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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.

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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.

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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.

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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)

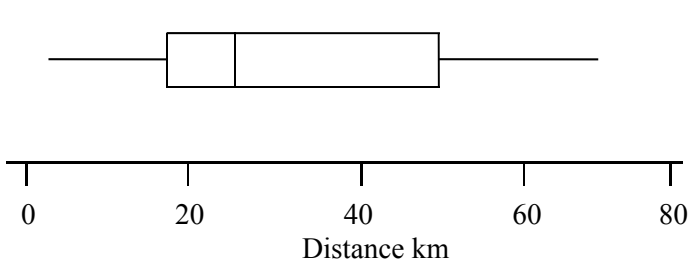
Penalties

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 SCB1if 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	

Question	Answer	Marks	Guidance
2(ii)	$1.5 \times \text{IQR} = 48$ **Method 1** LQ – 48 = –ve, (i.e. < 0) UQ + 48 = 98 (i.e. > 70)	**M1**	Attempt to find 1.5 × 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 LQ – 5 = 13 ($<$ 48) 70 – UQ = 20 ($<$ 48)	**M1**	Compare their 1.5 × 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(diff colours) = $\frac{64}{132}\ (\frac{16}{33})$ (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(diff colours) = $\frac{64}{132}\ (\frac{16}{33})$ oe	**A1**	Correct answer
	Method 3 P(diff colours) = $\frac{({}^{4}C_{1} \times {}^{8}C_{1})}{{}^{12}C_{2}}$	**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>	**B1**	Prob distribution table drawn, top row correct, condone additional values with $p = 0$ stated
		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	

Question	Answer	Marks	Guidance
3(iii)	$\mathrm{E}(X) = 1 \times \frac{16}{33} + 2 \times \frac{3}{33} = \frac{16}{33} + \frac{6}{33} = \frac{22}{33}$ $(\frac{2}{3})$	**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
	σ = 2000 μ = 32000	**A1**	Both correct answers
		5	
4(b)	$\mathrm{P}(X < 3\mu) = \mathrm{P}\left(z < \frac{3\mu - \mu}{(4\mu/3)}\right)$ or $\mathrm{P} = \left(z < \frac{(9\sigma/4) - (3\sigma/4)}{\sigma}\right)$	**M1**	Standardise, in terms of one variable, accept σ^2 or $\sqrt{\sigma}$
	$\mathrm{P}(z < \frac{6}{4})$	**M1**	$\frac{6}{4}$ or $\frac{6}{4\sigma}$ seen
	= 0.933	**A1**	Correct final answer
		3	

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)	$\mu = 145 \times 0.22 = 31.9$ $\sigma^2 = 145 \times 0.22 \times 0.78 = 24.882$	**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	

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

Question	Answer	Marks	Guidance
7(i)	$\frac{9!}{2!2!} = 90720$	**B1**	Must see 90720
		1	
7(ii)	**Method 1** ↑ * * * * * A	**B1**	5! seen multiplied (arrangement of consonants allowing repeats)
	No. arrangements of consonants × ways of inserting vowels =	**B1**	${}^6\text{P}_4$ oe (i.e. $6 \times 5 \times 4 \times 3$, ${}^6C_4 \times 4!$) seen mult (allowing repeats) no extra terms
	$\frac{5!}{2!} \times \frac{{}^6\text{P}_4}{2!}$	**B1**	Dividing by at least one 2! (removing at least one set of repeats)
	Answer $\frac{{}^6\text{P}_4}{2!} \times \frac{5}{2} = 10\,800$	**B1**	Correct final answer
		4	
7(iii)	${}^5\text{C}_3 = 10$	**M1**	${}^5\text{C}_x$ or ${}^5\text{P}_x$ seen alone, $x = 2$ or 3
		A1	Correct final answer not from ${}^5\text{C}_2$
		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	$^xC_3$ only seen, no other terms
	ME *** = $^7C_3$ = 35	**A1**	Correct final answer
		3	

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