Meteorology 3510
Exercise #2
Due Thursday, January 24, 2008

In these exercises, you will calculate the kinetic energy of a moving mass and molecular speeds of several gases.

1. (a) Calculate the bulk (center-of-mass) kinetic energy per unit mass of air parcels that are moving at 10 m/s and 100 m/s.
   (b) Calculate the molecular kinetic energy per unit mass of air parcels with temperatures of 200 K and 300 K.

2. We found that the average kinetic energy per molecule is related the temperature:

$$\frac{1}{2}\langle mv^2 \rangle = \frac{3}{2}kT,$$

   where the angle brackets indicate an average over the distribution of molecular speeds v and molecular masses m, k is Boltzmann's constant, and T is absolute temperature. The rms (root mean square) speed is

$$v_{\text{rms}} = \left(\frac{\langle mv^2 \rangle}{\langle m \rangle} \right)^{\frac{1}{2}},$$

   where $\langle m \rangle$ is the average mass per molecule.
   (a) Calculate and plot (using Matlab, on a single graph) the rms molecular speed versus temperature for the following pure gases: hydrogen, helium, neon, nitrogen, oxygen, argon, krypton, and xenon. (Their molecular weights are listed in Table 1 of the Notes.) Let the temperature range from 200 to 400 K with an increment of 1 K. Label the curves using the Matlab command `legend`.
   (b) From your plot, estimate the values of the rms molecular speeds of hydrogen, helium, nitrogen, and xenon for $T = 300$ K. (The matlab command `grid on` may be helpful.) *Hint:* The rms molecular speed of helium at $T = 300$ K is 1368 m/s.