# DPP - Daily Practice Problems

Date : ____ Start Time : ____ End Time : ____

# PHYSICS

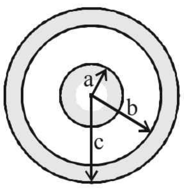
CP15

**SYLLABUS :** Electric Charges and Fields

**Max. Marks : 120** **Marking Scheme :** (+4) for correct & (–1) for incorrect answer **Time : 60 min.**

**INSTRUCTIONS** : This Daily Practice Problem Sheet contains 30 MCQs. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.

**1.** A solid conducting sphere of radius a has a net positive charge 2Q. A conducting spherical shell of inner radius b and outer radius c is concentric with the solid sphere and has a net charge –Q. The surface charge density on the inner and outer surfaces of the spherical shell will be respectively




(a) $-\frac{2Q}{4\pi b^2}, \frac{Q}{4\pi c^2}$ (b) $-\frac{Q}{4\pi b^2}, \frac{Q}{4\pi c^2}$

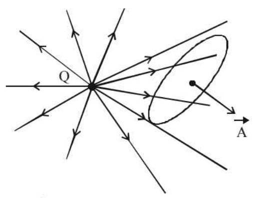
(c) $0, \frac{Q}{4\pi c^2}$ (d) $\frac{Q}{4\pi c^2}, 0$

**2.** The surface charge density of a thin charged disc of radius R is $\sigma$. The value of the electric field at the centre of the disc is $\frac{\sigma}{2\epsilon_0}$. With respect to the field at the centre, the electric field along the axis at a distance R from the centre of the disc reduces by

(a) 70.7% (b) 29.3%

(c) 9.7% (d) 14.6%

**3.** In the figure, the net electric flux through the area $A$ is $\phi = \vec{E} \cdot \vec{A}$ when the system is in air. On immersing the system in water the net electric flux through the area




(a) becomes zero (b) remains same

(c) increases (d) decreases

**4.** An electric dipole is placed in a uniform electric field. The dipole will experience

(a) a force that will displace it in the direction of the field

(b) a force that will displace it in a direction opposite to the field.

(c) a torque which will rotate it without displacement

(d) a torque which will rotate it and a force that will displace it

| RESPONSE GRID | 1. ⓐⓑⓒⓓ | 2. ⓐⓑⓒⓓ | 3. ⓐⓑⓒⓓ | 4. ⓐⓑⓒⓓ |
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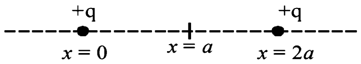
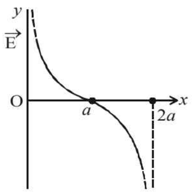
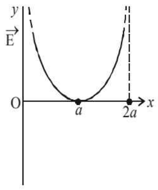
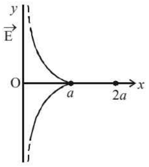
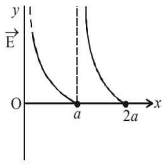
**5.** Figure shows two charges of equal magnitude separated by a distance 2a. As we move away from the charge situated at x = 0 to the charge situated at x = 2a, which of the following graphs shows the correct behaviour of electric field ?




(a)


(b)


(c)


(d)


**6.** An uniform electric field E exists along positive x-axis. The work done in moving a charge 0.5 C through a distance 2 m along a direction making an angle 60° with x-axis is 10 J. Then the magnitude of electric field is

(a) $5\,Vm^{-1}$ (b) $2\,Vm^{-1}$ (c) $\sqrt{5}\,Vm^{-1}$ (d) $20\,Vm^{-1}$

**7.** An electric dipole is placed along the x-axis at the origin O. A point P is at a distance of 20 cm from this origin such that OP makes an angle $\pi/3$ with the x-axis. If the electric field at P makes an angle $\theta$ with the x-axis, the value of $\theta$ would be

(a) $\frac{\pi}{3}$ (b) $\frac{\pi}{3}+\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

(c) $\frac{2\pi}{3}$ (d) $\tan^{-1}\left(\frac{\sqrt{3}}{2}\right)$

**8.** A spherically symmetric charge distribution is characterised by a charge density having the following variations:

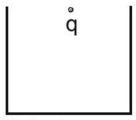
$$\rho(r)=\rho_0\left(1-\frac{r}{R}\right) \text{ for } r<R \quad \rho(r)=0 \text{ for } r\geq R$$

Where r is the distance from the centre of the charge distribution $\rho_o$ is a constant. The electric field at an internal point (r < R) is:

(a) $\frac{\rho_0}{4\varepsilon_o}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$ (b) $\frac{\rho_0}{\varepsilon_o}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$

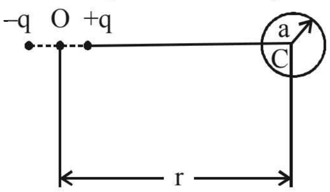
(c) $\frac{\rho_0}{3\varepsilon_o}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$ (d) $\frac{\rho_0}{12\varepsilon_o}\left(\frac{r}{3}-\frac{r^2}{4R}\right)$

**9.** A charge q is placed at the centre of the open end of a cylindrical vessel. The flux of the electric field through the surface of the vessel is




(a) zero (b) $q/\varepsilon_o$ (c) $q/2\varepsilon_o$ (d) $2q/\varepsilon_o$

**10.** A short electric dipole of dipole moment $\vec{p}$ is placed at a distance r from the centre of a solid metallic sphere of radius a (<< r) as shown in the figure. The electric field intensity at the centre of sphere C due to induced charge on the sphere is



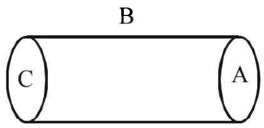

(a) zero (b) $\frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ along CO

(c) $\frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}$ along OC (d) $\frac{1}{4\pi\varepsilon_0}\frac{p}{r^3}$ along CO

**11.** A semi-circular arc of radius '$a$' is charged uniformly and the charge per unit length is $\lambda$. The electric field at the centre of this arc is

(a) $\frac{\lambda}{2\pi\varepsilon_0 a}$ (b) $\frac{\lambda}{2\pi\varepsilon_0 a^2}$ (c) $\frac{\lambda}{4\pi^2\varepsilon_0 a}$ (d) $\frac{\lambda^2}{2\pi\varepsilon_0 a}$

**12.** A hollow cylinder has a charge $q$ coulomb within it. If $\phi$ is the electric flux in units of voltmeter associated with the curved surface $B$, the flux linked with the plane surface $A$ in units of voltmeter will be




(a) $\frac{q}{2\varepsilon_0}$ (b) $\frac{\phi}{3}$

(c) $\frac{q}{\varepsilon_0}-\phi$ (d) $\frac{1}{2}\left(\frac{q}{\varepsilon_0}-\phi\right)$

**13.** A point Q lies on the perpendicular bisector of an electrical dipole of dipole moment p. If the distance of Q from the dipole is r (much larger than the size of the dipole), then the electric field at Q is proportional to

(a) $p^{-1}$ and $r^{-2}$ (b) p and $r^{-2}$ (c) $p^2$ and $r^{-3}$ (d) p and $r^{-3}$

**14.** A solid sphere of radius $R$ has a charge $Q$ distributed in its volume with a charge density $\rho = \kappa r^a$, where $\kappa$ and $a$ are constants and $r$ is the distance from its centre.

If the electric field at $r=\frac{R}{2}$ is $\frac{1}{8}$ times that at $r = R$, find the value of $a$

(a) 2 (b) 3 (c) 5 (d) 6

| RESPONSE GRID | | | | | |
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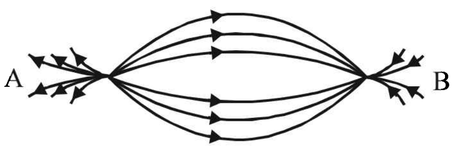
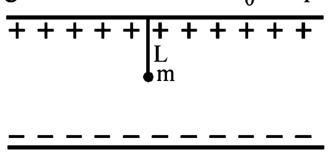
| | 5. ⓐⓑⓒⓓ | 6. ⓐⓑⓒⓓ | 7. ⓐⓑⓒⓓ | 8. ⓐⓑⓒⓓ | 9. ⓐⓑⓒⓓ |
| | 10. ⓐⓑⓒⓓ | 11. ⓐⓑⓒⓓ | 12. ⓐⓑⓒⓓ | 13. ⓐⓑⓒⓓ | 14. ⓐⓑⓒⓓ |

**15.** The spatial distribution of electric field due to charges (A, B) is shown in figure. Which one of the following statements is correct ?




(a) A is +ve and B –ve, |A| > |B|
(b) A is –ve and B +ve, |A| = |B|
(c) Both are +ve but A > B
(d) Both are –ve but A > B

**16.** A small sphere carrying a charge 'q' is hanging in between two parallel plates by a string of length L. Time period of pendulum is $T_0$. When parallel plates are charged, the time period changes to T. The ratio $T/T_0$ is equal to



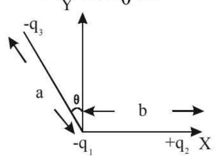

(a) $\left(\dfrac{g+\dfrac{qE}{m}}{g}\right)^{1/2}$ (b) $\left(\dfrac{g}{g+\dfrac{qE}{m}}\right)^{3/2}$

(c) $\left(\dfrac{g}{g+\dfrac{qE}{m}}\right)^{1/2}$ (d) None of these

**17.** In a medium of dielectric constant K, the electric field is $\vec{E}$. If $\epsilon_0$ is permittivity of the free space, the electric displacement vector is

(a) $\dfrac{K\vec{E}}{\epsilon_0}$ (b) $\dfrac{\vec{E}}{K\epsilon_0}$ (c) $\dfrac{\epsilon_0\vec{E}}{K}$ (d) $K\epsilon_0\vec{E}$

**18.** 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) $\dfrac{q_2}{b^2}-\dfrac{q_3}{a^2}\cos\theta$ (b) $\dfrac{q_2}{b^2}+\dfrac{q_3}{a^2}\sin\theta$

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

**19.** An oil drop of radius r and density ρ is held stationary in a uniform vertically upwards electric field 'E'. If $\rho_0$ (< ρ) is the density of air and e is quanta of charge, then the drop has–

(a) $\dfrac{4\pi r^3(\rho-\rho_0)g}{3eE}$ excess electrons

(b) $\dfrac{4\pi r^2(\rho-\rho_0)g}{eE}$ excess electrons

(c) deficiency of $\dfrac{4\pi r^3(\rho-\rho_0)g}{3eE}$ electrons

(d) deficiency of $\dfrac{4\pi r^2(\rho-\rho_0)g}{eE}$ electrons

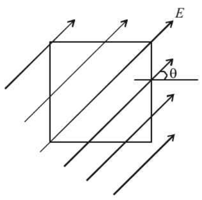
**20.** A surface has the area vector $\vec{A}=\left(2\hat{i}+3\hat{j}\right)m^2$. The flux of an electric field through it if the field is $\vec{E}=4\hat{i}\dfrac{V}{m}$ :

(a) 8V-m (b) 12V-m (c) 20V-m (d) zero

**21.** Two small similar metal spheres A and B having charges 4q and – 4q, when placed at a certain distance apart, exert an electric force F on each other. When another identical uncharged sphere C, first touched with A then with B and then removed to infinity, the force of interaction between A and B for the same separation will be

(a) F/2 (b) F/8 (c) F/16 (d) F/32

**22.** A square surface of side $L$ meter in the plane of the paper is placed in a uniform electric field $E$ (volt/m) acting along the same plane at an angle θ with the horizontal side of the square as shown in Figure. The electric flux linked to the surface, in units of volt. $m$, is




(a) $EL^2$ (b) $EL^2\cos\theta$ (c) $EL^2\sin\theta$ (d) zero

**23.** Two point dipoles of dipole moment $\vec{p}_1$ and $\vec{p}_2$ are at a distance $x$ from each other and $\vec{p}_1 \parallel \vec{p}_2$. The force between the dipoles is :

(a) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{4p_1p_2}{x^4}$ (b) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{3p_1p_2}{x^3}$

(c) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{6p_1p_2}{x^4}$ (d) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{8p_1p_2}{x^4}$

| RESPONSE GRID | | | | | |
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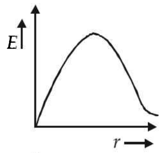
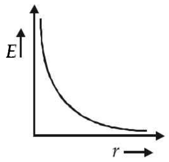
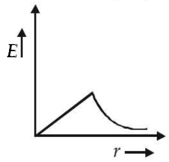
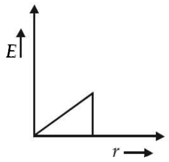
| | 15. ⓐⓑⓒⓓ | 16. ⓐⓑⓒⓓ | 17. ⓐⓑⓒⓓ | 18. ⓐⓑⓒⓓ | 19. ⓐⓑⓒⓓ |
| | 20. ⓐⓑⓒⓓ | 21. ⓐⓑⓒⓓ | 22. ⓐⓑⓒⓓ | 23. ⓐⓑⓒⓓ | |

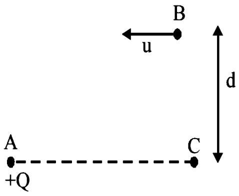
**24.** In a uniformly charged sphere of total charge $Q$ and radius $R$, the electric field $E$ is plotted as function of distance from the centre. The graph which would correspond to the above will be:

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

**25.** A particle of mass m and charge q is placed at rest in a uniform electric field E and then released. The kinetic energy attained by the particle after moving a distance $y$ is

(a) $qEy^2$ (b) $qE^2y$ (c) $qEy$ (d) $q^2Ey$

**26.** A positive charge +Q is fixed at a point A. Another positively charged particle of mass m and charge +q is projected from a point B with velocity u as shown in the figure. The point B is at the large distance from A and at distance d from the line AC. The initial velocity is parallel to the line AC. The point C is at very large distance from A. The minimum distance (in meter) of +q from +Q during the motion is $d(1+\sqrt{A})$. Find the value of A. [Take $Qq = 4\pi\varepsilon_0 mu^2 d$ and $d = (\sqrt{2}-1)$ meter.]

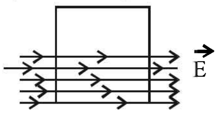



(a) 3 (b) 2 (c) 4 (d) 5

**27.** Which of the following is a wrong statement?

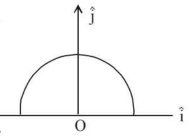
(a) The charge of an isolated system is conserved
(b) It is not possible to create or destroy charged particles
(c) It is possible to create or destroy charged particles
(d) It is not possible to create or destroy net charge

**28.** A square surface of side L metres is in the plane of the paper. A uniform electric field $\vec{E}$ (volt /m), also in the plane of the paper, is limited only to the lower half of the square surface (see figure). The electric flux in SI units associated with the surface is




(a) $EL^2/2$ (b) zero (c) $EL^2$ (d) $EL^2/(2\varepsilon_0)$

**29.** A thin semi-circular ring of radius r has a positive charge $q$ distributed uniformly over it. The net electric field $\vec{E}$ at the centre $O$ is




(a) $\dfrac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$ (b) $-\dfrac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$

(c) $-\dfrac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$ (d) $\dfrac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$

**30.** Two positive ions, each carrying a charge $q$, are separated by a distance $d$. If $F$ is the force of repulsion between the ions, the number of electrons missing from each ion will be ($e$ being the charge of an electron)

(a) $\dfrac{4\pi\varepsilon_0 Fd^2}{e^2}$ (b) $\sqrt{\dfrac{4\pi\varepsilon_0 Fe^2}{d^2}}$

(c) $\sqrt{\dfrac{4\pi\varepsilon_0 Fd^2}{e^2}}$ (d) $\dfrac{4\pi\varepsilon_0 Fd^2}{q^2}$

| RESPONSE GRID | |
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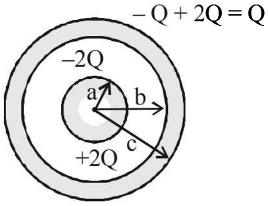
| | 29. ⓐⓑⓒⓓ 30. ⓐⓑⓒⓓ |

| DAILY PRACTICE PROBLEM DPP CHAPTERWISE CP15 - PHYSICS | | | |
|---|---|---|---|
| Total Questions | 30 | Total Marks | 120 |
| Attempted | | Correct | |
| Incorrect | | Net Score | |
| Cut-off Score | 45 | Qualifying Score | 60 |
| Success Gap = Net Score – Qualifying Score | | | |
| Net Score = (Correct × 4) – (Incorrect × 1) | | | |

1. **(a)** Surface charge density $(\sigma) = \dfrac{\text{Charge}}{\text{Surface area}}$

So $\sigma_{inner} = \dfrac{-2Q}{4\pi b^2}$

and $\sigma_{Outer} = \dfrac{Q}{4\pi c^2}$




2. **(a)** Electric field intensity at the centre of the disc.

$E = \dfrac{\sigma}{2\epsilon_0}$ (given)

Electric field along the axis at any distance x from the centre of the disc

$$E' = \frac{\sigma}{2\epsilon_0}\left(1 - \frac{x}{\sqrt{x^2 + R^2}}\right)$$

From question, x = R (radius of disc)

$$\therefore E' = \frac{\sigma}{2\epsilon_0}\left(1 - \frac{R}{\sqrt{R^2 + R^2}}\right)$$

$$= \frac{\sigma}{2\epsilon_0}\left(\frac{\sqrt{2}R - R}{\sqrt{2}R}\right)$$

$$= \frac{4}{14}E$$

$\therefore$ % reduction in the value of electric field

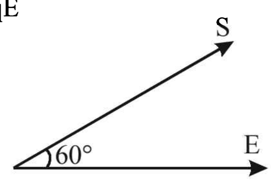
$$= \frac{\left(E - \frac{4}{14}E\right) \times 100}{E} = \frac{1000}{14}\% \simeq 70.7\%$$

3. **(d)** Since electric field $\vec{E}$ decreases inside water, therefore flux $\phi = \vec{E}.\vec{A}$ also decreases.

4. **(c)** When a dipole is placed in a uniform electric field, two equal and opposite forces act on it. Therefore, a torque acts which rotates the dipole.

5. **(a)** For the distances close to the charge at x = 0 the field is very high and is in positive direction of x-axis. As we move towards the other charge the net electric field becomes zero at x = a thereafter the influence of charge at x = 2a dominates and net field increases in negative direction of x-axis and grows unboundedly as we come closer and closer to the charge at x = 2a.

6. **(d)** Force acting on the charged particle due to electric field $= q\vec{E}$




work done in moving through distance S,

$W = q\vec{E}.\vec{S} = (qE) \times S \times \cos\theta$

$\therefore\ 10\,J = (0.5\,C) \times E \times 2\cos 60°$

$E = 10 \times 2 = 20\,NC^{-1} = 20\,Vm^{-1}$

7. **(b)** From figure, $\theta = \dfrac{\pi}{3} + \alpha$, where

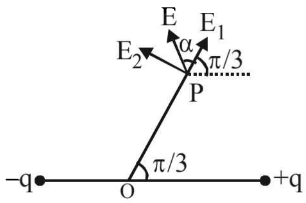
$$\tan\alpha = \frac{E_2}{E_1} = \left(\frac{p\sin\theta}{4\pi\epsilon_0 r^3}\right)\left(\frac{4\pi\epsilon_0 r^3}{2p\cos\theta}\right) = \frac{1}{2}\tan\theta$$

$$\tan\left(\theta - \frac{\pi}{3}\right) = \frac{1}{2}\tan\frac{\pi}{3} = \frac{\sqrt{3}}{2}$$

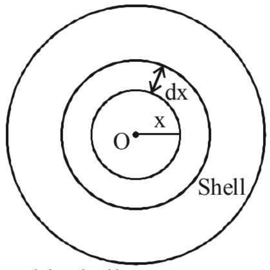
or $\theta - \dfrac{\pi}{3} = \tan^{-1}\left(\dfrac{\sqrt{3}}{2}\right)$

or $\alpha = \tan^{-1}\left(\dfrac{\sqrt{3}}{2}\right)$

or $\theta = \dfrac{\pi}{3} + \tan^{-1}\left(\dfrac{\sqrt{3}}{2}\right)$




8. **(b)** Let us consider a spherical shell of radius x and thickness dx.




Charge on this shell

$$dq = \rho.4\pi x^2 dx = \rho_0\left(1 - \frac{x}{R}\right).4\pi x^2 dx$$

$\therefore$ Total charge in the spherical region from centre to r (r < R) is

$$q = \int dq = 4\pi\rho_0 \int_0^r \left(1 - \frac{x}{R}\right)x^2 dx$$

$$= 4\pi\rho_0\left[\frac{x^3}{3} - \frac{x^4}{4R}\right]_0^r$$

$$= 4\pi\rho_0\left[\frac{r^3}{3} - \frac{r^4}{4R}\right]$$

$$= 4\pi\rho_0 r^3\left[\frac{1}{3} - \frac{r}{4R}\right]$$

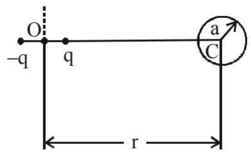
$\therefore$ Electric field at r, $E=\frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2}$

$$=\frac{1}{4\pi\varepsilon_0}.\frac{4\pi\rho_0 r^3}{r^2}\left[\frac{1}{3}-\frac{r}{4R}\right]$$

$$=\frac{\rho_0}{\varepsilon_0}\left[\frac{r}{3}-\frac{r^2}{4R}\right]$$

**9. (a)** The flux is zero according to Gauss' Law because it is a open surface which enclosed a charge q.

**10. (b)**



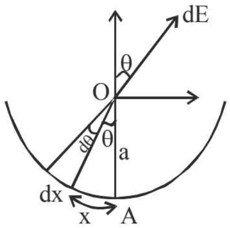

Electric field at C due to electric dipole

$$=\frac{1}{4\pi\varepsilon_0}\frac{2p}{r^3}\text{ along OC}$$

Electric field at C due to induced charge must be equal and opposite to electric field due to dipole as net field at C is zero.

**11. (a)** $\lambda$ = linear charge density;

Charge on elementary portion $dx=\lambda\,dx$.




Electric field at $O$, $dE=\frac{\lambda dx}{4\pi\varepsilon_0 a^2}$

Horizontal electric field, i.e., perpendicular to $AO$, will be cancelled.

Hence, net electric field = addition of all electrical fields in direction of $AO$

$=\Sigma dE\cos\theta$

$$\Rightarrow E=\int\frac{\lambda dx}{4\pi\varepsilon_0 a^2}\cos\theta$$

Also, $d\theta=\frac{dx}{a}$ or $dx=a\,d\theta$

$$E=\int_{-\pi/2}^{\pi/2}\frac{\lambda\cos\theta d\theta}{4\pi\varepsilon_0 a}=\frac{\lambda}{4\pi\varepsilon_0 a}[\sin\theta]_{-\pi/2}^{\pi/2}$$

$$=\frac{\lambda}{4\pi\varepsilon_0 a}[1-(-1)]=\frac{\lambda}{2\pi\varepsilon_0 a}$$

**12. (d)** Since $\phi_{\text{total}}=\phi_A+\phi_B+\phi_C=\frac{q}{\varepsilon_0}$,

where $q$ is the total charge.

As shown in the figure, flux associated with the curved surface B is $\phi=\phi_B$

Let us assume flux linked with the plane surfaces $A$ and $C$ be

$\phi_A=\phi_C=\phi'$

Therefore,

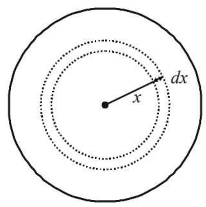
$$\frac{q}{\varepsilon_0}=2\phi'+\phi_B=2\phi'+\phi$$

$$\Rightarrow\phi'=\frac{1}{2}\left(\frac{q}{\varepsilon_0}-\phi\right)$$

**13. (d)** $E=\frac{p}{4\pi\varepsilon_0 .r^3}$

Apparently, $E\propto p$ and $E\propto\frac{1}{r^3}\propto r^{-3}$.

**14. (a)** Let us consider a spherical shell of radius $x$ and thickness $dx$. The volume of this shell is $4\pi x^2(dx)$. The charge enclosed in this spherical shell is




$$dq=(4\pi x^2)dx\times kx^a$$

$\therefore\quad dq=4\pi kx^{2+a}dx$.

**For $r=R$:**

The total charge enclosed in the sphere of radius $R$ is

$$Q=\int_0^R 4\pi k\,x^{2+a}\,dx=4\pi k\frac{R^{3+a}}{3+a}.$$

$\therefore$ The electric field at $r=R$ is

$$E_1=\frac{1}{4\pi\varepsilon_0}\frac{4\pi kR^{3+a}}{(3+a)R^2}=\frac{1}{4\pi\varepsilon_0}\frac{4\pi k}{3+a}R^{1+a}$$

**For $r=R/2$:**

The total charge enclosed in the sphere of radius $R/2$ is

$$Q'=\int_0^{R/2}4\pi k\,x^{2+a}dx=\frac{4\pi k(R/2)^{3+a}}{3+a}$$

$\therefore$ The electric field at $r=R/2$ is

$$E_2=\frac{1}{4\pi\varepsilon_0}\frac{4\pi k}{3+a}\frac{(R/2)^{3+a}}{(R/2)^2}=\frac{1}{4\pi\varepsilon_0}\frac{4\pi k}{3+a}\left(\frac{R}{2}\right)^{1+a}$$

Given, $E_2=\frac{1}{8}E_1$

$$\therefore\quad\frac{1}{4\pi\varepsilon_0}\frac{4\pi k}{(3+a)}\left(\frac{R}{2}\right)^{1+a}=\frac{1}{2^3}\times\frac{1}{4\pi\varepsilon_0}\frac{4\pi k}{3+a}R^{1+a}$$

$\Rightarrow\ 1+a=3\Rightarrow a=2$

**15. (a)** Since lines of force starts from A and ends at B, so A is +ve and B is –ve. Lines of forces are more crowded near A, so A > B.

**16. (c)** $T_0 = 2\pi\sqrt{\frac{L}{g}}$

When the plates are charged, the net acceleration is,

$g' = g + a$

$$g' = g + \frac{qE}{m} \qquad \left(a = \frac{qE}{m}\right)$$

$$\therefore \quad T = 2\pi\sqrt{\frac{L}{g + \frac{qE}{m}}}$$

$$\therefore \quad \frac{T}{T_0} = \left(\frac{g}{g + \frac{qE}{m}}\right)^{1/2}$$

**17. (d)** Electric displacement vector, $\vec{D} = \varepsilon\vec{E}$

As, $\varepsilon = \varepsilon_0 K \qquad \therefore \vec{D} = \varepsilon_0 K\vec{E}$

**18. (b)** Force on charge $q_1$ due to $q_2$ is

$$F_{12} = k\frac{q_1 q_2}{b^2}$$

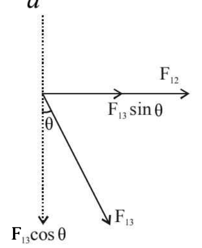
Force on charge $q_1$ due to $q_3$ is

$$F_{13} = k\frac{q_1 q_3}{a^2}$$

The $X$ - component of the force $(F_x)$ on $q_1$ *is* $F_{12} + F_{13}\sin\theta$

$$\therefore \quad F_x = k\frac{q_1 q_2}{b^2} + k\frac{q_1 q_2}{a^2}\sin\theta$$

$$\therefore \quad F_x \propto \frac{q_2}{b^2} + \frac{q_3}{a^2}\sin\theta$$




**19. (c)** Net downward force on the drop $= \frac{4}{3}\pi r^3(\rho - \rho_0)g$

For equilibrium, electric force must be upwards i.e. charge on the drop is positive.

$$neE = \frac{4}{3}\pi r^3(\rho - \rho_0)g \quad \text{i.e.} \quad n = \frac{4\pi r^3(\rho - \rho_0)g}{3eE}$$

**20. (a)** $\phi = \vec{E}.\vec{A} = 4\hat{i}.(2\hat{i} + 3\hat{j}) = 8$ V-m

**21. (b)** $F = \frac{1}{4\pi\varepsilon_0}\frac{(4q)(-4q)}{r^2}$

when C is touched with A, then charge on A & C each = 2q after that C is touched with B, charge on

$$B = \frac{2q + (-4q)}{2} = -q$$

Now, force $F' = \frac{1}{4\pi\varepsilon_0}\frac{(2q)(-q)}{r^2} \Rightarrow F' = \frac{F}{8}$

**22. (d)** Electric flux, $\phi = EA\cos\theta$,

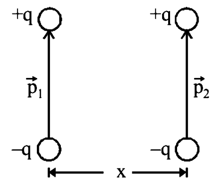
where $\theta$ = angle between $E$ and normal to the surface.

Here $\theta = \frac{\pi}{2}$

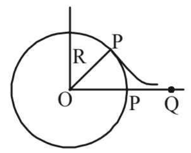
$\Rightarrow \quad \phi = 0$

**23. (c)** Force of interaction

$$F = \frac{1}{4\pi\epsilon_0}.\frac{6p_1p_2}{(x)^4}$$




**24. (c)** $\vec{E}$ inside the charged sphere




$\vec{E}_{in} = 0 \qquad \ldots$(i)

$\vec{E}$ on the surface of the charged sphere

$\vec{E}_s = \frac{1}{4\pi\epsilon_0}\frac{q}{R^2}$ i.e., $\vec{E}_s \propto \frac{1}{R^2}\hat{n} \quad \ldots$(ii)

$\vec{E}$ on any point away from the uniformly charged sphere is given

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{n}$$

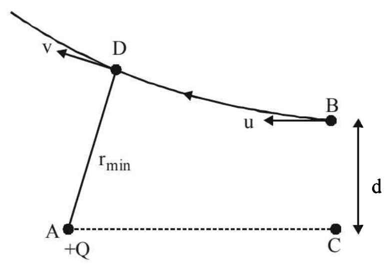
$\vec{E} \propto \frac{1}{r^2}\hat{n} \qquad \ldots$(iii)

$\because R$ is the radius of the sphere, which is constant, thus $\vec{E}$ is maximum and constant at the surface of the sphere. But decreases on moving away from the surface of the uniformally charged sphere.

**25. (c)** K.E. = Force × distance = qE.y

**26. (b)** The path of the particle will be as shown in figure. At the point of minimum distance (D) the velocity of the particle will be ⊥ to its position vector w.r.t. +Q.

$$\frac{1}{2}mu^2 + 0 = \frac{1}{2}mv^2 + \frac{kQq}{r_{min}} \qquad \ldots\ldots\ldots\ldots(1)$$



$\because$ Torque on q about Q is zero hence angular momentum about Q will be conserved.

$\Rightarrow mvr_{min} = mud$ ............ (2)

By eq. (2) in eq. (1)

$$\frac{1}{2}mu^2 = \frac{1}{2}m\left(\frac{ud}{r_{min}}\right)^2 + \frac{kQq}{r_{min}}$$

$$\Rightarrow \frac{1}{2}mu^2\left(1-\frac{d^2}{r_{min}^2}\right) = \frac{mu^2 d}{r_{min}} \qquad \{\because kQq = mu^2 d\}$$

$$\Rightarrow r_{min}^2 - 2r_{min}d - d^2 = 0$$

$$\Rightarrow r_{min} = \frac{2d \pm \sqrt{4d^2+4d^2}}{2} = d(1 \pm \sqrt{2})$$

$\because$ distance cannot be negative

$\therefore\ r_{min} = d(1+\sqrt{2})$

**27. (b)** It is possible to create or destroy charged particles but it is not possible to create or destroy net charge. The charge of an isolated system is conserved.

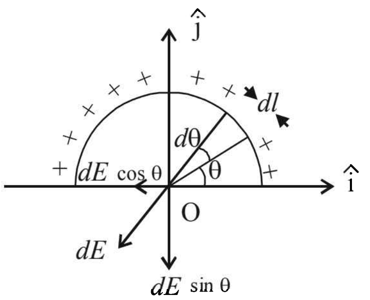
**28. (b)** Flux $= \vec{E}\,.\vec{A}$.

$\vec{E}$ is electric field vector & $\vec{A}$ is area vector.

Here, angle between $\vec{E}$ & $\vec{A}$ is 90°.

So, $\vec{E}\,.\vec{A} = 0$; Flux $= 0$

**29. (c)** Let us consider a differential element $dl$. charge on this element.




$$dq = \left(\frac{q}{\pi r}\right)dl$$

$$= \frac{q}{\pi r}(rd\theta) \qquad (\because dl = rd\theta)$$

$$= \left(\frac{q}{\pi}\right)d\theta$$

Electric field at O due to $dq$ is

$$dE = \frac{1}{4\pi\epsilon_0}\cdot\frac{dq}{r^2} = \frac{1}{4\pi\epsilon_0}\cdot\frac{q}{\pi r^2}d\theta$$

The component $dE\cos\theta$ will be counter balanced by another element on left portion. Hence resultant field at O is the resultant of the component $dE\sin\theta$ only.

$$\therefore\ E = \int dE\sin\theta = \int_0^{\pi}\frac{q}{4\pi^2 r^2\epsilon_0}\sin\theta d\theta$$

$$= \frac{q}{4\pi^2 r^2\epsilon_0}[-\cos\theta]_0^{\pi}$$

$$= \frac{q}{4\pi^2 r^2\epsilon_0}(+1+1) \qquad = \frac{q}{2\pi^2 r^2\epsilon_0}$$

The direction of $E$ is towards negative y-axis.

$$\therefore\ \vec{E} = -\frac{q}{2\pi^2 r^2\epsilon_0}\hat{j}$$

**30. (c)** Let $n$ be the number of electrons missing.

$$F = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q^2}{d^2}$$

$$\Rightarrow\ q = \sqrt{4\pi\varepsilon_0 d^2 F} = ne$$

$$\therefore\ n = \sqrt{\frac{4\pi\varepsilon_0 F d^2}{e^2}}$$