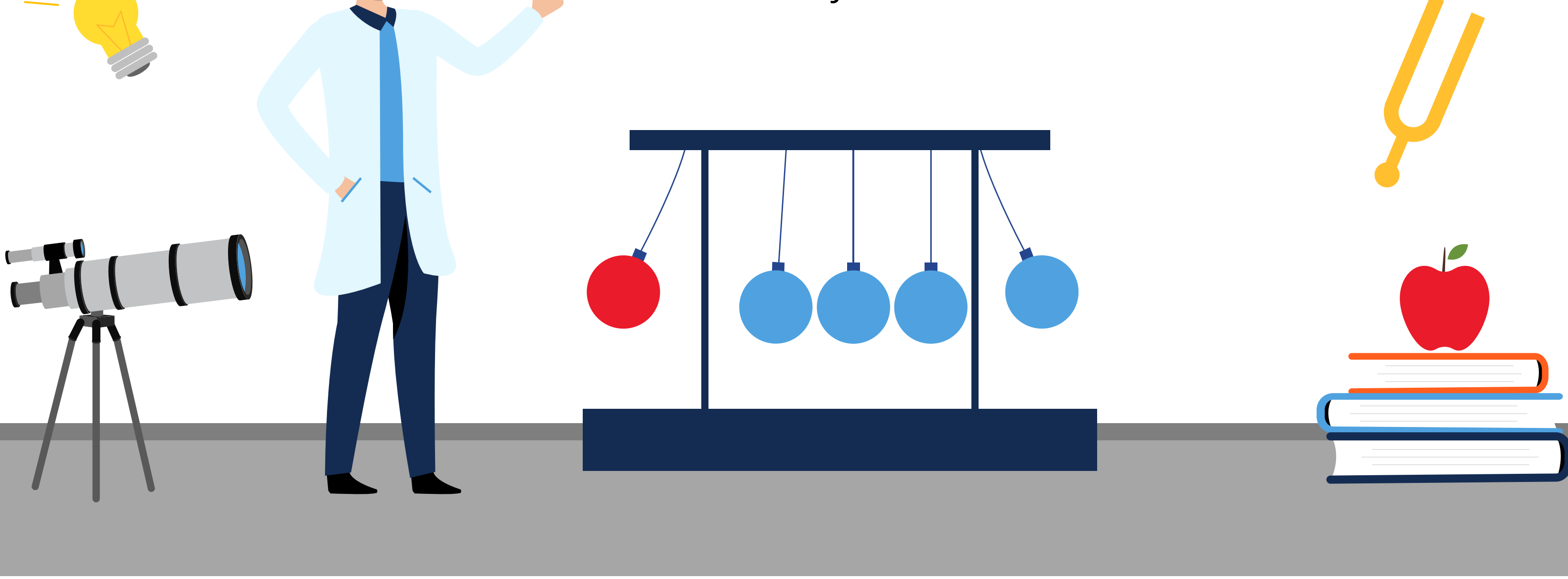
İstanbul Bilgi University

Course Khana

كورس خانة

PHYSICS II

Dr. Louay Karaker

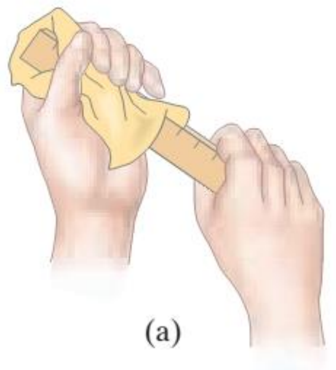


Electricity and Magnetism

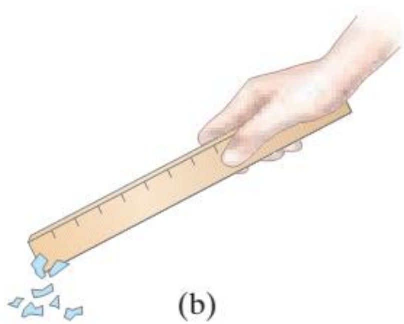
Richard Megna/Fundamental Photographs, NYC

Electric Charge and Electric Field

1 Static Electricity; Electric Charge and Its Conservation

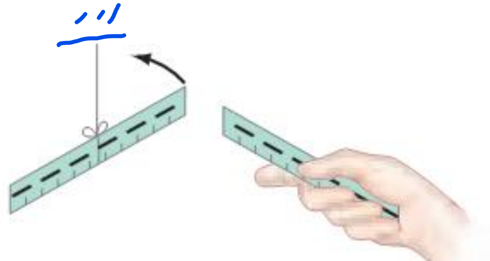


(a)

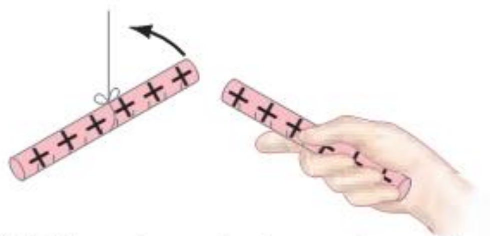


(b)

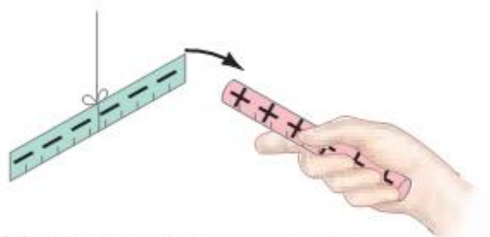
FIGURE 1 (a) Rub a plastic ruler and (b) bring it close to some tiny pieces of paper.



(a) Two charged plastic rulers repel



(b) Two charged glass rods repel



(c) Charged glass rod attracts charged plastic ruler

LAW OF CONSERVATION OF ELECTRIC CHARGE

2 Electric Charge in the Atom

قيمة الشحنة الالكترون واحد = قيمة الشحنة للبروتون واحد

إذا كسب الذرة الالكترونات ← الشحنة سالبة

" فقدت الذرة " ← " موجبة

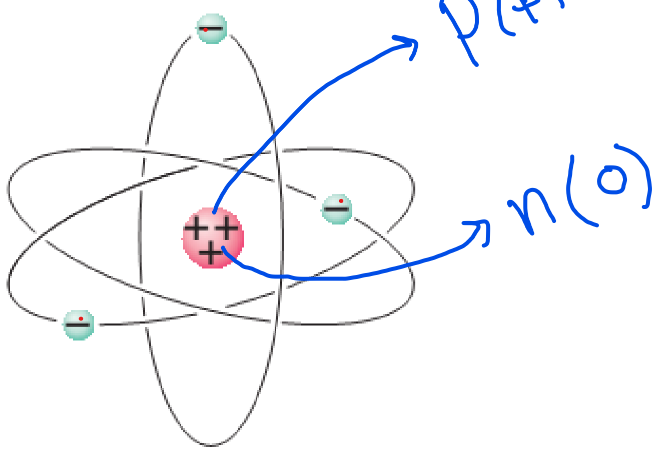


FIGURE 3 Simple model of the atom.

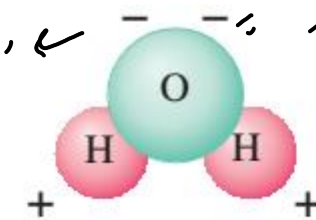


FIGURE 4 Diagram of a water molecule. Because it has opposite charges on different ends, it is called a "polar" molecule.

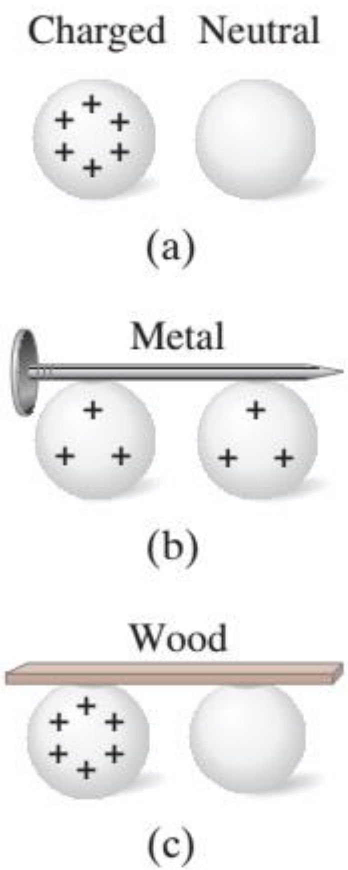
- ✓ q is the standard symbol used for electric charge
- ✓ Electric charge exists as discrete packets
- ✓ $q = Ne$
  - N is an integer
  - e is the fundamental unit of charge
- ✓ Electron: $q = -e$
- ✓ Proton: $q = +e$

$q = N \times e$

$q^- = 10(-e)$

$q^+ = 15(+e)$

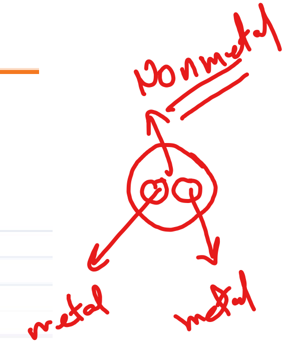
3 Insulators and Conductors



ناقل	عازل
Conductor:	**Insulator:**
Charge flows freely	Almost no charge flows
Metals	Most other materials

non conductor

Some materials are semiconductors.



4 Induced Charge; the Electroscope

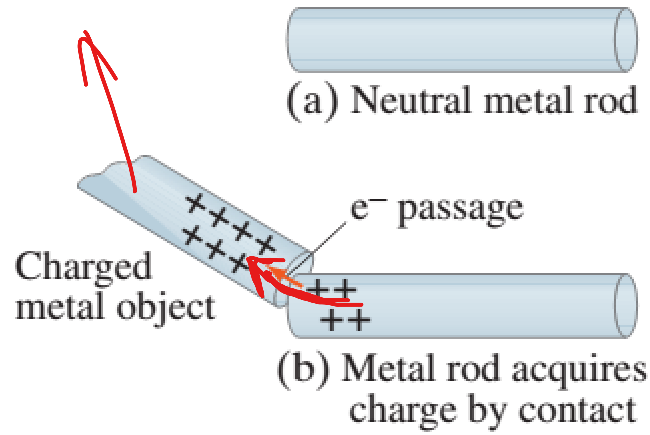


FIGURE 6 A neutral metal rod in (a) will acquire a positive charge if placed in contact (b) with a positively charged metal object. (Electrons move as shown by the orange arrow.) This is called charging by conduction.

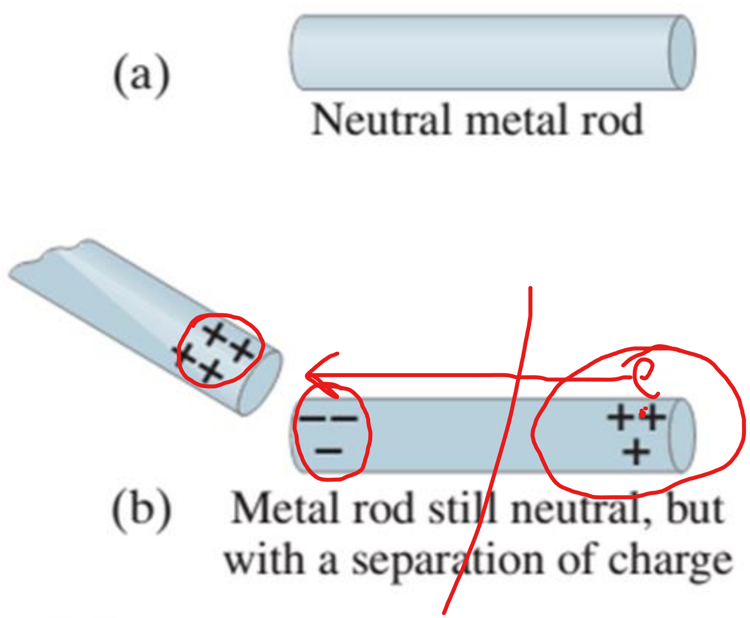


FIGURE 7 Charging by induction.

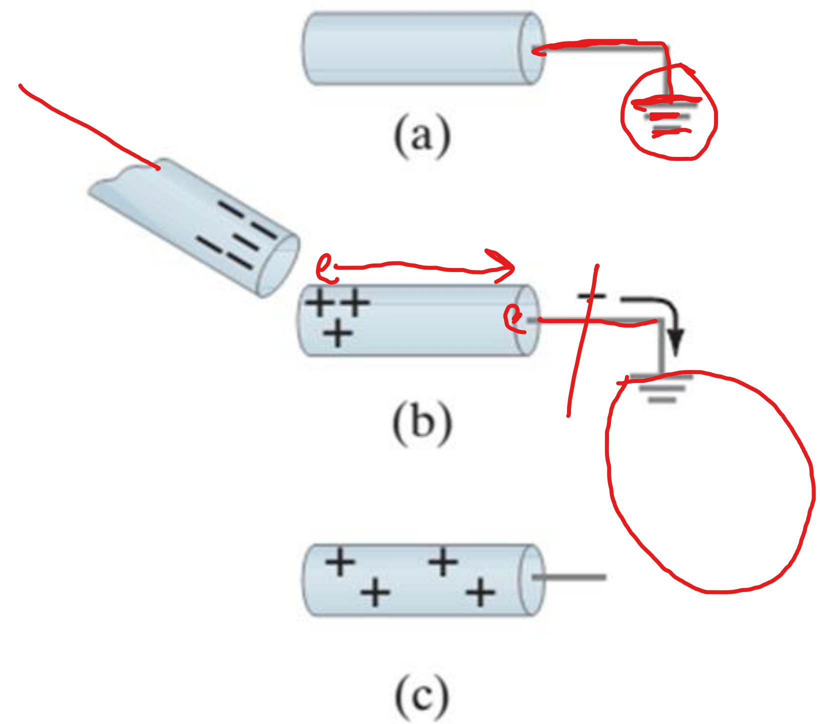


FIGURE 8 Inducing a charge on an object connected to ground.

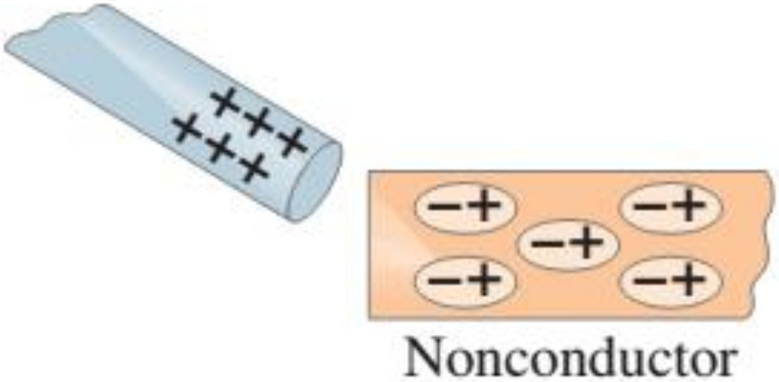


FIGURE 9 A charged object brought near an insulator causes a charge separation within the insulator's molecules.

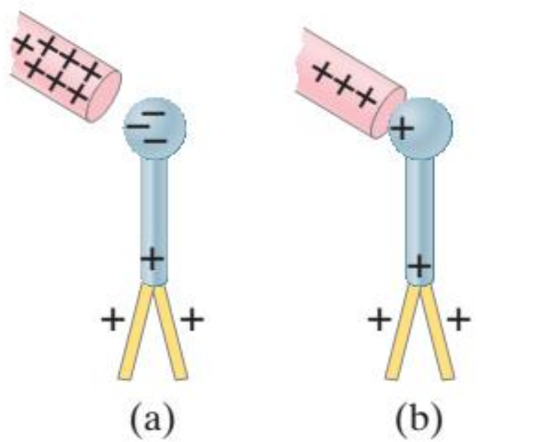


FIGURE 11 Electroscope charged (a) by induction, (b) by conduction.

FIGURE 12 A previously charged electroscope can be used to determine the sign of a charged object.

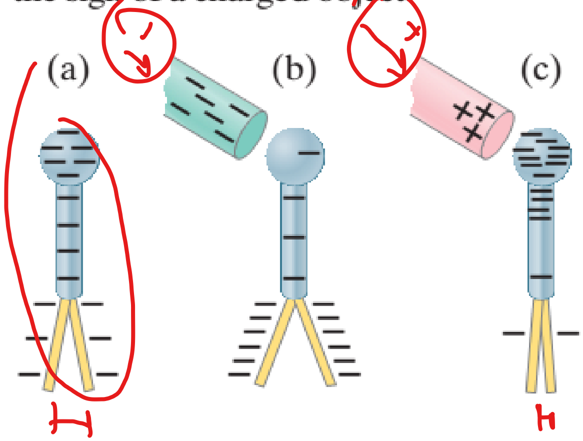
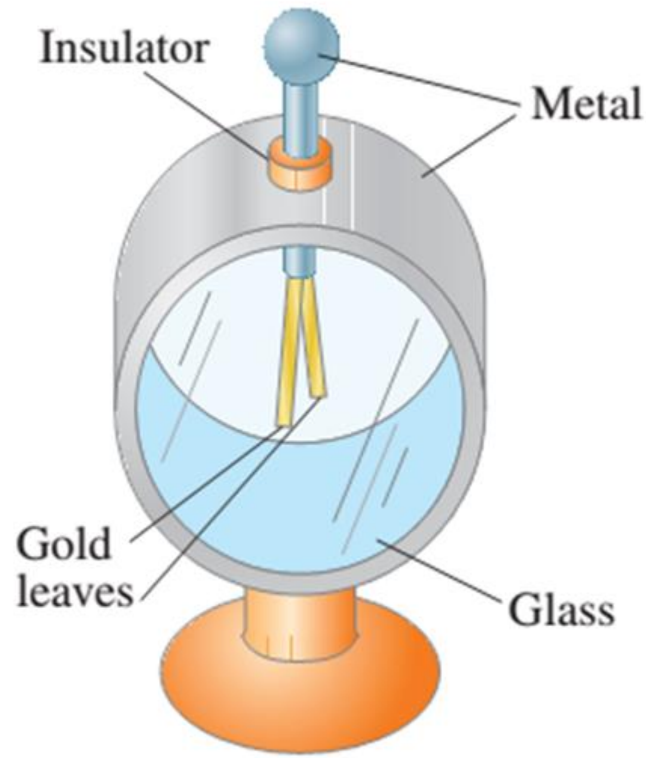
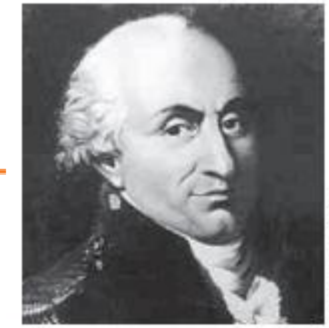


FIGURE 10 Electroscope.



5 Coulomb's Law

Scalar vs vector

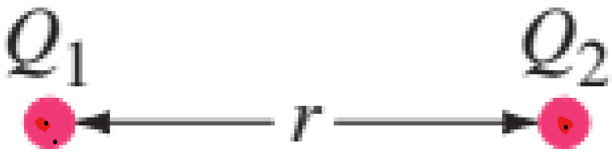


Charles Coulomb
French physicist (1736–1806)

Electric Force:

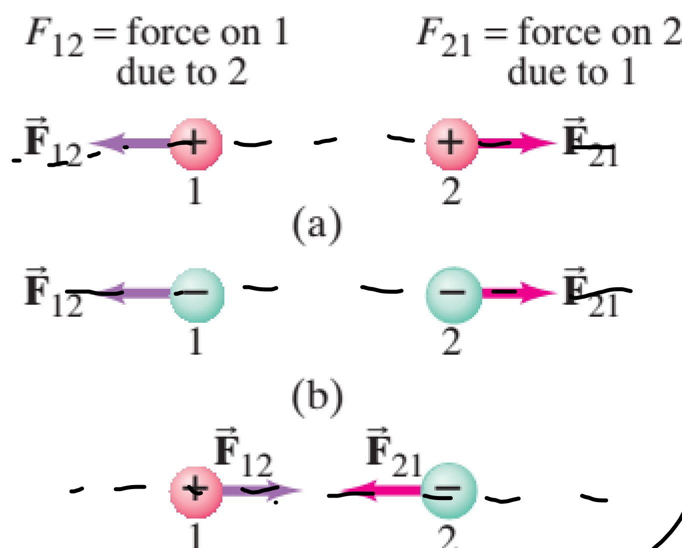
Direction

Magnitude



$F \propto Q_1, Q_2$

$F \propto \frac{1}{r^2}$



$$|\vec{F}| = k\frac{|Q_1 Q_2|}{r^2},$$

(N) (C) (C) (m)

where k is a proportionality constant.‡

Unit of charge: coulomb, C.

The proportionality constant in Coulomb's law is then:

$$k = 8.99 \times 10^9\ N \cdot m^2/C^2.$$ $= 9 \times 10^9$

Charges that we are going to deal with are in general in the order of microcoulombs:

$$1\ \mu C = 10^{-6}\ C.$$

Charge of the electron:

$$e = 1.602 \times 10^{-19}\ C.$$

Electric charge is quantized in units of the electron charge.

The proportionality constant k can also be written in terms of ϵ_o, the permittivity of free space:

$$F = k\frac{|Q_1 Q_2|}{r^2} = \frac{1}{4\pi\epsilon_o}\frac{|Q_1 Q_2|}{r^2}$$

where

$$\epsilon_o = \frac{1}{4\pi k} = 8.85 \times 10^{-12} C^2/N \cdot m^2$$

$q_1 = 5 \times 10^{-6}\ C$

$q_1 = 5\ \mu C$

$= 5 \times 10^{-6}\ C$

$q_2 = -10\ \mu C$

$= -10 \times 10^{-6}\ C$

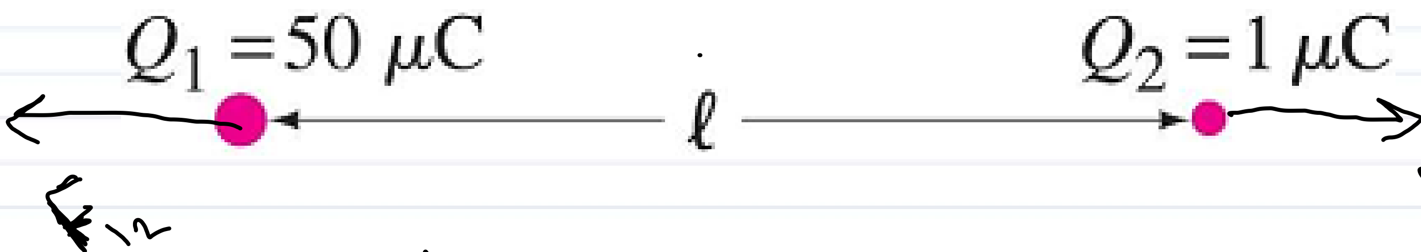
$q_3 = +80\ nC$

$= +80 \times 10^{-9}\ C$

21.5 Coulomb's Law – Example 21-1

Which charge exerts the greater force?

For the two positive charges with $Q_1 = 50\mu C$ and $Q_1 = 1\mu C$, determine which one exerts a larger force on the other?



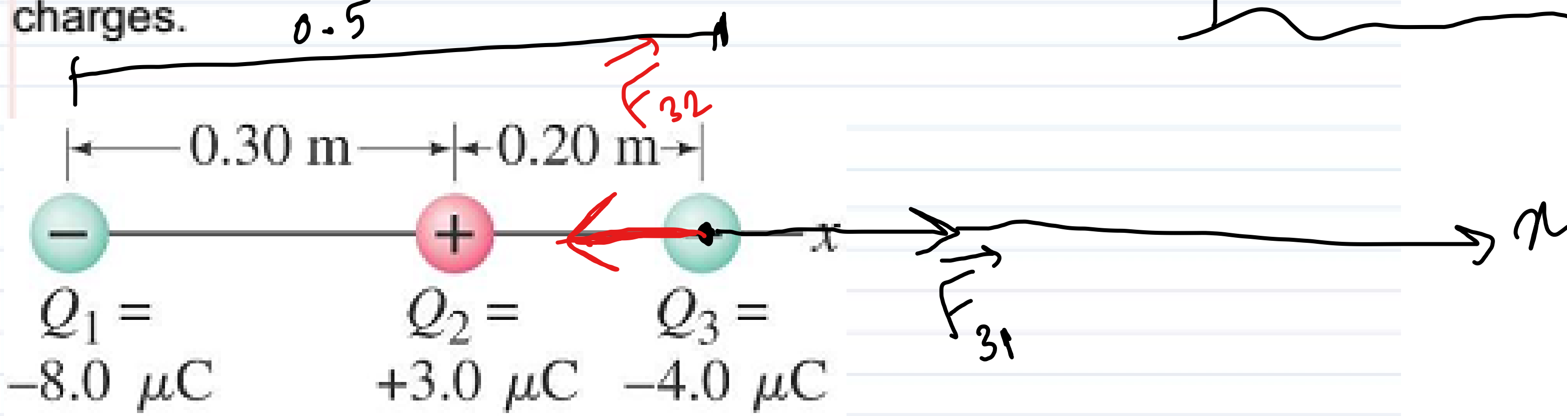
$$|F_{12}| = k\frac{|Q_1 Q_2|}{\ell^2} = F_{21} = k\frac{|Q_2 Q_1|}{\ell^2}$$

21.5 Coulomb's Law – Example 21-2

Three charges on a line.

Three charged particles are arranged in a line, as shown. Calculate the net electrostatic force on particle 3 (the -4.0 μC on the right) due to the other two charges.

$$|\vec{F}| = k\frac{|Q_1 Q_2|}{r^2}$$



$$|\vec{F}_{31}| = k\frac{|Q_3 Q_1|}{r_{31}^2} = 9\times10^9\,\frac{4\times10^{-6}\times8\times10^{-6}}{(0.5)^2} = 1.152\ \text{N}$$

$$|\vec{F}_{32}| = k\frac{|Q_3 Q_2|}{r_{32}^2} = 9\times10^9\,\frac{4\times10^{-6}\times3\times10^{-6}}{(0.2)^2} = 2.7\ \text{N}$$

Force in vector

$F_{net} = |F_{31}| + |F_{32}|$

$\vec{F_3} = \vec{F_{31}} + \vec{F_{32}}$

$= 1.152 + 2.7$

$=$

$\vec{F_{31}} = 1.152\ \hat{i}$

$\vec{F_{32}} = -2.7\ \hat{i}$

$\Rightarrow \vec{F_3} = 1.152\ \hat{i} + (-2.7)\ \hat{i}$

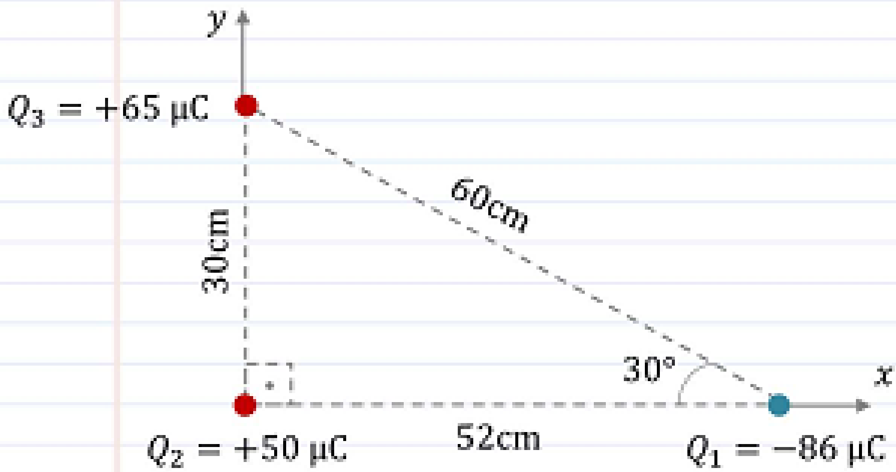
$\vec{F_3} = -1.548\ \hat{i}$ (N)

$|\vec{F_3}| = 1.548\ N$

21.5 Coulomb's Law – Example 21-3

Electric force using vector components.

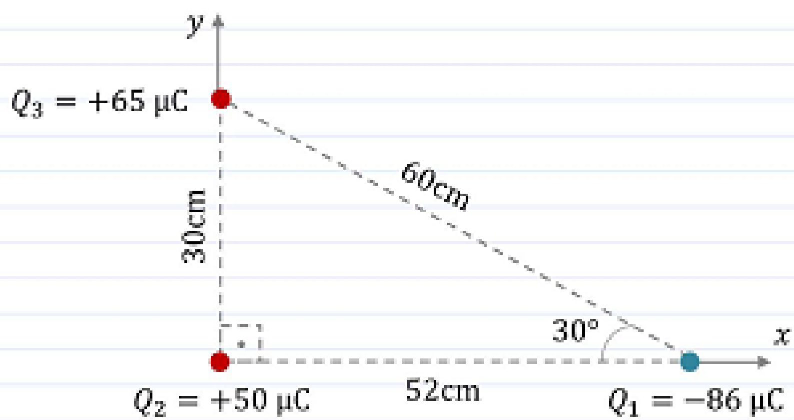
Calculate the net electrostatic force on charge Q_3 shown in the figure due to the charges Q_1 and Q_2.



21.5 Coulomb's Law – Homework 21-1

Consider the previous problem. Make the force on Q_3 zero.

Where could you place a fourth charge, Q_4 = -50 μC, so that the net force on Q_3 would be zero?



ANY QUESTION

THANK YOU