Problem Set 1: Review of Classical Physics

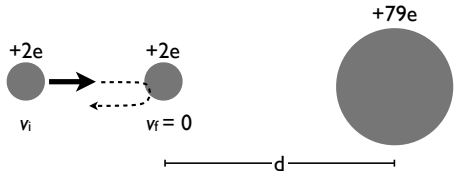
Instructions:

1. Answer all questions below. Show your work for full credit.
2. All problems are due Tues 15 January 2013 by the end of the day.
3. You may collaborate, but everyone must turn in their own work.

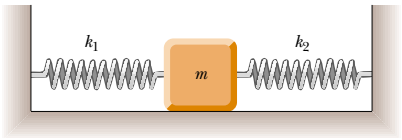
1. An atom of mass $m_1 = m$ moves in the positive x direction with velocity $v_1 = v$. It collides with and sticks to an atom of mass $m_2 = 2m$ moving in the positive y direction with speed $v_2 = \frac{2}{3}v$. **(a)** Find the resultant speed and direction of motion of the combination. **(b)** Find the kinetic energy lost in this inelastic collision.

2. **(a)** On the unrealistic assumption that there are no other charged particles in the vicinity, at what distance below a proton would the upward force on an electron equal its weight? **(b)** What is the induced EMF between the ends of the wingtips of a Boeing 737 when it is flying over the magnetic north pole? Google has the numbers you require.

3. In Rutherford's famous scattering experiments that led to the planetary model of the atom, alpha particles (having charge $+2e$ and masses of 6.64×10^{-27} kg) were fired toward a gold nucleus with charge $+79e$. An alpha particle, initially very far from the gold nucleus, is fired at a speed of $v_i = 2.00 \times 10^7$ m/s directly toward the nucleus, as shown below. How close does the alpha particle get to the gold nucleus before turning around? Assume the gold nucleus remains stationary, and that energy is conserved.



4. A block of mass m is connected to two springs of force constants k_1 and k_2 as shown below. The block moves on a frictionless table after it is displaced from equilibrium and released. Determine the period of simple harmonic motion.



5. Calculate the fraction of molecules in a gas that are moving with translational kinetic energies between $0.02\,k_B T$ and $0.04\,k_B T$.