① $T + mg\cos\theta = \dfrac{mv^2}{l}$

② $Mg(0) + \dfrac{1}{2}m(3gl) = mg(l + l\cos\theta) + \dfrac{1}{2}mv^2$

$\Rightarrow mv^2 = mgl - 2mgl\cos\theta$

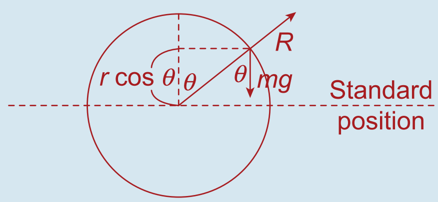
Putting this result into equation ① gives:

$T + mg\cos\theta = mg - 2mg\cos\theta$

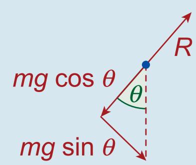
$\Rightarrow T = mg - 3mg\cos\theta$

When the string goes slack, $T = 0 \Rightarrow 0 = mg - 3mg\cos\theta \Rightarrow \cos\theta = \dfrac{1}{3}$

Q. 2. **Forces**



Resolved



① $mg\cos\theta - R = \dfrac{mv^2}{r}$

② $mgr + \dfrac{1}{2}m\left(\dfrac{gr}{2}\right) = mgr\cos\theta + \dfrac{1}{2}mv^2$

$\Rightarrow mv^2 = \dfrac{5}{2}mgr - 2mgr\cos\theta$

Putting this result into equation ① gives:

$mg\cos\theta - R = \dfrac{5}{2}mg - 2mg\cos\theta$

When the particle leaves the sphere, $R = 0$

$\therefore mg\cos\theta = \dfrac{5}{2}mg - 2mg\cos\theta$

$\Rightarrow \cos\theta = \dfrac{5}{6}$

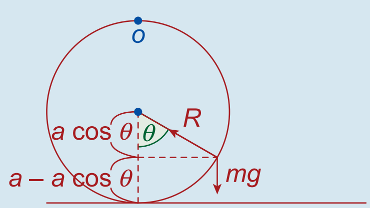
$\Rightarrow \theta = 33^\circ\ 34'$

Putting this result back into equation ② gives:

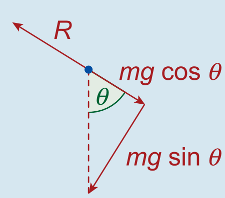
$mv^2 = \dfrac{5}{2}mgr - 2mgr\left(\dfrac{5}{6}\right)$

$\Rightarrow v = \sqrt{\dfrac{5gr}{6}}$

Q. 3. **Forces**



Resolved



Assume that it just reaches the top

$Mg0 + \dfrac{1}{2}mu^2 = mg(2a) + \dfrac{1}{2}m(0)^2$

$\Rightarrow u^2 = 4ga$

$\Rightarrow u = \sqrt{4ga}$