Home Work Assignment No. 1, Air Pollution Meteorology Part 1 of 2

1. Geostrophic Flow: Should horizontal winds turn clockwise or counter clockwise in the Southern Hemisphere? Demonstrate with a force diagram at the surface and aloft (ie, vector diagram of press, coriolis and drag accelerations for air parcel between isobars).

2. Hydrostatic Balance: A drinking straw of length L is standing vertically in a glass of water with a depth of $h_0$. You put your finger over the end to seal it, and withdraw the straw. Derive an equation for the height of liquid remaining in the straw after no more water drips out. State any assumptions.

3. Hydrostatic balance: Derive an expression for $p(z)$ in a constant lapse rate atmosphere, ie where:

$$T(z) = T_o - \gamma z,$$
and $\gamma$ is constant and $g(z) = g$

4. A parcel of air with an initial temperature of 15°C and dew point of 2°C is lifted adiabatically from the 1000 mb level. Determine its lifting condensation level (i.e., cloud base, the point at which RH=100%) and temperature at that height. If the parcel is lifted 200 mb more above cloud base, what is its final temperature and how much liquid water is condensed during this rise. (use attached chart below)

5. Breaking a Nighttime Inversion
A town suffers from severe nighttime smoke pollution during the winter months because of domestic wood burning and strong temperature inversions. Consider the temperature profile measured at dawn shown in the figure. We determine in this problem the amount of solar heating necessary to break the inversion and ventilate the town.
a. Show on the figure (redraw in your solution) the minimum temperature rise required to ventilate the town.

![Fig. 4-28 Vertical profile of temperature at dawn.](image)

b. Show that the corresponding heat input per unit area of surface is \( Q = 2.5 \times 10^6 \) J m\(^{-2}\). Use \( \rho = 1\) kg m\(^{-3}\) for the air density and \( c_p = 1 \times 10^3 \) J kg\(^{-1}\) K\(^{-1}\) for the specific heat of air at constant pressure.

c. Solar radiation heats the surface after sunrise, and the resulting heat flux \( F \) from the surface to the atmosphere is approximated by

\[
F = F_{\text{max}} \cos \left( \frac{2\pi(t-t_{\text{noon}})}{\Delta t} \right); \quad 6 \text{ am} < t < 6 \text{ pm}
\]

Where \( F_{\text{max}} = 300 \) W m\(^{-2}\) is the maximum flux at noon = 12 pm, and \( \Delta t = 24 \) hours. At what time of day will the town finally be ventilated?

6. Air at a temperature of 20°C and a water vapor mixing ratio of 10 g/kg is lifted from 1000mb to 700mb by moving over a mountain. What is the initial dew point of the air and determine the temperature of the air after it has descended to 900mb on the other side of the mountain if 80% of the condensed water vapor is removed by precipitation during the ascent. (use attached chart below)