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DPP – 1 (Electrostatics)

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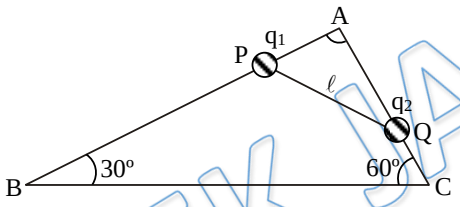
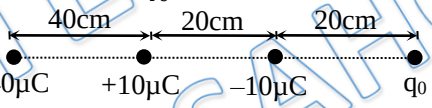
Q 1. A rigid insulated wire frame in the form of a right-angled triangle ABC, is set in a vertical plane as shown. Two beads of equal masses m and carrying charges q_1 and q_2 are connected by a cord of length l and can slide without friction on the wires. Considering the case when the beads are stationary, determine
the angle a = ∠APQ,



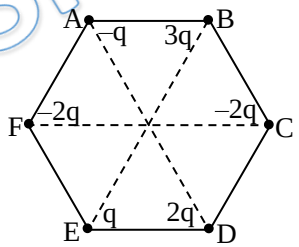
(a) 60° (b) 30° (c) 45° (d) 37°

Q 2. Four point charges are placed in a straight line with magnitude and separation as shown in the diagram. What should be the value of q_0 such that + 10mC charge is in equilibrium?



(a) – 80 μC (b) + 40 μC (c) + 80 μC (d) – 20 μC

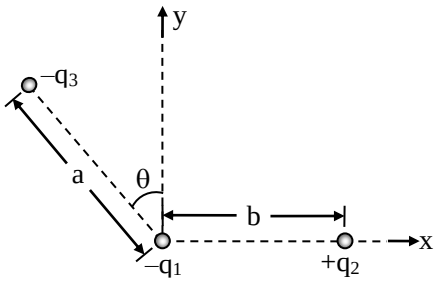
Q 3. Six charges are placed at the corner of a regular hexagon as shown. If an electron is placed at its centre O, force on it will be –



(a) zero (b) along OF (c) along OC (d) none of these

Q 4. Five balls numbered 1 to 5 are suspended using separate threads, Pairs (1, 2), (2, 4), (4, 1) shows electrostatics attraction, while pairs (2, 3) and (4, 5) show repulsion therefore ball 1 must be –
(a) Positively charged (b) Negative charged
(c) Neutral metal (d) None of these

Q 5. Three charges $-q_1$, $+q_2$ and $-q_3$ are placed as shown in the figure. The x-component of the force on $-q_1$ is proportional to –

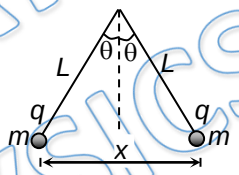


(a) $\frac{q_2}{b^2}-\frac{q_3}{a^2}\sin q$ (b) $\frac{q_2}{b^2}-\frac{q_3}{a^2}\cos q$ (c) $\frac{q_2}{b^2}+\frac{q_3}{a^2}\sin q$ (d) $\frac{q_2}{b^2}+\frac{q_3}{a^2}\cos q$

Q 6. Three charged particles are in equilibrium under their electrostatic forces only –
(a) The particles must be collinear
(b) All the charges cannot have the same magnitude
(c) All the charges cannot have the same sign.
(d) The equilibrium is unstable

Q 7. Two identical charges +Q are kept at fixed distance apart. A small particle P with charge q is placed midway between them. If P is given a small displacement D, it will undergo simple harmonic motion if –
(Take g = 10m/s^2, density of water is 10^3 kg/m^3)
(a) q is positive and D is along the line joining the charges
(b) q is positive and D is perpendicular to the line joining the charges
(c) q is negative and D is perpendicular to the line joining the charges
(d) q is negative and D is along the line joining the charges

Q 8. Two similar conducting balls of mass *m* are hung from silk threads of length *L* and carry similar charges *q* as shown in the figure. Assuming θ to be small, the distance *x* between the balls is



(a) $\left[\frac{q^2L}{4\pi\varepsilon_0 mg}\right]^{1/3}$ (b) $\left[\frac{q^2L}{2\pi\varepsilon_0 mg}\right]^{1/3}$ (c) $\left[\frac{q^2L}{4\pi\varepsilon_0 mg}\right]^{3/2}$ (d) $\left[\frac{q^2L}{2\pi\varepsilon_0 mg}\right]^{1/2}$

Q 9. A charge *Q* is placed at each of the two opposite corners of a square. A charge *q* is placed at each of the other two corners. If the resultant force on *Q* is zero, then

(a) $Q=\sqrt{2}q$ (b) $Q=-\sqrt{2}q$ (c) $Q=2\sqrt{2}q$ (d) $Q=-2\sqrt{2}q$

Q 10. Two pith balls having charge 3q and 2q are placed at distance of 'a' from each other. For what value of charge transferred from 1st ball to 2nd ball, repulsive force between balls becomes maximum?
(a) $\frac{9}{2}\rho g R^2$ (b) $\frac{3}{2}\rho g R^2$ (c) rgR^2 (d) Zero

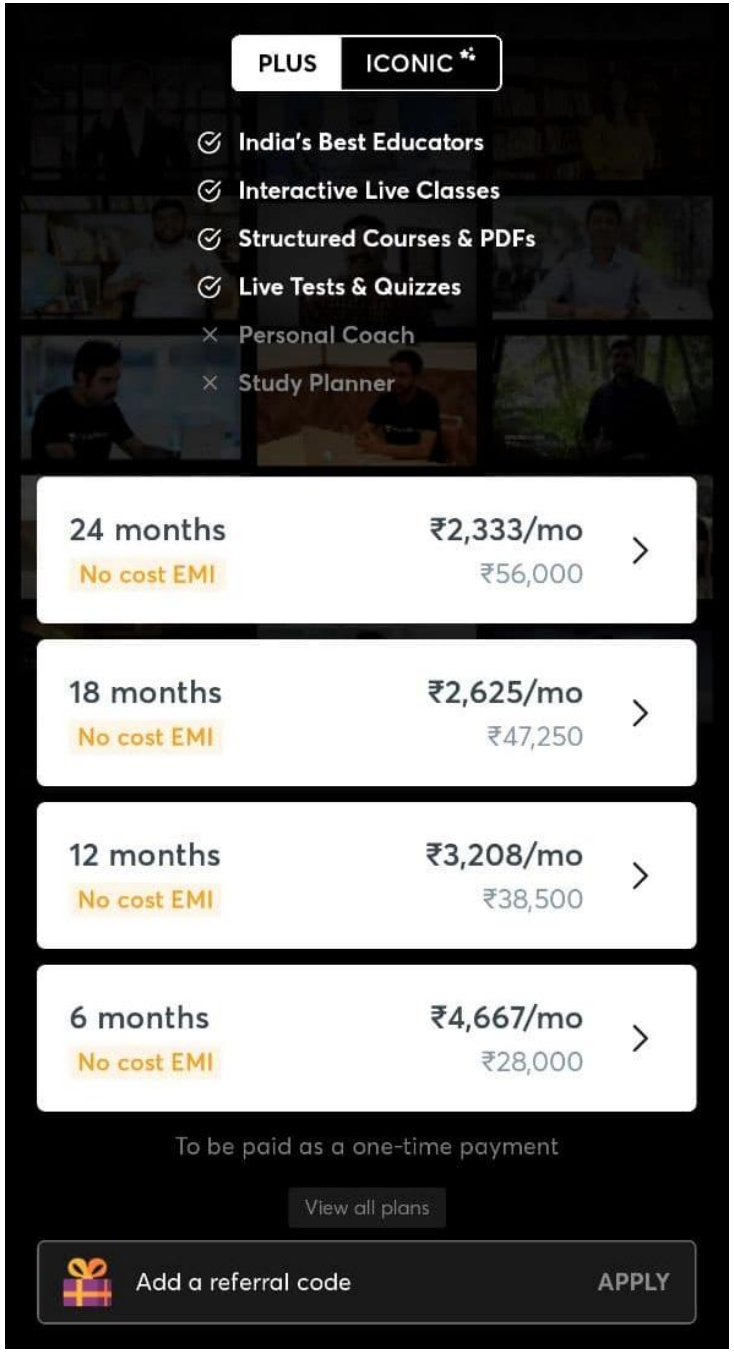
Q 11. Two small spherical bobs of same mass and radius having equal charges are suspended from the same point by strings of same length. The bobs are immersed in a liquid of relative permittivity k and density σ. Find the density of the bob for which the angle of divergence of the strings is the same in the air and in the liquid?

(a) $\frac{\sigma k}{k-1}$ (b) $\frac{\sigma k}{k+1}$ (c) $\frac{2\sigma k}{k-1}$ (d) None

Q 12. A point charge is placed at point of suspension of simple pendulum and equal charge is supplied to bob. Due to these charges time period of pendulum
(a) Increases (b) Decreases
(c) Remains same (d) Answer depend on magnitude of charge

Answer Key

Q.1 a	**Q.2 c**	**Q.3 d**	**Q.4 c**	**Q.5 c**
Q.6 a, b, c, d	**Q.7 a, c**	**Q.8 b**	**Q.9 d**	**Q.10 a**
Q.11 a	**Q.12 c**			



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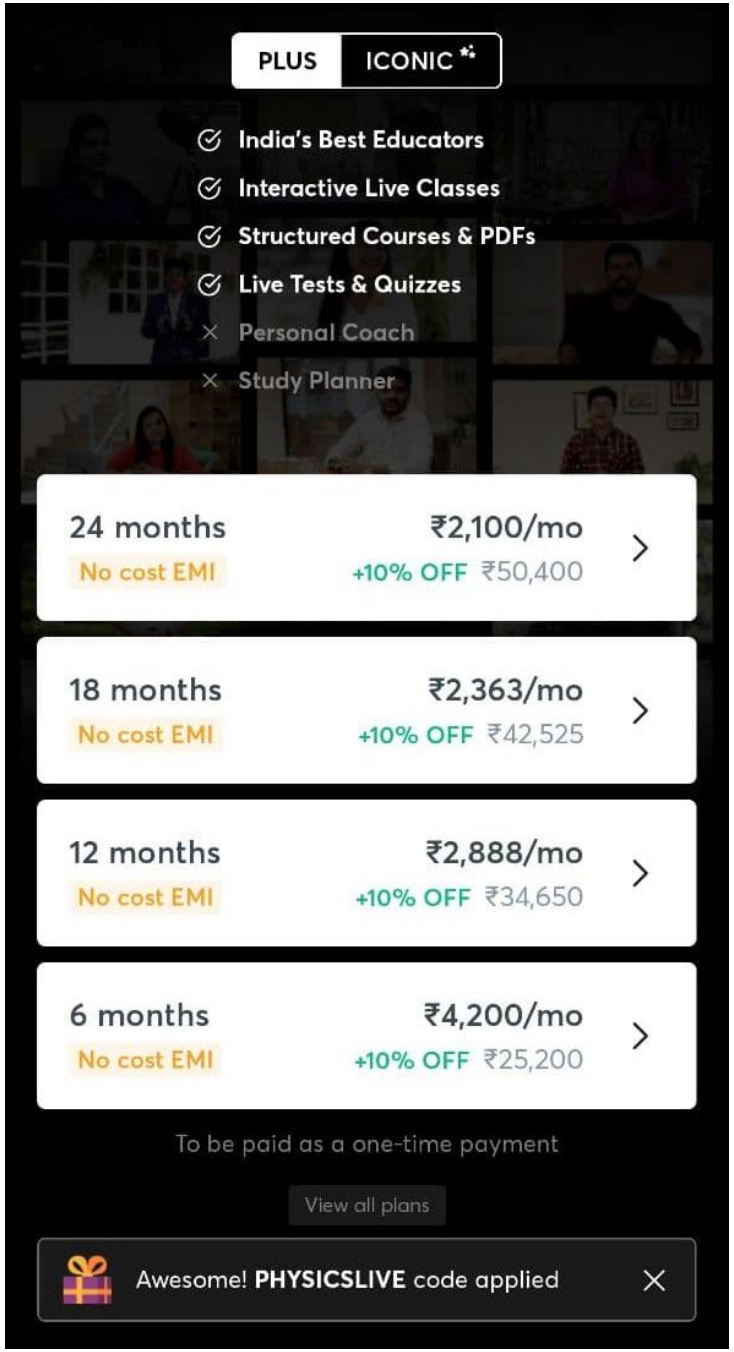


Written Solution

DPP-1 Electrostatics: Coulomb's Law

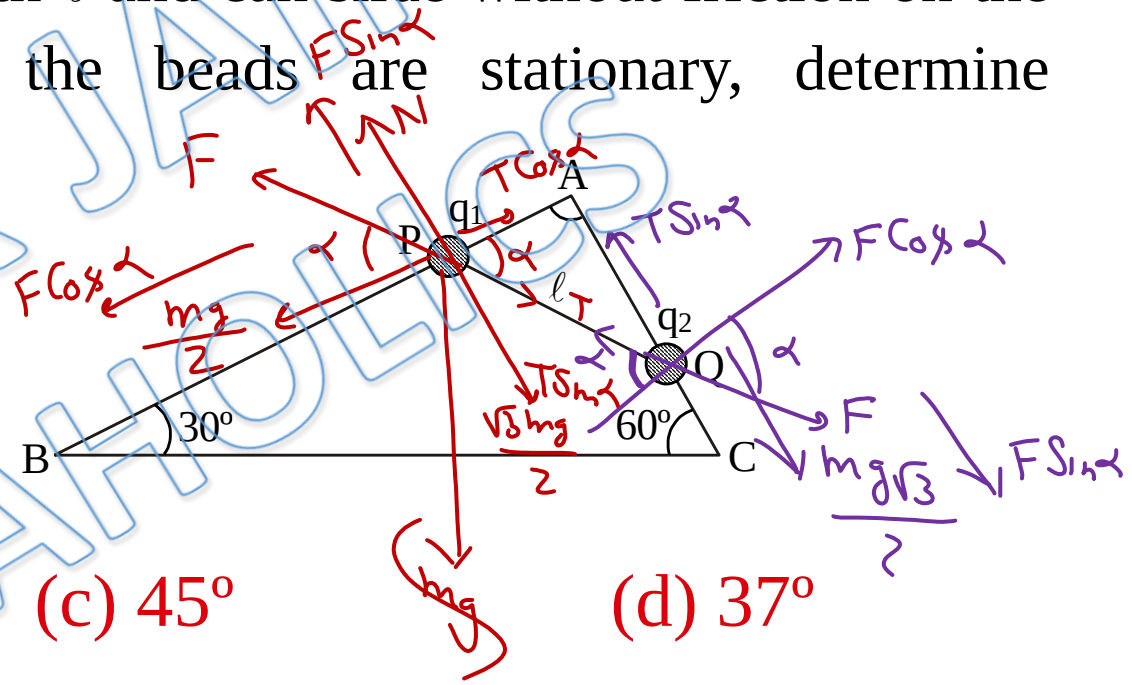
By Physicsaholics Team

Q1) A rigid insulated wire frame in the form of a right-angled triangle ABC, is set in a vertical plane as shown. Two beads of equal masses m and carrying charges q_1 and q_2 are connected by a cord of length ℓ and can slide without friction on the wires. Considering the case when the beads are stationary, determine the angle $\alpha = \angle APQ$,

$F = \frac{Kq_1q_2}{\ell^2}$

$T\cos\alpha = F\cos\alpha + mg/2$

$(T-F)\cos\alpha = \frac{mg}{2} \quad --(I)$



(a) 60° (b) 30° (c) 45° (d) 37°

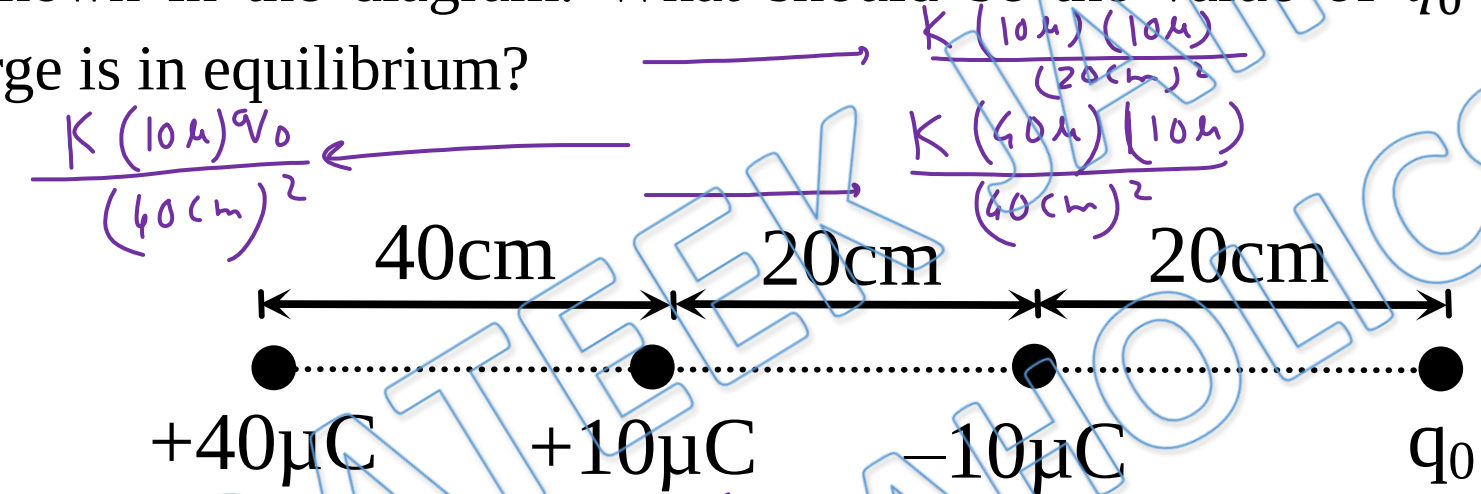
$T\sin\alpha = F\sin\alpha + \frac{mg\sqrt{3}}{2}$

$(T-F)\sin\alpha = \frac{mg\sqrt{3}}{2} \quad --(II)$

$\tan\alpha = \frac{mg\sqrt{3}/2}{mg/2} = \sqrt{3}$

$\alpha = 60$

Q2) Four point charges are placed in a straight line with magnitude and separation as shown in the diagram. What should be the value of q_0 such that + 10μC charge is in equilibrium?



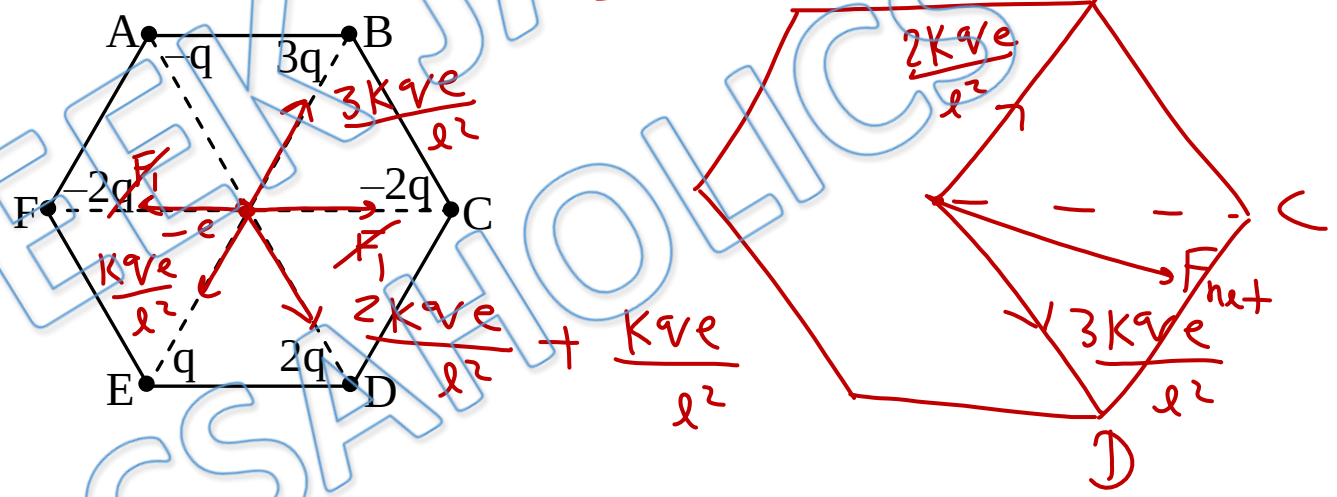
$$\frac{K q_0 (10\mu)}{(40cm)^2} = \frac{K(10\mu)(10\mu)}{(20cm)^2} + \frac{K(40\mu)(10\mu)}{(40cm)^2}$$

(a) – 80 μC (b) + 40 μC (c) + 80 μC (d) – 20 μC

$$\frac{q_0}{4} = 10\mu + \frac{40\mu}{4}$$

$$\frac{q_0}{4} = 20\mu$$

Q3) Six charges are placed at the corner of a regular hexagon as shown. If an electron is placed at its centre O, force on it will be -



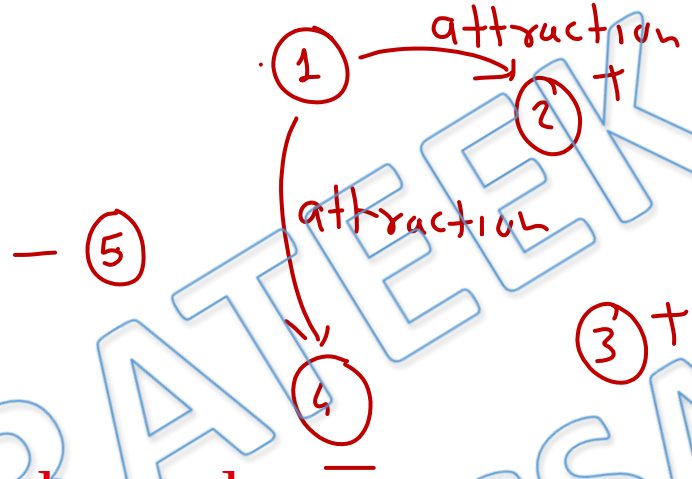
(a) zero

(b) along OF

(c) along OC

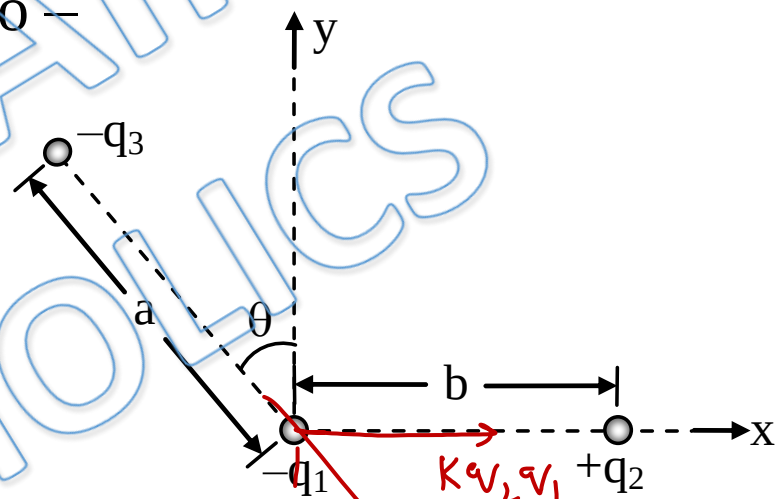
(d) none of these

Q4) Five balls numbered 1 to 5 are suspended using separate threads, Pairs (1, 2), (2, 4), (4, 1) shows electrostatics attraction, while pairs (2, 3) and (4, 5) show repulsion therefore ball 1 must be -



(a) Positively charged
(b) Negative charged
(c) Neutral metal
(d) None of these

Q5) Three charges $-q_1$, $+q_2$ and $-q_3$ are placed as shown in the figure. The x-component of the force on $-q_1$ is proportional to –



$F_x = \frac{Kq_2q_1}{b^2} + \frac{Kq_1q_3}{a^2}\sin\theta$

$= Kq_1\left[\frac{q_2}{b^2} + \frac{q_3}{a^2}\sin\theta\right]$

$\frac{Kq_2q_1}{b^2}$

$\frac{Kq_1q_3}{a^2}$

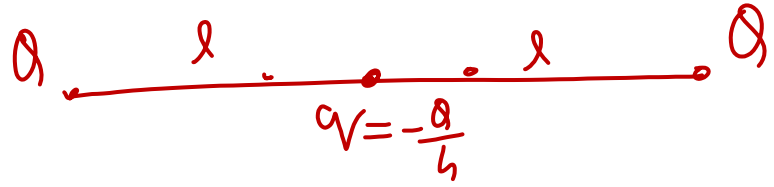
(a) $\frac{q_2}{b^2} - \frac{q_3}{a^2}\sin\theta$

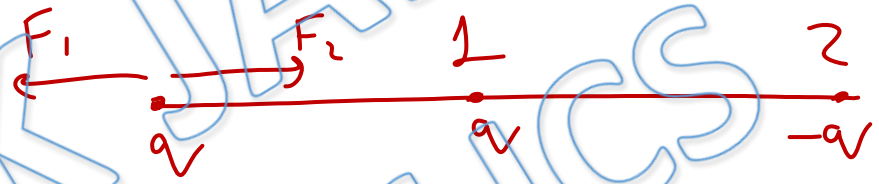
(b) $\frac{q_2}{b^2} - \frac{q_3}{a^2}\cos\theta$

(c) $\frac{q_2}{b^2} + \frac{q_3}{a^2}\sin\theta$

(d) $\frac{q_2}{b^2} + \frac{q_3}{a^2}\cos\theta$

Q6) Three charged particles are in equilibrium under their electrostatic forces only –





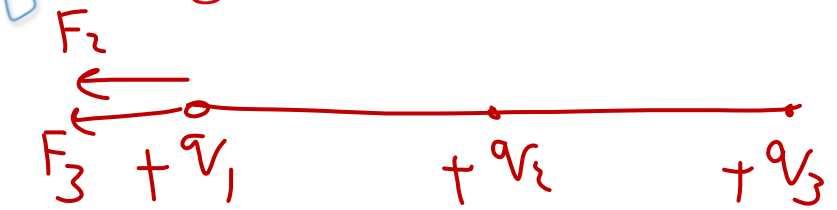
$F_2 < F_1$ since 2 is at large distance

(a) The particles must be collinear

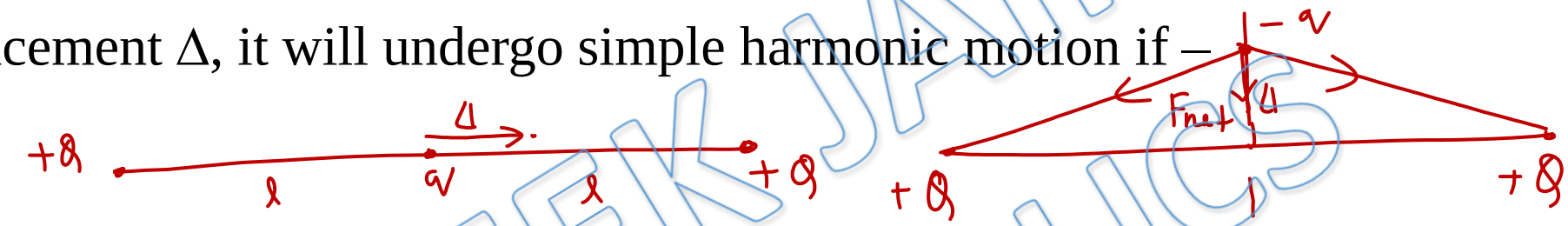
(b) All the charges cannot have the same magnitude

(c) All the charges cannot have the same sign.

(d) The equilibrium is unstable



Q7) Two identical charges +Q are kept at fixed distance apart. A small particle P with charge q is placed midway between them. If P is given a small displacement Δ, it will undergo simple harmonic motion if –



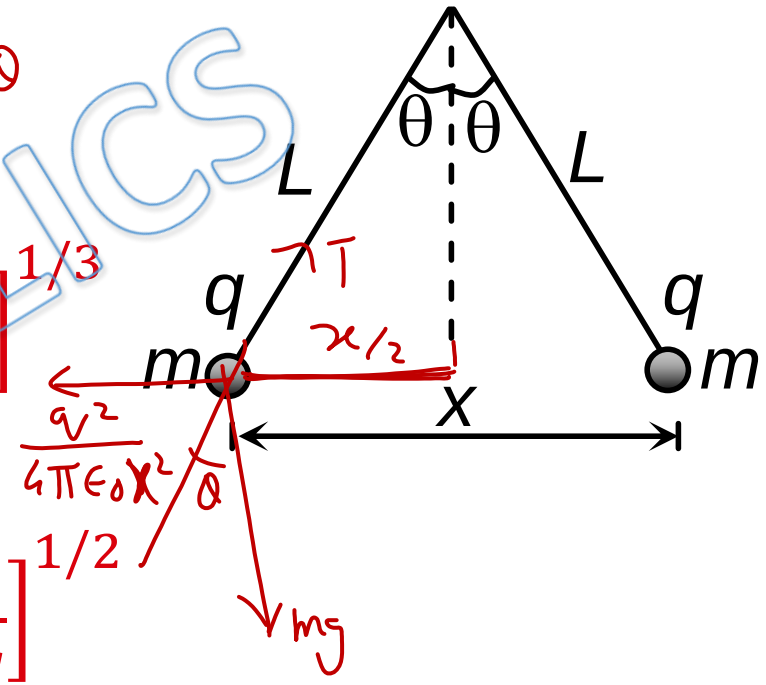
(a) q is positive and Δ is along the line joining the charges

(b) q is positive and Δ is perpendicular to the line joining the charges

(c) q is negative and Δ is perpendicular to the line joining the charges

(d) q is negative and Δ is along the line joining the charges

Q8) Two similar conducting balls of mass m are hung from silk threads of length L and carry similar charges q as shown in the figure. Assuming θ to be small, the distance x between the balls is



(a) $\left[\frac{q^2L}{4\pi\varepsilon_0 mg}\right]^{1/3}$

(b) $\left[\frac{q^2L}{2\pi\varepsilon_0 mg}\right]^{1/3}$

(c) $\left[\frac{q^2L}{4\pi\varepsilon_0 mg}\right]^{3/2}$

(d) $\left[\frac{q^2L}{2\pi\varepsilon_0 mg}\right]^{1/2}$

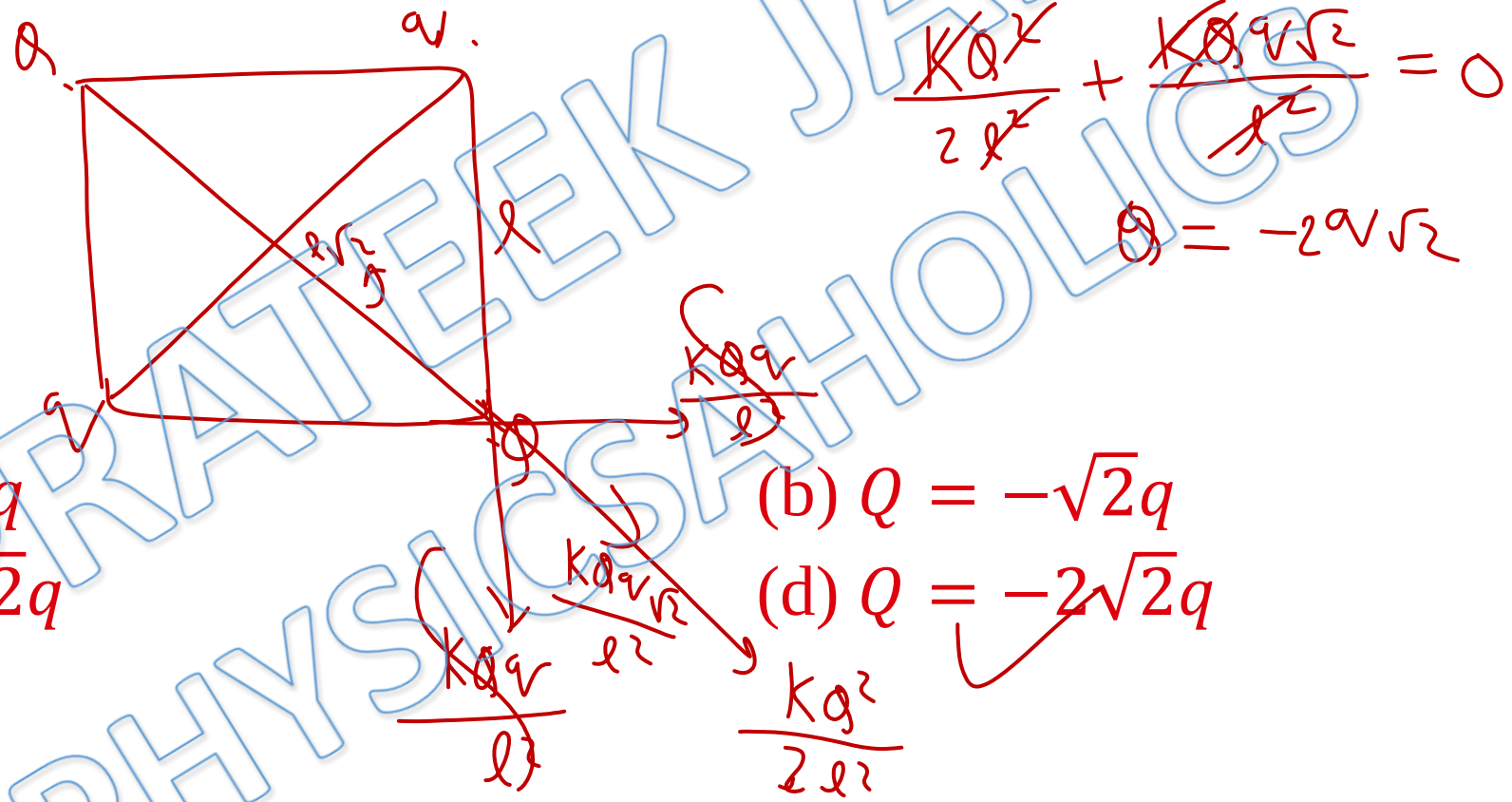
$\tan\theta = \frac{q^2}{4\pi\epsilon_0 x^2 mg} \simeq \sin\theta$

$\frac{q^2}{4\pi\epsilon_0 x^2 mg} = \frac{x}{2L}$

$x^3 = \frac{2q^2L}{4\pi\epsilon_0 mg}$

$x = \left(\frac{q^2L}{2\pi\epsilon_0 mg}\right)^{1/3}$

Q9) A charge Q is placed at each of the two opposite corners of a square. A charge q is placed at each of the other two corners. If the resultant force on Q is zero, then



(a) $Q = \sqrt{2}q$

(b) $Q = -\sqrt{2}q$

(c) $Q = 2\sqrt{2}q$

(d) $Q = -2\sqrt{2}q$

Q10) Two pith balls having charge 3q and 2q are placed at distance of 'a' from each other. For what value of charge transferred from 1st ball to 2nd ball, repulsive force between balls becomes maximum?

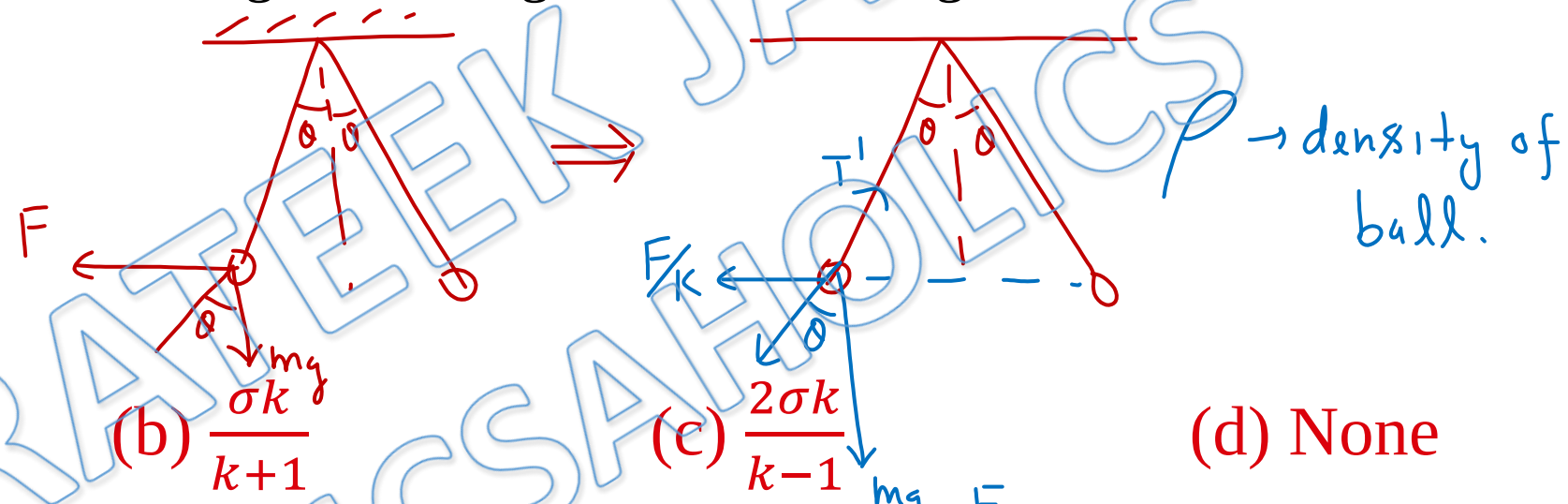
$$F = \frac{K(3q-Q)(2q+Q)}{a^2} = \frac{K}{a^2}\left[6q^2 - Q^2 + qQ\right]$$

(a) $\frac{q}{2}$ (b) $\frac{5q}{2}$ (c) q (d) 0

$$\frac{dF}{dQ} = 0 \Rightarrow \frac{K}{a^2}\left[-2Q + q\right] = 0$$

$$Q = q/2$$

Q11) Two small spherical bobs of same mass and radius having equal charges are suspended from the same point by strings of same length. The bobs are immersed in a liquid of relative permittivity k and density σ. Find the density of the bob for which the angle of divergence of the strings is the same in the air and in the liquid?



(a) $\frac{\sigma k}{k-1}$ (b) $\frac{\sigma k}{k+1}$ (c) $\frac{2\sigma k}{k-1}$ (d) None

$$\tan\theta = \frac{F}{mg} = \frac{F/k}{mg\left(1-\frac{\sigma}{\rho}\right)}$$

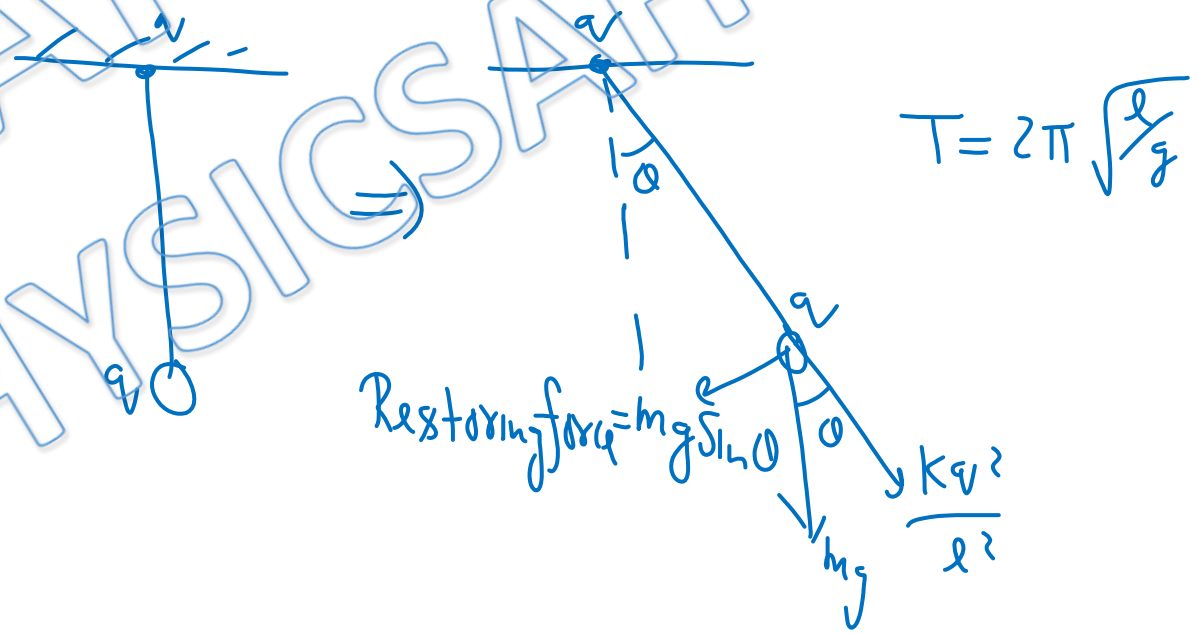
$$mg - F_b = mg\left(1-\frac{\sigma}{\rho}\right)$$

$$1-\frac{\sigma}{\rho} = \frac{1}{k} \Rightarrow \frac{\sigma}{\rho} = 1-\frac{1}{k} = \frac{k-1}{k} \Rightarrow \rho = \frac{\sigma k}{k-1}$$

Q12) A point charge is placed at point of suspension of simple pendulum and equal charge is supplied to bob. Due to these charges time period of pendulum

(a) Increases (b) Decreases

(c) Remains same (d) Answer depend on magnitude of charge



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