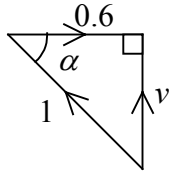
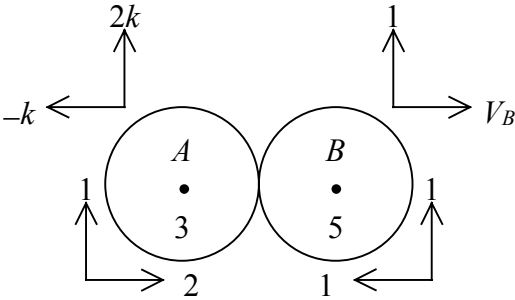


Question Number	Scheme	Marks
1.	$-4v = 2 \frac{dv}{dt}$ $-2dt = \frac{dv}{v}$ $-2t = \ln v; \quad (-\ln 5)$ $v = 5e^{-2t}$	M1 A1 M1 A1 ft; A1 A1 (6) (6 marks)
2. (a)	 <p>(vector triangle)</p> $\cos \alpha = 0.6$ $\alpha = 53.1^\circ \text{ upstream to bank}$	M1 M1 A1 (3) M1 A1 A1 ft (3) (6 marks)
2. (b)	$v = \sqrt{1^2 - 0.6^2}$ $= 0.8 \text{ ms}^{-1}$ $\text{Time} = \frac{336}{0.8} = \underline{420 \text{ s}}$	M1 A1 M1 A1 A1 M1 A1 M1 A1 (9) B1 (1) (10 marks)
3. (a)	$-(mg + mkv^2) = mv \frac{dv}{ds}$ $\int_0^H ds = \int_{\sqrt{\frac{g}{k}}}^0 \frac{v dv}{g + kv^2}$ $H = \frac{1}{2k} \left[\ln(g + kv^2) \right]_0^{\sqrt{\frac{g}{k}}}$ $= \frac{1}{2k} \ln 2$	M1 A1 M1 A1 A1 M1 A1 M1 A1 (9) B1 (1) (10 marks)
3. (b)	Spin, variation in g	B1 (1)

Question Number	Scheme	Marks
<p>4. (a)</p>	 $V_A = k \begin{pmatrix} -1 \\ 2 \end{pmatrix}$ <p>but $2k = 1 \Rightarrow k = \frac{1}{2}$</p> $\therefore V_A = \begin{pmatrix} -\frac{1}{2} \\ 1 \end{pmatrix}$ <p>(b) CLM: $(3 \times 2) - (5 \times 1) = \left(3 \times -\frac{1}{2}\right) + 5V_B$</p> <p>NIL: $V_B + \frac{1}{2} = e(2 + 1)$</p> <p>Solving</p> $e = \frac{1}{3}$	<p>M1 A1</p> <p>M1 A1 ft</p> <p>A1 ft (5)</p> <p>M1 A1 ft</p> <p>M1 A1 ft</p> <p>M1</p> <p>A1 (6)</p> <p>(11 marks)</p>
<p>5. (a)</p>	<p>In equilibrium: $mg = 2 \frac{mge}{l} \Rightarrow e = \frac{1}{2}l$</p> $mg - T - 2m\omega \dot{x} = m\ddot{x}$ $mg - \frac{2mg}{l} \left(x + \frac{1}{2}l\right) - 2m\omega \dot{x} = m\ddot{x}$ $\ddot{x} + 2\omega \dot{x} + 2\omega^2 x = 0$ <p>(b) AE: $m^2 + 2\omega m + 2\omega^2 = 0$</p> $m = -\omega(1 \pm i)$ $x = e^{-\omega t} (A \cos \omega t + B \sin \omega t) \quad \left(\omega = \sqrt{\frac{g}{l}}\right)$ <p>(c) Period = $2\pi \sqrt{\frac{l}{g}}$</p>	<p>M1 A1</p> <p>M1 A1 A1</p> <p>M1</p> <p>A1 (7)</p> <p>M1</p> <p>A1</p> <p>M1 A1 ft (4)</p> <p>B1 (1)</p> <p>(12 marks)</p>

Question Number	Scheme	Marks
6. (a)	$V_T \uparrow 6 \text{ ms}^{-1} \quad V_C \leftarrow 24 \text{ ms}^{-1}$ $V_{C-T} = V_C - V_T$ $\left {}_C V_T \right = \sqrt{6^2 + 24^2} = \underline{24.7 \text{ ms}^{-1}}$ $\text{Direction} = \arctan \left(\frac{6}{24} \right) = 14.04^\circ, \text{ bearing of } 256^\circ$	B1 B1 M1 A1 ft M1 A1 ft (6)
(b)	$s = \sqrt{200^2 + 960^2} = 980.6$ $\alpha = \arctan \frac{200}{960} = 11.77^\circ$ $\beta = \theta - \alpha = 14.04 - 11.77 = 2.27^\circ$ $p = s \sin \beta = 38.8 \text{ m}$	M1 A1 M1 A1 M1 A1 ft M1 A1 (8)
		(14 marks)
7. (a)	$-mga \sin \theta; \frac{mg}{2a} (2a \sin \theta - a)^2$ $V = -mga \sin \theta + \frac{mg}{2a} (2a \sin \theta - a)^2 + c$ $= -mga \sin \theta + \frac{mg}{2a} (4a^2 \sin^2 \theta - 4a \sin \theta + a^2) + c$ $= \underline{mga(2 \sin^2 \theta - 3 \sin \theta) + \text{constant}}$	B1; M1 A1 M1 A1 A1 (6)
(b)	$\frac{dV}{d\theta} = mga(4 \sin \theta \times \cos \theta - 3 \cos \theta)$ $= mga \cos \theta (4 \sin \theta - 3) = 0$ $\theta = \arcsin \left(\frac{3}{4} \right)$ $= \underline{0.848^\circ}$	M1 A1 A1 M1 A1 (5)
(c)	$\frac{d^2V}{d\theta^2} = mga(4 \cos 2\theta + 3 \sin \theta)$ $\theta = \arcsin \left(\frac{3}{4} \right); V'' = mga \left(-\frac{4}{8} + \frac{9}{4} \right) = \frac{7}{4} mga \therefore \text{Stable}$	M1 A1 M1 A1 A1 ft (5)
		(16 marks)