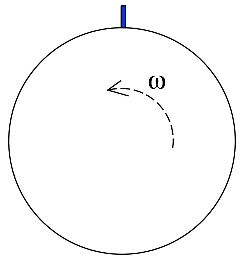
Problem 10.11

An incredibly tall building (height "h") sits on the earth, which is spinning with angular speed ω .

a.) As a body falls, how far to the east will the body land, assuming gravity acts uniformly throughout.

This is one of those problem where you have to cobble together a bunch of information in the hopes of accumulating enough to solve the problem. So let's start cobbling.



The object's tangential velocity at ground level will be:

$$v_{ground} = R_{earth}\omega$$

The object's tangential velocity at the top will be:

$$v_{top} = (R_{earth} + h)\omega$$

The difference will be:

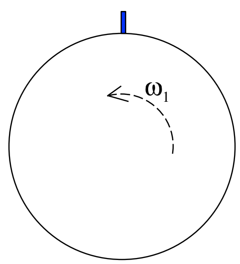
$$\Delta v = h\omega$$

Taking the ground to be y = 0, the time of flight will be:

$$\cancelto{0}{y_2} = y_1 + \cancelto{0}{v_{1,y}}(\Delta t) + \frac{1}{2}a_y(\Delta t)^2$$

$$\Rightarrow \quad 0 = h + \frac{1}{2}(-g)(\Delta t)^2$$

$$\Rightarrow \quad t = \left(\frac{2h}{g}\right)^{1/2}$$



So the deflection should be that tangential velocity difference times the time of flight, or:

$$\Delta x = \Delta v \Delta t$$

$$= (h\omega)\left(\frac{2h}{g}\right)^{1/2}$$

$$= \omega h^{3/2}\left(\frac{2}{g}\right)^{1/2}$$

b.) What is the displacement for h = 50.0 meters

$$\Delta x = \quad \omega \quad h^{3/2} \quad \left(\frac{2}{g}\right)^{1/2}$$

$$= \left(\frac{\left(2\pi\ \frac{\text{rad}}{\cancel{\text{day}}}\right)}{\left(\frac{3.60\text{x}10^3\ \text{sec}}{1.00\ \cancel{\text{hour}}}\right)\left(\frac{24.0\ \cancel{\text{hr}}}{1.00\ \cancel{\text{day}}}\right)}\right)(50.0\ \text{m})^{3/2}\left(\frac{2.00}{9.80\ \frac{\text{m}}{\text{sec}^2}}\right)^{1/2}$$

$$= 1.16\text{x}10^{-2}\ \text{m} \qquad (= 1.16\ \text{cm})$$

c.) This is a tiny deflection in comparison to the 50.0 meter drop, so *yes*, we were justified in ignoring this in previous freefall problems.

d.) Looking at the relationship as it stands, if the angular speed were to diminish, the deflection would also decrease.