Intro Electricity and Magnetism

Van De Graaff Generator
Capacitor
RC Circuit

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What is electric charge?

**Elektra**

Elektra (or Electra) was the Okeanid Nymph, wife of the sea god Thaumas, and mother of Iris, the rainbow, and the storm-wind Harpyiai.

**Greek Name:** Elektrē

**Transliteration:** Élektrē

**Latin Spelling:** Electra

**Amber Coloured:** (élektron)

**Examples of Electrostatics**

Initially, rods neither attract nor repel

Plastic Fur

Two plastic rods rubbed with fur repel each other

Silk Glass

Two glass rods rubbed with silk repel each other

Silk attracts glass rod from (d)

Rods attract

Plastic rod rubbed with fur

Glass rod rubbed with silk

Fur attracts plastic rod from (b)
Important stuff about electric charge

- There are two kinds of charges: + and –
- There is charge conservation
- Equal charges repel, unequal charges attract
- Subatomic particles are the source of electricity
- Charge of e = - charge of p
- Charge of e is a unit of charge
- Electrons can be removed from atoms
- “Ions” are atoms with excess charge
Conductors, insulators and induced charge

- **Conductors** must be charged in isolation.
  - "Conductors" can conduct electrons.
  - Insulators cannot conduct.
  - Semiconductors are in between.

- Insulators can be charged by friction.

- Conductors must be charged in isolation.

The wire conducts charge from the negatively charged plastic rod to the metal ball.
Van de Graaff generator
Capacitance

- Any two conductors can store charge and be a capacitor
- Capacitance = ability of the capacitor to store charges under a V. [F]
- \( C = \frac{Q}{V} = \frac{\varepsilon_0 A}{d} \) \( \varepsilon_0 = 8.85 \times 10^{-12} \text{ F/m} \)
RC Circuit

• Charging a capacitor \[ q = Q \left(1 - e^{-t/\tau}\right) \]
• Discharging \[ q = Q e^{-t/\tau} \]

• Where does this come from?
• Using Kirchhoff’ law...
• \( \varepsilon - IR - \frac{q}{C} = 0 \) --> a differential equation!
• \( \frac{dq}{dt} = -\frac{q}{RC} + \frac{\varepsilon}{R} \)
• \( \frac{dq}{(q-C\varepsilon)} = -\frac{dt}{RC} \)  
  Things worth noting for tau
  \( \tau = RC \) --> 66% of charge

• \[ \int_{0}^{\tau} \frac{dq}{q-C\varepsilon} = -\frac{1}{RC} \int_{0}^{\tau} dt \]
• \[ q = C\varepsilon \left(1 - e^{-t/RC}\right) \]