PHYS 121 Feb. 12, 2025

To do:

- Complete HW 6 by 23:59 Feb. 21.
- Complete HW 7 by 23:59 Feb. 28.
- Complete Pre-Lab #3 before start of Lab #3
- Midterm Feb. 26
  see course website for details

- Finding changes in potential from $\vec{E}$

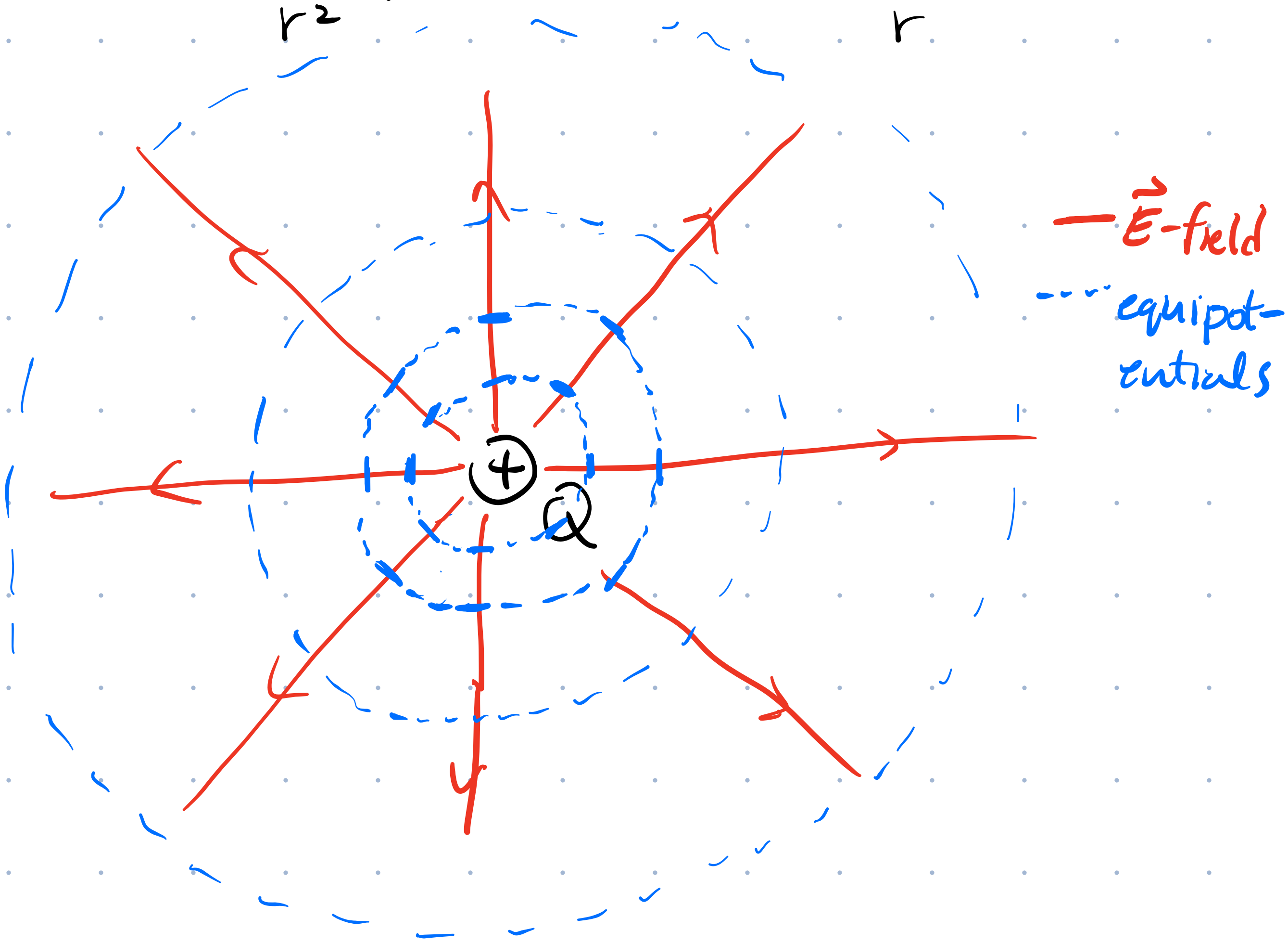
$$\Delta V = -\int_1^2 \vec{E} \cdot d\vec{s}$$

- Finding components of $\vec{E}$ from V

$$E_s = -\frac{dV}{ds} \qquad s = x, y, z, r$$

For a point charge:

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



Eg. Find the $\vec{E}$-field vector & magnitude if

$V = 2x^2y + y^3\pi$

Use : $E_s = -\frac{dV}{ds}$ } s-component of $\vec{E}$.

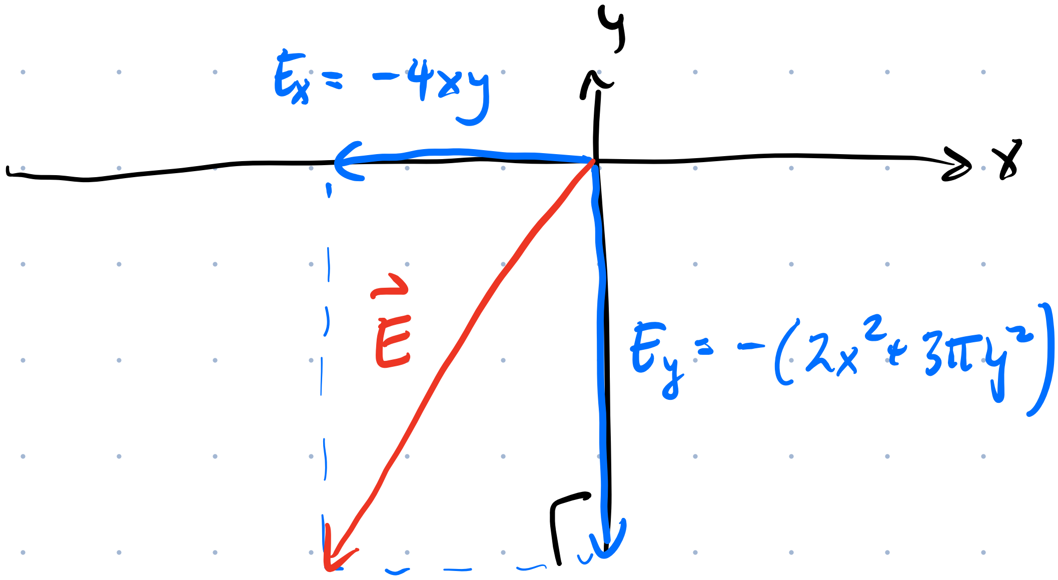
Find x-component $E_x = -\frac{dV}{dx} = -\frac{d}{dx}\left(2x^2y + \pi y^3\right)$

$\therefore E_x = -4xy$

Find y-component $E_y = -\frac{dV}{dy} = -\frac{d}{dy}\left(2x^2y + \pi y^3\right)$

$= -\left(2x^2 + 3\pi y^2\right)$

$$\boxed{\begin{aligned}\vec{E} &= E_x\hat{i} + E_y\hat{j} \\ &= -\left[4xy\,\hat{i} + \left(2x^2 + 3\pi y^2\right)\hat{j}\right]\end{aligned}}$$



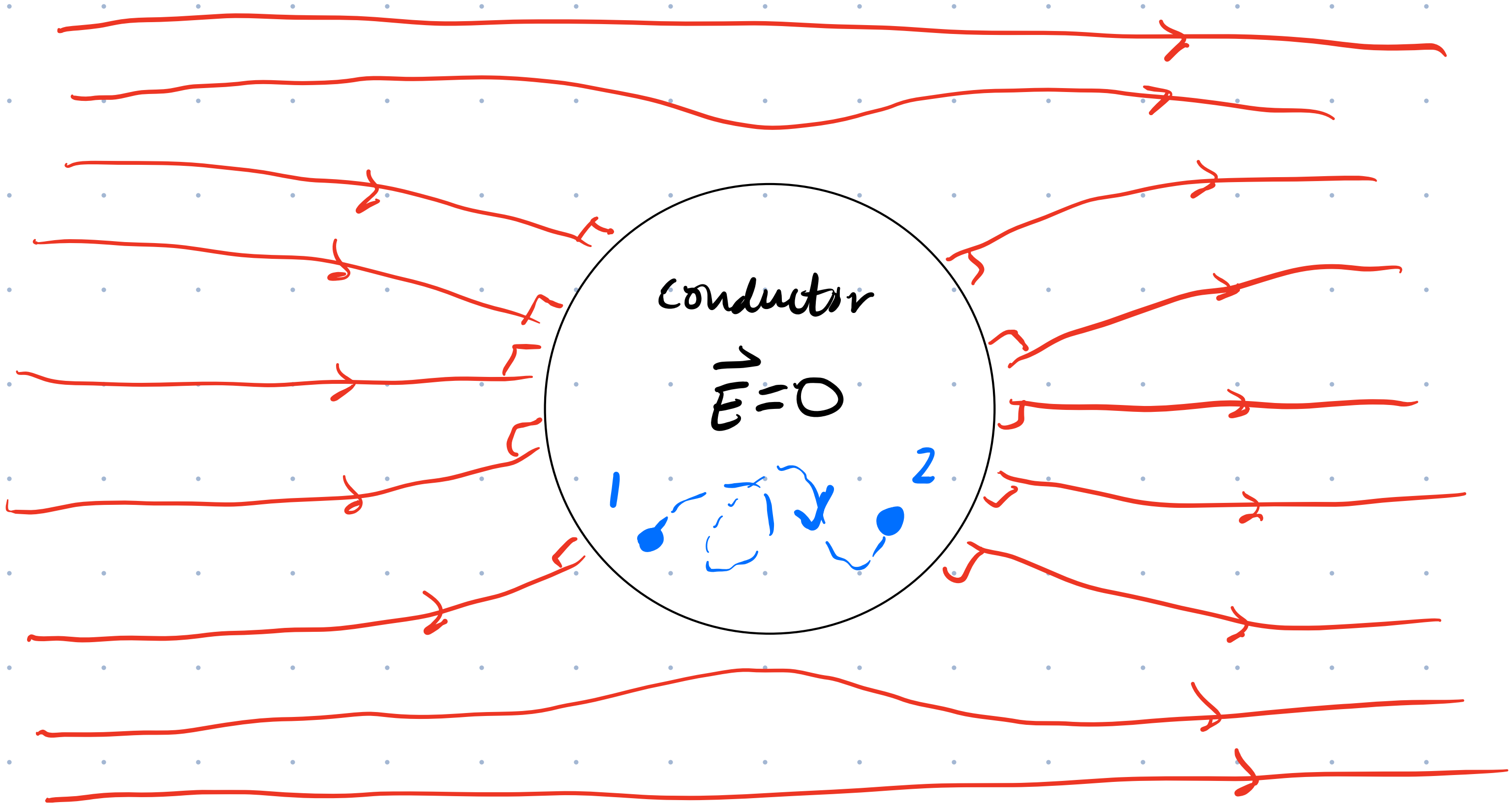
$$\boxed{\begin{aligned}|\vec{E}| &= \sqrt{E_x^2 + E_y^2} \\ &= \sqrt{(4xy)^2 + (2x^2 + 3\pi y^2)^2}\end{aligned}}$$

Electric field magnitude.

One more fact about conductors in Equil.

We already know:

- $\vec{E} = 0$ inside
- $\vec{E} \perp$ to conductor surface outside the conductor
- All excess charge is @ conductor surface.



Potential difference for $\vec{E}$.

$$\Delta V = -\int_1^2 \vec{E} \cdot d\vec{s}$$

since $\vec{E} = 0$ everywhere inside conductor & pts 1 & 2 are in the conductor, $\vec{E} \cdot d\vec{s} = 0$ everywhere along the path connecting 1 & 2.

$$\therefore \quad \Delta V = V_2 - V_1 = -\int_1^2 \cancel{\vec{E} \cdot d\vec{s}}^{\,0}$$

$$\therefore \quad \Delta V = V_2 - V_1 = 0$$

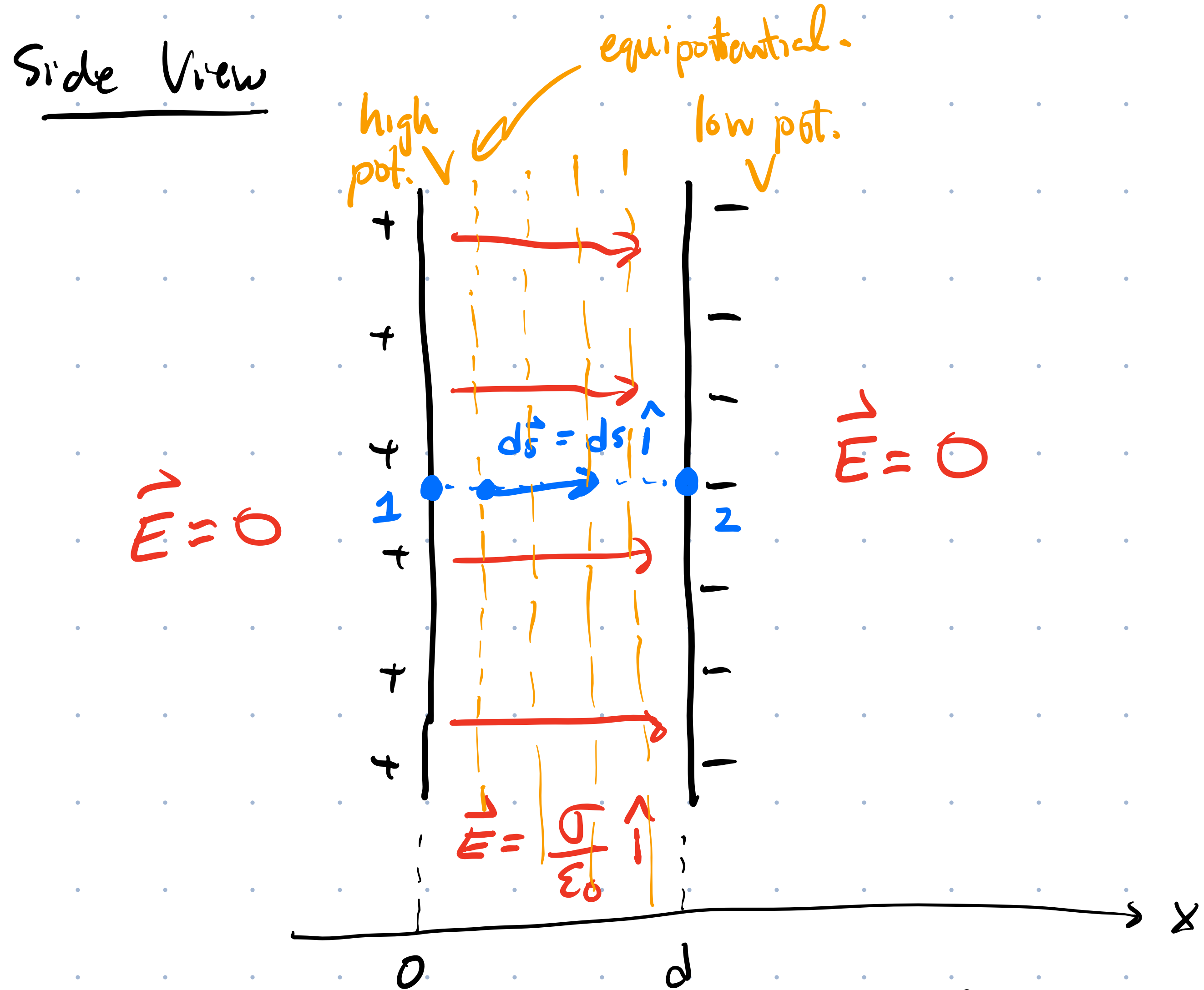
$$\Rightarrow \boxed{V_2 = V_1}$$

A conductor in equilibrium is at a constant electric potential V everywhere.

Note the potential is const, <u>not</u> necessarily zero.

Eg. Consider a pair of large parallel plates w/ equal but opposite charge.

Uniform charge per unit area $\sigma = \frac{Q}{A}$



Each plate creates an electric field of magnitude $E = \frac{\sigma}{2\varepsilon_0}$

(a) If the plates are separated by a dist. d, find the potential diff. ΔV between the pair of plates.

$$\Delta V = -\int_1^2 \vec{E}\cdot d\vec{s}$$

Choose a straight line path from pos plate (1) to neg plate (2), s.t.

$$d\vec{s} = ds\,\hat{i}$$

$$\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{i}$$

$$\vec{E}\cdot d\vec{s} = \left(\frac{\sigma}{\varepsilon_0}\hat{i}\right)\cdot\left(ds\,\hat{i}\right)$$

$$\left(\frac{\sigma}{\varepsilon_0}\right)(ds)\underbrace{\cos 0}_{1} = \frac{\sigma}{\varepsilon_0}ds$$

$$\Delta V = V_2 - V_1 = -\int_1^2 \vec{E}\cdot d\vec{s}$$

$$\therefore \Delta V = -\int_1^2 \frac{\sigma}{\varepsilon_0}\, ds = -\frac{\sigma}{\varepsilon_0}\underbrace{\int_1^2 ds}_{\substack{\text{total dist.}\\ \text{from 1 to 2}\\ = d}}$$

$$\boxed{\Delta V = V_2 - V_1 = -\frac{\sigma}{\varepsilon_0} d}$$

$\Rightarrow$ $\therefore$ Since $\Delta V < 0$, must be the case that $V_1 > V_2$.

(b) Add lines of equipotential to our diagram.

Know equipotentials $\perp \vec{E}$.

In our current problem, since $\vec{E}$ is const., equipotentials that are equally spaces result in the same ΔV.

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

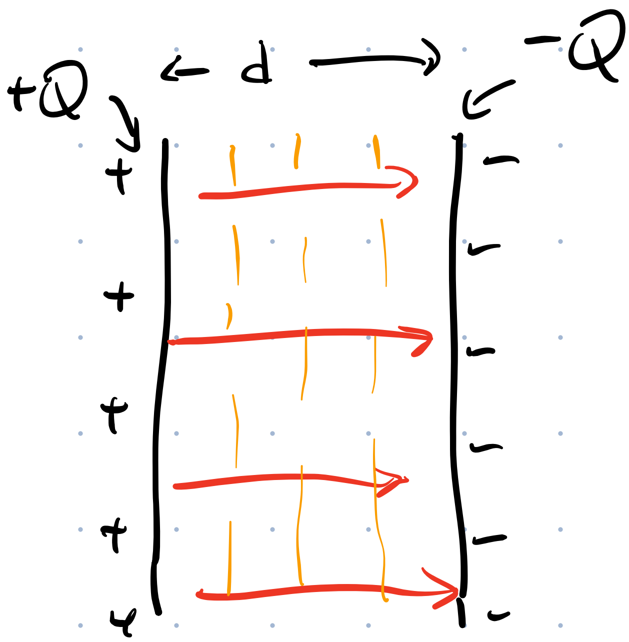
$$= -E \int ds$$

$$\therefore \Delta V = -E\,\Delta s \implies$$ consistent Δs gives same ΔV.

Midterm Cutoff Finished up to & including Ch. 7.

OSUPv2 Chapter 8: Capacitors.

A parallel plate capacitor is made from a pair of parallel conducting sheets w/ equal but opposite charge.



Definition of capacitance:

$$C = \frac{Q}{|\Delta V|}$$

capacitance

Units: $[C] = \frac{[Q]}{[\Delta V]} = \frac{C}{V} \equiv \underbrace{F}_{\text{Farad.}}$

Coulomb

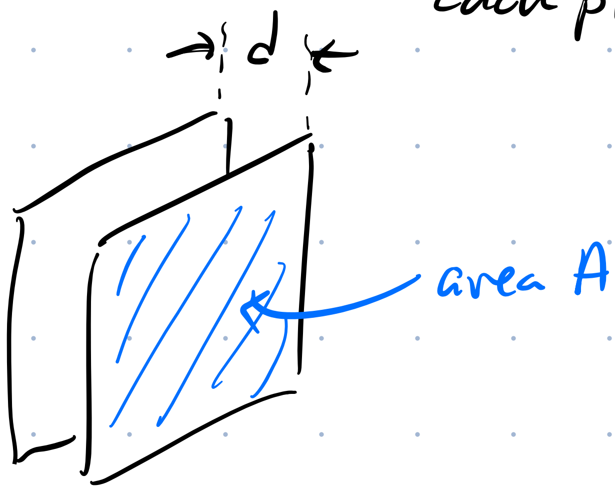
volt

Know $\Delta V = -\frac{\sigma}{\varepsilon_0} d$ (just worked it out)

$$C = \frac{Q}{\left(\frac{\sigma}{\varepsilon_0} d\right)} = \varepsilon_0 \frac{Q}{\sigma d}$$

recall $\sigma = \frac{Q}{A}$

charge per unit area on each plate.



$$\therefore C = \varepsilon_0 \frac{\cancel{Q}}{\left(\frac{\cancel{Q}}{A}\right) d}$$

$$\boxed{\therefore C = \varepsilon_0 \frac{A}{d}}$$

Capacitance of a parallel-plate capacitor.