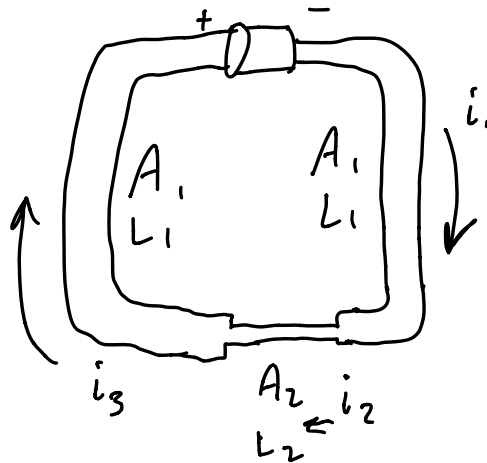


Consider the circuit:

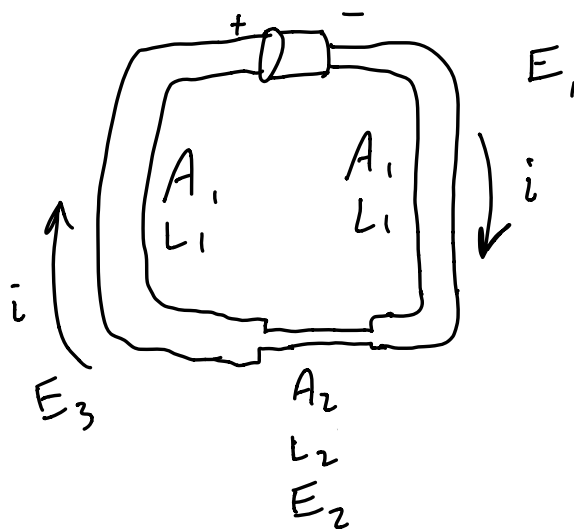


What is i_2 ?

$$i_2 = i_1 = i_3$$

What is i_3 ?

What is \vec{E} in the wire?



$$i_{in} = i_{out}$$

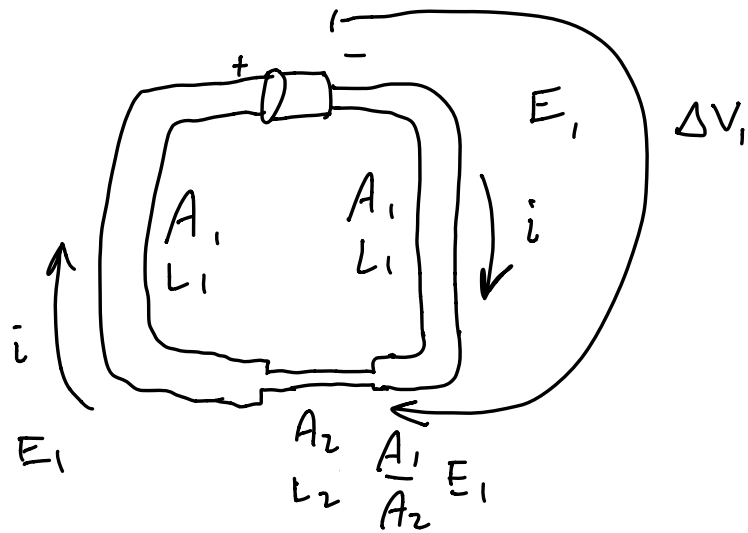
$$n A_1 \bar{v}_1 = n A_2 \bar{v}_2$$

$$A_1 v \bar{E}_1 = A_2 v \bar{E}_2$$

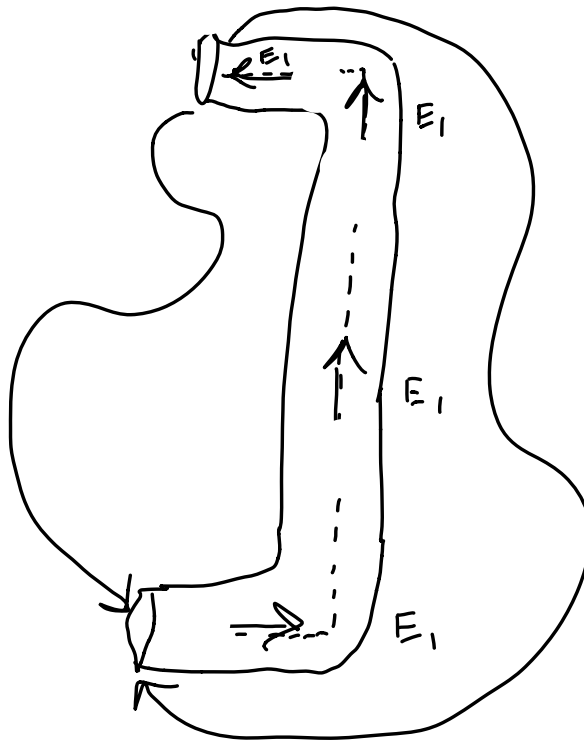
$$\bar{E}_1 = \frac{A_2}{A_1} \bar{E}_2$$

$$A_2 E_2 = A_1 E_3$$

$$E_3 = \frac{A_2}{A_1} E_2 = E_1$$



$$\Delta V = - \int \vec{E} \cdot d\vec{\ell}, \text{ along any path}$$



Choose the path along the wire

Then: $|\vec{E}|$ is always E_1

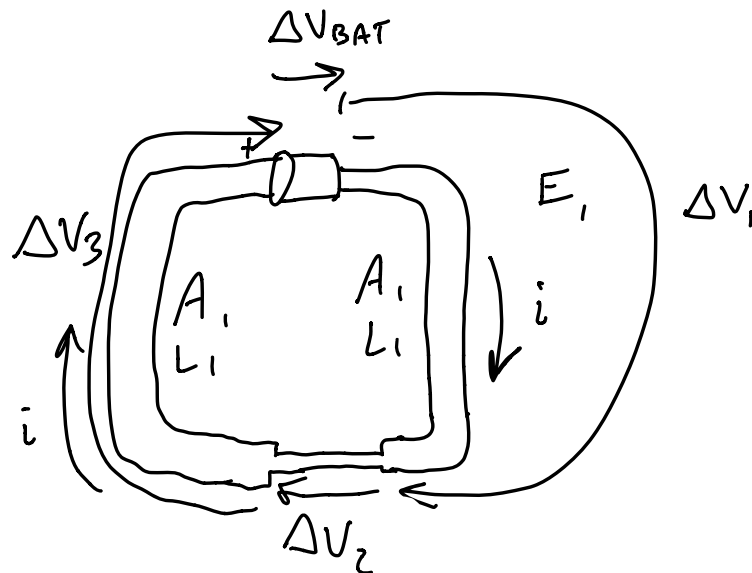
$$\vec{E} \cdot d\vec{\ell} = E_1 dl \cos(\pi) = -E_1 dl$$

$$\Delta V_1 = -\int \vec{E} \cdot d\vec{\ell} = -\int_0^{L_1} E_1 dl = -E_1 L_1$$

$$\Delta V_1 = E_1 L_1$$

$$\Delta V_2 = E_2 L_2 = \frac{A_1}{A_2} E_1 L_2$$

$$\Delta V_3 = E_1 L_1$$



$$\Delta V_{\text{loop}} = 0$$

$$\text{so } \Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_{\text{BAT}} = 0$$

The loop rule

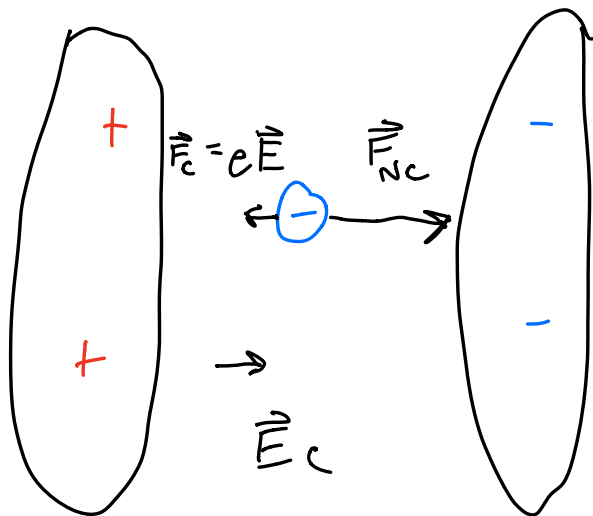
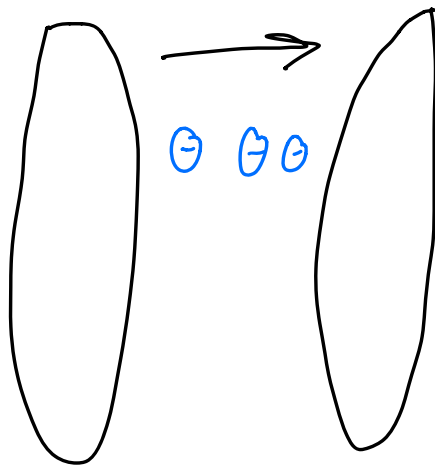
$\sum \Delta V$ around any loop
in the circuit is 0

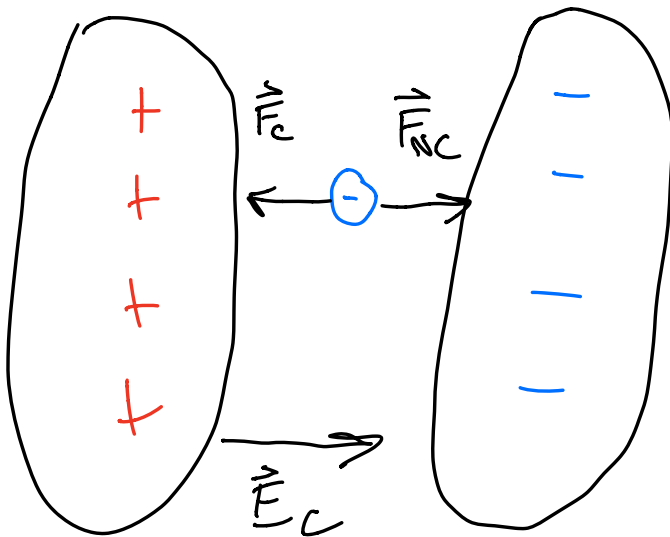
Energy Conservation

$$\Delta V_{\text{BAT}}$$



What is $\Delta V_{\text{of battery}}$?

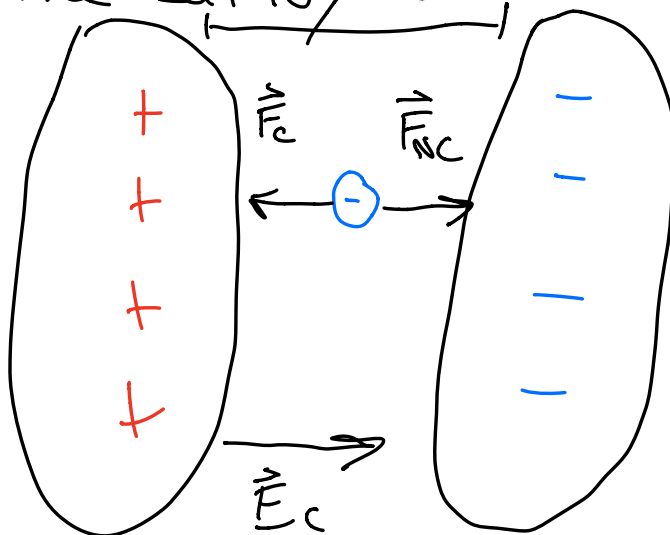




$|\vec{F}_c| = |\vec{F}_{nc}|$: Maximum charge separation

\vec{F}_{nc} Depends on energy available to the battery s

$$|\Delta V_{BAT}| = (E_c)(s)$$



$$\Delta V_{BAT} = E_c s = \frac{F_{nc}}{e} s \equiv \text{emf}$$

$$\Delta V_{BAT} = \text{emf} = \mathcal{E}$$

This is the number
printed on the battery

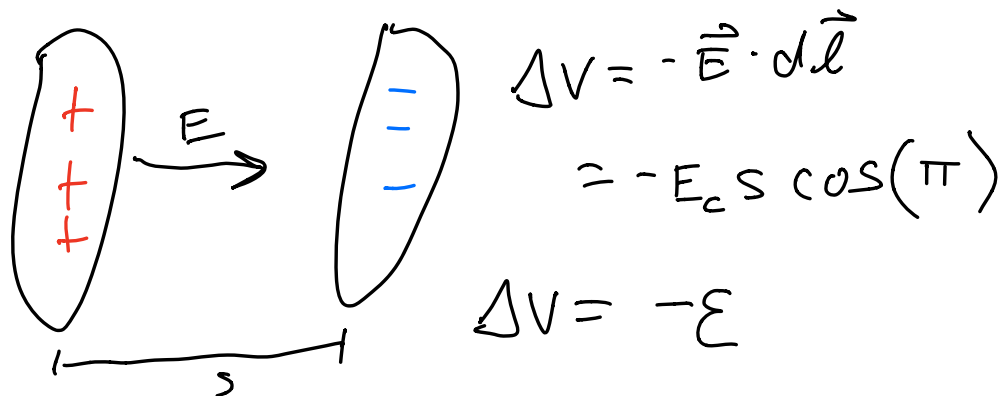
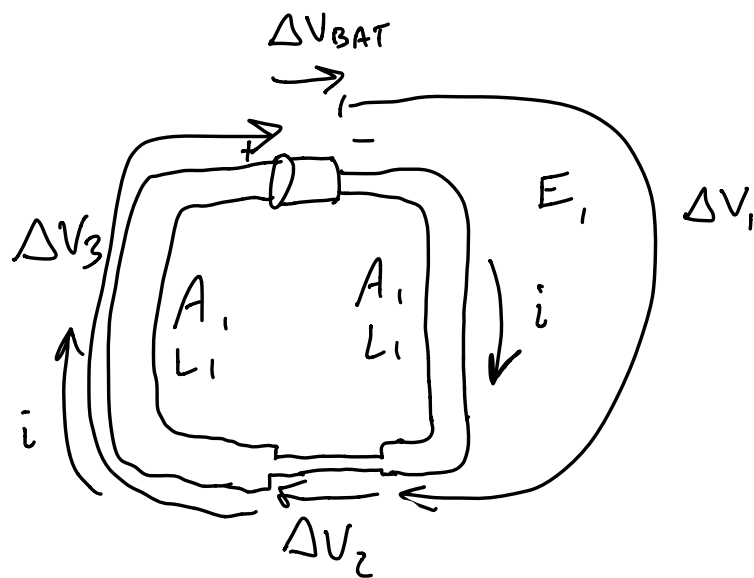
AA \rightarrow 1.5 V

Car battery \sim 12-13 V

$$\Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_{BAT} = 0$$

$$|\Delta V_{BAT}| = \mathcal{E} \leftarrow \text{emf}$$

+ or - ?



- Path FROM + TO -

$$\Delta V_{BAT} = -\mathcal{E}$$

- Path FROM - TO +

$$\Delta V_{BAT} = \mathcal{E}$$

$$\Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_{BAT} = 0$$

$$\Delta V_1 + \Delta V_2 + \Delta V_3 - \mathcal{E} = 0$$

$$E_1 L_1 + \frac{A_1}{A_2} E_1 L_2 + E_1 L_1 = \mathcal{E}$$

$$E_1 \left(2L_1 + \frac{A_1}{A_2} L_2 \right) = \mathcal{E}$$

$$E_1 = \frac{\varepsilon}{2L_1 + \frac{A_1}{A_2} L_2}$$