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Mark Scheme (Results)

January 2013

GCE Mechanics M2 (6678/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

EDEXCEL GCE MATHEMATICS

General Instructions for Marking

1. The total number of marks for the paper is 75.

2. The Edexcel Mathematics mark schemes use the following types of marks:

- **M** marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- **A** marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- **B** marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

In some instances, the mark distributions (e.g. M1, B1 and A1) printed on the candidate's response may differ from the final mark scheme.

3. Abbreviations

These are some of the traditional marking abbreviations that will appear in the mark schemes.

- bod – benefit of doubt
- ft – follow through
- the symbol $\surd$ will be used for correct ft
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC: special case
- oe – or equivalent (and appropriate)
- dep – dependent
- indep – independent
- dp decimal places
- sf significant figures
- $\ast$ The answer is printed on the paper
- $\lfloor$ The second mark is dependent on gaining the first mark

4. All A marks are 'correct answer only' (cao.), unless shown, for example, as A1 ft to indicate that previous wrong working is to be followed through. After a misread however, the subsequent A marks affected are treated as A ft, but incorrect answers should never be awarded A marks.

5. For misreading which does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, in that part of the question affected.

6. If a candidate makes more than one attempt at any question:
    - If all but one attempt is crossed out, mark the attempt which is NOT crossed out.

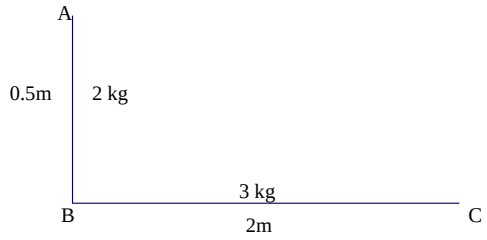
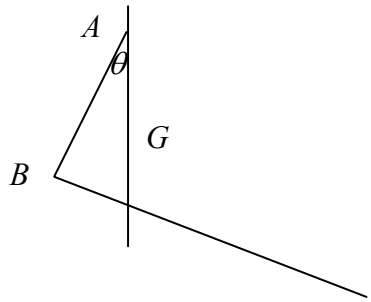
- If either all attempts are crossed out or none are crossed out, mark all the attempts and score the highest single attempt.

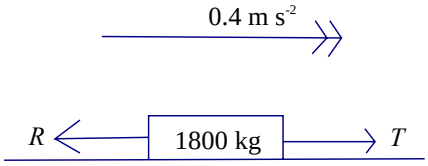
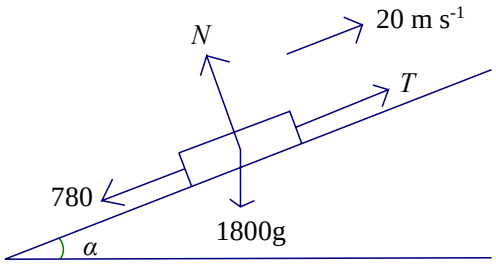
7. Ignore wrong working or incorrect statements following a correct answer.

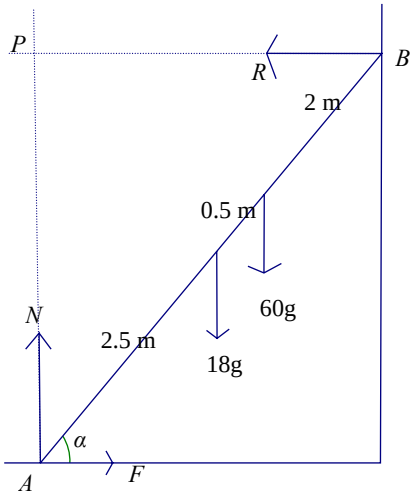
8. The maximum mark allocation for each question/part question(item) is set out in the marking grid and you should allocate a score of '0' or '1' for each mark, or "trait", as shown:

	0	1
aM		●
aA	●	
bM1		●
bA1	●	
bB	●	
bM2		●
bA2		●

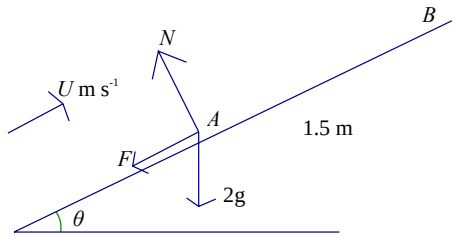
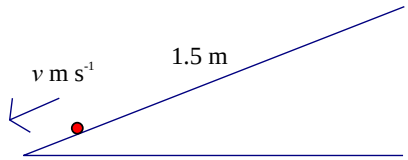
January 2013
6678 M2
Mark Scheme

Q.	Scheme	Marks	
1. (a)		M1	
	$5\bar{y} - 2 \times 0.25(+0)$	A1	Moments equation with lengths ¼, 1 and (ratio of) masses 2, 3. Allow moments about a parallel axis Use of length for mass is M0.
	$\bar{y} = \frac{2 \times 0.25}{5} = 0.1$		For distance from BC
(b)			
		M1	
	$\tan\theta = \frac{0.6}{0.5 - 0.1}$	A1ft	Must suspend from A. Use of tan with 0.6 and $0.5 - \bar{y}$ Could be wrong way up. Must be using 0.6
		A1	Correct way up. ft their $\bar{y}$.
	$\theta = \tan^{-1}\left(\frac{6}{4}\right) = 56.3° = 56°$		Accept awrt 56.3

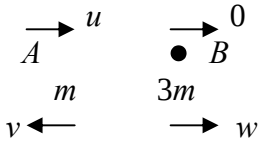
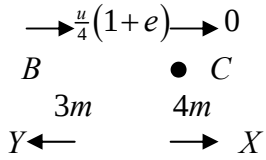
Q.	Scheme	Marks	
2 (a)		B1	
	$T = \frac{30000}{20} \quad (=1500)$	M1	Use of $P = Fv$
	$T - R = 1800a$	A1	Equation of motion. Need all 3 terms. Condone sign errors
	$T - R = 1800 \times 0.4$ $R = 1500 - 1800 \times 0.4$ $= 780$	A1	Equation correct (their T) Only
(b)		M1	
	$T - 1800g\sin\alpha - R = 0$	A1	Equation of motion. Need all 3 terms. Weight must be resolved. Condone cos for sin. Condone sign errors Correct equation. Allow with R not substituted or with their R.
	$T = 1800 \times \frac{1}{12}g + 780$	DM1	
	Power $= \left(1800 \times \frac{1}{12}g + 780\right) \times 20$	A1	Use of $P = Tv$
		A1	Correctly substituted equation (for their R)
	$= 45000$ W or 45 kW		cao

Q	Scheme	Marks	
3			
	$F = \mu N$	B1	Used. Condone an inequality.
	$\mathrm{R}(\uparrow)$ $18g + 60g = N$	M1	Resolve vertically
	$=78g$	A1	
	$\mathrm{R}(\rightarrow)$ $R = F = \mu N$		
P	$2.5 \times 18g\cos\alpha + 3 \times 60g\cos\alpha = 5F\sin\alpha$	M1A2	Moments equation. Condone sign errors. Condone sin/cos confusion
A	$18g \times 2.5\cos\alpha + 60g \times 3\cos\alpha = R \times 5\sin\alpha$		-1 each error
C	$\frac{1}{2}\cos\alpha \times 18g + 3\sin\alpha F + 2\sin\alpha R = 3\cos\alpha N$		
B	$5\cos\alpha N = 5\sin\alpha F + 2.5\cos\alpha \times 18g + 2\cos\alpha \times 60$		
W	$60g \times \frac{1}{2}\cos\alpha + 2.5N\cos\alpha = 2.5R\sin\alpha + 2.5F\sin\alpha$		
	$45\times\frac{3}{5}g + 180\times\frac{3}{5}g = 4R$	DM1	Eliminate α. Dependent on the second M1.
	$R = \frac{135}{4}g$		
	$78g\mu = \frac{135}{4}g$	DM1	Equation in μ only. (Dependent on the first two M marks.)
	$\mu = \frac{135}{4\times 78} = \frac{135}{312} = 0.432... = 0.43$	A1	NB g cancels. 0.43269..., $\frac{225}{520}$, $\frac{45}{104}$, awrt 0.433 Do not accept an inequality.
	NB If use just two moments equations, M1A2 for the better attempt, M1A1 for the other. Remaining marks as above.		
4		B1	

Q	Scheme	Marks	
(a)	$t = \frac{5}{4}$	M1	1.25
(b)	$\mathbf{r} = \left(2t^2 - 5t\right)\mathbf{i} + 3t\mathbf{j}\left(+\mathbf{c}\right)$		Integrate the velocity vector
		A1	NB Also correct to use suvat with $\boldsymbol{a}$ = 4**i** and $\boldsymbol{u}$ = -5**i** + 3**j**.
		DM1	Correct
	$t = 0 \quad 2\mathbf{i} + 5\mathbf{j} = \mathbf{c}$	A1	Use $\mathbf{r}_0$ to find C
	$\mathbf{r} = \left(2t^2 - 5t\right)\mathbf{i} + 3t\mathbf{j} + \left(2\mathbf{i} + 5\mathbf{j}\right)$		oe
	$(2t^2 - 5t + 2)\mathbf{i} + (3t + 5)\mathbf{j}$	B1	
(c)	$\mathbf{r}_Q = 11\mathbf{i} + 2\mathbf{j} - 2t\mathbf{i} + ct\mathbf{j}$		Correct **j** component of $\mathbf{r}_Q$
	$(11 - 2t)\mathbf{i} + (2 + ct)\mathbf{j}$		Do not actually require the whole thing - can answer the Q by considering only the **j** component.
	$\mathbf{r}_P = \left(2t^2 - 5t + 2\right)\mathbf{i} + \left(3t + 5\right)\mathbf{j}$		
	$\mathbf{r}_Q = \mathbf{r}_P = d\mathbf{i} + 14\mathbf{j}$	$2t^2 - 5t$	
	$3t + 5 = 14$	M1	Form an equation in t only
	$t = 3$	A1	
	$2 + ct = 14 \Rightarrow c = 4$	A1 ft	Their t
	$d = 11 - 2 \times 3 = 5$ or		Their t
	$d = 2 \times 3^2 - 5 \times 3 + 2 \Rightarrow d = 5$		
	Alt: $2t^2 - 5t + 2 = 11 - 2t = d \Rightarrow t = \frac{11 - d}{2}$		
	$2\left(\frac{11-d}{2}\right)^2 - 5\left(\frac{11-d}{2}\right) + 2 = d$,		
	$d^2 - 19d + 70 = 0 = (d - 5)(d - 14)$		

Q.	Scheme	Marks	
5			
(a)	$N = 2g\cos\theta = \frac{14}{25}g$	M1	Resolve perpendicular to plane. Condone trig confusion.
	$F = \mu N = \frac{5}{12}\times\frac{14}{25}g = \frac{7g}{30}$	B1	Correct value of F seen or implied
	Work done $= \frac{7}{30}g\times 1.5 = 3.43... = 3.4$ J	DM1	Their F x 1.5
		A1	$\frac{7g}{20}$, 3.4 or 3.43 only
(b)	$3.43 + 2g\sin\theta\times 1.5 = \frac{1}{2}\times 2U^2$	M1	Energy equation - needs all 3 terms, but condone sign errors & trig confusion. Must have an expression for the vertical height.
		A1	Correct with one slip for their WD.
		A1	All correct for their WD
	$U = 5.626.... = 5.6$	A1	5.6 & 5.63 only
(c)			
	$2g\sin\theta\times 1.5 = 3.43 + \frac{1}{2}\times 2v^2$	M1	Energy equation - needs all three terms. Condone sign errors & trig. confusion. Extra terms give M0.
	OR: $\frac{1}{2}\times 2U^2 = 2\times 3.43 + \frac{1}{2}\times 2v^2$	A1	All correct (their WD & U)
	$v^2 = 3g\sin\theta - 3.43$		
	$v = 4.979...$		
	Speed = 5.0 m s^{-1}	A1	Accept 4.98
Alt			
(c)	$mg\sin\theta - F = ma$ and $v^2 = (u^2) + 2as$	M1	Equation of motion - needs all three terms. Condone sign errors & trig. confusion. Together with *suvat*
	$2g\sin\theta - \frac{7g}{30} = \frac{48g}{25} - \frac{7g}{30} = 2a$		
	$a = \frac{253g}{300} = 8.26....$	A1	
	$v^2 = 24.794$, v = 5.0	A1	Accept 4.98

Q.	Scheme	Marks	
6 (a)	$2 = -2u\sin\theta + \frac{1}{2}g \times 4$	M1	Vertical distance. Condone sign errors. Must have used $t = 2$, but could be using $u_y = u\sin\theta$
	$\left(-2 = u\sin\theta t - \frac{1}{2}gt^2\right)$ $u\sin\theta = g - 1$	A1	All correct
	$2u\cos\theta = 8 \quad (u\cos\theta = 4)$ $(u\cos\theta t = 8)$	B1	Horizontal distance. Accept $u_x = 4$ o.e.
	$\tan\theta = \frac{g-1}{4} = 2.2$ *	M1	Divide to obtain expression for $\tan\theta$
		A1	**Given answer** It is acceptable to quote and use the equation for the projectile path. Incorrect equation is 0/5.
(b)	$u\cos\theta = 4$	M1	Use the horizontal distance and θ to find u 9.67 or 9.7
	$u = \frac{4}{\cos\theta} = 9.66... = 9.7$ OR use components from (a) and Pythagoras.	A1	NB $\theta = 65.6°$ leading to 9.68 is an accuracy penalty.
(c)	$6 = (1-g)T + \frac{1}{2} \times 9.8T^2$	M1	Equation for vertical distance $= \pm 6$ to give a quadratic in T. Allow their u_y
	$4.9T^2 - 8.8T - 6 = 0$ $T = \frac{8.8 \pm \sqrt{\left[(-)8.8\right]^2 + 24 \times 4.9}}{9.8}$	DM1	Solve a 3 term quadratic
	$T = 2.323... = 2.32$ or 2.3	A1	2.3 or 2.32 only
(d)	$v^2 = 8.8^2 + 2g \times 6$ or v = -8.8+gT	M1	Use *suvat* to find vertical speed
		A1	Correct equation their u_y, T
	$v = 13.96...$ Horiz speed = 4 $\tan\alpha = \frac{v}{4}$	DM1	Correct trig. with their vertical speed to find the required angle.
		A1	Correct equation
	$\alpha = 74.01... = 74°$	A1	$74°$ or $74.0°$. Allow 106.
	Alternative: $\frac{1}{2}m(9.6664)^2 + 6mg = \frac{1}{2}mv^2$	M1	Conservation of energy to find speed
	$v = 14.52719...$	A1	
	$\cos\alpha = \frac{4}{14.5}$	DM1	Correct method for α
		A1	
	$\alpha = 74.01... = 74°$	A1	Allow 106

Q	Scheme	Marks	
7(a)			If the signs on their diagram and in their working are inconsistent, ignore the diagram. Penalise inconsistency between the two equations in the second accuracy mark.
	$mu = -mv + 3mw$	M1	CLM. Allow for v in either direction. Needs all 3 terms. Condone sign errors.
	$u = -v + 3w$	A1	v in either direction. Ignore diagram if equations "correct" but inconsistent with diagram.
	$eu = w + v$	M1	Impact law. Must be the right way round, but condone sign errors
		A1	Correct equation. Signs consistent with CLM equn.
	$w = \frac{u}{4}(1+e)$	DM1	Solve for v or w.
		A1	One correct
	$v = -w + eu = \frac{u}{4}(3e-1)$	A1	Both correct. $1-3e \rightarrow$ A0 for v
(b)			If the signs on their diagram and in their working are inconsistent, ignore the diagram. Penalise inconsistency between the two equations in the B mark.
	$3mw = 4mX - 3mY$	M1	CLM for their w.
		A1ft	Correct unsimplified (their w)
	$2ew = X + Y$	B1ft	Impact law. Must be the right way up. Their w
	$7Y = W(8e-3)$	DM1	Solve for (7)Y
	Or $2ue(1+e) - \frac{3u}{4}(1+e) = 7Y$		
	$\rightarrow e > \frac{3}{8}$	A1	
	$Y > 0 \rightarrow \frac{3}{8} < e \leq \frac{1}{2}$	A1	NB No longer ft. Condone <.
(c)	$\frac{u}{28}(1+e)(8e-3) > \frac{u}{4}(3e-1)$	M1	For a second collision their Y > their v
	$2e^2 - 4e + 1 > 0$		
	$e = \frac{4 \pm \sqrt{16-8}}{4} = 1.707,\ 0.293$	DM1	Obtain the critical values
	$2e^2 - 4e + 1 < 0$ for $\frac{3}{8} < e \leq \frac{1}{2}$ so no second collision.	A1	Compare 0.293 (o.e.) with $\frac{3}{8}$ to reach correct conclusion for correct reason.

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