ESCI 342 – Atmospheric Dynamics I
Answers to Selected Exercises for Lesson 4

2. If the atmosphere was incompressible (density constant at all altitudes), 100 km thick, and had a surface pressure of 1000 mb, at what altitude would the pressure be 250 mb? Sketch the graph of pressure vs. altitude for this case and discuss how it compares with the real atmosphere.

Answer: 75 km.

3. If the thickness of the 1000 – 500 mb layer is 5400 m, what is the layer average temperature (in °C)?

Answer: −7°C

4. Find an expression for the vertical profile of pressure in an atmosphere that has a constant lapse rate of γ. [$T(z) = T_0 - \gamma z$]

Answer: $p = p_0\left[1 - \dfrac{\gamma}{T_0} z\right]^{g/R_d\gamma}$

6. An atmosphere has a temperature profile as a function of pressure given by $T(p) = T_0 + a\ln(p/p_0)$ where T_0 is the temperature at sea level and p_0 is the pressure at sea level

a. For this atmosphere find a general expression for the layer-average temperature for a layer lying between pressures p_1 and p_2 ($p_2 > p_1$).

Answer: $\overline{T} = T_0 + a\left(\dfrac{1}{2}\ln\left(p_1 p_2\right) - \ln p_0\right)$

b. Use the expression found in part a. to find the geopotential height of the 500 mb pressure surface (use p_0 = 1000 mb, T_0 = 288 K, and a = 36 K.

Answer: $\overline{T}$ = 275.5 K; Z = 5591 m

7. If the temperature profile is linear in height ($\gamma = -\partial T/\partial z$ = constant), find an expression for temperature as a function of pressure. Hint: Start with the chain rule,

$$\frac{dT}{dp} = \frac{dT}{dz}\frac{dz}{dp}.$$

Answer: $T = T_0\left(\dfrac{p}{p_0}\right)^{\gamma R_d/g}$