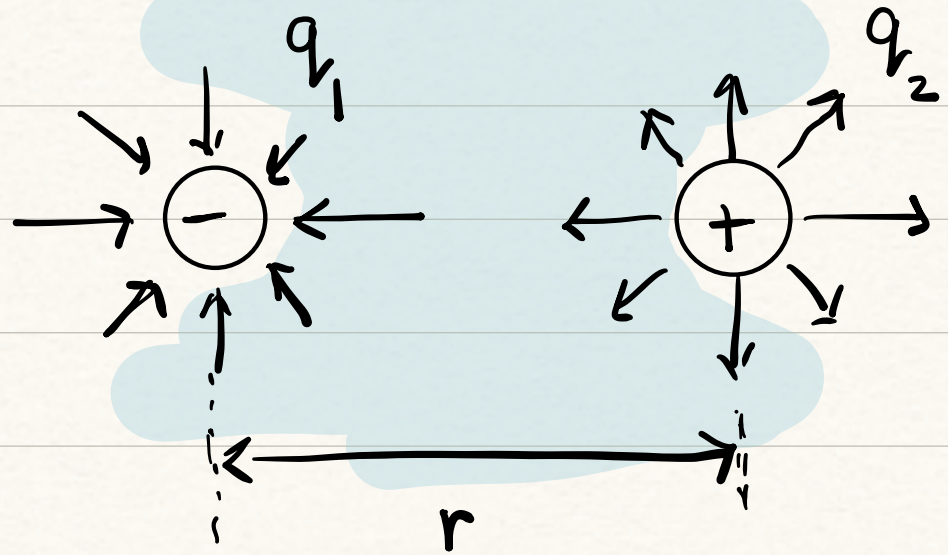


# Coulomb's Law

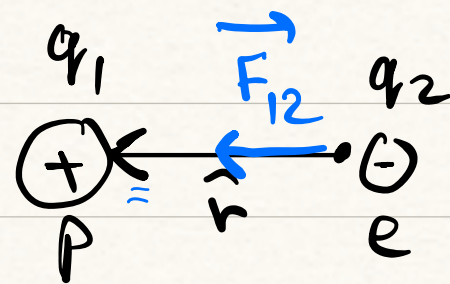
$$\vec{F}_{12} = K \frac{|q_1| |q_2|}{r_{12}^2} \hat{r}_{12}$$
$$K = \frac{1}{4\pi\epsilon_0}$$



## Example 1

an electron & proton of hydrogen atom are separated on average by distance of approximately  $5.3 \times 10^{-11}$  m. Find the magnitude of the electric force & gravitational force between the two particles & the ratio  $F_e/F_g$ . Then compute the acceleration caused by the electric force of the proton on electron & repeat it for the gravitational acceleration.

$$\boxed{1} \quad \vec{F}_{12} = k \frac{|q_1| |q_2|}{r^2} = 9 \times 10^9 \frac{(1.6 \times 10^{-19}) (1.6 \times 10^{-19})}{(5.3 \times 10^{-11})^2} = 8.2 \times 10^{-8} \text{ N}$$



$$\boxed{2} \quad \vec{F}_g = G \frac{m_p m_e}{r^2} = 6.674 \times 10^{-11} = \frac{(1.67 \times 10^{-27}) (9.11 \times 10^{-31})}{(5.3 \times 10^{-11})^2} = 3.61 \times 10^{-47} \text{ N}$$

$$\frac{F_c}{F_g} = \frac{8.2 \times 10^{-8}}{3.61 \times 10^{-47}} = 2 \times 10^{39} \quad \left. \vphantom{\frac{F_c}{F_g}} \right\} \begin{array}{l} \text{the gravitational} \\ \text{force is} \\ \text{negligible} \end{array}$$

$$F_c = m_e a_c \Rightarrow a_c = \frac{F_c}{m_e} = \frac{8.2 \times 10^{-8}}{9.11 \times 10^{-31}} = 9 \times 10^{22} \text{ m/s}^2$$

$$F_g = m_e a_g \Rightarrow a_g = \frac{F_g}{m_e} = \frac{3.61 \times 10^{-47}}{9.11 \times 10^{-31}} = 3.9 \times 10^{-17} \text{ m/s}^2$$

## Example 2

Consider three point charges as shown in figure

Where:

$$\begin{aligned} q_1 &= 6 \times 10^{-9} \text{ C} \\ q_2 &= 2 \times 10^{-9} \text{ C} \\ q_3 &= 5 \times 10^{-9} \text{ C} \end{aligned}$$

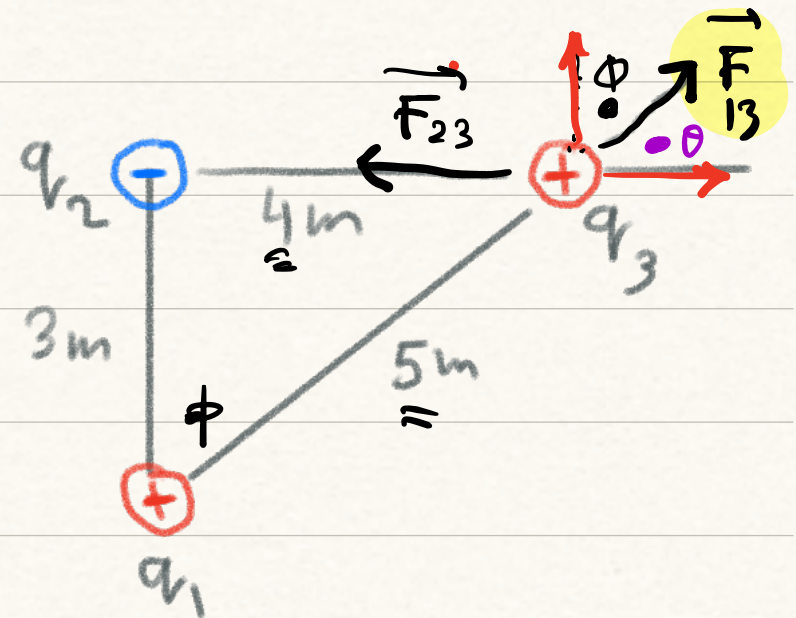
① Find the components of the force  $\vec{F}_{23}$  exerted by  $q_2$  on  $q_3$

② Find the components of the force  $\vec{F}_{13}$  exerted by  $q_1$  on  $q_3$

③ Find the resultant force on  $q_3$  both magnitude & direction

$$\begin{aligned} \vec{F}_{23} &= K \frac{|q_2| |q_3|}{r^2} \hat{r}_{23} \\ \vec{F}_{23} &= 9 \times 10^9 \frac{2 \times 10^{-9} \cdot 5 \times 10^{-9}}{16} = 5.625 \times 10^{-9} \text{ N} \\ \vec{F}_{23} &= -5.625 \times 10^{-9} \hat{i} \end{aligned}$$

$$\vec{F}_{13} = K \frac{|q_1| |q_3|}{r^2} \hat{r}_{13}$$



$$\vec{F}_{13} = 9 \times 10^9 \frac{6 \times 10^{-9} \cdot 5 \times 10^{-9}}{25} = 1.08 \times 10^{-8} \text{ N}$$

$$\left. \begin{aligned} F_{13x} &= F_{13} \cos \theta \\ F_{13x} &= (1.08 \times 10^{-8}) \cos 37 \\ F_{13x} &= 8.64 \times 10^{-9} \end{aligned} \right\} \begin{aligned} \sin \phi &= \frac{4}{5} \\ \phi &= \sin^{-1} (4/5) \\ \phi &= 53^\circ \end{aligned}$$

المركبة السينية

$$\theta = 90 - 53 = 37^\circ$$

$$F_{13y} = F_{13} \cdot \sin \theta$$

$$F_{13y} = (1.08 \times 10^{-8}) \sin 37 = 6.5 \times 10^{-9} \text{ N}$$

$$\vec{F}_{13} = \underline{8.64 \times 10^{-9} \hat{i}} + 6.5 \times 10^{-9} \hat{j} \quad *$$

$$\vec{F}_r = \vec{F}_{23} + \vec{F}_{13} = \underline{3.015 \times 10^{-9} \hat{i}} + \underline{6.5 \times 10^{-9} \hat{j}} \quad \text{المجموع}$$

$$F_r = \sqrt{(3.015 \times 10^{-9})^2 + (6.5 \times 10^{-9})^2} = \underline{\underline{7.16 \times 10^{-9} \text{ N}}}$$

$$\theta = \tan^{-1} \left[ \frac{6.5 \times 10^{-7}}{3.015 \times 10^{-7}} \right] = 65.1^\circ$$

