Version

General Certificate of Education (A-level)
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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.

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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**.

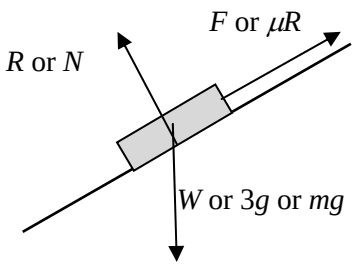
Otherwise we require evidence of a correct method for any marks to be awarded.

MM1B

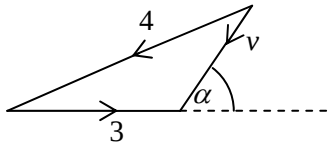
Q	Solution	Marks	Total	Comments
1(a)(i)	$640 = \frac{1}{2}(12+20)t$ $t = \frac{640\times 2}{32} = 40$ s	M1A1 A1	3	M1: Use of constant acceleration equation to find t with s = 640, 20 and 12. A1: Correct equation. A1: Correct time. For two equation methods, award no marks until an equation for t is obtained. Using a = 0.2 to find t = –40 scores M1A0A0
(a)(ii)	$12^2 = 20^2 + 2\times a\times 640$ $a = \frac{12^2-20^2}{2\times 640} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2}) OR $12 = 20 + 40a$ $a = \frac{-8}{40} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2}) OR $640 = 20\times 40 + \frac{1}{2}a\times 40^2$ $a = \frac{-160}{800} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2})	M1A1 A1 (M1A1F) (A1F) (M1A1F) (A1F)	3 (3) (3)	M1: Use of constant acceleration equation to find a with u = 20 and v = 12. A1F: Correct equation. A1F: Correct deceleration. Do not award for a = 0.2 Accept –0.2 or $\pm\frac{1}{5}$ m s^{-2} for deceleration Follow through incorrect times from part (a). For two equation methods, award no marks until an equation for a is obtained. Accept $\frac{8}{40} = 0.2$ provided that the equations $20 = 12 + 40a$ or $20^2 = 12^2 + 1280a$ are not seen $a = \frac{8}{40} = 0.2$ scores M1A1A0 unless a is defined as deceleration

Q	Solution	Marks	Total	Comments
1(b)(i)	$1820 = 12\times 70 + \frac{1}{2}\times a\times 70^2$ $a = \frac{1820-12\times 70}{2450} = 0.4\ \text{m s}^{-2}$	M1A1 A1	3	M1: Constant acceleration equation to find a with $u = 12$ (or 20), $s = 1820$ and $t = 70$. A1F: Correct equation. A1F: Correct acceleration. Accept $\frac{2}{5}\ \text{m s}^{-2}$ oe.
(b)(ii)	$1820 = \frac{1}{2}(12+v)\times 70$ $v = \frac{1820}{35} - 12 = 40\ \text{m s}^{-1}$ OR $v = 12 + 0.4\times 70$ $= 40\ \text{m s}^{-1}$ OR $v^2 = 12^2 + 2\times 0.4\times 1820$ $v = \sqrt{1600} = 40\ \text{m s}^{-1}$ OR $1820 = 70v - \frac{1}{2}\times 0.4\times 70^2$ $v = 40\ \text{m s}^{-1}$	M1A1 A1 (M1A1F) (A1F) (M1A1F) (A1F) (M1A1F) (A1F)	3 (3) (3) (3)	M1: Constant acceleration equation to find v with $s = 1820$ and $t = 70$. A1F: Correct equation. A1F: Correct velocity. For two equation methods, award no marks until an equation for v is obtained.
(c)	Average Speed $= \frac{640+1820}{40+70}$ $= \frac{2460}{110} = 22.4\ \text{m s}^{-1}$	M1 A1F	2	M1: Division of 2460 by their total time (70 + their answer to (a)). A1F: Correct time. Accept 22.3 or AWRT 22.4
	Total		**14**	

Q	Solution	Marks	Total	Comments
2(a)	$(\mathbf{F} =)9\mathbf{i} - 3\mathbf{j} + 5\mathbf{i} + 8\mathbf{j} - 7\mathbf{i} + 3\mathbf{j} = 7\mathbf{i} + 8\mathbf{j}$	M1A1	2	M1: Adding the three forces with one component correct. A1: Correct answer.
(b)	$(F =)\sqrt{7^2 + 8^2} = \sqrt{113} = 10.6$ N	M1A1F	2	M1: Finding magnitude with a + sign. A1F: Correct magnitude. Accept AWRT 10.63 and $\sqrt{113}$ Follow through incorrect answers to part (a).
(c)	$(a =)\dfrac{\sqrt{113}}{5} = 2.13$ m s^{-2}	M1A1F	2	M1: Dividing their force from part (a) or magnitude by 5. A1F: Correct acceleration. Accept 2.12 (from truncation or 10.6/5) or $\dfrac{\sqrt{113}}{5}$ or AWRT 2.13. Follow through incorrect answers to parts (a) and (b). Seeing just **a** = 1.4**i** + 1.6**j** scores M1 A0
(d)	$\cos\alpha = \dfrac{7}{\sqrt{113}}$ or $\dfrac{7}{10.6}$ OR $\sin\alpha = \dfrac{8}{\sqrt{113}}$ or $\dfrac{8}{10.6}$ OR $\tan\alpha = \dfrac{8}{7}$ $(\alpha =)48.8°$	M1A1F A1F	3	M1: Trig equation to find the angle with: cos with 7 or 8 in the numerator and $\sqrt{113}$ in denominator sin with 7 or 8 in the numerator and $\sqrt{113}$ in denominator tan with 7 and 8 in any position A1F: Correct equation. A1F: Correct angle. Accept 49° or AWRT 49° Follow through incorrect answers to parts (a) and (b).
	Total		**9**	

Q	Solution	Marks	Total	Comments
3(a)		B1	1	Diagram with exactly three forces showing arrow heads and labelled. If components are also shown they must use a different style e.g. dashed lines then they can be ignored. Friction must be up the slope.
(b)	$(R =)3\times 9.8\cos 40° = 22.5$ N	M1A1	2	M1: Resolving perpendicular to the slope. Can use sin40° or cos50° for method mark, with *g* or 9.8. A1: Correct normal reaction. Accept AWRT 22.5 (Note use of 9.81 still gives 22.5 N.)
(c)	$(F =)0.2R = 4.50$ N	M1A1F	2	M1: Use of $F = \mu R$. A1F: Correct friction. Accept 4.5 N or AWRT 4.50. (Accept 4.51 N from the use of 9.81.) Follow through incorrect normal reaction from part (b).
(d)	$3a = 3\times 9.8\sin 40° - 4.504$ $a = 4.80$ m s^{-2}	M1A1F A1F	3	M1: Three term equation of motion with correct terms, with 3*a*, either component of weight and their answer to part (c) for *F*. A1F: Equation of motion with correct terms and signs. A1F: Correct acceleration. Accept 4.8 or AWRT 4.80. (Note that using 9.81 still gives 4.80 m s^{-2}). Follow through friction from part (c).
(e)	No air resistance force acting or No other forces acting on the box. or They (forces in the diagram) are the only forces that act. **OR** No turning effect (due to forces). or Forces are concurrent. OE	B1	1	B1: Correct assumption. Ignore irrelevant comments
	Total		**9**	

Q	Solution	Marks	Total	Comments
4(a)	$5900\times0.2=2500-800-R$ $(R=)2500-1180-800=520$ N	M1A1 A1	3	M1: Equation of motion for tractor and trailer as a single particle, with 2500, 800, *R* (which might be implied by seeing 1180 and 1700 or 1180 and 3300) and 5900 × 0.2 OE, with any signs. A1: Correct equation. A1: Correct *R*. If tension found first, do not award any marks until an equation for *R* is obtained. Award M1 for $3500\times0.2=\pm2500\pm R\pm1280$.
(b)	$T-800=2400\times0.2$ $(T=)800+480=1280$ N **OR** $3500\times0.2=2500-520-T$ $(T=)2500-700-520=1280$ N	M1A1 A1 (M1A1F) (A1F)	3 (3)	M1: Equation for trailer with 2400 and 800. A1: Correct equation. A1: Correct tension. M1: Equation for tractor with 3500, 2500 and 520. A1F: Correct equation. A1F: Correct tension. Follow through incorrect *R* from part (a). If the tension has been found in part (a) it only needs to be stated here.
(c)	1280 N	B1F	1	B1F: Same answer as part (b). Do not accept –1280
	Total		**7**	
5	Case 1: where 0.6 is taken as positive $5\times4-4\times3=5\times0.6+4v$ $8=3+4v$ $v=1.25$ m s^{-1} Case 2: where 0.6 is taken as negative $5\times4-4\times3=5\times(-0.6)+4v$ $8=-3+4v$ $v=2.75$ m s^{-1}	M1A1 A1 M1A1 A1	6	M1: Conservation of momentum, with left hand side as $5\times4\pm4\times3$. A1: Correct equation (8 = 3 +4*v* OE). A1: Correct speed (1.25). M1: Seeing one of $8=-3\pm4v$ or $-8=3\pm4v$ or $32=-3\pm4v$ or $-32=3\pm4v$ OE A1: Seeing ±2.75 or $\pm\frac{11}{4}$ A1: Correct speed. Accept $\frac{11}{4}$ If *mg* used consistently instead of *m* deduct one mark, to give a maximum of 5 marks.
	Total		**6**	

Q	Solution	Marks	Total	Comments
6(a)	$\tan\alpha = \frac{4}{3}$ or $\cos\alpha = \frac{3}{5}$ or $\sin\alpha = \frac{4}{5}$ $\alpha = 53.1°$ AG	M1 A1	2	M1: Trig equation to find the angle with: cos with 3 or 4 in the numerator and 5 in denominator sin with 3 or 4 in the numerator and 5 in denominator tan with 3 and 4 in any position A1: Correct angle from correct working. (Allow 90 – 36.9 = 53.1°). Final answer must be 53.1 Note, for example, $\tan^{-1}\frac{4}{3} = 53.1$ scores M1A1
(b)	 (Note: diagram not needed for the award of marks)			
	$4^2 = 3^2 + v^2 - 2\times 3\times v\times\cos(180 - 53.1...)$ $v^2 + 3.6v - 7 = 0$ $v = 1.40$ or $v = -5.00$ $v = 1.40$ m s^{-1}	B1 M1A1 A1 dM1 A1	6	B1: For seeing 180 – 53.1 (= 126.9). M1: Using cosine rule with 3, 4, v and any angle. Must see v **and** v^2. A1: Correct equation. A1: Correct simplified quadratic. dM1: Solving the quadratic. A1: Selecting positive root. (Can be implied.) Accept 1.4 or 1.39
	OR $\frac{\sin(180 - 53.13)}{4} = \frac{\sin\theta}{3}$ $\theta = 36.87°$ $180 - 36.87 - 126.87 = 16.26°$ $\frac{v}{\sin 16.26°} = \frac{4}{\sin(180 - 53.13)}$ OR $\frac{3}{\sin 36.87°}$ $v = 1.40$ m s^{-1}	(B1) (M1A1) (A1) (dM1) (A1)	(6)	B1: For seeing 180 – 53.1 (= 126.9). M1: Using sine rule with 3, 4 and 126.9º. A1: Correct equation. A1: For finding 16.26. Accept 16.3 or 16.2 or 16.26... . dM1: Second application of sine rule with v and 3 or 4 with at least one correct angle. A1: Correct velocity. Accept 1.4 or 1.39. Note: the result below can be proved. $v = 4\sin\alpha - 3\cos\alpha$ SC4: seeing $4\sin\alpha - 3\cos\alpha$ with incorrect answer. SC6: seeing $4\sin\alpha - 3\cos\alpha$ with answer as 1.4 or 1.39.
	Total		**8**	

Q	Solution	Marks	Total	Comments
7(a)	$\mathbf{v} = (6\mathbf{i} + 2.4\mathbf{j}) + (-0.8\mathbf{i} + 0.1\mathbf{j})t$	M1A1	2	M1: Using constant acceleration equation to get **v**. A1: Correct expression for the velocity. Allow equivalent column vector answer.
(b)	$\mathbf{r} = (6\mathbf{i} + 2.4\mathbf{j})t + \frac{1}{2}(-0.8\mathbf{i} + 0.1\mathbf{j})t^2 + 13.6\mathbf{i}$ $\left(= (6t - 0.4t^2 + 13.6)\mathbf{i} + (2.4t + 0.05t^2)\mathbf{j}\right)$	M1A1 A1	3	M1: Use of $\mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$ or other constant acceleration equation. A1: Position vector with or without 13.6**i**. A1: Correct position vector.
(c)	$\mathbf{v} = (6 - 0.8t)\mathbf{i} + (2.4 + 0.1t)\mathbf{j}$ $6 - 0.8t = -(2.4 + 0.1t)$ $8.4 = 0.7t$ $t = \frac{8.4}{0.7} = 12$ s $\mathbf{r} = 28\mathbf{i} + 36\mathbf{j}$ $d = \sqrt{28^2 + 36^2} = 45.6$ m	B1 M1A1 A1 dM1A1 A1	7	B1: Velocity simplified into **i** and **j** components. Could be implied. M1: $6 - 0.8t = \pm(2.4 + 0.1t)$ A1: Correct equation. A1: Correct *t*. dM1: Finding position vector using their time. A1: Correct position vector. A1: Correct distance. Accept AWRT 45.6 Do not penalise the use of other methods, such as trial and improvement, to find the time.
	Total		**12**	

Q	Solution	Marks	Total	Comments
8(a)	$(V_H =)\dfrac{38.4}{2.4} = 16 \text{ m s}^{-1}$	M1A1	2	M1: Horizontal range divided by time. A1: Correct speed.
(b)	$3 = V_V \times 2.4 - \dfrac{1}{2} \times 9.8 \times 2.4^2$ $V_V = \dfrac{3 + 28.224}{2.4} = 13.01$ $V = \sqrt{13.01^2 + 16^2} = 20.6 \text{ m s}^{-1}$	M1A1 A1 dM1A1	5	M1: Equation to find the vertical component, with $s = \pm 3$, $t = 2.4$ and $a = \pm g$ or ± 9.8 or ± 9.81. A1: Correct equation with g or 9.8 or ± 9.81. A1: Correct vertical component. Accept AWRT 13. dM1: Finding speed using their answer from part (a) and their vertical component. A1:Correct final speed. Accept AWRT 20.6.
(c)	$\tan\alpha = \dfrac{13.01}{16}$ or $\sin\alpha = \dfrac{13.01}{20.6}$ or $\cos\alpha = \dfrac{16}{20.6}$ $\alpha = 39.1°$	M1A1F A1F	3	M1: Trig equation to find the angle with: cos with 13 or 16 in the numerator and 20.6 in denominator sin with 13 or 16 in the numerator and 20.6 in denominator tan with 13 and 16 in any position A1F: Correct equation. A1F: Correct angle. Accept AWRT 39° Follow through incorrect answers to part (a) and (b), provided their speed from (b) is the resultant of two components.
	Total		**10**	
	TOTAL		**75**	