PHYS 121 Jan. 15, 2024

To do:
- ✓ Complete PHYS 121 online survey by 23:59 tonight. Link to survey in Canvas.
- ✓ Complete HW1 by 23:59 on Wed. Jan. 17
- ✓ Complete HW2 by 23:59 on Fri. Jan. 19
- ✓ Labs & Tutorials start the week of Jan. 22

Last Time:
- two types of charges ⇒ pos. & neg.
- Likes repel, opposites attract
- Charged objects attract neutral objects due to polarization.

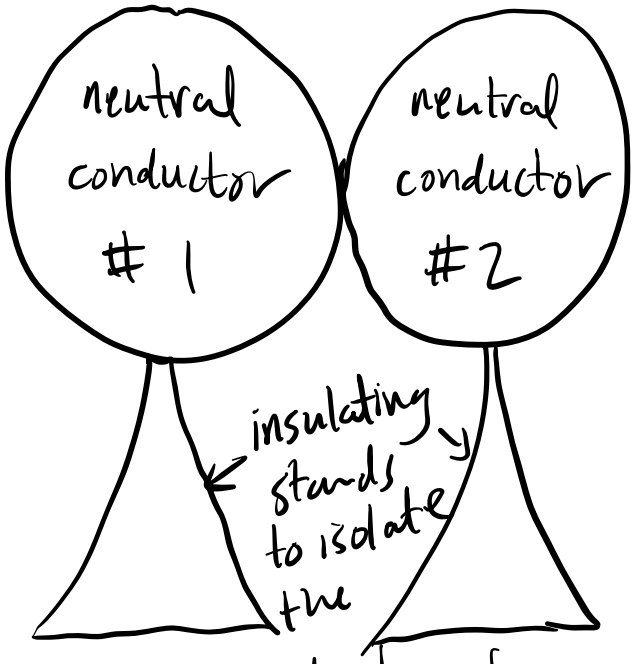
Today: Charging conductors by induction & Coulomb's Law

Charging by Induction

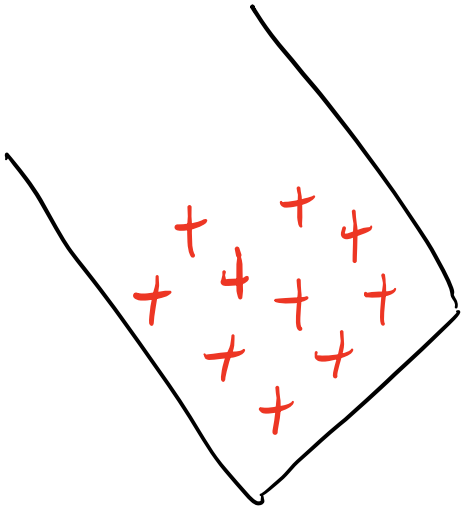
→ Charge conductors w/o touching them.

In conductors, some of the electrons are free to move throughout the material. They are not tied to any particular atom.

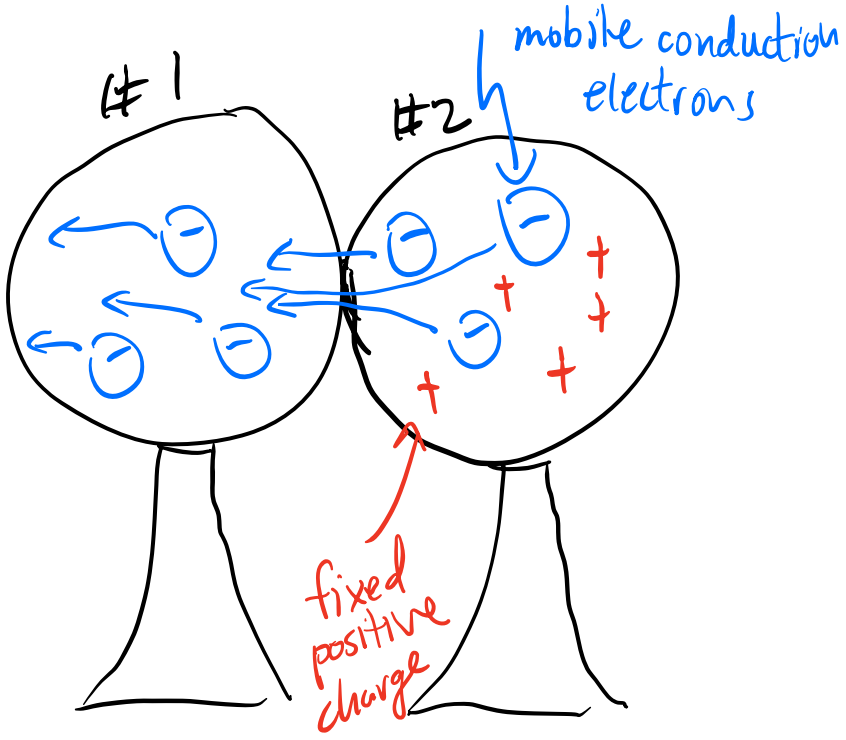
Step (A) Place two neutral conductors in contact with one another



Step (B) Bring a charged object next to, but not in contact with, the conductors

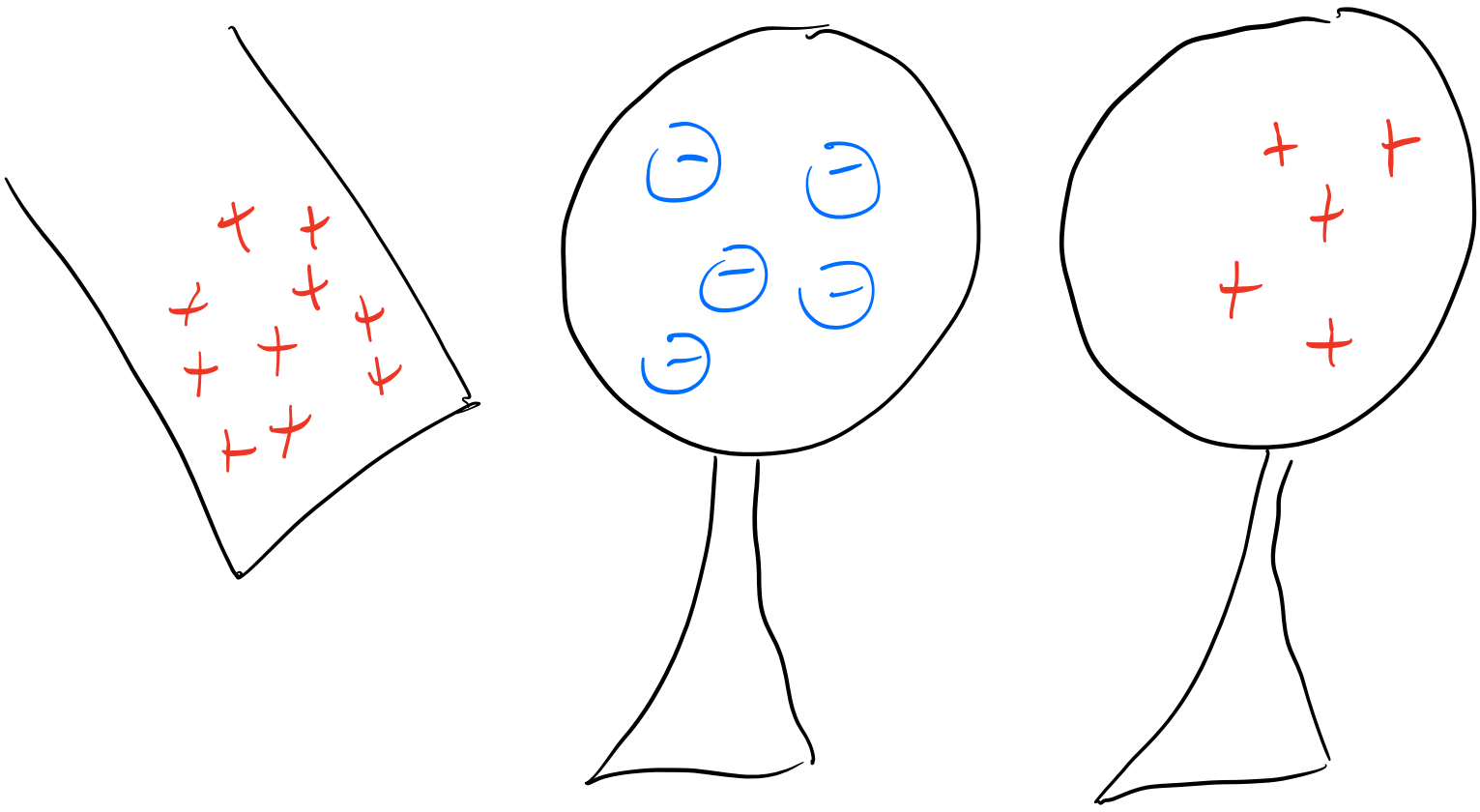


charged rod.



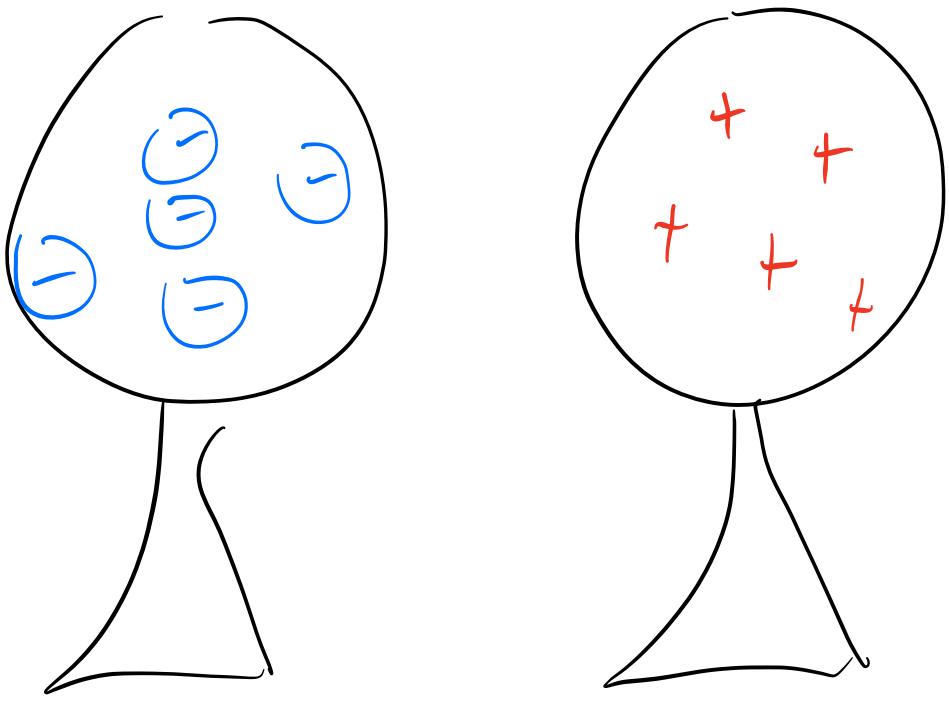
The positively-charge rod attracts mobile conduction electrons. Therefore, there is a migration of electrons from conductor #2 to conductor #1. This process leaves behind an excess positive charge on #2 due to fixed positive nuclei.

Step ⓒ With the positive rod still nearby, separate the two conductors.



Now have isolate negatively (#1) & positively (#2) charge conductors.

Step (D) Remove charged rod.



Section 5.3 from OSUPv2.

Coulomb's Law → Force between a Pair of point charges.

Observations:

1. Force is directed along a line joining the two charges.

2. Force is attractive if have opp. charges & repulsive if we have like charges.

3. Force is proportional to the inverse square of the separation distance r

"proportional to" ↙

$$|\vec{F}_{21}| = |\vec{F}_{12}| \propto \frac{1}{r^2}$$

4. Magnitude of the electrostatic force is also proportional to both q_1 & q_2.

$$|\vec{F}_{21}| = |\vec{F}_{12}| \propto |q_1||q_2|$$

Magnitude of electrostatic force is given by

Coulomb's Law

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

k_e: Coulomb's constant

$$k_e = 8.99 \times 10^9 \frac{N m^2}{C^2}$$

Often will see Coulomb's constant expressed as

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

where $\varepsilon_0 = \frac{1}{4\pi k_e} = 8.85 \times 10^{-12} \frac{C^2}{N m^2}$

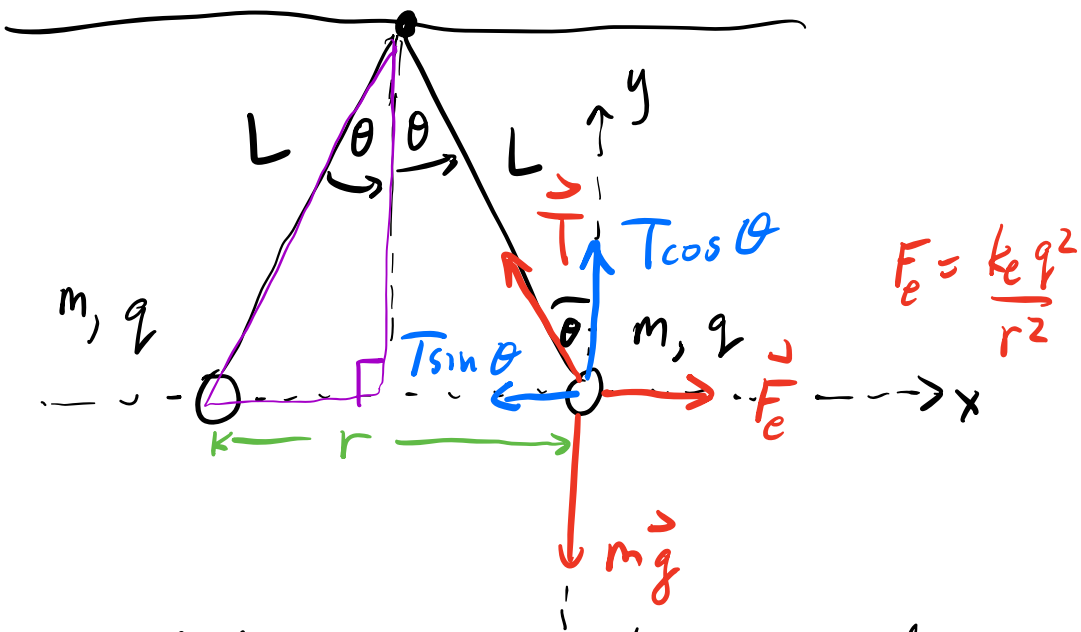
ε_0: permittivity of free space.

$$F = k_e \frac{|q_1||q_2|}{r^2} = \frac{1}{4\pi\varepsilon_0} \frac{|q_1||q_2|}{r^2}$$

similar to gravitation between masses

$$F_G = G\frac{m_1 m_2}{r^2}$$ similar to form of Coulomb's Law.

Example.



Suspend identical masses m with identical charges q from strings of length L. Find the value of θ.

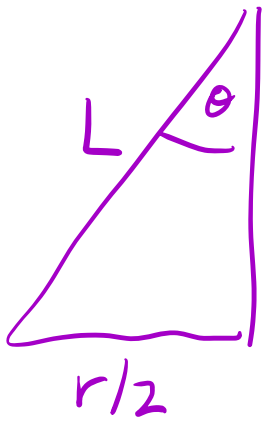
Vertical forces:

$$F_{net,y} = T\cos\theta - mg = 0$$

$$\therefore \quad T = \frac{mg}{\cos\theta}$$

Horizontal Forces

$$F_{net,x} = \frac{k_e q^2}{r^2} - T\sin\theta = 0$$



$$\sin\theta = \frac{r/2}{L}$$

$$\therefore \frac{r}{2L} = \sin\theta$$

$$\therefore r = 2L\sin\theta$$

$$\frac{k_e q^2}{(2L\sin\theta)^2} - \frac{mg}{\cos\theta}\sin\theta = 0$$

Rearrange s.t. everything involving θ is on the left.

$$\frac{\cos\theta}{\sin^3\theta} = \frac{mg\,4L^2}{k_e q^2}$$