Sri Pratyangira Institute

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Class 12

Electric Charges and Fields

Based on Coulomb's Force

1. If two charges q_1 and q_2 are separated with distance $'d'$ and placed in a medium of dielectric constant K. What will be the equivalent distance between charges in air for the same electrostatic force?

   (a) $d\sqrt{k}$ (b) $k\sqrt{d}$

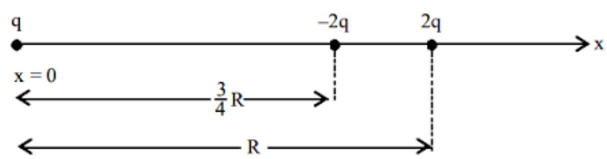
   (c) $1.5\, d\sqrt{k}$ (d) $2d\sqrt{k}$ [24 Jan 2023, (Shift - I)]

2. A $10\ \mu C$ charge is divided into two parts and placed at $1\ cm$ distance so that the repulsive force between them is maximum. The charges of the two parts are:

   (a) $9\ \mu C, 1\ \mu C$ (b) $5\ \mu C, 5\ \mu C$

   (c) $7\ \mu C, 3\ \mu C$ (d) $8\ \mu C, 2\ \mu C$ [13 April 2023 (Shift II)]

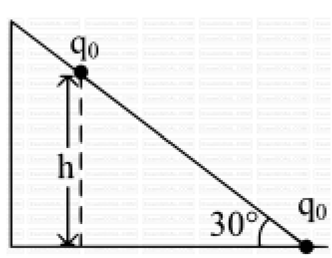
3. Three point charges $q, -2q$ and $2q$ are placed on x-axis at a distance $x = 0, x = \frac{3}{4}R$ and $x = R$ respectively from origin as shown. If $q = 2 \times 10^{-6}\ C$ and $R = 2\ cm$, the magnitude of net force experienced by the charge $-2q$ is ________N.



[13 April 2023, (Shift - II)]

4. As shown in the figure a configuration of two equal point charges $(q_0 = +2\mu C)$ is placed on an inclined plane. Mass of each point charge is $20\ g$. Assume that there is no friction between the charge and plane. For the system of two point charge to be in equilibrium (at rest) the height $h = x \times 10^{-3}\ m$. The value of x is ________ mm.

   $\left(\text{Take } \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{Nm}^2\text{C}^{-2}, \text{g} = 10\ \text{ms}^{-1}\right)$



[11 April 2023, (Shift - I)]

5. Two equal positive point charges are separated by a distance $2a$. The distance of a point from the centre of the line joining two charges on the equatorial line (perpendicular bisector) at which force experienced by a test charge q_0 becomes maximum is $\frac{a}{\sqrt{x}}$. The value of x is

[1 Feb 2023, (Shift - I)]

6. A point charge $q_1 = 4q_0$ is placed at origin. Another point charge $q_2 = -q_0$ is placed at $x = 12\ cm$. Charge of proton is q_0. The proton is placed on x-axis so that the electrostatic force on the proton is zero. In this situation, the position of the proton from the origin is ________ cm.

[29 Jan 2023, (Shift - I)]

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

(a) $3F/2$ (b) $3F/4$

(c) F (d) $2F$ **[29 July 2022, (Shift - II)]**

8. 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 Coulomb's force is

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

(c) $x = \frac{d}{\sqrt{2}}$ (d) $x = \frac{d}{2\sqrt{2}}$ **[29 June 2022, (Shift - II)]**

9. Two identical charge 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 $g = 10\ ms^{-2}$]

(a) $12\ cm$ (b) $10\ cm$

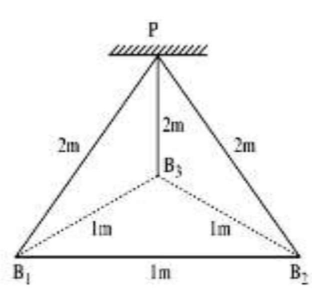
(c) $8\ cm$ (d) $5\ cm$ **[24 June 2022, (Shift - II)]**

10. A charge of $4\ \mu C$ 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 **[27 July 2022, (Shift - II)]**

(a) $1\mu C$ and $3\mu C$ (b) $2\mu C$ and $2\mu C$

(c) 0 and $4\mu C$ (d) $1.5\mu C$ and $2.5\ \mu C$

11. Three identical charged balls each of charge $2C$ 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 $1\ m$.



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

(a) $1:1$ (b) $1:4$

(c) $\sqrt{3}:2$ (d) $\sqrt{3}:1$ **[27 June, 2022 (Shift II)]**

12. Three point charges of magnitude $5\mu C$, $0.16\ \mu C$, and $0.3\mu C$ are located at the vertices A, B, C of a right angle 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. **[26 July, 2022 (Shift II)]**

13. A charge of $4\mu C$ 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 **[27 July, 2022 (Shift II)]**

(a) $1\mu C$ and $3\mu C$ (b) $2\mu C$ and $2\ \mu C$

(c) 0 and $4\mu C$ (d) $1.5\mu C$ and $2.5\ \mu C$

14. A disk of radius R with uniform positive charge density σ is placed on the xy plane with its centre at the origin. The coulomb potential along z-axis is

$$V(z) = \frac{\sigma}{2\varepsilon_0}\left(\sqrt{R^2 + z^2} - z\right)$$

A particle of positive charge q is placed initially at rest at a point on the z axis with $z - z_0$ and $z_0 > 0$. In addition to the coulomb force, the particle experiences a vertical force $F = -c\hat{k}$ with $c > 0$. Let $\beta = \frac{2c\varepsilon_0}{q\sigma}$. Which of the following statements is (are) correct?

(a) For $\beta = \frac{1}{4}$ and $z_0 = \frac{25}{7}R$, the particle reaches the origin

(b) For $\beta = \frac{1}{4}$ and $z_0 = \frac{3}{7}R$, the particle returns back to $z = z_0$

(c) For $\beta = \frac{1}{4}$ and $z_0 = \frac{R}{\sqrt{3}}$, the particle reaches the origin

(d) For $\beta > 1$ and $z_0 > 0$, the particle always reaches the origin. **[JEE Adv. 2022]**

15. 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 $'\theta'$ with the vertical?

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

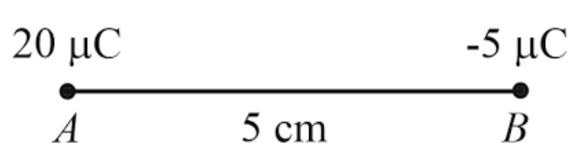
(c) $x = \left(\frac{q^2 l^2}{2\pi\varepsilon_0 m^2 g^2}\right)^{1/3}$ (d) $x = \left(\frac{q^2 l^2}{2\pi\varepsilon_0 m^2 g}\right)^{1/2}$ **[27 July, 2021 (Shift II)]**

16. A certain charge Q is divided into parts q and $(Q - q)$. How should the charges Q and q be divided so that q amd $(Q - q)$ placed at a certain distance apart experience maximum electrostatic repulsion?

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

(c) $Q = 2q$ (d) $Q = 3q$ **[20 July, 2021 (Shift I)]**

17. Two particles A and B having charges $20\ \mu C$ and $-5\ \mu C$ 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?



(a) At 5 cm from 20μC on the left side of the system
(b) At 1.25 cm from −5μC between two charges
(c) At midpoint between two charges
(d) At 5 cm from −5μC on the right side. **[31 Aug, 2021 (Shift I)]**

18. 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. Then charge on each of the sphere is $\frac{a}{21} \times 10^{-8}$ C. The value of $'a'$ will be ______________. **[25 Feb, 2021 (Shift II)]**

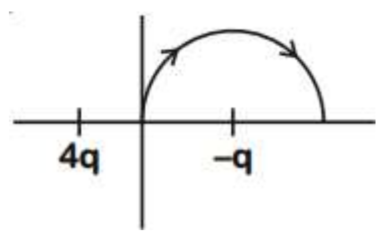
19. A particle of mass 1 mg and charge q is lying at the mid point of two stationary particles kept at a distance $'2\ m'$ when each is carrying same charge $'q'$. If the free charged particle is displaced from its equilibrium position through distance $'x'(x \ll 1m)$. The particle executes SHM. Its angular frequency of oscillation will be ___________ $\times 10^5$ rad/s if $q^2 = 10\ \mathrm{C}^2$.
[25 July, 2021 (Shift I)]

20. 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] **[25 Feb, 2021 (Shift II)]**

21. An oil drop of radius 2 mm with a density 3 gem^{-3} is held stationary under a constant electric field $3.55 \times 10^5\ \mathrm{Vm}^{-1}$ in the Milkman's oil drop experiment. What is the number of excess electrons that the oil drops will possess? (Consider $g = 9.81\ m/s^2$)
(a) 1.73×10^{10}
(b) 48.8×10^{11}
(c) 1.73×10^{12}
(d) 17.3×10^{10} **[18 Mar, 2021 (Shift I)]**

22. An infinite number of point charges, each carrying 1 μC charge, are placed along the y-axis at $y = 1\ m, 2m, 3m, 4m, 8m$. The total force on a 1 C point charge, placed at the origin, is $x \times 10^3$ N. The value of x to the nearest integer, is _____________. $\left[\text{Take } \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \frac{\mathrm{Nm}^2}{\mathrm{C}^2}\right]$
[18 Mar, 2021 (Shift II)]

23. A two point charges $4q$ and $-q$ are fixed on the x-axis at $x = -\frac{d}{2}$ and $x = \frac{d}{2}$, respectively. If a third point charge $'q'$ is taken from the origin to $x = d$ along the semicircle as shown in the figure, the energy of the charge will



[4 Mar, 2020 (Shift I)]

(a) Decrease by $\frac{q^2}{4\pi\varepsilon_0 d}$
(b) Decrease by $\frac{4q^2}{3\pi\varepsilon_0 d}$
(c) Increase by $\frac{2q^2}{3\pi\varepsilon_0 d}$
(d) Increase by $\frac{3q^2}{4\pi\varepsilon_0 d}$

24. 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?
(a) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ for all r
(b) $F = \frac{1}{4\pi\varepsilon_0}\frac{qQ}{R^2} > F > 0$ for $r < R$
(c) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ for $r > R$

(d) $F = \frac{1}{4\pi\varepsilon_0}\frac{Qq}{r^2}$ for $r < R$ **[6 Sep, 2020 (Shift II)]**

25. Two identical non-conducting solid spheres of same mass and charge are suspended in air from a common point by two non-conducting, massless strings of same length. At equilibrium, the angle between the string is α. The spheres are now immersed in a dielectric liquid of density 800 kg/m^3 and dielectric constant 21. If the angle between the strings remains the same after the immersion, then
    (a) Electric force between the spheres remains unchanged
    (b) Electric force between the sphere reduces
    (c) Mass density of the spheres is 840 kg m^{-3}
    (d) The tension in the strings holding the spheres remains unchanged. **[JEE Adv. 2020]**

26. 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
    (a) $a = \frac{3R}{2^{1/4}}$
    (b) $a = R/\sqrt{3}$
    (c) $a = 8^{-1/4}R$
    (d) $a = 2^{-1/4}R$ **[12 April 2019 (Shift II)]**

27. 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
    (a) $-Q/4$
    (b) $+Q/2$
    (c) $+Q/4$
    (d) $-Q/2$ **[9 Jan, 2019 (Shift I)]**

28. Charge is distributed within a sphere of radius R with a volume charge density $\rho(r) = \frac{A}{r^2}e^{-2r/a}$, where A and a are constants. If Q is the total charge of this charge distribution the radius R is
    (a) $a\log\left(1 - \frac{Q}{2\pi aA}\right)$
    (b) $\frac{a}{2}\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$
    (c) $a\log\left(\frac{1}{1-\frac{Q}{2\pi aA}}\right)$
    (d) $\frac{a}{2}\log\left(1 - \frac{1}{2\pi aA}\right)$ **[9 Jan, 2019 (Shift II)]**

29. The bob of a simple pendulum has mass $2\ g$ and a charge of $5.0\ \mu\text{C}$. It is at rest in a uniform horizontal electric field of intensity 2000 V/m. At equilibrium, the angle that the pendulum makes with the vertical is (Take $\text{g} = 10 \text{ m/s}^2$) **[8 April, 2019 (Shift I)]**
    (a) $\tan^{-1}(5.0)$
    (b) $\tan^{-1}(2.0)$
    (c) $\tan^{-1}(0.5)$
    (d) $\tan^{-1}(0.2)$

30. A point charge of $10\mu C$ is placed at the origin. At what location on the X-axis should be a point charge of $40\mu C$ be placed so that the net electric field is zero at $x = 2\ cm$ in the X-axis?

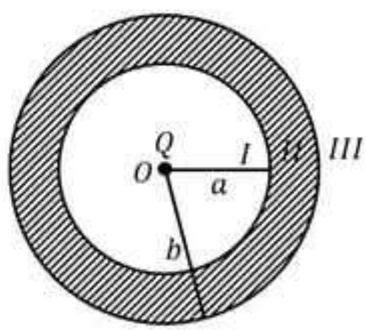
(a) $x = 6\ cm$ (b) $x = 4\ cm$

(c) $x = 8\ cm$ (d) $x = -4\ cm$

31. As shown in the figure, a point charge Q is placed at the centre of conducting spherical shell of inner radius a and outer radius b. The electric field due to charge Q in three different regions I, II and III is given by: $(I : r < a, II : a < r < b, III : r < b)$

(a) $E_I = 0, E_{II} = 0, E_{III} \neq 0$ (b) $E_1 \neq 0, E_{II} = 0, E_{III} \neq 0$

(c) $E_I \neq 0, E_{II} = 0, E_{III} = 0$ (d) $E_I = 0, E_{II} = 0, E_{III} = 0$

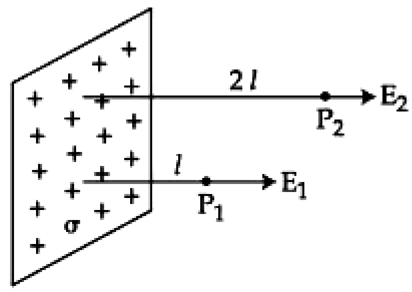


32. A thin infinite sheet charge and an infinite line charge of respective charge densities $+\sigma$ and $+\lambda$ are placed parallel at $5\ m$ distance from each other. Points $'P'$ and $'Q'$ are at $\frac{3}{\pi}\ m$ and $\frac{4}{\pi}\ m$ perpendicular distance from line charge towards sheet charge, respectively. $'E_p'$ and $'E_Q'$ are the magnitudes of resultant electric field intensities at point $'P'$ and $'Q'$ respectively. If $\frac{E_P}{E_Q} = \frac{4}{a}$ for $2|\sigma| = |\lambda|$. Then the value of a is ___________.

33. Two point charges A and B of magnitude $+8 \times 10^{-6}$ 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

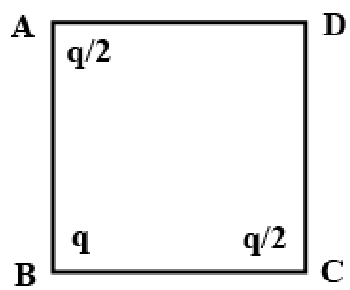
(a) $2.0\ m$ (b) $3.0\ m$
(c) $1.0\ m$ (d) $4.0\ m$

34. 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 at P_1 and P_2 respectively are



(a) $E_1 = \sigma/\varepsilon_0, E_2 = \sigma/2\varepsilon_0$ (b) $E_1 = 2\sigma/\varepsilon_0, E_2 = \sigma/\varepsilon_0$
(c) $E_1 = E_2 = \sigma/2\varepsilon_0$ (d) $E_1 = E_2 = \sigma/\varepsilon_0$

35. The three charge $q/2, q$ and $q/2$ are placed at the corners A, B and C of a square of side $'a'$ as shown in the figure. The magnitude of electric field (E) at the corner D of the square, is



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

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

36. An oil drop of radius 2 mm with a density 3 gcm^{-3} Is held stationary under a constant electric field $3.55\ \times 10^5$ Vm^{-1} in the Milkman's oil drop experiment. What is the number if excess electrons that the oil drop will possess? (Consider $g = 9.81\ m/s^2$)

(a) 1.73×10^{10} (b) 48.8×10^{13}

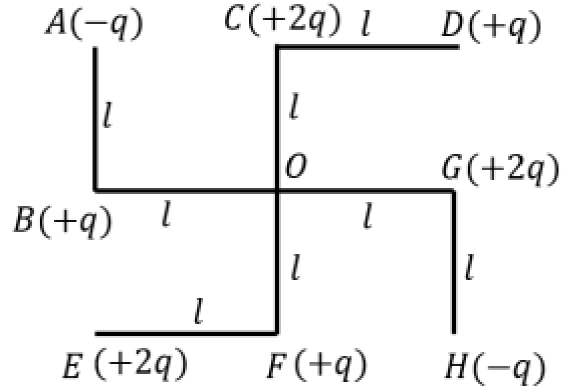
(c) 1.73×10^{12} (d) 17.3×10^{10}

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

(a) $E = \frac{\sigma}{2\varepsilon_0}\left(1 + \frac{Z}{(Z^2+R^2)^{\frac{1}{2}}}\right)$ (b) $E = \frac{\sigma}{2\varepsilon_0}\left(1 + \frac{Z}{(Z^2+R^2)^{\frac{1}{2}}}\right)$

(c) $E = \frac{2\varepsilon_0}{\sigma}\left(\frac{1}{(Z^2+R^2)^{\frac{1}{2}}} + Z\right)$ (d) $E = \frac{\sigma}{2\varepsilon_0}\left(\frac{1}{(Z^2+R^2)} + \frac{1}{Z^2}\right)$

38. 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?



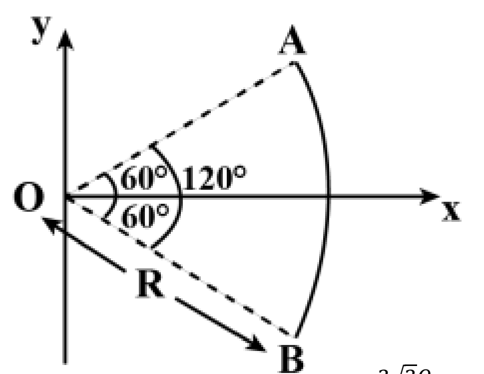
(a) $\frac{1}{4\pi\varepsilon_0}\frac{q}{(2l^2)}\left(2\sqrt{2}-1\right)$

(b) $\frac{q}{4\pi\varepsilon_0(2l)^2}$

(c) $\frac{1}{4\pi\varepsilon_0}\frac{q}{l^2}$

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

39. 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?



(a) $\frac{3\sqrt{3}Q}{8\pi^2\varepsilon_0R^2}(-\hat{\imath})$

(b) $\frac{3\sqrt{3}Q}{8\pi^2\varepsilon_0R^2}(\hat{\imath})$

(c) $\frac{3\sqrt{3}Q}{8\pi\varepsilon_0R^2}(\hat{\imath})$

(d) $\frac{3\sqrt{3}Q}{16\pi^2\varepsilon_0R^2}(\hat{\imath})$

40. A current of $5\ \mathrm{A}$ is passing through a non-linear magnesium wire of cross-section $0.04\ m^2$. At every point the direction of current density is at an angle of $60°$ with the unit vector of area of cross-section. The magnitude of electric field at every point of the conductor is

(Resistivity of magnesium, $\rho = 44 \times 10^{-8}\ \Omega m$)

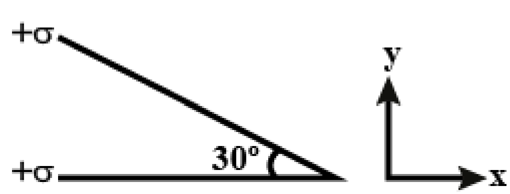
(a) $11 \times 10^{-7}\ \mathrm{V/m}$

(b) $11 \times 10^{-2}\ \mathrm{V/m}$

(c) $11 \times 10^{-5}\ \mathrm{V/m}$

(d) $11 \times 10^{-3}\ \mathrm{V/m}$

41. 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:



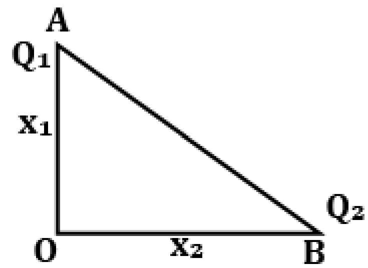
(a) $\frac{\sigma}{2\varepsilon_0}\left[\left(1-\frac{\sqrt{3}}{2}\right)\hat{y}-\frac{\hat{x}}{2}\right]$

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

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

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

42. 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



(a) $\frac{x_1^3}{x_2^3}$

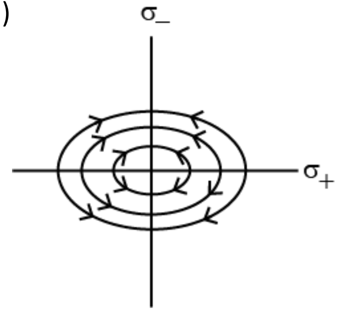
(b) x_2^2

(c) $\frac{x_1}{x_2}$

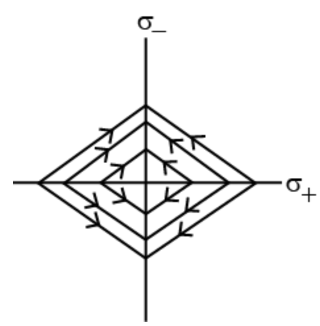
(d) $\frac{x_2}{x_1}$

43. 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?

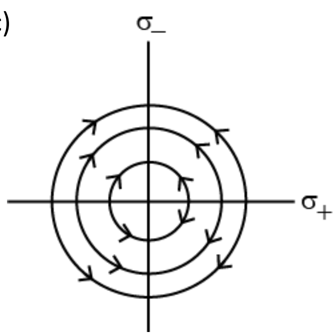
(a)



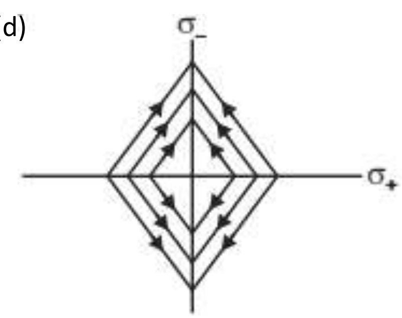
(b)



(c)



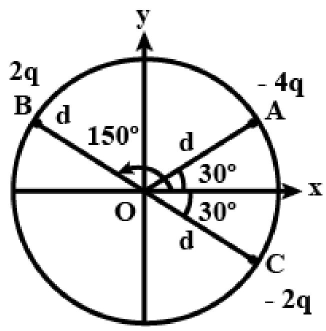
(d)



[JEE Main Sept 20]

44. 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 form an equilateral triangle as shown in the figure. Electric field at O along x-direction is

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



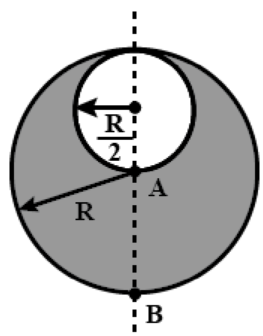
(b) $\frac{3\sqrt{3}q}{4\pi\varepsilon_0 d^2}$

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

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

[JEE Main Sept 20]

45. 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 $\left|\frac{\overrightarrow{E_A}}{\overrightarrow{E_B}}\right|$ of magnitude of electric field $\overrightarrow{E_A}$ and $\overrightarrow{E_B}$ respectively, at points A and B due to the remaining portion is



(a) $\frac{18}{34}$

(b) $\frac{21}{34}$

(c) $\frac{17}{54}$

(d) $\frac{9}{17}$ [JEE Main Jan 20]

46. Suppose the intensity of a laser is $\left(\frac{315}{\pi}\right) W/m^2$. The rms electric field, in units of V/m associated with this source is close to the nearest integer is
$(\varepsilon_0 = 8.86 \times 10^{-12} C^2 Nm^{-2}; c = 3 \times 10^8\ ms^{-1})$

47. Two point charges $q_1(\sqrt{10}\ \mu C)$ 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,

(a) $(63\hat{\imath} - 27\hat{\imath}) \times 10^2$

(b) $(-63\hat{\imath} - 27\hat{\imath}) \times 10^2$

(c) $(81\hat{\imath} - 81\hat{\imath}) \times 10^2$

(d) $(-81\hat{\imath} - 81\hat{\imath}) \times 10^2$

48. 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

(a) $\frac{R}{\sqrt{5}}$

(b) $\frac{R}{\sqrt{2}}$

(c) R

(d) $R\sqrt{2}$

49. Four 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 $D \gg d$, will vary as

(a) $E \propto \frac{1}{D}$

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

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

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

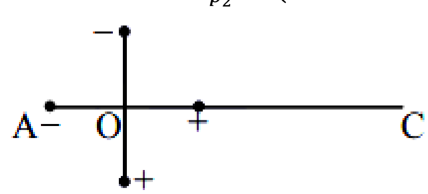
50. The electric field due to a short electric dipole at a large distance (r) from centre of dipole on the equatorial plane varies with distance as:

(a) r (b) $\frac{1}{r}$

(c) $\frac{1}{r^3}$ (d) $\frac{1}{r^2}$

51. Two charges each of magnitude 0.01 C and separated by a distance of $0.4\ mm$ constitute an electric dipole. If the dipole is placed in an uniform electric field $'\vec{E}'$ of 10 dyne/C making $30°$ angle with $\vec{E}$, the magnitude of torque acting on dipole is
(a) 4.0×10^{-10} Nm (b) 2.0×10^{-10} Nm
(c) 1.0×10^{-8} Nm (d) 1.5×10^{-9} Nm
52. A dipole comprises of two charged particles of identical magnitude q and opposite in nature. The mass m of the positive charged particle is half of the mass of the negative charged particle. The two charges are separated by a distance l. If the dipole is placed in a uniform electric field $\vec{E}$; such a way that dipole axis makes a very small angle with the electric field $\vec{E}$. The angular frequency of the oscillations of the dipole when released is given by:
(a) $\sqrt{\frac{8qqE}{3ml}}$ (b) $\sqrt{\frac{4qE}{ml}}$
(c) $\sqrt{\frac{4qE}{3ml}}$ (d) $\sqrt{\frac{8qE}{ml}}$
53. An electric dipole of dipole moment is $6.0 \times 10^{-6}\ cm$ placed in a uniform electric field of $1.5 \times 10^3\ \text{NC}^{-1}$ in such a way that dipole moment is along electric field. The work done in rotating dipole by $180°$ in this field will be ____________ mJ
54. 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 change 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:

(a) Both Statement I and Statement II are true
(b) Both Statement I and Statement II are false
(c) Statement I is true but Statement II is false
(d) Statement I is false but Statement II is true
55. Two electric dipoles of dipole moments 1.2×10^{-50} and $2.4 \times 10^{-3}\ cm$ are placed in two different uniform electric field of strengths $5 \times 10^6\ \text{NC}^{-1}$ and $15 \times 10^4\ \text{NC}^{-1}$ respectively. The ratio of maximum torque experienced by the electric dipoles will be $\frac{1}{x}$. The value of x is __________.
56. 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 37° with the axis.
The ratio of the dipole moment of A and B, $\frac{p_1}{p_2}$ is: $\left(\text{take } \sin 37° = \frac{3}{5}\right)$



(a) $\frac{3}{8}$ (b) $\frac{3}{2}$

(c) $\frac{4}{3}$ (d) $\frac{2}{3}$

57. An electric dipole is placed on x-axis in proximity to a line charge of linear density $3.0 \times 10^{-6} C/m$. 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 charge of the dipole.

(a) 0.485 mC (b) 8.8 μC

(c) 815.1 nC (d) 4.44 μC

58. Two identical electric point dipoles have dipole moments $\overrightarrow{p_1} = p\hat{\imath}$ and $\overrightarrow{p_2} = -p\hat{\imath}$ are held on 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

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

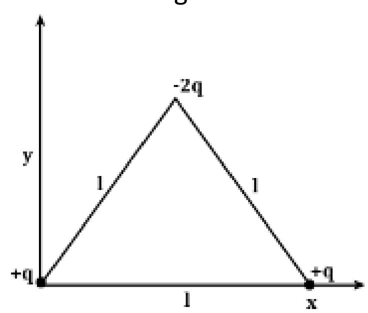
(c) $\frac{p}{a}\sqrt{\frac{2}{\pi\varepsilon_0 ma}}$ (d) $\frac{p}{a}\sqrt{\frac{3}{2\pi\varepsilon_0 ma}}$

59. An electric dipole of moment $\vec{p} = \left(-\hat{\imath} - 3\hat{\jmath} + 2\hat{k}\right) \times 10^{-29}$ C. m. is at the origin $(0,0,0)$. The electric field due to this dipole at $\vec{r} = (\hat{\imath} + 3\hat{\jmath} + 5\hat{k})$ (note that $\vec{r}.\vec{p} = 0$) is parallel to

(a) $\left(\hat{\imath} + 3\hat{\jmath} - 2\hat{k}\right)$ (b) $\left(-\hat{\imath} + 3\hat{\jmath} - 2\hat{k}\right)$

(c) $(+\hat{\imath} - 3\hat{\jmath} - 2\hat{k})$ (d) $(-\hat{\imath} - 3\hat{\jmath} + 2\hat{k})$

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



(a) $\sqrt{3}ql\frac{\hat{\jmath}-\hat{\imath}}{\sqrt{2}}$ (b) $(ql)\frac{\hat{\imath}+\hat{\jmath}}{\sqrt{2}}$

(c) $2ql\hat{\jmath}$ (d) $-\sqrt{3}ql\hat{\jmath}$

61. A point dipole $\vec{p} = -p_0\hat{x}$ is kept at the origin. The potential and electric field due to this dipole on the y-axis at a distance d are, respectively

(Take $V = 0$ at infinity)

(a) $\frac{|\vec{p}|}{4\pi\varepsilon_0 d^2}, \frac{\vec{p}}{4\pi\varepsilon_0 d^3}$ (b) $\frac{|\vec{p}|}{4\pi\varepsilon_0 d^2}, \frac{-\vec{p}}{4\pi\varepsilon_0 d^3}$

(b) $0, \frac{-\vec{p}}{4\pi\varepsilon_0 d^3}$ (d) $0, \frac{\vec{p}}{4\pi\varepsilon_0 d^3}$

62. 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

(a) $\sqrt{\frac{qE}{2md}}$ (b) $2\sqrt{\frac{qE}{md}}$

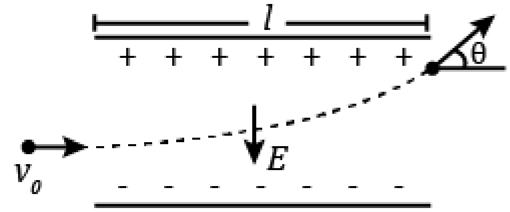
(c) $\sqrt{\frac{2qE}{md}}$ (d) $\sqrt{\frac{qE}{md}}$

63. A point charge of 2×10^{-2} C is moved from P to S in a uniform electric field of $30\ N/C$ directed along positive x-axis. If coordinates of P and S are $(1, 2, 0)\ m$ and $(0, 0, 0)m$ respectively, the work done by electric field

(a) 1200 mJ (b) 600 mJ

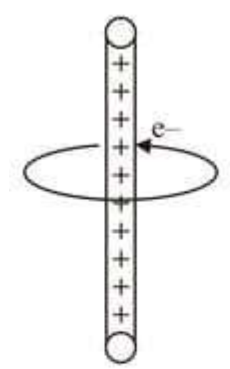
(c) -600 mJ (d) -1200 m

64. A uniform electric field of 10 N/C is created between two parallel charged plates (as shown in figure). An electron enters the field symmetrically between the plates with a kinetic energy 0.5eV. The length of each plate is $10\ cm$. The angle (θ) of deviation of the path of electron as it comes out of the field (in degree).



65. A stream of a positively charged particles having $\frac{q}{m} = 2 \times 10^{11} \frac{\text{C}}{\text{Kg}}$ and velocity $\overrightarrow{v_0} = 3 \times 10^7\ \hat{\imath}\ m/s$ is deflected by an electric field $1.8\ \hat{\jmath}k\ V/m$. The electric field exists in a region of $10\ cm$ along x direction. Due to the electric field, the deflection of the charge particle in the y direction is ____________ mm.

66. An electron revolves around an infinite cylindrical wire having uniform linear charge density $2 \times 10^{-8}\ cm^{-1}$ in circular path under the influence of attractive electrostatic field as shown in the figure. The velocity of electron with which it is revolving is __________ $\times 10^6$ ms^{-1}. Given mass of electron $= 9 \times 10^{-31}$ kg.

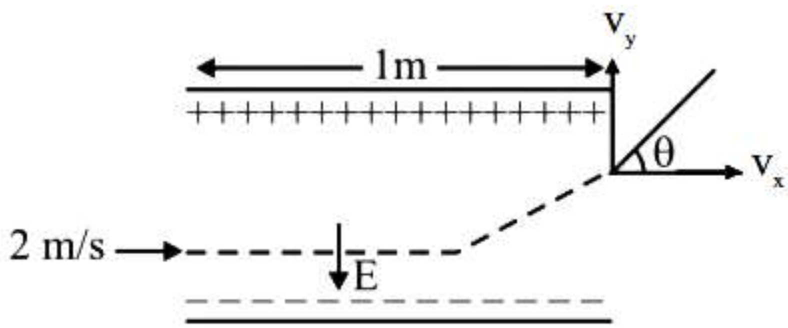


67. A vertical electric field of magnitude 4.9×10^5 N/C just prevents a water droplet of a mass $0.1\ g$ from falling. The value of charge on the droplet will be: Give $g = 9.8\ m/s^2$)

(a) 1.6×10^{-9} C (b) 2.0×10^{-9} C

(c) 3.2×10^{-9} C (d) 0.5×10^{-9} C

68. 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 electrons enters the field symmetrically between the plates with a speed of $2\ m/s$. The angle of deviation (θ) of the path of the electrons as it comes out of the field will be ________.



(a) $\tan^{-1}(4)$ (b) $\tan^{-1}(2)$

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

69. 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:

(a) $\frac{\rho q R^2}{4\varepsilon_0}$ (b) $\frac{\rho q R^2}{2\varepsilon_0}$

(c) $\frac{q\rho}{4\varepsilon_0 R^2}$ (d) $\frac{4\varepsilon_0 R^2}{q\rho}$

70. A positive charge particle of mass $100\ mg$ is thrown in opposite direction to a uniform electric field of strength $1 \times 10^5\ \mathrm{NC^{-1}}$. If the charge on the particle is $40\ \mu\mathrm{C}$ and the initial velocity is $200\ ms^{-1}$, how much distance it will travel before coming to the rest momentarily:

(a) $1\ m$ (b) $5\ m$

(c) $10\ m$ (d) $0.5\ m$

71. A body having specific charge $8\ \mu\mathrm{C/g}$ 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 $100\ \mathrm{V/m}$ 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.

72. A charge 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

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

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

73. 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 consonants. 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

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

(c) $\sqrt{\frac{1}{a}}$ (d) a

74. An electron of mass m and magnitude of charge $|e|$ initially at rest gets accelerated by a constant electric field E. The rate of charge of de-Broglie wavelength of the electron at time t ignoring relativistic effects is

(a) $-\frac{h}{|e|Et}$ (b) $-\frac{h}{|e|E\sqrt{t}}$

(c) $-\frac{h}{|e|Et^2}$ (d) $\frac{|e|Et}{h}$

75. 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 its is correctly given by (graphs are schematic and not drawn to scale)

76. 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 them correctly describe the trajectory of the mass? (Curves are drawn schematically and are not to scale).

77. A uniform electric field $\vec{E} = -40\sqrt{3}\hat{y}\text{NC}^{-1}$ is applied on a region. A charged particle of mass m carrying positive charge q is projected in this region with an initial speed of $2\sqrt{10} \times 10^6\ ms^{-1}$. This particle is aimed to hit a target T, which is $5\ m$ away from its entry point into the field as shown schematically in the figure. Take $\frac{q}{m} = 10^{10}\ \text{CKg}^{-1}$. Then

(a) The particle will hit T if projected at an angle $45°$ from the horizontal

(b) The particle will hit T if projected either at an angle $30°$ or $60°$ from the horizontal

(c) Time taken by the particle to hit T could be $\sqrt{\frac{5}{6}}\,\mu s$ as well as $\sqrt{\frac{5}{3}}\,\mu s$

(d) Time taken by the particle to hit T is $\sqrt{\frac{5}{6}}\,\mu s$

78. Two large circular discs separated by a distance of $0.01\ m$ are connected to a battery via a switch as shown in the figure. Charged oil drops of density $900\ kg\ m^{-3}$ are released through a tiny hole at the center of the top disc. Once some oil drops achieve terminal velocity, the switch is closed to apply a voltage of 200 V across the discs. As a result, an oil drops of radius $8 \times 10^{-7}\ m$ stops moving vertically and floats between the discs. The number of electrons present in this oil drop is ____________.
(Neglect the buoyancy force, take acceleration due to gravity $= 10\ ms^{-2}$ and charge on an electron $(e) = 1.6 \times 10^{-19}$ C)

79. A positive point charge is released from rest at a distance r_0 from a positive line charge with uniform density. The speed (v) of the point charge, as a function of instantaneous distance r from line charge, is proportional to

(a) $v \propto \sqrt{\ln\left(\frac{r}{r_0}\right)}$ (b) $v \propto e^{+\frac{r}{r_0}}$

(c) $v \propto \ln\left(\frac{r}{r_0}\right)$ (d) $v \propto \left(\frac{r}{r_0}\right)$

80. A uniformly charged ring of radius $3a$ and total charge q is placed in xy-plane centred at origin. A point charge q is moving towards the ring along the z-axis and has speed v at $z = 4a$. The minimum value of v such that it crosses the origin is:

(a) $\sqrt{\frac{2}{m}}\left(\frac{1}{5}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$ (b) $\sqrt{\frac{2}{m}}\left(\frac{1}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$

(c) $\sqrt{\frac{2}{m}}\left(\frac{4}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$ (d) $\sqrt{\frac{2}{m}}\left(\frac{2}{15}\frac{q^2}{4\pi\varepsilon_0 a}\right)^{1/2}$

81. In free space, a particle A of charge $1\ \mu C$ is held fixed P. Another particle B of the same charge and mass $4\mu g$ is kept at a distance of $1\ mm$ from P. If B is released then its velocity at a distance of $9\ mm$ from P is
[Take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ Nm^2C^{-2}$]

(a) $1.5 \times 10^2\ m/s$ (b) $2.0 \times 10^3\ m/s$

(c) $1.0\ m/s$ (d) $3.0 \times 10^4\ m/s$

82. In a cuboid of dimension $2L \times 2L \times L$, a charge q is placed at the centre of the surface $'S'$ having area of $4L^2$. The flux through the opposite surface to $'S'$ is given by

(a) $\frac{q}{12\varepsilon_0}$ (b) $\frac{q}{3\varepsilon_0}$

(c) $\frac{q}{2\varepsilon_0}$ (d) $\frac{q}{6\varepsilon_0}$

83. Expression for an electric field is given by $\vec{E} = 4000x^2\hat{i}\frac{V}{m}$. The electric flux through the cube of side $20\ cm$ when placed in electric field (as shown in the figure) is _____________ V cm.

84. 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

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

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

85. A charge q is surrounded by a closed surface consisting of an inverted cone of height h and base radius R as shown in the figure. The electric flux through the conical surface is $\frac{nq}{6\varepsilon_0}$ (in SI units). The value of n is ____________.

86. A charge $'q'$ is placed at one corner of a cube as shown in figure. The flux of electrostatic field E through the shaded area is

(a) $\frac{q}{48\,\varepsilon_0}$ (b) $\frac{q}{8\,\varepsilon_0}$

(c) $\frac{q}{24\,\varepsilon_0}$ (d) $\frac{q}{4\,\varepsilon_0}$

87. 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 option given below:

(a) Statement-I is true but Statement-II is false.
(b) Statement-I is false but Statement-II is true.
(c) Both Statement-I and Statement-II are true.
(d) Both Statement-I and Statement-II are false.

88. A point charge of $+12\mu\text{C}$ is at a distance $6\ cm$ vertically above the centre of a squared of side $12\ cm$ as shown in figure. The magnitude of the electric flux through the square will be _______________$\times 10^3\ \text{Nm}^2/\text{C}$.

89. The total charge enclosed in an incremental volume of $2 \times 10^{-9}\ m^3$ located at the origin is ___________ nC. If electric flux density of its field is found as

$$\vec{D} = e^{-x}\sin y\,\hat{\imath} - e^{-x}\cos y\,\hat{\jmath} + 2z\hat{k}\,\frac{C}{m^2}$$

90. The electric field in a region is given by $\vec{E} = \left(\frac{3}{5}E_0\hat{\imath} + \frac{4}{5}E_0\hat{\jmath}\right)\frac{N}{c}$. 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 $a =$ __________________ (round off to nearest integer) [Here $\hat{\imath}, \hat{\jmath}$ and $\hat{k}$ are unit vectors along x, y and z axes respectively]

91. The electric field in a region is given by $\vec{E} = \left(\frac{2}{5}\,E_0\hat{\imath} + \frac{3}{5}\,E_0\hat{\jmath}\right)$ with $E_0 = 4.0 \times 10^3\,\frac{\text{N}}{\text{C}}$. The flux of the field through a rectangular surface area $0.4\ m^2$ parallel to the $Y - Z$ plane is ____________ Nm^2C^{-1}.

92. An electric field $\vec{E} = 4x\hat{\imath} - (y^2 + 1)\hat{\jmath}\ N/C$ passes through the box shown in figure. The flux of the electric field through surface $ABCD$ and $BCGF$ and marked as $(\phi_1 - \phi_2)$ is $(in\ \text{Nm}^2/C)$

93. A circular disc of radius R carries surface charge density $\sigma(r) = \sigma_0\left(1 - \frac{r}{R}\right)$, where σ_0 is a constant and r is the distance from the centre of the disc. Electric flux through a large spherical surface that encloses the charged disc completely is ϕ_0. Electric flux through another spherical surface of radius $\frac{R}{4}$ and concentric with the disc is ϕ. Then the ratio $\frac{\phi_0}{\phi}$ is

94. A charged shell of radius R carries a total charge Q. Given ϕ as the flux of electric field through a closed cylindrical surface of height h, radius r and with its center same as that of the shell. Here, center of the cylinder which is equidistant from its top and bottom surfaces. Which of the following option(s) is/are correct [ε_0 is the permittivity of free space]

(a) If $h > 2R$ and $r > R$ then $\phi = \frac{Q}{\varepsilon_0}$

(b) If $h < \frac{8R}{5}$ and $r = \frac{3R}{5}$ then $\phi = 0$

(c) If $h > 2R$ and $r = \frac{4R}{5}$ then $\phi = \frac{Q}{5\varepsilon_0}$

(d) If $h > 2R$ and $r = \frac{3R}{5}$ then $\phi = \frac{Q}{5\varepsilon_0}$

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
(a)	(b)	(5440)	[300]	[2]	[24]	(b)	(d)	(a)	(b)
11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
(d)	[17]	(b)	(a,c, d)	(b)	21.	22.	23.	24.	25.
26.	27.	28.	29.	30.	31.	32.	33.	34.	35.
36.	37.	38.	39.	40.	41.	42.	43.	44.	45.
46.	47.	48.	49.	50.	51.	52.	53.	54.	55.
56.	57.	58.	59.	60.	61.	62.	63.	64.	65.
66.	67.	68.	69.	70.	71.	72.	73.	74.	75.
76.	77.	78.	79.	80.	81.	82.	83.	84.	85.
86.	87.	88.	89.	90.	91.	92.	93.	94.	95.