# Physics 3210 Spring 2019 Discussion #19 Answers

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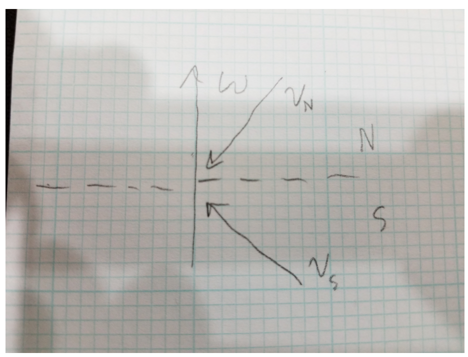
## 1

The first thing this problem wants is to determine the direction of deflection caused by the Coriolis force on the falling object and if the deflection is the same in the southern and northern hemispheres. To find all of these things all we need to use is the right hand rule. The following diagram is helpful in envisioning how to successfully use the right hand rule:



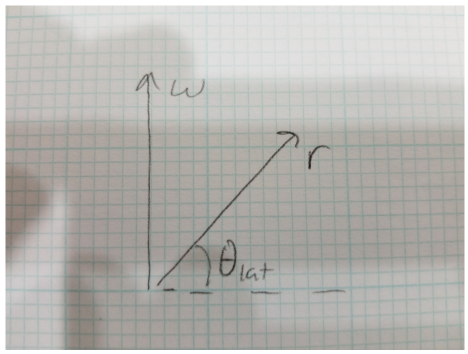

Consider the case of the northern hemisphere. We have placed the rotation of the earth in the $\hat{z}$ direction WLOG. The falling object is falling in the $-\hat{r}$ direction. Using the right hand rule according to the diagram results in our thumb pointing out of the page, which on the earth would correspond to west. The Coriolis force has a negative so we flip the previous result and come to the conclusion that the Coriolis force causes the falling object to drift to the east.

Doing the same procedure for something falling on the southern hemisphere shows that the falling object drifts east. So in the end you would see the same effect if you were in the northern or southern hemisphere.

# 2

Now the problem asks for the magnitude of deflection we would see (in centimeters) if we were to drop a ball off of the top of the Utah state capital.

Let's use the following diagram to help us determine the Coriolis force:




From this we see that, if we take the velocity to lie in the $\hat{r}$ direction then the magnitude of the Coriolis force is the following:

$$F_c = 2m\omega v_r \sin\left(\frac{\pi}{2} - \theta_{lat}\right)$$
$$= 2m\omega v_r \cos\theta_{lat} \quad (1)$$

The equation for the falling ball is given by the following:

$$F_r = -mg \quad (2)$$

Since the acceleration is constant we may use the kinematic equations. This gives us the following two equations:

$$y(t) = H - \frac{1}{2}gt^2 \quad (3)$$

$$v_r(t) = -gt \quad (4)$$

Where H is the height of the capital building. Now that we have (4), we may substitute that into (1) and obtain the following acceleration:

$$a_c = 2\omega\cos\theta_{lat} gt\hat{E} \quad (5)$$

Where $\hat{E}$ is pointing eastward. Integrating (5) twice gives the distance travelled due to the Coriolis force:

$$x(t) = \frac{1}{3}g\omega\cos(\theta_{lat})t^3 \quad (6)$$

Now we need the time at which the ball reached the ground. To do this we set (3) equal to zero and solve for the time. Doing so gives the following:

$$t_g = \sqrt{\frac{2H}{g}} \tag{7}$$

Plugging (7) into (6) and plugging in numbers gives the following distance travelled:

$$\begin{aligned} x(t) &= \frac{1}{3} g\omega \cos\left(\theta_{lat}\right) \left(\sqrt{\frac{2H}{g}}\right)^3 \hat{E} \\ &= 1.343cm \quad east \end{aligned}$$