

SP212 Blurb 1 S10

1. Course Policy, Roll Call, CAPA System
2. Ben Franklin & Fun with static charge
3. Charge Rules!
4. Coulomb's Law
5. Electric Field Definition
6. **E** field due to a point charge.

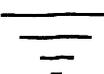
Charge Rules!

1. Only two types (+ and -)
2. Charge is quantized
 $q_{\text{electron}} = -1.602 \times 10^{-19} \text{ Coulomb}$
 $q_{\text{proton}} = +1.602 \times 10^{-19} \text{ Coulomb}$
(smallest magnitude of charge ever observed)
3. Opposites attract, likes repel.
4. Net charge is conserved.
5. Moves easily through conductors, not through insulators.
6. Static charge resides on the outside of conductors.

Triboelectric Series
Positive (+)
Asbestos
Glass
Nylon
Wood
Lead
Silk
Aluminum
Paper
Cotton
Steel
Hard Rubber
Nickel
Copper
Brass
Silver
Synthetic Rubber
Orlon
Saran Wrap
Polyethylene
Teflon
Silicone Rubber
Negative (-)

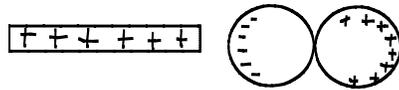
Charges can be separated by rubbing dissimilar materials. The table shows selections from the triboelectric series. If two materials from the table are rubbed together the highest one in the table gets charged positively, while the lower one gets charged negatively.

The earth is so large that we can't significantly change its charge. It acts like an infinite reservoir we call ground.

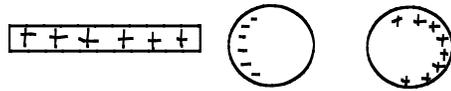
 symbol for ground

Objects can be charged by induction.

Step 1



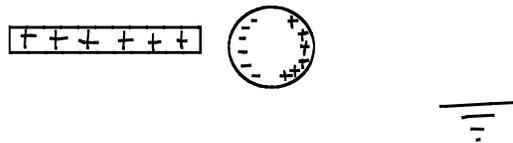
Step 2



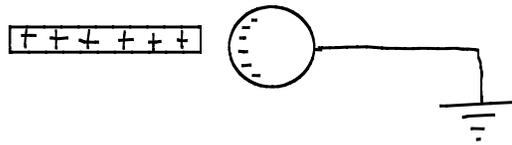
Step 3



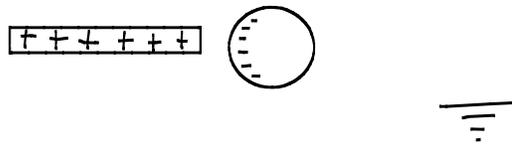
Step 1



Step 2



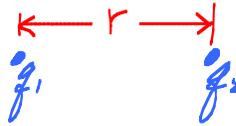
Step 3



Step 4



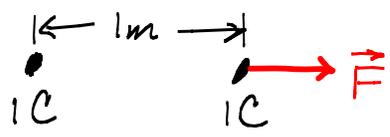
Coulomb's Law: The force between two point charges is described by,

$$F = \frac{k |q_1 q_2|}{r^2}$$


k is a proportionality constant; $k = 8.99 \times 10^9 \frac{Nm^2}{C^2}$

Another common form is, $k = \frac{1}{4\pi\epsilon_0}$ where $\epsilon_0 = 8.854 \times 10^{-12} \frac{C^2}{Nm^2}$
 Permittivity of free space

Example: Find the force on two 1.0 Coulomb charges separated by 1.0 meter.

$$F = \frac{k q_1 q_2}{r^2} = \frac{(9.0 \times 10^9 \frac{Nm^2}{C^2})(1C)(1C)}{(1m)^2}$$


$$= 9 \times 10^9 N$$

$$= 9 \times 10^9 N * \frac{2.2 lbs}{9.8 N} = 2.22 \times 10^9 lbs * \frac{1 ton}{2000 lbs} = 1.11 \times 10^6 tons$$

⇒ 1C is a lot of charge and the electric force is quite strong!

The Electric Field: The olde ones thought long and hard about how the charges "communicate" to each other. Concepts involving invisible fluids flowing between charges and the like were eventually disproved. The electric field associated with a charge is imagined to permeate the space around that charge. If a second charge is in the vicinity, it then interacts with the electric field it finds itself immersed in. The electric field **E** at a point in space is defined as the force per unit charge on a small charge placed at that point.

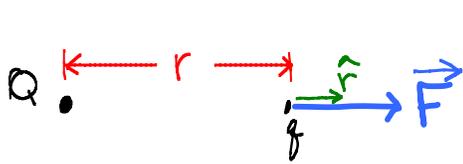
$$\vec{E} = \frac{\vec{F}}{q}$$

As mysterious as the electric field might seem, all we need to define and measure it is a small charge on the end of a spring. Since force is a vector and charge is a scalar, we see from the definition that the electric field is a vector.

E field due to a point charge

The E field near a point charge is easy to describe using Coulomb's Law and the electric field definition.

Initially assume both charges are positive.



$$\vec{F} = \frac{kQq}{r^2} \hat{r}$$

$$\vec{F} = \frac{\vec{F}}{q} \Rightarrow \vec{E} = \frac{kQ}{r^2} \hat{r}$$

Note that q has dropped out so **E** is associated with Q and a point in space.



If Q is negative then the force on q is attractive and E points toward Q rather than away from it.

Question: How does the **E** field direction change if the test charge is negative?