Order-of-Magnitude Physics – Lab 4

Guidelines:

- Break up into groups of 1, 2, or 3 people.
- At any given moment, there should be ≤ 1 "scribe" (person with marker/pen).
- The scribe has complete control over what to write down (and what not to write down).
- Please change scribes when switching to another problem, but not within a given problem.
- When you have an answer, write it down on the "Answer Board" where everyone's answers will be collected.
- If you are done, feel free to leave, or you can observe other groups.

Problem 1. iFLY

iFLY offers indoor skydiving in a vertical wind tunnel. See the promotional video at sfbay.iflyworld.com.

Estimate the cost (in dollars) in electricity per customer per minute of flying time.[1]

Problem 2. The Earth Wobbles (But Won't Fall Down)

On timescales of days, ocean-scale storms come and go. In a storm, the ocean water level rises above what is normal. The water level rise is driven in part by abnormally low atmospheric pressure. Storm surges, driven by both pressure and wind, can inundate small islands.

Ocean-scale storms contribute to the wobble of the Earth. As reported in the August 2006 issue of *Physics Today*: using global positioning system (GPS) data, Lambert et al. (2006, Geophysical Research Letters) measured irregular, day-to-day displacements in the Earth's rotational pole position.

Estimate a characteristic amplitude (in units of length) for the displacements of the Earth's rotational pole position due to ocean-scale storms.

Hint: In a storm, the atmospheric pressure at sea level can be $\sim$10% below normal. You don't have to use this fact to solve the problem (you can do anything you want to solve the problem, short of looking up the answer).

[1] According to iFLY, a few minutes of flying is enough to physically tire most people. The experience is said to be a form of extreme swimming.

Problem 3. Migration

Take a look at Vance Tucker's plot of minimum cost of transport vs. body mass on page 120 of the Course Reader. Examine both animate (pigeon) and inanimate (DC-8 airplane) fliers below the "migratory line". From the plot, verify that for such migrating objects, the minimum cost of transport is fairly insensitive to body weight. This problem shows why this is true.

Prove that if fuel is a fixed fraction of body weight, the *maximum* distance a migratory flier can travel is independent of body weight. That is, prove that a pigeon with a full stomach and a jumbo jet with a full tank of gas travel the same distance when flying under minimum-cost conditions.

Do not merely invoke Tucker's plot, but use your understanding of the power requirements for flying.

Assuming this fixed fuel fraction is order unity, estimate the maximum distance (in km) one can fly without refueling.