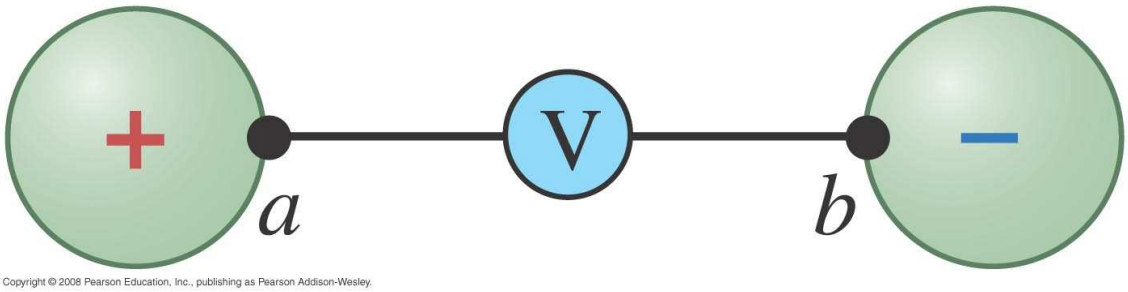
PHYS 161
Summer 2012 Homework
Assignment #3
Due June 22

#1 A particle with a charge $+5.50\,nC$ is in a uniform electric field directed to the left. Another force, in addition to the electric force, acts on the particle so that when it is released from rest, it moves to the right. After it has moved $12.0\,cm$, the additional force has done $6.50 \times 10^{-5}\,J$ of work and the particle has $2.75 \times 10^{-5}\,J$ of kinetic energy. (a) What work was done by the electric force? (b) What is the potential of the starting point with respect to the end point? (c) What is the magnitude of the electric field?

#2 Two oppositely charged, identical insulating spheres, each 35.0 cm in diameter and carrying a uniform charge of magnitude 150 μC, are placed 1.00 m apart center to center (Fig. P23.58). (a) If a voltmeter is connected between the nearest points (a and b) on their surfaces, what will it read? (b) Which point, a or b, is at the higher potential. How can you know this without any calculations?



#3 **The H_2^+ Ion** The H_2^+ ion is composed of two protons, each of charge $+e = 1.60 \times 10^{-19}\,C$, and an electron of charge e and mass $9.11 \times 10^{-31}\,kg$. The separation between the protons is $1.07 \times 10^{-10}\,m$. The protons and electron may be treated as point charges. (a) Suppose the electron is located at the point midway between the two protons. What is the potential energy of the interaction between the electron and the two protons? (Do not include the potential energy due to the interaction between the two protons.) (b) Suppose the electron in part (a) has a velocity of magnitude $1.50 \times 10^6\,m/s$ in a direction along the perpendicular bisector of the line connecting the two protons. How far from the point midway between the two protons can the electron move? Because the masses of the protons are much greater than the electron mass, the motions of the protons are very slow and can be ignored.

#4 **Coaxial Cylinders** A long metal cylinder with radius a is supported on an insulating stand on the axis of a long, hollow, metal tube with radius b. The positive charge per unit length on the inner cylinder is λ, and there is an equal negative charge per unit length on the outer cylinder. (a) Calculate the potential $V(r)$ for (i) $r < a$; (ii) $a < r < b$; (iii) $r > b$. Take $V = 0$ at $r = b$. (b) Show that potential of the inner cylinder with respect to the outer is

$$V_{ab} = \frac{\lambda}{2\pi\epsilon_0} \ln \frac{b}{a}$$

(c) Use this equation and the result from part (a) to show that the electric field at any point between the cylinders has magnitude

$$E(r) = \frac{V_{ab}}{\ln(b/a)} \frac{1}{r}$$

(d) What is the potential difference between the two cylinders if the outer cylinder has no net charge?

#5 A $22.5-\mu F$ capacitor is connected to a power supply that keeps a constant potential difference of $16.0\,V$ across the plates. A piece of material having a dielectric constant of 5.20 is placed between the plates, completely filling the space between them. (a) How much energy is stored in the capacitor before and after the dielectric is inserted? (b) By how much did the energy change during the insertion. Did it increase or decrease?

#6 Electronic flash units for cameras contain a capacitor for storing the energy used to produce the flash. In one such unit, the flash lasts for $\frac{1}{675}\,s$ with an average light power output of $3.1 \times 10^5\,W$. (a) If the conversion of electrical energy to light is 89% efficient (the rest of the energy goes to thermal energy), how much energy must be stored in the capacitor for one flash? (b) The capacitor has a potential difference between its plates of $125\,V$ when the stored energy equals the value calculated in part (a). What is the capacitance?

#7 A parallel-plate air capacitor is made using two plates $12\,cm$ square, spaced $5.0\,mm$ apart. It is connected to a $16-V$ battery. (a) What is the capacitance? (b) What is the charge on each plate? (c) What is the electric field between the plates? (d) What is the energy stored in the capacitor? (e) If the battery is disconnected and then the plates are pulled apart to a separation of $7.4\,mm$, what are the answers to parts (a)-(d)?