PHYS 121 Feb. 5, 2025

To do:

- complete HW5 on PL by Feb. 7 @ 23:59

- Pre-Lab #2 is optional. It introduces computational methods that can be used to solve problems in physics.
    - Complete it if interested/curious. It is not worth marks, but we will grade the submissions received.

- Hands-On bonus project proposals due Feb. 10 @ 23:59
    - Email me a discription of your idea. Groups of 2 maximum.

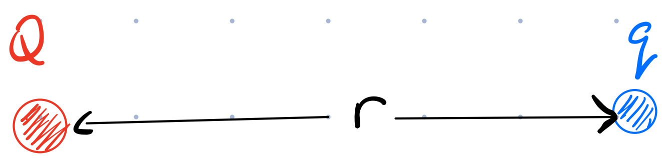
- No office hours Fri. Feb. 7. They will be on Thur. Feb 6 9:30-10:30 instead.

Last Time:

The work done by the electric force $\vec{F}_E = q\vec{E}$ is path independent.

$\Rightarrow$ The electric force is conservative & we can define a potential energy U associated with this force.

For a pair of pt. charges Q & q separated by distance r



$$U = \frac{k_e q Q}{r}$$

- $U \propto \frac{1}{r}$
- U is a scalar (no associated dir'n)
- $[U] = J$ (Joules)

P.E. of a pair of pt. charges

$$U = \frac{k_e q Q}{r}$$

Force between a pair of pt. charges

$$\vec{F} = \frac{k_e q Q}{r^2}\hat{r}$$

Imagine that Q establishes an electric potential V (voltage) that interacts w/ other nearby charges.

$$V = \frac{k_e Q}{r}$$

electric potential/voltage due to Q.

$$U = qV$$

P.E. of q in the potential V of Q.

Imagine that Q establishes an $\vec{E}$-field that exerts a force on q.

$$\vec{E} = \frac{k_e Q}{r^2}\hat{r}$$

$$\vec{F}_q = q\vec{E}$$

Calculating change in potential (ΔV) from electric fields.

Start w/ Work-KE Theorem

$$\Delta K = \int \vec{F} \cdot d\vec{s}$$

Recall $\Delta K + \Delta U = 0 \Rightarrow \Delta K = -\Delta U$

(conservation of energy)

$$\therefore \Delta U = -\int \vec{F} \cdot d\vec{s}$$

For a charge moving in an electric field $\vec{E}$, know

$$\vec{F} = q\vec{E}$$

electric potential energy [J]

We also just defined the relationship $U = qV$

electric potential

$\left[\frac{J}{C}\right] = 1$ volt.

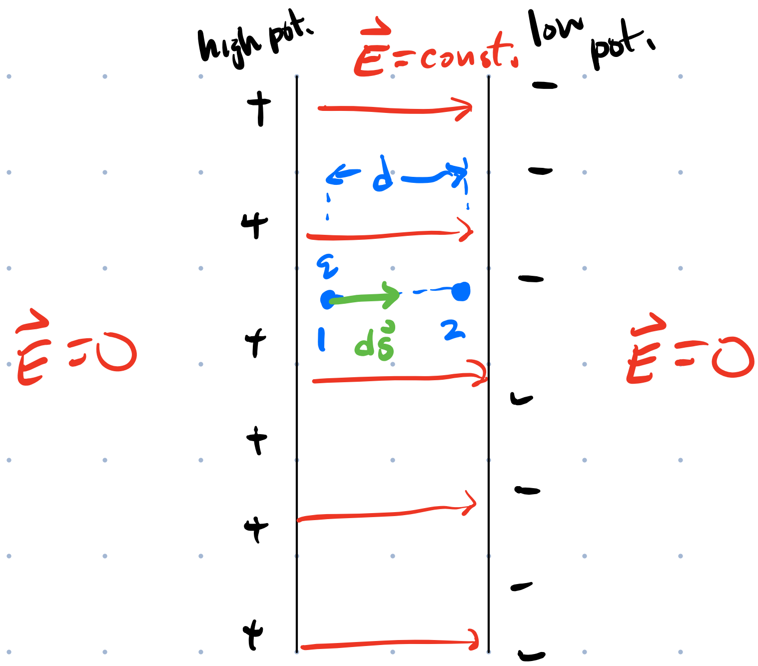
$$\therefore \Delta U = q\,\Delta V$$

$$\therefore \cancel{q}\Delta V = -\int \cancel{q}\vec{E}\cdot d\vec{s}$$

$$\boxed{\therefore \Delta V = -\int \vec{E}\cdot d\vec{s}}$$

Calculating changes in potential V from $\vec{E}$.

Example: moving a charge in the uniform electric field of a capacitor. Find the change in potential



$$\Delta V = V_2 - V_1$$

know:

$$\Delta V = -\int \vec{E}\cdot d\vec{s}$$

$$\vec{E}\cdot d\vec{s} = E\,ds$$

since $\vec{E} \parallel d\vec{s}$

$$\Delta V = -\int E\,ds = -E\underbrace{\int ds}_{d}$$ since E is a const.

$$\boxed{\therefore \Delta V = -Ed}$$

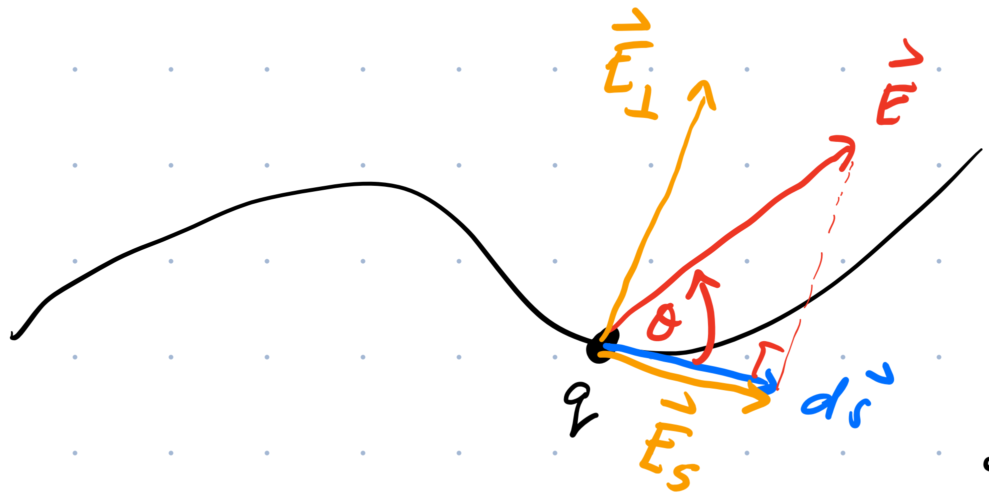
Note that: $\Delta V = V_2 - V_1 = -Ed < 0$

$\therefore V_1 > V_2$

$\boxed{\therefore \text{ We have deduced that } \vec{E} \text{ point from high potential } (V_1) \text{ to low potential } (V_2)}$

Calculating $\vec{E}$-fields from potentials V.

Consider a pt. charge in an $\vec{E}$-field.



$E_s = E\cos\theta$ ← component of $\vec{E}$ in the dir'n of the displacement $d\vec{s}$

From work-K.E. theorem: $dK = \vec{F}\cdot \underbrace{d\vec{s}}_{}$

small step for which we assume $\vec{F}$ is approx. const.

- $dK = -dU = -q\,dV$
- $\vec{F} = q\vec{E}$

$$\therefore -\cancel{q}\,dV = \cancel{q}\,\vec{E}\cdot d\vec{s}$$

$$\therefore -dV = \vec{E}\cdot d\vec{s}$$
$$= E\,ds\cos\theta$$

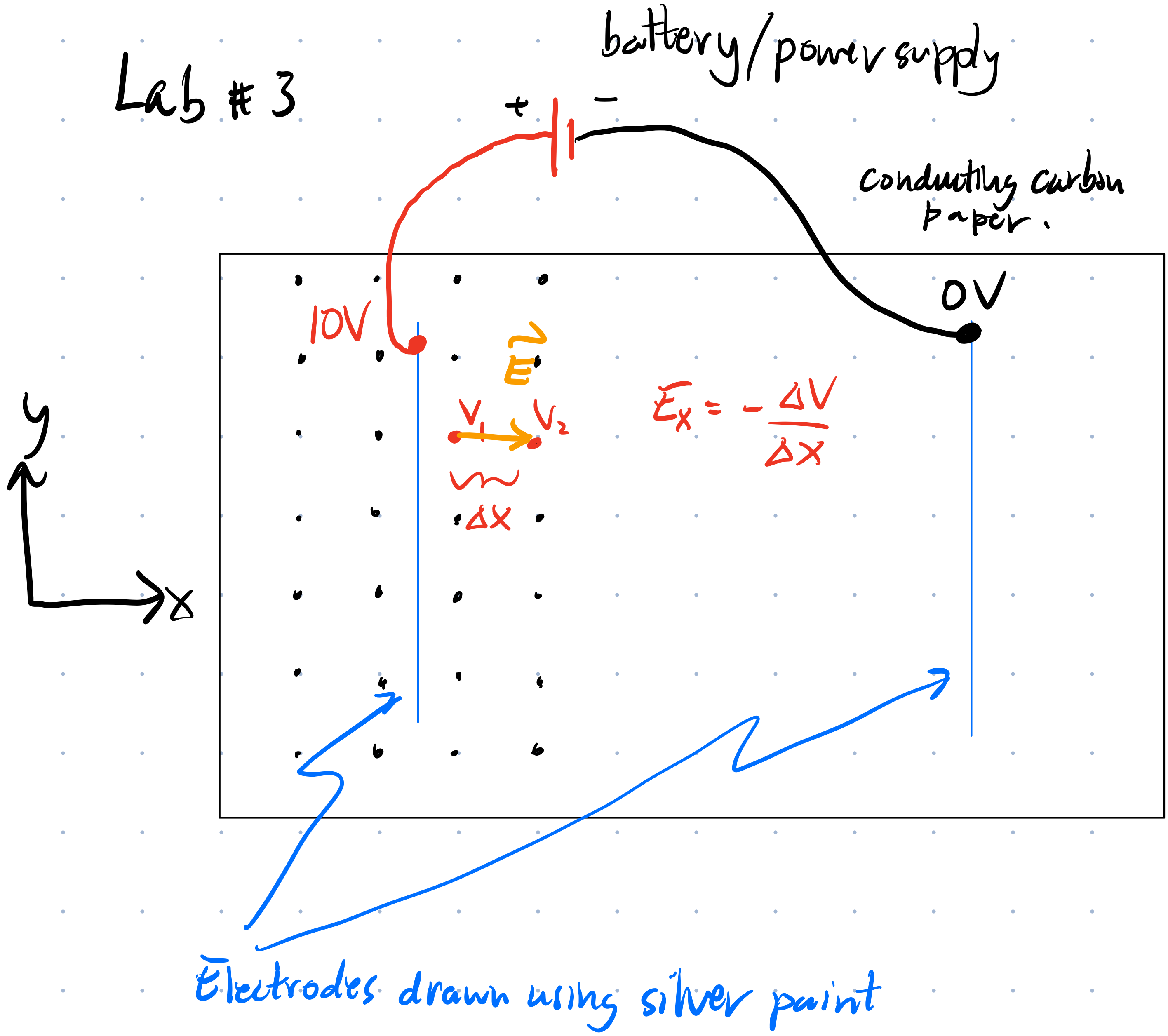
$$\therefore -dV = \underbrace{(E\cos\theta)}_{E_s}\,ds$$

$$\therefore -dV = E_s\,ds$$ Finally, divide by ds.

$$\boxed{\therefore E_s = -\frac{dV}{ds}}$$

Calculating components of $\vec{E}$ when we know V, the electric potential.

Lab # 3



Use a handheld voltmeter to map out how the electric potential/voltage varies w/ position on the carbon paper.

Using measurements of voltage, deduce the electric field of the geometry.

Know $E_s = -\frac{dV}{ds}$

To find the component of $\vec{E}$ in the x-dir'n, set $s = x$.

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

Likewise, we can find the y-components using

$$E_y = -\frac{dV}{dy} = \frac{-\Delta V}{\Delta y}$$

So finally $\vec{E} = E_x \hat{\imath} + E_y \hat{\jmath}$