22.01

Electric Fields

"Action At a Distance"

- Particles that don't physically "touch" can stil have electrostatic forces exchanged
  - How does that work if the particles aren't "touching"?
    - **Answer**: *electric fields*

About This Chapter

- *Three* goals of this chapter
  1. Define **electric field**
  2. Learn about analytic methods of describing electric fields
  3. Learn about how electric fields can affect charged particles

What is an "Electric Field"?

- **Field** = an object where each element in some specified **domain** is *uniquely* mapped to another **value**
  - Very similar to the concept behind a *function*
  - **Domain** = the space over which the field is described
  - The **value** can be **scalar** or **vector**
    - **Scalar** = a mathematical object that specifies *magnitude*
      - **Fields** where the *associated values* are scalars are called a **scalar field**
    - **Vector** = a mathematical object that specifies *magnitude* and *direction*
      - **Fields** where the *associated values* are vectors are called a **vector field**
      - More abstractly, a **vector** is just a mathematical object that contains many **scalar** values
    - **Scalars** and **vectors** each have systems of operators that define how arithmetic works within their world and between
  - Examples
    - Temperature field in an oven
    - Pressure field in a pool

- **Electric Field** = a **vector field** that maps individual points in space to electrostatic force per unit charge
  - Mathematically, it looks like this

$$\vec{E} = \frac{\vec{F}}{q_0}$$

  - where q_0 is an extremely small, positive charge, and $\vec{F}$ is the electrostatic force exerted on the particle of charge q_0
  - *Notice* that, since q_0 is a *positive* charge, $\vec{E}$ and $\vec{F}$ *must* point in the same direction
  - The SI unit for electric field is $\frac{\vec{N}}{C}$, which is a **vector** object

Procedure For Figuring Out $\vec{E}$

1. Take a particle of a very small, positive charge q_0
2. Place that particle at a point $\vec{P}$ near some charged object O
3. Determine the electrostatic force between O and the particle of charge q_0 through empirical means
   - Perhaps measure acceleration and use newtonian mechanics to find $\vec{F}$
4. Calculate $\vec{E}$ at $\vec{P}$ by the following equation

$$\vec{E}_{\vec{P}} = \frac{\vec{F}_{\vec{P}}}{q_0}$$

Why Does q_0 Need to be Small?

- The purpose of q_0 is to detect the strength of $\vec{E}$ at any given point
  - If q_0 were large, it would have a non-negligible affect on the electric field is is trying to measure!