
MATHEMATICS

9709/61

Paper 6

October/November 2018

MARK SCHEME

Maximum Mark: 50

Published

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Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

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This document consists of **13** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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 FT 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.
 - Note: B2 or A2 means that the candidate can earn 2 or 0.
B2/1/0 means that the candidate can earn anything from 0 to 2.

The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.
- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking g equal to 9.8 or 9.81 instead of 10.

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The following abbreviations may be used in a mark scheme or used on the scripts:

AEF/OE Any Equivalent Form (of answer is equally acceptable) / Or Equivalent

AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)

CAO Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)

CWO Correct Working Only – often written by a ‘fortuitous’ answer

ISW Ignore Subsequent Working

SOI Seen or implied

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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Question	Answer	Marks	Guidance
1	${}^9C_4 \times {}^5C_3 \times {}^2C_2$	B1	${}^9C_4$ or ${}^9C_3$ or ${}^9C_2$ seen (<i>1st group</i>)
	$=126 \times 10 \times 1$	B1	${}^5 \text{ or } {}^7C_3$ or ${}^6 \text{ or } {}^7C_4$ or ${}^6 \text{ or } {}^5C_2$ times an integer (<i>2nd group</i>)
	$=1260$	B1	Correct answer
		3	

Question	Answer	Marks	Guidance
2(i)	$6p + 0.1 = 1$ $p = 0.15$	B1	Correct answer
		1	
2(ii)	$\text{Var}(X) = 1 \times p + 1 \times 2p + 4 \times 2p + 16 \times 0.1 - 1.15^2$	M1	Correct unsimplified formula, <i>their</i> p substituted (allow 1 error)
	$0.15 + 0 + 0.3 + 1.2 + 1.6 - 1.15^2$ $= 1.9275 = 1.93$ (3sf)	A1	Correct answer
		2	

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Question	Answer	Marks	Guidance
3(i)	Scenarios are: 4V + 1C + 1DB: ${}^{11}C_4 \times {}^5C_1 \times {}^4C_1$	M1	${}^{11}C_a \times {}^5C_b \times {}^4C_c, a+b+c=6,$
	4V + 2C: ${}^{11}C_4 \times {}^5C_2$ 5V + 1C: ${}^{11}C_5 \times {}^5C_1$	B1	2 correct unsimplified options
	6600 + 3300 + 2310	M1	Add 2 or 3 correct scenarios only
	= 12210	A1	Correct answer
		4	
3(ii)	$4! \times 3!$	M1	k multiplied by 3! or 4!, k an integer ≥ 1
		A1	Correct unsimplified expression
	= 144	A1	Correct answer
		3	

Question	Answer	Marks	Guidance
4(a)	$P(X < 29.4) = P\left(Z < \frac{29.4 - 31.4}{\sqrt{3.6}}\right)$ = $P(Z < -1.0541)$	M1	Standardise, no cc, must have sq rt.
	= 1 – 0.8540	M1	Obtain 1 – prob
	= 0.146	A1	Correct final answer
		3	

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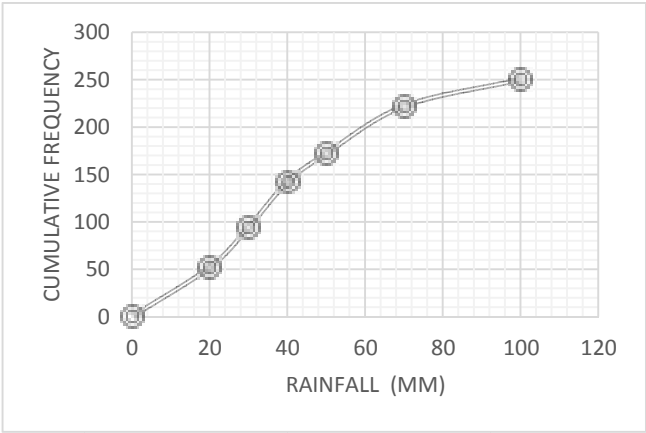
Question	Answer	Marks	Guidance
4(b)	$P(X < 12) = \frac{42}{400} = 0.105$ and $P(X > 19) = \frac{58}{400} = 0.145$	M1	Eqn with μ, σ and a z-value. Allow cc, wrong sign, but not $\sqrt{\sigma}$ or σ^2
	$\frac{12 - \mu}{\sigma} = -1.253$	B1	Any form with z value rounding to ± 1.25
	$\frac{19 - \mu}{\sigma} = 1.058$	B1	Any form with z value rounding to ± 1.06
	$12 - \mu = -1.253\sigma$ $19 - \mu = 1.058\sigma$ $7 = 2.307\sigma$ or $36.455 + 2.307\mu = 0$ oe	M1	Solve 2 equations in μ, σ eliminating to 1 unknown
	$\mu = 15.8, \sigma = 3.03$	A1	Correct answers
		5	

Question	Answer	Marks	Guidance
5(i)	$1 - (P(7) + P(8) + P(9))$ $= 1 - ({}^9C_7 0.8^7 \times 0.2^2 + {}^9C_8 0.8^8 \times 0.2^1 + {}^9C_9 0.8^9 \times 0.2^0)$	M1	Any binomial term of form ${}^9C_x p^x (1-p)^{9-x}, x \neq 0$
		M1	Correct unsimplified expression
	$= 1 - (0.3019899 + 0.3019899 + 0.1342177)$ $= 0.262$	A1	Correct answer
		3	

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Question	Answer	Marks	Guidance
5(ii)	Mean = $200 \times 0.8 = 160$; var = $200 \times 0.8 \times 0.2 = 32$	B1	Both unsimplified
	$P(X > 166) = P\left(Z > \frac{166.5 - 160}{\sqrt{32}}\right)$	M1	Standardise, $z = \pm \frac{x - \text{their } 160}{\sqrt{\text{their } 32}}$ with square root
		M1	166.5 or 165.5 seen in attempted standardisation expression
	$= P(Z > 1.149) = 1 - 0.8747$	M1	1 – a Φ -value, correct area expression, linked to final answer
	$= 0.125$	A1	Correct final answer
		5	
5(iii)	$np = 160, nq = 40$: both > 5 (so normal approx. holds)	B1	Both parts required
		1	

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Question	Answer	Marks	Guidance
6(i)		B1	Appropriate linear scales starting at (0,0), axes labelled cf and Rainfall, mm
		B1	Correct graph, points plotted at ucb, allow straight lines or curve
		2	
6(ii)		M1	Read off from increasing graph at cf = 150
	42	A1	Correct answer ($41 \leq r \leq 43$)
		2	

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Question	Answer	Marks	Guidance
6(iii)	Frequencies 52, 42, 48, 30, 50, 28	B1	Correct frequencies
	Mean age = $(10 \times 52 + 25 \times 42 + 35 \times 48 + 45 \times 30 + 60 \times 50 + 85 \times 28) / 250$	B1	Correct midpoints (allow one error)
	=9980/250	M1	Using $\Sigma fx/250$ with mid-points attempt, not cf, cw, lb, ub
	= 39.9(2) oe	A1	Correct answer
	Variance = $10^2 \times 52 + 25^2 \times 42 + 35^2 \times 48 + 45^2 \times 30 + 60^2 \times 50 + 85^2 \times 28) / 250 - \text{mean}^2$ = 539.59	M1	Attempt at variance using their midpoints and their mean
	$\sigma = 23.2$	A1	Correct answer for sd
		6	

Question	Answer	Marks	Guidance
7(i)	$52/160 = 13/40, 0.325$	B1	oe
		1	
7(ii)	P(boy) = 96/160: P(Music) = 52/160 P(boy and Music) = 40/160	M1	Use of $P(B) \times P(M) = P(B \cap M)$, appropriate probabilities used
	$96/160 \times 52/160 \neq 40/160$: Not independent	A1	Numerical comparison and conclusion stated
		2	

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Question	Answer	Marks	Guidance
7(iii)	Method 1		
	$P(\text{not Music/girl}) = P(\text{not Music and girl})/P(\text{girl})$ $(27/160) / (64/160)$	M1	Appropriate probabilities in a fraction
	$= \frac{27}{64}$	A1	Correct answer www implies method
	Method 2		
	<i>Direct from table</i>	M1	$27/a$ or $b/64$, $a \neq 160$
	$\frac{27}{64}$	A1	Correct answer www implies method
		2	
7(iv)	$P(B M) \times P(B NM) \times P(G NM)$ or $P(G M) \times P(B NM) \times P(B NM)$	M1	One scenario identified with 3 probs multiplied
	$40/160 \times 56/159 \times 52/158$ or $12/160 \times 56/159 \times 55/158$	A1	One scenario correct (ignore multiplying factor)
	$\times 3!$ $\times 3!/2!$	B1	Both multiplying factors correct
	0.17387 0.02759 $P = 0.17387 + 0.02759$	M1	Both cases attempted and added (multiplying factor not required), accept unsimplified
	$= 0.201$ Note: If score in this part is 0, award SCB1 for $\frac{1}{160} \times \frac{1}{159} \times \frac{1}{158} \times k$, for positive integer k , seen	A1	Correct answer, oe

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Question	Answer	Marks	Guidance
7(iv)	Method 2		
	$\frac{\binom{40}{1} \times \binom{56}{1} \times \binom{52}{1} + \binom{12}{1} \times \binom{56}{2}}{\binom{160}{3}}$	M1	One scenario identified with 2 or 3 combination multiplied
		A1	One scenario correct
		B1	Denominator correct
	$\frac{116480 + 18480}{669920}$	M1	Both scenarios attempted, and added, seen as a numerator of a fraction
	$\frac{1687}{8374}$	A1	Correct answer, oe
		5	

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Penalties

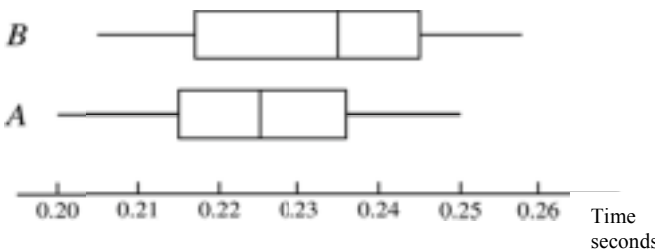
MR –1 A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through” marks. MR is not applied when the candidate misreads his 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.

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1(i)	$\frac{11!}{4!4!2!}$	M1	$\frac{11!}{4! \times k}$ or $\frac{11!}{2! \times k}$, k a positive integer
	= 34650	A1	Correct final answer
		2	
1(ii)	Method 1		
	$P(SS) = \frac{4}{11} \times \frac{3}{10} = \frac{12}{110}$ (= 0.10911)	B1	One of P(SS), P(PP) or P(II) correct, allow unsimplified
	$P(PP) = \frac{2}{11} \times \frac{1}{10} = \frac{2}{110}$ (= 0.01818) $P(II) = \frac{4}{11} \times \frac{3}{10} = \frac{12}{110}$ (= 0.10911) $\frac{4}{11} \times \frac{3}{10}$	M1	Sum of probabilities from 3 appropriate identifiable scenarios (either by labelling or of form $\frac{4}{11} \times \frac{a}{b} + \frac{2}{11} \times \frac{c}{b} + \frac{4}{11} \times \frac{a}{b}$ where $a = 4$ or 3 , $b = 11$ or 10 , $c = 2$ or 1)
	Total = $\frac{26}{110} = \frac{13}{55}$ oe (0.236)	A1	Correct final answer
	Method 2		
	Total number of selections = ${}^{11}C_2 = 55$ Selections with 2 Ps = 1	B1	Seen as the denominator of fraction (no extra terms) allow unsimplified
	Selections with 2 Ss = ${}^4C_2 = 6$ Selections with 2 Is = ${}^4C_2 = 6$,	M1	Sum of 3 appropriate identifiable scenarios (either by labelling or values, condone use of permutations. May be implied by 2,12,12)
	Total selections with 2 letters the same = 13 Probability of 2 letters the same = $\frac{13}{55}$ oe (0.236)	A1	Correct final answer, without use of permutations
		3	

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Question	Answer	Marks	Guidance												
2(i)	median = 0.225; LQ = 0.215: UQ = 0.236	B1	Correct median (Q_2)												
	IQR = 0.236 – 0.215	M1	$0.232 < UQ (Q_3) < 0.238 - 0.204 < LQ (Q_1) < 0.219$												
	= 0.021	A1	www Omission of all decimal points MR-1 <u>If M0 awarded</u> SCB1 for both LQ = 0.215: UQ = 0.236 seen												
		3													
2(ii)		B1	Linear scale between 0.20 to 0.26 (condone omission of 0.26) axis labelled (time and seconds), at least one box plot attempted, no lines through boxes, whiskers not at corner of boxes												
		B1 ft	Labelled correct graph for A, (ft their median/quartiles), condone lines through boxes, whiskers at corner of boxes												
	<table><tr><td>A</td><td>0.200</td><td>0.215</td><td>0.225</td><td>0.236</td><td>0.250</td></tr><tr><td>B</td><td>0.205</td><td>0.217</td><td>0.235</td><td>0.245</td><td>0.258</td></tr></table>	A	0.200	0.215	0.225	0.236	0.250	B	0.205	0.217	0.235	0.245	0.258	B1	Labelled correct graph for B, condone lines through boxes, whiskers at corner of boxes SC If B0B0 scored because graphs not labelled/labels reversed SCB1 if both ‘correct’ Penalty MR-1 if graphs plotted on separate axes unless both scales align exactly.
	A	0.200	0.215	0.225	0.236	0.250									
B	0.205	0.217	0.235	0.245	0.258										
	3														

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Question	Answer	Marks	Guidance
3(i)	Method 1		
	$P(3) + P(4) + P(5) = {}^5C_3 \cdot 0.75^3 \times 0.25^2 +$	M1	One binomial term ${}^5C_x p^x (1-p)^{5-x}$, $x \neq 0$ or 5 , any p
	${}^5C_4 \cdot 0.75^4 \times 0.25^1 + {}^5C_5 \cdot 0.75^5 \times 0.25^0$	M1	Correct unsimplified expression
	$= 0.26367 + 0.39551 + 0.23730$ $= 0.896 \text{ (459/512)}$	A1	Correct final answer, allow 0.8965 (isw) but not 0.897 alone
	Method 2		
	$1 - P(0) - P(1) - P(2) = 1 - {}^5C_0 \cdot 0.75^0 \times 0.25^5$	M1	One binomial term ${}^5C_x p^x (1-p)^{5-x}$, $x \neq 0$ or 5 , any p
	$- {}^5C_1 \cdot 0.75^1 \times 0.25^4 - {}^5C_2 \cdot 0.75^2 \times 0.25^3$	M1	Correct simplified expression
	$= 1 - 0.00097656 - 0.014648 - 0.087891$ $= 0.896 \text{ (459/512)}$	A1	Correct final answer, allow 0.8965 (isw) but not 0.897 alone
		3	

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Question	Answer	Marks	Guidance
3(ii)	Method 1		
	$P(C,C) + P(C,C') + P(C',C)$ 0.8×0.9	B1	Unsimplified prob completed on both days
	$0.8 \times 0.1 + 0.2 \times 0.6$	M1	Unsimplified prob $0.8 \times a + 0.2 \times b$, $a = 0.1$ or 0.4 , $b = 0.6$ or 0.9
	$= 0.92$ oe	A1	Correct final answer
	Method 2		
	$1 - P(C',C') = 1 - 0.2 \times 0.4$	B1	Unsimplified prob completed on no days
		M1	$1 - 0.2 \times a$, $a=0.1$ or 0.4 allow unsimplified
	$= 0.92$	A1	Correct final answer
		3	

Question	Answer	Marks	Guidance
4(i)	$5! \times 6! \times 2$	B1	$k \times 5!$ or $m \times 6!$ (k, m integer, $k, m \geq 1$), no inappropriate addition
		B1	$n \times 5! \times 6!$ (n integer, $n \geq 1$), no inappropriate addition
	$= 172800$	B1	Correct final answer, isw rounding (www scores B3) All marks based on their final answer
		3	

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Question	Answer	Marks	Guidance
4(ii)	... G ... G ... G ... G ... G ... G ... No. ways girls placed $\times$ No. ways boys placed in gaps =	M1	$k \times 6!$ or $k \times {}^7P_5$ (k is an integer, $k \geq 1$) no inappropriate add. (${}^7P_5 \equiv 7 \times 6 \times 5 \times 4 \times 3$ or ${}^7C_5 \times 5!$)
	$6! \times {}^7P_5$	M1	Correct unsimplified expression
	= 1814400	A1	Correct exact final answer (ignore subsequent rounding)
		3	

Question	Answer	Marks	Guidance
5(i)	$\frac{15.5 \times 12 + 910}{12 + 20}$	M1	Unsimplified total age divided by <i>their</i> total members (not 12, 20 or 2)
	= 34.25 or $34\frac{1}{4}$ (years)	A1	Correct exact answer (isw rounding), oe (34 years 3 months)
		2	
5(ii)	Considering Juniors: variance = $\frac{\sum x^2}{12} - 15.5^2 = 1.2^2$	M1	$\frac{\sum x^2}{k} - 15.5^2 = 1.2^2$, $k = 12$ or 20
	$\sum x^2 = 2900.28$	A1	Answer wrt 2900
	Considering whole group: $\sum z^2 = \sum x^2 + \sum y^2 = 2900.28 + 42850 = 45750$ Variance = $\frac{\sum z^2}{32} - \mu^2 = \frac{\text{their } 45750}{12 + 20} - (\text{their } 34.25)^2$ (= 256.63)	M1	<i>Their</i> 45750 > 42850 (not 85700 or rounding to 1.8×10^9) in correct variance or std deviation formula ($\sum x^2$ and addition may not be seen)
	s d = 16.0(2)	A1	Correct final answer, condone 16.03
		4	

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Question	Answer	Marks	Guidance														
6(i)	<table><tr><td>x</td><td>-2</td><td>-1</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>p</td><td>$\frac{1}{12}$</td><td>$\frac{2}{12}$</td><td>$\frac{3}{12}$</td><td>$\frac{3}{12}$</td><td>$\frac{2}{12}$</td><td>$\frac{1}{12}$</td></tr></table>	x	-2	-1	0	1	2	3	p	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{3}{12}$	$\frac{2}{12}$	$\frac{1}{12}$	B1	-2, -1, 0, 1, 2, 3 seen as top line of a pdf table with at least 1 probability OR attempting to evaluate P(-2), P(-1), P(0), P(1), P(2), P(3) (condone additional values with $p=0$ stated)
	x	-2	-1	0	1	2	3										
	p	$\frac{1}{12}$	$\frac{2}{12}$	$\frac{3}{12}$	$\frac{3}{12}$	$\frac{2}{12}$	$\frac{1}{12}$										
		B1	At least 4 probs correct (need not be in table)														
	B1	All probs correct in a table															
	3																
6(ii)	$E(X) = \frac{-2 \times 1 - 1 \times 2 + 0 + 1 \times 3 + 2 \times 2 + 1 \times 3}{12} = 0.5$	M1	Unsimplified expression for mean using <i>their</i> pdf table (or correct) with at least 2 non-zero values (may be seen in variance). Numerator terms may be implied by values.														
	$Var(X) = \frac{(-2)^2 \times 1 + (-1)^2 \times 2 + 1^2 \times 3 + 2^2 \times 2 + 3^2 \times 1}{12} - (their\ 0.5)^2$	M1	Unsimplified expression for variance using <i>their</i> pdf table (or correct) with at least 2 non-zero values and <i>their</i> E(X). Numerator terms may be implied by values. If $-k^2$ is seen for $(-k)^2$, the method must be confirmed by seeing value used correctly														
	$26/12 - 1/4 = 23/12$	A1	Correct final answer														
		3															

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Question	Answer	Marks	Guidance
6(iii)	Method 1		
	$P(X \text{ non-zero}) = 9/12$	B1ft	If Binomial distribution used 0/3 $P(X \text{ non-zero})$ ft from <i>their</i> pdf table, $\Sigma p=1$ oe
	$P(X = 1 X \text{ non-zero}) = \frac{P(X = 1 \cap X \text{ non-zero})}{P(X \text{ non-zero})} = \frac{\frac{3}{12}}{\frac{9}{12}}$	M1	<i>Their</i> $P(X = 1)$ / <i>their</i> $P(X \text{ non-zero})$ from <i>their</i> pdf table oe
	$= 1/3$ oe	A1	Correct final answer www
	Method 2		
	$P(X = 1 X \text{ non-zero}) = \frac{\text{Number of outcomes} = 1}{\text{Number of non-zero outcomes}}$	B1ft	Number of non-zero outcomes (expect 9) ft from <i>their</i> outcome table or pdf table numerators oe
		M1	a/b , $a = \text{their } 3$ from <i>their</i> outcome table or pdf table numerators, $b = \text{their } 9$ (not 12)
	$= \frac{3}{9} = \frac{1}{3}$ oe	A1	Correct final answer www
		3	

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Question	Answer	Marks	Guidance
7(a)(i)	$P(X < 4) = P\left(Z < \frac{4 - 3.24}{0.96}\right)$	M1	±Standardisation formula, no cc, no sq rt, no square
	$= P(Z < 0.7917) = 0.7858$	A1	0.7855 < p ≤ 0.7858 or p = 0.786 Cao (implies M1A1 awarded), may be seen used in calculation
	<i>their</i> $0.7858 \times 365 = 286$ (or 287)	B1ft	<i>Their</i> probability × 365 provided 4sf probability <u>seen</u> . FT answer rounded or truncated to nearest integer. No approximation notation used.
		3	
7(a)(ii)	$P(X < k) = P\left(Z < \frac{k - 3.24}{0.96}\right) = 0.8$	B1	(z=) ± 0.842 seen
	$\frac{k - 3.24}{0.96} = 0.842$	M1	$z = \pm \frac{k - 3.24}{0.96}$, allow cc, sq rt or square equated to a z-value (0.7881, 0.2119, 0.158, 0.8, 0.2 etc. are not acceptable)
	$k = 4.05$	A1	Correct final answer, www
		3	
7(a)(iii)	$P(-1.5 < Z < 1.5) =$	M1	$\Phi(z = 1.5)$ or $\Phi(z = -1.5)$ seen used or $p = 0.9332$ seen
	$\Phi(1.5) - \Phi(-1.5) = 2\Phi(1.5) - 1$ $= 2 \times 0.9332 - 1$ oe	M1	Correct final area expression using <i>their</i> probabilities
	$= 0.866$	A1	Correct final answer
		3	

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Question	Answer	Marks	Guidance
7(b)	$P(Y > 0) = P\left(Z > \frac{0 - \mu}{\sigma}\right) \equiv P\left(Z > \frac{0 - \mu}{3\mu/4}\right) \text{ or}$ $P\left(Z > \frac{0 - \left(\frac{4\sigma}{3}\right)}{\sigma}\right)$	M1	±Standardisation attempt in terms of one variable no sq rt or square, condone ±0.5 as cc
	$= P(Z > -4/3)$	A1	Correct unsimplified standardisation, no variables
	$= 0.909$	A1	Correct final answer
		3	

Alternative methods for Question 1(ii)**Method 3**

$$P(S, S') = \frac{4}{11} \times \frac{7}{10} = \frac{28}{110}$$

$$P(P, P') = \frac{2}{11} \times \frac{9}{10} = \frac{18}{110}$$

$$P(I, I') = \frac{4}{11} \times \frac{7}{10} = \frac{28}{110}$$

$$P(M, M') = \frac{1}{11} \times \frac{10}{10} = \frac{10}{110}$$

$$Total = \frac{84}{110}$$

$$P(Same) = 1 - \frac{84}{110} = \frac{26}{110}$$

B1 one of products correct**M1** 1 – sum of probabilities from 4 appropriate scenarios**A1** Correct final answer

Method 4

$$PP' = \frac{2 \times 9}{2} = 9$$

$$SS' = \frac{4 \times 7}{2} = 14$$

$$II' = \frac{4 \times 7}{2} = 14$$

$$MM' = \frac{1 \times 10}{2} = 5$$

$$\text{Total number of ways} = \frac{10 \times 11}{2} = 55$$

$$\text{Number of ways of letters repeating} = 55 - (9 + 14 + 14 + 5) = 13$$

$$P(\text{Same}) = \frac{13}{55}$$

B1 ${}^{11}C_2$ seen as the denominator of fraction (no extra terms) allow unsimplified

M1 1 – sum of 4 appropriate scenarios

A1 Correct final answer

MATHEMATICS

9709/63

Paper 6

October/November 2018

MARK SCHEME

Maximum Mark: 50

Published

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.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the October/November 2018 series for most Cambridge IGCSE™, Cambridge International A and AS Level components and some Cambridge O Level components.

This document consists of **15** printed pages.

PUBLISHED**Generic Marking Principles**

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptors for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

GENERIC MARKING PRINCIPLE 5:

Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).

GENERIC MARKING PRINCIPLE 6:

Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

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 FT 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.
 - Note: B2 or A2 means that the candidate can earn 2 or 0.
B2/1/0 means that the candidate can earn anything from 0 to 2.

The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.
- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking g equal to 9.8 or 9.81 instead of 10.

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The following abbreviations may be used in a mark scheme or used on the scripts:

AEF/OE Any Equivalent Form (of answer is equally acceptable) / Or Equivalent

AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)

CAO Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)

CWO Correct Working Only – often written by a ‘fortuitous’ answer

ISW Ignore Subsequent Working

SOI Seen or implied

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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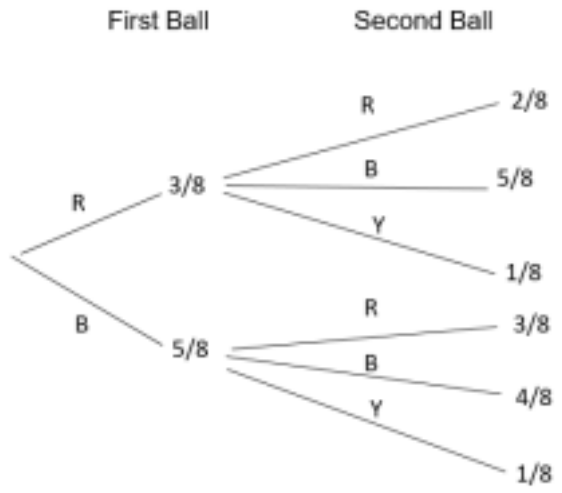
Question	Answer	Marks	Guidance
1	Method 1		
	... M ... M ... M ... M ... M ...	M1	$k \times 5!$ (120) or $k \times 6P_2$ (30), k is an integer ≥ 1 ,
	No. ways men placed $\times$ No. ways women placed in gaps $= 5! \times {}^6P_2$	M1	Correct unsimplified expression
	$= 3600$	A1	Correct answer
	Method 2		
	Number with women together $= 6! \times 2$ (1440) Total number of arrangements $= 7!$ (5040)	M1	$6! \times 2$ or $7! - k$ seen, k is an integer ≥ 1
	Number with women not together $= 7! - 6! \times 2$	M1	Correct unsimplified expression
	$= 3600$	A1	Correct answer
		3	

Question	Answer							Marks	Guidance														
2(i)	<table><tr><td>x</td><td>-2</td><td>-1</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>$P(X = x)$</td><td>$\frac{2}{18}$</td><td>$\frac{4}{18}$</td><td>$\frac{5}{18}$</td><td>$\frac{4}{18}$</td><td>$\frac{2}{18}$</td><td>$\frac{1}{18}$</td></tr></table>							x	-2	-1	0	1	2	3	$P(X = x)$	$\frac{2}{18}$	$\frac{4}{18}$	$\frac{5}{18}$	$\frac{4}{18}$	$\frac{2}{18}$	$\frac{1}{18}$	B1	-2, -1, 0, 1, 2, 3 seen as top line of a pdf table OR attempting to evaluate P(-2), P(-1), P(0), P(1), P(2), P(3),
	x	-2	-1	0	1	2	3																
	$P(X = x)$	$\frac{2}{18}$	$\frac{4}{18}$	$\frac{5}{18}$	$\frac{4}{18}$	$\frac{2}{18}$	$\frac{1}{18}$																
								B1	At least 4 probs correct (need not be in table)														
							B1	All probs correct in a table															
							3																

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Question	Answer	Marks	Guidance
2(ii)	$E(X) = \frac{-4 - 4 + 0 + 4 + 4 + 3}{18} = \frac{1}{6}$	M1	Correct unsimplified expression for the mean using their table, $\Sigma p = 1$, may be implied
	$\text{Var}(X) = \frac{8 + 4 + 0 + 4 + 8 + 9}{18} - \left(\frac{1}{6}\right)^2$ $= 11/6 - 1/36 \text{ (1.8333 - 0.02778)}$	M1	Correct, unsimplified expression for the variance using their table, and their mean ² subtracted. Allow $\Sigma p \neq 1$
	$= 65/36, (1.81)$	A1	Correct answer
		3	

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Question	Answer	Marks	Guidance
3(i)	First Ball Second Ball 	B1	Fully correct labelled tree and correct probabilities for ‘First Ball’
		B1	Correct probabilities (with corresponding labels) for ‘Second Ball’
		2	
3(ii)	$P(RR) + P(BB) = 3/8 \times 2/8 + 5/8 \times 4/8 = 3/32 + 5/16$	M1	Correct unsimplified expression from their tree diagram, $\Sigma p = 1$ on each branch
	$= 13/32 \text{ (0.406)}$	A1	Correct answer
		2	

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Question	Answer	Marks	Guidance
3(iii)	$P(RB) = 3/8 \times 5/8 = 15/64$	M1	$P(\text{1st ball red}) \times P(\text{2nd ball blue})$ from their tree diagram seen unsimplified as numerator or denominator of a fraction Allow $\Sigma p \neq 1$ on each branch
	$P(B) = 3/8 \times 5/8 + 5/8 \times 4/8 = 35/64$	M1	Correct unsimplified expression for $P(B)$ from their tree diagram seen as denominator of a fraction. Allow $\Sigma p \neq 1$ on each branch
	$P(R B) = P(RB) / P(B) = (15/64) \div (35/64) = 3/7$ (0.429)	A1	Correct answer
		3	

Question	Answer	Marks	Guidance
4(i)	Total number of selections = ${}^{12}C_7 = 792$	B1	Seen as denominator of fraction
	Selections with boy included = ${}^{11}C_6$ or ${}^{12}C_7 - {}^{11}C_7 = 462$	M1	Correct unsimplified expression for selections with boy included seen as numerator of fraction
	Probability = $462/792 = 7/12$ (0.583)	A1	Correct answer
	OR		
	prob of boy not included = $11/12 \times 10/11 \times \dots \times 5/6 = 5/12$	B1	Correct unsimplified prob
	$1 - 5/12$	M1	Subtracting prob from 1
	$= 7/12$	A1	Correct answer
		3	

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Question	Answer	Marks	Guidance
4(ii)	Method 1		
	Scenarios are: 2G + 5B: ${}^4C_2 \times {}^8C_5 = 336$	B1	One unsimplified product correct
	3G + 4B: ${}^4C_3 \times {}^8C_4 = 280$ 4G + 3B: ${}^4C_4 \times {}^8C_3 = 56$	M1	No of selections (products of ${}^nC_r$ and ${}^nP_r$) added for 2, 3 and 4 girls with no of girls and no of boys summing to 7
	Total = 672	A1	Correct total
	Probability = $672/792$ (28/33) (0.848)	A1ft	Correct answer – ‘total’/(‘total no of selections’ from i)
	Method 2		
	0G + 7B ${}^4C_0 \times {}^8C_7 = 8$	B1	One unsimplified no of selections correct
	1G + 6B ${}^4C_1 \times {}^8C_6 = 112$ Total = $8 + 112 = 120$	M1	No of selections (products of ${}^nC_r$ and ${}^nP_r$) added for 0 and 1 girls with no of girls and no of boys summing to 7
	$({}^{12}C_7 - 120)/792$ or $1 - 120/792$	A1	$792 - 120 = 672$ or $1 - 120/792$
	Probability = $672/792$ (28/33) (0.848)	A1ft	‘672’ over ‘792’ from i
	Method 3 (probability)		
	$1 - P(0) - P(1)$ $= 1 - (8/12 \times 7/11 \times \dots \times 2/6) - (8/12 \times \dots \times 3/7 \times 4/6 \times 7)$	B1	One correct unsimplified prob for 0 or 1
	$= 1 - 1/99 - 14/99$	M1	Subtracting ‘P(0)’ and ‘P(1)’ (using products of 7 fractions with denominators from 12 to 6) from 1
		A1	Both probs correct unsimplified
	$= 84/99 = 28/33$	A1ft	$1 - ‘P(0)’ - ‘P(1)’$

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Question	Answer	Marks	Guidance
4(ii)	Method 4 (probability)		
	$P(2) + P(3) + P(4) =$	B1	One correct unsimplified prob for 2, 3 or 4
	$42/99 + 35/99 + 7/99$	M1	Adding 'P(2)', 'P(3)' and P(4)' (using products of 7 fractions with denominators from 12 to 6)
		A1	Three probs correct unsimplified
	$= 84/99 = 28/33$	A1ft	'P(2)'+ 'P(3)' + 'P(4)'
		4	

Question	Answer	Marks	Guidance
5(i)	$z_1 = \pm \frac{90-120}{24} = -\frac{5}{4}, z_2 = \pm \frac{140-120}{24} = \frac{5}{6}$	M1	At least one standardisation, no cc, no sq rt, no sq using 120 and 24 and either 90 or 140
	$= \Phi\left(\frac{20}{24}\right) - \Phi\left(-\frac{30}{24}\right)$	A1	-5/4 and 5/6 unsimplified
	$= \Phi(0.8333) - (1 - \Phi(1.25))$ $= 0.7975 - (1 - 0.8944) \text{ or } 0.8944 - 0.2025 = 0.6919$	M1	Correct area $\Phi - \Phi$ legitimately obtained and evaluated from phi(their z_2) – phi (their z_1)
	$= 0.692 \text{ AG}$	A1	Correct answer obtained from 0.7975 and 0.1056 oe to 4sf or 0.6919 seen www
		4	

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Question	Answer	Marks	Guidance
5(ii)	Method 1		
	Probability = $P(2, 3, 4)$ $= 0.692^2(1 - 0.692)^2 \times {}^4C_2 + 0.692^3(1 - 0.692) \times {}^4C_3 + 0.692^4$	M1	Any binomial term of form ${}^4C_x p^x (1-p)^{4-x}$, $x \neq 0$ or 4
		B1	One correct bin term with $n = 4$ and $p = 0.692$,
	$= 0.27256 + 0.40825 + 0.22931$	M1	Correct unsimplified expression using 0.692 or better
	$= 0.910$	A1	Correct answer
	Method 2:		
	$1 - P(0, 1) =$	M1	Any binomial term of form ${}^4C_x p^x (1-p)^{4-x}$, $x \neq 0$ or 4
	$1 - 0.692^0(1 - 0.692)^4 \times {}^4C_0 - 0.692^1(1 - 0.692)^3 \times {}^4C_1$	B1	One correct bin term with $n = 4$ and $p = 0.692$
	$= 1 - 0.00899 - 0.0808757$	M1	Correct unsimplified expression using 0.692 or better
	$= 0.910$	A1	Correct answer
		4	

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Question	Answer	Marks	Guidance
6(i)	$P(X > 1800) = 0.96$, so $P(Z > \frac{1800 - 2000}{\sigma}) = 0.96$	B1	± 1.75 seen
	$\Phi(\frac{200}{\sigma}) = 0.96$ $\frac{200}{\sigma} = 1.751$	M1	$z = \pm \frac{1800 - 2000}{\sigma}$, allow cc, allow sq rt, allow sq equated to a z-value
	$\sigma = 114$	A1	Correct final answer www
		3	
6(ii)	Mean = $300 \times 0.2 = 60$ and variance = $300 \times 0.2 \times 0.8 = 48$	B1	Correct unsimplified mean and variance
	$P(X < 70) = P(Z > \frac{69.5 - 60}{\sqrt{48}})$	M1	$Z = \pm \frac{x - \text{their } 60}{\sqrt{\text{their } 48}}$
	$= \Phi(1.371)$	M1	69.5 or 70.5 seen in an attempted standardisation expression as cc
	$= 0.915$	A1	Correct final answer
		4	
6(iii)	$np = 60$, $nq = 240$: both > 5 , (so normal approximation holds)	B1	Both parts evaluated are required
		1	

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Question	Answer	Marks	Guidance																					
7(i)	<table><tr><td>Anvils</td><td></td><td>Brecons</td></tr><tr><td>8</td><td>15</td><td></td></tr><tr><td>9 5</td><td>16</td><td>6</td></tr><tr><td>5 3 2 0</td><td>17</td><td>0 1 2 2 8</td></tr><tr><td>4 1 0</td><td>18</td><td>1 2 3 3</td></tr><tr><td>6</td><td>19</td><td>2</td></tr><tr><td></td><td></td><td>Key: 5 16 6 means 165 cm for Anvils and 166 cm for Brecons</td></tr></table>	Anvils		Brecons	8	15		9 5	16	6	5 3 2 0	17	0 1 2 2 8	4 1 0	18	1 2 3 3	6	19	2			Key: 5 16 6 means 165 cm for Anvils and 166 cm for Brecons	B1	Correct stem, up or down
	Anvils		Brecons																					
	8	15																						
	9 5	16	6																					
	5 3 2 0	17	0 1 2 2 8																					
4 1 0	18	1 2 3 3																						
6	19	2																						
		Key: 5 16 6 means 165 cm for Anvils and 166 cm for Brecons																						
		B1	Correct Anvils labelled on left, leaves in order from right to left and lined up vertically, no commas																					
		B1	Correct Brecons labelled on same diagram on right hand side in order from left to right and lined up vertically, no commas																					
		B1	Correct key, not split, both teams, at least one with cm																					
		4																						
7(ii)	Median = 173	B1	Correct median (or Q2)																					
	LQ = 169; UQ = 181 IQR = 181 – 169	M1	Either UQ = 181 ± 4, or LQ = 169 ± 4 and evaluating UQ – LQ																					
	= 12	A1	Correct answer from 181 and 169 only																					
		3																						

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Question	Answer	Marks	Guidance
7(iii)	$\Sigma x = 1923 + 166 + 172 + 182 (= 2443)$ $\Sigma x^2 = 337221 + 166^2 + 172^2 + 182^2 (= 427485)$	M1	Correct unsimplified expression for Σx and Σx^2 , may be implied
	Mean = $\frac{\Sigma x}{14} = \frac{2443}{14} = 174.5$	M1	Correct unsimplified mean
	Variance = $\frac{\Sigma x^2}{14} - \left(\frac{\Sigma x}{14}\right)^2 = \frac{427485}{14} - \left(\frac{2443}{14}\right)^2$	M1	Correct unsimplified variance using 14, their Σx and their Σx^2 , not using 1923 and/or 337221
	S d = 9.19	A1	Correct answer
		4	