Physics 122 – Class #18
Date: 10/21/14

Questions?
Announcements/reminders

HW08 and written HW08 are due Today, 9/21/14

Exam 2 – Thursday, October 23!
See tips on the class website, there is an updated document.

Check the website regularly to make sure of assignments and due dates.
(http://www.physics.nmt.edu/~saska/phys122.html)
The exam... (Only calculator, ruler, pen/pencil and your cheat sheet allowed)

The cheat sheet: 1-page, 1-sided. Hand written. Longer cheat sheet will deduct one full letter grade!

You are studying for it ... Almost ready?

You are doing problems. You are able to re-do your homework problems, recitation and in-class problems.

There will be 4 conceptual questions, 4 problems, and 1 extra credit problem.

Ask for help if you are not understanding some problems you come across!
Physics 122 – Class #19

Last class: Potential and Field, Capacitors, Dielectrics.

Today: Capacitors, Current, Resistance, ...
Capacitors & Dielectrics

\[ E_0 = \frac{(\Delta V_c)_0}{d} \]

\[ \vec{E}_{\text{net}} = \vec{E}_0 + \vec{E}_{\text{induced}} = - (E_0 - E_{\text{ind}}) \hat{z} \]

\[ \chi = \frac{E_0}{E} \]

\[ \epsilon = \frac{E_0}{X} \]
\[ E_0 = \frac{(\Delta V_c)_0}{d} \]

\[ E = \frac{E_0}{x} = \frac{(\Delta V_c)_0}{xd} \]

\[ \Delta V_c = \frac{(\Delta V_c)_0}{x} \]

\[ C = \frac{Q}{\Delta V_c} = \frac{Q}{(\Delta V_c)_0} = \frac{x \left( \frac{Q}{(\Delta V_c)_0} \right)}{x} = k C_0 \]

\[ C = k C_0 \]

\[ k > 1 \]
Problem 29.68

$\Delta V = 1000 \text{ V}$

$R = 2.5 \text{ cm}$

d = 0.50 \text{ mm}

$k = 4.7 \text{ (pyrex)}$

$\eta \quad \eta_{\text{induced}}$

\begin{align*}
C_0 &= \frac{\varepsilon_0 A}{d} \\
A &= \pi R^2 \\
C &= \chi C_0 = \chi \frac{\varepsilon_0 A}{d} \\
C &= \frac{Q}{\Delta V_c} = \frac{\eta A}{\Delta V_c}
\end{align*}

(1)

(2)

From (1) & (2):
\[
\frac{k \varepsilon_0 A}{d} = \frac{\eta A}{\Delta V_c} \Rightarrow \left( \frac{x \varepsilon_0}{d} = \frac{1}{\Delta V_c} \right) \Rightarrow \\
\eta = \frac{x \varepsilon_0}{d} \Delta V_c = \frac{83.2 \times 10^{-6}}{C/m^2}
\]

For the pyrex:

\[
E = \frac{\eta_{induced}}{E_0} = ?
\]

\[
\frac{\eta_{induced}}{E_0} = E_{induced} = E_0 - E = E_0 - \frac{E_0}{X} = E_0 \left(1 - \frac{1}{X}\right)
\]
\[ \eta_{\text{induced}} = \eta \left(1 - \frac{1}{k}\right) \]

\[ \eta_{\text{induced}} = \eta \left(1 - \frac{1}{k}\right) = 83.2 \times 10^{-6} \frac{C}{m^2} \times \left(1 - \frac{1}{4.7}\right) = 1.4 \times 10^{-5} \frac{C}{m^2} \]
Current

moving charge ← current

electrons ← charge carriers

Electron current

\[ i_e = \frac{N_a}{\Delta t} \]

units: \[ \text{[} \frac{1}{s} \text{]} \]
The electron has frequent collisions with ions, but it undergoes no net displacement.

\[ \vec{v}_x = \vec{v}_{x_0} + a_x \Delta t \]

\[ \vec{v}_x = \vec{v}_{x_0} + \frac{eE}{m} \Delta t \]

A net displacement in the direction opposite to \( \vec{E} \) is superimposed on the random thermal motion.
drift velocity \sim \frac{10^{-3} m}{s} \sim \nu_d

\nu_d = \frac{eE}{m} \tau \quad \cdots \text{(*)}

\tau - \text{average time interval between collisions}
\[ i_e = \frac{N_e}{\Delta t} \]

\( N_e \) - number density
(\( \# \) e\(^-\) per unit volume)

\[ \Delta x = v_d \Delta t \]
\[ V = A \Delta x \]

\( v_d \rightarrow \Delta x \rightarrow \)
\[ N_e = n_e V = n_e A v_d \Delta t \]

\[ \Rightarrow i_e = \frac{N_e}{\Delta t} \Rightarrow i_e = n_e A v_d \]

\[ (* \text{ Consider}) \]

\[ i_e = n_e A \frac{eE}{m} \tau \]
Problem 30.7

\[ \tau = 4.2 \times 10^{-15} \text{ s} \]
\[ E = 0.065 \text{ V} \]
\[ R = 0.9 \text{ mm} \]
\[ i_e = ? \]

\[ n_e = 8.5 \times 10^{28} \frac{1}{\text{m}^3} \]

\[ i_e = n_e A u_d \]

\[ u_d = \frac{eE}{m} \tau \]

\[ i_e = n_e A \frac{eE}{m} \tau \]

\[ i_e = 1.0 \times 10^{20} \frac{1}{\text{S}} \]