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Mark Scheme (Results)

Summer 2013

GCE Mechanics 4 (6680/01R)

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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.
- 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.

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
- * The answer is printed on the paper
- ⌐ 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 manifestly absurd 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. 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

General Rules for Marking Mechanics

- Usual rules for M marks: correct no. of terms; dim correct; all terms that need resolving (i.e. multiplied by cos or sin) are resolved.

- Omission or extra g in a resolution is accuracy error not method error.

- Omission of mass from a resolution is method error.

- Omission of a length from a moments equation is a method error.

- Omission of units or incorrect units is not (usually) counted as an accuracy error.

- DM indicates a dependent method mark i.e. one that can only be awarded if a previous specified method mark has been awarded.

- Any numerical answer which comes from use of g = 9.8 should be given to 2 or 3 SF.

- Use of g = 9.81 should be penalised once per (complete) question.

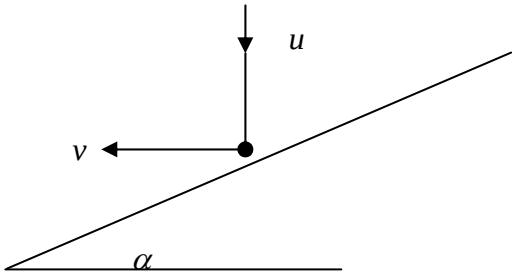
- N.B. Over-accuracy or under-accuracy of correct answers should only be penalised *ONCE* per complete question.

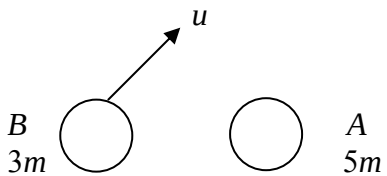
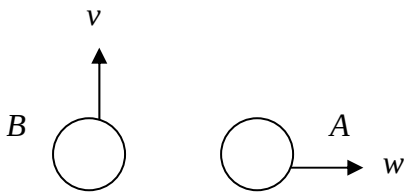
- In all cases, if the candidate clearly labels their working under a particular part of a question i.e. (a) or (b) or (c),……then that working can only score marks for that part of the question.

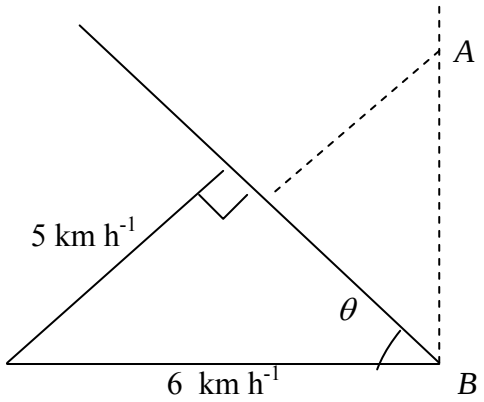
- Accept column vectors in all cases.

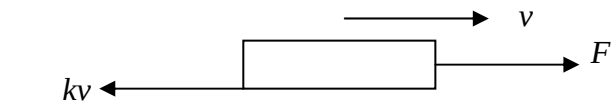
Misreads – if a misread does not alter the character of a question or materially simplify it, deduct two from any A or B marks gained, bearing in mind that after a misread, the subsequent A marks affected are treated as A ft.

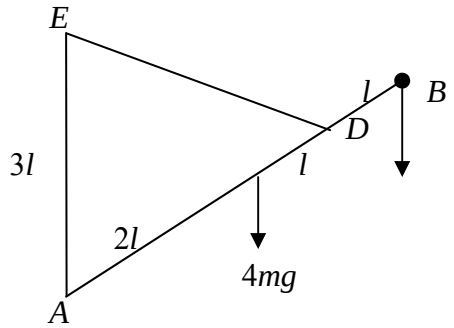
Question Number	Scheme	Marks	
1. (a)	${}_A\mathbf{v}_B = \mathbf{v}_A - \mathbf{v}_B$ $= -3\mathbf{i} + 9\mathbf{j}$ km h^{-1}	M1	
	Mag $= \sqrt{9+81} = 3\sqrt{10}$	M1A1 **(3)**	9.5 or better
(b)	$\tan\theta = \frac{3}{9}$	M1	Allow ± or reciprocal
	$\theta = 18.4°$		Or 71.6°
	Direction $= 360 - 18.4$ $= 342°$	A1 **(2)** **[5]**	Allow 341.6°

Question Number	Scheme	Marks	
2.			
	CLM: $u\sin\alpha = v\cos\alpha$	M1 A1	Must be in correct direction but condone trig confusion
	Impact: $\frac{1}{3}u\cos\alpha = v\sin\alpha$	M1 A1	Condone consistent trig confusion
	$\frac{1}{3}\times\frac{1}{\tan\alpha} = \tan\alpha$	M1	
	$\tan\alpha = \frac{1}{\sqrt{3}}$		
	$\alpha = 30°$ $\left(\text{or } \frac{\pi}{6} \text{ or } 0.52\,\text{rad}\right)$	A1	
		(6) **[6]**	

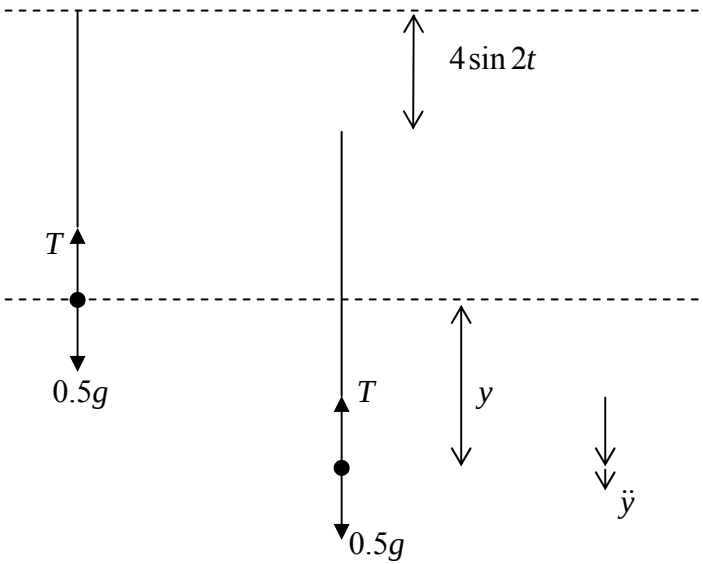
Question Number	Scheme	Marks	
3.			
(a)			
	After impact B moves perpendicular to the line of centres	B1	can be implied by appropriate use of θ in an equation, or seen on the diagram
	Perp. to line of centres: $v = u\sin 60 = u\dfrac{\sqrt{3}}{2}$	M1A1	
		(3)	
(b)	Parallel to line of centres:		
	Con of Mom $3mu\cos 60 + 5m\times 0 = 3m\times 0 + 5mw$	M1A1	
	N.L.R. $eu\cos 60 = w$	M1A1	
	$\dfrac{1}{2}eu = w$ & $\dfrac{3}{2}u = 5w$		
	$\rightarrow \dfrac{1}{2}eu = \dfrac{3}{10}u$	DM1	Dependent on the two previous M marks
	$e = \dfrac{3}{5}$	A1	
		(6)	
		[9]	

Question Number	Scheme	Marks	
4.		B1	Right angled triangle with the right angle opposite the 6 seen in diagram or implied in working
(a)	$\sin\theta = \frac{5}{6}$ $\theta = 56.44...$ Bearing = 056^{o}	M1 A1 A1 **(4)**	Correct trig. Allow 56.4°
(b)	Least distance = $4\cos\theta = \frac{\left(4\sqrt{11}\right)}{6}$ or 2.211 km oe	M1 A1 **(2)**	Correct for their angle 2.2 or better
(c)	${}_{B}v_{A} = \sqrt{6^2 - 5^2} = \sqrt{11}$ $t = \frac{4\sin\theta}{\sqrt{11}} \quad \left(= 1.0050...\right)$ time = 11 am	B1 M1 A1ft B1 **(4)** **[10]**	3.32 Condone consistent trig confusion Ft on their √11

Question Number	Scheme	Marks	
5.			
(a)	$Fv = 40000$		
	$1200\dfrac{\mathrm{d}v}{\mathrm{d}t} = \dfrac{40000}{v} - kv$	M1 A1	
	$\dfrac{\mathrm{d}v}{\mathrm{d}t} = 0.3 \qquad 1200\times 0.3 = \dfrac{40000}{40} - 40k$	M1	Use initial conditions to find k
	$k = 16$	A1	
	$1200\dfrac{\mathrm{d}v}{\mathrm{d}t} = \dfrac{40000}{v} - 16v$		
	$1200v\dfrac{\mathrm{d}v}{\mathrm{d}t} = 40000 - 16v^2$	M1	
	$75v\dfrac{\mathrm{d}v}{\mathrm{d}t} = 2500 - v^2$	A1	**<u>Given Answer</u>**
		(6)	
(b)	$75\displaystyle\int \frac{v}{2500 - v^2}\,\mathrm{d}v = \int \mathrm{d}t$	M1	Separate and attempt integration
	$-\dfrac{75}{2}\ln\left(2500 - v^2\right) = t \quad (+c)$	A1	
	$t = 0 \;\; v = 0 \;\Rightarrow -\dfrac{75}{2}\ln 2500 = c$	M1	Use initial values to find c
	$-\dfrac{75}{2}\ln\left(\dfrac{2500 - v^2}{2500}\right) = t$	A1	Or equivalent
	$\dfrac{2500 - v^2}{2500} = \mathrm{e}^{-\frac{2t}{75}} \;\rightarrow\; v^2 = 2500\left(1 - \mathrm{e}^{-\frac{2t}{75}}\right)$	M1	Find v or v^2 in terms of t
	$v = 50\sqrt{1 - \mathrm{e}^{-\frac{2t}{75}}}$	A1	
		(6) **[12]**	

Question Number	Scheme	Marks	
6.			
(a)	Length of string = $2\times 3l\sin\theta$	B1	
	Extension = $6l\sin\theta - l$		
	E.P.E. = $\frac{4mg}{2l}\left(6l\sin\theta - l\right)^2$		
	G.P.E. of rod = $4mg\times 2l\cos 2\theta$		
	G.P.E. of mass at B = $kmg\times 4l\cos 2\theta$		
	$V = \frac{4mg}{2l}\left(6l\sin\theta - l\right)^2 + 8mgl\cos 2\theta + 4kmgl\cos 2\theta + \text{ const}$	M1	EPE term needs to be dimensionally correct. Need all three terms.
		A2	Correct unsimplified
	$V = \frac{4mg}{2l}\left(6l\sin\theta - l\right)^2 + 8mgl\left(1-2\sin^2\theta\right) + 4kmgl\cos 2\theta + \text{const}$	M1	All in $\sin\theta$
	$= 2mgl\left(36\sin^2\theta - 12\sin\theta - 8\sin^2\theta - 4k\sin^2\theta\right) + \text{ const}$		
	$= 8mgl\left(\left(7-k\right)\sin^2\theta - 3\sin\theta\right) + \text{ constant}$	A1	**Given Answer**
		(6)	

Question Number	Scheme	Marks	
(b)	$\frac{\mathrm{d}V}{\mathrm{d}\theta} = 8mgl\left(2(7-k)\sin\theta\cos\theta - 3\cos\theta\right)$	M1	Differentiate
	$\frac{\mathrm{d}V}{\mathrm{d}\theta} = 0 \quad \left(2(7-k)\sin\theta - 3\right)\cos\theta = 0$	M1	Set derivative = 0
	$\sin\theta = \frac{3}{2(7-k)} \quad \left(\text{or } \cos\theta = 0, \text{ need not be seen}\right)$	A1	
	$\theta \leqslant \frac{\pi}{6} \quad \Rightarrow \frac{3}{2(7-k)} \leqslant \frac{1}{2}$	M1	Use of $\sin\theta \leq \frac{1}{2}$
	$3 \leqslant 7-k \quad k \leqslant 4$ *	A1	
		(5)	
(c)	$k = 4 \Rightarrow \theta = \frac{\pi}{6}$	B1	
	$\frac{\mathrm{d}^2V}{\mathrm{d}\theta^2} = 8mgl\left[6\cos^2\theta - \left(6\sin\theta - 3\right)\sin\theta\right]$	M1	Second derivative ($8mgl$ or $24mgl$ not needed) $\left[\text{or differentiate } 8mgl\left(3\sin 2\theta - 3\cos\theta\right)\right]$
	$= 8mgl\left[6\times\left(\frac{\sqrt{3}}{2}\right)^2 - 6\times\left(\frac{1}{2}\right)^2 + 3\times\frac{1}{2}\right]$	A1	Numerical unsimplified
	$\frac{\mathrm{d}^2V}{\mathrm{d}\theta^2} > 0$	M1	by numerical evaluation or justification from trig terms $\left(36mgl\right)$
	V is min. $\quad \therefore$ stable equilibrium	A1	CSO
		(5) **[16]**	

Question Number	Scheme	Marks	
7			
(a)	In equilibrium $T = 0.5g = \dfrac{2.7e}{0.6}$	M1	
	$e = \dfrac{g}{9} = \dfrac{9.8}{9} = \dfrac{49}{45}$	A1	
	$0.6 + \dfrac{49}{45} - 4\sin 2t + y = 0.6 + x$		
	$y + \dfrac{49}{45} = x + 4\sin 2t$	A1	**Given Answer** – must see justification
		(3)	
(b)	$0.5g - \dfrac{2.7x}{0.6} = 0.5\ddot{y}$	M1A1	Equation of motion for P
	$g - 9x = \ddot{y}$		
	$g - 9\left(y + \dfrac{g}{9} - 4\sin 2t\right) = \ddot{y}$	DM1 A1	Substitute for x
	$\ddot{y} + 9y = 36\sin 2t$	A1	**Given Answer**
		(5)	

Question Number	Scheme	Marks	
(c)	C.F. is $y = A\cos 3t + B\sin 3t$	M1	
	Gen. soln. is $y = A\cos 3t + B\sin 3t + \frac{36}{5}\sin 2t$	A1	
	$t = 0 \quad y = 0 \Rightarrow A = 0$	B1	
	$\dot{y} = 3B\cos 3t + \frac{72}{5}\cos 2t$	M1	Independent. Differentiate and use initial conditions to find B
	$t = 0 \ \ \dot{y} = 0 \Rightarrow 3B = -\frac{72}{5} \qquad B = -\frac{24}{5}$		
	$\therefore y = -\frac{24}{5}\sin 3t + \frac{36}{5}\sin 2t$	A1	
		(5)	
(d)	$\dot{y} = -\frac{72}{5}\cos 3t + \frac{72}{5}\cos 2t$	M1A1	
	$\dot{y} = -\frac{72}{5}\cos \pi + \frac{72}{5}\cos \frac{2}{3}\pi$	M1	Substitute $t = \frac{\pi}{3}$ in derivative to find $\dot{y}$
	$\dot{y} = 7.2$	A1	Final answer
		(4)	
		[17]	

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