# Module 4 Part 1
# Electricity

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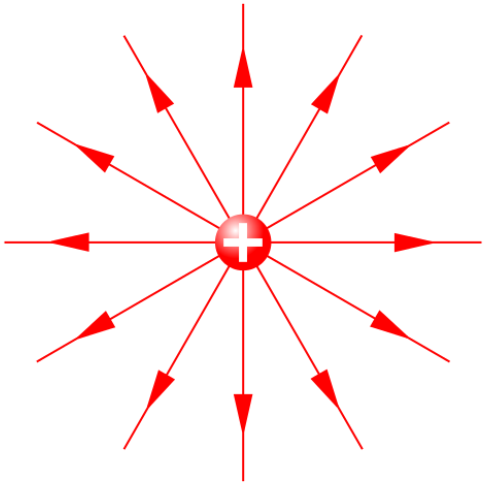
# Agenda



- Electric Charge
- Coulombs Law
- The Electric Field
- Ohm's Law
- Lab: Electricity
  - http://phet.colorado.edu/sims/charges-and-fields/charges-and-fields_en.html

# Course Modules

| # | Module | Weeks | Reading | Quiz |
|---|---|---|---|---|
| 1 | Newton's laws | 1 | Ch 4,5 * | |
| 2 | Conservation of Energy and Momentum | 2,3 | Ch 6,7,8 | Quiz 1 |
| 3 | Thermodynamics | 4,5 | Ch 12,13,14 | |
| 4 | **Electromagnetism** | **6,7** | **Ch 17,18** | **Quiz 2** |
| 5 | Waves, Sound, and Light | 8,9 | Ch 16, 20, 21 | Quiz 3 |
| 6 | Modern Physics | 10 | Ch 23 | Final Exam |
| | | | | |

* **it is strongly recommended you read chapters 0 - 3**

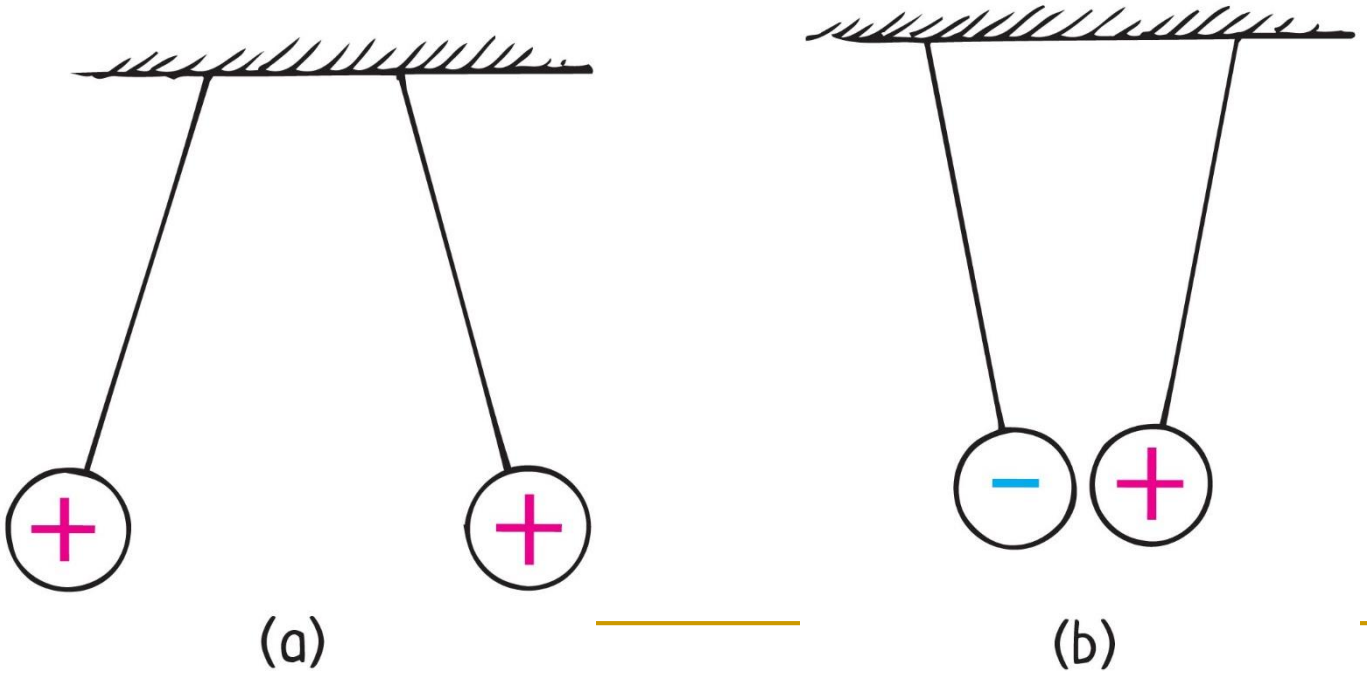
# Module 4

- Reading: Chapters 17,18
  - Chapter 17 – Basic Electricity
  - Chapter 18 = Magnetism
- Exercise 4, due start of week 8 (4%)
- Quiz 2 – next week in class
- Labs
  - **Electricity (3.75%)**
  - Electromagnetic Lab (3.75%)

# Electric Force and Charge

Central rule of electricity

- opposite charges attract one another;
  like charges repel



# Electric Force and Charge

Protons

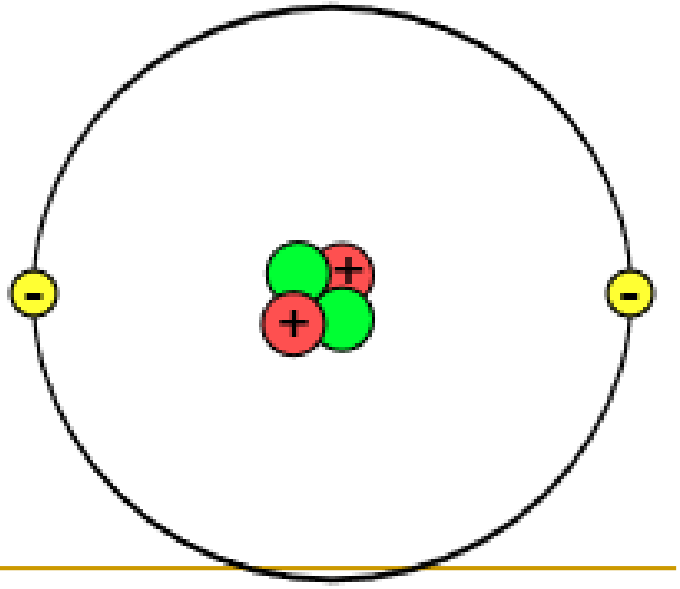
- positive electric charges
- repel positives, but attract negatives

Electrons

- negative electric charges
- repel negatives, but attract positives

Neutrons

- neutral electric charge

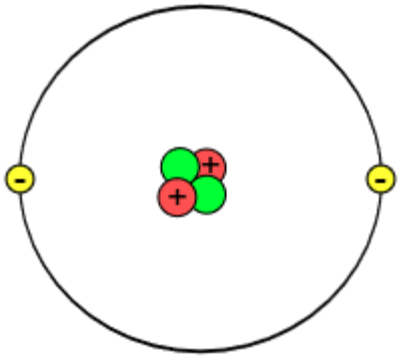


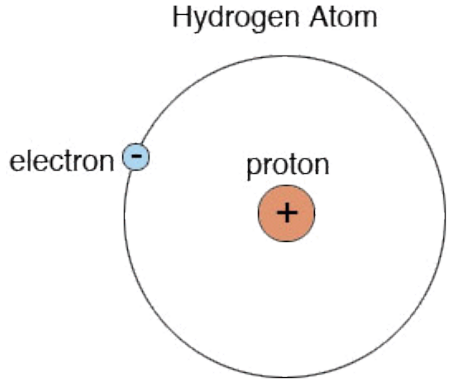
# Electric Force and Charge

Fundamental facts about atoms

1. Every atom is composed of a positively charged nucleus surrounded by negatively charged electrons.

2. Each of the electrons in any atom normally has the same quantity of negative charge and the same mass.





# Electric Force and Charge

Fundamental facts about atoms (continued)

3. Protons and neutrons compose the nucleus. Protons are about **1800** times more massive than electrons, but each one carries an amount of positive charge equal to the negative charge of electrons. Neutrons have slightly more mass than protons and have no net charge.

4. Atoms usually have as many electrons as protons, so the atom has zero net charge.

# Electric Force and Charge

**Ion**

- positive ion—atom losing one or more electrons has positive net charge
- negative ion—atom gaining one or more electrons has negative net charge

# Electric Force and Charge

## Electrons in an atom

### Examples:

- When rubbing a comb through your hair, electrons transfer from your hair to the comb. Your hair has a deficiency of electrons (positively charged).
- When rubbing a glass rod with silk, electrons transfer from the rod onto the silk and the rod becomes positively charged.

# Electric Force and Charge
# CHECK YOUR NEIGHBOR

When you brush your hair and scrape electrons from your hair, the charge of your hair is

A. positive.
B. negative.
C. both A and B
D. neither A nor B

# Electric Force and Charge
# CHECK YOUR ANSWER

When you brush your hair and scrape electrons from your hair, the charge of your hair is

**A. positive.**

B. negative.

C. both A and B

D. neither A nor B

*Comment*:

And if electrons were scraped off the brush onto your hair, your hair would have a negative charge.

# Electric Force and Charge

Conservation of Charge

- In any charging process, no electrons are created or destroyed. Electrons are simply transferred from one material to another.

# Coulomb's Law

Coulomb's law

- relationship among electrical force, charge, and distance discovered by **Charles Coulomb** in the 18th century
- states that for a pair of charged objects the force between them varies directly, as the product of their charges, and inversely, as the square of the separation distance
- electrical forces may be either attractive or repulsive

# Coulomb's Law

Coulomb's law (continued)

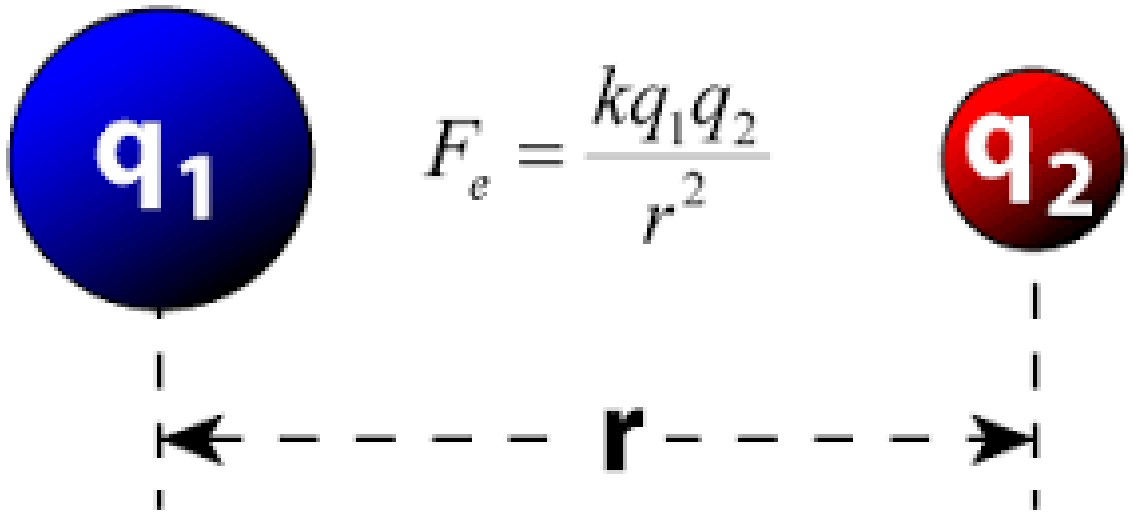
- If the charges are alike in sign, the force is repelling; if the charges are not alike, the force is attractive.
- in equation form:

$$F = \frac{kq_1q_2}{r^2}$$

k = 9,000,000,000 $Nm^2/C^2$

- unit of charge is coulomb, C

# Coulomb's Law



# Coulomb's Law
# CHECK YOUR NEIGHBOR

According to Coulomb's law, a pair of particles that are placed twice as far apart will experience forces that are

A. half as strong.
B. one-quarter as strong.
C. twice as strong.
D. four times as strong.

# Coulomb's Law
# CHECK YOUR ANSWER

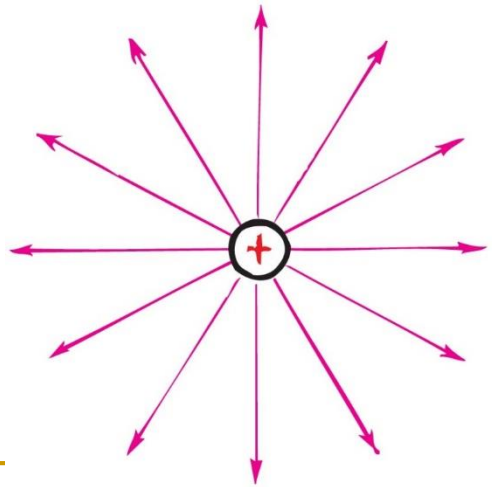
According to Coulomb's law, a pair of particles that are placed twice as far apart will experience forces that are

A. half as strong.
B. **one-quarter as strong.**
C. twice as strong.
D. four times as strong.

# Electric Field

Electric field

- Charge exhibits an electric field
- space surrounding an electric charge (an energetic aura)
- describes electric force
- around a charged particle obeys inverse-square law
- force per unit charge



# Electric Potential

Electric potential difference

- Energy possessed by a charged particle due to its location in an electric field.
- Charge flows from higher potential to lower potential
- A difference in potential between two points
  - charges in conductor flow from higher potential to lower potential
  - maintained for continuous flow by pumping device
    - A battery or generator can maintain a steady flow of charge

# Electric Current

Rate of electric flow

- measured in ampere (1 coulomb of charge per second)
- charge flows *through* a circuit; voltage is established *across* a circuit
- Relationship of current flow to material resistance and voltage (electrical potential)
  - *OHMS LAW*
    - $V = IR$

# Ohm's Law

Ohm's law

- relationship between voltage, current, and resistance
- states that the current in a circuit varies in direct proportion to the potential difference, or voltage, and inversely with the resistance

# Ohm's Law

## Ohm's law (continued)

- in equation form:

$$current = \frac{voltage}{resistance}$$

  example:
  - for a constant resistance, current will be twice as much for twice the voltage
  - for twice the resistance and twice the voltage, current will be unchanged

## Resistors

- circuit elements that regulate current inside electrical devices

# Electric Circuits

## Circuits

- connected in two common ways
  - series
    - forms a single pathway for electron flow between the terminals of the battery, generator, or wall outlet
  - parallel
    - forms branches, each of which is a separate path for the flow of electrons