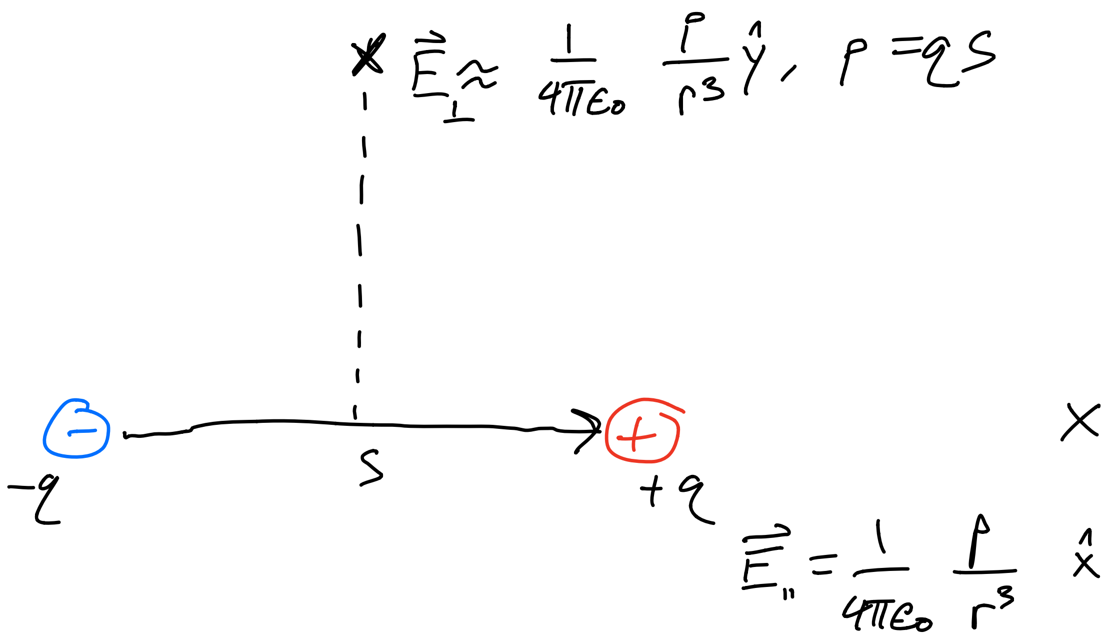
- Hook:
  - Have you ever noticed how, in the winter time, after you walk across the room you end up getting shocked by the doorknob?
  - Ever seen someone rub a balloon on their clothes and then it sticks to them?
  - These are both electrostatic phenomena. Our job today is to understand what is happening.
- Brief review of Big Concepts so far
  - In chapter 13 we introduced the idea of electric charge, electric force and electric fields
  - Sometimes objects carry an electric charge, similar to a mass. Charges interact with each other.
  - We used the concept of the force between interacting charges to generalize the concept of electric field.
    - Review diagram. Field of q1 causes force F2 on charge q2.
    - Field is always there, whether or not charge feels it.
  - We saw the expression for electric field of a point charge, and discovered that the net electric field of many charges can be found simply by adding the individual field of each charge as a vector sum
  - At the end of chapter 13, we saw an important application: dipoles



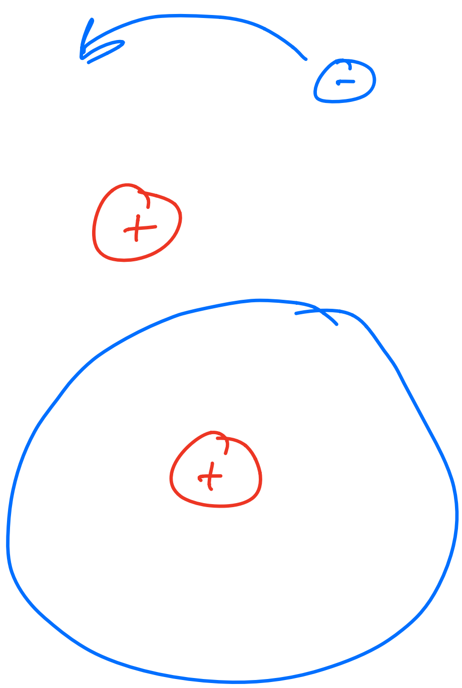
- Question: what if we had a dipole in the presence of a uniform Electric field?
  - Net charge = 0
  - Net force = 0
  - Net torque > 0

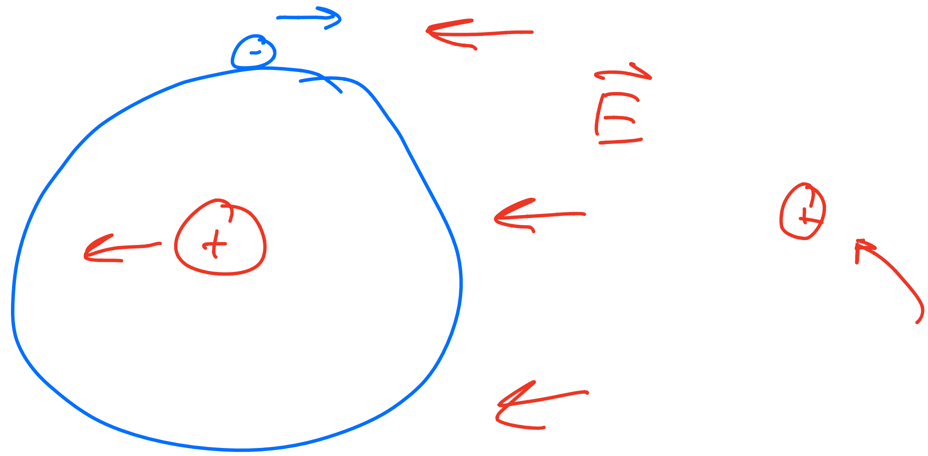
- Now we want to talk some more about electric charge and how it behaves within matter
  - TAPE DEMO
  - I've got two pieces of tape here. I'm going to stick them facing down on the lectern like this and peel them off quickly.
  - Now when I bring them close to each other, what happens? (they repel)
  - Ask class: what just happened?
  - Clearly, the pieces of tape are charged.
    - Were they always charged? Repeat if necessary with two ordinary pieces. No repulsion.
  - The tape became charged when we ripped it off of the desk

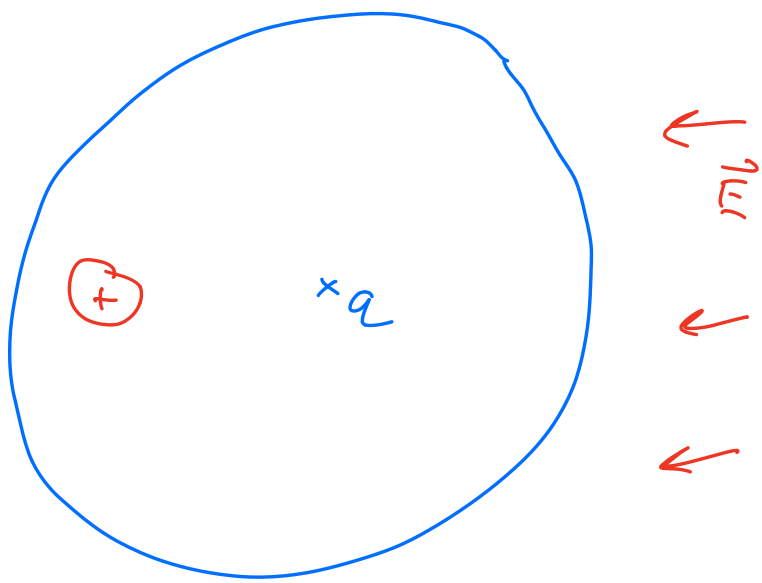
- This is what we call charging by contact
    - So did the desk just produce electrons?
        - No. Either the tape *stole* some electrons from the desk, or left some its own behind when it was ripped off
        - This is *always* the case. Net charge does cannot be created or destroyed. Conservation of net charge.
    - I input energy to create relative motion between the two objects, this energy is enough to overcome weak electron-nucleus or ionic bonds

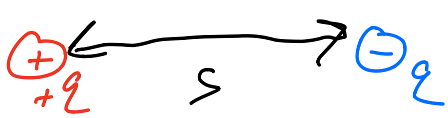
- How do I know it is electrons that are being transferred and not protons?
    - Protons are tightly bound deep inside of the atom
    - Much more energy required to kick a proton out of the atom than to kick out an electron (~10 eV / ~10^6 eV)
    - Protons do not move

- I have this rod, which is uncharged, and this piece of cloth, also charge neutral
    - I've just touched this ball so it, too, is neutral
    - I'm now going to charge this rod but rubbing it with the cloth
    - Now watch what happens when I bring it near to the ball? (Ball is attracted)
    - We understand how the rod became charged, but why did the ball move?
- Let's consider the atomic structure of the ball for a moment
    - Ball is made up of many atoms. Each atom is charge neutral (number of protons = number of electrons)









Dipole!

- Neutral atom in the presence of an external field resembles an electric dipole
    - Still charge neutral, but non-zero electric field

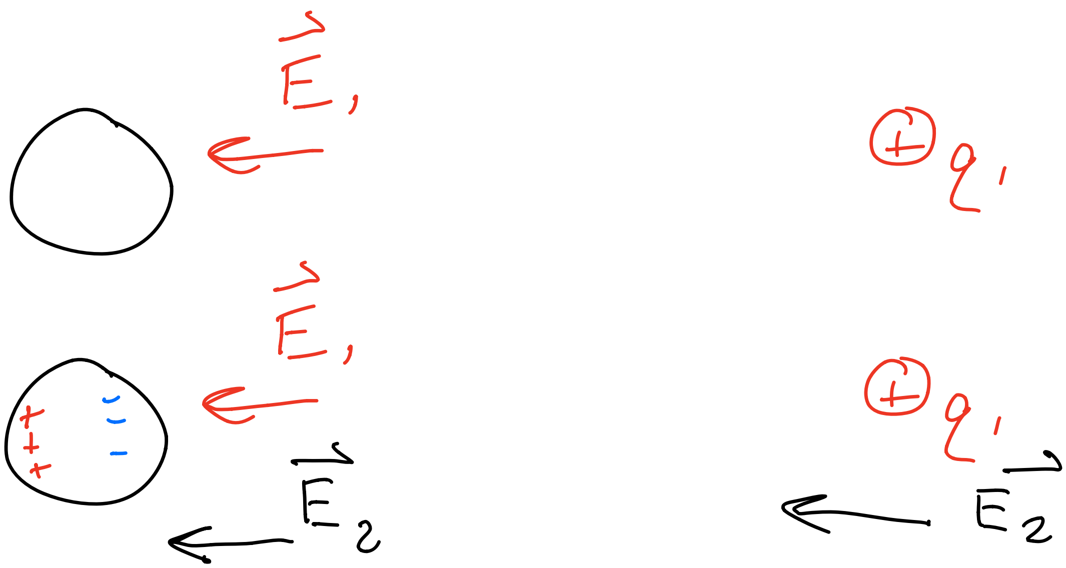
- Typically, the induced dipole moment is proportional to the applied electric field: p = aE

$$\vec{p} = q\vec{s} = \alpha \vec{E}$$

Ex:

Point chg near neutral atom

Force on point charge?



$$\vec{F}_1 = q_1 \vec{E}_2$$

$\vec{E}_2$ = dipole on-axis

$$|\vec{E}_2| = \frac{1}{4\pi\epsilon_0} \frac{2p}{r^3}$$

$$p = \alpha \vec{E}_1$$

$$|\vec{E}_2| = \frac{1}{4\pi\epsilon_0} \frac{2\alpha|\vec{E}_1|}{r^3}$$

$$|\vec{E}_1| = \frac{1}{4\pi\epsilon_0} \frac{q_1}{r^2}$$

$$|\vec{E}_2| = \frac{1}{4\pi\epsilon_0} \frac{2\alpha}{r^3} \frac{1}{4\pi\epsilon_0} \frac{q_1}{r^2}$$

$$|\vec{E}_2| = \left(\frac{1}{4\pi\epsilon_0}\right)^2 \frac{2\alpha q_1}{r^5}$$

$$|\vec{F}_1| = q_1 E_2 = \left(\frac{1}{4\pi\epsilon_0}\right)^2 \frac{2\alpha q_1^2}{r^5}$$

- Repeat pith ball experiment, explaining step by step
- Can a charged object ever *repel* a neutral object?
- Announcements
  - Read 14.4-14.5 for Friday
  - HW due Friday
  - Quiz on Friday
  - Lab tomorrow