DPP – 6 (Electrostatics)

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Q 1. If three electric di-poles are placed in some closed surface, then the electric flux emitting from the surface will be-
(a) Zero (b) positive
(c) Negative (d) None of these

Q 2. A rectangular surface of 2 metre width and 4 metre length, is placed in an electric field of intensity 20 newton/C, there is an angle of 60º between the perpendicular to surface and electrical field intensity. Then total flux emitted from the surface will be- (In Volt-metre):
(a) 80 (b) 40 (c) 20 (d) 120

Q 3. A sphere of radius 50 cm has a surface charge density of 8.85 x 10^{-6} C/m^2. The electric field near the surface in N/C is-
(a) 8.85×10^{-6} (b) 8.85×10^{6}
(c) 1×10^{6} (d) Zero

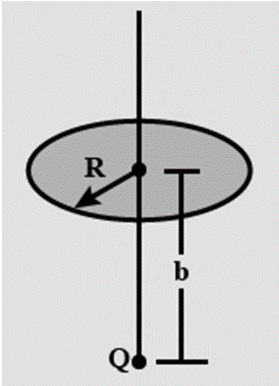
Q 4. The Earth has an electric field with a magnitude roughly 100 N/C at its surface. Assuming there is a point charge at the Earth's center creating this field, how much charge does the earth possess? (Radius of earth = 6371 km)
(a) 450.9×10^{3} C (b) 451.4×10^{6} C
(c) 1×10^{3} C (d) 10^{6} C

Q 5. In X-Y plane, there is a surface charge density of $5 \times 10^{-6}\ C/m^2$. on a long uniformly charged sheet. A circular loop of radius 0.1m is placed as that plane of loop makes an angle of 30° with Z axis. Determine the electric flux through the loop
(a) 4 kVm (b) 4.44 kVm
(c) 500 kVm (d) 5.55 kVm

Q 6. A point charge q is placed at a distance $\frac{a}{2}$ perpendicular to the above the center of a square of side a. The electric flux through the square is:
(a) $\frac{q}{\varepsilon_o}$ (b) $\frac{q}{\pi\varepsilon_o}$ (c) $\frac{q}{4\varepsilon_o}$ (d) $\frac{q}{6\varepsilon_o}$

Q 7. The electric field in a region is given by $\vec{E} = a\hat{\imath} + b\hat{\jmath}$. Here a and b are constants. Find the net flux passing through a square area of side L_o parallel to y-z plane:
(a) $\sqrt{a^2 + b^2}L_o^2$ (b) $2aL_o^2$ (c) aL_o^2 (d) $(a + b)L_o^2$

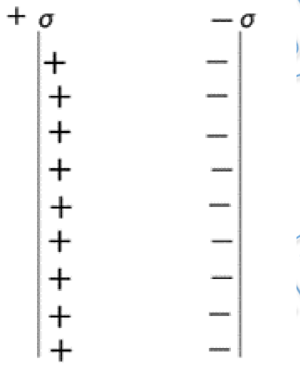
Q 8. A point charge Q is located on the axis of a disc of radius R at a distance b from the plane of the disc (figure). Show that if one-fourth of the electric flux from the charge passes through the disc, then:



(a) $R = b$ (b) $R = \sqrt{2}b$

(c) $R = \sqrt{3}b$ (d) $R = 2b$

Q 9. Two infinite plane parallel sheets, separated by a distance d have equal and opposite uniform charge densities $+\sigma$ & - σ. Electric field at a point between the sheets is:



(a) $\frac{\sigma}{2\varepsilon_o}$

(b) $\frac{\sigma}{\varepsilon_o}$

(c) zero

(d) depends on the location of the point

Q 10. The electric intensity due to an infinite cylinder of radius R and having charge q per unit length at a distance r (r>R) from its axis is:

(a) Directly proportional to r^2

(b) Directly proportional to r^3

(c) Inversely proportional to r

(d) Inversely proportional to r^2

Q 11. The electric intensity outside a charged sphere of radius R and surface charge density σ at a distance r(r > R) is:(Charge is distributed uniformly over its surface)

(a) $\frac{\sigma R^2}{\varepsilon_o r^2}$ (b) $\frac{\sigma r^2}{\varepsilon_o R^2}$

(c) $\frac{\sigma r}{\varepsilon_o R}$ (d) $\frac{\sigma R}{\varepsilon_o r}$

Q 12. Let $\rho = \frac{Qr^2}{\pi R^5}$ be the volume charge density at distance r from the centre for a a soild sphere of radius R and charge Q. The electric field at $r = \frac{R}{2}$ from the centre will be:

(a) $\frac{Q}{4\pi\varepsilon_o R^2}$ (b) $\frac{Q}{40\pi\varepsilon_o R^2}$

(c) $\frac{Q}{8\pi\varepsilon_o R^2}$ (d) None of these

Q 13. A spherical volume has a uniformly distributed charge density $2 \times 10^{-4}\ C/m^3$. The electric field at a point inside the volume at a distance 4.0 cm from the centre is:

(a) $3.01 \times 10^5\ N/C$ (b) $2.1 \times 10^5\ N/C$

(c) $6.2 \times 10^5\ N/C$ (d) None of these

Q 14. The surface charge density of a thin charge disc of radius R is σ. The value of the electric field at the centre of the disc is $\frac{\sigma}{2\varepsilon_o}$. With respect to the field at the centre, the electric field along the axis at a distance R From the centre of the disc:

(a) reduces by 70.7% (b) reduces by 29.3%

(c)reduces by 9.7% (d) reduces by 14.6%

Q 15. Potential difference between centre and the surface of sphere of radius R and uniform volume charge density ρ within it will be:

(a) $\frac{\rho R^2}{2\varepsilon_o}$ (b) $\frac{\rho R^2}{4\varepsilon_o}$

(c) zero (d) $\frac{\rho R^2}{6\varepsilon_o}$

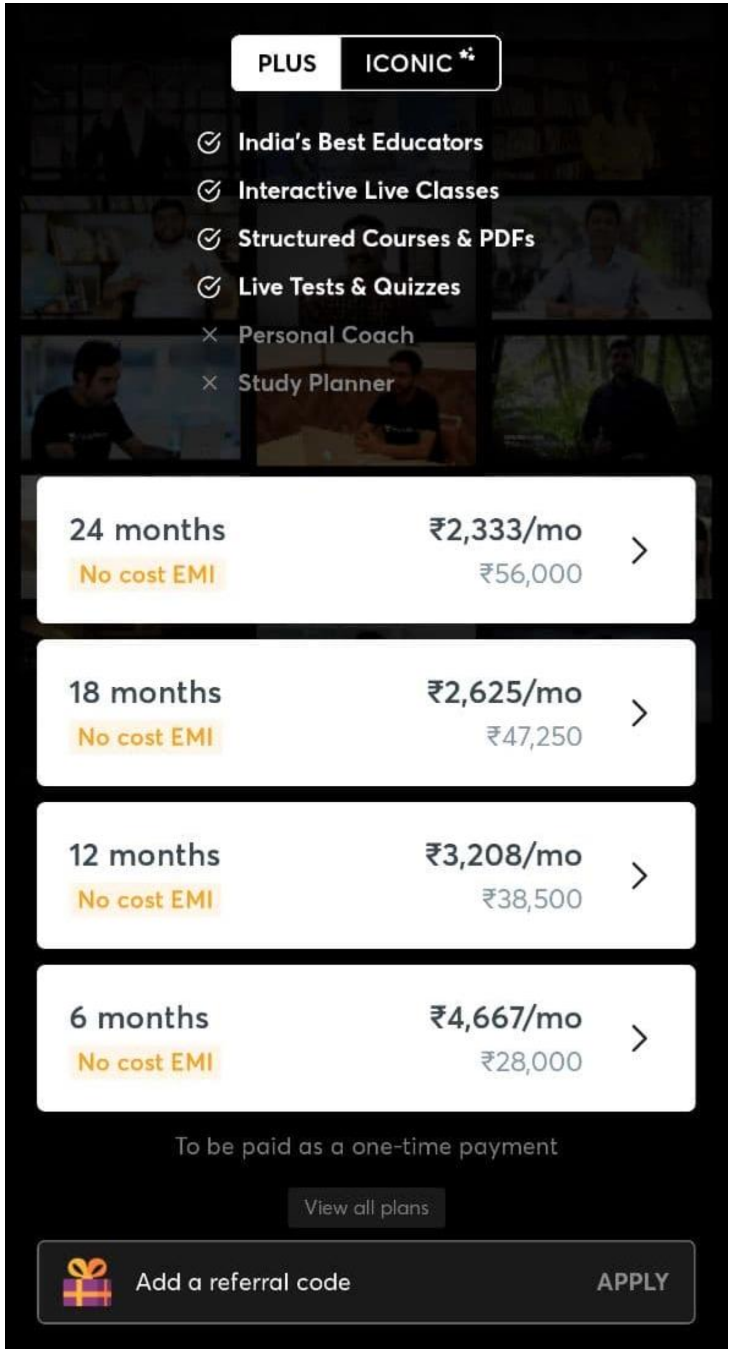
Q 16. Sphere of radius a = 1m with an empty spherical cavity of radius b = 0.25m, has a positive volume charge density $\rho = 10^{-6}\ C/m^3$. The center of the cavity is at the distance d = 0.5m from the center of the charged sphere. Find the electric field intensity at a point inside the cavity:

(a) 18.8 N/C (b) 10 kN/C

(c) 18.8 kN/C (d) depends on the position of the point

Answer Key

Q.1 a	**Q.2 a**	**Q.3 c**	**Q.4 a**	**Q.5 b**
Q.6 d	**Q.7 c**	**Q.8 c**	**Q.9 b**	**Q.10 c**
Q.11 a	**Q.12 b**	**Q.13 a**	**Q.14 a**	**Q.15 d**
Q.16 c				



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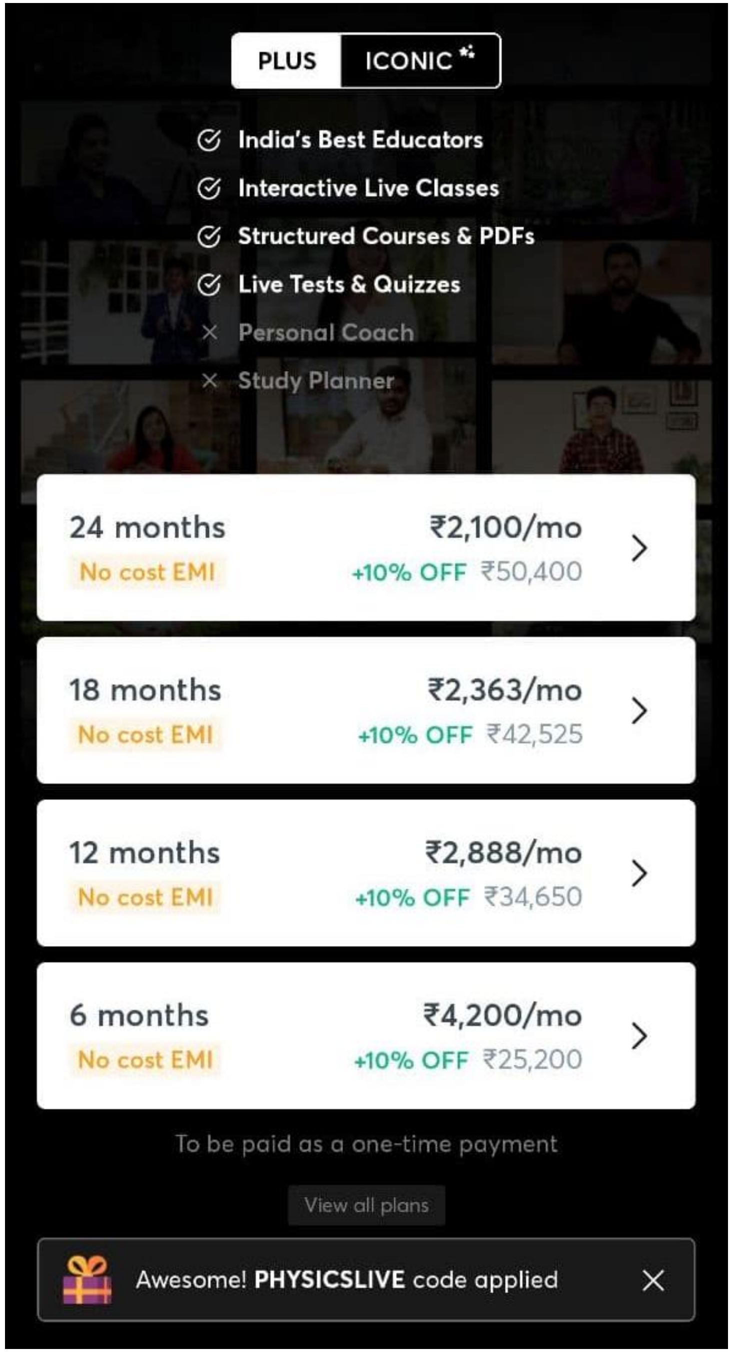

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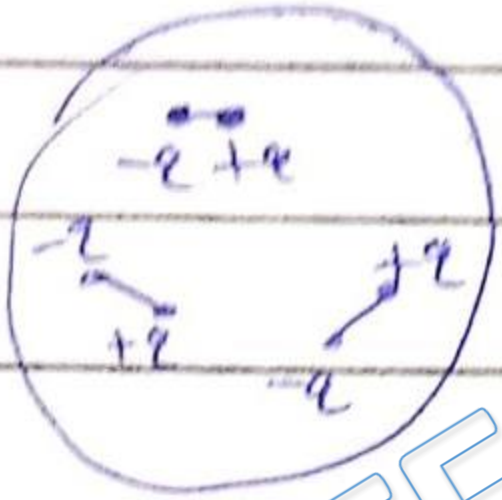
Written Solution

DPP-6 Gauss's Law

By Physicsaholics Team

Solution: 1

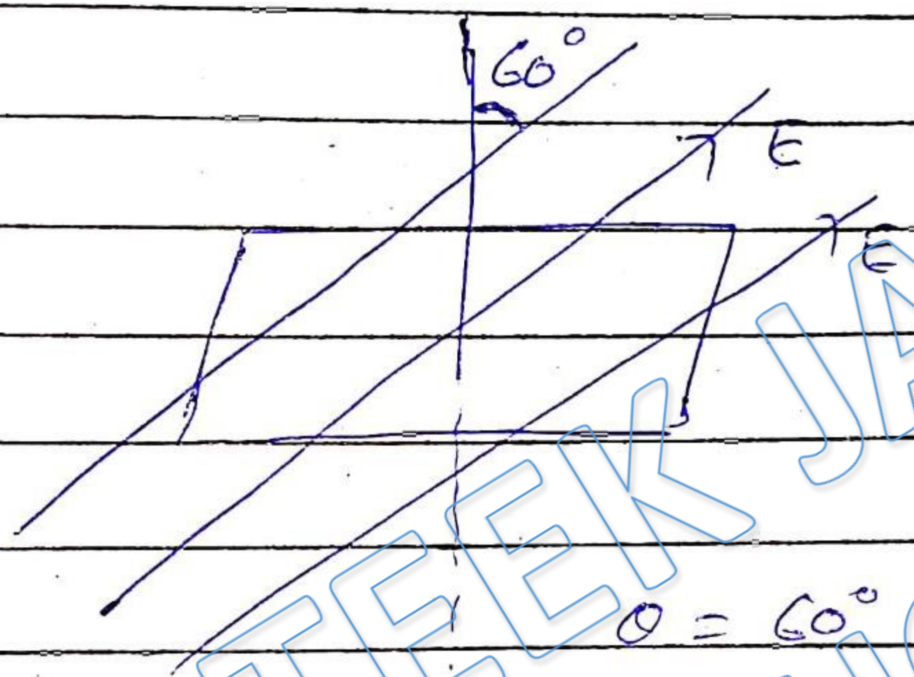


$$(q_{net})_{inside} = 0$$

$$\phi = \frac{q_{in}}{\epsilon_0} = \text{zero}$$

Ans. a

Solution: 2



$\theta = 60°$

$\phi = E \cdot A \cos\theta$

$\phi = 20 \times (2 \times 4) \times \cos(60°)$

$= 20 \times 8 \times \frac{1}{2}$

$\boxed{\phi = 80 \text{ V-m}}$

Ans. a

Solution: 3

Electric field near a charged surface $E = \frac{\sigma}{\epsilon_0}$

σ = Surface charge density (C/m^2)

(or) Electric field due to sphere

$$E = \frac{kQ}{r^2}$$

for near to Surface; $r = R$

$$E = \frac{kQ}{R^2}$$

$$Q = \sigma \times Area = \sigma \times 4\pi R^2$$

$$E = \frac{1}{4\pi\epsilon_0}\left(\frac{\sigma \times 4\pi R^2}{R^2}\right)$$

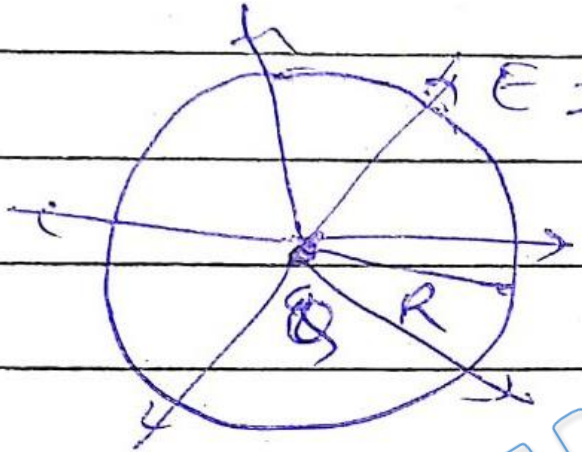
$$E = \frac{\sigma}{\epsilon_0}$$

$$E = \frac{8.85 \times 10^{-6}}{8.85 \times 10^{-12}}$$

$$E = 1 \times 10^{6}\ N/C$$

Ans. c

Solution: 4



$$E = \frac{kQ}{R^2}$$

$$100 = \frac{9\times10^9 \times Q}{(6371\times10^3)^2}$$

$$Q = \frac{(6371)^2}{90}$$

$$Q = 450.9\times10^3\ C$$

Ans. a

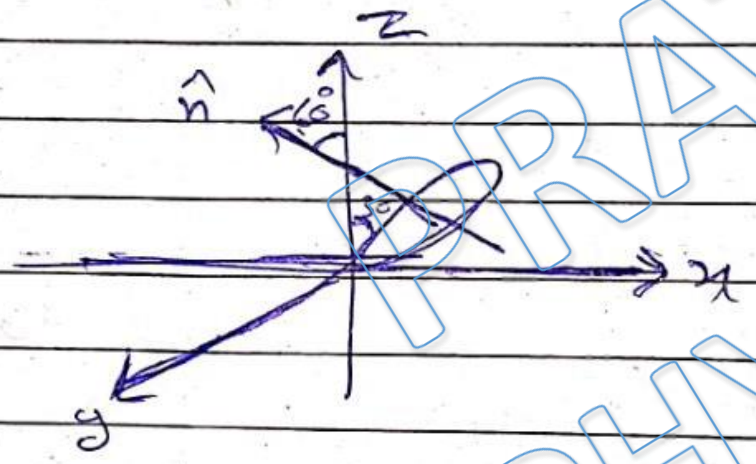
Solution: 5

$$E = \frac{\sigma}{2\epsilon_0} = \frac{5\times10^{-6}}{2\times8.85\times10^{-12}}$$

$$E = 0.2824\times10^{6}$$

$$E = 2.824\times10^{5}\ N/C$$

$$A = \pi r^2 = \pi(0.1)^2 = \pi\times10^{-2}\,m^2$$



$$\theta = 60^\circ$$

$$\phi = EA\cos\theta$$

$$\phi = 2.824\times10^{5}\times(\pi\times10^{-2})\cos60^\circ$$

$$= 2.8\times10^{5}\times\pi\times10^{-2}\times\frac{1}{2}$$

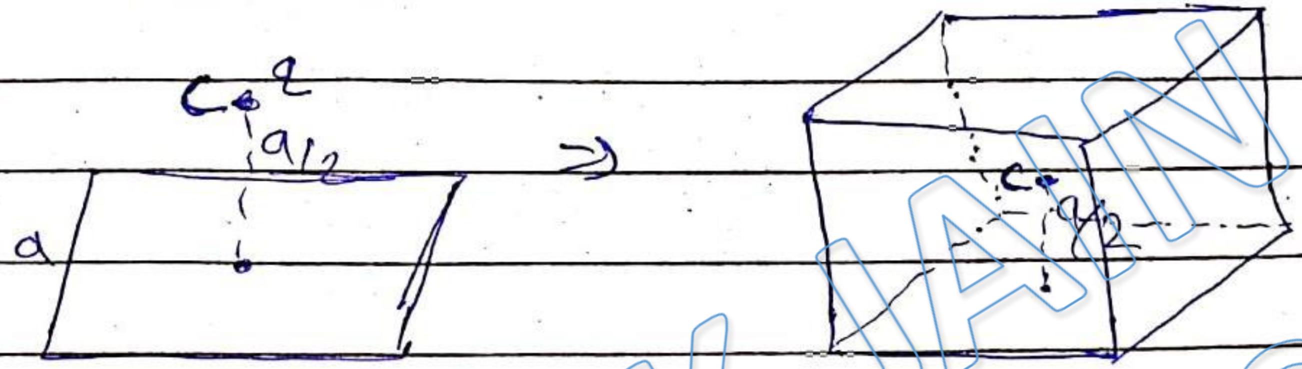
$$= 1.412\times\pi\times10^{3}$$

$$= 4.436\times10^{3}$$

$$\boxed{\phi = 4.4\ kVm}$$

Ans. b

Solution: 6



c, is the centre of cube of side 'a'.

∴ Flux through the square

is $\phi = \frac{1}{6}\left(\frac{q}{\epsilon_0}\right)$

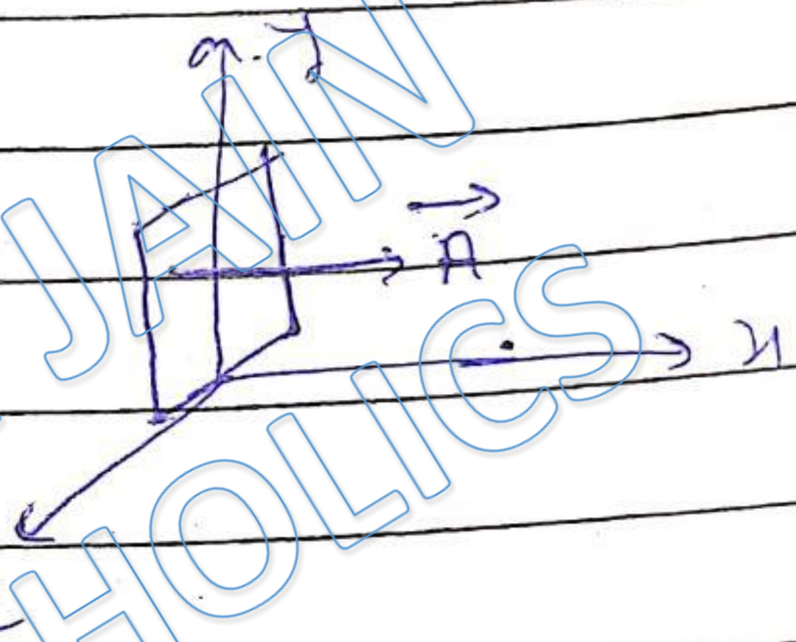
$$\boxed{\phi = \frac{q}{6\epsilon_0}}$$

Ans. d

Solution: 7

$$\vec{A} = L_0^2\,\hat{j}$$

$$\vec{E} = a\hat{j} + b\hat{j}$$



$$\phi = \vec{E}\cdot\vec{A}$$

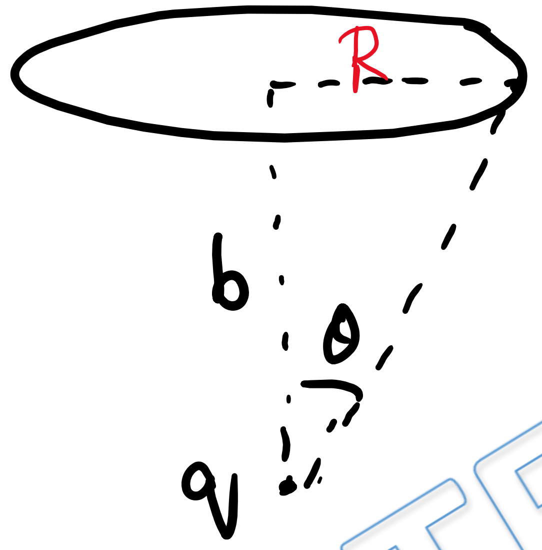
$$= (a\hat{i} + b\hat{j})\cdot(L_0^2\,\hat{j})$$

$$\boxed{\phi = aL_0^2}$$

Ans. c

Solution: 8

Sol :



$$\phi = \frac{q}{2\epsilon_0}(1-\cos\theta)$$

$$\frac{q}{4\epsilon_0} = \frac{q}{2\epsilon_0}(1-\cos\theta)$$

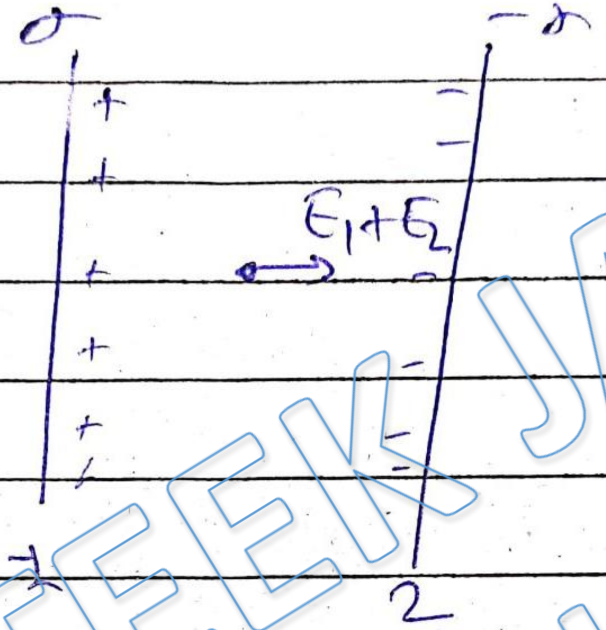
$$\Rightarrow \cos\theta = 1/2 \Rightarrow \tan\theta = \sqrt{3}$$

$$\Rightarrow \frac{R}{b} = \sqrt{3}$$

$$\Rightarrow R = \sqrt{3}\, b$$

Ans (c)

Solution: 9



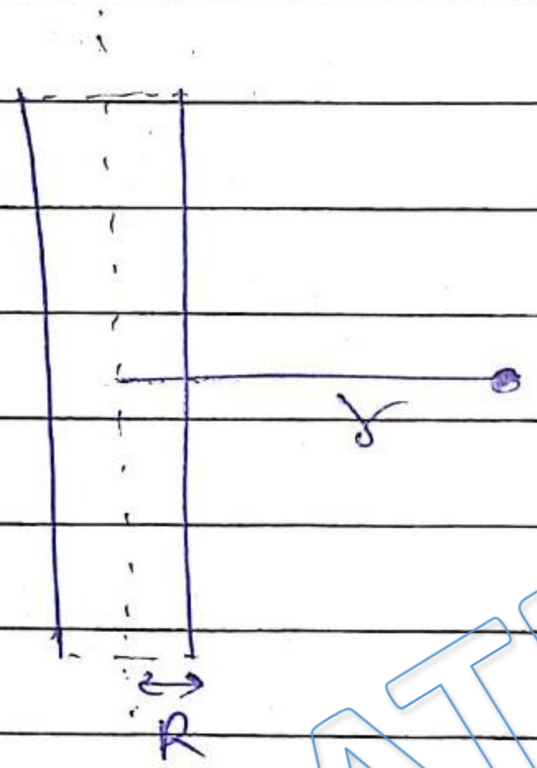
$$E = E_1 + E_2$$

$$= \frac{\sigma}{2\epsilon_0} + \frac{\sigma}{2\epsilon_0}$$

$$\boxed{E = \frac{\sigma}{\epsilon_0}}$$

Ans. b

Solution: 10



$$E = \frac{2K\lambda}{r}$$

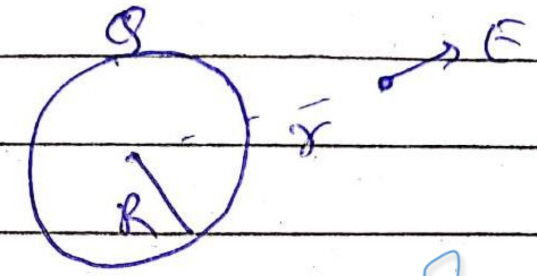
$\lambda \rightarrow$ linear charge density on wire/cylinder.

$\because$ for outside point, cylinder behave like a line charge distribution.

$$\therefore \boxed{E \propto \frac{1}{r} \text{ or } E \propto r^{-1}}$$

Ans. c

Solution: 11



$$E = \frac{kq}{r^2}$$

$$q = \sigma(4\pi R^2) \quad [\because q = \sigma A]$$

$$E = \frac{k(4\pi R^2)\sigma}{r^2}$$

$$E = \frac{1}{4\pi\epsilon_0}\frac{(4\pi R^2)\sigma}{r^2}$$

$$\boxed{E = \frac{\sigma R^2}{\epsilon_0 r^2}}$$

Ans. a

Solution: 12

$$\rho = \frac{Q r^2}{\pi R^5}$$

$$dV = 4\pi r^2 \cdot dr$$

$$dq = \frac{Q r^2}{\pi R^5}(4\pi r^2 dr)$$

$$dq = \frac{4Q}{R^5} r^4 dr$$ [charge in element of thickness dr]

charge enclose in volume of radius 'r'.

$$\int dq = \int_0^r \frac{4Q}{R^5} r^4 dr$$

$$q_r = \frac{4Q}{R^5}\left(\frac{r^5}{5}\right)_0^r$$

$$q_r = \frac{4Q r^5}{5R^5}$$

∴ Charge enclosed inside volume of radius $r = R/2$

$$q_{in} = \frac{4Q}{5R^5}\left(\frac{R}{2}\right)^5 = \frac{2^2 Q R^5}{5 \times R^5 \times 2^5}$$

$$q_{in} = \frac{Q}{40}$$

$$\therefore \oint E \cdot dA = \frac{q_{in}}{\epsilon_0} = \frac{Q}{40\epsilon_0}$$

$$E \cdot 4\pi\left(\frac{R}{2}\right)^2 = \frac{Q}{40\epsilon_0}$$

$$\boxed{E = \frac{Q}{40\pi\epsilon_0 R^2}}$$

Ans. b

Solution: 13

$$E = \frac{\rho r}{3\epsilon_0}$$

$$E = \frac{2\times10^{-4} \times 4\times10^{-2}}{3\times 8.85\times10^{-12}}$$

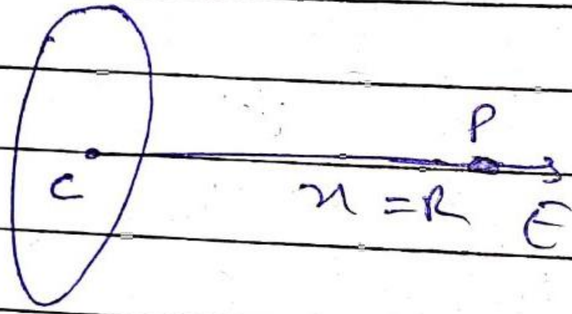
$$= \frac{2\times4}{3\times8.85}\times10^{6}$$

$$E = \frac{2\times4\times10}{3\times8.85}\times10^{5}$$

$$E = 3.01\times10^{5}\ N/C$$

Ans. a

Solution: 14



$$E = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{x}{\sqrt{R^2 + x^2}}\right]$$

$$E_C = \frac{\sigma}{2\epsilon_0}$$

$$E_P = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{R}{\sqrt{R^2 + R^2}}\right]$$

$$= \frac{\sigma}{2\epsilon_0}\left[1 - \frac{1}{\sqrt{2}}\right] = \frac{\sigma}{2\epsilon_0}\left[1 - \frac{1}{\sqrt{2}}\right]$$

$$\Delta E = E_C - E_P = \frac{\sigma}{2\epsilon_0}\left[\frac{1}{\sqrt{2}}\right]$$

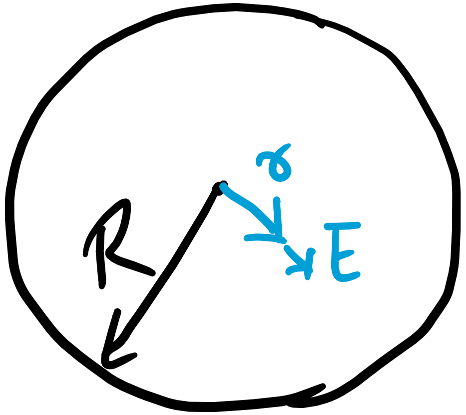
$$\Delta E\% = \frac{\Delta E}{E_C} \times 100 = \frac{\frac{\sigma}{2\epsilon_0} \times \frac{1}{\sqrt{2}}}{\frac{\sigma}{2\epsilon_0}} \times 100$$

$$\%\Delta E = \frac{100}{\sqrt{2}} = 70.7\%$$

Ans. a

Solution: 15

Sol →



$$E = \frac{\rho r}{3\epsilon_0}$$

$$dV = -\vec{E} \cdot d\vec{r}$$

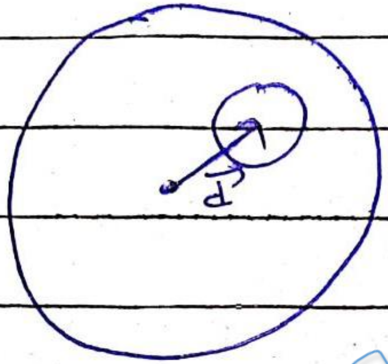
$$\Rightarrow \int_{V_{centre}}^{V_{surface}} dV = -\frac{\rho}{3\epsilon_0}\int_0^R r\,dr$$

$$\Rightarrow V_{surface} - V_{centre} = \frac{-\rho R^2}{6\epsilon_0}$$

$$\Rightarrow V_{centre} - V_{surface} = \frac{\rho R^2}{6\epsilon_0}$$

Ans. d

Solution: 16



$$\vec{E} = \frac{\rho \vec{d}}{3\epsilon_0}$$

$$E = \frac{\rho d}{3\epsilon_0}$$

$$E = \frac{10^{-6} \times 0.05}{3 \times 8.85 \times 10^{-12}}$$

$$= \frac{0.5 \times 10^{6}}{3 \times 8.85}$$

$$= \frac{500}{3 \times 8.85} \times 10^{3}$$

$$\boxed{E = 18.8 \text{ kN/C}}$$

uniform inside ~~the~~ the cavity.

Ans. c

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