

1. Net frictional torque and angular momentum conservation.

- a. (10 pts) Complete part a.) of problem 6 at the end of Grotjahn (2020) Chapter 1.
- b. (1 pt) If half of the Earth's area lies between 30S and 30N, why should your answer be different than 30 degrees latitude?

2. Atmospheric mass.

- a. (2 pts) Write down the general formula for the total amount of mass in the atmosphere for a column with horizontal area 1 m^2 . Calculate the mass in the column if the surface pressure is 1010hPa.
- b. (2 pts) Write down the general formula for the total amount of mass in an atmospheric column when density is specified. (Assume a general profile of density is known, but at this point unspecified.)
- c. (3 pts) Use your formula in part b. to estimate the mass in the unit column given surface density $\rho_0 = 1.25 \text{ kg/m}^3$ and assuming density varies with a constant scale height based on vertical average $T_{\text{ave}} = 260\text{K}$.
- d. (5 pts) Write down the general formula for the total amount of mass in the atmosphere given surface density ρ_0 and vertical average temperature T_{ave} . Solve that formula for $\rho_0 = 1.25 \text{ kg/m}^3$ and $T_{\text{ave}} = 255\text{K}$.
- e. (7 pts) Find the total amount of mass in the atmosphere given a surface pressure p_s that is defined $p_s = 1003(1 - b \cos(2\phi))$. Where p_s is given in hPa and $b = 0.01$.

3. Mountain Torque.

- a. (2 pts) Figure 4.4d suggests a pressure difference of 8 hPa across the Andes of Chile. Deduced from SLP values: $p_w = 1016 \text{ hPa}$, $p_E = 1008 \text{ hPa}$. Using the RHS of (1.2), calculate the mountain torque from $\phi = -\pi/4$ to $-\pi/3$.
- b. (2 pts) Figure 4.5d suggests the low level *zonal* winds are small, or 0-15 m/s. Assuming the zonal wind component at the surface is $u = 2 \text{ m/s}$ and the wind speed is $|\mathbf{V}| = 7 \text{ m/s}$, calculate the LHS of (1.2).
- c. (1 pt) The mountain torque is what fraction of the friction? Compute your answer by taking the ratio of your answer to part a.) and divide by your answer to part b.).

NOTE: all homework is to be done by you as an INDIVIDUAL: no 'group' efforts, please. For written answers, please use a word processor, so that penmanship is not an issue. Equations and derivations can be *neatly* hand-written.

Any plot must be completely and unambiguously labeled, including title and axes.