

August 26th

Electric Charge
Chapter 22

Electric Charge

- Review from yesterday
 - There are 2 types of charge + and -
 - Like charges repel; unlike charges attract
 - Most objects are electrically neutral; there are equal numbers of neg. and pos. charges so the net charge = 0
 - An object becomes charged (net charge $\neq 0$) by adding or removing electrons
 - Conductors are materials where some of the electrons can move freely
 - Insulators are materials where none of the charges can move freely

Electric Charge

- Charge is **quantized** – comes in discrete values
 - Proven by Millikan oil-drop experiment (section 23-8)
- 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
- $e = 1.60 \times 10^{-19} \text{ C}$

Particle	Electric Charge	Mass
Electron	$-e = -1.6 \times 10^{-19} \text{ C}$	$M_e = 9.11 \times 10^{-31} \text{ kg}$
Proton	$+e = 1.6 \times 10^{-19} \text{ C}$	$M_p = 1.672 \times 10^{-27} \text{ kg}$
Neutron	0	$M_n = 1.674 \times 10^{-27} \text{ kg}$

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

Electric Charge

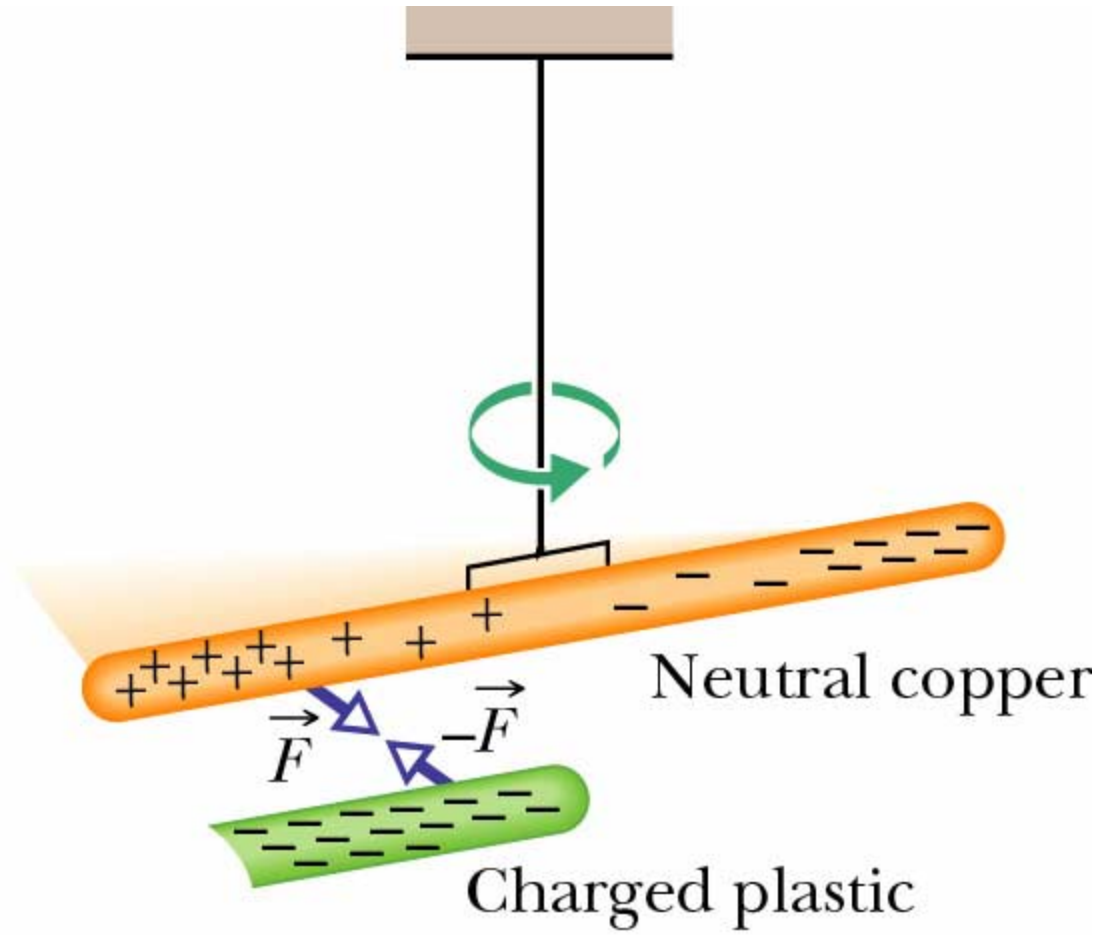
- An object can be given a charge by **conduction** or **induction**
- In **conduction** the charge is transferred between objects by direct contact. For example,
 - Rubbing a glass rod (an insulator) with silk
 - Connecting 2 conductors through a conducting pathway (such as a wire) or by grounding the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

Demos

- Van de Graaf - rubber belt transfers charge to metal sphere using conduction

Electric Charge

- 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?



Demos

- Obedient ruler – meter stick glued to bottle so isolated system, foil on one end, silk and glass rod
 - Charge rod, bring near foil end, will attract by induction
 - What will happen at wood end?
 - Will also attract due to induction – ruler still neutral
 - Ruler is insulator so charges don't move freely but molecules align so get attraction
- Why can we stick a balloon to the wall by rubbing it on our hair or shirt?
 - Transfer charge to balloon by conduction
 - Induction causes molecules to align in wall and attract balloon

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

Electric Force

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

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

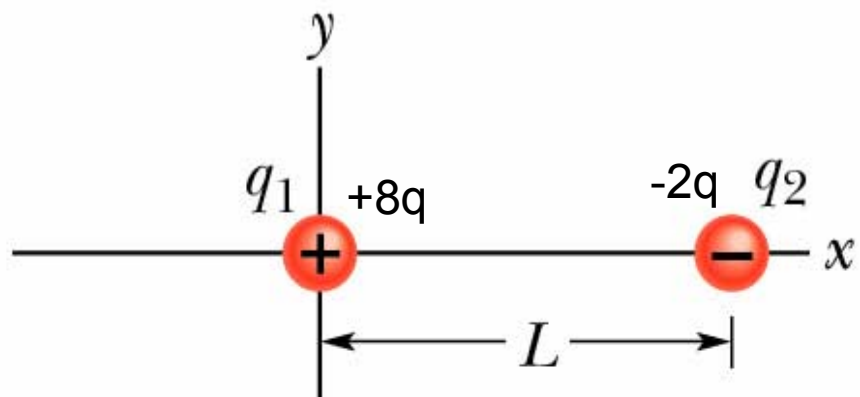
- k is called the electrostatic constant

$$k = \frac{1}{4\pi\epsilon_0} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$$

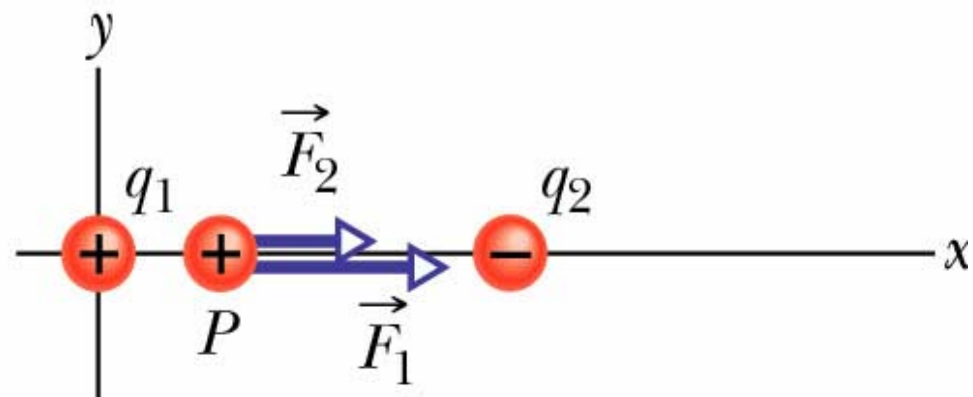
- ϵ_0 is called the permittivity constant

Electric Force

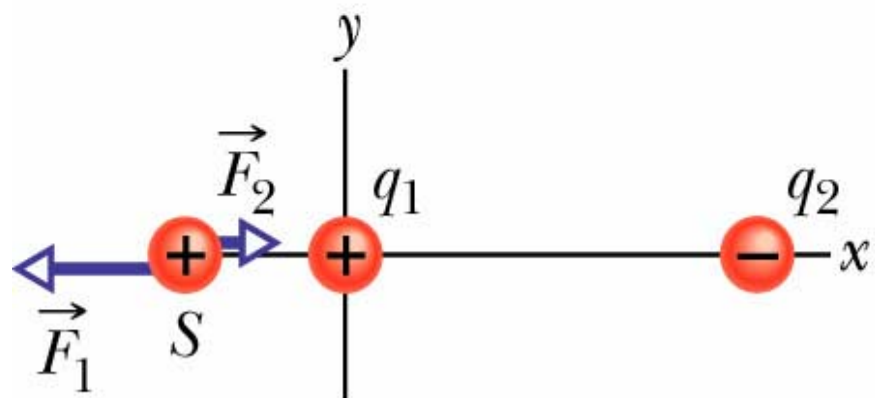
- Electrostatic force and gravitational force are both inverse square laws involving a property of the interacting particles
- Electrostatic force differs from gravitational:
 - Can be either attractive or repulsive
 - Holds for all experimental tests and over all ranges
- Both obey the superposition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



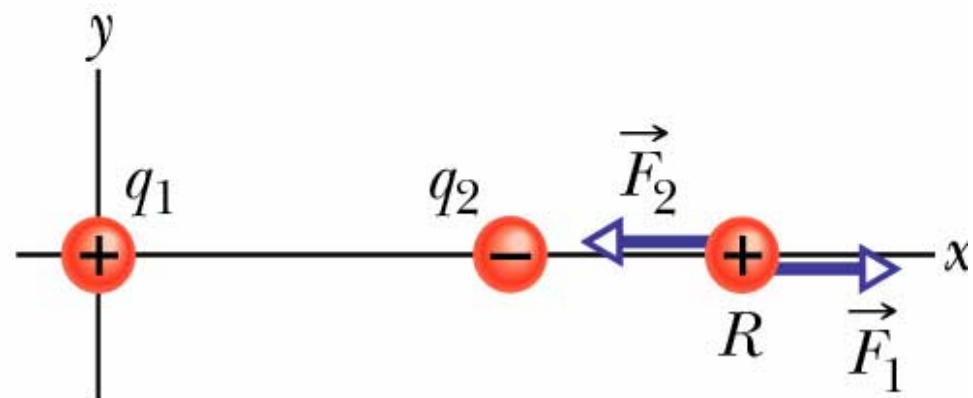
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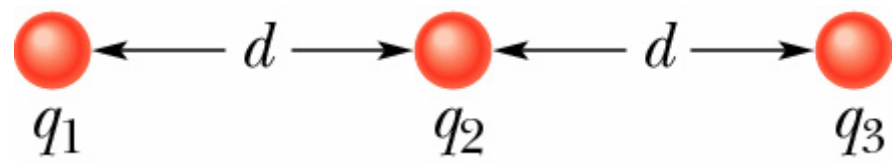
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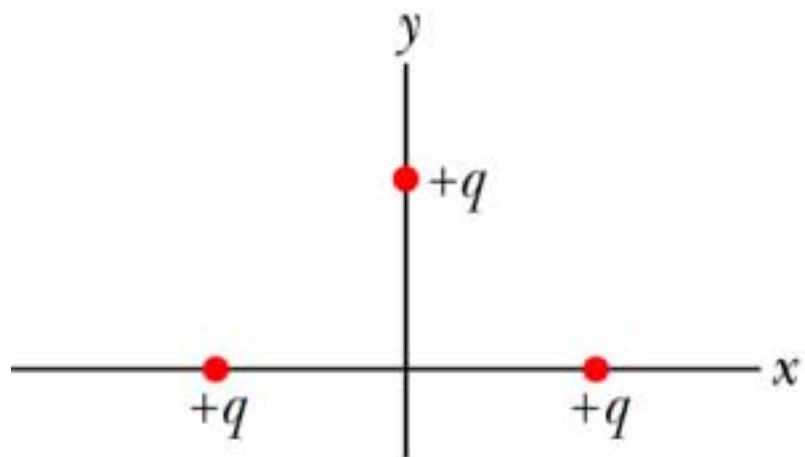


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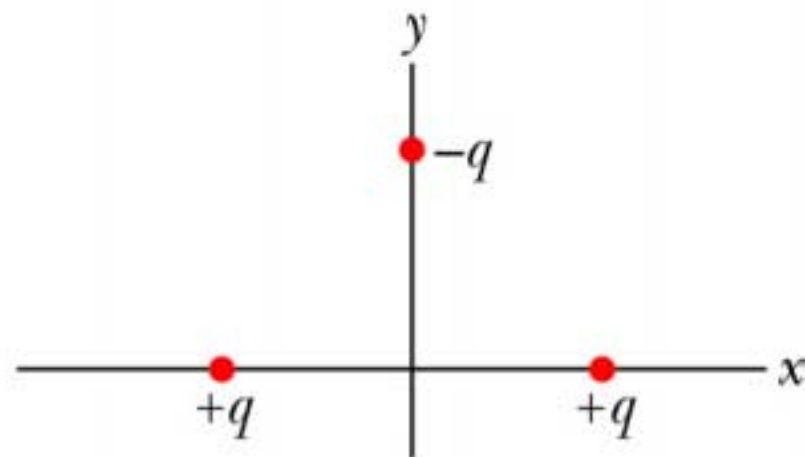


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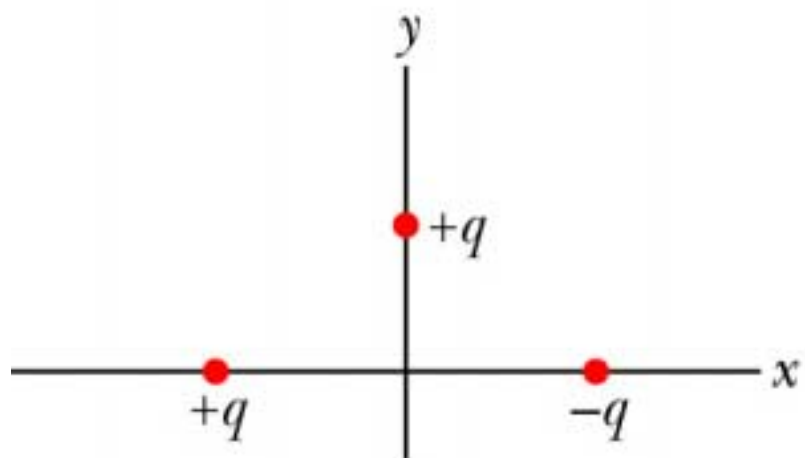




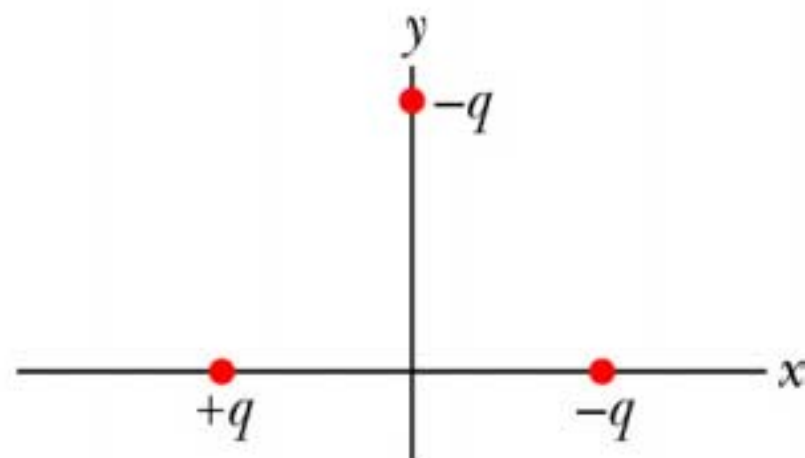
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