
MATHEMATICS

9709/61

Paper 6

May/June 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.

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GENERIC MARKING PRINCIPLE 1:

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- 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.

PUBLISHED**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:

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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)

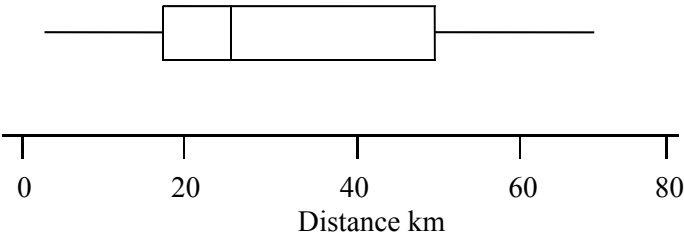
Penalties

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	$\Sigma(x - 10) = 186 - 12 \times 10 = 66$	B1	Correct answer
	$\frac{\Sigma(x - 10)^2}{12} - \left(\frac{\Sigma(x - 10)}{12} \right)^2 = 4.5^2$	M1	Consistent substituting in the correct coded variance formula OR Valid method for Σx^2 then expanding $\Sigma(x - 10)^2$, 3 terms with at least 2 correct
	$\Sigma(x - 10)^2 = 606$	B1	Correct answer
		3	

Question	Answer	Marks	Guidance
2(i)	LQ = 18, Median = 25, UQ = 50	B1	median correct
		B1	LQ and UQ correct
		B1	Quartiles and median plotted as box graph with linear scale min 3 values
		B1ft	Whiskers drawn to correct end points with linear scale, not thr' box, not joining at top or bottom of box. Ft their UQ and LQ. Whiskers must be with ruler If scale non-linear or non-existent SCB1 if all 5 data values (quartiles and end points) have values shown and all are correct numerically and fulfil the 'box' and 'whiskers ruled line' requirements
		B1	Label to include 'distance or travelled' and 'km,' allow 'total km', linear scale, numbered at least 5 – 70.
		5	

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Question	Answer	Marks	Guidance
2(ii)	$1.5 \times \text{IQR} = 48$ Method 1 $\text{LQ} - 48 = -\text{ve}$, (i.e. < 0) $\text{UQ} + 48 = 98$ (i.e. > 70)	M1	Attempt to find $1.5 \times$ their IQR and add to UQ or subt from LQ
	hence no outliers	A1	Correct conclusion from correct working, need both ends. No need to state comparisons.
	Method 2 $\text{LQ} - 5 = 13 (< 48)$ $70 - \text{UQ} = 20 (< 48)$	M1	Compare their $1.5 \times \text{IQR} (= 48) >$ gap (20) between UQ and max 70 or LQ and min 5
	Hence no outliers	A1	Correct conclusion from correct working, need both ends. No need to state comparisons
		2	

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Question	Answer	Marks	Guidance								
3(i)	$P(RB) + P(BR) = \frac{4}{12} \times \frac{8}{11} + \frac{8}{12} \times \frac{4}{11}$ oe	M1	Multiply 2 probs together and summing two 2-factor probs, unsimplified, condone replacement								
	$P(\text{diff colours}) = \frac{64}{132} \left(\frac{16}{33} \right) (0.485)$ oe	A1	Correct answer								
	Method 2 $1 - P(BB) - P(RR) = 1 - \frac{4}{12} \times \frac{3}{11} - \frac{8}{12} \times \frac{7}{11}$	M1	Multiply 2 probs together and subtracting two 2-factor probs from 1, unsimplified, condone replacement								
	$P(\text{diff colours}) = \frac{64}{132} \left(\frac{16}{33} \right)$ oe	A1	Correct answer								
	Method 3 $P(\text{diff colours}) = \frac{{}^4C_1 \times {}^8C_1}{{}^{12}C_2}$	M1	Multiply 2 combs together and dividing by a combination								
	$= \frac{16}{33}$	A1	Correct answer								
		2									
3(ii)	<table><tr><td>Number of red socks</td><td>0</td><td>1</td><td>2</td></tr><tr><td>Prob</td><td>$\frac{14}{33}$</td><td>$\frac{16}{33}$</td><td>$\frac{3}{33}$</td></tr></table>	Number of red socks	0	1	2	Prob	$\frac{14}{33}$	$\frac{16}{33}$	$\frac{3}{33}$	B1	Prob distribution table drawn, top row correct, condone additional values with $p = 0$ stated
	Number of red socks	0	1	2							
	Prob	$\frac{14}{33}$	$\frac{16}{33}$	$\frac{3}{33}$							
		B1	P(0) or P(2) correct to 3sf (need not be in table)								
	B1	All probs correct to 3sf, condone P(0) and P(2) swapped if correct									
	3										

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Question	Answer	Marks	Guidance
3(iii)	$E(X) = 1 \times \frac{16}{33} + 2 \times \frac{3}{33} = \frac{16}{33} + \frac{6}{33} = \frac{22}{33} \left(\frac{2}{3} \right)$	B1ft	ft their table if 0, 1, 2 only, $0 < p < 1$
		1	

Question	Answer	Marks	Guidance
4(a)	$z_1 = 2.4$	B1	± 2.4 seen accept 2.396
	$z_2 = -0.5$	B1	± 0.5 seen
	$2.4 = \frac{36800 - \mu}{\sigma}$	M1	Either standardisation eqn with z value, not 0.5082, 0.7565, 0.0082, 0.6915, 0.3085, 0.6209, 0.0032 or any other probability
	$-0.5 = \frac{31000 - \mu}{\sigma}$	M1	Sensible attempt to eliminate μ or σ by substitution or subtraction from their 2 equations (z -value not required), need at least 1 value stated
	$\sigma = 2000$ $\mu = 32000$	A1	Both correct answers
		5	
4(b)	$P(X < 3\mu) = P\left(z < \frac{3\mu - \mu}{(4\mu/3)}\right)$ or $P\left(z < \frac{(9\sigma/4) - (3\sigma/4)}{\sigma}\right)$	M1	Standardise, in terms of one variable, accept σ^2 or $\sqrt{\sigma}$
	$P\left(z < \frac{6}{4}\right)$	M1	$\frac{6}{4}$ or $\frac{6}{4\sigma}$ seen
	$= 0.933$	A1	Correct final answer
		3	

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Question	Answer	Marks	Guidance
5(i)	$P(4, 5, 6) = {}^{15}C_4(0.22)^4(0.78)^{11} + {}^{15}C_5(0.22)^5(0.78)^{10} +$	M1	One binomial term ${}^{15}C_x p^x (1-p)^{15-x}$ $0 < p < 1$
	${}^{15}C_6(0.22)^6(0.78)^9$	A1	Correct unsimplified expression
	$= 0.398$	A1	Correct answer
		3	
5(ii)	$\mu = 145 \times 0.22 = 31.9 \quad \sigma^2 = 145 \times 0.22 \times 0.78 = 24.882$	B1	Correct unsimplified mean and variance
	$P(x > 26) = P\left(z > \frac{26.5 - 31.9}{\sqrt{24.882}}\right) = P(z > -1.08255)$	M1	Standardising must have sq rt
		M1	25.5 or 26.5 seen as a cc
	$= \Phi(1.08255)$	M1	Correct area Φ , must agree with their μ
	$= 0.861$	A1	Correct final answer accept 0.861, or 0.860 from 0.8604 not from 0.8599
		5	

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Question	Answer	Marks	Guidance
6(i)	$P(\text{SLL}) = (0.3)(0.55)(0.55) = 0.09075 \left(\frac{363}{4000} \right)$	M1	P(SLL), P(SRR), P(SSL) or P(SSR) seen
	$P(\text{SRR}) = (0.3)(0.15)(0.15) = 0.00675 \left(\frac{27}{4000} \right)$	A1	Two correct options 0.09075 or 0.00675 can be unsimplified
	Total = ${}^3C_1 \times P(\text{SLL}) + {}^3C_1 \times P(\text{SRR})$ = 0.27225 + 0.02025	M1	Summing 6 prob options not all identical
	Prob = 0.293 accept 0.2925 $\left(\frac{117}{400} \right)$	A1	Correct answer
		4	
6(ii)	$P(\text{SSS} \mid \text{all same dir}^n) = \frac{P(\text{SSS and same dir}^n)}{P(\text{same direction})}$	B1	$(0.3)^3$ oe seen on its own as num or denom of a fraction
		M1	Attempt at $P(\text{SSS} + \text{LLL} + \text{RRR})$ seen anywhere
	$= \frac{0.3 \times 0.3 \times 0.3}{(0.15)^3 + (0.55)^3 + (0.3)^3}$	A1	$(0.15)^3 + (0.55)^3 + (0.3)^3$ oe seen as denom of a fraction
	$= 0.137 \left(\frac{108}{787} \right)$	A1	Correct answer
		4	

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Question	Answer	Marks	Guidance
7(i)	$\frac{9!}{2!2!} = 90720$	B1	Must see 90720
		1	
7(ii)	Method 1 $\uparrow$ * * * * * A	B1	5! seen multiplied (arrangement of consonants allowing repeats)
	No. arrangements of consonants $\times$ ways of inserting vowels =	B1	${}^6P_4$ oe (i.e. $6 \times 5 \times 4 \times 3$, ${}^6C_4 \times 4!$) seen mult (allowing repeats) no extra terms
	$\frac{5!}{2!}$ $\times \frac{{}^6P_4}{2!}$	B1	Dividing by at least one 2! (removing at least one set of repeats)
	Answer $\frac{{}^6P_4}{2!} \times \frac{5}{2} = 10\,800$	B1	Correct final answer
		4	
7(iii)	${}^5C_3 = 10$	M1	${}^5C_x$ or ${}^5P_x$ seen alone, $x = 2$ or 3
		A1	Correct final answer not from ${}^5C_2$
		2	

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Question	Answer	Marks	Guidance
7(iv)	Method 1 Considering separate groups	M1	Considering two scenarios of MME or EEM or MMEE with attempt, may be probs or perms
	MME** = ${}^5C_2 = 10$ MEE** = ${}^5C_2 = 10$ MMEE* = ${}^5C_1 = 5$	M1	Summing three appropriate scenarios from the four need ${}^5C_x$ seen in all of them
	ME*** = ${}^5C_3 = 10$ see (iii) Total = 35	A1	Correct final answer
	Method 2 Considering criteria are met if ME are chosen	M1	${}^7C_x$ only seen, no other terms
		M1	${}^x C_3$ only seen, no other terms
	ME *** = ${}^7C_3 = 35$	A1	Correct final answer
		3	

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Question	Answer	Marks	Guidance
1(i)	38	B1	
		1	
1(ii)	Median = 38.5	B1	CAO
	IQR = 40 – 38	M1	$39 < UQ < 45 - 36 < LQ \leq 38$
	= 2	A1	If M0 awarded SCB1 for both UQ = 40 or 40.5 and LQ = 38 or 37.75 seen
		3	

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Question	Answer	Marks	Guidance
2(i)	Method 1 $P(M \cap H) = \frac{3}{4} \times \frac{3}{5} = \frac{9}{20} \text{ (0.45)}$	B1	Seen, accept unsimplified
	$P(F \text{ or } M \cap H) = \frac{1}{4} + \frac{9}{20} = \frac{14}{20}$	M1	Numerical attempt at $P(F) + P(M \cap H)$
		A1	Correct unsimplified expression
	$= \frac{7}{10} \text{ (0.7) OE}$	A1	Correct final answer
	Method 2 $P(M \cap H') = \frac{3}{4} \times \frac{2}{5} = \frac{6}{20} \text{ (0.3)}$	B1	Seen, accept unsimplified
	$P(F \text{ or } M \cap H) = 1 - P(M \cap H')$	M1	Numerical attempt at $1 - P(M \cap H')$
	$= 1 - \frac{3}{4} \times \frac{2}{5}$	A1	Correct unsimplified expression
	$= \frac{7}{10} \text{ (0.7) OE}$	A1	Correct final answer

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Question	Answer	Marks	Guidance
2(i)	Method 3 $P(F \cap H' \text{ or } H) = \frac{1}{4} \times \frac{1}{5} + \frac{1}{4} \times \frac{4}{5} + \frac{3}{4} \times \frac{3}{5}$	B1	$\frac{3}{4} \times \frac{3}{5} (\frac{9}{20})$ or $\frac{1}{4} \times \frac{4}{5} (\frac{4}{20})$ or $\frac{3}{4} \times \frac{3}{5} + \frac{1}{4} \times \frac{4}{5} (\frac{13}{20})$ seen
	$= \frac{1}{20} + \frac{4}{20} + \frac{9}{20}$	M1	Numerical attempt at $P(F \cap H') + P(F \cap H) + P(M \cap H)$
		A1	Correct unsimplified expression
	$= \frac{7}{10} \text{ (0.7) oe}$	A1	Correct final answer
	Method 4 – Venn diagram style approach $P(F \cup H) = P(F) + P(H) - P(F \cap H)$	B1	$\frac{3}{4} \times \frac{3}{5} (\frac{9}{20})$ or $\frac{1}{4} \times \frac{4}{5} (\frac{4}{20})$ or $\frac{3}{4} \times \frac{3}{5} + \frac{1}{4} \times \frac{4}{5} (\frac{13}{20})$ seen
	$= \frac{1}{4} + \frac{1}{4} \times \frac{4}{5} + \frac{3}{4} \times \frac{3}{5} - \frac{1}{4} \times \frac{4}{5}$	M1	Numerical attempt at $P(F) + P(H) - P(F \cap H)$
	$= \frac{1}{4} + \frac{4}{20} + \frac{9}{20} - \frac{4}{20}$	A1	Correct unsimplified expression
	$= \frac{7}{10} \text{ (0.7) oe}$	A1	Correct final answer
		4	

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Question	Answer	Marks	Guidance
2(ii)	Method 1 $(P(M) \times P(H) =) \frac{3}{4} \times \text{their } \frac{13}{20} = \frac{39}{80}$ $(P(M \cap H) =) \frac{3}{4} \times \frac{3}{5} = 0.45$	M1	Unsimplified, or better, legitimate numerical attempt at $P(M) \times P(H)$ and $P(M \cap H)$ Descriptors $P(M \cap H)$ and $P(M) \times P(H)$ seen, correct numerical evaluation and comparison, conclusion stated
	$\frac{39}{80}$ (0.4875) $\neq$ 0.45, not independent	A1	
	Method 2 $P(M H) = \frac{P(M \cap H)}{P(H)} = \frac{\frac{9}{20}}{\text{their } \frac{13}{20}} = \frac{9}{13}$ $P(M) = \frac{3}{4}$	M1	Unsimplified, or better, numerical attempt at $P(H)$ and $P(M \cap H)$, $P(M)$
	$\frac{9}{13} \neq \frac{3}{4}$, not independent	A1	Descriptors $P(M \cap H)$, $P(H)$ and $P(M)$ OR $P(M H)$ and $P(M)$ seen, numerical evaluation and comparison, conclusion stated Any appropriate relationship can be used, the M is awarded for an unsimplified, or better, numerical attempt at the terms required, the A mark requires the correct descriptors, numerical evaluation and comparison and the conclusion
		2	

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Question	Answer	Marks	Guidance
3(i)	$z = -1.282$	B1	± 1.282 seen
	$-1.282 = \frac{440 - \mu}{9}$	M1	$\pm$ Standardisation equation with 440, 9 and μ , equated to a z -value, (not $1 - z$ -value or probability e.g. 0.1841, 0.5398, 0.6202, 0.8159)
	$\mu = 452$	A1	Correct answer rounding to 452, not dependent on B1
		3	
3(ii)	$P(z > 1.8) = 1 - 0.9641 = 0.0359$	B1	
	Number = 0.0359×150 = 5.385	M1	$p \times 150, 0 < p < 1$
	(Number of cartons =) 5	A1FT	Accept either 5 or 6, not indicated as an approximation, e.g. $\sim$, about FT <i>their</i> $p \times 150$, answer as an integer
		3	

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Question	Answer	Marks	Guidance								
4(i)	<table><tr><td>X</td><td>0</td><td>1</td><td>2</td></tr><tr><td>Prob</td><td>$\frac{2}{7}$</td><td>$\frac{4}{7}$</td><td>$\frac{1}{7}$</td></tr></table>	X	0	1	2	Prob	$\frac{2}{7}$	$\frac{4}{7}$	$\frac{1}{7}$	B1	Prob distribution table drawn, top row correct with at least one probability $0 < p < 1$ entered, condone additional values with $p = 0$ stated
	X	0	1	2							
	Prob	$\frac{2}{7}$	$\frac{4}{7}$	$\frac{1}{7}$							
	$P(0) = \frac{5}{7} \times \frac{4}{6} \times \frac{3}{5} = \frac{2}{7}$ (0.2857)	B1	One probability correct (need not be in table)								
	$P(1) = \frac{2}{7} \times \frac{5}{6} \times \frac{4}{5} \times {}^3C_1 = \frac{4}{7}$ (0.5713)	B1	Another probability correct (need not be in table).								
$P(2) = \frac{2}{7} \times \frac{1}{6} \times \frac{5}{5} \times {}^3C_2 = \frac{1}{7}$ (0.1429)	B1	Values in table, all probs correct (to 3SF) or 3 probabilities summing to 1									
	4										
4(ii)	$\text{Var}(X) = 1 \times \frac{4}{7} + 4 \times \frac{1}{7} - \left(\frac{6}{7}\right)^2$ $= \frac{8}{7} - \left(\frac{6}{7}\right)^2$	M1	Unsimplified correct numerical expression for variance or <i>their</i> probabilities from (i) $0 < p < 1$ in unsimplified variance expression								
	$= \frac{20}{49} \text{ or } 0.408$	A1	Correct answer (0.40816...) nfw Final answer does not imply the method mark								
		2									

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Question	Answer	Marks	Guidance
5(i)	$a = 40$	B1	
		1	
5(ii)	Mean = $\frac{0.5 \times 14 + 1.5 \times 46 + 3.5 \times 102 + 7.5 \times \text{their } 40 + 20 \times 40}{242}$ $= \frac{1533}{242}$	M1	Numerator: 5 products with at least 3 acceptable mid-points $\times$ appropriate frequency FT (i) . Denominator: 242 CAO $\frac{1533}{242}$ implies M1, but if FT an unsimplified expression required
	$= 6\frac{81}{242}$ or 6.33	A1	CAO (6.3347... rounded to 3 or more SF)
		2	
5(iii)	fd = 14, 46, 34, ($\frac{\text{their } (i)}{5} =$) 8, 2	M1	Attempt at fd [f/(attempt at cw)] or scaled freq
		A1FT	Correct heights seen on diagram with linear vertical scale from (x, 0) FT their $\frac{a}{5}$ only
		B1	Correct bar widths (1:1:3:5:20) at axis, visually no gaps, with linear horizontal scale from (0, y), first bar starting at (0,0)
		B1	Labels (time, mins, and fd(OE) seen, some may be as a title) and a linear scale with at least 3 values marked on each axis. (Interval notation not acceptable)
		4	

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Question	Answer	Marks	Guidance
6(a)(i)	(AAAIU) * * * * Arrangements of vowels/repeats × arrangements of (consonants & vowel group) =	M1	$k \times 5!$ (k is an integer, $k \geq 1$)
	$\frac{5! \times 5!}{3!}$	M1	$\frac{m}{3}!$ (m is an integer, $m \geq 1$) Both Ms can only be awarded if expression is fully correct
	= 2400	A1	Correct answer
		3	
6(a)(ii)	E.g. R * * * T * * * L . Arrangements of consonants RL, RS, SL = ${}^3P_2 = 6$ Arrangements of remaining letters = $\frac{6!}{3!} = 120$	M1	$k \times \frac{6!}{3!}$ or $k \times {}^3P_2$ or $k \times {}^3C_2$ or $k \times 3!$ or $k \times 3 \times 2$ (k is an integer, $k \geq 1$), no irrelevant addition
	Total 120×6	M1	Correct unsimplified expression or $\frac{6!}{3!} \times {}^3C_2$
	= 720 ways	A1	Correct answer
		3	

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Question	Answer	Marks	Guidance
6(b)	Method 1 N(2) R(8) Br(4) 1 2 1 = $2 \times {}^8C_2 \times 4 = 224$	M1	Multiply 3 combinations, ${}^2C_x \times {}^8C_y \times {}^4C_z$. Accept ${}^2C_1 = 2$ etc.
	2 1 1 = $1 \times {}^8C_1 \times 4 = 32$ 1 1 2 = $2 \times 8 \times {}^4C_2 = 96$	A1	3 or more options correct unsimplified
	2 0 2 = $1 \times 1 \times {}^4C_2 = 6$ 1 0 3 = $2 \times 1 \times 4 = 8$	M1	Summing <i>their</i> values of 4 or 5 legitimate scenarios (no extra scenarios)
	Total = 366 ways	A1	Correct answer
	Method 2 ${}^{14}C_4 - (2N2R \text{ or } 1N3R \text{ or } 4R \text{ or } 3R1B \text{ or } 2R2B \text{ or } 1R3B \text{ or } 4B)$	M1	' ${}^{14}C_4 - k$ ' seen, k an integer from an expression containing ${}^8C_x$
	$1001 - (1 \times {}^8C_2 + 2 \times {}^8C_3 + {}^8C_4 + {}^8C_3 \times 4 + {}^8C_2 \times {}^4C_2 + 8 \times 4 + 1)$	A1	4 or more 'subtraction' options correct unsimplified, may be in a list
	$1001 - (28 + 112 + 70 + 224 + 168 + 32 + 1)$	M1	<i>Their</i> ${}^{14}C_4 - [\textit{their values of 6 or more legitimate scenarios}]$ (no extra scenarios, condone omission of final bracket)
	= 366	A1	Correct answer
		4	

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Question	Answer	Marks	Guidance
7(i)	Method 1 $P(< 11) = 1 - P(11, 12, 13)$	M1	Binomial expression of form ${}^{13}C_x (p)^x(1-p)^{13-x}$, $0 < x < 13$, $0 < p < 1$
	$= 1 - {}^{13}C_{11}(0.6)^{11}(0.4)^2 - {}^{13}C_{12}(0.6)^{12}(0.4) - (0.6)^{13}$	M1	Correct unsimplified answer
	$= 0.942$	A1	CAO
	Method 2 $P(< 11) = P(0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10)$	M1	Binomial expression of form ${}^{13}C_x (p)^x(1-p)^{13-x}$, $0 < x < 13$, $0 < p < 1$
	$= (0.4)^{13} + {}^{13}C_1(0.4)^{12}(0.6) + \dots + {}^{13}C_{10}(0.4)^3(0.6)^{10}$	M1	Correct unsimplified answer
	$= 0.942$	A1	CAO
		3	
7(ii)	$\mu = 130 \times 0.35 = 45.5$ $\text{var} = 130 \times 0.35 \times 0.65 = 29.575$	B1	Correct unsimplified mean and var (condone $\sigma^2 = 29.6$, $\sigma = 5.438$)
	$P(\geq 50) = P\left(z > \frac{49.5 - 45.5}{\sqrt{29.575}}\right) = P(z > 0.7355)$	M1	Standardising, using $\pm \left(\frac{x - \text{their mean}}{\text{their } \sigma}\right)$, x = value to standardise 49.5 or 50.5 seen in $\pm$ standardisation equation
	$= 1 - \Phi(0.7355)$	M1	Correct final area
	$= 1 - 0.7691$	M1	
	$= 0.231$	A1	Correct final answer
		5	

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Question	Answer	Marks	Guidance
7(iii)	$1 - (0.65)^n > 0.98$ or $0.02 > (0.65)^n$	M1	Eqn or inequality involving, 0.65^n and 0.02 or 0.35^n and 0.98
	$n > 9.08$	M1	Attempt to solve their eqn or inequality by logs or trial and error
	$n = 10$	A1	CAO
		3	

MATHEMATICS

9709/63

Paper 6

May/June 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.

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This document consists of **14** 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.

PUBLISHED**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

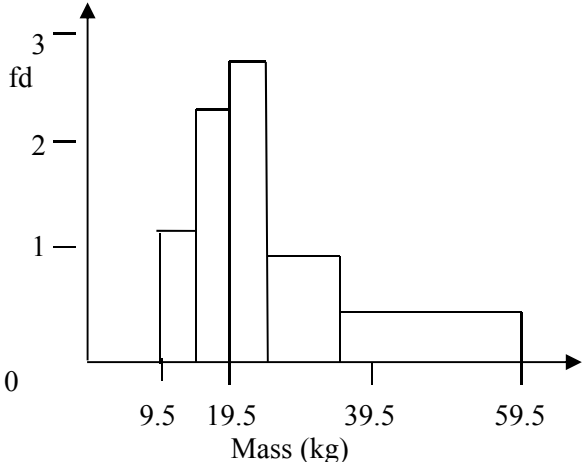
SR Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

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(i)	15–19 (kg) cao	B1	kg not necessary; condone 14.5 – 19.5
	Total:	1	
1(ii)	fd = 1.2, 2.4, 2.8, 1, 0.32 	M1	Attempt at fd [$f/(\text{attempt at } cw)$] or scaled freq (may be implied by 4 correct)
		A1	Correct heights seen on diagram with linear vertical scale from (x, 0)
		B1	Correct bar widths (1:1:1:2:5) visually no gaps with linear horizontal scale from (9.5, y) and first bar starting at (9.5, y)
		B1	Histogram, using attempted fds, with labels (mass, kg and fd seen) and at least 3 linearly spaced values on each axis. Horizontal axis must range from at least 9.5 to 59.5 If horizontal axis clearly starts from zero, either a break in the scale must be indicated or the scale must be linear from zero.

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Question	Answer	Marks	Guidance
2(i)	$z = 0.674$	B1	z value ± 0.674
	$0.674 = \frac{0 - -3}{\sigma}$	M1	$\pm$ Standardising with 0 and equating to a z -value
	$\sigma = 4.45$	A1	Correct answer www ie not ignoring a minus sign
	Total:	3	
2(ii)	$P(0, 1)$	M1	Any bin of form ${}^8C_x(0.75)^x(0.25)^{8-x}$ any x
	$= (0.75)^8 + {}^8C_1(0.25)(0.75)^7$	M1	Correct unsimplified answer, may be implied by numerical values
	$0.1001 + 0.2670 = 0.367$	A1	Correct answer
	Method 2 $1 - P(8, 7, 6, 5, 4, 3, 2) = 1 - (0.25)^8 - {}^8C_1(0.75)(0.25)^7 - \dots$ $- {}^8C_2(0.75)^6(0.25)^2$ $= 0.367$	M1	Any bin of form ${}^8C_x(0.75)^x(0.25)^{8-x}$ any x
		M1	Correct unsimplified answer
		A1	Correct answer
	Total:	3	

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Question	Answer	Marks	Guidance
3(i)	$(1-x)$ and 0.45 (or 0.3)	B1	Seen, either on tree diagram or elsewhere
	Beginners: $0.7 \times x + '0.45' \times '(1-x)' = 0.5$ Or Advanced: $'0.3' \times x + 0.55 \times '(1-x)' = 0.5$ Or $0.7 \times x + '0.45' \times '(1-x)' = '0.3' \times x + 0.55 \times '(1-x)'$	M1	One of the three correct probability equations
	$x = 0.2$ oe	A1	Correct answer
	Total:	3	
3(ii)	$P(M \mid A) = \frac{P(M \cap A)}{P(A)} = \frac{0.2 \times 0.3}{0.5}$	M1	'i' $\times$ 0.3 as num or denom of a fraction
		M1	0.5 (or $(1 - 'i') \times 0.55 + 'i' \times 0.3$ unsimplified) seen as denom of a fraction
	$= 0.12 \left(\frac{3}{25} \right)$	A1	Correct answer
	Total:	3	

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Question	Answer	Marks	Guidance
4(i)	Mean = $(30 \times 1500 + 21 \times 2400)/51$	M1	Multiply by 30 and 21, summing and dividing total by 51 $\left(\frac{45\,000 + 50\,400}{51} \right)$
	= 1870 (1870.59)	A1	correct answer (to 3sf)
	Total:	2	
4(ii)	$230^2 = \frac{\Sigma x_F^2}{30} - 1500^2$ so $\Sigma x_F^2 = 69\,087\,000$	M1	One correct substitution into a correct variance formula
		A1	Correct Σx_F^2 (rounding to 69 000 000 2sf)
	$160^2 = \frac{\Sigma x_L^2}{21} - 2400^2$ so $\Sigma x_L^2 = 121\,497\,600$	A1	Correct Σx_L^2 (rounding to 121 000 000 3sf)
	New var = $\frac{69\,087\,000 + 121\,497\,600}{51} - 1870.588^2 = 237\,853$	M1	using ' Σx_F^2 ' + ' Σx_L^2 ' dividing by 51 and subtracting 'i' squared. (Correct ' Σx_F^2 ' + ' $\Sigma x_L^2 = 190\,584\,600$)
	New sd = 488	A1	Correct answer accept anything between 486 and 490
	Total:	5	

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Question	Answer	Marks	Guidance															
5(i)	$P(0) = 0.6 \times 0.25 \times 0.5 = 0.075$ $P(1) = 0.4 \times 0.25 \times 0.5 + 0.6 \times 0.75 \times 0.5 + 0.6 \times 0.25 \times 0.5 = 0.35$ $P(2) = 0.4 \times 0.75 \times 0.5 + 0.4 \times 0.25 \times 0.5 + 0.6 \times 0.75 \times 0.5 = 0.425$ $P(3) = 0.4 \times 0.75 \times 0.5 = 0.15$	B1	0, 1, 2, 3 seen as top line of a pdf table OR attempting to evaluate P(0), P(1), P(2) and P(3)															
		M1	Multiply 3 probabilities together from 0.4 or 0.6, 0.25 or 0.75, 0.5 with or without a table															
	<table><tr><td>No of heads</td><td>0</td><td>1</td><td>2</td><td>3</td></tr><tr><td>Prob</td><td>0.075</td><td>0.35</td><td>0.425</td><td>0.15</td></tr><tr><td></td><td>$\left(\frac{3}{40}\right)$</td><td>$\left(\frac{7}{20}\right)$</td><td>$\left(\frac{17}{40}\right)$</td><td>$\left(\frac{3}{20}\right)$</td></tr></table>	No of heads	0	1	2	3	Prob	0.075	0.35	0.425	0.15		$\left(\frac{3}{40}\right)$	$\left(\frac{7}{20}\right)$	$\left(\frac{17}{40}\right)$	$\left(\frac{3}{20}\right)$	M1	Summing 3 probabilities for P(1) or P(2) with or without a table
	No of heads	0	1	2	3													
	Prob	0.075	0.35	0.425	0.15													
		$\left(\frac{3}{40}\right)$	$\left(\frac{7}{20}\right)$	$\left(\frac{17}{40}\right)$	$\left(\frac{3}{20}\right)$													
		B1	One correct probability seen.															
	A1	All correct in a table																
	Total:	5																
5(ii)	$E(X) = 0.35 + 2 \times 0.425 + 3 \times 0.15 = 1.65 \left(\frac{33}{20} \text{ oe}\right)$	M1	Correct unsimplified expression for the mean using their table, $\sum p = 1$; can be implied by correct answer															
5(ii)	$\text{Var}(X) = 0.35 + 4 \times 0.425 + 9 \times 0.15 - 1.65^2$	M1	Correct unsimplified expression for the variance using their table and their mean ² subtracted, $\sum p = 1$															
	$= 0.678 \text{ (0.6775)} \left(\frac{271}{400} \text{ oe}\right)$	A1	Correct answer															
	Total:	3																

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Question	Answer	Marks	Guidance
6(i)	$z_1 = \pm \frac{4.1 - 5.7}{0.8} = -2 \quad z_2 = \pm \frac{5 - 5.7}{0.8} = -0.875$	M1	At least one standardising no cc no sq rt no sq using 5.7 and 0.8 and either 4.1 or 5
	$P(\text{Toffee Apple}) = P(d < 5.0) - P(d < 4.1)$ $= P(z < -0.875) - P(z < -2)$ $= \Phi(-0.875) - \Phi(-2)$ $= \Phi(2) - \Phi(0.875)$	M1	Correct area $\Phi - \Phi$ legitimately obtained – need 2 negative z-values or 2 positives – not one of each
	$= 0.9772 - 0.8092 = 0.168$ (or $0.1908 - 0.0228$)	A1	Correct final answer
	Total:	3	
6(ii)	$np = 250 \times 0.168 = 42, \quad npq = 34.944$	B1ft	Correct unsimplified mean and var – ft their prob for (i) providing ($0 < p < 1$) Implied by $\sigma = \sqrt{34.944} = 5.911$
	$P(< 50) = P\left(z < \frac{49.5 - 42}{\sqrt{34.944}}\right) = P(z < 1.2687)$	M1	$\pm$ Standardising using 50, their mean and sd; must have sq rt.
		M1	49.5 or 50.5 seen as a cc
	$= \Phi(1.2687)$	M1	Correct area $\Phi(> 0.5 \text{ for } +z \text{ and } < 0.5 \text{ for } -z)$ in their final answer
	$= 0.898$	A1	Correct final answer
	Total:	5	

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Question	Answer	Marks	Guidance
7(i)	****E****	M1	Mult by 8! or ${}^8P_8$ oe (arrangements ignoring repeats)
	Other letters arranged in $\frac{8!}{2!3!}$	A1	Correct final answer www
	= 3360 ways		
	OR	M1	Correct numerator (161 280)
	$\frac{8 \times 7 \times 6 \times 5 \times 4 \times 4 \times 3 \times 2 \times 1}{4!2!} = 3360$ ways	A1	Correct final answer www
	Total:	2	
7(ii)	* * * * *	M1	k mult by ${}^6C_4$ or ${}^6P_4$ oe (ways to insert Es ignoring repeats), k can = 1
	↑ Arrangements other letters × ways Es inserted		or k mult by $\frac{5!}{2!}$
	$= \frac{5!}{2!} \times {}^6C_4 \left(\frac{5!}{2!} \times \frac{{}^6P_4}{4!} \right)$	M1	Correct unsimplified expression or $\frac{5!}{2!} \times {}^6P_4$
	= 900 ways	A1	Correct answer
	OR	M1	7560 unsimplified – k
	Total no of ways – no of ways with Es touching $9!/(4! \times 2!) - \dots$ or $7\,560 - \dots$ $\frac{6!}{2!} + {}^6P_2 \times \frac{5!}{2!} + \frac{{}^6P_2}{2!} \times \frac{5!}{2!} + \frac{{}^6P_3}{2! \times \frac{5!}{2!}}$ $= 360 + 1800 + 900 + 3600 = 6660$	M1	Attempting to find four ways of Es touching (4 Es, 3Es and a single, 2 lots of 2 Es, 2 Es and 2 singles)
	$7\,560 - 6\,660 = 900$	A1	Correct answer

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Question	Answer	Marks	Guidance
7(ii)	OR Adding the number of ways with the first E in the 1 st (E ₁), 2 nd (E ₂) or 3 rd (E ₃) position. $\frac{5!}{2!} (E_1 + E_2 + E_3)$ where $E_1 = 10$, $E_2 = 4$, $E_3 = 1$	M1	For any values for E ₁ , E ₂ and E ₃
	$\frac{5!}{2!} (E_1 + E_2 + E_3)$	M1	For any two correct values of E ₁ , E ₂ and E ₃
	$600 + 240 + 60 = 900$	A1	Correct answer
	Total:	3	
7(iii)	EENN* in 3 ways	B1	Numerical value must be stated
	Total:	1	

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Question	Answer	Marks	Guidance
7(iv)	EE *** with no N: 1 way EEN** 3C2 or listing 3 ways EENN* 3 ways from (iii)	M1	Identifying the three different scenarios of EE, EEE or EEEE
		A1	Total no of ways with two Es (7 or 3 + 3 + 1)
	EEE** with no N: 3 ways EEEN* 3 ways EEENN 1 way	A1	Total no. of ways with 3 Es (7)
	EEEE* no N 3 ways EEEEEN 1 way Total 18 ways	A1	Correct answer stated
	Method List containing ways with 2Es, 3Es and 4Es List containing at least 8 correct different ways List of all 18 correct ways Total 18	M1	At least 1 option listed for each of EE^^, EEE^^, EEEE^
		A1	Ignore repeated options
		A1	Ignore repeated/incorrect options
		A1	Correct answer stated
	Total:	4	