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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.

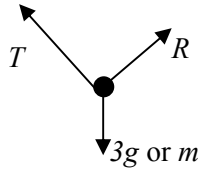
Where the permitted calculator has functions which reasonably allow the solution of the question directly, the correct answer without working earns **full marks**, unless it is given to less than the degree of accuracy accepted in the mark scheme, when it gains **no marks**.

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

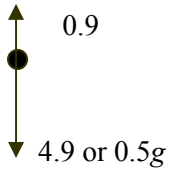
MM1B

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 3g 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 3g 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 $(\mathbf{a}=)\ \dfrac{12\mathbf{i}+8\mathbf{j}}{4}$	M1		M1: Use of Newton's second law with $4\mathbf{a}$ and their answer to part (a).
	$(\mathbf{a}=)3\mathbf{i}+2\mathbf{j}$ **AG**	A1	2	A1: Correct acceleration from correct equation.
(c)(i)		B1		B1: Seeing $60\mathbf{i}+40\mathbf{j}$ or $(3\mathbf{i}+2\mathbf{j})\times 20$
	$40\mathbf{i}+32\mathbf{j}=\mathbf{v}+(3\mathbf{i}+2\mathbf{j})\times 20$ $40\mathbf{i}+32\mathbf{j}=\mathbf{v}+60\mathbf{i}+40\mathbf{j}$	M1		M1: Use of constant acceleration equation with $t=20$ and $\mathbf{a}=3\mathbf{i}\pm 2\mathbf{j}$.
	$\mathbf{v}=(40\mathbf{i}+32\mathbf{j})-(60\mathbf{i}+40\mathbf{j})$ $=-20\mathbf{i}-8\mathbf{j}$ **AG**	A1	3	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 "$\mathbf{v}=$" does not need to be seen.
(c)(iii)	$(\mathbf{v}=)\ (3t-20)\mathbf{i}+(2t-8)\mathbf{j}$	M1		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.
	$(3t-20)^2+(2t-8)^2=8^2$	dM1 A1		dM1: Equation based on speed of 8. A1: Correct unsimplified equation.
	$13t^2-152t+400=0$	A1		A1: Simplified quadratic equation
	$t=\dfrac{152\pm\sqrt{152^2-4\times 13\times 400}}{2\times 13}$	dM1		dM1: Solving quadratic equation, to obtain two solutions.
	$t=4$ or $t=7.69$	A1	6	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**	

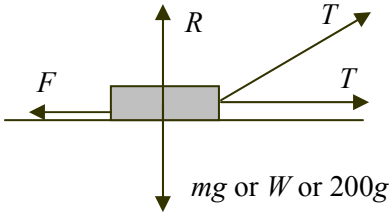
MM1B (cont)

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)	$T_2 - 550 - 300 = 500 \times 0.5$ $T_2 = 550 + 300 + 250 = 1100$ N **OR** $T_2 - 600 = 1000 \times 0.5$ $T_2 = 600 + 500 = 1100$ N	M1A1 A1 (M1) (A1) (A1)	3 (3)	M1: Four term equation of motion for Carriage 1 including 550 and 300 with mass 500 A1: Correct equation. A1: Correct force 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. A1: Correct tension
(d)	$P - 1100 - 400 = 2000 \times 0.5$ $P = 1100 + 400 + 1000 = 2500$ **OR** $P - 1000 = 3000 \times 0.5$ $P = 1000 + 1500 = 2500$	M1 A1F A1F (M1) (A1F) (A1F)	3 (3)	M1: Four term equation of motion for engine with mass 2000, a force of 400 and their answer to part (c). A1F: Correct equation. A1F: Correct force M1: Three term equation of motion for whole train with mass 3000 and 1000 (OE) force. A1F: Correct equation. 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 $200g$ 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**	