

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/61

Paper 6, maximum raw mark 50

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

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7	(i) if throw H then smallest score is 2 $P(T, 1) = 1/2 \times 1/4 = 1/8$ AG	B1 B1	2	Or equivalent																		
	(ii) $P(3)$ from two dice = $2/16$ seen $P(H, 3) = 1/2 \times 2/16 = 2/32$ $P(T, 3) = 1/2 \times 1/4 = 1/8$ 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) <table border="1"><tr><td>X</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td></tr><tr><td>Prob</td><td></td><td>$5/32$</td><td></td><td>$7/32$</td><td></td><td>$3/32$</td><td></td><td></td></tr></table>	X	1	2	3	4	5	6	7	8	Prob		$5/32$		$7/32$		$3/32$			B1 B1 B1	 3	One correct prob A second correct prob A third correct prob
X	1	2	3	4	5	6	7	8														
Prob		$5/32$		$7/32$		$3/32$																
	(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																		

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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
	$= P(z < -1.219)$	M1		Correct area, i.e. < 0.5
	$= 1 - 0.8886$ $= 0.111$	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
	$= 0.128 \text{ (14/109)}$	A1		Correct answer
3	(i) $z = 0.878$ $\frac{190 - 160}{\sigma} = 0.878$ $\sigma = 34.2$	B1		$\pm 0.878, 0.88$, rounding to 0.88 seen $(190 - 160)/\sigma = \text{something}$
		M1		
		A1	[3]	Correct answer
	(ii) $P(\text{at least } 1) = 1 - P(0)$	M1		Using $1 - P(0)$, $1 - P(0, 1)$, $P(1, 2 \dots 12)$ or $P(2, \dots 12)$ 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 $= 1.5 \times 50 = 75$ (AG)	B1	[1]	Must see 1.5×50
	(ii) freqs are 10, 25, 50, 75, 30 (15, 15)	M1		Attempt at freqs not fd
		A1		Correct freqs
	Mean $= (10 \times 125 + 25 \times 162.5 + 50 \times 187.5 + 75 \times 225 + 30 \times 300)/190$ $= 40562.5/190 = 213 \text{ (213.48 ...)}$	M1		attempt at mid points not cw or ucb or lcb
		A1		correct mean
	$sd^2 = 10 \times 125^2 + 25 \times 162.5^2 + 50 \times 187.5^2 + 75 \times 225^2 + 30 \times 300^2)/190 - (213.48 \dots)^2$	M1		subst their Σfx^2 in correct variance formula
	$sd = 46.5 \text{ or } 46.6$	A1	[6]	
	(iii) have used the mid-point of each interval and not the raw data	B1	[1]	

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5	(i) $P(4, 5, 6) = (0.22)^4(0.78)^4 {}^8C_4 + (0.22)^5(0.78)^3 {}^8C_5 + (0.22)^6(0.78)^2 {}^8C_6$ $= 0.0763$	M1 M1	[3]	Bin term with ${}_8C_r p^r (1-p)^{8-r}$ seen $r \neq 0$ any $p < 1$ Summing 2 or 3 bin probs $p = 0.22$, $n = 8$ Correct answer
		A1		
		B1 B1ft		
		M1		
		M1		
		M1		
6	(ii) prob = 0.13 mean = $300 \times 0.13 = 39$ var = $300 \times 0.13 \times 0.87 = 33.93$ $P(30 < x < 50) = P\left(\frac{30.5 - 39}{\sqrt{33.93}} < z < \frac{49.5 - 39}{\sqrt{33.93}}\right)$ $= P(-1.4592 < z < 1.8026)$ $= \Phi(1.8026) + \Phi(1.4592) - 1$ $= 0.9643 + 0.9278 - 1 = 0.892$	B1 M1 A1	[6]	Correct prob can be implied Correct unsimplified np and npq ft wrong 0.13 Standardising a value need sq rt Cont correction 30.5 / 31.5 or 48.5/49.5 only Correct area $\Phi_1 + \Phi_2 - 1$ oe Rounding to correct answer SC $P(31, \dots, 49) = {}^{300}C_{31}(0.13)^{31}(0.87)^{269} + \dots + {}^{300}C_{49}$ etc.) B1B1
		M1		
		M1		
		M1		
		M1		
		A1		
6	(i) 1663200 (ii) M xxxxxxxxxxx M Number of ways = $\frac{9!}{3!2!} = 30240$ (iii) 4 vowels together = $8! \times 4/2!2! = 40320$ $1663200 - 40320 = 1622880$ (iv) Exactly 2 Es $4C2 = 6$ Exactly 3 Es $4C1 = 4$ Total = 10 ways OR $5C2 = 10$	B1	[1]	9! or 9P9 seen
		M1		
		A1		
		M1		
		M1		
		B1		
		M1		
		B1		
		M1		
		B1		
		A1		
		M2		
		A1		
		M1		
		B1		
		A1		
		M1		
		B1		
		A1		
		M2		
		A1		

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

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1 bars are not touching oe Area not rep by frequency, not used fd, not labelled fd	B1	Sensible reason involving not touching, no gaps, class boundaries, group data not continuous (may be the negative)
	B1 2	Must be frequency density oe. Wrong height not sufficient. (Best 2 reasons awarded)
2 $P(13.6 < X < 14.8) = P\left(\frac{13.6 - 14}{0.52} < z < \frac{14.8 - 14}{0.52}\right)$ $= P(-0.7692 < z < 1.538)$ $= \Phi(1.538) - [1 - \Phi(0.7692)]$ $= 0.9380 - [1 - 0.7791]$ $= 0.7171$ $P(8) = (0.7171)^8 (0.2829)^2 {}_{10}C_8$ $= 0.252$	M1 M1 A1 M1 A1 5	Standardising 1 expression, no cc, no sq rt, no sq, $\pm$, mean on num. $\Phi 1 + \Phi 2 - 1$ (indep) oe ($\Phi 2 - \Phi 1$ if cc used) Correct probability rounding to 0.72 here Binomial expression $10C_8 p^8 q^2$, $\Sigma p + q = 1$, 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) $(0.85)^n \geq 0.1$ $n \leq 14.2$ $n = 14$	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) $(220 \times 20 + 118 \times 25)/45$ $= 163$	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

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5 (a) $P(X < q + 82) = 0.72$ $z = 0.583$ $\frac{\pm q}{7.4} \text{ or } \frac{\pm 2q}{7.4} = z \text{ or probability (o.e.)}$ $q = 4.31$	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/multiplied) 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 be 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

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7	(i) $P(\text{same}) = P(1, 1) + P(3, 3) + P(5, 5)$ $= \frac{2}{9} \times \frac{1}{8} + \frac{4}{9} \times \frac{3}{8} + \frac{3}{9} \times \frac{2}{8}$ $= 5/18 \text{ (0.278)}$ Alt. method: $\frac{2C_2 + 4C_2 + 3C_2}{9C_2}$ or $\frac{2 \times 1 + 3 \times 4 + 2 \times 3}{9C_2 \times 2} \text{ oe}$	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) $P(5, \bar{5}) + P(\bar{5}, 5)$ $= \frac{3}{9} \times \frac{6}{8} + \frac{6}{9} \times \frac{3}{8} = \frac{36}{72} = \frac{1}{2} \text{ or } 0.5$ Alt. method: $\frac{6C_1 \times 3C_1 (\times 2)}{9C_2 (\times 2)} \text{ oe}$	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) $P(5 \cap \bar{5}) = \frac{3}{9} \times \frac{6}{8} = \frac{1}{4}$ $P(\bar{5}) = \frac{1}{4} + \frac{6}{9} \times \frac{5}{8} = 48/72 = 0.6666$ $P(5_1 \bar{5}_2) = \frac{1/4}{48/72} = 3/8$ $= 0.375$	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) <table border="1"><tr><td>x</td><td>0</td><td>1</td><td>2</td></tr><tr><td>P(X = x)</td><td>5/12</td><td>1/2</td><td>1/12</td></tr></table> $P(0) = P(\bar{5}, \bar{5}) = \frac{6}{9} \times \frac{5}{8} = 30/72 \text{ (5/12)}$ (0.4166) $P(1) = 0.5$ from part (ii) $P(2) = 6/72 \text{ (1/12)}$ (0.0833) from part (i)	x	0	1	2	P(X = x)	5/12	1/2	1/12	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 $\Sigma p = 1$, no –ve values, all probabilities <1
x	0	1	2								
P(X = x)	5/12	1/2	1/12								