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General Certificate of Education (A-level)
June 2011

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 candidates' 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 candidates' 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.

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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.

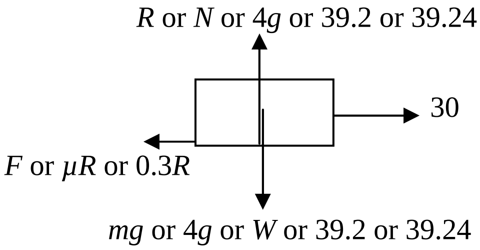
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

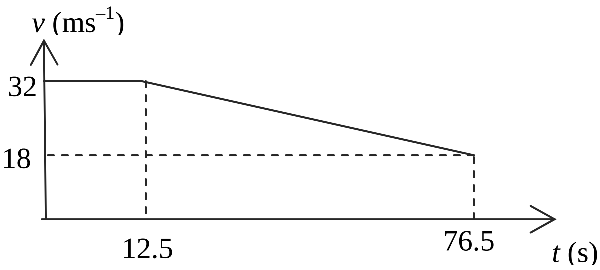
MM1B

Q	Solution	Marks	Total	Comments
1(a)(i)	$0.6^2 = 0^2 + 2a \times 0.9$	M1A1		M1: Correct use of constant acceleration equation with u = 0 to find a.
	$a = \dfrac{0.6^2}{1.8} = 0.2 \text{ ms}^{-2}$ **AG**	A1	3	A1: Correct equation. A1: Correct a but some intermediate working must be seen. Note that $0^2 = 0.6^2 + 2a \times 0.9$ Scores M0A0A0 Verification methods require a conclusion for full marks to be awarded. Condone seeing just the second line of working.
(a)(ii)	$0.9 = \dfrac{1}{2}(0 + 0.6)t$	M1		M1: Correct use of constant acceleration equation with u = 0 (and a = 0.2 if needed) to find t.
	$t = \dfrac{0.9}{0.3} = 3$ seconds	A1	2	A1: Correct time. Note: Do not penalise $0.9 = \dfrac{1}{2}(0.6 + 0)t$ in the first method.
	OR $0.6 = 0 + 0.2t$	(M1)		Note: $0 = 0.6 + 0.2t$ scores M0A0 in the second method.
	$t = \dfrac{0.6}{0.2} = 3$ seconds	(A1)		
	OR $0.9 = \dfrac{1}{2}0.2t^2$	(M1)		
	$t = 3$ seconds	(A1)		
(b)	$T - 800 \times 9.8 = 800 \times 0.2$	M1A1		M1: Three term equation of motion. Must have these three terms but can have incorrect signs. Must use a = 0.2
	$T = 7840 + 160 = 8000$ N	A1	3	A1: Correct equation with correct signs. (Allow 800g) A1: Correct tension. Accept 8008 or 8010 from use of g = 9.81.
	Total		**8**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
2(a)		B1	1	B1: Diagram with four forces showing arrow heads and labelled. Ignore negative signs in labels. Note: Award mark if forces drawn on the diagram in the question. Note: Do not accept 4kg for the weight. Note Accept μR for F.
(b)	$(R = 4\times 9.8 =)39.2$ N	B1	1	B1: Correct normal reaction. Accept $4g$
(c)	$(F =)0.3\times 39.2 = 11.76 = 11.8$ N (to 3sf)	M1 A1	2	M1: Use of $(F =)\mu R$ A1: Correct friction. Accept $1.2g$ or 11.7 or 11.76 N. Do not condone further work after the value for friction has been obtained.
(d)	$4a = 30 - 11.76$ $a = \dfrac{30-11.76}{4} = 4.56 \text{ ms}^{-2}$	M1A1F A1F	3	M1: Three term equation of motion. A1F: Correct equation. A1F: Correct acceleration. FT candidates F from part (c). Accept 4.55 from 11.8.
	Total		**7**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(a)	$s = 32 \times 12.5 = 400$ m	B1	1	B1: Correct distance.
(b)	$1600 = \frac{1}{2}(32+18)t$ $t = \frac{1600}{25} = 64$ seconds	M1dM1 A1	 3	M1: Seeing 2000 – candidate's answer to part (a) calculated dM1: Use of constant acceleration equation(s) to find t, with u = 32 and v = 18 A1: Correct time. Accept only 64
(c)		B1 B1 B1F	 3	B1: Shape of the graph. B1: Correct velocities (ie 18 and 32) on vertical axis. B1F: Correct times (ie 12.5 and 76.5) on the horizontal axis. (Follow through incorrect answers to part (b)). Award marks for graph if seen in earlier parts.
(d)	Average Speed $= \frac{2000}{12.5+64} = 26.1$ ms^{-1}	M1 A1F	 2	M1: Use of 2000 over candidate's total time (not 64 or 12.5). A1F: Correct speed. AWRT 26.1. FT candidate's answer to part (b) or (c).
	Total		**9**	
4 (a)	$6(5\mathbf{i}+18\mathbf{j}) + m(2\mathbf{i}-5\mathbf{j}) = 6(8\mathbf{i}) + m(V\mathbf{j})$ $6\times5 + 2m = 6\times8$ $30 + 2m = 48$ $m = \frac{48-30}{2} = 9$	M1 A1 A1	 3	M1: Conservation of momentum, with addition of terms, as either 4 term vector equation (seen either in part (a) or part (b) **OR** three term equation for **i** component. Allow one error, for example switching masses. A1: Correct equation for **i** components. A1: Correct m.
(b)	$6\times18 - 5\times9 = 9V$ $108 - 45 = 9V$ $V = \frac{108-45}{9} = 7$	M1A1F A1F	 3	M1: Conservation of momentum for **j** component with correct signs. Allow one error, for example switching masses. Note: omitting any mass scores M0. A1F: Correct equation. Allow m instead of 9 at this stage. A1F: Correct velocity. Condone 7**j** FT candidate's mass from part (a). Only award FT marks if mass positive. Note $V = \frac{108}{m} - 5$
	Total		**6**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
5 (a)	$5g - T = 5a$ $T - 3g = 3a$ $2g = 8a$ $a\left(=\frac{2g}{8}\right) = 2.45\ \text{ms}^{-2}$ **AG**	M1A1 M1A1 A1	5	M1: Three term equation of motion with $5g$ or 49, $5a$ (not $5ga$) and T. A1: Correct equation. M1: Three term equation of motion with $3g$ or 29.4, $3a$ (not $3ga$) and T. A1: Correct equation. A1: Correct acceleration from correct working. Note: Do not penalise candidates who consistently use signs in the opposite direction throughout, provided they then give their final answer as 2.45. If the final answer is –2.45 don't award the final A1 mark. Special Case: Whole String Method $2g = 8a$ and $a = \frac{2g}{8} = 2.45$ OE M1A1A1.
(b)	$T = 3\times 9.8 + 3\times 2.45$ $= 36.75$ $= 36.8$ N (to 3 sf)	M1 A1	2	M1: Substitution of a = 2.45 into a three term equation of motion to find the tension. Contains T, mg and ma where m = 3 or 5 A1: Correct tension. Accept 36.75 or 36.7
(c)	Light and Inextensible	B1B1	2	B1: Light B1: Inextensible (Allow inelastic or not stretchy) Ignore irrelevant non-contradictory assumptions.
(d)(i)	$0.196 = \frac{1}{2}\times 2.45\times t^2$ $t = \sqrt{\frac{2\times 0.196}{2.45}} = 0.4$ seconds	M1 A1 A1	3	M1: Use of constant acceleration equation with s = 0.196, u = 0 and a = 2.45 to find t. A1: Correct equation. A1: Correct t
(ii)	$v^2 = 0^2 + 2\times 2.45\times 0.196$ $v = 0.98$ **OR** $v = 0 + 2.45\times 0.4 = 0.98\ \text{ms}^{-1}$ **OR** $0.196 = \frac{1}{2}(0+v)\times 0.4$ $v = 0.98\ \text{m s}^{-1}$	M1A1 (M1A1) (M1) (A1)	2	M1: Use of constant acceleration equation with s = 0.196, a = 2.45, u = 0 and candidate's time (as needed) to find v. A1: Correct v.
	Total		**14**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6 (a)	$1000 = V \times 4$ $V = 250 \text{ ms}^{-1}$	M1 A1	 2	M1: Equation for horizontal motion to find *V*. Must not contain *g*. Could contain cos0° or equivalent. A1: Correct *V*.
(b)	$(h =)\frac{1}{2}\times 9.8\times 4^2$ $= 78.4$ metres to 3sf	M1 A1	 2	M1: Vertical equation to find height with $u = 0$ and $a = \pm 9.8$. A1: Correct height. Accept –78.4
(c)	$(v_y =) 9.8\times 4 = 39.2 \text{ ms}^{-1}$ or $(v_y =)\sqrt{2\times 9.8\times 78.4} = 39.2 \text{ ms}^{-1}$ $(v =)\sqrt{250^2 + 39.2^2} = 253 \text{ ms}^{-1}$	M1A1 dM1A1	 4	M1: Calculation of vertical component of velocity with $u = 0$ and $a = \pm 9.8$. A1: Correct vertical component. dM1: Calculation of speed. A1: Correct speed.
(d)	$\tan\alpha = \frac{39.2}{250} \quad \left(\text{or } \tan\alpha = \frac{250}{39.2}\right)$ $\alpha = 8.91°$ **OR** $\sin\alpha = \frac{39.2}{253} \quad \left(\text{or } \sin\alpha = \frac{250}{253}\right)$ $\alpha = 8.91°$ **OR** $\cos\alpha = \frac{250}{253(.055)} \quad \left(\text{or } \cos\alpha = \frac{39.2}{253}\right)$ $\alpha = 8.91°$	M1A1F A1 (M1A1F) (A1) (M1A1F) (A1)	 3	M1: Using tan to find angle with opposite and adjacent sides. Can be inverted as shown in brackets. A1F: Correct trig expression. A1: Correct angle. M1: Using sin to find angle with hypotenuse and one other side. Can be changed as shown in brackets. A1F: Correct trig expression. A1: Correct angle. M1: Using cos to find angle with hypotenuse and one other side. Can be changed as shown in brackets. A1F: Correct trig expression. A1: Correct angle. Accept 8.83° from this method. Note: Accept 8.98° from 253.1 Accept negative angles Note: FT value of *V* from (a) and speed from (c) if needed. Do not FT 39.2 from (c) in place of 253. Note: Accept energy methods if used correctly in part (c).
	Total		**11**	

MM1B(cont)

Q	Solution	Marks	Total	Comments
7(a)	$\mathbf{v} = (0.5\mathbf{i} + 0.375\mathbf{j}) \times 20 \left(= 10\mathbf{i} + 7.5\mathbf{j}\right)$ $v = \sqrt{10^2 + 7.5^2} = 12.5 \text{ ms}^{-1}$	M1A1 dM1A1	4	M1: Calculating velocity with $\mathbf{u} = 0\mathbf{i} + 0\mathbf{j}$ and $t = 20$. A1: Correct expression for velocity. dM1: Calculating speed. A1: Correct speed.
(b)	$\tan\theta = \frac{0.5}{0.375}$ or $\frac{10}{7.5}$ $\left(\text{or } \tan\theta = \frac{0.375}{0.5} \text{ or } \frac{7.5}{10}\right)$ $\theta = 053°$ **OR** $\cos\theta = \frac{7.5}{12.5}$ or $\frac{0.375}{0.625}$ $\left(\text{or } \cos\theta = \frac{10}{12.5}\right)$ $\theta = 053°$ **OR** $\sin\theta = \frac{10}{12.5}$ or $\frac{0.5}{0.625}$ $\left(\text{or } \sin\theta = \frac{7.5}{12.5}\right)$ $\theta = 053°$	M1A1F A1 (M1A1F) (A1) (M1A1F) (A1)	3	M1: Using trig to find angle. Can be inverted as shown in brackets. A1F: Correct trig expression with any correct equivalent fraction. A1: Correct angle to the nearest degree. Accept 53°. Note: For 37° award M1A0A0 But for 90 – 37 = 53° award M1A1A1. For 127°, award M1A1A0 Note: 53.1° as final answer scores M1A1A0 Condone finding angle from acceleration or position vector.
(c)	$(\mathbf{r} =)\frac{1}{2}(0.5\mathbf{i} + 0.375\mathbf{j})t^2 \left(= 0.25t^2\mathbf{i} + 0.1875t^2\mathbf{j}\right)$ $500^2 = \left(0.25t^2\right)^2 + \left(0.1875t^2\right)^2$ $t = \sqrt[4]{\frac{500^2}{0.25^2 + 0.1875^2}} = 40$ seconds **OR** $a = 0.625$ $500 = \frac{1}{2}0.625t^2$ $t = 40$ **OR** $400 = \frac{1}{2} \times 0.5t^2$ or $300 = \frac{1}{2} \times 0.375t^2$ $t^2 = 1600$ $t = 40$	M1A1 dM1A1 A1 (M1A1) (dM1A1) (A1) (M1A1) (A1) (dM1) (A1)	5	M1: Finding an expression for position vector in terms of *t*. A1: Correct position vector. dM1: Using distance to form an equation for *t*. A1: Correct equation. A1: Correct time. M1: Finding magnitude of acceleration. A1: Correct acceleration dM1: Using distance to form an equation for *t*. A1: Correct equation. A1: Correct time. M1: Working with one component. A1: Correct distance (300 or 400) A1: Correct equation. dM1: Solving for *t*. A1: Correct *t*. Note: 500÷12.5=40 is not acceptable and scores 0
	Total		**12**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)	$P\cos 80° - Q\cos 80° = 250a$ $P\sin 80° + Q\sin 80° = 250g$ $P - Q = \frac{250a}{\cos 80°}$ $P + Q = \frac{250g}{\sin 80°}$ **AG** $2P = \frac{250a}{\cos 80°} + \frac{250g}{\sin 80°}$ $P = 125\left(\frac{a}{\cos 80°} + \frac{g}{\sin 80°}\right)$	M1A1 B1 dM1 A1	 5	M1: Horizontal equation of motion in the form $P\cos 80° \pm Q\cos 80° = 250a$ or $P\sin 80° \pm Q\sin 80° = 250a$ A1: Correct horizontal equation. B1: Correct vertical equation. Note: the above marks could be awarded for a correct vector equation. dM1: Solving for P with an attempt to eliminate Q. A1: Correct result from correct working. Must see an expression for $2P$ or $2P\sin 80°\cos 80°$
(b)	$P\cos 80° = 250a$ $P\sin 80° = 250g$ $\frac{1}{\tan 80°} = \frac{a}{g}$ $a = \frac{g}{\tan 80°} = 1.73$	M1 dM1 A1	 3	M1: Using $Q = 0$ into correct original equation(s) or resolving without Q. dM1: Eliminating P A1: Correct a. Note: use of $P = \pm Q$ scores M0dM0A0 Note: use of $P = 0$ can lead to ± 1.73 but scores M0dM0A0 unless fully justified by a symmetry argument.
	Total		**8**	
	TOTAL		**75**	