MAE578 fall 2011 Homework #5

Variation of temperature/potential temperature with latitude

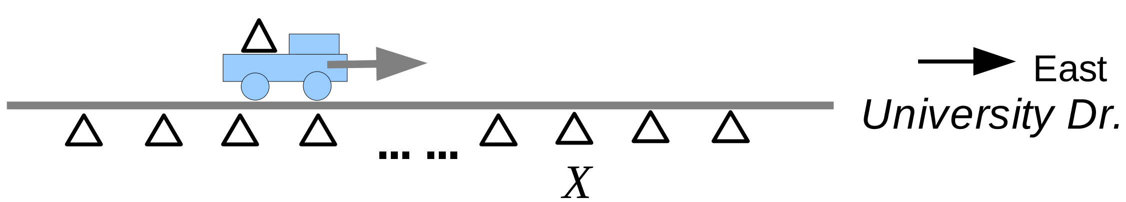
1. **(a)** Solve Prob 2 of Chap. 5 in M&P textbook. In addition, make a plot of the surface temperature as a function of latitude. **(b)** Adopt the N-layer model in Prob 5 of Chap. 2 (with perfect absorption of IR radiation by the atmosphere) and set N = 9. Moreover, assume that the temperatures of layer 1, 2, 3, ..., 9, and surface represent the temperatures at 100, 200, 300, ..., 900, and 1000 hPa. Make a contour and/or color plot of $T(\phi,p)$ where ϕ is latitude and p is pressure. (Try to make the plot in the same fashion as various latitude-pressure plots in Chap. 5. To use Matlab functions for plotting, You may discretize latitude at 5° interval. The basic Matlab commands for color and contour plots are **`pcolor`** and **`contour`**) **(c)** Same as (b) but now make a plot of the potential temperature, $\theta(\phi,p)$. **[3 points]**

Baroclinic instability and slantwise convection

2. Solve Prob 5 of Chap. 8. **[4 points]**

Eulerian vs. Lagrangian framework

3. A field campaign was conducted to assess the variation of temperature across the city of Mesa. Two teams were deployed to measure the air temperature along University Drive which runs in the east-west direction through the city. The first team consisted of local volunteers whose houses happen to be located on University Dr. Thermometers were set up in their front yards (illustrated as the line of triangles) for continuous monitoring of temperature at each location. The second team operated a mobile unit (see illustration) with a thermometer on board a truck that moved eastward along University Dr. at a speed of 5 m/s. The 1st team reported that at any given time during the campaign temperature decreases eastward along University Dr. with a constant rate of 0.1 °C/km. The 2nd team reported a constant decrease in temperature at a rate of 1.0 °C/hour as recorded by the mobile thermometer. What would be the rate of change (in time) of temperature as measured by any of the volunteers at a fixed location (for instance the one marked by an "X") ? **[1 point]**



Static and total energy for the atmosphere

4. The "moist static energy", $E_S \equiv C_P T + gz + Lq$ (see Sec. 4.5.2), can be regarded as the total energy (per unit mass) of an air parcel at rest. It is approximately conserved for an air parcel undergoing a moist adiabatic process. Taking into account atmospheric motion, the total energy is $E = E_S + E_K$, where $E_K \equiv (1/2)\,|\mathbf{v}|^2$ is kinetic energy ($\mathbf{v}$ is the 3-D velocity vector; cf. Eq. (8-14)). Using the collection of figures in Chap. 5 for the climatological mean state of the atmosphere as a function of latitude and height (or pressure), try to estimate the magnitude of the individual components of E at selected latitudes and pressure levels and fill the blanks in the following table. Comment on your results. The purpose of this exercise is for you to become familiar with the climatological state presented in Chap. 5. We will revisit the detail of energy balance in Chap. 8. **[2 points]**

	$C_P T$	gz	Lq	$(1/2)|\mathbf{v}|^2$	E
@ Equator and 1000 mb level					
@ Equator and 200 mb level					
@ 45°N and 1000 mb level					
@ 45°N and 200 mb level					

All quantities are in m^2/s^2

Note: (1) The height field shown in Fig. 5.13 is the "anomaly", i.e., departure from a certain global-mean value. More precisely, if we denote the anomaly as $z^*(\phi,p)$ (ϕ is latitude) and the global mean as $Z(p)$, then the total height is $z(\phi,p) = z^*(\phi,p)+Z(p)$. It is this total height that should be used for evaluating the "gz" term. For this exercise, let's assume that the global mean $Z(p)$ is 12 km at p = 200 mb and 0 km at p = 1000 mb. (2) Strictly speaking, the $\mathbf{v}$ for the evaluation of kinetic energy should be the three-dimensional velocity. Since for global-scale circulation the "zonal component" (u) tends to be greater than v and w, for this exercise we will approximate $|\mathbf{v}|^2$ by $|u|^2$, where the magnitude of u can be inferred from its "zonal mean" in Fig. 5.20. (We have not discussed Fig. 5.20 but will come back to it after the introduction of thermal wind balance in Chap. 7.)