Objectives

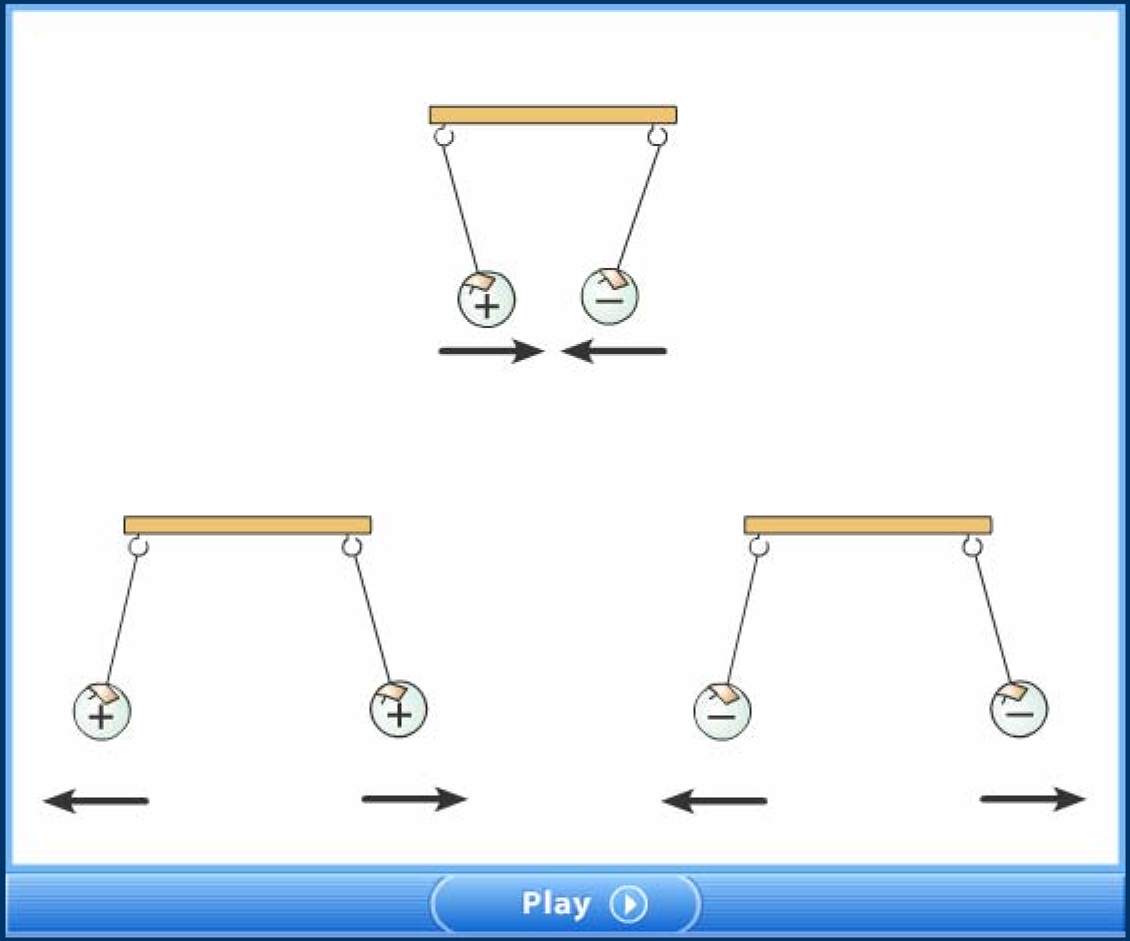
- **Understand** the basic properties of electric charge.
- **Differentiate** between conductors and insulators.
- **Distinguish** between charging by contact, charging by induction, and charging by polarization.
- Calculate force exerted on charged particles

End Of Slide

Properties of Electric Charge

- There are two kinds of electric charge.
  - like charges repel
  - unlike charges attract
- Electric charge is conserved.
  - Positively charged particles are called *protons*.
  - Uncharged particles are called *neutrons*.
  - Negatively charged particles are called *electrons*.

Electric Charge



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Properties of Electric Charge, *continued*

- Electric charge is *quantized.* That is, when an object is charged, its charge is always a multiple of a *fundamental unit of charge*.
- Charge is measured in coulombs (C).
- The fundamental unit of charge, *e*, is the magnitude of the charge of a single electron or proton.

$$1\ e = 1.60 \times 10^{-19}\ \text{C}$$

or

$$1\ \text{C} = 6.25 \times 10^{18}\ \text{elementary charges}$$

End Of Slide

Quantity of charge practice problem

- A charge of 50 elementary particles is equal to what coulomb charge?
  - Where..

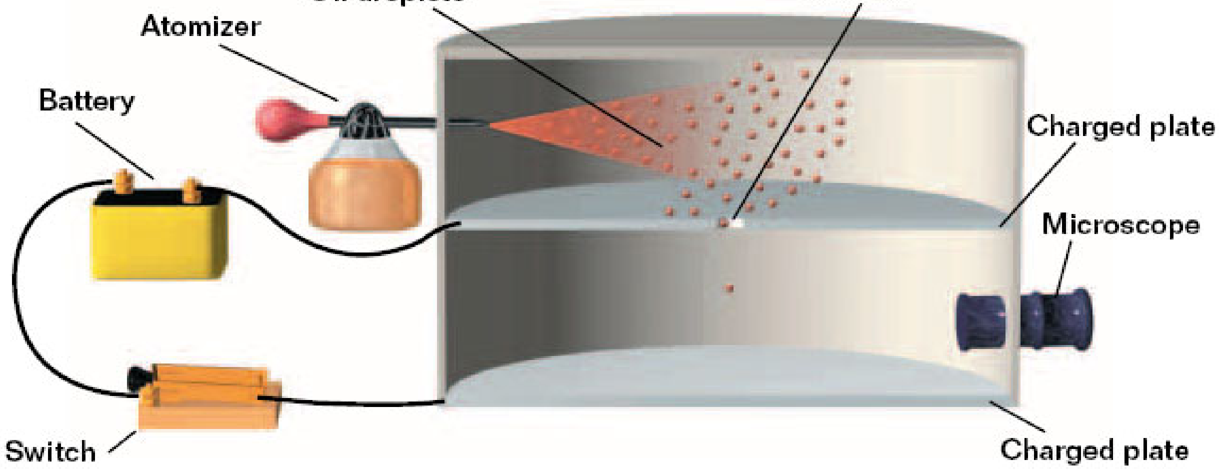
    1 C = 6.25×10^{18} elementary charges

Practice Problem #2

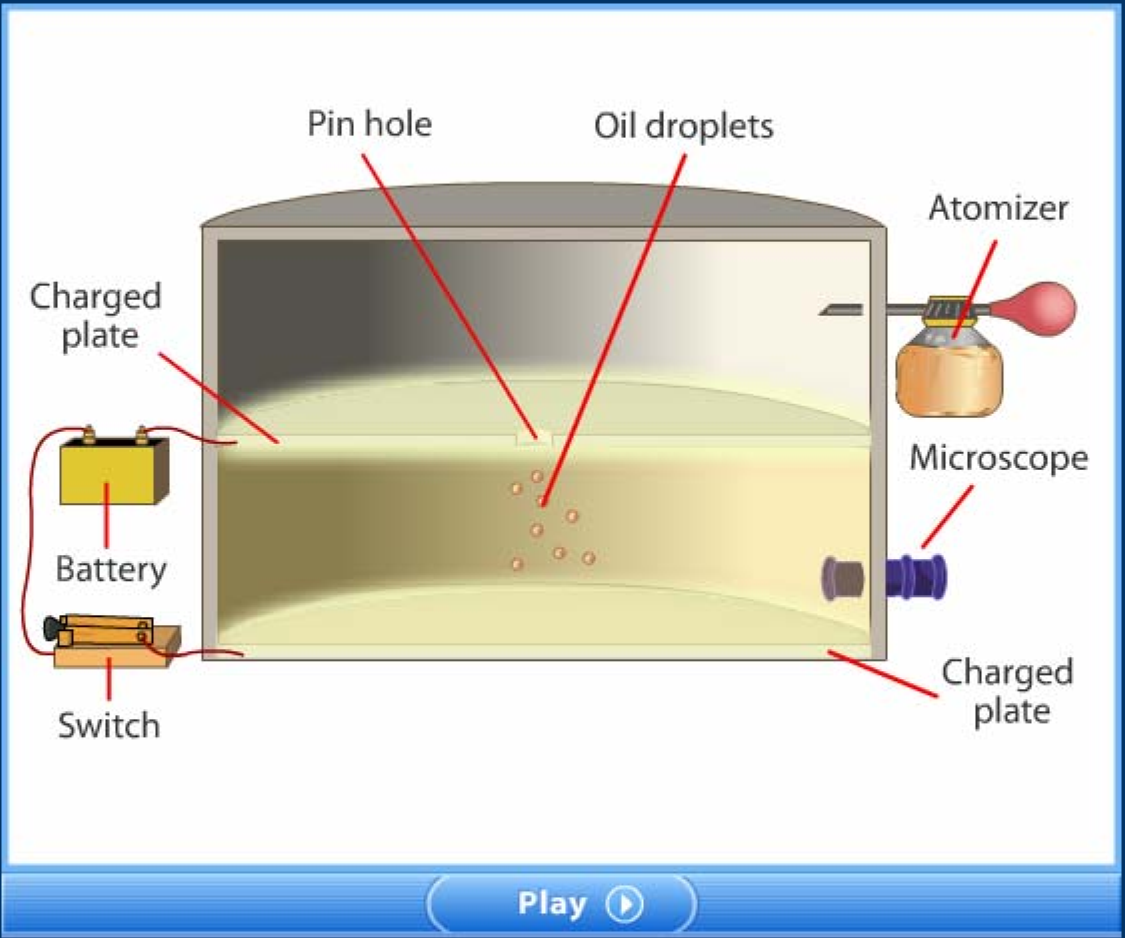
An object *cannot* have a charge of

A) 4.5×10^{-19} C B) 3.2×10^{-19} C C) 8.0×10^{-19} C D) 9.6×10^{-19} C

The Milikan Experiment



Milikan’s Oil Drop Experiment



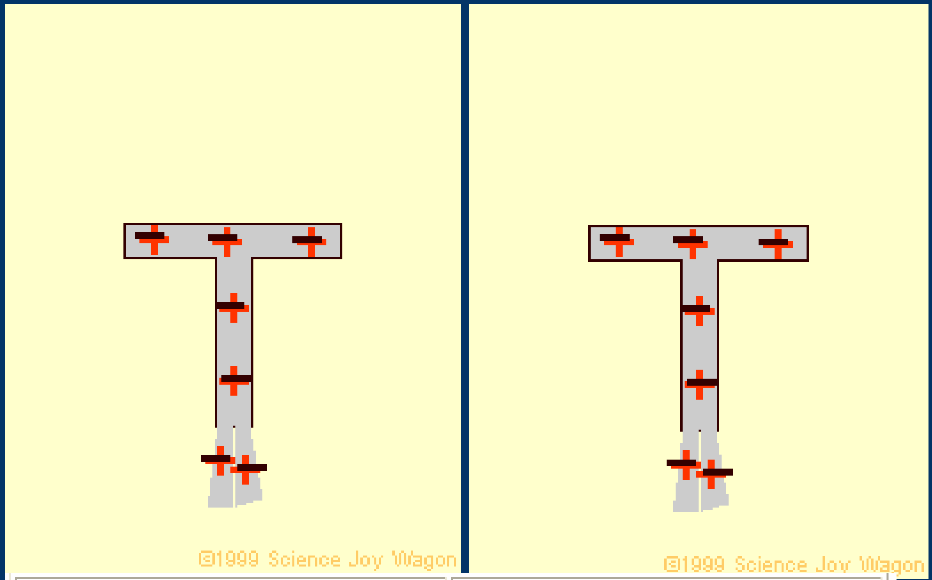
Transfer of Electric Charge

- An **electrical conductor** is a material in which charges can move freely.
- An **electrical insulator** is a material in which charges cannot move freely.

Transfer of Electric Charge, *continued*

- Insulators and conductors can be charged by contact.
- Conductors can be charged by **induction**.
- **Induction** is a process of charging a conductor by bringing it near another charged object and grounding the conductor.

How does a electroscope respond to a charged object?



• Electrons pushed by negative object toward the bottom of the electroscope. • The foil leaves at the bottom have a negative charge so they repel each other.	• Electrons attracted by the positive object toward the top of the electroscope. • The foil leaves at the bottom have a positive charge so they repel each other.

- When the charged object moves away, the electrons in the electroscope redistribute evenly so the leaves fall back down.
- The observable behavior is the same, so we can not use this test to determine what kind of charge we have.

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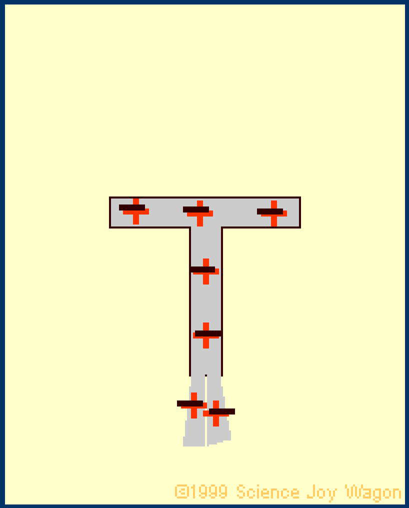
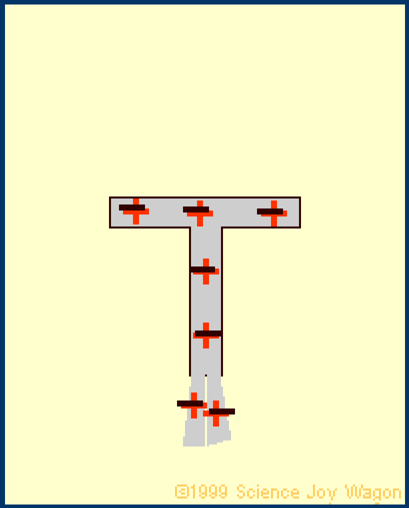
Charging by Conduction





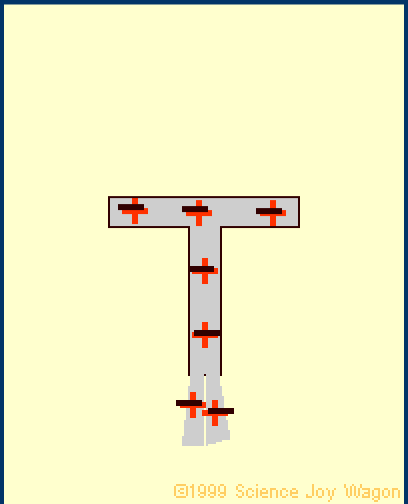
When charging something by contact it is important to note the following properties

The objects must actually touch and transfer some electrons.

The objects become charged alike.

The original charged object becomes less charged because it actually lost some charge. Therefore, there is a limit to how many times it could be used to charge something without being recharged.

Charging by Induction

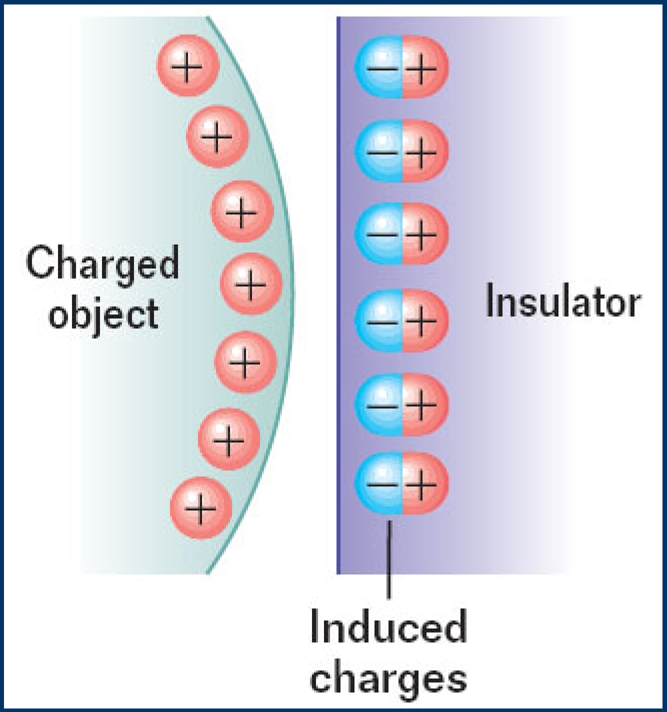


Charged object **does not touch** the electroscope.

Electroscope ends up **oppositely charged** to the object used to charge it.

The first charge is strong and **stays strong** each time the electroscope is recharged. (This is due to the original object not losing any charge in the process.)

Transfer of Electric Charge, *continued*

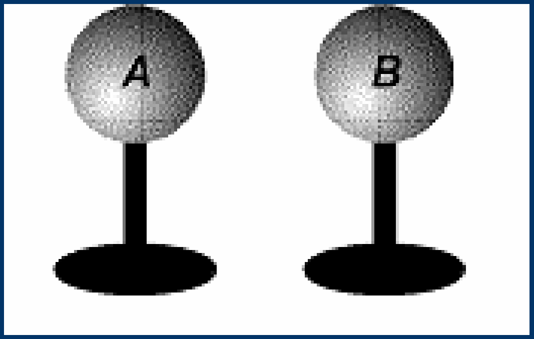


- A surface charge can be induced on insulators by *polarization.*
- With polarization, the charges within individual molecules are realigned such that the molecule has a slight charge separation.

DEMO: Charge is transferred between objects

- Two spheres on glass insulating rods have the charges shown below. If the make contact and a separated, what is the charge on each sphere?

+4 C +6 C



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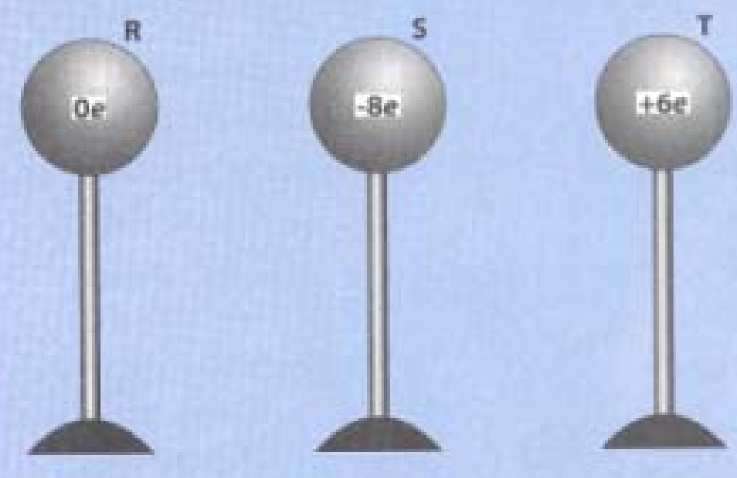
SAMPLE PROBLEM

The diagram below shows the initial charges and positions of three metal spheres, R, S, and T, on insulating stands.



Sphere R is brought into contact with sphere S and then removed. Then sphere S is brought into contact with sphere T and removed. What is the charge on sphere T after this procedure is completed?

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Coulomb's Law

- Two charges near one another exert a force on one another called the *electric force.*

- Coulomb's law states that the electric force is proportional to the magnitude of each charge and inversely proportional to the square of the distance between them.

$$F_{electric} = k_C \left(\frac{q_1 q_2}{r^2} \right)$$

$$\text{electric force} = \text{Coulomb constant} \times \frac{(\text{charge 1})(\text{charge 2})}{(\text{distance})^2}$$

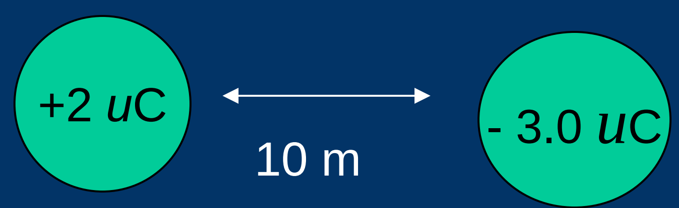
End Of Slide

Coulomb's Law, *continued*

- The Coulomb force is a *field force*.
- A field force is a force that is exerted by one object on another even though there is no physical contact between the two objects.

Coulomb's Law practice problem

- What is the electrostatic force between two small spheres possessing net charges of +2.0 coulombs and –3.0 coulombs, if the distance between them is 10.0 m?



k = electrostatic constant = 8.99×10^9 N-m^2 / C^2

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