Chapter 14

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

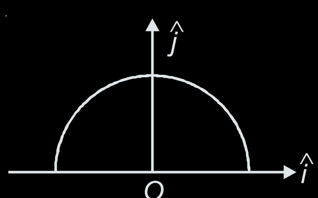
(4) $-2\sqrt{2}$

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 r(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]**

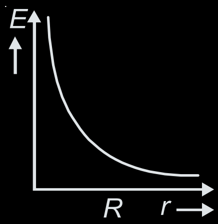
(1) $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1 - \frac{2}{\sqrt{5}}\right)$

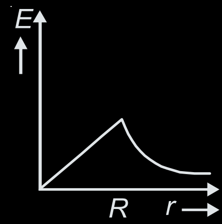
(2) $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1 - \frac{1}{\sqrt{5}}\right)$

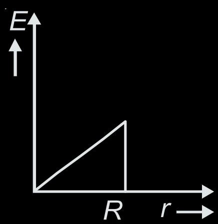
(3) Zero

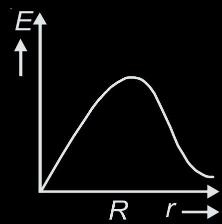
(4) $\frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left(1 + \frac{1}{\sqrt{5}}\right)$

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

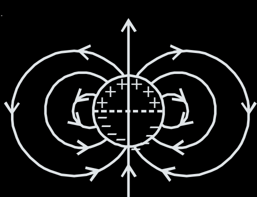
(2) $-y$

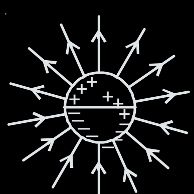
(3) $\frac{1}{y}$

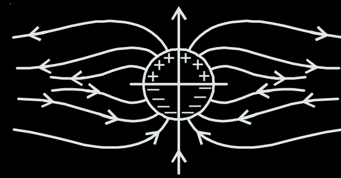
(4) $-\frac{1}{y}$

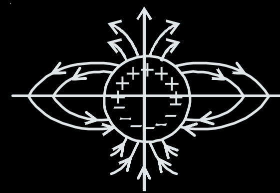
9. A long cylindrical shell carries positive surface charge s in the upper half and negative surface charge –s in the lower half. The electric field lines around the cylinder will look like figure given in **[JEE (Main)-2015]**

(figures are schematic and not drawn to scale)

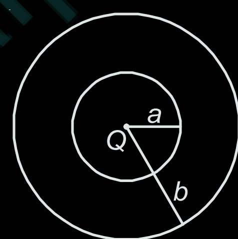
(1) 

(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 q 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 q 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 $q_1(\sqrt{10}\ \mu C)$ and $q_2(-25\text{ mC})$ 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) $(63\hat{i} - 27\hat{j})\times10^2$

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

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

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

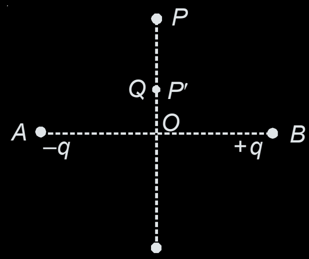
15. Charge is distributed within a sphere of radius R with volume charge density $\rho(r) = \frac{A}{r^2}e^{\frac{-2r}{a}}$, where A and a are constants. If Q is the total charge of this charge distribution, the radius R is

[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) $3F$

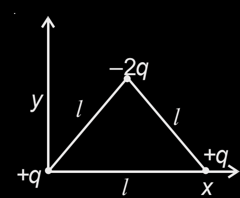
17. An electric field of 1000 V/m is applied to an electric dipole at angle of 45°. The value of electric dipole moment is 10^{-29} Cm. What is the potential energy of the electric dipole? **[JEE (Main)-2019]**

(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 w is:

[JEE (Main)-2019]

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

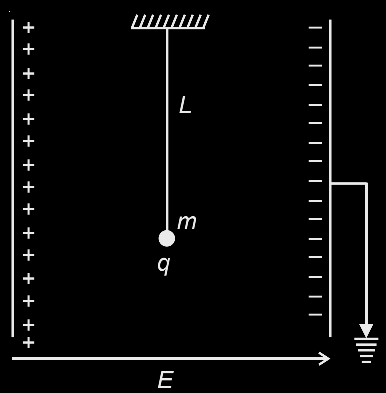
(3) $\sqrt{\frac{qE}{2md}}$ (4) $\sqrt{\frac{qE}{md}}$

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

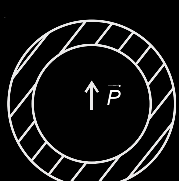
21. A simple pendulum of length L is placed between the plates of a parallel plate capacitor having electric field E, as shown in figure. Its bob has mass m and charge q. The time period of the pendulum is given by **[JEE (Main)-2019]**



(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

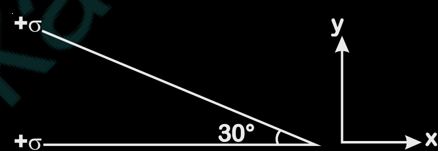
23. Let a total charge 2 Q be distributed in a sphere of radius R, with the charge density given by r(r) = kr, where r is the distance from the centre. Two charges A and B, of $-Q$ each, are placed on diametrically opposite points, at equal distance, a, from the centre. If A and B do not experience any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



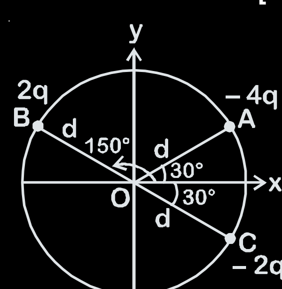
(1) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\sqrt{3}\right)\hat{y}+\frac{\hat{x}}{2}\right]$

(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 e_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.

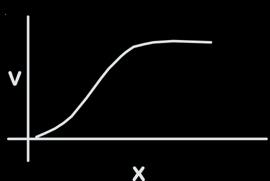
(2) Only when $|\vec{E}|$ = constant on the surface.

(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)


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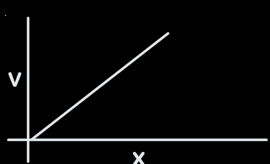

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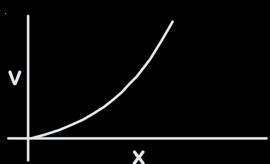

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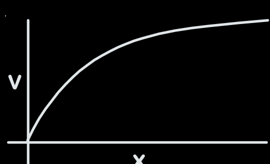
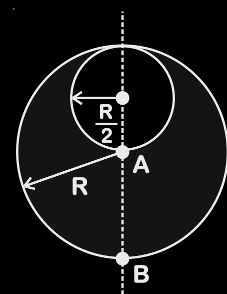


28. Consider a sphere of radius R which carries a uniform charge density r. If a sphere of radius $\frac{R}{2}$ is carved out of it, as shown, the ratio $\frac{|\vec{E}_A|}{|\vec{E}_B|}$ of magnitude of electric field $\vec{E}_A$ and $\vec{E}_B$, respectively, at points A and B due to the remaining portion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

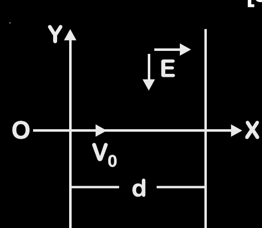
(note that $\vec{r}.\vec{p} = 0$) is paralled to

(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

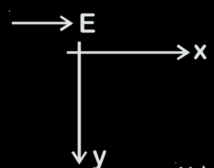
[JEE (Main)-2020]

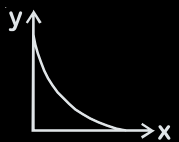


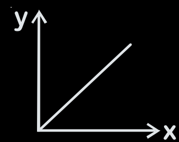
(1) $y = \frac{qEd}{mV_0^2}(x - d)$ (2) $y = \frac{qEd^2}{mV_0^2}x$

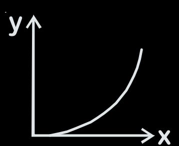
(3) $y = \frac{qEd}{mV_0^2}\left(\frac{d}{2} - x\right)$ (4) $y = \frac{qEd}{mV_0^2}x$

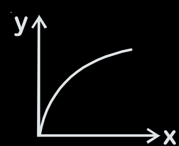
31. A small point mass carrying some positive charge on it, is released from the edge of a table. There is a uniform electric field in this region in the horizontal direction. Which of the following options then correctly describe the trajectory of the mass? (Curves are drawn schematically and are not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



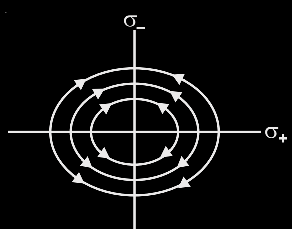
(1) 

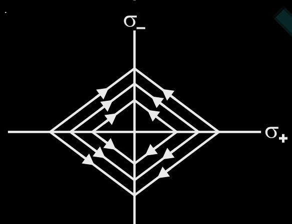
(2) 

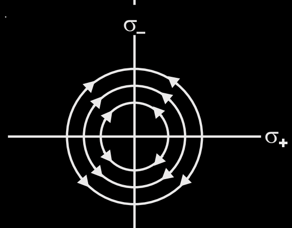
(3) 

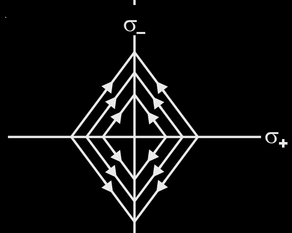
(4) 

32. Two charged thin infinite plane sheets of uniform surface charge density s+ and s_, where |s+| > |s_|, 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) $V = 0$; $E = 0$

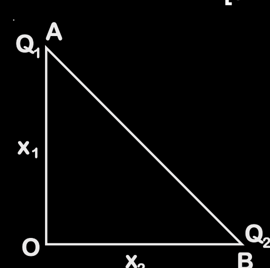
(2) $V = \dfrac{10q}{4\pi\varepsilon_0 R}$; $E = \dfrac{10q}{4\pi\varepsilon_0 R^2}$

(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

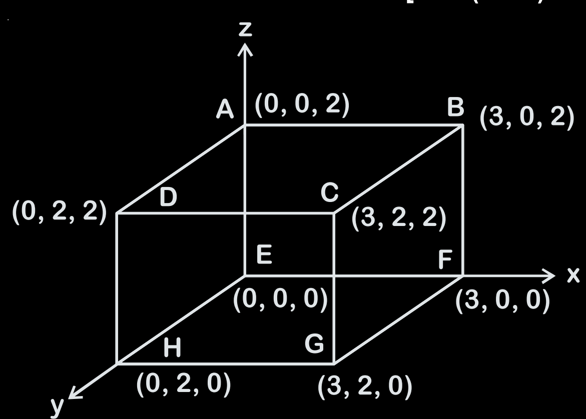
(2) $\frac{1}{4\pi\varepsilon_0}\frac{qQ}{R^2} > F > 0$ for $r < R$

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

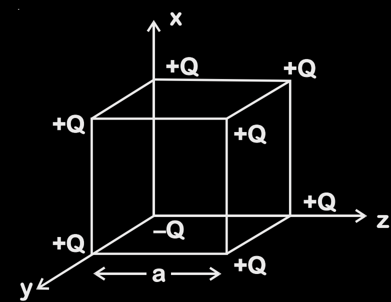
(4) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{R^2}$ for $r < R$

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 f_I and f_{II} respectively. The difference between $(f_I - f_{II})$ is (in Nm^2/C) ______.

[JEE (Main)-2020]



39. A cube of side 'a' has point charges +Q located at each of its vertices except at the origin where the charge is –Q. The electric field at the centre of cube is : **[JEE (Main)-2021]**



(1) $\frac{-Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(2) $\frac{Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(3) $\frac{2Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

(4) $\frac{-2Q}{3\sqrt{3}\pi\varepsilon_0 a^2}(\hat{x}+\hat{y}+\hat{z})$

40. Two electrons each are fixed at a distance '2d'. A third charge proton placed at the midpoint is displaced slightly by a distance x(x << d) perpendicular to the line joining the two fixed charges. Proton will execute simple harmonic motion having angular frequency: (m = mass of charged particle) **[JEE (Main)-2021]**

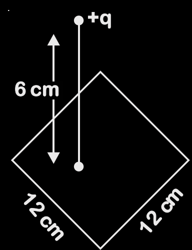
(1) $\left(\frac{q^2}{2\pi\varepsilon_0 md^3}\right)^{\frac{1}{2}}$

(2) $\left(\frac{2\pi\varepsilon_0 md^3}{q^2}\right)^{\frac{1}{2}}$

(3) $\left(\frac{2q^2}{\pi\varepsilon_0 md^3}\right)^{\frac{1}{2}}$

(4) $\left(\frac{\pi\varepsilon_0 md^3}{2q^2}\right)^{\frac{1}{2}}$

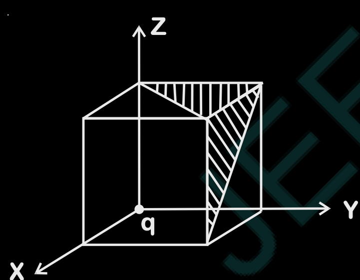
41. A point charge of + 12mC is at a distance 6 cm vertically above the centre of a square of side 12 cm as shown in figure. The magnitude of the electric flux through the square will be _______ $\times 10^3$ Nm^2/C. **[JEE (Main)-2021]**



42. The electric field in a region is given by $\vec{E} = \left(\frac{3}{5}E_0\hat{i} + \frac{4}{5}E_0\hat{j}\right)\frac{N}{C}$. The ratio of flux of reported field through the rectangular surface of area 0.2 m^2 (parallel to y – z plane) to that of the surface of area 0.3 m^2 (parallel to x – z plane) is a : b, where a = _________.

[Here, $\hat{i}$, $\hat{j}$ and $\hat{k}$ are unit vectors along x, y and z-axes respectively] **[JEE (Main)-2021]**

43. A charge 'q' is placed at one corner of a cube as shown in figure. The flux of electrostatic field $\vec{E}$ through the shaded area is: **[JEE (Main)-2021]**



(1) $\frac{q}{4\varepsilon_0}$ (2) $\frac{q}{24\varepsilon_0}$

(3) $\frac{q}{48\varepsilon_0}$ (4) $\frac{q}{8\varepsilon_0}$

44. Two identical conducting spheres with negligible volume have 2.1 nC and –0.1 nC charges, respectively. They are brought into contact and then separated by a distance of 0.5 m. The electrostatic force acting between the spheres is _________ $\times 10^{-9}$ N.

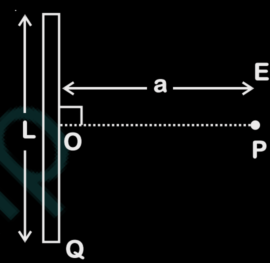
[Given : $4\pi\varepsilon_0 = \frac{1}{9\times10^9}$ SI unit]

[JEE (Main)-2021]

45. Two small spheres each of mass 10 mg are suspended from a point by threads 0.5 m long. They are equally charged and repel each other to a distance of 0.20 m. The charge on each of the sphere is $\frac{a}{21}\times10^{-8}$ C. The value of 'a' will be.

[Given g = 10 ms^{-2}] **[JEE (Main)-2021]**

46. Find the electric field at point P (as shown in figure) on the perpendicular bisector of a uniformly charged thin wire of length L carrying a charge Q. The distance of the point P from the centre of the rod is $a = \frac{\sqrt{3}}{2}L$. **[JEE (Main)-2021]**



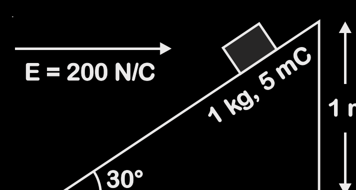
(1) $\frac{Q}{3\pi\varepsilon_0 L^2}$ (2) $\frac{Q}{4\pi\varepsilon_0 L^2}$

(3) $\frac{\sqrt{3}\,Q}{4\pi\varepsilon_0 L^2}$ (4) $\frac{Q}{2\sqrt{3}\,\pi\varepsilon_0 L^2}$

47. An inclined plane making an angle of 30° with the horizontal is placed in a uniform horizontal electric field $200\,\frac{N}{C}$ as shown in the figure. A body of mass 1 kg and charge 5 mC is allowed to slide down from rest at a height of 1 m. If the coefficient of friction is 0.2, find the time taken by the body to reach the bottom.

$$\left[g = 9.8\text{ m/s}^2;\ \sin 30^\circ = \frac{1}{2};\ \cos 30^\circ = \frac{\sqrt{3}}{2}\right]$$

[JEE (Main)-2021]



(1) 2.3 s (2) 1.3 s

(3) 0.92 s (4) 0.46 s

48. Given below are two statements :

Statement I : An electric dipole is placed at the centre of a hollow sphere. The flux of electric field through the sphere is zero but the electric field is not zero anywhere in the sphere.

Statement II : If R is the radius of a solid metallic sphere and Q be the total charge on it. The electric field at any point on the spherical surface of radius r (< R) is zero but the electric flux passing through this closed spherical surface of radius r is not zero.

In the light of the above statements, choose the correct answer from the options given below.

[JEE (Main)-2021]

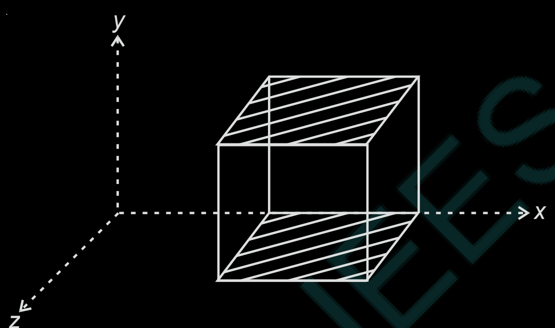
(1) Statement I is false but Statement II is true

(2) Both Statement I and Statement II are false

(3) Statement I is true but Statement II is false

(4) Both Statement I and Statement II are true

49. A cube is placed inside an electric field, $\vec{E} = 150y^2\hat{j}$. The side of the cube is 0.5 m and is placed in the field as shown in the given figure. The charge inside the cube is: **[JEE (Main)-2021]**



(1) 8.3×10^{-11} C (2) 3.8×10^{-11} C

(3) 8.3×10^{-12} C (4) 3.8×10^{-12} C

50. The electric field in a region is given by $\vec{E} = \frac{2}{5}E_0\hat{i} + \frac{3}{5}E_0\hat{j}$ with $E_0 = 4.0 \times 10^3 \frac{N}{C}$. The flux of this field through a rectangular surface area 0.4 m^2 parallel to the Y – Z plane is ________ Nm^2 C^{-1}.

[JEE (Main)-2021]

51. An oil drop of radius 2 mm with a density 3 g cm^{-3} is held stationary under a constant electric field 3.55×10^5 V m^{-1} in the Millikan's oil drop experiment. What is the number of excess electrons that the oil drop will process?

Consider g = 9.81 m/s^2 **[JEE (Main)-2021]**

(1) 1.73×10^{12} (2) 1.73×10^{10}

(3) 48.8×10^{11} (4) 17.3×10^{10}

52. An infinite number of point charges, each carrying 1 mC charge, are placed along the y-axis at y = 1 m, 2 m, 4 m, 8 m _______.

The total force on a 1 C point charge, placed at the origin, is x × 10^3 N.

The value of x, to the nearest integer, is ______.

[Take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ Nm^2/C^2]

[JEE (Main)-2021]

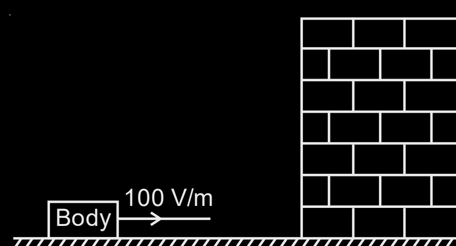
53. A certain charge Q is divided into two parts q and $(Q - q)$. How should the charges Q and q be divided so that q and $(Q - q)$ placed at a certain distance apart experience maximum electrostatic repulsion? **[JEE (Main)-2021]**

(1) $Q = 4q$ (2) $Q = \frac{q}{2}$

(3) $Q = 3q$ (4) $Q = 2q$

54. A body having specific charge 8 mC/g is resting on a frictionless plane at a distance 10 cm from the wall (as shown in the figure). It starts moving towards the wall when a uniform electric field of 100 V/m is applied horizontally towards the wall. If the collision of the body with the wall is perfectly elastic, then the time period of the motion will be ______ s.

[JEE (Main)-2021]



55. An electric dipole is placed on x-axis in proximity to a line charge of linear charge density 3.0×10^{-6} C/m. Line charge is placed on z-axis and positive and negative charge of dipole is at a distance of 10 mm and 12 mm from the origin respectively. If total force of 4 N is exerted on the dipole, find out the amount of positive or negative charge of the dipole. **[JEE (Main)-2021]**

(1) 0.485 mC

(2) 815.1 nC

(3) 8.8 mC

(4) 4.44 mC

56. The total charge enclosed in an incremental volume of 2×10^{-9} m^3 located at the origin is _____ nC, if electric flux density of its field is found as

$$D = e^{-x} \sin y\, \hat{i} - e^{-x} \cos y\, \hat{j} + 2z\, \hat{k}\ \text{C/m}^2$$

[JEE (Main)-2021]

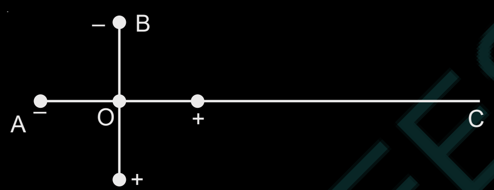
57. A particle of mass 1 mg and charge q is lying at the mid-point of two stationary particles kept at a distance '2 m' when each is carrying same charge 'q'. If the free charged particle is displaced from its equilibrium position through distance 'x' (x << 1 m). The particle executes SHM. Its angular frequency of oscillation will be _____ $\times 10^5$ rad/s if $q^2 = 10$ C^2.

[JEE (Main)-2021]

58. Two ideal electric dipoles A and B, having their dipole moment p_1 and p_2 respectively are placed on a plane with their centres at O as shown in the figure. At point C on the axis of dipole A, the resultant electric field is making an angle of 37° with the axis.

The ratio of the dipole moment of A and B, $\frac{p_1}{p_2}$ is:

(take $\sin 37° = \frac{3}{5}$) **[JEE (Main)-2021]**



(1) $\frac{2}{3}$ (2) $\frac{4}{3}$

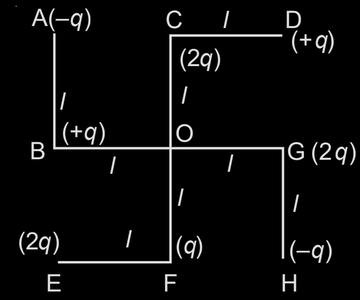
(3) $\frac{3}{2}$ (4) $\frac{3}{8}$

59. Two identical tennis balls each having mass 'm' and charge 'q' are suspended from a fixed point by threads of length 'l'. What is the equilibrium separation when each thread makes a small angle 'q' with the vertical? **[JEE (Main)-2021]**

(1) $x = \left(\dfrac{q^2 l^2}{2\pi\varepsilon_0 m^2 g}\right)^{1/3}$ (2) $x = \left(\dfrac{q^2 l^2}{2\pi\varepsilon_0 m^2 g^2}\right)^{1/3}$

(3) $x = \left(\dfrac{q^2 l}{2\pi\varepsilon_0 mg}\right)^{1/2}$ (4) $x = \left(\dfrac{q^2 l}{2\pi\varepsilon_0 mg}\right)^{1/3}$

60. What will be the magnitude of electric field at point O as shown in figure? Each side of the figure is l and perpendicular to each other?



[JEE (Main)-2021]

(1) $\dfrac{q}{4\pi\varepsilon_0 (2l)^2}$ (2) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{2q}{2l^2}(\sqrt{2})$

(3) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{l^2}$ (4) $\dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{(2l^2)}(2\sqrt{2}-1)$

61. A uniformly charged disc of radius R having surface charge density s is placed in the xy plane with its center at the origin. Find the electric field intensity along the z-axis at a distance Z from origin:

[JEE (Main)-2021]

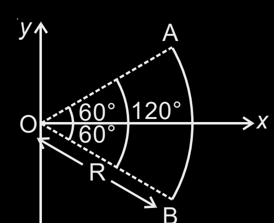
(1) $E = \dfrac{\sigma}{2\varepsilon_0}\left(1 - \dfrac{Z}{(Z^2+R^2)^{1/2}}\right)$

(2) $E = \dfrac{2\varepsilon_0}{\sigma}\left(\dfrac{1}{(Z^2+R^2)^{1/2}} + Z\right)$

(3) $E = \dfrac{\sigma}{2\varepsilon_0}\left(\dfrac{1}{(Z^2+R^2)} + \dfrac{1}{Z^2}\right)$

(4) $E = \dfrac{\sigma}{2\varepsilon_0}\left(1 + \dfrac{Z}{(Z^2+R^2)^{1/2}}\right)$

62. Figure shows a rod AB, which is bent in a 120° circular arc of radius R. A charge (–Q) is uniformly distributed over rod AB. What is the electric field $\vec{E}$ at the centre of curvature O? **[JEE (Main)-2021]**



(1) $\dfrac{3\sqrt{3}\,Q}{8\pi^2\varepsilon_0 R^2}(\hat{i})$ (2) $\dfrac{3\sqrt{3}\,Q}{8\pi^2\varepsilon_0 R^2}(-\hat{i})$

(3) $\dfrac{3\sqrt{3}\,Q}{8\pi\varepsilon_0 R^2}(\hat{i})$ (4) $\dfrac{3\sqrt{3}\,Q}{16\pi^2\varepsilon_0 R^2}(\hat{i})$

63. Two particles A and B having charges 20 mC and –5 mC respectively are held fixed with a separation of 5 cm. At what position a third charged particle should be placed so that it does not experience a net electric force?

[JEE (Main)-2021]

(1) At 5 cm from –5 mC on the right side

(2) At 1.25 cm from a –5 mC between two charges

(3) At 5 cm from 20 mC on the left side of system

(4) At midpoint between two charges

64. Choose the **incorrect** statement**[JEE (Main)-2021]**

(a) The electric lines of force entering into a Gaussian surface provide negative flux.

(b) A charge ‘q’ is placed at the centre of a cube. The flux through all the faces will be the same.

(c) In a uniform electric field net flux through a closed Gaussian surface containing no net charge, is zero.

(d) When electric field is parallel to a Gaussian surface, it provides a finite non-zero flux.

Choose the **most appropriate** answer from the options given below

(1) (d) only

(2) (c) and (d) only

(3) (a) and (c) only

(4) (b) and (d) only

65. A vertical electric field of magnitude 4.9×10^5 N/C just prevents a water droplet of a mass 0.1 g from falling. The value charge on the droplet will be

(Given $g = 9.8$ m/s^2) **[JEE (Main)-2022]**

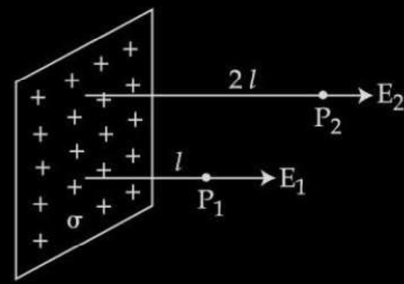
(1) 1.6×10^{-9} C

(2) 2.0×10^{-9} C

(3) 3.2×10^{-9} C

(4) 0.5×10^{-9} C

66. In the figure, a very large plane sheet of positive charge is shown. P_1 and P_2 are two points at distance l and $2l$ from the charge distribution. If σ is the surface charge density, then the magnitude of electric fields E_1 and E_2 and P_1 and P_2 respectively are



[JEE (Main)-2022]

(1) $E_1 = \frac{\sigma}{\varepsilon_0}, E_2 = \frac{\sigma}{2\varepsilon_0}$

(2) $E_1 = \frac{2\sigma}{\varepsilon_0}, E_2 = \frac{\sigma}{\varepsilon_0}$

(3) $E_1 = E_2 = \frac{\sigma}{2\varepsilon_0}$

(4) $E_1 = E_2 = \frac{\sigma}{\varepsilon_0}$

67. Given below two statements: One is labelled as Assertion (A) and other is labelled as Reason (R).

Assertion (A) : Non-polar materials do not have any permanent dipole moment.

Reason (R) : When a non-polar material is placed in an electric field, the centre of the positive charge distribution of it’s individual atom or molecule coincides with the centre of the negative charge distribution.

In the light of above statements, choose the most appropriate answer from the options given below.

[JEE (Main)-2022]

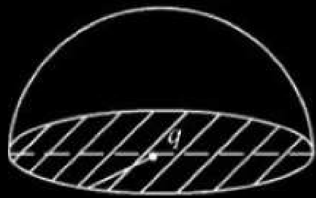
(1) Both (A) and (R) are correct and (R) is the correct explanation of (A).

(2) Both (A) and (R) are correct and (R) is not the correct explanation of (A).

(3) (A) is correct but (R) is not correct.

(4) (A) is not correct but (R) is correct.

68. If a charge q is placed at the centre of a closed hemispherical non-conducting surface, the total flux passing through the flat surface would be:



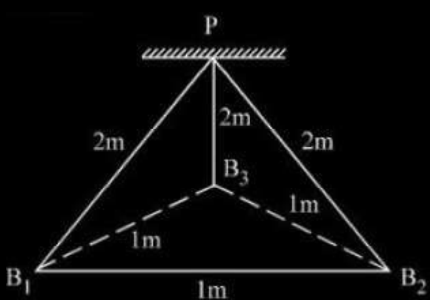
[JEE (Main)-2022]

(1) $\frac{q}{\varepsilon_0}$ (2) $\frac{q}{2\varepsilon_0}$

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

69. Three identical charged balls each of charge 2 C are suspended from a common point P by silk threads of 2 m each (as shown in figure). They form an equilateral triangle of side 1 m. **[JEE (Main)-2022]**

The ratio of net force on a charged ball to the force between any two charged balls will be:



(1) 1 : 1

(2) 1 : 4

(3) $\sqrt{3}:2$

(4) $\sqrt{3}:1$

70. Given below are two statements

Statement-I: A point charge is brought in an electric field. The value of electric field at a point near to the charge may increase if the charge is positive.

Statement-II: An electric dipole is placed in a non-uniform electric field. The net electric force on the dipole will not be zero.

Choose the correct answer from the options given below **[JEE (Main)-2022]**

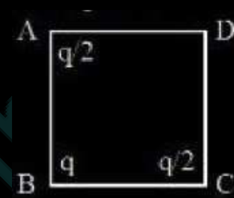
(1) Both statement-I and statement-II are true

(2) Both statement-I and statement-II are false

(3) Statement-I is true but statement-II is false

(4) Statement-I is false but statement-II is true

71. The three charges $\frac{q}{2}$, q and $\frac{q}{2}$ are placed at the corners A, B and C of a square of side 'a' as shown in figure. The magnitude of electric field (E) at the corner D of the square is **[JEE (Main)-2022]**



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

(3) $\frac{q}{4\pi\varepsilon_0 a^2}\left(1-\frac{1}{\sqrt{2}}\right)$ (4) $\frac{q}{4\pi\varepsilon_0 a^2}\left(\frac{1}{\sqrt{2}}-\frac{1}{2}\right)$

72. Two point charges A and B of magnitude $+8\times10^{-6}$ C and -8×10^{-6} C respectively are placed at a distance d apart. The electric field at the middle point O between the charges is 6.4×10^{4} NC^{-1}. The distance 'd' between the point charges A and B is:

[JEE (Main)-2022]

(1) 2.0 m (2) 3.0 m

(3) 1.0 m (4) 4.0 m

73. A positive charge particle of 100 mg is thrown in opposite direction to a uniform electric field of strength 1×10^{5} NC^{-1}. If the charge on the particle is 40 μC and the initial velocity is 200 ms^{-1}, how much distance it will travel before coming to the rest momentarily?

[JEE (Main)-2022]

(1) 1 m (2) 5 m

(3) 10 m (4) 0.5 m

74. Two point charges Q each are placed at a distance d apart. A third point charge q is placed at a distance x from mid-point on the perpendicular bisector. The value of x at which charge q will experience the maximum Coulombs force is : **[JEE (Main)-2022]**

(1) $x = d$

(2) $x = \frac{d}{2}$

(3) $x = \frac{d}{\sqrt{2}}$

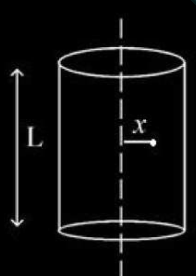
(4) $x = \frac{d}{2\sqrt{2}}$

75. The volume charge density of a sphere of radius 6 m is 2 μC cm^{-3}. The number of lines of force per unit surface area coming out from the surface of the sphere is _______ × 10^{10} NC^{-1}.

[Given : Permittivity of vacuum $\epsilon_0 = 8.85 \times 10^{-12}$ C^2 N^{-1} – m^{-2}). **[JEE (Main)-2022]**

76. A long cylindrical volume contains a uniformly distributed charge of density ρ Cm^{-3}. The electric field inside the cylindrical volume at a distance $x = \frac{2\varepsilon_0}{\rho}$ m from its axis is _______ Vm^{-1}

[JEE (Main)-2022]



77. A charge of 4 μC is to be divided into two. The distance between the two divided charges is constant. The magnitude of the divided charges so that the force between them is maximum, will be:

[JEE (Main)-2022]

(1) 1 μC and 3 μC

(2) 2 μC and 2 μC

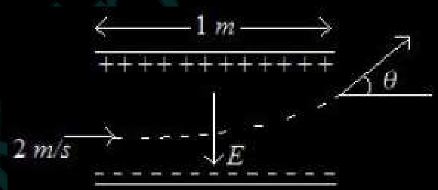
(3) 0 and 4 μC

(4) 1.5 μC and 2.5 μC

78. Two electric dipoles of dipole moments 1.2×10^{-30} C-m and 2.4×10^{-30} C-m are placed in two different uniform electric fields of strength 5×10^4 NC^{-1} and 15×10^4 NC^{-1} respectively. The ratio of maximum torque experienced by the electric dipoles will be $\frac{1}{x}$. The value of x is _______.

[JEE (Main)-2022]

79. A uniform electric field E = (8m/e) V/m is created between two parallel plates of length 1 m as shown in figure, (where m = mass of electron and e = charge of electron). An electron enters the field symmetrically between the plates with a speed of 2 m/s. The angle of the deviation (θ) of the path of the electron as it comes out of the field will be_______.



[JEE (Main)-2022]

(1) $\tan^{-1}(4)$

(2) $\tan^{-1}(2)$

(3) $\tan^{-1}\left(\frac{1}{3}\right)$

(4) $\tan^{-1}(3)$

80. A spherically symmetric charge distribution is considered with charge density varying as

[JEE (Main)-2022]

$$\rho(r) = \begin{cases} \rho_0\left(\frac{3}{4} - \frac{r}{R}\right) & \text{for } r \le R \\ \text{zero} & \text{for } r > R \end{cases}$$

Where, $r (r < R)$ is the distance from the centre O (as shown in figure). The electric field at point P will be :

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

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

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

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

81. Two identical metallic spheres *A* and *B* when placed at certain distance in air repel each other with a force of *F*. Another identical uncharged sphere *C* is first placed in contact with *A* and then in contact with *B* and finally placed at midpoint between spheres *A* and *B*. The force experienced by sphere *C* will be

[JEE (Main)-2022]

(1) $3F/2$ (2) $3F/4$

(3) F (4) $2F$

82. Two identical charged particles each having a mass 10 g and charge 2.0×10^{-7} C are placed on a horizontal table with a separation of *L* between them such that they stay in limited equilibrium. If the coefficient of friction between each particle and the table is 0.25, find the value of *L*. [Use $g = 10\ \text{ms}^{-2}$]

[JEE (Main)-2022]

(1) 12 cm (2) 10 cm

(3) 8 cm (4) 5 cm

83. Three point charges of magnitude 5 μC, 0.16 μC and 0.3 μC are located at the vertices *A*, *B*, *C* of a right angled triangle whose sides are $AB = 3$ cm, $BC = 3\sqrt{2}$ cm and $CA = 3$ cm and point *A* is the right angle corner. Charge at point *A*, experiences _______N of electrostatic force due to the other two charges. **[JEE (Main)-2022]**

84. A long cylindrical volume contains a uniformly distributed charge of density ρ. The radius of cylindrical volume is *R*. A charge particle (*q*) revolves around the cylinder in a circular path. The kinetic energy of the particle is:

[JEE (Main)-2022]

(1) $\dfrac{\rho q R^2}{4\varepsilon_0}$ (2) $\dfrac{\rho q R^2}{2\varepsilon_0}$

(3) $\dfrac{q\rho}{4\varepsilon_0 R^2}$ (4) $\dfrac{4\varepsilon_0 R^2}{q\rho}$

85. Two identical positive charges *Q* each are fixed at a distance of '2*a*' apart from each other. Another point charge q_0 with mass '*m*' is placed at midpoint between two fixed charges. For a small displacement along the line joining the fixed charges, the charge q_0 executes SHM. The time period of oscillation of charge q_0 will be

[JEE (Main)-2022]

(1) $\sqrt{\dfrac{4\pi^3\varepsilon_0 ma^3}{q_0 Q}}$ (2) $\sqrt{\dfrac{q_0 Q}{4\pi^3\varepsilon_0 ma^3}}$

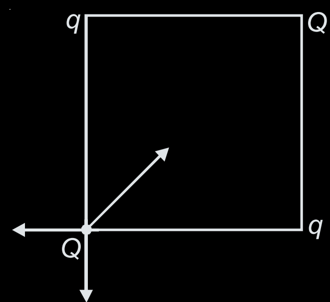
(3) $\sqrt{\dfrac{2\pi^2\varepsilon_0 ma^3}{q_0 Q}}$ (4) $\sqrt{\dfrac{8\pi^3\varepsilon_0 ma^3}{q_0 Q}}$

❑ ❑ ❑

Chapter 14

Electric Charges and Fields

1. Answer (4)

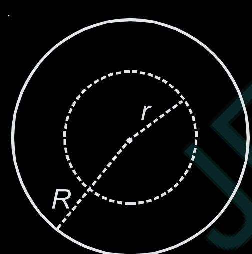


Either of Q or q must be negative for equilibrium.

$$\sqrt{2}\frac{kQq}{l^2} = \frac{kQ^2}{2l^2}$$

$$\frac{|Q|}{|q|} = 2\sqrt{2}$$

2. Answer (2)



Consider a gaussian surface of radius r_1

$$\oint \vec{E}.\overrightarrow{dA} = \frac{Q_{en}}{\varepsilon_0}$$

$$E4\pi r_1^2 = \frac{1}{\varepsilon_0}\int \rho\, dV$$

$$= \frac{1}{\varepsilon_0}\int_0^{r_1} \frac{Q\,r}{\pi R^4}\, 4\pi r^2\, dr$$

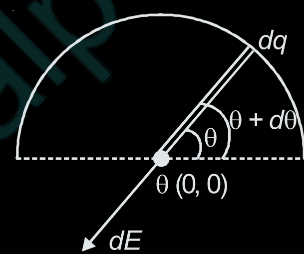
$$E = \frac{Qr_1^4}{4\pi\varepsilon_0 R^4 r_1^2} = \frac{Qr_1^2}{4\pi\varepsilon_0 R^4}$$

3. Answer (4)

By symmetry, $\int dE\cos\theta = 0$

$$\vec{E} = -\int dE\sin\theta\,\hat{j}$$

$$\vec{E} = -\left[\int \frac{dq}{4\pi\varepsilon_0 r^2}\sin\theta\right]\hat{j}$$



Now, $dq = \frac{q}{\pi}d\theta$

$$E = -\int_0^{\pi} \frac{q}{4\pi^2\varepsilon_0 r^2}\sin\theta\, d\theta\,\hat{j} = \frac{-q}{2\pi^2\varepsilon_0 r^2}\hat{j}$$

4. Answer (3)

Charge enclosed by a Gaussian sphere of radius $r(< R)$ is

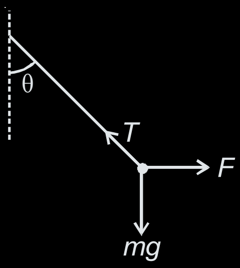
$$Q_{in} = \int \rho\, dV = \int_0^r \rho_0\left(\frac{5}{4} - \frac{r}{R}\right)4\pi r^2 dr$$

$$= \rho_0\left[\frac{5}{4}\times 4\pi\frac{r^3}{3} - \frac{4\pi r^4}{4R}\right]_0^r$$

$$= \rho_0\left[\frac{5}{3}\pi r^3 - \frac{\pi r^4}{R}\right]$$

$$E = \frac{Q_{in}}{4\pi\varepsilon_0 r^2} = \frac{\rho_0 r}{4\varepsilon_0}\left[\frac{5}{3} - \frac{r}{R}\right]$$

5. Answer (4)



For equilibrium, $F = mg\tan\theta$

in oil $F' = mg'\tan\theta$

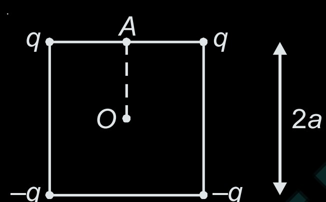
$$\frac{F}{F'} = \frac{g}{g'} \Rightarrow k = \frac{1}{\left(1-\frac{\rho}{\sigma}\right)} = \frac{1}{1-\frac{0.8}{1.6}} = 2$$

6. Answer (2)

$K = Q(V_A - V_0)$

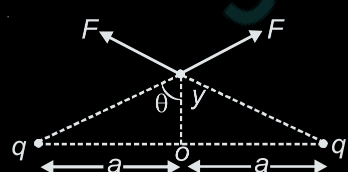
$$V_0 = 0,\ V_A = \frac{q}{4\pi\varepsilon_0 a}\times 2 - \frac{q}{4\pi\varepsilon_0(\sqrt{5}a)}\times 2$$

$$\Rightarrow \quad K = \frac{1}{4\pi\varepsilon_0}\frac{2qQ}{a}\left[1-\frac{1}{\sqrt{5}}\right]$$



7. Answer (3)

8. Answer (1)



$F_{net} = 2F\cos\theta$

$$= \frac{2\times kq^2}{2(a^2+y^2)}\times\frac{y}{(a^2+y^2)^{1/2}}$$

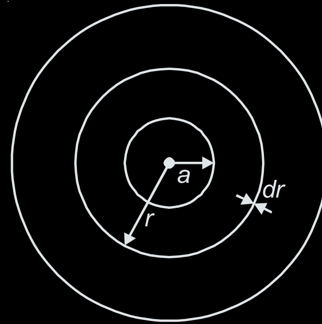
$$F \approx \frac{kq^2y}{a^3}$$

$F \propto y$

9. Answer (1)

The field line should resemble that of a dipole.

10. Answer (4)



At $r = a$

$$E_a = \frac{kQ}{a^2}$$

Take a shell at $r = r$

$(a \le r \le b)$

$$dq = 4\pi r^2 dr\frac{A}{r}$$

$\therefore$ q from $r = a$ to $r = r$

$$q = 4\pi A\int_a^r r\,dr = 2\pi A[r^2 - a^2]$$

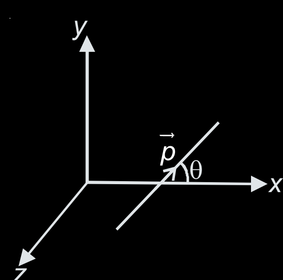
$\therefore$ Charge from $r = a$ to $r = b$

$q = 2\pi A[b^2 - a^2]$

Now, field at $r = b$ is $E_b = \dfrac{2\pi A[b^2-a^2]+Q}{\varepsilon_0\times 4\pi b^2}$

Now, $E_a = E_b$ gives, $A = \dfrac{Q}{2\pi a^2}$

11. Answer (3)



$$\vec{p} = p\cos\theta\hat{i} + p\sin\theta\hat{j}$$

$$\vec{E}_1 = E\hat{i}$$

$$\vec{T}_1 = \vec{p}\times\vec{E}_1$$

$$= (p\cos\theta\hat{i} + p\sin\theta\hat{j})\times E\left(\hat{i}\right)$$

$$\tau\hat{k} = pE\sin\theta\left(-\hat{k}\right) \quad \ldots\text{(i)}$$

$$\vec{E}_2 = \sqrt{3}E_1\hat{j}$$

$\overrightarrow{T_2} = (p\cos\theta\hat{i} + p\sin\theta\hat{j}) \times \sqrt{3}E_1\hat{j}$

$-\tau\hat{k} = \sqrt{3}pE_1\cos\theta\hat{k}$ ...(ii)

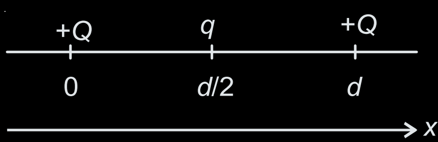
From (i) & (ii)

$pE\sin\theta = \sqrt{3}pE\cos\theta$

$\tan\theta = \sqrt{3}$

$\theta = 60°$

12. Answer (3)



$$F_Q = \frac{-Q^2}{4\pi\varepsilon_0 d^2} + \frac{Qq \times 4}{4\pi\varepsilon_0 d^2} = 0$$

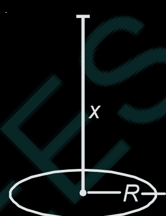
$\Rightarrow$ q must be (–ve)

$$\Rightarrow \frac{Qq.4}{4\pi\varepsilon_0 d^2} = \frac{Q^2}{4\pi\varepsilon_0 d^2}$$

$$\Rightarrow q = \frac{Q}{4}(-\text{ve})$$

13. Answer (1)

$$E(x) = \frac{Q.x}{4\pi\varepsilon_0\left(R^2 + x^2\right)^{\frac{3}{2}}}$$



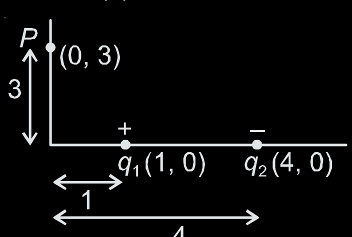
$\because \frac{dE}{dx} = 0$ for maximum

$$\Rightarrow \frac{Q}{4\pi\varepsilon_0}\left[\frac{(R^2+x^2)^{\frac{3}{2}} - x\cdot\frac{3}{2}\left(R^2+x^2\right)^{\frac{1}{2}}.2x}{(R^2+x^2)^3}\right] = 0$$

$$\Rightarrow \frac{(R^2+x^2)^{\frac{1}{2}}Q}{4\pi\varepsilon_0.(R^2+x^2)^3}\left(x^2 + R^2 - 3x^2\right) = 0$$

$$\Rightarrow x = \frac{R}{\sqrt{2}} \qquad \Rightarrow h = \frac{R}{\sqrt{2}}$$

14. Answer (1)



$\vec{E} = \vec{E}_1 + \vec{E}_2$

$$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0} \times \frac{\sqrt{10}\times 10^{-6}}{10} \times \left[\frac{-\hat{i} + 3\hat{j}}{\sqrt{10}}\right]$$

$$\vec{E}_2 = \frac{1}{4\pi\varepsilon_0} \times \frac{(-25\times 10^{-6})}{25} \times \left[\frac{-4\hat{i} + 3\hat{j}}{5}\right]$$

$$\vec{E} = 9\times 10^9 \times 10^{-6}\left[\frac{-\hat{i}+3\hat{j}}{10} - \left(\frac{-4\hat{i}+3\hat{j}}{5}\right)\right]$$

$$= \frac{9\times 10^3}{10}\left[-\hat{i} + 3\hat{j} + 8\hat{i} - 6\hat{j}\right]$$

$$= 9\times 10^2\left[+7\hat{i} - 3\hat{j}\right]$$

$$= \left(63\hat{i} - 27\hat{j}\right)\times 10^2$$

15. Answer (1)

$$Q = \int_0^R 4\pi r^2 \cdot \frac{A}{r^2}e^{-2r/a}\,dr$$

$$= \frac{4\pi Aa}{-2}e^{-2r/a}\Big|_0^R = 2\pi aA\left[1 - e^{\frac{-2R}{a}}\right]$$

$$= e^{-2R/a} = 1 - \frac{Q}{2\pi aA}$$

$$\Rightarrow e^{\frac{2R}{a}} = \frac{1}{\left(1 - \frac{Q}{2\pi aA}\right)}$$

$$\Rightarrow R = \frac{a}{2}\ln\left(\frac{1}{1 - \frac{Q}{2\pi aA}}\right)$$

16. Answer (3)

$F = \frac{Kp}{y^3}Q$ for electric dipole

and, $F' = \frac{Kp}{(y/3)^3}Q = \frac{27\,KpQ}{y^3}$

$\therefore \quad F' = 27\,F$

17. Answer (3)

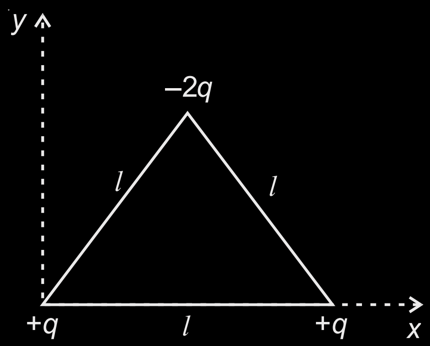
$U = -\vec{p}\cdot\vec{E}$

$= -pE\cos 45°$

$= -10^{-29} \times 10^3 \times \frac{1}{\sqrt{2}}$

$U = -7 \times 10^{-27}$ J

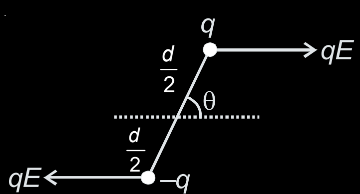
18. Answer (3)



$\vec{P} = -2\cdot ql\cos 30^\circ\ \hat{j}$

$\vec{P} = -\sqrt{3}\ ql\ \hat{j}$

19. Answer (1)

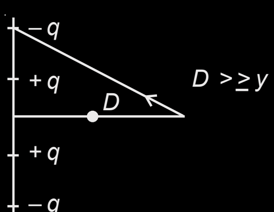


$$-Eqd\theta = I\frac{d^2\theta}{dt^2} = 2\frac{md^2}{4}.\frac{d^2\theta}{dt^2}$$

$$\Rightarrow \frac{d^2\theta}{dt^2} - \frac{2Eq\theta}{md}$$

$$\Rightarrow \omega = \sqrt{\frac{2Eq}{md}}$$

20. Answer (3)



$$\vec{E} = \frac{2qD}{4\pi\varepsilon_0\left(D^2+4y^2\right)^{\frac{3}{2}}} - \frac{2qD}{4\pi\varepsilon_0(D^2+y^2)^{\frac{3}{2}}}\ (-ve\ \vec{x})$$

$$|\vec{E}| = \frac{2qD}{4\pi\varepsilon_0 D^3}\left[\frac{1}{\left(1+\left(\frac{2y}{D}\right)^2\right)^{\frac{3}{2}}} - \frac{1}{\left(1+\left(\frac{y}{D}\right)^2\right)^{\frac{3}{2}}}\right]$$

$$\Rightarrow \vec{E} = \frac{2q}{4\pi\varepsilon_0 D^2}\left(1-\frac{3}{2}\cdot\frac{4y^2}{D^2}-1+\frac{3}{2}\frac{y^2}{D^2}\right) = \frac{9qy^2}{4\pi\varepsilon_0 D^4}$$

21. Answer (3)

$$t = 2\pi\sqrt{\frac{L}{g_{\text{eff}}}}$$

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

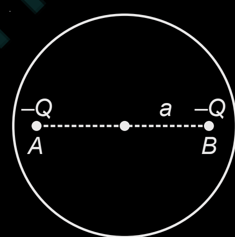
$$\Rightarrow t = 2\pi\sqrt{\frac{L}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$$

22. Answer (3)

Since dipole is having zero net charge. So inside surface shall have non-zero non-uniform charge distribution. And net field outside the region would be same as that would have been for point charge at surface.

23. Answer (4)

$$E\times 4\pi a^2 = \frac{q_{\text{in}}}{\varepsilon_0}$$



$$q_{\text{in}} = \int_0^a (kr)\times 4\pi r^2 dr\ \ = 4\pi k\cdot\left(\frac{a^4}{4}\right)$$

$$\therefore\ E\times 4\pi a^2 = \frac{4\pi k a^4}{4\varepsilon_0} \Rightarrow E = \frac{ka^2}{4\varepsilon_0}$$

$$\therefore\ \frac{ka^2}{4\varepsilon_0}\times Q = \frac{Q^2}{4\pi\varepsilon_0\times 4a^2}$$

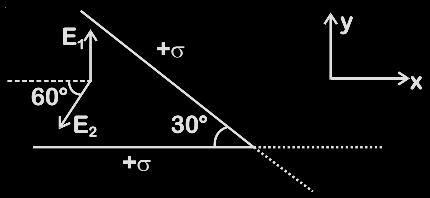
$$\frac{2Q}{\pi R^4}\cdot\frac{a^2Q}{4\varepsilon_0} = \frac{Q^2}{4\pi\varepsilon_0\times 4a^2} \Rightarrow 8a^4 = R^4$$

$$\Rightarrow 8^{1/4}\cdot a = R$$

$$\Rightarrow a = \frac{R}{8^{1/4}}$$

As, $2Q = \frac{4\pi k R^2}{4} \Rightarrow k = \frac{2Q}{\pi R^4}$

24. Answer (3)



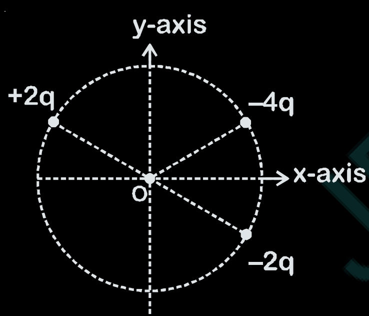
$$\overrightarrow{E_1} = \frac{\sigma}{2\varepsilon_0}\hat{y}$$

$$\overrightarrow{E_2} = \frac{\sigma}{2\varepsilon_0}(-\cos 60°\,\hat{x} - \sin 60°\,\hat{y})$$

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

$$\therefore\ \overrightarrow{E_P} = \overrightarrow{E_1} + \overrightarrow{E_2} = \frac{\sigma}{2\varepsilon_0}\left[-\frac{1}{2}\hat{x} + \left(1 - \frac{\sqrt{3}}{2}\right)\hat{y}\right]$$

25. Answer (1)



Electric field due to charge +2q at centre O –

$$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0}\frac{2q}{d^2}\left[\frac{+\sqrt{3}\,\hat{i} - \hat{j}}{2}\right]$$

Due to –2q

$$\vec{E}_2 = \frac{1}{4\pi\varepsilon_0} \times \frac{2q}{d^2}\left[\frac{\sqrt{3}\,\hat{i} - \hat{j}}{2}\right]$$

Due to –4q

$$\vec{E}_3 = \frac{1}{4\pi\varepsilon_0} \times \frac{4q}{d^2}\left[\frac{\sqrt{3}\,\hat{i} + \hat{j}}{2}\right]$$

Net electric field at point O

$$\vec{E}_0 = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 = \frac{\sqrt{3}\,q}{\pi\varepsilon_0 d^2}\hat{i}$$

26. Answer (1)

By Gauss law

$$\oint \vec{E}\cdot\overrightarrow{dA} = \frac{Q_{in}}{\varepsilon_0}$$

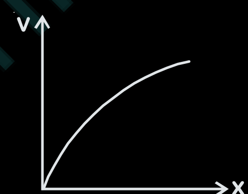
If $|\vec{E}| = \dfrac{Q_{in}}{|\vec{A}|\varepsilon_0}$

or $|\vec{E}|\,|\vec{A}| = \dfrac{Q_{in}}{\varepsilon_0}$

then $\vec{E} \parallel \vec{A}$

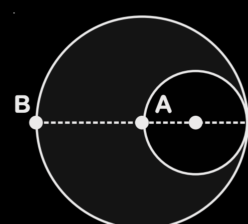
$\therefore$ Surface is equipotential too.

27. Answer (4)



$$v^2 = \frac{2qE}{m}\cdot x$$

28. Answer (1)



$$E_A = \frac{\sigma(R/2)}{3\varepsilon_0} = \left(\frac{\sigma R}{6\varepsilon_0}\right)$$

$$E_B = \frac{\sigma R}{3\varepsilon_0} - \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{(\sigma)}{\left(\frac{3R}{2}\right)^2}\frac{4\pi}{3}\left(\frac{R}{2}\right)^3$$

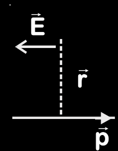
$$= \frac{\sigma R}{3\varepsilon_0} - \frac{\sigma R}{54\varepsilon_0}$$

$$\Rightarrow \quad E_B = \frac{17}{54}\left(\frac{\sigma R}{\varepsilon_0}\right)$$

$$\left|\frac{E_A}{E_B}\right| = \frac{1\times 54}{6\times 17} = \left(\frac{9}{17}\right)$$

29. Answer (4)

$$\hat{E} = -\hat{p}$$

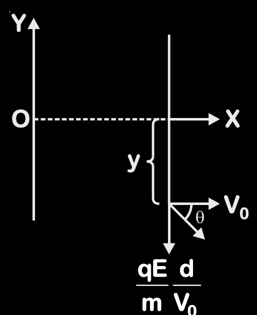


$$\Rightarrow \quad \hat{E} = -\left[\frac{-\hat{i}-3\hat{j}+2\hat{k}}{\sqrt{14}}\right]$$

$$|\vec{E}| = \frac{k\,|\vec{p}\,|}{r^3}$$

$\hat{E}$ is parallel to $\left(\hat{i}+3\hat{j}-2\hat{k}\right)$

30. Answer (3)



$$y = \frac{1}{2}\left(\frac{qE}{m}\right)\left(\frac{d}{V_0}\right)^2$$

$$y = -\frac{qEd}{mV_0^2}x + C$$

At x = d, $y = -\dfrac{qEd^2}{2mV_0^2}$

$$\Rightarrow \quad C = \frac{qEd^2}{2mV_0^2}$$

$$y = -\frac{qEd}{mV_0^2}x + \frac{qEd^2}{2mV_0^2}$$

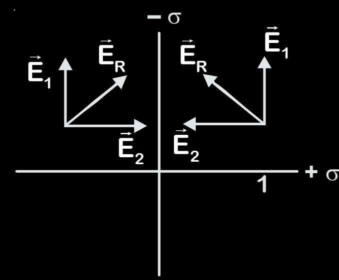
$$y = \frac{qEd}{mV_0^2}\left(\frac{d}{2}-x\right)$$

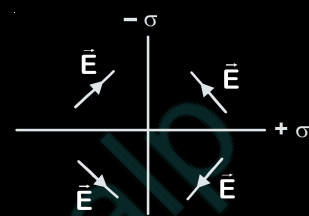
31. Answer (2)

$$\vec{F} = qE\hat{i} + mg\hat{j}$$

Since initial velocity is zero. It will move in straight line.

32. Answer (4)





33. Answer (1)

$E = E_0(1 - ax^2)$

$$\frac{vdv}{dx} = \frac{qE_0}{m}(1-ax^2)$$

$$\Rightarrow \quad \frac{v^2}{2} = \frac{qE_0}{m}\left[x - \frac{ax^3}{3}\right] = 0$$

$$\Rightarrow \quad x = \sqrt{\frac{3}{a}}$$

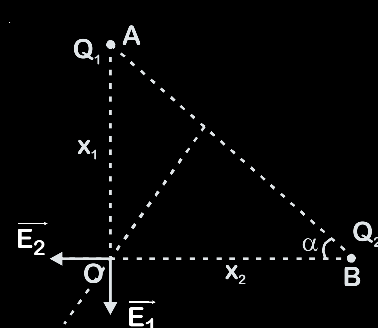
34. Answer (1)

$\Sigma Q = 0$

$\Rightarrow$ V = 0

Also, field of one charge will get cancelled due to another symmetrical charge in front of it.

35. Answer (3)



Net field along AB at O must be zero.

$E_2 \cos\alpha = E_1 \sin\alpha$

$$\frac{kQ_2}{x_2^2}\cdot\frac{x_2}{AB}=\frac{kQ_1}{x_1^2}\cdot\frac{x_1}{AB}$$

$$\frac{Q_1}{Q_2}=\frac{x_1}{x_2}$$

36. Answer (1)

$\vec{p}$ $\qquad\qquad$ $\overleftarrow{p\bullet}$

$$U=-\vec{p}\cdot\vec{E}$$

$$\vec{E}=\frac{2\vec{p}}{4\pi\varepsilon_0\times a^3}$$

$$\therefore\quad \Delta U_{\text{loss}}=\frac{2p^2}{4\pi\varepsilon_0 a^3}=2\times\frac{1}{2}mv^2$$

$$\Rightarrow\quad v=\frac{p}{a}\sqrt{\frac{1}{2\pi\varepsilon_0 ma}}$$

37. Answer (3)

For spherical shell

$$E=\frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} \qquad (r > R)$$

$$= 0 \qquad (r < R)$$

Force on charge in electric field

F = qE

38. Answer (–48)

$$\phi_I = \int \vec{E}.\vec{dA}=0$$

$$\phi_{II} = \left[4x\hat{i}-(y^2+1)\hat{j}\right].4\hat{i}$$

$$= 16x$$

$$\phi_{II} = \frac{48\ Nm^2}{C}$$

$$\phi_I-\phi_{II} = -48$$

39. Answer (4)

Field due to all charges will cancel out except two charges +Q and –Q placed along body diagonal.

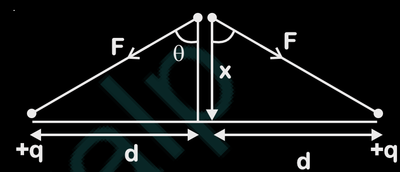
$$\vec{E}_{-Q}=-\frac{Q}{4\pi\varepsilon_0\frac{3a^2}{4}}\frac{(\hat{x}+\hat{y}+\hat{z})}{\sqrt{3}}$$

$$\vec{E}_{+Q}=\frac{-Q(\hat{x}+\hat{y}+\hat{z})}{3\pi\varepsilon_0 a^2\sqrt{3}}$$

$$\vec{E}_{net}=\frac{-2Q(\hat{x}+\hat{y}+\hat{z})}{3\sqrt{3}\ \pi\varepsilon_0 a^2}$$

40. Answer (1)

$F_{net} = 2F\cos\theta$



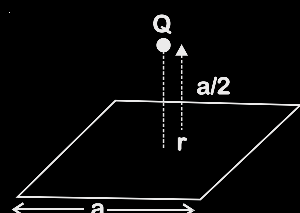
$$F=\frac{q^2}{4\pi\varepsilon_0(x^2+d^2)}$$

$$F_{net}=\frac{2q^2x}{4\pi\varepsilon_0(x^2+d^2)^{3/2}}$$

$$\frac{q^2x}{2\pi\varepsilon_0 d^3}=-m\omega^2x$$

$$\omega^2=\frac{q^2}{2\pi\varepsilon_0 md^3}$$

41. Answer (226)



$$\phi = \frac{Q}{6\varepsilon_0}$$

$$= \frac{12\times10^{-6}}{6}\times4\pi\times9\times10^9$$

$$= 226.28\times10^3\ \frac{\text{N-m}^2}{\text{C}}$$

42. Answer (1)

$$\vec{E} = \frac{3}{5}E_0\,\hat{i} + \frac{4}{5}E_0\,\hat{j}\quad \frac{\text{N}}{\text{C}}$$

$$\phi_1 = \vec{E}\cdot\vec{A}_1 = \frac{6}{50}E_0$$

$$\phi_2 = \vec{E}\cdot\vec{A}_2 = \frac{12}{50}E_0$$

$$\frac{\phi_1}{\phi_2} = \frac{1}{2}$$

43. Answer (2)

Complete the cube with double the side with charge at centre

$$\text{flux, } \phi = \frac{1}{3}\times\frac{q}{8\varepsilon_0} = \frac{q}{24\varepsilon_0}$$

44. Answer (36)

$$q_1' = q_2' = \frac{Q_1+Q_2}{2} = 1\,\text{nC}$$

$$F = \frac{1}{4\pi\varepsilon_0}.\frac{q_1'q_2'}{r^2} = 9\times10^9\times\frac{10^{-9}\times10^{-9}}{(0.5)^2}$$

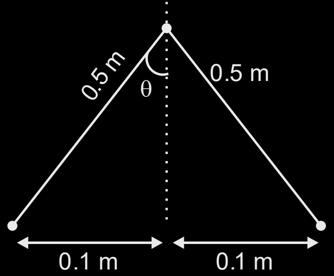
$$= 36\times10^{-9}\text{ N}$$

45. Answer (20)

$$T\cos\theta = mg$$

$$T\sin\theta = \frac{q^2}{4\pi\varepsilon_0(0.4)^2}$$

$$\tan\theta = \frac{q^2}{4\pi\varepsilon_0(0.4)^2 mg}$$



$$\frac{0.10}{\sqrt{0.24}} = \frac{q^2\times9\times10^9}{(0.2)^2\times10^{-4}}$$

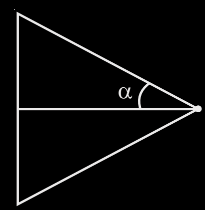
$$q^2 = \frac{0.04\times0.10}{9\times10^{13}\times\sqrt{0.24}}$$

$$q = \frac{0.2\times10^{-8}}{3}\times\sqrt{\frac{1}{\sqrt{24}}}$$

$$q = \frac{4}{3}\times\sqrt{\frac{1}{\sqrt{24}}}\times10^{-8}\text{C} = 0.88\times10^{-8}\text{C}$$

$$a \approx 20$$

46. Answer (4)



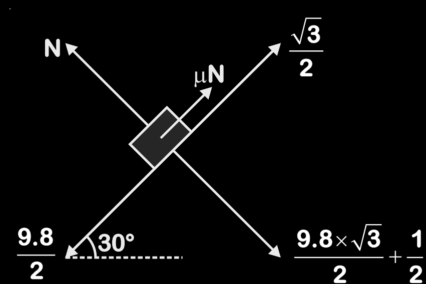
$$\lambda = \frac{Q}{L}$$

$$E = \frac{\lambda}{4\pi\varepsilon_0 a}\times2\sin\alpha$$

$$\alpha = 30°$$

$$E = \frac{Q}{4\pi\varepsilon_0 L\times\sqrt{3}\frac{L}{2}} = \frac{Q}{2\sqrt{3}\pi\varepsilon_0 L^2}$$

47. Answer (2)



$$a = 4.9-(0.2)\left\{\frac{9.8\sqrt{3}+1}{2}\right\}-\frac{\sqrt{3}}{2}$$

$$= 2.24\text{ m/s}^2$$

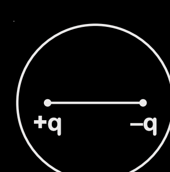
$$T = \sqrt{\frac{2\times1}{(\sin30)\times2.24}} = 1.3\text{ s}$$

48. Answer (3)

$$\phi_{Tot} = \frac{q_{inc}}{\varepsilon_0}$$

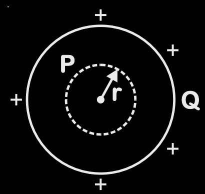
$$q_{inc} = 0 \;\Rightarrow\; \phi_{Tot} = 0$$

$$\vec{E} \neq 0$$

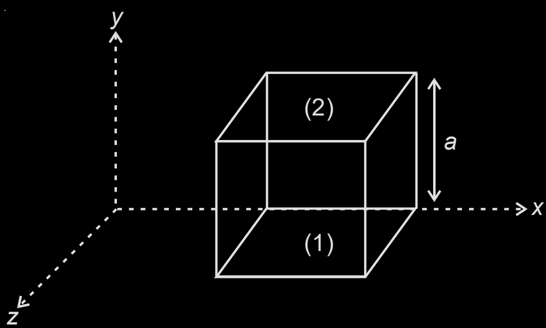


At P,

$E = 0$ and $\phi = 0$



49. Answer (1)



Flux through surface (1) = 0 as electric field is zero

Flux through surface (2) = 150 $a^2.a^2$

$$=150a^4.=150\times\left(\frac{1}{2}\right)^4$$

Flux through other surfaces are zero as electric field is perpendicular to Area vector

Now, using Gauss Law

$$\frac{Q_{in}}{\varepsilon_0}=\phi_{total}=\frac{150}{16}$$

$$Q_{in}=\frac{150}{16}\times\varepsilon_0$$

$\approx 8.3 \times 10^{-11}$ C

50. Answer (640)

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

$$=\frac{E_0}{5}\left(2\hat{i}+3\hat{j}\right)\cdot\left(0.4\hat{i}\right)$$

$$=\frac{4000}{5}(2\times 0.4)$$

$= 640$ Nm^2 C^{-1}

51. Answer (2)

The electrostatic field will balance the weight of oil drop

$$\Rightarrow \frac{4}{3}\pi r^3\times\rho\times g = neE$$

$$\Rightarrow n=\frac{\frac{4}{3}\pi r^3\rho g}{eE}=\frac{\frac{4}{3}\times\pi\times(2\times10^{-3})^3\times(3\times10^3)\times 9.81}{1.6\times10^{-19}\times3.55\times10^5}$$

$= 173.65 \times 10^8$

$= 1.73 \times 10^{10}$

52. Answer (12)

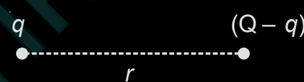
$$F = (k)\left(10^{-6}\right)\left[\frac{1}{1^2}+\frac{1}{2^2}+\frac{1}{4^2}+\ldots\ldots\right]$$

$$=\frac{(k)10^{-6}}{1-\frac{1}{4}}=\frac{\left(9\times10^9\right)\times4\times10^{-6}\,N}{3}$$

$= 12 \times 10^3$ N

53. Answer (4)

$$F=\frac{(k)(q)(Q-q)}{r^2}$$



$f(q) = q(Q - q)$

$f'(q) = Q - 2q$

$f'(q) = 0 \Rightarrow \quad q=\dfrac{Q}{2}$

54. Answer (1)

$F = 100 \times 8\text{ m} \times 10^{-3}$ N

$a = 800 \times 10^{-3}$ m/s^2

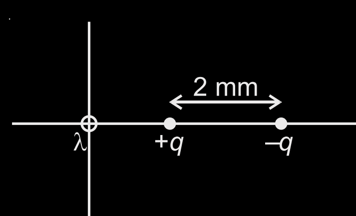
$d = 10 \times 10^{-2}$ m

$$t=\sqrt{\frac{2\times10\times10^{-2}}{800\times10^{-3}}}\,\text{s}=\frac{1}{2}\text{s}$$

Total time taken to come back = $2t$

= 1 s

55. Answer (4)



$|F| = q(E_1 - E_2)$

$$= (q)2k\lambda\left[\frac{2}{10\times 12\times 10^{-3}}\right]$$

$$4 = (q)\times 2\times 9\times 10^{9}\times(3\times 10^{-6})\left[\frac{2}{120\times 10^{-3}}\right]$$

$\Rightarrow\ q = 4.44\ \mu C$

56. Answer (4)

$$\overline{D} = \varepsilon_0\overline{E}$$

$$\text{div. } \overline{E} = \frac{\rho}{\varepsilon_0}$$

$$\Rightarrow\ \text{div. } \overline{D} = \rho$$

$$\Rightarrow\ \frac{\partial}{\partial x}\left(e^{-x}\sin y\right) + \frac{\partial}{\partial y}\left(-e^{-x}\cos y\right) + \frac{\partial}{\partial z}(2z) = \rho$$

$\Rightarrow\ \rho = 2$ (a constant)

$$V = 2\times 10^{-9}\,m^3$$

$$q = 2\times 2\times 10^{-9} = 4\ nC$$

57. Answer (6000)

$$F_{res} = kq^2\left(\frac{1}{(1-x)^2} - \frac{1}{(1+x)^2}\right)$$

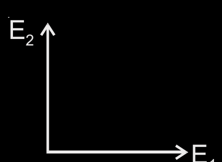
$$= \frac{kq^2\times 4x}{(1-x^2)^2} \cong 4kq^2x$$

$$a = \frac{4\times 10^9\times 9\times 10}{10^{-6}}x$$

$\Rightarrow\ \omega = 6\times 10^8$ rad/s

58. Answer (1)

$$\vec{E}_C = \vec{E}_1 + \vec{E}_2$$



$$E_1 = \frac{2p_1}{4\pi\varepsilon_0 r^3}\hat{i}$$

$$E_2 = \frac{p_2}{4\pi\varepsilon_0 r^3}\hat{j}$$

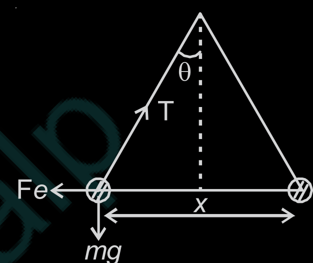
$$\tan 37^\circ = \frac{E_2}{E_1} = \frac{p_2}{2p_1}$$

$$\frac{3}{4} = \frac{p_2}{2p_1}$$

$$\frac{p_1}{p_2} = \frac{2}{3}$$

59. Answer (4)

T cosθ = mg



T sinθ = F_e

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

$$\frac{x}{2l} = \frac{q^2}{4\pi\varepsilon_0 x^2 mg}$$

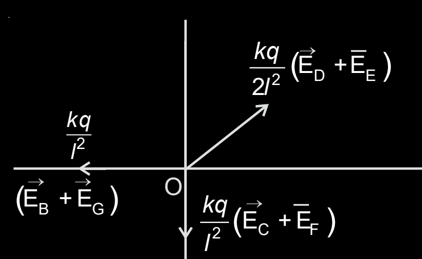
$$x^3 = \frac{q^2 l}{2\pi\varepsilon_0 mg}$$

$$x = \left(\frac{q^2 l}{2\pi\varepsilon_0 mg}\right)^{\frac{1}{3}}$$

60. Answer (4)

$$\overline{E}_0 = \overline{E}_A + \overline{E}_B + \overline{E}_C + \overline{E}_D + \overline{E}_E + \overline{E}_F + \overline{E}_G + \overline{E}_H$$

$$\overline{E}_A + \overline{E}_H = 0$$

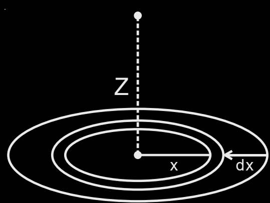


$$\Rightarrow \quad \left|\vec{E}_0\right| = \left|\frac{kq}{2l^2} - \frac{kq}{l^2}\sqrt{2}\right|$$

$$= \frac{kq}{l^2}\left|\left(\frac{1}{2} - \sqrt{2}\right)\right|$$

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

61. Answer (1)



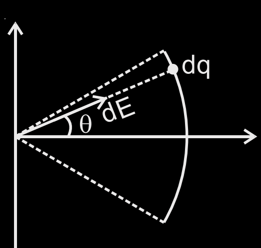
$$dE = \frac{(k)(dq)x}{(x^2 + Z^2)^{3/2}}$$

$$E = \int dE$$

$$= \int_0^R \left(\frac{1}{4\pi\varepsilon_0}\right)\frac{(\sigma)(2\pi x)(dx)x}{(x^2 + Z^2)^{3/2}}$$

$$= \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{Z}{\sqrt{R^2 + Z^2}}\right]$$

62. Answer (1)



$$E = \int dE\cos\theta$$

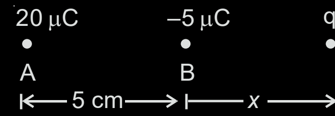
$$= \int_{-\pi/3}^{\pi/3} \frac{K \times (+Q)}{\frac{2\pi}{3}R} \times \frac{Rd\theta}{R^2} \times \cos\theta$$

$$= +\frac{3}{2\pi}\frac{KQ}{R^2}[\sin\theta]_{-\pi/3}^{\pi/3}$$

$$= +\frac{3}{2\theta}\frac{KQ}{R} \times \frac{2\sqrt{3}}{2}$$

$$\therefore \ \vec{E} = \frac{3\sqrt{3}}{8\pi^2\varepsilon_0 R^2}(\hat{i})$$

63. Answer (1)



$$\frac{kq \times 20}{(5 + x)^2} = \frac{kq5}{x^2}$$

$$\frac{2}{5 + x} = \frac{1}{x}$$

2x = 5 + x

x = 5 cm

64. Answer (1)

We know, total flux through close surface, $\phi = \frac{Q_{in}}{\varepsilon_0}$

if $\phi = 0$, $Q_{in} = 0$

If electric field is parallel to surface then electric flux = 0

65. Answer (2)

Since the droplet is at rest

$\Rightarrow$ Net force = 0

$\Rightarrow$ $mg = qE$

$$\Rightarrow \quad q = \frac{mg}{E} = 2 \times 10^{-9}\text{ C}$$

66. Answer (3)

For an infinite charged plane

$E = \frac{\sigma}{2\varepsilon_0}$ for any value of l

$$\Rightarrow \quad E_1 = E_2 = \frac{\sigma}{2\varepsilon_0}$$

67. Answer (3)

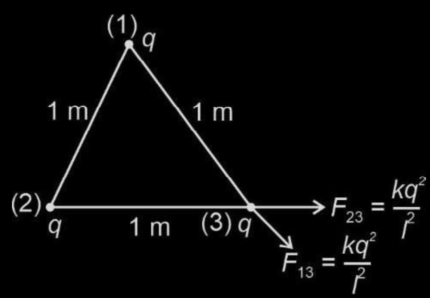
Non polar material does not have any permanent dipole moment and when placed in an electric field the positive and negative charges displace in opposite directions and result into an induced dipole moment as long as the field is applied.

68. Answer (2)

Flux passing through flat surface = Flux passing through curved surface.

So $\phi = \dfrac{q}{2\varepsilon_0}$

69. Answer (4)



F_{net} on charge 3, $F_1 = \dfrac{\sqrt{3}kq^2}{1^2}$

Force between any 2 charges

$F_2 = \dfrac{kq^2}{1^2}$

So, $\dfrac{F_1}{F_2} = \sqrt{3}$

70. Answer (1)

As one moves closer to a positive charge (isolated) the density of electric field line increases and so does the electric field intensity

$\Rightarrow$ Statement I is true

As opposite poles of an electric dipole would experience equal and opposite forces so net force on a dipole in a uniform electric field will be zero

$\Rightarrow$ Statement II is true

71. Answer (1)

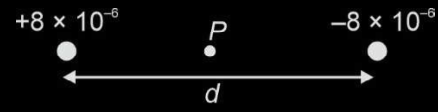
$$|E_0| = \frac{kq/2}{a^2}\sqrt{2} + \frac{kq}{\left(a\sqrt{2}\right)^2}$$

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

$$= \frac{kq}{a^2}\left(\frac{1}{\sqrt{2}} + \frac{1}{2}\right),\ k = \frac{1}{4\pi\varepsilon_0}$$

$\Rightarrow$ Option (1) is correct

72. Answer (2)



Electric field at P will be

$$E = \frac{kq}{(d/2)^2} \times 2 = \frac{8kq}{d^2}$$

So, $\dfrac{8 \times 9 \times 10^9 \times 8 \times 10^{-6}}{d^2} = 6.4 \times 10^4$

So, $d = 3$ m

73. Answer (4)

$v^2 - u^2 = 2aS$

$$\Rightarrow 0^2 - 200^2 = 2\left(\frac{-qE}{m}\right)(S)$$

$$\Rightarrow -200^2 = 2\left[\frac{-40 \times 10^{-6} \times 10^5}{100 \times 10^{-6}}\right][S]$$

$$\Rightarrow S = \frac{4}{2 \times 4}\ \text{m} = 0.5\ \text{m}$$

74. Answer (4)

Force experienced by the charge q

$$F = \frac{kQqx}{\left[\left(\frac{d}{2}\right)^2 + x^2\right]^{\frac{3}{2}}}$$

For maximum Coulomb's force for x

$$\frac{dF}{dx} = 0$$

On solving $x = \dfrac{d}{2\sqrt{2}}$

75. Answer (45)

$\rho = 2\ \mu c/cm^3$

$R = 6$ m

Number of lines of force per unit area = Electric field at surface.

$$= \frac{KQ}{R^2}$$

$$= \frac{1}{4\pi\varepsilon_0} \frac{\rho \frac{4}{3}\pi R^3}{R^2}$$

$$= \frac{\rho R}{3\ \varepsilon_0}$$

$$= \frac{2 \times 10^{-6} \times 10^{6} \times 6}{3 \times 8.85 \times 10^{-12}}$$

$= 0.45197 \times 10^{12}$

$= 45.19 \times 10^{10}$ N/C

$\simeq 45 \times 10^{10}$

76. Answer (1)

$$E = \frac{\rho r}{2\varepsilon_0}$$

at $r = \dfrac{2\varepsilon_0}{\rho}$

$$E = \frac{\rho}{2\varepsilon_0}\left(\frac{2\varepsilon_0}{\rho}\right)$$

$= 1$

77. Answer (2)

so $F = \dfrac{k\,q(4-q)\times 10^{-12}}{r^2}$

so F_{max} will be at $q = 2\ \mu C$

78. Answer (6)

$$\frac{\rho_1}{\rho_2} = \frac{\mu_1 B_1 \sin 90}{\mu_2 B_2 \sin 90}$$

$$= \frac{1.2 \times 10^{-30} \times 5 \times 10^{4}}{2.4 \times 10^{-30} \times 15 \times 10^{4}}$$

$$= \frac{1}{6}$$

79. Answer (2)

$$E = \frac{8\ m}{e}\ \text{V/m}$$

$l = 1$ m

$v_x = 2$ m/s

$a_y = -8$ m/s^2

$$t = \frac{l}{v_x} = \frac{1}{2}\ \text{s}$$

$\Rightarrow |v_y| = 4$ m/s

$\Rightarrow$ angle of deviation = θ

$$\tan\theta = \frac{v_y}{v_x}$$

$$\theta = \tan^{-1}\left(\frac{4}{2}\right) = \tan^{-1}(2)$$

80. Answer (3)

$$(4\pi r^2)E_\rho = \frac{Q_{in}}{\varepsilon_0}$$

$$= \frac{\int_0^r \rho_0\left(\frac{3}{4} - \frac{r}{R}\right)4\pi r^2 dr}{\varepsilon_0}$$

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

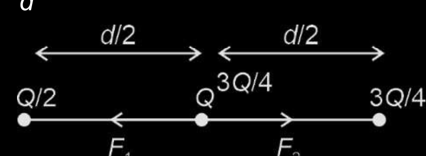
$$E_\rho = \frac{\rho_0}{4\,\varepsilon_0}\left(r - \frac{r^2}{R}\right)$$

$$= \frac{\rho_0 r}{4\,\varepsilon_0}\left(1 - \frac{r}{R}\right)$$

81. Answer (2)

When two identical sphere come in contact with each other, the total charge on them is equally distribute.

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



$$F' = \frac{k9Q^2}{16 \times \frac{d^2}{4}} - \frac{k3Q^2}{8 \times \frac{d^2}{4}}$$

$$= \frac{9kQ^2}{4d^2} - \frac{3kQ^2}{2d^2}$$

$$= \frac{kQ^2}{d^2}\left[\frac{9}{4} - \frac{3}{2}\right]$$

$$= \frac{6}{8}F = \frac{3}{4}F$$

82. Answer (1)

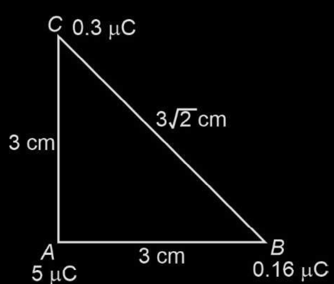
According to given information :

$$\frac{kQ^2}{L^2} = \mu mg$$

Putting the values, we get

L = 12 cm

83. Answer (17)



$$F_{AC} = \frac{k(5 \times 0.3) \times 10^{-12}}{9 \times 10^{-4}}$$

$$F_{AB} = \frac{k(5 \times 0.16) \times 10^{-12}}{9 \times 10^{-4}}$$

$$F_{net} = \frac{k \times 10^{-12}}{9 \times 10^{-4}}\sqrt{1.5^2 + (0.8)^2}$$

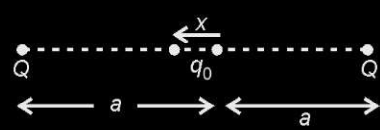
$$= \frac{10^9 \times 10^{-12}}{10^{-4}} \times 1.7 = 17$$

84. Answer (1)

$$\frac{mv^2}{r} = \frac{2k\rho \times \pi R^2 q}{r}$$

$$\Rightarrow \frac{1}{2}mv^2 = \frac{\rho R^2 q}{4\varepsilon_0}$$

85. Answer (1)



(x << a) (α is acceleration)

$$F_{net} = -\left(\frac{kq_0Q}{(a-x)^2} - \frac{kQq_0}{(a+x)^2}\right)$$

$$m\alpha = -\frac{kq_0Q}{a^4}4ax$$

$$\Rightarrow \quad \alpha = -\frac{4kq_0Q}{ma^3}x$$

So, $T = 2\pi\sqrt{\frac{4\pi\varepsilon_0 ma^3}{4q_0Q}}$

or $T = \sqrt{\frac{4\pi^3\varepsilon_0 ma^3}{q_0Q}}$