Lecture 3 (12-1)

Sunday, February 28, 2021 1:41 AM

23.3 Coulomb's Law

Point charge → of zero volume.

- The magnitude of the electric force between two point charges is given by:

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

$r \equiv$ distance between q_1 and q_2

$k_e \equiv$ Coulomb's constant $\sim 9 \times 10^9 \frac{N \cdot m^2}{C^2}$

$k_e = \frac{1}{4\pi\varepsilon_0}$, $\varepsilon_0 \equiv$ permitivity of free space

$\approx 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}$

See Table 23.1 [electron vs proton vs neutron]

$|q_e| = |q_p| = 1.6 \times 10^{-19}$ C

$m_p = 1.67 \times 10^{-27}$ kg , $m_e = 9.11 \times 10^{-31}$ kg

Ex 23.1: $r = 5.3 \times 10^{-11}$ m $F_e = ?$, $F_g = ?$

$$F_e = k_e \frac{|q_e||q_p|}{r^2} = \cdots \Rightarrow \boxed{F_e = 8.2 \times 10^{-8}\ N}$$

$F_g = 3.6 \times 10^{-47}$ N

$F = k_e$

$$F_g = G\,\frac{m_e m_p}{r^2} = \cdots \Rightarrow \boxed{F_g = 3.6\times 10^{-47}\ \text{N}}$$

$\hookrightarrow = 6.674\times 10^{-11}\ \frac{N\cdot m^2}{kg^2}$

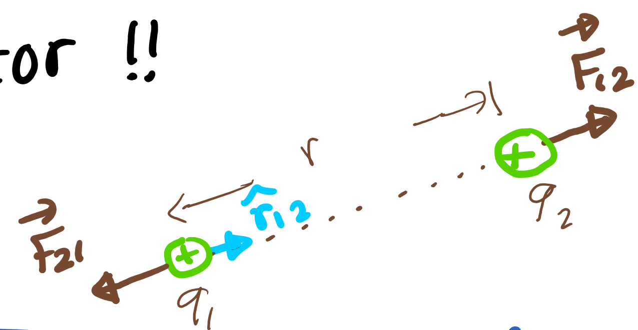
Note that $\frac{F_e}{F_g} \approx 2\times 10^{39}$!!

$\hookrightarrow$ F_g between charged atomic particles is negligible compared to F_e.

Force is a vector !!

$\vec{F}_{12}$: by q_1 on q_2

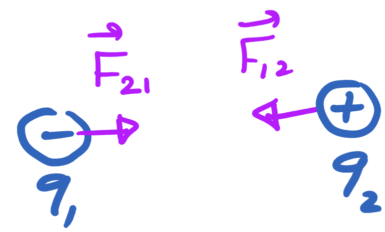
$\vec{F}_{21}$: by q_2 on q_1



$$\boxed{\vec{F}_{12} = k_e\,\frac{q_1 q_2}{r^2}\,\hat{r}_{12}} \Rightarrow \text{Vector form of Coulomb's law}$$

$\hat{r}_{12} \equiv$ unit vector directed from q_1 to q_2.

Note that $\vec{F}_{21} = -\vec{F}_{12}$



- If you have more point charges !!

↳ For instance, if you have 4 point charges ⇒ Net force on q_1 = ?

⇒ $\vec{F}_1 = \vec{F}_{21} + \vec{F}_{31} + \vec{F}_{41}$

Question: If the force between Q_1 and Q_2 has a magnitude of F when the distance between the charges is r. Now if $r \to 3r$ ⇒ F_{new} = ?

$$F = k_e \frac{Q_1 Q_2}{r^2}$$

$$F_{new} = k_e \frac{Q_1 Q_2}{(3r)^2} = \underbrace{k_e \frac{Q_1 Q_2}{r^2}}_{F} \frac{1}{9}$$

$$\Rightarrow \boxed{F_{new} = \frac{F}{9}}$$

QQ 23.3 / Page 696 : $q_A = +2\,\mu C$
$q_B = +6\,\mu C$

Answer is (b)

$$\vec{F}_{AB} = -\vec{F}_{BA}$$