Electric Force

16.2

Objectives

- **Calculate** electric force using Coulomb's law.
- **Compare** electric force with gravitational force.
- **Apply** the superposition principle to find the resultant force on a charge and to find the position at which the net force on a charge is zero.

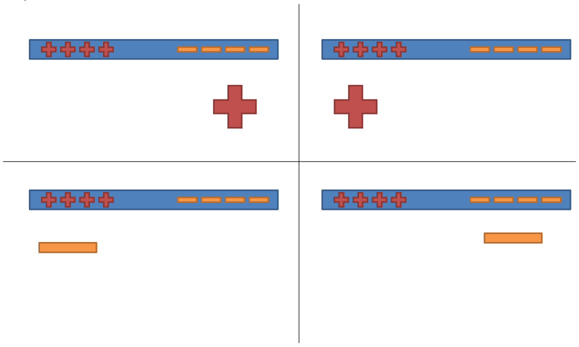
Electric Force

- Recall the experiment with the rubber rod and the paper holes. What happened?
- This meant that the force between the paper holes and the rod were (stronger, weaker) than the attraction of gravity.
- We also learned the electric forces can be attractive or repulsive.

They do not have to touch!

Electric Force

(Charged Hanging Rod Example)



Forces on Charged Objects

- The results of your tape experiments and these actions of the charged rods in the previous slides can be summarized in the following way:
  1. There are two kinds of electric charges: positive and negative.
  2. Charges exert forces on other charges at a distance.
  3. The force is stronger when the charges are closer together.
  4. Like charges repel; opposite charges attract.

Forces on Charged Objects

- Neither a strip of tape nor a large rod that is hanging in open air is a very sensitive or convenient way of determining charge. Instead, a device called an electroscope is used.
- An electroscope consists of a metal knob connected by a metal stem to two thin, lightweight pieces of metal foil, called leaves.
- The figure at right shows a neutral electroscope. Note that the leaves hang loosely and are enclosed to eliminate stray air currents.

Forces on Charged Objects

Negative Charge brought near

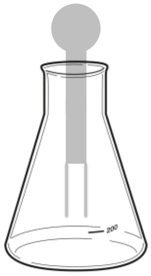
Positive Charge brought near

Forces on Charged Objects

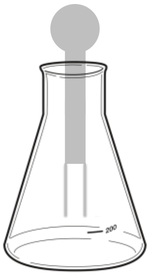
- Grounding can be used as a source of electrons.
- If a positive rod is brought near the knob of a grounded electroscope, electrons will be attracted from the ground, and the electroscope will obtain a negative charge.
- When this process is employed, the charge induced on the electroscope is opposite that of the object used to charge it.
- Because the rod never touches the electroscope, its charge is not transferred, and it can be used many times to charge objects by induction.

electroscope

Negative Charge brought near



Positive Charge brought near



Coulomb's Law

- The amount of charge that an object has is difficult to measure directly. Coulomb's experiments, however, showed that the quantity of charge could be related to force.
- Thus, Coulomb could define a standard quantity of charge in terms of the amount of force that it produces.
- The SI standard unit of charge is called the coulomb (C).
- One coulomb is the charge of 6.24×10^{18} electrons or protons.
- The charge on a single electron is 1.60×10^{-19} C. The magnitude of the charge of an electron is called the elementary charge.

Coulomb's Law

- Even small pieces of matter, such as coins, contain up to 10^{6} C of negative charge.
- This enormous amount of negative charge produces almost no external effects because it is balanced by an equal amount of positive charge.
- If the charge is unbalanced, even as small a charge as 10^{-9} C can result in large forces.

Coulomb's Law

- According to Coulomb's law, the magnitude of the force on charge q_A caused by charge q_B a distance r away can be written as follows.

Coulomb's Law $$F = K\frac{q_A q_B}{r^2}$$

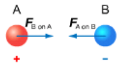
- The force between two charges is equal to Coulomb's constant, times the product of the two charges, divided by the square of the distance between them.
- The Coulomb's law equation gives the magnitude of the force that charge q_A exerts on q_B and also the force that q_B exerts on q_A. These two forces are equal in magnitude but opposite in direction.

Coulomb's Law

- The electric force, like all other forces, is a vector quantity. Force vectors need both a magnitude and a direction.
- However, the Coulomb's law equation gives only the magnitude of the force.
- To determine the direction, you need to draw a diagram and interpret charge relations carefully.

Coulomb's Law

- If two positively charged objects, A and B, are brought near, the forces they exert on each other are repulsive.
- If, instead, B is negatively charged, the forces are attractive.

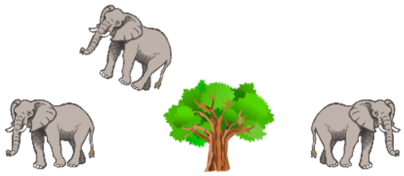


Coulomb's Law

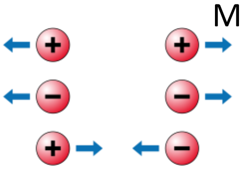
- Coulomb's law is valid only for point charges or uniform spherical charge distributions.
- That is, a charged sphere may be treated as if all the charge were located at its center if the charge is spread evenly across its entire surface or throughout its volume.
- Therefore, it is important to consider how large and how far apart two charged spheres are before applying Coulomb's law.
- When shapes such as long wires or flat plates are considered, Coulomb's law must be modified to account for the nonpoint charge distributions.

Principle of Superposition

- Essentially applying Coulomb's Law to multiple charges
  - Kind of like the elephant problem earlier



Math Help



Make sure to watch (and print off) the 2.5 Videos pertaining to todays lesson!