MAE578, Spring 2019 Homework #3
See HW1,2 for rules on collaboration and guideline on submission of report

Prob 1. (60%) An air parcel has an initial temperature of 300 °K and initial *specific humidity* of 10 g/kg. It is initially located at the 1000 mb pressure level (marked as "Level 1" in Fig. 1). (a) What are the *relative humidity* and *partial pressure of water vapor* for this air parcel? (b) If the parcel is adiabatically lifted upward, at what *pressure level* will condensation begin to occur in the parcel? What is the temperature of the parcel at this level? To set up the next question, let us call this level "Level 2". (c) If the parcel is further lifted from Level 2 upward by 2 km (see Fig. 1), what will be the temperature, specific humidity, and pressure of the parcel at its final destination (marked as "Level 3" in Fig. 1)? In Part (c), we still assume that the parcel is lifted adiabatically but allow internal heating by condensation. [For the calculations in this problem, it is acceptable to treat the latent heat of condensation L as independent of temperature. We suggest that the value of L = 2450 J/g be used.]

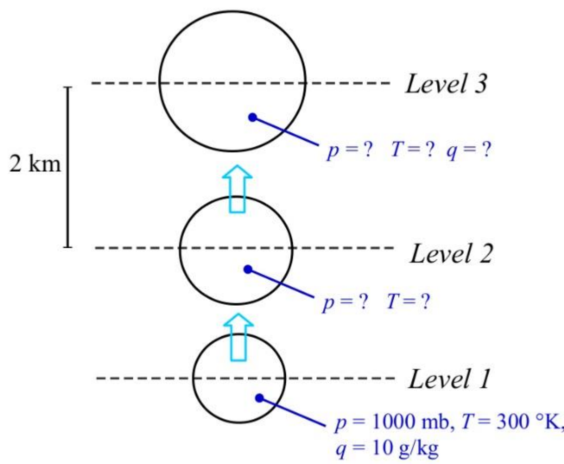

Fig.1

Prob 2. (40%) In the afternoon of a hot summer day, the surface generally warms up (by solar radiative heating) faster than the air aloft. This produces a near-surface layer with an enhanced lapse rate of temperature, as illustrated in Fig. 2. Consider an environmental temperature profile, shown as the solid line in Fig. 2, with a constant lapse rate of 8 °C/km above 400 m and an enhanced (also constant) lapse rate of 10.5 °C/km from the surface to 400 m height. The surface temperature and pressure are given as 300°K and 1000 mb. The air is completely dry. If an air parcel initially located at the surface is pushed up with an initial upward velocity of 0.01 m/s (i.e., $w(0)$ = 0.01 m/s and $z(0)$ = 0, where $w(t)$ and $z(t)$ are the vertical velocity and height of the parcel as a function of time), find the maximum height, H, that the parcel will reach. This is the height where the parcel first comes to a stop. In addition, plot the vertical velocity of the parcel as a function of height over the range of $0 \le z \le H$. [As usual, we assume that the parcel undergoes an adiabatic process as it ascends; The parcel does not exchange heat with the environment and does not experience a loss of energy by viscous dissipation.]

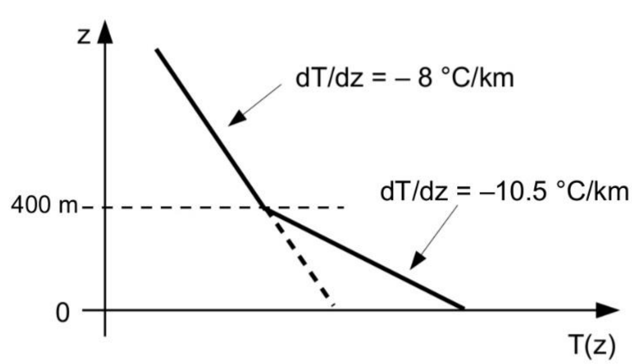

Fig. 2