Mark Scheme (Results)
January 2010

GCE

Mechanics M3 (6679)

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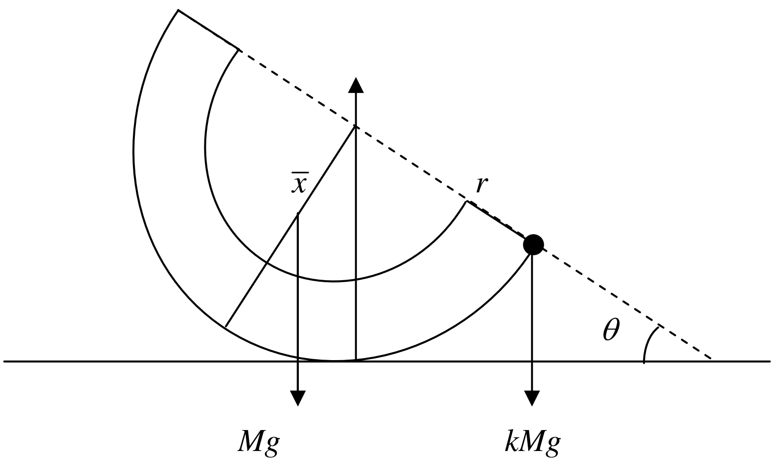
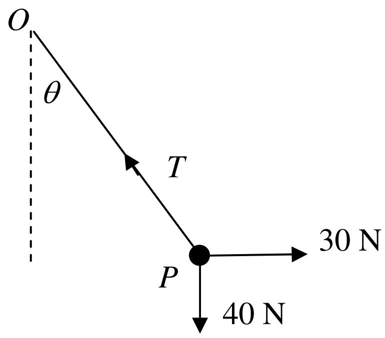
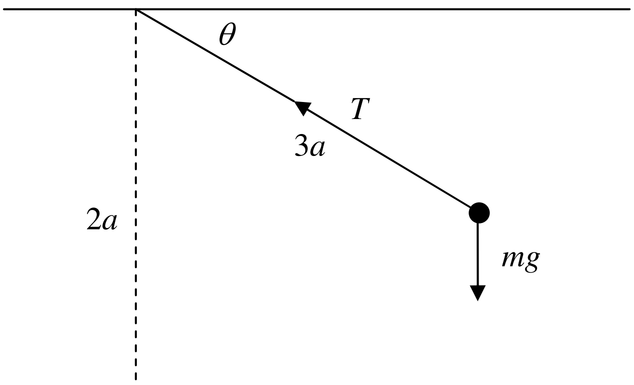
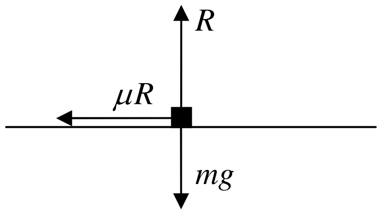
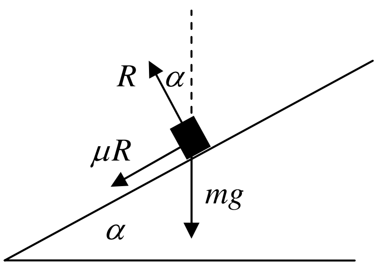
Question Number	Scheme	Marks
Q1.	$0.5a = 4 + \cos(\pi t)$	B1
	Integrating $\quad 0.5v = 4t + \dfrac{\sin(\pi t)}{\pi} \; (+C)$	M1 A1
	Using boundary values $3 = 4 + C \Rightarrow C = -1$	M1 A1
	When $t = 1.5$ $0.5v = 6 - \dfrac{1}{\pi} - 1$	M1
	$v \approx 9.36 \; (\text{m s}^{-1})$ cao	A1 (7) [7]

Question Number	Scheme	Marks
Q2.	(a) $\frac{2\pi}{\omega} = 2.4 \quad \Rightarrow \omega = \frac{5\pi}{6}\left(\approx 2.62\right)$	M1 A1
	$x = 0, t = 0 \quad \Rightarrow \quad x = a\sin\omega t$	
	when $t = 0.4$, $x = a\sin\left(\frac{5\pi}{6}\times 0.4\right) \qquad \left(=\frac{\sqrt{3}}{2}a\right)$	M1
	$v^2 = \omega^2\left(a^2 - x^2\right) \quad \Rightarrow \quad 16 = \frac{25\pi^2}{36}\left(a^2 - \frac{3a^2}{4}\right) \quad \Rightarrow \quad a = \frac{48}{5\pi}\left(\approx 3.06\right)$	M1 A1
	$v_{max} = a\omega = 8$ (or awrt 8.0 if decimals used earlier) cao	M1 A1 (7)
	(b) $\ddot{x}_{max} = a\omega^2 = \frac{20\pi}{3}$ awrt 21	M1 A1 (2)
		[9]
	Alternative in (a)	
	(a) $\frac{2\pi}{\omega} = 2.4 \Rightarrow \omega = \frac{5\pi}{6}$	M1 A1
	$x = 0, t = 0 \quad \Rightarrow \quad x = a\sin\omega t$	
	$\dot{x} = a\omega\cos\omega t$	M1
	$4 = a\omega\cos\left(\frac{5\pi}{6}\times 0.4\right)$	M1
	$a = \frac{48}{5\pi}\left(\approx 3.06\right)$ or $a\omega = 8$	A1
	$v_{max} = a\omega = 8$	M1 A1 (7)

Question Number	Scheme	Marks
Q3.	(a) Mass ratios: s 8, B 19, S 27 — anything in correct ratio	B1
	$\bar{x}$: $\frac{3}{8}\times\frac{2}{3}r$, $\bar{x}$, $\frac{3}{8}r$	B1
	$8\times\frac{1}{4}r+19\bar{x}=27\times\frac{3}{8}r$	M1 A1ft
	$\bar{x}=\frac{65}{152}r$ *	A1 (5)
	(b) 	
	$Mg\times\bar{x}\sin\theta=kMg\times r\cos\theta$	M1 A1=A1
	leading to $k=\frac{13}{38}$	M1 A1 (5)
		[10]

Question Number	Scheme	Marks
Q4.		
	↑ $T\cos\theta = 40$ M1 attempt at both equations	M1 A1
	→ $T\sin\theta = 30$	A1
	leading to $T = 50$	M1 A1
	$E = \dfrac{\lambda x^2}{2a} = 10$	B1
	HL $T = \dfrac{\lambda x}{a} = 50$	M1
	leading to $x = 0.4$	M1 A1
	$OP = 0.5 + 0.4 = 0.9\,(\text{m})$	A1ft (10)
		[10]

Question Number	Scheme	Marks
Q5.	(a) 	
	$\frac{1}{2}m\times 2ag-\frac{1}{2}mv^2=mg\left(2a-3a\sin\theta\right)$	M1 A1=A1
	leading to $v^2=2ga\left(3\sin\theta-1\right)$ * cso	M1 A1 (5)
	(b) minimum value of T is when $v=0 \Rightarrow \sin\theta=\frac{1}{3}$	B1
	$T=mg\sin\theta=\frac{mg}{3}$	M1 A1
	maximum value of T is when $\theta=\frac{\pi}{2}$ $\left(v^2=4ag\right)$	
	$\uparrow$ $T=\frac{mv^2}{3a}+mg$	M1 A1
	$=\frac{7mg}{3}$	A1 (6)
	$\left(\frac{mg}{3}\le T\le\frac{7mg}{3}\right)$	[11]

Question Number	Scheme	Marks
Q6.	(a) 	
	↑ $R = mg$	B1
	Use of limiting friction, $F_r = \mu R$	B1
	← $\mu R = \frac{m28^2}{120}$	M1 A1
	$\mu = \frac{28^2}{120 \times 9.8} = \frac{2}{3}$ * cao	M1 A1 (6)
	(b) 	
	↑ $R\cos\alpha - \mu R\sin\alpha = mg$	M1 A1
	← $\mu R\cos\alpha + R\sin\alpha = \frac{mv^2}{r}$	M1 A1
	$\frac{\mu\cos\alpha + \sin\alpha}{\cos\alpha - \mu\sin\alpha} = \frac{v^2}{rg}$ Eliminating R	M1
	$\frac{2\cos\alpha + 3\sin\alpha}{3\cos\alpha - 2\sin\alpha} = \frac{25}{24}$ Substituting values	M1
	leading to $\tan\alpha = \frac{27}{122}$ awrt 0.22	M1 A1 (8)
		[14]

Question Number	Scheme	Marks
Q7.	(a)	
	$\frac{1}{2}mv^2 + \frac{3mgx^2}{4a} = mg(a+x)$	M1 A2 (1, 0)
	leading to $v^2 = 2g(a+x) - \frac{3gx^2}{2a}$ ∗ cso	A1 (4)
	(b) Greatest speed is when the acceleration is zero	
	$T = \frac{\lambda x}{a} = \frac{3mgx}{2a} = mg \quad \Rightarrow \quad x = \frac{2a}{3}$	M1 A1
	$v^2 = 2g\left(a + \frac{2a}{3}\right) - \frac{3g}{2a} \times \left(\frac{2a}{3}\right)^2 \left(= \frac{8ag}{3}\right)$	M1
	$v = \frac{2}{3}\sqrt{(6ag)}$ accept exact equivalents	A1 (4)
	(c) $v = 0 \quad \Rightarrow \quad 2g(a+x) - \frac{3gx^2}{2a} = 0$	M1
	$3x^2 - 4ax - 4a^2 = (x-2a)(3x+2a) = 0$	
	$x = 2a$	M1 A1
	At D, $m\ddot{x} = mg - \frac{\lambda \times 2a}{a}$ ft their $2a$	M1 A1ft
	$\lvert\ddot{x}\rvert = 2g$	A1 (6)
		[14]
	Alternative to (b)	
	$v^2 = 2g(a+x) - \frac{3gx^2}{2a}$	
	Differentiating with respect to x	
	$2v\frac{\mathrm{d}v}{\mathrm{d}x} = 2g - \frac{3gx}{a}$	
	$\frac{\mathrm{d}v}{\mathrm{d}x} = 0 \Rightarrow x = \frac{2a}{3}$	M1 A1
	$v^2 = 2g\left(a + \frac{2a}{3}\right) - \frac{3g}{2a} \times \left(\frac{2a}{3}\right)^2 \left(= \frac{8ag}{3}\right)$	M1
	$v = \frac{2}{3}\sqrt{(6ag)}$ accept exact equivalents	A1 (4)

Question Number	Scheme	Marks
Q7.	*Alternative approach using SHM for* (b) *and* (c) If SHM is used mark (b) and (c) together placing the marks in the gird as shown.	
	Establishment of equilibrium position $T = \frac{\lambda x}{a} = \frac{3mge}{2a} = mg \quad \Rightarrow \quad e = \frac{2a}{3}$	bM1 bA1
	N2L , using y for displacement from equilibrium position $m\ddot{y} = mg - \frac{\frac{3}{2}mg\left(y+e\right)}{a} = -\frac{3g}{2a}y$	bM1 bA1
	$\omega^2 = \frac{3g}{2a}$	
	Speed at end of free fall $\quad u^2 = 2ga$	cM1
	Using A for amplitude and $v^2 = \omega^2\left(a^2 - x^2\right)$ $u^2 = 2ga$ when $y = -\frac{2}{3}a \quad \Rightarrow \quad 2ga = \frac{3g}{2a}\left(A^2 - \frac{4a^2}{9}\right)$	cM1
	$A = \frac{4a}{3}$	cA1
	Maximum speed $\quad A\omega = \frac{4a}{3} \times \sqrt{\left(\frac{3g}{2a}\right)} = \frac{2}{3}\sqrt{\left(6ag\right)}$	cM1 cA1
	Maximum acceleration $\quad A\omega^2 = \frac{4a}{3} \times \frac{3g}{2a} = 2g$	cA1

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