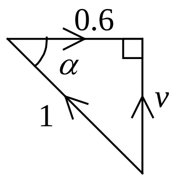
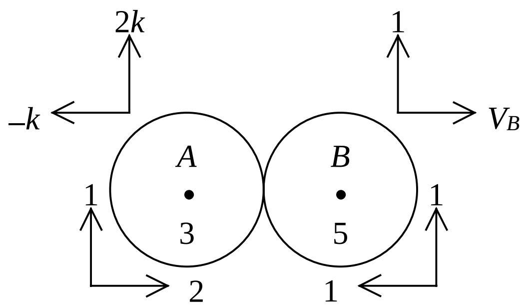
Question Number	Scheme	Marks
1.	$-4v = 2\frac{\mathrm{d}v}{\mathrm{d}t}$	M1 A1
	$-2\mathrm{d}t = \frac{\mathrm{d}v}{v}$	M1
	$-2t = \ln v$; $(-\ln 5)$	A1 ft; A1
	$v = 5\mathrm{e}^{-2t}$	A1 (6)
		(6 marks)
2. (*a*)	 (vector triangle)	M1
	$\cos\alpha = 0.6$	M1
	$\alpha = 53.1°$ upstream to bank	A1 (3)
(*b*)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

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

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