Edexcel
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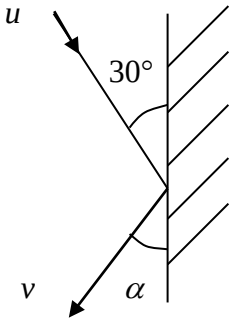
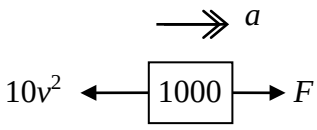
Mock Paper Mark Scheme

Advanced Subsidiary/Advanced GCE
General Certificate of Education

Subject **MECHANICS** Paper No. **Mock M4**

Question number	Scheme	Marks
1.	 $v\cos\alpha = u\cos 30°$ $v\sin\alpha = \frac{1}{3}u\sin 30°$ squaring and adding, $v^2 = u^2(\frac{3}{4} + \frac{1}{36})$ $v = \frac{u\sqrt{7}}{3}$	M1 A1 M1 A1 M1 A1 **(6)**
2.	 $F = \frac{12000}{v}$ $\frac{12000}{v} - 10v^2 = 1000v\frac{dv}{dx}$ $\int dx = 100\int\frac{v^2\,dv}{1200 - v^3}$ $X = -\frac{100}{3}\left[\ln(1200 - v^3)\right]_5^{10}$ = 56.1 m (3 s.f.)	B1 M1 A1 M1 M1 A1 M1 A1 **(8)**

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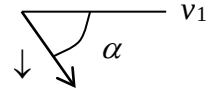
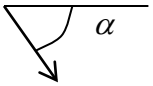
3.	$\rightarrow u\cos 30°$ $\quad\rightarrow 0$ $\quad v_1 + v_2 = u\cos 30°$	M1 A1
	$\downarrow$ A (m) $\quad\downarrow$ B (m) $\quad -v_1 + v_2 = eu\cos 30°$	M1 A1
	$u\sin 30°$ $\quad 0$	
	 $\quad\rightarrow v_2$	
	$u\sin 30°$ $\quad 0$	
	subtracting, $v_1 = \frac{u\sqrt{3}}{4}(1-e)$	A1
	 $\quad \tan\theta = \tan(\alpha - 30°) = \frac{\tan\alpha - \tan 30°}{1 + \tan\alpha\tan 30°}$	M1
	$\tan\alpha = \frac{u\sin 30°}{v_1} = \frac{2}{\sqrt{3}(1-e)}$	M1 A1
	$\tan\theta = \frac{\frac{2}{\sqrt{3}(1-e)} - \frac{1}{\sqrt{3}}}{1 + \frac{2}{\sqrt{3}(1-e)}\frac{1}{\sqrt{3}}}$	M1
	$= \frac{(1+e)\sqrt{3}}{5-3e}$ (*)	A1 **(10)**

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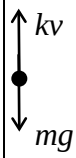
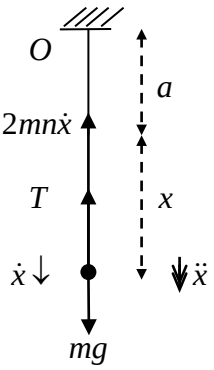
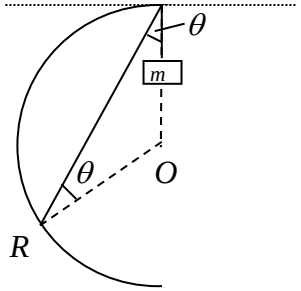
4.	 $mg - 100k = 0$ at terminal speed	M1
	$k = \dfrac{mg}{100}$	A1
	$mg - \dfrac{mg}{100}v = m\dfrac{\mathrm{d}v}{\mathrm{d}t}$	M1 A1 A1
	$\displaystyle\int \mathrm{d}t = \frac{100}{g}\int \frac{\mathrm{d}v}{100 - v}$	M1
	$T = \dfrac{100}{g}\left[\ln(100 - v)\right]_{60}^{0}$	A1 A1(limits)
	$= \dfrac{100}{g}\ln\left(\dfrac{100}{40}\right)$	M1
	$= 9.35$ s (3 s.f.)	A1

Question number	Scheme	Marks
5. (*a*)		
	$mg - T - 2mn\dot{x} = m\ddot{x}$	M1 A1 A1
	$mg - \dfrac{2man^2x}{a} - 2mn\dot{x} = m\ddot{x}$	M1
	$\ddot{x} + 2n\dot{x} + 2n^2x = g$ (*)	A1 (5)
(*b*)	AE: $u^2 + 2nu + 2n^2 = 0$	M1
	$(u + n)^2 = -n^2$	
	$u = -n \pm ni$	A1
	CF: $x = e^{-nt}(A\cos nt + B\sin nt)$, PI: $x = \dfrac{g}{2n^2}$	M1
	GS: $x = e^{-nt}(A\cos nt + B\sin nt) + \dfrac{g}{2n^2}$	A1
	$t = 0, x = a, \dot{x} = 0$: $A = a - \dfrac{g}{2n^2}$	M1
	$\dot{x} = e^{-nt}(-An\sin nt + Bn\cos nt) - ne^{-nt}(A\cos nt + B\sin nt)$	M1
	$x = e^{-nt}\left(a - \dfrac{g}{2n^2}\right)(\cos nt + \sin nt) + \dfrac{g}{2n^2}$	A1 (7)
		(12)

Question number		Scheme	Marks
6.	(*a*)	$(\mathbf{v}_P - \mathbf{v}_Q)^2 = \mathbf{v}_P{}^2$ ①	M1 A1
		$(\mathbf{v}_P + \mathbf{v}_Q)^2 = 4\mathbf{v}_P{}^2$ ②	M1 A1
		$4\mathbf{v}_P \,.\, \mathbf{v}_Q = 3\mathbf{v}_P{}^2$ ② – ①	M1 A1
		From ①: $2\mathbf{v}_P \,.\, \mathbf{v}_Q = \mathbf{v}_Q{}^2$ ③	M1 A1
		$\therefore \sqrt{\frac{2}{3}} = \frac{\lvert\mathbf{v}_P\rvert}{\lvert\mathbf{v}_Q\rvert}$	A1 (9)
	(*b*)	From ③ above, $2 \lvert \mathbf{v}_P \rvert \lvert \mathbf{v}_Q \rvert \cos\theta = \lvert \mathbf{v}_Q \rvert^2$	M1 A1
		$\cos\theta = \frac{1}{2}\sqrt{\frac{3}{2}} = \frac{\sqrt{6}}{4}$	A1 (3)
			(12)
7.	(*a*)	 $AR = 2r\cos\theta$	B1
		For P: $-mg\,(L - 2r\cos\theta)$	B1
		For R: $-mg\,2r\cos^2\theta$	M1 A1
		$V = 2mgr\,(\cos\theta - \cos^2\theta) - mgL$ (*)	M1 A1 (6)
	(*b*)	$\frac{\mathrm{d}V}{\mathrm{d}\theta} = 2mgr\,(-\sin\theta + 2\cos\theta\sin\theta)$	M1 A1
		$= 2mgr\sin\theta\,(2\cos\theta - 1)$	A1
		$0 = 2mgr\sin\theta\,(2\cos\theta - 1)$	M1
		$\sin\theta = 0$ or $\cos\theta = \frac{1}{2}$	
		$\theta = 0$ or $\theta = \frac{\pi}{3}$	A1 A1 (6)
	(*c*)	$\frac{\mathrm{d}^2V}{\mathrm{d}\theta^2} = 2mgr\,(-\cos\theta + 2\cos 2\theta)$	M1 A1
		$\theta = 0$, $\frac{\mathrm{d}^2V}{\mathrm{d}\theta^2} = 2mgr > 0 \Rightarrow$ STABLE	M1 A1
		$\theta = \frac{\pi}{3}$, $\frac{\mathrm{d}^2V}{\mathrm{d}\theta^2} = -3mgr < 0 \Rightarrow$ UNSTABLE	A1 (5)
			(17)