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

$$\frac{1}{4\pi\varepsilon_0} = 9\times10^9 \ \frac{N\text{-}m^2}{C^2}$$

$$F_{medium} = \frac{F_{air}}{\varepsilon_r}$$

$\varepsilon_r \rightarrow \underline{K} \rightarrow$ (dielectric Constant)

$\varepsilon_r = \underline{K} \rightarrow \infty$ (For conductor)

$$\boxed{K > 1}$$

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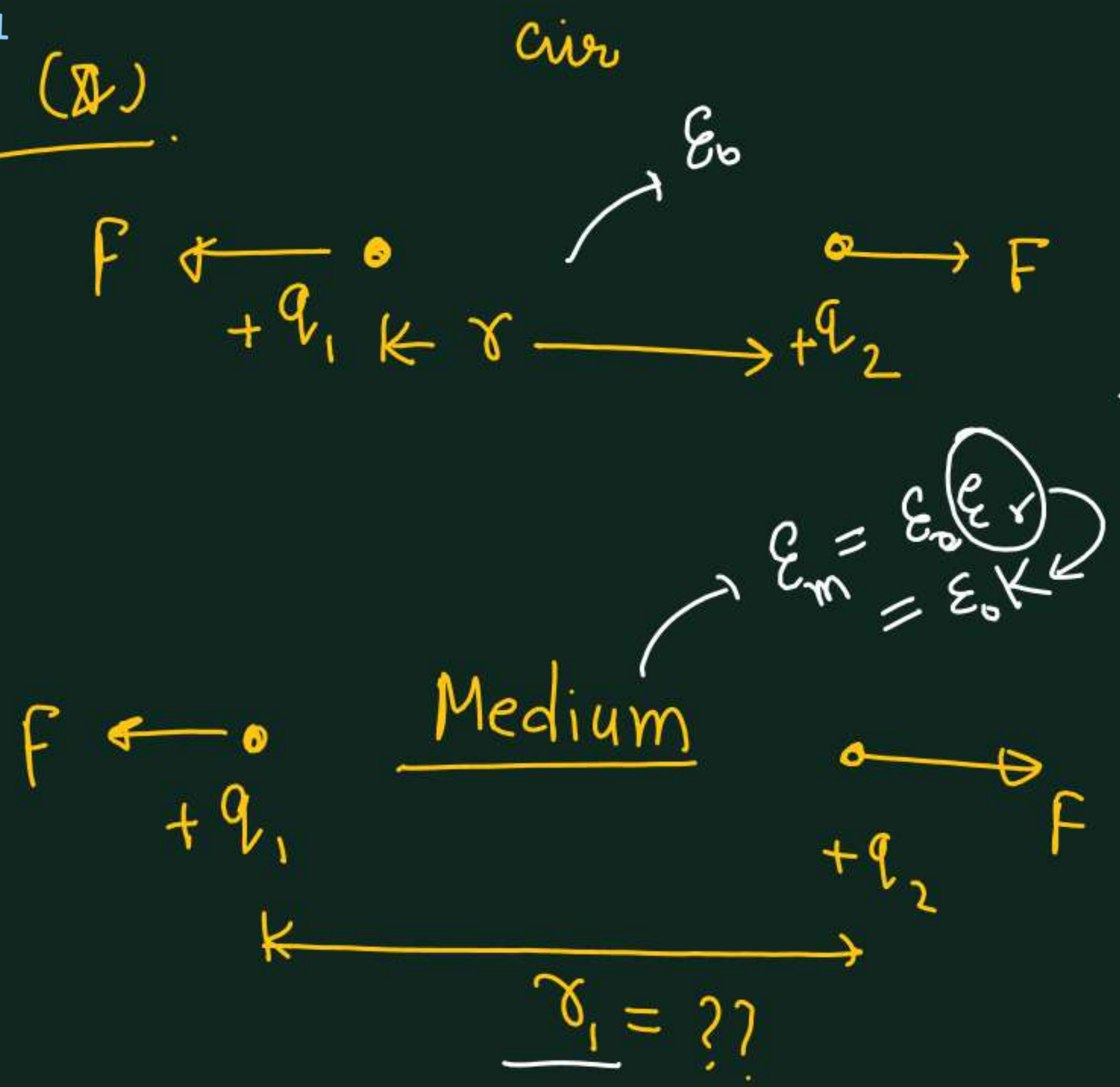
(Q)




Find $r_1$ so that Coulombic force doesn't change.

Sol$^n$:- According to question

$$F_{air} = F_{medium}$$

$$\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2} = \frac{1}{K 4\pi\varepsilon_0}\frac{q_1 q_2}{r_1^2}$$

$$r^2 = K r_1^2$$

$$\boxed{r = \sqrt{K}\, r_1}$$

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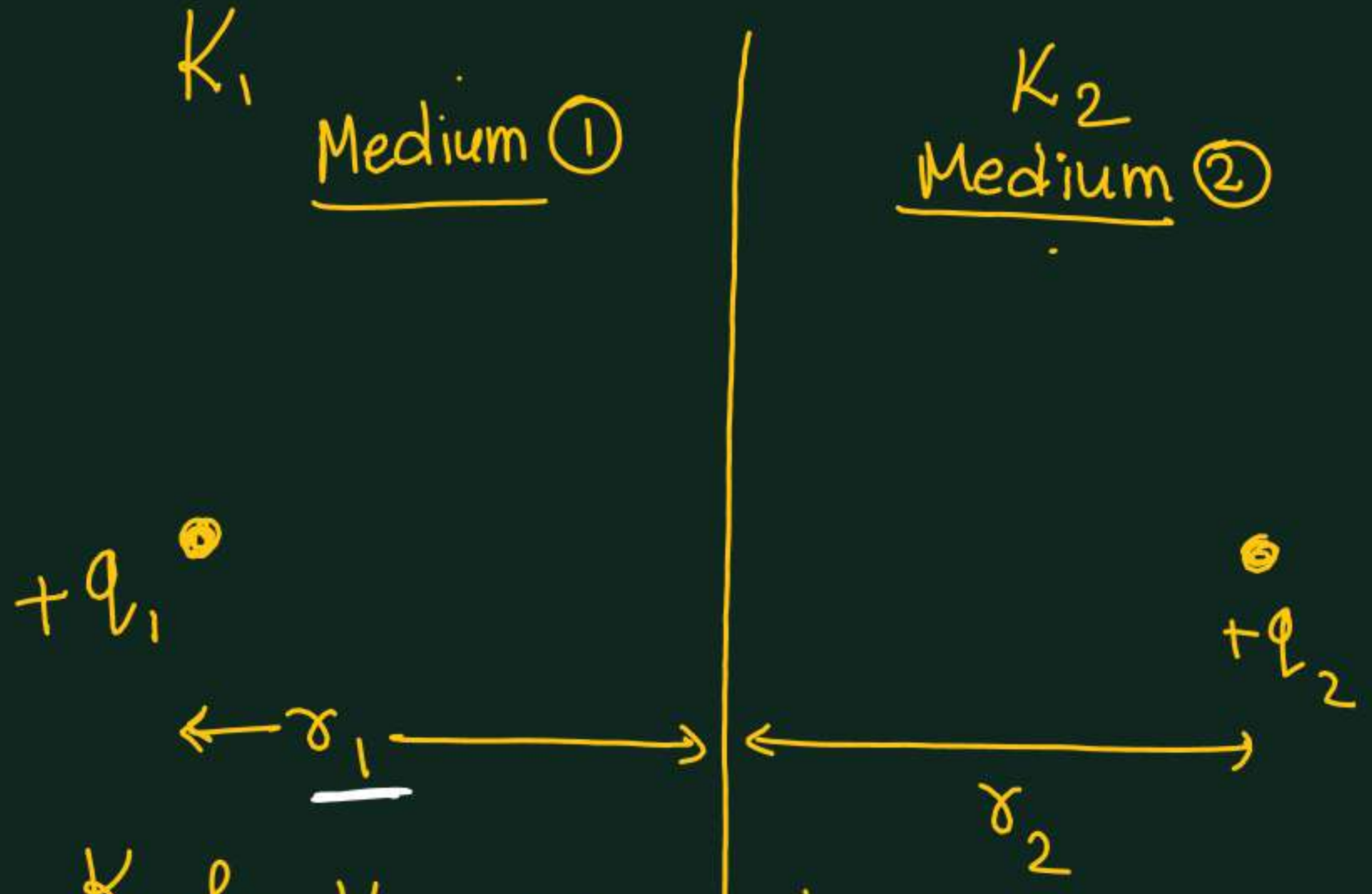
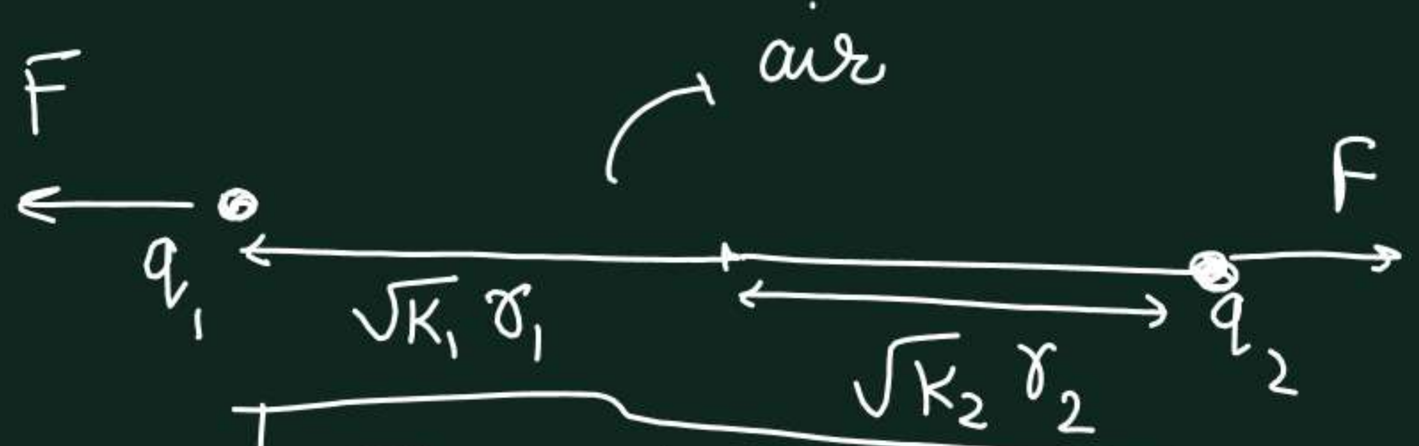



$K_1$ & $K_2$ are dielectric constant of medium 1 & medium 2

$$\boxed{r_{air} = \sqrt{K}\, r_{medium}}$$

Sol$^n$:- Make the medium homgenious. i.e calculate the effective distance in air.




$$\boxed{F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{\left(\sqrt{K_1}\, r_1 + \sqrt{K_2}\, r_2\right)^2}}$$

$F_{air} = F_{medium}$

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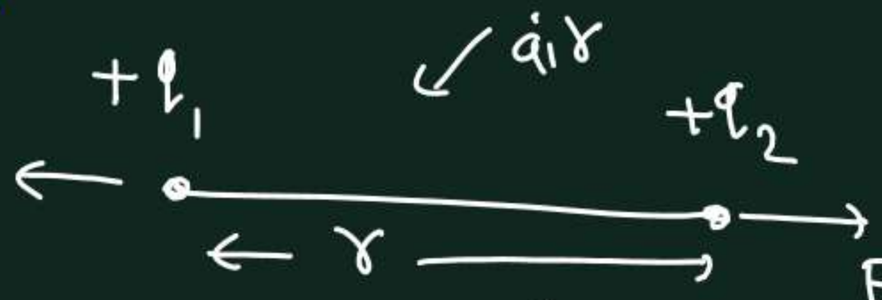
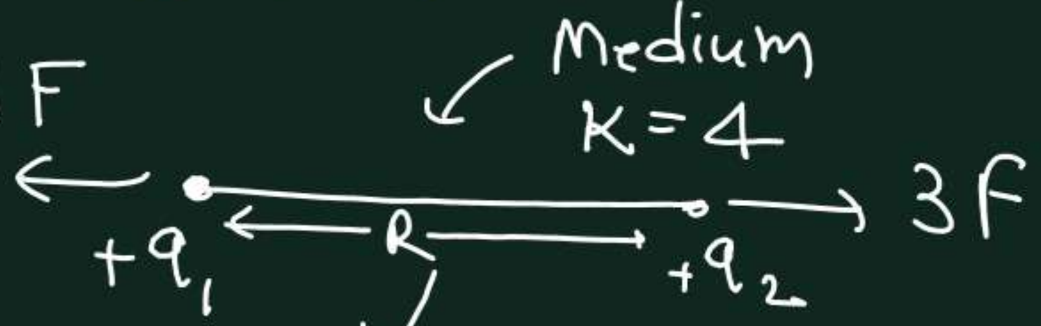
(4). Two Charges $(+q_1)$ and $(+q_2)$ Seperated by distance '$r$' have force F. if the Same Charges are kept in a medium having dielectric Constant $K=4$ then force b/w them become $3F$. and the Speration in medium is R. then find the relation b/w R & $r$.

Sol$^n$




$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$$

$$Fr^2 = \frac{1}{4\pi\varepsilon_0}q_1q_2 \quad \text{— (1)}$$

$$3F = \frac{1}{4\pi(4)\varepsilon_0}\frac{q_1q_2}{R^2} \quad \text{— (2)}$$

$$\varepsilon_m = K\varepsilon_0, \quad K = 4$$

From (1) & (2)

$$3\cancel{F} = \frac{\cancel{F}r^2}{4R^2}$$

$$r^2 = 12R^2$$

$$\boxed{r = 2\sqrt{3}R}$$

Ans.

→ Coulombic force is a Central force.
i.e always acts along the line joining the two Charge.

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$\Rightarrow$ Coulombic force always follow Newton's 3rd law.

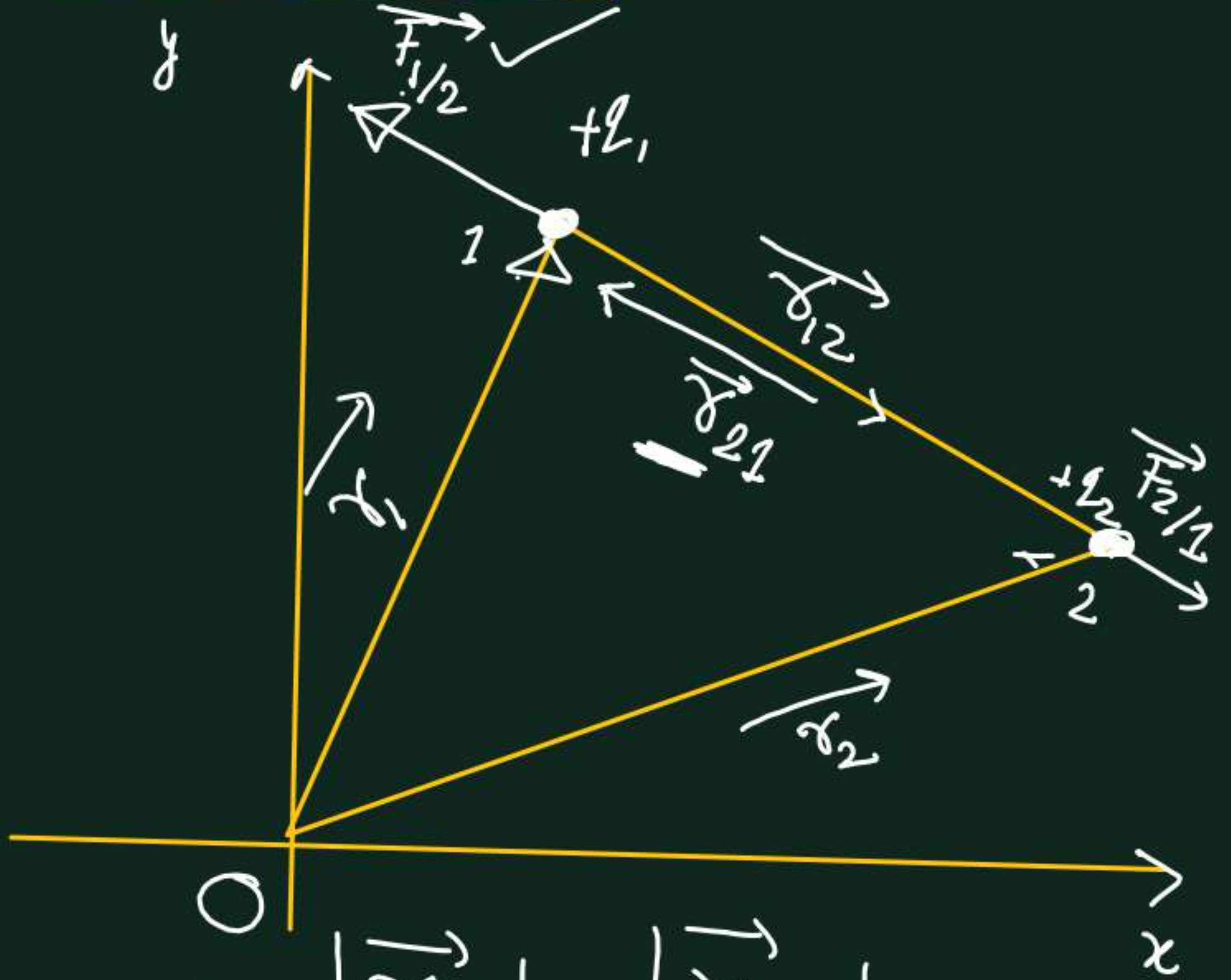
## Vector form of Coulombic force

$$\vec{F}_{1/2} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{21}|^2}\cdot \hat{r}_{21}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{21}|^2}\frac{\vec{r}_{21}}{|\vec{r}_{21}|}$$

$$= \left[\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{21}|^3}\right](\vec{r}_{21})$$

$$\boxed{\vec{F}_{2/1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{12}|^3}\cdot \vec{r}_{12}}$$




$$\vec{r}_{12} = -\vec{r}_{21}$$

$$|\vec{r}_{12}| = |\vec{r}_{21}|$$

$$\left(\hat{r} = \frac{\vec{r}}{|\vec{r}|}\right)$$

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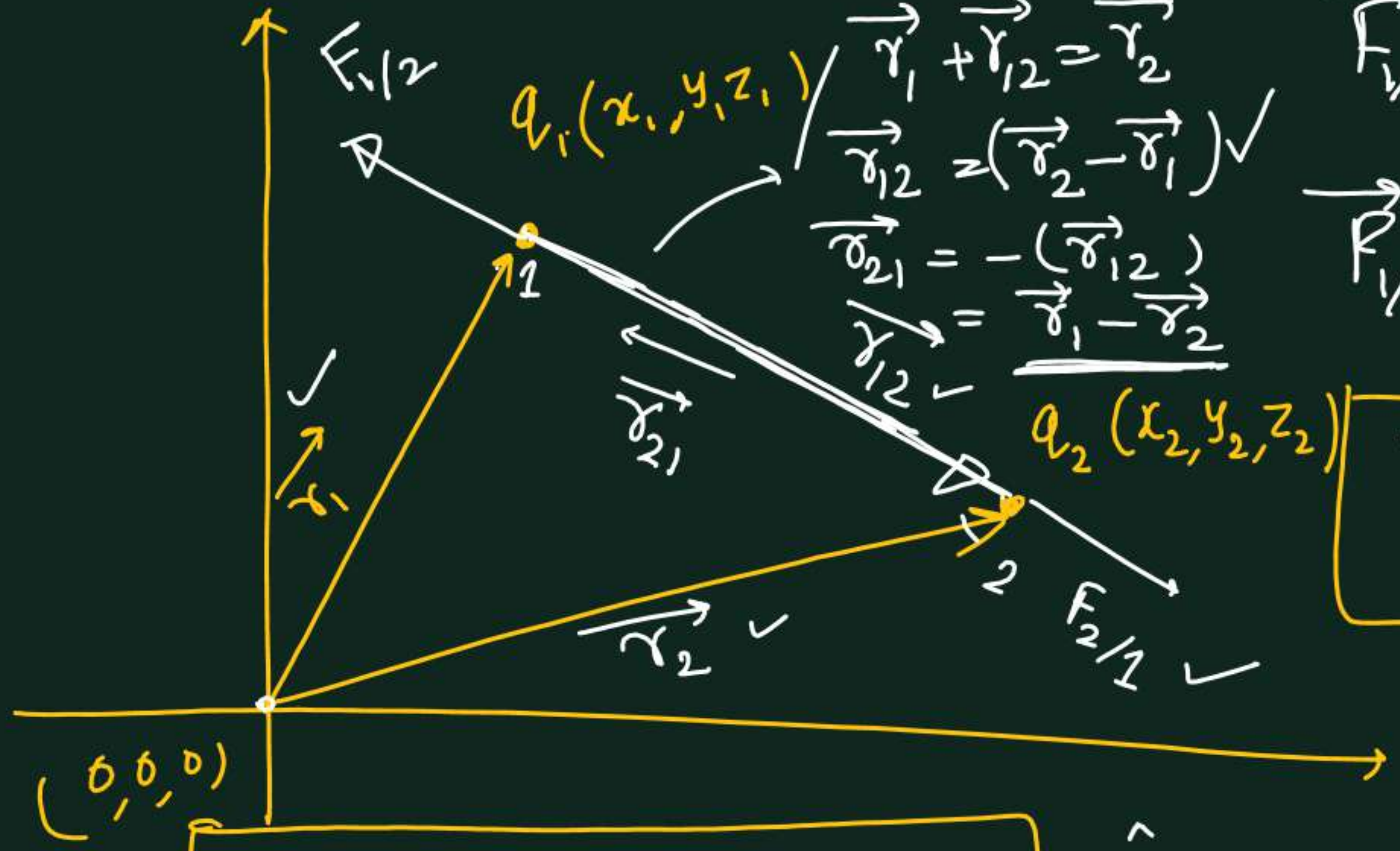


$\vec{r}_1 + \vec{r}_{12} = \vec{r}_2$

$\vec{r}_{12} = (\vec{r}_2 - \vec{r}_1)$

$\vec{r}_{21} = -(\vec{r}_{12})$

$\vec{r}_{21} = \vec{r}_1 - \vec{r}_2$

$$\boxed{\begin{aligned}\vec{r}_1 &= x_1\hat{i} + y_1\hat{j} + z_1\hat{k}\\ \vec{r}_2 &= x_2\hat{i} + y_2\hat{j} + z_2\hat{k}\end{aligned}}$$

$\hat{r}_{21} \longrightarrow$

$2 \longrightarrow 1$

$\hat{r}_{12}$

$1 \longrightarrow 2$

$$\vec{F}_{1/2} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{21}|^2}(\hat{r}_{21}) = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{21}|^3}\vec{r}_{21}$$

$$\vec{F}_{1/2} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_1 - \vec{r}_2|^2}\frac{\vec{r}_1 - \vec{r}_2}{|\vec{r}_1 - \vec{r}_2|}$$

$$\boxed{\vec{F}_{1/2} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_1 - \vec{r}_2|^3}\cdot(\vec{r}_1 - \vec{r}_2)}$$

$$\vec{F}_{2/1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{12}|^2}\cdot\frac{\vec{r}_{12}}{|\vec{r}_{12}|}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{12}|^3}(\vec{r}_{12})$$

$$\boxed{\vec{F}_{2/1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_2 - \vec{r}_1|^3}(\vec{r}_2 - \vec{r}_1)}$$

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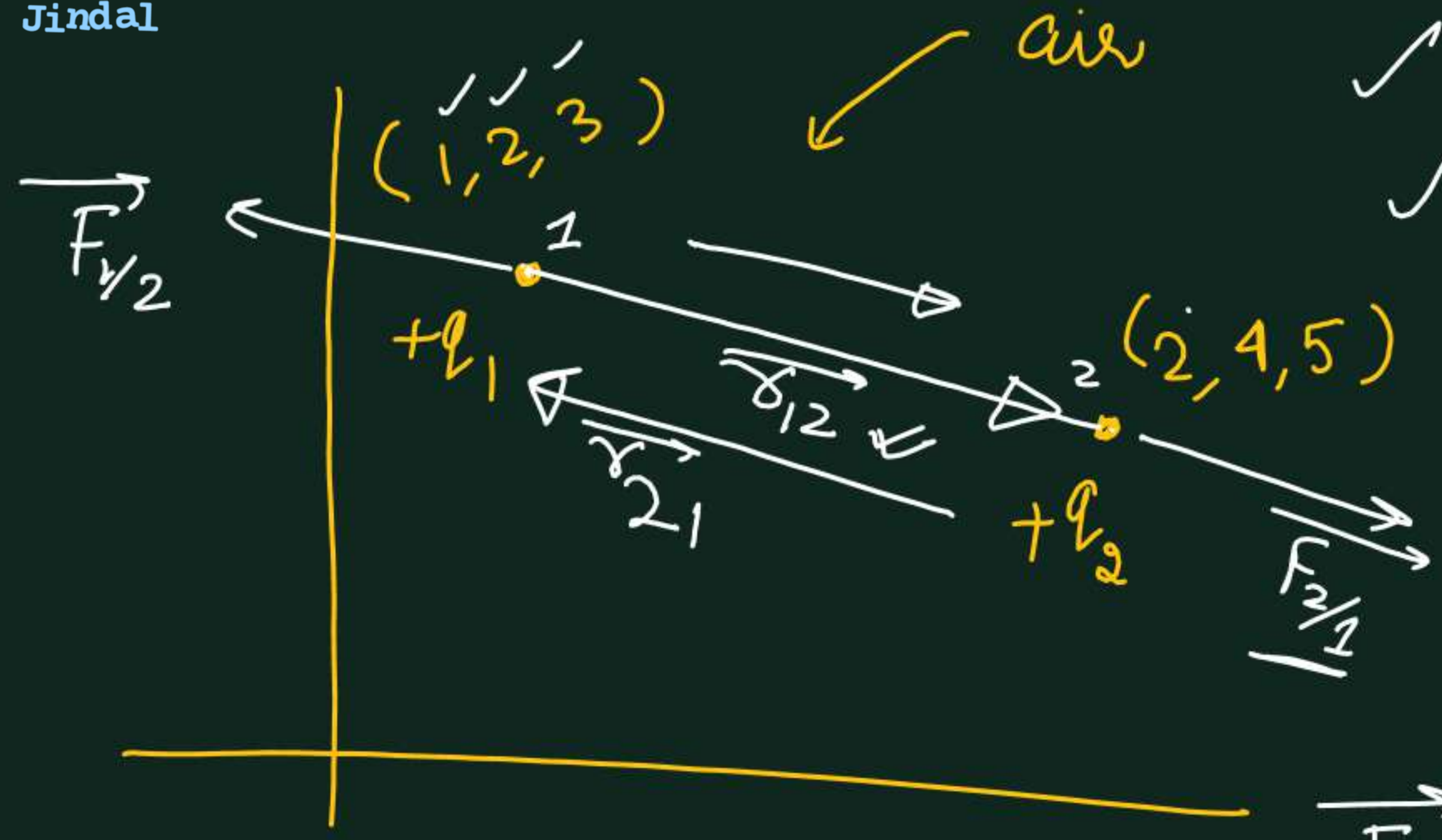



$$\vec{r}_{12} = (2-1)\hat{i} + (4-2)\hat{j} + (5-3)\hat{k}$$

$$\vec{r}_{12} = (\hat{i} + 2\hat{j} + 2\hat{k})$$

$$|\vec{r}_{12}| = \sqrt{9} = 3$$

$$\vec{r}_{21} = (-\vec{r}_{12})$$

$$\vec{F}_{2/1} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{|\vec{r}_{12}|^3} \times (\vec{r}_{12})$$

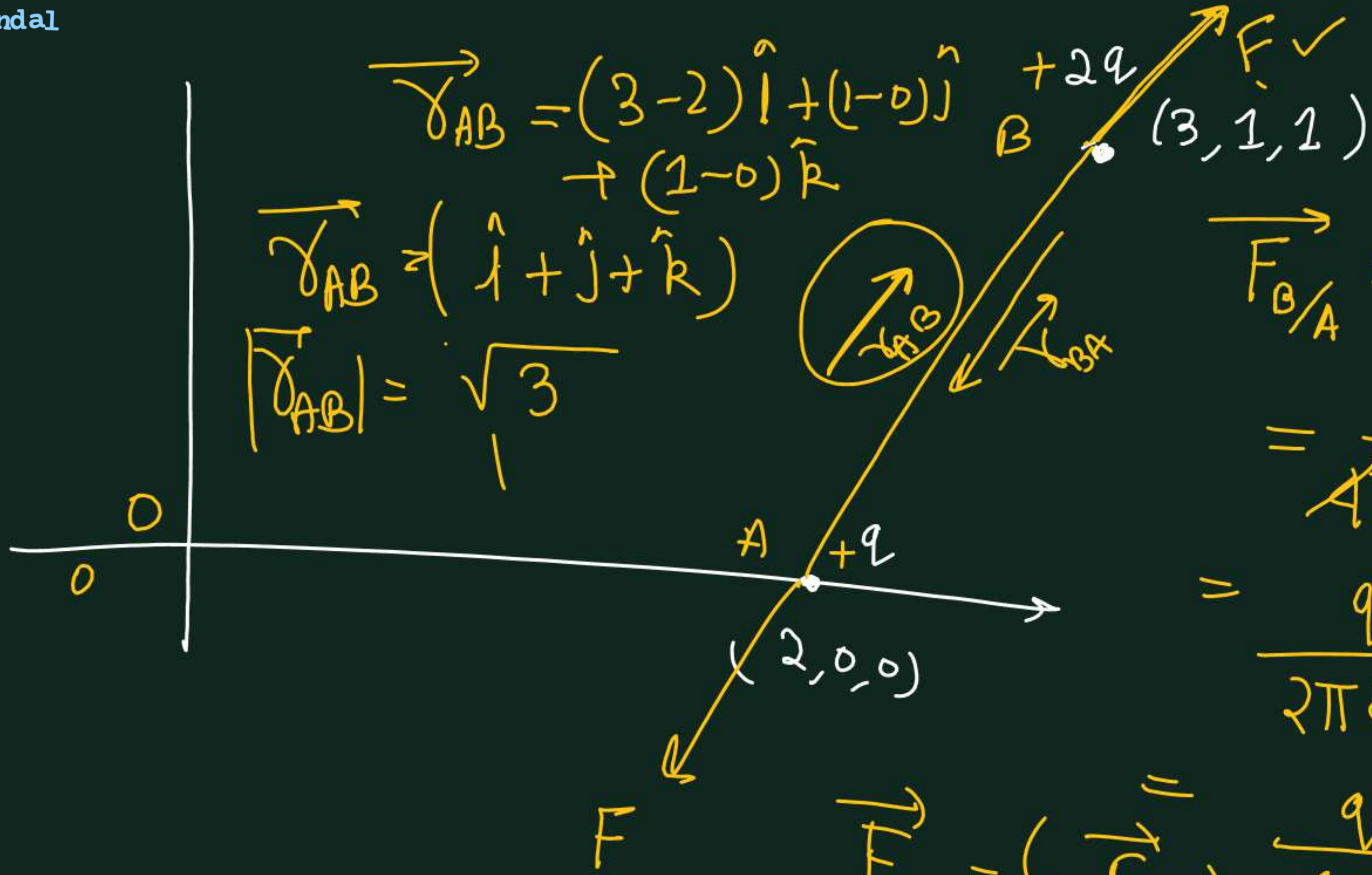
$$\vec{F}_{2/1} = \left(\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{27}\right)(\hat{i} + 2\hat{j} + 2\hat{k})$$

$$\boxed{\vec{F}_{1/2} = -\vec{F}_{2/1}}$$

$$\vec{r}_{AB} = (3-2)\hat{i} + (1-0)\hat{j} + (1-0)\hat{k}$$

$$\vec{r}_{AB} = (\hat{i}+\hat{j}+\hat{k})$$

$$|\vec{r}_{AB}| = \sqrt{3}$$




$$\vec{F}_{B/A} = \frac{1}{4\pi\varepsilon_0}\frac{q(2q)}{|\vec{r}_{AB}|^3}\cdot\vec{r}_{AB}$$

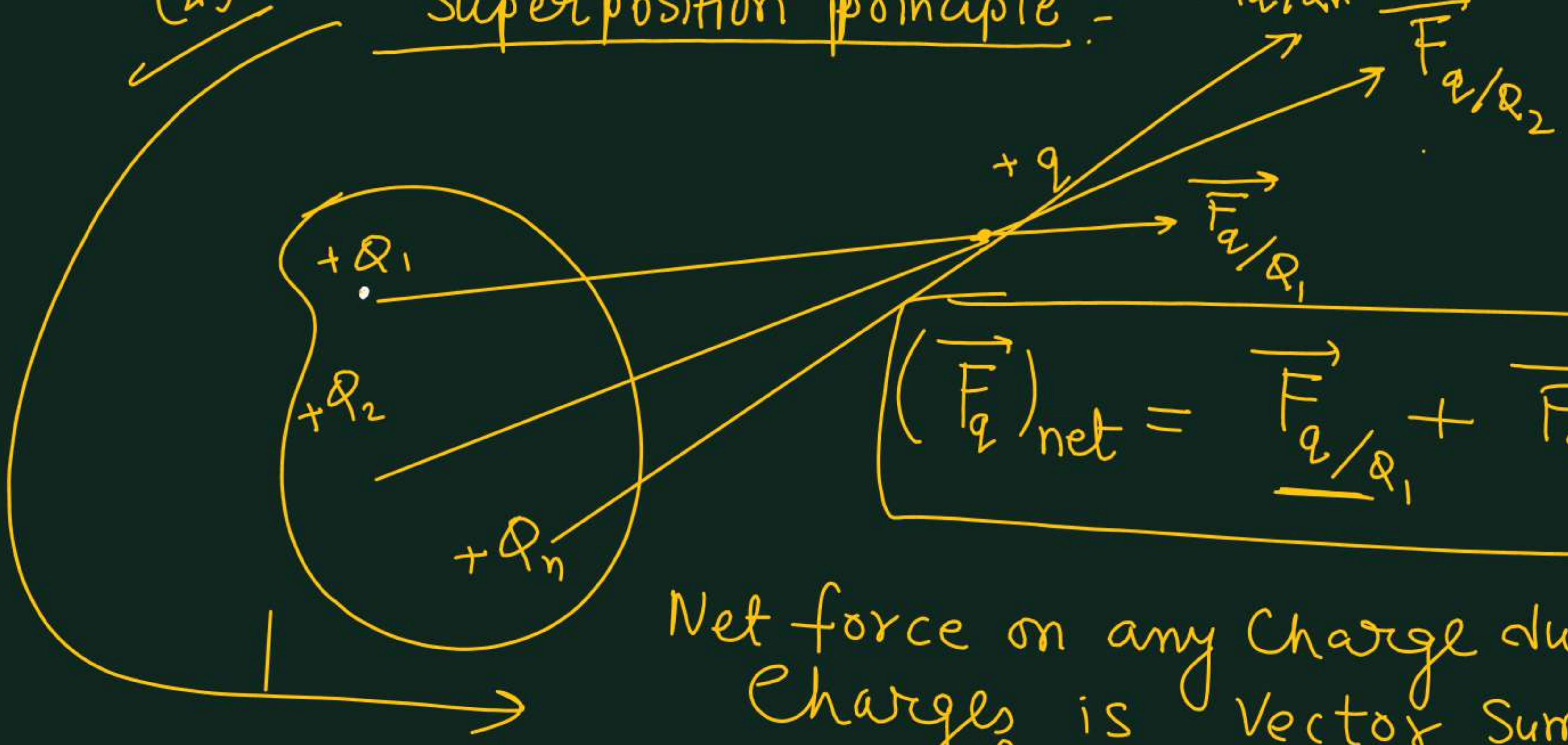
$$= \frac{1}{\cancel{4}\pi\varepsilon_0}\frac{\cancel{2}q^2}{(3)^{3/2}}(\hat{i}+\hat{j}+\hat{k})$$

$$= \frac{q^2}{2\pi\varepsilon_0}\frac{1}{(3\sqrt{3})}(\hat{i}+\hat{j}+\hat{k})$$

$$= \frac{q^2}{6\pi\varepsilon_0\sqrt{3}}(\hat{i}+\hat{j}+\hat{k})$$

$$\vec{F}_{A/B} = (-\vec{F}_{B/A})$$

## Superposition principle :-




$$\boxed{(\vec{F}_q)_{net} = \vec{F}_{q/Q_1} + \vec{F}_{q/Q_2} \cdots + \vec{F}_{q/Q_n}}$$

Net force on any charge due to other charges is vector sum of all the forces due to individual charges. (Neglecting the presence of other)

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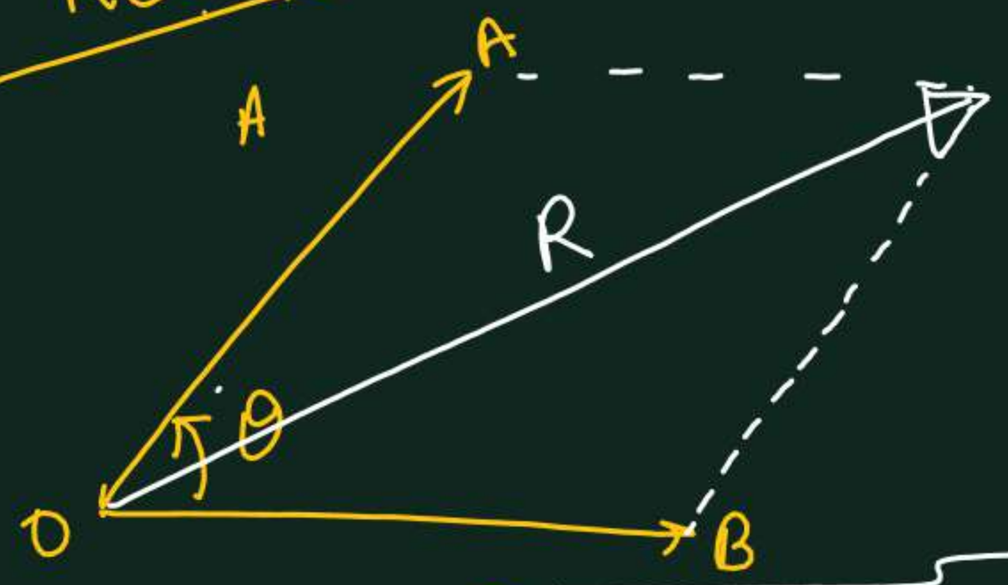
# ReCape




$|\vec{OA}| = A$

$|\vec{OB}| = B$

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

$\theta \rightarrow$ Angle b/w the two vectors

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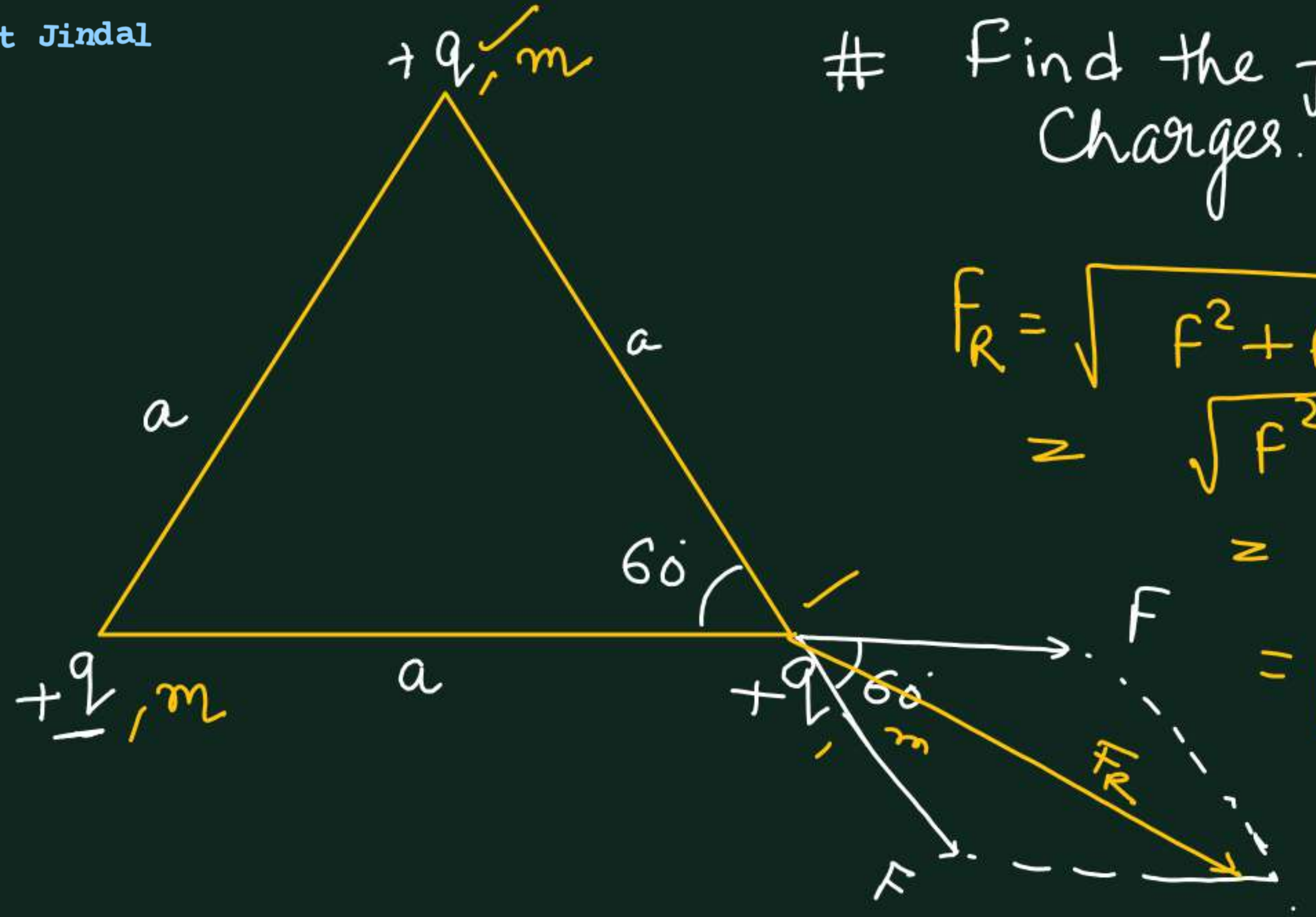
# Find the force acting b/w any two charges.




$$F_R = \sqrt{F^2 + F^2 + 2F.F\cos 60^\circ}$$

$$= \sqrt{F^2 + F^2 + F^2}$$

$$= \sqrt{3}\,F$$

$$= \left(\sqrt{3}\,\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a^2}\right)$$

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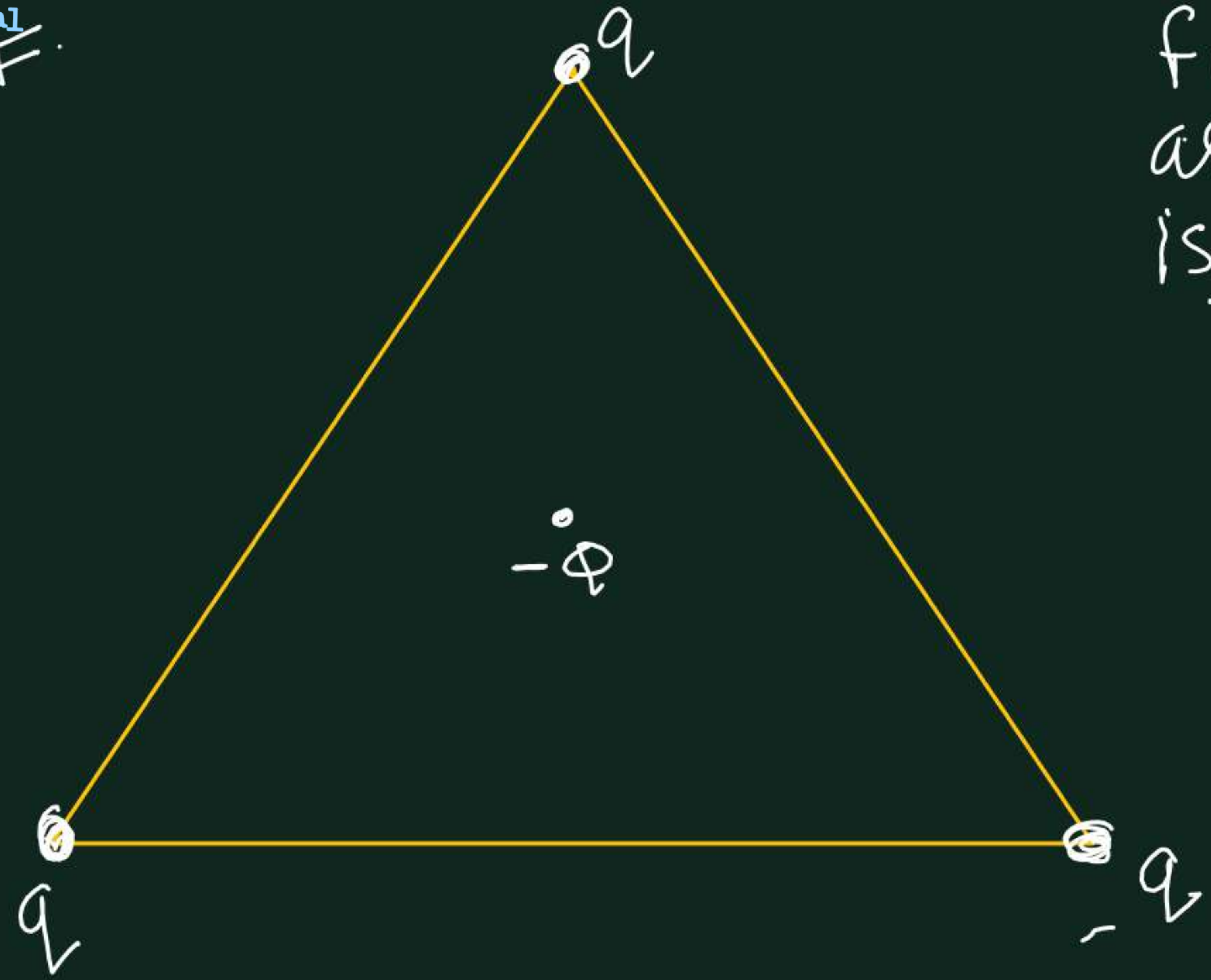
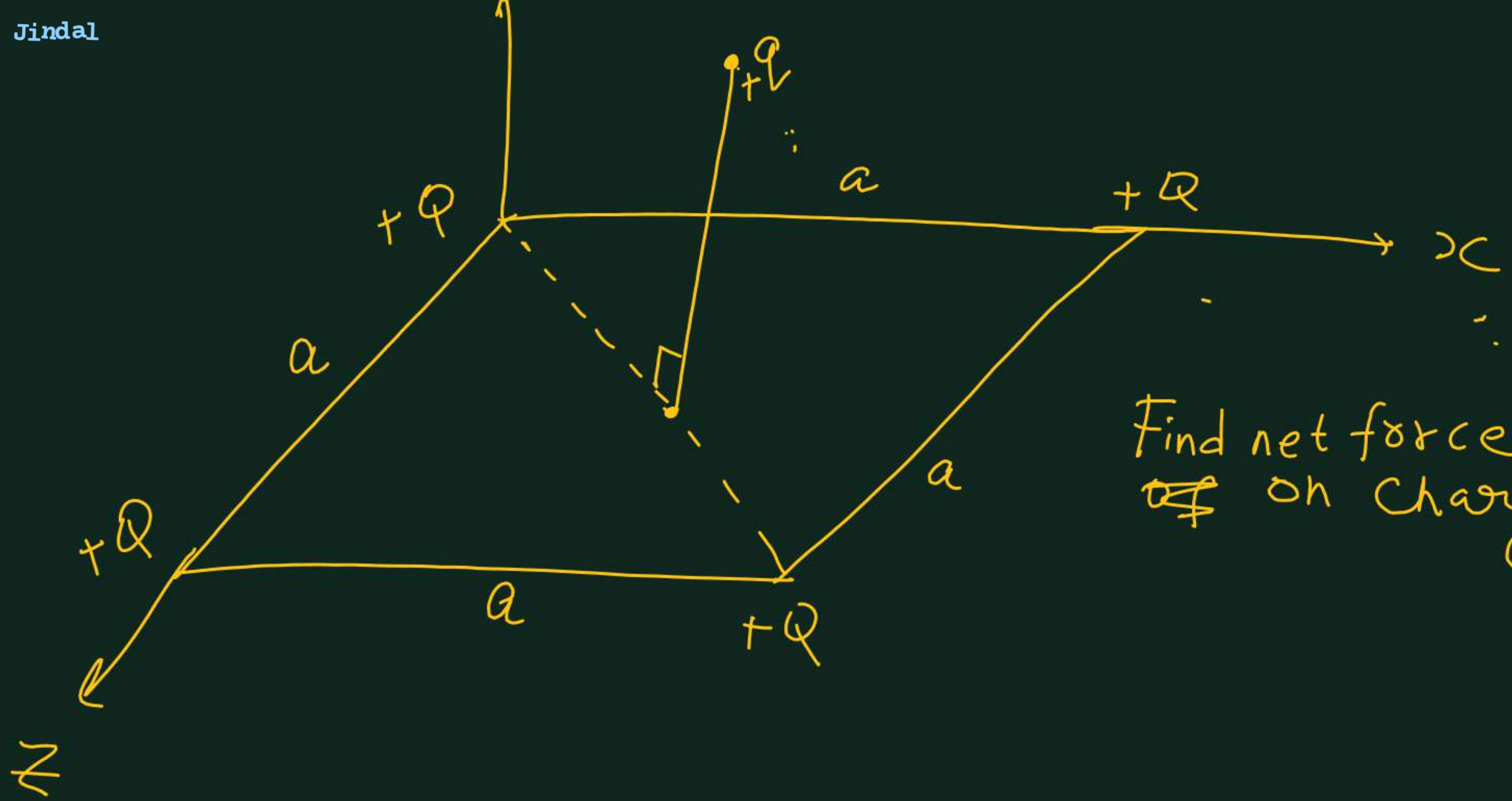
#.




Find the value of Q as well as sign so that the whole system is in equilibrium.




Find net force ~~of~~ on Charg +q