

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the May/June 2015 series

9709 MATHEMATICS

9709/61

Paper 6, 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

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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.

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- 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.
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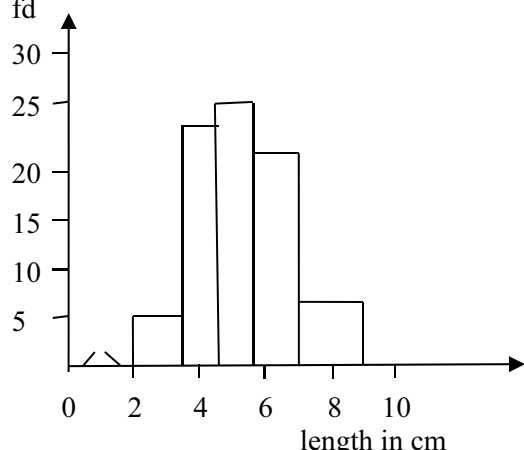
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SOS	See Other Solution (the candidate makes a better attempt at the same question)
SR	Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular 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.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

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1	$P(x < 3.273) = 0.5 - 0.475 = 0.025$ $z = -1.96$ $\frac{3.2 - \mu}{0.714} = -1.96$ $\mu = 4.60s$	M1 A1 M1 A1 [4]	Attempt to find z-value using tables in reverse ± 1.96 seen Solving their standardised equation z-value not nec Correct ans accept 4.6
2 (i)	UQ 5.5 – 7.0 cm	B1 [1]	
(ii)	fd 5.33, 25, 28, 20.7, 6, fd 	M1 A1 B1 B1 [4]	Attempt at fd or scaled freq [fr/cw] Correct heights seen on graph Correct bar widths no gaps Labels (fd and length/cm) and correct bar ends
3 (i)	$P(A) = \frac{1}{3} \times \frac{2}{3} + \frac{2}{3} \times \frac{1}{3} = \frac{4}{9}$ $P(B) = \frac{27}{36} = \frac{3}{4}$ $P(A \cap B) = \frac{12}{36} = \frac{1}{3}$ $P(A) \times P(B) = \frac{4}{9} \times \frac{3}{4} = \frac{1}{3}$ Independent as $P(A \cap B) = P(A) \times P(B)$	M1 M1 B1 M1 A1 [5]	Sensible attempt at $P(A)$ Sensible attempt at $P(B)$ correct $P(A \cap B)$ Cf $P(A \cap B)$ with $P(A) \times P(B)$ need at least 1 correct Correct conclusion following all correct working
(ii)	Not mutually exclusive because $P(A \cap B) \neq 0$ Or give counter example e.g. 1 and 6	B1 [1]	ft their $P(A \cap B)$
4 (i)	$(1 - x)0.9 + x \times 0.24 = 0.801$ $x = 0.15$	M1 A1 A1 [3]	Eqn with sum of two 2-factor probs = 0.801 Correct equation Correct answer

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(ii)	$P(\geq 100 \text{ times given } \leq 3 \text{ views})$ $\frac{P(\geq 100 \text{ times} \cap \geq 3 \text{ views})}{P(\geq 3 \text{ views})} =$ $\frac{0.85 \times 0.1}{0.85 \times 0.1 + 0.15 \times 0.76 \text{ or } 1 - 0.801}$ $= 0.427$	B1 M1 A1 A1 [4]	0.85×0.1 seen on its own as num or denom of a fraction Attempt at $P(\geq 3 \text{ views})$ either $(0.85 \times p_1 + 0.15 \times p_2)$ or $1 - 0.801$ seen anywhere Correct unsimplified $P(\geq 3 \text{ views})$ as num or denom of a fraction Correct answer
5 (i)	$\text{new mean} = \frac{9 \times 7.1 + 18 \times 5.2}{27}$ $= 5.83$	M1 A1 [2]	Mult by 9 and 18 and dividing by 27 correct answer
(ii)	$1.45^2 = \text{so } \frac{\sum x_i^2}{9} = 472.6125 \text{ mm}$ $0.96^2 = \frac{\sum x_g^2}{18} - 5.2^2 \text{ so}$ $\sum x_g^2 = 503.3088$ $\frac{\text{New sd}^2}{27} = \frac{472.6125 + 503.3088}{27} - 5.83^2 = 2.117$ $\text{New sd} = 1.46$	M1 A1 A1 M1 A1 [5]	subst in a correct variance formula sq rt or not correct $\sum x_i^2$ (rounding to 470) correct $\sum x_g^2$ (rounding to 500) using $\sum x_i^2 + \sum x_g^2$, dividing by 27 and subtr comb mean ² correct answer
6 (i)	$P(5, 6, 7) = {}^8C_5(0.68)^5(0.32)^3 + {}^8C_6(0.68)^6(0.32)^2 + {}^8C_7(0.68)^7(0.32)$ $= 0.722$	M1 M1 A1 A1 [4]	Binomial term ${}^8C_x p^x(1-p)^{8-x}$ seen $0 < p < 1$ Summing 3 binomial terms Correct unsimplified answer Correct answer
(ii)	$np = 340, npq = 108.8$ $P(x > 337) = P\left(z > \frac{337.5 - 340}{\sqrt{108.8}}\right)$ $= P(z > -0.2396)$ $= 0.595$	B1 M1 M1 M1 A1 [5]	Correct (unsimplified) mean and var standardising with sq rt must have used 500 cc either 337.5 or 336.5 correct area (> 0.5) must have used 500 correct answer
(iii)	$np(340) > 5 \text{ and } nq(160) > 5$	B1 [1]	must have both or at least the smaller, need numerical justification
7 (a) (i)	$\frac{9!}{2!2!3!}$ $= 15120 \text{ ways}$	B1 B1 [2]	Dividing by 2!2!3! Correct answer

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(ii)	*****3 in $\frac{8!}{2!2!3!} = 1680$ ways *****7 in $\frac{8!}{2!3!} = 3360$ ways Total even = 15120 – 1680 – 3360 = 10080 ways OR *****2 in $\frac{8!}{2!3!} = 3360$ ways *****6 in $\frac{8!}{2!2!3!} = 1680$ ways *****8 in $\frac{8!}{2!2!2!} = 5040$ways Total = 10080 ways OR “15120” $\times 6/9 = 10080$	B1 B1 M1 A1 [4] B1 B1 M1 A1 M2 A2	Correct ways end in 3 Correct ways end in 7 Finding odd and subtr from 15120 or their (i) Correct answer One correct way end in even correct way end in another even Summing 2 or 3 ways Correct answer Mult their (i) by 2/3 oe Correct answer
	(b) T(3) S(6) G(14) 1 1 3 in $3 \times 6 \times {}^{14}C_3 = 6552$ 1 3 1 in $3 \times {}^6C_3 \times 14 = 840$ 3 1 1 in $1 \times 6 \times 14 = 84$ 2 2 1 in ${}^3C_2 \times {}^6C_2 \times 14 = 630$ 2 1 2 in ${}^3C_2 \times 6 \times {}^{14}C_2 = 1638$ 1 2 2 in $3 \times {}^6C_2 \times {}^{14}C_2 = 4095$ Total ways = 13839 (13800)	M1 M1 M1 B1 A1 [5]	Mult 3 (combinations) together assume $6 = {}^6C_1$ etc Listing at least 4 different options Summing at least 4 different options At least 3 correct numerical options Correct answer

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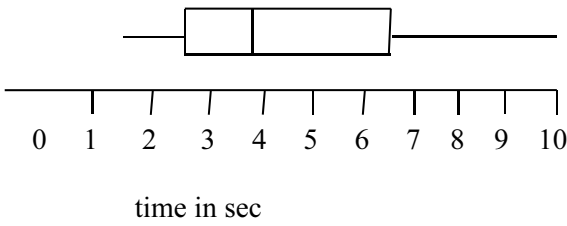
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1	$P(3, 4, 5) =$ ${}^{10}C_3\left(\frac{1}{6}\right)^3\left(\frac{5}{6}\right)^7 + {}^{10}C_4\left(\frac{1}{6}\right)^4\left(\frac{5}{6}\right)^6 + {}^{10}C_5\left(\frac{1}{6}\right)^5\left(\frac{5}{6}\right)^5$ $= 0.222$	M1 A1 A1 3	Bin expression of form ${}^{10}C_x(p)^x(1-p)^{10-x}$ any x any p Correct unsimplified answer accept (0.17, 0.83), (0.16, 0.84), (0.16, 0.83), (0.17, 0.84) or more accurate Correct answer
2	mid points 13, 30.5, 40.5, 50.5, 73 Mean = $\frac{4 \times 13 + 24 \times 30.5 + 38 \times 40.5 + 34 \times 50.5 + 20 \times 73}{120}$ $= \frac{5500}{120} = 45.8$ var = $\frac{4 \times 13^2 + 24 \times 30.5^2 + 38 \times 40.5^2 + 34 \times 50.5^2 + 20 \times 73^2}{120} - (45.8\dots)^2$ $= \frac{278620}{120} - 45.8\dots^2$ $= 2321.8333 - 45.8\dots^2$ sd = 14.9	M1 M1 A1 M1 A1 5	Attempt at midpoints at least 3 correct Using their midpoints i.e. cw, ucb, 1/2 cw and freqs into correct formula must be divided by 120 Correct answer from correct working Evaluating $\frac{\sum fx^2}{120} - \text{their } \bar{x}^2$ must see their 45.8^2 subtracted allow cw etc Correct answer
3 (i)		B1 B1 ✓ B1 B1 4	LQ = 2.6 med = 3.8–3.85, UQ = 6.4–6.6 Correct quartiles and median on graph ft linear from 2–10 End whiskers correct not through box Label need seconds and linear 2–10 axis or can have 5 values on boxplot no line provided correct
(ii)	$1.5 \times \text{IQR} = 1.5 \times 3.8 = 5.7$ $\text{LQ} - 5.7 = -\text{ve}$, $\text{UQ} + 5.7 = 12.1$ i.e. > 10 So no outliers AG	M1 A1 2	Attempt to find $1.5 \times \text{IQR}$ and add to UQ or sub from LQ OR compare $1.5 \times \text{IQR}$ with gap 3.6 between UQ and max 10 Correct conclusion from correct working need both
4 (i)	$0.3 \times 0.72 + 0.7 \times x = 0.783$ $x = 0.81$	M1 A1 A1 3	Eqn with sum of two 2-factor probs = 0.783 Correct equation Correct answer

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(ii)	$P(S \text{ given not like}) = \frac{P(S \cap NL)}{P(NL)}$ $= \frac{0.3 \times 0.28}{0.3 \times 0.28 + 0.7 \times 0.19 \text{ or } 1 - 0.783}$ $= 0.387 \text{ (12/31)}$	B1 M1 A1 A1	0.3×0.28 seen on its own as num or denom of a fraction Attempt at P(NL) either (0.3 × p ₁) + (0.7 × p ₂) or 1 – 0.783 seen anywhere Correct unsimplified P(NL) as num or denom of a fraction Correct answer																				
5 (i)	$P(2Es \ 1O) = \frac{3}{5} \times \frac{2}{4} \times \frac{2}{3} \times {}^3C_2 = \frac{3}{5} \text{ (0.6)}$ OR $P(2Es \ 1O) = \frac{{}^3C_2 \times {}^2C_1}{{}^5C_3} = \frac{6}{10}$ $= 0.6$ OR 241, 247, 261, 267, 461, 467 = 6 options 124 126 127 146 147 167 246 247 267 467 Prob = 6/10	M1 M1 A1 M1 M1 A1 M1 M1 A1	3 5×4×3 seen in denom Mult a prob by ³ C ₂ oe Correct answer ³ C _x or ^y C ₂ or ² C ₁ oe seen mult by k ≥ 1 in num ⁵ C ₃ seen in denom Correct answer List at least 3 of 241, 247, 261, 267, 461, 467 ⁵ C ₃ or list to get all 10 options in denom see below Correct answer																				
(ii)	<table><tr><td>124</td><td>126</td><td>127</td><td>146</td><td>147</td><td>167</td></tr><tr><td>246</td><td>247</td><td>267</td><td>467</td><td></td><td></td></tr></table> <table><tr><td>s</td><td>1</td><td>2</td><td>4</td></tr><tr><td>P(S=s)</td><td>6/10</td><td>3/10</td><td>1/10</td></tr></table>	124	126	127	146	147	167	246	247	267	467			s	1	2	4	P(S=s)	6/10	3/10	1/10	M1 A1 B1 B1 B1	5 Attempt at listing with at least 7 correct All correct and no others or all 60 1, 2, 4 only seen in top row Any two correct All correct
124	126	127	146	147	167																		
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s	1	2	4																				
P(S=s)	6/10	3/10	1/10																				
6 (a) (i)	N*****B $\text{Number of ways} = \frac{5!}{3!}$ $= 20$	B1 B1 B1	3 5! Seen in num oe or alone mult by k ≥ 1 3! Seen in denom can be mult by k ≥ 1 Correct final answer																				
(ii)	B(AAA)NNS $\text{Number of ways} = \frac{5!}{2!} \text{ or } {}^5P_3$ $= 60$	M1 M1 A1	3 5! seen as a num can be mult by k ≥ 1 Dividing by 2! Correct final answer																				
(b)	¹⁴ C ₉ total options = 2002 T and M both in ¹² C ₇ = 792 Ans 2002 – 792 = 1210 OR Neither in ¹² C ₉ = 220 One in ¹² C ₈ = 495 Other in ¹² C ₈ = 495	M1 B1 A1 M1 B1	3 ¹⁴ C ₉ or ¹⁴ P ₉ in subtraction attempt ¹² C ₇ (792) seen Correct final answer Summing 2 or 3 options at least 1 correct condone ¹² P ₉ + ¹² P ₈ + ¹² P ₈ here only Second correct option seen accept another 495 or if M1 not awarded, any correct option																				

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	total = 1210	A1	Correct final answer
7 (a) (i)	$\text{prob} = p\left(z < \frac{30 - 35.2}{4.7}\right)$ $= P(z < -1.106)$ $= 1 - 0.8655 = 0.1345$ $0.1345 \times 52 = 6.99$	M1 M1 A1 A1 4	Standardising no sq rt no cc no sq $1 - \Phi$ Correct ans rounding to 0.13 Correct final answer accept 6 or 7 if 6.99 not seen but previous prob 0.1345 correct
(ii)	$\Phi(t) = 0.648 \quad z = 0.380$ $0.380 = \frac{t - 35.2}{4.7}$ $t = 37.0$	B1 M1 A1 3	0.648 seen standardising allow cc, sq rt, sq, need use of tables not 0.148, 0.648, 0.352, 0.852 correct answer rounding to 37.0
(b)	$\frac{7 - \mu}{\sigma} = -0.8 \quad \text{so} \quad 7 - \mu = -0.8\sigma$ $\frac{10 - \mu}{\sigma} = 0.44 \quad \text{so} \quad 10 - \mu = 0.44\sigma$ $\mu = 8.94 \quad \sigma = 2.42$	B1 B1 M1 M1 A1 5	± 0.8 seen ± 0.44 seen An eqn with z-value, μ and σ no sq rt no cc no sq Sensible attempt to eliminate μ or σ by subst or subtraction, need at least one value Correct answers

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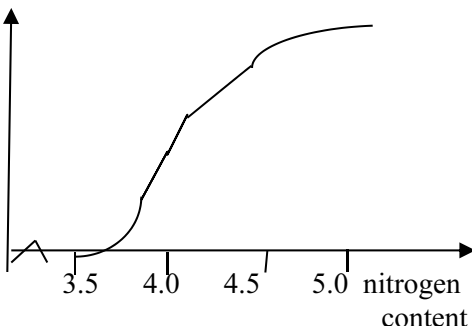
Penalties

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.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

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1	$z = 1.136$ $1.136 = \frac{195 - \mu}{22}$ $\mu = 170$	B1 M1 A1 [3]	± 1.136 seen, not ± 1.14 , Standardising, no cc no sq rt, equated to their z not 0.128 or 0.872 Correct answer, nfw																
2 (i)	<table border="1"> <tr> <td></td><td>Kitchen mess</td><td>Kitchen not mess</td><td>Total</td></tr> <tr> <td>On time</td><td>1/10</td><td>1/10</td><td></td></tr> <tr> <td>Not on time</td><td>1/2</td><td></td><td>4/5</td></tr> <tr> <td>Total</td><td>3/5</td><td>4/10</td><td></td></tr> </table>		Kitchen mess	Kitchen not mess	Total	On time	1/10	1/10		Not on time	1/2		4/5	Total	3/5	4/10		B1 B1 B1 [3]	All values may be decimals or % 2 probabilities correct 2 further probabilities correct 2 further probabilities correct
	Kitchen mess	Kitchen not mess	Total																
On time	1/10	1/10																	
Not on time	1/2		4/5																
Total	3/5	4/10																	
(ii)	$P(\text{not on time given kitchen mess}) = \frac{1/2}{3/5}$ $= 5/6$ o.e.	M1 A1 [2]	A cond prob fraction seen (using corresponding combined outcomes and total) FT from their values, 3sf or better, <1 , $3/5 < 1$																
3	$\mu = 300 \times 0.072 = 21.6$, $\sigma^2 = 20.0448$ $P(x < 18) = P\left(z < \frac{17.5 - 21.6}{\sqrt{20.0448}}\right)$ $= P(z < -0.9157)$ $= 1 - 0.8201$ $= 0.180$	B1 M1 M1 M1 A1 [5]	300×0.072 seen and $300 \times 0.072 \times 0.928$ seen or implied ($\sigma = 4.4771$, $\sigma^2 = 20.0448$) oe $\pm$ Standardising, their mean/var, with sq root Cont corr 17.5 or 18.5 Correct area $1 - \Phi$ Answer wrt 0.180, nfw																
4 (i)	$P(1W) = 6/9 \times 3/8 + 3/9 \times 6/8$ $= \frac{1}{2}$ AG OR $\frac{{}^6C_1 \times {}^3C_1}{{}^9C_2}$ $= \frac{1}{2}$ AG	M1 A1 [2] M1 A1	summing 2 two-factor probs (condone replacement) not $\frac{1}{2} \times \frac{1}{2} + \frac{1}{2} \times \frac{1}{2}$ Correct answer, fully justified Using combinations consistent, correct format Correct answer, fully justified																
(ii)	$P(\overline{W}, \overline{W}) = 3/9 \times 2/8 = 6/72$ (1/12) $P(W, W) = 6/9 \times 5/8 = 30/72$ (5/12) <table border="1"> <tr> <td>x</td><td>0</td><td>1</td><td>2</td></tr> <tr> <td>Prob</td><td>1/12</td><td>1/2</td><td>5/12</td></tr> </table>	x	0	1	2	Prob	1/12	1/2	5/12	B1 B1 B1 [3]	Distribution table with 0,1,2 only $P(W, W)$ or $P(\overline{W}, \overline{W})$ correct $P(W, W) + P(\overline{W}, \overline{W}) = 0.5$								
x	0	1	2																
Prob	1/12	1/2	5/12																
(iii)	$E(X) = 16/12$ (4/3) (1.33) isw	B1 [1]	Condone 1(.3) if correct working seen, nfw																

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5	(i)	$P(\text{large}) = 1 - \Phi\left(\frac{29 - 21.7}{6.5}\right)$ $= 1 - \Phi(1.123) = 1 - 0.8692$ $= 0.1308$ $P(0,1) = (0.8692)^8 + {}^8C_1(0.1308)(0.8692)^7$ $= 0.718$	M1 M1 A1 M1 M1 A1	[6] Standardising no cc no sq rt Correct area $1 - \Phi$ Rounding to 0.13 Any bin term with ${}^8C_x p^x (1 - p)^{8-x}$ $0 < p < 1$ Summing bin $P(0) + P(1)$ only with $n = 8$, oe Correct ans												
	(ii)	$= 1 - (0.8692)^n > 0.98$ $(0.8692)^n < 0.02$ Least number = 28	M1 M1 A1	[3] eq/ineq involving their $(0.8692)^n$ or $(0.1308)^n$, 0.02 or 0.98 oe with or without a 1 solving attempt (could be trial and error) – may be implied by their answer correct answer												
6	(i)	cf 	B1 M1 A1	[3] Uniform axes cf and nitrogen content labelled, at least 0 to 70 and 3.5 to 4.8 seen 5 points plotted correctly on graph paper <table border="1" data-bbox="1027 1084 1466 1162"><tr><td>3.5</td><td>3.8</td><td>4.0</td><td>4.2</td><td>4.5</td><td>4.8</td></tr><tr><td>0</td><td>6</td><td>18</td><td>41</td><td>62</td><td>70</td></tr></table> All points correct and a reasonable curve (condone 1 missed point) or line segments.	3.5	3.8	4.0	4.2	4.5	4.8	0	6	18	41	62	70
3.5	3.8	4.0	4.2	4.5	4.8											
0	6	18	41	62	70											
	(ii)	$70 - \text{their } 55 = 15$ $= 21.4\%$	M1 A1	[2] Subt a value > 41 from 70 (or $n/70$, $n < 29$) Correct ans, accept 18.5 – 22												
	(iii)	median = 4.15	B1	[1] Accept $4.1 < \text{median} < 4.2$, nfw												

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(iv)	<table><tr><td>nit</td><td>3.5–</td><td>3.8–</td><td>4.0–</td><td>4.2–</td><td>4.5–</td></tr><tr><td>cont</td><td>3.8</td><td>4.0</td><td>4.2</td><td>4.5</td><td>4.8</td></tr><tr><td>fr</td><td>6</td><td>12</td><td>23</td><td>21</td><td>8</td></tr><tr><td>fd</td><td>20</td><td>60</td><td>115</td><td>70</td><td>26.7</td></tr></table>	nit	3.5–	3.8–	4.0–	4.2–	4.5–	cont	3.8	4.0	4.2	4.5	4.8	fr	6	12	23	21	8	fd	20	60	115	70	26.7	M1	Attempt at freqs, at least 3 correct, ignore labelling
	nit	3.5–	3.8–	4.0–	4.2–	4.5–																					
	cont	3.8	4.0	4.2	4.5	4.8																					
	fr	6	12	23	21	8																					
	fd	20	60	115	70	26.7																					
		M1	Attempt at fd as f/cw only at least 3 correct FT (Accept f/cw × k)																								
		A1	Correct heights seen on graph (plot at 4.8,27 A0) Graph paper must be used (3 correct relative heights implies M1M1)																								
		B1	Correct bar ends seen on graph – graph paper used																								
		B1	[5] Correct linear scale and labels.																								
7	(i) W S D 1 1 3 = 6×4× ³ C ₃ = 24 1 3 1 = 6× ⁴ C ₃ ×3 = 72 3 1 1 = ⁶ C ₃ ×4×3 = 240 1 2 2 = 6× ⁴ C ₂ × ³ C ₂ = 108 2 1 2 = ⁶ C ₂ ×4× ³ C ₂ = 180 2 2 1 = ⁶ C ₂ × ⁴ C ₂ ×3 = 270 Total = 894	M1 M1 M1 B1 A1	Listing at least 4 different options Mult 3 (combs) together assume 6 = ⁶ C ₁ , Σr=5 Summing at least 4 different evaluated/unsimplified options >1 At least 3 correct unsimplified options Correct answer																								
	(ii) ³ P ₂ × ¹⁰ P ₈ = 10886400	B1 B1 B1	³ P ₂ oe seen multiplied either here or in (iii) ^k ¹⁰ P _x seen or ^k ^y P ₈ with no addition, ^k ≥ 1, ^y >8, ^x <10 Correct answer, nfw																								
	(iii) DSWSWSWD or DWSWSWSWD D in ³ P ₂ ways = 6 S in ⁴ P ₄ ways = 24 W in ⁶ P ₄ = 360 Swap SW in 2 ways Total = 103680 ways	B1 B1 B1	If ³ P ₂ has not gained credit in (ii) may be awarded ⁴ P ₄ or ⁶ P ₄ oe seen multiplied or common in all terms (no division) Mult by 2 (condone 2!) Correct answer, 3sf or better, nfw																								