

Homework #5: Dry Adiabatic Lapse Rate (100 pts)
Due Wednesday 28 February 2018

Answer in complete sentences and on back. Please don't jam your answers in on this sheet.

$$\frac{\Delta T}{\Delta t} = \frac{1}{c_p} \frac{\Delta q}{\Delta t} + \frac{1}{c_p \rho} \frac{\Delta p}{\Delta t}$$

<i>Total temp Change Experienced by Air Parcel</i>	<i>Diabatic Change Experienced by Air Parcel</i>	<i>Adiabatic Change Experienced by Air Parcel</i>
--	--	---

1. The equation above is a version of the First Law of Thermodynamics. Over the time frame of several hours the diabatic term is one to two orders of magnitude smaller than the adiabatic term. Thus the diabatic term can be dropped out on an order of magnitude basis. Rewrite the equation thus simplified. (20 pts)

$$\frac{\Delta T}{\Delta t} \approx \frac{1}{c_p \rho} \frac{\Delta p}{\Delta t}$$

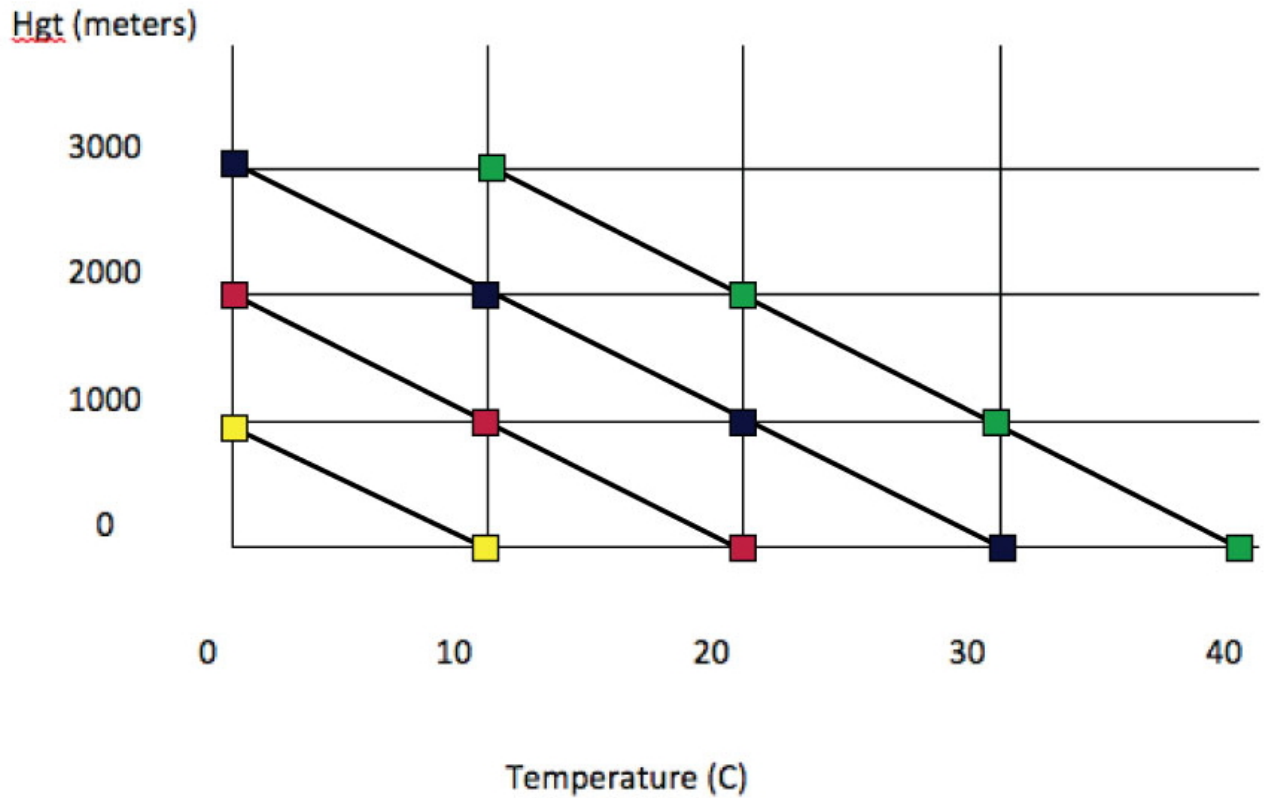
2. The adiabatic term is also called the dry adiabatic lapse rate. Substituting realistic values for the atmosphere into the equation gives:

$$\frac{1}{c_p \rho} \frac{\Delta p}{\Delta t} = \frac{g}{c_p} W$$

where

$$\frac{g}{c_p} = \Gamma_a$$
$$\Gamma_a = \frac{-1.0^\circ C}{100m} = \frac{-5.5^\circ F}{1000ft}$$

The dry adiabatic lapse rate corresponds to the temperature rate of change that a dry air parcel (explained in class) would experience when moving upward (or downward). For the each surface temperature, plot lines that show the temperature change experienced by a vertically moving parcel. First, compute the temperature a parcel with a surface temperature of 20C would have at 1000, 2000, and 3000 m. Plot those temperatures as points or crosses, then connect each with a line, neatly. Do the same for surface parcels at 10C, 30C and 40C. (30 points)



3. In (2) you have drawn the dry adiabats on a simple thermodynamic diagram. A simple type of thermodynamic diagram (like the one we have used most extensively in this portion of the course) is a Stüve Diagram or Emagram. One is included below.

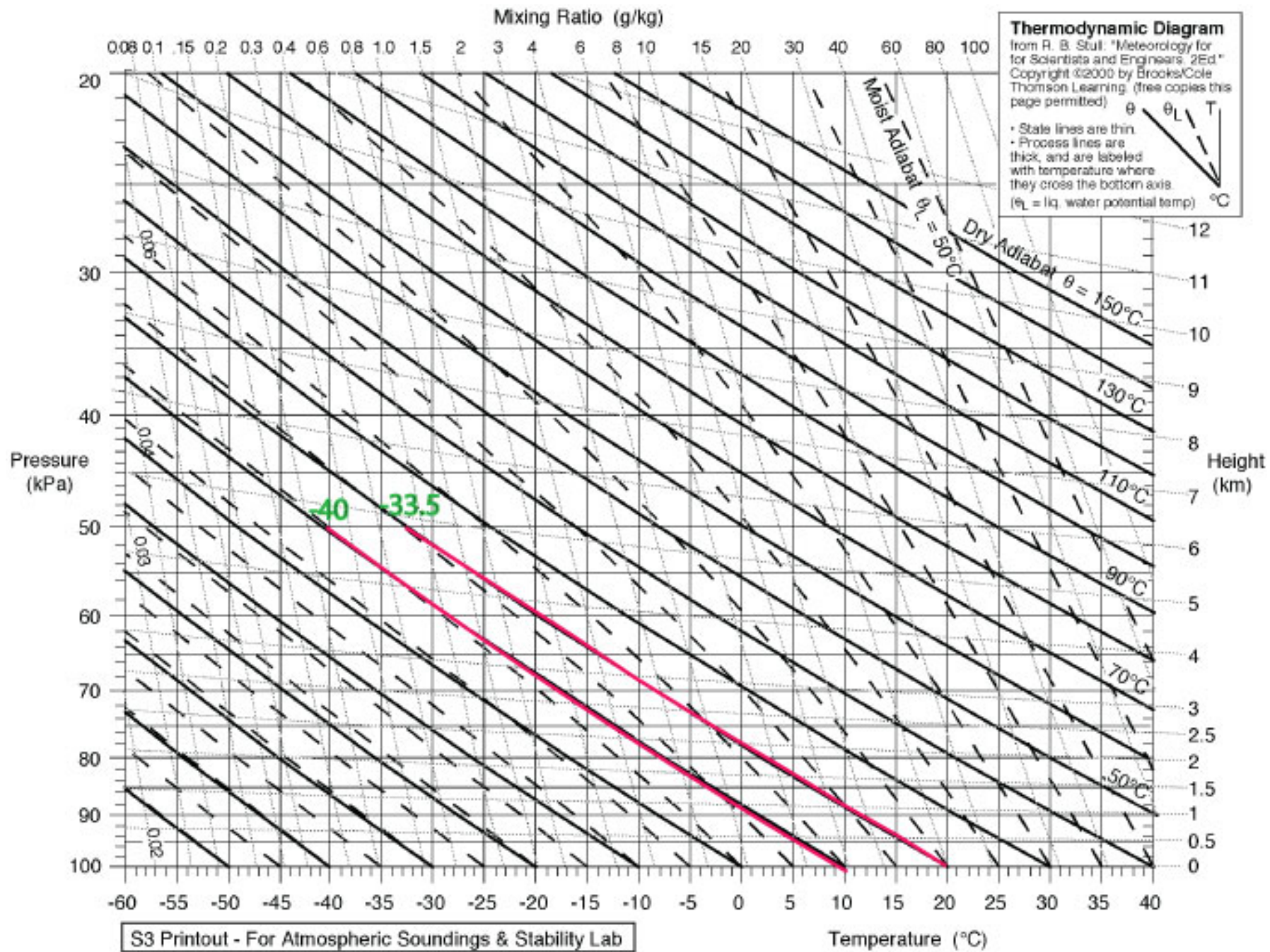
- Highlight in red the dry adiabats passing from the surface temperatures of 10C and 20C. (10 pts)
- Using these two lines, determine the temperature an air parcel lofted to a pressure height of 500 mb (or 5.6 km or so) would have
 Surface Temperature 10C; 500 mb Temperature -40 C (15 pts)
 Surface Temperature 20C; 500 mb Temperature -33.5 C (15 pts)
- The dry adiabats are labeled on the right margin of the diagram. Notice that one of them has the “master” legend for those lines, and defines the Dry Adiabats as the Greek Letter Theta. This is the meteorological symbol for Potential Temperature.

You highlighted the Potential Temperature lines for 10 and 20C.

Explain why these lines are called “lines of potential temperature. (10 pts)

Since a dry air parcel cools at the dry adiabatic rate when it rises, or warms at the dry adiabatic rate when it subsides, the air parcel will always be linked to the 1000 mb temperature from which the dry adiabat extends. Thus, potentially, an air parcel at any level of the atmosphere would have, if it were brought dry adiabatically to 1000 mb (nominally, the ground), the temperature that forms the basis for the label of the adiabat.

Clarifications: This is the definition of potential temperature....the temperature an air parcel would have if it were brought dry adiabatically from any elevation to a pressure height of 1000 mb. In the examples shown here, air parcels at, say, 500 mb with a temperature of -40C actually have the same potential temperature as air parcels at 1000 mb with a temperature of 10C. Straightforward use of the gas law would show that the density of air parcels along potential temperature contours is exactly the same.



S3 Printout - For Atmospheric Soundings & Stability Lab