AQA Maths Mechanics 1

Mark Scheme Pack

2006-2015

Version 1.0: 0106

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2006 examination – January series

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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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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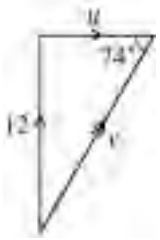
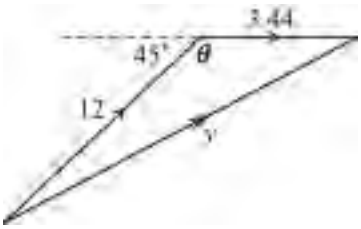
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

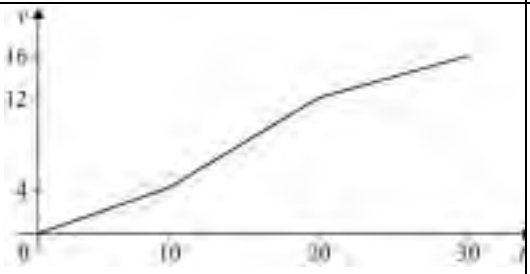
MM1B

Q	Solution	Marks	Total	Comments
1(a)	$\rightarrow 6\text{ms}^{-1}$ 2 kg ○ ○ 3 kg $\rightarrow v$			
	$2\times 6 = 3\times v$	M1		
	$v = 4\,\text{ms}^{-1}$	A1 A1	3	
(b)	$\rightarrow 6\text{ms}^{-1}$ 2 kg ○ ○ 3 kg $\leftarrow v$ $\rightarrow 4v$			
	$2\times 6 = -2\times v + 3\times 4v$	M1		all terms
	$12 = 10v$	A1		
	$v = 1.2\,\text{ms}^{-1}$	A1√	3	√sign error $(v = 0.857)$
	Total		**6**	
2(a)	$\mathbf{v} = 4\mathbf{i} + (-3\mathbf{i} + 12\mathbf{j})t$	M1 A1	2	use of $\mathbf{v} = \mathbf{u} + \mathbf{a}t$
(b)	$t = 0.5,\ \mathbf{v} = 2.5\mathbf{i} + 6\mathbf{j}$	B1√		√ 2 terms and t subs
	$\text{Speed} = \sqrt{(2.5^2 + 6^2)}$	M1		2 terms
	$\text{Speed} = 6.5\,\text{m s}^{-1}$	A1√	3	√ 2 terms
	Total		**5**	
3(a)(i)	$s = ut + \frac{1}{2}at^2$			
	$25 = 0 + 4.9t^2$	M1		full method
	$t = 2.26\,\text{sec}$ (2.236) $(\text{if g} = 10)$ (2.259)	A1	2	
(ii)	$v^2 = u^2 + 2as$			
	$v^2 = 0 + 2\times 9.8\times 25$	M1		
	$v = 22.1\,\text{m s}^{-1}$ (21.913) (22.14)	A1	2	
(b)	(Time longer) air resistance slows down motion, links with motion, no contradictions	M1 A1	2	(or Time less) package large so less distance to travel
	Total		**6**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
4(a)(i)	$v = 12.5 \quad (12.48)$	M1		$\frac{12}{\sin \text{ or } \cos \text{ of } 74^\circ \text{ or } 16^\circ}$
		A1	2	or Pythagoras with 3.44
(ii)				**SC** if Pythagoras used in circular solution M1 (1^{st} use) A1 A1 each answer (3 max)
	$\tan 74^\circ = \frac{12}{u}$	M1A1F		√incorrect v if used
	$u = 3.44$	A1	3	cao
(b)				Alt: 12 cos or sin 45° B1 Full method $v^2 = (12\sin 45)^2 + (3.44 + 12\sin 45)^2$ M1 $(8.485) \quad (11.925)$ A1 14.6 A1
	$\theta = 135^\circ$	B1		
	$v^2 = 3.44^2 + 12^2 - 2\times 12\times 3.44\cos 135^\circ$	M1		subs
		A1√		all correct
	$v = 14.6$	A1√	4	√ incorrect subtraction $\rightarrow 135°$
	Total		**9**	
5(a)	$s = ut + \frac{1}{2}at^2$			
	$0 = 2\frac{1}{2}ut - \frac{1}{2}gt^2$	M1		full method required for time
		A1		(equation of motion, or standard result)
	$0 = t\left(2\frac{1}{2}u - \frac{1}{2}gt\right)$	m1		
	$t = \frac{5u}{g}$	A1	4	(if $g = 9.8$ used, lose last A1)
(b)	$OA = 6u \times \frac{5u}{g}$	M1		
	$= \frac{30u^2}{g}$	A1	2	cao
(c)	$\text{speed}^2 = (6u)^2 + \left(2\frac{1}{2}u\right)^2$	M1		
	$\text{speed} = 6\frac{1}{2}u$	A1	2	cao
(d)	Least speed, at top, $= 6u$	B1	1	
	Total		**9**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)(i)		B1 B1 B1	3	3 straight lines correct end points sensible scales + labelled *v*/*t*
(ii)	$s=\frac{1}{2}\times10\times4+\frac{1}{2}\times(4+12)\times10+$ $\frac{1}{2}(12+16)\times10$ $s=240$ metres	M1 m1 A1 A1√	4	area attempt / full method / equation correct / √ one slip Or: equation attempted / full method / all correct / √ one slip
(iii)	Average speed $=\frac{240}{30}$ $=8\,\text{m s}^{-1}$	M1 A1√	2	√distance
(iv)	Greatest acceleration $=2^{\text{nd}}$ stage $=\frac{12-4}{10}$ $=0.8\,\text{m s}^{2}$	M1 A1	2	cao
(b)(i)	Less area below curve < area below line/velocity lower	B1 B1	2	no additional incorrect statements
(ii)	Change in velocity more gradual oe	B1	1	
	Total		**14**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(a)(i)	$T = 0.6 \times 9.8 = 5.88N$ Or $0.6g$	B1	1	
(ii)	Force $= 2T = \downarrow 11.76N$ Or 11.8 N	B1		Magnitude
	Or $1.2g$	B1	2	Direction
(b)(i)	$Q : 0.8g - T = 0.8a$	M1 A1		Either equation
	$T - 0.6g = 0.6a$	A1		
	$0.2g = 1.4a$	m1		Alternative for m1 A1 if solving for T
	$a = 1.4$	A1		m1 method for solving, A1 accurate attempt
	$T = 6.72$N	A1	6	cao | SC whole string to find a :$0.2g$ = 1.4a M1 a = 1.4 A1
(ii)	Force $= 2T = 13.44$N	B1	1	cao | to find T :M1 A1
	Total		**10**	
8(a)(i)	$R = 80\cos 25^\circ$	M1		component attempted
		A1		correct component
	$R = 72.5$N	A1	3	cao
(ii)	$F = 0.32 \times 72.5$	M1		condone inequality
	$F = 23.2$N	A1	2	cao
(iii)	$T + F = 80\cos 65^\circ$	M2		3 forces direction correct, component attempted
		A1		component
	$T = 10.6$N	A1√	4	√ friction
(iv)	$T = F + 80\cos 65^\circ$	M1		3 forces, direction correct, component attempted
		A1		component
	$T = 57.0$N (57N)	A1√	3	√ friction
(iv)	Mass $= \frac{80}{g} = (8.16\text{kg})$	B1	1	
(b)	$80\cos 65^\circ - F =$ mass $\times$ acceleration	M1		3 terms, component attempted
	$10.6 = \frac{80}{g} \times$ acc	A1		all correct
	acc $= 1.30\,\text{m s}^{-2}$ $(1.3\,\text{ms}^{-2})$	A1	3	cao
	Total		**16**	
	Total		**75**	

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MM1B

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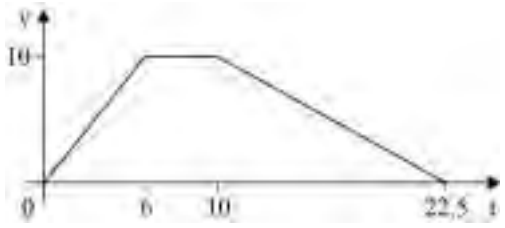
1(a)	$s = 0 + \frac{1}{2} \times 9.8 \times 4^2$	M1 A1		Full method Correct subs, accept ±9.8
	$s = 78.4$ metres	A1	3	CAO (need positive)
(b)	Average speed $= \frac{78.4}{4}$	M1		Also accept full method with use of velocities at $t = 0$ and 4, or at $t = 2$
	$= 19.6$ ms^{-1}	A1F	2	FT distance
(c)	Only force acting is weight	B1	1	Acc resistance forces negligible or ignored, (not friction, or air friction)
	Total		**6**	
2(a)	$P = 5 + 8\cos 60^\circ$	M1		Both relevant forces, component of 8N attempted
		A1		All correct
	$P = 9$	A1	3	CAO
(b)	$Q = 8\cos 30^\circ$	M1		Component of 8N attempted
	$Q = 6.93$ or $4\sqrt{3}$	A1	2	AWRT 6.93
	Total		**5**	
3(a)	$v = u + at$ $0 = 10 + (-0.8) \times t$	M1		Full method with u, v used correctly Accept ±0.8
	$t = 12.5$ sec	A1	2	CAO (correct subs and answer)
(b)		B1 B1 B1		each line, straight and correct end points SC: B1 for 3 lines giving correct shape but no values shown SC: first error in labelling times loses B1, repeated errors no further penalty
		B1	4	axes labelled v, t
(c)	distance $= \frac{1}{2} \times 10 \times (4 + 22.5)$	M1		Full correct method
		A1F		Correct subs, FT graph if final $t = 12.5$
	$= 132.5$ metres	A1F	3	FT one slip, AWRT 133
(d)	Acceleration unlikely to: change so abruptly or be constant or velocity unlikely to be constant	B1	1	
	Total		**10**	

MM1B (cont)

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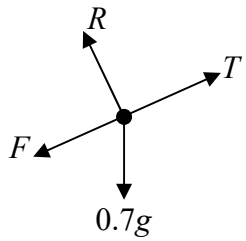
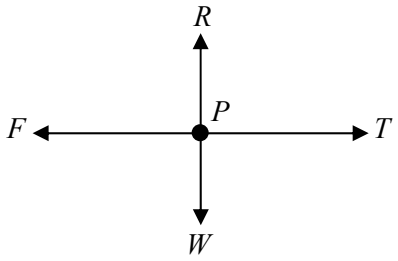
4(a)		B1	1	Accept W or mg (or 6.86) for weight Arrows and labels needed (can replace W with 2 correct components)
(b)	$R = 0.7g\cos 22^\circ$ $R = 6.36$ N	M1 A1 A1	3	component of weight attempted all correct, including signs CAO
(c)	$F = 0.25 \times 6.36$ $F = 1.59$N	M1 A1	2	CAO
(d)	$5.6 - 0.7g\sin 22^\circ - 1.59 = 0.7a$ $a = 2.06\text{ms}^{-2}$	M1 A2 A1F	4	4 terms with weight component attempted A marks -1 each error, accept $\pm 0.7a$ FT one error, accept $\pm$
	Total		**10**	
5(a)(i)		B1	1	Accept mg, $0.4g$ or 3.92 for weight Arrows and labels needed
(ii)	$F = 0.5 \times (0.4 \times 9.8)$ $F = 1.96$N	M1 A1	2	Need to see 0.4×9.8 or 3.92 used
(b)	$T - 1.96 = 0.4a$ $0.3g - T = 0.3a$ $a = 1.4\text{ms}^{-2}$	M1A1 M1A1 A1	5	Consistent reversal of signs in both equations 4 marks; reversal of signs in one equation, M1 A1 M1 A0 Sign change needs justification (whole string: equation, $0.3g - 1.96 = 0.7a$ M1A1 $a = 1.4$ A1) max 3/5
(c)	$v = 1.4 \times 3$ $v = 4.2\text{ms}^{-2}$	M1 A1	2	Full method CAO
(d)	P : Friction will cause speed to decrease Q : Gravity will cause speed to increase	M1 A1 M1 A1	4	Accept decelerate or comes to rest Accept accelerate
	Total		**14**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)	$\mathbf{d} = 3\mathbf{i} - 6\mathbf{j}$	B1		Accept $\pm\mathbf{d}$ or displacements of 3, 6 shown on a diagram
	$3\mathbf{i} - 6\mathbf{j} = (\mathbf{i} - 2\mathbf{j})t$	M1		Or equivalent method for t Accept ratio of vectors leading directly to ± 3
	$t = 3$	A1	3	CAO
(b)(i)	$\mathbf{r} = (\mathbf{i} - 2\mathbf{j}) \times 4 + \frac{1}{2} \times 2\mathbf{j} \times 16$	M1		Full method for vector expression giving change in position
		A1		For correct subs (gives $4\mathbf{i} + 8\mathbf{j}$)
	$+6\mathbf{i} - 4\mathbf{j}$	M1		
	$= 10\mathbf{i} + 4\mathbf{j}$	A1F	4	FT slip provided obtain vector expression $(\mathbf{u} = 0$ gives $6\mathbf{i} + 12\mathbf{j})$
(ii)	$A(3,2)$ $C(10,4)$			
	$\mathbf{d} = 7\mathbf{i} + 2\mathbf{j}$	M1		Attempt to find vector $\overrightarrow{AC}$ or $\overrightarrow{CA}$ (using candidate's C
	$\lvert\mathbf{d}\rvert = \sqrt{7^2 + 2^2}$			
	$AC = \sqrt{53} = 7.28$	A1F	2	FT **d** provided two non-zero components Accept $\sqrt{53}$
	Total		**9**	
7(a)	$57 = 24\cos 40^\circ \times t$	M1		Component attempted and acceleration $= 0$
		A1		All correct
	$t = 3.10$ sec	A1	3	CAO
(b)	$h = 24\sin 40^\circ \times 3.1 - \frac{1}{2} \times 9.8 \times 3.1^2$	M1		Component attempted & acceleration = 9.8
		A1		All correct
	$h = 0.734$ m	A1F	3	FT one slip e.g. +9.8 used Accept 2 s.f. answer, AWRT $0.71 - 0.74$
(c)(i)	horizontal, $u = 24\cos 40^\circ = 18.39$ ms^{-1}	B1		Seen anywhere in (c) accept 18.4
	vertical, $v = 24\sin 40^\circ - 9.8 \times 3.1$	M1		Component attempted & acceleration = 9.8
	$v = -14.95$ ms^{-1}	A1		(Accept -15.0)
	$V = \sqrt{(18.39)^2 + (-14.95)^2}$	M1		Use of candidate's u and new v (when $t = 3.1$)
	$V = 23.7$ ms^{-1}	A1F	5	FT use of candidate's u and v and new v when $t = 3.1$
(ii)	$\tan\theta = \frac{14.95}{18.39}$	M1		Use of candidate's u and v Accept inverted ratio
	$\theta = 39.1^\circ$ or 39.2° Also 140.8° or 140.9° } accept $\pm$	A1F	2	FT use of candidates u and v and V
	Total		**13**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)	$m(5\mathbf{i} - 3\mathbf{j}) + 0.2(2\mathbf{i} + 3\mathbf{j})$	M1		Momentum terms added
		A1	2	All correct
(b)(i)	$(0.2 + m)(k\mathbf{i} + \mathbf{j})$	B1		Seen or used to find m
	use of conservation of momentum	M1		Used with candidate's expressions in 2D equation or used to give one of the 1D equations below
	$-3m + 0.6 = 0.2 + m$			
	$m = 0.1$	A1	3	Full verification accepted, CAO
(ii)	$5m + 0.4 = 0.2k + mk$	A1		
	substitute m	m1		
	$k = 3$	A1	3	
	Total		**8**	
	TOTAL		**75**	

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Dr Michael Cresswell Director General

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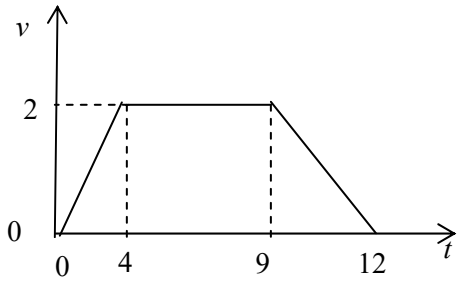
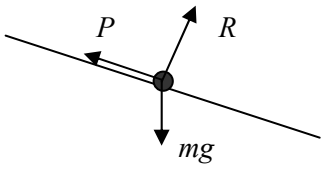
	$4=5v$			
	$v=\frac{4}{5}=0.8$	A1	3	Correct speed (for use of *mg* instead of *m* deduct the first A1)
(b)	$3\times4+2\times(-4)=3\times0.4+2v$	M1 A1		Four term equation for conservation of momentum. Correct equation
	$4=1.2+2v$			
	$v=\frac{4-1.2}{2}=1.4$	A1	3	Correct speed (for use of *mg* instead of *m* deduct the first A1)
			6	
2(a)		B1 B1 B1 B1	4	Starts and finishes at rest Correct shape Correct values on *t*-axis Correct values on *v*-axis Condone omission of the origin
(b)	$s=\frac{1}{2}(5+12)\times2$	M1		Use of the area under the graph (or equivalent) to find *s*
	or $s=\frac{1}{2}\times2\times4+5\times2+\frac{1}{2}\times2\times3=17$			
	$=17$	A1	2	Correct distance **SC** When 21 used instead of 12 allow full marks for $s=26$
(c)	$\max a=\frac{2}{4}=0.5$	B1		Maximum acceleration
	$300\times0.5=T-300\times9.8$	M1		Three term equation of motion using their *a*
		A1		Correct equation using $a=0.5$
	$T=2940+150=3090$	A1	4	Correct tension
			10	

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(a)	$F = \sqrt{6^2 + 5^2}$	M1A1		Obtaining an equation for F with square or root. Correct equation
	$= \sqrt{61} = 7.81$	A1	3	Correct force
	Alt			
	$\alpha = \tan^{-1}\left(\frac{5}{6}\right) = 39.8°$			
	$F = \frac{6}{\cos 39.8} = 7.81$ or	(M1A1)		Equation for F with a value for α. Correct equation
	$F = \frac{5}{\sin 39.8} = 7.81$	(A1)		Correct force
(b)	$\alpha = \tan^{-1}\left(\frac{5}{6}\right)$ or $\cos^{-1}\left(\frac{6}{7.81}\right)$ or $\sin^{-1}\left(\frac{6}{7.81}\right)$	M1 A1		Obtaining an equation for α using trigonometry. Correct equation (using their F)
	$= 39.8°$	A1	3	Correct angle
	Alt			Accept values between 39.7 and 39.9
	$\frac{\sin\alpha}{5} = \frac{\sin 90°}{\sqrt{61}}$			
	$\alpha = 39.8°$			
	Total		**6**	
4(a)	The string is light and inextensible or inelastic or taut	B1 B1	2	First assumption Second assumption
(b)	$6 = 0 + 4a$	M1		Finding a using a CA equation
	$a = \frac{6}{4} = 1.5$	A1	2	Correct a from correct working
(c)	$7 \times 9.8 - T = 7 \times 1.5$	M1A1		Three term equation of motion with F for the 7 kg particle. Correct equation
	$T = 68.6 - 10.5 = 58.1$	A1	3	Correct tension
(d)	$58.1 - F = 13 \times 1.5$	M1A1		Three term equation of motion with F for the 13 kg particle. Correct equation
	$F = 58.1 - 19.5 = 38.6$	A1		Correct F
	$R = 13.98 = 127.4$	B1		Correct R
	$38.6 = \mu \times 127.4$	dM1		Use of $F = \mu R$
	$\mu = \frac{38.6}{127.4} = 0.303$	A1	6	Correct coefficient of friction
			13	

MM1B (cont)

Q	Solution	Marks	Total	Comments
5(a)	$v = \sqrt{0.3^2 + 0.1^2} = \sqrt{0.1} = 0.316 \text{ ms}^{-1}$	M1A1	2	Use of Pythagoras to find *v*. Correct *v*
(b)	$\alpha = \tan^{-1}\left(\frac{0.3}{0.1}\right) = 71.6°$	M1A1 A1	3	Use of trigonometry with reasonable choice of sides to find α. Correct expression Correct angle **CAO**
(i)	$t = \frac{15}{0.3} = 50\text{s}$	M1 A1	2	Use of *s/v* to find *t* with *s* and *t* consistent Correct *t*
(ii)	$s = 50 \times \sqrt{0.1} = 15.8\text{m}$	M1A1	2	Use of their *t* in $t \times v$ to find *s* or the use of trigonometry. Correct distance **CAO**
	Total		**9**	
6(a)		B1	1	Correct diagram with arrows and labels Must not use *F* instead of *P* Condone resistance instead of *P*
(b)	$P = 100 \times 9.8 \sin 4°$ $= 68.4$	M1 M1 A1	3	Resolving weight (must see 100) Using $\sin 4°$ or $\cos 86°$ **AG** Correct *P* from correct working
(c)	$100a = 100 \times 9.8 \sin 5° - 100 \times 9.8 \sin 4°$ $a = \frac{100 \times 9.8 \sin 5° - 100 \times 9.8 \sin 4°}{100}$ $= 0.171$	M1 A1 A1 A1	4	Three term equation of motion Weight resolved correctly Correct equation Correct *a*. (Accept 0.170 or 0.17)
(d)	You would expect *P* to vary with the speed of the car.	B1	1	Correct explanation
			9	

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(a)	$0^2 = (50\sin 40°)^2 + 2\times(-9.8)h$	M1A1		Equation for h with $v = 0$ and a component of velocity. Correct equation
	$h = \dfrac{(50\sin 40°)^2}{2\times 9.8} = 52.7$	dM1 A1		Solving for h Correct h
	Alt			
	$0 = 50\sin 40° - 9.8t$	(M1)		Equation for t with $v = 0$ and a component of velocity
	$t = \dfrac{50\sin 40°}{9.8} = 3.280$	(A1)		Correct t
	$h = 50\sin 40°\times 3.280 - \dfrac{1}{2}\times 9.8\times 3.280^2$	(dM1)		Expression for h with a component of velocity
	$= 52.7$ ALLOW 52.6	(A1)	4	Correct h
(b)	$6 = 50\sin 40°t - 4.9t^2$	M1A1		Forming a quadratic in t. Correct terms with any signs
	$0 = 4.9t^2 - 50\sin 40°t + 6$	A1		Correct equation
	$t = \dfrac{50\sin 40° \pm \sqrt{(50\sin 40°)^2 - 4\times 4.9\times 6}}{2\times 4.9}$	dM1		Solving quadratic
	$= 0.192$ or 6.37 $t = 6.37$	A2	6	Correct solution selected
	Alt			
	$46.7 = 4.9t_1^2$	(M1) (dM1)		Finding two times Equation for time to go down
	$t_1 = 3.087$	(A1)		Correct time
	$t_2 = 3.280$	(A1)		Time to go up
	$t = 3.087 + 3.280 = 6.37$	(A2)		Correct total
	Total		**10**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)	$75\mathbf{i} = (5\mathbf{i} - 2\mathbf{j}) \times 10 + \frac{1}{2}\mathbf{a} \times 10^2$	M1		Equation to find **a** from $\mathbf{r} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$
		A1		Correct expression
	$\mathbf{a} = \frac{75\mathbf{i} - 50\mathbf{i} + 20\mathbf{j}}{50} = 0.5\mathbf{i} + 0.4\mathbf{j}$	A1	3	**AG** Correct **a** from correct working
(b)	$\mathbf{r} = (5\mathbf{i} - 2\mathbf{j}) \times 8 + \frac{1}{2}(0.5\mathbf{i} + 0.4\mathbf{j}) \times 8^2$	M1		Expression for **r** using $t = 8$ with no extra terms
		A1		Correct expressions
	$= 56\mathbf{i} - 3.2\mathbf{j}$	A1	3	Correct position vector
(c)	$\mathbf{v} = (5 + 0.5t)\mathbf{i} + (0.4t - 2)\mathbf{j}$	M1A1		Expression for **v**. Correct expression
	$0.4t - 2 = 0$	dM1		**j** component equal to zero
	$t = \frac{2}{0.4} = 5$	A1		Correct t
	$\mathbf{r} = (5\mathbf{i} - 2\mathbf{j}) \times 5 + \frac{1}{2}(0.5\mathbf{i} + 0.4\mathbf{j}) \times 5^2$	dM1		Expression for **r** using t from **j** component equal to zero
	$= 31.25\mathbf{i} - 5\mathbf{j}$			
	$= 31.3\mathbf{i} - 5\mathbf{j}$	A1	6	Correct position vector
	Total		**12**	
	TOTAL		**75**	

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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2007 examination - June series

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Registered address: AQA, Devas Street, Manchester M15 6EX
Dr Michael Cresswell Director General

Key to mark scheme and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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.

June 07

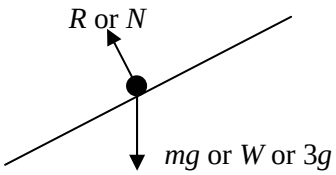
MM1B

Q	Solution	Marks	Total	Comments
1(a)	$v = 0 + 1.5 \times 9.8$	M1		Use of constant acceleration equation to find v
	$= 14.7 \text{ ms}^{-1}$	A1	2	AG Correct v from correct working $1.5 \times 9.8 = 14.7$ is not enough on its own
(b)	$h = \frac{1}{2} \times 9.8 \times 1.5^2$	M1		Use of constant acceleration equation with $a = 9.8$ to find h
	$= 11.0$ m (to 3 sf)	A1	2	Correct h Allow 11 m; ignore negative signs
(c)	$5^2 = 0^2 + 2 \times 9.8s$	M1		Use of constant acceleration equation with $u = 0$ to find s
		A1		Correct equation
	$s = \frac{25}{19.6} = 1.28$ m (to 3 sf)	A1	3	Correct s Accept 1.27
	OR			
	$t = \frac{5}{9.8} = 0.510$ $s = \frac{1}{2}(0+5)\frac{5}{9.8} = 1.28$ m			
	OR			
	$s = 0 + \frac{1}{2} \times 9.8 \times \left(\frac{5}{9.8}\right)^2 = 1.28$ m			
	Total		**7**	
2(a)	$2\begin{bmatrix} 3 \\ -2 \end{bmatrix} + 3\begin{bmatrix} -4 \\ 1 \end{bmatrix} = 5\mathbf{v}$	M1		Three term vector equation, with a '+' sign, for conservation of momentum
		A1		Correct equation Deduct this first A mark for use of mg
	$\mathbf{v} = \frac{1}{5}\begin{bmatrix} -6 \\ -1 \end{bmatrix} = \begin{bmatrix} -1.2 \\ -0.2 \end{bmatrix}$	A1	3	Correct velocity
(b)	$v = \sqrt{1.2^2 + 0.2^2} = 1.22 \text{ ms}^{-1}$	M1		Finding speed from their velocity in part (a) (Must include addition of two terms)
		A1F	2	Correct speed from their velocity Accept 1.21
	Total		**5**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(a)	$T_1 \sin 35° = T_2 \sin 35°$	M1		Resolving two forces and forming an equation, with different tensions for each string
	$T_1 = T_2$	A1	2	Correct result from correct working
	OR			
	$T_1 \cos 55° = T_2 \cos 55°$			
	$T_1 = T_2$			
(b)	$T_1 \cos 35° + T_2 \cos 35° = 2 \times 9.8$	M1		Resolving forces to form a three term vertical equation
	$T_1 \cos 35° + T_1 \cos 35° = 2 \times 9.8$	A1		Correct equation
		A1		T_1 or T_2 eliminated correctly
		dM1		Solving for T_1 or T_2
	$T_1 = \frac{2 \times 9.8}{2 \cos 35°} = 12.0$ N (to 3sf)	A1	5	Correct tension Accept 12 N or 11.9 N
(c)	$2 \times 40 \cos 35° = 9.8m$	M1		Forming an equation with two tensions to find m
		A1		Correct equation
	$m = \frac{80 \cos 35°}{9.8} = 6.69$ kg	A1	3	Correct mass Accept 6.68
	OR			
	$m = \frac{40}{11.96} \times 2$	(M1)		
		(A1)		
	$= 6.69$ kg	(A1)		
	Total		**10**	
4(a)	$T - 800 = 1200 \times 0.4$	M1		Three term equation of motion for the car
		A1		Correct equation
	$T = 800 + 480$			
	$= 1280$ N	A1	3	Correct tension Treat calculation of two tensions as two methods unless one selected Treat sum or difference of two tensions as an incorrect method
(b)	$3000 - 800 - F = 4000 \times 0.4$	M1		Four term equation of motion (truck or both)
		A1		Correct terms
		A1		Correct signs
	$F = 3000 - 800 - 1600$			
	$F = 600$ N	A1	4	AG Correct resistance force from correct working
	OR			
	$3000 - 1280 - F = 2800 \times 0.4$			
	$F = 3000 - 1280 - 1120$			
	$F = 600$ N			
(c)	Increase, because a greater tension would be needed so that the horizontal component would be the same as the tension above.	B1		Greater
		B1	2	Reason Second B1 dependent on the first B1 mark
	Total		**9**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
5(a)	$V = 150\tan 30°$	M1		Using trigonometry (usually tan or sine rule) to find V
	$= 86.6$ ms^{-1}	A1	2	AG Correct answer from correct working (Division by 2 only acceptable if sin30° or cos60° seen)
	OR $\frac{V}{\sin 30°} = \frac{150}{\sin 60°}$ AG $V = 86.6$ ms^{-1}			
(b)	$\frac{150}{v} = \cos 30°$	M1		Using trigonometry or Pythagoras to find v
		A1		Correct expression
	$v = \frac{150}{\cos 30°} = 173$ ms^{-1} (to 3sf)	A1	3	Correct answer
	Total		**5**	
6(a)(i)		B1	1	Correct diagram with arrows and labels
(ii)	$3a = 3g\sin 30°$	M1		Two term equation of motion
	$a = g\sin 30° = 4.9$ ms^{-2}	A1	2	AG Correct acceleration from correct working (Allow $a = g\sin 30°$)
(b)(i)	$5 = \frac{1}{2}a \times 2^2$	M1		Constant acceleration equation with $u = 0$
	$a = 2.5$ ms^{-2}	A1	2	AG Correct answer from correct working. (Use of $v = 5$ must be justified)
(ii)	$3 \times 2.5 = 3g\sin 30° - F$	M1		Three term equation of motion
		A1		Correct equation
	$F = 3g\sin 30° - 7.5$ $= 7.20$ N (to 3 sf)	A1	3	Correct F Accept 7.2 N
(iii)	$R = 3g\cos 30°$ (= 25.46)	M1		Resolving perpendicular to the slope to find R
		A1		Correct R
	$7.2 = \mu \times 3g\cos 30°$	M1		Use of $F = \mu R$
		A1F		Correct expression
	$\mu = \frac{7.2}{3g\cos 30°} = 0.283$	A1F	5	Correct μ Accept 0.282 (Follow through from incorrect F from above, but not an incorrect R)
(iv)	Reduce a, as the air resistance would reduce the magnitude of the resultant force or because the air resistance increases as the velocity increases towards its terminal value	B1		Reduces
		B1	2	Explanation Second B1 dependent on the first B1 mark
	Total		**15**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(a)	A particle or no spin	B1		First assumption
	No air resistance or no wind or only gravity acting	B1	2	Second assumption If more than 2 assumptions given, subtract one mark for each incorrect additional assumption
(b)	$0 = 25\sin 40° t - 4.9t^2$	M1		Equation for time of flight
		A1		Correct equation
	$0 = t(25\sin 40° - 4.9t)$	dM1		Solving for t
	$t = 0$ or $t = \dfrac{25\sin 40°}{4.9}$			
	Time of flight = 3.28 s	A1	4	AG Correct final answer from correct working (Verification method M1A1M1A0)
(c)	$s = 3.28 \times 25\cos 40° = 62.8$ m	M1		Finding range
		A1	2	Correct range
(d)	25 ms^{-1} at 40° **below** the horizontal	B1		Speed
		B1	2	Direction
(e)	$v_{min} = 25\cos 40° = 19.2$ ms^{-1}	M1		Horizontal component of velocity
		A1	2	Correct speed Accept 19.1 ms^{-1}
	OR			
	$v_{min} = \dfrac{62.807}{3.2795} = 19.2$ ms^{-1}			
	Total		**12**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)	$\mathbf{u} = 5\mathbf{i}$ or $\begin{bmatrix} 5 \\ 0 \end{bmatrix}$	B1	1	Correct velocity
(b)	$\mathbf{v} = 5\mathbf{i} + (-0.2\mathbf{i} + 0.25\mathbf{j})t$	M1		Use of constant acceleration equation, with **u** and **a** not zero
		A1	2	Correct velocity M1A0 for using 5**j** or just 5
	OR $\mathbf{v} = \begin{bmatrix} 5 - 0.2t \\ 0.25t \end{bmatrix}$			
(c)	$5 - 0.2t = 0$	M1 A1		Easterly component zero Correct equation
	$t = \frac{5}{0.2} = 25$ seconds	A1	3	Correct t
(d)	$\mathbf{r} = 5\mathbf{i} \times 25 + \frac{1}{2}(-0.2\mathbf{i} + 0.25\mathbf{j}) \times 25^2$	M1		Use of constant acceleration equation with t from part (c)
		A1F		Correct expression based on t from part (c)
	$= 62.5\mathbf{i} + 78.125\mathbf{j}$	A1		Correct simplification CAO
	$\theta = \tan^{-1}\left(\frac{62.5}{78.125}\right)$	dM1 A1F		Using tan to find the angle Correct expression based on t from part (c), with correct two values(either way)
	$= 038.7°$	A1	6	Correct angle Accept 38.6° or 039°
	OR			
	$\mathbf{r} = \frac{1}{2}(5\mathbf{i} + 6.25\mathbf{j}) \times 25$	(M1) (A1F) (A1)		
	$\theta = \tan^{-1}\left(\frac{5}{6.25}\right) = 038.7°$	(dM1) (A1F) (A1)		
	Total		**12**	
	TOTAL		**75**	

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ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2008 examination - January series

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√or ft or F	follow through from previous incorrect result	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
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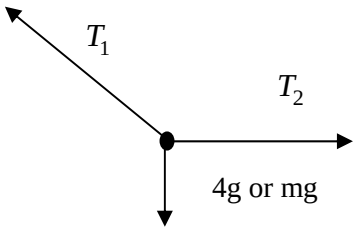
MM1B

Q	Solution	Marks	Total	Comments
1. (a)	$8 = \frac{1}{2} a \times 5^2$ **AG**	M1		Use of constant acceleration equation with $u = 0$ to find *a*.
	$a = \frac{2 \times 8}{25} = 0.64$ ms^{-2}	A1	2	Correct answer from correct working, showing evidence of solving for *a*. Allow verification / substitution.
(b)	$T - 70 \times 9.8 = 70 \times 0.64$	M1		Three term equation of motion for crate.
		A1		Correct equation
	$T = 730.8 = 731$ N to 3 sf	A1	3	Correct tension
(c)	$v = \frac{8}{5} = 1.6$ ms^{-1}	B1	1	Correct average speed. Accept $\frac{8}{5}$ Allow $\frac{3.2 + 0}{2} = 1.6$ ms^{-1}
	Total		**6**	
2.(a)	$U = \sqrt{10^2 - 8^2} = 6$	M1		Expression/equation for *U* based on a right angled triangle.
		A1	2	Correct *U*. Note $10^2 + 8^2$ gives M1A0
(b)	$\cos\theta = \frac{8}{10}$	M1		Use of trigonometry to find angle. Allow $\begin{cases} \tan\theta = \frac{8}{6} \text{ or } \frac{6}{8} \\ \sin/\cos\theta = \frac{8}{10} \text{ or } \frac{6}{10} \end{cases}$
	$\theta = 037°$	A1	2	Correct angle. Accept 36.9° etc. Note 143° gives M1A0
	Total		**4**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
3.(a)		B1	1	Diagram with three forces, labels and arrow heads. Different variables must be used for each tension
(b)	$T_1 \sin 30° = 4 \times 9.8$ $T_1 = \dfrac{4 \times 9.8}{\sin 30°} = 78.4$ N **AG**	M1 A1 A1	 3	Two term equation from resolving vertically. Must see a sin or cos term for M1 Correct equation Correct tension form correct working.
(c)	$T_2 = 78.4 \cos 30° = 67.9$ N	M1 A1	 2	Two term equation from resolving horizontally. Correct tension.
	Total		**6**	
4. (a)(i)	$5\begin{bmatrix} 2U \\ U \end{bmatrix} + 15\begin{bmatrix} V \\ -1 \end{bmatrix} = 20\begin{bmatrix} V \\ 0 \end{bmatrix}$ $5U - 15 = 0$ $U = 3$	M1 dM1 A1F	 3	Three term equation for conservation of momentum. Equation for U based on conservation of momentum. Correct value for U. Deduct one mark for using weight instead of mass.
(a)(ii)	$30 + 15V = 20V$ $30 = 5V$ $V = \dfrac{30}{5} = 6$	M1 A1F	 2	Equation for V based on conservation of momentum. Correct value for V. Deduct one mark for using weight instead of mass.
(b)	$v = \sqrt{3^2 + 6^2} = 3\sqrt{5} = 6.71$ ms^{-1}	M1 A1F	 2	Calculation of speed. Correct speed. Allow $\sqrt{45}$
	Total		**7**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
5(a)(i)	$0.2a = -0.2 \times 9.8 \sin 20°$ **AG**	M1		Two term equation of motion with weight resolved
		A1		Correct equation
	$a = -9.8 \sin 20° = -3.35$ ms^{-2}	A1	3	Correct acceleration from correct working SC No negative sign but otherwise correct award M1A1A0 Allow $a = -g \sin 20°$
(a)(ii)	$0 = 4^2 + 2 \times (-3.35)s$	M1		Use of constant acceleration equation with $v = 0$ and $u = 4$
		A1		Correct equation
	$s = \frac{16}{6.7} = 2.39$ m	A1	3	Correct distance
(a)(iii)	The puck slides back down the slope as the puck is at rest and the resultant force is now acting down the slope / no friction / smooth slope.	B1		Slides back down
		E1	2	Acceptable explanation
(b)(i)	$R = 0.2 \times 9.8 \cos 20°$ **AG**	M1		Finding normal reaction by resolving. Must see a trig term.
	$F = 0.5 \times 0.2 \times 9.8 \cos 20°$	M1		Use of $F = \mu R$
	$= 0.921$ N	A1	3	Correct friction from correct working.
(b)(ii)	$0.2a = -0.921 - 0.2 \times 9.8 \sin 20°$	M1		Three term equation of motion with the weight resolved
		A1		Correct equation
	$a = -7.96$ ms^{-2}	A1	3	Correct acceleration (with or without the minus sign, applied to both A1 marks)
(b)(iii)	The puck stays at rest because the friction has a maximum of 0.921 and the component of the weight down the slope is less (0.670)	B1		Stays at rest
		dE1	2	Acceptable explanation
	Total		**16**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)	$F = 0.4\times1000\times9.8$ $= 3920$ **AG**	M1 A1	2	Use of $F = \mu R$ Correct friction from correct working. Allow $F = 0.4\times9800$ Allow verification
(b)	$P - 3920 = 5000\times0.8$ $P = 7920$ N **AG**	M1 A1 A1	3	Three term equation of motion including an explicit 0.8 Correct equation Correct force from correct working. Allow $P = 5000\times0.8 + 3920$
(c)	$T - 3920 = 1000\times0.8$ $T = 4720$ N or $7920 - T = 4000\times0.8$ $T = 4720$ N	M1 A1 A1	3	Three term equation of motion Correct equation Correct tension
(d)	Friction is reduced because the normal reaction is reduced.	B1 E1	2	Friction reduced Acceptable explanation
	Total		**10**	
7(a)	It is a particle /No air resistance / lift forces act on the ball.	B1 B1	2	Particle Other acceptable assumption Deduct one mark for each additional incorrect assumption.
(b)	$V\sin40°t - \frac{1}{2}\times9.8t^2 = 0$ $t = \frac{V\sin40°}{4.9}$ $s = V\cos40°\times\frac{V\sin40°}{4.9}$ **AG** $= \frac{V^2\cos40°\sin40°}{4.9}$	M1 A1 dM1 A1 M1 A1	6	Vertical equation to find *t*. Correct equation (Equals zero may be implied) Solving for *t* Correct *t* Finding range with their *t* Correct range from correct working SC Quoting the formula for the range 2 marks.
(c)	$76 < \frac{V^2\cos40°\sin40°}{4.9} < 82$ $\sqrt{\frac{76\times4.9}{\cos40°\sin40°}} < V < \sqrt{\frac{82\times4.9}{\cos40°\sin40°}}$ $27.5 < V < 28.6$	M1 A1 A1 A1	4	An equation to find one value of *V*. Correct value for *V* Other value of *V* correct Correct range of values Accept 27.5 – 28.6 but not 28.6-27.5 For using values close to 76 and 82 deduct one mark.
	Total		**12**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)	$4\mathbf{i} = 5\mathbf{j} + 40\mathbf{a}$	M1		Forming a vector equation based on constant acceleration
	$\mathbf{a} = \dfrac{4\mathbf{i} - 5\mathbf{j}}{40} = 0.1\mathbf{i} - 0.125\mathbf{j}$ **AG**	A1		Correct equation
		dM1		Solving for **a**
		A1	4	Correct **a** from correct working
				For $\dfrac{4\mathbf{i} - 5\mathbf{j}}{40}$ on its own give M0
				Allow verification
(b)	$\mathbf{r} = 5\mathbf{j} \times 40 + \dfrac{1}{2}(0.1\mathbf{i} - 0.125\mathbf{j}) \times 40^2$	M1		Finding position vector
		A1		Correct expression
	$= 80\mathbf{i} + 100\mathbf{j}$	A1	3	Correct simplified result
(c)(i)	$\mathbf{v} = 5\mathbf{j} + (0.1\mathbf{i} - 0.125\mathbf{j})t$	M1		Expression for **v**
	$= 0.1t\mathbf{i} + (5 - 0.125t)\mathbf{j}$	A1		Correct expression for **v** seen or implied
	$5 - 0.125t = -0.1t$	dM1		Equating components, with or without a minus sign
	$5 = 0.025t$	A1		Correct equation
	$t = \dfrac{5}{0.025} = 200$	A1	5	Correct time.
(c)(ii)	$\mathbf{v} = 0.1 \times 200\mathbf{i} + (5 - 0.125 \times 200)\mathbf{j}$	M1		Finding velocity using their time
	$= 20\mathbf{i} - 20\mathbf{j}$	A1F	2	Correct velocity for their time
	Total		**14**	
	TOTAL		**75**	

Note for question 8. Consistent use of $\mathbf{u} = 4\mathbf{i}$ or $5\mathbf{i}$ or $\mathbf{a} = 0.1\mathbf{i} + 0.125\mathbf{j}$ award method marks only.

Version 1.0: 0608

ASSESSMENT and QUALIFICATIONS ALLIANCE

General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2008 examination - June series

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Key to mark scheme and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

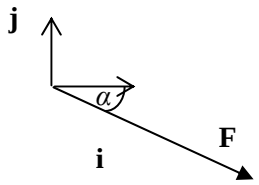
Where the answer can be reasonably obtained without showing working and it is very unlikely that the correct answer can be obtained by using an incorrect method, we must award **full marks**. However, the obvious penalty to candidates showing no working is that incorrect answers, however close, earn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

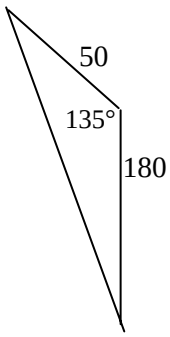
MM1B

Q	Solution	Marks	Total	Comments
1(a)	$s = \frac{1}{2}(3+10)\times 3$	M1		Finding distance by summing 3 areas or using formula for the area of a trapezium
		A1		Correct equation/3 correct expressions for the areas
	$= 19.5$ m	A1	3	Correct total distance
(b)	$a = \frac{3}{4} = 0.75$ ms^{-2}	B1	1	Correct acceleration as a decimal or as a fraction
(c)	$T - 400g = 400\times 0.75$	M1		Three term equation of motion containing T, $400g$ and 400×0.75 or equivalent
		A1F		Correct equation
	$T = 3920 + 300 = 4220$ N	A1F	3	Correct tension Only ft from $a = \frac{4}{3}$ (ft 4453 N or 4450 N from $a = \frac{4}{3}$ scores M1A1A1)
	Total		**7**	
2(a)	$\mathbf{F} = 5\mathbf{j} + 8\mathbf{i} - 7\mathbf{j} = 8\mathbf{i} - 2\mathbf{j}$	M1		Adding the two forces. For incorrect answers, evidence of adding must be seen
		A1	2	Correct resultant
(b)	$F = \sqrt{8^2 + 2^2} = \sqrt{68} = 8.25$ N	M1		Finding magnitude (must see addition and not subtraction)
		A1F	2	Correct magnitude Accept $2\sqrt{17}$, $\sqrt{68}$ or AWRT 8.25 (eg 8.246)
(c)		B1		Diagram with force in the correct quadrant and with correct direction shown by an arrow.
	$\tan\alpha = \frac{2}{8}$	M1		Using trig to find angle: if tan, 8 in denominator; if sin or cos, 8.25 or their answer to part (b) in denominator
	$\alpha = 14.0°$	A1	3	Correct angle Accept 14.1 or 14 or AWRT 14.0 (eg 14.04) M1 and A1 not dependent on B1
	Total		**7**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(a)(i)	$T = 6\times 9.8 = 58.8$ N	B1	1	Use of tension being equal to the weight Accept $6g$
(a)(ii)	$58.8 = T + 4\times 9.8$	M1		Three term equation for equilibrium containing 58.8, T and 4×9.8 or equivalent terms. For M1, 58.8 can be replaced by candidates answer to part (a)(i) provided it is not zero.
		A1		Correct equation
	$T = 58.8 - 39.2$ $= 19.6$ N	A1	3	Correct tension Accept $2g$
(b)	$6g - T = 6a$	M1		Three term equation of motion for 6 kg particle containing 58.8 or $6g$, T and $6a$.
		A1		Correct equation
	$T - 4g = 4a$	M1		Three term equation of motion for 4 kg particle containing 39.2 or $4g$, T and $4a$.
		A1		Correct equation
	$2g = 10a$ $a = 1.96$ ms^{-2}	A1	5	Correct acceleration Candidates who work consistently to obtain $a = -1.96$ gain full marks.
	Special Case for whole system $6g - 4g = 10a$	(M1)		Difference in weights equal to $10a$
		(A1)		A1: Correct equation
	$a = 1.96$	(A1)	(3)	A1: Correct acceleration
	Total		**9**	

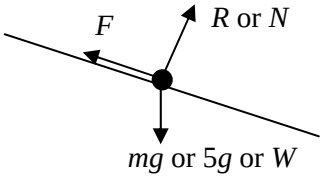
MM1B (cont)

Q	Solution	Marks	Total	Comments
4(a)		B1		Diagram (may be implied) The shape is sufficient, but 50 and 180 must be seen. The 135° may be replaced by 45° or be absent.
	$v^2 = 50^2 + 180^2 - 2\times 50\times 180\cos 135°$	M1		Use of cosine rule with 50, 180 and either 135° or 45°
		A1		Correct equation
	$v = 218$ ms^{-1}	A1	4	Correct result for v
	ALTERNATIVE SOLUTION	**OR**		
	$180 + 50\cos 45° = 215.36$	(M1)		Calculation of northerly component with 180, 50 and 45°
		(A1)		Correct component
	$50\sin 45° = 35.36$	(B1)		Correct westerly component
	$v = \sqrt{215.36^2 + 35.36^2} = 218$ ms^{-1}	(A1)		Correct result for v Accept AWRT 218
(b)	$\frac{\sin\alpha}{50} = \frac{\sin 135°}{218.24}$	M1		Use of the sine rule with 50, 135° or 45° and AWRT 218 or candidate's answer to part (a) to at least 3SF.
		A1F		Correct equation (must have 135° not 45°).
	$\alpha = 9.3°$	A1		Correct angle
	Bearing is 351°	A1	4	Three figure bearing
				Note the cosine rule could be used instead of the sine rule here. Apply mark scheme as for sine rule.
	ALTERNATIVE SOLUTION			
	$\tan\alpha = \frac{35.36}{215.36}$	(M1)		Use of trig to find angle
		(A1)		Correct equation
	$\alpha = 9.3°$	(A1)		Correct angle
	Bearing is 351°	(A1)		Three figure bearing
	Total		**8**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
5				Use of column vectors is acceptable throughout this question.
(a)	$\mathbf{v} = 20\mathbf{i} + (-0.4\mathbf{i} + 0.5\mathbf{j})t$	M1		Use of constant acceleration equation to find expression for **v**
		A1	2	Any correct expression.
(b)	$\mathbf{v} = (20 - 0.4t)\mathbf{i} + 0.5t\mathbf{j}$	M1		Simplifying **v**. (May be implied.) (Missing brackets may be condoned if followed by correct working.)
	$20 - 0.4t = 0$	m1		Putting **i** component equal to zero
	$t = \frac{20}{0.4} = 50$ seconds	A1	3	Correct time Candidates who are able to see the correct time without supporting working gain full marks. Condone $\frac{20\mathbf{i}}{0.4\mathbf{i}} = 50$
(c)	$\mathbf{r} = 20\mathbf{i} \times t + \frac{1}{2}(-0.4\mathbf{i} + 0.5\mathbf{j}) \times t^2$	M1		Use of constant acceleration equation to find expression for **r**
		A1	2	Any correct expression
(d)(i)	$\mathbf{r} = 20\mathbf{i} \times 100 + \frac{1}{2}(-0.4\mathbf{i} + 0.5\mathbf{j}) \times 100^2$	m1		Substituting $t = 100$ into their expression for **r** (dependent on M1 in part (c))
	$= 2000\mathbf{i} - 2000\mathbf{i} + 2500\mathbf{j}$ $= 2500\mathbf{j}$	A1		Correct simplified position vector ie $2500\mathbf{j}$
	Therefore due north	A1	3	Conclusion that helicopter is due north provided their position vector is of the form $k\mathbf{j}$, where $k>0$ Note if integration is used there is no need to prove that the constant is zero. Note marks for (d) (i) can be awarded if part c scores zero.
(d)(ii)	$\mathbf{v} = (20 - 0.4 \times 100)\mathbf{i} + 0.5 \times 100\mathbf{j}$	m1		Substituting $t = 100$ into their expression for **v** (dependent on M1 in part (a)) or use of other constant acceleration equation and their position vector (dependent on M1 in part (c))
	$= -20\mathbf{i} + 50\mathbf{j}$	A1		Correct simplified velocity
	$v = \sqrt{20^2 + 50^2} = 53.9$	A1	3	Correct speed (accept $10\sqrt{29}$) Note marks for (d) (ii) can be awarded if part a scores zero.
	Total		**13**	

MM1B(cont)

Q	Solution	Marks	Total	Comments
6(a)		B1	1	Correct force diagram with labels and arrows Accept components of the weight if shown in a different notation with the weight also shown. B0 if components are shown instead of the weight.
(b)	$(R =)5\times 9.8\cos 40° = 37.5$ N **AG**	M1 A1	2	Attempt at resolving perpendicular to the slope (eg 49sin40°) Correct value from correct working
(c)	$5\times 0.8 = 5\times 9.8\sin 40° - \mu\times 5\times 9.8\cos 40°$	B1 M1 A1 A1		Use of $F = \mu R$ at any stage and with any F but with R = 37.5 OE Three term equation of motion from resolving parallel to the slope with weight component, friction and *ma* term. Correct terms seen (may be as 31.5, 37.5μ (or F) and 4) Correct signs
	$\mu = \dfrac{5\times 9.8\sin 40° - 5\times 0.8}{5\times 9.8\cos 40°} = 0.733$	m1 A1	6	Solving for μ A1: Correct value for μ Allow 0.732 but not $\frac{11}{15}$ unless converted to a decimal
(d)	There is less friction so the coefficient of friction must be less.	B1 B1	2	Less friction Smaller coefficient of friction If the answer and explanation contradict each other, award no marks
	Total		**11**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(a)(i)	$0 = 40\sin 35° t - 4.9t^2$	M1		Equation to find time of flight with 40, sin/cos35° and –4.9 or $-\frac{g}{2}$
		A1		Correct equation
	$t = \frac{40\sin 35°}{4.9} = 4.68$ s **AG**	m1 A1	4	Solving for t Correct time from correct working Note: candidates must have a method for the complete time of flight before any marks can be awarded. Condone the use of a formula for the time of flight.
(a)(ii)	$AB = 40\cos 35° \times 4.682 = 153$ m	M1		Calculating the range using 40, cos/sin35° and 4.68 and acceleration zero.
		A1	2	Correct range Accept AWRT 153
(b)	$-1 = 40\sin 35° t - 4.9t^2$ $4.9t^2 - 40\sin 35° t - 1 = 0$	M1		Equation to find time of flight with a ±1, 40, sin/cos35° and –4.9 or $-\frac{g}{2}$
		A1 A1		Correct terms Correct signs
	$t = \frac{40\sin 35° \pm \sqrt{(40\sin 35°)^2 - 4 \times 4.9 \times (-1)}}{2 \times 4.9}$	m1		Solving quadratic equation
	$t = 4.73$ or $t = -0.0432$	A1		Accept AWRT 4.73 or 4.72
	$t = 4.73$	A1	6	Rejection of negative solution indicated (Only 4.73 or 4.72 given award 5/6 marks)
	Alternative methods based on finding two times. For example, $t = 4.682 + 0.044 = 4.73$ $t = 2.341 + 2.384 = 4.73$	(M1) (A1) (m1) (A1) (A1) (A1)		Addition of two times Use of AWRT 4.68 or AWRT 2.34 Calculation of time for 'second' part Correct expression for time for 'second' part Correct time (Allow AWRT 0.04 or AWRT 2.38) Correct total time Accept 4.72
	Total		**12**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)	$2m - 2\times3 = m\times(-0.5) + 3\times0.5$	M1		Equation for conservation of momentum with four terms: $2m$, 2×3, $0.5m$ and 3×0.5 regardless of signs.
		A1		Correct equation with correct signs
	$2.5m = 7.5$			
	$m = 3$ kg	A1	3	Correct mass Arguments based on the symmetry of the situation that lead to $m = 3$ can be awarded full marks. Note: Consistent use of mg instead of m: deduct one mark. Note: Use of all positive signs leads to $m = -3$, which might be changed to +3 by candidates (M1A0A0). Note: $m = 3$ can be obtained via $1.5m = 4.5$, which will usually score M1A0A0
(b)	$2m - 2\times3 = m\times0.5 + 3\times0.5$	M1		Four term equation for conservation of momentum with ±0.5 for both velocities (no marks for $3m\times0.5$)
		A1		Correct equation
	$1.5m = 7.5$			
	$m = 5$ kg	A1		Correct mass for velocity used
	or			
	$2m - 2\times3 = m\times(-0.5) + 3\times(-0.5)$	M1		Equation for conservation of momentum with opposite sign for the 0.5
	$2.5m = 4.5$			
	$m = 1.8$ kg	A1	5	Correct mass for the velocity used
	Total		**8**	
	TOTAL		**75**	

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General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2009 examination - January series

Final

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Dr Michael Cresswell Director General

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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	$2.5\times12+1.5\times4=4v$	M1		M1: Three term momentum equation, correct values but condone incorrect signs.
		A1		A1: Correct equation with correct signs.
	$v=\frac{36}{4}=9\ \text{ms}^{-1}$	A1	3	A1: Correct speed Note: Consistent use of *mg* instead of *m* throughout deduct 1 mark.
	Total		**3**	
2 (a)	$t=0,\ \ t=30,\ \ t=50$ seconds	B1		B1: Any one correct time
		B1	2	B1: The other two correct times Deduct one mark for each extra time if more than three times are given. (eg 0, 15, 30, 50 scores B1B0) (eg 0, 15, 30, 40, 50 scores B0B0) Condone 49 or 48 instead of 50
(b)	$s_1=\frac{1}{2}\times30\times5=75$ m **AG**	M1		M1: Finding distance by calculation of area. (Must see use of 0.5 or ½)
		A1	2	A1: Correct answer from correct working. (If candidates use two constant acceleration equations, both must be seen for the M1 mark.)
(c)	$s_2=\frac{1}{2}\times4\times20=40$ m	M1		M1: Finding distance using area of the second triangle.
		A1		A1: Correct distance (ignore any negative signs). (If candidates use two constant acceleration equations, both must be seen for the M1 mark.) Accept 38/36 from use of 49/48 instead of 50
	$s=75+40=115$ m	M1		M1: Addition of the 75 metres and their distance. (75 – 40 = 35 OE scores M0)
		A1F	4	A1F: Correct result using their value for second area. eg Accept 113/111 from use of 49/48 instead of 50
(d)	$s=75-40=35$ m	M1		M1: Difference between 75 and their value for the second distance. (Allow their distance – 75) (75 – (– 40) = 115 OE scores M0)
		A1F	2	A1F: Correct result using their value for second area. (eg 40 – 75 = –35 M1A0) eg Accept 37/39 from use of 49/48 instead of 50
	Total		**10**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(a)	$4a = 4g\sin 40°$	M1		M1: Resolving and application of Newton's second law. Allow cos40°.
		A1		A1: Correct expression.
	$a = g\sin 40° = 6.30\ \text{ms}^{-2}$ **AG**	A1	3	A1: Correct result from correct working. Must see 6.30 not 6.3. Just seeing $g\sin 40° = 6.30\ \text{ms}^{-2}$ scores full marks. Use of g = 9.81 gives 6.31, M1A1A0, but don't penalise again on the same script.
(b)	$0.9 = 0 + \frac{1}{2}\times a\times 0.6^2$	M1		M1: Use of a constant acceleration equation to find a, with s =0.9, u =0 and t = 0.6.
		A1		A1: Correct equation
	$a = \frac{0.9\times 2}{0.6^2} = 5\ \text{ms}^{-2}$	A1		A1: Correct acceleration
	ALT Method			
	$0.9 = \frac{1}{2}(\ 0 + v\ )\times 0.6$			
	$v = 3$			No marks at this stage.
	$3 = 0 + 0.6a$	(M1A1)		M1: Constant acceleration equation with u = 0 and t = 0.6.
		(A1)	3	A1: Correct equation
	$a = 5\ \text{ms}^{-2}$			A1: Correct acceleration.
(c)	The acceleration is reduced because of air resistance or the fact that there is friction.	B1	1	B1: Must mention air resistance/resistive forces or friction. Do not allow air friction.
	Total		**7**	

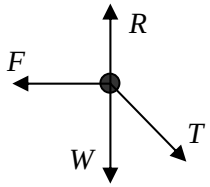
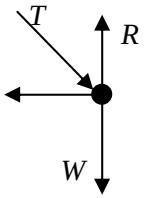
MM1B (cont)

Q	Solution	Marks	Total	Comments
4(a)	Peg is smooth	B1	1	B1: Correct assumption
(b)	String is light	B1		B1: First correct assumption
	String is inextensible or inelastic	B1	2	B1: Second correct assumption
	Tension is the same throughout the string			Note: Ignore any additional assumptions.
(c)	$11g - T = 11a$	M1		M1: Equation of motion for *A*, containing *T*, 11g or 107.8 and 11*a*.
		A1		A1: Correct equation
	$T - 9g = 9a$	M1		M1: Equation of motion for *B* containing *T*, 9*g* or 88.2 and 9*a*.
		A1		A1: Correct equation
	$2g = 20a$ $a = 0.98$ ms^{-2} **AG**	A1	5	A1: Correct acceleration from correct working. Note: Do not penalise candidates who consistently use signs in the opposite direction throughout, provided they give their final answer as 0.98. If final answer is – 0.98 don't award final A1 mark. **Special Case:** Whole String Method $2g = 20a$ and $a = 2g / 20 = 0.98$ OE M1A1A1 Use of g = 9.81 gives 0.981. If this is the first time award M1A1M1A1A0, but don't penalise again on the same script.

MM1B (cont)

Q	Solution	Marks	Total	Comments
4(d)(i)	$v = 0 + 0.98 \times 0.5 = 0.49$ ms^{-1}	M1 A1	 2	M1: Use of constant acceleration equation to find v with $u = 0$, $a = 0.98$ and $t = 0.5$. A1: Correct v
(d)(ii)	$s = 0 + \frac{1}{2} \times 0.98 \times 0.5^2 = 0.1225$ m **OR** $0.49^2 = 0^2 + 2 \times 0.98s$ $s = \frac{0.49^2}{2 \times 0.98} = 0.1225$ $d = 2 \times 0.1225$ $= 0.245$ m	M1 A1 (M1) (A1) M1 A1	 4	M1: Finding distance travelled by each particle with $u = 0$, $a = 0.98$ and $t = 0.5$. A1: Correct distance. Accept 0.122 or 0.123 M1: Finding distance travelled by each particle with $u = 0$, $a = 0.98$ and their v. A1: Correct distance. Accept 0.122 or 0.123 M1: Doubling distance or use of $d/2$ in their original equation. A1: Correct final distance. Allow 0.244 or 0.246. (Use of $0.5 \times 0.49 = 0.245$ scores zero unless justified)
				If candidates calculate the distance first award marks as above (see (d)(i)) or: M1: Use of constant acceleration equation to find v with $u = 0$, $a = 0.98$ and $s = 0.1225$. A1: Correct v **Note: If parts (i) and (ii) are not separated or clearly labelled still award marks for both parts if justified.**
	Total		**14**	

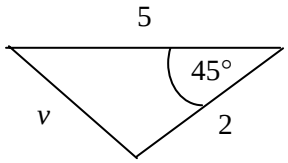
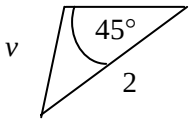
MM1B (cont)

Q	Solution	Marks	Total	Comments
5(a)		B1	1	B1: Diagram with four forces showing arrow heads and labelled. Allow *mg* or 8*g*. Allow *T* or 40 or other reasonable notation. Allow μR. Direction of friction must be to the left. Any components must be shown in a different style.
	OR 			
(b)	$8g + 40\sin 30° (= R)$	M1		M1: Expression for normal reaction, with *mg* or 8*g* and 40sin30° or 40cos30°. Allow incorrect signs.
		A1		A1: Correct expression with correct signs.
	$(R =) 98.4$ N **AG**	A1	3	A1: Correct value from correct working. Use of $g = 9.81$ gives 98.5 N. Do not penalise if you have already done so earlier in the script. Otherwise penalise by 1 mark.
(c)	$F = 40\cos 30° = 34.6$ N	M1		M1: Use of 40cos30° or 40sin30°. Award M0 if any extra terms.
		A1	2	A1: Correct value for friction. Don't need to see *F*.
(d)	$40\cos 30° \le \mu \times 98.4$	M1		M1: Use of $F \le \mu R$ (or $F = \mu R$). Must use *R* = 98.4 and a positive value for *F*.
		A1F		A1F: Correct inequality or equation Allow use of $F = \mu R$ throughout.
	$\mu \ge \frac{40\cos 30°}{98.4}$			
	$\mu \ge 0.352$	A1F	3	A1F: Correct minimum value. For follow through must use *R* = 98.4 and their value for *F* from part (c). For example use of sin 30° in part (c) gives 0.203.
	Total		**9**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)	Resultant $= (6\mathbf{i} - 3\mathbf{j}) + (3\mathbf{i} + 15\mathbf{j})$ $= 9\mathbf{i} + 12\mathbf{j}$	M1 A1	2	M1: Summing the two vectors A1: Correct resultant
(b)	Magnitude $= \sqrt{9^2 + 12^2}$ $= 15$ N	M1 A1F	2	M1: Finding magnitude with an addition sign. A1F: Correct magnitude based on their answer to part (a).
(c)	$1.5m = 9$ or $2m = 12$ $m = 6$ kg $m = 6$ kg	M1 A1F	2	M1: Applying Newton's second law to one or both of the components. A1F: Correct mass, follow through their answer to part (a). Do not award this mark if vector division with 2 components has been used, eg $\frac{9\mathbf{i} + 12\mathbf{j}}{1.5\mathbf{i} + 2\mathbf{j}} = 6$ or $6\mathbf{i} + 6\mathbf{j}$ etc without a correct previous statement gives M0A0
(d)(i)	$\mathbf{r} = \frac{1}{2}(1.5\mathbf{i} + 2\mathbf{j})t^2$	M1 A1	2	M1: Using a constant acceleration equation to find the position vector with $\mathbf{u} = 0\mathbf{i} + 0\mathbf{j}$ A1: Correct position vector.
(d)(ii)	$\mathbf{r} = \frac{1}{2}(1.5\mathbf{i} + 2\mathbf{j}) \times 2^2 = 3\mathbf{i} + 4\mathbf{j}$ $d = \sqrt{(3)^2 + (4)^2}$ $= \sqrt{25} = 5$	M1 A1	2	M1: Finding the position vector when $t = 2$. ($\mathbf{r} = (1.5\mathbf{i} + 2\mathbf{j}) \times 2 = 3\mathbf{i} + 4\mathbf{j}$ scores M0 unless it is clear how the 2 was obtained, possibly by a correct formula in (d) (i)) A1: Correct distance
	Total		**10**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(a)		B1		B1: Forming a triangle or diagram to find *v*. Do not penalise if the sides are not in proportion. (See example) 
	Followed by			(may be implied later by a correct equation)
	$v^2 = 2^2 + 5^2 - 2\times 2\times 5\cos 45°$	M1		M1: Using cosine rule with 2, 5 and any angle to find *v*. Equation must contain a negative sign and a cosine.
		A1		A1: Correct equation. Note that the implied B1 can be awarded at this stage.
	$v = 3.85459 = 3.85$ ms^{-1} (to 3sf) **AG**	A1		A1: Correct velocity from correct working with an intermediate calculation shown or a final value from a value with more than 3 sf.
	OR			
	$v_1 = 5 - 2\cos 45°$ (= 3.5858)	(M1)		M1: Two perpendicular equations, with 2, 5 and sin45° or cos45°.
	$v_2 = 2\cos 45°$ (= 1.414)	(A1)		A1: Both components with correct magnitude. Note that the implied B1 can be awarded at this stage.
	$v = \sqrt{(5 - 2\cos 45°)^2 + (2\cos 45°)^2}$			
	$v = 3.85459 = 3.85$ ms^{-1} (to 3sf) **AG**	(A1)	4	A1: Correct velocity from correct working with an intermediate calculation shown or a final value from a value with more than 3 sf.

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(b)	$\frac{\sin\theta}{2} = \frac{\sin 45°}{3.855}$	M1		M1: Use of sine rule, with 2, 3.855 or 3.85 or awrt 3.85 and any angle.
		A1		A1: Correct expression
	$\theta = 21.5°$	A1		A1: Correct angle. Awrt 21° or 22°
	Bearing = 270 +21.5 = 292°	A1		A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291°
	OR			
	$\frac{\sin\theta}{5} = \frac{\sin 45°}{3.855}$	(M1)		M1: Use of sine rule, with 5, 3.855 or 3.85 or awrt 3.85 and any angle.
		(A1)		A1: Correct expression
	$\theta = 113°$	(A1)		A1: Correct angle. Allow awrt 113° or 114°. Also allow awrt 66° or 67°.
	Bearing = 360 – (113.3 – 45) = 292°	(A1)		A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291°
	OR			
	$\tan\theta = \frac{2\cos 45°}{5 - 2\cos 45°}$	(M1)		M1: Consideration of perpendicular components using values from part (a).
		(A1)		A1: Correct expression
	$\theta = 21.5°$	(A1)		A1: Correct positive angle. Awrt 21° or 22° Also allow method leading to awrt 68° or 69°
	Bearing = 270 +21.5 = 292°	(A1)		A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291°
	OR			
	$\cos\theta = \frac{3.855^2 + 5^2 - 2^2}{2\times 5\times 3.855}$	(M1)		M1: Use of cosine rule, with 2, 3.855 or 3.85 or awrt 3.85 and 5.
		(A1)		A1: Correct expression
	$\theta = 21.5°$	(A1)		A1: Correct angle. Awrt 21° or 22°
	Bearing = 270 +21.5 = 292°	(A1)	4	A1: Correct bearing. Do not penalise candidates who include decimals. Accept 291°
	Total		**8**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8				If candidates have already used $g = 9.81$ do not penalise again on this question.
(a)	$0^2 = (\ 28\sin 50°\ )^2 + 2\times(-9.8)s$	M1 A1		M1: Equation to find the max height, with $v = 0$, $u = 28\sin 50°$ or $u = 28\cos 50°$ and –9.8 or $-g$. A1: Correct equation
	$s = \dfrac{(\ 28\sin 50°\ )^2}{2\times 9.8} = 23.5$ m	dM1 A1		dM1: Solving for the height A1: Correct height. Awrt 23.5 Note: If using a memorised formula, either 4 marks if final answer correct, 3 marks if substituted correctly but evaluated incorrectly, otherwise zero.
	OR			
	$0 = 28\sin 50° - 9.8t$	(M1)		M1: Equation to find time to the max height, with $v = 0$, $u = 28\sin 50°$ or $u = 28\cos 50°$ and –9.8 or $-g$.
	$t = \dfrac{28\sin 50°}{9.8} = 2.1887$	(A1)		A1: Correct time
	$s = 28\sin 50°\times 2.1887 - 4.9\times 2.1887^2 = 23.5$	(dM1) (A1)	4	dM1: Finding the height with their time and $u = 28\sin 50°$ or $u = 28\cos 50°$ and –4.9 or $-g/2$ A1: Correct height. Awrt 23.5

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(b)	$2 = 28\sin 50°t - 4.9t^2$	M1		M1: Quadratic equation in t with a ± 2, $u = 28\sin 50°$ or $u = 28\cos 50°$ and -4.9 or $-g/2$.
		A1		A1: Correct terms
		A1		A1: Correct signs for equation
	$0 = 4.9t^2 - 28\sin 50°t + 2$			
	$t = 0.0953$ or $t = 4.282$	dM1		dM1: Solving the quadratic equation
	$t = 4.282 = 4.28$ s (to 3 sf) **AG**	A1		A1: Correct larger time selected from two values.
	OR			
		(M1)		M1: Calculation of two times, which sum or differ to give the time of flight.
	$0 = 28\sin 50° - 9.8t$			
	$t = \dfrac{28\sin 50°}{9.8} = 2.1887$	(A1)		A1: Correct time by equation for zero vertical component of velocity or maximum height.
	OR			
	$23.5 = 28\sin 50°t - 4.9t^2$			
	$t = 2.1887$			
	$21.5 = 4.9t^2$	(dM1)		dM1: Correct expression for time to fall.
	$t = \sqrt{\dfrac{21.5}{4.9}} = 2.0947$	(A1)		A1: Correct time.
	2.1887 + 2.0947 = 4.2834 = 4.28 (to 3sf) **AG**	(A1)	5	A1: Correct time. Accept 4.29 if their answer rounds to 4.29.

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(c)	$v_x = 28\cos 50° \ (= 18.00 \text{ ms}^{-1})$	B1		B1: Horizontal component, need not be evaluated.
	$v_y = 28\sin 50° - 9.8 \times 4.282 = -20.51 \text{ ms}^{-1}$	M1		M1: Equation for vertical component with $28\sin 50°$ (or $28\cos 50°$ if sin50° used for horizontal component), -9.8 and awrt 4.28.
		A1		A1: Correct vertical component. Awrt ± 20.5
	$v = \sqrt{18.00^2 + 20.51^2} = 27.3 \text{ ms}^{-1}$	dM1		dM1: Finding speed with a + sign inside the square root.
		A1F	5	A1F: Correct speed. Awrt 27.3. Intermediate values can be implied by final answer.
	Total		**14**	
	TOTAL		**75**	

Version 1.0: 0609

General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2009 examination - June series

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 meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting 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 the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting 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 candidates' 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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Dr Michael Cresswell Director General

Key to mark scheme and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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)	$3\begin{bmatrix}6\\-2\end{bmatrix}+7\begin{bmatrix}-1\\4\end{bmatrix}=10\mathbf{v}$	M1		M1: Forming three term equation for conservation of momentum, but condone incorrect signs. Must see combined mass of 10.
		A1		A1: Correct equation with correct signs. Accept $3\begin{bmatrix}6\\-2\end{bmatrix}+7\begin{bmatrix}-1\\4\end{bmatrix}=3\mathbf{v}+7\mathbf{v}$ oe
	$\mathbf{v}=\frac{1}{10}\begin{bmatrix}11\\22\end{bmatrix}=\begin{bmatrix}1.1\\2.2\end{bmatrix}$	A1	3	A1: Correct velocity Consistent use of *mg* instead of *m* throughout deduct 1 mark
(b)	$v=\sqrt{1.1^2+2.2^2}$	M1		M1: Finding speed. Must be + inside square root.
	$v=2.46$ ms^{-1}	A1F	2	A1F: Correct speed for their velocity Accept $1.1\sqrt{5}$ or $\frac{11\sqrt{5}}{10}$ or 2.45 or AWRT 2.46
	Total		**5**	
2(a)	$16=\frac{1}{2}(u+4.2)\times5$ $32=5u+21$ $5u=11$	M1A1		M1: Using a constant acceleration equation to find u with $v=4.2$ and $a\neq9.8$. Could be derived from a velocity–time graph. A1: Correct equation
	$u=\frac{11}{5}=2.2$ ms^{-1}	A1		A1: Correct value for u
	OR First solution from (b) to find acceleration followed by any constant acceleration equation to find u: eg. $4.2=u+0.4\times5$ $u=2.2$	(M1) (A1) (A1)	3	Eg $s=\frac{1}{2}(u+v)t$ followed by $16=(u+4.2)\times5$ or similar scores M1A0

MM1B (cont)

Q	Solution	Marks	Total	Comments
2(b)	$4.2 = 2.2 + 5a$ $5a = 2$ $a = \frac{2}{5} = 0.4 \text{ ms}^{-2}$ OR $16 = 2.2 \times 5 + \frac{1}{2} \times a \times 5^2$ $16 = 11 + 12.5a$ $a = \frac{5}{12.5} = 0.4 \text{ ms}^{-2}$ OR $16 = 4.2 \times 5 - \frac{1}{2} \times a \times 5^2$ $16 = 21 - 12.5a$ $a = \frac{5}{12.5} = 0.4 \text{ ms}^{-2}$ OR $4.2^2 = 2.2^2 + 2a \times 16$ $a = \frac{17.64 - 4.84}{32} = 0.4 \text{ ms}^{-2}$	M1 A1F A1F (M1) (A1F) (A1F) (M1) (A1F) (A1F) (M1) (A1F) (A1F)	3	M1: Using a constant acceleration equation to find a with $u \neq 0$. A1F: Correct equation. Follow through for their incorrect u. A1F: Correct value for a, which must be > 0. Follow through for their incorrect u. (If acceleration found correctly in part (a) and simply quoted as answer to (b) give full marks).
	Total		**6**	
3(a)	Resultant Force = 3000 – 600 = 2400 N	M1 A1	2	M1: Difference between the two forces. A1: Correct magnitude of resultant force. Must be a positive answer. (600 – 3000 = –2400 scores M1A0)
(b)	$2400 = 1200a$ $a = \frac{2400}{1200} = 2 \text{ ms}^{-2}$	M1 A1	2	M1: Use of Newton's second Law to find acceleration. A1: Correct acceleration ($a = \frac{-2400}{1200} = -2 \text{ ms}^{-2}$ scores M1A0)
	Total		**4**	
4(a)	$v = \frac{16}{10} = 1.6 \text{ ms}^{-1}$ AG	B1	1	B1: Printed result obtained from correct division. Must see 16 divided by 10.
(b)	$V^2 = 1.6^2 + 1.2^2$ $V = \sqrt{4} = 2 \text{ ms}^{-1}$	M1A1 A1	3	M1: Equation to find V based on Pythagoras. Must involve addition of the squares of two components. A1: Correct equation A1: Correct V

MM1B (cont)

Q	Solution	Marks	Total	Comments
4(c)	$\sin\alpha = \frac{1.6}{2}$ or $\frac{1.2}{2}$	M1		M1: Trigonometric equation to find α.
	$\alpha = 53.1°$	A1F		A1F: Correct α. Follow through incorrect answer to (b).
	OR			
	$\cos\alpha = \frac{1.2}{2}$ or $\frac{1.6}{2}$	(M1)		Ignore diagrams
	$\alpha = 53.1°$	(A1F)		
	OR			
	$\tan\alpha = \frac{1.6}{1.2}$ or $\frac{1.2}{1.6}$	(M1)		
	$\alpha = 53.1°$	(A1F)	2	
(d)	The boat is a particle	B1	1	B1: Statement of particle assumption. Ignore any other assumptions.
	Total		**7**	
5(a)	$R = 14\times 9.8 = (137.2)$	M1		M1: Finding the normal reaction. Accept $14g$.
	$F = 0.25\times 137.2$ OR $F = 0.25\times 14\times 9.8$	M1		M1: Use of $F = \mu R$
	$F = 34.3$ N	A1	3	A1: Correct friction Use of $g = 9.81$ gives $R = 137.3$ and $F = 34.3$ so in this case do not penalise use of $g = 9.81$.
(b)	$6g - T = 6a$	M1A1		M1: Equation of motion for the particle, containing T, $6g$ or 58.8 and $6a$. A1: Correct equation with correct signs.
	$T - 34.3 = 14a$	M1A1		M1: Equation of motion for the block, containing T, 34.3 or their F and $14a$. A1: Correct equation with correct signs.
	$6g - 34.3 = 20a$			A1: Correct acceleration from correct working.
	$a = \frac{6g - 34.3}{20} = 1.225$ ms^{-2} AG	A1	5	If –1.225 is obtained from consistent working award 4 marks and if changed to +1.225 with an explanation, award full marks. Special Case: Whole string method $6g - 34.3 = 20a$ OE $a = 1.225$ award M1A1A1 Use of $g = 9.81$ gives $a = 1.228$ penalise use of $g = 9.81$ by deducting 1 mark, but don't penalise again on the same script.

MM1B (cont)

Q	Solution	Marks	Total	Comments
5(c)	$T-34.3=14\times1.225$ $T=17.15+34.3=51.5$ N	M1 A1		M1: Use of either of candidates equations of motion to find tension, with $a=\pm1.225$ and their F (Method 1). A1: Correct tension Accept 51.45 or 51.4. Don't penalise use of g = 9.81 if already done in part (b).
	OR			
	$6g-T=6\times1.225$ $T=6\times9.8-6\times1.225=51.5$	(M1) (A1)	2	
(d)	$v^2=0^2+2\times1.225\times0.8$ $v=\sqrt{1.96}=1.4$ ms^{-1}	M1A1 A1		M1: Use of constant acceleration equation to find speed with $u=0$. A1: Correct equation A1: Correct speed AWRT 1.4
	OR			
	$0.8=\frac{1}{2}\times1.225t^2$ $t=(1.1428)$ $v=1.225\times1.1428$ $=1.40$	(M1) (A1) (A1)	3	In method 2, no marks awarded for just finding t.
(e)	$v^2=1.4^2+2\times9.8\times0.5$ $v=3.43$ ms^{-1}	M1 A1F A1F		M1: Use of constant acceleration equation to find speed with u = 1.4 or their answer to part (d), a = ±9.8 and s = 0.5. A1F: Correct equation. Follow through their answer to part (d). A1F: Correct speed. Don't penalise use of g = 9.81 if already done earlier in question.
	OR			
	$0.5=1.4t+4.9t^2$ $t=0.2071$ $v=1.4+9.8\times0.2071$ $=3.43$ ms^{-1}	(M1) (A1F) (A1F)	3	In method 2, no marks awarded for just finding t.
	Total		**16**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)	$20\sin 50°t - 4.9t^2 = 0$ $t = \frac{20\sin 50°}{4.9}$ or $3.126... = 3.13$ s AG	M1A1 dM1 A1		M1: Equation to find time, with $y = 0$, $u = 20\sin 50°$ or $u = 20\cos 50°$ and ± 9.8 or $\pm g$. A1: Correct equation dM1: Solving for t. A1: Correct time from correct working. Must see division by 4.9 oe or more than 3sf Verification methods can only gain first 2 marks Special case $t = \frac{15.3}{4.9} = 3.12$ or 3.13 scores M1A1dM1A0
	OR $0 = 20\sin 50° - 9.8t$ $t = \frac{20\sin 50°}{9.8} = 1.563$ $T = 2 \times 1.563$ $= 3.13$	(M2) (A2)	4	M2: doubling time to max height (could use cos instead of sin) but must use ± 9.8 or $\pm g$. A2: Correct time from correct working. Don't penalise use of $g = 9.81$ if already done earlier on script. Would obtain time as 3.12 seconds. Note: If using a memorised formula either 4 marks if final answer correct, 3 marks if substituted correctly, otherwise zero. Special case $T = 2 \times 1.56 = 3.12$ or 3.13 scores M2A1
(b)	$PQ = 20\cos 50° \times 3.127 = 40.2$ m	M1 A1	2	M1: Calculation of range, could use sin instead of cos. A1: Correct range Accept 40.1
(c)	No change because a greater mass would not change the acceleration. OR Mass is not used in the equations.	B1 B1	2	B1: No change B1: Explanation following a correct statement.

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(d)	$0=(20\sin 50°)^2+2\times(-9.8)s$ $s=\dfrac{(20\sin 50°)^2}{2\times 9.8}=12.0$ m OR $t=\dfrac{3.13}{2}=1.565$ $h=20\sin 50°\times 1.565-4.9\times 1.565^2$ $=12.0$	M1 A1 A1 (M1) (A1) (A1)	3	M1: Equation to find height, with $u=20\sin 50°$ or $u=20\cos 50°$ and ± 9.8 or $\pm g$ (and t between 1.56 and 1.57 if method 2 used). A1: Correct equation A1: Correct height. Accept 12 or 11.9 or AWRT 12.0 In method 2, no marks awarded for just finding t. Don't penalise use of g = 9.81 if already done earlier on script. Should still get 12. Note: If using a memorised formula either 3 marks if final answer correct, 2 marks if substituted correctly, otherwise zero.
(e)	20 ms^{-1} at 50° below the horizontal.	B1 B1	2	B1: Speed AWRT 20 B1: Direction AWRT 50°. Must indicate below, or down. Could be implied by a diagram.
	Total		**13**	
7(a)	$\mathbf{v}=(-2\mathbf{i}+2\mathbf{j})+(0.25\mathbf{i}+0.3\mathbf{j})\times 20$ $\mathbf{v}=3\mathbf{i}+8\mathbf{j}$	M1 A1 A1	3	M1: Finding velocity using $\mathbf{v}=\mathbf{u}+\mathbf{a}t$. A1: Correct expression. A1: Correct velocity in simplest form.
(b)	$-2+0.25t=0$ $t=8$ s $\mathbf{v}=(2+0.3\times 8)\mathbf{j}=4.4\mathbf{j}$	M1A1 A1 A1	4	M1: One component equal to zero (either **i** or **j** component). A1: Correct equation A1: Correct time A1: Correct velocity
(c)	$\mathbf{r}=(-2\mathbf{i}+2\mathbf{j})\times 20+\dfrac{1}{2}(0.25\mathbf{i}+0.3\mathbf{j})\times 20^2+(9\mathbf{i}+7\mathbf{j})$ **OR** $\mathbf{r}=\dfrac{1}{2}\big((-2\mathbf{i}+2\mathbf{j})+(3\mathbf{i}+8\mathbf{j})\big)\times 20+(9\mathbf{i}+7\mathbf{j})$ $\mathbf{r}=19\mathbf{i}+107\mathbf{j}$	M1 A1 A1	3	M1: Finding position vector using a constant acceleration equation with or without the initial position with $t=20$. A1: Correct expression for position vector including initial position. A1: Correct position vector in simplest form.
(d)	$\mathbf{v}_{AVERAGE}=\dfrac{(19\mathbf{i}+107\mathbf{j})-(9\mathbf{i}+7\mathbf{j})}{20}$ $=\dfrac{10\mathbf{i}+100\mathbf{j}}{20}$ $=0.5\mathbf{i}+5\mathbf{j}$	M1 A1F	2	M1: Finding average velocity based on change of position. Subtraction of initial position must be seen or implied. Division by 8 scores M0 A1F: Correct average velocity. Follow through incorrect answers from part (c). Allow $\dfrac{\mathbf{u}+\mathbf{v}}{2}$
	Total		**12**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)(i)	$20\times9.8=R+60\sin30°$	M1		M1: Equation or expression for normal reaction with *mg* or 20*g* or 196 and 60sin30° or 60cos30°.
		A1		A1: Correct equation or expression with correct signs.
	$(R=)20\times9.8-60\sin30°=166$ N AG	A1	3	A1: Correct value from correct working. Must be positive.
				Don't penalise use of g = 9.81 if already done earlier on script. Should still get 166, but from 166.2.
(ii)	$166\mu=60\cos30°$	M1		M1: Use of $F=\mu R$, with R = 166 or 166.2. Do not allow inequalities here.
		M1A1		M1: Resolving horizontally with cos30° or sin30° oe.
	$\mu=\dfrac{60\cos30°}{166}$			A1: Correct equation
	$=0.313$	A1	4	Examples:
				$166\mu=60$ M1M0A0
				$166\mu=-60\cos30°$ M1M1A0
				A1: Correct coefficient of friction.
(b)	$20\times0.8=T\cos30°-0.313(20\times9.8-T\sin30°)$	B1		B1: $20g-T\sin30°$ oe seen.
		M1		M1: Three term equation of motion, where normal reaction is dependent on T.
		A1F		A1F: Correct equation
	$T=\dfrac{20\times0.8+0.313\times20\times9.8}{\cos30°+0.313\sin30°}=75.6$ N	dM1		dM1: Solving for T including factorisation.
		A1F	5	A1F: Correct tension.
				AWRT 75.6
				Follow through incorrect values of μ from part (a).
				Don't penalise use of g = 9.81 if already done earlier on script. Should get 75.7. Allow 75.8 if intermediate values rounded.
	Total		**12**	
	TOTAL		**75**	

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General Certificate of Education

Mathematics 6360

MM1B Mechanics 1B

Mark Scheme

2010 examination - January series

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 meeting attended by all examiners and is the scheme which was used by them in this examination. The standardisation meeting 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 the standardisation meeting each examiner analyses a number of candidates' scripts: alternative answers not already covered by the mark scheme are discussed at the meeting and legislated for. If, after this meeting, examiners encounter unusual answers which have not been discussed at the meeting 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 candidates' 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 and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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.

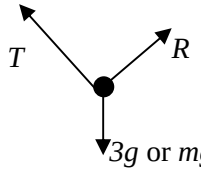
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

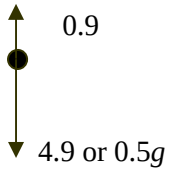
MM1B

Q	Solution	Marks	Total	Comments
1	$7\times10+3\times20=10v$	M1 A1		M1: Three term equation for conservation of momentum. Do not penalise inclusion of negative signs. Must see a combined mass of 10. A1: Correct equation. Accept $3v+7v$ in place of $10v$.
	$v=\frac{130}{10}=13\text{ ms}^{-1}$	A1	3	A1: Correct speed. Consistent use of *mg* instead *m* throughout deduct 1 mark.
	Total		**3**	
2(a)	$10=0\times2.5+\frac{1}{2}a\times2.5^2$	M1 A1		M1: Use of constant acceleration equation to find a with $u=0$. A1: Correct equation. NOTE: If v is found first, do not award any marks for part (a) until an equation to find a is produced. This could be from graphical method or from the use of $s=\frac{1}{2}(u+v)t$.
	$a=\frac{20}{2.5^2}=3.2\text{ ms}^{-2}$	A1	3	A1: Correct acceleration
(b)	$10=\frac{1}{2}(0+v)\times2.5$ $v=8\text{ ms}^{-1}$	M1 A1	2	M1: Use of constant acceleration equation to find v with $u=0$. A1: Correct speed from correct working.
	OR $10=\frac{1}{2}v\times2.5$ $v=8\text{ ms}^{-1}$			NOTE: If v is found in part (a), with correct working award full marks.
	OR $v^2=(0^2+)2\times3.2\times10$ $v=8\text{ ms}^{-1}$			NOTE: Accept 3.2 × 2.5 = 8
	OR $v=(0+)3.2\times2.5=8\text{ ms}^{-1}$ **AG**			
(c)	$t=\frac{90}{8}=11.25\text{ s}$	B1		B1: Calculation of correct additional time. Could be implied by later working.
	Total Time $=2.5+11.25$ $=13.75$ $=13.8\text{ s}$	M1 A1	3	M1: Addition of their time for the 90 metres and the 2.5 seconds. A1: Correct total time. Accept 13.75. NOTE: $22.5+2.5=25$ scores B0M1A0
(d)	$\frac{100}{13.75}=7.27\text{ ms}^{-1}$	M1 A1F	2	M1: Finding average speed. Must see 100 and their answer from part (c). A1F: Follow through candidate's time from part (c), regardless of working in part (c). Allow 7.25 ms^{-1} from 13.8 seconds.
	Total		**10**	

MM1B(cont)

Q	Solution	Marks	Total	Comments
3(a)		B1	1	B1: Correct force diagram with arrows and sensible labels. If *R* is shown as vertical award B0. If *F* is included, award B0 Accept a reflection of the diagram in a vertical line. Ignore components if shown with a different notation, eg dotted lines.
(b)	$(R=)3g\cos 60°$	M1		M1: Resolving perpendicular to the slope. Must see cos60° or sin30° or cos30° or sin60° and 3*g* or 29.4. NOTE: $\frac{3g}{2}=14.7$ or equivalent without the use of a trig term scores M0.
	$(R=)14.7$ **AG**	A1	2	A1: Correct value from correct working. NOTE: If candidates use g = 9.81, deduct one mark here. If candidates obtain 14.7 from 14.715 they will have used g = 9.81. Note: "*R* = " does not need to be seen.
(c)	$(T=)3g\sin 60°$	M1		M1: Resolving parallel to the slope. Must see cos60° or sin30° or cos30° or sin60° and 3*g* or 29.4.
	$(T=)25.5$	A1	2	A1: Correct value. AWRT 25.5 or truncation to 25.4. NOTE: If candidates use g = 9.81 again, do not penalise. Use of g = 9.81 gives 25.5 for the tension. Note: "*T* = " does not need to be seen.
	Total		**5**	

MM1B(cont)

Q	Solution	Marks	Total	Comments
4(a)	$v^2 = 0^2 + 2\times 9.8\times 15$ $v^2 = 294$ $v = 17.1$ ms^{-1}	M1 A1 A1	3	M1: Use of constant acceleration equation to find v with $u = 0$ and $a = \pm 9.8$. A1: Correct equation A1: Correct speed from correct working. Accept AWRT 17.1. Accept 17.15. Accept $7\sqrt{6}$ Note: If g = 9.81 is used for the first time deduct one mark. Should get 17.2 ms^{-1} from g = 9.81.
(b)(i)		B1	1	B1: Correct diagram, with arrows and labels. Must see 0.9 and 4.9 or 0.5g (or 4.905 if working with g = 9.81).
(b)(ii)	$4.9 - 0.9 = 0.5a$ $(a =)\dfrac{4}{0.5} = 8$ ms^{-2} **AG**	M1B1 A1	3	M1: Uses 0.5a. B1: Explicit statement of "4.9 – 0.9" or "mg – 0.9" or "0.5g – 0.9". A1: Correct acceleration from correct working. Can be awarded without the B1 mark. Must see $\dfrac{4.9(\text{or } 0.5g) - 0.9}{0.5}$ or $\dfrac{4}{0.5}$ or 4 = 0.5a Note: If g = 9.81 is used candidates will get 8.01 ms^{-2}. Deduct 1 mark if 8.01 is seen. Examples: $4.9 = 0.5a + 0.9$ $a = 8$ M1B0A0 $4 = 0.5a$ $a = 8$ M1B0A1 If candidates only write $a = \dfrac{4}{0.5} = 8$ award M0B0A0.
(b)(iii)	$v^2 = 0^2 + 2\times 8\times 15$ $v = 15.5$ ms^{-1}	M1 A1	2	M1: Use of constant acceleration equation to find v with $u = 0$ and $a = \pm 8$. A1: Correct speed from correct working. Accept AWRT 15.5 or truncated to 15.4. Accept $4\sqrt{15}$.
(b)(iv)	The air resistance force will not be constant, but changes **as the speed of the ball changes** (or **changes as the ball accelerates**).	B1	1	B1: Correct explanation, key words in bold. Do not award mark for statements that imply that the acceleration causes the air resistance to change.
	Total		**10**	

MM1B(cont)

Q	Solution	Marks	Total	Comments
5(a)	$(8\mathbf{i}+12\mathbf{j})+(4\mathbf{i}-4\mathbf{j})=12\mathbf{i}+8\mathbf{j}$	M1A1	2	M1: Adding forces to find resultant. A1: Correct resultant force.
(b)	$4\mathbf{a}=12\mathbf{i}+8\mathbf{j}$ or $(\mathbf{a}=)\ \dfrac{12\mathbf{i}+8\mathbf{j}}{4}$ $(\mathbf{a}=)3\mathbf{i}+2\mathbf{j}$ **AG**	M1 A1	2	M1: Use of Newton's second law with 4**a** and their answer to part (a). A1: Correct acceleration from correct equation.
(c)(i)	$40\mathbf{i}+32\mathbf{j}=\mathbf{v}+(3\mathbf{i}+2\mathbf{j})\times 20$ $40\mathbf{i}+32\mathbf{j}=\mathbf{v}+60\mathbf{i}+40\mathbf{j}$ $\mathbf{v}=(40\mathbf{i}+32\mathbf{j})-(60\mathbf{i}+40\mathbf{j})$ $=-20\mathbf{i}-8\mathbf{j}$ **AG**	B1 M1 A1	3	B1: Seeing 60i + 40j or (3i + 2j) × 20 M1: Use of constant acceleration equation with $t=20$ and $\mathbf{a}=3\mathbf{i}\pm 2\mathbf{j}$. A1: Correct velocity from correct working, with one of the intermediate lines of working (or equivalent) shown. Note: Candidates may use **u** instead of **v** in their working. Example: Starting with $\mathbf{v}=40\mathbf{i}+32\mathbf{j}+(3\mathbf{i}+2\mathbf{j})\times 20$ Scores B1M1A0. Note on Verification Method: $\mathbf{v}=(-20\mathbf{i}-8\mathbf{j})+(3\mathbf{i}+2\mathbf{j})\times 20$ B1M1 $=(-20+60)\mathbf{i}+(-8+40)\mathbf{j}$ $=40\mathbf{i}+32\mathbf{j}$ A1 Similarly, verification to confirm acceleration from the two velocities is acceptable.
(c)(ii)	$(\mathbf{v}=)(-20\mathbf{i}-8\mathbf{j})+(3\mathbf{i}+2\mathbf{j})t$	B1	1	B1: Correct velocity vector. Note "**v** = " does not need to be seen.
(c)(iii)	$(\mathbf{v}=)\ (3t-20)\mathbf{i}+(2t-8)\mathbf{j}$ $(3t-20)^2+(2t-8)^2=8^2$ $13t^2-152t+400=0$ $t=\dfrac{152\pm\sqrt{152^2-4\times 13\times 400}}{2\times 13}$ $t=4$ or $t=7.69$	M1 dM1 A1 A1 dM1 A1	6	M1: Velocity vector seen split into components. Condone omission of **i** and **j** Note: This can be implied by later working, such as the second line of this solution. dM1: Equation based on speed of 8. A1: Correct unsimplified equation. A1: Simplified quadratic equation dM1: Solving quadratic equation, to obtain two solutions. A1: Both correct solutions. Accept AWRT 7.7 or 7.6 or $\dfrac{100}{13}$. Note: Using calculator to solve quadratic is acceptable.
	Total		**14**	

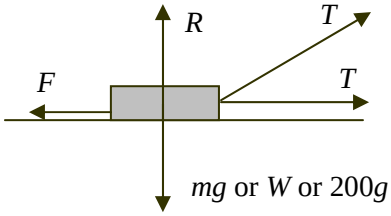
MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)		B1	1	B1: Force diagram with two arrows clearly in opposite directions. Must see 300 and one other label (a letter) or 550. Do not penalise if vertical forces included, even if wrong.
(b)	$T_1 - 300 = 500 \times 0.5$ $(T_1 =)\ 300 + 250$ $= 550$ N **AG**	M1 A1	2	M1: Three term equation of motion. A1: Correct force from correct working. Examples: $T_1 = 300 + 250 = 550$ N scores M0A0 $T_1 - 300 = 250$, $T_1 = 550$ N scores M1A1 $T_1 = 300 + 500 \times 0.5 = 550$ N scores M1A1 Just $300 + 500 \times 0.5 = 550$ N scores M0A0 $700 + T_1 = 2500 \times 0.5$, $T_1 = 550$ scores M0A0
(c)	$T_2 - 550 - 300 = 500 \times 0.5$	M1A1		M1: Four term equation of motion for Carriage 1 including 550 and 300 with mass 500 A1: Correct equation.
	$T_2 = 550 + 300 + 250 = 1100$ N	A1	3	A1: Correct force
	OR			M1: Three term equation of motion for Carriages 1 and 2 together including 300 twice or 600 with mass 1000. A1: Correct equation. Accept $T_2 = 600 + 500$ or similar.
	$T_2 - 600 = 1000 \times 0.5$	(M1) (A1)		
	$T_2 = 600 + 500 = 1100$ N	(A1)	(3)	A1: Correct tension
(d)	$P - 1100 - 400 = 2000 \times 0.5$	M1 A1F		M1: Four term equation of motion for engine with mass 2000, a force of 400 and their answer to part (c). A1F: Correct equation.
	$P = 1100 + 400 + 1000 = 2500$	A1F	3	A1F: Correct force
	OR			M1: Three term equation of motion for whole train with mass 3000 and 1000 (OE) force. A1F: Correct equation.
	$P - 1000 = 3000 \times 0.5$	(M1) (A1F)		
	$P = 1000 + 1500 = 2500$	(A1F)	(3)	A1F: Correct force Follow through from incorrect T_2 in part (c). Don't penalise candidates who use a letter other than P.
	Total		**9**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(a)	$5=\frac{1}{2}\times 9.8t^2$	M1 A1		M1: Equation based on vertical motion with no velocity component, with ±5 and ±9.8 A1: Correct equation
	$t=\sqrt{\frac{5}{4.9}}=1.01$ s **AG**	A1	3	A1: Correct time from correct working. Must see square root or $t^2=1.02$ OE Note: If g = 9.81 is used for the first time deduct one mark. Should still get 1.01 seconds.
(b)	$15=V\times\sqrt{\frac{5}{4.9}}$	M1		M1: Using distance = speed×time OE
	$V=15\sqrt{\frac{4.9}{5}}=14.8$	A1	2	A1: Correct speed. Accept AWRT 14.8 or 14.9. Note: If g = 9.81 is used for the first time deduct one mark. Should get 14.9 ms^{-1} from g = 9.81.
(c)	$v_V=\pm 9.8\times\sqrt{\frac{5}{4.9}}\left(=\pm 9.899\right)$ or $v_V=\sqrt{2\times 9.8\times 5}=9.899$	M1A1		M1: Calculating vertical component of velocity. A1: Correct value. Accept 9.9 or similar
	$v=\sqrt{9.899^2+14.8^2}=17.8$ ms^{-1}	dM1 A1F	4	dM1: Finding magnitude (with addition not subtraction of squares inside the square root). A1: Correct speed. Accept AWRT 17.8 or AWRT 17.9. Note: If g = 9.81 is used for the first time deduct one mark. Should get 17.9 ms^{-1} from g = 9.81
(d)	$\tan\alpha=\frac{9.899}{14.8}$ or $\frac{14.8}{9.899}$ $\alpha=34°$	M1 A1F A1F	3	M1: Use of one of trig equations shown. A1F: Anything which rounds to 34° or 56° A1F: 34° CAO (33° scores M1A1A0)
	$\sin\alpha=\frac{9.899}{17.8}$ or $\frac{14.8}{17.8}$ $\alpha=34°$	(M1) (A1F) (A1F)		Only follow through if all method marks in (b) and (c) have been awarded (except the dM if tan used) .
	$\cos\alpha=\frac{14.8}{17.8}$ or $\frac{9.899}{17.8}$ $\alpha=34°$	(M1) (A1F) (A1F)		
(e)	Particle Experiences no air resistance **or** no wind **or** only gravity **or** no other forces acting **or** no spin.	B1 B1	2	B1: Particle assumption B1: Other assumption. Ignore any other assumptions.
	Total		**14**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)		B1 B1	2	B1: *F*, *R* and *mg* (or equivalent) with arrows and labels. B1: Two **equal** tension forces with arrows and labels. Ignore components if shown with a different notation, eg dotted lines.
(b)	$R + T\sin 20° = 1960$ **OR** $R + T\sin 20° = 200\text{g}$	M1A1		M1: Resolving vertically with three terms. Must include sin20° or cos20° or sin 70° or cos70° with *T* and 200*g* or 1960. A1: Correct equation.
	$(R =) 1960 - T\sin 20°$ **OR** $(R =) 200g - T\sin 20°$	A1	3	A1: Correct expression for the normal reaction. Note: If $g = 9.81$ is used for the first time deduct one mark. Should get 1962 instead of 1960.
(c)	$T\cos 20° + T - F = 200 \times 0.3$	M1A1		M1: Four term equation of motion. Must include sin20° or cos20° or sin 70° or cos70° with *T* and a second *T* term with no trig. A1: Correct equation
	$T\cos 20° + T - 0.4(1960 - T\sin 20°) = 200 \times 0.3$	M1		M1: Use of friction law with their expression for *R*, provided that *R* has two terms. Note that this mark does not depend on any previous marks. Example If Candidate gives 1960 as answer to part (b), then: $F = 0.4 \times 1960 = 784$ scores M0 here
	$T = \dfrac{60 + 784}{\cos 20° + 1 + 0.4\sin 20°} = 406$	dM1 A1	5	dM1: Solving for *T*. Note: This mark requires both of the previous M marks. A1: Correct tension. Accept AWFW 406 to 407. Note: If $g = 9.81$ is used should get 407 instead of 406.
	Total		**10**	
	TOTAL		**75**	

Version 1.0

General Certificate of Education
June 2010

Mathematics MM1B

Mechanics 1B

Mark Scheme

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Key to mark scheme and abbreviations used in marking

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	MC	mis-copy
CAO	correct answer only	MR	mis-read
CSO	correct solution only	RA	required accuracy
AWFW	anything which falls within	FW	further work
AWRT	anything which rounds to	ISW	ignore subsequent work
ACF	any correct form	FIW	from incorrect work
AG	answer given	BOD	given benefit of doubt
SC	special case	WR	work replaced by candidate
OE	or equivalent	FB	formulae book
A2,1	2 or 1 (or 0) accuracy marks	NOS	not on scheme
–*x* EE	deduct *x* marks for each error	G	graph
NMS	no method shown	c	candidate
PI	possibly implied	sf	significant figure(s)
SCA	substantially correct approach	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. However, there are situations in some units where part marks would be appropriate, particularly when similar techniques are involved. Your Principal Examiner will alert you to these and details will be provided on the mark scheme.

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.

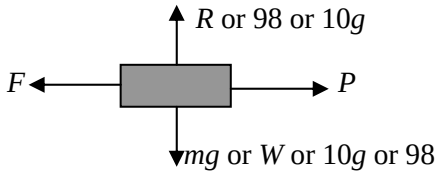
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

MM1B

Q	Solution	Marks	Total	Comments
1(a)	30 seconds	B1	1	B1: Correct statement of time.
(b)	$s_1 = \frac{1}{2} \times 40 \times 20 = 400$ m	M1 A1	2	M1: A method for calculating the first distance. Must see 40 and $\frac{1}{2}$. A1: Correct distance.
	OR			
	$s_1 = \frac{1}{2} \times (20 + 0) \times 40 = 400\,\text{m}$	(M1) (A1)		
	OR			
	$a = -\frac{20}{40} = -\frac{1}{2}$			Note on third method: Must see $-\frac{1}{2}$ or $-\frac{20}{40}$ plus attempt to find distance for M1.
	$0^2 = 20^2 + 2\left(-\frac{1}{2}\right)s$	(M1)		
	$s = 20^2 = 400$ m	(A1)		
(c)	$s_2 = \frac{1}{2} \times 50 \times 20 = 500\,\text{m}$	M1		M1: Method for finding the second distance and calculating the total distance.
	OR			
	$s_2 = \frac{1}{2} \times (0 + 20) \times 50 = 500\,\text{m}$	(M1)		
	OR			
	$a = \frac{20}{50} = \frac{2}{5}$			
	$20^2 = 0^2 + 2\left(\frac{2}{5}\right)s$	(M1)		Note on third method: Must see $\frac{2}{5}$ or $\frac{20}{50}$ plus attempt to find distance.
	$s = 20^2 \times \frac{5}{4} = 500$ m			
	Total = 400 + 500 = 900 m	A1F	2	A1F: Correct total distance. Award the follow through mark for correct addition of 500 and their answer to (b).
(d)	$v_{AVERAGE} = \frac{900}{120} = 7.5\ \text{ms}^{-1}$	M1 A1F	2	M1: Their total distance divided by 120 A1F: Correct average speed based on their answer to (c).
(e)	$120 \times 20 - 900 = 1500$ m	M1A1F	2	M1: Multiplication of 20 and 120 to find distance. Note: Award M1 if 2400 seen in this part. A1F: Correct difference based on their answer to (c) provided final answer is positive.
	Total		**9**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
2(a)		B1	1	B1: Correct force diagram with arrows and labels. Note: Award mark if forces drawn on the diagram in the question. Note: Do not accept 10 kg for the weight. Note: Do not accept μR or $0.5R$ for F.
(b)(i)	$(R = 10\times 9.8 =) 98$ N	B1	1	B1: Correct normal reaction. Accept 10g. No need to see the letter R or working.
(ii)	$(F \leq) 0.5\times 98$ $(F \leq) 49$	B1F	1	B1: Correct maximum value for friction. Accept 5g. No need to see the letter F or any working. Ignore any inequalities. For FT, must be 0.5 of candidate's answer to (b)(i).
(iii)	$(F =) 30$ N	B1	1	B1: Correct friction. Allow – 30.
(c)	$80 - 49 = 10\,a$	M1A1F		M1: Three term equation motion, containing 80, candidate's 49 and 10a (not 10ga) in any combination. A1F: Correct equation including signs.
	$a = 3.1\,\text{ms}^{-2}$	A1F	3	A1F: Correct acceleration. FT candidate's answer to (b)(ii).
	Total		**7**	
				Allow use of g = 9.81 (b)(i) 98. 1 B1 (b)(ii) 49.05 or 49.1 or 49 B1 (c) 3.095 or 3.09 or 3.1 M1A1A1

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(a)	$6\begin{bmatrix}2\\4\end{bmatrix}+m\begin{bmatrix}3\\-2\end{bmatrix}=6\begin{bmatrix}1\\3\end{bmatrix}+m\begin{bmatrix}7\\b\end{bmatrix}$	M1 A1		M1: Four term conservation of momentum equation. Allow sign errors. A1: Correct equation with correct signs. Vector equation may be implied by later correct working in this part of the question.
	$6\times2+3m=6\times1+7m$	A1		A1: Correct equation for correct component.
	$12+3m=6+7m$ $6=4m$			
	$m=1.5$	A1	4	A1: Correct m. Example if only $12+3m=6-7m$ without a vector equation award M1A0A0A0.
(b)	$6\times4+1.5\times(-2)=6\times3+1.5b$	B1F		B1F: Correct equation using m or candidates m from (a). B1F: Correct b from candidate's m from (a).
	$24-3=18+1.5b$ $3=1.5b$			
	$b=2$	B1F	2	Note: $b=\frac{6}{m}-2$.
	Total		**6**	
				Consistent use of mg instead of m throughout penalise 1 mark.

MM1B (cont)

Q	Solution	Marks	Total	Comments
4(a)	$50\cos\theta = 60\cos 48°$	M1A1		M1: Equation for two forces, with both forces resolved horizontally in the same way. (Accept $50\sin\theta = 60\sin 48°$ for M1.) A1: Correct equation.
	OR			
	$50\cos\theta = 60\sin 42°$	(M1) (A1)		
	OR (from vector triangle and sine rule)			
	$\dfrac{50}{\sin 42°} = \dfrac{60}{\sin(90-\theta)}$	(M1) (A1)		(M1: Use of sine rule with 50, 60 and 42°.) (A1: Correct equation.)
	OR (from Lami's Theorem)			
	$\dfrac{50}{\sin 138°} = \dfrac{60}{\sin(90+\theta)}$	(M1) (A1)		(M1: Use of Lami's Theorem with 50, 60 and 138°.) (A1: Correct equation.)
	For example: $\theta = \cos^{-1}\left(\dfrac{60\cos 48°}{50}\right)$ $= 36.59°$ $= 36.6°$ (to 3SF)	dM1 A1	4	dM1: Solving for θ. A1: Correct θ. Note: Final answer of 63.1° from using resolving incorrectly with sines award M1A0dM1A0. Accept 36.5 (truncation) and 36.7 and AWRT 36.6.
(b)	$50\sin 36.59° + 60\sin 48° = 9.8\,m$	M1 A1F		M1: Three term vertical equation, including *mg* with forces resolved vertically in the same way (accept $50\cos 36.59° + 60\cos 48° = 9.8\,m$ for M1). A1F: Correct equation.
	OR correct equivalent, for example:			
	$50\sin 36.59° + 60\cos 42° = 9.8\,m$	(M1) (A1F)		
	OR (from vector triangle and sine rule)			
	$\dfrac{50}{\sin 42°} = \dfrac{mg}{\sin 84.6°}$	(M1) (A1F)		(M1: Use of vector triangle and sine rule.)
	OR (from Lami's Theorem)			
	$\dfrac{50}{\sin 138°} = \dfrac{60}{\sin 95.4°}$	(M1) (A1F)		(M1: Use of Lami's Theorem.)
	For example: $m = \dfrac{50\sin 36.59° + 60\sin 48°}{9.8} = 7.59$	A1	3	A1: Correct value for *m* CAO. Accept 7.58, AWRT 7.6.
	Total		**7**	
				Allow use of $g = 9.81$ (b) 7.58 M1A1A1

MM1B (cont)

Q	Solution	Marks	Total	Comments
5(a)	$(v=)\sqrt{30^2+100^2}$ $=104.4$ $=104\ \text{ms}^{-1}\ \ (\text{to 3SF})$	M1A1 A1	3	M1: Equation or expression to find v based on Pythagoras. Must be +. For example: 10 900 oe scores M1. A1: Correct equation or expression, with square root. A1: Correct v. Accept 104.4.
(b)	$\theta=\tan^{-1}\left(\frac{30}{100}\right)$ or $\tan^{-1}\left(\frac{100}{30}\right)$ $=017°$ **OR** $\theta=\sin^{-1}\left(\frac{30}{104.4}\right)$ or $\sin^{-1}\left(\frac{100}{104.4}\right)$ $=017°$ **OR** $\theta=\cos^{-1}\left(\frac{100}{104.4}\right)$ or $\cos^{-1}\left(\frac{30}{104.4}\right)$ $=017°$	M1 A1F (M1) (A1F) (M1) (A1F)	2	M1: Trigonometric equation to find α. A1F: Correct α. Follow through incorrect answer from (b). Note: Subtracting 17 etc from other values such as 360 or 90 can not be ignored and will score M1. Accept 16 or 17 or 16.6 or 16.7 or 16.8. Also accept all of these with a zero in front, eg 016.
	Total		**5**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)	$12g - T = 12a$	M1A1		M1: Three term equation of motion, with $12g$ (or 117.6), $12a$ (not $12ga$) and T. A1: Correct equation
	$T - 8g = 8a$	M1A1		M1: Three term equation of motion, with $8g$ (or 78.4), $8a$ (not $8ga$) and T. A1: Correct equation
	$4g = 20a$			
	$a\left(=\frac{4g}{20}\right) = 1.96 \text{ ms}^{-2}$ AG	A1	5	A1: Correct acceleration from correct working. Note: Do not penalise candidates who consistently use signs in the opposite direction throughout, provided they give their final answer as 1.96. If final answer is – 1.96 don't award final A1 mark. Special Case: Whole String Method $4g = 20a$ and $a = \frac{4g}{20} = 1.96$ OE M1A1A1
(b)	$T = 8g + 8 \times 1.96 = 94.1\text{N}$	M1A1	2	M1: Use of three term equation of motion to find T, with a = 1.96. A1: Correct tension. Accept 94.08.
(c)(i)	$v = 0 + 1.96 \times 2 = 3.92 \text{ ms}^{-1}$	M1A1	2	M1: Use of constant acceleration equation to find v, with a = 1.96 and u = 0. A1: Correct v. Using s = 4 scores M0.
(ii)	$v^2 = 3.92^2 + 2 \times 9.8 \times 4$	M1 A1F		M1: Use of constant acceleration equation to find v, with $a = \pm 9.8$ and $u \neq 0$. A1F: Correct equation. FT initial velocity from (c)(i).
	$v = 9.68 \text{ ms}^{-1}$	A1F	3	A1F: Correct v. FT initial velocity from (c)(i). For example 11.8 from 7.84.

MM1B (cont)

Q	Solution	Marks	Total	Comments
(c)(iii)	$4 = \frac{1}{2}(-3.92 + 9.68)t$	M1A1 A1		M1: Use of $s = \frac{1}{2}(u+v)t$ A1: Correct values. A1: Correct signs.
	$t = 1.39$	dM1 A1	5	dM1: Solving for *t*. A1: Correct *t*.
	OR			
	$-4 = 3.92t - 4.9t^2$	(M1)		M1: Forming a quadratic with candidates *u* from (c)(i) or *v* from (c)(ii)with 4.9 or 9.8.
	$4.9t^2 - 3.92t - 4 = 0$	(A1)		A1: Correct terms in quadratic.
	$t = \frac{3.92 \pm \sqrt{3.92^2 - 4\times 4.9\times(-4)}}{2\times 4.9}$	(A1)		A1: Correct signs in quadratic.
	$t = 1.39$ or $t = -0.588$	(dM1)		dM1: Solving quadratic (do not penalise for negative discriminant).
	$t = 1.39$	(A1)		A1: Correct root seen (other root does not need to be seen).
	OR			
	$t_{up} + t_{down} = 0.4 + 0.4 + 0.588$	(M1) (A1) (dM1) (A1)		M1: Finding total time from two or three times. A1: 0.4 or 0.8 seen. dM1: Finding second or third time for downward motion.
	$= 1.39$ (to 3SF)	(A1)		A1: Obtaining 0.588 or 0.988. A1: 1.39. Accept 1.38.
	OR			
	$9.68 = -3.92 + 9.8t$	(M1) (A1) (A1)		M1: Use of $v = u + at$ A1: Correct values. A1: Correct signs.
	$t = \frac{13.6}{9.8} = 1.39$	(dM1) (A1)		dM1: Solving for *t* A1: Correct *t*
	Total		**17**	
				Use of $g = 9.81$ (a) 1.962 M1A1M1A1A0 (b) 94.2 M1A1 (c) (ii) 9.69 M1A1A1 (c) (iii) 1.39 M1A1A1dM1A1

MM1B(cont)

Q	Solution	Marks	Total	Comments
7(a)	$10\,\mathbf{a} = 9\,\mathbf{i} + 12\,\mathbf{j}$	M1		M1: Application of Newton's second Law with $m = 10$ in vector form.
	$\mathbf{a} = (0.9\,\mathbf{i} + 1.2\,\mathbf{j})\ \text{ms}^{-2}$	A1	2	A1: Correct acceleration. If acceleration incorrect follow their value through for the rest of this question.
(b)(i)	$\mathbf{r}(5) =$			
	$(2.2\,\mathbf{i} + 1\,\mathbf{j}) \times 5 + \frac{1}{2}(0.9\,\mathbf{i} + 1.2\,\mathbf{j}) \times 5^2$	M1		M1: Use of constant acceleration to find position vector at $t = 5$, with $\mathbf{u} \neq 0\,\mathbf{i} + 0\,\mathbf{j}$.
	$= 22.25\,\mathbf{i} + 20\,\mathbf{j}$	A1F		A1F: Correct position vector, for candidate's acceleration which must be a vector. Allow 22.3**i** + 20**j**.
	$d = \sqrt{22.25^2 + 20^2} = 29.9$ metres	dM1 A1F	4	dM1: Calculation of distance from position vector. Must see + sign. A1F: Correct distance, for their acceleration. Accept 30 from 22.3**i** + 20**j**.
(ii)	$\mathbf{v} = (2.2\,\mathbf{i} + 1\,\mathbf{j}) + (0.9\,\mathbf{i} + 1.2\,\mathbf{j})t$	M1 A1F	2	M1: Use of constant acceleration equation to find an expression for **v,** with $\mathbf{u} \neq 0\,\mathbf{i} + 0\,\mathbf{j}$. A1F: Correct **v** for their acceleration.
(iii)	$\mathbf{v} = (2.2 + 0.9t)\,\mathbf{i} + (1 + 1.2t)\,\mathbf{j}$	M1		M1: Equation involving both **i** and **j** components of their velocity. Could have incorrect signs, for example $2.2 + 0.9t = -(1 + 1.2t)$.
	$2.2 + 0.9t = 1 + 1.2t$	A1F		A1F: Correct equation.
	$1.2 = 0.3t$ $t = 4$	A1F	3	A1F: Correct time, for their acceleration.
	Total		**11**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)	$14.7\sin\alpha - 9.8t\,(=0)$	M1A1		M1: Equation for vertical velocity being zero at highest point. Must have $\sin\alpha$ with ± 9.8. A1: Correct equation.
	$t = \dfrac{14.7\sin\alpha}{9.8} = \dfrac{3\sin\alpha}{2}$ **AG**	A1	3	A1: Correct result from correct working.
	OR			
	$14.7\sin\alpha T - 4.9T^2\ (=0)$			
	$T = \dfrac{14.7\sin\alpha}{4.9} = 3\sin\alpha$	(M1)		All marks awarded for last line, from correct working.
	$t = \dfrac{3\sin\alpha}{2}$	(A1) (A1)		
(b)(i)	$7 = 14.7\sin\alpha\left(\dfrac{3\sin\alpha}{2}\right) - 4.9\left(\dfrac{3\sin\alpha}{2}\right)^2$	M1 A1		M1: Expression including vertical displacement at height 7, using expression from part (a) and with $\pm g$ or equivalent. A1: Correct expression.
	$7 = 11.025\sin^2\alpha$	dM1		dM1: Simplified expression with $\sin^2\alpha$.
	$\alpha = \sin^{-1}\left(\sqrt{\dfrac{7}{11.025}}\right) = 52.8°$	dM1 A1	5	dM1: Finding an angle. Must have previous dM1 mark. A1: Correct angle. Accept 52.7°, 52.9°.
	OR			
	$0^2 = (14.7\sin\alpha)^2 + 2\times(-9.8)\times 7$	(M1)		
	$\sin^2\alpha = \dfrac{2\times 9.8\times 7}{14.7^2}$	(A1) (dM1)		
	$\alpha = 52.8°$	(dM1) (A1)		
(ii)	$OA = 14.7\cos 52.8°\times 3\sin 52.8°$	B1M1		B1: Use of $3\sin\alpha$ with their α. M1: Finding horizontal displacement. including $14.7\cos\alpha$ with $3\sin\alpha$ or $\dfrac{3\sin\alpha}{2}$.
	$OA = 21.2$ m	A1	3	A1: Correct distance. Accept 21.3 m.
(c)	Ball is a particle/No spin. No air resistance/No wind/Constant acceleration of 9.8/Only force is weight.	B1 B1	2	B1: Particle assumption. B1: Air resistance assumption.
	Total		**13**	
	TOTAL		**75**	
				Use of g = 9.81: (a) M1A1A0 (b)(i) 52.8° or 52.9° M1A1dM1dM1A1 (b)(ii) 21.2 B1M1A1

Version1.0

General Certificate of Education (A-level)
January 2011

Mathematics MM1B

(Specification 6360)

Mechanics 1B

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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	$5\times 6=(m+5)\times 2.4$ $30=2.4m+12$ $m=\dfrac{30-12}{2.4}=7.5$	M1A1 A1	3	M1: Equation for conservation of momentum with correct number of terms. A1: Correct equation. A1: Correct mass CAO Consistent use of weight instead of mass penalise final A1 mark.
	Total		**3**	
2(a)	$s=\dfrac{1}{2}\times 10\times 4+10\times 4+\dfrac{1}{2}\times(4+7)\times 10+\dfrac{1}{2}\times 7\times 10$ $(=20+40+55+35)$ $=150$ m **OR** $s=\dfrac{1}{2}\times(10+20)\times 4+\dfrac{1}{2}\times(4+7)\times 10+\dfrac{1}{2}\times 7\times 10$ $(=60+55+35)$ $=150$ m **OR** $s=\dfrac{1}{2}\times 10\times 4+10\times 4+10\times 4+\dfrac{1}{2}\times 10\times 3+\dfrac{1}{2}\times 7\times 10$ $(=20+40+40+15+35)$ $=150$ m	M1M1A1 A1 (M1M1A1) (A1) (M1M1A1) (A1)	4	M1: Any one term correct. M1: A second term correct. A1: Correct expression for total distance. A1: Total distance correct.
(b)	Average Speed $=\dfrac{150}{40}=3.75$ ms^{-1}	M1 A1F	2	M1: Their total distance divided by 40. A1F: Correct average speed based on their distance from part (a). Must be correct to three or more significant figures.
(c)	$a=\dfrac{4}{10}=0.4$ ms^{-2}	M1 A1	2	M1: Any division involving the numbers 10 and 4. A1: Correct acceleration. CAO **Note on use of constant acceleration equations:** award M1 for correct equation with correct values and A1 for correct final answer.
(d)	$F=200000\times 0.4=80000$ N	M1A1F	2	M1: Multiplication of , 2×10^n , for any integer *n*, by candidate's acceleration from part (c). A1F: Correct force based on their answer to part (c) multiplied by 200000. Note: use of a = 2.5 gives 500000 N Accept 80kN
	Total		**10**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(a)(i)	$P - 500 = 2200 \times 0.8$ $P = 1760 + 500$ $= 2260$	M1A1 A1	3	M1: Equation of motion for car and caravan as a single body. Must see 2200 (or 1200+1000) multiplied by 0.8, and 500 (or 200+300). Allow sign errors. A1: Correct equation. A1: Correct value for *P*. (Award full marks for: (*P* =) 1760 + 500 = 2260 or similar to obtain correct final answer.)
	OR (If finding the tension first)			
	$P - 1100 - 200 = 1200 \times 0.8$ $P = 960 + 1100 + 200$ $= 2260$	(M1A1) (A1)		M1: Equation of motion for car with their value for the tension. Must see 1200 multiplied by 0.8, 200 and their tension. Allow sign errors. A1: Correct equation. A1: Correct value for *P*. (Award full marks for: (*P* =) 960 + 200 + 1100 = 2260 or similar to obtain correct final answer.)
(a)(ii)	$T - 300 = 1000 \times 0.8$ $T = 300 + 800$ $= 1100$	M1A1 A1	3	M1: Equation of motion for caravan. Must see 300 and 1000 multiplied by 0.8. Allow sign errors. A1: Correct equation. A1: Correct tension. CAO
	OR			
	$2260 - 200 - T = 1200 \times 0.8$ $T = 2260 - 200 - 960$ $= 1100$ N	(M1A1) (A1)		M1: Equation of motion for car. Must see 2260 (or candidate's *P*), 200 and 1200 multiplied by 0.8. Allow sign errors. A1: Correct equation. A1: Correct tension. CAO If candidates find tension first it must be stated in part (a)(ii) to gain any marks. The working does not have to be repeated if seen in part (a)(i).

MM1B (cont)

Q	Solution	Marks	Total	Comments
3(b)(i)	$15 = 7 + 0.8t$ $t = \frac{15-7}{0.8} = 10$ seconds	M1A1 A1	 3	M1: Use of a constant acceleration equation to find t, with 7, 15 and 0.8. A1: Correct equation. A1: Correct time. CAO
(b)(ii)	$15^2 = 7^2 + 2\times 0.8s$ $s = \frac{15^2 - 7^2}{1.6} = 110$ m **OR** $s = \frac{1}{2}(7+15)\times 10 = 110$ m **OR** $s = 7\times 10 + \frac{1}{2}\times 0.8\times 10^2 = 110$ m	M1A1 A1 (M1A1F) (A1F) (M1A1F) (A1F)	 3	M1: Use of a constant acceleration equation to find s, with 7, 15 and 0.8. A1: Correct equation A1: Correct distance. CAO M1: Use of a constant acceleration equation to find s, with 7, 15 and candidate's time. A1F: Correct equation. A1F: Correct distance. M1: Use of a constant acceleration equation to find s, with 7, 0.8 and candidate's time. A1F: Correct equation. A1F: Correct distance. If candidates find distance first it must be stated in part (b)(ii) to gain any marks. The working does not have to be repeated if seen in part (b)(i).
(c)	Resistance forces <u>vary with speed</u> (or velocity) **OR** Speed (or velocity) changes (or increases) **OR** It accelerates	B1	1	B1: Correct explanation. Must not mention friction in main argument
	Total		**13**	

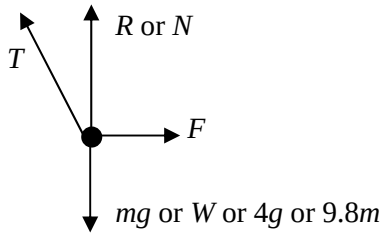
MM1B (cont)

Q	Solution	Marks	Total	Comments
4(a)	$(V=)\sqrt{2^2+4^2}=\sqrt{20}$ $=2\sqrt{5}$ $=4.47\ \text{ms}^{-1}$	M1A1	2	M1: Equation or expression to find V based on Pythagoras. Must be +. A1: Correct velocity. Accept $\sqrt{20}$, $2\sqrt{5}$, 4.47 or more accurate answer from 4.472135…
(b)	$\tan\alpha=\frac{4}{2}$ $\alpha=63.4°$ **OR** $\sin\alpha=\frac{4}{2\sqrt{5}}$ or $\frac{4}{4.47}$ $\alpha=63.4°$ **OR** $\cos\alpha=\frac{2}{2\sqrt{5}}$ or $\frac{2}{4.47}$ $\alpha=63.4°$	M1 A1F (M1) (A1F) (M1) (A1F)	2	M1: Trigonometric equation to find angle. Can be any of those as shown. For tan, fraction can be inverted. For sin, 2 can be used instead of 4. For cos, 4 can be used instead of 2. Can use their V from part (a). A1F: Correct angle. Accept 63 or AWRT 63.4 or 63.5.
(c)	$t=\frac{20}{4}=5\ \text{seconds}$ **OR** $t=\frac{\sqrt{500}}{\sqrt{20}}=5\,\text{seconds}$	M1 A1	2	M1: Division of distance by speed (for example, $\frac{10}{2}$ or $\frac{20}{4}$ or $\frac{\sqrt{500}}{\sqrt{20}}$ or $\frac{22.4}{4.47}$) Do not award M1 if distance and speed don't correspond (eg $\frac{10}{4}$ or $\frac{20}{2}$ or $\frac{20}{4.47}$) A1: Correct time CAO. Accept 5.00 or 5.0
	Total		**6**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
5(a)	$\mathbf{v} = (4\mathbf{i} + 0.5\mathbf{j}) + (-0.4\mathbf{i} + 0.2\mathbf{j})t$	M1A1	2	M1: Use of constant acceleration equation to find **v** with $\mathbf{u} \neq 0\mathbf{i} + 0\mathbf{j}$ A1: Correct **v**. (Could be done as a column vector.)
(b)(i)	$\mathbf{v} = (4\mathbf{i} + 0.5\mathbf{j}) + (-0.4\mathbf{i} + 0.2\mathbf{j}) \times 22.5$ $= -5\mathbf{i} + 5\mathbf{j}$	M1 A1	2	M1: Substitution of 22.5 into their expression for the velocity, even if no marks awarded in part (a). A1: Correct velocity CAO (Could be done using column vectors.)
(b)(ii)	North-west	B1	1	B1: Correct statement of direction. Accept 315°. Must follow from correct answer to (b)(i).
(c)	$(\mathbf{v} =)(4 - 0.4t)\mathbf{i} + (0.5 + 0.2t)\mathbf{j}$ $5^2 = (4 - 0.4t)^2 + (0.5 + 0.2t)^2$ $0.2t^2 - 3t - 8.75 = 0$ $t^2 - 15t - 43.75 = 0$ $t = 17.5$ or $t = -2.5$ $t = 17.5$	B1 M1A1 A1 dM1 A1	6	B1: Grouping **i** and **j** components at some point in the solution. (Could be done as column vectors.) Allow $5 = (4 - 0.4t)\mathbf{i} + (0.5 + 0.2t)\mathbf{j}$ M1: Seeing both components of their velocity squared and added A1: Correct equation. (Condone including **i** and **j**.) For example: $5 = (4 - 0.4t)\mathbf{i}^2 + (0.5 + 0.2t)\mathbf{j}^2$ scores B1M1A0 $5^2 = (4 - 0.4t)\mathbf{i}^2 + (0.5 + 0.2t)\mathbf{j}^2$ scores B1M1A1 A1: Any correct simplified quadratic equation, with exactly three terms. dM1: Solving the quadratic equation. (Allow one substitution error in correctly quoted formula) Candidates with an incorrect quadratic equation must show method to get dM1. A1:Correct positive solution stated.
	Total		**11**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
6(a)	$T = 2\times 9.8 = 19.6$ N	M1A1	2	M1: Equating tension and weight. A1: Correct tension CAO Accept $2g$ Accept 19.62 from $g = 9.81$
(b)		B1 B1	2	B1: R, F (not μR) and mg correct B1: T correct, must be in roughly correct direction. If more than four forces shown, do not award more than one mark. Note all forces must be shown as arrows and have labels. Note some candidates may draw the force diagram in the section with the question. Components can be ignored if shown in a different notation eg dashed arrows.
(c)	$T\cos 30° + R = 4\times 9.8$ $(R =) 39.2 - 19.6\cos 30°$ $= 39.2 - 16.9741...$ $= 22.2259....$ $= 22.2$ N (to 3sf) AG	M1 A1 A1	3	M1: Resolving vertically to form a three term equation. (May be implied) A1 Correct expression for R or equation for R. Must see 19.6cos30 or equivalent (eg $2g\sin 60$) A1: Correct force. Must see intermediate working, for example third or fourth line of working in solution opposite. Example: $19.6\sin 30° - R = 4\times 9.8$ scores M1A0A0. Use of $g = 9.81$ still gives 22.2 N as the final answer.
(d)	$T\cos 60° = F$ $F = 19.6\cos 60° = 9.8$ $19.6\cos 60° \le \mu(39.2 - 19.6\cos 30°)$ $\mu \ge \dfrac{19.6\cos 60°}{39.2 - 19.6\cos 30°}$ $\mu \ge 0.441$	M1 A1 dM1 A1	4	M1: Resolving horizontally A1: Correct expression for friction dM1: Use of $F = \mu R$ or $F \le \mu R$ (do not allow $F \ge \mu R$) A1: Final answer of $\mu = 0.441$ or $\mu \ge 0.441$ from correct working Use of $g = 9.81$ still gives 0.441 as the final answer.
	Total		**11**	

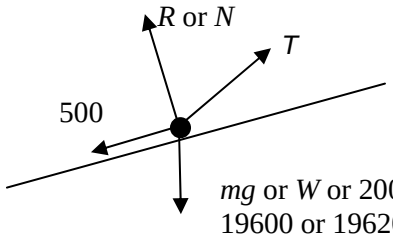
MM1B (cont)

Q	Solution	Marks	Total	Comments
7(a)	$12\sin 30°t - 4.9t^2 = -0.5$ $4.9t^2 - 12\sin 30°t - 0.5 = 0$ $t = 1.30281...or - 0.078323...$ $t = 1.30$ seconds (to 3sf) AG	M1A1A1 dM1 A1	5	M1: Three term equation for vertical motion, with $\pm g$, ± 0.5 (or ± 1 and ± 1.5) and $12\sin 30°t$ or $12\cos 30°t$. A1: Correct terms. (one must be equivalent to ± 0.5) A1: Correct signs. dM1: Solving the quadratic to find *t*. Must see use of quadratic equation formula or can be implied by seeing 1.303 or 1.302 or similar. A1: Correct time from correct working. Must see more than 3 significant figures in candidate's working before the final answer or two correct solutions to the quadratic (eg 1.3 and –0.08). Accept 1.3
	OR time up = 0.6122 time down = 0.6122+0.0783=0.6905 total time = 0.6122+0.6905 = 1.30 (to 3sf)	 (M1A1 dM1A1A1)		M1:Adding time up to time down having used a quadratic. A1: 0.6122 dM1: Finding time down with a quadratic A1: 0.6905 A1: Correct answer Accept 1.3
	OR $-6.767 = 12\sin 30° - gt$ $t = \dfrac{12\sin 30° + 6.767}{g} = 1.30281 = 1.30$ (to 3sf)	 (M1A1A1) (dM1A1)		M1:Forms an equation to find *t* having found *v* first A1: Correct terms A1: Correct signs dM1: Solving for *t* A1: Correct time from correct working. Must see more than 3 significant figures in candidate's working before the final answer. Accept 1.3
(b)	$12\cos 30° \times 1.303 = 13.5$ m	M1A1	2	M1: Finding horizontal displacement using 1.30 (or better) and $12\cos 30°$. Do not allow $12\sin 30°$. A1: Correct distance. AWRT 13.5.

MM1B (cont)

Q	Solution	Marks	Total	Comments
7(c)	$v_y = 12\sin 30° - 9.8\times 1.3028 \ (= -6.767)$ $v = \sqrt{(12\cos 30°)^2 + (-6.767)^2} = 12.4 \text{ ms}^{-1}$	M1A1 dM1A1	4	M1: Finding vertical component of velocity or velocity squared at impact. Must include $12\sin 30°$ or $12\cos 30$ and $\pm g$ A1: Correct expression for vertical component. May have 1.3 or 1.30 instead of 1.3028. (Accept +6.767 or similar) dM1: Finding speed from two components. May use 6.74. A1: Correct speed. Allow 12.3 or AWRT 12.4. Note using g = 9.81 still gives 12.4.
(d)	$\tan\theta = \dfrac{6.767}{12\cos 30°}$ $\theta = 33.1°$ **OR** $\sin\theta = \dfrac{6.767}{12.4}$ $\theta = 33.1°$ **OR** $\cos\theta = \dfrac{10.4}{12.4}$ $\theta = 33.1°$	M1 A1F	2	M1: Trigonometric equation to find angle. Can only be those shown opposite or described below. For tan, fraction can be inverted. For sin, 10.4 can be used instead of 6.767. For cos, 6.767 can be used instead of 10.4. Can use their values from part (c) (eg 6.74 or 6.77). A1F: Correct angle. Accept AWRT 33°. Follow though vertical component or final speed from part (c).
(e)	The weight is the only force acting. OR No air resistance.	B1	1	B1: Appropriate assumption.
	Total		**14**	

MM1B (cont)

Q	Solution	Marks	Total	Comments
8(a)				B1: *R*, 500 and *mg* correct B1: Tension in roughly correct direction. If more than four forces shown, do not award more than one mark. Note all forces must be shown as arrows and have labels. Note some candidates may draw the force diagram in the section with the question. Components can be ignored if shown in a different notation eg dashed arrows.
	mg or *W* or 2000*g* or 19600 or 19620 or 9.8*m*	B1 B1	2	
(b)	$2000\times 0.6 = T\cos 12° - 500 - 2000\times 9.8\sin 5°$	M1A1A1		M1: Resolving parallel to the slope to obtain a four term equation of motion. The weight and tension terms must be resolved. A1: Correct terms. A1: Correct signs. dM1: Solving for *T*. A1: Correct tension. AWRT 3480. Allow AWRT 3490 from use of *g* = 9.81.
	$T = \dfrac{1200 + 500 + 19600\sin 5°}{\cos 12°}$	dM1		
	$\left(= \dfrac{3408.25}{\cos 12°}\right)$			
	$(= 3484.4)$			
	$= 3480$ (to 3sf) AG	A1	5	
	Total		**7**	
	TOTAL		**75**	

Version 1.0

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.

It must be stressed that a mark scheme is a working document, in many cases further developed and expanded on the basis of candidates' 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.

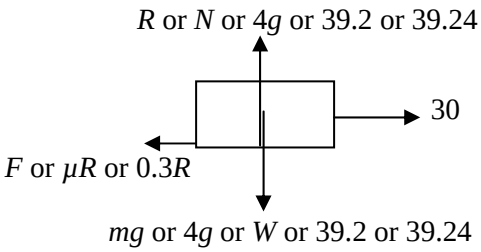
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

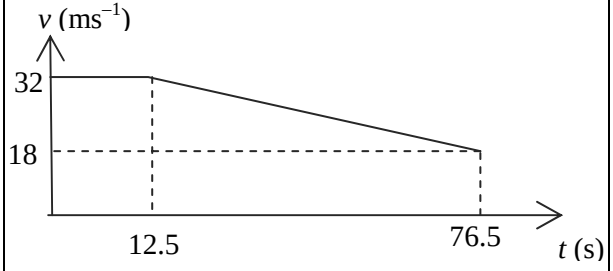
MM1B

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.
	$a = \dfrac{0.6^2}{1.8} = 0.2$ 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. Note: $0 = 0.6 + 0.2t$ scores M0A0 in the second method.
	OR			
	$0.6 = 0 + 0.2t$	(M1)		
	$t = \dfrac{0.6}{0.2} = 3$ 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 $a = 0.2$ A1: Correct equation with correct signs. (Allow 800g) A1: Correct tension. Accept 8008 or 8010 from use of $g = 9.81$.
	$T = 7840 + 160 = 8000$ N	A1	3	
	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)	$4a = 30 - 11.76$ $a = \dfrac{30-11.76}{4} = 4.56$ 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)	$1600 = \frac{1}{2}(32+18)t$	M1dM1		M1: Seeing 2000 – candidate's answer to part (a) calculated dM1: Use of constant acceleration equation(s) to find t, with $u = 32$ and $v = 18$
	$t = \frac{1600}{25} = 64$ seconds	A1	3	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)	$1000 = V \times 4$	M1		M1: Equation for horizontal motion to find V. Must not contain g. Could contain cos0° or equivalent.
	$V = 250$ ms^{-1}	A1	2	A1: Correct V.
(b)	$(h =) \frac{1}{2} \times 9.8 \times 4^2$	M1		M1: Vertical equation to find height with $u = 0$ and $a = \pm 9.8$.
	= 78.4 metres to 3sf	A1	2	A1: Correct height. Accept –78.4
(c)	$(v_y =) 9.8 \times 4 = 39.2$ ms^{-1}	M1A1		M1: Calculation of vertical component of velocity with $u = 0$ and $a = \pm 9.8$.
	or			A1: Correct vertical component.
	$(v_y =) \sqrt{2 \times 9.8 \times 78.4} = 39.2$ ms^{-1}			dM1: Calculation of speed.
				A1: Correct speed.
	$(v =) \sqrt{250^2 + 39.2^2} = 253$ ms^{-1}	dM1A1	4	
(d)	$\tan\alpha = \frac{39.2}{250}$ $\left(\text{or } \tan\alpha = \frac{250}{39.2}\right)$	M1A1F		M1: Using tan to find angle with opposite and adjacent sides. Can be inverted as shown in brackets.
	$\alpha = 8.91°$	A1	3	A1F: Correct trig expression.
	OR			A1: Correct angle.
	$\sin\alpha = \frac{39.2}{253}$ $\left(\text{or } \sin\alpha = \frac{250}{253}\right)$	(M1A1F)		M1: Using sin to find angle with hypotenuse and one other side. Can be changed as shown in brackets.
	$\alpha = 8.91°$	(A1)		A1F: Correct trig expression.
	OR			A1: Correct angle.
	$\cos\alpha = \frac{250}{253(.055)}$ $\left(\text{or } \cos\alpha = \frac{39.2}{253}\right)$	(M1A1F)		M1: Using cos to find angle with hypotenuse and one other side. Can be changed as shown in brackets.
	$\alpha = 8.91°$	(A1)		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)	$\mathbf{v} = (0.5\mathbf{i} + 0.375\mathbf{j}) \times 20 \left(= 10\mathbf{i} + 7.5\mathbf{j}\right)$	M1A1		M1: Calculating velocity with $\mathbf{u} = 0\mathbf{i} + 0\mathbf{j}$ and $t = 20$.
	$v = \sqrt{10^2 + 7.5^2} = 12.5 \text{ ms}^{-1}$	dM1A1	4	A1: Correct expression for velocity. dM1: Calculating speed. A1: Correct speed.
(b)	$\tan\theta = \frac{0.5}{0.375}$ or $\frac{10}{7.5}$ $\left(\text{ or } \tan\theta = \frac{0.375}{0.5} \text{ or } \frac{7.5}{10}\right)$	M1A1F		M1: Using trig to find angle. Can be inverted as shown in brackets. A1F: Correct trig expression with any correct equivalent fraction.
	$\theta = 053°$	A1	3	A1: Correct angle to the nearest degree. Accept 53°.
	OR			
	$\cos\theta = \frac{7.5}{12.5}$ or $\frac{0.375}{0.625}$ $\left(\text{ or } \cos\theta = \frac{10}{12.5}\right)$	(M1A1F)		Note: For 37° award M1A0A0 But for 90 – 37 = 53° award M1A1A1. For 127°, award M1A1A0
	$\theta = 053°$	(A1)		Note: 53.1° as final answer scores M1A1A0
	OR			Condone finding angle from acceleration or position vector.
	$\sin\theta = \frac{10}{12.5}$ or $\frac{0.5}{0.625}$ $\left(\text{ or } \sin\theta = \frac{7.5}{12.5}\right)$	(M1A1F)		
	$\theta = 053°$	(A1)		
(c)	$(\mathbf{r} =) \frac{1}{2}(0.5\mathbf{i} + 0.375\mathbf{j})t^2 \left(= 0.25t^2\mathbf{i} + 0.1875t^2\mathbf{j}\right)$	M1A1		M1: Finding an expression for position vector in terms of t. A1: Correct position vector.
	$500^2 = \left(0.25t^2\right)^2 + \left(0.1875t^2\right)^2$	dM1A1		dM1: Using distance to form an equation for t. A1: Correct equation. A1: Correct time.
	$t = \sqrt[4]{\frac{500^2}{0.25^2 + 0.1875^2}} = 40$ seconds	A1	5	
	OR			
	$a = 0.625$	(M1A1)		M1: Finding magnitude of acceleration. A1: Correct acceleration dM1: Using distance to form an equation for t. A1: Correct equation. A1: Correct time.
	$500 = \frac{1}{2}0.625t^2$	(dM1A1)		
	$t = 40$	(A1)		
	OR			
	$400 = \frac{1}{2} \times 0.5t^2$ or $300 = \frac{1}{2} \times 0.375t^2$	(M1A1) (A1)		M1: Working with one component. A1: Correct distance (300 or 400) A1: Correct equation. dM1: Solving for t. A1: Correct t.
	$t^2 = 1600$	(dM1)		
	$t = 40$	(A1)		Note: 500÷12.5=40 is not acceptable and scores 0
	Total		**12**	

MM1B (cont)

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

Version 1.0

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January 2012

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

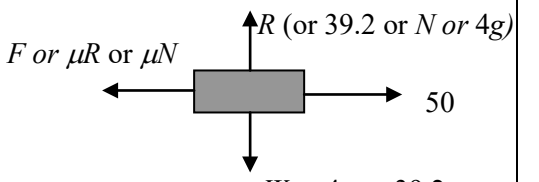
Where the question specifically requires a particular method to be used, we must usually see evidence of use of this method for any marks to be awarded.

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	$7(3\mathbf{i}+8\mathbf{j})+3(6\mathbf{i}-5\mathbf{j})=10\mathbf{v}$ $\mathbf{v}=3.9\mathbf{i}+4.1\mathbf{j}$	M1A1 A1	 3	M1: Three term equation for conservation of momentum with addition of terms and total mass of 10. Allow one error, for example switching masses or omitting negative sign in velocity. A1: Correct equation for velocity. A1: Correct velocity. Accept $\begin{bmatrix}3.9\\4.1\end{bmatrix}$ Finding speed as 5.66 without showing velocity scores M1 A0 A0 Finding speed after having correct velocity should be considered as further work and not penalised. Note: For consistent use of weight deduct one mark.
	Total		**3**	
2(a)		B1	1	B1: Correct force diagram with four forces with arrows and labels. Accept words eg friction instead of letters Ignore negative signs in labels. Do not accept 4 kg for the weight. Award marks if forces are drawn on the diagram in the question.
(b)	39.2 N	B1	1	B1: Correct reaction force. Accept 4*g*. Do not accept 39.
(c)	$50-F=4\times3$ $F=38$	M1A1 A1	 3	M1: Three term equation of motion with the correct terms. A1: Correct equation with correct signs. A1: Correct friction.
(d)	$38=\mu\times39.2$ $\mu=\frac{38}{39.2}=0.969$	M1 A1F	 2	M1: Use of $F=\mu R$ with their answers to (b) and (c). A1F: Correct μ based on their answers to (b) and (c). Accept AWRT 0.969. Note: F = 12 leads to 0.306 and award M1 A1F Condone 0.97 or FT to 2sf Condone use of inequalities.
(e)	Less friction, so a smaller coefficient of friction.	B1 B1	 2	B1: Less friction. B1: Smaller μ. Note: More friction anywhere scores B0 B0 Less friction, greater μ scores B1 B0 Smaller μ with no/inexact reason B0 B1
	Total		**9**	

Q	Solution	Marks	Total	Comments
3(a)	$s_1 = \frac{1}{2} \times 5 \times 28 = 70$ m	M1A1	2	M1: For $\frac{1}{2} \times 5 \times 28$ or equivalent. A1: Correct distance.
(b)	$s = 70 + \frac{1}{2} \times 5 \times 22$ $= 70 + 55$ $= 125$ m	B1M1 A1F	 3	B1: For $\pm\frac{1}{2} \times 5 \times 22$ or equivalent. M1: For adding the distances. A1F: Correct distance. Follow through their answer from part (a) only.
(c)	Average speed $= \frac{125}{50} = 2.5$ m s^{-1}	M1 A1F	2	M1: For their answer to (b) divided by 50. A1F: Correct average speed. Follow through answers from part (b).
(d)	Displacement from $O = 70 - 55$ $= 15$ m	 B1	 1	B1: Correct displacement.
(e)	Average velocity $= \frac{15}{50} = 0.3$ m s^{-1}	M1 A1F	2	M1: For their answer to (d) divided by 50, provided they have subtracted in (d). A1F: Correct average velocity. Follow through answers from part (d) Award no marks if the final answer is 0.
(f)	$a = \frac{5}{18} = 0.278$ m s^{-2}	B1	1	B1: Correct acceleration. Accept $\frac{5}{18}$ or equivalent fraction or 0.277 or AWRT 0.278. Condone 0.28
	Total		**11**	

Q	Solution	Marks	Total	Comments
4(a)	$V\sin 30° = 3$	M1A1		M1: Resolving parallel to the bank. Accept $V\cos 30° = 3$.
	$V = \dfrac{3}{\sin 30°} = 6$	A1	3	A1: Correct equation. A1: Correct V.
(b)	$t = \dfrac{200}{6\sin 60°} = 38$ (seconds)	M1 A1F A1F	3	M1: 200 divided by $V\sin 60°$ or $V\sin 30°$ or equivalent with their value for V from (a). A1F: Correct expression for t. A1F: Correct value for t to nearest second. Follow through their answer to part (a)
	OR			
	$h = \dfrac{200}{\sin 60°} = 230.94$	(M1)		M1:Distance divided by corresponding velocity.
	$t = \dfrac{230.94}{6} = 38$ (seconds)	(A1F) (A1F)		A1F: Correct expression for t A1F: Correct value for t to nearest second. Follow through their answer to part (a)
	OR			
	resultant velocity = $\sqrt{27}$	(M1)		Do not accept 38.5
	$t = \dfrac{200}{\sqrt{27}} = 38$ (seconds)	(A1F) (A1F)		
	Total		**6**	
5(a)	$4720 - 3R = 2200 \times 1.6$	M1A1		M1: Three term horizontal equation of motion with mass of 2200 kg and $3R$ (or $2R$ and R).
	$R = \dfrac{4720 - 3520}{3} = 400$	A1 A1	4	A1: All terms correct (4720, $3R$ and 2200×1.6). A1: Correct signs. A1: Correct value for R.
	OR			
	$4720 - R - T = 1200 \times 1.6$	(M1A1)		M1: Forming an equation for each body and adding to eliminate T.
	$T - 2R = 1000 \times 1.6$	(A1)		A1: Two correct equations.
	$4720 - 3R = 3520$	(A1)		A1: Correct equation in R.
	$R = 400$			A1: Correct value for R.
(b)	$T - 2 \times 400 = 1000 \times 1.6$	M1A1F		M1: Three term equation of motion for caravan with T, $2R$ and 1000×1.6.
	$T = 800 + 1600 = 2400$ N	A1F	3	A1F: Correct equation, with their value for R from part (a). A1F: Correct tension. Follow through from part (a) using $T = 1600 + 2R$
	OR			
	$4720 - T - 400 = 1200 \times 1.6$	(M1)		M1: Four term equation of motion for car with 4720, T, R and 1200×1.6.
	$T = 4720 - 400 - 1920 = 2400$ N	(A1F) (A1F)		A1F: Correct equation, with their value for R from part (a) A1F: Correct tension. Follow through from part (a) using $T = 2800 - R$ Note: do not follow through if a negative value is used for R.
	Total		**7**	

Q	Solution	Marks	Total	Comments
6(a)(i)	$10^2 = 4^2 + 2 \times a \times 50$ $a = \frac{100-16}{100} = 0.84 \text{ m s}^{-2}$	M1A1 A1	3	M1: Use of a constant acceleration equation to find a, with v and u substituted correctly. For example $4^2 = 10^2 + 100a$ scores M0A0A0. A1: Correct constant acceleration equation. A1: Correct a. Note if t found first award M1 for use of $v = u + at$ or $s = ut + \frac{1}{2}at^2$.
(ii)	$50 = \frac{1}{2}(4+10)t$ $t = \frac{50}{7} = 7.14 \text{ s}$ OR $10 = 4 + 0.84t$ $t = \frac{6}{0.84} = 7.14 \text{ s}$ OR $50 = 4t + \frac{1}{2} \times 0.84t^2$ $0.42t^2 + 4t - 50 = 0$ $t = 7.14$ (or $t = -16.6$)	M1A1 A1 (M1A1F) (A1) (M1A1F) (A1)	3	M1: Use of a constant acceleration equation to find t. A1F: Correct constant acceleration equation with their acceleration from (a)(i) seen. A1: Correct t. Accept $\frac{50}{7}$ or $7\frac{1}{7}$ or AWRT 7.14. If t has been found in part (a) the working does not have to be repeated, but value of t must be stated. Do not follow through incorrect values of a.
(b)	$70 \times 0.84 = 58.8 \text{ N}$	M1A1F	2	M1: Use of $F = ma$ with $m = 70$ and their a from (a)(i). A1F: Correct F. Follow through their value of a from part (a)(i).
(c)(i)	$58.8 = 70 \times 9.8 \sin\alpha$ $\sin\alpha = \frac{58.8}{70 \times 9.8} = 0.08571$ $\alpha = 4.92°$	M1A1F A1F	3	M1: Resolving parallel to the slope must see $70g$ or mg OE with sin α or cos α and their answer to part (b). A1F: Correct equation. Follow through their answer to part (b) provided sin α < 1 A1F: Correct angle. Follow through their answer to part (b). Accept 4.91° provided sin α < 1.

Q	Solution	Marks	Total	Comments
6(c)(ii)	$70 \times 9.8 \sin\alpha - 30 = 58.8$ $\sin\alpha = 0.12945$ $\alpha = 7.44°$	M1A1F A1F	3	M1: Three term equation of motion. must see 70*g* or *mg* OE with sin α or cos α. A1F: Correct equation. Follow through their answer to part (b) provided sin α < 1 A1F: Correct angle. Follow through their answer to part (b) provided sin α < 1. Accept 7.43°. Accept 7.41º from 0.129.
(d)	The air resistance force will increase (vary or change) with speed.	B1	1	B1: Correct statement.
	Total		**15**	

Q	Solution	Marks	Total	Comments
7(a)	$h = \frac{1}{2} \times 2.5 \times 20^2$ $= 500$ m	M1 A1A1	3	M1: Expression for height or position vector at $t = 20$. A1: Correct expression for height or position vector with correct **j** component (…**i** + 500 **j**) A1: Correct height stated. Condone 500 **j**.
(b)	$\mathbf{v}(20) = (4.2\mathbf{i} + 2.5\mathbf{j}) \times 20$ $= 84\mathbf{i} + 50\mathbf{j}$	M1 A1	2	M1: Using $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ to find the velocity at $t = 20$ with $\mathbf{u} = 0\mathbf{i} + 0\mathbf{j}$. A1: Correct velocity.
(c)	$1.25t^2 = 180$ $t = \sqrt{\frac{180}{1.25}} = 12$ s $\mathbf{v} = (4.2\mathbf{i} + 2.5\mathbf{j}) \times 12$ $= 50.4\mathbf{i} + 30\mathbf{j}$ $v = \sqrt{50.4^2 + 30^2} = 58.7$ m s^{-1} OR $a = \sqrt{4.2^2 + 2.5^2} = 4.89$ $v = 4.89 \times 12 = 58.7$ m s^{-1} OR $x = 4.2 \times \frac{180}{2.5} = 302.4$ $v_x = \sqrt{2 \times 4.2 \times 302.4} = 50.4$ $v_y = \sqrt{2 \times 2.5 \times 180} = 30$ $v = \sqrt{50.4^2 + 30^2} = 58.7$	M1A1 A1 dM1 A1 dM1A1 (dM1A1) (dM1A1) (M1A1) (dM1A1) (A1) (dM1A1)	7	M1: Equation based on height of 180 to find t. A1: Correct equation. A1: Correct t. dM1: Using $\mathbf{v} = \mathbf{u} + \mathbf{a}t$ to find the velocity at their time with $\mathbf{u} = 0\mathbf{i} + 0\mathbf{j}$. A1: Correct velocity. dM1: Finding speed from their velocity. A1: Correct speed. Accept 58.6 or AWRT 58.7. dM1: finding magnitude of acceleration. A1: correct magnitude. dM1: acceleration × 12. A1: correct speed. M1: finding horizontal displacement when height is 180. Must see 4.2, 2.5 and 180. May be implied by seeing 302.4. A1: Seeing 302.4 dM1: Finding both components of velocity. A1: Seeing 50.4. A1: Seeing 30. dM1: Finding the speed. A1: Final answer of 58.7

Q	Solution	Marks	Total	Comments
7(c) cont	OR $v_y = \sqrt{2 \times 2.5 \times 180} = 30$ $30 = 0 + 2.5t$ $t = \frac{30}{2.5} = 12$ $v_x = 0 + 4.2 \times 12 = 50.4$ $v = \sqrt{50.4^2 + 30^2} = 58.7 \text{ m s}^{-1}$	(M1A1) (A1) (dM1A1) (dM1A1)		M1: Equations based on height of 180 to find v and then t. A1: Correct equation for t. A1: Correct t. dM1: Using $v = u + at$ to find the **j** component of velocity at their time with $u = 0$. A1: Correct velocity. dM1: Finding speed from their velocity. A1: Correct speed. Accept 58.6 or AWRT 58.7.
	OR $\tan^{-1}\left(\frac{2.5}{4.2}\right) = 30.76°$ $v_v = \sqrt{2 \times 2.5 \times 180} = 30$ $v = \frac{30}{\sin 30.76} = 58.7 \text{ m s}^{-1}$	(M1A1) (A1) (dM1A1) (dM1A1)		M1: Finding angle using acceleration components. A1: Correct expression for acceleration components A1: Correct angle. dM1: Finding v_y at height of 180 A1: Correct speed of 30. dM1: Using trig to get v. A1: Correct speed. Accept 58.6 or AWRT 58.7.
	Total		**12**	

Q	Solution	Marks	Total	Comments
8(a)	$\tan\alpha = \frac{6}{10}$ $\alpha = 31.0°$	M1 A1	2	M1: Using tan with 10 and 5 or 6, OR sin or cos with $\sqrt{136}$ and 6 or 10, OR sin or cos with $\sqrt{125}$ and 5 or 10. Note: $\sin\alpha = \frac{6}{\sqrt{136}}$ and $\cos\alpha = \frac{10}{\sqrt{136}}$ A1: Correct angle. Accept 30.9° or AWRT 31°
(b)	$8\sin\alpha t + 4.9t^2 = 6$ $4.9t^2 + 4.116t - 6 = 0$ $t = 0.76359$ or $t = -1.60$ s $t = 0.764$	M1 A1FA1F A1 dM1 A1	6	M1: equation for the vertical motion containing ±6 or ±5, $\pm 4.9t^2$ and ±8sinα or ±8cosα, where α has a value related to their answer to part (a) (May be a negative angle). A1F: Correct terms. A1F: Correct signs and terms Follow through angle from part (a). A1: Correct equation rearranged equal to zero, but may be implied by subsequent working. dM1: Attempting to solve their quadratic equation. Only award method mark if method seen or correct answers obtained or –0.764 with +1.60. A1: Correct solution obtained. Accept 0.763 or AWRT 0.764.
	OR			
	$v = \sqrt{(8\sin 31.0°)^2 + 2\times 9.8\times 6} = 11.60$ $11.60 = 8\sin 31° + 9.8t$ $t = \frac{11.60 - 8\sin 31°}{9.8} = 0.763$	(M1) (A1FA1F) (dM1) (A1) (A1)		M1: Use a constant acceleration equation $v^2 = u^2 + 2as$ to find v. A1F: Correct equation. A1F: Correct v. dM1: Use of $v = u + at$ to find t A1: Correct equation. A1: Correct t (0.763)
(c)	$d = 10 - 8\cos\alpha \times 0.764$ $= 10 - 5.238$ $= 4.76$ m	M1dM1 A1 A1	4	M1: Finding a horizontal distance using 8cosα or 8sinα multiplied by their time from part (b). dM1: For subtracting their distance from 10. A1: Seeing AWRT 5.24 or 5.23 from 0.763. A1: Correct final answer. Accept AWRT 4.76. Accept 4.77 from use of 0.763.
	Total		**12**	
	TOTAL		**75**	

Version 1.0

General Certificate of Education (A-level)
June 2012

Mathematics MM1B

(Specification 6360)

Mechanics 1B

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.

MM1B

Q	Solution	Marks	Total	Comments
1(a)	$(V^2 =)5^2 + 2^2$	M1		M1: Correct expression for V or V^2.
	$(V =)5.39$ ms^{-1}	A1	2	A1: Correct speed. Accept 5.38 or $\sqrt{29}$ or AWRT 5.39 or 5.38. Do not accept 5.4
(b)	$\tan\theta = \frac{2}{5}$	M1		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
	$\theta = 21.8°$	A1		A1: Correct angle. Accept AWRT 22° or 68° from correct working.
	Bearing $= 360 - 21.8 = 338°$ (to 3sf)	A1	3	A1: Correct bearing. Accept AWRT 338.
	Or			Note that incorrect diagrams should not be penalised if "correct" working shown.
	$\tan\theta = \frac{5}{2}$			
	$\theta = 68.2°$			
	Bearing $= 270 + 68.2 = 338°$ (to 3sf)			
	Total		**5**	
2	$2\times4 + 3m = 3.8(2 + m)$	M1A1		M1: Three term equation for conservation of momentum with correct RHS. Allow $2\times4 - 3m$ on the LHS A1: Correct equation. A1: Correct answer.
	$8 + 3m = 7.6 + 3.8m$			
	$0.4 = 0.8m$			
	$m = \frac{0.4}{0.8} = 0.5$ kg	A1	3	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)	$10^2 = 20^2 + 2 \times a \times 75$ $a = \frac{100 - 400}{150} = -2 \text{ ms}^{-2}$	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**	

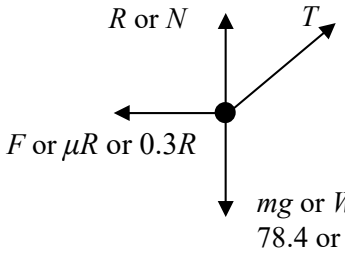
MM1B

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 $\cos\theta$ 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 $\cos\theta$ 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 ($18g - F = 30 \times 3$): 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 $0.3R$ 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 $8g$ 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 $a = \pm 9.8$. 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 $a = \pm 9.8$. 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**	

Version

General Certificate of Education (A-level)
January 2013

Mathematics MM1B

(Specification 6360)

Mechanics 1B

Final

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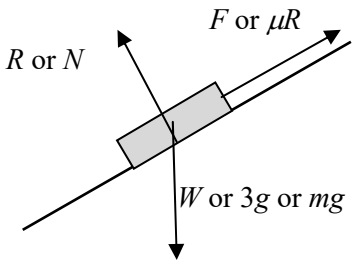
Otherwise we require evidence of a correct method for any marks to be awarded.

MM1B

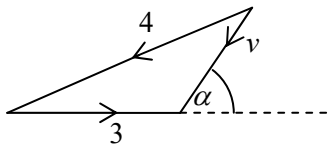
Q	Solution	Marks	Total	Comments
1(a)(i)	$640 = \frac{1}{2}(12+20)t$	M1A1		M1: Use of constant acceleration equation to find t with s = 640, 20 and 12.
	$t = \frac{640\times 2}{32} = 40$ s	A1	3	A1: Correct equation. A1: Correct time. For two equation methods, award no marks until an equation for t is obtained. Using a = 0.2 to find t = –40 scores M1A0A0
(a)(ii)		M1A1		M1: Use of constant acceleration equation to find a with u = 20 and v = 12.
	$12^2 = 20^2 + 2\times a\times 640$ $a = \frac{12^2-20^2}{2\times 640} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2})	A1	3	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
	OR $12 = 20 + 40a$	(M1A1F)		Follow through incorrect times from part (a).
	$a = \frac{-8}{40} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2})	(A1F)	(3)	
	OR $640 = 20\times 40 + \frac{1}{2}a\times 40^2$	(M1A1F)		For two equation methods, award no marks until an equation for a is obtained.
	$a = \frac{-160}{800} = -0.2$ m s^{-2} (Deceleration = 0.2 m s^{-2})	(A1F)	(3)	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)	$1820 = \frac{1}{2}(12+v)\times 70$ $v = \frac{1820}{35} - 12 = 40\ \text{m s}^{-1}$	M1A1 A1	3	M1: Constant acceleration equation to find v with $s = 1820$ and $t = 70$. A1F: Correct equation. A1F: Correct velocity.
	OR $v = 12 + 0.4\times 70$ $= 40\ \text{m s}^{-1}$	(M1A1F) (A1F)	(3)	For two equation methods, award no marks until an equation for v is obtained.
	OR $v^2 = 12^2 + 2\times 0.4\times 1820$ $v = \sqrt{1600} = 40\ \text{m s}^{-1}$	(M1A1F) (A1F)	(3)	
	OR $1820 = 70v - \frac{1}{2}\times 0.4\times 70^2$ $v = 40\ \text{m s}^{-1}$	(M1A1F) (A1F)	(3)	
(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 +4v 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**	

Version 1.0

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.

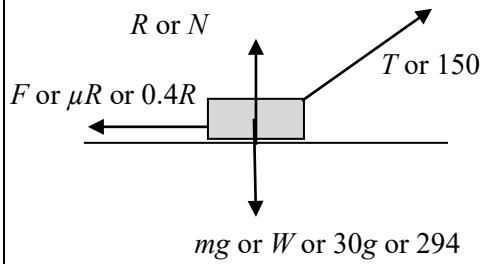
Q	Solution	Marks	Total	Comments
1	$0.3 \times 2.8 = (0.3 + 0.2)v$ $v = \dfrac{0.3 \times 2.8}{0.5} = 1.68 \text{ m s}^{-1}$	M1A1 A1	3	M1: Use of 2 or 3 term equation for conservation of momentum with 0.5 or equivalent on the RHS. Condone missing brackets if recovered. A1: Correct equation. A1: Correct 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)	$(v =)\sqrt{7^2 + 1.4^2}$	M1		M1: Equation or expression to find v or v^2 based on Pythagoras. Must have a +.
	$(v =)7.14 \text{ m s}^{-1}$	A1	2	A1: Correct speed. Accept 7.13
				Note that just $v^2 = 7^2 + 1.4^2$ Scores M1A0.
(b)	$\tan\alpha = \frac{1.4}{7}$	M1A1		M1: Use of tan with 1.4 and 7. A1: Correct expression for tan α.
	$\alpha = 011°$	A1	3	A1: Correct bearing to nearest degree. Accept 11°.
				Note that a final answer of 79° scores M1A0A0.
	OR			
	$\sin\alpha = \frac{1.4}{\sqrt{50.96}}$	(M1 A1F)		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.
	$\alpha = 011°$	(A1)	(3)	A1: Correct bearing to nearest degree.
	OR			
	$\cos\alpha = \frac{7}{\sqrt{50.96}}$	(M1 A1F)		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 $-1 \leq \cos\alpha \leq 1$.
	$\alpha = 011°$	(A1)	(3)	A1: Correct bearing to nearest degree.
				Note that 11.3° or 011.3° scores M1A1A0.
	Total		**5**	
4(a)	$F^2 = 70^2 + 40^2 - 2\times 40\times 70\cos 150°$	M1		M1: Use of cosine rule with an obtuse angle and a – sign.
	$F = \sqrt{11350}$	A1		A1: Correct expression.
	$F = 107$	dM1 A1	4	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,			
	$70 + 40\cos 30°(= 104.64)$	(M1		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.
	$40\sin 30°(= 20)$	A1)		A1: Both components correct. (Note that resolving parallel and perpendicular to the 40 N force gives components of 100.6 and 35)
	$F = \sqrt{104.64^2 + 20^2} = 107$ N	(dM1) (A1)	(4)	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 resultant force on each particle would be reduced.	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)	$200 = -17.5t + 0.25t^2 + 500$ $0.25t^2 - 17.5t + 300 = 0$ $t = 40$ or 30	M1A1 A1		M1: Forming equation for one component based on position of the rock and their position vector. A1: Correct quadratic equation. A1: At least one correct solution3.
	$-400 = -27t + 0.3t^2 + 200$ $0.3t^2 - 27t + 600 = 0$ $t = 40$ or 50 $\therefore t = 40$	dM1 A1 dM1 A1	7	dM1: Forming equation for the other component. A1: Correct equation. dM1: Obtaining one or two positive solutions. A1: Selecting 40.
	OR $-27 \times 40 + 0.3 \times 40^2 + 200 = -1080 + 480 + 200$ $= -400$ $\therefore t = 40$	 (dM1) (A1) (dM1) (A1)		dM1: Substituting 40 into the other component. A1: Correct substitution dM1: Checking this component of the position vector 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 $t = 40.9$ $0.25 \times 40^2 - 17.5 \times 40 + 300 = 0$ $0.3 \times 40^2 - 27 \times 40 + 600 = 0$ $\therefore t = 40$	 (A1) (dM1) (A1)		A1: At least one correct solution dM1: Checking one or both solutions A1: concluding $t = 40$
	$0.05t^2 - 9.5t + 300 = 0$ $t = 40$ or $t = 150$ $0.25 \times 40^2 - 17.5 \times 40 + 300 = 0$ $0.3 \times 40^2 - 27 \times 40 + 600 = 0$ $\therefore t = 40$	 (A1) (dM1) (A1)		A1: At least one correct solution dM1: Checking one or both solutions A1: concluding $t = 40$

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**	