AQA

AS
Mathematics

MM1B Mechanics 1
Mark scheme

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Version 1.0: Final Mark Scheme

Mark schemes are prepared by the Lead Assessment Writer 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 associates 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 associate understands and applies it in the same correct way. As preparation for standardisation each associate 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, associates encounter unusual answers which have not been raised they are required to refer these to the Lead Assessment Writer.

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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.

Do not allow mis-reads in this question.				
Q	**Solution**	**Mark**	**Total**	**Comment**
1. (a)	$3\times 6-2\times 8=5v$ $v=\frac{2}{5}=0.4$	**M1A1** **A1**	**3**	M1: Three term equation for conservation of momentum. Allow incorrect signs with correct values, eg $3\times 6+2\times 8=\pm 5v$. A1: Correct equation. A1: Correct v. CAO. Accept $\frac{2}{5}$ or 0.40.
1. (b)	$0.4\times 5=0.1(m+5)$ $2=0.1m+0.5$ $m=\frac{1.5}{0.1}=15$	**M1F** **A1F** **A1F**	**3**	Follow through incorrect v from part (a). M1F: Two / three term equation for conservation of momentum with $(m+5)$ or equivalent. A1F: Correct equation based on their value for v. A1F: Correct mass based on their v from part (a). Note: $m=50v-5$ Do not award last A1F if mass is seen as negative at any stage of the working. (Note that 6.8 from (a) produces m = 335.)
	Total		**6**	
				If weight used consistently instead of mass deduct 1 mark.

Do not allow mis-reads in this question.				
Q	**Solution**	**Mark**	**Total**	**Comment**
2. (a)	$(4\mathbf{i}+7\mathbf{j})+(p\mathbf{i}+5\mathbf{j})+(-8\mathbf{i}+q\mathbf{j})$ $=(p-4)\mathbf{i}+(12+q)\mathbf{j}$	**B1**	**1**	B1: Any correct version of the resultant force. (Does not need to be simplified, can be awarded for the first line.) Condone missing brackets.
2. (b)	$(p-4)\mathbf{i}+(12+q)\mathbf{j}=5(2\mathbf{i}-\mathbf{j})$ $p-4=5\times 2$ $p=14$ $12+q=5\times(-1)$ $q=-17$	**M1** **A1** **M1** **A1**	**4**	M1: Their **i** component equated to 5×2. A1: Correct value for p. Condone 14**i**. M1: Their **j** component equated to 5×(-1). A1: Correct value for q. Condone -17**i**.
2. (c)	$\mathbf{r}=\frac{1}{2}(2\mathbf{i}-\mathbf{j})\times 4^2$ $=16\mathbf{i}-8\mathbf{j}$ **OR** $\mathbf{v}=(2\mathbf{i}-\mathbf{j})\times 4=8\mathbf{i}-4\mathbf{j}$ $\mathbf{r}=\frac{((0\mathbf{i}+0\mathbf{j})+(8\mathbf{i}-4\mathbf{j}))}{2}\times 4$ $=16\mathbf{i}-8\mathbf{j}$	**M1A1** **A1** **(M1A1)** **(A1)**	**3**	M1: Using $\mathbf{r}=\mathbf{u}t+\frac{1}{2}\mathbf{a}t^2$ (or $\mathbf{v}=\mathbf{u}+\mathbf{a}t$ AND $\mathbf{r}=\frac{1}{2}(\mathbf{u}+\mathbf{v})t$) with $\mathbf{u}=0\mathbf{i}+0\mathbf{j}$. A1: Correct expression or components. A1: Correct displacement. Do not penalise candidates who go on to find the magnitude of this. (ISW).
	Total		**8**	
				Do not penalise the use of column vectors. award full marks for answers $\begin{pmatrix} p-4 \\ 12+q \end{pmatrix}$ or $\begin{pmatrix} 16 \\ -8 \end{pmatrix}$.

Do not allow mis-reads in this question.				
Q	**Solution**	**Mark**	**Total**	**Comment**
3. (a)	$1.08 = \frac{1}{2} a \times 1.2^2$ $a = \frac{1.08 \times 2}{1.44} = 1.5 \text{ m s}^{-2}$	**M1** **M1** **A1**	**3**	M1: Using $s = ut + \frac{1}{2}at^2$ with $u = 0$, $s = 1.08$ and $t = 1.2$. M1: Solving for a. A1: Correct acceleration. Accept $\frac{3}{2}$ or 1.50.
3. (b)	$v = 0 + 1.5 \times 1.2$ $= 1.8 \text{ m s}^{-1}$ **OR** $1.08 = \frac{1}{2}(0 + v) \times 1.2$ $v = \frac{2 \times 1.08}{1.2} = 1.8 \text{ m s}^{-1}$ **OR** $v = \sqrt{2 \times 1.5 \times 1.08} = 1.8 \text{ m s}^{-1}$	**M1** **A1**	**2**	M1: Use of a constant acceleration equation to find v, with $t = 1.2$ or $s = 1.08$. A1: Correct speed. Accept 1.80.
3. (c)	**Resolving parallel to slope** $mg \sin \alpha = ma$ $g \sin \alpha = 1.5$ $\alpha = \sin^{-1}\left(\frac{1.5}{9.8}\right) = 8.80° \approx 9°$	**M1** **A1** **dM1** **A1**	**4**	M1: Resolving parallel to the slope to obtain a two term equation, with their acceleration from part (a). Allow cos instead of sin. Must include $\pm g$. A1: Correct equation. May include m. dM1: Solving for α to obtain an angle. A1: Correct angle to nearest degree. Allow methods based on $\sin \alpha = \frac{1.5k}{9.8k}$ where k can have any value. Using $g = 9.81$ gives the same angle.
	Total		**9**	

Do not allow mis-reads in this question.				
Q	**Solution**	**Mark**	**Total**	**Comment**
4. (a)	$240 = 20V$ $V = \frac{240}{20} = 12$	**M1** **A1**	**2**	M1: Correct equation. A1: Correct V.
4. (b)	$v = \sqrt{90^2 + 12^2} = 90.8\,\text{m s}^{-1}$	**M1A1**	**2**	M1: Equation or expression to find v or v^2 based on the use of Pythagoras. Must have a +. Allow their value of V from part (a). A1: Correct velocity. AWRT 90.8 OR (If finding the angle first.) M1: Using 12 or 90 with the sin or cos of their angle. Allow their value of V from part (a). A1: Correct velocity. AWRT 90.8
4. (c)	$\tan\alpha = \frac{12}{90}$ $\alpha = 008°$ **Or** $\sin\alpha = \frac{12}{\sqrt{8244}}$ $\alpha = 008°$ **Or** $\cos\alpha = \frac{90}{\sqrt{8244}}$ $\alpha = 008°$ **OR** $\tan^{-1}\left(\frac{90}{12}\right) = 82.4$ $\alpha = 90 - 82 = 008°$ **Or** $\sin^{-1}\left(\frac{90}{\sqrt{8244}}\right) = 82.4$ $\alpha = 90 - 82 = 008°$ **Or** $\cos^{-1}\left(\frac{90}{\sqrt{8244}}\right) = 82.4$ $\alpha = 90 - 82 = 008°$	**M1A1** **A1**	**3**	M1: seeing tan with 12 or their V from (a) and 90, either way round. A1: Seeing AWRT 8 or 82. A1: Final answer of 008°. CAO M1: Use of sin or cos with 12 or their V from (a) or 90 and their value, which may be approximated, from part (b). A1: Seeing AWRT 8 or 82. A1: Final answer of 008°. CAO If working in radians, do not award final A1 mark unless converted to degrees. Note that intermediate answers of AWRT 0.13 or AWRT 1.4 can be accepted for M1A1.
	Total		**7**	

Do not allow mis-reads in this question.				
Q	**Solution**	**Mark**	**Total**	**Comment**
5. (a)	$7g - T = 7a$ $T - 3g = 3a$ $4g = 10a$ AG $a = \frac{4g}{10} = 3.92\ \text{m s}^{-2}$	**M1** **M1** **A1** **dM1** **A1**	**5**	M1: Three term equation of motion for one particle. Accept: $7g - T = 7a$ $3g - T = 3a$ $T - 7g = 7a$ $T - 3g = 3a$ M1: Three term equation of motion from the list above for the other particle. A1: Two consistent equations, that is either $\begin{matrix}7g - T = 7a \\ T - 3g = 3a\end{matrix}$ **or** $\begin{matrix}T - 7g = 7a \\ 3g - T = 3a\end{matrix}$. dM1: Solving equations to find a. A1: Obtaining 3.92 from consistent working. SC3: For whole string method.
5. (b)	$v^2 = 0^2 + 2 \times 3.92 \times 0.8$ $= 6.272$ $v = 2.50\ \text{m s}^{-1}$	**M1A1** **A1**	**3**	M1: Using $v^2 = u^2 + 2as$ with $u = 0$, $s = 0.8$ or 80 and $a = 3.92$. A1: Correct equation. A1: Correct speed. Accept 2.5 or AWRT 2.50.
5.(c)	$0^2 = 6.272 + 2 \times (-9.8)s$ $s = \frac{6.272}{19.6} = 0.32\ \text{m}$ Total height $= 32 + 80 = 112\ \text{cm}$	**M1A1** **A1** **B1**	**4**	M1: Using $v^2 = u^2 + 2as$ with $v = 0$, their value for v from (b) for u and $a = \pm 9.8$. A1: Correct equation. Allow 6.25 from 2.5^2. A1: Obtaining AWRT ±0.32 from correct working. B1: Adding 80 or 0.8 to the height from their intermediate working. Must use same units and obtain an answer greater than 80 or 0.8 depending on units used.
	Total		**12**	

Do not allow mis-reads in this question.				
Q	**Solution**	**Mark**	**Total**	**Comment**
6. (a)	$R = T\sin 60° + 49$	**M1A1**	**2**	M1: Seeing ±49 or 5*g* or *mg* and *T* sin60° or *T* sin30° or *T* cos60° or *T* cos30°, with no other terms. A1: Any correct expression for *R* in terms of only *T*, but need not write *R* = at the start. Allow 5*g* but not *mg*.
6. (b)	$F = 0.2(T\sin 60° + 49)$	**M1A1**		M1: Using $F = 0.2R$ where *R* is their answer to (a) and a function of *T*. A1: Correct expression for *F*.
	$T\cos 60° - F = 5 \times 0.9$	**M1** **A1F**		M1: Resolving horizontally to obtain a three term equation of motion. Must contain *T* sin60° or *T* sin30° or *T* cos60° or *T* cos30° and *F* or their *F* and 5×0.9. A1F: Correct equation. Allow their *F*.
	$T\cos 60° - 0.2(T\sin 60° + 49) = 4.5$	**dM1**		dM1: Substituting expression for *F*.
	$T = \dfrac{4.5 + 9.8}{\cos 60° - 0.2\sin 60°} = 43.8$ N	**A1**	**6**	A1: Correct *T* **from correct working**. Accept AWFW 43.7 to 43.8 Using *g* = 9.81 still gives 43.8 as the final answer.
	Total		**8**	

Do not allow mis-reads on this question.				
Q	**Solution**	**Mark**	**Total**	**Comment**
7. (a)	$1 = 12\sin 50°t - 4.9t^2$ $4.9t^2 - 12\sin 50°t + 1 = 0$ $t = 0.116$ or $t = 1.76$ $t = 1.76\,\text{s}$	**M1A1** **A1** **dM1** **A1**	**5**	M1: Seeing three terms equation with: 12 sin50° or 12 cos50° **and** 1 **and** $\pm 4.9t^2$. A1: Correct terms with possible sign errors. A1: Correct equation. **Solving their quadratic if full working seen (e.g. use of quadratic equation formula):** dM1: At least one solution seen and no more than one substitution error in formula. A1: Correct solution selected. AWRT 1.76. **If working not shown in full (e.g. values obtained directly from a calculator):** dM1: Obtaining at least one correct solution to the quadratic. A1 Showing the two solutions and selecting the correct one. AWRT 1.76. Note that use of $g = 9.81$ gives the same final answers.
	OR Time Up = 0.9380 Time Down = 0.8221 Total Time = 0.9380 + 0.8221 = 1.76 s	**(M2A1 A1A1)**		M2: Complete method to find total time by adding two (or more) times. A1: Correct time up. A1: Correct time down. A1: Correct total time.
	OR $v^2 = (12\sin 50°)^2 + 2\times(-9.8)\times 1$ $v = -8.056$ $-8.056 = 12\sin 50° - 9.8t$ $t = 1.76\text{s}$	**(M1A1 A1)** **(dM1) (A1)**		M1: Using two constant acceleration equations to find t. A1: Correct first equation. A1: Seeing AWRT -8.06. dM1: Correct second constant acceleration equation with $\pm$ their v. A1 Correct time. Allow AWRT 1.76.
7. (b)	$x = 12\cos 50° \times 1.76 = 13.6\,\text{m}$	**M1A1**	**2**	M1: 12cos50° or 12sin50° multiplied by their answer to (a). A1: Correct distance. Accept AWRT 13.6.

7. (c)	$13.576+3=16.576$ $16.576=V\cos 50°t$ $t=\dfrac{16.576}{V\cos 50°}$ $1=V\sin 50°t-4.9t^2$ $1=16.576\tan 50°-\dfrac{4.9\times 16.576^2}{V^2\cos^2 50°}$ $V^2=\dfrac{4.9\times 16.576^2}{(16.576\tan 50°-1)\cos^2 50°}$ $V=13.2$ m s^{-1} **OR** $13.576+3=16.576$ $16.576=V\cos 50°t$ $V=\dfrac{16.576}{t\cos 50°}$ $1=V\sin 50°t-4.9t^2$ $1=16.576\tan 50°-4.9t^2$ $t^2=\dfrac{16.576\tan 50°-1}{4.9}$ $t=1.9579$ $V=\dfrac{16.576}{1.9579\times\cos 50°}=13.2$ m s^{-1}	**M1** **dM1** **A1F** **B1** **dM1** **A1** **A1** **M1** **dM1** **A1F** **B1** **dM1** **A1** **A1**	**7**	M1:Adding 3 to their answer to part (b). dM1: Horizontal equation with $V\cos 50°t$ or $V\sin 50°t$ equated to their answer from (b) plus 3. A1F: Correct expression for *t*. Follow through their answer from (b). B1: Correct vertical equation. dM1: Correctly substituting their expression for *t* into the vertical equation. (Dep on both previous method marks) A1: Correct equation. A1:Correct *V*. Allow AWFW 13.1 and13.3. Condone '16.6' in working M1:Adding 3 to their answer to part (b). dM1: Horizontal equation with $V\cos 50°t$ or $V\sin 50°t$ equated to their answer from (b) plus 3. A1F: Correct expression for *V*. Follow through their answer from (b). B1: Correct vertical equation. dM1: Correctly substituting their expression for *V* into the vertical equation. A1: Correct expression for t^2. A1:Correct *V*. Allow AWFW 13.1 and 13.3. Condone '16.6' in working Note that use of $g = 9.81$ gives the same final answer.
7. (d)	Dimensions of ball need to be taken into account.	**B1**	**1**	B1: Statement about the size of the ball. Ignore irrelevant statements but if weight is zero is included B0.
	Total		**15**	

Do not allow mis-reads on this question				
Q	**Solution**	**Mark**	**Total**	**Comment**
8	$\mathbf{v}_A = (8-0.2t)\mathbf{i} + (4+0.1t)\mathbf{j}$	**B1**		B1: Correct velocity for A. May be implied.
	$\mathbf{v}_B = (6+0.2t)\mathbf{i} + (9-0.1t)\mathbf{j}$	**B1**		B1: Correct velocity for B. May be implied.
	$k(8-0.2t) = 6+0.2t$			
	$k(4+0.1t) = 9-0.1t$			
	$\frac{6+0.2t}{8-0.2t} = \frac{9-0.1t}{4+0.1t}$	**M1A1**		M1: Forming an equation based on the ratio of **i** and **j** components of both velocity vectors. Allow $\frac{6+0.2t}{8-0.2t} = \frac{4+0.1t}{9-0.1t}$ oe.
	$(6+0.2t)(4+0.1t) = (9-0.1t)(8-0.2t)$			
	$24+1.4t+0.02t^2 = 72-2.6t+0.02t^2$			
	$4t = 48$			
	$t = 12$	**A1**		A1: Correct value of t.
				SC3 For obtaining $t = 12$ by trial and improvement. Replaces M1A1A1 above. Also award B1B1.
	$\mathbf{r}_A = (8\times12-0.1\times12^2)\mathbf{i} + (4\times12+0.05\times12^2)$	**dM1**		dM1: Finding position vectors of A and B at the time found by candidate provided that they have previous M1 or 12 from the SC.
	$= 81.6\mathbf{i} + 55.2\mathbf{j}$	**A1**		A1: Correct position vector for A.
	$\mathbf{r}_B = (40+6\times12+0.1\times12^2)\mathbf{i} +$ $(50+9\times12-0.05\times12^2)\mathbf{j}$			
	$= 126.4\mathbf{i} + 150.8\mathbf{j}$	**A1**		A1: Correct position vector for B.
	$d = \sqrt{44.8^2+95.6^2} = 106$ m	**dM1**		dM1: Finding the difference between the position vectors.
		A1	**10**	A1: Correct distance. Accept AWRT 106
	Total		**10**	