Electric Charges and Fields

1. A charge Q is placed at each of the opposite corners of a square. A charge q is placed at each of the other two corners. If the net electrical force on Q is zero, then $\frac{Q}{q}$ equals **[AIEEE-2009]**

(1) -1

(2) 1

(3) $-\frac{1}{\sqrt{2}}$

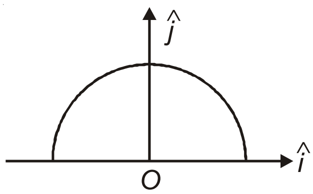
(4) $-2\sqrt{2}$

2. Let $\rho(r) = \frac{Q}{\pi R^4} r$ be the charge density distribution for a solid sphere of radius R and total charge Q. For a point 'p' inside the sphere at distance r_1 from the centre of the sphere, the magnitude of electric field is **[AIEEE-2009]**

(1) $\frac{Q}{4\pi\varepsilon_0 r_1^2}$ (2) $\frac{Q r_1^2}{4\pi\varepsilon_0 R^4}$

(3) $\frac{Q r_1^2}{3\pi\varepsilon_0 R^4}$ (4) 0

3. A thin semi-circular ring of radius r has a positive charge q distributed uniformly over it. The net field $\vec{E}$ at the centre O is **[AIEEE-2010]**



(1) $\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$ (2) $\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$

(3) $-\frac{q}{4\pi^2\varepsilon_0 r^2}\hat{j}$ (4) $-\frac{q}{2\pi^2\varepsilon_0 r^2}\hat{j}$

4. Let there be a spherically symmetric charge distribution with charge density varying as $\rho(r) = \rho_0\left(\frac{5}{4} - \frac{r}{R}\right)$ upto $r = R$, and $\rho(r) = 0$ for $r > R$, where r is the distance from the origin. The electric field at a distance $r(r < R)$ from the origin is given by **[AIEEE-2010]**

(1) $\frac{\rho_0 r}{3\varepsilon_0}\left(\frac{5}{4} - \frac{r}{R}\right)$ (2) $\frac{4\pi\rho_0 r}{3\varepsilon_0}\left(\frac{5}{3} - \frac{r}{R}\right)$

(3) $\frac{\rho_0 r}{4\varepsilon_0}\left(\frac{5}{3} - \frac{r}{R}\right)$ (4) $\frac{4\rho_0 r}{3\varepsilon_0}\left(\frac{5}{4} - \frac{r}{R}\right)$

5. Two identical charged spheres are suspended by strings of equal lengths. The strings make an angle of 30° with each other. When suspended in a liquid of density 0.8 g cm^{-3}, the angle remains the same. If density of the material of the sphere is 1.6 g cm^{-3}, the dielectric constant of the liquid is **[AIEEE-2010]**

(1) 1 (2) 4

(3) 3 (4) 2

6. Two positive charges of magnitude 'q' are placed at the ends of a side (side 1) of a square of side '$2a$'. Two negative charges of the same magnitude are kept at the other corners. Starting from rest, if a charge Q moves from the middle of side 1 to the centre of square, its kinetic energy at the centre of square is **[AIEEE-2011]**

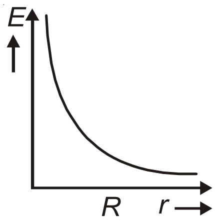
(1) $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1 - \frac{2}{\sqrt{5}}\right)$

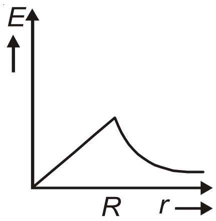
(2) $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1 - \frac{1}{\sqrt{5}}\right)$

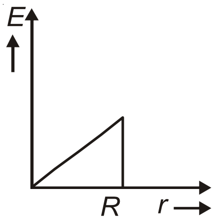
(3) Zero

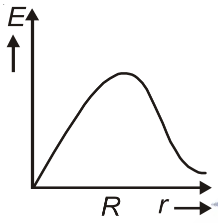
(4) $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1 + \frac{1}{\sqrt{5}}\right)$

7. In a uniformly charged sphere of total charge Q and radius R, the electric field E is plotted as a function of distance from the centre. The graph which would correspond to the above will be :
[AIEEE-2012]

(1) 

(2) 

(3) 

(4) 

8. Two charges, each equal to q, are kept at $x = -a$ and $x = a$ on the x-axis. A particle of mass m and charge $q_0 = \frac{q}{2}$ is placed at the origin. If charge q_0 is given a small displacement ($y << a$) along the y-axis, the net force acting on the particle is proportional to **[JEE (Main)-2013]**

(1) y

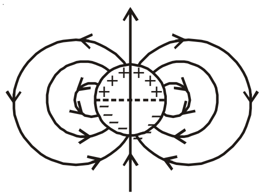
(2) $-y$

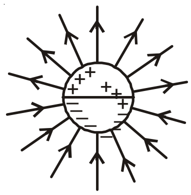
(3) $\frac{1}{y}$

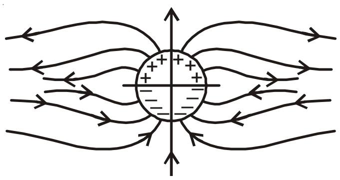
(4) $-\frac{1}{y}$

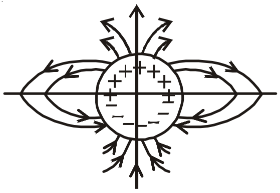
9. A long cylindrical shell carries positive surface charge σ in the upper half and negative surface charge $-\sigma$ in the lower half. The electric field lines around the cylinder will look like figure given in
[JEE (Main)-2015]

(figures are schematic and not drawn to scale)

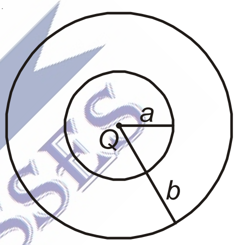
(1) 

(2) 

(3) 

(4) 

10. The region between two concentric spheres of radii 'a' and 'b', respectively (see figure), has volume charge density $\rho = \frac{A}{r}$, where A is a constant and r is the distance from the centre. At the centre of the spheres is a point charge Q. The value of A such that the electric field in the region between the spheres will be constant, is :
[JEE (Main)-2016]



(1) $\frac{Q}{2\pi(b^2 - a^2)}$ (2) $\frac{2Q}{\pi(a^2 - b^2)}$

(3) $\frac{2Q}{\pi a^2}$ (4) $\frac{Q}{2\pi a^2}$

11. An electric dipole has a fixed dipole moment $\vec{p}$, which makes angle θ with respect to x-axis. When subjected to an electric field $\vec{E}_1 = E\hat{i}$, it experiences a torque $\vec{T}_1 = \tau\hat{k}$. When subjected to another electric field $\vec{E}_2 = \sqrt{3}E_1\hat{j}$ it experiences a torque $\vec{T}_2 = -\vec{T}_1$. The angle θ is
[JEE (Main)-2017]

(1) 30° (2) 45°

(3) 60° (4) 90°

12. Three charges $+Q$, q, $+Q$ are placed respectively, at distance, 0, $d/2$ and d from the origin, on the x-axis. If the net force experienced by $+Q$, placed at $x = 0$, is zero then value of q is **[JEE (Main)-2019]**

(1) $\frac{+Q}{2}$ (2) $\frac{-Q}{2}$

(3) $\frac{-Q}{4}$ (4) $\frac{+Q}{4}$

13. For a uniformly charged ring of radius R, the electric field on its axis has the largest magnitude at a distance h from its centre. Then value of h is

[JEE (Main)-2019]

(1) $\frac{R}{\sqrt{2}}$ (2) $\frac{R}{\sqrt{5}}$

(3) R (4) $R\sqrt{2}$

14. Two point charges $q_1\left(\sqrt{10}\ \mu C\right)$ and $q_2(-25\ \mu C)$ are placed on the x-axis at $x = 1$ m and $x = 4$ m respectively. The electric field (in V/m) at a point $y = 3$ m on y-axis is, **[JEE (Main)-2019]**

$\left[\text{take } \frac{1}{4\pi\varepsilon_0} = 9\times10^9\ \text{Nm}^2\,\text{C}^{-2}\right]$

(1) $\left(63\hat{i} - 27\hat{j}\right)\times10^2$

(2) $\left(81\hat{i} - 81\hat{j}\right)\times10^2$

(3) $\left(-81\hat{i} + 81\hat{j}\right)\times10^2$

(4) $\left(-63\hat{i} + 27\hat{j}\right)\times10^2$

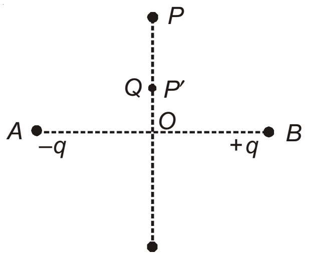
15. Charge is distributed within a sphere of radius R with volume charge density $\rho(r) = \frac{A}{r^2}e^{\frac{-2r}{a}}$, where A and a are constants. If Q is the total charge of this charge distribution, the radius R is

[JEE (Main)-2019]

(1) $\frac{a}{2}\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$ (2) $\frac{a}{2}\log\left(1-\frac{Q}{2\pi aA}\right)$

(3) $a\log\left(1-\frac{Q}{2\pi aA}\right)$ (4) $a\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$

16. Charges $-q$ and $+q$ located at A and B, respectively, constitute an electric dipole. Distance AB = $2a$, O is the mid point of the dipole and OP is perpendicular to AB. A charge Q is placed at P where $OP = y$ and $y >> 2a$. The charge Q experiences an electrostatic force F. If Q is now moved along the equatorial line to P' such that $OP' = \left(\frac{y}{3}\right)$, the force on Q will be close to $\left(\frac{y}{3} >> 2a\right)$ **[JEE (Main)-2019]**



(1) $\frac{F}{3}$ (2) $9F$

(3) $27F$ (4) $3F$

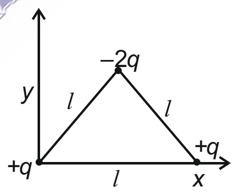
17. An electric field of 1000 V/m is applied to an electric dipole at angle of 45°. The value of electric dipole moment is 10^{-29} Cm. What is the potential energy of the electric dipole? **[JEE (Main)-2019]**

(1) -9×10^{-20} J (2) -10×10^{-29} J

(3) -7×10^{-27} J (4) -20×10^{-18} J

18. Determine the electric dipole moment of the system of three charges, placed on the vertices of an equilateral triangle, as shown in the figure

[JEE (Main)-2019]



(1) $2ql\,\hat{j}$ (2) $\sqrt{3}\,ql\,\frac{\hat{j}-\hat{i}}{\sqrt{2}}$

(3) $-\sqrt{3}\,ql\,\hat{j}$ (4) $(ql)\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

19. An electric dipole is formed by two equal and opposite charges q with separation d. The charges have same mass m. It is kept in a uniform electric field E. If it is slightly rotated from its equilibrium orientation, then its angular frequency ω is:

[JEE (Main)-2019]

(1) $\sqrt{\frac{2qE}{md}}$ (2) $2\sqrt{\frac{qE}{md}}$

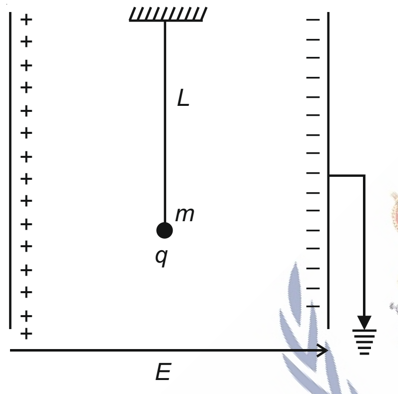
(3) $\sqrt{\frac{qE}{2md}}$ (4) $\sqrt{\frac{qE}{md}}$

20. For point charges $-q$, $+q$, $+q$ and $-q$ are placed on y-axis at $y = -2d$, $y = -d$, $y = +d$ and $y = +2d$, respectively. The magnitude of the electric field E at a point on the x-axis at $x = D$, with $D >> d$, will behave as **[JEE (Main)-2019]**

(1) $E \propto \frac{1}{D^3}$ (2) $E \propto \frac{1}{D}$

(3) $E \propto \frac{1}{D^4}$ (4) $E \propto \frac{1}{D^2}$

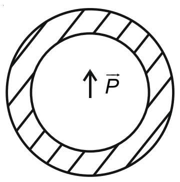
21. A simple pendulum of length L is placed between the plates of a parallel plate capacitor having electric field E, as shown in figure. Its bob has mass m and charge q. The time period of the pendulum is given by **[JEE (Main)-2019]**



(1) $2\pi\sqrt{\frac{L}{\left(g - \frac{qE}{m}\right)}}$ (2) $2\pi\sqrt{\frac{L}{\left(g + \frac{qE}{m}\right)}}$

(3) $2\pi\sqrt{\frac{L}{\sqrt{g^2 + \left(\frac{qE}{m}\right)^2}}}$ (4) $2\pi\sqrt{\frac{L}{\sqrt{g^2 - \frac{q^2E^2}{m^2}}}}$

22. Shown in the figure is a shell made of a conductor. It has inner radius a and outer radius b, and carries charge Q. At its centre is a dipole $\vec{P}$ as shown. In this case: **[JEE (Main)-2019]**



(1) Surface charge density on the outer surface depends on $|\vec{P}|$

(2) Surface charge density on the inner surface is uniform and equal to $\frac{(Q/2)}{4\pi a^2}$

(3) Electric field outside the shell is the same as that of point charge at the centre of the shell

(4) Surface charge density on the inner surface of the shell is zero everywhere

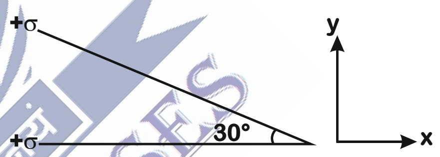
23. Let a total charge $2Q$ be distributed in a sphere of radius R, with the charge density given by $\rho(r) = kr$, where r is the distance from the centre. Two charges A and B, of $-Q$ each, are placed on diametrically opposite points, at equal distance, a, from the centre. If A and B do not experience any force, then: **[JEE (Main)-2019]**

(1) $a = \frac{3R}{2^{1/4}}$ (2) $a = R/\sqrt{3}$

(3) $a = 2^{-1/4}R$ (4) $a = 8^{-1/4}R$

24. Two infinite planes each with uniform surface charge density $+\sigma$ are kept in such a way that the angle between them is 30°. The electric field in the region shown between them is given by

[JEE (Main)-2020]



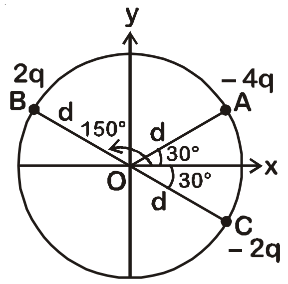
(1) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\sqrt{3}\right)\hat{y} + \frac{\hat{x}}{2}\right]$

(2) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\sqrt{3}\right)\hat{y} - \frac{\hat{x}}{2}\right]$

(3) $\frac{\sigma}{2\varepsilon_0}\left[\left(1-\frac{\sqrt{3}}{2}\right)\hat{y} - \frac{\hat{x}}{2}\right]$

(4) $\frac{\sigma}{\varepsilon_0}\left[\left(1+\frac{\sqrt{3}}{2}\right)\hat{y} + \frac{\hat{x}}{2}\right]$

25. Three charged particles A, B and C with charges $-4q$, $2q$ and $-2q$ are present on the circumference of a circle of radius d. The charged particles A, C and centre O of the circle formed an equilateral triangle as shown in figure. Electric field at O along x-direction is **[JEE (Main)-2020]**



(1) $\frac{\sqrt{3}q}{\pi\varepsilon_0 d^2}$ (2) $\frac{3\sqrt{3}q}{4\pi\varepsilon_0 d^2}$

(3) $\frac{\sqrt{3}q}{4\pi\varepsilon_0 d^2}$ (4) $\frac{2\sqrt{3}q}{\pi\varepsilon_0 d^2}$

26. In finding the electric field using Gauss law the formula $|\vec{E}| = \frac{q_{enc}}{\varepsilon_0 |A|}$ is applicable. In the formula ε_0 is permittivity of free space, A is the area of Gaussian surface and q_{enc} is charge enclosed by the Gaussian surface. This equation can be used in which of the following situation?

[JEE (Main)-2020]

(1) Only when the Gaussian surface is an equipotential surface and $|\vec{E}|$ is constant on the surface.

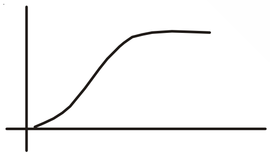
(2) Only when $|\vec{E}|$ = constant on the surface.

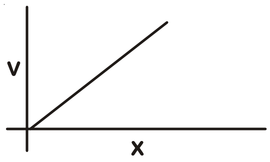
(3) Only when the Gaussian surface is an equipotential surface.

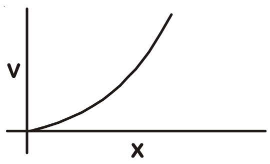
(4) For any choice of Gaussian surface.

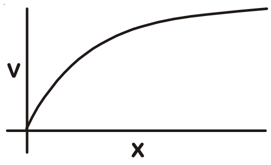
27. A particle of mass m and charge q is released from rest in a uniform electric field. If there is no other force on the particle, the dependence of its speed v on the distance x travelled by it is correctly given by (graphs are schematic and not drawn to scale)

[JEE (Main)-2020]

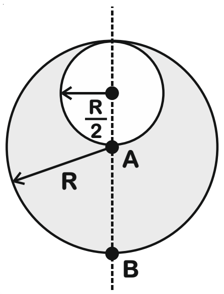
(1) 

(2) 

(3) 

(4) 

28. Consider a sphere of radius R which carries a uniform charge density ρ. If a sphere of radius $\frac{R}{2}$ is carved out of it, as shown, the ratio $\frac{|\vec{E}_A|}{|\vec{E}_B|}$ of magnitude of electric field $\vec{E}_A$ and $\vec{E}_B$, respectively, at points A and B due to the remaining portion is **[JEE (Main)-2020]**



(1) $\frac{18}{34}$ (2) $\frac{18}{54}$

(3) $\frac{21}{34}$ (4) $\frac{17}{54}$

29. An electric dipole of moment $\vec{p} - = (-\hat{i} - 3\hat{j} + 2\hat{k}) \times 10^{-29}$ C.m is at the origin (0, 0, 0). The electric field due to this dipole at $\vec{r} = +\hat{i} + 3\hat{j} + 5\hat{k}$ **[JEE (Main)-2020]**

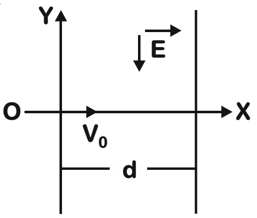
(note that $\vec{r} \cdot \vec{p} = 0$) is paralled to

(1) $(-\hat{i} - 3\hat{j} + 2\hat{k})$ (2) $(+\hat{i} - 3\hat{j} - 2\hat{k})$

(3) $(-\hat{i} + 3\hat{j} - 2\hat{k})$ (4) $(+\hat{i} + 3\hat{j} - 2\hat{k})$

30. A charged particle (mass m and charge q) moves along X-axis with velocity V_0. When it passes through the origin it enters a region having uniform electric field $\vec{E} = -E\hat{j}$ which extends upto $x = d$. Equation of path of electron in the region $x > d$ is

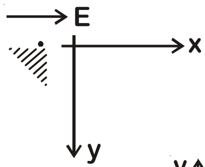
[JEE (Main)-2020]

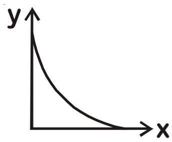


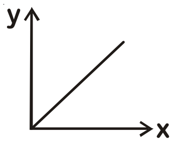
(1) $y = \frac{qEd}{mV_0^2}(x - d)$ (2) $y = \frac{qEd^2}{mV_0^2}x$

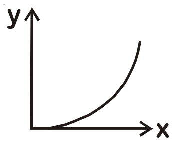
(3) $y = \frac{qEd}{mV_0^2}\left(\frac{d}{2} - x\right)$ (4) $y = \frac{qEd}{mV_0^2}x$

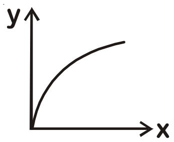
31. A small point mass carrying some positive charge on it, is released from the edge of a table. There is a uniform electric field in this region in the horizontal direction. Which of the following options then correctly describe the trajectory of the mass? (Curves are drawn schematically and are not to scale). **[JEE (Main)-2020]**



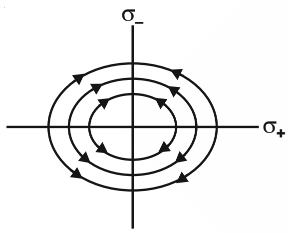
(1) 

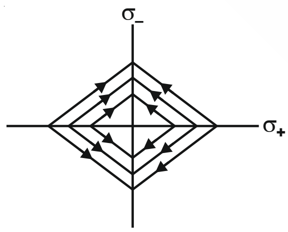
(2) 

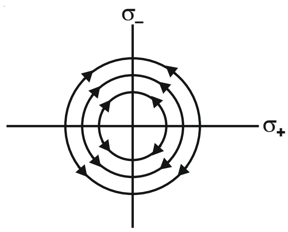
(3) 

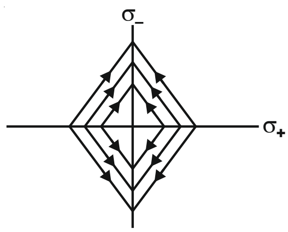
(4) 

32. Two charged thin infinite plane sheets of uniform surface charge density σ_+ and σ_-, where $|\sigma_+| > |\sigma_-|$, intersect at right angle. Which of the following best represents the electric field lines for this system? **[JEE (Main)-2020]**

(1) 

(2) 

(3) 

(4) 

33. A particle of charge q and mass m is subjected to an electric field $E = E_0(1 - ax^2)$ in the x-direction, where a and E_0 are constants. Initially the particle was at rest at $x = 0$. Other than the initial position the kinetic energy of the particle becomes zero when the distance of the particle from the origin is

[JEE (Main)-2020]

(1) $\sqrt{\frac{3}{a}}$ (2) $\sqrt{\frac{2}{a}}$

(3) $\sqrt{\frac{1}{a}}$ (4) a

34. Ten charges are placed on the circumference of a circle of radius R with constant angular separation between successive charges. Alternate charges 1, 3, 5, 7, 9 have charge $(+q)$ each, while 2, 4, 6, 8, 10 have charge $(-q)$ each. The potential V and the electric field E at the centre of the circle are respectively. **[JEE (Main)-2020]**

(Take $V = 0$ at infinity)

(1) $V = 0$; $E = 0$

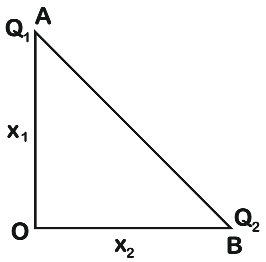
(2) $V = \dfrac{10q}{4\pi\varepsilon_0 R}$; $E = \dfrac{10q}{4\pi\varepsilon_0 R^2}$

(3) $V = \dfrac{10q}{4\pi\varepsilon_0 R}$; $E = 0$

(4) $V = 0$; $E = \dfrac{10q}{4\pi\varepsilon_0 R^2}$

35. Charges Q_1 and Q_2 are at points A and B of a right angle triangle OAB (see figure). The resultant electric field at point O is perpendicular to the hypotenuse, then Q_1/Q_2 is proportional to

[JEE (Main)-2020]



(1) $\dfrac{x_1^3}{x_2^3}$ (2) $\dfrac{x_2^2}{x_1^2}$

(3) $\dfrac{x_1}{x_2}$ (4) $\dfrac{x_2}{x_1}$

36. Two identical electric point dipoles have dipole moments $\overrightarrow{p_1} = p\hat{i}$ and $\overrightarrow{p_2} = -p\hat{i}$ and are held on the x axis at distance 'a' from each other. When released, they move along the x-axis with the direction of their dipole moments remaining unchanged. If the mass of each dipole is 'm', their speed when they are infinitely far apart is

[JEE (Main)-2020]

(1) $\frac{p}{a}\sqrt{\frac{1}{2\pi\varepsilon_0 ma}}$ (2) $\frac{p}{a}\sqrt{\frac{2}{\pi\varepsilon_0 ma}}$

(3) $\frac{p}{a}\sqrt{\frac{1}{\pi\varepsilon_0 ma}}$ (4) $\frac{p}{a}\sqrt{\frac{3}{2\pi\varepsilon_0 ma}}$

37. Consider the force F on a charge 'q' due to a uniformly charged spherical shell of radius R carrying charge Q distributed uniformly over it. Which one of the following statements is true for F, if 'q' is placed at distance r from the centre of the shell ? **[JEE (Main)-2020]**

(1) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ for all r

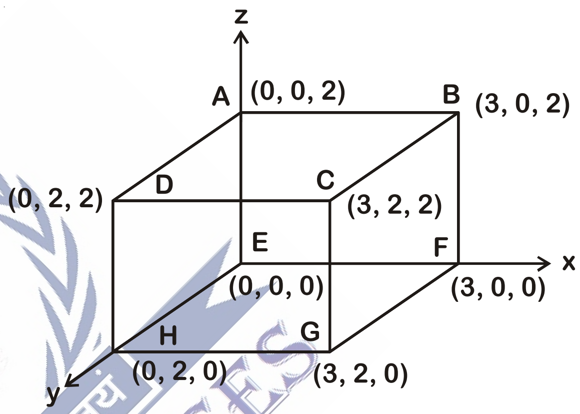
(2) $\frac{1}{4\pi\varepsilon_0}\frac{qQ}{R^2} > F > 0$ for $r < R$

(3) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ for $r > R$

(4) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{R^2}$ for $r < R$

38. An electric field $\vec{E} = 4x\hat{i} - (y^2 + 1)\hat{j}$ N/C passes through the box shown in figure. The flux of the electric field through surfaces $ABCD$ and $BCGF$ are marked as ϕ_I and ϕ_{II} respectively. The difference between $(\phi_I - \phi_{II})$ is (in Nm^2/C) ______.

[JEE (Main)-2020]



❑ ❑ ❑