Assignment IV, PHYS 308
Fall 2016
Due 9/23/16 at start of class

NOTE: Just like last homework, please leave your answers in terms of actual numbers (with appropriate units) when appropriate. Please provide full, legible, easy to follow solutions to the following problems. I can't give you credit if I can't read it (or I can't follow your reasoning). Extensive exposition on your thought process or strategy is always appreciated.

1. I put up a horrible, nasty equation in class that gave a very good fit for the saturation vapor pressure as a function of temperature for water. A much simpler expression that is pretty close is:

$$e_s(T) = 6.112 \exp\left(\frac{17.67T}{T + 243.5}\right)$$

with T in degrees Celcius and e_s in hPa (or mb, since they are the same thing). If necessary, feel free to use a computer aid to plot this relationship and/or a graphing calculator of some sort. Use this equation to answer the following:

   a) If the external temperature is 83 degrees Fahrenheit and the current water vapor pressure is 10 hPa, what is the approximate Relative Humidity?

   b) If the external temperature is 45 degrees Fahrenheit and the current water vapor pressure is 10 hPa, what is the approximate Relative Humidity?

   c) If the external temperature is 83 degrees Fahrenheit and the current water vapor pressure is 10 hPa, what is the approximate dew Point Temperature (in °F)?

   d) If the external temperature is 45 degrees Fahrenheit and the current water vapor pressure is 10 hPa, what is the approximate dew Point Temperature (in °F)?

2. An impermeable membrane divides a rigid, well-insulated tank into two equal sub-volumes. The left side contains air at 40 degrees Fahrenheit at 60% relative humidity. The right side contains air at 75 degrees Fahrenheit at 95% relative humidity.

   a) What is the current water vapor pressure on the left hand side?

   b) What is the current water vapor pressure on the right hand side?

   c) If the membrane is punctured and the two volumes of air are allowed to mix, the temperature of the combined gas will be the arithmetic average of the two temperatures. The total amount of water vapor in the box is not going to change. What is the relative humidity of the mixed gas? (Assume that the density of air on both sides is the same. Although not technically true, it is close enough.)

3. You are visiting a friend in Colorado and you know (somehow) that the absolute humidity outside is known to be 4 g/m^3. The TV meteorologist says the temperature outside is 72°F, and you know that you are at an altitude of 1200 meters above sea level. The TV reports a sea-level equivalent pressure of 1019 hPa. Assume that the scale height of the atmosphere is 8500 meters, and that the mass density of dry air decreases as $\rho = \rho_\circ e^{-z/H}$ with $\rho_\circ = 1.25$ kg/m^3 at sea level. Clearly state any assumptions you make. Calculate the current:

   a) specific humidity

   b) mixing ratio

   c) relative humidity (note: you can obtain the current vapor pressure by multiplying the current atmospheric pressure by the specific humidity, when the specific humidity is reported dimensionlessly).

   d) dew point temperature (in degrees Fahrenheit)

4. Explain why $\Gamma_{\rm dry} > \Gamma_{\rm s}$.

5. What is larger, dew point temperature or frost point temperature? Explain.

6. A radiosonde tells you that air at the surface is at 280K. Then the temperature decreases (linearly for simplicity) down to 265K at an altitude of 4 km. From 4 km to 8 km the temperature decreases from 265K (linearly) to 220K. From 8 km to 10 km, the temperature stays the same. (Note – this is not at all realistic, but allows us to explain the temperature profile very simply).

   a) Is the air between the surface and 4 km absolutely stable, absolutely unstable, or conditionally unstable?

   b) Is the air between 4 km and 8 km absolutely stable, absolutely unstable, or conditionally unstable?

   c) Is the air between 8 km and 10 km absolutely stable, absolutely unstable, or conditionally unstable?

7. The temperature on the surface is 280K. An air parcel rises from the surface up to 2.7 km where it starts to form a cloud.

   a) What is the dew point on the surface?

   b) What is the approximate relative humidity on the surface?

   c) What is the temperature of the air at 2.7 km?

   d) If forced to continue to rise (and assuming there is enough water vapor to continue cloud formation as it rises), what would be the temperature of the air at 4 km?