

MARK SCHEME for the May/June 2014 series

9709 MATHEMATICS

9709/61

Paper 6, maximum raw mark 50

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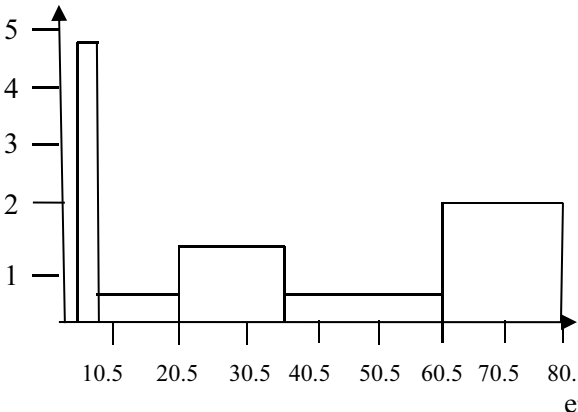
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1	$P(21.6 < x < 28.7)$ $= P\left(\left(\frac{21.6-24}{4.7}\right) < z < \left(\frac{28.7-24}{4.7}\right)\right)$ $= P(-0.5106 < z < 1) = \Phi(1) - \Phi(-0.5106)$ $= 0.8413 - (1 - 0.6953)$ $= 0.537 \text{ (0.5366)}$	M1 A1 M1 A1	4	Standardising; no cc, no sq rt One rounding to $\Phi(0.841 \text{ or } 0.695)$ $\Phi_1 + \Phi_2 - 1$ Correct answer								
2	$1.751 = \frac{12 - \mu}{\sigma}$ $0.468 = \frac{9 - \mu}{\sigma}$ $\sigma = 2.34$ $\mu = 7.91$	B1 B1 M1 M1 A1	5	Rounding to ± 1.75 seen ± 0.468 seen An eqn with a z-value, μ and σ no $\sqrt{\sigma}$, no σ^2 Sensible attempt to eliminate μ or σ by substitution or subtraction, need a value correct answers								
3	(i) constant / given p , independent trials, fixed / given no. of trials, only two outcomes	B1 B1	2	Any one correct Any 3 correct								
	(ii) $P(x \geq 3) = 1 - P(0, 1, 2)$ $= 1 - [(0.85)^{18} + (0.85)^{17}(0.15) \times 18 + (0.85)^{16}(0.15)^2 \times {}^{18}C_2]$ $= 0.520$	M1 M1 A1	3	Any binomial expression $p^r(1-p)^{18-r} {}^{18}C_r$ seen $1 - P(0, 1, 2)$, any n, p, q Correct answer								
4	(i) $P(\text{exactly } 2) = \frac{{}^6C_2}{{}^8C_4} = \frac{15}{70} = \frac{3}{14}$ AG OR $P(2) = \frac{6}{8} \times \frac{5}{7} \times \frac{2}{6} \times \frac{1}{5} \times {}^4C_2 = \frac{3}{14}$ AG	M1 A1	2	${}^6C_x / {}^8C_x$ seen or ${}^4C_2$ mult by 4 fractions (last 2 can be implied) Answer legit obtained								
	(ii) <table border="1"><tr><td>x</td><td>2</td><td>3</td><td>4</td></tr><tr><td>Prob</td><td>3/14</td><td>8/14</td><td>3/14</td></tr></table>	x	2	3	4	Prob	3/14	8/14	3/14	B1 B1 B1✓	3	2, 3, 4 only in top line one correct prob other than $P(2)$ third correct prob ft $\Sigma = 1$
x	2	3	4									
Prob	3/14	8/14	3/14									
	(iii) $\text{Var}(X) = \frac{12}{14} + \frac{72}{14} + \frac{48}{14} - 3^2$ $= \frac{3}{7} \text{ (0.429)}$	M1 A1	2	using $\Sigma x^2 p - 3^2$ (or their $\{E(X)\}^2$) must be evaluated correct answer								

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5 (i) $P(X \text{ and } P) = \frac{1}{4} \times \frac{4}{9} = \frac{1}{9}$ $P(Y \text{ and } P) = \frac{1}{4} \times \frac{2}{12} = \frac{1}{24}$ $P(Z \text{ and } P) = \frac{1}{2} \times \frac{1}{16} = \frac{1}{32}$ $P(P) = \frac{53}{288} = 0.184$	M1 A1 M1 A1 4	Mult a playground prob with a P prob One correct prob Summing at least two 2-factor probs Correct answer
(ii) $P(Y C) = \frac{P(Y \cap C)}{P(C)}$ $\frac{\frac{1}{4} \times \frac{1}{12}}{\frac{1}{4} \times \frac{1}{12} + \frac{1}{2} \times \frac{4}{16}}$ $= \frac{1}{\frac{48}{7}} = \frac{1}{7}$	M1 M1 A1 A1 4	Attempt at $P(Y \cap C)$ as numerator of a fraction Attempt at $P(C)$ in form of summing two 2-factor products, seen anywhere Correct unsimplified $P(C)$ seen anywhere Correct answer
6 (i) $\frac{6!}{2!} = 360$	B1 B1 2	6! Seen alone Dividing by 2! only
(ii) $\frac{4!}{2!} \times \frac{4!}{3!}$ $= 48$	B1 B1 B1 3	4! seen mult Dividing by 2! or 3! (Mult by 4 implied B1B1) Correct answer
(iii) 1N and 1A: N A xx in ${}^3C_2$ $= 3$ ways	M1 A1 2	${}^3C_x$ or ${}^x C_2$ seen alone Correct answer
(iv) 0 A : Nxxx = 1 way 2 As: NAAx in ${}^3C_1 = 3$ ways 3 As: NAAA in 1 way Total = 8 ways	M1 M1 A1 3	Finding ways with 0 or 2 or 3 As Summing 3 or 4 options Correct answer

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7 (i) class widths 5, 15, 15, 25, 20 $fd = \frac{24}{5}, \frac{9}{15}, \frac{21}{15}, \frac{15}{25}, \frac{42}{20}$ $= 4.8, 0.6, 1.4, 0.6, 2.1$ fd  errors	M1 B1 M1 A1 B1	Attempt at class widths Correct widths of bars, with or without halves, seen on diagram Attempt at fd or scaled freq Correct heights seen on graph fit their fd Correct labels, scales and halves
(ii) mean = $\frac{(3 \times 24 + 13 \times 9 + 28 \times 21 + 48 \times 15 + 70.5 \times 42)}{111}$ = 40.2 errors	M1 M1 A1	Using mid points using (Σ their fx) / their 111 correct answer
(iii) LQ in 6 – 20 UQ in 61 – 80 Least value of IQ range is 61 – 20 = 41	B1 B1 B1^{ft}	3 fit any or both wrong quartile ranges if sensible

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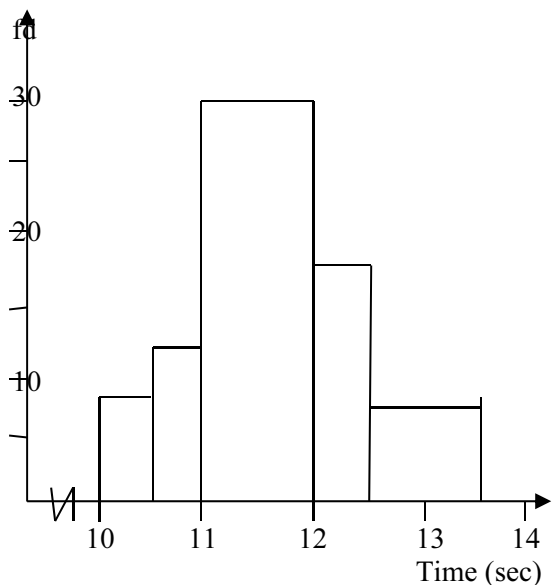
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1	$X \sim B(19, 0.12)$ $P(X < 4) = P(0, 1, 2, 3)$ $= (0.88)^{19} + {}^{19}C_1(0.12)^1(0.88)^{18} +$ ${}^{19}C_2(0.12)^2(0.88)^{17} + {}^{19}C_3(0.12)^3(0.88)^{16}$ $= 0.813$	M1 M1 M1 A1		Any binomial term ${}^{19}C_x p^x (1 - p)^{19 - x}$, $0 < p < 1$ Any binomial term ${}^n C_x (0.12 \text{ or } 0.88)^x (0.88 \text{ or } 0.12)^{n - x}$ P(0, 1, 2, 3) binomial expr with at least 2 consistent terms Correct answer										
2	Y1(7) Y2(2)Y3(2) $1 \quad 2 \quad 2 = 7 \times 1 \times 1 = 7$ $2 \quad 1 \quad 2 = {}^7C_2 \times {}^2C_1 \times 1 = 42$ $2 \quad 2 \quad 1 = {}^7C_2 \times 1 \times {}^2C_1 = 42$ $3 \quad 1 \quad 1 = {}^7C_3 \times {}^2C_1 \times {}^2C_1 = 140$ Total = 231	B1 B1 M1 A1		One unsimplified correct 3-factor product of combinations A second unsimplified correct 3-factor product of combinations Summing 3 or 4 options allow perms, wrong combs but second numbers must sum to 5 etc. Correct answer										
3	(i) $P(RR) = 0.6 \times 0.7 = 0.42$ $P(AA) = 0.4 \times 0.75 = 0.3$ $P(2 \text{ sets in match}) = 0.72$	B1 B1 B1 ^{ft}	3	Only 2 factors Only 2 factors ft previous answers										
	(ii) $\frac{P(A \text{ wins and 2 sets})}{P(2 \text{ sets})} = \frac{P(AA)}{P(2 \text{ sets})}$ $= \frac{0.3}{0.72} = \frac{5}{12} (0.417)$	B1 ^{ft} B1 ^{ft}	2	Correct num or correct denom of a fraction ft their (i) Correct answer ft their or recovered AA/their or recovered (i)										
4	(i) A: $P(H) = 2/3$, $P(T) = 1/3$ B: $P(H) = 1/4$, $P(T) = 3/4$ $P(1H) = P(HTT) + P(THT) + P(TTH)$ $= (2/3 \times 1/3 \times 3/4) + (1/3 \times 2/3 \times 3/4)$ $+ (1/3 \times 1/3 \times 1/4) = 13/36$ AG	M1 M1 A1	3	Using some of $2/3$, $1/3$, $1/4$ or $3/4$ in a calculation involving prod of 3 probs Summing 3 options not all the same Correct answer										
	(ii) <table border="1"><tr><td>x</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>P</td><td>3/36</td><td>13/36</td><td>16/36</td><td>4/36</td></tr></table> $P(0H) = P(TTT) = 1/3 \times 1/3 \times 3/4 = 1/12$ $P(2H) = P(HHT) + P(HTH) + P(THH)$ $= (2/3 \times 2/3 \times 3/4) + (2/3 \times 1/3 \times 1/4)$ $+ (1/3 \times 2/3 \times 1/4) = 4/9$ not $2/3 \times 2/3$ $P(3H) = P(HHH) = 2/3 \times 2/3 \times 1/4 = 1/9$	x	0	1	2	3	P	3/36	13/36	16/36	4/36	B1 B1 B1 B1 ^{ft}	4	0, 1, 2, 3 seen for table no probs needed, table not absolutely necessary if calcs shown One prob correct other than (i) condone 0.083 for 0.0833 A second prob correct need 3 factors can be implied A third prob correct ft $23/36 - \Sigma$ their 2 probs
x	0	1	2	3										
P	3/36	13/36	16/36	4/36										
	(iii) $E(X) = 13/36 + 32/36 + 12/36$ $= 57/36 (19/12) (1.58)$	M1 A1	2	Attempt to evaluate Σxp at least 3 vals of x in table Correct answer										

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5	(i) $5! \times 3!$ or $6!$ $= 720$	B1		$5!$ or $3!$ or $6!$ oe seen mult or alone
		B1	2	Correct final answer
	(ii) $3^{**}4, 3^{**}8, 4^{**}8$ $= 5 \times 4 + 5 \times 4 + 5 \times 4 = 60$	M1		considering at least 2 types of 4-figure options ending with 4 or 8 and starting with 3 or 4
		B1		One option correct unsimplified can be implied
		A1	3	Correct final answer
	(iii) $5, *5, **5,$ $= 1 + 7 + 7^2$ $= 57$	M1		Appreciating that the number must end in 5 (can be implied)
		M1		summing numbers ending in 5 with at least 2 different numbers of digits
		A1	3	Correct final answer
6	(i) 6	B1	1	Must see in (i)
	(ii) freqs 4 6 30 9 8 fd 8 12 30 18 8	M1		Attempt at scaled freq or fd (must be f/cw) at least three f/cw
	A1		Correct heights seen on graph	
		B1		Correct-looking widths from 10, 10.5 etc. no gaps no extra lines
		B1	4	Labels and linear axes or squiggle need time or secs, fd,
	(iii) $E(X) = (10.25 \times 4 + 10.75 \times 6 + 11.5 \times 30 + 12.25 \times 9 + 13 \times 8) / 57$ $= 11.7(11.662)$ $\text{Var}(X) = (10.25^2 \times 4 + 10.75^2 \times 6 + 11.5^2 \times 30 + 12.25^2 \times 9 + 13^2 \times 8) / 57 - (11.662 \dots)^2$ $= 0.547$	M1		Using mid-point attempt (not end points) with their freq or cf at least 2 sensible ones
		A1		Correct mean
		M1		numerical attempt at correct variance formula with mean ² subt ft their “midpoints” i.e. ucb, cw, etc.
		A1	4	accept answers between 0.547 and 0.610 condone 0.6, 0.60

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7	(i) $z = -0.842$ $P(x > 1.35) = P\left(z > \frac{1.35 - 1.9}{\sigma}\right)$ $-0.842 = -0.55/\sigma$ $\sigma = 0.653$	B1 M1 A1	 3	$\pm$ rounding to 0.84 seen $\pm \frac{1.35 - 1.9}{\sigma} =$ a prob or a z-value NOT 0.8 or 0.2 allow a 1-...
	(ii) $P(x < 2) = P\left(z < \frac{2 - 1.9}{0.6532}\right)$ $= P(z < 0.1531)$ $= 0.561$	M1 A1	 2	$\pm$ standardising no continuity correction their σ Correct answer
	(iii) $X \sim N(160, 32)$ $P(162.5 < x < 173.5) =$ $P\left(\frac{162.5 - 160}{\sqrt{32}} < z < \frac{173.5 - 160}{\sqrt{32}}\right)$ $P(0.442 < z < 2.386)$ $= \Phi(2.386) - \Phi(0.442)$ $= 0.9915 - 0.6707$ $= 0.321$	B1 M1 M1 M1 A1 A1	 6	Unsimplified 160 and 32 seen Standardising need sq rt Any of 162.5, 163.5, 172.5, 173.5 seen $\Phi_2 - \Phi_1$ oe One correct Φ to 3sf Correct answer accept 0.320

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4	(i) new mean $\frac{172.6 \times 28 - 161.8}{27} = 173$	M1 A1	2	Mult by 28, subt 161.8 and dividing by 27 or 28 Correct ans
	(ii) original $\Sigma x^2 = (4.58^2 + 172.6^2) \times 28$ $= 834728.6$ (835000) Remaining $\Sigma x^2 = 834728.6 - 161.8^2$ $= 808549.36$ sd of remaining $= \sqrt{\frac{808549.36}{27} - 173^2}$ $= 4.16$	M1 A1 M1 A1	 4	Subst in formula to find Σx^2 and attempt to make Σx^2 subject, with 2 terms both squared Correct answer Subtract 161.8^2 from their original Σx^2 Correct ans, accept 4.15 or 3.93
	5 (i) $z = -1.282$ $-1.282 = \frac{t - 6.5}{1.76}$ $t = 4.24$	B1 M1 A1	 3	Rounding to ± 1.28 seen Standardising, no cc, no sq or sq rt, $z \neq \pm 0.9, \pm 0.1$ Correct answer, accept 4.25
	(ii) $P(z < 1) = 0.8413$ $P(\text{within 1sd of mean}) = 2\Phi - 1$ $= 0.6826$ $P(8, 9)$ $= {}^9C_8(0.6826)^8(0.3174) + (0.6826)^9$ $= 0.167$	M1 B1 M1 M1 A1	 5	$z = 1$ used to find a probability correct prob, accept answer rounding to 0.66, 0.67, 0.68, not from wrong working. If quoted, then implies first M1. Binomial term $p^r(1-p)^{9-r} {}^9C_r$, ${}^9C_r$ must be seen Binomial expression for $P(8)+P(9)$, any p Correct ans
	6 (i) $P(\text{B champ}) = 0.7 \times 0.7 = 0.49$	B1	1	
	(ii) $P(\text{B champ})$ $= P(\text{WW}) + P(\text{WLW}) + P(\text{LWW})$ $= (0.7 \times 0.7) + (0.7 \times 0.3 \times 0.7) +$ $(0.3 \times 0.7 \times 0.7)$ $= 0.49 + 0.147 + 0.147$ $= 0.784$	M1 B1 A1	 3	Summing at least 2 options, at least one of which is 3-factor 0.147 seen, unsimplified Correct answer
	(iii) $P(T2 T) = \frac{P(T2 \cap T)}{P(T)}$ $= \frac{0.3 \times 0.3 + 0.7 \times 0.3 \times 0.3}{0.216}$ $= 0.708$	M1 A1 M1 A1	 4	Attempt $P(T2 \cap T)$ seen anywhere sum of 2 terms Correct unsimplified num of a fraction Dividing by their $(1 - (\text{ii})^{\frac{1}{2}})$ oe Correct answer

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7 (i) (a) $6!$ $(\times) 4!$ OR $(\times) 4 \times 3$ $\div 2!2!3!$ OR $\div 2!3!$ Total 720 ways	M1 M1 M1 A1 4	Seen in a single term expression as numerator Seen in a single term expression as numerator (denominator may be 1) Seen in a single term expression as denominator Correct ans
(i) (b) $1*****3 = \frac{7!}{3!2!} = 420$ $3*****1 = 420$ $3*****3 = 420$ Total = 1260 ways	B1 M1 A1 3	$\frac{7!}{3!2!}$ seen oe Attempting to evaluate and sum at least 2 of $1***3$, $3***1$, $3***3$ Correct ans
(ii) (a) $5 \times 4 \times 3 = 60$ ways (${}^5P_3$)	M1 A1 2	${}^5P_3$ or ${}^5C_3 \times 3!$ (can be implied) Correct ans
(ii) (b) 2^{**} in 212, 213, 214, 216, 221, 223, 224, 226, 231, 232, 233, 234, 236, 241, 242, 243, 246 261, 262, 263, 264, 266 Total = 22 ways Alternative Methods: $3 \times {}^4C_1 + 2 \times {}^5C_1$ OR ${}^5P_2 + {}^2C_1$ OR ${}^4P_2 + 2 \times {}^4P_1 + {}^2C_1$	M1 A1 2 M1 OR M1 OR M1	Listing attempt starting with 2, at least 10 correct entries Correct ans $p \times {}^4C_1 + q \times {}^5C_1$, oe $p + q > 2$ ${}^5P_2$ seen Any 2 terms added