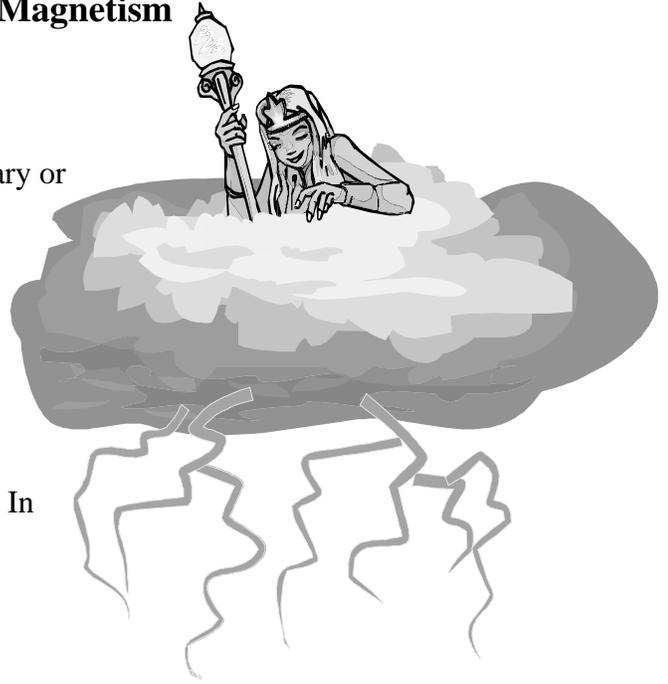


# Electricity, Energy and Magnetism

## 1. Static Electricity

**A. Introduction** The word *static* means stationary or not moving. While a light bulb is turned on and attached to a battery, the electrons are constantly moving. That's *not* static electricity. If, however, a bed sheet in the drier has acquired extra electrons, the electrons sit there, temporarily not moving out of the bed sheet, so we say that the sheet has been statically charged.



Example 1 Ions, as you recall, are charged atoms. In nature, where do you find ions?

Example 2 When heterogeneous or other large objects gain or lose electrons, we say they are *statically charged*. But basically they share the same characteristics with ions:

Static Charge	Characteristic
-	Too many electrons (electrons > protons)
+	Not enough electrons (protons > electrons)
0 ( neutral)	# of protons = # of electrons

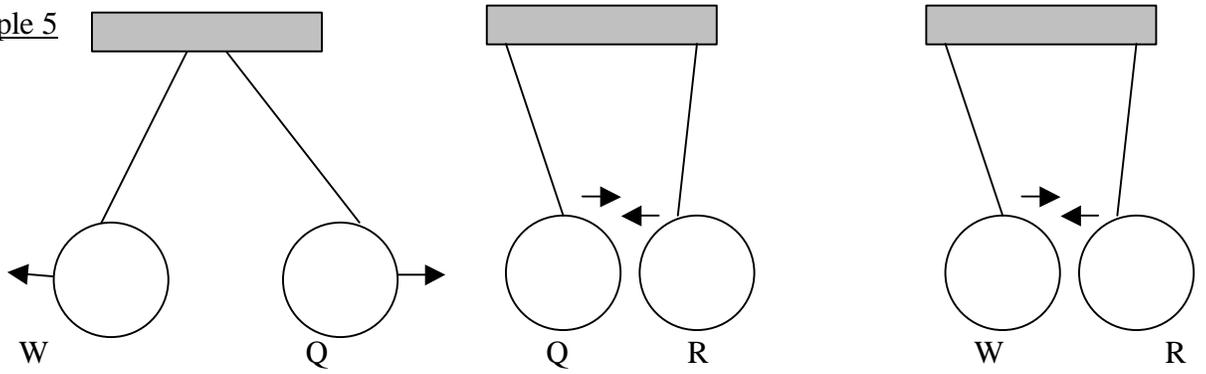
Example 3 The rules of attraction and repulsion that applied to ions also apply to objects that have gathered static electricity:

Charges	How They Behave Towards Each Other
+, -	
+, +	
-, -	
-, neutral	
+, neutral	
neutral and neutral	

Example 4. On a dry day, rub a balloon against your hair. Then press it gently against a wall or place it near small bits of paper. What happens? Why?

## Static Electricity

Example 5

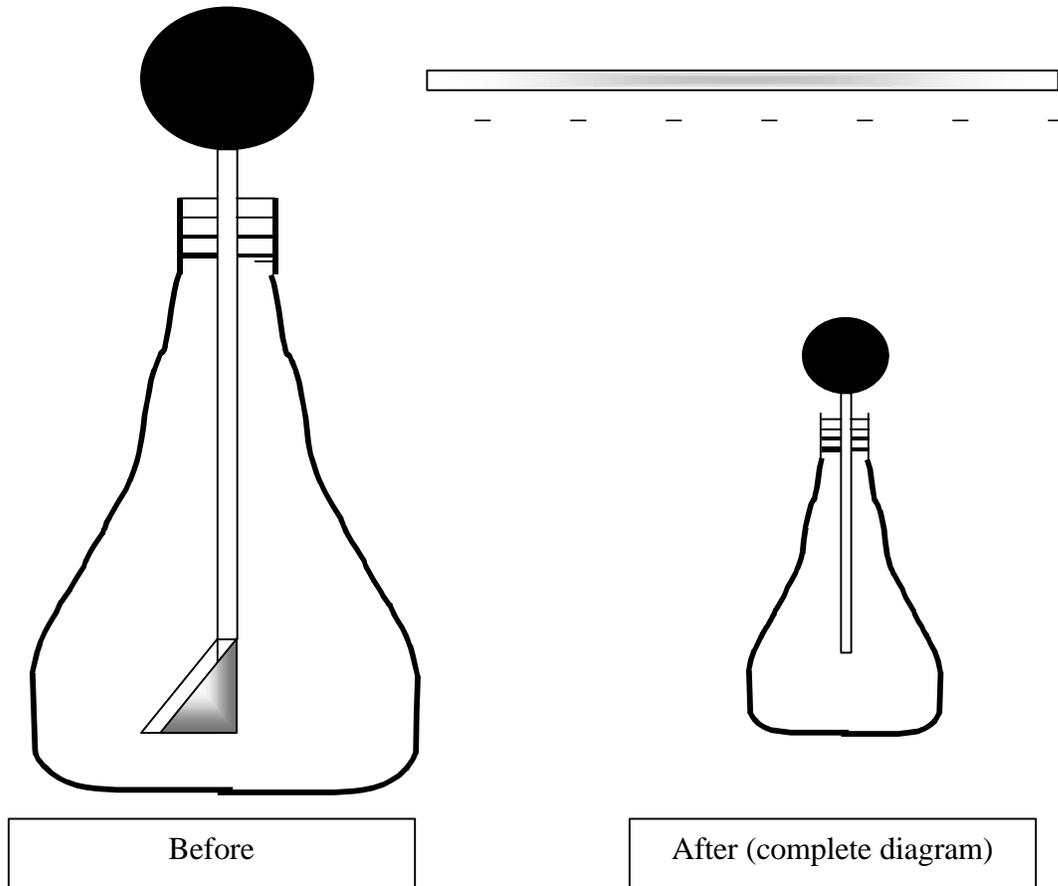


What can you conclude about the charges of W, Q and R?

Example 6

A student brings a negatively charged glass rod toward the knob of an electroscope. The electroscope consists of a metal knob attached to a long rod that slips through a hole in a rubber stopper, and at the end of the rod there are two thin sheets of silver referred to as “leaves”.

What do you think will happen if she comes close to the knob but never touches it?



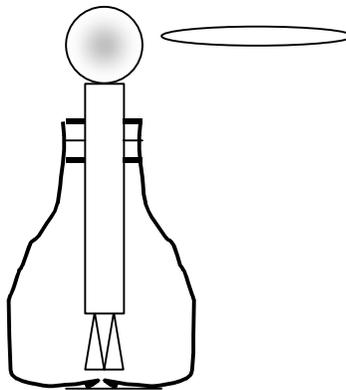
# Electricity, Energy and Magnetism

## Exercises

1. For each of the questions below, choose one of the following possible charges for the object mentioned:
    - Neutral
    - Positive
    - Negative
  - a. After rubbing her feet on the carpet, Graziella's body acquired the same charge as that of chloride \_\_\_\_\_
  - b. A piece of plastic was repelled by a positive piece of plastic \_\_\_\_\_
  - c. When rubber is rubbed with silk, rubber gains electrons from silk. That leaves silk with this charge \_\_\_\_\_
  - d. This object has less protons than electrons \_\_\_\_\_
  - e. This object has the same charge as helium \_\_\_\_\_
  - f. Object A repels a positive charge. Object B attracts A. Object C repels B. C = \_\_\_\_\_
  - g. If little pieces of an object are attracted to a negatively charged comb, then the object can be either \_\_\_\_\_ or \_\_\_\_\_.
2. If you comb your hair repeatedly on a dry day, that comb will attract small neutral pieces of paper. Use a drawing to show why this happens.
  3. When any two of the substances from the following list are rubbed together, the one that is higher on the list becomes negatively charged.
    - Rubber
    - Silk
    - Wool
    - Glass

If you rub a rubber ball with a woolen sweater, how will the ball behave towards a glass ball that has been rubbed with a silk shirt?

4. a. Show what will happen to the electroscope if it is approached but not touched by a negatively charged object.  
b. Repeat for a positively charged object.

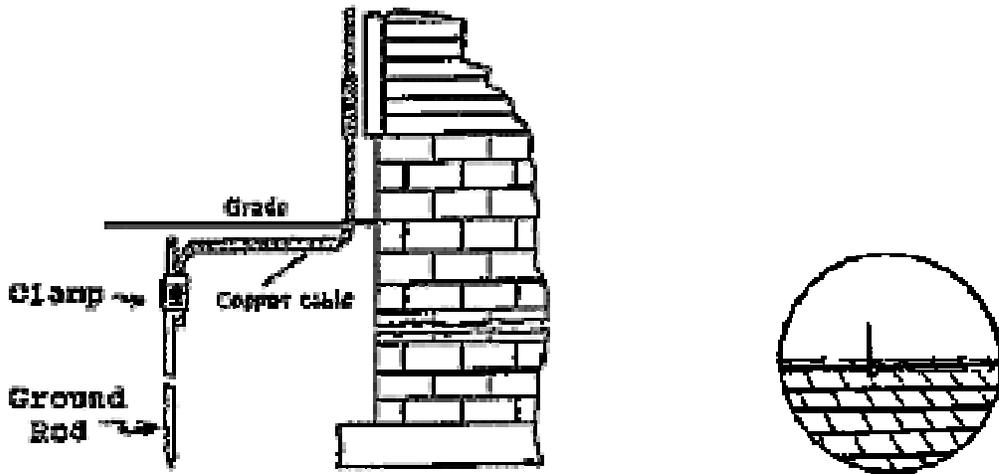


# Static Electricity

**B. Grounding:** is the process by which an object is allowed to discharge ( get rid of its excess charge).

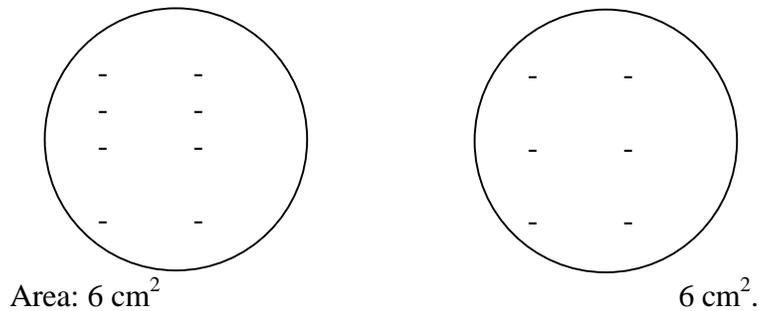
- (1) If the object to be grounded is negatively charged, grounding lets excess electrons to flow from the object into the earth or other large substance, or
- (2) If the object is positively charged, electrons flow from the earth or other large neutral substance into the object.

Example 1     *Why Does Grounding Happen?*



## C. Charge Density

Example 1     What would happen if the two spheres were in contact?



## Electricity, Energy and Magnetism

Example 2 Now imagine the same sphere in contact with the earth. What will happen to the charge? The earth's area is  $4.69 \times 10^{18} \text{ cm}^2$ .

Example 3 Two spheres are in contact with one another. Each originally has the same charge. But one of the spheres is smaller (area =  $9 \text{ cm}^2$ ), so it loses 4 units of charge to the less crowded and larger sphere (area =  $18 \text{ cm}^2$ ).

How many units of charge did each sphere begin with?

Example 4 (430 only) The force,  $F$ , between two objects with charge  $q_1$  and  $q_2$ , is given by:

$$F = -\frac{k q_1 q_2}{r^2}, \text{ where } r = \text{distance between the two charges in meters}$$

$$k = \text{Coulomb's constant} = 9 \times 10^9 \text{ Nm}^2/\text{C}^2.$$

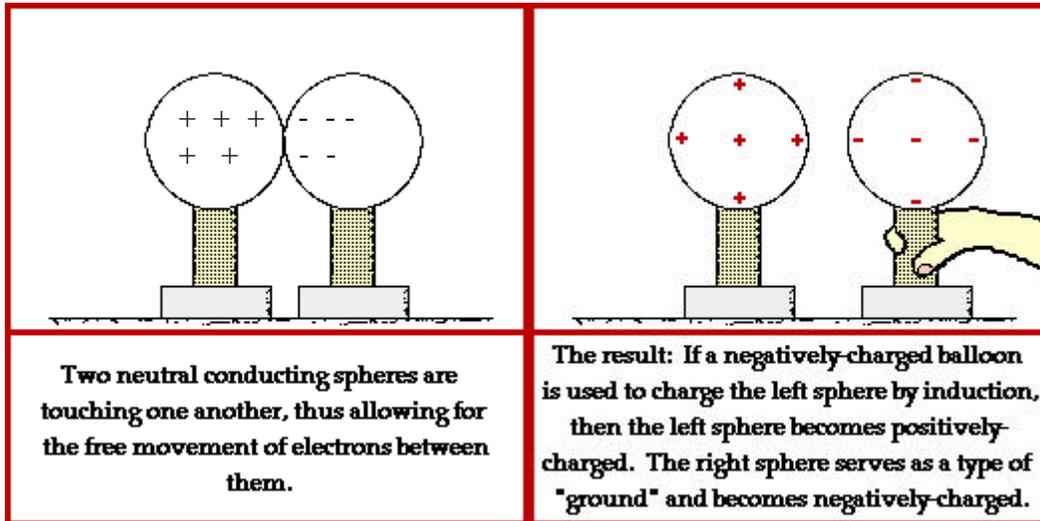
(1) By what factor would the attractive force between two oppositely charged objects increase if we decreased the distance between them to half of the original distance?

(2) What would happen to the force between two negatively-charged objects if we doubled the distance between them and replaced  $q_1$  with  $2q_1$ ?

# Static Electricity

## Exercises

1. Study the situation below. What would cause the electrons to flow out of one sphere and into the other? Draw in the answer in the first picture.



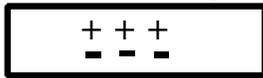
2. Turntables, those ancient record-players that consisted of a needle at the tip of a mechanical arm which made contact with a turning vinyl record, had to be grounded to the amplifier. In other words, aside from the wires that brought in the current and sent the sound signals, there was a third ground wire connecting the back of the two components. Why?
3. You are asked to see if two electric charges have the same sign, using the following materials:
  - 2 plastic rulers
  - 1 piece of string
  - 1 ring stand
  - 1 piece of wool

Explain the produce you would use to do this.

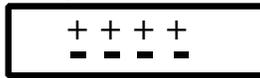
4. Two spheres are in contact with one another. Each originally has the same charge. But one of the spheres is smaller (area =  $12 \text{ cm}^2$ ), so it loses 4 units of charge to the less crowded and larger sphere (area =  $36 \text{ cm}^2$ ).
  - a. How many units of charge did each sphere begin with?
  - b. What is each sphere's charge density after the transfer?

## Electricity, Energy and Magnetism

5. Silk and glass are two electrically neutral materials. Silk can be represented by



and glass by



After these materials are rubbed together, silk becomes negatively charged and glass becomes positively charged.

Which of the following models may represent silk and glass after these materials have been rubbed together?

- A) silk glass
- B) silk glass
- C) silk glass
- D) silk glass

6. (430 only)

- a. What happens to the force between two charges if the distance separating them triples?
  - b. If the repulsive force between two objects is to remain the same, and if one object's charge becomes sixteen times bigger, what distance should separate the charges?
7. Explain why it's safer to hook up a static generator to the sink before touching it for the hair-raising trick.