P($R \cap S$)

sum	9	10	11	12
Prob	24/720	216/720	360/720	120/720

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1	bars are not touching oe	B1		Sensible reason involving not touching, no gaps, class boundaries, group data not continuous (may be the negative)
	Area not rep by frequency, not used fd, not labelled fd	B1	**2**	Must be frequency density oe. Wrong height not sufficient. (Best 2 reasons awarded)
2	$P(13.6 < X < 14.8) = P\left(\frac{13.6-14}{0.52} < z < \frac{14.8-14}{0.52}\right)$	M1		Standardising 1 expression, no cc, no sq rt, no sq, ±, mean on num.
	$= P(-0.7692 < z < 1.538)$ $= \Phi(1.538) - [1 - \Phi(0.7692)]$ $= 0.9380 - [1 - 0.7791]$ $= 0.7171$	M1 A1		$\Phi 1 + \Phi 2 - 1$ (indep) oe ($\Phi 2 - \Phi 1$ if cc used) Correct probability rounding to 0.72 here
	$P(8) = (0.7171)^8(0.2829)^2{}_{10}C_8$ $= 0.252$	M1 A1	**5**	Binomial expression $10C8\ p^8q^2$, $\Sigma p + q = 1$, any p Correct answer (rounding to 0.252)
3	**(i)** $(p =)0.85$ $P(< 12) = 1 - P(12, 13, 14)$ $= 1 - [(0.85)^{12}(0.15)^2{}_{14}C_{12} + (0.85)^{13}(0.15)_{14}C_{13} + (0.85)^{14}]$ $= 1 - 0.6479$ $= 0.352$	B1 M1 A1	**3**	$(p =)0.85$ oe seen anywhere Summing 2 or 3 consistent bin probs, any $p < 1$, $n = 14$ (or summing 12 or 13 consistent bin probs) Correct answer
	(ii) $(0.85)^n \geqslant 0.1$ $n \leqslant 14.2$ $n = 14$	M1 M1 A1	**3**	Eqn or inequality in 0.85(or 0.15), n, 0.1, n as a power Attempt to solve (can be implied) if n a power Correct answer – must be equals, not approx. MR allowed for 0.01, M1M1A0 max.
4	**(i)** $(220\times20 + 118\times25)/45$ $= 163$	M1 A1	**2**	Mult by 20 and 25 and dividing their sum by 45 Correct answer, 163.3 or 490/3 oe acceptable
	(ii) $\Sigma x_o^2/20 - 220^2 = 32^2$ $\Sigma x_o^2 = 988480$ $\Sigma x_l^2/25 - 118^2 = 12^2$ $\Sigma x_l^2 = 351700$ $\Sigma x_o^2 + \Sigma x_l^2 = 1340180$ New var $= 1340180/45 - (7350/45)^2$ $= 3100 - 3120$	M1 A1 A1 M1 A1	**5**	Subst in correct variance formula Correct Σx_o^2 correct Σx_l^2 Subst their combined results in correct var formula Correct answer

5	**(a)**	P($X < q + 82$) = 0.72 $z = 0.583$ $\frac{\pm q}{7.4}$ *or* $\frac{\pm 2q}{7.4} = z$ *or probabilty* (o.e.) $q = 4.31$	M1 M1 A1 **3**	Rounding to ± 0.58 or ± 0.15 seen Standardising, no cc, no sq, no sq rt correct answer
	(b)	$\frac{0.5\mu - \mu}{\sigma} = \frac{\pm 0.5\mu}{\sigma}$ $\frac{0.2\sigma^2}{\sigma} = -0.2\sigma = -0.580$ $\sigma = 2.90$ $\mu = 3.36$	M1 B1 M1 A1 **4**	Standardising attempt some μ/σ allow cc, sq rt, sq Can be implied ± 0.580 seen (accept ±0.58) substituting to eliminate μ or σ , arriving at numerical solution, any *z* value or probability – not dependent both answers correct , accept 2.9
6	**(i)**	$\frac{8!}{3!2!2!}$ = 1680	M1 A1 **2**	8! Divided by at least one of 3!2!2! oe Correct answer
	(ii)	5! = 120	M1 A1 **2**	5! Seen (not added, may be divided/multipled) Correct answer
	(iii)	$\frac{5!4!}{3!2!2!}$ = 120	B1 M1 A1 **3**	5! Or 4! Seen in sum or product in numerator (denominator may by 1) $\frac{k5!4!}{3!2!2!}$ in a numerical expression Correct final answer
	(iv)	GG with AA, AE, EE, RA, RE, RT, TA, TE, = 8 ways GGG with A, E, R, T = 4 ways Total = 12 ways	M1 A1 A1 **3**	Summing 2 options (could be lists) 1 correct option Correct answer

7	**(i)**	P(same) = P(1, 1)+ P(3, 3) + P(5, 5) $= \frac{2}{9}\times\frac{1}{8}+\frac{4}{9}\times\frac{3}{8}+\frac{3}{9}\times\frac{2}{8}$ = 5/18 (0.278) Alt. method: $\frac{2C2+4C2+3C2}{9C2}$ or $\frac{2\times1+3\times4+2\times3}{9C2\times2}$ *oe*	M1 M1 A1 **3**	Summing 3 two-factor options Multiplying terms by one less in the numerator or denominator Correct answer M1 for numerator, M1 for denominator, A1 correct answer
	(ii)	P($5,\bar{5}$) + P($\bar{5},5$) $= \frac{3}{9}\times\frac{6}{8}+\frac{6}{9}\times\frac{3}{8}=\frac{36}{72}$ = ½ or 0.5 Alt. method: $\frac{6C1\times3C1(\times2)}{9C2(\times2)}$ *oe*	M1 M1 A1 **3**	Mult 2 probs whose numerators sum to 9 o.e. Summing 2 options or mult by 2 (may be 4 options) Correct answer M1 for numerator, M1 for denominator, A1 correct answer
	(iii)	P($5\cap\bar{5}$) = $\frac{3}{9}\times\frac{6}{8}=\frac{1}{4}$ P($\bar{5}$) = $\frac{1}{4}+\frac{6}{9}\times\frac{5}{8}$ = 48/72 = 0.6666 P($5_1 \mid \bar{5}_2$) = $\frac{1/4}{48/72}$ = 3/8 = 0.375	M1 M1 A1 A1 **4**	Attempt at P(5 and not 5) seen as numerator or denominator of a fraction Attempt at P(not 5) sum of 2 two-factor terms seen anywhere Correct P($\bar{5}$) as numerator or denominator in fraction Correct answer
	(iv)	x | 0 | 1 | 2 P($X = x$) | 5/12 | 1/2 | 1/12 P(0) = P($\bar{5},\bar{5}$) = $\frac{6}{9}\times\frac{5}{8}$ = 30/72 (5/12) (0.4166) P(1) = 0.5 from part (ii) P(2) = 6/72 (1/12) (0.0833) from part (i)	B1 B1 B1ft **3**	Values 0, 1, 2 seen in table with at least 1 prob Correct P(0) unsimplified If x=0,1,2(,3) ft Σp = 1, no –ve values, all probabilities <1