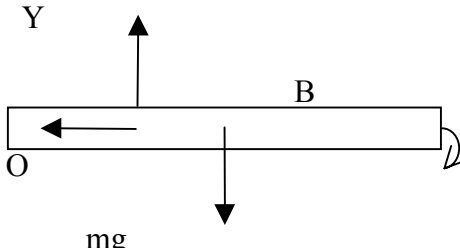


Question Number	Scheme	Marks
1.	<p>(a) $\overrightarrow{AB} = (\mathbf{i} - 5\mathbf{j}) \text{ m}$ $(14\mathbf{i} + 2\mathbf{j} + 3\mathbf{k}) \cdot (\mathbf{i} - 5\mathbf{j}) = 4\text{J}$</p> <p>(b) $\frac{1}{2} \times 0.125 \times v^2 = 4$ $v = 8 \text{ ms}^{-1}$</p>	<p>B1 M1 A1 (3) M1 A1 ft (2) (5 marks)</p>
2.	<p>(a) $I = \int_{-a}^a \frac{m}{2a} x^2 dx$ $= \frac{ma^2}{3}$</p> <p>(b) $I_x = I_y = 2 \left(\frac{ma^2}{3} + ma^2 \right) = \frac{8ma^2}{3}$ \therefore by perpendicular axes, $I_z = \frac{16ma^2}{3}$</p>	<p>M1 A1 A1 (3) M1 A1 M1 A1 ft (4) (7 marks)</p>
3.	<p>(a) $\mathbf{F} = (3\mathbf{i} + 4\mathbf{j}) + (2\mathbf{i} - \mathbf{j} + \mathbf{k})$ $= (5\mathbf{i} + 3\mathbf{j} + \mathbf{k}) \text{ N}$</p> <p>(b) Moment of $\mathbf{F}_1, \mathbf{F}_2$ about $O = \begin{pmatrix} 2 \\ 0 \\ 0 \end{pmatrix} \times \begin{pmatrix} 3 \\ 4 \\ 0 \end{pmatrix} + \begin{pmatrix} 1 \\ 1 \\ 0 \end{pmatrix} \times \begin{pmatrix} 2 \\ -1 \\ 1 \end{pmatrix}$ $= \begin{pmatrix} 0 \\ 0 \\ 8 \end{pmatrix} + \begin{pmatrix} 1 \\ -1 \\ -3 \end{pmatrix}$ $\therefore \begin{pmatrix} 1 \\ -1 \\ 5 \end{pmatrix} + \mathbf{G} = \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix} \Rightarrow \mathbf{G} = \begin{pmatrix} -1 \\ 1 \\ -5 \end{pmatrix} \text{ Nm} = (-\mathbf{i} + \mathbf{j} - 5\mathbf{k}) \text{ Nm}$</p>	<p>M1 A1 (2) M1 A1 A1 M1 A1 (5) (7 marks)</p>

Question Number	Scheme	Marks
<p>4. (a)</p>	$I = \left(\frac{1}{2} \times 2ma^2 + 2ma^2\right) + m(a\sqrt{2})^2$ $= 5ma^2$ $ma\sqrt{20ag} = 5ma^2 \omega$ $\omega = \sqrt{\frac{4g}{5a}}$ <p>(b) PE Gain = 2mga</p> $\left. \begin{aligned} \text{KE Loss} &= \frac{1}{2} \times 5ma^2 \times \frac{4g}{5a} = 2mga \end{aligned} \right\}$	<p>M1 A1 A1</p> <p>A1</p> <p>M1 A1</p> <p>A1 (7)</p> <p>A1</p> <p>M1 A1 (3)</p> <p>(10 marks)</p>
<p>5. (a)</p>	$I_{AB} = \frac{1}{3}ma^2$ $I_A = 2 \times \frac{1}{3}ma^2 \quad (\text{perpendicular axes})$ <p>(b) $M(A), mg \frac{a}{\sqrt{2}} \sin \theta = -\frac{2}{3}ma^2 \ddot{\theta}$</p> $\ddot{\theta} \approx \frac{-3g}{2a\sqrt{2}} \theta \text{ for small } \theta, \text{ hence SHM}$ <p>(c) $t = \frac{1}{4} \times \text{period} = \frac{\pi}{2} \sqrt{\frac{2a\sqrt{2}}{3g}}$</p> $\left(= \pi \sqrt{\frac{a\sqrt{2}}{6g}} \right)$	<p>B1</p> <p>M1 A1 (3)</p> <p>M1 A1 A1</p> <p>M1 A1 (5)</p> <p>M1 A1 (2)</p> <p>(10 marks)</p>

Question Number	Scheme	Marks
<p>6. (a)</p> <p>A X</p> <p>(b)</p> <p>(c)</p>	 <p style="text-align: right;"> $I_0 = \frac{1}{12} m(AB)^2 + ma^2 = \frac{7}{3} ma^2$ $mga = \frac{7ma^2}{3} \ddot{\theta}$ $\ddot{\theta} = \frac{3g}{7a}$ </p> <p> $\frac{1}{2} \times \frac{7ma^2}{3} \dot{\theta}^2 = mga \Rightarrow a \dot{\theta}^2 = \frac{6g}{7}$ </p> <p> $R(\downarrow): mg - Y = ma \cdot \frac{3g}{7a} \Rightarrow Y = \frac{4mg}{7}$ </p> <p> $R(\leftarrow): X = ma \dot{\theta}^2 = \frac{6mg}{7}$ </p> <p> $R = \frac{mg}{7} \sqrt{4^2 + 6^2} = \frac{mg}{7} \sqrt{52}$ </p>	<p>M1 A1</p> <p>M1</p> <p>A1 (4)</p> <p>M1 A1 (2)</p> <p>M1 A1</p> <p>M1</p> <p>M1 A1 (5)</p> <p style="text-align: right;">(11 marks)</p>

Question Number	Scheme	Marks
7. (a)	$m = \frac{4}{3} \pi r^3 \rho \quad (\rho \text{ constant})$	
	$\frac{dm}{dt} = \frac{4}{3} \pi \rho \times 3r^2 \frac{dr}{dt} = 4\pi \rho r^2 \cdot kr = 3km$	M1 A1 (2)
(b)	$mg \delta t = (m + \delta m)(v + \delta v) - mv$	M1
	$mg = v \frac{dm}{dt} + m \frac{dv}{dt}$	A1
	$mg = v \times 3km + m \frac{dv}{dt}$	M1
	$g - 3kv = \frac{dv}{dt}$	A1 (4)
(c)	$\int dt = \int \frac{dv}{g - 3kv}$	M1
	$t = -\frac{1}{3k} \ln(g - 3kv) + c$	A1
	$t = 0, v = u : c = \frac{1}{3k} \ln(g - 3ku)$	A1
	$\frac{g - 3ku}{g - 3kv} = e^{3kt} \quad (\text{or equivalent})$	M1
	$v = \frac{g}{3k} - \left(\frac{g}{3k} - u \right) e^{-3kt}$	A1 (5)
(d)	$\text{As } t \rightarrow \infty, e^{-3kt} \rightarrow 0$	
	$v \rightarrow \frac{g}{3k}$	B1 (1)
(12 marks)		

Question Number	Scheme	Marks
8. (a)	$m^2 + 9 = 0 \Rightarrow m = \pm 3\mathbf{i}$ $r = A \sin 3t + B \cos 3t$ Let $r = p \sin t\mathbf{i}$ $\dot{r} = p \cos t\mathbf{i}$ $\ddot{r} = -p \sin t\mathbf{i}$ $-p \sin t\mathbf{i} + 9p \sin t\mathbf{i} = 8 \sin t\mathbf{i}$ $\Rightarrow p = 1$ $r = A \sin 3t + B \cos 3t + \sin t\mathbf{i}$ $t = 0: 0 = B$ $\dot{r} = 3A \cos 3t + \cos 3t + \cos t\mathbf{i}$ $t = 0: \mathbf{i} + 3\mathbf{j} = 3A + \mathbf{i} \Rightarrow A = \mathbf{j}$ $\therefore r = \sin t\mathbf{i} + \sin 3t\mathbf{j}$	M1 A1 M1 A1 M1 A1 M1 A1 A1 A1 A1 (11)
(b)	$\sin t = \sin 3t = 0$ $\Rightarrow t = \pi$	M1 A1 (2) (13 marks)