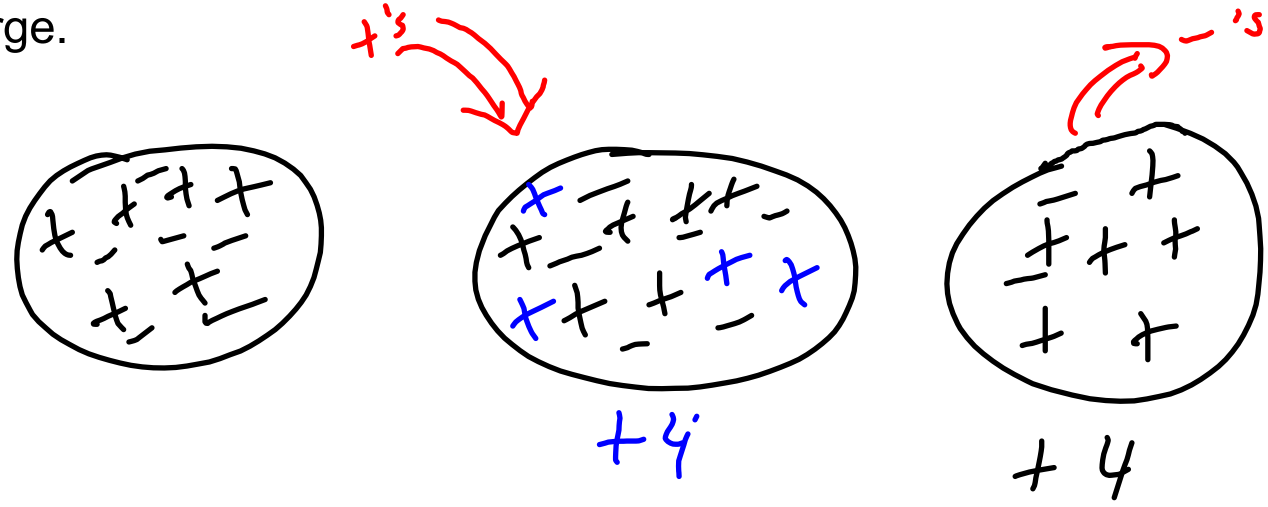
Ch 15 Electric Forces & Electric Fields
15.1 Electric Charge

There are 2 types of electric charge, positive and negative. Like charges repel each other; different charges attract each other.

At the atomic level, charge arises from the presence of protons (positive) and electrons (negative). We find that electric charge is "conserved." We don't see the creation or the destruction of electric charge, only its rearrangement.

We can give charge to an object by adding or taking away charges from it. For example, I can give an object a positive charge by (1) adding positive charge or (2) taking away negative charge.



We also find that charge is "quantized"--it comes in discrete units, not with continuous values.

electron − e^- ⇒ charge = -1.60×10^{-19} coulombs

proton − p^+ ⇒ charge = $+1.60 \times 10^{-19}$ coulombs

nothing (isolated) with a charge different than

integer × 1.6×10^{-19} C

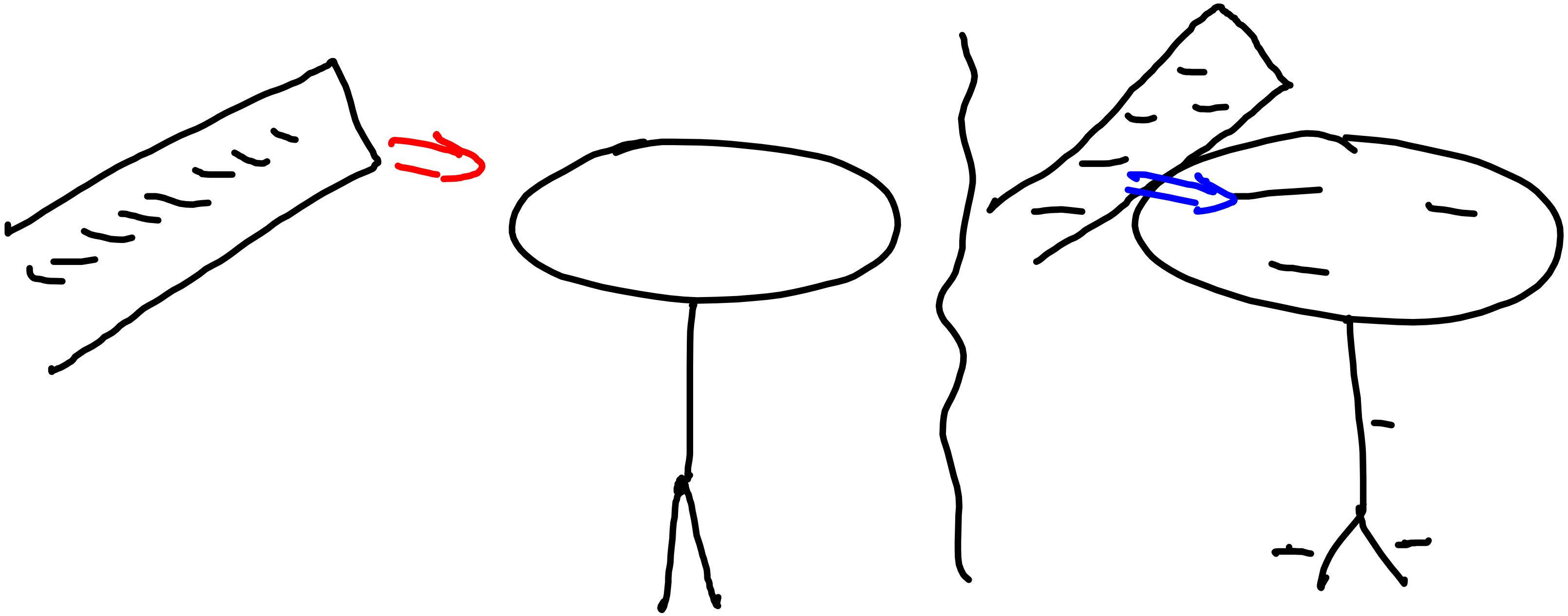
$e = 1.60 \times 10^{-19}$ coulomb

coulomb (C) = S.I. of charge

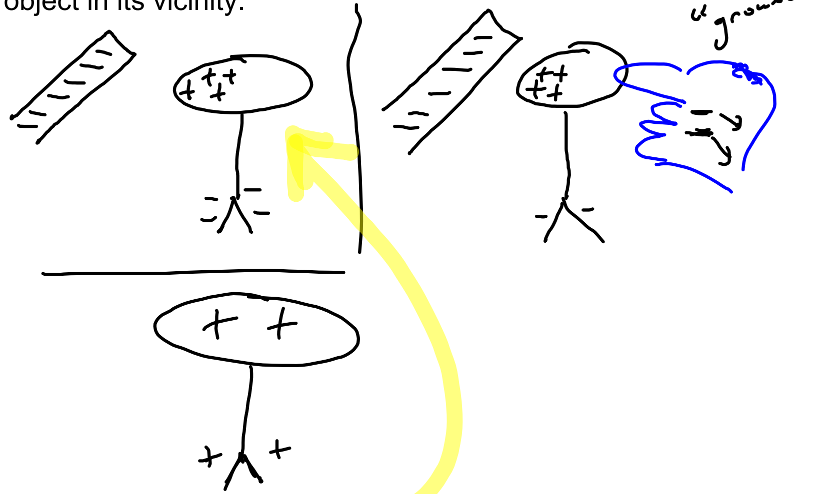
15.2 Insulators & Conductors

An **insulator** is a substance that doesn't allow the free movement of charge; a **conductor** is a substance that does allow the free movement of charge.

Charging by conduction - the direct transfer of charge from one charged object to another neutral object.

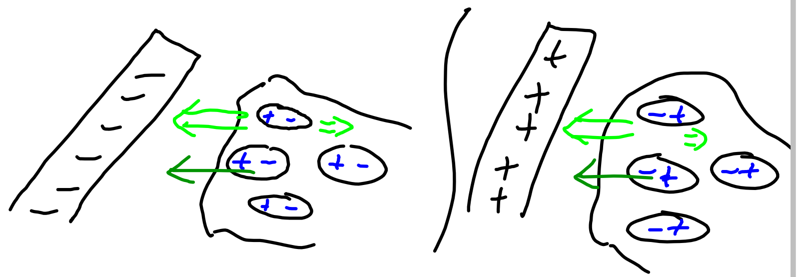


Charging by induction -- charging an object using a charged object in its vicinity.



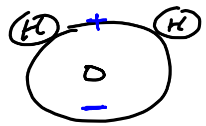
Polarization

Even with insulators, there can be some movement of charge on the molecular level



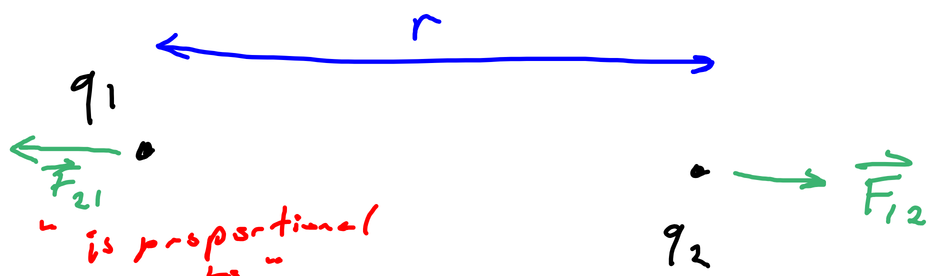
It's always the case that the opposite ends up closer to the charged object and, thus, feels a greater attraction than the repulsion of the like charges.

Bend water



15.3 Coulomb's Law

Take 2 point charges, q_1 & q_2, separated by a distance r



"$\propto$" "is proportional to"

$F_e \propto q_1$; $F_e \propto q_2$; $F_e \propto 1/r^2$

"inverse-square force"

$$F_e = k_e \frac{|q_1| \cdot |q_2|}{r^2} = |\vec{F}_e| \quad \left(F_G = G \frac{m_1 m_2}{r^2} \right)$$

$k_e \equiv$ Coulomb's constant $= 8.9875 \times 10^9 \ N \cdot m^2 / C^2$

(9.0×10^9)

$\vec{F}_e$ is attractive for opposite charges, repulsive for similar charges

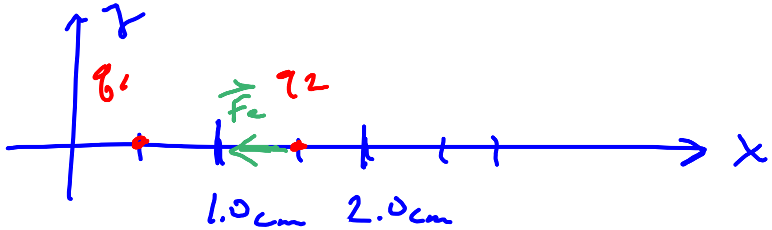
We will also use

$$\varepsilon_0 = 8.85 \times 10^{-12} \; C^2/N \cdot m^2$$

$$\varepsilon_0 = \frac{1}{4\pi k_e}$$

= "permittivity of free space"

Example: Find the force on the right-most charge below:



μ = "micro-" = $10^{-6}\times$

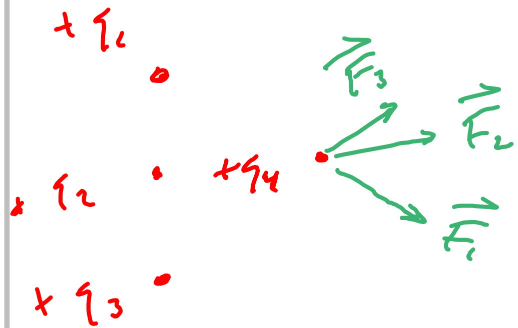
$q_1 = 2.00\,\mu C$; $q_2 = -6.00\,\mu C$

$$|\vec{F}_e| = k_e \frac{|q_1|\cdot|q_2|}{r^2}$$

$$= (8.99\times10^9\ N\cdot m^2/C^2)\,\frac{(2.00\times10^{-6}\ C)(6.00\times10^{-6}\ C)}{(0.0100\ m)^2}$$

$\vec{F}_e = 1080\ N$ to the left

Note: w/ multiple charges, just add up the separate force vectors



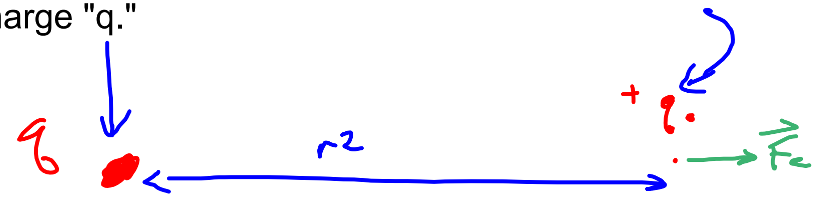
net $\vec{F} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$

15.4 The Electric Field

The electric force involves 2 charges interacting with each other. How can we describe the effect of a single charged object on its environment? To do so , we use the electric field, **E**, which the force per unit charge.

$$\vec{E} \equiv \vec{F_e}/q_0$$

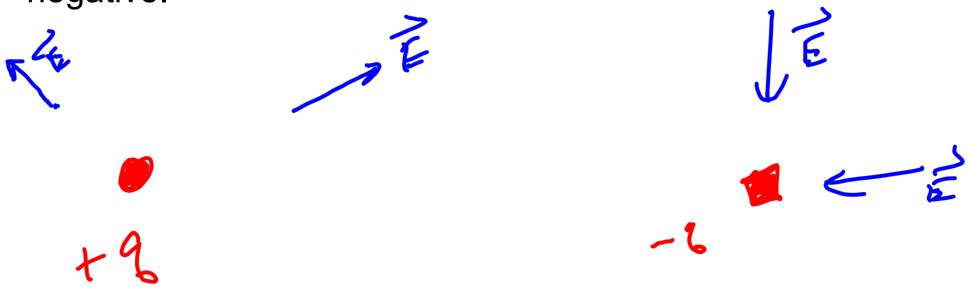
Imagine there is small, positive charge -- a "test charge" -- near a larger charge "q."



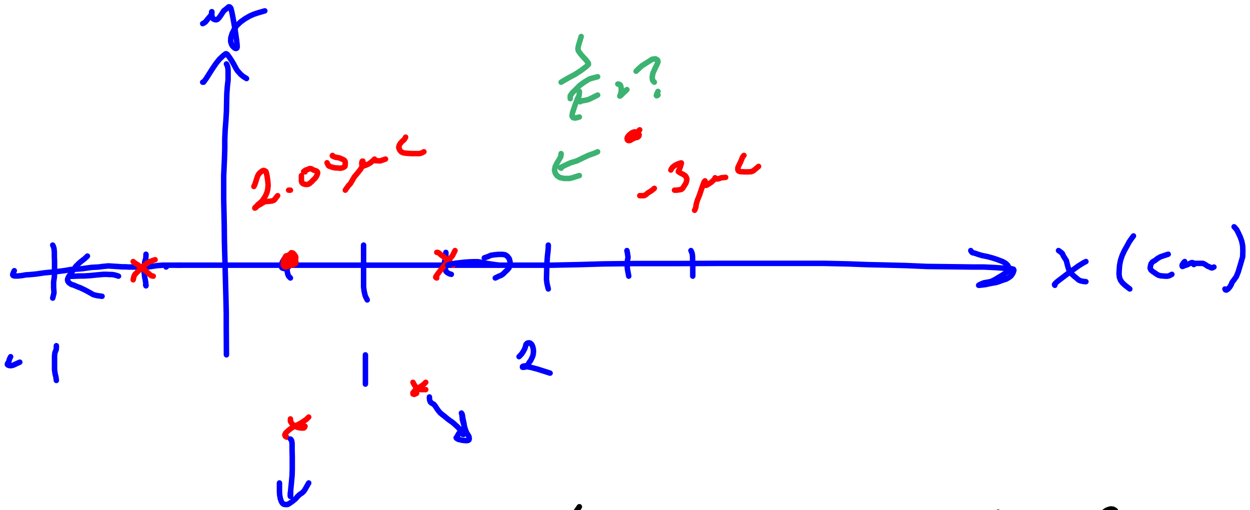
$$|\vec{F_e}| = k_e \frac{|q| q_0}{r^2}$$

$$|E| = |F_e|/q_0 = k_e \frac{|q|}{r^2}$$

Direction of **E**: away from q if q is positive; toward q if it's negative.



Going back to the previous example, let's find the electric field 1.00 cm away from the 2.00 μC charge.



$$E = k_e \, q/r^2 = \left(8.99\times10^9 \, N\cdot m^2/C^2\right)\cdot \frac{2.00\times10^{-6}\, C}{(0.0100\, m)^2}$$

$$= +1.80\times10^8 \, N/C$$

Direction - away

electric field units: newtons/coulomb

$$\vec{F}_e = q_i \vec{E} \qquad \left(q_i k_e \cdot q/r^2\right)$$

Homework: pp 524-526:
Problems 1, 3, 4, 17, 19, 23