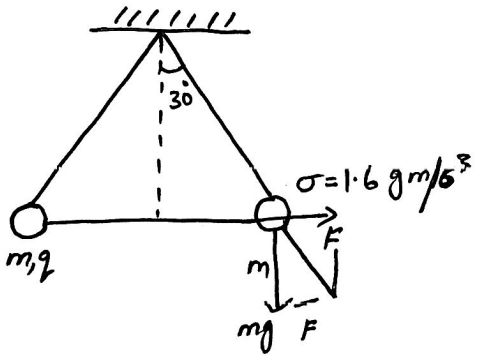
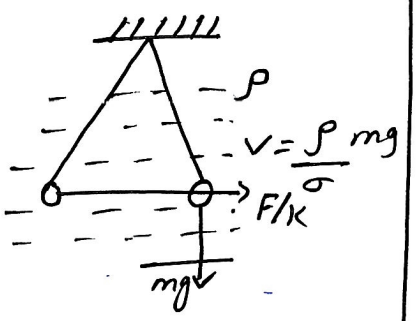
Electrostatics

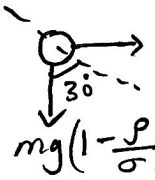
Sol-01



$\tan 30^\circ = \frac{F}{mg}$ — (1)



Ans – B



$\tan 30^\circ = \frac{F}{Kmg\left(1-\frac{\rho}{\sigma}\right)}$ — (2)

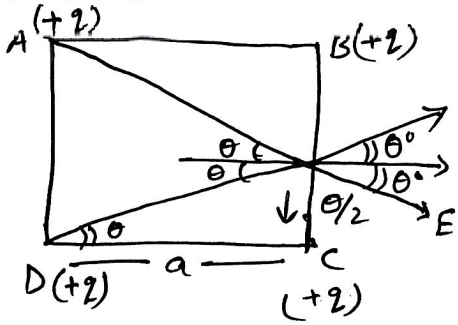
$\frac{F}{mg} = \frac{F}{Kmg\left(1-\frac{\rho}{\sigma}\right)}$

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

$K\left(1-\frac{0.8}{1.6}\right) = 1$

$\boxed{K = 2}$

Sol-02



$E_N = 2E\cos\theta$

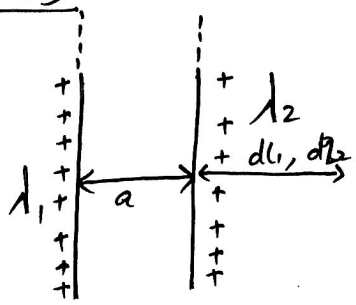
$E_N = 2 \times \frac{kq}{\frac{5a^2}{4}} \times \frac{2}{\sqrt{5}}$

$E_N = 16 \times \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{5\sqrt{5}a^2}$

$E_N = \frac{4q}{\pi\epsilon_0 5\sqrt{5}a^2}$

Ans D

Sol-03



$dF_2 = dq_2 \cdot E_1$

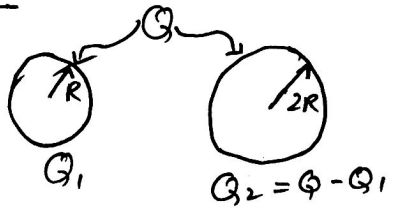
$dF_2 = \lambda_2\, dl \cdot \frac{2k\lambda_1}{a}$

$\epsilon_k = \frac{2k\lambda_1}{a} \cdot \frac{dF_2}{dl} = 2 \times \frac{1}{4\pi\epsilon_0} \frac{\lambda_1\lambda_2}{a}$

$\boxed{\frac{dF_2}{dl} = \frac{\lambda_1\lambda_2}{2\pi\epsilon_0 a}}$

Ans – (C)

Sol-04



$\sigma_1 = \sigma_2$

$\frac{Q_1}{4\pi R^2} = \frac{Q \cdot Q_1}{4\pi \times 4R^2}$

$\Rightarrow 4Q_1 = Q - Q_1$

$5Q_1 = Q$

$Q = Q/5$

$Q_2 = Q = \frac{Q}{5}$

$\boxed{Q_2 = \frac{4Q}{5}}$

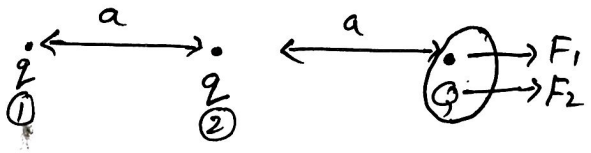
Ans – (A)

Sol-05 Ans – A

Sol-06 Ans – A

Sol-07 Ans – C

Sol-08



$F_1 + F_2 = 0$

$\frac{kQ^2}{ka^2} + \frac{kQq}{a^2} = 0$

$\boxed{q = -\frac{Q}{4}}$ Ans – C

Sol-09 Ans – C

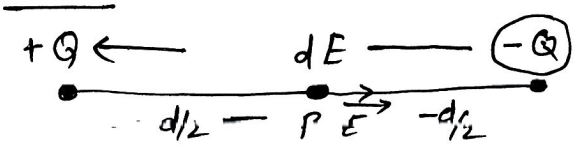
Sol-10 $Q = 10^{-12}$ $C = ne$

$10^{-12} = n = 1.6 \times 10^{-19}$

$\boxed{n = 6.25 \times 10^{6}}$

Ans – C

Sol-11



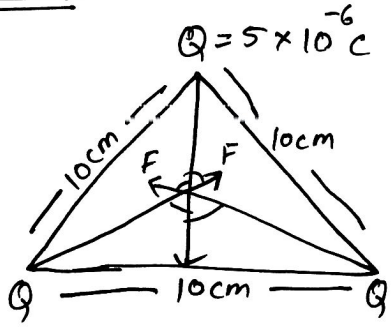
$E_P = 2E$

$= 2 \times \frac{kQ}{d^2/4}$

$E_P = \frac{2Q}{\pi\epsilon_0 d^2}$ $\left[= \frac{8Q}{4\pi\epsilon_0 d^2}\right]$

Ans – B

Sol-12



$F_N = 0$

Ans – D

Sol – 13

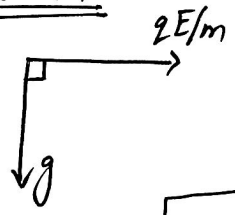
$$F_N = \sqrt{3}\,F$$

$$= \sqrt{3} \times \frac{kq \times (2q)}{a^2}$$

$$= \frac{2\sqrt{3}\,q^2}{4\pi\epsilon_0 a^2} = \frac{\sqrt{3}\,q^2}{2\pi\epsilon_0 a^2}$$

Ans – B

Sol – 14



$$g_{eff} = \sqrt{g^2 + \left(\frac{qE}{m}\right)^2}$$

$$T = 2\pi\sqrt{\frac{l}{g_{eff}}}$$

$$T = 2\pi\sqrt{\frac{L}{g^2 + \left(\frac{qE}{m}\right)^2}}$$

Ans – A

Sol – 15 Ans – D

Sol – 16

$$V_1 = \frac{kq}{R} - \frac{kq}{\sqrt{R^2+d^2}}$$

$$V_2 = -\frac{kq}{R} + \frac{kq}{\sqrt{R^2+d^2}}$$

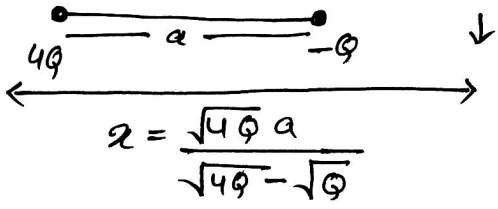
$$V_1 - V_2 = \frac{2kq}{R} - \frac{2kq}{\sqrt{R^2+d^2}}$$

$$= 2kq\left(\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right)$$

$$\boxed{V_1\,V_2 = \frac{q}{3\pi\epsilon_0}\left(\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right)}$$

Ans – B

Sol – 17



$$x = \frac{\sqrt{4q}\,a}{\sqrt{4q} - \sqrt{q}}$$

$$\boxed{x = 2a}$$

Ans – A

Sol – 18

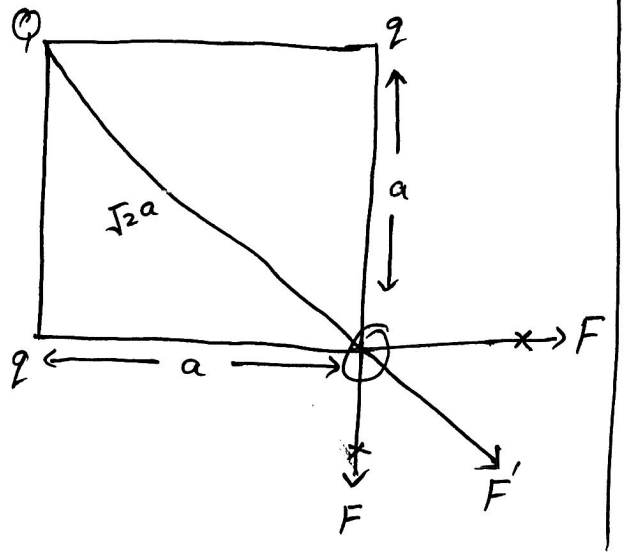
$$\vec{F_1} + \vec{F_2} + \vec{F_3} + \vec{F_4} + \vec{F_5} + \vec{F_6} = 0$$

$$\vec{F_1} + \ldots\ldots + \vec{F_5} = -\vec{F_6}$$

$$= \frac{kqq_0}{a^2}$$

Ans – D

Sol – 19



$$F_N = \sqrt{2}F + F' = 0$$

$$\sqrt{2} = \frac{kqQ}{a^2} + \frac{kQ}{2a^2} = 0$$

$$\sqrt{2}\,\frac{kqQ}{a^2} = \frac{-kQ^2}{2a^2}$$

$$\boxed{\frac{Q}{q} = \frac{-2\sqrt{2}}{1}}$$

Ans – A

Sol – 20 $V = 10 - 7x$

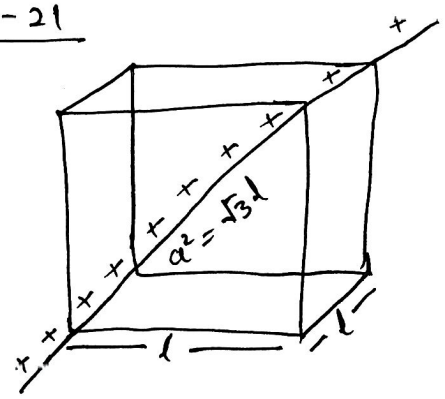
$$\frac{dv}{dx} = -7$$

$$\vec{E} = -\frac{dV}{dx}\hat{i}$$

$$\vec{E} = +7\hat{i}$$

Ans – D

Sol – 21

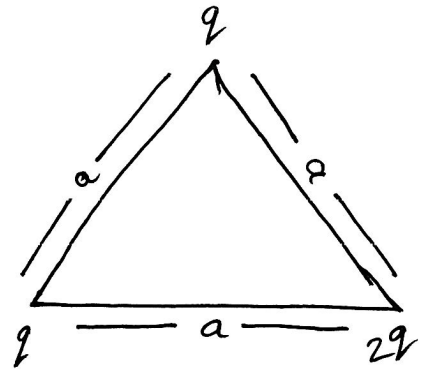


$$q_{arc} = \lambda\sqrt{3}\,l$$

$$\phi_{max} = \frac{\lambda\sqrt{3}\,l}{\varepsilon_0}$$

Ans – C

Sol – 22



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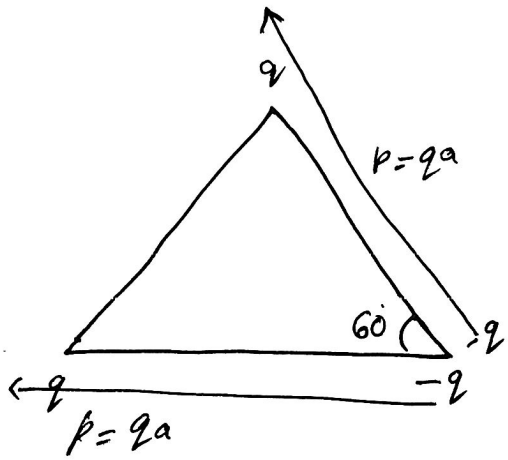
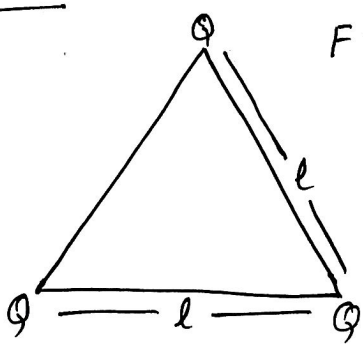


$$p_N = \sqrt{3}p = \sqrt{3}\,qa$$

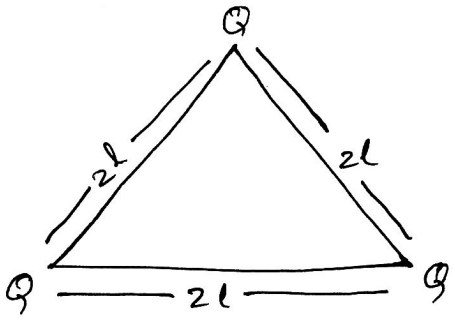
Ans – C

Sol-23



$F = \frac{kQ^2}{l^2}$

$\equiv$



$W_{ag} = \Delta U_{system} = U_f + U_i$

$U_f = \frac{3 \times kQ^2}{2l}$

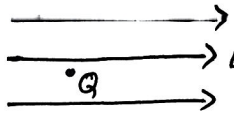
$U_i = \frac{3kQ^2}{l}$

$\Delta U = -\frac{3}{2}\frac{kQ^2}{l}$

$W_{ag} = -\frac{3}{2}\frac{kQ^2}{l} = -\frac{3}{2}Fl$

Ans - C

Sol-24



Ans - C

Sol-25 $V_{centre} = \frac{kq}{d} + \frac{kq'}{\gamma}$

$V_c = V_s \Rightarrow = 0$

$\frac{kq}{d} + \frac{kq'}{\gamma} = 0$

$\boxed{q' = -q\frac{\gamma}{d}}$

Ans - C

Sol
~~Ans~~ **-26**

$E_N = \sqrt{2}E$

$= \sqrt{2}\frac{kq}{(l/\sqrt{2})^2}$

$= \frac{2\sqrt{2}kq}{l^2}$

Ans - B

Sol-27

$V = \frac{Q_1}{\gamma'}$

$\vec{E} = -\frac{dv}{d\gamma}(\hat{\gamma})$

$\vec{E} = -\left(-\frac{Q_1}{\gamma^2}\right)\frac{\vec{\gamma}}{|\vec{\gamma}|}$

$\vec{E} = \frac{Q_1}{\gamma^3}(\vec{\gamma})$

$\vec{\gamma} = \hat{i} + \hat{j} + \hat{k}$

$|\vec{\gamma}| = \sqrt{3}$

$\vec{E} = \frac{27}{3\sqrt{3}}(\hat{i} + \hat{j} + \hat{k})$

$= 9\sqrt{3}(\hat{i} + \hat{j} + \hat{k})$

Ans - A

Sol - 28

$K_i + V_i = K_f + V_f$

$\frac{1}{2}mv^2 + qV_i = 0 + qV_f$

$\frac{1}{2}mv^2 = q(V_f - V_i)$

$v^2 = \frac{2q}{m}\left(\frac{kQ}{R} - \frac{kQ}{\sqrt{2}R}\right)$

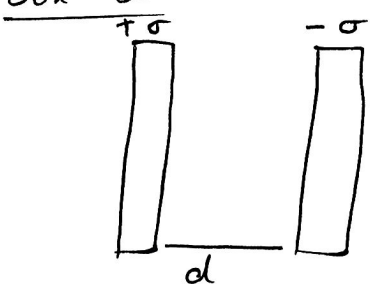
$v^2 = \frac{\sqrt{2}kQq}{mR}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$

$v = \sqrt{\frac{kQq}{mR}(2-\sqrt{2})}$

Ans- A

Sol - 29 Ans- C

Sol - 30



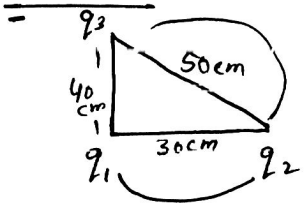
$E_- = \frac{\sigma}{E_0}$ $E_+ = \frac{\sigma}{\epsilon_0}$

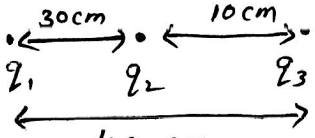
P

$E_P = 0$

Ans - D

Sol - 31





$U_f = \frac{kq_1q_2}{0.3} + \frac{kq_2q_3}{0.1} + \frac{kq_1q_3}{0.4}$

$U_i = \frac{kq_1q_2}{0.3} + \frac{kq_3q_2}{0.5} + \frac{kq_1q_3}{0.4}$

$U_f - U_i = kq_2q_3(10-2)$

$= 8 \times \frac{q_2q_3}{4\pi\epsilon_0}$

$= \frac{q_3}{4\pi\epsilon_0} \times 8q_2$

Ans - C

Sol - 32 Ans - B

Sol - 33

$K_i + U_i = K_f + U_f$

$\frac{1}{2}mv^2 + qV_i = 0 + qV_f$

$\frac{1}{2}mv^2 = q[V_f - V_i]$

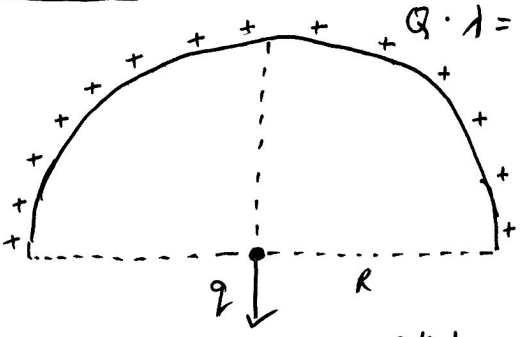
$\frac{1}{2}mv^2 = q\left(\frac{2kq}{2R} - \frac{kq}{R}\right)$

$mv^2 = \frac{kq^2}{R}$

$v = q/\sqrt{R/mR}$

$v = \frac{q}{\sqrt{4\pi\epsilon_0 mR}}$

Sol - 34



$Q \cdot \lambda = \frac{Q}{\pi R}$

$E = \frac{2k\lambda}{R} \sin\frac{\theta}{2} = \frac{2k\lambda}{R}$

$F = qE$

$F = q\,\frac{2k\lambda}{R}$

$F = \frac{1}{4\pi\epsilon_0} \times \frac{2q}{R} \times \frac{Q}{\pi R}$

$F = \frac{Qq}{2\pi^2\epsilon_0 R^2}$

Ans - C

Sol - 35 $E_1 = 0$

$E_2 = \frac{kq_1}{r^2} \quad R_1 < r < R_2$

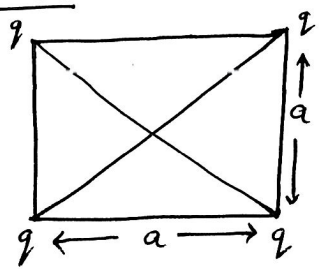
$V_1 = \frac{kq_1}{R_1} + \frac{kq_2}{R_2}$

$V_2 = \frac{kq_1}{r} + \frac{kq_2}{R_2}$

A → S
B → R
C → P
D → Q

Ans - B

Sol - 36



$U = \frac{4kq^2}{a} + \frac{2kq^2}{\sqrt{2}a}$

$U = \frac{2kq^2}{a} \cdot \left(2 + \frac{1}{\sqrt{2}}\right)$

$U = \frac{4kq^2}{a}\left(1 + \frac{1}{\sqrt{2}}\right)$

Ans - B

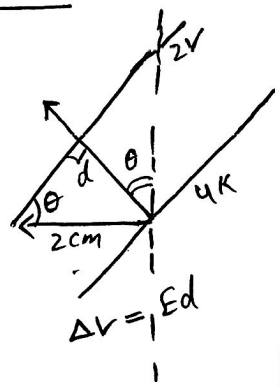
Sol - 37

$V_{\text{mixer}} = \frac{kq'}{r_1} + \frac{kq}{r_2} = 0$

$q' = -\frac{r_1 q}{r_2}$

Ans - C

Sol - 38



$\sin\theta = \frac{d}{2\text{cm}}$

$d = 2 \times \frac{1}{2}\text{ cm}$

$2v = E \times \frac{2}{\sqrt{5}} \times 10^{-3}\text{ m}$

$E = 100\sqrt{5}\text{ V/m}$

$E_x = -E\sin\theta$

$E_x = -100\sqrt{5} \times \frac{1}{\sqrt{5}}$

$E_x = -100\text{ V/m}$

$E_y = +E\cos\theta$

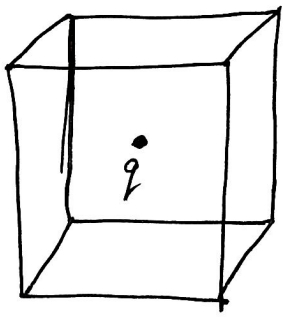
$E_y = +100\sqrt{5} \times \frac{2}{\sqrt{5}}$

$E_y = +200\text{ V/m}$

Sol -39 Ans - B

Sol -40 Ans - A

Sol -41

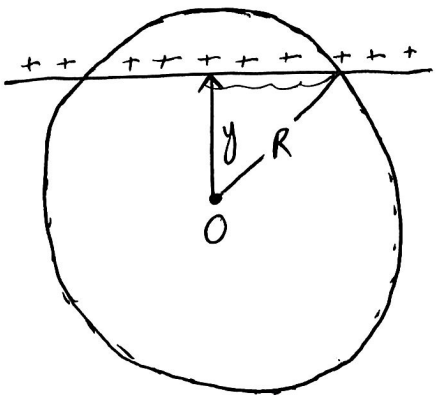


$$\phi_T = \frac{q}{\epsilon_0}$$

$$\phi_{\text{each face}} = \frac{q}{6\epsilon_0} = \frac{4\pi q}{6(4\pi\epsilon_0)}$$

Ans - A

Sol - 42



$$R^2 = x^2 + y^2$$

$$x = \sqrt{R^2 + y^2}$$

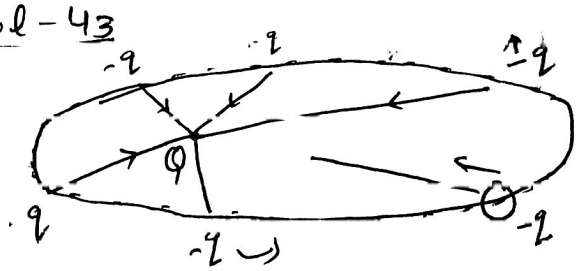
$$l_{max} = 2\sqrt{R^2 - y^2}$$

$$q_{use} = \lambda \cdot 2\sqrt{R^2 - y^2}$$

$$\phi = \frac{2\lambda\sqrt{R^2 - y^2}}{\epsilon_0}$$

Ans - C

Sol - 43



Ans - A

i) L = constant

Sol - 44

$$\phi_A = \frac{+q}{\epsilon_0} > 0$$

$$\phi_B = 0$$

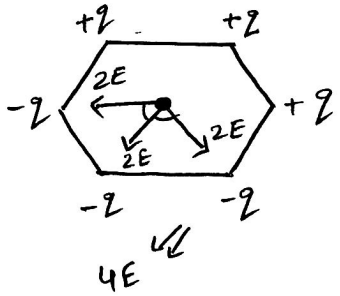
$$E_{mA} = \frac{kq}{d^2}$$

$$E_{mB} = 0$$

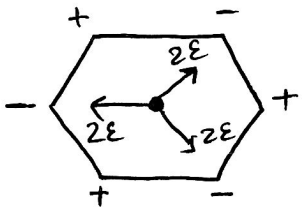
A → P
B → Q
C → P
D → Q

Ans - C

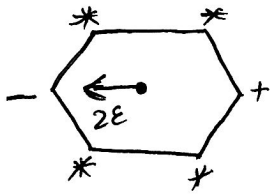
Sol - 45



$4E$

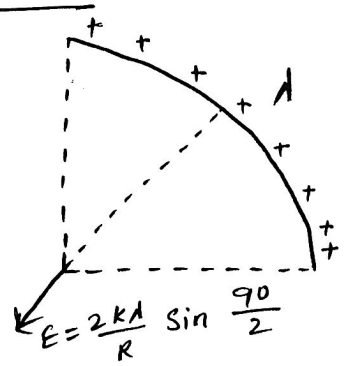


$E = 0$



Ans - C

Sol - 46



$$E = \frac{\sqrt{2}K\lambda}{R}$$

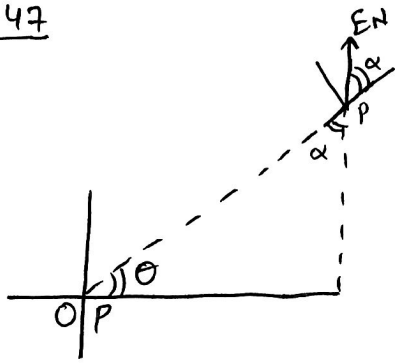
$$\vec{E}_N = \sqrt{2}E(-\hat{i})$$

$$\vec{E}_N = -\sqrt{2}\cdot\sqrt{2}\times\frac{1}{4\pi\epsilon_0}\cdot\frac{\lambda}{R}\hat{i}$$

$$\vec{E}_N = -\frac{\lambda}{2\pi\epsilon_0 R}\hat{i}$$

Ans - A

Sol - 47



$$\tan\alpha = \frac{1}{2}\tan\theta$$

$$\tan(90-\theta) = \frac{1}{2}\tan\theta$$

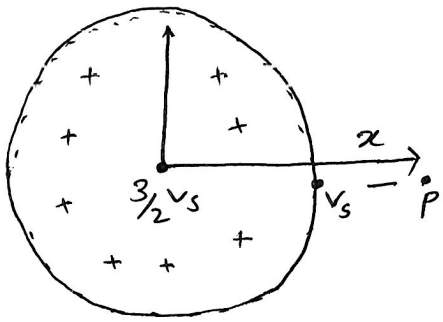
$$\tan^2\theta = 2$$

$$\tan\theta = \sqrt{2}$$

$$\theta = \boxed{\tan\sqrt{2}}$$

Ans - B

Sol - 48



$$V_c = \frac{3}{2}\frac{RQ}{R} = \frac{3}{2}V_s$$

$$V_p = \frac{3}{4}V_s$$

$$V_p = \frac{\cancel{RQ}}{x} = \frac{3}{4}\cdot\frac{\cancel{RQ}}{R}$$

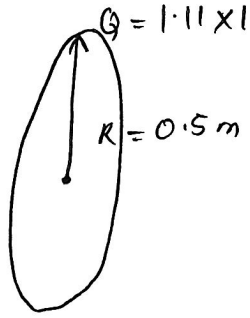
$$x = \frac{4R}{3}$$

$$\text{from surface} = \frac{4R}{3} - R$$

$$= \frac{R}{3}$$

Ans - C

Sol-49



$$\Delta V = -\int_{\infty}^{0} \vec{E}\cdot d\vec{l}$$

$$V_f - V_i = -\int_{\infty}^{0} \vec{E}\cdot d\vec{l}$$

$$V_c - V_\infty = -\int_{\infty}^{0} \vec{E}\cdot d\vec{l}$$

$$-\int_{\infty}^{0} \vec{E}\cdot d\vec{l} = V_c = \frac{KQ}{R}$$

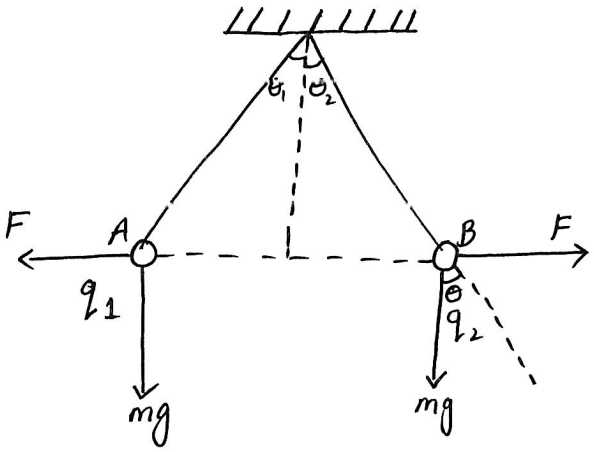
$$= \frac{9\times10^{9}\times 1\cdot11\times10^{-10}}{1/2}$$

$$= 9\cdot99\times2\times10^{-11}$$

$$= +2 \text{ volt}$$

Ans- A

Sol-50



$q_1 > q_2$

$\tan\theta = \frac{T}{mg}$

$\theta_1 - \theta_2$

Ans- C