2	$\uparrow N_1 \cos\theta_1 = mg$ $\rightarrow N_1 \sin\theta_1 = m(r\sin\theta_1)\omega_1^2$
	$\uparrow N_2 \cos\theta_2 = mg$ $\rightarrow N_2 \sin\theta_2 = m(r\sin\theta_2)\omega_2^2$
	$\dfrac{\frac{5}{4}g}{\frac{5}{3}g} = \dfrac{r\omega_1^2}{r\omega_2^2}$
	$\dfrac{\omega_1}{\omega_2} = \frac{1}{2}\sqrt{3}$

3(a)	$\frac{dv}{dt} = -\frac{1}{2}\left(v^2 + 4\right)$ $\frac{1}{2}\tan^{-1}\left(\frac{1}{2}v\right) = -\frac{1}{2}t\ [+A]$
	$t = 0,\ v = 2:\quad A = \frac{1}{2}\tan^{-1}\left(\frac{2}{2}\right) = \frac{1}{8}\pi$
	$v = \frac{dx}{dt} = 2\tan\left(\frac{1}{4}\pi - t\right)$ $x = 2\ln\left(\cos\left(t - \frac{1}{4}\pi\right)\right)[+B]$
	$x = 0,\ t = 0:\quad B = \ln 2$ $x = 2\ln\left(\cos\left(t - \frac{1}{4}\pi\right)\right) + \ln 2\ \left[= \ln\left(2\cos^2\left(t - \frac{1}{4}\pi\right)\right)\right]$
3(b)	$2\ln\left(\cos\left(t - \frac{1}{4}\pi\right)\right) + \ln 2 = 0$
	$t = \frac{1}{2}\pi$

4	In equilibrium, $\frac{5mge}{a} = 5mg, \quad e = a$.
	Let x be the length of the string when speed of P is $\sqrt{\frac{7}{5}ag}$. Energy equation in subsequent motion: $\frac{5mga^2}{2a} - \frac{5mg(x-a)^2}{2a} = mg(e+a-x) + \frac{1}{2}m\left(\frac{7}{5}ag\right)$
	$25x^2 - 60ax + 27a^2 = 0$
	$x = \frac{9}{5}a$ only.
	Alternative method for question 4
	In equilibrium, $\frac{5mge}{a} = 5mg, \quad e = a$.
	Let x be the extension when P is released. Energy equation in subsequent motion: $\frac{5mga^2}{2a} - \frac{5mgx^2}{2a} = mg(e-x) + \frac{1}{2}m\left(\frac{7}{5}ag\right)$
	$25x^2 - 10ax - 8a^2 = 0$
	$(5x+2a)(5x-4a) = 0, \quad x = \frac{4}{5}a$ only. Required length of string = $\frac{9}{5}a$.

5(a)	$\overline{x} = ka + \frac{1}{3}h$
	$\overline{x} = \frac{1}{3}(3ka + h)$
	$\overline{y} = a + \frac{1}{3}(h - a) = \frac{1}{3}(2a + h)$
	Alternative method for question 5(a)
	Coordinates $A(ka,0)$, $B(ka+h,h)$, $C(ka,2a)$ $\overline{x} = \frac{1}{3}(ka + ka + h + ka) = \frac{1}{3}(3ka + h)$
	$\overline{y} = \frac{1}{3}(0 + h + 2a) = \frac{1}{3}(h + 2a)$

5(b)	Taking moments about the x-axis: $\bar{x}\left(2ka^2 + ah\right) = 2ka^2 \times \frac{1}{2}ka + ah\left(ka + \frac{1}{3}h\right)$
	For equilibrium, $\bar{x} \leqslant ka$, so $\frac{a^2k^2 + ahk + \frac{1}{3}h^2}{2ak + h} \leqslant ka$
	$(0 \leqslant)h \leqslant \sqrt{3}ka$
5(c)	Point of toppling means $h = \sqrt{3}ka\,[= a]$. $\bar{x} = \frac{1}{3}a\left(\sqrt{3} + 1\right)$
	[$h = a$, meaning triangle ABC is isosceles.] $\bar{y} = a$ (by symmetry)

7(a)	$\dfrac{dy}{dx} = \tan\theta - \dfrac{2gx}{2u^2\cos^2\theta}$
	$\dfrac{dy}{dx} = -1$
	$-1 = \frac{4}{3} - \frac{2}{45}x_A$
	$x_A = \frac{105}{2}$
	$y_A = \frac{35}{4}$
	Alternative method for question 7(a)
	Horizontally: $v_H = 25\cos\theta = 15$ Vertically: $v_V = 25\sin\theta - gt = 20 - gt$
	At A: $\dfrac{v_V}{v_H} = -\tan 45° = -1$
	$\dfrac{20 - gt}{15} = -1,\ \ t = \frac{7}{2}$
	$x_A = \frac{105}{2}$
	$y_A = \frac{35}{4}$

7(b)	Let v be the velocity before the collision at A. $u_x = u\cos\theta = 15 = v_x$
	$v_y = -v_x = -15$
	Speed: $\sqrt{v_x^2 + v_y^2} = 15\sqrt{2}$ $(\mathrm{m\,s^{-1}})$
7(c)	Let w be the velocity after the collision. $w = ev = \frac{5}{3}\sqrt{2}$
	$-\frac{35}{4} = x\tan 45 - \dfrac{gx^2}{2\left(\frac{5}{3}\sqrt{2}\right)^2(\cos 45)^2}$, $\frac{9}{5}x^2 - x - \frac{35}{4} = 0$. OR $\frac{35}{4} = -\frac{5}{3}\sqrt{2} \times \frac{1}{2}\sqrt{2}t + \frac{1}{2}gt^2$, $t = \frac{3}{2}$ $x = (w\cos 45)t$ $\left[= \frac{5}{3} \times \frac{3}{2}\right]$
	$x = \frac{5}{2}$ (metres)