LAKSHYA JEE

LAKSHYA KO HAR HAAL ME PAANA HAI

Electrostatics

-Er. Rohit Gupta

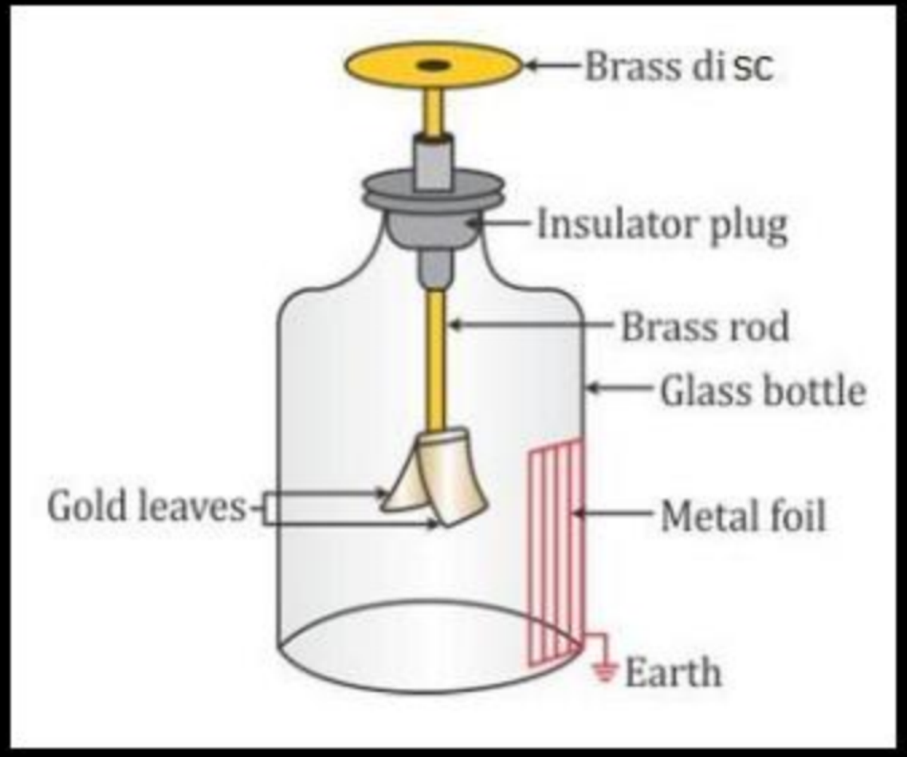
Charles Augustin de Coulomb

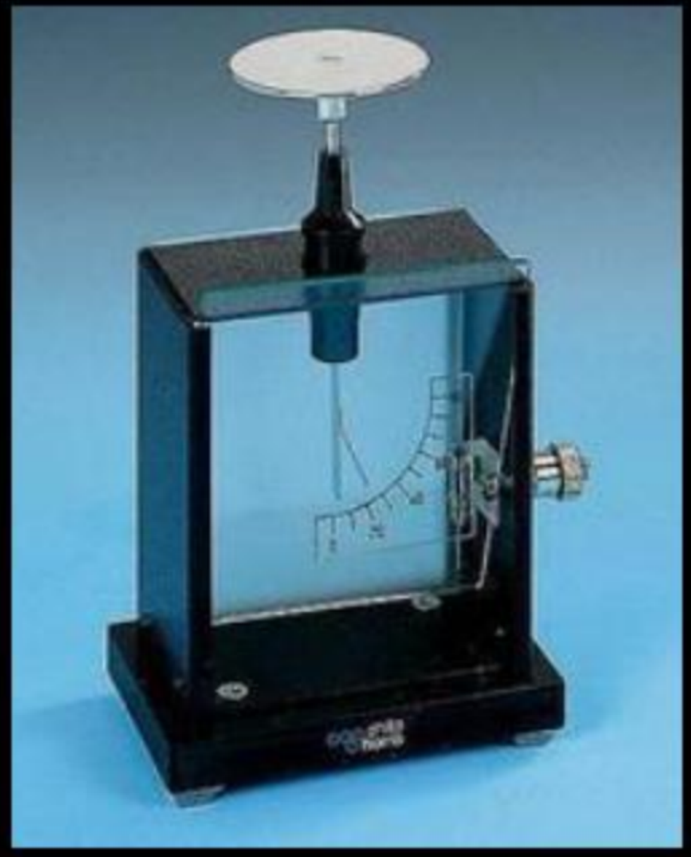
Today's GOAL!

Coulomb's Law (1785)
Principle of Superposition
Effect of medium

Electroscope

The electroscope is an instrument used to detect the presence of electric charge on a body.





Working of Electroscope

Coulomb's Law

The electrostatic force between two point charges is directly proportional to the product of the charges & inversely proportional to the square of distance between them.

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

$K = 9 \times 10^9 \ N m^2/C^2$

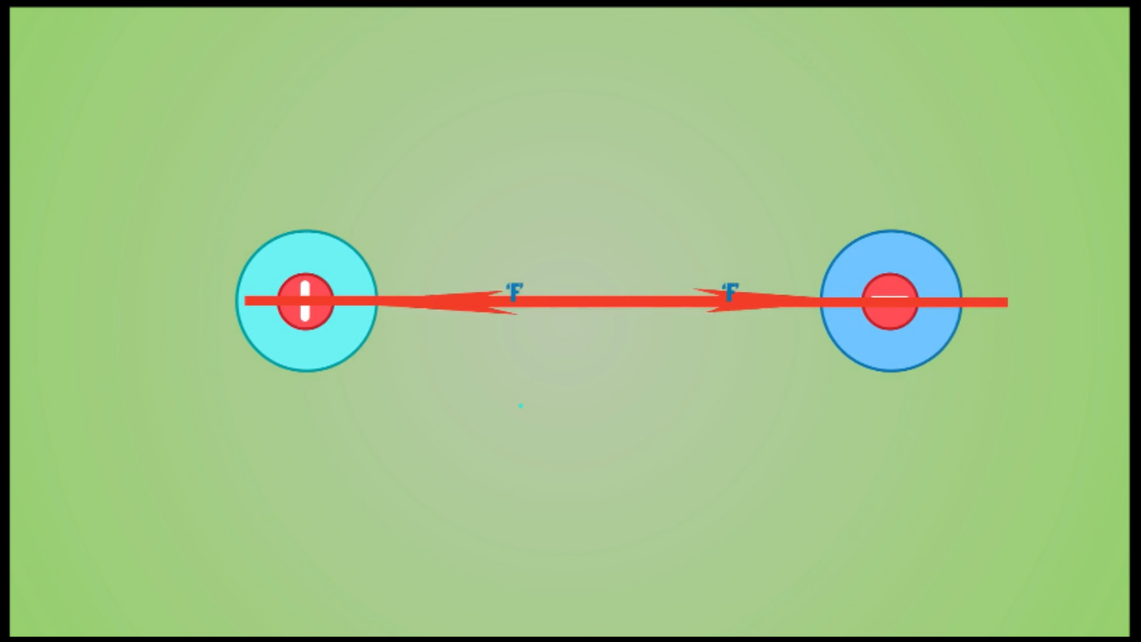
$K = 1 \ \text{dyne cm}^2/(\text{Stat C})^2$

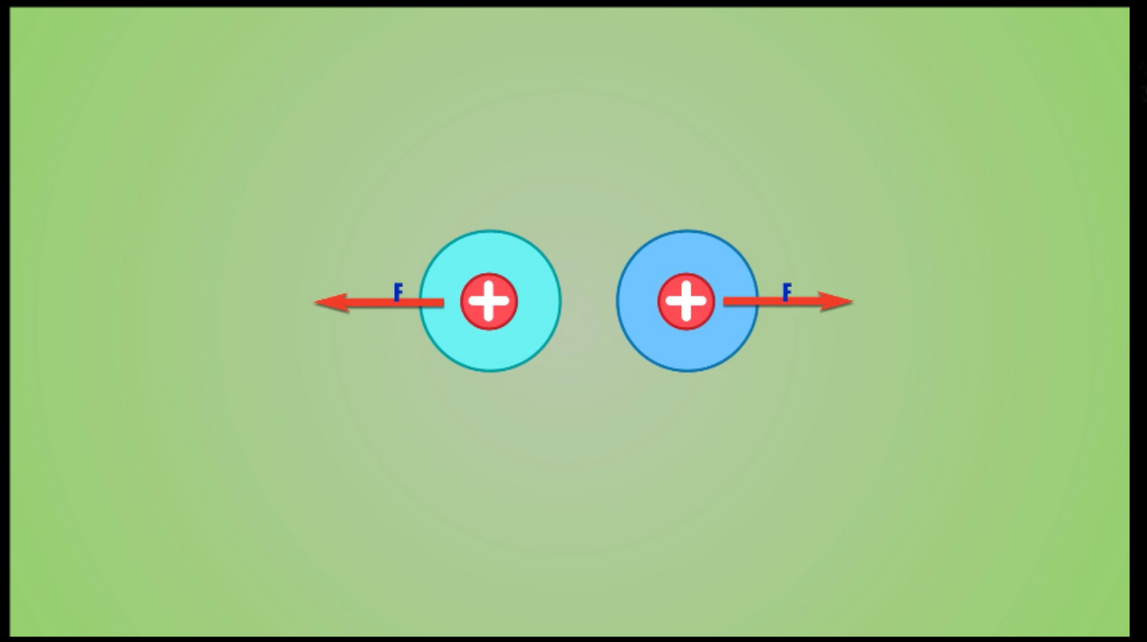
$$K = \frac{1}{4\pi\varepsilon_0}$$

↳ permitivity of vacuum

free space

$$\varepsilon_0 = 8.854 \times 10^{-12} \; N^{-1} m^{-2} C^2$$


F
F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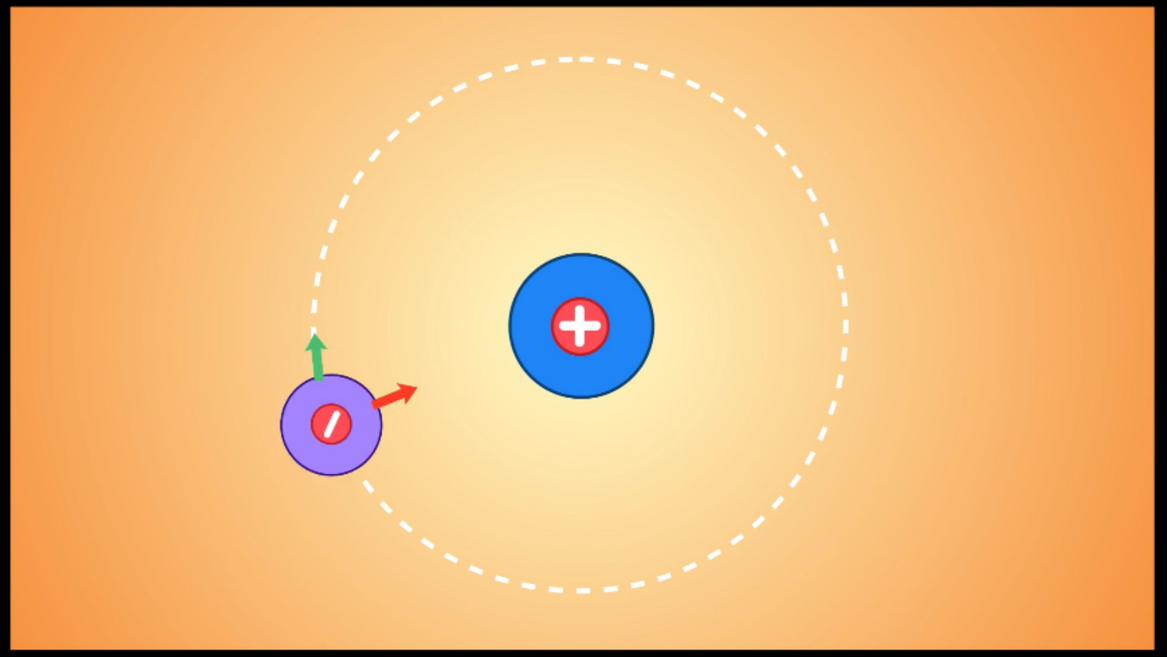
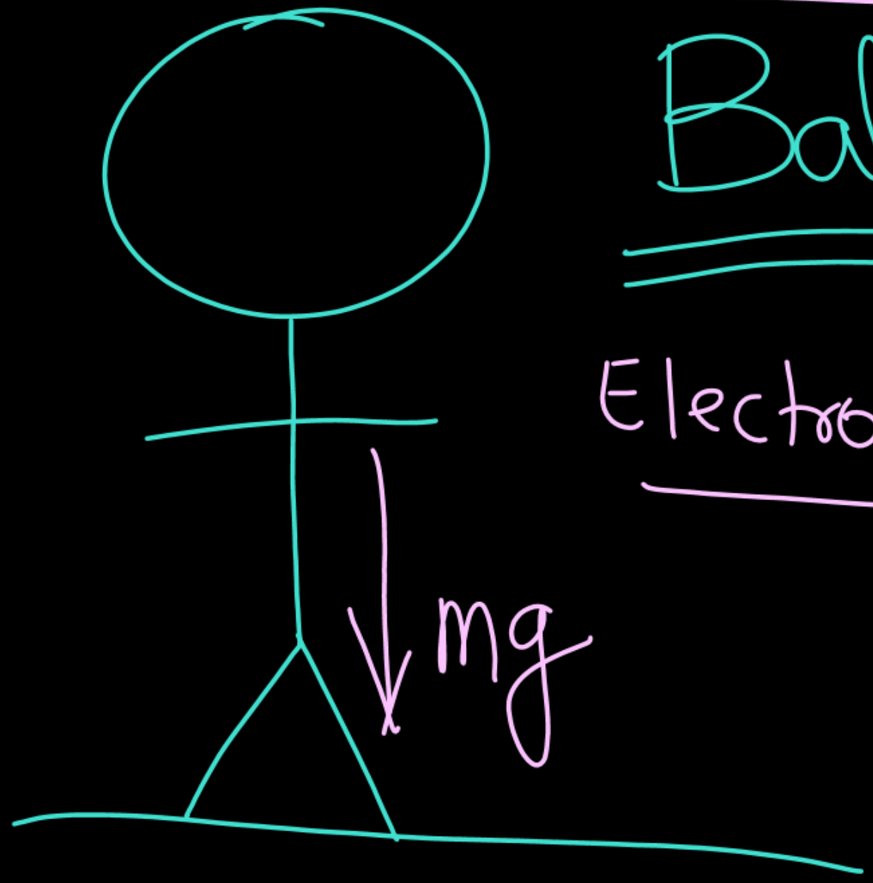
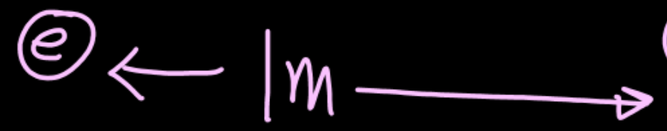


Electrostatic vs Gravitational force



Bala

Electrostatics



$e = -1.6 \times 10^{-19} C$

$m = 9.1 \times 10^{-31} kg$

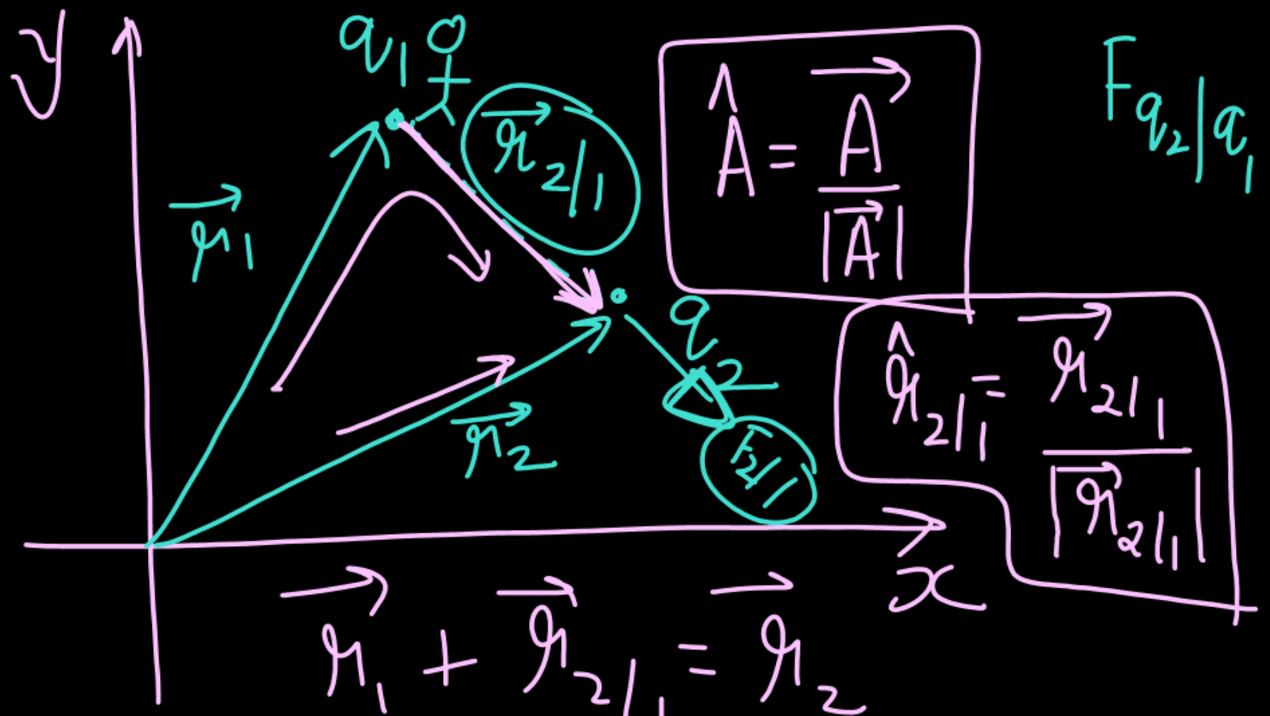
$$F_e = \frac{9 \times 10^9 \times (-1.6 \times 10^{-19})^2}{1^2}$$

$$F_g = \frac{(6.67 \times 10^{-11}) \times (9.1 \times 10^{-31})^2}{1^2}$$

$$\frac{F_e}{F_g} = \frac{9 \times 2.56 \times 10^9 \times 10^{-38}}{6.67 \times 81 \times 10^{-62}}$$

$$= \frac{2.56 \times 9}{6.67 \times 81} \times 10^{9+62-38}$$

Coulomb's law in vector form



$$\hat{A} = \frac{\vec{A}}{|\vec{A}|}$$

$$\hat{r}_{2|1} = \frac{\vec{r}_{2|1}}{|\vec{r}_{2|1}|}$$

$$F_{q_2|q_1} = \frac{K q_1 q_2}{(r_{2|1})^2}\,\hat{r}_{2|1}$$

$\hat{r}_{2|1}$ ↓ unit vector along $\vec{r}_{2|1}$.

$$= \frac{K q_1 q_2}{(\vec{r}_2 - \vec{r}_1)^2}\left[\frac{(\vec{r}_{2|1})}{|\vec{r}_{2|1}|}\right]$$

$$= \frac{K q_1 q_2}{(\vec{r}_2 - \vec{r}_1)^2}\,\frac{(\vec{r}_2 - \vec{r}_1)}{|\vec{r}_2 - \vec{r}_1|}$$

$\vec{r}_1 + \vec{r}_{2|1} = \vec{r}_2$

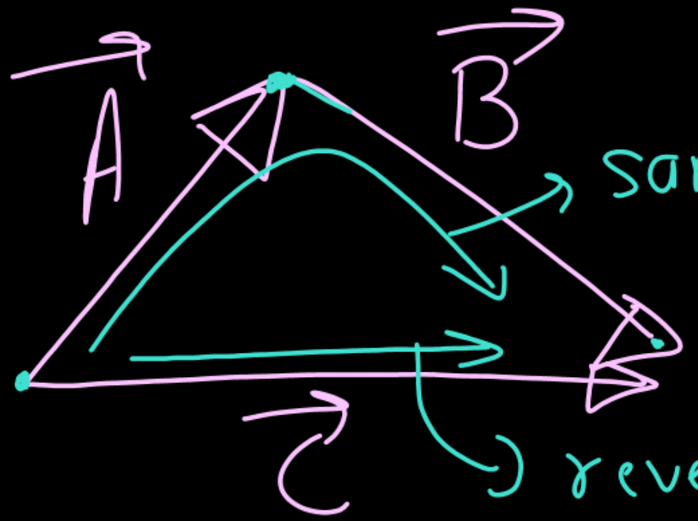
same order → out of order.

$$\vec{r}_{2|1} = \vec{r}_2 - \vec{r}_1$$

$$\vec{F}_{2|1} = \frac{k q_1 q_2 \left(\vec{r}_2 - \vec{r}_1\right)}{\left|\vec{r}_2 - \vec{r}_1\right|^3}$$

Put q_1 & q_2 with sign.

Vectors Basic



$$\vec{A} + \vec{B} = \vec{C}$$

cap

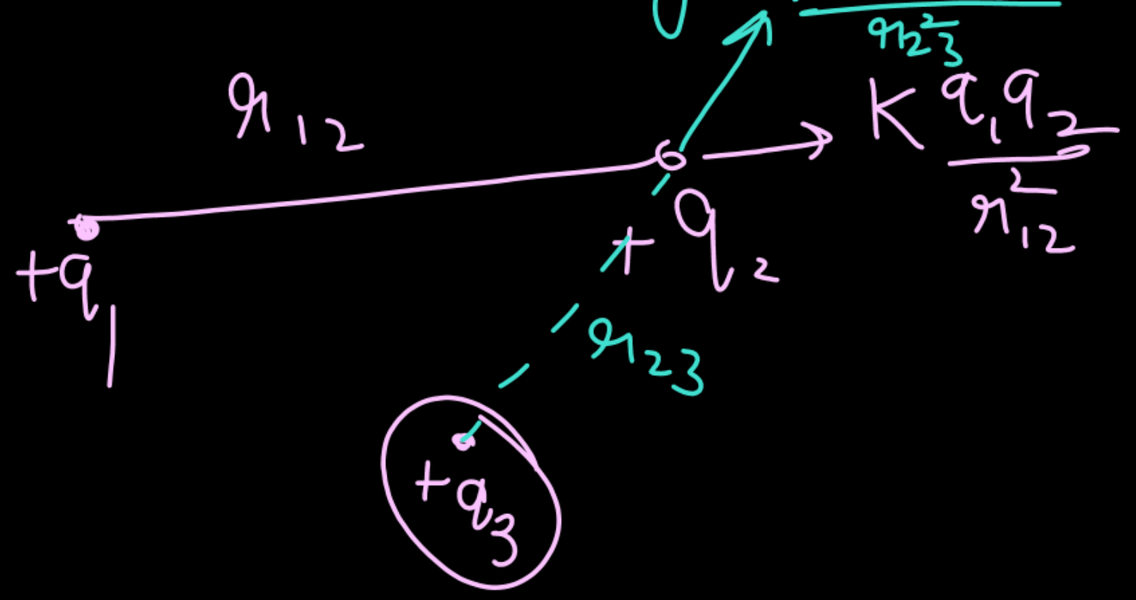
$$\hat{A} = \frac{\vec{A}}{|\vec{A}|}$$

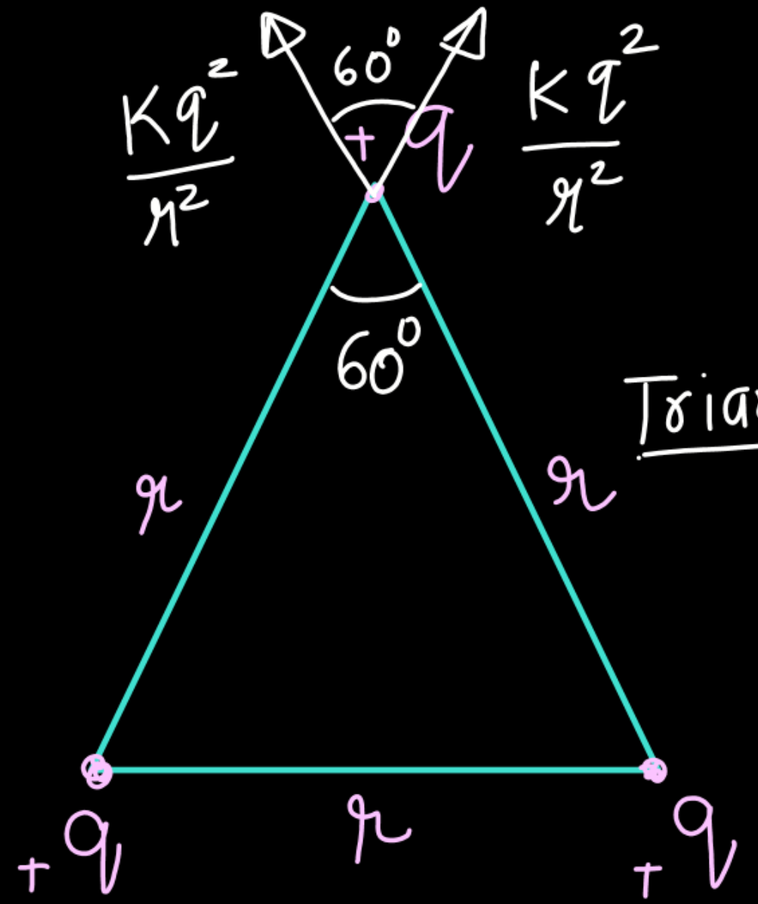
unit vector

$$|\hat{A}| = 1$$

Principle of Superposition

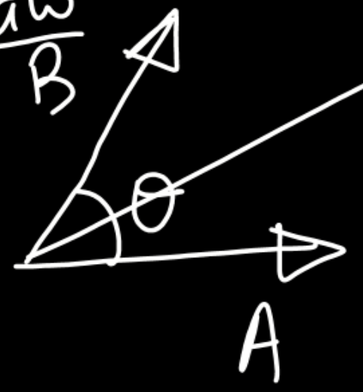
Electrostatic force on one charge particle due to other is independent of any third charge particle in surrounding.





Find the net force on any one of the charge particles.

Triangle law



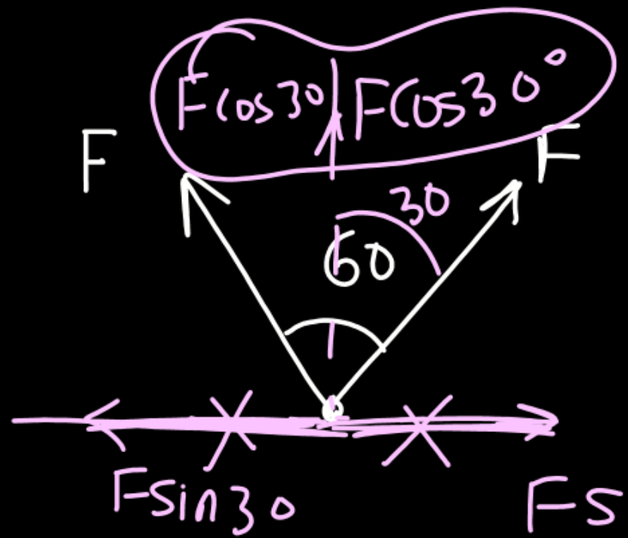
$$R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$$

If $A = B$.

$$R = 2A\cos\frac{\theta}{2}$$

$$R = 2A\cos\left(\frac{60^{30}}{2}\right)$$

$$= \cancel{2}A\frac{\sqrt{3}}{\cancel{2}}$$

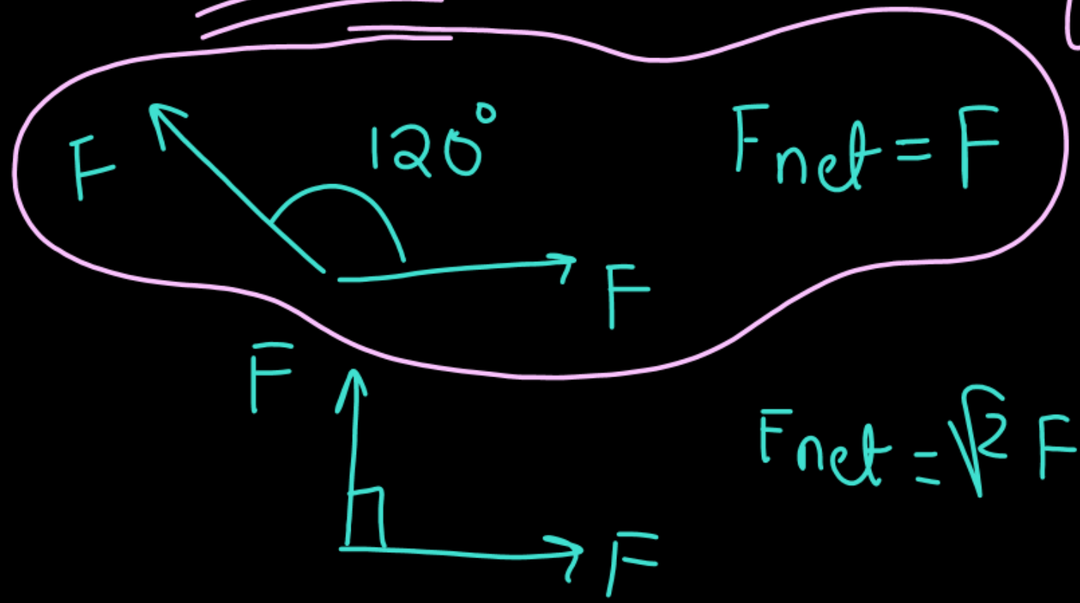


$$F_{net} = 2F\cos 30$$

$$= 2F\frac{\sqrt{3}}{2}$$

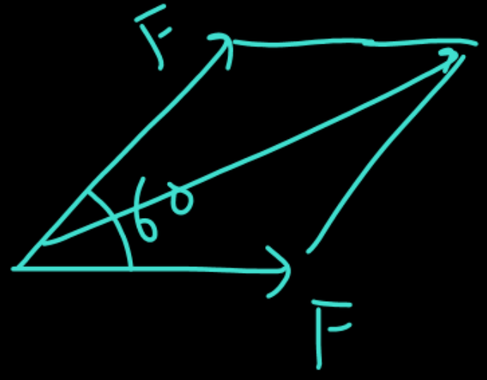
$$F_{net} = F\sqrt{3}$$

Siddhi

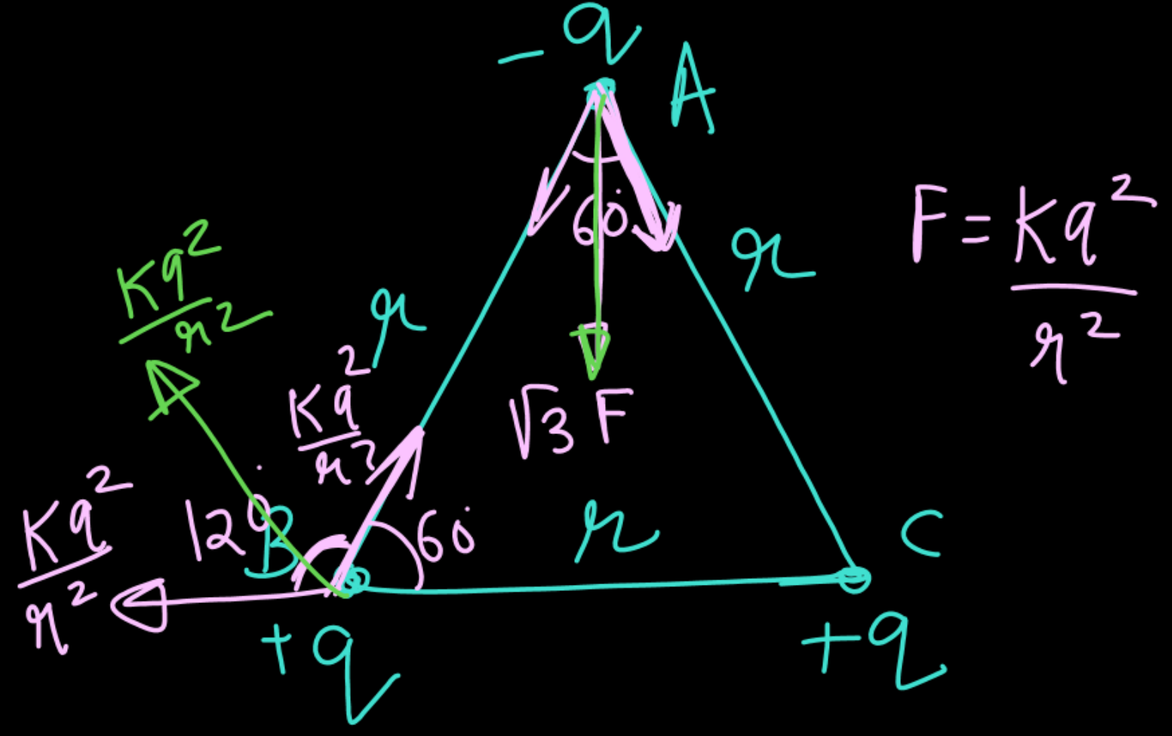


$F_{net} = F$

$F_{net} = \sqrt{2}F$



$F_{net} = \sqrt{3}F$



$F = \frac{Kq^2}{r^2}$

$\frac{Kq^2}{r^2}$

$\frac{Kq^2}{r^2}$

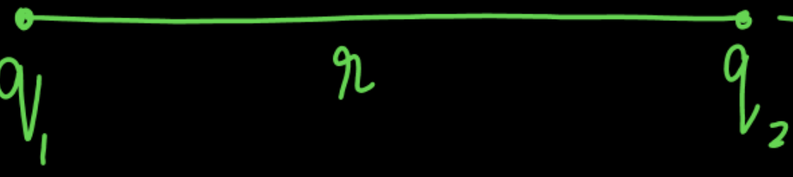
$\frac{Kq^2}{r^2}$

$F_{net} = F = \frac{Kq^2}{r^2}$

Find the force acting on charge placed at-

(1) A (2) B.

Effect of medium on Coulomb force



$$\rightarrow \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

Force on q_2 due to q_1 is independent of medium.

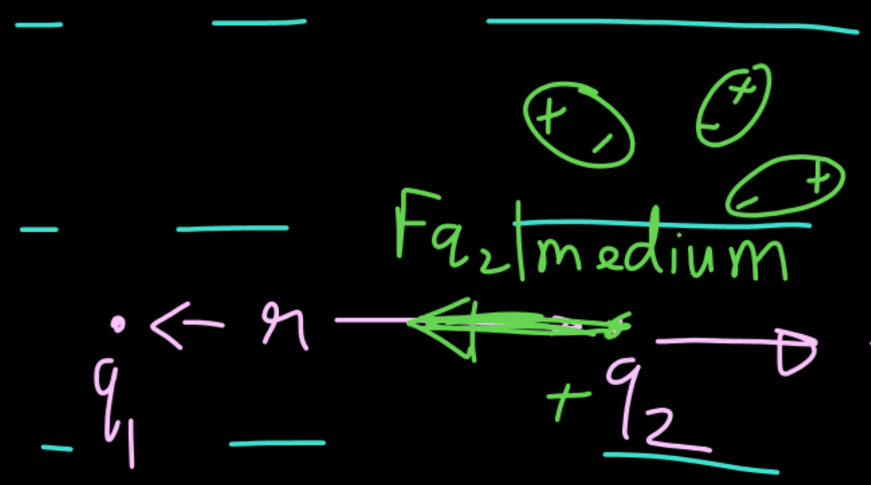
$\Rightarrow$ Permitivity of medium 'ε'

relative permitivity

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}$$

$\Downarrow$

dielectric constant = relative permitivity = ε_r



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

$$F_{net} = F_{q_2|q_1} - F_{q_2|medium}$$

$$\frac{1}{4\pi\varepsilon}\frac{q_1 q_2}{r^2} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} - F_{q_2|medium}$$

$$F_{q_2|medium} = \frac{1}{4\pi}\frac{q_1 q_2}{r^2}\left(\frac{1}{\varepsilon_0} - \frac{1}{\varepsilon}\right) \Rightarrow \boxed{\varepsilon = \varepsilon_0 \varepsilon_r}$$

Thank You Lakshyians