General Physics 204, Section . . . Monday, Feb 09, 2015
Quiz #2 Electric Potential, Potential Energy, & Capacitors

Name:

1) CLASS(2)
Pieter van Musschenbroek uses two plates connected to a voltage $\Delta V = V_+ - V_- = 8.0$ kV to accelerate electrons. See fig. 1. The mass of an electron is $m_e = 9.1 \times 10^{-31}$ kg, and the charge of an electron is $-e = -1.6 \times 10^{-19}$ C. Find the velocity of the electrons when they come out of the positive plate. Assume electrons start at rest when leaving the negative plate. **[4 pts]**

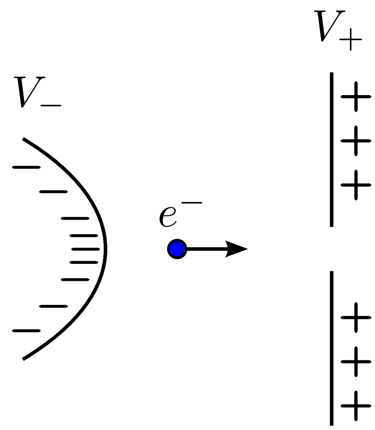

Figure 1: The electron gun.

$K_f - K_i = -(U_f - U_i) = -q(V_f - V_i)$

$= K_f = \frac{1}{2} m v_f^2 = e(V_+ - V_-)$

$\frac{1}{2}\, 9.1 \times 10^{-31}\, \text{kg}\; v_f^2 = 1.6 \times 10^{-19} \times 8.0\text{k J}$

$\rightarrow v_f = 5.3 \times 10^7$ m/s.

2) CLASS(2)
There are six charges q, with the same mass m, fixed (pinned down) on the corners of a hexagon with side length l. We name these six charges 1, 2, 3, 4, 5, and 6. See fig. 2.
a) We release charge number 1. What will be its velocity when it is far away from the others? **[2 pts]**
b) There are five charges left. Among them, charge number 2 gets released. What will be its velocity when it is far away from the others? We continue to release the charges one by one, and in order. Find each one's velocity when reaching far away from rest of them which remain intact. **[4 pts]**

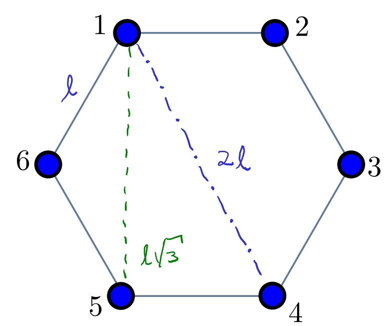

Figure 2: A hexagon with six charges q on its corners.

a) ΔU = the bonds we missed by removing 1

$= -\Delta K \rightarrow K_f = -(U_f - U_i) = \frac{1}{2} m v_1^2 = \frac{kq^2}{\ell}\left[2 + \frac{2}{\sqrt{3}} + \frac{1}{2}\right]$. (2,6; 3,5; 4)

b) Similarly $\frac{1}{2} m v_2^2 = \frac{kq^2}{\ell}\left[1 + \frac{2}{\sqrt{3}} + \frac{1}{2}\right]$, (3; 4,6; 5) $\frac{1}{2} m v_3^2 = \frac{kq^2}{\ell}\left[1 + \frac{1}{\sqrt{3}} + \frac{1}{2}\right]$, (4; 5; 6)

$\frac{1}{2} m v_4^2 = \frac{kq^2}{\ell}\left[1 + \frac{1}{\sqrt{3}}\right]$, (5; 6) $\frac{1}{2} m v_5^2 = \frac{kq^2}{\ell}[1]$. (6)

3) CLASS(2)
Robert A. Millikan charges a capacitor with a $V = 9$ V battery. The capacitor is a parallel plate capacitor with vacuum inside. He disconnects the capacitor from the battery, increases the distance between the plates twofold, and submerges it inside a dielectric liquid with dielectric constant $\kappa = 20$. What is the new voltage between the plates? **[4 pts]**

The charge stays const. after disconnecting the capacitor from the battery $\rightarrow Q = CV = C'V'$

& we know $C = \varepsilon_0 \frac{A}{d}$, $C' = \kappa \varepsilon_0 \frac{A}{2d}$. So $V' = \frac{C}{C'} V = \frac{2}{\kappa} V = 0.9$ V.