Physicsaholics

DPP – 6 (Electrostatics)

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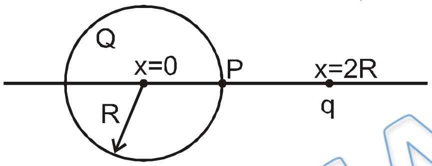
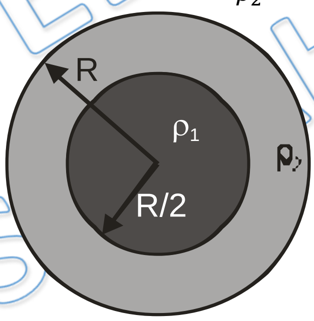
Q 1. A sphere of radius R contains a total charge +Q which is uniformly distributed throughout its volume. At a distance 2R from the centre of sphere, a particle having charge +q is fixed. P is a point on surface of sphere and lying on line joining the centre of sphere and point charge. Distance of point from P where net electric field is zero, is R/2. Then q may be



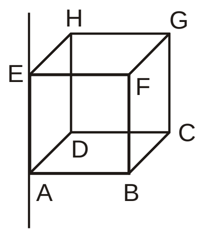
(a) $\frac{9Q}{8}$ (b) Q (c) $\frac{1}{9}$Q (d) 2Q

Q 2. Consider a solid non conducting sphere of radius R. There is uniform volume charge density ρ_1 from r = 0 to r = $\frac{R}{2}$, and from r = $\frac{R}{2}$ and r = R, the volume charge density is ρ_2. If electric field at r = $\frac{R}{2}$ and r = R have same magnitude then $\frac{\rho_1}{\rho_2}$ is :



(a) 4/1 (b) 8/3 (c) 7/3 (d) 5/4

Q 3. An infinite long line charge of charge per unit length l is passing through one the edge of a cube. Length of edge of the cube is l. Total flux linked with



(a) cube is $\frac{\lambda\ell}{2\varepsilon_0}$ (b) cube is $\frac{\lambda\ell}{4\varepsilon_0}$

(c) BCGF is $\frac{\lambda\ell}{8\varepsilon_0}$ (d) ABFE is zero

Q 4. Two point charges 4q and – q are placed at some distance. What fraction of field lines originating from 4q will terminate to q.[Assume absence of any other charge in space]

(a) 1/4 (b)3/4 (c) 1 (d) ½

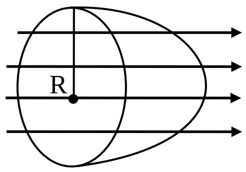
Q 5. Consider a triangular surface whose vertices are three points having co-ordinate A (2a, 0, 0), B(0, a, 0), C(0, 0, a). If there is a uniform electric field $E_0\hat{\imath} + 2E_0\hat{\jmath} + 3E_0\hat{k}$ then flux linked to triangular surface ABC is-

(a) $\frac{7E_0a^2}{2}$ (b) $3E_0a^2$ (c) $\frac{11E_0a^2}{2}$ (d) Zero

Q 6. A cylinder of radius (R) and length (L) is placed in a uniform electrical field (E) parallel to the axis of the cylinder. The total flux for the surface of the cylinder is given by –

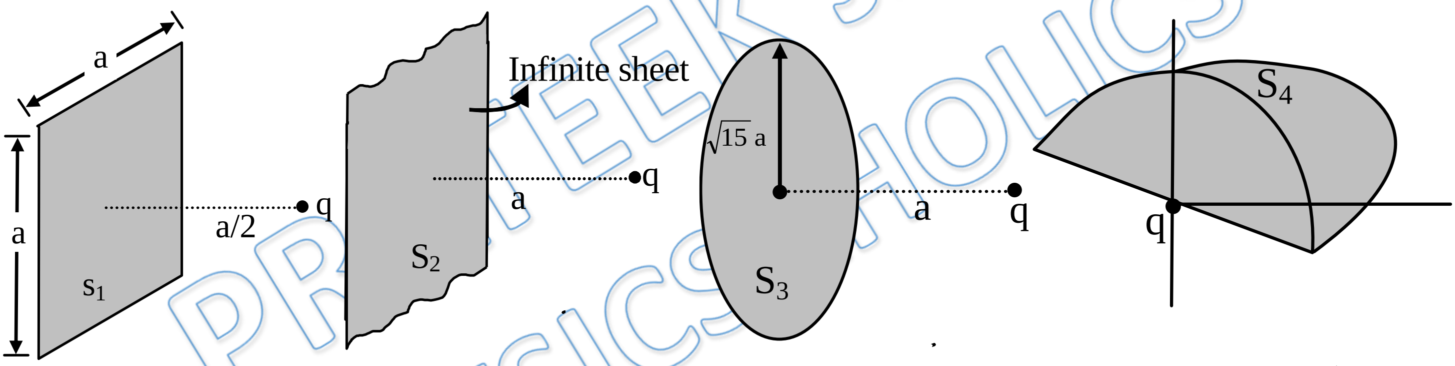
(a) $2\pi R^2E$ (b) πR^2E (c) $\frac{\pi R^2+\pi R^2}{E}$ (d) zero

Q 7. A hemisphere (radius R) is placed in electric field as shown in fig. Total outgoing flux is –



(a) πR^2E (b) $2\pi R^2E$ (c) $4\pi R^2E$ (d) $(\pi R^2E)/2$

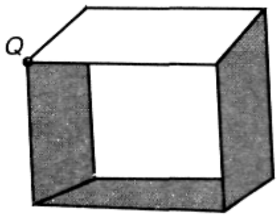
Q 8. Consider the imaginary surfaces S_1, S_2, S_3 and S_4 drawn near a point charge as shown in fig.



Column I give different surfaces and Column II corresponding electric flux. Match the entries of Column I to Column II.

Column I	**Column II**
(A) S_1	(P) $\frac{3q}{8\varepsilon_0}$
(B) S_2	(Q) $\frac{q}{2\varepsilon_0}$
(C) S_3	(R) $\frac{q}{6\varepsilon_0}$
(D) S_4	(S) $\frac{q}{4\varepsilon_0}$

Q 9. If a point charge is placed at vertex of cube then flux linked to surface shaded in figure



(a) $\frac{q}{8\varepsilon_0}$ (b) $\frac{q}{3\varepsilon_0}$ (c) $\frac{q}{12\varepsilon_0}$ (d) Zero

Q 10. In a region of space, the electric field is in the x-direction and proportional to x, i.e., $\vec{E} = E_0 x\hat{i}$. Consider an imaginary cubical volume of edge a, with its edges parallel to the axes of coordinates. The charge inside this volume is

(a) zero (b) $\varepsilon_0 E_0 a^3$ (c) $\frac{1}{\varepsilon_0} E_0 a^3$ (d) $\frac{1}{6}\varepsilon_0 E_0 a^2$

Q 11. Charges Q_1 and Q_2 are inside and outside respectively of a closed surface *S*. Let *E* be the field at any point on *S* and ϕ be the flux of *E* over *S*. Then choose the correct statements

(a) if Q_1 changes both and *E* and ϕ will change

(b) if Q_2 changes, *E* will change but ϕ will not change

(c) if $Q_1 = 0$ and $Q_2 = 0$, then $E \neq 0$ but $\phi = 0$

(d) if $Q_1 = 0$ and $Q_2 = 0$, then $E = 0$ and $\phi = 0$

Q 12. In a spherical volume of radius R , volume charge density $\rho = r^3$ (where r is distance from centre). Electric Field at distance r (r < R) from centre is

(a) $\frac{r^4}{5\varepsilon_0}$ (b) $\frac{r^4}{4\varepsilon_0}$ (c) $\frac{r^4}{6\varepsilon_0}$ (d) $\frac{r^4}{3\varepsilon_0}$

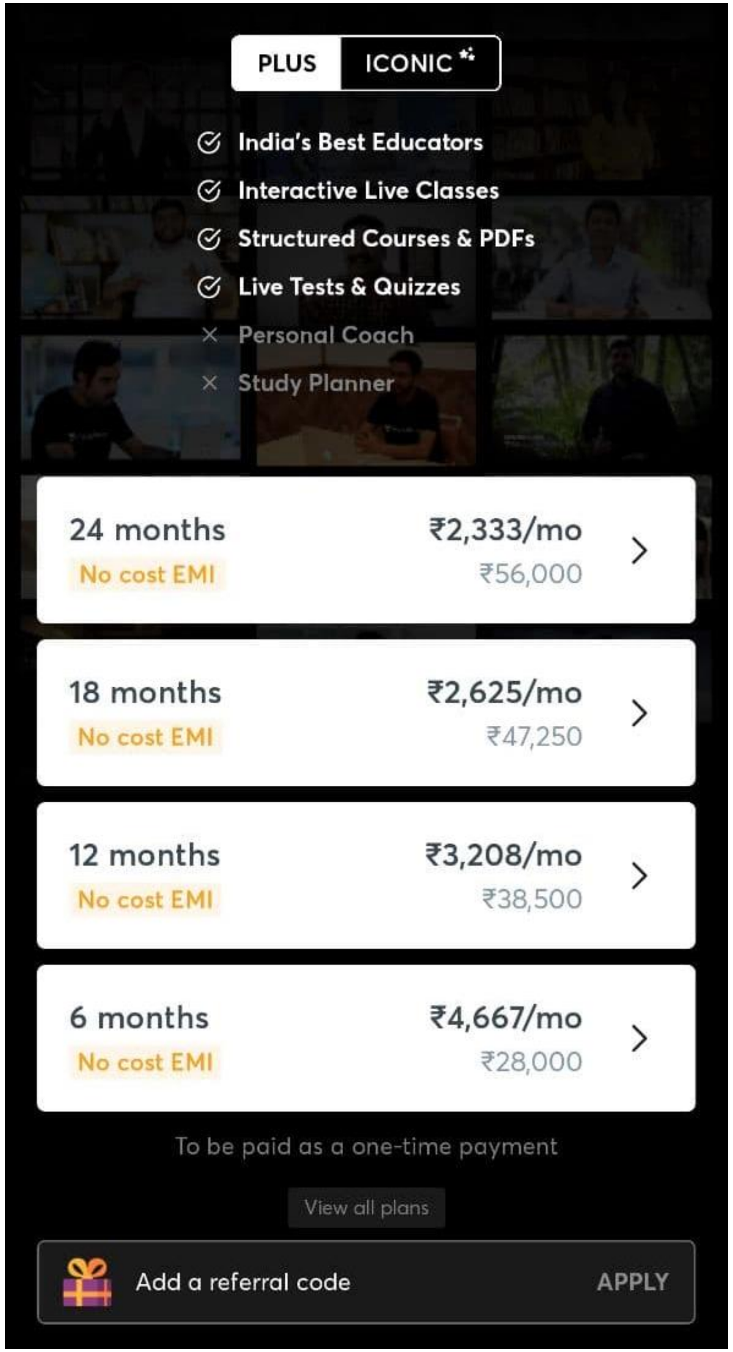
Q 13. In a nonuniformly charged solid sphere of radius R electric field at distance r from centre is E $= r^2$ in radially outward direction. Charge density at distance r from centre (r < R) is

(a) $\varepsilon_0 r$ (b) $4\varepsilon_0 r$ (c) $2\varepsilon_0$ (d) $\varepsilon_0 r^2$

Answer Key

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

Q.8 A → R; B → Q; C → P; D → S



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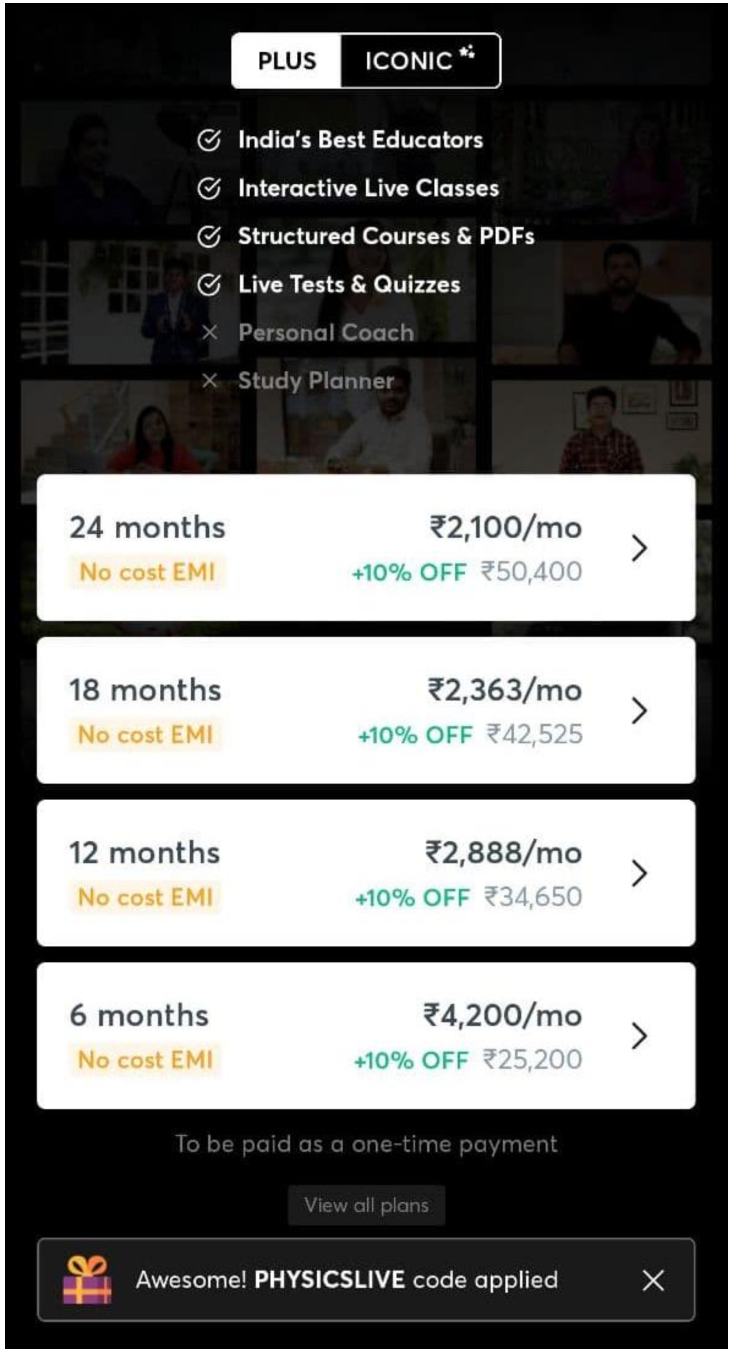

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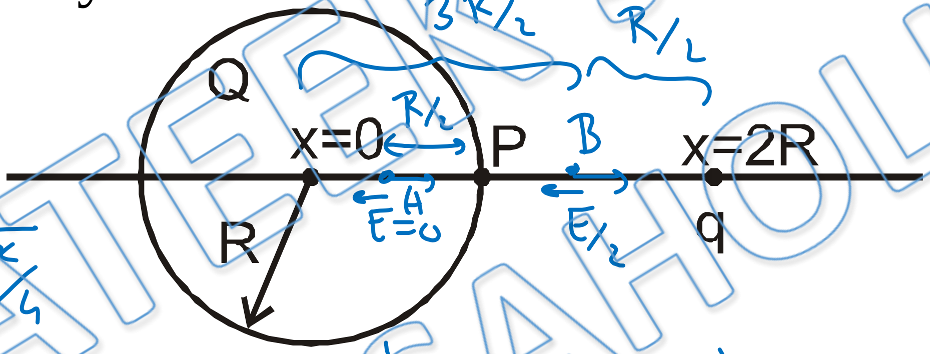
Written Solution

DPP- 6 Electrostatics : Gauss’s Law

By Physicsaholics Team

Q1) A sphere of radius R contains a total charge +Q which is uniformly distributed throughout its volume. At a distance 2R from the centre of sphere, a particle having charge +q is fixed. P is a point on surface of sphere and lying on line joining the centre of sphere and point charge. Distance of point from P where net electric field is zero ,is R/2 . Then q may be



field at A = 0

$\Rightarrow \dfrac{KQ\,R/2}{R^3} = \dfrac{Kq}{9R^2/4}$

$\Rightarrow \dfrac{Q}{2} = \dfrac{4q}{9} \Rightarrow q = \dfrac{9Q}{8}$

field at B = 0

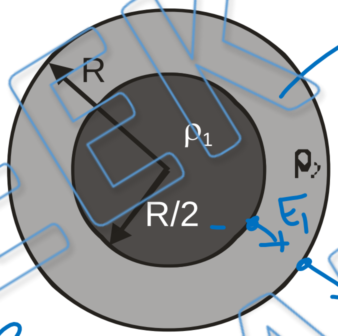
$\Rightarrow \dfrac{KQ}{9R^2/4} = \dfrac{Kq}{R^2/4}$

$\Rightarrow q = Q/9$

(a) $\frac{9Q}{8}$ (b) Q (c) $\frac{1}{9}$Q (d) 2Q

Q2) Consider a solid non conducting sphere of radius R. There is uniform volume charge density ρ_1 from r = 0 to r = $\frac{R}{2}$, and from r = $\frac{R}{2}$ and r = R the volume charge density is ρ_2. If electric field at r = $\frac{R}{2}$ and r = R have same magnitude then $\frac{\rho_1}{\rho_2}$ is :

$$E_1 = \frac{\rho_1 (R/2)}{3\epsilon_0} = \frac{\rho_1 R}{6\epsilon_0}$$



$$\text{Volume} = \frac{4}{3}\pi R^3 - \frac{4}{3}\pi \frac{R^3}{8}$$

$$= 7 \times \frac{4}{3}\pi \frac{R^3}{8}$$

$$E_2 = \frac{K\left[\rho_1 \frac{4}{3}\pi \frac{R^3}{8} + \rho_2 \frac{4}{3}\pi \frac{R^3}{8} \times 7\right]}{R^2}$$

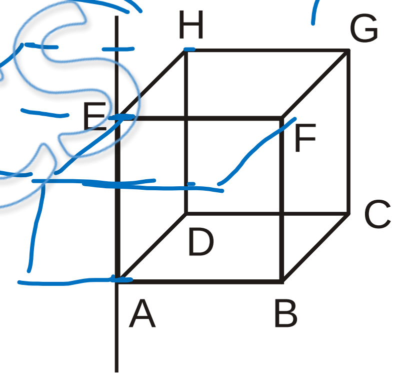
$$= \frac{\frac{4\pi}{3} R^3/8 \left[\rho_1 + 7\rho_2\right]}{4\pi\epsilon_0 R^2} = \frac{\left[\rho_1 + 7\rho_2\right] R}{24\epsilon_0}$$

(a) 4/1 (b) 8/3 (c) 7/3 ✓ (d) 5/4

$$E_1 = E_2 \Rightarrow \frac{\rho_1 R}{6\epsilon_0} = \frac{(\rho_1 + 7\rho_2) R}{24\epsilon_0} \Rightarrow 4\rho_1 = \rho_1 + 7\rho_2$$

$$\Rightarrow \frac{\rho_1}{\rho_2} = 7/3$$

Q3) An infinite long line charge of charge per unit length λ is passing through one the edge of a cube. Length of edge of the cube is ℓ. Total flux linked with



$4\phi = \frac{\lambda l}{\epsilon_0}$

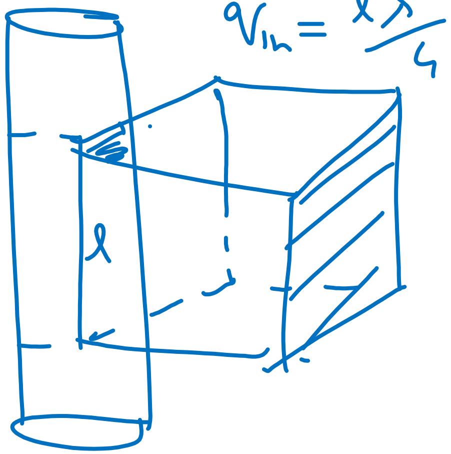
$\Rightarrow \phi = \frac{\lambda l}{4\epsilon_0}$

flux through top, bottom, front & left surfaces = 0

(Since field lines are ∥ to surfaces)

$\phi_{BCGF} = \phi_{HGCD}$, $\phi_{BCGF} + \phi_{HGCD} = \frac{\lambda l}{4\epsilon_0}$

$q_{in} = \frac{\lambda l}{4}$



(a) cube is $\frac{\lambda\ell}{2\varepsilon_0}$ (b) cube is $\frac{\lambda\ell}{4\varepsilon_0}$

(c) BCGF is $\frac{\lambda\ell}{8\varepsilon_0}$ (d) ABFE is zero

Q4) Two point charges 4q and – q are placed at some distance. What fraction of field lines originating from 4q will terminate to q.[Assume absence of any other charge in space]

n lines
4q

n/4 lines
−q

no of field lines $\propto |q|$

(a) 1/4 (b)3/4 (c) 1 (d) ½

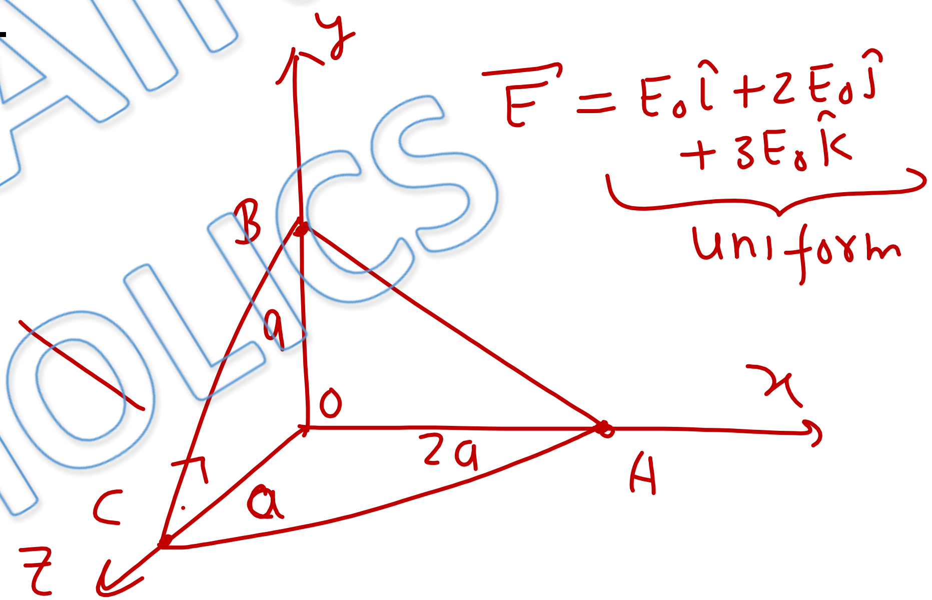
Q5) Consider a triangular surface whose vertices are three points having co-ordinate A (2a, 0, 0), B(0, a, 0), C(0, 0, a). If there is a uniform electric field $E_0\hat{\imath} + 2E_0\hat{\jmath} + 3E_0\hat{k}$ then flux linked to triangular surface ABC is-

$$\phi_{OBC} = \left(\frac{1}{2}a \times a\right)E_0 = \frac{a^2E_0}{2}$$

$$\phi_{OAB} = \left(\frac{1}{2} \times 2a \times a\right)3E_0 = 3a^2E_0$$

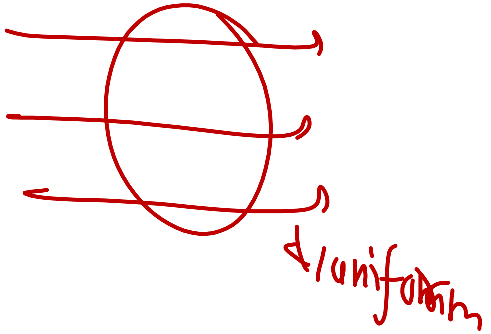
$$\phi_{OAC} = \left(\frac{1}{2} \times 2a \times a\right)2E_0 = 2E_0a^2$$

$$\phi_{sum} = \frac{11}{2}E_0a^2$$

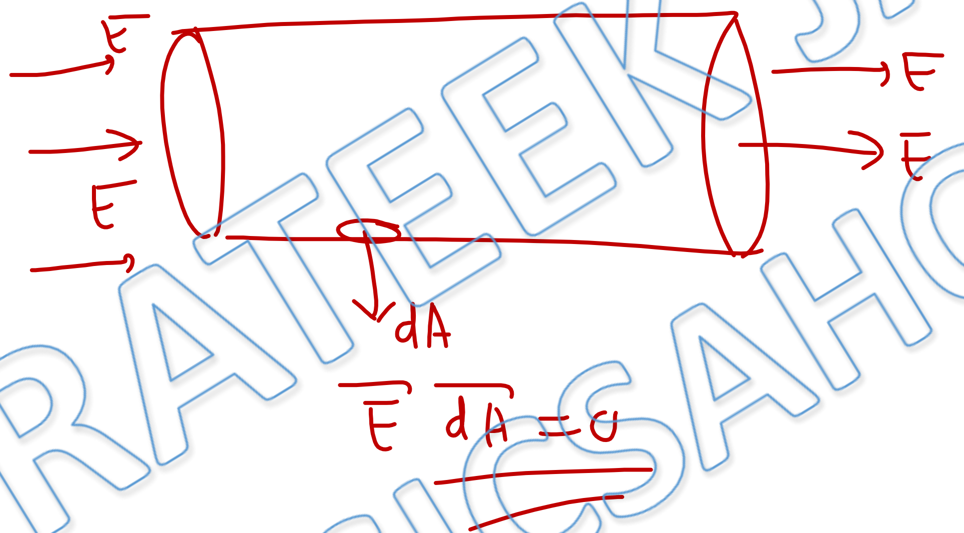


(a) $\frac{7E_0a^2}{2}$ (b) $3E_0a^2$ (c) $\frac{11E_0a^2}{2}$ (d) Zero

$$|\phi_{ABC}| = |\phi_{OBC}| + |\phi_{OAB}| + |\phi_{OAC}| = \frac{11}{2}E_0a^2$$



Q6) A cylinder of radius (R) and length (L) is placed in a uniform electrical field (E) parallel to the axis of the cylinder. The total flux for the surface of the cylinder is given by -



(a) $2\pi R^2 E$

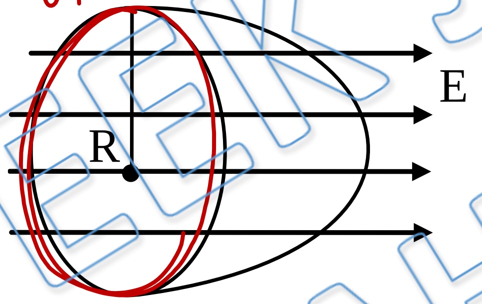
(b) $\pi R^2 E$

(c) $\frac{\pi R^2+\pi R^2}{E}$

(d) zero

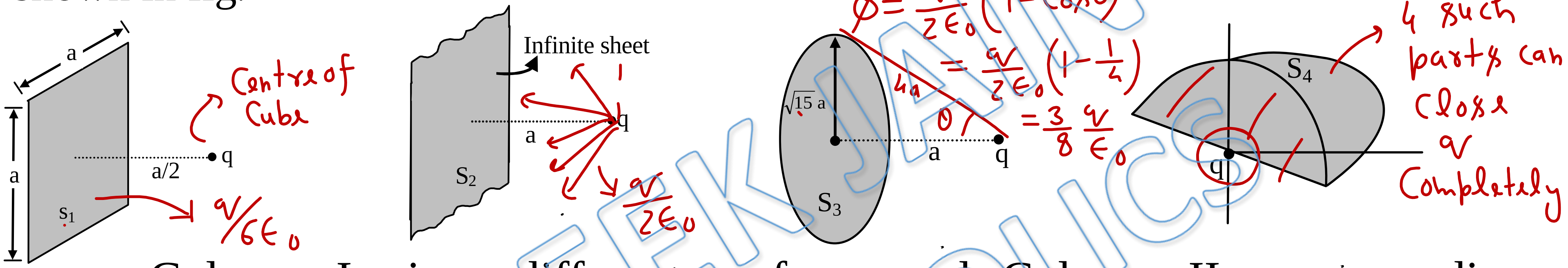
Q7) A hemisphere (radius R) is placed in electric field as shown in fig. Total outgoing flux is -

$|\phi_{outgoing}| = |\phi_{incomming}| = E \cdot \pi R^2$



(a) $\pi R^2 E$ (b) $2\pi R^2 E$ (c) $4\pi R^2 E$ (d) $(\pi R^2 E)/2$

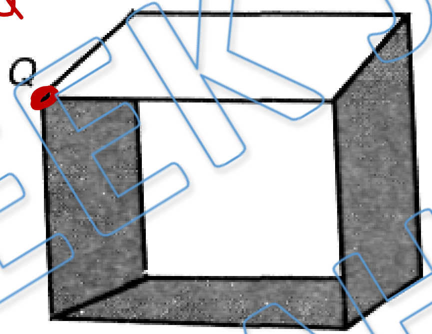
Q8) Consider the imaginary surfaces S_1, S_2, S_3 and S_4 drawn near a point charge as shown in fig.



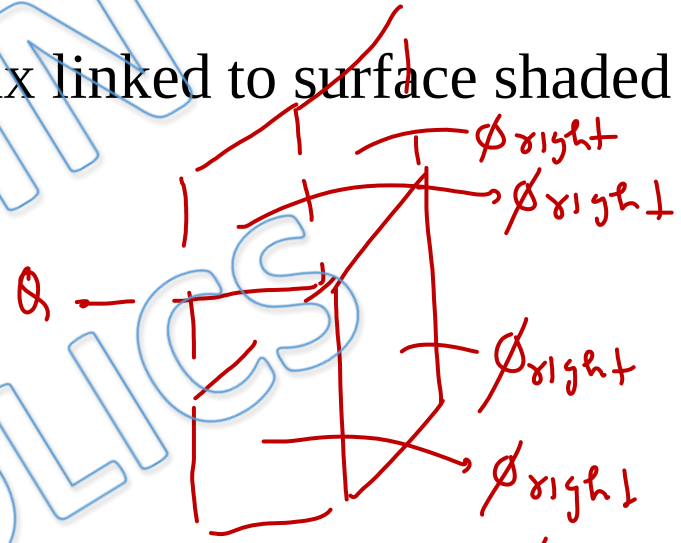
Column I gives different surfaces and Column II corresponding electric flux. Match the entries of Column I to Column II.

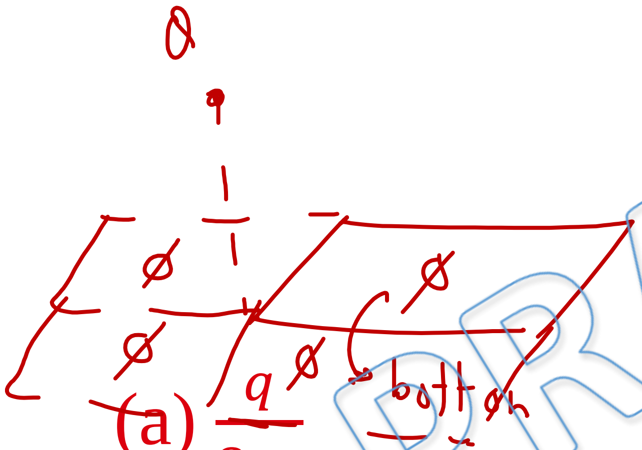
Column I	**Column II**
(A) S_1	(P) $\frac{3q}{8\varepsilon_0}$
(B) S_2	(Q) $\frac{q}{2\varepsilon_0}$
(C) S_3	(R) $\frac{q}{6\varepsilon_0}$
(D) S_4	(S) $\frac{q}{4\varepsilon_0}$

Q9) If a point charge is placed at vertex of cube then flux linked to surface shaded in figure



$\phi_{Left} = 0$ (field lines are ∥ to left surface)





(a) $\frac{q}{8\varepsilon_0}$ (b) $\frac{q}{3\varepsilon_0}$ (c) $\frac{q}{12\varepsilon_0}$ (d) Zero

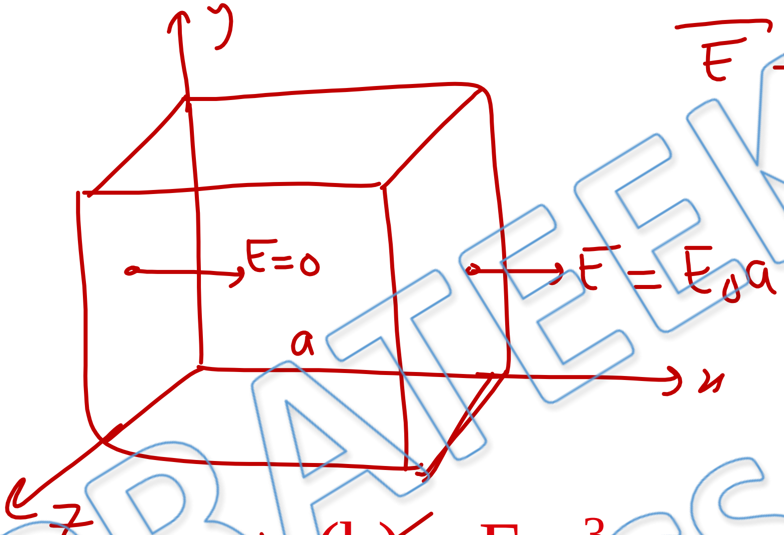
$4\phi_{right} = q/6\epsilon_0$ (cubical symmetry)

$\phi_{right} = q/24\epsilon_0$

$4\phi_{bottom} = q/6\epsilon_0$

$\phi_{bottom} = q/24\epsilon_0$

Q10) In a region of space, the electric field is in the x-direction and proportional to x, i.e., $\vec{E} = E_0 x\hat{i}$. Consider an imaginary cubical volume of edge a, with its edges parallel to the axes of coordinates,. The charge inside this volume is



$\vec{E} = E_0 x \hat{i} \Rightarrow \phi_{top} = \phi_{bottom} = \phi_{front} = \phi_{back} = 0$

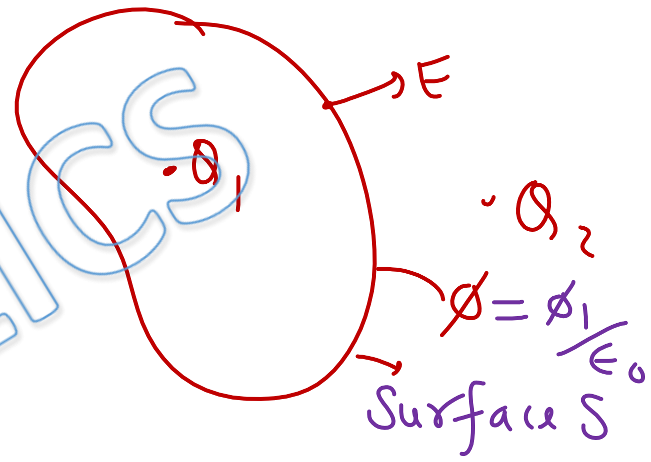
$\phi_{left} = 0$ Since $E = 0$

$\phi_{right} = E_0 a \times a^2 = E_0 a^3$

(a) zero (b) $\varepsilon_0 E_0 a^3$ (c) $\frac{1}{\varepsilon_0} E_0 a^3$ (d) $\frac{1}{6}\varepsilon_0 E_0 a^2$

$\phi_{total} = E_0 a^3 = \frac{q_{in}}{\varepsilon_0}$

Q11) Charges Q_1 and Q_2 are inside and outside respectively of a closed surface *S*. Let *E* be the field at any point on *S* and ϕ be the flux of *E* over *S*. Then choose the correct statements



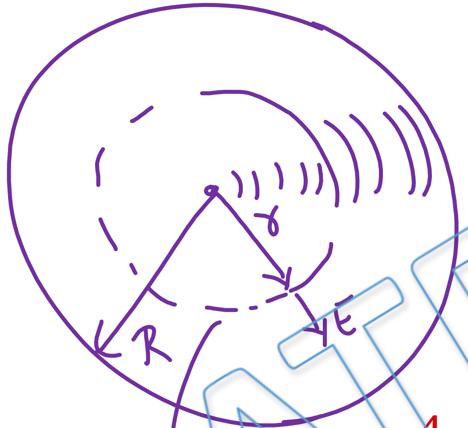
(a) if Q_1 changes both and *E* and ϕ will change

(b) if Q_2 changes, *E* will change but ϕ will not change

(c) if $Q_1 = 0$ and $Q_2 = 0$, then $E \neq 0$ but $\phi = 0$

(d) if $Q_1 = 0$ and $Q_2 = 0$, then $E = 0$ and $\phi = 0$

Q12) In a spherical volume of radius R , volume charge density $\rho = r^3$ (where r is distancs from centre). Electric Field at distance r (r < R) from centre is



$q \rightarrow$ charge with in radius r

$q = \int_0^r (4\pi r^2 dr) r^3 = 4\pi \frac{r^6}{6}$

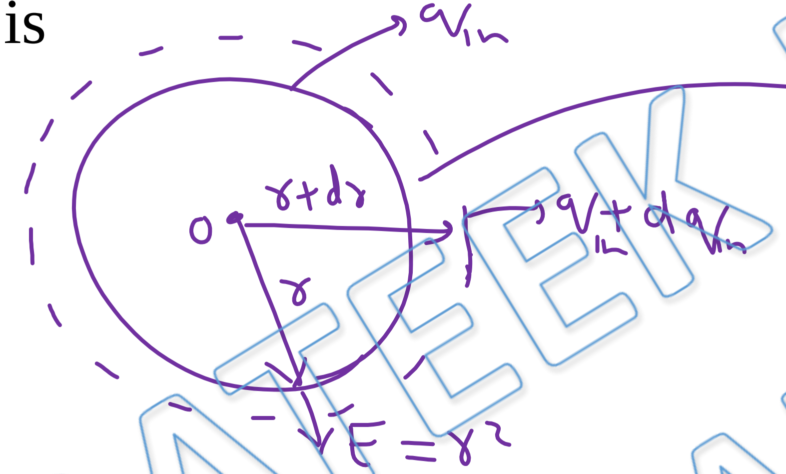
$E = \frac{Kq}{r^2} = \frac{4\pi r^6}{4\pi\epsilon_0 \, 6 r^2} = \frac{r^4}{6\epsilon_0}$

(a) $\frac{r^4}{5\varepsilon_0}$ (b) $\frac{r^4}{4\varepsilon_0}$ (c) $\frac{r^4}{6\varepsilon_0}$ (d) $\frac{r^4}{3\varepsilon_0}$

$\oint \vec{E} \cdot d\vec{A} = \frac{q_{in}}{\epsilon_0}$

$\Rightarrow E \cdot 4\pi r^2 = \frac{4\pi r^6}{6\epsilon_0} = \frac{r^4}{6\epsilon_0}$

Q13) In a nonuniformly charged solid sphere of radius R electric field at distance r fron centre is E = r^2 in radially outward direction. Charge density at distance r from centre (r < R) is



$\phi = \int \vec{E} \cdot \vec{dA} = r^2 \cdot 4\pi r^2$

$\phi = 4\pi r^4 = \frac{q_{in}}{\epsilon_0}$

$q_{in} = 4\pi \epsilon_0 r^4$

$dq_{in} = 4\pi\epsilon_0 \times 4r^3 dr$

(a) $\varepsilon_0 r$ (b) $4\varepsilon_0 r$ (c) $2\varepsilon_0$ (d) $\varepsilon_0 r^2$

charge on shell of thickness dr

$dq_{in} = \rho\, 4\pi r^2 dr = 4\pi\epsilon_0 4r^3 dr$

$\rho = 4\epsilon_0 r$

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Chalo Niklo