Physicsaholics

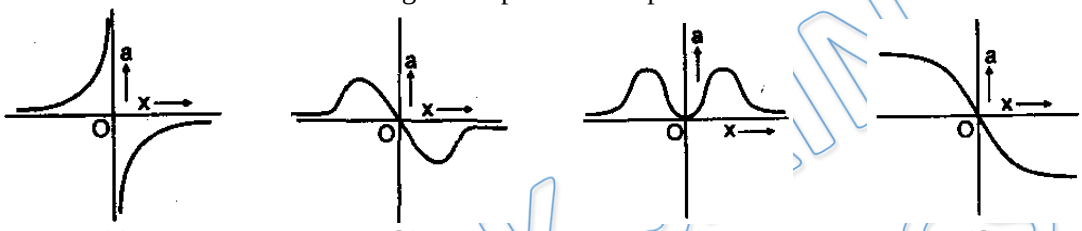
DPP – 2 (Electrostatics)

Video Solution on Website:- https://physicsaholics.com/home/courseDetails/93

Video Solution on YouTube:- https://youtu.be/gRV0_wc4gOI

Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/39

Q 1. Two identical positive charges are fixed on the y-axis, at equal distances from the origin o. A particle with a negative charge starts on the negative x-axis at a large distance from o, moves along the x-axis, passed through o and moves far away from o. Its acceleration a is taken as positive along its direction of motion. The particle's acceleration a is plotted against its x-coordinate. Which of the following best represents the plot?



(a) (b) (c) (d)

Q 2. A positively charged thin metal ring of radius R is fixed in the x-y plane with its centre at the origin o. A negatively charged particle P is released from rest at the point (0, 0, z_0) where $z_0 > 0$. Then the motion of P is:

(a) periodic for all values of z_0 satisfying $0 < z_0 < \infty$

(b) simple harmonic for all values of z_0 satisfying $0 < z_0 \leq R$

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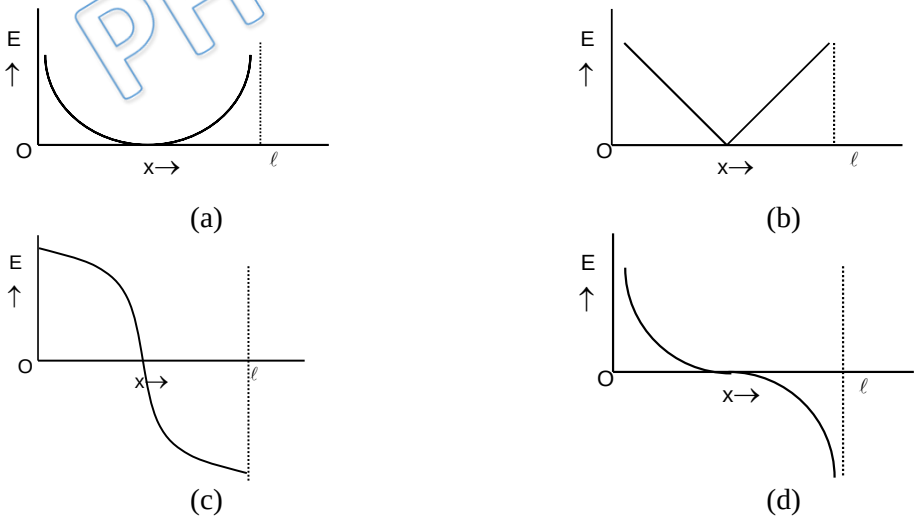
(d) such that P crosses o and continues to move along the negative z-axis towards $z = -\infty$

Q 3. Two identical point charges are placed at a separation of ℓ. P is a point on the line joining the charges, at a distance x from any one charge. The field at P is E. E is plotted against x for values of x from close to zero to slightly less than ℓ. Which of the following best represents the resulting curve?

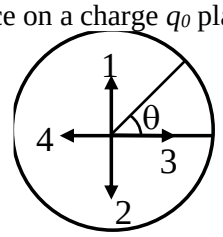


(a) (b) (c) (d)

Q 4. A uniform rod of length l and mass m is charged with a charge q is hanging from one of its ends as shown in figure. At t = 0 a horizontal electric field E is switched on in the horizontal direction perpendicular to the rod. Find the minimum value of E so that the rod rotates up to horizontal level.

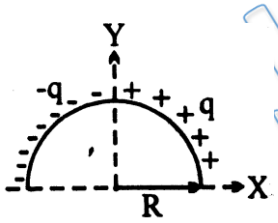
(a) $\frac{2mg}{q}$ (b) $\frac{mg}{q}$ (c) $\frac{mg}{2q}$ (d) None

Q 5. Charge over a non-conducting ring is distributed so that the linear charge density varies as $\lambda = \lambda_0 \sin\theta$. What is direction of force on a charge q_0 placed at the center?



(a) along 1 if q_0 is –ve (b) along 2 if q_0 is +ve
(c) along 3 if q_0 is +ve (d) along 4 if q_0 is –ve

Q 6. The electric field at centre of semicircular ring shown in figure. (Charge q and –q are uniformly distributed on respective parts)



(a) $\frac{4KQ}{\pi R^2}$ (b) $\frac{KQ}{\pi R^2}$ (c) $\frac{2KQ}{R^2}$ (d) $\frac{KQ}{2\pi R^2}$

Q 7. Three infinitely long charged thin wire are placed along x, y, z axis. Their line charge densities are λ_1 , λ_2 and λ_3 respectively. Then

(a) E_x at point (a, a, 0) is independent to λ_2

(b) E_z at point (a, a, a) is proportional to $\sqrt{{\lambda_1}^2 + {\lambda_2}^2}$

(c) E at point (a, a, 0) is proportional to $\sqrt{{\lambda_1}^2 + {\lambda_2}^2}$

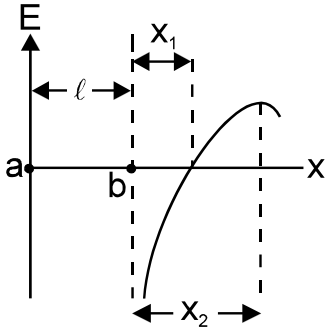
(d) None of these

Q 8. A 10 cm long rod carries a charge of + 50 μC distributed uniformly along its length, Find the magnitude of the electric field at a point 10 cm from both the ends of the rod.

(a) 5.2×10^7 N/C (b) 2.6×10^7 N/C (c) 1.3×10^7 N/C (d) 6.5×10^7 N/C

COMPREHENSION

Two point charges are placed at point a and b. The field strength to the right of the charge Q_b on the line that passes through the two charges varies according to a law that is represented graphically in the figure. The electric field is taken positive if its direction is towards right and negative if its direction is towards left.

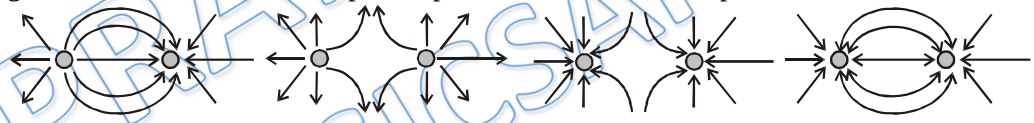


Q 9. Choose the correct statement regarding the signs of the charges.
(a) Charge at point a is positive and charge at point b is negative.
(b) Charge at point a is negative and charge at point b is positive.
(c) Both charges are positive
(d) Both charges are negative

Q 10. Ratio of magnitudes of charges $\left|\frac{Q_a}{Q_b}\right|$ will be equal to:
(a) $\left(1+\frac{\ell}{x_1}\right)$ (b) $\left(1+\frac{\ell}{x_1}\right)^2$ (c) $1+\left(\frac{\ell}{x_1}\right)^2$ (d) $\left(1+\frac{\ell}{x}\right)^4$

Q 11. The distance x_2 from point b where the field is maximum, will be
(a) $\frac{\ell}{\left(\frac{\ell+x_1}{x_1}\right)^{\frac{2}{3}}-1}$ (b) $\frac{\ell}{\left(\frac{\ell+x_1}{x_1}\right)^{\frac{1}{3}}-1}$ (c) $\frac{\ell}{\left(\frac{\ell+2x_1}{x_1}\right)^{\frac{2}{3}}-1}$ (d) $\frac{\ell}{\left(\frac{\ell+2x_1}{x_1}\right)^{\frac{1}{3}}-1}$

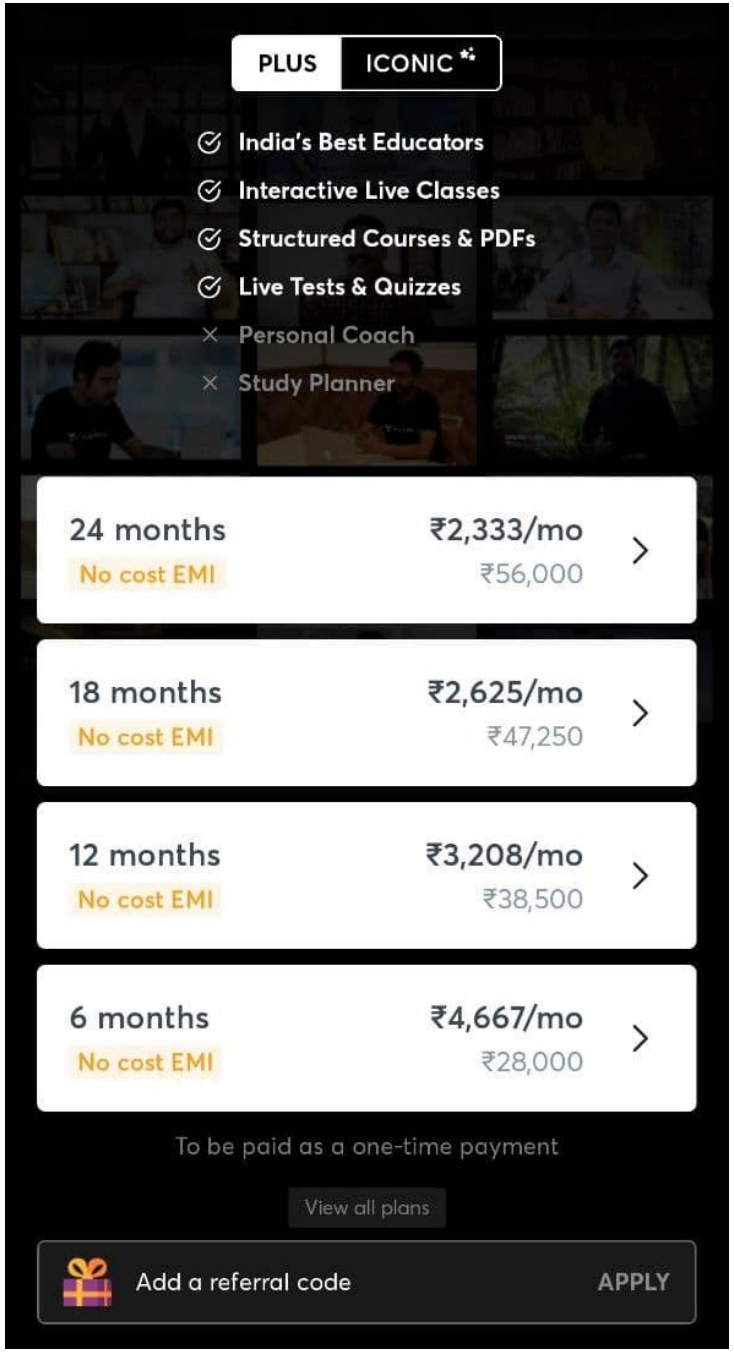
Q 12. Assume that gravitational lines of forces represent gravitational field just like electric lines of forces represent electric field. Which of the following diagram correctly represents the gravitational field lines for a pair of point masses shown in options below?


(a) (b) (c) (d)

Q 13. There is a uniformly charged fixed horizontal ring of radius R. A point charge is placed on its axis at height .5R from its centre. If charge is in equilibrium, the equilibrium is
(a) Stable
(b) Unstable
(c) Neutral
(d) None of these

Answer Key

Q.1 b	**Q.2 c**	**Q.3 d**	**Q.4 b**	**Q.5 a, b**
Q.6 a	**Q.7 d**	**Q.8 a**	**Q.9 a**	**Q.10 b**
Q.11 a	**Q.12 c**	**Q.13 b**		



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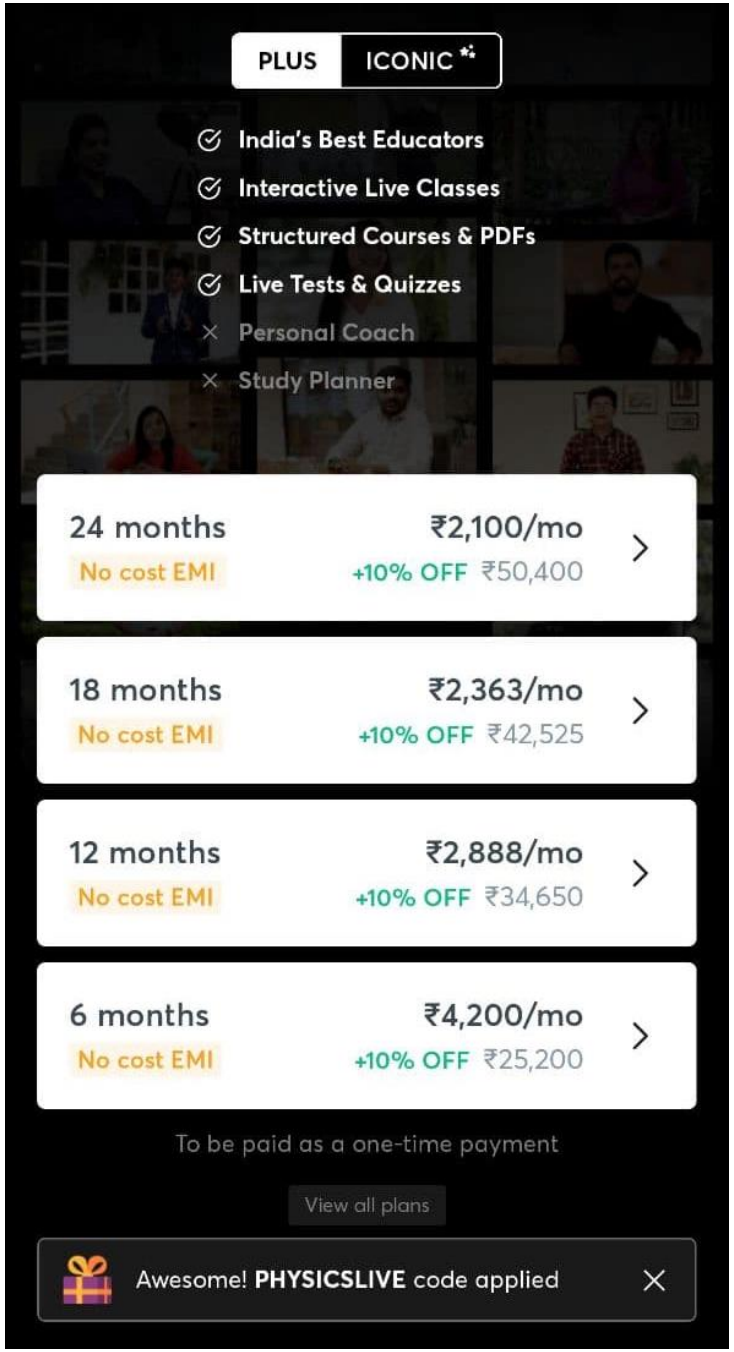


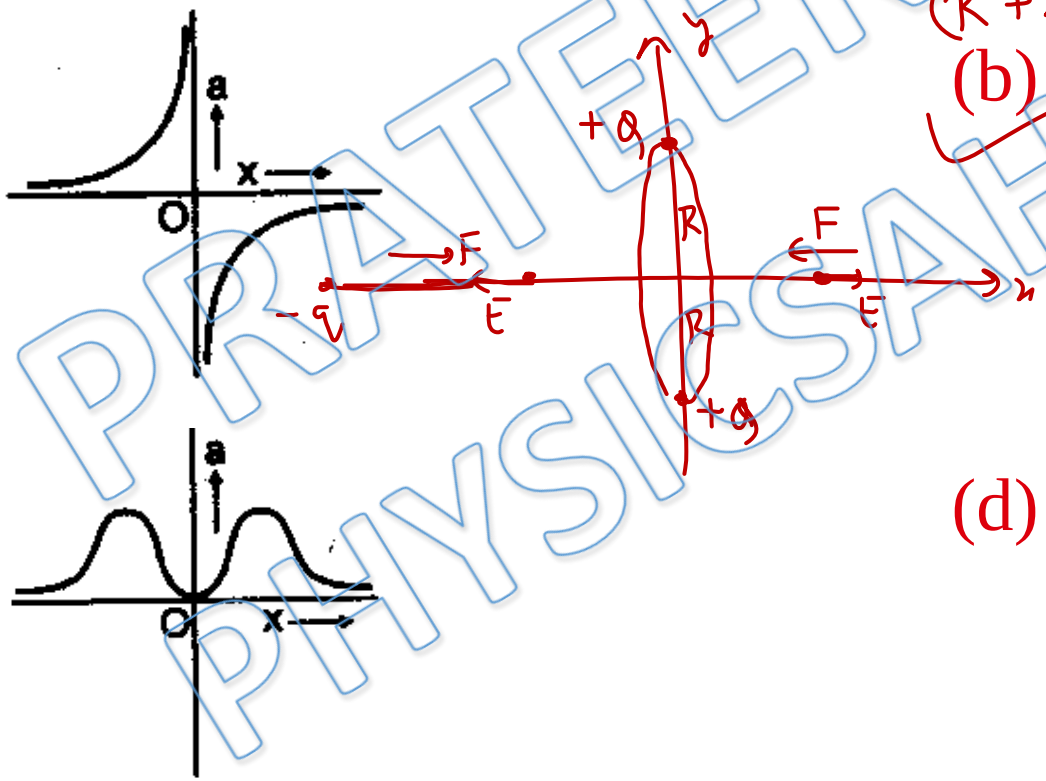
Written Solution

DPP- 2 Electrostatics: Electric field (Due to Point charge, linear charge distribution & Charged Ring)

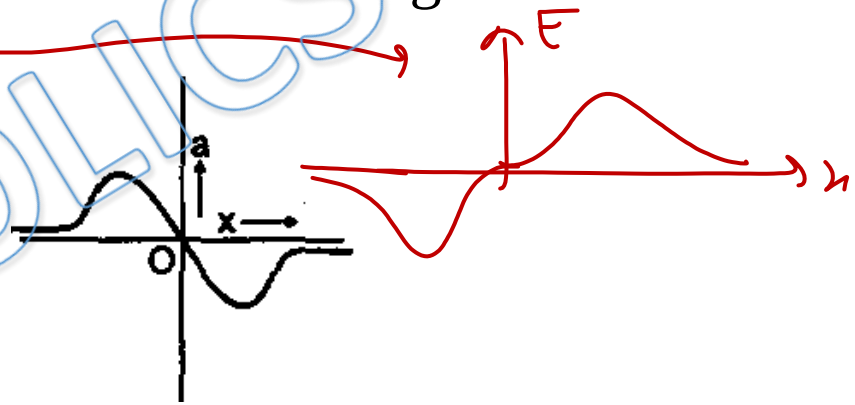
By Physicsaholics Team

Q1) Two identical positive charges are fixed on the y-axis, at equal distances from the origin o. A particle with a negative charge starts on the negative x-axis at a large distance from o, moves along the x-axis, passed through o and moves far away from o. Its acceleration a is taken as positive along its direction of motion. The particle's acceleration a is plotted against its x-coordinate. Which of the following best represents the plot?

(a)

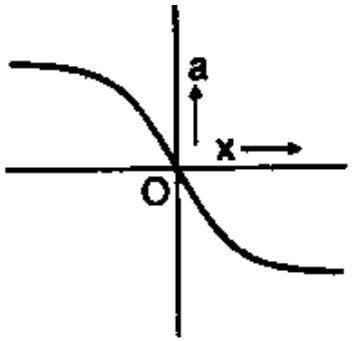


(b)



(c)

(d)

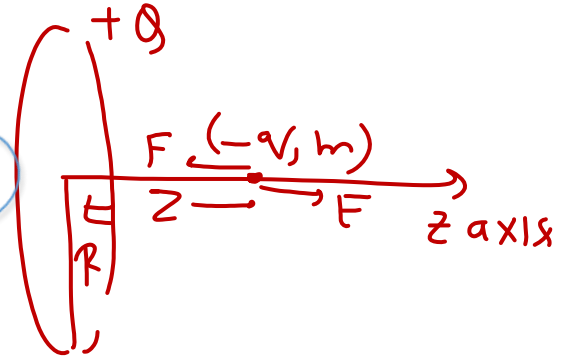


Q2) A positively charged thin metal ring of radius R is fixed in the x-y plane with its centre at the origin o. A negatively charged particle P is released from rest at the point $(0, 0, z_0)$ where $z_0 > 0$. Then the motion of P is:

E at z = z

$$E = \frac{+KQz}{(R^2+z^2)^{3/2}}$$

$$F = -\frac{KQqz}{(R^2+z^2)^{3/2}}$$



(a) periodic for all values of z_0 satisfying $0 < z_0 < \infty$

(b) simple harmonic for all values of z_0 satisfying $0 < z_0 \leq R$

(c) approximately simple harmonic provided $z_0 << R$

(d) such that P crosses o and continues to move along the negative z-axis towards $z = -\infty$

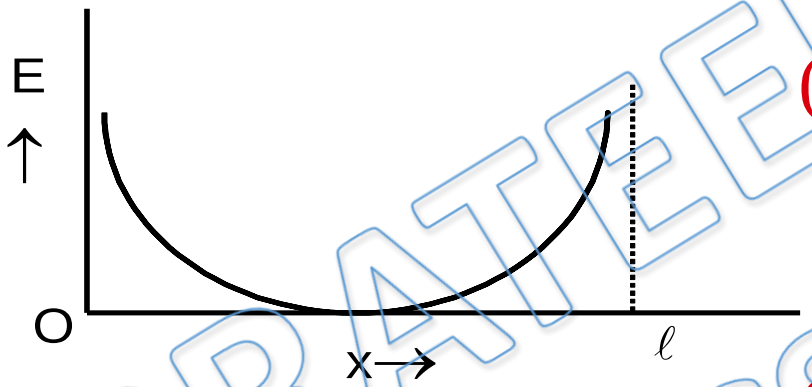
$$a = -\frac{KQqz}{m(R^2+z^2)^{3/2}}$$

If $z \ll R$

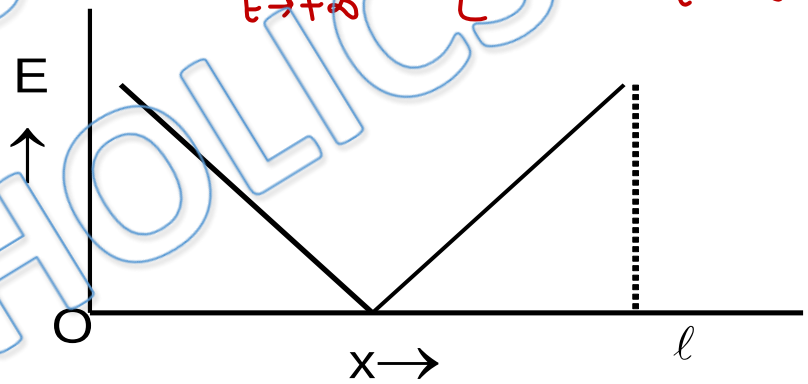
$$a = -\frac{KQqz}{mR^3} \rightarrow \text{SHM}$$

Q3) Two identical point charges are placed at a separation of ℓ. P is a point on the line joining the charges, at a distance x from any one charge. The field at P is E. E is plotted against x for values of x from close to zero to slightly less than ℓ. Which of the following best represents the resulting curve?

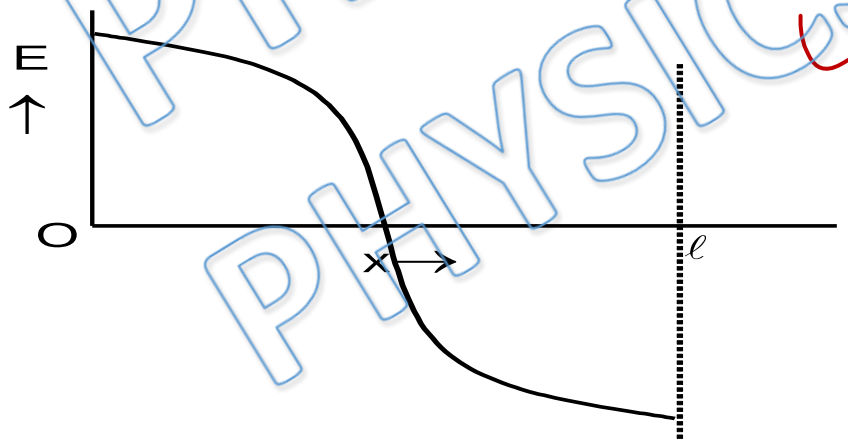
(a)



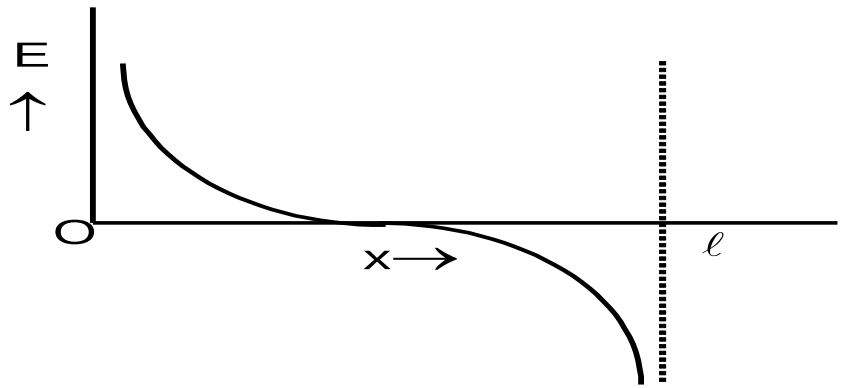
(b)



(c)



(d)



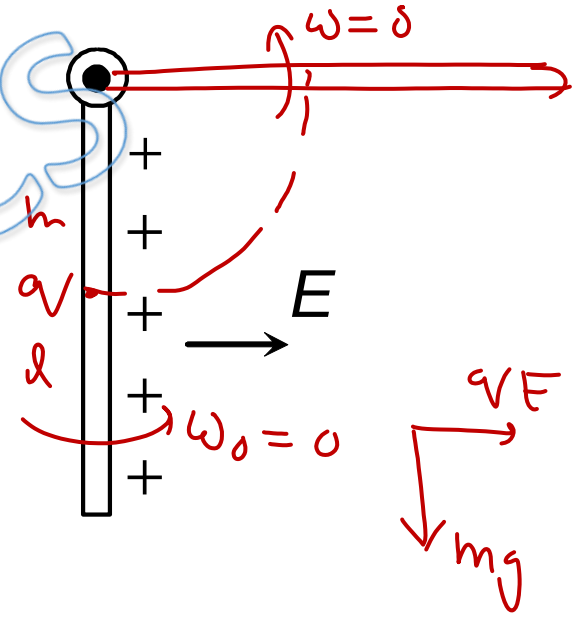
Q4) A uniform rod of length l and mass m is charged with a charge q is hanging from one of its ends as shown in figure. At t = 0 a horizontal electric field E is switched on in the horizontal direction perpendicular to the rod. Find the minimum value of E so that the rod rotates up to horizontal level.

$W_{all} = K_f - K_i$ → work energy theorem

$W_{mg} + W_E = 0 - 0$

$-mg\,l/2 + qE\,l/2 = 0$

$\Rightarrow qE = mg \Rightarrow E = \frac{mg}{q}$



(a) $\frac{2mg}{q}$ (b) $\frac{mg}{q}$ (c) $\frac{mg}{2q}$ (d) None

Q5) Charge over a non-conducting ring is distributed so that the linear charge density varies as $\lambda = \lambda_0 \sin\theta$. What is direction of force on a charge q_0 placed at the center?

(a) along 1 if q_0 is –ve

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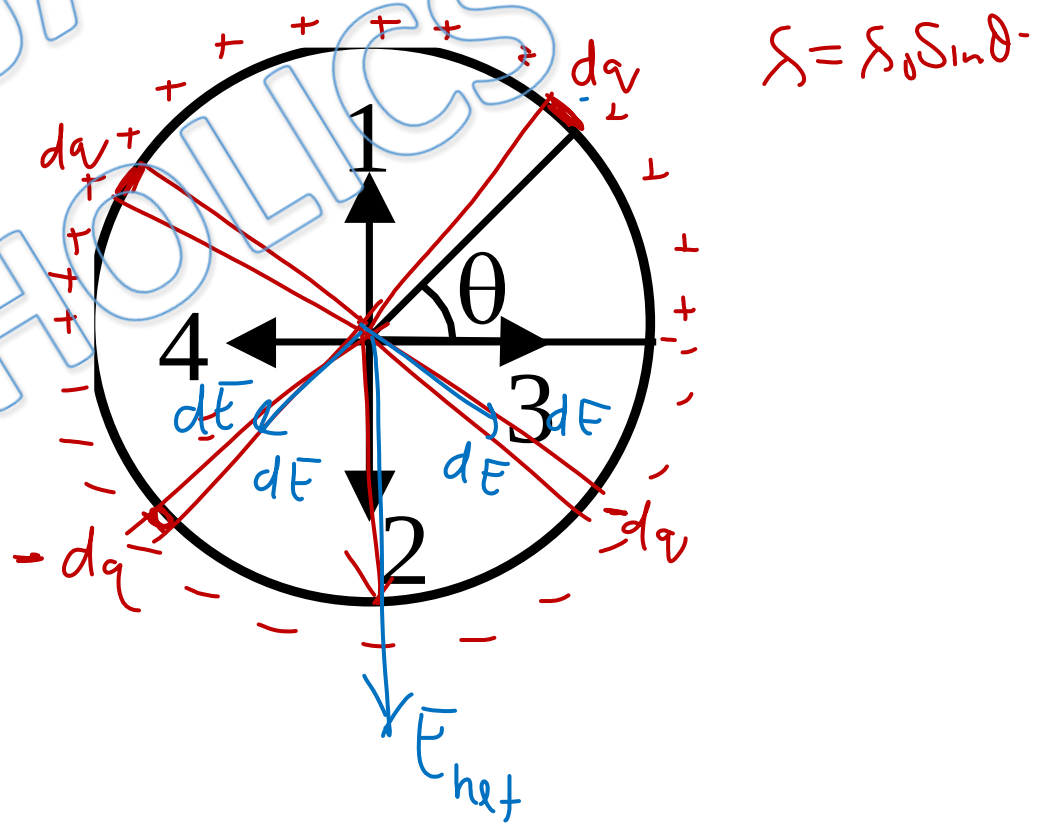
(c) along 3 if q_0 is +ve

(d) along 4 if q_0 is –ve



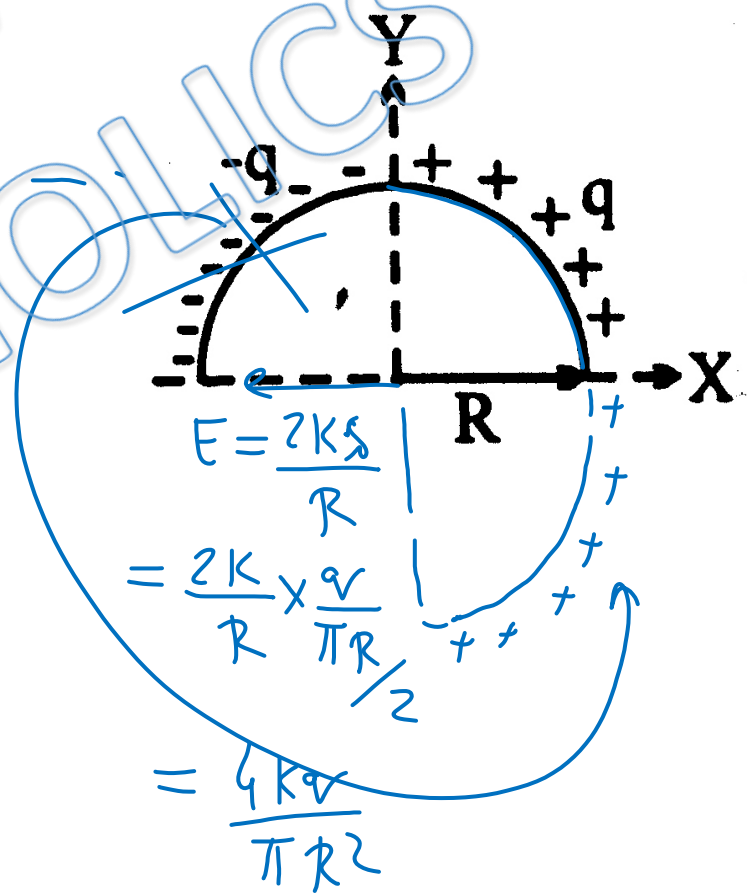
Q6) the electric field at centre of semicircular ring shown in figure. (Charge q and –q are uniformly distributed on respective parts)

(a) $\frac{4KQ}{\pi R^2}$

(b) $\frac{KQ}{\pi R^2}$

(c) $\frac{2KQ}{R^2}$

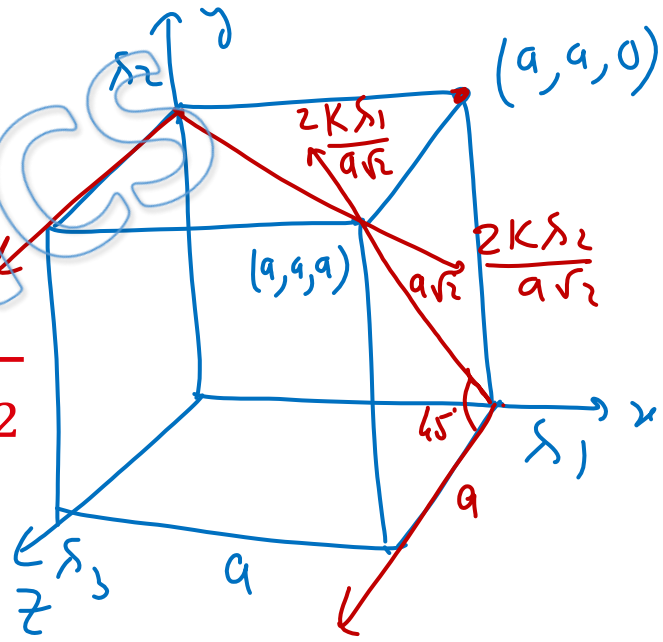
(d) $\frac{KQ}{2\pi R^2}$



Q7) Three infinitely long charged thin wire are placed along x, y, z axis. Their line charge densities are λ_1 , λ_2 and λ_3 respectively. Then

at (a, a, a)

$$E_z = \frac{2K\lambda_1}{a\sqrt{2}}\cos 45^\circ + \frac{2K\lambda_2}{a\sqrt{2}}\cos 45^\circ$$



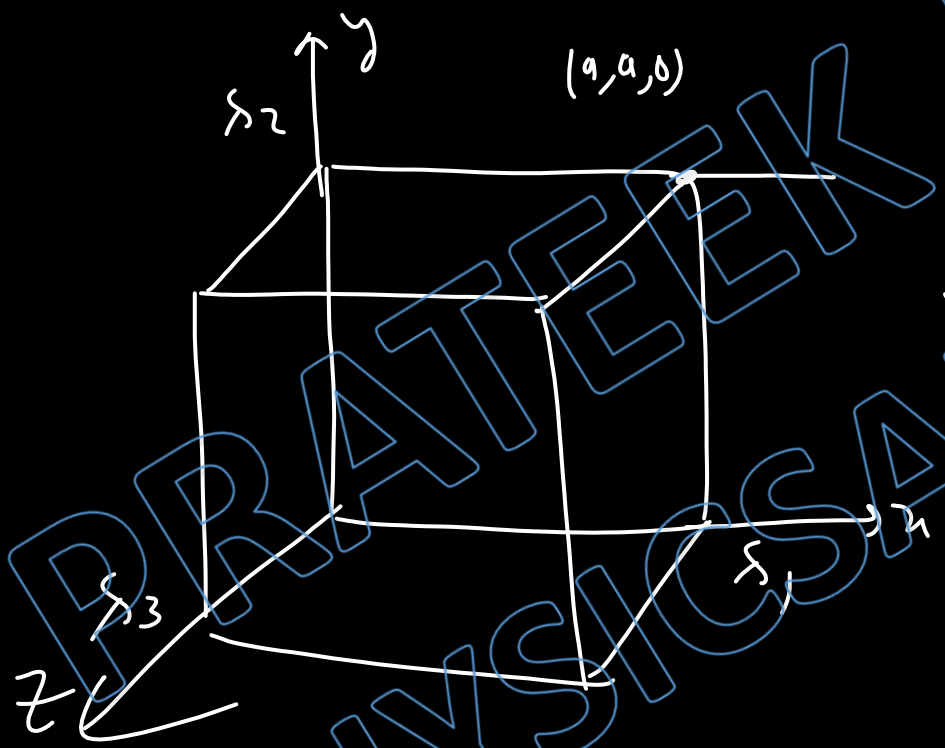
(a) E_x at point (a, a, 0) is independent to λ_2

(b) E_z at point (a, a, a) is proportional to $\sqrt{\lambda_1^2 + \lambda_2^2}$

(c) E at point (a, a, 0) is proportional to $\sqrt{\lambda_1^2 + \lambda_2^2}$

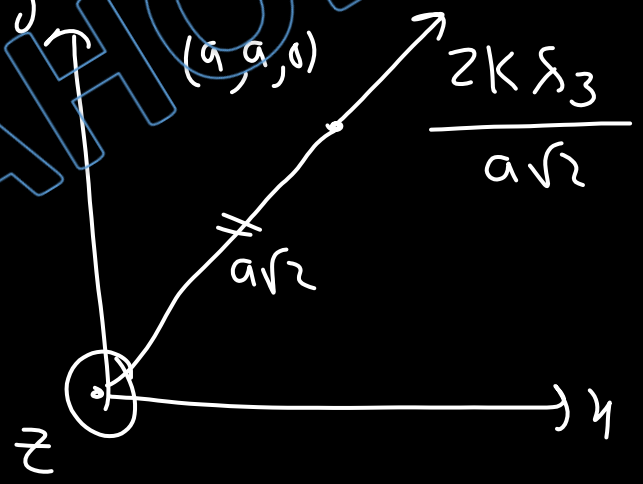
(d) None of these

Ans. d

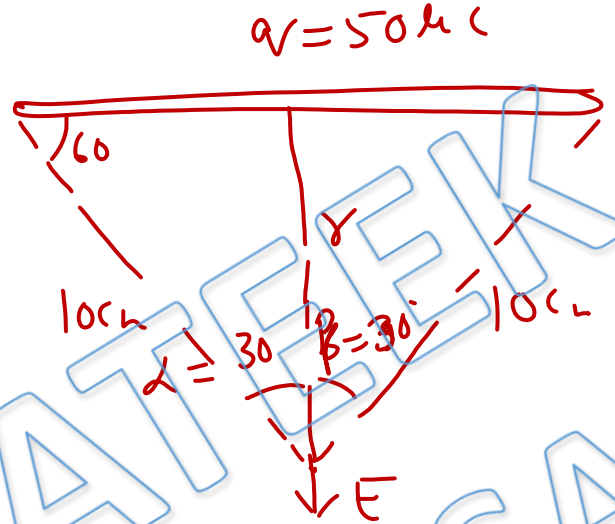


At (a, a, 0)

$$\vec{E} = \frac{2K\lambda_1}{a}\hat{j} + \frac{2K\lambda_2}{a}\hat{i} + \frac{2K\lambda_3}{a\sqrt{2}}\cos 45^\circ \hat{i} + \frac{2K\lambda_3}{a\sqrt{2}}\sin 45^\circ \hat{j}$$



Q8) A 10 cm long rod carries a charge of + 50 μC distributed uniformly along its length, Find the magnitude of the electric field at a point 10 cm from both the ends of the rod.



$r = 10 \sin 60$

$= 5\sqrt{3}$ cm

$E = E_y = \frac{K\lambda}{r}(\sin\alpha + \sin\beta)$

$= \frac{9\times10^9 \times 50\times10^{-6}}{5\sqrt{3}\times10^{-2}\times10^{-1}}[\sin 30 + \sin 30]$

$= \frac{9}{\sqrt{3}}\times10^7 = 3\sqrt{3}\times10^7 \simeq 5.2\times10^7$ N/C

(a) 5.2×10^7 N/C

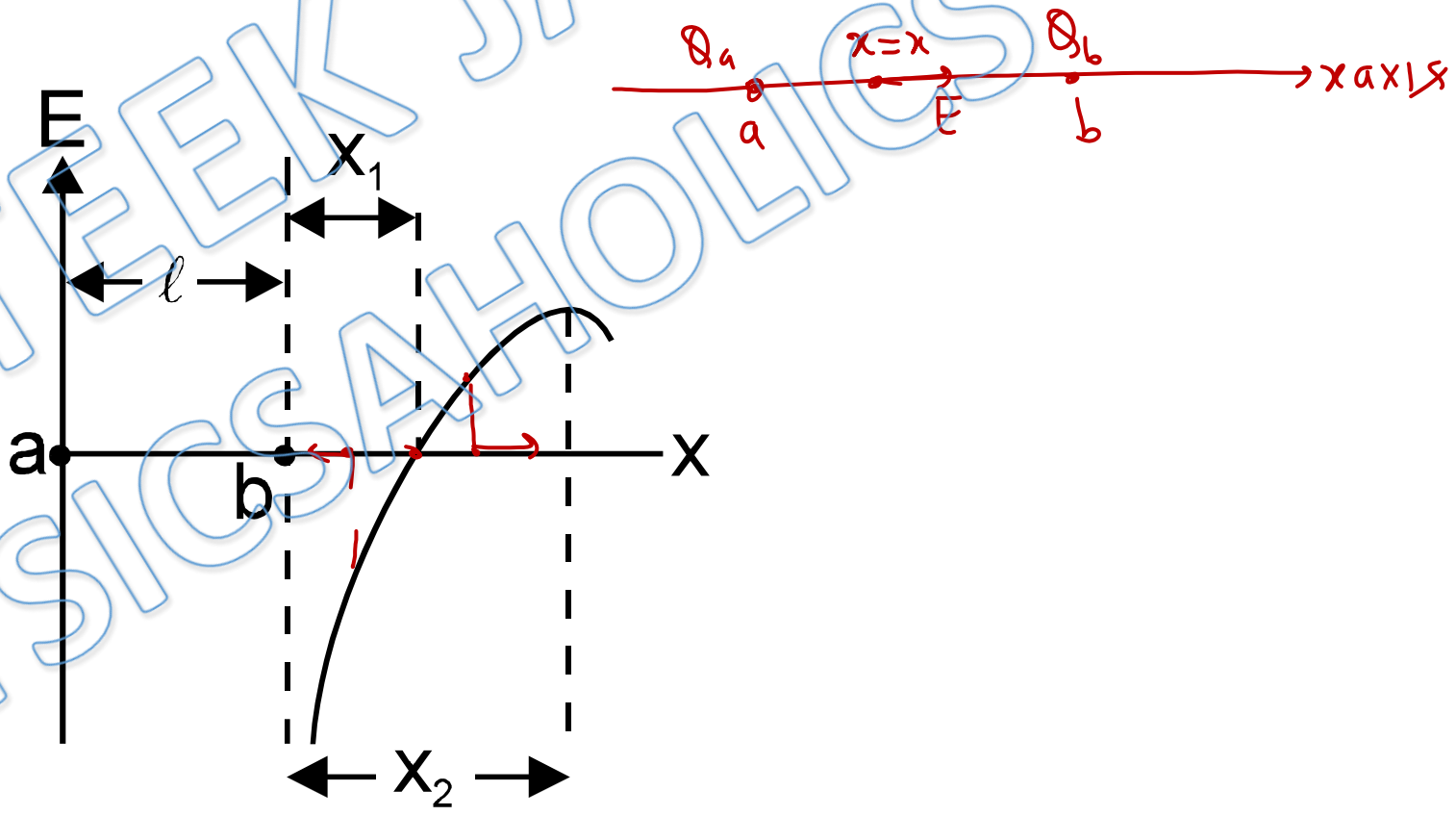
(b) 2.6×10^7 N/C

(c) 1.3×10^7 N/C

(d) 6.5×10^7 N/C

COMPREHENSION

Two point charges are placed at point a and b. The field strength to the right of the charge Q_b on the line that passes through the two charges varies according to a law that is represented graphically in the figure. The electric field is taken positive if its direction is towards right and negative if its direction is towards left.



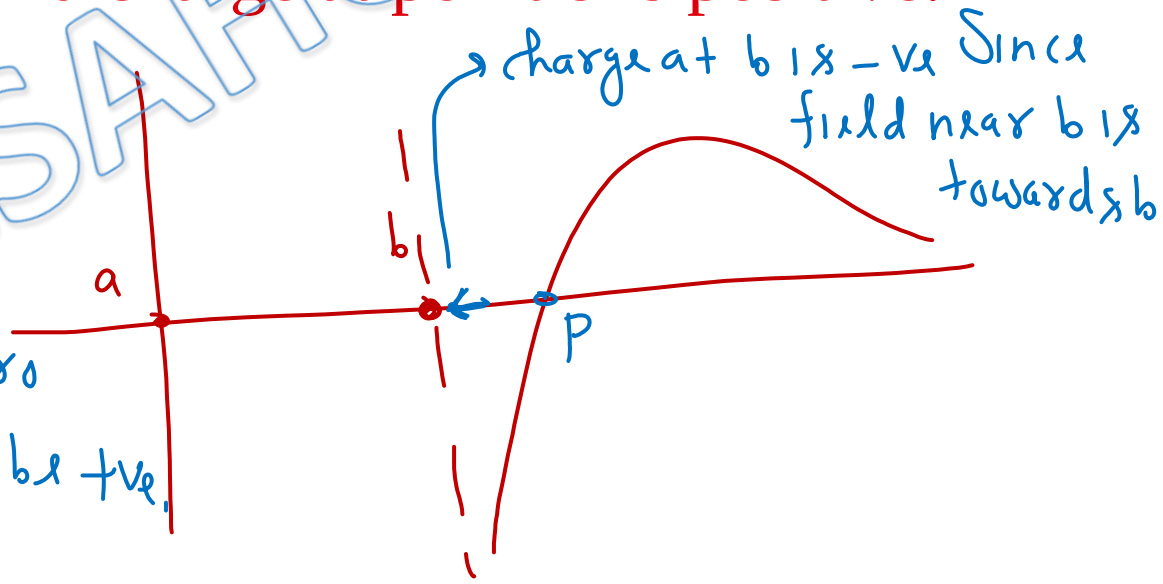
Q9) Choose the correct statement regarding the signs of the charges.

(a) Charge at point a is positive and charge at point b is negative.

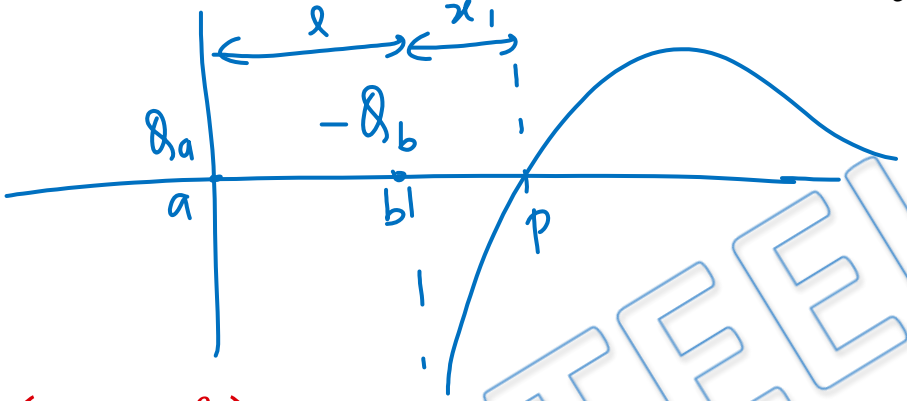
(b) Charge at point a is negative and charge at point b is positive.

(c) Both charges are positive

(d) Both charges are negative



Q10) Ratio of magnitudes of charges $\left|\frac{Q_a}{Q_b}\right|$ will be equal to:



(a) $\left(1+\frac{\ell}{x_1}\right)$

(b) $\left(1+\frac{\ell}{x_1}\right)^2$

(c) $1+\left(\frac{\ell}{x_1}\right)^2$

(d) $\left(1+\frac{\ell}{x}\right)^4$

E at P is zero

$$\frac{KQ_a}{(\ell+x_1)^2} = \frac{KQ_b}{x_1^2}$$

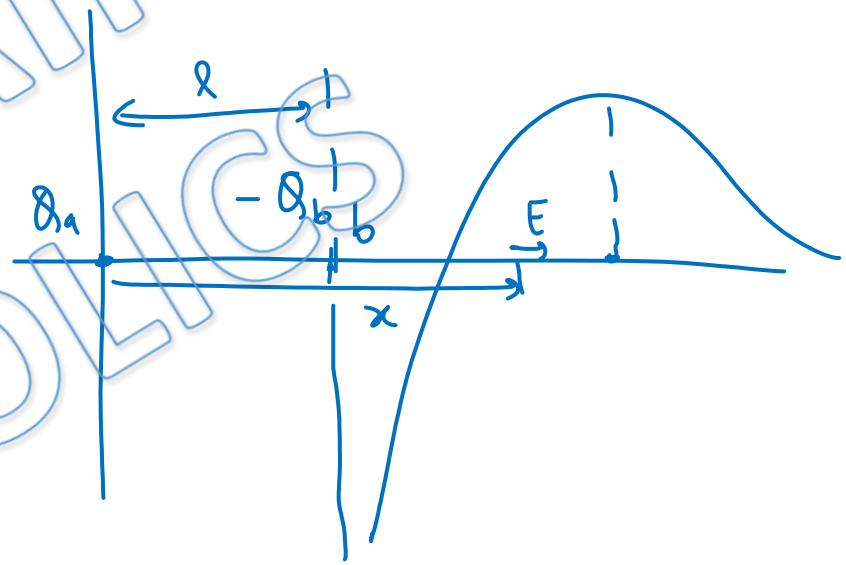
$$\frac{Q_a}{Q_b} = \left(\frac{\ell+x_1}{x_1}\right)^2$$

$$= \left(1+\frac{\ell}{x_1}\right)^2$$

Q11) The distance x_2 from point b where the field is maximum, will be

field at $x = x$ where $x > \ell$

$$E = \frac{KQ_a}{x^2} - \frac{KQ_b}{(x-\ell)^2}$$



(a) $\frac{\ell}{\left(\frac{\ell+x_1}{x_1}\right)^{\frac{2}{3}}-1}$

$$\frac{dE}{dx} = -\frac{2KQ_a}{x^3} + \frac{2KQ_b}{(x-\ell)^3}$$

(b) $\frac{\ell}{\left(\frac{\ell+x_1}{x_1}\right)^{\frac{1}{3}}-1}$

(c) $\frac{\ell}{\left(\frac{\ell+2x_1}{x_1}\right)^{\frac{2}{3}}-1}$

for maxima $\frac{dE}{dx} = 0$

(d) $\frac{\ell}{\left(\frac{\ell+2x_1}{x_1}\right)^{\frac{1}{3}}-1}$

$$\frac{Q_a}{x^3} = \frac{Q_b}{(x-\ell)^3}$$

$$\left(\frac{x-\ell}{x}\right)^3 = \frac{Q_b}{Q_a} = \left(\frac{x_1}{x_1+\ell}\right)^2 \Rightarrow$$

$$1 - \frac{\ell}{x} = \left(\frac{x_1}{x_1+\ell}\right)^{2/3}$$

$$\frac{\ell}{x} = 1 - \left(\frac{x_1}{x_1+\ell}\right)^{2/3}$$

Ans. a

$$x = \frac{l}{1-\left(\frac{x_1}{x_1+l}\right)^{2/3}}$$

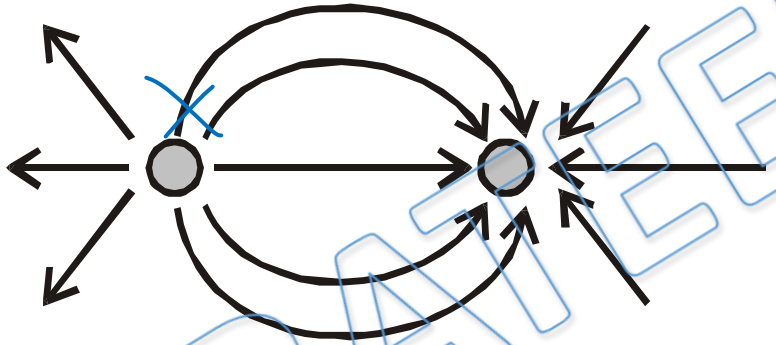
Distance from b

$$= x - l = \frac{l}{1-\left(\frac{x_1}{x_1+l}\right)^{2/3}} - l$$

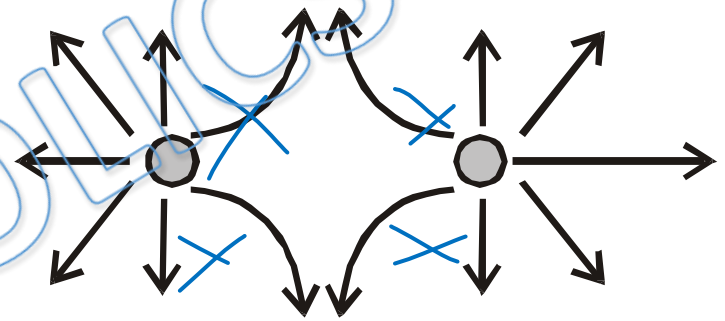
$$= \frac{l - l + l\left(\frac{x_1}{x_1+l}\right)^{2/3}}{1-\left(\frac{x_1}{x_1+l}\right)^{2/3}} = \frac{l}{\left(\frac{x_1+l}{x_1}\right)^{2/3} - 1}$$

Q12) Assume that gravitational lines of forces represent gravitational field just like electric lines of forces represent electric field. Which of the following diagram correctly represents the gravitational field lines for a pair of point masses shown in options below?

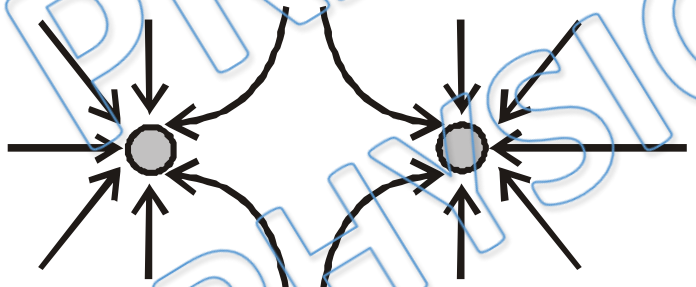
(a)



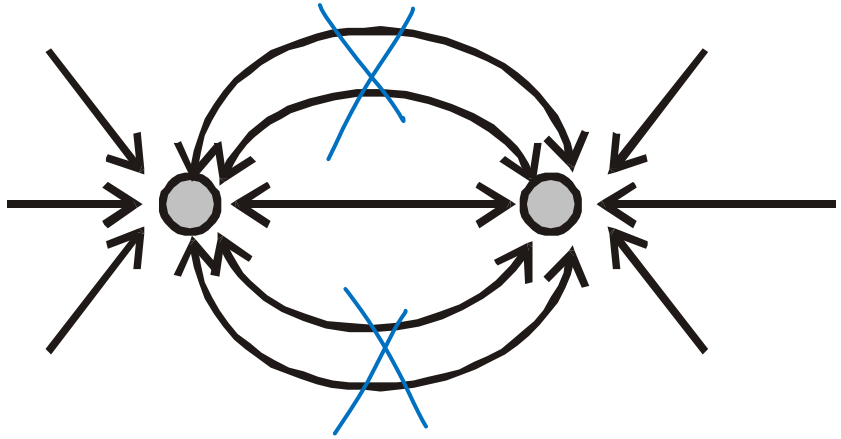
(b)



(c)



(d)



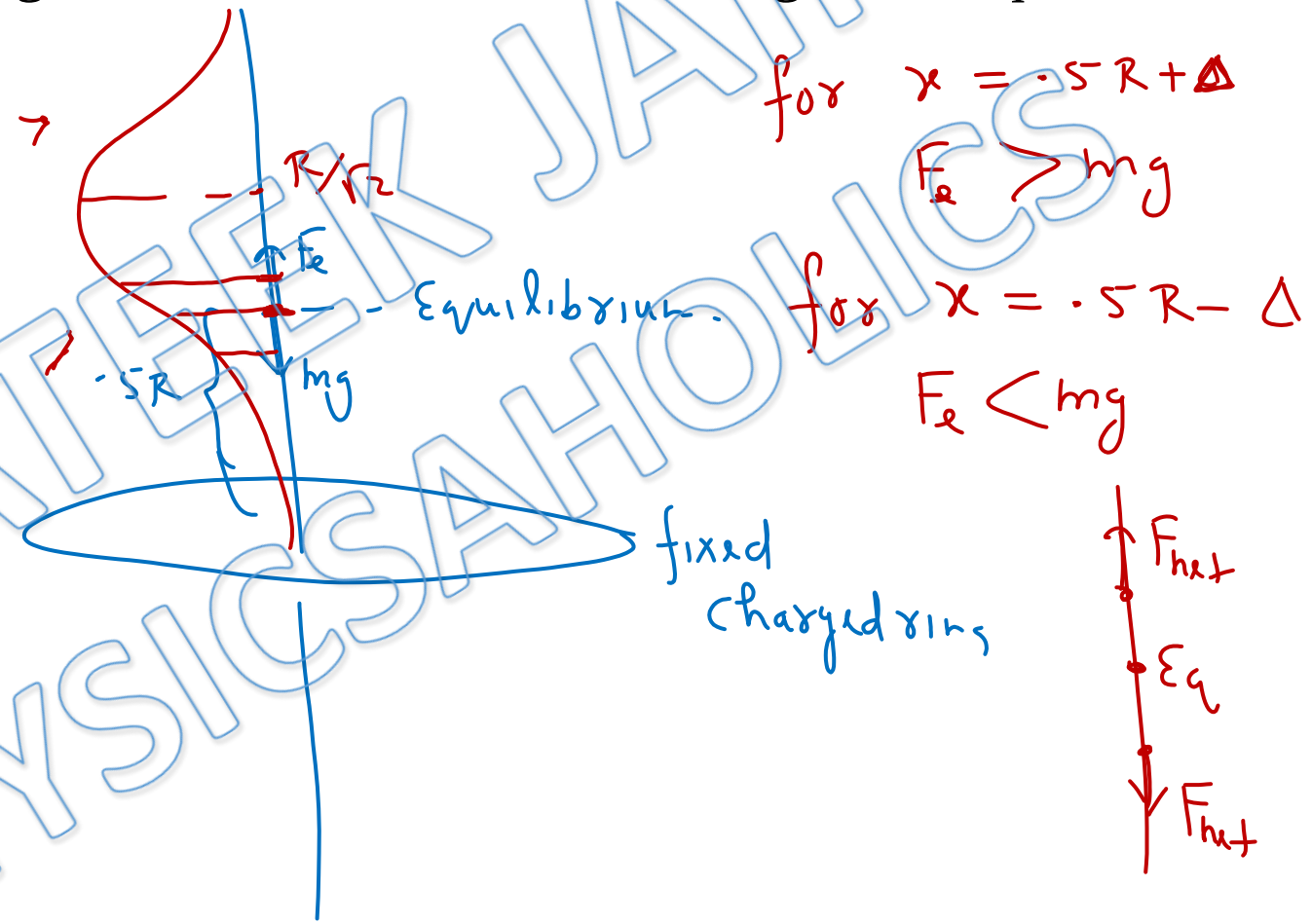
Q13) There is a uniformly charged fixed horizontal ring of radius R. A point charge is placed on its axis at height .5R from its centre. If charge is in equilibrium, the equilibrium is

(a) Stable

(b) ~~Unstable~~

(c) Neutral

(d) None of these



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