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Mark Scheme (Results)

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GCE Mechanics M2 6678/01
Original Paper

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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.

Question Number	Scheme	Marks	Notes
1. (a)	$2\begin{pmatrix} a \\ 3 \end{pmatrix} + 3\begin{pmatrix} 3 \\ -1 \end{pmatrix} + m\begin{pmatrix} -2 \\ 4 \end{pmatrix} = (m+5)\begin{pmatrix} 0 \\ 2 \end{pmatrix}$		
	$6 - 3 + 4m = (m+5) \times 2$	M1 A2	Moments equation for y coordinate. Terms of correct structure but condone sign slips -1 each error
	$(7 = 2m)$, $m = 3.5$	A1 **(4)**	
(b)	$2a + 9 - 2m = 0 \, (\times (m+5))$	M1 A1	Moments equation for x coordinate. Terms of correct structure but condone sign slips
	$2a + 9 - 7 = 0$ use their m	M1	Substitute their m and solve for a.
	$a = -1$	A1 **(4)**	
		[8]	
2. (a)	Use of $\dfrac{P}{V} = F$	M1	
	$\dfrac{32000}{V} = 800$	A1	
	$V = 40$	A1 **(3)**	
(b)	$F = \dfrac{32000}{20} = 1600$	M1	Find the driving force
	$1600 - 800 + 1200g\sin\theta = 1200a$	M1	Equation of motion for their F. Requires all 4 terms. Condone sign errors and trig confusion
	$800 + \dfrac{1200g}{40} = 1200a$	A1	Correct equation (allow with $\sin\theta$)
	$a = 0.91\,(\text{m s}^{-2})$,	A1	Accept 0.912
		(4)	

Question Number	Scheme	Marks	Notes
		[7]	
3. (a)	Momentum $= 0.25 \times ((2-12)\,\mathbf{i} + (9+6)\,\mathbf{j})$	M1	Substitution of $m = 0.25$ and $t = 3$
	$= \text{-}2.5\mathbf{i} + 3.75\mathbf{j}$	A1	or simplified equivalent $-\dfrac{5}{2}\mathbf{i} + \dfrac{15}{4}\mathbf{j}$
		(2)	
(b)	$\mathbf{a} = \text{-}4\mathbf{i} + (2t+2)\mathbf{j}$	M1	Differentiate $\mathbf{v}$
		A2	A1 for each term
	Use of $\mathbf{F} = m\mathbf{a}$	M1	
	Use of Pythagoras on $\mathbf{F}$ or $\mathbf{a}$	M1	
	$\left\|F\right\| = 0.25 \times \sqrt{16 + (6+2)^2} = \sqrt{5}$	A1	2.24 or better
		(6)	
(c)	$\mathbf{s} = \left(2t - 2t^2\right)\mathbf{i} + \left(\dfrac{t^3}{3} + t^2\right)\mathbf{j}\ (+\ \mathbf{r_0})$	M1	Integrate to find displacement
		A2	A1 for each component. $\mathbf{r_0}$ not required.
	Use of $\mathbf{r_0}$ and $t = 3$	M1	
	Position vector of A is $\text{-}10\mathbf{i} + 14\mathbf{j}$	A1	
		(5)	
		[13]	

Question Number	Scheme	Marks	Notes
4. (a)	Energy at A = Energy at B	M1	Equation requires all 3 terms. Condone sign errors
	$\frac{1}{2}m\times15^2 = \frac{1}{2}m\times12^2 + mgh$	A2	-1 each error
	$h = \frac{27\times3}{2g} \approx 4.1$	A1	Allow 4.13 $\frac{405}{98}$ is A0
		(4)	
(b)	Use of $s = ut + \frac{1}{2}gt^2$	M1	or equivalent complete method to an equation in α
	$4 = 12\sin\alpha\times1.5 - \frac{g}{2}\times1.5^2$	A1	Correct unsimplied equation
	$(\sin\alpha = 0.834......)\quad \alpha = 56.6°$	A1	Or 57°
		(3)	
(c)	$\cos\theta = \frac{12\cos\alpha}{15}$	M1 A1ft	Use of horizontal component and speed to find direction, or equivalent. follow their α 6.606, 13.47, 15
	$\theta = 64°$	A1	63.9 from calculator values, 64.2 from 57
		(3)	
		[10]	

Question Number	Scheme	Marks	Notes
5. (a)	Moments about OE: $\dfrac{a}{2} \times 1 + (a+2) \times 1 = 2\bar{x}$	M1 A2	Moments equation. Needs to include both rectangles and the whole shape. -1 each error. or equivalent
	$2\bar{x} = \dfrac{3a}{2} + 2$, $\bar{x} = \dfrac{3a}{4} + 1$	A1	Or simplified equivalent.
		(4)	
(b)	Moments about OA: $2 \times 1 + \dfrac{a}{2} \times 1 = 2\bar{y}$ o.e.	M1 A2	Moments equation. Needs to include both rectangles and the whole shape. -1 each error. or equivalent
	$\bar{y} = 1 + \dfrac{a}{4}$ o.e.	A1	Or simplified equivalent.
		(4)	
(c)	Hanging in Equilibrium: $\tan\alpha = \dfrac{\bar{x}}{\bar{y}} = \dfrac{\dfrac{3a}{4}+1}{1+\dfrac{a}{4}}$	M1 A1ft	Condone reciprocal For their $\bar{x}$, $\bar{y}$
	$\dfrac{4}{3} = \dfrac{\dfrac{3a}{4}+1}{1+\dfrac{a}{4}} = \dfrac{3a+4}{4+a}$, $4(4+a) = 3(3a+4)$ $16 + 4a = 9a + 12$, $4 = 5a$,	DM1	Their $\tan\alpha = \dfrac{4}{3}$ and solve for a
	$a = \dfrac{4}{5}$	A1	Or 0.8
		(4)	
		[12]	

Question Number	Scheme	Marks	Notes
6. (a)			
	Moments about A: $30 \times 1.5 \cos 15 = d \times N$	M1	Requires correct terms of correct structure. Condone with value of d not yet found.
	$30 \times 1.5 \cos 15 = \dfrac{0.45}{\sin 15} N$	A2	-1 each error. Requires a value for d. Accept unsimplified. $d = 1.738\ldots..$
	$N = 100 \cos 15 \sin 15 = 25 \,(N)$ ***AG***	A1	Watch out for given answer
		(4)	
(b)	Moments about P: $R \times d \cos 15 = 30 \times (d - 1.5) \cos 15$	M1	Terms of correct structure. Condone sign errors & trig confusion.
		A2ft	their d. Correct unsimplified. -1 each error
	$R = \dfrac{30(d - 1.5)}{d} = 4.118095\ldots\ldots.$	A1	4.1 or better
		(4)	
(c)	Resolving horizontally at P: $N \cos 75 = F \cos 15$	M1 A1	Condone trig confusion
	$F = \dfrac{N \cos 75}{\cos 15}$		
	$\mu \geq \dfrac{F}{N}: \ \ \mu \geq \dfrac{\cos 75}{\cos 15}$	M1	Use of $F \leq \mu N$
	$\mu \geq 0.268$	A1	0.27 or better
		(4)	
		[12]	

Question Number	Scheme	Marks	Notes
7. (a)			
	Q collides with wall: $v' = \dfrac{1}{3} \times 3u = u$ towards P	M1 A1	Correct use of impact law
	P and Q collide. Conservation of momentum: $m \times 2u - 2m \times u = 2m \times w - m \times v$	M1 A1	Requires all 4 terms. Condone sign errors
	$0 = 2m \times w - m \times v, \quad 2w = v$ *AG*	A1	**Watch out**
		(5)	
(b)	Impact law: $v + w = e(2u + u)$	M1	Correct use of impact law to find w
	$3w = 3eu, \quad w = eu$	A1	
	Kinetic energy: $\dfrac{1}{2}\left[\dfrac{1}{2}m.4u^2 + \dfrac{1}{2}2m.u^2\right] = \dfrac{1}{2}m.v^2 + \dfrac{1}{2}2m.w^2$	M1 A2	Requires all terms. Each term of correct structure -1 each error
	$\dfrac{1}{2}3u^2 = \dfrac{1}{2}4w^2 + \dfrac{1}{2}2w^2 = 3w^2$	M1	Solve for w
	$w = \dfrac{1}{\sqrt{2}}u$	A1	
	$e = \dfrac{1}{\sqrt{2}}$	A1	0.71 or better
		(8)	
		[13]	