PHYS 2604
Assignment #1

Given: Tuesday, September 15, 2009
Due: Thursday, September 24, 2009 **in class**

1. This is an exercise to review the concept and use of distribution functions. The speed distribution function of a set of N particles is given by $dN = \alpha(10v - v^3/1000)dv$, where dN is the number of particles that have speeds between v and $v + dv$ and α is a constant. The range of speeds for this set of particles is from $v = 0$ to $v = 100$ in arbitrary units. It is probably useful for you to plot the distribution function as dN/dv versus v.

   Find the constant α in terms of N.

   Calculate the most probable speed, v^*, the average speed, $\bar{v}$, and the root mean square speed, v_{rms}.

   Find the fraction of particles with speeds in the range from v_{rms} to the maximum velocity.

2. One type of apparatus used to verify the Maxwell speed distribution, known as a Zartman-Ko apparatus, consists of an oven and a rapidly rotating drum (see diagram on next page). A collimated beam of gas molecules from the oven enters the drum through a slit, when the slit is coincident with the beam. The pulse of molecules admitted to the drum passes through it to the far side, striking a glass plate. The density of molecules deposited on the glass plate can be measured to determine the speed distribution.

   The drum of a Zartman-Ko apparatus has a radius of 8 cm and rotates at 6000 rpm. The oven contains mercury atoms at a temperature of 600 K. Two atoms of mercury, one with the most probable speed v^* at oven temperature and the other with the root mean square speed v_{rms} for the same temperature, leave the oven and enter the drum together. These two atoms are deposited on a glass plate at the far side of the drum. What is the separation of these two atoms on the plate?

3. What is the total translational kinetic energy of the atoms of 4 moles of helium at a temperature of 300 K? What would be the answer for the same amount of any other ideal gas?

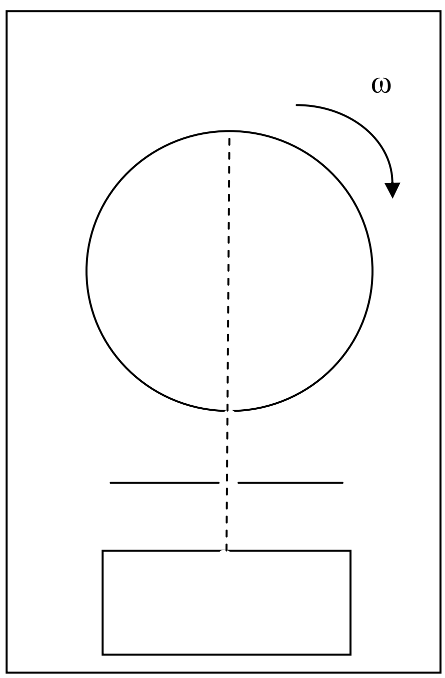
4. Like ordinary gas molecules, neutrons have a distribution of speeds and this distribution is important in the theory of nuclear reactors. A **thermal neutron** is usually defined as a neutron having the most probable speed of a Maxwellian distribution at a temperature of 293 K. Find the translational kinetic energy (in Joules and in eV) and the speed of a thermal neutron. Sometimes a thermal neutron is called a "kT" neutron. Why?

5. The Maxwell speed distribution gives the fractional number of particles with speeds between v and $v + dv$ as

$$\frac{dN}{N} = \left(\frac{m}{2\pi kT}\right)^{3/2} e^{-mv^2/2kT}(4\pi v^2)dv$$

Derive the following corresponding distribution in translational kinetic energy (denoted as E below):

$$\frac{dN}{N} = \frac{2}{\sqrt{\pi}}\left(\frac{1}{kT}\right)^{3/2} e^{-E/kT}\left(\sqrt{E}\right)dE.$$



Zartman Ko apparatus