1

Electric Charges and Fields

Single Correct Type Questions

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*) $1.5d\sqrt{k}$ (*d*) $2d\sqrt{k}$

2. A 10 μC 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 μC, 1 μC (*b*) 5 μC, 5 μC

(*c*) 7 μC, 3 μC (*d*) 8 μC, 2 μC

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

4. A charge of 4μC 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:

(*a*) 1μC and 3μC (*b*) 2μC and 2μC

(*c*) 0 and 4μC (*d*) 1.5μC and 2.5μC

5. 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 'θ' with the vertical?

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

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

(*c*) $x = \left(\frac{q^2\ell^2}{2\pi\varepsilon_0 m^2 g^2}\right)^{1/3}$

(*d*) $x = \left(\frac{q^2\ell^2}{2\pi\varepsilon_0 m^2 g}\right)^{1/3}$

6. A certain charge Q is divided into 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?

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

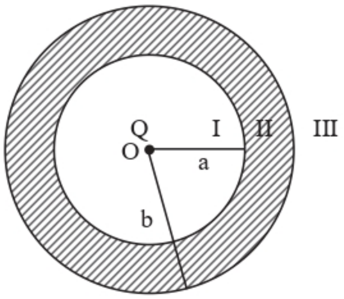
(*c*) $Q = 2q$ (*d*) $Q = 3q$

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

(*a*) x = 6 cm (*b*) x = 4 cm

(*c*) x = 8 cm (*d*) x = –4 cm

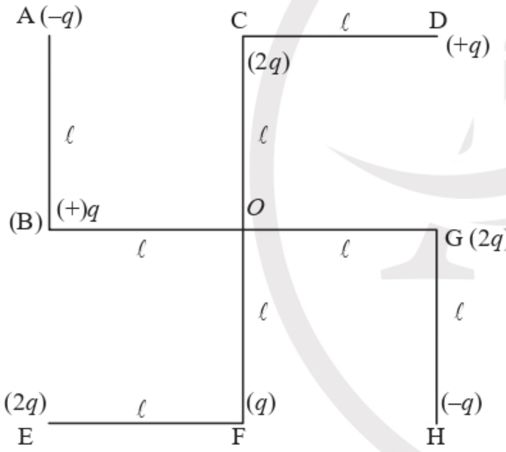
8. As shown in the figure, a point charge Q is placed at the centre of conducting spherical shell of inner radius a and outer radius b. The electric field due to charge Q in three different regions I, II and III is given by: ($I : r < a$, $II : a < r < b$, $III : r < b$)



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

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

9. 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?



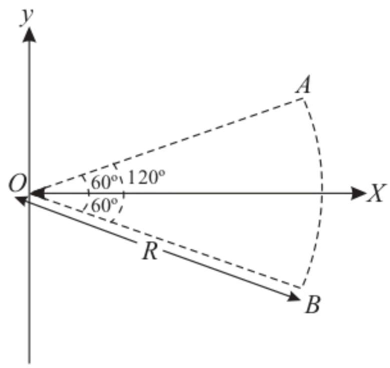
(a) $\frac{1}{4\pi\varepsilon_0}\frac{q}{(2\ell^2)}\left(2\sqrt{2}-1\right)$

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

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

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

10. 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?



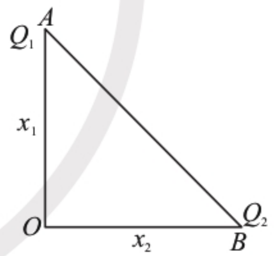
(a) $\frac{3\sqrt{3}Q}{8\pi^2\varepsilon_0 R^2}(-\hat{i})$

(b) $\frac{3\sqrt{3}Q}{8\pi^2\varepsilon_0 R^2}(\hat{i})$

(c) $\frac{3\sqrt{3}Q}{8\pi\varepsilon_0 R^2}(\hat{i})$

(d) $\frac{3\sqrt{3}Q}{16\pi^2\varepsilon_0 R^2}(\hat{i})$

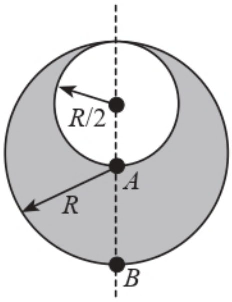
11. Charges Q_1 and Q_2 are at points A and B of a right angle triangle OAB (see figure). The resultant electric field at point O is perpendicular to the hypotenuse, then Q_1/Q_2 is proportional to



(a) $\frac{x_1^3}{x_2^3}$ (b) $\frac{x_2^2}{x_1^2}$

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

12. Consider a sphere of radius R which carries a uniform charge density ρ. If a sphere of radius $R/2$ 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 point A and B due to the remaining portion is:



(a) $\frac{18}{34}$ (b) $\frac{17}{54}$

(c) $\frac{18}{54}$ (d) $\frac{21}{34}$

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

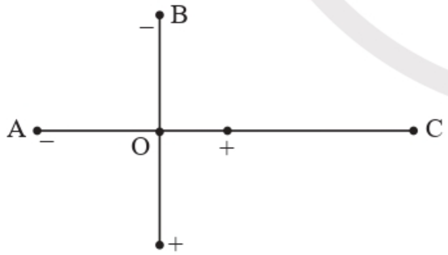
(a) $\frac{R}{\sqrt{5}}$ (b) $\frac{R}{\sqrt{2}}$

(c) R (d) $R\sqrt{2}$

14. 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 $\sin 37^\circ = \frac{3}{5}$)



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

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

15. An electric dipole is placed on x – axis in proximity to a line charge of linear 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 charge of the dipole.

(a) 0.485 mC (b) 8.8 μC
(c) 815.1nC (d) 4.44 μC

16. Two identical electric point dipoles have dipole moments $\vec{p_1} = p\hat{i}$ and $\vec{p_2} = -p\hat{i}$ 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:

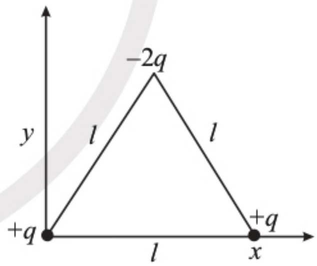
(a) $\frac{p}{a}\sqrt{\frac{1}{\pi \epsilon_0 ma}}$

(b) $\frac{p}{a}\sqrt{\frac{1}{2\pi \epsilon_0 ma}}$

(c) $\frac{p}{a}\sqrt{\frac{2}{\pi \epsilon_0 ma}}$

(d) $\frac{p}{a}\sqrt{\frac{3}{2\pi \epsilon_0 ma}}$

17. 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) $\sqrt{3}ql\frac{\hat{j}-\hat{i}}{\sqrt{2}}$ (b) $(ql)\frac{\hat{i}+\hat{j}}{\sqrt{2}}$

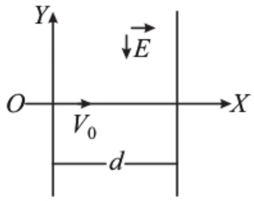
(c) $2ql\hat{j}$ (d) $-\sqrt{3}ql\hat{j}$

18. 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 will be

(a) 1200 mJ (b) 600 mJ

(c) –600 mJ (d) –1200 m

19. 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



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

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

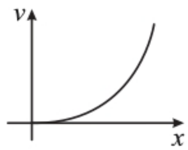
20. A particle of charge q and mass m is subjected to an electric field $E = E_0(1 - ax^2)$ in the x-direction, where a and E_0 are constants. Initially the particle was at rest at $x = 0$. Other than the initial position the kinetic energy of the particle becomes zero when the distance of the particle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

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

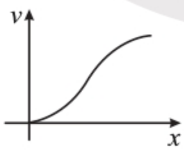
(c) $\sqrt{\dfrac{1}{a}}$ (d) a

21. 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)

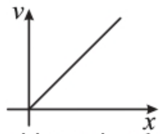
(a)



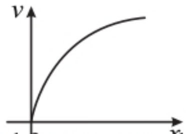
(b)



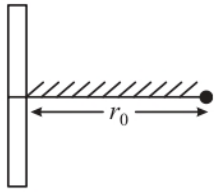
(c)



(d)



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

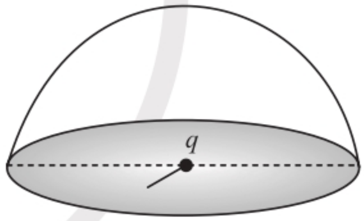
(c) $v \propto \ln\left(\dfrac{r}{r_0}\right)$ (d) $v \propto \left(\dfrac{r}{r_0}\right)$

23. 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) $\dfrac{q}{12\varepsilon_0}$ (b) $\dfrac{q}{3\varepsilon_0}$

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

24. If a charge q is placed at the center of a closed hemi-spherical non-conducting surface, just inside the flat surface the total flux passing through the flat surface would be

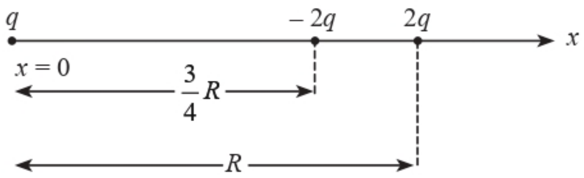


(a) $\dfrac{q}{\epsilon_0}$ (b) $\dfrac{q}{2\epsilon_0}$

(c) $\dfrac{q}{4\epsilon_0}$ (d) $\dfrac{q}{2\pi\epsilon_0}$

Integer Type Questions

25. Three point charges q, $-2q$ and $2q$ are placed on x-axis at a distance $x = 0, x = \dfrac{3}{4}R$ 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.



26. 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*.

27. Two identical conducting spheres with negligible volume have 2.1nC 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 $\left[\text{Given}: 4\pi \epsilon_0 = \frac{1}{9\times10^9} \text{SI Unit}\right]$

28. A stream of a positively charged particles having $\frac{q}{m} = 2\times10^{11}\frac{C}{kg}$ and velocity $\vec{v}_0 = 3\times10^7\hat{i}m/s$ is deflected by an electric field $1.8\hat{j}kV/m$. The electric field exists in a region of 10 *cm* along x direction. Due to the electric field, the deflection of the charge particles in the y direction is ________ mm.

29. 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 $E_0 = 4.0\times10^3\frac{N}{C}$. The flux of this field through a rectangular surface area 0.4 m^2 parallel to the $Y-Z$ plane is __________ Nm^2C^{-1}

30. 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 surface $ABCD$ and $BCGF$ and marked as ϕ_I and ϕ_{II} respectively. The difference between $(\phi_I - \phi_{II})$ is (in Nm^2/C)