Electric Charge

- Electric charge is a fundamental property of atomic particles
  - such as electrons and protons
- Two types of charge: negative and positive
  - Electron is negative, proton is positive
- Usually object has equal amounts of each type of charge so no net charge
- Object is said to be electrically neutral

Charged Object

- Object has a net charge if two types of charge are not in balance
- Object is said to be charged
- Net charge is always small compared to the total amount of positive and negative charge contained in an object
- The net charge of an isolated system remains constant

Law of Electric Charges

- Charged objects interact by exerting forces on one another
- **Law of Charges**:

  Like charges repel, and opposite charges attract

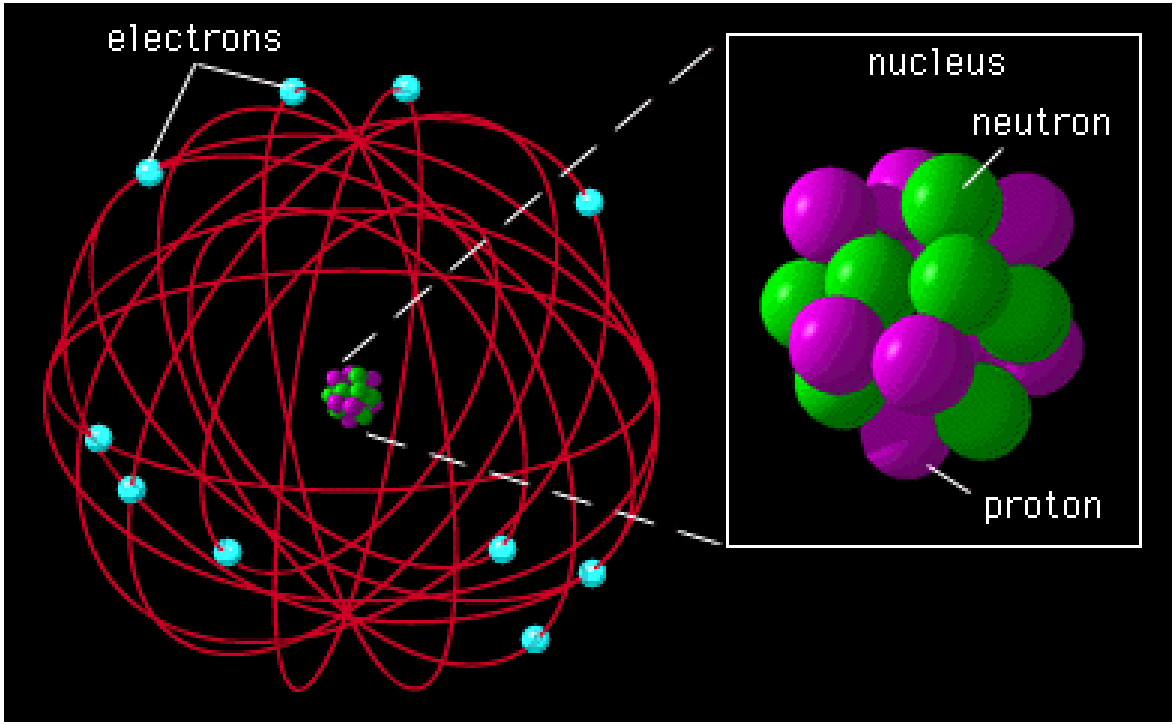
- The standard unit (SI) of charge is the Coulomb (C)

Electric Properties

- Electrical properties of materials such as metals, water, plastic, glass and the human body are due to the structure and electrical nature of atoms

- Atoms consist of protons (+), electrons (-), and neutrons (electrically neutral)

Atom



Schematic view of an atom

- Electrically neutral atoms contain equal numbers of protons and electrons

Conductors and Insulators

- Atoms combine to form solids
- Sometimes outermost electrons move about the solid leaving positive ions
- These mobile electrons are called conduction electrons
- Solids where electrons move freely about are called conductors – metal, body, water
- Solids where charge can’t move freely are called insulators – glass, plastic

Charging Objects

- Only the conduction electrons can move
- The positive ions are fixed in place
- Electric charge transfer is a transfer of electrons
- Charging positively: Removal of electrons from an object
- Charging negatively: Addition of electrons to an object

Quantization of Charges

- Charge is quantized – comes in discrete values

- Electric charge *q* is an integer multiple of the fundamental (or elementary) charge constant *e*
- *q=ne* where n = 0, $\pm 1, \pm 2, \pm 3$ and
- $e = 1.60 \times 10^{-19}$ C

Particle	Electric Charge	Mass
Electron	$-e = -1.6E10^{-19}$ C	M_e=9.11E10^{-31} kg
Proton	$+e = 1.6E10^{-19}$ C	M_p=1.672E10^{-27} kg
Neutron	0	M_n=1.674E10^{-27} kg

Net Electric Charge

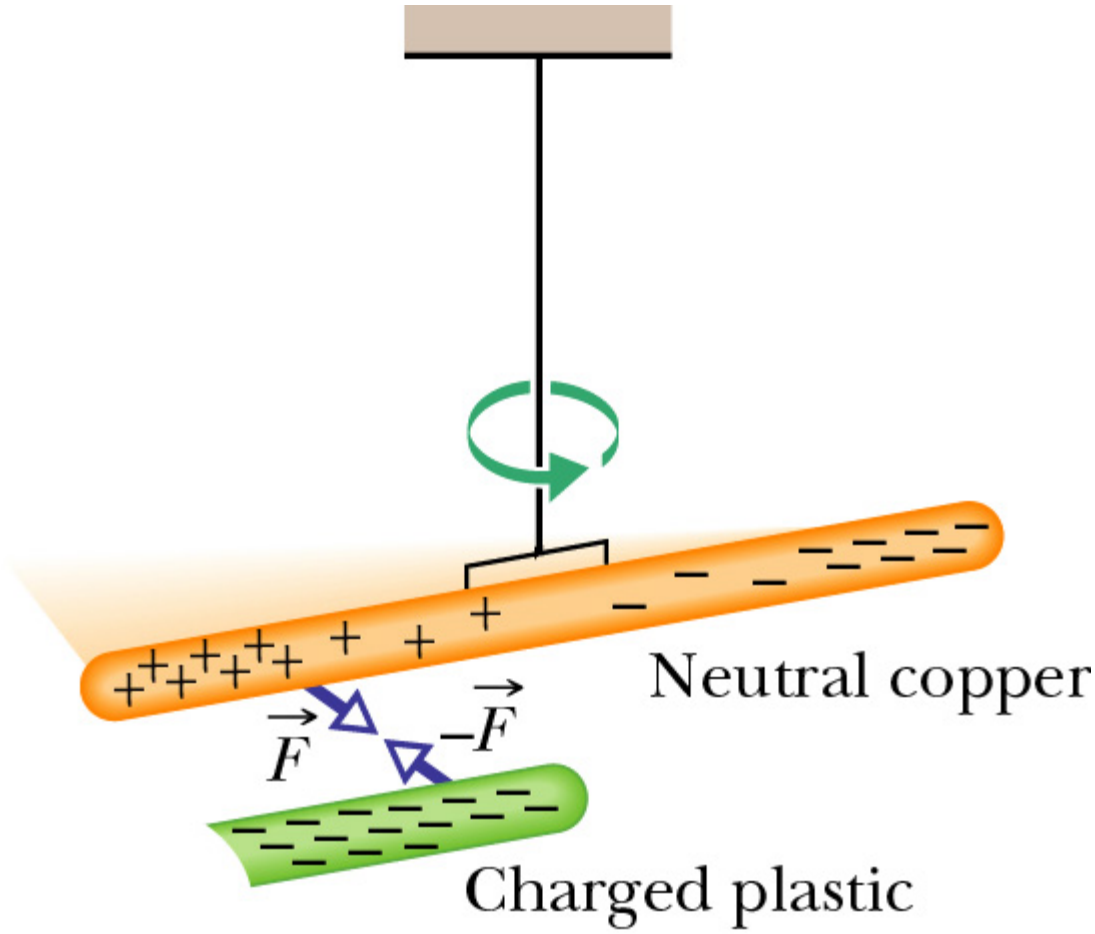
- Net charge of an object is the difference between the number of protons and electrons in it times *e*
- Charge is conserved
  - Net charge of any isolated system cannot change
  - Same as energy, linear and angular momentum

Conduction and Induction

- An object can be given a charge by conduction or induction
- In conduction the charge is transferred between objects by direct contact. For example,
  - Rubbing a glass rod (an insulator) with silk
  - Connecting 2 conductors through a conducting pathway (such as a wire) or by grounding the object

Induction

- An electrically neutral object can have an induced charge when some of its positive and negative charges separate due to a nearby charge
- Neutral object will display characteristics of a charged object even though there is no net charge
- Can we get an induced charge with an insulator?


Neutral copper
$\vec{F}$
$-\vec{F}$
Charged plastic

Electric Force

- The magnitude of the electrostatic force, *F*, between 2 charged particles with charges q_1 and q_2, respectively, and separated by a distance *r* is defined as

$$F = \frac{k|q_1||q_2|}{r^2}$$

- This is Coulomb's law where *k* is a constant
- The forces on 2 point charges are equal and opposite, pointing to (away from) the other particle for unlike (like) charges

Electrostatic and Gravitational Forces

- Coulomb's law should remind you of Newton's equation for the gravitational force

$$F = \frac{Gm_1m_2}{r^2}$$

- *k* is called the electrostatic constant

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \, N \cdot m^2 / C^2$$

- ε_0 is called the permittivity constant

Electrostatic and Gravitational Forces

- Electrostatic force and gravitational force are both inverse square laws involving a property of the interacting particles
- Electrostatic force differs from gravitational:
  - Can be either attractive or repulsive
  - Holds for all experimental tests and over all ranges
- Both obey the superposition principle:
  - The net force acting on any charge is the vector sum of the forces due to all other charges in a given distribution