

## Electricity

“Electricity is actually made up of extremely tiny particles called electrons that you cannot see with the naked eye unless you have been drinking.”

-- Dave Barry, *American Writer/Humorist*

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### Some History...

- ◆ The process of electrifying or charging objects has been known for over 2500 years.
- ◆ **Thales of Miletus** (640-546 BC), a Greek philosopher, observed that amber, when rubbed, could pick up light objects (*such as feathers or straw*).



Amber – a yellow-brown fossilized resin

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- ◆ This “magical” attraction of amber was also known to diminish over time.
- ◆ This is unlike the attraction or pull of the earth (*gravity*), which is always present.
  - ◆ Objects always fall

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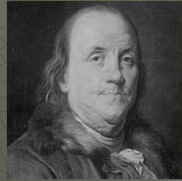
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- ◆ During the 1700's, the process of electrifying objects started to receive serious scientific attention.



Charles-Francois de Cisternay Dufay



Ben Franklin

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### Electrification Properties Observed:

- ◆ Glass rod (*silk*) **repels** glass rod (*silk*)
- ◆ Amber rod (*fur*) **repels** amber rod (*fur*)
- ◆ Glass rod (*silk*) **attracts** amber rod (*fur*)

*Before we go any further, we need to define this property that is causing the observed attracting and repelling motion.*

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### ◆ electrical mass (?)

- Used by Charles Coulomb (*late 1700's*) based on his observations of electrical objects attracting other objects in a manner similar to "mass"ive objects (*i.e. gravity*)

### ◆ Problem!

- Electrical objects not only attract but repel, which gravity does not ever seem to do. Therefore, this may not be a good name analogy.

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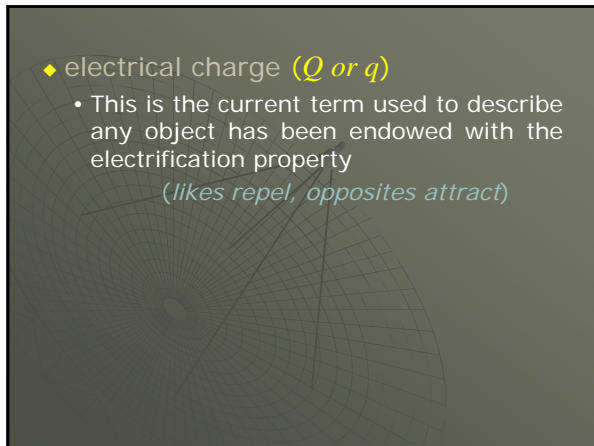
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- ◆ electrical charge (*Q or q*)
  - This is the current term used to describe any object has been endowed with the electrification property  
*(likes repel, opposites attract)*

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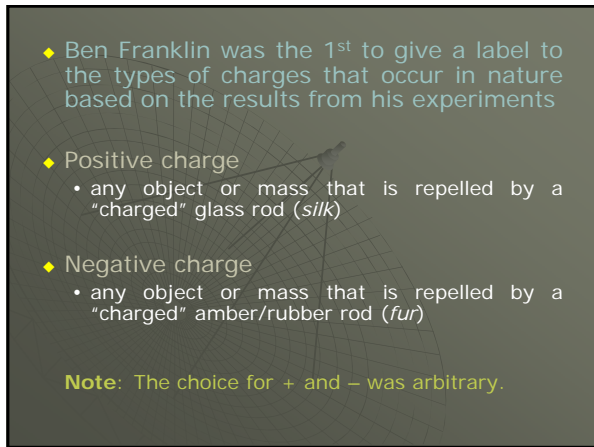
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- ◆ Ben Franklin was the 1<sup>st</sup> to give a label to the types of charges that occur in nature based on the results from his experiments
- ◆ Positive charge
  - any object or mass that is repelled by a "charged" glass rod (*silk*)
- ◆ Negative charge
  - any object or mass that is repelled by a "charged" amber/rubber rod (*fur*)

**Note:** The choice for + and – was arbitrary.

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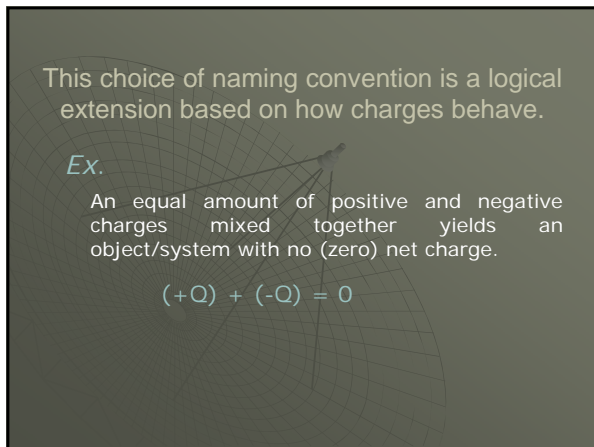
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This choice of naming convention is a logical extension based on how charges behave.

*Ex.*  
An equal amount of positive and negative charges mixed together yields an object/system with no (zero) net charge.

$$(+Q) + (-Q) = 0$$

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Ben Franklin also theorized that the charge of an isolated system was constant

- Charges may be moved/transferred from 1 location to another, but charge can never be created out of nothing or destroyed.

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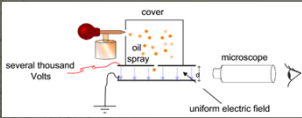
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 **Robert Millikan**  
(1868-1953)



- In his now famous oil drop experiment, he found that electric charge always occurs in some integral multiple of a fixed value (later referred to as the fundamental unit of electric charge  $[e]$ )

→  $q = ne$  ( $q = \text{net charge of an object}$ )

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The fundamental unit of charge ( $e$ )

- The smallest known value of a charge  
 $|e| = 1.602 \times 10^{-19} \text{ C}$   
This value is the charge of a single proton ( $e$ ) or electron ( $-e$ )
- The SI units associated with electric charge are Coulombs (C)  
1 C = the charge of  $6.24 \times 10^{18}$  electrons or protons

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### Summary of Electric Charge Properties:

- ◆ Charges occur in 2 types, positive & negative
- ◆ Like charges repel, opposite charges attract  
{electrification property, now known as the **Law of Charges**}
- ◆ Charge is conserved
- ◆ Charge is quantized (*discrete or localized*)
- ◆ Charges combine algebraically like scalars

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Different materials react differently when exposed to an electric charge. How they respond determines how they are classified.

- ◆ **Conductors**
  - Material that allows electric charge to move freely through it

*Ex.*

- Metals
- Impure water
- Conductive polymers (polythiophenes)

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- ◆ **Insulators (*dielectrics*)**
  - Materials that block or restrict the movement of electric charge

*Ex.*

- Wood
- Rubber
- Glass
- Most plastics/polymers
- Pure water

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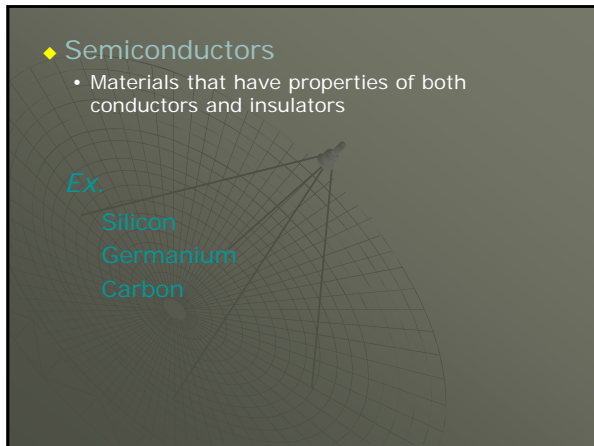
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◆ Semiconductors

- Materials that have properties of both conductors and insulators

Ex.

- Silicon
- Germanium
- Carbon



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**NOTE:** Some insulators can be charged temporarily, but only locally.



© 2004 Thomson - Brooks/Cole

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Now that we have looked at what a charge is defined as, what many of its properties are and how it interacts with matter, the next logical question is:

How do you charge an object?

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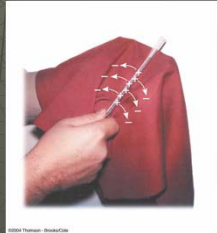
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How objects become charged:

- ◆ Transfer of electric charges
  - Creates an imbalance of charge

Ex.  
Rubbing things together



DEMO

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◆ Induction

**Note:** Any free charge is on a journey to make its way to the earth where it neutralizes with opposite charges located there. The process of charges returning to the earth is called grounding.

- Charges will try to get back to the earth or ground the quickest way possible. Given the opportunity, it will take shortcuts.
- *What happens when a net charge is placed on an isolated conduction surface?*  
*The charge sits there on the surface until it has somewhere to go*

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Comment

- ◆ All charged objects not in a vacuum will eventually become neutral (*uncharged*).
- ◆ Charge "leaks" away either by direct contact with other objects or through contact with the air.  
*(faster in humid air)*

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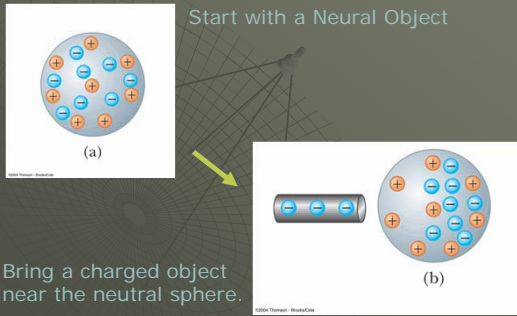
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### The Process of Charging by Induction



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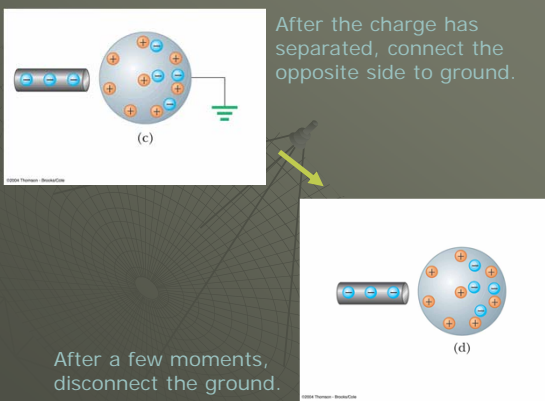
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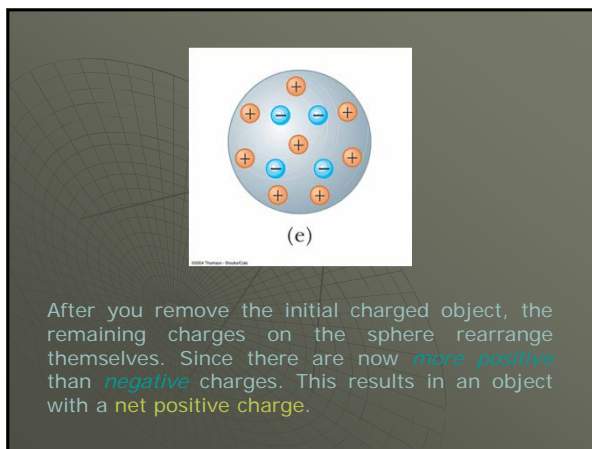
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**Remarks**

- ◆ Electricity is the study of the behavior and motion of electrical charges.
- ◆ In mechanics, the fundamental property of matter that produced all the natural motion of objects was **mass**  
*(through the force of gravity)*
- ◆ In electricity, the fundamental property of matter that produces all the natural motion of objects is **charge**  
*(through the force of electricity)*

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**Fundamental Problem in Electromagnetic Theory**

◆ Given



- ◆ What is the **net force** on the **test charge** due to all the **source charges**?

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**Simple in Principle, but complex in scope...**

- ◆ Are the **source charges** moving? If so, how fast?
- ◆ Is the **test charge** moving? If so, how fast?
- ◆ What is the orientation of the **source charges**?
- ◆ How many **source charges** are there?
- ◆ ...

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- ◆ We will consider the simplest possible setup to this problem.
- ◆ 1 source charge (at rest) and 1 test charge (at rest or in motion)
  - Electrostatics

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- ◆ Test charge moves due to the influence of the a stationary source charge in one of two ways:
  - Like Charges
  - Opposite Charges
- ◆ The model for the force that causes this type of behavior is called Coulomb's Law.

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### Coulomb's Law

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

where  $k = \text{Coulomb's Constant}$   
 $k = 9 \times 10^9 \frac{Nm^2}{C^2}$



Charles Coulomb

**Note** If  $q = 0$  or  $Q = 0$ , then  $F = 0$ .

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### Comparison

$$F_e = \frac{kQq}{r^2}$$

Electric Force

$$F_g = -\frac{GMm}{r^2}$$

Gravitational Force

◆ Similar but different...

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### Differences...

- ◆ Two types of charges, one type of mass
- ◆  $F = ma$  only depends on mass, not charge
  - Electron and Proton will **accelerate at different rates** even though their charges are equal in magnitude because they have different masses
- ◆ Mass can be any value, but  $q = ne$
- ◆  $F_e$  acts only thru charge,  $F_g$  only acts thru mass

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### Hydrogen Atom

◆ Gravitation Force between  $p$  and  $e^-$  in a hydrogen atom:

$$F_g = -\frac{GMm}{r^2}$$

$$F_g = -\frac{\left(6.67 \times 10^{-11} \frac{Nm^2}{kg^2}\right) (1.672 \times 10^{-27} kg) (9.11 \times 10^{-31} kg)}{\left(5.3 \times 10^{-11} m\right)^2}$$

$F_g = -3.6 \times 10^{-47} N$      Insanely Small !!!

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### Hydrogen Atom

- ◆ **Electric Force** between  $p$  and  $e^-$  in a hydrogen atom:

$$F_e = \frac{kQq}{r^2}$$

$$F_g = \frac{\left(9 \times 10^9 \frac{Nm^2}{kg^2}\right) (1.6 \times 10^{-19} kg) (-1.6 \times 10^{-19} kg)}{(5.3 \times 10^{-11} m)^2}$$

$F_e = -8.2 \times 10^{-8} N$       Small, but 39 orders of magnitude ( $10^{39}$ ) larger than gravitational force

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### Another Useful Concept

- ◆ **Electric Field (E)**
  - A region of influence around any charged object that will effect any other charged object that enters this region
- ◆ The Force an electric field exerts on some **test charge**  $q$  is given by:

$$F = qE$$


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### Fact or Fiction?

- ◆ What is this?



- ◆ What is it for?

Q-Ray Bracelets are Wellness-Lifestyle Bracelets that work to balance your own negative and positive energy forces, optimizing your Bio-Energy.

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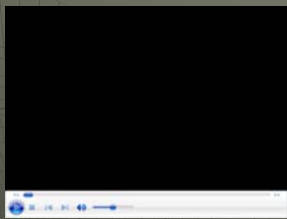
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◆ How does it work?



◆ **Nugget of Truth:**

- Bodies run on electric impulses

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**Some comments from the FAQ**

◆ How long should I wear my Q-Ray before it needs to be replaced?

- Every 2 years

◆ Can I shower or sleep while wearing the Q-Ray Bracelet?

- Yes, but not in the ocean

◆ How do I tell if I have purchased an "imposter"?

- look for the Q-Ray or Q2 logo stamped at the ends of the bracelet

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**Do's and Don'ts**

- ◆ **DO** try to wear your Q-Ray® all the time - especially while sleeping or exercising.
- ◆ **DO NOT** wear the bracelet if you have an electronic or medical device such as a pacemaker.
- ◆ **DO NOT** wear the Natural Finish bracelet if you are allergic to bare (non-plated) metal.
- ◆ **DO NOT** continue to wear the bracelet if any type of discomfort occurs after the bracelet is worn.
- ◆ **DO NOT** wear while using electric blankets, magnetic products, or tanning beds.
- ◆ **DO NOT** wear any other metals or a watch **ON THE SAME WRIST** as Q-Ray. Rings may be worn on the same wrist as Q-Ray.
- ◆ **DO NOT** allow the ends of the bracelet to come in contact with one another.
- ◆ **DO NOT** wear bracelets near any high voltage areas or areas where there is any strong electrical exposure.

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### Some interesting deletions over the years to their website

- ◆ Dropped the description of permanently ionized
- ◆ Removed the phrase:
  - Q-Ray makes no claim that there is a scientific consensus regarding this product
- ◆ Dropped how to tell the difference between Q-Ray and an "Imposter"
  - Q-Ring (Bio-Digital) Test & Applied Kinesiology Test
- ◆ Dropped the Disclaimer
  - "The statements on this site have not been evaluated by the FDA. The product is not intended to diagnose, treat, cure or prevent any disease."

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### Interesting New Addition

- ◆ Q-Ray Bracelets are the only bracelets that feature our exclusive and innovative process. This protected process is what separates Q-Ray from all other bracelets.
- ◆ **NEVER** hints at or even suggests what this process is or involves!

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### Another Contender...

- ◆ iRenew



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### Some comments from the FAQ

- ◆ **What is the iRenew bracelet made of and how long will it last?**
  - The iRenew bracelet is made of silicone and stainless steel created using the technological process of Selective Frequency Resonance™ (SFR), the technology **may** help support balance, endurance, and strength when the bracelet is worn. Once the technology is embedded in the bracelet, it will be effective **forever**.

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### Some comments from the FAQ...

- ◆ **How long should I wear my Q-Ray before it needs to be replaced?**
  - Forever
- ◆ **Can I shower or sleep while wearing the Q-Ray Bracelet?**
  - Yes, It can be worn 24/7

Gives great stats from research but never gives reference!

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### Do These Devices Really Work?

- ◆ Signs point to **NO**
  - No real evidence
  - No verifiable research
  - Unknown construction processes
  - Placebo effect?

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