

3C5 2012 Answers

1 (a)  $\frac{4}{3}ma^2, 2ma^2, 2ma^2$

(b)  $ma^2 \begin{bmatrix} 2/3 & 0 & -3/8 \\ 0 & 1 & 0 \\ -3/8 & 0 & 1 \end{bmatrix}$

(c)  $\frac{3}{8}ma^2\Omega^2\mathbf{j}$

2 (a)  $-mg\cos\theta\mathbf{j}$

(b)  $\dot{\phi} = 2\sqrt{\frac{g}{a\sin\theta}}$

(c) (i)  $\sqrt{\frac{\theta^3 g}{a}}$  relative to a frame *fixed in the table*

(ii)  $-2\sqrt{\frac{g}{a}}\left(\frac{\pi}{2}-\theta\right)$  relative to a frame in which *contact point with table stays fixed*

4 (a)  $\frac{1}{3}M_1L^2\ddot{\theta}_1 + \frac{1}{2}M_1gL\sin\theta_1 - kL^2\sin(\theta_2 - \theta_1) = 0$

(b)  $M = \frac{L^2}{3} \begin{bmatrix} M_1 & 0 \\ 0 & M_2 \end{bmatrix}, K = \begin{bmatrix} \frac{1}{2}M_1gL + kL^2 & -kL^2 \\ -kL^2 & \frac{1}{2}M_2gL + kL^2 \end{bmatrix}$

$$\omega^2 = \frac{3g}{2L}, \frac{kL^2(M_1 + M_2) + gLM_1M_2/2}{M_1M_2L^2/3}$$