Experiment #1: Moist thermodynamics and the wet-bulb thermometer.

For this assignment you will have to collect a series of measurements over several days using your sling psychrometers (so plan ahead!) First, theory.

1. Using the hydrostatic equation and the equation for $T(p)$, derive the dry adiabatic lapse rate $\frac{dT}{dz} = dT/dz$.

2. Combining this result with the Clausius-Clapeyron equation, find an expression for the saturation water vapor mixing ratio $w_s$ as a function of $z$ in an adiabatic, unsaturated layer, given $w_s = w_0$ at $z=0$ (where $p=1000$ hPa). At what height would such a layer become saturated if the relative humidity were 80% at the surface? Does the answer depend strongly on the value of $w_s$?

3. The air against the wet bulb of a thermometer attains a temperature $T_w$ that is lower than $T$ in the ambient air. This air is saturated with water vapor and has the same $q_e$ value as it had before passing through the wet covering. Using these facts and the approximate formula for $q_e$ given in class, derive the expression for the ambient relative humidity, where $w_{ws}$ is the saturation mixing ratio calculated at ambient pressure and $T_w$. Assume that the wet-bulb depression $T-T_w$ is small compared with $T$ in making approximate linear expansions.

4. Use this formula to convert the $T$ and $T_w$ measured in class by the instructor to RH. Then use a tephigram to graphically determine $w$ and $w_s$, and check whether the RH obtained from these numbers matches that of the formula. If the air was saturated outside, and came into the building without changing its $w$ or $p$, what was the temperature outside?

Now, experiment…

5. Use your psychrometers to take the following temperature and humidity observations. With each observation, record the time and date and prevailing weather (cloudiness). Later, determine RH and $T_D$ from each observation using equations, tables, or graphs as you prefer.
   a. Indoors and outdoors at about the same time and geographic location, preferably when temperatures differ noticeably.
   b. Outdoors once in the morning (as early as possible) and again later the same day, preferably on a day when no fronts pass through. That evening, log onto the Yale weather web page (accessible from www.geology.yale.edu by clicking at the bottom) and print out or transcribe the time series of temperature and humidity observations over the course of the previous 24 hours observed by the weather station on the roof of KGL.
c. Outdoors on at least three different days, at similar times of day (preferably days with different weather).

6. With regard to 6a, did either of the moisture quantities remain about the same indoors and out? Why do you think that is? (think about whether there are any sources of moisture or heat in the building and how these effect the moisture variables.).

7. With regard to 6b, compare your observations to those from KGL. Is $T_D$ or RH more constant over a 24-hour period? Why?

8. With regard to 6c, plot your RH and $T_D$ observations against the cloudiness you noted each day. Comment on any relationships you notice or would have expected.