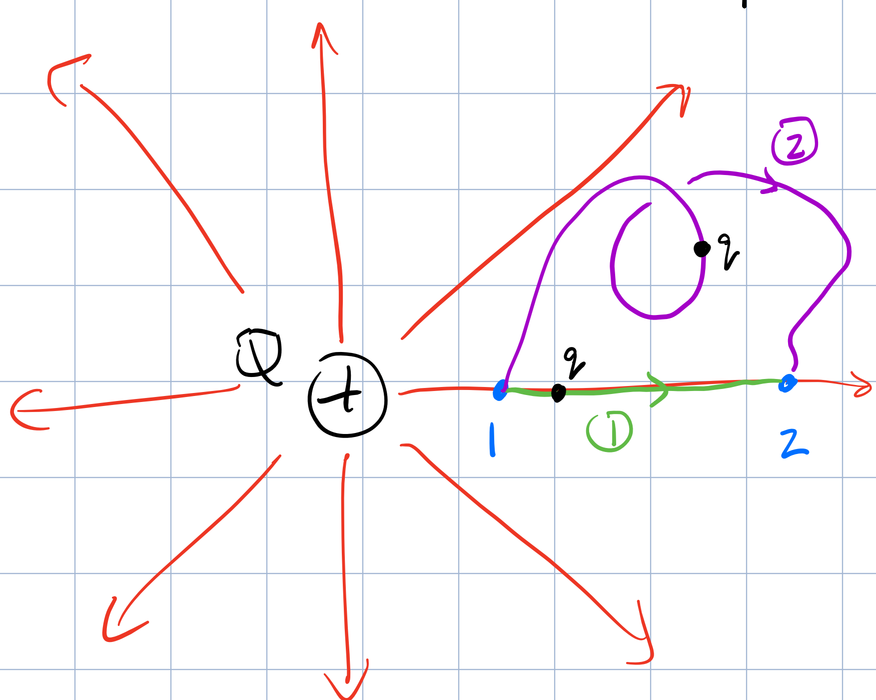
PHYS 121 Feb. 9, 2024

<u>To do</u>: - Complete HW5 by 23:59 today

- Complete Pre-Lab #3 before your lab next week.
- If participating in Hands-On Bonus project, please email me your project proposal by 23:59 on Monday, February 12.

Two Classes ago : Work by the Electrostatic force is path independent.



Work-K.E. Theorem: $W_{①} = W_{②} = \int_1^2 \vec{F}\cdot d\vec{s} = \Delta K$

For pt. charge q moving through $\vec{E}$-field of pt. charge Q:

$$\boxed{W = -k_e q Q\left(\frac{1}{r_2} - \frac{1}{r_1}\right)}$$

The electrostatic force is conservative (work indep. of path). Can define a potential energy U s.t.

$$\underbrace{\Delta K}_{W} + \Delta U = 0$$

Conservation of Mechanical energy.

$$\Delta U + \left[-k_e q Q\left(\frac{1}{r_2} - \frac{1}{r_1}\right)\right] = 0$$

$\therefore$ Change in P.E. is

$$\Delta U = U_2 - U_1 = k_e q Q \left(\frac{1}{r_2} - \frac{1}{r_1} \right)$$

For our system of two pt. charges separated by dist. r, we have

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

P.E. of a pair of pt. charges q & Q.

P.E. Energy 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 due to Q.

$$U = qV$$

P.E. of q in the potential

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

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

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

of Q.

Calculating changes in potential (ΔV) from electric fields.

Start w/ Work-K.E. theorem

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

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

For a charge in an electric field:

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

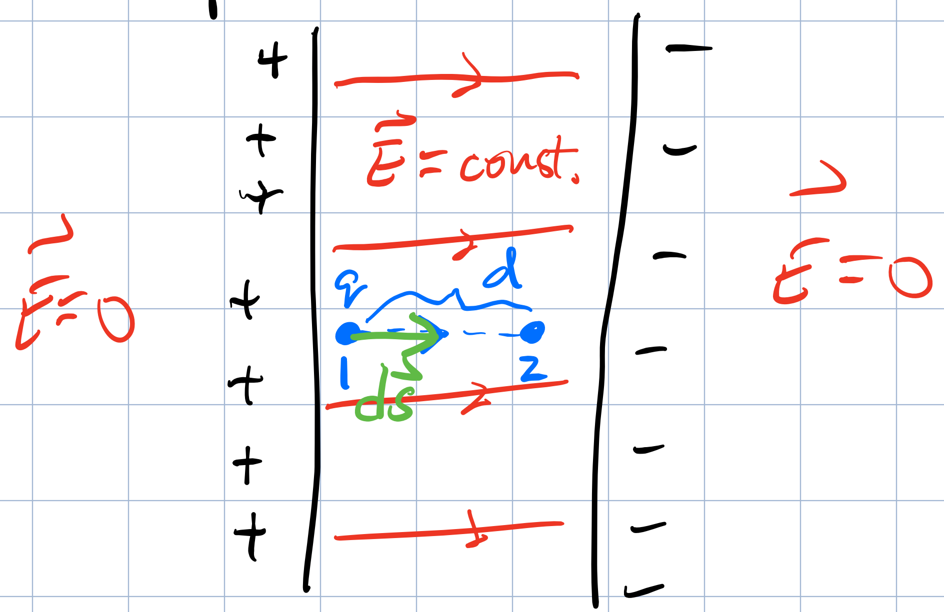
$$\Delta U = q\Delta V$$

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

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

change in electric potential from $\vec{E}$.

Example



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

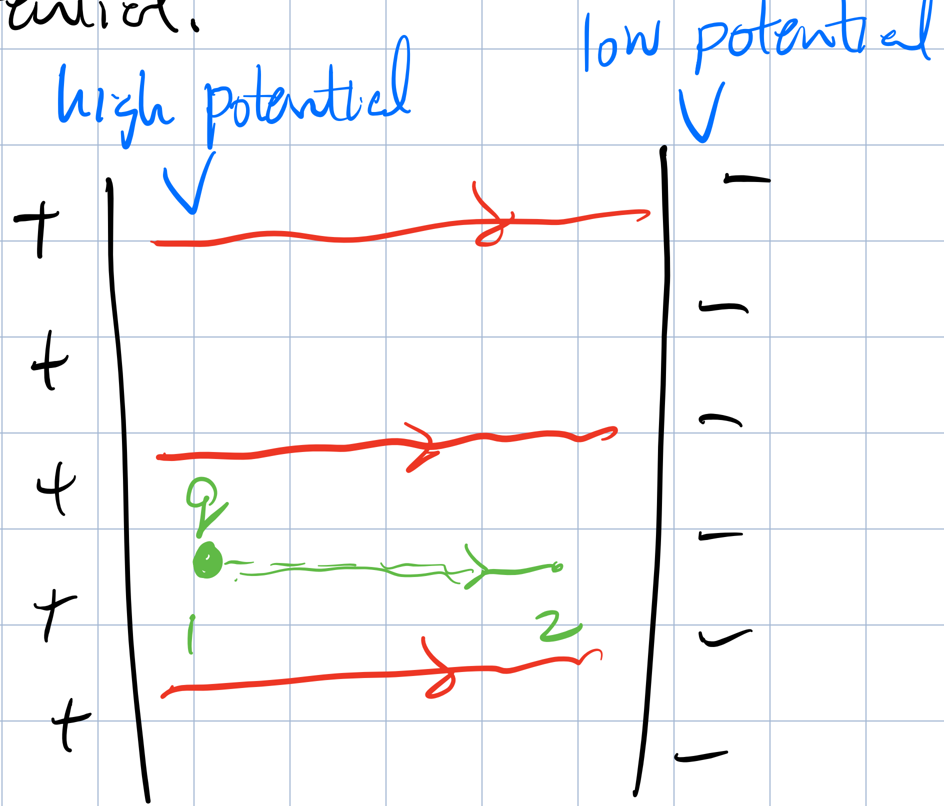
$$\Delta V = -\int E\,ds = -E \underbrace{\int ds}_{d}$$

since E is const, factor out of integral

$\therefore$ For a const. electric field $\boxed{\Delta V = -Ed}$

Notice that when we move in dir'n of $\vec{E}$, the change in potential $\Delta V < 0$.

Electric fields point from high to low potential.



$$\Delta U = q\Delta V$$

$$\Delta U = q(-Ed)$$

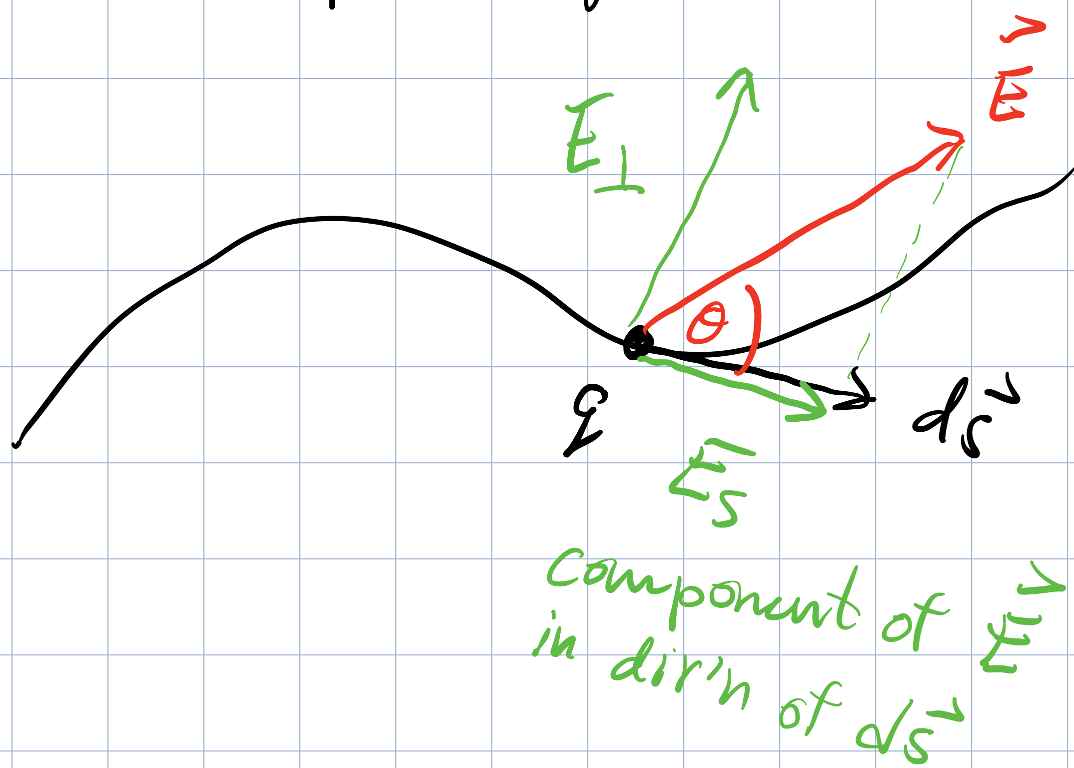
$$= -qEd < 0.$$

Expect q to gain K.E. as it moves from 1 to 2.

∴ it must loss P.E.

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

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



From work-KE theorem

$$\Delta K = \vec{F} \cdot \underbrace{\Delta \vec{s}}_{\text{small step.}}$$

$$-\Delta U = q\vec{E} \cdot \Delta \vec{s}$$

$$-\cancel{q}\Delta V = \cancel{q} E \Delta s \cos\theta$$

$$\Delta V = -\underbrace{(E\cos\theta)}_{E_s}\Delta s$$

E_s component of $\vec{E}$ that is $\parallel \Delta\vec{s}$

$$\therefore \Delta V = -E_s \Delta s$$

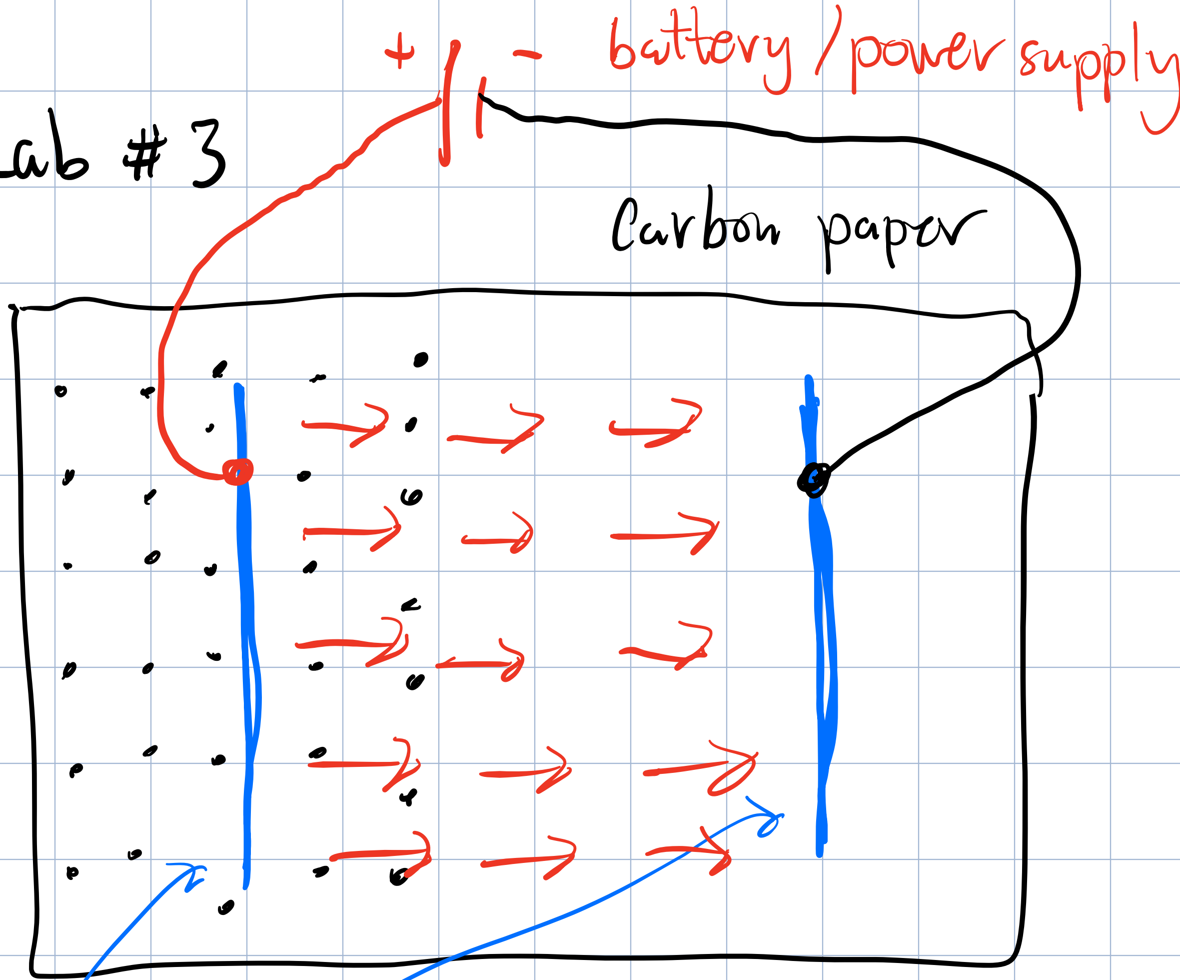
solve for $E_s = -\dfrac{\Delta V}{\Delta s}$

In the limit that $\Delta s \to 0$

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

component of $\vec{E}$ in dir'n of s

Lab # 3



Electrodes drawn using silver paint.

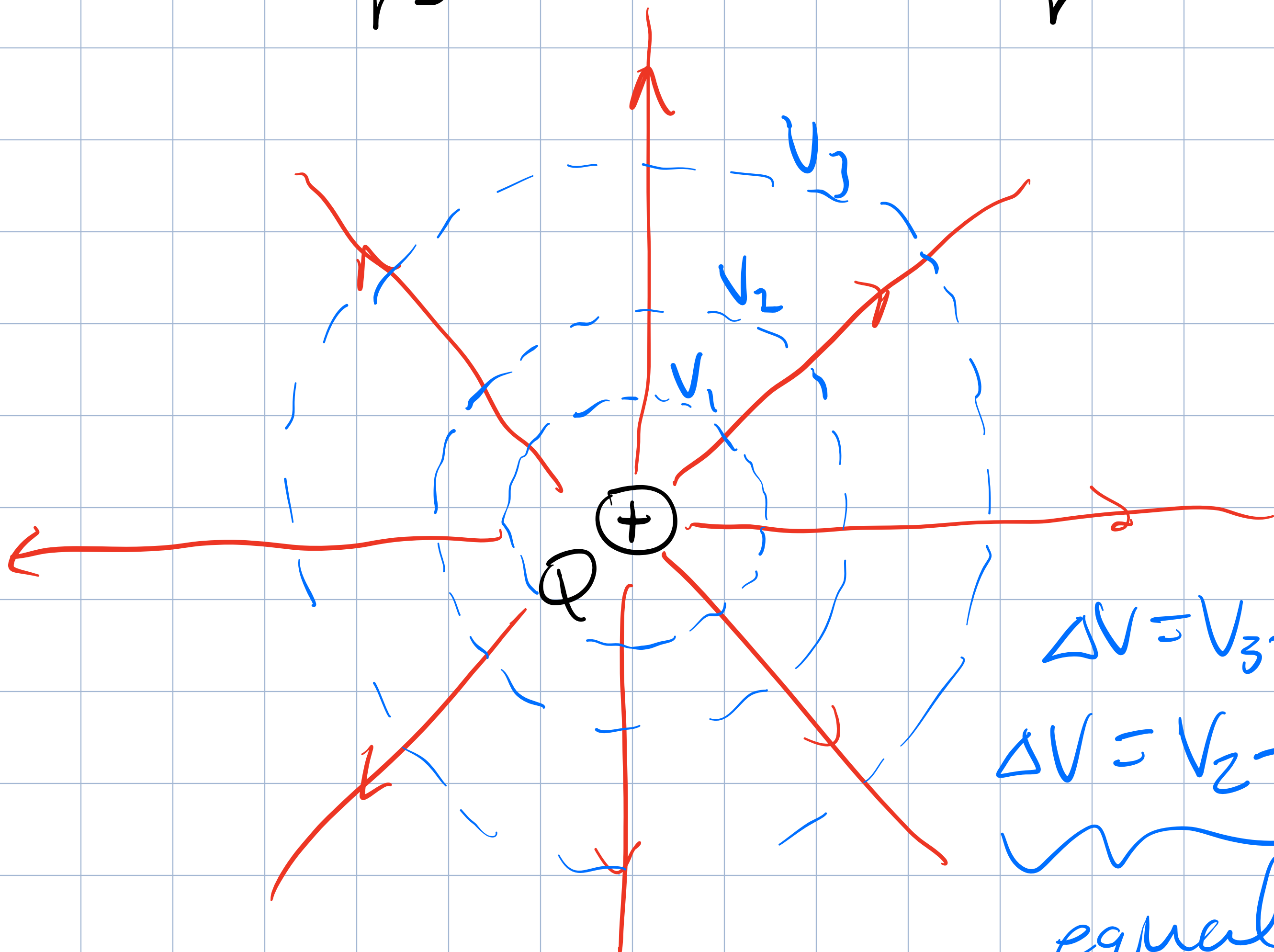
- Map out the potential / voltage on carbon paper

- $E_x = -\dfrac{\Delta V}{\Delta x}$ $\qquad E_y = \dfrac{-\Delta V}{\Delta y}$

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

Return to a point charge Q.

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



$\Delta V = V_3 - V_2$

$\Delta V = V_2 - V_1$

equal.

To this plot of $\vec{E}$, add lines of constant potential V (equipotential lines).

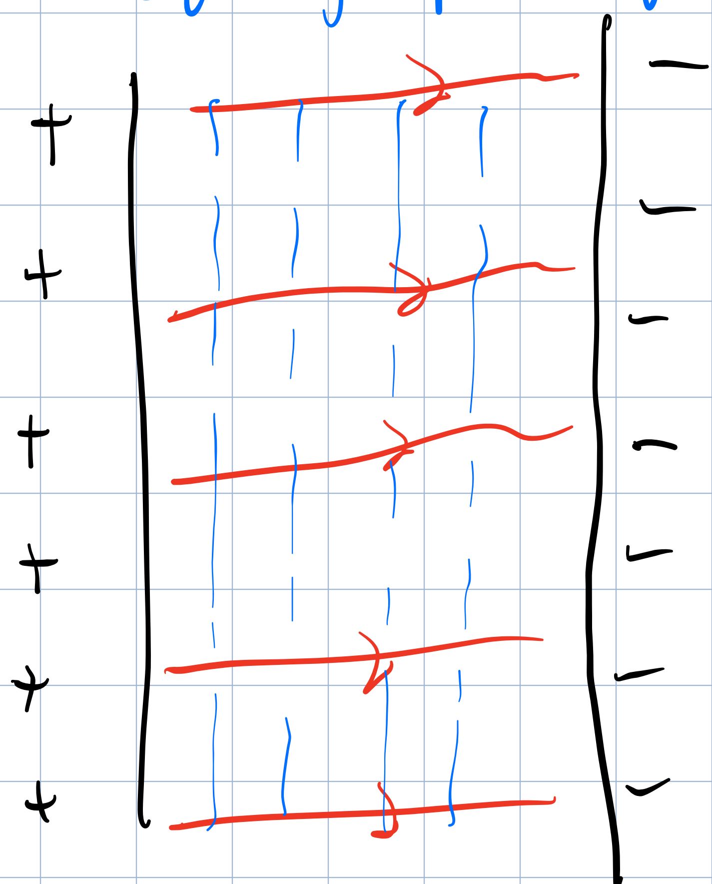
- - - - - - equipotential lines

——— $\vec{E}$-field

$$\delta V = -\int \vec{E}\cdot d\vec{s}$$ ← suggests that

for the same $d\vec{s}$, ΔV gets smaller as $\vec{E}$ decrease. To maintain a const. ΔV, we need to take larger steps as $\vec{E}$ gets weaker.

equally-space equipotentials



since $\vec{E}$ is constant between charged sheets.