HW 6

Due November 9, 2007

Please answer all questions clearly and concisely. While you need not transcribe the question completely, it should be clear from your answer alone what you are talking about.

You are strongly encouraged to discuss the homework with your classmates, but you must complete the written homework by yourself, and of course, the material you submit must be your own.

Remember, show all of your work!

1. The air around us is (to good approximation) made up of Di-Nitrogen molecules (NN), and has a typical pressure of $\sim 15 pounds/sq.in$, or, in units we like, about $10^5 N/m^2$ (or 100KPa). First, note that for an ideal gas:

   $$P = nk_bT$$

   where n is the number density of atoms, k_b is Boltzmann's constant $= 1.38 \times 10^{-23} J/K$, and T is the temperature of the gas. You may assume room temperature is 300K.

   (a) What is the approximate density of molecules near the surface of the earth?

   (b) How many molecules are in a small room $20m^3$?

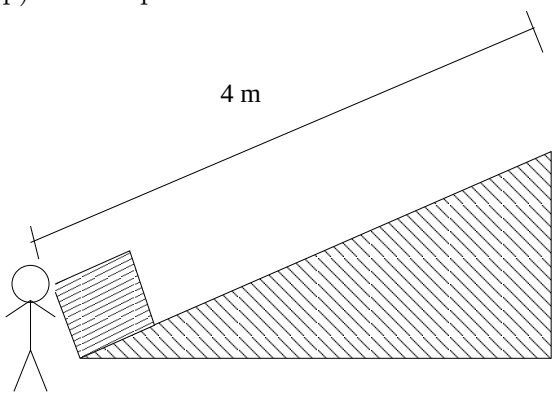
   (c) The thermal energy of a monatomic gas (which is good enough for this problem) is:

   $$E_{th} = \frac{3}{2} N k_b T$$

   where N is the total number of molecules. What is the thermal energy of all of the gas in the room?

   (d) A 100W lightbulb is shining in the room (which is insulated perfectly so that no heat can escape). After 10 minutes, how much will the average temperature in the room have risen?

2. A required problem from the Fraternal Order of Physics Professors. You are pushing a crate (to make it more exciting, let's say that it's a crate full of gold doubloons!) up a ramp with a length 4m. The crate has a mass of 50 kg. The ramp has an angle of 20 degrees, and the coefficient of kinetic friction between the ramp and crate is 0.2. You apply a constant force of 300N parallel to (up) the ramp.



(a) What is the instantaneous acceleration on the crate?

(b) How much work do you do on the crate moving it from the bottom to the top?

(c) How much work does friction do on the crate (remember the sign!)?

(d) How much heat is produced in the crate and the ramp?

(e) What is the change in potential energy that the crate gets from the bottom of the ramp to the top?

(f) From these, what is the kinetic energy of the crate at the top of the ramp?

3. 6.P.43
4. 6.P.45
5. 6.P.55
6. 6.P.58