Charge, Coulomb's Law, & Electric Fields

Reality is merely an illusion, albeit a very persistent one.

Charges

- What are the two types of electric charges?

  +, −

- What parts of the atom are charged? protons, +; electron, −, e^-

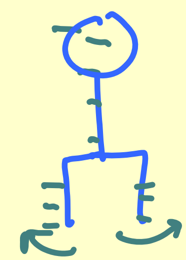
- Like charges repel; unlike charges attract

- Electric charge is conserved

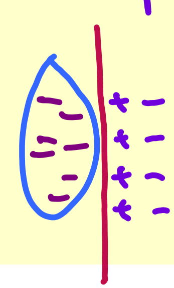
- Charge is quantized, which means they exist in discrete packets.

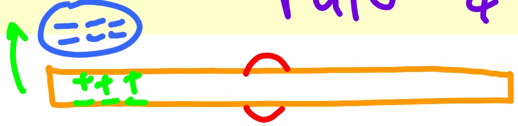
Methods of charging

- Charging by friction : rub to transfer e^-
  - Demo balloon & hair
- Charging by conduction/contact : e^- transfer by touching
  - Demo electroscope



- Charging by induction : separation of charge w/o necessarily e^- transfer (polarize the charge)
  - Demo balloon w/wall, ruler & balloon

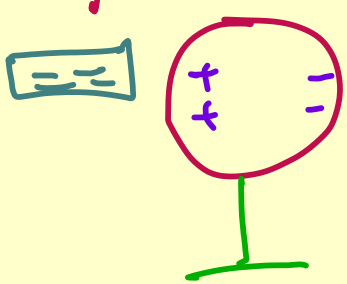




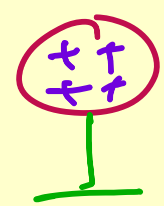
Conductors and Insulators

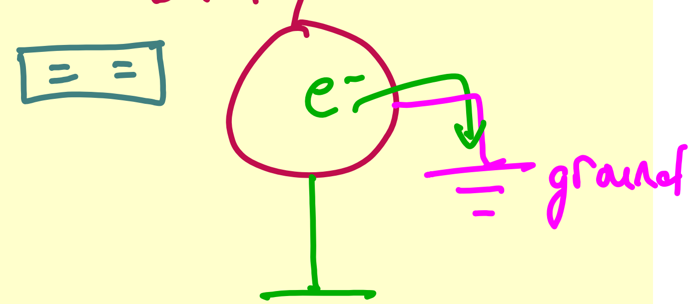
- Conductors allow charge to flow easily
  i.e. metal
- Insulators do not allow charge to flow easily
  i.e. rubber, wood
- Grounding is when an object is connected to the earth ⇒ ∞ supply or sink of e^-
- Induction example with grounding

① bring "−" rod near metal sphere ② touch the sphere briefly



③ remove rod



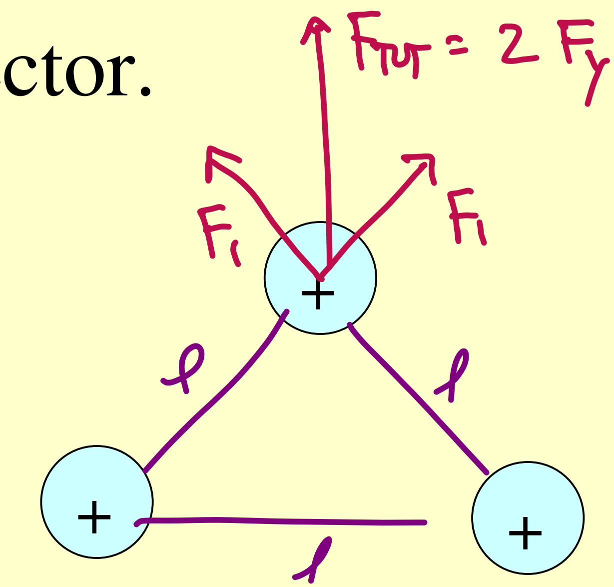


Coulomb's Law

- $F_e = \frac{k_e \cdot q_1 \cdot q_2}{r^2}$ q_1, q_2 – charges (Coulombs, C)
- $k_e = 8.9875 \times 10^9\ N \cdot m^2/C^2$
- $k = 1/(4\Pi\epsilon_o)$ $k = \frac{1}{4\pi\epsilon_0}$
- ϵ_o is the permittivity of free space
- $\epsilon_o = 8.8542 \times 10^{-12}\ C^2/N \cdot m^2$
- Smallest *q* possible is $e^- = \pm 1.60219 \times 10^{-19}\ C$
- Table 23.1, page 715 has atomic properties

Forces

- If force is negative, charges attract (+)→ ←(−)
- If force is positive, charges repel
- Gravity only attracts, electric forces can attract & repel
- Like all forces this is a vector.
- HW #10. $x << d$



Electric Field

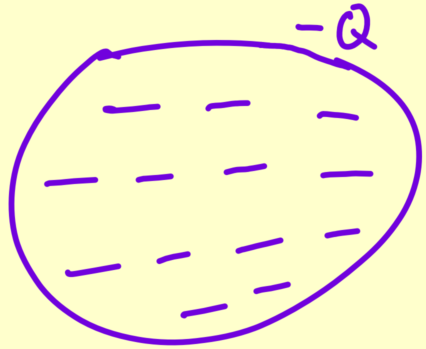
- Field theory is used to conceptualize forces that act through space even though the objects are not in physical contact.
- Our first field was the gravity
- The gravitational field strength, $\boldsymbol{g} = \mathbf{F_g/m}$
- An electric field exists in the region of space around a charged object.
- Consider a small, positive test charge q_o that enters a region around another much greater charge, Q.

Electric Field Strength

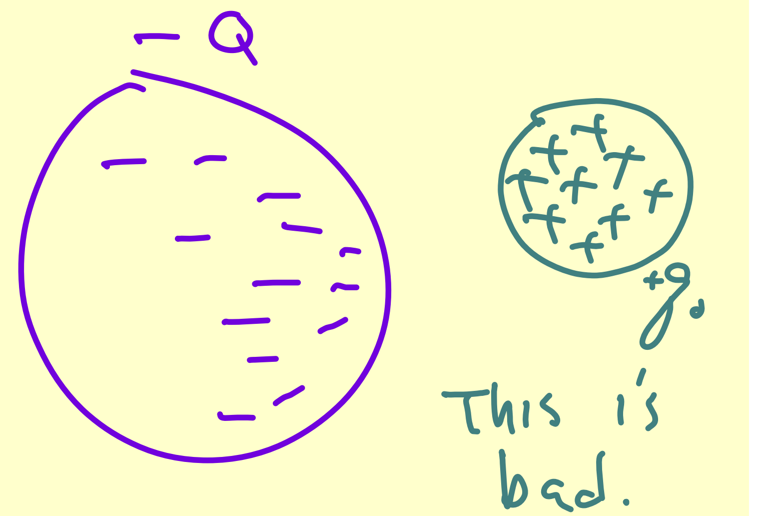
- The electric field strength is the force *per unit charge*.
- The electric field E at a point in space is the electric force acting on a *positive* test charge divided by the magnitude of the test charge.
- $E = \frac{F_e}{q_0}$
- Units of E are $\frac{N}{C}$
- An electric field exists at a point if a test charge at rest experiences an electric force. The electric field exists regardless of whether a test charge is located there.

Test Charges & E

- Must use small test charge.



$\oplus q_0$ does not affect −Q distribution



- Use Coulomb's Law to find E.

$$E = \frac{F_e}{q_0} = \frac{k q_1 q_0}{r^2 q_0}$$

$$\boxed{E = \frac{k q_1}{r^2}}$$

- E is a vector. Therefore, at any point, P, the total electric field due to a group of charges is the vector sum of the electric fields of the individual charges.