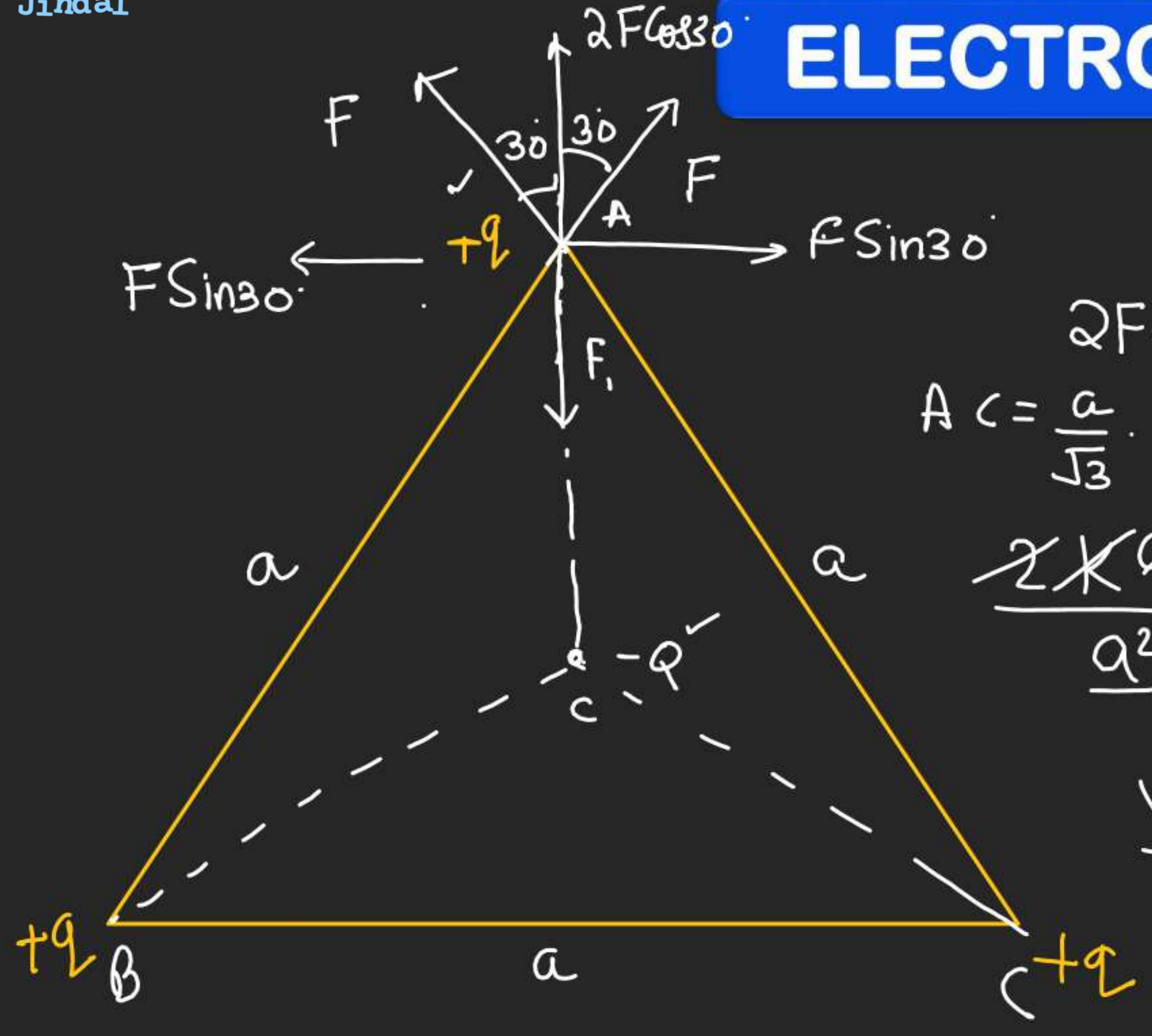
Nishant Jindal

ELECTROSTATICS



For Charge to be in equilibrium

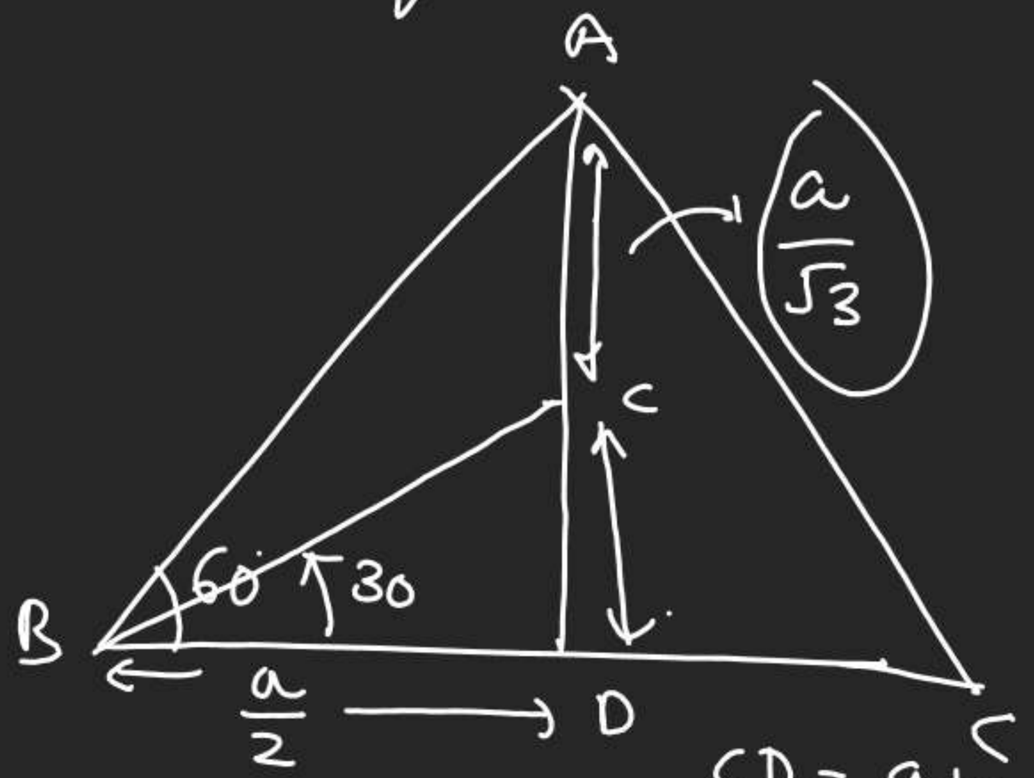
$$2F\cos 30^\circ = F_1$$

$$AC = \frac{a}{\sqrt{3}}$$

$$\frac{\cancel{2}\cancel{K}q^{\cancel{2}}}{a^2} \times \frac{\sqrt{3}}{\cancel{2}} = \frac{\cancel{K}\cancel{q}Q}{\left(\frac{a}{\sqrt{3}}\right)^2}$$

$$\sqrt{3}\,q = 3Q$$

$$\boxed{Q = \left(\frac{q}{\sqrt{3}}\right)}$$



$$\tan 60^\circ = \frac{AD}{BD}$$

$$AD = \frac{\sqrt{3}a}{2}$$

$$CD = \frac{a}{2}\tan 30^\circ$$

$$CD = \frac{a}{2}\cdot\frac{1}{\sqrt{3}}$$

$$CD = \frac{a}{2\sqrt{3}}$$

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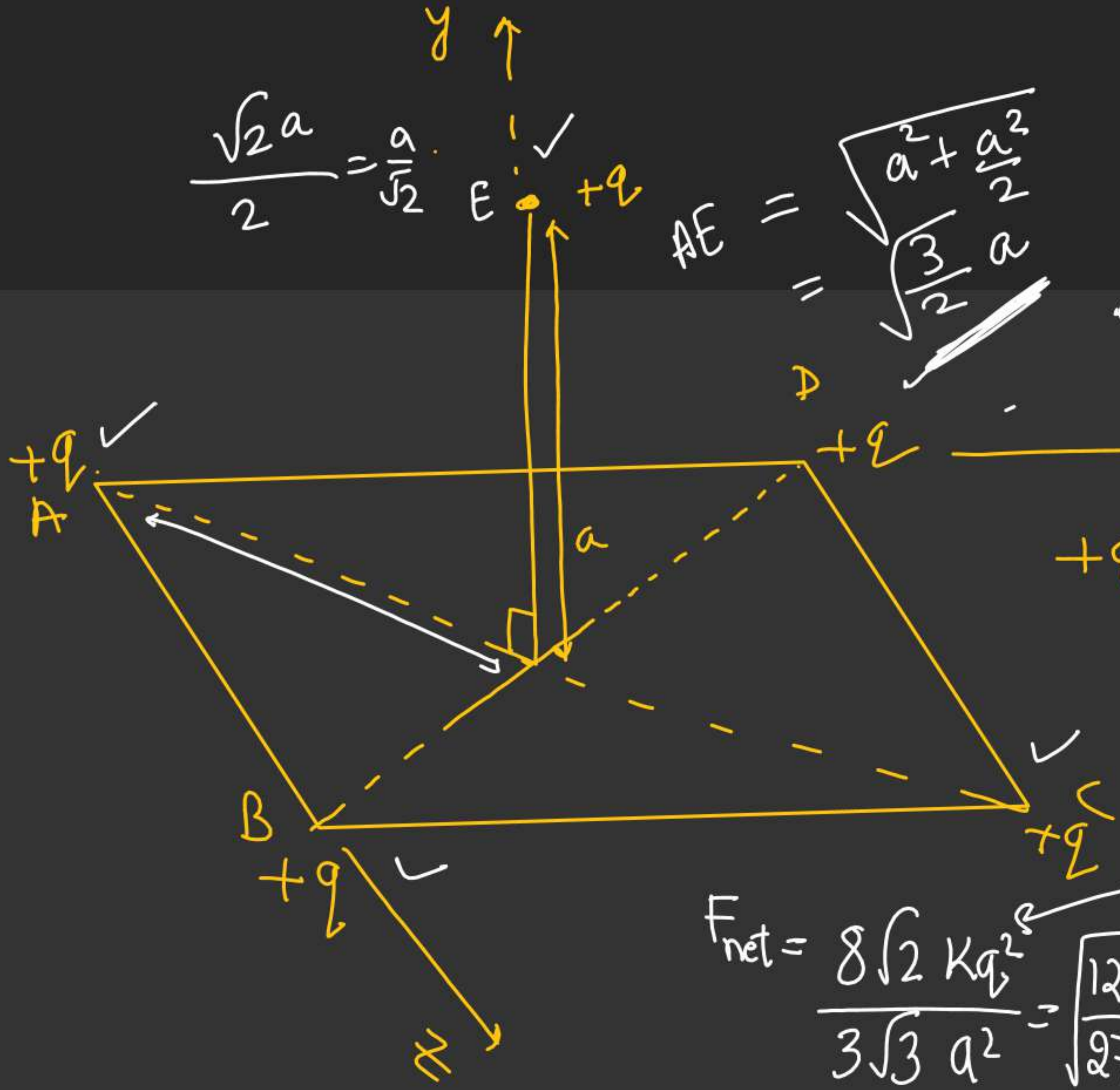
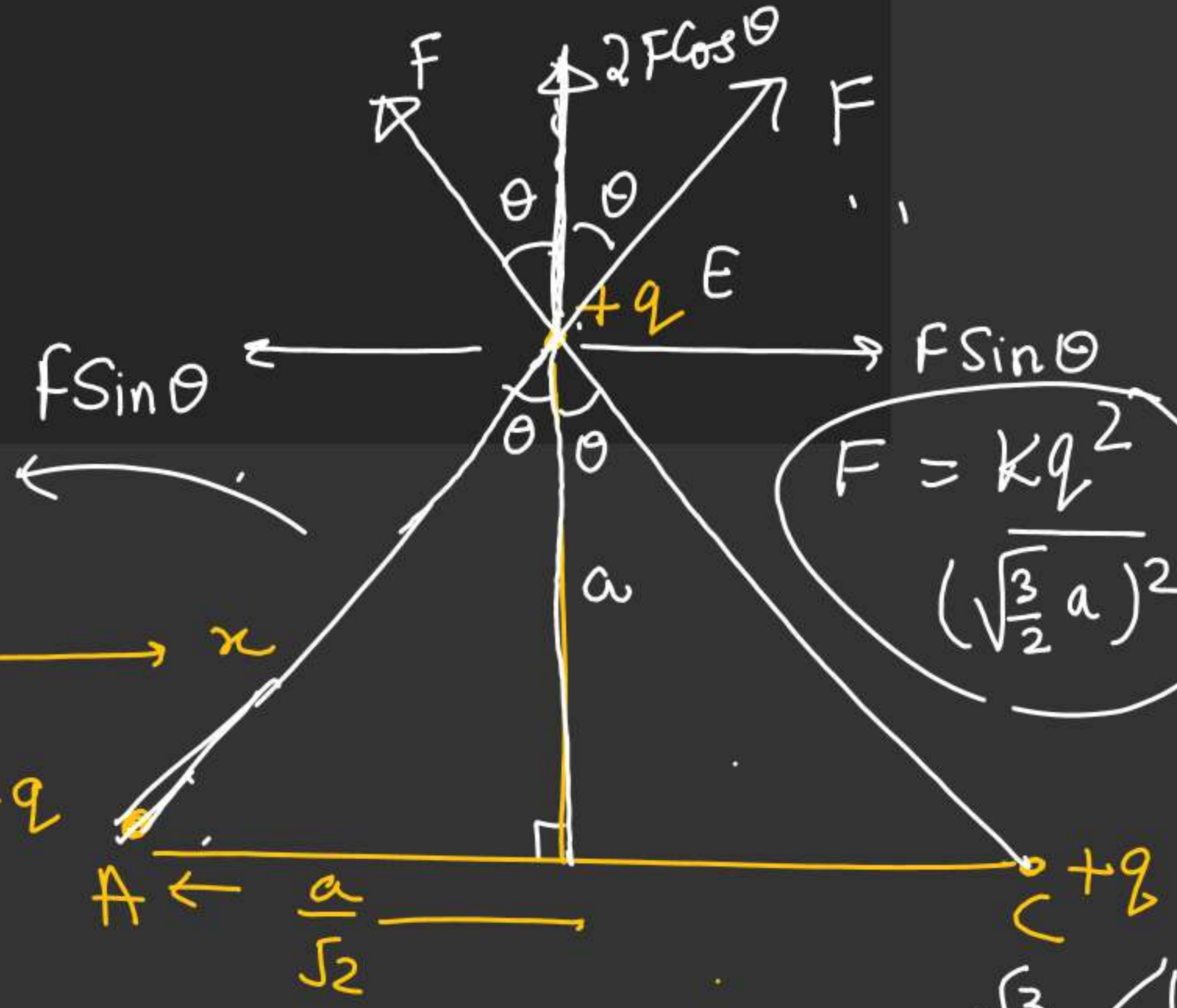


$$\frac{\sqrt{2}a}{2} = \frac{a}{\sqrt{2}}$$

$$AE = \sqrt{a^2 + \frac{a^2}{2}} = \sqrt{\frac{3}{2}}\,a$$



$$F = \frac{Kq^2}{\left(\sqrt{\frac{3}{2}}\,a\right)^2}$$

$$\tan\theta = \frac{a/\sqrt{2}}{a} = \frac{1}{\sqrt{2}}$$

$$F_{net} = 2(2F\cos\theta) = 4F\cos\theta = \frac{4Kq^2}{\frac{3}{2}a^2} \times \frac{\sqrt{2}}{\sqrt{3}}$$

$$F_{net} = \frac{8\sqrt{2}\,Kq^2}{3\sqrt{3}\,a^2} = \sqrt{\frac{128}{27}}\,\frac{Kq^2}{a^2}$$

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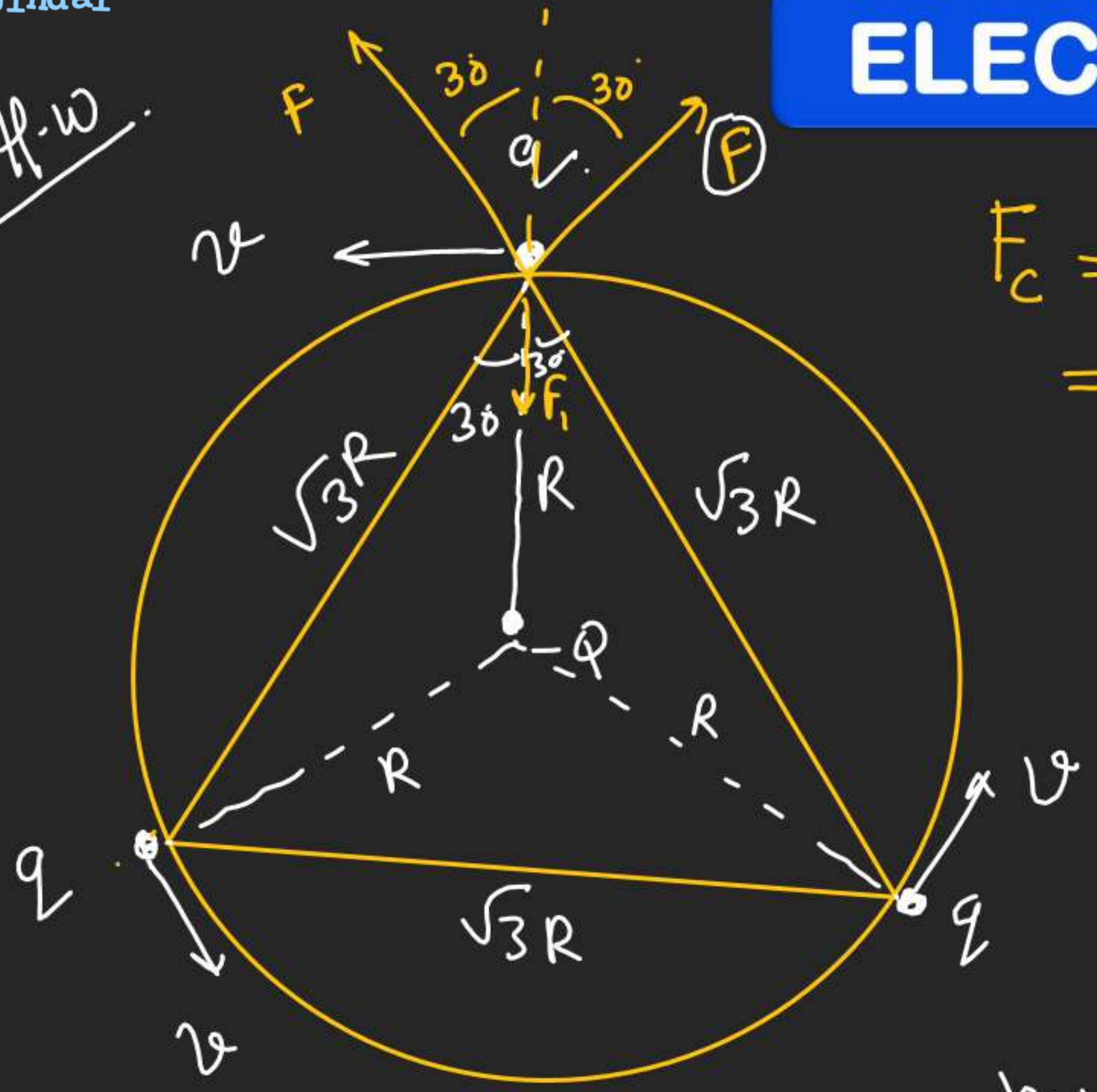
H.W

$$T = \frac{2\pi R}{v}$$

All the 3 'q' Charges moving with Constant Velocity v. find time period of motion



$$F_c = F_1 - 2F\cos 30^\circ$$

$$= \frac{KqQ}{R^2} - \cancel{2} \times \frac{\sqrt{3}}{\cancel{2}} \times \frac{Kq^2}{(\sqrt{3}R)^2}$$

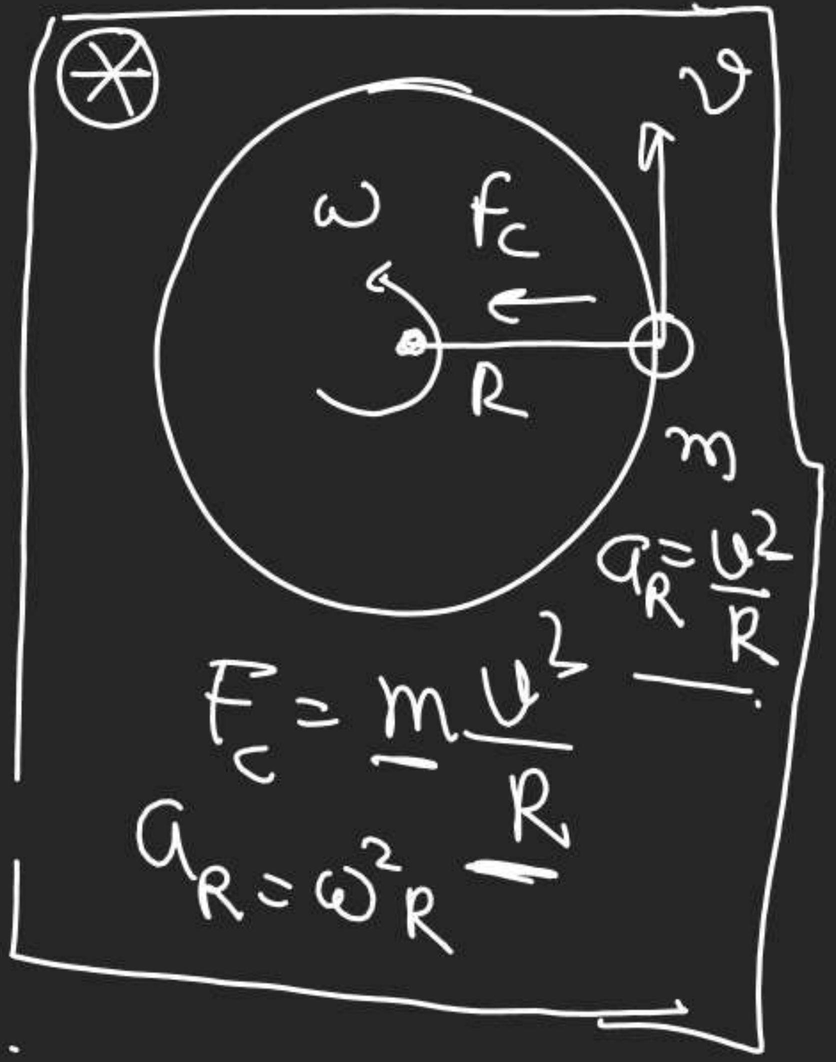
$$F_c = \left(\frac{KqQ}{R^2} - Kq^2\right)$$

$$\Downarrow$$

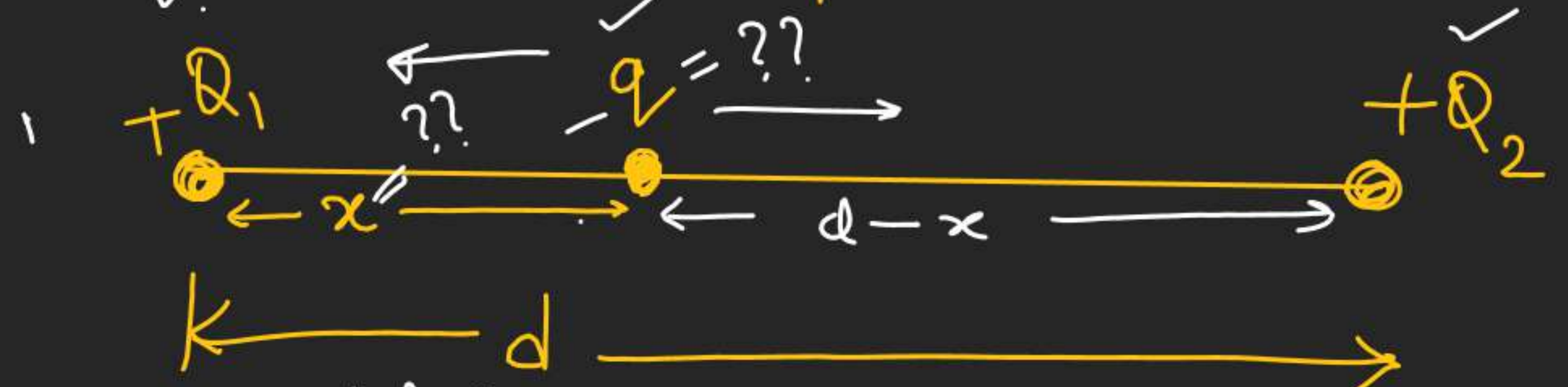
$$\frac{mv^2}{R} = \left(\frac{KqQ}{R^2} - \frac{Kq^2}{\sqrt{3}R^2}\right)$$

$$\frac{mv^2}{\cancel{R}} = \frac{Kq}{\cancel{R^2}}\left(Q - \frac{q}{\sqrt{3}}\right)$$

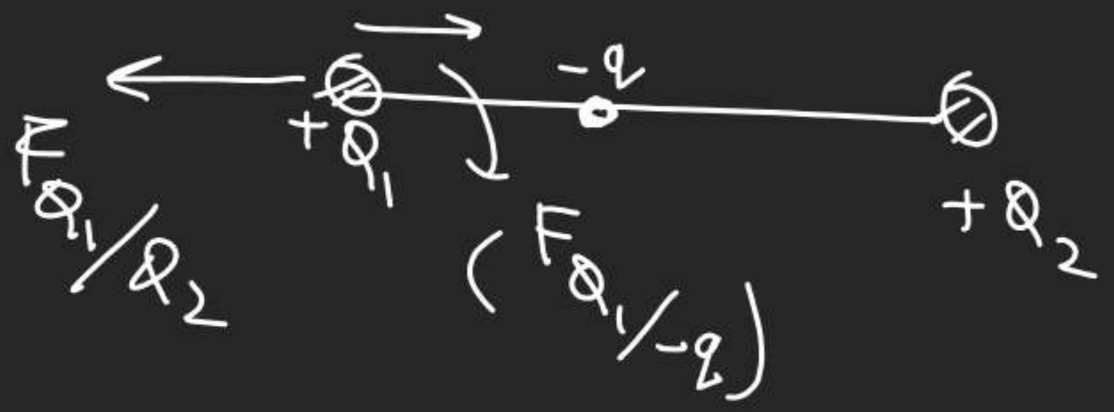
$$v = \sqrt{\frac{Kq}{mR}\left(Q - \frac{q}{\sqrt{3}}\right)}$$



Three Charges $+Q_1$, $+Q_2$ and q are arranged as shown in fig. Find the value of 'q' as well as distance from Q_1 where it kept so that whole system is in equilibrium.



Net force on Q_1 is also zero



Net force on $-q$ is zero

$$F_{q/Q_1} = F_{q/Q_2}$$

$$\frac{\cancel{K} Q_1 \cancel{q}}{x^2} = \frac{\cancel{K} Q_2 \cancel{q}}{(d-x)^2}$$

$$\sqrt{\frac{Q_1}{Q_2}} = \left(\frac{x}{d-x}\right) \quad \text{— (1)}$$

$$\vec{F}_{q/Q_1} + \vec{F}_{q/Q_2} = 0$$

$$\vec{F}_{q/Q_1} = -\vec{F}_{q/Q_2}$$

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$$\rightarrow \frac{\cancel{K}\cancel{Q_1}Q_2}{d^2} = \frac{\cancel{K}\cancel{Q_1}q}{x^2}$$

$$\rightarrow \sqrt{\frac{Q_2}{q}} = \frac{d}{x} \quad - (2)$$

$$x = d\sqrt{q/Q_2} \checkmark$$

$$x = \left(\frac{d\sqrt{Q_1}}{\sqrt{Q_1}+\sqrt{Q_2}}\right) \underline{\text{Ans}} \checkmark$$

$$\sqrt{\frac{Q_1}{Q_2}} = \frac{x}{d-x} \quad - (2)$$

$$\sqrt{\frac{Q_2}{Q_1}} = \frac{d-x}{x} = \frac{d}{x} - 1$$

$$\frac{\sqrt{Q_2}}{\sqrt{Q_1}} + 1 = \frac{d}{x} = \frac{\sqrt{Q_2}}{\sqrt{q}}$$

$$\frac{\sqrt{Q_2}+\sqrt{Q_1}}{\sqrt{Q_1}\sqrt{Q_2}} = \frac{1}{\sqrt{q}} \Rightarrow q = \frac{Q_1 Q_2}{(\sqrt{Q_1}+\sqrt{Q_2})^2} \checkmark$$

$\hookrightarrow$ Ans

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COULOMB'S LAW

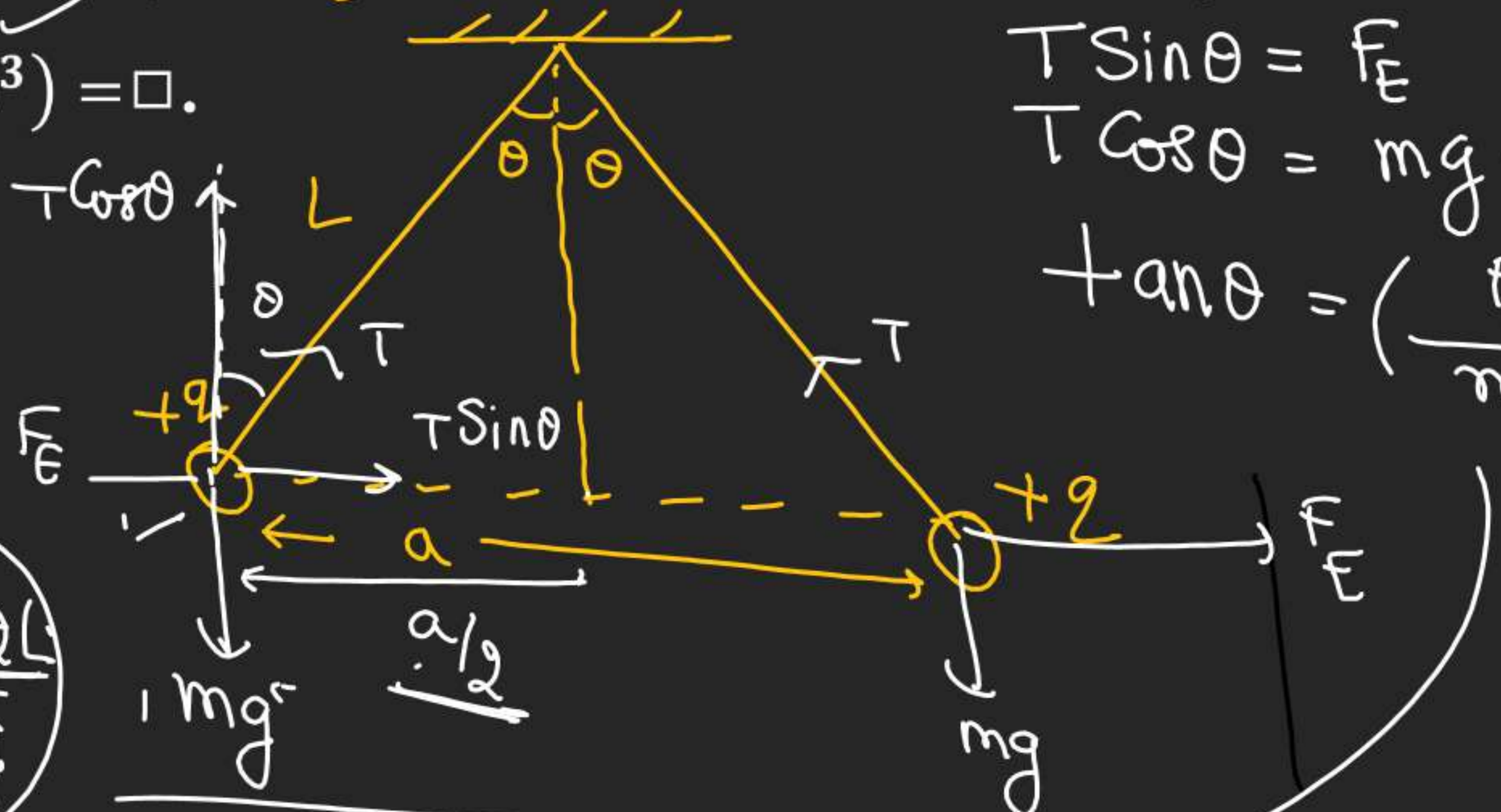
$\tan\theta \simeq \sin\theta \simeq \theta$

Q. Two identical small equally charged conducting balls are suspended from long threads secured at one point. The charges and masses of the balls are such that they are in equilibrium when the distance between them is a (the length of the thread $L >> a$). One of the balls is then discharged. Again for the certain value of distance $b (b << l)$ between the balls, the equilibrium is restored, the value of $(a^3/b^3) = \square$.

$$\tan\theta = \left(\frac{Kq^2}{a^2}\right) \times \frac{1}{mg}$$

$$\sin\theta = \frac{Kq^2}{a^2 mg}$$

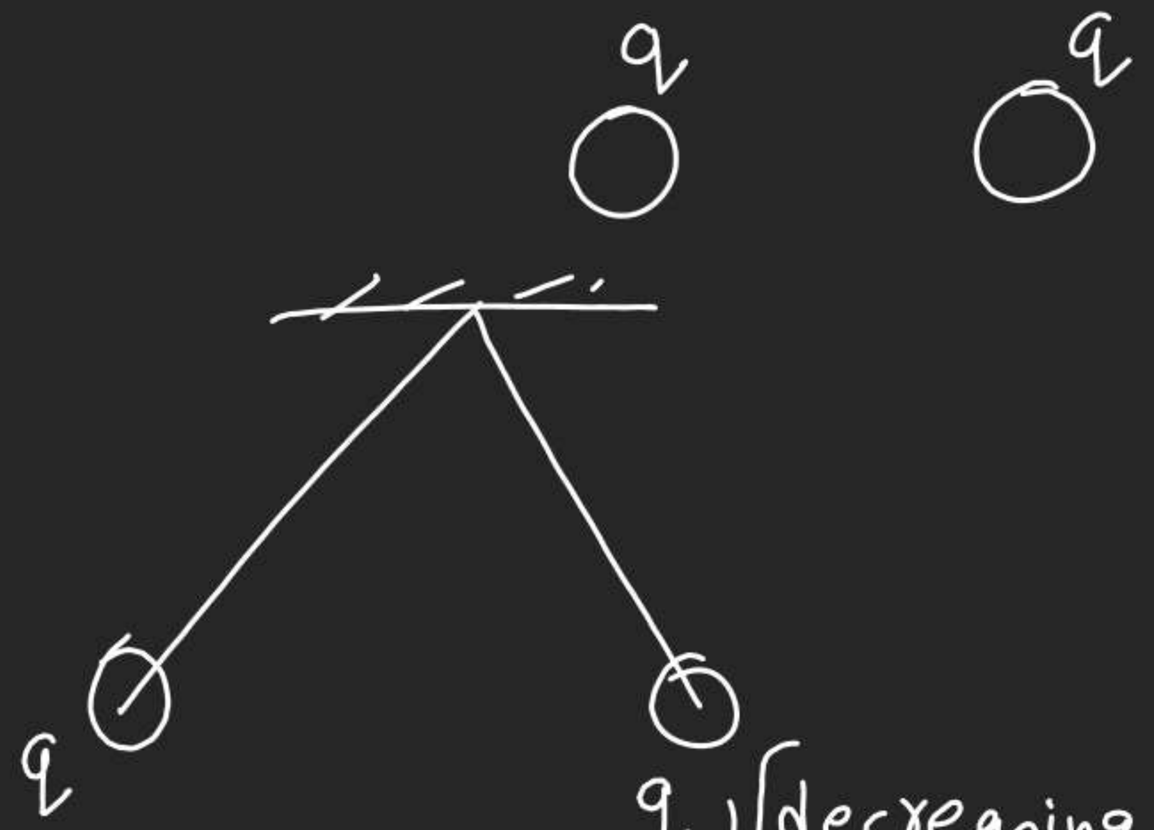
$$\frac{a}{2L} = \frac{Kq^2}{a^2 mg} \Rightarrow a^3 = \frac{Kq^2 2L}{mg}$$



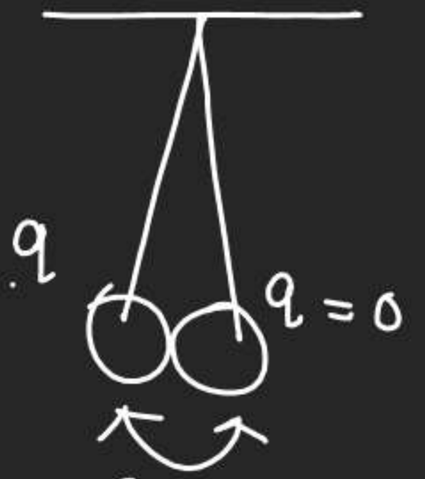
$$T\sin\theta = F_E$$

$$T\cos\theta = mg$$

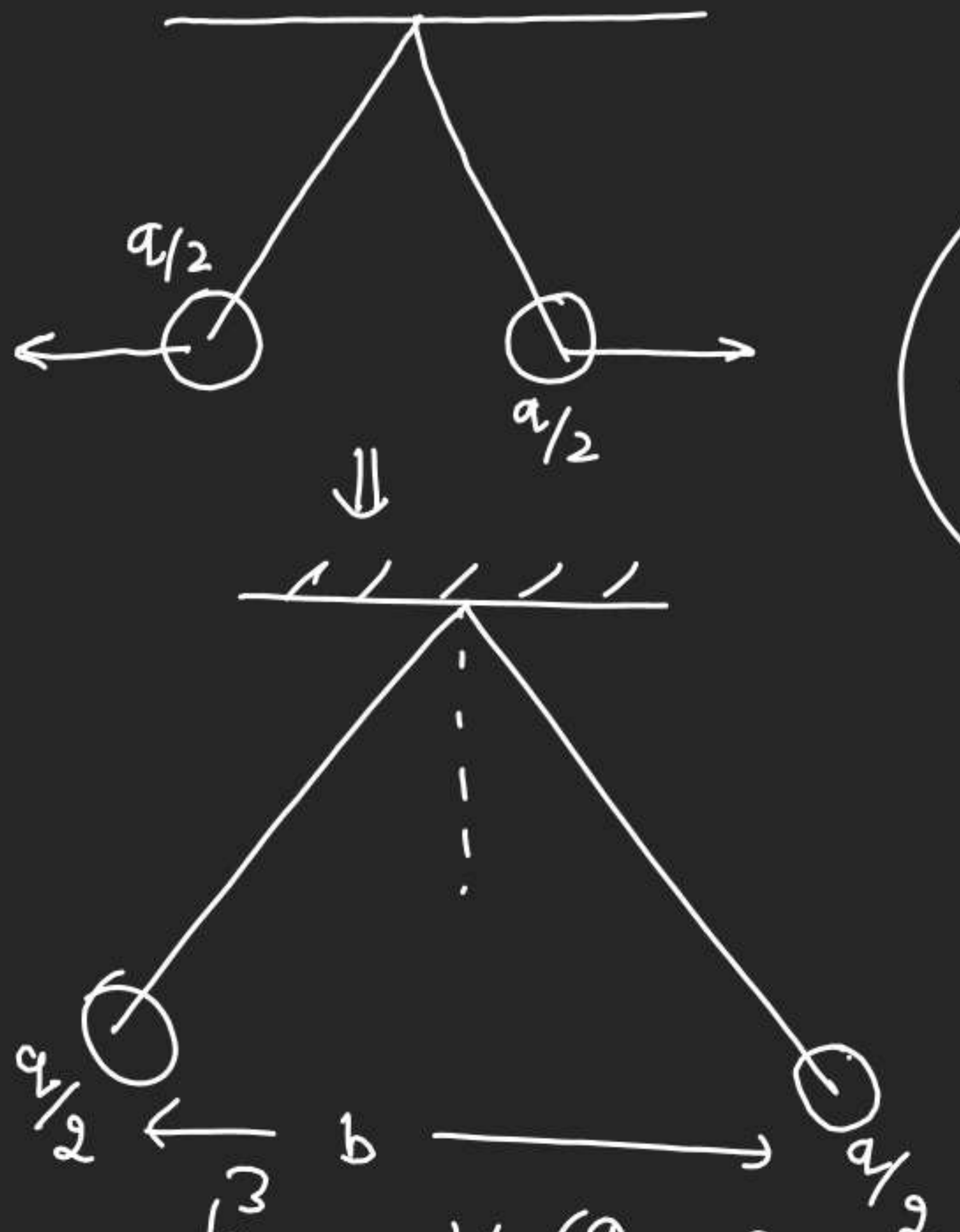
$$\tan\theta = \left(\frac{F_E}{mg}\right)$$



q ↓ [decreasing by discharging]



Conduction

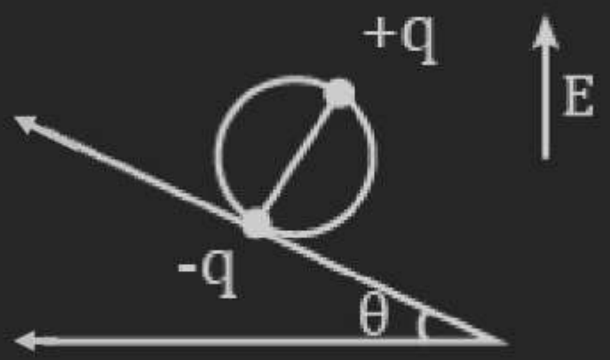


$$b^3 = \frac{K\left(q/2\right)^2 2L}{mg}$$

$$\frac{a^3}{b^3} = \frac{4}{1}$$

COULOMB'S LAW

Q. A wheel having mass m has charges $+q$ and $-q$ on diametrically opposite points. It remains in equilibrium on a rough inclined plane in the presence of uniform vertical electric field $E =$:



(A) $\frac{mg}{q}$

(B) $\frac{mg}{2q}$

(C) $\frac{mg\tan\theta}{2q}$

(D) none

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COULOMB'S LAW

$F = \frac{KQ^2}{d^2}$, $F' = \frac{K\left(\frac{Q}{2}\right)\left(\frac{3Q}{4}\right)}{d^2}$

$F' = \frac{3F}{8}$

Q. In frame I, two identical conducting spheres, A and B, carry equal amounts of excess charge that have the same sign. The spheres are separated by a distance d; and sphere A exerts an electrostatic force on sphere B which has a magnitude F. A third sphere, C, which is handled only by an insulated rod, is introduced in frame II. Sphere C is identical to A and B except that it is initially uncharged. Sphere C is touched first to sphere A, in frame II, and then to sphere B, in frame III, and is finally removed in frame IV.

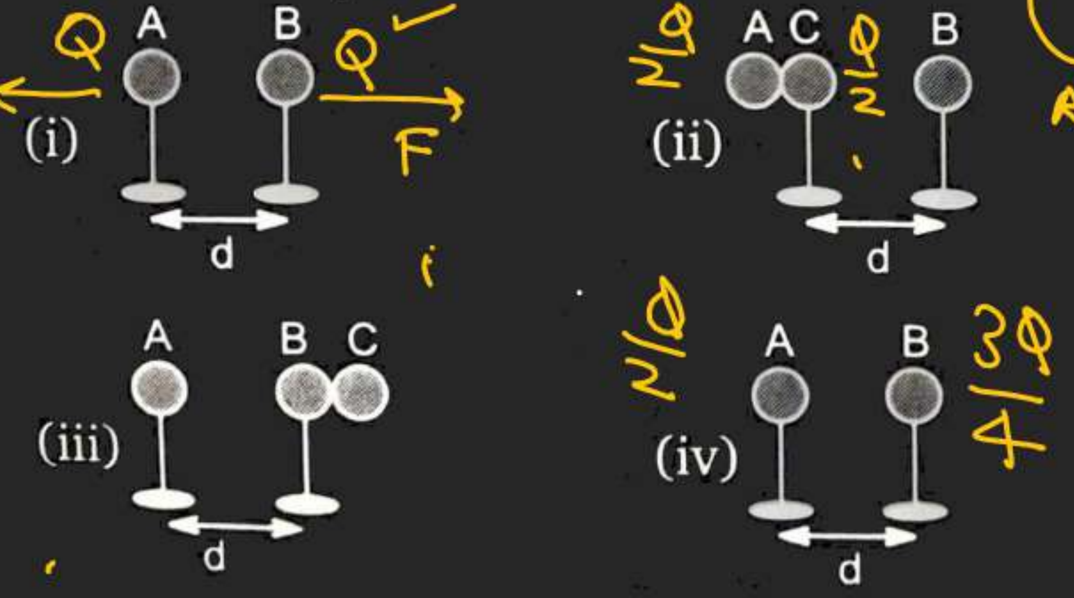
Determine the magnitude of the electrostatic force that sphere A exerts on sphere B in frame IV:

(A) F / 2

(B) F / 3

(C) 3 F / 4

(D) 3 F / 8



COULOMB'S LAW

Q. Two particles A and B having charges $20\mu C$ and $-5\mu C$ respectively are held fixed with a separation of $5\ cm$. At what position a third charged particle should be placed so that it does not experience a net electric force?

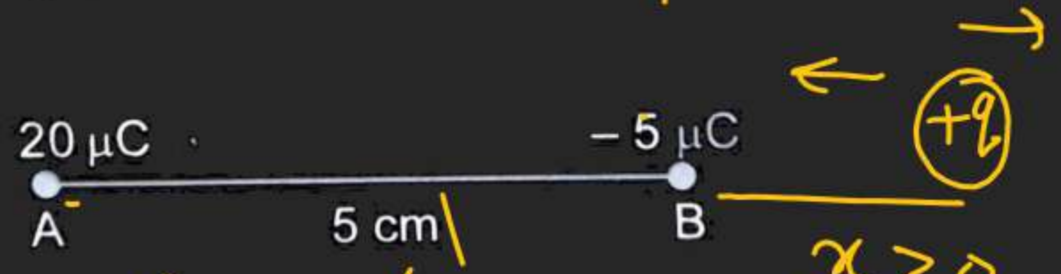
[JEE Mains - 2021]

(A) At $5\ cm$ from $-5\mu C$ on the right side

(B) At $1.25\ cm$ from a $-5\mu C$ between two charges

(C) At $5\ cm$ from $20\mu C$ on the left side of system

(D) At midpoint between two charges



$x > 0$

$$\frac{\cancel{K}(5)\cancel{q}}{x^2} = \frac{\cancel{K}(20)\cancel{q}}{(5+x)^2}$$

$$\left(\frac{5+x}{x}\right)^2 = 4$$

$$\frac{5+x}{x} = \pm 2$$

$$5 + x = 2x$$

$$\boxed{5 = x}$$