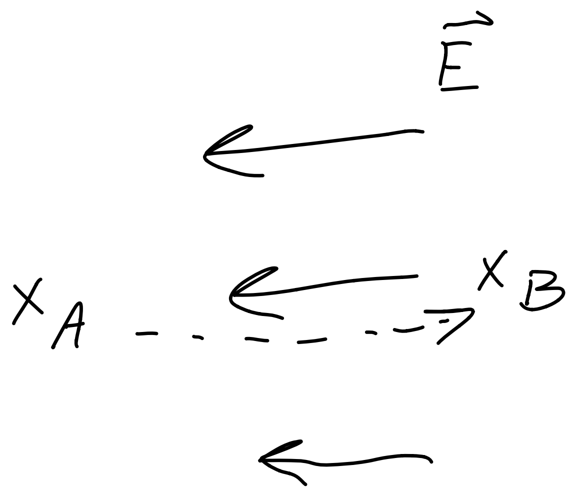
- Intuition on electric potential
    - Electric potential increases in the same direction as potential energy
    - Which direction does the charge "want" to move?
        - Decreasing U=> negative delta U
    - If I move it the opposite way, delta U is positive



ΔV pos or neg?

It takes work to move a positive q from A to B, so ΔV is pos

$$\Delta V = -\vec{E}\cdot\Delta\vec{r} = -|\vec{E}||\Delta\vec{r}|\cos 180^\circ > 0$$

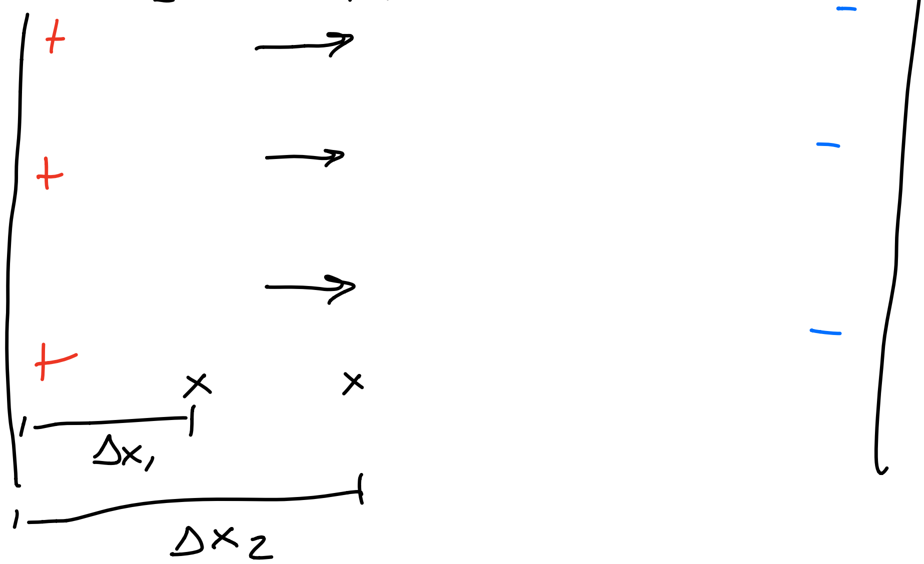
- B is at higher potential than A
  - Positive charges move from higher to lower potential
  - Negative charges move from lower to higher potential

- This also means that if we know delta V, we know the direction of E

- if $V_A > V_B$, what is direction of $\vec{E}$?
- Positive charge moves to lower potential
  $\vec{E}$ is $\longrightarrow$

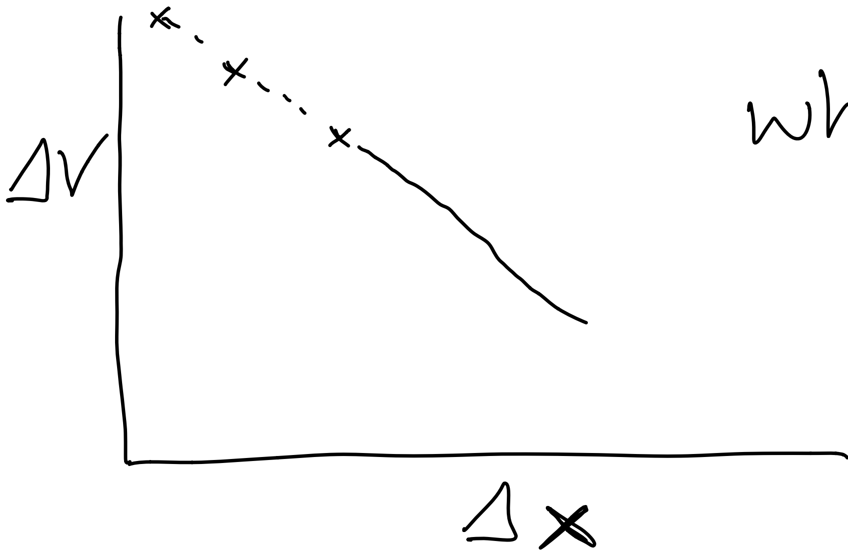
- E as derivative of V

$\vec{E} = \langle E_x, 0, 0 \rangle$



$$\Delta V_1 = -E_x \Delta x_1$$

$$\Delta V_2 = -E_x \Delta x_2, \ldots$$



what's the slope?

$y = mx$, $\Delta V = -E_x \Delta x$

$m = -E_x$

$-E_x = \frac{dV}{dx} \Rightarrow \boxed{E_x = -\frac{dV}{dx}}$

Another way:

$\Delta V = -E_x \Delta x$

$E_x = -\frac{\Delta V}{\Delta x}$

$$\lim_{\Delta x \to 0} \frac{-\Delta V}{\Delta x} = -\frac{dV}{dx}$$

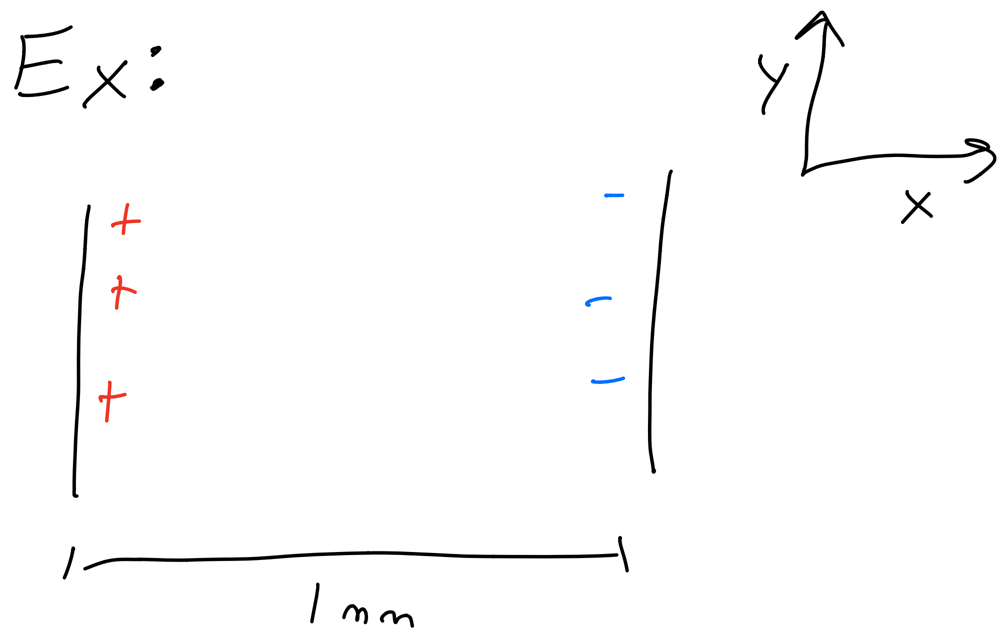
$$E_x = -\frac{dV}{dx}$$

Same for y, z

$E_x = -\frac{dV}{dx}$, $E_y = -\frac{dV}{dy}$, $E_z = -\frac{dV}{dz}$

$$\vec{E} = -\left(\frac{dV}{dx}, \frac{dV}{dy}, \frac{dV}{dz} \right)$$

Ex:



$$\Delta V = 50\text{ V}$$

$$|\vec{E}| = \left| -\frac{\Delta V}{\Delta x} \right| = \frac{50}{10^{-3}} = 5\times10^{4}\,\frac{\text{V}}{\text{m}}$$

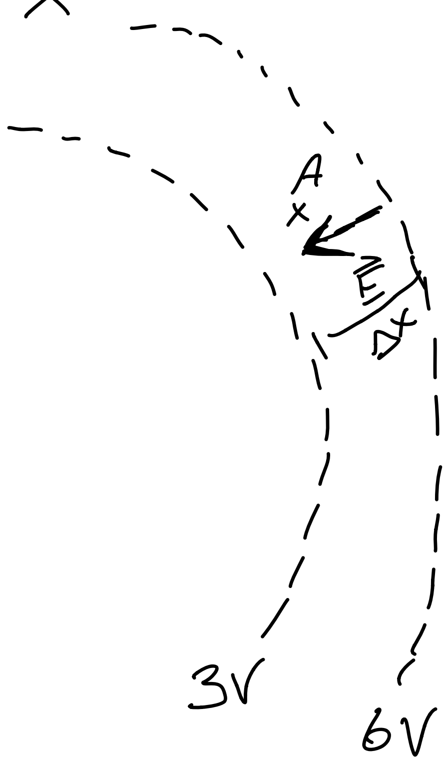
Direction? $\hat{x}$

$$\vec{E} = -5\times10^{4}\,\frac{\text{V}}{\text{m}}\ \hat{x}$$

$\frac{\text{V}}{\text{m}}$? or $\frac{\text{N}}{\text{C}}$

$$\text{V} = \frac{\text{J}}{\text{C}} = \frac{\text{Nm}}{\text{C}},\ \text{so}\ \frac{\text{V}}{\text{m}} = \frac{\text{Nm}}{\text{Cm}} = \frac{\text{N}}{\text{C}}\ \checkmark$$

Ex



$\vec{E}_A = ?$

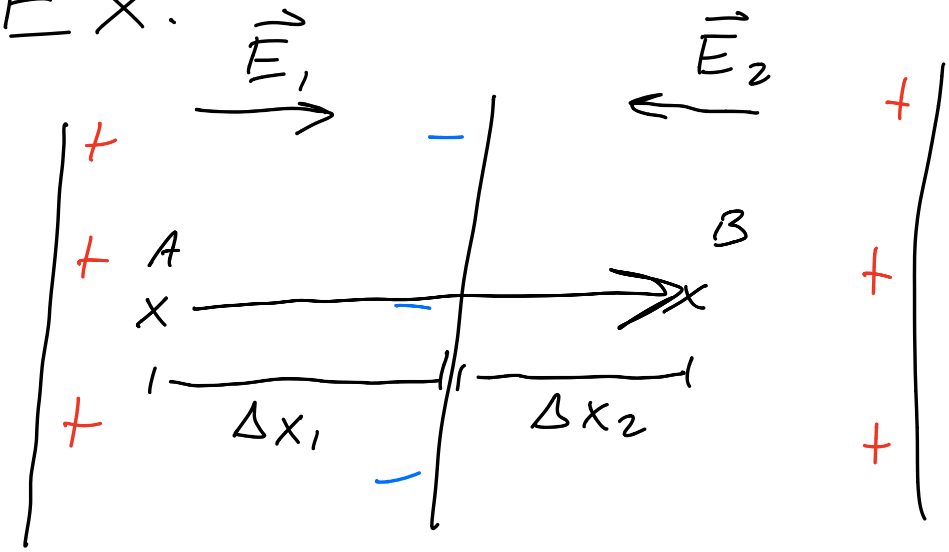
$\vec{E}$ is $\perp$

$\vec{E}$ points from high to low

$|\vec{E}|$? Measure Δx (2 cm)

$$|\vec{E}| = \left| -\frac{\Delta V}{\Delta x} \right| = \frac{3}{2\times10^{-2}} = 150\ \frac{V}{m}$$

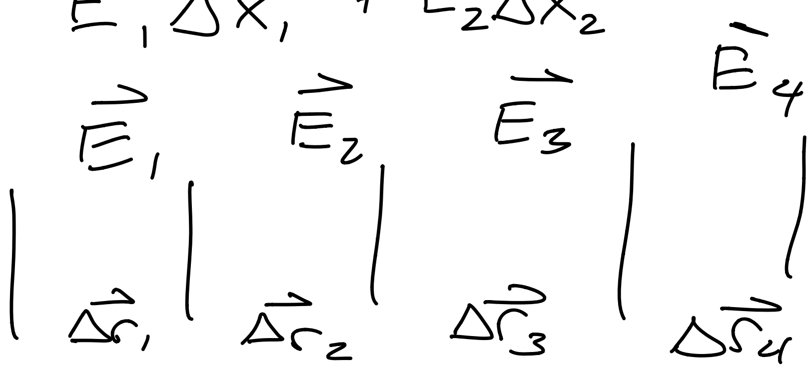
Ex:



What $\Delta V = V_B - V_A$?

$$\Delta V = \Delta V_1 + \Delta V_2$$

$$= -E_1 \Delta x_1 + E_2 \Delta x_2$$

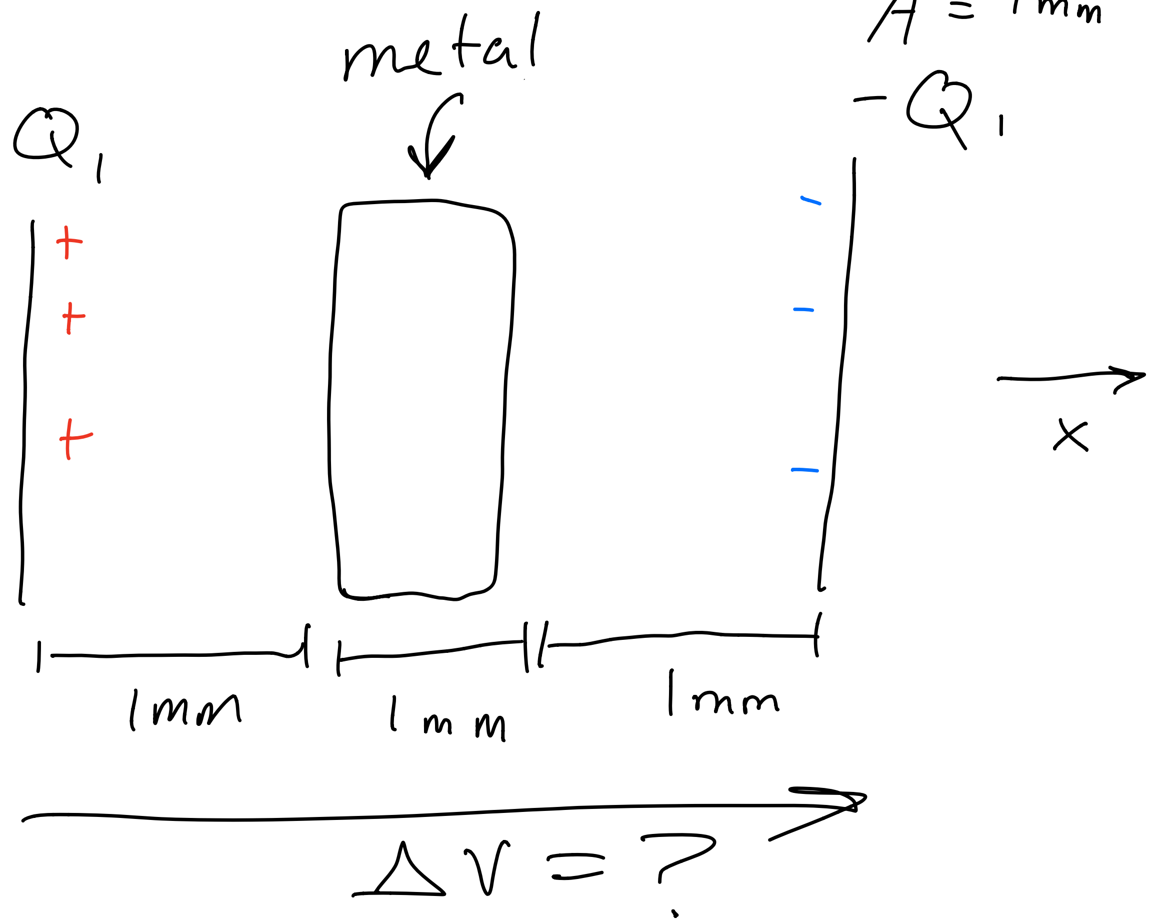


$$\Delta V = -\vec{E}_1 \cdot \Delta\vec{r}_1 - \vec{E}_2 \cdot \Delta\vec{r}_2 \quad \ldots$$

$$\Delta V = -\sum \vec{E}_i \cdot \Delta \vec{r}_i$$

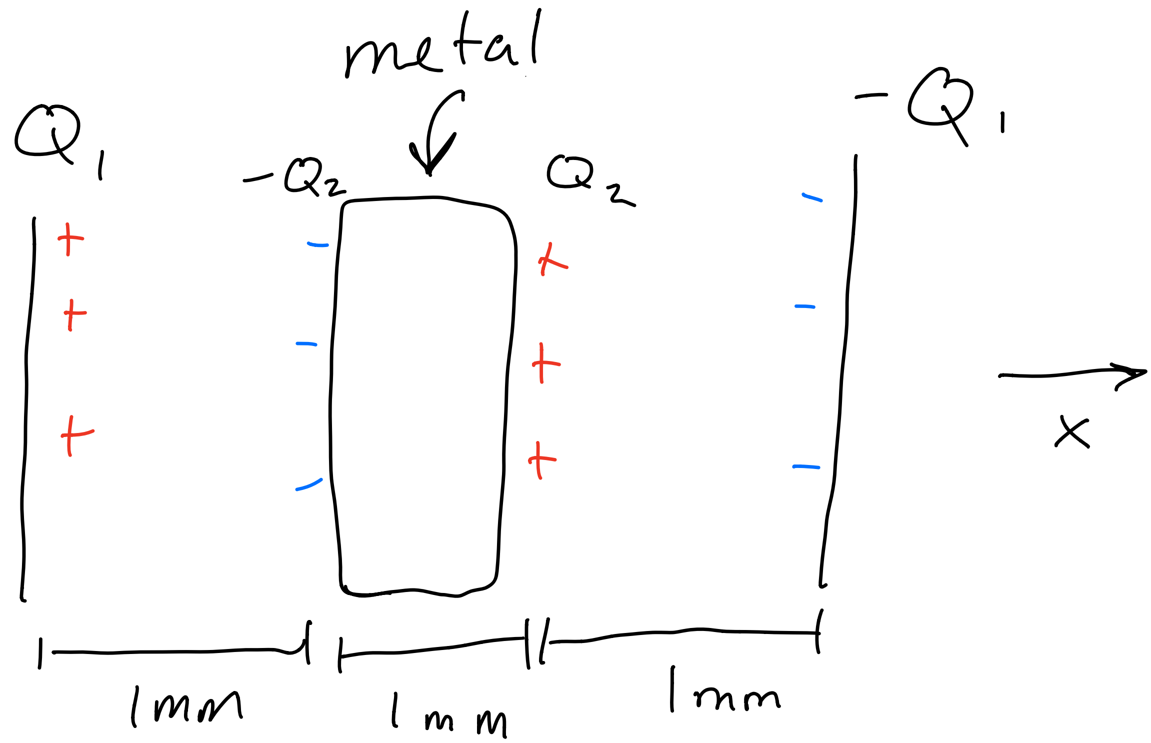
$Q_1 = 1 \mu C$

$A = 1 mm^2$



$$\Delta V = -\vec{E} \cdot \Delta \vec{r}$$

What is $\vec{E}$?



$$\vec{E} = \frac{Q_1/A}{\epsilon_0}\hat{x}$$

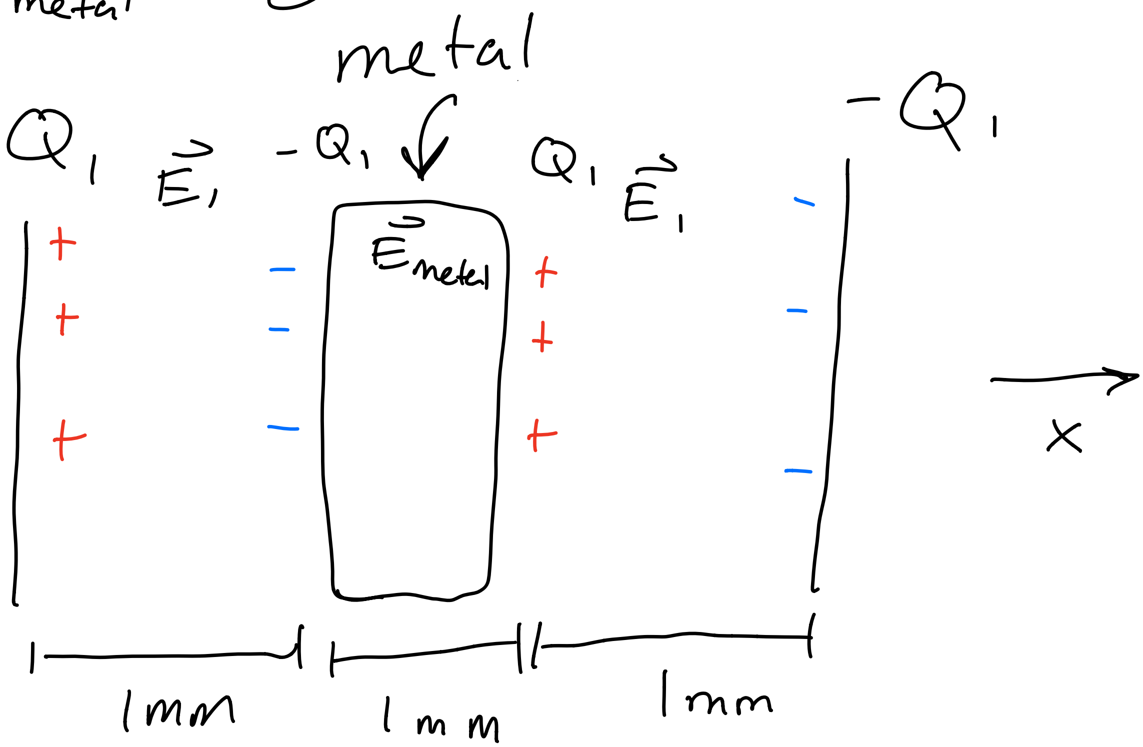
$\vec{E}$ inside the metal?

$$\vec{E} = 0$$

$$\vec{E}_{metal} = \vec{E} + \vec{E}_{ind}$$
$$= \frac{Q_1/A}{\epsilon_0}\hat{x} - \frac{Q_2/A}{\epsilon_0}\hat{x} = 0$$

$$Q_1 = Q_2$$

$\vec{E}_{metal} = 0$



Two capacitors!

$$\Delta V = -E_{1x}\Delta x - E_{1x}\Delta x$$

$$= -2E_{1x}\Delta x$$

$$\Delta V = -2\frac{Q_1/A}{\epsilon_0}(1\,mm)$$