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MATHEMATICS **9709/41**

Paper 4 **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.

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	$-5 = 24t - 5t^2$	**M1**	Use $s = ut + \frac{1}{2}at^2$
	$5t^2 - 24t - 5 = 0$	**M1**	Solve relevant 3 term quadratic
	$t = 5$	**A1**	
		3	
	Alternative scheme for Question 1		
	$0 = 24 - 10t_1 \rightarrow t_1 = 2.4$	**M1**	Attempt to find the time taken to reach the highest point
	$0 = 24^2 + 2 \times (-10) \times h \rightarrow h = 28.8$ And $33.8 = \frac{1}{2} g t_2^2 \rightarrow t_2 = 2.6$	**M1**	Find total height h reached and attempt to find time taken from highest point to ground level
	$t = t_1 + t_2 = 5$	**A1**	

Question	Answer	Marks	Guidance
2	[10 cos α = 8 or 10 cos β = 6]	**M1**	Introduce α or β, an angle between the 10N force and the vertical or horizontal and attempt to resolve forces
	α = 36.9 or β = 53.1	**A1**	
	Angle between 6N and 10N is 126.9	**B1**	
	Angle between 8N and 10N is 143.1	**B1**	
		4	
	Alternative scheme for Question 2		
	$\frac{10}{\sin 90} = \frac{6}{\sin \gamma} = \frac{8}{\sin \delta}$	**M1**	Attempt to use Lami's theorem γ (8 and 10), δ (6 and 10)
	All correct	**A1**	
	Angle between 8N and 10N is γ =143.1	**B1**	
	Angle between 6N and 10N is δ =126.9	**B1**	

Question	Answer	Marks	Guidance
3(i)		**M1**	Attempt to resolve forces along the plane (2 terms)
	$100 \cos \theta = 8g \sin 30 \rightarrow \theta = 66.4$	**A1**	
	$[R = 8g \cos 30 + 100 \sin \theta]$	**M1**	Resolve forces perpendicular to the plane (3 terms)
	$R = 161$	**A1**	
		4	
3(ii)	$100 \cos 30 - 8g \sin 30 = 8a$	**M1**	Apply Newton's 2nd law parallel to the plane (3 terms)
	$a = 5.83$	**A1**	
		2	

Question	Answer	Marks	Guidance
4(i)		**M1**	Attempt differentiation
	$v = 3t^2 - 8t + 4$	**A1**	
		2	
4(ii)	$3t^2 - 8t + 4 = 0$	**M1**	Set $v = 0$ and attempt to solve a relevant 3 term quadratic
	$t = \frac{2}{3}$ and $t = 2$	**A1**	
		2	

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Question	Answer	Marks	Guidance
4(iii)	$[6t - 8 = 0]$	**M1**	Differentiate v and equate to 0
	$[t = \frac{4}{3}, v = 3(\frac{4}{3})^2 - 8(\frac{4}{3}) + 4]$	**M1**	Solve for t and attempt v
	$v = -\frac{4}{3}$	**A1**	
		3	
	Alternative scheme for Question 4(iii)		
	$[v = 3(t^2 - \frac{8}{3}t) + 4 = 3(t - \frac{4}{3})^2 + ...]$	**M1**	Attempt to complete the square for v
	$[t = \frac{4}{3}, v = 3(t - \frac{4}{3})^2 - \frac{4}{3}]$	**M1**	Find value of t for minimum v and attempt to find v
	$v = -\frac{4}{3}$	**A1**	

Question	Answer	Marks	Guidance
5(i)	$[s_1 = \frac{1}{2}(0 + 12) \times 6]$	**M1**	Use constant acceleration equations or find area in (t,v) graph to find the distance s_1 travelled in the first 6 seconds
	$[s_2 = 10 \times 12]$	**M1**	Use constant acceleration equations or find area in (t,v) graph to find s_2 the distance travelled between 6s and 16s
	Distance for first 16 s is $36 + 10 \times 12 = 156$	**A1**	
	Curve concave up for $0 < t < 6$ starting at (0 , 0) ending at (6 , 36)	**B1**	Co-ordinates refer to (t,s) in a displacement-time graph
	Line, positive gradient, $6 < t < 16$ starts at (6 , 36) ends at (16 , 156)	**B1**	
	Curve concave down, $16 < t < 20$ from (16 , 156) to (20 , 200)	**B1**	
		6	
5(ii)	$[44 = \frac{1}{2}(12 + V) \times 4]$	**M1**	Use relevant constant acceleration equations or the area property of a v–t graph
	$V = 10$	**A1**	
		2	

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Question	Answer	Marks	Guidance
6(i)	[P = DF × v = 850 × 36]	**M1**	Apply P = DF × v with DF = Resistance force
	Power = rate of working = 30.6 kW	**A1**	
		2	
6(ii)	[DF = 1250 g × 0.1 + 850]	**M1**	Driving force comprising of resistance plus a weight component
	DF = $\frac{63000}{v}$	**M1**	DF = $\frac{P}{v}$
	v = 30 so speed of car is 30 ms^{-1}	**A1**	
		3	
6(iii)	Gain in KE = $\frac{1}{2}$ × 1250 × ($24^2 - 20^2$)	**B1**	[= 110 000]
	Loss in PE = 1250 g × 176 × 0.1	**B1**	[= 220 000]
	WD by car's engine = 20 000 × 8	**B1**	[= 160 000]
	[160 000 + 220 000 = WD against resistance + 110 000]	**M1**	4 term work energy equation
	WD = 270 000 J = 270 kJ	**A1**	
		5	

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Question	Answer	Marks	Guidance
7(i)	*A* $T - 0.8g \sin 45 = 0.8a$ *B* $1.2g \sin 30 - T = 1.2a$ System $1.2g \sin 30 - 0.8g \sin 45 = 2a$	**M1**	Apply Newton 2nd law to either *A* or to *B* or to the system
		A1	One correct equation
		A1	A second correct equation
	$a = 0.171$	**M1**	Solve for a
	$v^2 = 2 \times a \times 0.4$	**M1**	Use $v^2 = u^2 + 2as$ with $u = 0$
	$v = 0.370$ so speed of *A* is 0.370 ms^{-1}	**A1**	
		6	
	Alternative scheme for Question 7(i)		
		M1	Attempt KE gain or PE loss
	KE gain = $\frac{1}{2} \times 0.8 \times v^2 + \frac{1}{2} \times 1.2 \times v^2$	**A1**	v is the required speed of *A*
	PE loss = $1.2g \times 0.4 \sin 30 - 0.8g \times 0.4 \sin 45$	**A1**	
	$\frac{1}{2} \times 0.8 \times v^2 + \frac{1}{2} \times 1.2 \times v^2 =$ $1.2g \times 0.4 \sin 30 - 0.8g \times 0.4 \sin 45$	**M1**	4 term energy equation
		M1	Solving for v
	$v = 0.370$ so speed of *A* is 0.370 ms^{-1}	**A1**	

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Question	Answer	Marks	Guidance
7(ii)	$R_A = 0.8g\cos 45 = 4\sqrt{2}$ $R_B = 1.2g\cos 30 = 6\sqrt{3}$	**B1**	For either R_A or R_B
	$F_A = 4\sqrt{2}\ \mu$ and $F_B = 6\sqrt{3}\,\mu$	**M1**	Either F_A or F_B used
	A $0.8\,g\sin 45 + F_A = T$ B $1.2\,g\sin 30 - F_B = T$ or system equation: $12\sin 30 - 8\sin 45 = F_A + F_B$	**M1**	Resolve parallel to the plane either for both particles A and B **or** for the system equation
	Correct equation(s)	**A1**	
		M1	Eliminate T and solve for μ
	$\mu = \dfrac{\left(6-4\sqrt{2}\right)}{\left(6\sqrt{3}+4\sqrt{2}\right)}$ $= 0.0214$	**A1**	
		6	

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