Go to: Course homepage, Lectures

Lecture: 24 (iq21) Ch19 (review), and first part of Ch20

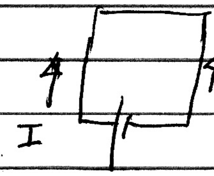
1. Selected hw-problems in **Ch19-h1**
   a. 002
   b. 009 (notice that only 3 compasses illustrated will be considered in ths problem)
   c. 013: Surface charge distribution of a circuit with a battery and two resistors, where R1>>R2.
   d. 014, 015 selected choices in these two questions will be discussed.
2. Selected topics related to **Ch20-h1**
   a. Ohm's law:
      - Ohm's law-I (without specification on dimensions): J=sigma E, where sigma=|q|nu, the conductivity of the matter.
      - Ohm's law II (with dimensions): V=IR, R=rho l/A, rho is the resistivity.
   b. 002
   c. `003
   d. 017, 18 spherical capacitor
   e. Time dependence of RC circuit.

Announcement:

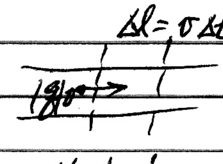
Midterm 2: Class average is 67.

- Reminder: How to determine the letter grade you made for this midterm?
  - Find you scaled score which is located near the bottom of the grading page.
  - Two letter grades for each exam:
    - letter grade-1 based on % cutoffs.
    - Letter grade-2 based on scaled score cutoffs.
  - The letter grade you have made for this exam is the higher of the two letter grades, if there is a difference.

~~Ch19-L1~~ Microscopic description of a circuit



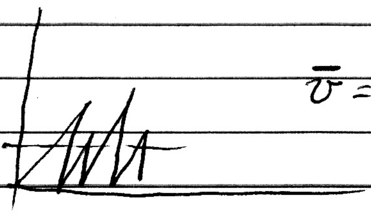
electron# current : $i = \frac{\Delta N}{\Delta t}$



$n, A, v, \Delta t$ $\qquad \Delta N = n A \Delta l = n A v \Delta t$

$$\therefore \frac{\Delta N}{\Delta t} = n A v$$

Drude model. Taking into account collisions along the way,



$$\bar{v} = a \bar{t}_c = \frac{eE}{m} \bar{t}_c = \left(\frac{e \bar{t}_c}{m}\right) E$$

Since $|v_{thermal}| >> |\bar{v}_{drift}|$

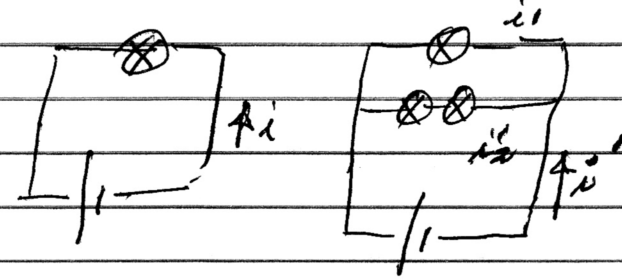
$10^3 km/s \qquad \sim 0.1 mm/s$

$$t_c = \frac{|l_c|}{|\vec{v}_{th} + \bar{v}_{drf}|} \sim \frac{|l_c|}{|v_{th}|} = \text{const at a given temp.}$$

$$\bar{v} = u E$$

mobility

Ch19-L1-002



Compare i_1' with i: $E_1'L = \mathcal{E}$

$EL = \mathcal{E}$

$\therefore E_1' = E$, or for identical bulbs $i_1' = i$

$nAuE_1' = nAu\frac{\mathcal{E}}{L} = nAuE$

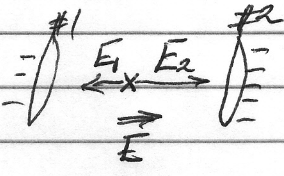
Compare i_2' vs i

Loop ABCA $\mathcal{E} - 2E_2'L = 0$

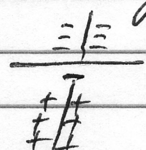
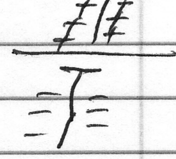
$E_2' = \frac{\mathcal{E}}{2L}$, $E_2' = \frac{E}{2}$, or $i_2' = \frac{i}{2}$

Compare i' with i, $i' = i_1 + i_2 = i + \frac{i}{2} = \frac{3i}{2}$

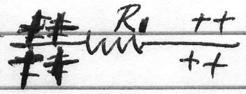
Ch19-h1-013 Phym: Change of local surface charge density leads to the local E within the wire



Inspection on wrong choices:

6  Wrong sign should be 

3. $R_1 = 25\,\Omega$, $R_2 = 5\,\Omega$



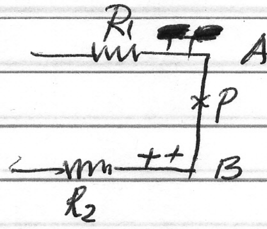
$\Delta V_1 = IR_1$

$\Delta V_2 = IR_2$

Picture has smaller charge density change across R_1. So $\Delta V_1 < \Delta V_2$

This contradicts to $R_1 > R_2$

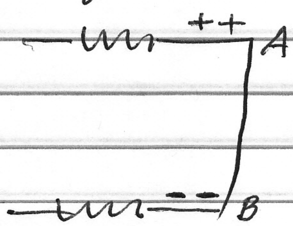
4.



Current flow should be clockwise, i.e. from A to B, or at P, I is downward, or E_P is downward.

The surface charge leads to $E_P^{surface}$ upward which is inconsistent with CW current flow.

5. Surface charge distribution implies



There is a potential difference between A & B.
This ~~[illegible]~~ is inconsist with ~~[illegible]~~ set up where $V_A - V_B$ across a wire should have $\Delta V = 0$.

Ch19-61-14.

choices 1. Incorrect. In the steady flow circuit $i = const$, $E = const$ but $E \neq 0$.

2. At G and at C, the cross section is the same
$i_G = n A_G u E_G$, $i_C = n A_C u E_C$. So $i_G = i_C$ implies
$E_G = E_C$.

3. Correct by inspection

4. Incorrect. We need excess charges to generate E, in turn the current in the wire.

ch19-hl 015.

1. Correct. Here $i_E = i_D = i_C$ (flow within 1 loop) steady

$$i_C = n A_C u E_C$$

$$i_D = n A_D u E_D$$

$$\therefore A_C E_C = A_D E_D, \quad E_D = \frac{A_C E_C}{A_D}$$

Since E_D is much bigger, local surface charge gradient must be larger also.

2. Yes. There is a steady current flow.
The electron current is the same throughout the current loop.

Preview on chap20.

Ohm's Law: Conventional "macroscopic" ohm's Law are:

Ohm's Law-1: $J = \sigma E$ (1) where σ is the conductivity

Ohm's Law-2: $V = IR$ (2)

How are they related to $i = nAuE$?

Define $I = |q| i = |q| n A u E$.

So $J = \frac{I}{A} = |q| n u E$.

$\therefore \sigma = |q| n u$.

Ohm's Law II follows since:

$$E = \frac{V}{L} = \frac{1}{\sigma} J = \rho \frac{I}{A},$$

or $V = \left(\frac{\rho L}{A}\right) I$

$= RI$, where $R = \frac{\rho L}{A}$ is used.