# Exercise 3.44

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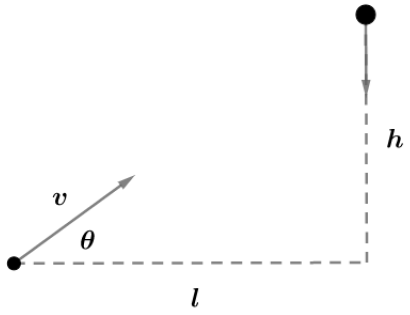


Note that

$$\cos\theta = \frac{l}{\sqrt{l^2+h^2}}$$

$$\sin\theta = \frac{h}{\sqrt{l^2+h^2}}$$

In the horizontal direction,

$$x = v_x t$$

$$l = (v\cos\theta)t_0$$

$$t_0 = \frac{l}{v\cos\theta}$$

At time $t_0$, the rock is at the horizontal position of the apple. In the vertical direction,

$$y = v_{oy}t - \frac{1}{2}gt^2$$

The height of the rock at $t_0$ is

$$h_{rock} = v\sin\theta t_0 - \frac{1}{2}gt_0^2 = l\tan\theta - \frac{gl^2}{2v^2\cos^2\theta} = h - \frac{g(l^2+h^2)}{2v^2}$$

At time $t_0$, the apple has fallen

$$h_{fall} = -\frac{1}{2}gt_0^2 = -\frac{gl^2}{2v^2\cos^2\theta} = -\frac{g(l^2+h^2)}{2v^2}$$

The height of the apple is

$$h_{apple} = h + h_{fall} = h - \frac{g(l^2+h^2)}{2v^2}$$

Therefore, $h_{rock} = h_{apple}$ and the rock hits the apple.