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General Certificate of Education (A-level)
June 2012

Mathematics MM1B

(Specification 6360)

Mechanics 1B

Mark Scheme

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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)	$\left(V^2 =\right)5^2+2^2$ $\left(V=\right)5.39\ \text{ms}^{-1}$	M1 A1	2	M1: Correct expression for V or V^2. A1: Correct speed. Accept 5.38 or $\sqrt{29}$ or AWRT 5.39 or 5.38. Do not accept 5.4
(b)	$\tan\theta=\frac{2}{5}$ $\theta=21.8°$ $\text{Bearing}=360-21.8=338°$ (to 3sf) Or $\tan\theta=\frac{5}{2}$ $\theta=68.2°$ $\text{Bearing}=270+68.2=338°$ (to 3sf)	M1 A1 A1	3	M1: Accept $\tan\theta=\frac{2}{5}$ or $\frac{5}{2}$ or $\sin\theta$ or $\cos\theta=\frac{2}{V}$ or $\frac{5}{V}$ with their V from part (a). Note: With use of sine or cosine rules, must get to $\sin\theta$ or $\cos\theta=\frac{2}{V}$ or $\frac{5}{V}$ OE A1: Correct angle. Accept AWRT 22° or 68° from correct working. A1: Correct bearing. Accept AWRT 338. Note that incorrect diagrams should not be penalised if "correct" working shown.
	Total		**5**	
2	$2\times4+3m=3.8(2+m)$ $8+3m=7.6+3.8m$ $0.4=0.8m$ $m=\frac{0.4}{0.8}=0.5$ kg	M1A1 A1	3	M1: Three term equation for conservation of momentum with correct RHS. Allow 2 ×4 – 3m on the LHS A1: Correct equation. A1: Correct answer. Note for consistent use of weight instead of mass penalise by one mark. Allow use of any letter for the mass.
	Total		**3**	

MM1B

Q	Solution	Marks	Total	Comments
3(a)(i)	$10^2 = 20^2 + 2 \times a \times 75$ $a = \dfrac{100-400}{150} = -2 \text{ ms}^{-2}$	M1A1 A1	 3	M1: Use of a constant acceleration equation to find a, with v = 10 and u = 20. $20^2 = 10^2 + 2 \times a \times 75$ scores M0 A1: Correct equation. A1: Correct acceleration. For two equation methods award no marks until an equation for a is obtained.
(ii)	$0 = 20 - 2t$ $t = 10$ seconds	M1 A1	 2	M1: Using a constant acceleration equation, with u = 20 and v = 0, to find t using their acceleration from (a) even if positive. Using s = 75 scores M0 A1: Correct time from correct working CSO.
(iii)	$F = 1400 \times 2$ $= 2800$ N	M1 A1F	 2	M1: Use of $F = ma$ with ± their acceleration and mass of 1400. A1F: Correct force. Follow through the magnitude of their acceleration. Answer must be positive. Sign changes do not need to be justified.
(b)	$F = 2800 - 200 = 2600$ N	B1F	1	B1F: The magnitude of their force minus 200. Do not award if M1 not awarded in (a)(iii). Final answer must be positive. Follow through only if their answer to (a)(iii) is greater than 200.
	Total		**8**	

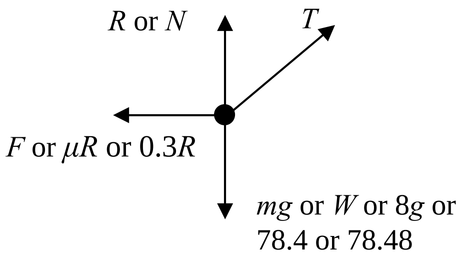
MM1B

Q	Solution	Marks	Total	Comments
4(a)	$20\cos\theta = 10$ $\cos\theta = \frac{1}{2}$ $\theta = 60°$	M1A1 A1	 3	M1: Resolving horizontally. Accept $\sin\theta$ or cos θ with the 20. A1: Correct equation. A1: Correct angle. Accept $\frac{\pi}{3}$ or 1.05 (radians). Allow 59.9 or better if they find W first
(b)	$(W =) 20\sin 60°$ $= 17.3$ N Or $(W =)\sqrt{20^2 - 10^2} = 17.3$ N	M1 A1 (M1) (A1)	 2	M1: Resolving vertically. Accept $\sin\theta$ or cos θ with the 20, where θ is their answer to part (a) or 90 minus their answer to part (a). A1: Correct weight CSO or M1: Correct use of Pythagoras eg $10^2 + W^2 = 20^2$ A1: Correct weight CSO Accept $10\sqrt{3}$ or AWRT 17.3
(c)	$m = \frac{20\sin 60°}{9.8}$ $= 1.77$ kg	M1 A1F	 2	M1: Their answer to part (b) divided by 9.8. A1F: Correct mass. Follow through their answer to part (b). Accept 1.76 or 1.8. Accept 2 sig figs in follow through. Note: Using g = 9.81 gives the answer 1.77, also accept 1.76.
	Total		**7**	
5(a)	$18g - T = 18a$ $T = 12a$ $18g - 12a = 18a$ $a = \frac{18g}{30} = 5.88$ ms^{-2}	M1A1 B1 A1	 4	M1: Three term equation of motion for the 18 kg particle. A1: Correct equation of motion for the 18 kg particle. (Accept T – 18g =18a) B1: Equation of motion for the block that has signs consistent with the first equation. A1: Correct acceleration from correct work. Accept $\frac{3g}{5}$ Do not penalise consistent use of negative acceleration, provided final answer positive. Special Case: Whole String Method 18g = 30a and $a = \frac{18g}{30} = 5.88$ OE M1A1 Note using g = 9.81 gives 5.89, also accept 5.88.

MM1B

Q	Solution	Marks	Total	Comments
5(b)(i)	$18g - T = 18 \times 3$ $T = 18g - 18 \times 3 = 122(.4)$ N	M1A1 A1	3	M1: Three term equation of motion for the 18 kg particle with a = 3 seen. A1: Correct equation. A1: Correct tension. Accept 122.4. Note using g = 9.81 gives 123, also accept 122.
(ii)	$(R = 12 \times 9.8 = 117.6$ N $=)$118 N(to 3sf)	B1	1	B1: Correct normal reaction. Accept 117 and 117.6. Final answer must be positive. Do not accept 12g. Note using g = 9.81 gives 118, also accept 117.
(iii)	$122.4 - F = 12 \times 3$ $F = 86.4$ $86.4 = \mu \times 117.6$ $\mu = \frac{86.4}{117.6} = 0.735$	M1A1F A1F dM1 A1	5	M1: Three term equation of motion for the block, containing their tension, F and 12 × 3. A1F: Correct equation. Follow through T from part (b) (i). A1F: Candidate's T minus 36. dM1: Use of $F = \mu R$ with AWRT 117 or 118 for R and the candidate's value of F provided positive. A1: Correct μ. Accept anything between 0.728 and 0.739 inclusive. Allow 0.73 and 0.74. Use of whole string method to find friction (18g – F = 30 × 3): M1A1A0
(c)	No air resistance or no other forces Horizontal String **Block** is a particle or **they** are particles	B1 B1	2	B1: One assumption from list B1: For another assumption from list. Do not penalise assumptions not in the list.
	Total		**15**	

MM1B

Q	Solution	Marks	Total	Comments
6(a)		B1	1	B1: Diagram with **exactly four** forces showing arrow heads and labelled. If components are also shown and they use a different style, eg dashed lines, they can be ignored. Note: Award mark if forces drawn on the diagram in the question. Note: Do not accept 8 kg for the weight. Note Accept μR or 0.3*R* for *F*.
(b)	$R + T\sin 30° = 8 \times 9.8$ $(R =) 78.4 - T\sin 30°$ $(R =) 78.4 - 0.5T$	M1A1 A1	3	M1: Resolving vertically to obtain a three term equation, with *R*, *T* sin or cos(30° or 60°) and 8*g* oe. A1: Correct equation A1: Correct expression for *R*. Accept $(R =) 8g - T\sin 30°$ Note if using g = 9.81 accept $R = 78.48 - 0.5T$ or $R = 78.5 - 0.5T$
(c)	$T\cos 30° - F = 8 \times 0.05$ $F = 0.3(78.4 - T\sin 30°)$ $T\cos 30° - 0.3(78.4 - T\sin 30°) = 0.4$ $T = \dfrac{23.52 + 0.4}{\cos 30° + 0.3\sin 30°} = 23.5$ N Or $T\cos 30° - F = 8 \times 0.05$ $T\cos 30° - 0.3R = 8 \times 0.05$ $R + T\sin 30° = 8 \times 9.8$ solving simultaneously gives $T = 23.5$	M1A1 M1A1 dM1A1 (M1A1) (M1A1) (dM1A1)	6	M1: Horizontal equation of motion with *F, T* sin or cos(30° or 60°) and 8×0.05 oe. A1: Correct equation. M1: Using $F = 0.3R$ with their *R* from part (b), provided it includes a term in *T*. A1: Correct expression for friction. dM1: Solving for *T*. Must see $(\cos 30° \pm 0.3\sin 30°)$ or similar in the denominator. (Dependent on both previous M marks.) A1: Correct *T*. Accept 23.6 or AWRT 23.5 M1: Horizontal equation of motion with *F, T* sin or cos(30° or 60°) and 8×0.05 oe. A1: Correct equation. M1: Using $F = 0.3R$ A1: Two correct equations involving only *T* and *R*. dM1: Solving for *T*. A1: Correct *T*. Accept 23.6 or AWRT 23.5 Note using g = 9.81 gives 23.6, also accept 23.5.
	Total		**10**	

MM1B

Q	Solution	Marks	Total	Comments
7(a)	$\mathbf{r} = (-\mathbf{i} + 3\mathbf{j})t + \frac{1}{2}(0.1\mathbf{i} - 0.2\mathbf{j})t^2$	M1A1	2	M1: Using constant acceleration equation to get **r**. A1: Correct expression for **r**. Allow equivalent column vector answer.
(b)	$3t - 0.1t^2 = 0$ $t(3 - 0.1t) = 0$ $t = 0$ or $t = 30$ $t = 30$ seconds	M1A1 A1	 3	M1: Putting their **j** component equal to zero to form a quadratic equation. A1: Correct equation. A1: For 30 seconds. No need to see t = 0.
(c)	$\mathbf{v} = (0.1t - 1)\mathbf{i} + (3 - 0.2t)\mathbf{j}$ $0.1t - 1 = -(3 - 0.2t)$ $2 = 0.1t$ $t = 20$ $\mathbf{v} = \mathbf{i} - \mathbf{j}$ $v = \sqrt{2} = 1.41$ ms^{-1}	B1 M1A1 A1 dM1 A1	 6	B1: Correct expression for the velocity in terms of t. Can be implied by subsequent working in terms of t. M1: For $0.1t - 1 = \pm(3 - 0.2t)$. May be with their components if velocity stated incorrectly. A1: Correct equation. A1: t =20 dM1: finding velocity and speed at their time A1: Correct speed. **Special cases** If the equation in t in line 2 is not seen: then seeing t=20 and **v**=**i - j** and v =1.41 award 4 out of 6 or then seeing t=20 and **v**=**i - j** award 2 out of 6
	Total		**11**	
8(a)	$22.4\sin\theta - 2 \times 9.8 = 0$ $\sin\theta = \frac{19.6}{22.4} = \frac{7}{8} = 0.875$ **AG** Or $0 = 22.4\sin\theta \times 4 - \frac{1}{2} \times 9.8 \times 4^2$ $\sin\theta = \frac{4.9 \times 16}{22.4 \times 4} = 0.875$	M1A1 A1 (M1A1) (A1)	 3	M1: Use of $v = u + at$ vertically with $u = 22.4\sin\theta$, v = 0, t = 2 and a = ±9.8. A1: Correct equation. (May be in terms of g or contain 9.81.. A1: Must see either $22.4\sin\theta = 19.6$ or $\frac{19.6}{22.4}$. M1: Use of $s = ut + \frac{1}{2}at^2$ with $u = 22.4\sin\theta$, s = 0, t = 4 and a = ±9.8. A1: Correct equation. A1: must see $89.6\sin\theta = 78.4$ or $\frac{78.4}{89.6}$ OE

MM1B

Q	Solution	Marks	Total	Comments
8(b)	$h_{MAX} = 22.4 \times \sin\theta \times 2 - \frac{1}{2} \times 9.8 \times 2^2$ $= 19.6$ m Or $0^2 = (22.4 \times \sin\theta)^2 + 2 \times (-9.8) h_{MAX}$ $h_{MAX} = 19.6$ m	M1A1 A1 (M1A1) (A1)	3	M1: Using a constant acceleration equation to find height, with t = 2, u=22.4 sin θ or 19.6 and $a = \pm 9.8$. A1: Correct equation. A1: Correct height. AWRT 19.6 Note using g = 9.81 gives 19.6, also accept 19.5. Note: other constant acceleration equations will lead to the same result
(c)	$\cos\theta = \frac{\sqrt{15}}{8} = 0.4841$ or $\theta = 61.04°$ $AB = 22.4 \times \frac{\sqrt{15}}{8} \times 4 = 43.4$ m	B1 M1A1F	3	B1: Correct value for $\cos\theta$ (accept 0.484) or θ (accept 61.0° or 61° or 1.06 or 1.065 or 1.07 radians). Can be implied. M1: Calculation for range with value for $\cos\theta$ and with t = 4. A1F: Correct distance. Follow through incorrect θ. Accept AWRT 43.4 or 43.3 or 43.2. Do not accept 43.
(d)	$22.4 \times (\sin\theta) t - 4.9t^2 = 5$ $4.9t^2 - 19.6t + 5 = 0$ $t = 0.274$ or $t = 3.726$ Time $= 3.726 - 0.274 = 3.45$ seconds	M1 A1 dM1 A1 A1	5	M1: Use of $s = ut + \frac{1}{2}at^2$ with correct terms, but not necessarily signs. A1: Correct equation. dM1: Solving their quadratic. A1: At least one correct solution. Allow 0.27 or 0.28 and 3.72 or 3.73 A1: Correct difference. Accept 3.46. Note: there are other methods which will lead to the correct time: M1dM1A1 for a constant acceleration equation that gives a time or times from which the final answer can be obtained A1 Correct time or times A1 Correct final answer
(e)	$v_{MIN} = 22.4 \times \cos\theta$ $= 10.8$ ms^{-1} Or $v_{\min} = \frac{43.4}{4} = 10.9$ to 3sf	M1 A1 (M1) (A1)	2	M1: Finding horizontal component with candidate's value for $\cos\theta$. Do not award if combined with a non-zero vertical component. A1: Correct speed. Accept 10.9 or 10.85. M1: range divided by time of flight A1: Correct speed. Accept 10.9 or 10.85.
	Total		**16**	
	TOTAL		**75**	