2018-02-07

Electric Charge

- Electrical charge comes in positive and negative
  - Measured in **Coulombs(C)**
  - The charge of an elementary particle is $e = 1.602 \times 10^{-19} C$
- Charge is also **quantized**
  - Really just a fancy way of saying it only increases in discrete chunks of e

Force Laws in E&M

- Dynamics learned in 8.01 still apply
  - But new force laws will be introduced
- **Coulomb's Law** = force law for charged particles

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

Fields

- One big difference between 8.02 and 8.01 is that 8.02 is oriented around **fields**
  - **Field** = a function that takes in parameters that span space and returns a value
    - Value can be a vector or a scalar
      - Scalar field examples (temperature map, density map, etc)
      - Vector field examples (wind map, **force field**, etc)
- Generally, force fields obey the principle of superposition

Field Lines

- **Field line** = a continuous curve that indicates a direction along itself that represents the direction of acceleration at each point in an electrical field

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Dipoles and Continuous Charge Distribution

Monopoles

- **Monopole** = any charge element
  - Called a “pole”, because field lines either diverge from or converge onto its spacial location
    - Think “north pole”

Electric Dipole

- **Electric Dipole** = two monopoles of opposite charge, seperated by a distance d
- **Dipole moment** = a metric associated with any given electrical dipole
  - Notationally, dipole moment is represented by $\vec{p}$
  - $\vec{r}_-$ is the vector pointing from the midpoint to the negative particle
  - $\vec{r}_+$ is the vector pointing from the midpoint to the positive particle particle
  - Then,

$$\vec{p} = \sum_{i=1}^{n} q_i \vec{r}_i$$

$$|\vec{p}| = 2aq, a = |\vec{r}_+|$$

  - Note similarity to formula for center of mass
    - We can’t divide by total charge, since that might be undefined(divide by zero)
- Dipoles are a very natural phenomenon
  - Hydrogen atom

Continuous Charge Distribution

- We can model systems of charged particles by using **charge densities**
  - Same exact idea as moving from discrete elements to mass to continuous mass distributions
  - λ = linear charge density
    - Units: $\frac{C}{m}$
  - σ = surface charge density
    - Units: $\frac{C}{m^2}$
  - ρ = volumetric charge density
    - Units: $\frac{C}{m^3}$

- Often times, at points of importance with regards to symmetry, we can use that symmetry to simplify the problem