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

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

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

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 $\dfrac{a^2k^2+ahk+\frac{1}{3}h^2}{2ak+h}\leqslant ka$
	$(0\leqslant)h\leqslant\sqrt{3}ka$
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)	$\dfrac{\mathrm{d}y}{\mathrm{d}x}=\tan\theta-\dfrac{2gx}{2u^2\cos^2\theta}$
	$\dfrac{\mathrm{d}y}{\mathrm{d}x}=-1$
	$-1=\frac{4}{3}-\frac{2}{45}x_A$
	$x_A=\frac{105}{2}$
	$y_A=\frac{35}{4}$
	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)