**Physics 81 Set 5 Solutions**

1. Exercise 1 of Appendix 6 (page 238)

   In any orbit, the force of gravity must be equal to the centrifugal force (or the satellite will crash into the earth or fly off into space). The balance of forces is thus

   $$Mg = M\frac{V^2}{R} = M\frac{(\Omega R)^2}{R}$$

   We know g ($9.8m/s^2$) and $\Omega$ ($2\pi$ radians/day $= 7.3\times10^{-5}$ radians/second), and M cancels, so we can easily solve for $R$:

   $$R = \frac{g}{\Omega^2} = 1.8\times10^9 m = 1.8\times10^6 km$$

   This is a decent first guess, but at large distances like this, we should really take into account the fact that the force of gravity depends on distance too. Taking this into account gives a value of $R = 4.2\times10^4 km$ (about 1/10th of the distance to the moon).

2. Exercise 2 of Appendix 6 (page 238)

   If one is travelling eastward at the equator with a velocity of $20m/s$ relative to the earth's surface, one experiences an additional centrifugal force, reducing one's weight by $200kg\times(20m/s)^2/R_{earth} = 0.0133N$. Similarly, travelling westward at $20m/s$ will reduce the centrifugal force already present due to the earth's rotation by $0.0133N$. Thus, the twin's weights differ by $0.0266N = 0.006lbs$.

   Note 1: I think Philander botched his conversion. A person with a mass of $200kg$ has a weight (when stationary) of $1960N = 441lbs$!.

   Note 2: $20m/s$ is reasonably fast (45 mph), so you can see that eastward travel is a difficult way to "lose" weight.

3. In appendix 6.2 of the text, Philander discusses motion of a parcel of tea in a cup that is being stirred. Place his example in the context of a moving air parcel in the earth's atmosphere. What direction (North, South, East, West, up from the surface, down toward the surface) does the motion of the tea represent? What is the direction of the coriolus force?

   In this example, the parcel of tea is equivalent to an air parcel hovering just above the surface of the earth, at the equator (other latitudes are possible, but this is the simplest one to describe). When the tea parcel starts to move faster than its surrounding, this is equivalent to motion due East. The coriolus force (acting to the right of the direction of motion) thus deflects the parcel upward (i.e. perpendicularly away from the surface of the earth). This is equivalent to being deflected in a direction perpendicular to the earth's axis of rotation.

   At other latitudes, the analogy still holds for eastward motion, and the deflection is still perpendicular to the earth's axis of rotation. The difference is that this is no longer perpendicular to the earth's surface.

4. Repeat the previous exercise for the merry-go-round example (also appendix 6.2). What is the real-world direction corresponding to a ball tossed from the middle of the merry-go-round to the rim? What is the direction of the resulting coriolus force?

   > Now we are viewing the earth from above the North Pole, and the *initial motion* is perpendicular to the earth's axis of rotation. A rocket launch from the equator going straight up into the sky would fit the bill nicely. As the rocket travels upward, an observer on the surface perceives a deflection westerward (but still in the equatorial plane).

5. Find a weather map (copy it from a paper, print it off a website, find one in a textbook, etc.) that shows both surface winds and isobars. Locate regions on the map where geostrophic winds are present and label them.

   Surface winds will do, but if you can find winds from higher levels in the atmosphere (for example, at the 750mbar level or the 500mbar level), the presence of geostrophic winds will be much more apparent.

   Be sure to indicate where you got your map.