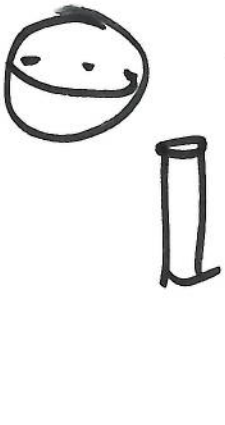
Physics 201 Day #4

More Gauss' Law

$$\oint \vec{E} \cdot d\vec{a} = \frac{Q_{in}}{\epsilon_0}$$

3 symetries:
- Sphere
- Cylinder
- Plane



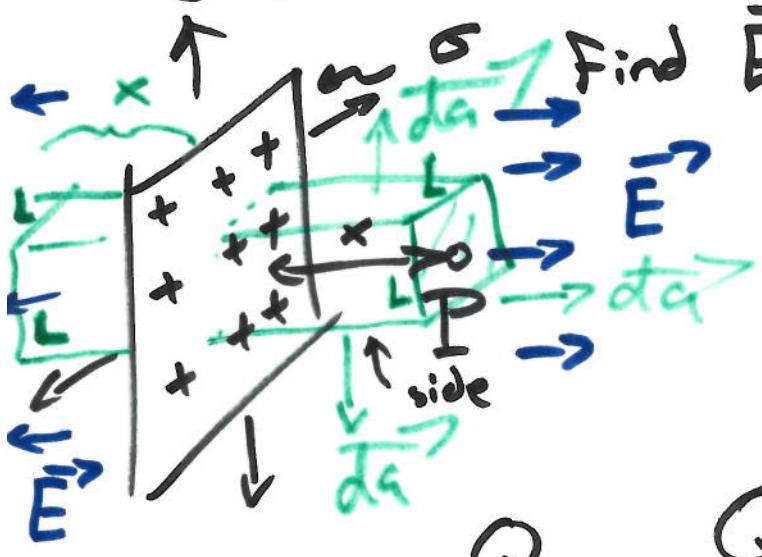
Also: use
σ Q/area
λ Q/length
ρ Q/volume

Superposition:
you can add $\vec{E}$ due to various objects.

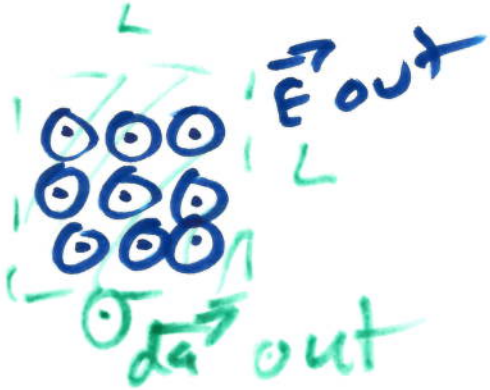
Written homeworks 1: point charges. **Quiz?**

Consider ∞ sheet of charge σ.

Find $\vec{E}$ at P.



front view



$$\sigma = \frac{Q}{\text{area}} = \frac{Q_{in}}{L^2}$$

$$\oint \vec{E} \cdot d\vec{a} = \underbrace{E L^2 \cdot 2}_{\text{ends}} + \underbrace{0}_{\text{sides}}$$

$$\oint \vec{E}\cdot d\vec{a} = \int_{\text{ends}} \vec{E}\cdot d\vec{a} + \int_{\text{sides}} \vec{E}\cdot d\vec{a}$$

$$= \int_{\text{ends}} E\,da\,\underbrace{\cos 0}_{1} + \int_{\text{sides}} E\,da\,\underbrace{\cos 90^\circ}_{0}$$

$$= E\int_{\text{ends}} da = E\,2L^2$$

$$\oint \vec{E}\cdot d\vec{a} = \frac{Q_{in}}{\epsilon_0}$$

$$2EL^2 = \frac{\sigma L^2}{\epsilon_0}$$

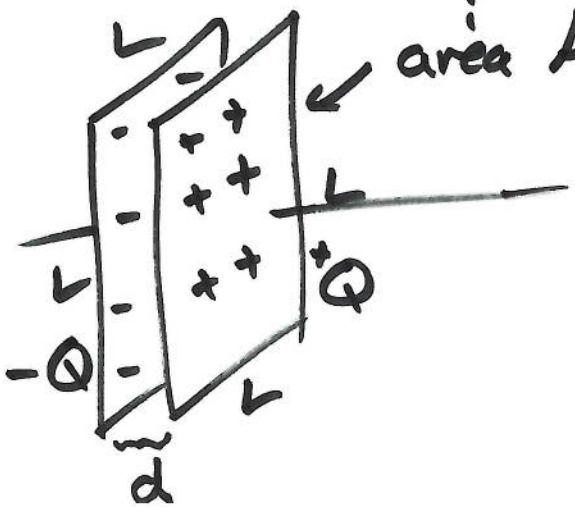
$$\boxed{E = \frac{\sigma}{2\epsilon_0}}$$

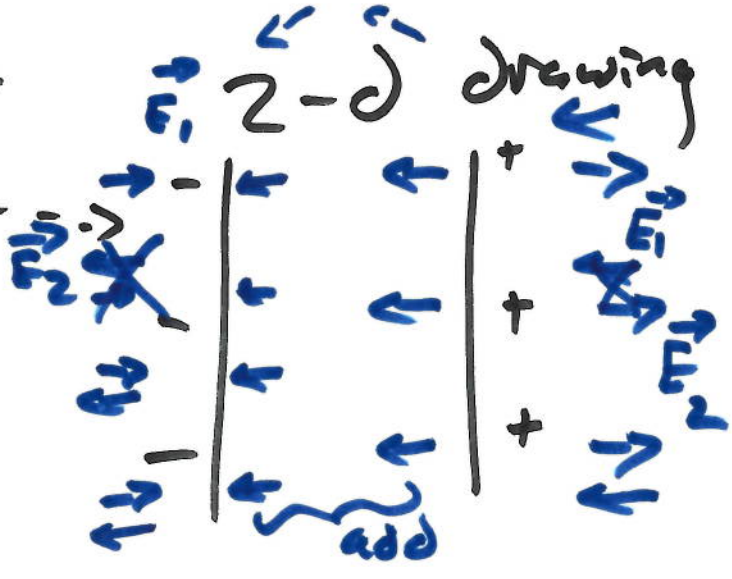
∞ sheet, const. σ

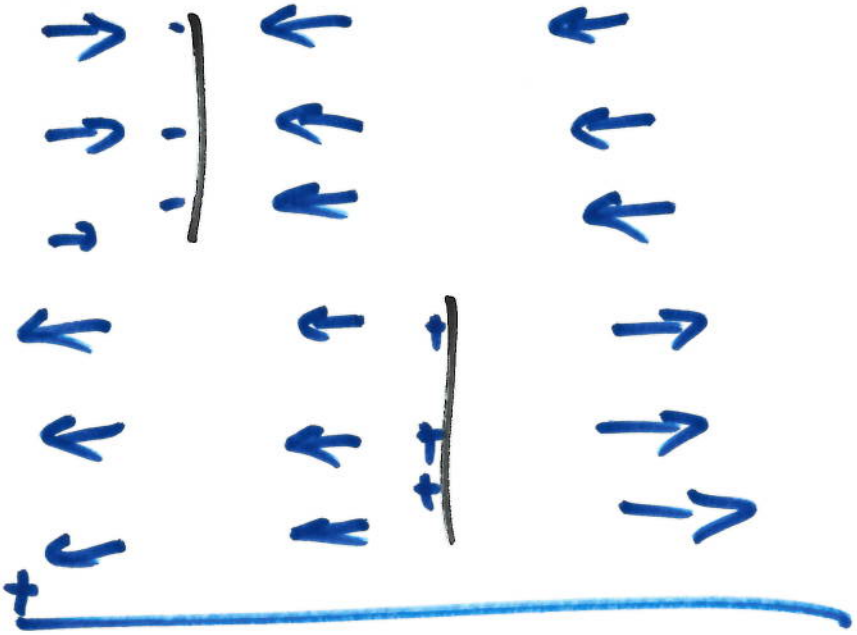
Superposition.

Can solve for $\vec{E}$ due to each part of object.

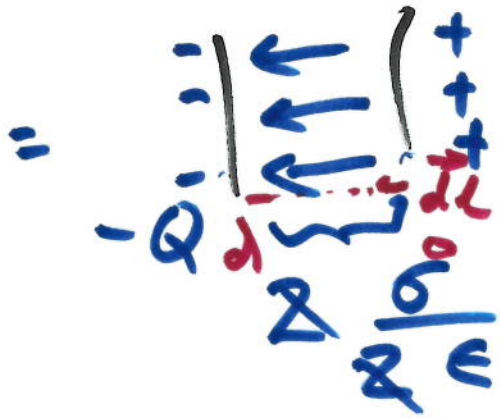
Total $\vec{E} = \sum \vec{E}_i$







$$E = \frac{\sigma}{2\epsilon_0}$$



$$\Delta \frac{\sigma_0}{2\epsilon_0} = \frac{\sigma}{\epsilon_0} \quad \text{where } \sigma = \frac{Q}{A}$$

The total U stored on capacitor

$$= U = -\int \vec{F} \cdot d\vec{l} \quad \text{or} \quad F_x = -\frac{dU}{dx}$$

$$= \int_0^d F\, dl \qquad F = \underbrace{q'}_{dq}\ \underbrace{E(q)}_{\frac{\sigma}{2\epsilon_0}}$$

$$= \int_0^d dl \int_0^{Q \leftarrow \text{tot } Q} dq\, \frac{q}{L^2 2\epsilon_0}$$

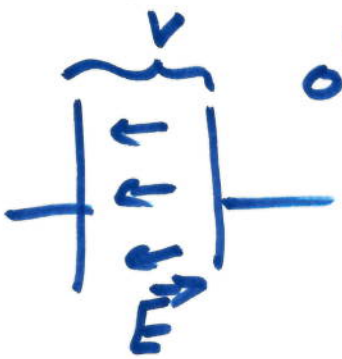
$$U = \frac{d\,Q^2}{2L^2 2\epsilon_0} = \frac{d\,Q^2}{4L^2\epsilon_0}$$

L^2 = area

d = gap in capacitor.

How to relate to voltage V?

$$V = \int_0^d \vec{E}\cdot d\vec{l} = E\cdot d$$



$$V = \frac{\sigma d}{\epsilon_0} = \frac{Q\,d}{A\cdot\epsilon_0}$$

$$V\left(\frac{A\cdot\epsilon_0}{d}\right) = Q$$

$\frac{A\cdot\epsilon_0}{d}$: Capacitance, C

unit: Farad (F)

$$\text{Farad} = \frac{1\ \text{Coulomb}}{\text{Volt}}.$$

$$\boxed{Q = CV}$$

Dielectric constants

usually Kappa κ (unitless)

$$\epsilon = \kappa \epsilon_0$$

↑ replaces ϵ_0 in all formula

$\kappa > 1$

Na^+ Cl^-

Example: $F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$

↑ κ goes here