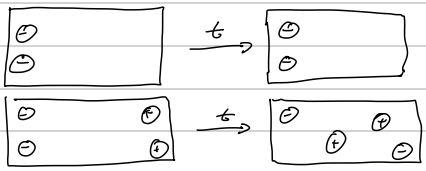
Need to write the Maxwell equations on the final exam!

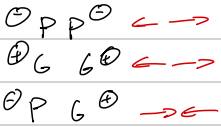
Electric Charges & Fields, Coulomb's Law, Superposition

Electric Charge

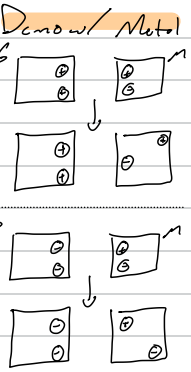
- charge is a fundamental prop. of matter
  - ↳ two types: ⊕ & ⊖ (matter (atoms) are normally neutral)
- Triboelectricity: Friction transfers charge
- Metal Rod in demo?
  - Plastic & crystal are insulators
    - → charge "stays where put"
  - Metals are conductors
    - → charge "flow freely"



Demo - Rods



Demo w/ Metal



Note: Atom is still neutral

- Charge is conserved
  - Rubbing transfers charge, but does not create nor destroy it
- Charge is quantized
  - Charge is always a multiple of $e = 1.6 \times 10^{-19}$ Coulombs (C) → electron = $-e$, proton = e
- Why the rods are moving!
  - Attraction or Repulsion => There is a force between the charges
    - ↳ Force is known as coulomb's force

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{qQ}{r^2} \quad \text{where} \quad \frac{1}{4\pi\varepsilon_0} = 9\times10^9 \ \frac{N\cdot m^2}{C^2}$$

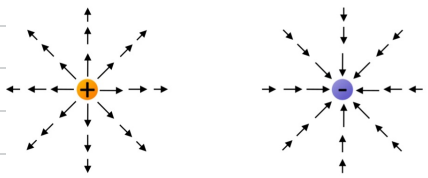
- When two charges q and Q are same signed → F is positive = Repulsive
- When they have opposite signs → F is negative = Attractive

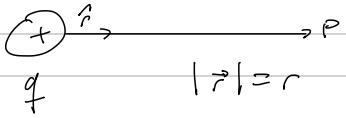
Electric Field and Coulomb's Law

Laws of Electrostatics

- Electrostatics = charges @ rest
  - charges produce electric fields
  - electric fields push charges

$$|\vec{E}| = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$





$$\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r}$$

Note: $r = |\vec{r}|$

$\hat{r}$ is a unit vector that points away from charge q

or alternatively (use $\hat{v} = |\vec{v}|\hat{v}$) so $\hat{r} = \frac{\vec{r}}{|\vec{r}|}$ and $\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^3} \vec{r}$

Equivalent!

Superposition Principle

In Words:

Electric Field produced by many point charges = Sum of the electric field produced by each point charge independently

In Math:

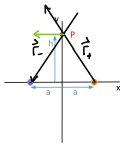
$$\vec{E}(q_1, q_2) = \frac{1}{4\pi\varepsilon_0} \frac{q_1}{r_1^3} \vec{r}_1 + \frac{1}{4\pi\varepsilon_0} \frac{q_2}{r_2^3} \vec{r}_2$$

Second Law of Electrostatics

Fields push/pull charges: $\vec{F} = Q\vec{E}$ => $\vec{F} = \frac{1}{4\pi\varepsilon_0} \frac{qQ}{r^2} \hat{r}$

{N} {C} {N/C}

Example: PollEv



Calculate the Electric field at point P.