Week 1 CHW Solution

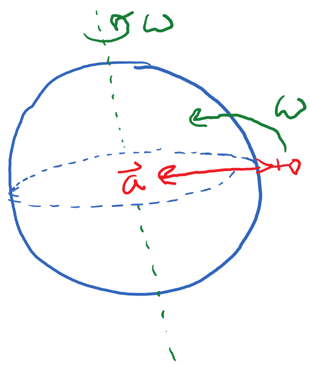
Question 1:

So far in your life, you may have assumed that as you are sitting in your chair right now, you are not accelerating. However, this picture is not quite complete! You are on the surface of the Earth, which is rotating. Which means you are in Uniform* Circular Motion about the North-South axis of the Earth!

(a) What is the linear acceleration of a person sitting in a chair on the equator?
(b) If you were sitting at the equator, would your mass times the gravitational acceleration of the Earth (*mg*) be greater than, less than, or equal to the normal force exerted on you by the chair you are sitting on? Explain.
(c) A classmate of yours asks you why we have ignored this acceleration for the whole first term of physics. “Is everything we’ve learned a lie?” they ask. Assuming you are at the equator, use order of magnitude sensemaking arguments comparing the normal force from your chair with your weight to assuage their fears.
(d) The latitude of Corvallis is 44.4°. If you were sitting in a chair in Corvallis, what would be your linear acceleration?

*actually the rotational speed of the Earth is decreasing with time at a rate of about 1.7 milliseconds per century! This means, as we will discover in the conserved rotational quantities lectures, that because angular momentum must be conserved, the moon is moving slowly away from us! We can

a)



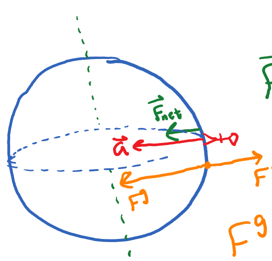
$$|\vec{a}| = a_{radial} = \frac{v^2}{r}$$

$$= \frac{\left(2\pi r_E/\Delta t\right)^2}{r_E}$$

$$= \frac{4\pi^2 r_E}{\Delta t^2} = \frac{4\pi^2 (6378.137\text{km})}{\left[\left(3600\frac{s}{hr}\right)\left(24\frac{hr}{day}\right)\right]^2}$$

$$= 3.37 \times 10^{-2}\ m/s^2$$

b)



$\vec{F}_{net} = m\vec{a}$

$F^g = mg$

you travel in a circle around the Earth ⇒ your acceleration is towards the center ⇒ F_{net} is towards center ⇒ $F^g > F^N$

⇒ $mg > F^N$

c) $\sum \vec{F} = m\vec{a}$

⇒ $-|F^g| + |F^N| = ma_r$

⇒ $-mg + |F^N| = m(3.37 \times 10^{-2}\ m/s^2)$

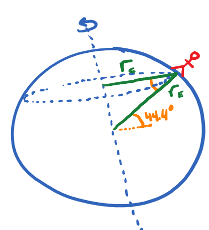
I'll us the avg N. American human mass
$m = 80.7$ kg
& $g = 9.78$ @ equator

$F^N = 792.0$ N
$mg = 789.3$ N

the normal force and gravitational force are the same order of magnitude as we would expect from our PH201 assumption that $F^N = mg$ and our $a = 0$

In fact, they only differ by 0.34%!

d)



$\cos(44.4°) = \frac{r_c}{r_E}$

⇒ $r_c = r_E \cos(44.4°)$

$= 4557.005$ m

$$a = \frac{v^2}{r_c} = \frac{\left((2\pi r_c)/\Delta t\right)^2}{r_c}$$

$$= 2.41 \times 10^{-5}\ m/s^2$$