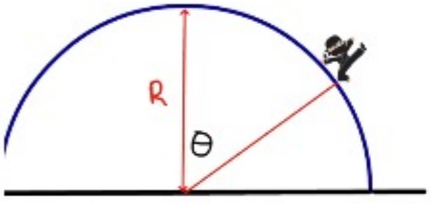
# Physics Ninja

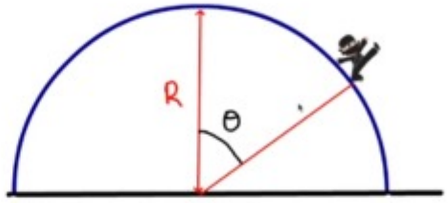
## Physics Ninja Slips Off the Roof

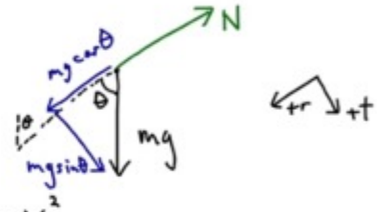



Question: Find the angle θ where Physics Ninja leaves the surface?

Physics NINJA

Free Body Diagram




1) $mg\cos\theta - N = ma_r = \frac{mv^2}{R}$

2) $mg\sin\theta = ma_T$

$$mg\cos\theta - \frac{mv^2}{R} = N$$

no more contact $N \Rightarrow 0$

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1) $mg\cos\theta - \frac{mv^2}{R} = N$

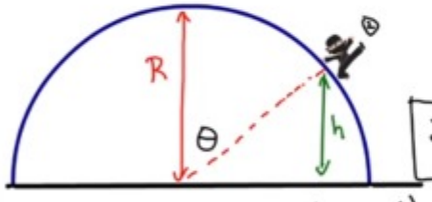
* Need to eliminate $v^2$

Conservation of energy

$U_{top} = U_h + \frac{1}{2}mv^2$

$mgR = mgR\cos\theta + \frac{1}{2}mv^2$

$$2mg(1-\cos\theta) = \frac{V}{R}\frac{mv^2}{R}$$




1') $mg\cos\theta - 2mg(1-\cos\theta) = N$

$$mg(3\cos\theta - 2) = N$$

$N = \phi \Rightarrow 3\cos\theta - 2 = 0$

$\cos\theta = \frac{2}{3} \Rightarrow \theta = \cos^{-1}\left(\frac{2}{3}\right) \approx 48^\circ$

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2) $a_T = g\sin\theta$

$\frac{dv}{dt} = g\sin\theta$

$v\frac{dv}{dt} = g\sin\theta\, v$

$\frac{1}{2}\frac{d(v^2)}{dt} = g\sin\theta(R\omega)$

$= gR\sin\theta\frac{d\theta}{dt} = \frac{d}{dt}\left(gR(-\cos\theta)\right)$

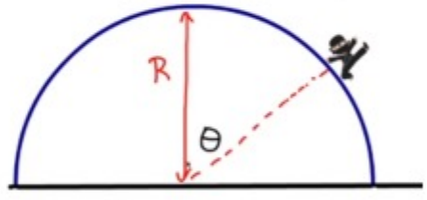
$\frac{1}{2}\frac{d(v^2)}{dt} = \frac{d}{dt}\left(gR(-\cos\theta)\right)$

$\frac{d}{dt}\left[v^2 + 2gR\cos\theta\right] = \phi$

invariant

$2gR = v^2 + 2gR\cos\theta$

$$2gR(1-\cos\theta) = v^2$$

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https://www.youtube.com/watch?v=8SwkNf3vshk