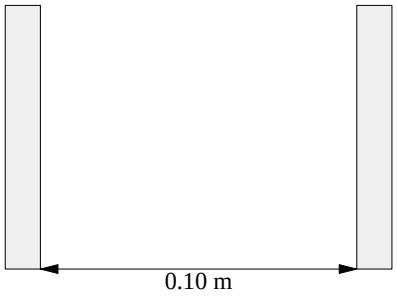
Physics 132-01 Physics IIa—Electricity and Magnetism
Monday, February 23, 2009
Test 1

Name: _____

Code Name (if you want your grades posted): _____

If any question is unclear, please ask immediately. Be sure to show your work **clearly**. Partial credit may be given for work *if* it can be understood.

Problem 1: (20 pts.) You have been charged with building an electron accelerator. Your goal is to accelerate electrons from rest to a speed of 3×10^6 m/s. (That is 1% of the speed of light.) Your design is a pair of parallel plates each of radius 1.00 m separated by a distance 0.10 m, as shown in the figure. The electron will be released from rest from the left-hand plate, and should reach the target speed just as it hits the right-hand plate. Assume that the plates are large enough that the field between the plates can be considered uniform. (This is the same assumption we always made in class.)



a. (10 pts.) What voltage difference would be required between the two plates?

b. (10 pts.) What are the required surface charge densities on the two plates? Be sure to include the signs. Show the signs explicitly on the figure above.

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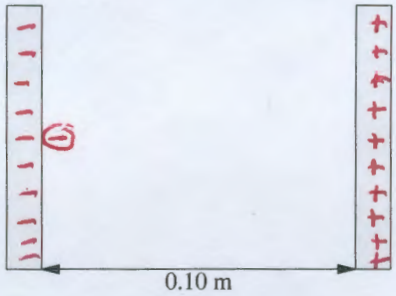
Problem 1: (20 pts.) You have been charged with building an electron accelerator. Your goal is to accelerate electrons from rest to a speed of 3×10^6 m/s. (That is 1% of the speed of light.) Your design is a pair of parallel plates each of radius 1.00 m separated by a distance 0.10 m, as shown in the figure. The electron will be released from rest from the left-hand plate, and should reach the target speed just as it hits the right-hand plate. Assume that the plates are large enough that the field between the plates can be considered uniform. (This is the same assumption we always made in class.)



a. (10 pts.) What voltage difference would be required between the two plates?

$$E_i = E_f$$

$$K_i + U_i = K_f + U_f$$

$$0 + (-e)V_i = \tfrac{1}{2}mv_f^2 + (-e)(V_f)$$

$$e(V_f - V_i) = \tfrac{1}{2}mv_f^2$$

$$(V_f - V_i) = \frac{1}{2}\frac{mv_f^2}{e} = \frac{1}{2}\frac{(9.109\times10^{-31})(3\times10^6)^2}{1.602\times10^{-19}}$$

$$\boxed{V_f - V_i = 25.6\,V}$$

b. (10 pts.) What are the required surface charge densities on the two plates? Be sure to include the signs. Show the signs explicitly on the figure above.

$$Q = CV = \left(\frac{\epsilon_0 A}{d}\right)V \Rightarrow \frac{Q}{A} = \sigma = \epsilon_0\left(\frac{V}{d}\right) = \boxed{2.27\times10^{-9}\,C/m^2}$$

(− on left, + on right).