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General Certificate of Education (A-level)
June 2013

Mathematics MM1B

(Specification 6360)

Mechanics 1B

Final

Mark Scheme

Mark schemes are prepared by the Principal Examiner and considered, together with the relevant questions, by a panel of subject teachers. This mark scheme includes any amendments made at the standardisation events which all examiners participate in and is the scheme which was used by them in this examination. The standardisation process ensures that the mark scheme covers the students' responses to questions and that every examiner understands and applies it in the same correct way. As preparation for standardisation each examiner analyses a number of students' scripts: alternative answers not already covered by the mark scheme are discussed and legislated for. If, after the standardisation process, examiners encounter unusual answers which have not been raised they are required to refer these to the Principal Examiner.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of students' reactions to a particular paper. Assumptions about future mark schemes on the basis of one year's document should be avoided; whilst the guiding principles of assessment remain constant, details will change, depending on the content of a particular examination paper.

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Key to mark scheme abbreviations

M	mark is for method
m or dM	mark is dependent on one or more M marks and is for method
A	mark is dependent on M or m marks and is for accuracy
B	mark is independent of M or m marks and is for method and accuracy
E	mark is for explanation
√or ft or F	follow through from previous incorrect result
CAO	correct answer only
CSO	correct solution only
AWFW	anything which falls within
AWRT	anything which rounds to
ACF	any correct form
AG	answer given
SC	special case
OE	or equivalent
A2,1	2 or 1 (or 0) accuracy marks
–*x* EE	deduct *x* marks for each error
NMS	no method shown
PI	possibly implied
SCA	substantially correct approach
c	candidate
sf	significant figure(s)
dp	decimal place(s)

No Method Shown

Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn **no marks**.

Where a question asks the candidate to state or write down a result, no method need be shown for full marks.

Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

Otherwise we require evidence of a correct method for any marks to be awarded.

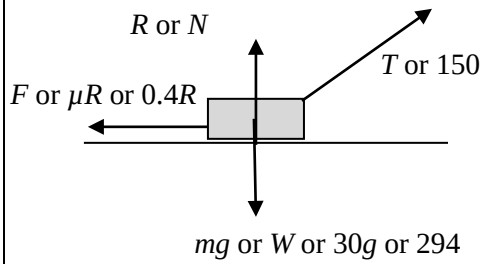
Q	Solution	Marks	Total	Comments
1	$0.3\times 2.8=(0.3+0.2)v$ $v=\dfrac{0.3\times 2.8}{0.5}=1.68\ \text{m s}^{-1}$	M1A1 A1	 3	M1: Use of 2 or 3 term equation for conservation of momentum with 0.5 or equivalent on the RHS. Condone missing brackets if recovered. A1: Correct equation. A1: Correct speed. CAO. Condone use of 300, 200 and 500 grams or use of correct ratios, eg 3, 2 and 5. Note for consistent use of weight instead of mass penalise by one mark.
	Total		**3**	
2(a)	$s=\dfrac{1}{2}(5+4)\times 6+\dfrac{1}{2}(4+7)\times 8+7\times 7$ $=27+44+49$ $=120\ \text{m}$	M1A1 A1 A1	 4	M1: Method based on three (or four or more!) areas / distances or equivalent added together. A1: Correct calculation or value for one area / distance for one time period (eg 0 to 6 seconds). A1: Correct calculation or value for area / distance for another time period. A1: Correct final distance. For example 24 + 44 + 49 = 117 scores M1A1A1A0.
(b)	Average Speed $=\dfrac{120}{21}=5.71\ \text{m s}^{-1}$	M1 A1F	2	M1: Their answer to part (a) divided by 21. A1F: Correct average speed. Accept $5\dfrac{5}{7}$ or $\dfrac{40}{7}$.
	Total		**6**	

Q	Solution	Marks	Total	Comments
3(a)	$(v =)\sqrt{7^2 + 1.4^2}$ $(v =)7.14 \text{ m s}^{-1}$	M1 A1	2	M1: Equation or expression to find v or v^2 based on Pythagoras. Must have a +. A1: Correct speed. Accept 7.13 Note that just $v^2 = 7^2 + 1.4^2$ Scores M1A0.
(b)	$\tan\alpha = \frac{1.4}{7}$ $\alpha = 011°$	M1A1 A1	3	M1: Use of tan with 1.4 and 7. A1: Correct expression for tan α. A1: Correct bearing to nearest degree. Accept 11°. Note that a final answer of 79° scores M1A0A0.
	OR			
	$\sin\alpha = \frac{1.4}{\sqrt{50.96}}$ $\alpha = 011°$	(M1 A1F) (A1)	(3)	M1: Use of sin with 1.4 or 7 and their answer to (a) as the denominator. A1F: Use of sin and 1.4 in numerator. A1: Correct bearing to nearest degree.
	OR			
	$\cos\alpha = \frac{7}{\sqrt{50.96}}$ $\alpha = 011°$	(M1 A1F) (A1)	(3)	M1: Use of cos with 1.4 or 7 and their answer to (a) as the denominator. A1F: Use of cos and 7 in the numerator, provided expression satisfies $-1 \leq \cos\alpha \leq 1$. A1: Correct bearing to nearest degree. Note that 11.3° or 011.3° scores M1A1A0.
	Total		**5**	
4(a)	$F^2 = 70^2 + 40^2 - 2\times 40\times 70\cos 150°$ $F = \sqrt{11350}$ $F = 107$	M1 A1 dM1 A1	4	M1: Use of cosine rule with an obtuse angle and a – sign. A1: Correct expression. dM1: Taking square root of a value > 6500. May be implied by final answer. A1: Correct resultant to 3sf or more. Accept AWRT 106 or 107.
	OR by components, $70 + 40\cos 30°(= 104.64)$ $40\sin 30°(= 20)$ $F = \sqrt{104.64^2 + 20^2} = 107 \text{ N}$	(M1 A1) (dM1) (A1)	(4)	M1: Finding two perpendicular components of the resultant, with same force (usually the 40 N force) resolved in both expressions. Allow consistent sin/cos confusion. A1: Both components correct. (Note that resolving parallel and perpendicular to the 40 N force gives components of 100.6 and 35) dM1: Finding the magnitude of the resultant. A1: Correct resultant to 3sf or more. Accept AWRT 106 or 107.

Q	Solution	Marks	Total	Comments
4(b)	$\frac{\sin\alpha}{40} = \frac{\sin 150°}{106.54}$	M1A1		M1: Use of sine rule with 150°, their answer to part (a) and 40 or 70. A1: Correct equation with AWRT 106 or 107.
	$\alpha = 10.8°$	A1	3	A1: Correct angle. Accept 10.9°.
	OR			
	$\tan\alpha = \frac{20}{104.64}$	(M1 A1)		M1: Use of tan with 20 and AWRT 104 or 105. A1: Expression for tan α in the form $\tan\alpha = \frac{20}{\text{AWRT 104 or 105}}$. Could be implied by their final answer.
	$\alpha = 10.8°$	(A1)	(3)	A1: Correct angle. Accept 10.9°.
	OR			
	$\sin\alpha = \frac{20}{106.53}$	(M1 A1)		M1: Use of sin with 20 or AWRT 104 or 105 in the numerator and their answer to (a) as the denominator. A1: Expression for sin α in the form $\sin\alpha = \frac{20}{\text{AWRT 106 or 107}}$. A1: Correct angle. Accept 10.9°
	$\alpha = 10.8°$	(A1)	(3)	
	OR			
	$\cos\alpha = \frac{104.64}{106.53}$	(M1 A1)		M1: Use of cos with 20 or AWRT 104 or 105 in the numerator and their answer to (a) as the denominator. A1: Expression for cos α in the form $\cos\alpha = \frac{\text{AWRT 104 or 105}}{\text{AWRT 106 or 107}}$. A1: Correct angle. Accept 10.9° or 10.7°.
	$\alpha = 10.8°$	(A1)	(3)	
				Apply ISW if 180° – α is seen after finding α.
	Total		**7**	

Q	Solution	Marks	Total	Comments
5(a)	$3g - T = 3a$ $T - g = a$ $2g = 4a$ $a = \frac{g}{2} = 4.9 \text{ m s}^{-2}$	M1A1 M1A1 A1	 5	M1: Three term equation of motion with $3g$ or 29.4, T and $3a$. A1: Correct equation. M1: Three term equation of motion with g or 9.8, T and a. A1: Correct equation. A1: Correct final answer. Accept $\frac{g}{2}$ Note: Do not penalise candidates who consistently use signs in the opposite direction throughout, provided they then give their final answer as 4.9, having seen –4.9 in their working. If the final answer is –4.9 don't award the final A1 mark. Special Case: Whole string method $2g = 4a$ and $a = \frac{2g}{4} = 4.9$ OE scores M1A1A1
(b)	$v^2 = 0^2 + 2 \times 4.9 \times 0.4$ $v = \sqrt{3.92} = 1.98 \text{ m s}^{-1}$	M1 A1F	 2	M1: Use of a constant acceleration equation to find v, with $u = 0$, their value for a from part (a) and $s = 0.4$ or 40. A1F: Correct speed. Follow through their acceleration from part (a). Use $v = \sqrt{0.8a}$ for FT. Accept 1.97 . If candidates use two equations, award no marks until they have an equation for v. (Note use of $t = 0.404$ or better required for A1)
(c)	$0^2 = \left(\sqrt{3.92}\right)^2 + 2 \times (-9.8)s$ $s = \frac{3.92}{2 \times 9.8} = 0.2 \text{ m}$ Total = $0.2 + 0.4 = 0.6$ m	M1 A1 A1	 3	M1: Use of a constant acceleration equation with $v = 0$, $a = \pm 9.8$ and their speed from (b). A1: Correct distance. A1: Correct total distance. Allow 60 cm from correct working. Note $0^2 = \left(\sqrt{392}\right)^2 + 2 \times (-9.8)s$ $s = \frac{392}{2 \times 9.8} = 20$ scores M1A0A0 If candidates use two equations, award no marks until they have an equation for s. (Note use of $t = 0.202$ or better required for A marks)

Q	Solution	Marks	Total	Comments
5(d)	The acceleration would be less, because the <u>resultant force</u> on each particle would be <u>reduced</u>.	B1 B1	2	B1: Less 'Slower acceleration' not acceptable B1: Appropriate reason. Only award second B1 if they say acceleration is less.
	Total		**12**	
6(a)	$8 = \frac{1}{2} \times 9.8t^2$ $t = \sqrt{\frac{16}{9.8}} = 1.28$ s	M1A1 A1	3	M1: Equation based on the vertical motion, with $u = 0$, $s = \pm 8$ and $a = \pm 9.8$. A1: Correct equation. A1: Correct time. Allow 1.27 or AWRT 1.28 .
(b)	$V \times \sqrt{\frac{16}{9.8}} = 20$ $V = 20\sqrt{\frac{9.8}{16}} = 15.7$ m s^{-1}	M1A1 A1	3	M1: Using 20 = speed × time. A1: Correct equation. A1: Correct speed. Accept 15.6 or $7\sqrt{5}$ or AWRT 15.6 or AWRT 15.7.
(c)	$v_y = 9.8 \times \sqrt{\frac{16}{9.8}} (= 12.52)$ $v = \sqrt{15.65^2 + 12.52^2} = 20.0$ m s^{-1}	M1A1 dM1 A1	4	M1: Finding vertical component of velocity, with $u = 0$, $a = \pm 9.8$ and their time from part (a). A1: Correct expression for velocity. dM1: Finding the magnitude (with addition). A1: Correct speed. Accept 20 or 20.1 or AWRT 20.0 .
	Total		**10**	

Q	Solution	Marks	Total	Comments
7(a)(i)		B1 B1	2	B2: Correct diagram with exactly four forces showing arrow heads and labelled. B1: Diagram with one error or omission. B0: Diagram with 2 or more errors or omissions. If components are also shown and they use a different style, eg dashed lines, they can be ignored. If both components are shown in the same style as other forces, this counts as two errors. Note; Do not accept 30kg for the weight.
(ii)	$R + 150\sin 20° = 30 \times 9.8$ $(R =) 30 \times 9.8 - 150\sin 20°$ $= 242.69.....$ $= 243$ N (to 3sf)	M1A1 A1	3	M1: Resolving vertically to obtain a three term equation, with R, 150 sin or cos(20° or 70°) and 30g oe. A1: Correct equation. Allow g instead of 9.8 . A1: **AG** Correct final answer having seen either 2nd or 3rd or both line of solution.
(iii)	$(F =) 0.4 \times 242.7 = 97.1$ N	M1A1	2	M1: Use of $F = \mu R$ or $F \leq \mu R$ A1: Correct final answer without an inequality. Accept 97.2.
(iv)	$30a = 150\cos 20° - 97.08$ $a = \dfrac{150\cos 20° - 97.08}{30} = 1.46$ m s^{-2}	M1A1 dM1 A1	4	M1: Three term equation of motion with 30a, 150 sin or cos(20 or 70°) and their friction from (a)(iii). Condone incorrect signs. A1: Correct equation. dM1: Solving for a. A1: Correct acceleration. Accept 1.45 or 1.47 or AWRT 1.46
(b)	$R = 30 \times 9.8 - T\sin 20°$ $F = 0.4(30 \times 9.8 - T\sin 20°)$ $T\cos 20° = 0.4(30 \times 9.8 - T\sin 20°)$ $T = \dfrac{0.4 \times 30 \times 9.8}{\cos 20° + 0.4\sin 20°} = 109$ N	B1 B1 M1A1 A1	5	B1: Correct normal reaction in terms of T. B1: Correct friction in terms of T M1: Resolving tension horizontally and equating to F, provided that F is in terms of T. A1: Correct equation. A1: Correct tension. AWRT 109.
(c)	The same	B1	1	B1: The same. Use of g = 9.81 gives acceptable final answers.
	Total		**17**	

Q	Solution	Marks	Total	Comments
8(a)	$\mathbf{r} = (-17.5\mathbf{i} - 27\mathbf{j})t + \frac{1}{2}(0.5\mathbf{i} + 0.6\mathbf{j})t^2 +$ $(500\mathbf{i} + 200\mathbf{j})$	M1A1 A1	3	M1: Use of $\mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ A1: Correct with or without the initial position. That is with the final term missing or on the wrong side. A1: Correct with the initial position included.
	OR $\mathbf{r} = (500 - 17.5t + 0.25t^2)\mathbf{i} +$ $(200 - 27t + 0.3t^2)\mathbf{j}$			
(b)	$200 = -17.5t + 0.25t^2 + 500$	M1A1		M1: Forming equation for one component based on position of the rock and their position vector.
	$0.25t^2 - 17.5t + 300 = 0$			A1: Correct quadratic equation.
	$t = 40$ or 30	A1		A1: At least one correct solution3.
	$-400 = -27t + 0.3t^2 + 200$	dM1 A1		dM1: Forming equation for the other component. A1: Correct equation.
	$0.3t^2 - 27t + 600 = 0$			
	$t = 40$ or 50	dM1		dM1: Obtaining one or two positive solutions.
	$\therefore t = 40$	A1	7	A1: Selecting 40.
	OR			dM1: Substituting 40 into the other component.
	$-27 \times 40 + 0.3 \times 40^2 + 200 = -1080 + 480 + 200$	(dM1)		A1: Correct substitution
	$= -400$	(A1)		dM1: Checking this component of the position vector
	$\therefore t = 40$	(dM1) (A1)		A1: Concluding that $t = 40$
				Note that alternative methods based on trial and improvement can be awarded full marks.
	Alternative methods $0.25t^2 - 17.5t + 300 = 0$ $0.3t^2 - 27t + 600 = 0$	(M1 A1) (dM1 A1)		Marks allocated as above
	$0.55t^2 - 44.5t + 900 = 0$ $t = 40$ or $t = 40.9$	(A1)		A1: At least one correct solution dM1: Checking one or both solutions
	$0.25 \times 40^2 - 17.5 \times 40 + 300 = 0$ $0.3 \times 40^2 - 27 \times 40 + 600 = 0$	(dM1)		A1: concluding $t = 40$
	$\therefore t = 40$	(A1)		
	$0.05t^2 - 9.5t + 300 = 0$ $t = 40$ or $t = 150$	(A1)		A1: At least one correct solution dM1: Checking one or both solutions
	$0.25 \times 40^2 - 17.5 \times 40 + 300 = 0$ $0.3 \times 40^2 - 27 \times 40 + 600 = 0$	(dM1)		A1: concluding $t = 40$
	$\therefore t = 40$	(A1)		

Q	Solution	Marks	Total	Comments
8(c)	Av. Velocity $= \dfrac{(200\mathbf{i} - 400\mathbf{j}) - (500\mathbf{i} + 200\mathbf{j})}{40}$ $= \dfrac{-300\mathbf{i} - 600\mathbf{j}}{40}$ $= -7.5\mathbf{i} - 15\mathbf{j}$	M1 A1F A1F	3	M1: Use of change in position over time, with a subtraction to obtain position. Do not award if one position is taken as the origin. A1F: Correct expression. A1F: Correct final answer. Follow through on their time from part (b). Av Vel $= \dfrac{-300\mathbf{i} - 600\mathbf{j}}{t}$
(d)	No – The helicopter will follow a curved path and not move along a straight line between the two positions.	B2,1	2	B1: No. B1: Mentions path is longer than the distance between the two points. Only award second B1 if the candidate has stated that the two quantities are not equal.
	Total		**15**	
	TOTAL		**75**	