

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 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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	Cambridge International AS/A Level – October/November 2015	9709	61

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.
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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)
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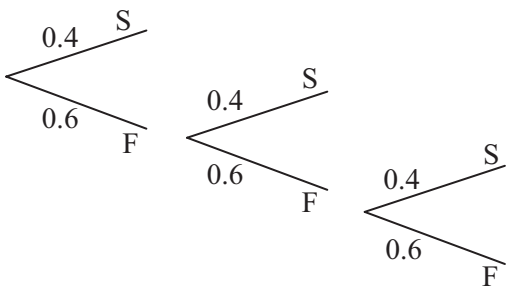
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1	$p = 0.76$ $P(\text{fewer than } 10) = 1 - P(10, 11)$ $= 1 - (0.76)^{10}(0.24)^{11}C_{10} - (0.76)^{11}$ $= 1 - 0.219$ $= 0.781$	M1 M1 M1 A1 [4]	Any binomial term ${}^{11}C_x p^x (1-p)^{11-x}, 0 < p < 1$ Any binomial term ${}^nC_x (0.76)^x (0.24)^{n-x}$ $1 - P(10, 11)$ oe binomial expression Correct answer
2	$\mu = 54.1$ $z = -1.11$ $-1.11 = \frac{50.9 - 54.1}{\sigma}$ $\sigma = 2.88$	B1 B1 M1 A1 [4]	Stated or evaluated Accept rounding to ± 1.1 Standardising no cc no sq rt Correct answer
3 (i)	$a = 9/cw$ $= 9/2 = 4.5$ $1.5 = b/4$ so $b = 6$	M1 A1 A1 [3]	Using $fd = f/cw$ Correct a Correct b
(ii)	Time in minutes	B1 B1 B1 [3]	Correct heights ft their b Correct widths, ie 3, 2, 3, 4 starting either 60 or 59.5 Labels fd, time or minutes and squiggle and bars from 59.5 to 71.5
4 (i)	$\bar{x} = 80 - 147/30 = 80 - 4.9$ $= 75.1$ $sd = \sqrt{\left(\frac{952}{30} - \left(\frac{147}{30}\right)^2\right)} = \sqrt{7.72...}$ $sd = 2.78$	M1 A1 M1 A1 [4]	For $-147/30$ oe seen Correct answer $952/30 - (\pm \text{their coded mean})^2$ Correct answer
(ii)	$P(x > 160) = P\left(z > \frac{160 - 148.6}{18.5}\right)$ $= P(z > 0.616)$ $= 1 - 0.7310$ $= 0.269$	M1 M1 A1 [3]	Standardising no cc no sq rt $1 - \Phi$ Correct answer

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5	(i)	5 (i) eg ** (EEEE) *** Number of ways = $\frac{6!}{2!2!} = 180$	M1 M1 A1 [3]	Mult by 6! oe Dividing by 2!2! oe Correct answer										
	(ii)	S*****T or T*****S Number of ways = $\frac{7!}{4!2!} \times 2$ = 210	M1 M1 A1 [3]	Mult by 7! Or dividing by one of 2! or 4! Mult by 2 Correct answer										
	(iii)	exactly one E in ${}^6C_3$ ways = 20	M1 M1 A1 [3]	${}^6C_x$ as a single answer ${}_xC_3$ as a single answer correct answer										
6	(i)		M1 A1 A1 [3]	3 pairs S (bank, log in, success oe) and F oe seen no extra bits. Exactly 3 pairs, must be labelled Correct diagram with all probs correct										
	(ii)	<table border="1" data-bbox="263 996 845 1086"> <tr> <td>x</td><td>0</td><td>1</td><td>2</td><td>3</td></tr> <tr> <td>Prob</td><td>0.4</td><td></td><td>0.144</td><td>0.216</td></tr> </table>	x	0	1	2	3	Prob	0.4		0.144	0.216	B1 M1 A1 B1 [4]	P(0) correct Multiplying two of more factors of 0.4 and 0.6 One more correct prob One more correct prob
x	0	1	2	3										
Prob	0.4		0.144	0.216										
	(iii)	$E(X) = 0.24 + 2 \times 0.144 + 3 \times 0.216$ = 1.176 (1.18)	M1 A1 [2]	Using $\sum p_i x_i$ Correct answer										
7	(i)	let $P(2, 4, 6) \text{ all} = p$ then $P(1, 3, 5) \text{ all} = 2p$ $3p + 6p = 1$ $p = 1/9$ so prob (3) = $2/9$ (0.222)	M1 M1 A1 [3]	Using $P(\text{even}) = 2P(\text{odd})$ or vice versa oe Summing $P(\text{odd} + \text{even})$ or $P(1, 2, 3, 4, 5, 6) = 1$ Correct answer										
	(ii)	$P(5, 5, 6) = 2/9 \times 2/9 \times 1/9 \times {}^3C_2$ = $4/243$ (0.0165)	M1 M1 A1 [3]	Mult three probs together Mult by 3 oe ie summing 3 options Correct answer										
	(iii)	$\mu = 100 \times 1/3 = 33.3$, $\sigma = 100 \times 1/3 \times 2/3 = 22.2$ $P(x \leq 37) = P\left(z \leq \frac{37.5 - \frac{100}{3}}{\sqrt{\frac{200}{9}}}\right) = P(z \leq 0.8839)$ = 0.812	B1 M1 M1 M1 A1 [5]	Unsimplified $100/3$ and $200/9$ seen Standardising need sq rt 36.5 or 37.5 seen correct area using their mean Correct answer										

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1	$\Sigma x - 100n = 216$ $2416 - 100n = 216$ $n = 22$ OR $\frac{2416}{n} = \frac{216}{n} + 100$ $n = 22$	B1 B1 B1 3 B1 B1 B1	$\Sigma x - 100n$ seen Subst 2416 for their Σx Correct answer 2416/n seen or 216/n + 100 oe eg $\Sigma x/n - 100 = 216/n$ correct equation Correct answer
2	P(no men) $\frac{{}^9C_6}{{}^{16}C_6} = \frac{84}{8008} = \frac{21}{2002} = \frac{3}{286}$ = 0.0105 OR $\frac{9}{16} \times \frac{8}{15} \times \frac{7}{14} \times \frac{6}{13} \times \frac{5}{12} \times \frac{4}{11} = 0.0105$	B1 B1 B1 3 B1 B1 B1	${}^9C_6$ seen anywhere ${}^{16}C_6$ seen as denom of fraction oe Correct final answer (9 × 8 × 7 × 6 × 5 × 4) seen anywhere Correct unsimplified denom Correct final answer
3 (i)	$\frac{1}{4}$	B1 1	
(ii)	$\left(\frac{3}{4}\right)^4 \left(\frac{1}{4}\right) = \frac{81}{1024} = 0.0791$	M1 A1 2	Expression of form $p^4(1-p)$ only, $p = 1/4$ or $3/4$ Correct answer
(iii)	P(all diff) = $\frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times 4!$ = $\frac{3}{32}$ (0.0938) OR $1 \times \frac{3}{4} \times \frac{2}{4} \times \frac{1}{4} = \frac{3}{32}$	M1 M1 A1 3	4! on numerator seen mult by $k \geq 1$ or $3 \times 2 \times 1$ on num oe, must be in a fraction. 4^4 on denom or 4^3 on denom with the $3 \times 2 \times 1$ Correct answer
4 (i)	Two in same taxi: ${}^6C_2 \times {}^4C_4 \times 2$ or ${}^6C_2 + {}^6C_4$ = 30	M1 M1 A1 3	${}^6C_4$ or ${}^6C_2$ oe seen anywhere 'something' ×2 only or adding 2 equal terms Correct final answer
(ii)	MJS in taxi $({}^5C_1 \times 2 \times 2) \times {}^4P_4$ = 480	M1 M1 M1 A1 4	${}^5P_1$, ${}^5C_1$ or 5 seen anywhere Mult by 2 or 4 oe Mult by ${}^4P_4$ oe eg 4! or $4 \times {}^3P_3$ or can be part of 5! Correct final answer

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5	(i)	<table><tr><th>team A</th><td></td><th>team B</th></tr><tr><td></td><td>7</td><td>5 7 9</td></tr><tr><td>4 4 2</td><td>8</td><td>2 3 4 6</td></tr><tr><td>9 8 7 6 1</td><td>9</td><td>4 5 6</td></tr><tr><td>9 7 4 0</td><td>10</td><td>1 8</td></tr><tr><td>6 5</td><td>11</td><td>1 3 5</td></tr><tr><td>2</td><td>12</td><td></td></tr></table>	team A		team B		7	5 7 9	4 4 2	8	2 3 4 6	9 8 7 6 1	9	4 5 6	9 7 4 0	10	1 8	6 5	11	1 3 5	2	12		B1	Correct stem can be upside down, ignore extra values, allow 70, 80 etc with suitable numerical key										
		team A		team B																															
			7	5 7 9																															
		4 4 2	8	2 3 4 6																															
9 8 7 6 1	9	4 5 6																																	
9 7 4 0	10	1 8																																	
6 5	11	1 3 5																																	
2	12																																		
B1	Correct team A must be on LHS, alignment ± half a space, no late entries squeezed in, no crossing out if shape is changed																																		
B1	Correct team B in single diagram can be either LHS or RHS																																		
B1 4	Correct key or keys for their diagram/s, need both teams, at least one kg.																																		
	(ii)	LQ = 91 UQ = 109 IQ range = 18	B1 B1 2	Both quartiles correct Correct IQR ft wrong quartiles, LQ < UQ, not 12 – 4 etc																															
	(iii)	Σx ₁₅ = 1399 Σx ₁₆ = 16 × 93.9 = 1502.4 New wt = 1502.4 – 1399 = 103 (103.4)	M1 M1 A1 3	Attempt at Σx ₁₅ for either team Mult 93.9 by 16 attempt Correct answer																															
6	(i)	<table><tr><td></td><td colspan="4">Spinner A</td></tr><tr><td></td><td>1</td><td>2</td><td>3</td><td>3</td></tr><tr><td rowspan="4">Spinner B</td><td>–3</td><td>(–2)</td><td>–1</td><td>0</td><td>0</td></tr><tr><td>–2</td><td>–1</td><td>0</td><td>(1)</td><td>1</td></tr><tr><td>–1</td><td>0</td><td>1</td><td>2</td><td>2</td></tr><tr><td>1</td><td>2</td><td>3</td><td>4</td><td>4</td></tr></table>		Spinner A					1	2	3	3	Spinner B	–3	(–2)	–1	0	0	–2	–1	0	(1)	1	–1	0	1	2	2	1	2	3	4	4	B1 1	
			Spinner A																																
	1	2	3	3																															
Spinner B	–3	(–2)	–1	0	0																														
	–2	–1	0	(1)	1																														
	–1	0	1	2	2																														
	1	2	3	4	4																														
(ii)	<table><tr><td>x</td><td>–2</td><td>–1</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td></tr><tr><td>prob</td><td>$\frac{1}{16}$</td><td>$\frac{2}{16}$</td><td>$\frac{4}{16}$</td><td>$\frac{3}{16}$</td><td>$\frac{3}{16}$</td><td>$\frac{1}{16}$</td><td>$\frac{2}{16}$</td></tr></table>	x	–2	–1	0	1	2	3	4	prob	$\frac{1}{16}$	$\frac{2}{16}$	$\frac{4}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{16}$	$\frac{2}{16}$	M1 M1 A1 3	Their values in (i) as the top line, seen listed in (ii) or used in part (iii) Attempt at probs seen evaluated, need at least 4 correct from their table Correct table seen																
x	–2	–1	0	1	2	3	4																												
prob	$\frac{1}{16}$	$\frac{2}{16}$	$\frac{4}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{16}$	$\frac{2}{16}$																												
	(iii)	E(X) = 1 Var(X) = ((–2) ² + 2 + 3 + 12 + 9 + 32)/16 – 1 ² = $\frac{62}{16}$ – 1 = $\left(\frac{23}{8}\right)$ (2.875) OR using Σp(x – $\bar{x}$) ² = (9 + 8 + 4 + 0 + 3 + 4 + 18)/16 = $\frac{46}{16}$ = 2.875	M1 M1 A1 3 M1 M1 A1	Attempt at E(X) from their table if Σp = 1 Evaluating Σx ² p – [their E(X)] ² allow Σp ≠ 1 but all p's < 1 Correct answer																															

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(iv)	P(even given +ve) $= \frac{5}{9}$	M1 A1 2	Counting their even numbers and dividing by their positive numbers Correct answer
	OR P(even given +ve) = $\frac{\left(\frac{5}{16}\right)}{\left(\frac{9}{16}\right)}$	M1	Using cond prob formula not P(E) × P(+ve) need fraction over fraction accept any of $\frac{5/16 \text{ or } 6/16 \text{ or } 9/16}{9/16 \text{ or } 10/16 \text{ or } 13/16}$
	$= \frac{5}{9}(0.556)$	A1	Correct answer
7 (a) (i)	$P(x > 3900) = P\left(z > \frac{3900 - 4520}{560}\right)$ $= P(z > -1.107) = \Phi(1.107)$ $= 0.8657$ Number of days = 365×0.8657 $= 315 \text{ or } 316 (315.98)$	M1 M1 A1 B1 4	Standardising no cc no sq rt no sq Correct area Φ ie > 0.5 Prob rounding to 0.866 Correct answer ft their wrong prob if previous A0, $p < 1$, ft must be accurate to 3sf
	(ii) $z = 1.165$ $1.165 = \frac{8000 - m}{560}$ $m = 7350 (7347.6)$	B1 M1 A1 3	± 1.165 seen Standardising eqn allow sq, sq rt, cc, must have z-value eg not 0.122, 0.878, 0.549, 0.810. Correct answer rounding to 7350
	(iii) $P(0, 1) = (0.878)^6 + {}^6C_1(0.122)^1(0.878)^5$ $= 0.840$ accept 0.84 Normal approx. to Binomial. M0, M0, A0	M1 M1 A1 3	Binomial term ${}^6C_x p^x(1-p)^{6-x}$ $0 < p < 1$ seen Correct unsimplified expression Correct answer
	(b) $P(< 2\mu) = P\left(z > \frac{2\mu - \mu}{\sigma}\right) = P(z < 1.5)$ $= 0.933$	M1 M1 A1 3	Standardising with μ and σ Attempt at one variable and cancel Correct answer

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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)

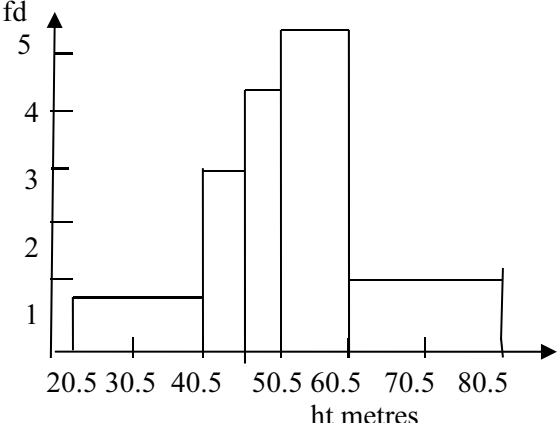
Penalties

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	coded mean = 0.3 oe $sd = \sqrt{\frac{96.1}{250} - (0.3)^2}$ $= 0.543$ Alt: $\Sigma(t-2.5)^2$ expanded $\Sigma t^2 = 2033.6$ $sd = \sqrt{\frac{2033.6}{250} - 2.8^2}$ $= 0.543$	B1 M1 A1 3 Or B1 M1 A1 3	$\Sigma(t - 2.5) = 75$ B0 until $\div 250$ Subst in variance formula both terms coded Correct answer Substituting their Σt^2 from expanded 3-term expression, 250 and 2.8 in variance formula
2 (i)	$P(X) = \frac{20}{28} \left(\frac{5}{7} \right) (0.714), 71.4\%$	B1 1	oe
(ii)	$P(F) = \frac{20}{28} \times \frac{1}{4} \times \frac{8}{28} \times \frac{6}{10} = \frac{7}{20}$	M1 A1 2	Summing two 2-factor probs created by One of $\frac{1}{4}$ or $\frac{3}{4}$ multiplied by $\frac{20}{28}$ or $\frac{8}{28}$ Added to $\frac{4}{10}$ or $\frac{6}{10} \times$ altn population prob Correct answer
(iii)	$P(X F) = \frac{5/28}{7/20} = \frac{25}{49} (0.510)$	M1 A1 2	Their unsimplified country X probability ($\frac{5}{28}$) as num or denom of a fraction Or (their fair hair population) $\div$ (total fair hair pop) Correct answer
3 (i)	$P(S) = \frac{3}{16}$ $P(T) = \frac{4}{16}$ $P(S \cap T) = \frac{2}{16}$ $P(S) \times P(T) = \frac{3}{64} \neq \frac{2}{16}$ Not independent	M1 M1 B1 M1 A1 5	Sensible attempt at $P(S)$ Sensible attempt at $P(T)$ Correct $P(S \cap T)$ comp $P(S) \times P(T)$ with $P(S \cap T)$ (their values), evaluated Correct conclusion following all correct working
(ii)	not exclusive since $P(S \cap T) \neq 0$ Or counter example e.g. 1 and 3 Or $P(S \cup T) \neq P(S) + P(T)$ with values	B1 1	FT their $P(S \cap T)$, not obtained from $P(S) \times P(T)$, with value and statement.
4 (i)	$z = 1.127$ $1.127 = \frac{136 - 125}{\sigma}$ $\sigma = 9.76$	B1 M1 A1 3	± 1.127 seen accept rounding to ± 1.13 Standardising no cc no sq rt, with attempt at z (not ± 0.8078, ± 0.5517, ± 0.13, ± 0.87) Correct ans

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(ii)	$P(131 < x < 141) = P\left(\frac{131-125}{9.76} < z < \frac{141-125}{9.76}\right)$ $= \Phi(1.639) - \Phi(0.6147)$ $= 0.9493 - 0.7307$ $= 0.2186$	M1	Standardising once with their sd, no $\sqrt{}$, ² , allow cc
		M1	Correct area $\Phi 2 - \Phi 1$
		M1	Mult by 170, $P < 1$
	Number = $0.2186 \times 170 = 37$ or 38 or awrt 37.2	A1 4	Correct answer, nfw
5 (a)	e.g. **(AAOOOI)***** $\frac{8!}{2!2!} \times \frac{6!}{2!3!} = 604800$	B1	8! ($8 \times 7!$) or 6! seen anywhere, either alone or in numerator)
		M1	Dividing by at least 3 of 2!2!2!3! (may be fractions added)
		A1 3	Correct answer
(b)	C(7) E(6) A(4) 1 1 2 = $7 \times 6 \times {}^4C_2 = 252$ 1 2 1 = $7 \times {}^6C_2 \times 4 = 420$ 1 3 0 = $7 \times {}^6C_3 \times 1 = 140$ 2 1 1 = ${}^7C_2 \times 6 \times 4 = 504$ 2 2 0 = ${}^7C_2 \times {}^6C_2 \times 1 = 315$ 3 1 0 = ${}^7C_3 \times 6 \times 1 = 210$	M1	Mult 3 appropriate combinations together assume $6 = {}^6C_1$, $1 = {}^4C_0$ etc., $\sum r = 4$, C&E both present
		A1	At least 3 correct unsimplified products
		M1* DM1	Listing at least 4 different correct options Summing at least 4 outcomes, involving 3 combs or perms, $\sum r = 4$
	Total = 1841	A1 5	Correct answer
			SC if CE removed, M1 available for listing at least 4 different correct options for remaining 2. DM1 for ${}^7C_1 \times {}^6C_1 \times (\text{sum of at least 4 outcomes})$
6 (i)	fd 0.9, 3, 4.2, 5.2, 1.4 	M1	Attempt at scaled freq [$f/(\text{attempt at cw})$]
		A1	Correct heights seen on diagram Scale no less than 1cm to 1 unit
		B1	Correct bar widths visually no gaps
		B1 4	Labels (ht/metres and fd or freq per 20 m etc.) and end points at 20.5 etc. condone 2 end point errors, scale no less than 1cm to 5m for 20,30... unless clearly accurate, linear scale between 20.5 and 80

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	(ii)	$(30.5 \times 18 + 43 \times 15 + 48 \times 21 + 55.5 \times 52 + 70.5 \times 28)/134$	M1	Attempt at unsimplified, mid points (at least 4 within 0.5)
		$= \frac{7062}{134} = 52.701$	M1 A1	Attempt at Σfx their mid points $\div 134$ Correct mean rounding to 53
		$\text{Var} = (30.5^2 \times 18 + 43^2 \times 15 + 48^2 \times 21 + 55.5^2 \times 52 + 70.5^2 \times 28)/134 - 52.701^2$ $= 392203.5/134 - 52.701^2 = 149.496$ $\text{sd} = 12.2$	M1	Attempts at Σfx^2 their mid points $\div$ their $\Sigma f - \text{mean}^2$
			A1 5	Correct answer, nfw
7	(i)	$P(0, 1, 2) = (0.92)^{19} + {}^{19}C_1(0.08)(0.92)^{18} + {}^{19}C_2(0.08)^2(0.92)^{17}$	M1 M1	Binomial term ${}^{19}C_x p^x (1-p)^{19-x}$ seen $0 < p < 1$ Correct unsimplified expression
		$= 0.809$	A1 3	Correct answer (no working SC B2)
	(ii)	$P(\text{at least } 1) = 1 - P(0)$ $= 1 - P(0.92)^n > 0.90$ $0.1 > (0.92)^n$ $n > 27.6$	M1 M1	Eqn with their 0.92^n , 0.9 or 0.1, 1 not nec Solving attempt by logs or trial and error, power eqn with one unknown power
		Ans 28	A1 3	Correct answer, not approx., $\approx$, $\geq$, $>$, $\leq$, $<$
	(iii)	$np = 1800 \times 0.08 = 144$ $npq = 132.48$	B1	correct unsimplified np and npq seen accept 132.5, 132, 11.5, awrt 11.51
		$P(\text{at least } 152) = P\left(z > \left(\frac{151.5 - 144}{\sqrt{132.48}}\right)\right)$	M1	standardising, with $\sqrt{\quad}$
		$= P(z > 0.6516)$	M1	cont correction 151.5 or 152.5 seen
		$= 1 - 0.7429$	M1	correct area $1 - \Phi$ (probability)
		$= 0.257$	A1 5	correct answer
	(iv)	Use because 1800×0.08 (and 1800×0.92 are both) > 5	B1 1	$1800 \times 0.08 > 5$ is sufficient $np > 5$ is sufficient if clearly evaluated in (iii) If $npq > 5$ stated then award B0