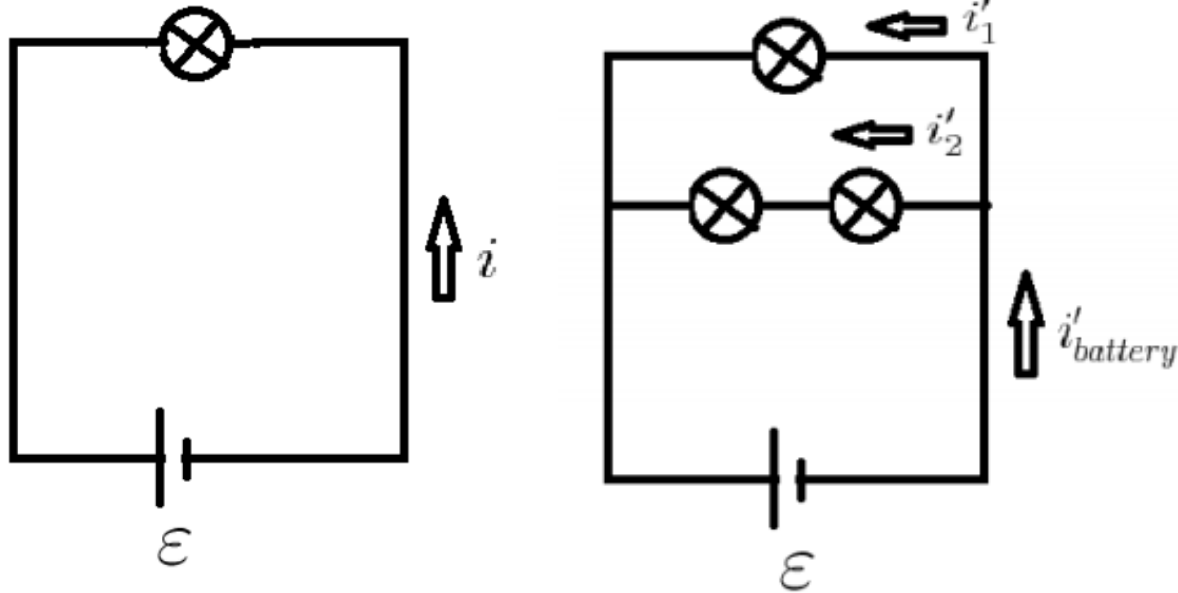


Lecture 24

Example Problem:



compare i'_1 with i

$$E'_1 L = \mathcal{E}$$

$$EL = \mathcal{E}$$

$\therefore E'_1 = E$ or for identical bulb: $i_1 = i$

$$nAuE'_1 = nAu\frac{\mathcal{E}}{L} = nAuE$$



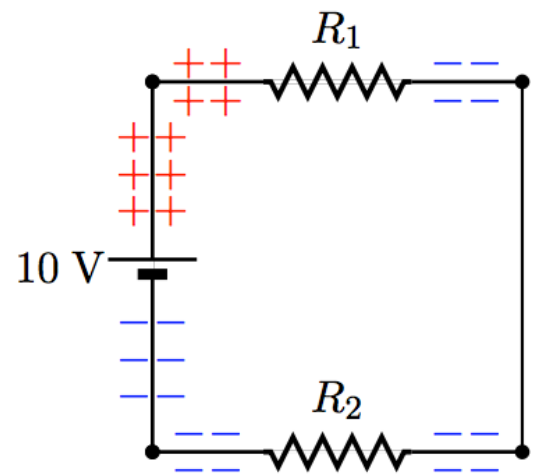
compare i'_2 vs i

Loop ABCA: $\mathcal{E} - 2E'_2L = 0$

$$E'_2 = \frac{\mathcal{E}}{2L}, \quad E'_2 = \frac{E}{2}, \quad \text{or } i'_2 = \frac{i}{2}$$

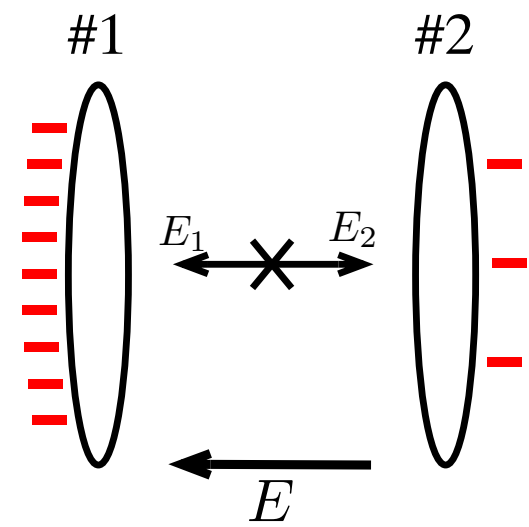
compare i' with i , $i' = i_1 + i_2 = i + \frac{i}{2} = \frac{3i}{2}$

Example Problem 2:

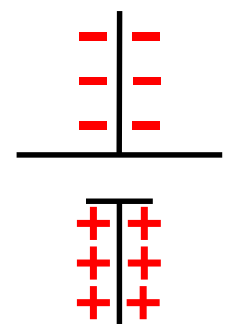


Of the following diagrams, which indicates the correct surface charge distribution of +’s and -’s on the circuit? Use the relation $\Delta V_i = I_i R_i$ (Ohm’s law) to assist in your qualitative reasoning.

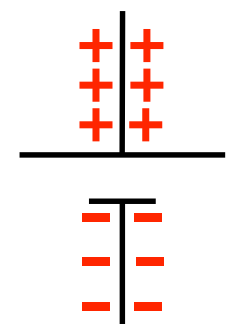
Change of local surface charge density leads to the local E within the wire.



Inspection on wrong choices:

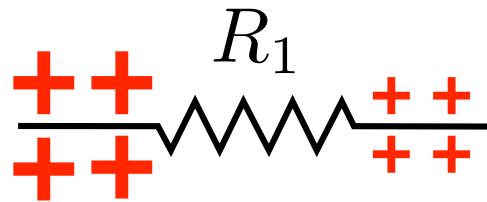


wrong sign, should be:

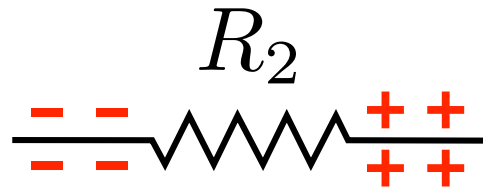


Inspection on wrong choices continued...

$$R_1 = 25\Omega, \quad R_2 = 5\Omega$$



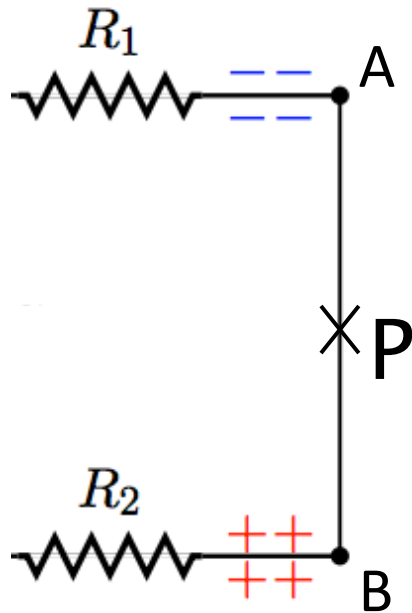
$$\Delta V_1 = IR_1$$



$$\Delta V_2 = IR_2$$

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

This is contradictory to the given, $R_1 > R_2$



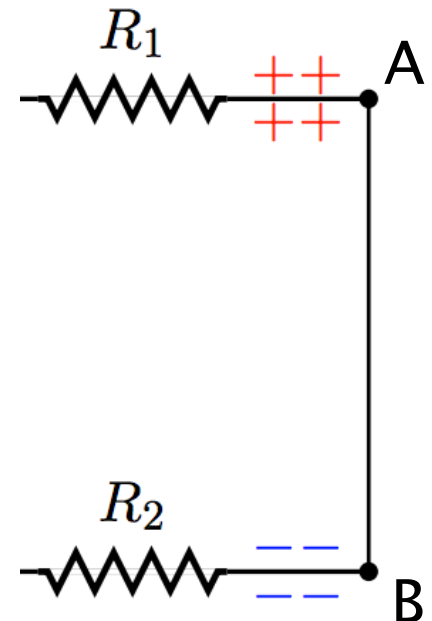
Current flow should be clockwise,

i.e. from A to B, or at P, I is downward or E_p is downward

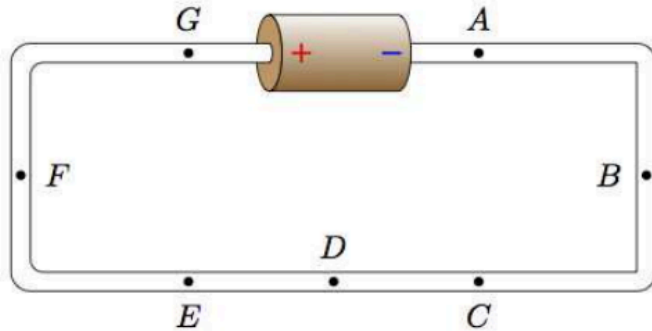
The surface charge leads to E_p upward which is inconsistent with CW current flows.

There is a potential difference between A and B.

This is inconsistent with set up where $V_A - V_B = 0$.



Example Problem 3: Which of the following statements are true?



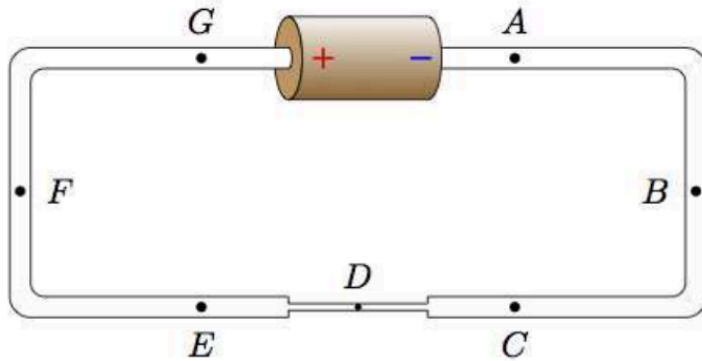
A steady-state current flows through the Nichrome wire in the circuit shown in the figure.

- 1 Inside the metal wire the magnitude of the electric field is zero.
- 2 The magnitude of the electric field is the same at locations G and C .
- 3 The electric field points to the left at location G .
- 4 There is no excess charge on the surface of the wire.
- 5 There is excess charge on the surface of the wire near the batteries but nowhere else
- 6 The magnitude of the electric field inside the wire is larger at location G than at location C .
- 7 The electric field at location D points to the left.
- 8 Because the current is not changing, the circuit is in static equilibrium.

We discuss the first 4 statements here:

1. Incorrect. In the steady flow, $i = \text{const.}$, $E = \text{const.}$, but E is not zero.
2. At G and at C , the cross section is the same :
 $i_G = nA_G u E_G$, $i_C = nA_C u E_C$ so $i_G = i_C$, and $E_G = E_C$
3. Correct by inspection
4. Incorrect. We need excess charges to generate E , in turn the excess in the wire.

Typical Homework Problem 4: Which of the following statements are true?



- 1 There is a large gradient of surface charge (relative to the rest of the wire) on the wire between locations *C* and *E*.
- 2 The electron current is the same at every location in this circuit.
- 3 Fewer electrons per second pass location *E* than location *C*.
- 4 The magnitude of the electric field at location *D* is larger than the magnitude of the electric field at location *G*.
- 5 There is no surface charge on the wire near location *G*.

We discuss the first 2 statements:

1. Correct. Here $i_e = i_o = i_c$ (steady flow within 1 loop)

$$i_C = nA_c u E_c$$

$$i_D = nA_D u E_D$$

$$\therefore A_c E_c = A_D E_D, \quad E_D = \frac{A_c E_c}{A_D}$$

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

2. Yes. There is a steady current flow. The # of electrons pass through each point must be the same to avoid the pile up.

Preview of Chapter 20:

Ohm's laws: conventional "macroscopic" ohm's law are:

$$\text{Ohm's Law-1: } J = \sigma E$$

$$\text{Ohm's Law-2: } V = IR$$

How are they related to $i = nAuE$?

$$\text{Define: } I = |q|i = |q|nAuE.$$

$$\text{So } J = \frac{I}{A} = |q|nuE = \sigma E, \quad \text{or Ohm's Law - 1}$$

where the definition: $\sigma = |q|nu$ is used.

Ohm's Law-2 follows

$$E = \frac{V}{L} = \frac{1}{\sigma} J = \rho \frac{I}{A} \quad \text{or} \quad V = \left(\frac{\rho L}{A} \right) I$$
$$= RI, \quad \text{where } R = \frac{\rho L}{A} \text{ is used.}$$