MAE578, Spring 2015 Homework #2
Collaboration is not allowed for this assignment

Prob 1 (80%)
An observation (by conventional sounding) of temperature as a function of pressure was made at a meteorological station. The data (mae578_2015_hw2_data.txt) is posted at our class website. A basic matlab code for reading the data is also posted at the class website, as detailed in the Appendix. The first record in the data file (p = 924 hPa, T = 12.2 °C) was measured at the surface. The elevation of the station is 751 m.
(a) From the data, calculate and plot the vertical profiles of pressure (p), temperature (T), density (ρ), and potential temperature (θ, using p_s = 1000 hPa as the reference pressure) as a function of height. If tropopause is defined as the location with the temperature minimum, what is the height of the tropopause in this observed profile?
(b) Calculate and plot the profile of the vertical gradient of potential temperature, $d\theta/dz$. Use it to discuss the (dry) static stability of the atmospheric column.
(c) Calculate and plot the vertical profile of the lapse rate of temperature, $\Gamma \equiv -dT/dz$. Compare it to the dry adiabatic lapse rate, $\Gamma_d \equiv g/c_p$, and use it as the basis to discuss the (dry) static stability of the atmospheric column. (Your conclusions from Part (c) and Part (b) should agree with each other.)

For this problem, you may assume that the atmosphere is a diatomic ideal gas with gas constant R = 287 J kg^{-1} °K^{-1} and heat capacity c_p = 1005 J kg^{-1} °K^{-1}. If needed, other related thermodynamic properties of dry air can be found in Table 1.4 of M&P textbook. You may also assume hydrostatic balance in the vertical direction.

Prob 2 (20%)
A tank is filled with a layer of oil (ρ = 0.8 g/cm^3) on top of a layer of water (ρ = 1.0 g/cm^3). A block of specially made plastic with ρ = 0.9 g/cm^3 and with a thickness of 10 cm is then carefully placed between the two layers. See Fig. 1. This system is statically stable. Starting from the perfectly balanced position with half of the block immersed in oil and half in water, if we push the plastic block down just slightly, the positive buoyancy it experiences will restore it back to its original position. Then, with its remnant upward velocity, it will keep moving upward until its kinetic energy is exhausted by negative buoyancy. The cycle would then continue as an oscillation of the vertical position of the block. *Estimate the period of this oscillation.*

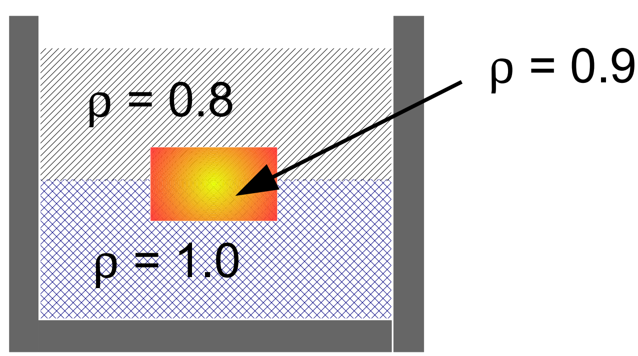

Fig. 1

Appendix: How to read the data for Prob 1

The data file (mae578_2010_hw2_data.txt) is available at our class website. It lists the observed pressure (in hPa) and temperature (in °C) in two columns. The following Matlab code, also available at our class website, will help you read the data from the file into two arrays of $p(115)$ and $T(115)$, where ($p(1)$, $T(1)$) are the pressure and temperature at the lowest level (or the level with the highest pressure), which is the surface. As a quick reference, the Matlab code also plots T as a function of p, as shown below.

```
clear
fid1 = fopen('mae578_2015_hw2_data.txt','r');
for n = 1:115
    p1 = fscanf(fid1,'%f7.1');
    T1 = fscanf(fid1,'%f7.1');
    p(n) = p1; T(n) = T1;
end
plot(T,p,'b-','LineWidth',2)
axis([-80 20 0 1000])
xlabel('T(p) (degC)'); ylabel('p (hPa)')
set(gca,'YDir','reverse')
```