Electric charge and Fields

1. A long string with a charge of λ per unit length passes through an imaginary cube of edge a. The maximum flux of the electric field through the cube will be

(A) $\frac{\lambda a}{\varepsilon_o}$ (B) $\frac{2\sqrt{2}\lambda a}{\varepsilon_o}$ (C) $\frac{6\lambda a^2}{\varepsilon_o}$ (D) $\frac{\sqrt{3}\lambda a}{\varepsilon_o}$

Answer: (D)

The maximum length of the string which can fit into the cube is $\sqrt{3}a$, equal to its body diagonal. The total charge inside the cube is $\sqrt{3}a\lambda$, and hence the total flux through the cube is $\frac{\sqrt{3}a\lambda}{\varepsilon_o}$.

2. Potential in the x-y plane is given as $V = 5(x^2 + xy)$ volts. The electric field at the point (1, −2) will be

(A) $3\hat{J}$ V/m (B) $-5\hat{J}$ V/m

(C) $5\hat{J}$ V/m (D) $-3\hat{J}$ V/m

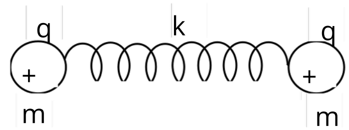
Answer: (B)

$E_x = -\frac{\partial V}{\partial x} = -(10x + 5y) = -10 + 10 = 0$

$E_y = -\frac{\partial V}{\partial x} = -5x = -5$

$\therefore \vec{E} = -5\hat{j}$ V/m.

3. The ratio of the time periods of small oscillation of the insulated spring and mass system before and after charging the masses is



(A) ≥ 1 (B) > 1 (C) ≤ 1 (D) $= 1$

Answer: (D)

In equilibrium of the charged small bodies $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{(\ell_0 + x_0)^2} = kx_0$ where x_0 is the elongration in the spring in equilibrium. Let a further small elongation of x is made in the spring.

Then net restoring force on any of the charged particle is given by,

$$F = -\left[k(x_0 + x) - \frac{1}{4\pi\varepsilon_0}\frac{q^2}{(\ell_0 + x_0 + x)^2}\right]$$

$= -kx$. Since $x << x_0$ from (1)

$\Rightarrow a = -\frac{2kx}{m}$

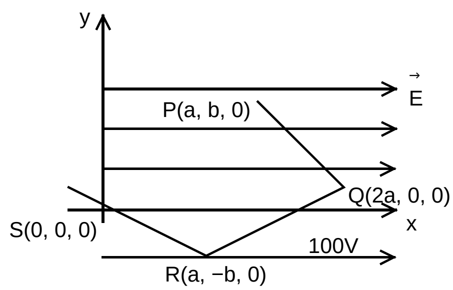
As $F = \mu a$ where $\mu = \frac{m \times m}{m + m} \Rightarrow a = -\omega^2 x$,

Hence $\omega = \sqrt{\frac{2k}{m}} \Rightarrow T = 2\pi\sqrt{\frac{m}{2k}}$

In absence of charge is $T_0 = 2\pi\sqrt{\frac{m}{2k}}$.

Therefore $\frac{T}{T_0} = 1$

4. A point charge q moves from point P to S along the path PQRS in a uniform electric field $\vec{E}$ pointing parallel to the positive direction of the x-axis. The coordinate of the point P, Q, R and S are (a, b, 0), (2a, 0, 0), (a, −b, 0) and (0, 0, 0) respectively. The work done by the field in the above process is given by the expression



(A) qaE (B) − qaE (C) $q\sqrt{(a^2+b^2)}E$ (D) $3qE\sqrt{(a^2+b^2)}$

Answer: (B)

The work done is independent of the path followed and is equal to $(q\vec{E}).\vec{r}$,

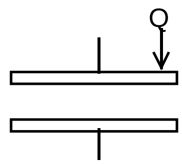
Where $\vec{r}$ = displacement from P to S

Here, $\vec{r} = a\hat{i} - b\hat{j}$, while $\vec{E} = E\hat{i}$

∴ work = $-(qE\hat{i}).(a\hat{i}+b\hat{j}) = -qaE$

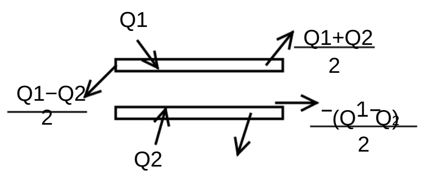
Hence, B is correct choice.

5. Charge Q is given to the upper plate of an isolated parallel plate capacitor of capacitance C. The potential difference between the plates



(A) $\frac{Q}{C}$ (B) $\frac{Q}{2}$ (C) $\frac{Q/2}{C}$ (D) zero

Answer: (C)



Q1+Q2
2

In general, for charge Q1 and Q2on upper and lower plate respectively the charge distributions on outer and inner part of the plates are shown in figure.

Here Q1 =Q, Q2 = 0

∴ Charge on inner side of plate are $\frac{Q}{2}$ and $-\frac{Q}{2}$ respectively.

Hence V = $\frac{Q/2}{C}$

Hence (C) is correct choice.

6. A dipole of dipole moment $\vec{p}$ is kept along an electric field $\vec{E}$ such that $\vec{E}$ and $\vec{p}$ are in the same direction. Find the work done in rotating the dipole by an angle π.

(A) W = 2Ep (B) W = −2Ep

(C) W = Ep (D) W = −Ep

Answer: (A)

W = ΔU = U2 − U1

Now U2 = −(Ep cos π) = Ep

U1 = −(Ep cos 0°) = −Ep

∴ W = 2Ep.

7. If a point charge q is placed at the centre of a cube what is the flux linked with the cube?

(A) $\varphi = \frac{1}{\in_o} q$ (B) $\varphi = \frac{3}{\in_o} q$

(C) $\varphi = \frac{6}{\in_o} q$ (D) $\varphi = \frac{1}{6\in_o} q$

Answer: (A)

From gauss's law, flux linked with a closed body is $\frac{1}{\in_o}$ times the charge enclosed. The cube encloses a charge q so flux linked with cube, $\varphi = \frac{1}{\in_o} q$

8. An electric dipole, made up of a positive and a negative charge, each of 1μC and placed at a distance 2 cm apart, is placed in an electric field 105N/C. Compute the maximum torque which the field can exert on the dipole, and the work that must be done to turn the dipole from a position θ = 0° to θ = 180° (A) 4×10^{-6}N-m or Joule (C) $4\times10^{+6}$N-m or Joule (B) 4×10^{-9}N-m or Joule (D) 4×10^{-3}N-m or Joule

Answer: (D)

The torque exerted by an electric field E on a dipole of moment p is given by

$\tau = pE \sin\theta$,

Where θ is the angle which the dipole is making with the field.

τ is a maximum, when θ = 90°. That is

$\therefore \tau_{max} = pE$

Here p = q(2ℓ) = $1\times10^{-6} \times 0.02$ C/m and E = 10^5 N/C

$\therefore \tau_{max} = 1\times10^{-6} \times 0.02 \times 10^5 = 2\times10^{-3}$ N-m

The work done in rotating the dipole from an angle θ_o to θ is given by

$W = \int_{\theta_o}^{\theta} pE\sin\theta d\theta = pE(\cos\theta_o - \cos\theta)$

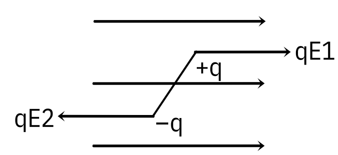
Here θ_o = 0° and θ = 180°

∴ W = pE (cos0°− cos180°) = 2pE = 4×10−3N-m or Joule
∴

9. An electric dipole is situated in non-uniform electric field. It may experience -
(A) resultant force and couple
(B) only force
(C) only couple
(D) all the these

Answer: (D)

If dipole is present in non-uniform field it experiences force and torque. However it can experience only force and only torque also.



10. The total electric flux, leaving spherical surface of radius 1 cm, and surrounding an electric dipole is
(A) q/ε_0 (B) zero (C) $2q/\varepsilon_0$ (D) $8\pi r^2 q/\varepsilon_0$

Answer: (B)

Electric flux passes as due to +q charge of dipole $= \frac{+q}{4pe0}$

Electric flux passes due to – q charge of dipole $= \frac{-q}{4pe0}$

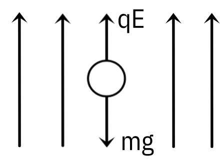
∴ Net flux passes due to both the charges $= \frac{q}{4pe_0} - \frac{q}{4pe0} = 0$

11. How many electrons should be removed from a coin of mass 1.6 gm, so that it may float in electric field intensity 109 N/C directed upwards?

(A) 9.8 × 107 (B) 9.8 × 105

(C) 9.8 × 103 (D) 9.8 × 101

Answer: (A)



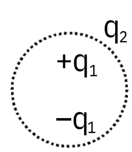
qE = mg

neE = mg

$n = \frac{mg}{eE} = \frac{1.6\times10-3\times9.8}{1.6\times10-19\times109}$

n = 9.8 × 107

12. Consider the charge configuration and a spherical Gaussian surface as shown in the fig. When calculating the flux of the electric field over the spherical surface, the electric field will be due to:



(A) q2 (B) only the positive charges

(C) all the charges (D) +q1 and −q1

Answer: (C)

At any point over the spherical Gaussian surface, net electric field is the vector slum of electric fields due to +q1,−q1andq2.

Don’t confuse with the electric flux which is zero (net) passing over the Gaussian surface as the net charge enclosing the surface is zero.

13. A point charge q is placed at origin. Let $\vec{E}_A$, $\vec{E}_B$ and $\vec{E}_C$ be the electric field at three points A(1, 2, 3), B(1, 1, −1) and C(2, 2, 2) due to charge q. Then

(A) $\vec{E}_A \parallel \vec{E}_B$ (B) $\vec{E}_A \parallel \vec{E}_C$

(C) $|\vec{E}_B| = 4|\vec{E}_C|$ (D) $|\vec{E}_B| = 8|\vec{E}_C|$

Answer: (C)

$\vec{E}_A$ is along $\vec{OA}$, $\vec{E}_B$ is along $\vec{OB}$ and $\vec{E}_C$ is along $\vec{OC}$

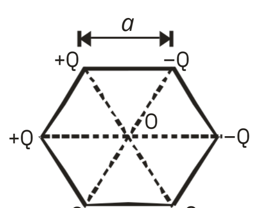
$\vec{OA} = \hat{i} + 2\hat{j} + 3\hat{k}$, and $\vec{OC} = 2\hat{i} + 2\hat{j} + 2\hat{k}$

$|\vec{E}| \propto \frac{1}{r^2}$

$|\vec{OC}| = 2|\vec{OB}|$

$|\vec{E}_B| = 4|\vec{E}_C|$

14. Six charges are placed at the vertices of a regular hexagon as shown in the figure. The electric field on the line passing through point O and perpendicular to the plane of the figure at a distance $x(>>a)$ from O is



(A) $\frac{Qa}{\pi\varepsilon_0 x^3}$ (B) $\frac{2Qa}{\pi\varepsilon_0 x^3}$ (C) $\frac{\sqrt{3}Qa}{\pi\varepsilon_0 x^3}$ (D) Zero

Answer: (A)

This is basically a problem of finding the electric field due to three dipoles. The dipole moment of each dipole is

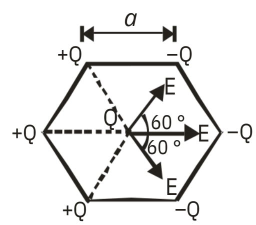
$p = Q(2a)$

Electric field due to each dipole will be (at its bisectorial position)

$$E = \frac{Kp}{x^3}$$

$$E_{net} = E + 2E\cos 60^\circ = 2E = 2\left(\frac{1}{4\pi\epsilon_0}\right)\left(\frac{2Qa}{x^3}\right) = \frac{Qa}{\pi\varepsilon_0 x^3}$$

The direction of electric field due to each dipole is as shown below

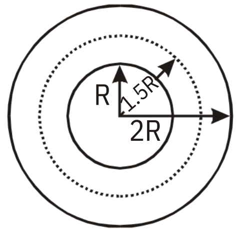


15. A spherical conductor has a radius of R and charge Q. A spherical shell of thickness R and uniform charge Q, is kept so as to be concentric to the conductor and touching the conductor. The electric field at a distance of 1.5 R from the center of the sphere is

(A) $\frac{83Q}{504\pi\varepsilon_0 R^2}$ (B) $\frac{75Q}{504\pi\varepsilon_0 R^2}$

(C) $\frac{83Q}{252\pi\varepsilon_0 R^2}$ (D) $\frac{53Q}{252\pi\varepsilon_0 R^2}$

Answer: (B)



Total flux through this area is

$= E.4\pi\,(1.5R)^2$

$$\frac{q_{net}}{\varepsilon_0} = \frac{1}{\varepsilon_0}\left[Q + \frac{Q\{(1.5R)^3 - R^3\}}{\{(2R)^3 - R^3\}}\right]$$

$$\frac{Q}{\varepsilon_0}\left[1 + \frac{19}{56}\right] = \frac{75Q}{56\varepsilon_0}$$

Gauss law $E.4\pi(1.5R)^2 = Q\,(75/56\varepsilon_0)$

$$E = \frac{75Q}{504\pi\varepsilon_0 R^2}$$

16. The electric potential V at any point (x, y, z) in space is given by $V = 6x^2$ volt, where all the distances are measured in metre. The electric field at the point (1 m, 0, 2 m) is

(A) $24\hat{i}$ V/m
(B) $-12\hat{i}$ V/m
(C) 24 V/m
(D) $12\sqrt{5}$ V/m

Answer: (B)

The potential V is a scalar function, whereas the field $\vec{E}$ is a vector function. The three components of $\vec{E}$ are given as

$$E_x = -\frac{\partial V}{\partial x} = -\frac{\partial}{\partial x}(6x^2) = -12x$$

$$E_y = -\frac{\partial V}{\partial y} = -\frac{\partial}{\partial y}(6x^2) = 0$$

$$E_z = -\frac{\partial V}{\partial z} = -\frac{\partial}{\partial z}(6x^2) = 0$$

$\therefore$ $\vec{E} = -12x\,\hat{i} + 0 + 0 = -12x\,\hat{i}$

at the given point, x = 1,

$\therefore$ $\vec{\mathbf{E}} = -12\,\hat{\mathbf{i}}$

17. Two bodies are charged by rubbing one against the other. During the process, one becomes positively charged while the other becomes negatively charged. Then

(A) mass of each body remains unchanged.

(B) mass of each body changes marginally.

(C) mass of each body changes slightly and hence the total mass.

(D) mass of each body changes slightly but the total mass remains the same.

Answer: (D)

The transfer of electrons from one body to the other results is development of charges.

Hence, no. of electrons given by one body = No. of electrons obtained by the other.

$\therefore$ Mass of negatively charged body slightly increases while mass of positively charged body slightly increases. whereas the total mass of the system remains the same.

$\therefore$ Hence, (D) is correct.

18. A neutron, a proton and an electron are placed in a uniform electric field.

(A) The forces acting on them will be equal.

(B) Their accelerations may be equal.

(C) Magnitude of acceleration may be equal.

(D) Magnitude of acceleration will be different.

Answer: (D)

Force on neutron = 0 (as charge = 0)

Force on proton = qE

Force on electron = qE

Masses of proton and electron are different.

Hence, their accelerations will be different.

∴ Hence, (D) is correct.

19. A charge Q has to be divided between two solid spheres of radius 'R' which are at distance d from each other (d > > R). What should be the value of charge, which we should place on spheres, so that the force of attraction between them is maximum?

(A) Q/4, 3Q/4 (B) Q/3, 2Q/3

(C) Q/2, Q/2 (D) Q/5, 4Q/5

Answer: (C)

Let us place a quantum of charge 'q' on the first sphere, so we have charge Q-q on the other sphere.

The force of attraction between the spheres is

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

$$\frac{dF}{dq} = \frac{1}{4\pi\varepsilon_0 d^2}[(Q-q)-q]=0$$

$\therefore$ q = Q/2

$\therefore$ Hence, (C) is correct.

20. If two like charges of magnitude 1×10^{-9} coulomb and 9×10^{-9} coulomb are separated by a distance of 1 meter, then the point on the line joining the charges, where the force experienced by a charge placed at that point is zero, is -

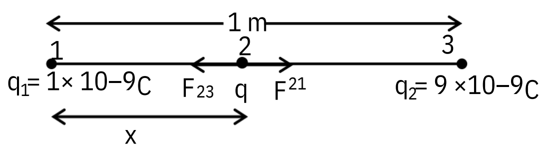
(A) 0.25 m from the charge 1×10^{-9} coul

(B) 0.75 m from the charge 9×10^{-9} coul

(C) both A and B

(D) at all points on the line joining the charges

Answer: (C)



$\because$ Force on charge q is zero

$\therefore$ $F_{21} = F_{23}$

or $\frac{kqq_1}{x^2} = \frac{kqq_2}{(1-x)^2}$

or $\frac{1\times10^{-9}}{x^2} = \frac{9\times10^{-9}}{(1-x)^2}$

or $\frac{1}{x} = \frac{3}{1-x}$

or $1 - x = 3x$

or x = 0.25 m from 1×10^{-9}C

∴ From 9×10^{-9}C, distance

= 1 – x

= 1 – 0.25

= 0.75

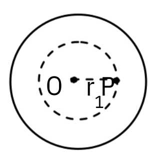
21. An insulating solid sphere of radius 'R' is charged in a non-uniform manner such that volume charge density $\rho = \frac{A}{r}$ where A is a positive constant and r the distance from centre. Electric field strength at any inside point at distance r_1 is -

(A) $\frac{1}{4\pi\varepsilon_0}\frac{4\pi A}{r_1}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{A}{r_1}$ (C) $\frac{A}{\pi\varepsilon_0}$ (D) $\frac{A}{2\varepsilon_0}$

Answer: (D)

P is any inside point at distance r_1 from O. we take a spherical surface of radius r_1 as Gaussian –surface of radius r_1 as Gaussian-surface.

$$\oint_s \vec{E}\cdot\vec{ds} = \frac{q_{in}}{\varepsilon_0}$$



By symmetry, E at all points on the surface is same and angle between $\vec{E}$ and $\vec{ds}$ is zero everywhere.

∴ $\oint_s \vec{E}\cdot\vec{ds} = Es = \frac{q_{in}}{\varepsilon_0}$ or $E\,4\pi r_1^2 = \frac{q_{in}}{\varepsilon_0}$ .....(i)

q_{in} : The sphere can be regarded as consisting of a large number of spherical shells.

Consider a shell of inner and outer radii r and r +dr. Its volume will be dV = 4πr2 dr. Charge in the shell,

dq = ρdV = $\frac{A}{r}$4πr2dr

Total charge enclosed by Gaussian-surface,

$q_{in} = \int dq = \int_0^{r_1} r\,dr = 4\pi A = r_1^2/2$

$q_{in} = 4pA \int_0^{r_1} r\,dr = 4\pi A\, r_1^2/2$

From Eq. (1) $E4\pi r_1^2 = 4\pi A r_1^2 / 2 / \varepsilon_0$

$\therefore E = \frac{A}{2\varepsilon_0}$

22. Two plates are at potentials –20 V and +20 V. If the separation between the plates be 2 cm, the electric field between them is

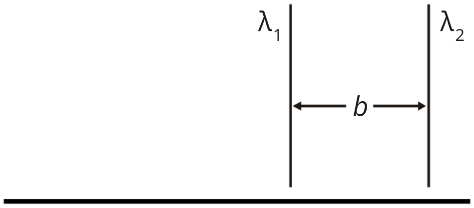
a) 2000 V/m
b) 1000 V/m
c) 500 V/m
d) 3000 V/m

Answer: (a)

Explanation:

$E = -\frac{dv}{dr} = \left(\frac{20-(-20)}{2cm}\right) = 2000$ V/m

23. Two parallel infinite length line charges of magnitude 1 and 2 are at a distance *b* apart as shown in the figure. The force per unit length is



a) $\frac{\lambda_1\lambda_2}{4\pi\varepsilon_0 b}$

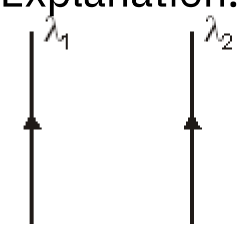
b) $\frac{\lambda_1\lambda_2}{2\pi\varepsilon_0 b}$

c) $\frac{\lambda_1\lambda_2}{\pi\varepsilon_0 b}$

d) $\frac{2\lambda_1\lambda_2}{\pi\varepsilon_0 b}$

Answer: (b)

Explanation:



$$F = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda_1\lambda_2}{b}$$

24. The SI unit Vacuum permittivity ε_0 is

a) C N-1 M-1

b) watt K^{-1} mol^{-1}

c) C2 N-1 M-2

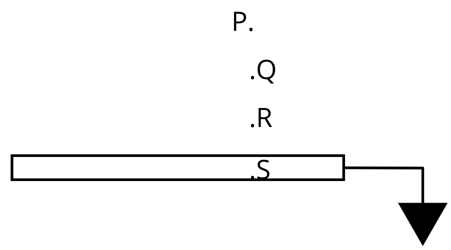
d) joule C^{-1} mol^{-1}

Answer: (c)

Explanation:

The SI unit Vacuum permittivity ε_0 is C2 N-1 M-2 and its Value approximately 8.85 x 10-12

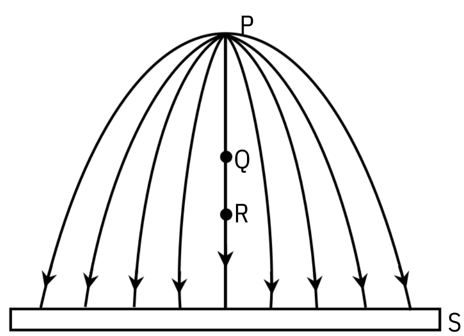
25. A positive point charge is placed at P in front of an earthed metal sheet S. Q & R are two points between P & S as shown in figure. If the electric field strength at Q & R are respectively EQ & ER and potential at Q & R are respectively VQ & VR . Then-



(A) EQ > ER (B) EQ < ER

(C) VQ > VR (D) VQ < VR

Answer: (C)



As we are are moving away from P toward sheet S spacing between electric lines of force is increasing.

∴ ER < EQ In direction of electric field potential decreases.

∴ VR < VQ

26. A hollow charged metal sphere has radius r. If the potential difference between its surface and a point at a distance 3r from the centre is V, then electric field intensity at distance 3 r from the centre is -

(A) $\frac{V}{3r}$ (B) $\frac{V}{4r}$ (C) $\frac{V}{6r}$ (D) $\frac{V}{2r}$

Answer: (C)

$V_A - V_B = \frac{KQ}{r} - \frac{KQ}{3r}$

$= \frac{KQ}{3r}2,\ V = \frac{2}{3}\frac{KQ}{r}$

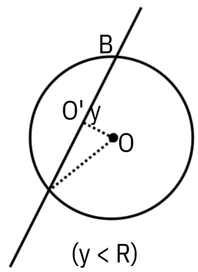
$E = \frac{KQ}{(3r)^2} = \frac{KQ}{9r^2} = \frac{3rV}{2\,9r^2}\ \therefore\ E = \frac{V}{6r}$

27. A uniformly charged and infinitely long line having a linear charge density 'λ' is placed at a normal distance y from a point O. Consider a sphere of radius R with O as centre and R > y. Electric flux through the surface of the sphere is-

(A) zero (B) $\frac{2\lambda R}{\varepsilon_0}$ (C) $\frac{2\lambda\sqrt{R^2-y^2}}{\varepsilon_0}$ (D) $\frac{\lambda\sqrt{R^2+y^2}}{\varepsilon_0}$

Answer: (C)

Electric flux $\oint_S \vec{E}.\vec{dS} = \frac{q_{in}}{\varepsilon_0}$ q_{in} is the charge enclosed by the Gaussian-surface which, in the present case, is the surface of given sphere. As shown, length AB of the line lies inside the sphere.



In ΔOO'A $\quad R^2 = y^2 + (O'A)^2$

$\therefore \quad O'A = \sqrt{R^2 - y^2}$

and $AB = 2\sqrt{R^2 - y^2}$

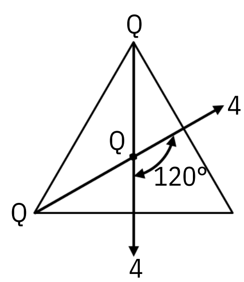
Charge on length $AB = 2\sqrt{R^2 - y^2} \times \lambda$

$\therefore$ electric flux = $\oint_S \vec{E} \cdot \vec{dS} = \frac{2\lambda\sqrt{R^2 - y^2}}{\varepsilon_0}$

28. A point charge + Q is placed at the centroid of an equilateral triangle. When a second charge +Q is placed at a vertex of the triangle, the magnitude of the electrostatic force on the central charge is 4N. What is the magnitude of the net force on the central charge when a third charge +Q is placed at another vertex of the triangle?

(A) Zero (B) 4 N (C) $4\sqrt{2}$ N (D) 8 N

Answer: (B)



$F_{Net} = \sqrt{4^2 + 4^2 + 2 \times 4^2 \cos 120°} = 4N$

29. A charge Q is given to a spherical shell of radius R, the work done to distribute charge Q on the surface of sphere is –

(A) $\frac{Q^2}{8\pi\varepsilon_0 R}$ (B) $\frac{Q^2}{4\pi\varepsilon_0 R}$

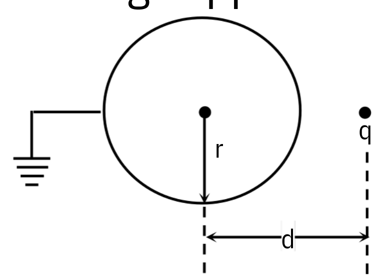
(C) $\frac{Q^2}{15\pi\varepsilon_0 R}$ (D) none of these

Answer: (A)

Work done = self-electric potential energy of system

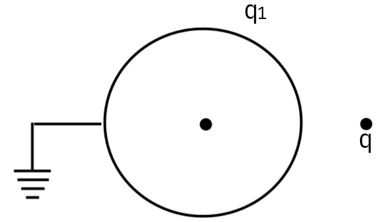
$= \frac{Q^2}{8\pi\varepsilon_0 R}$

30. In the given fig. the charge appears on the sphere is –



(A) q (B) $\frac{qd}{r}$ (C) $\frac{-qr}{d}$ (D) zero

Answer: (C)



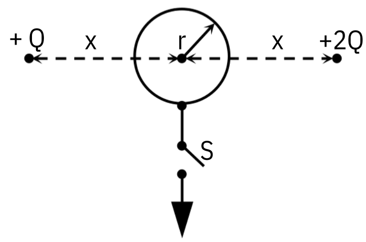
The net potential on the surface of earthed conductor is zero.

$\therefore V = \frac{q_1}{4\pi\varepsilon_0 r} + \frac{q}{4\pi\varepsilon_0 d} = 0$

$$\frac{q_1}{4\pi\varepsilon_0 r} = -\frac{q}{4\pi\varepsilon_0 d}$$

$$\Rightarrow q_1 = -\frac{qr}{d}$$

31. Two particles having positive charges + Q and + 2Q are fixed at equal distance x from centre of an conducting sphere having zero net charge and radius r as shown. Initially the switch S is open. After the switch S is closed, the net charge flowing out of sphere is -



(A) $\frac{Qr}{x}$ (B) $\frac{2Qr}{x}$ (C) $\frac{3Qr}{x}$ (D) $\frac{6Qr}{x}$

Answer: (C)

Initially the potential at centre of sphere is

$$V_C = \frac{1}{4\pi\varepsilon_0}\frac{Q}{x} + \frac{1}{4\pi\varepsilon_0}\frac{2Q}{x} = \frac{1}{4\pi\varepsilon_0}\frac{3Q}{x}$$

After the sphere grounded, potential at centre becomes zero. Let the net charge on sphere finally be q.

$\therefore \frac{1}{4\pi\varepsilon_0}\frac{q}{r} + \frac{1}{4\pi\varepsilon_0}\frac{3Q}{x} = 0$ or $q = -\frac{3Qr}{x}$

$\therefore$ The charge flowing out of sphere is $\frac{3Qr}{x}$

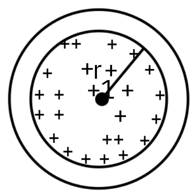
32. Let $P(r) = \frac{Q}{\pi R^4} r$ be the charge density distribution for a solid sphere of radius R and total charge Q. For a point ‘p’ inside the sphere at distance r1 from the centre of the sphere, the magnitude of electric field is –

(A) 0 (B) $\frac{Q}{4\pi\epsilon_0 r_1^2}$

(C) $\frac{Q r_1^2}{4\pi\epsilon_0 R^4}$ (D) $\frac{Q r_1^2}{3\pi\epsilon_0 R^4}$

Answer: (C)

$P(r) = \frac{Q}{\pi R^4} r$



From Gauss law

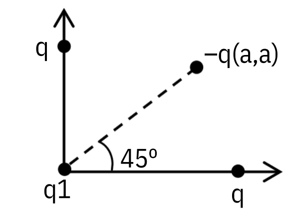
$\oint E.ds = \frac{q_{en}}{\varepsilon_0} = \frac{\int \rho V dV}{\varepsilon_0}$

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

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

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

33. Calculate the net force acting on the charge present at the origin -



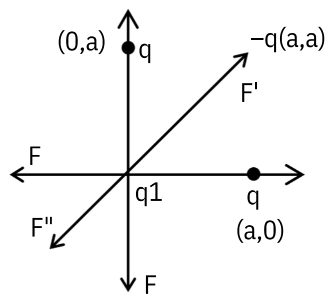
(A) $\frac{kqq1}{a^2} \times \sqrt{2}$

(B) $\frac{kqq_1}{\sqrt{2}a^2} + \frac{kqq1}{2a^2}$

(C) $\frac{kqq1}{a^2}\left(\sqrt{2} - \frac{1}{2}\right)$

(D) $\frac{kqq1}{a^2}\left(\frac{1}{2} - \sqrt{2}\right)$

Answer: (C)



$F'' = \sqrt{2}F$

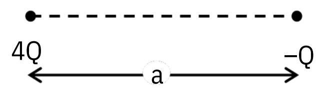
$F'' = \sqrt{2}\frac{kqq1}{a^2}$

$F' = \frac{kq1q}{(\sqrt{2}a)^2} = \frac{kq1q}{2a^2}$

$\therefore F_{Net} = F'' - F'$

$= \frac{kqq1}{a^2}\left(\sqrt{2} - \frac{1}{2}\right)$

34. The position of the point where net electric field will be zero -



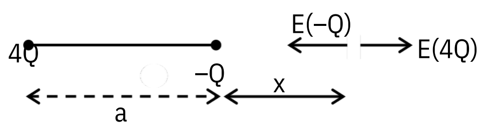
(A) (1+ a)m from 4Q

(B) a/2 m from – Q

(C) 1m from 4Q

(D) Neutral point not possible

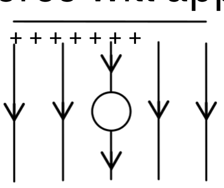
Answer: (A)

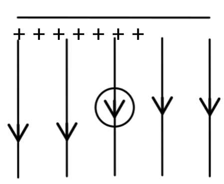


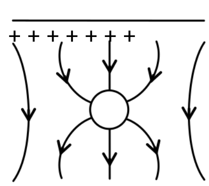
$$x = \frac{\sqrt{Q}}{\sqrt{4Q} - \sqrt{Q}}$$

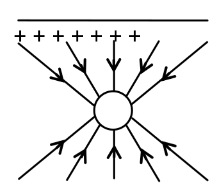
$$x = \frac{1}{2-1} = 1 \text{ m}$$

35. An uncharged sphere of metal is placed in uniform electric field produced by two oppositely charged plates. The lines of force will appear as -

(A) 

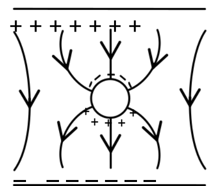
(B) 

(C) 

(D) 

Answer: (C)

Due to induction charges will appear on the surface of sphere as shown in diagram. Electric field lines never enters any conducting surface and are perpendicular at the surface. Hence correct answer is C.



36. Four equal charges, each +q are placed on the four corners of a square of side a. Then the coulomb force experienced by one charge due to the rest of three is - $\left[K = \frac{1}{4\pi\varepsilon_0}\right]$

(A) $(2\sqrt{2}+1)Kq^2/2a^2$ (B) $3Kq^2/a^2$ (C) $2\sqrt{2}Kq^2/a^2$ (D) zero

Answer: (A)

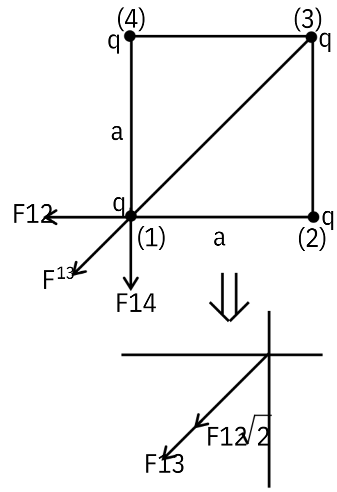
$F_{12} = F_{14} = \frac{kq^2}{a^2}$

Resultant of F_{12} & F_{14}

$= \sqrt{F_{12}^2+F_{14}^2}$

$= \sqrt{F_{12}^2+F_{12}^2}$

$= F_{12}\sqrt{2}$



∴ Net force on charge q is

$F = F_{12}\sqrt{2} + F_{13}$

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

37. An electric dipole is placed at an angle of 30º to a non-uniform electric field. The dipole experiences -

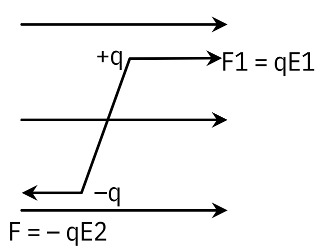
(A) a torque as well as a translational force

(B) a torque only

(C) a translational force only in the direction of field

(D) a translational force only in a direction normal to the direction of the field

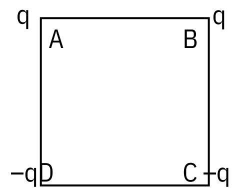
Answer: (A)



In non-uniform field both force and torque is non zero.

38. Charges are placed on the vértices of a square as shown.

Let $\vec{E}$ be the electric field and V the potential at the centre. If the charges on A and B are interchanged with those on D and C respectively, then –



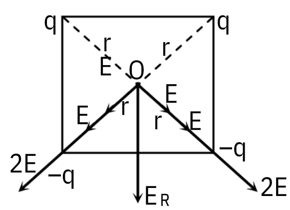
(A) $\vec{E}$ remains unchanged, V changes

(B) Both $\vec{E}$ and V changes

(C) $\vec{E}$ and V remains unchanged

(D) $\vec{E}$ changes, V remains unchanged

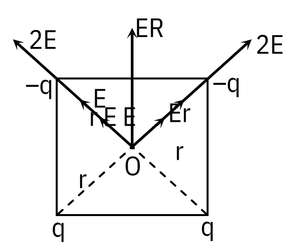
Answer: (D)



$V_0 = \frac{kq}{r} + \frac{kq}{r} - \frac{kq}{r} - \frac{kq}{r} = 0$

$E_R = 2\,(2E)\cos 45 = 2\sqrt{2}\frac{kq}{r^2}\,(-\hat{j})$

After interchanging



$V_0 = \frac{kq}{r} + \frac{kq}{r} - \frac{kq}{r} - \frac{kq}{r} = 0$

$E_R = 2\sqrt{2}\frac{kq}{r^2}\hat{j}$

Hence, Electric field will change.

39. The potential at a point x due to some charge is given by equation $V(x) = \frac{20}{(x^2-4)}$ volts. Then electric field at x =4 is given by -

(A) $\frac{5}{3}$ volt/m and in the –ve x direction

(B) $\frac{5}{3}$ volt/ m and in the +ve x direction

(C) $\frac{10}{9}$ volt/m and in the –ve x direction

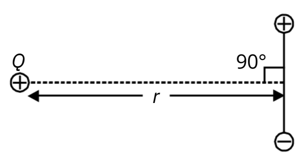
(D) $\frac{10}{9}$ volt/m and in the +ve x direction

Answer: (D)

$$E_x = -\frac{\delta V}{\delta x}\hat{i} = -\frac{\delta}{\delta x}\left(\frac{20}{x^2-4}\right)\hat{i} = \frac{20\times 2x}{(x^2-4)^2}\hat{i}$$

$$E_x = \frac{40x}{(x^2-4)^2}\hat{i} = \frac{40\times 4}{144} = \frac{10}{9} \text{ in + x direction.}$$

40. Force on short electric dipole in field of a point charge varies with its distance *r* as



a) $\propto$ to r^3

b) $\propto$ to r^2

c) $\propto$ to r^{-3}

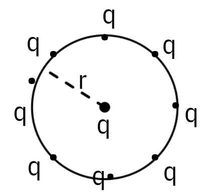
d) Zero

Answer: (d)

Explanation:

$$\because U = -pE\cos 90° = 0$$
$$F = 0$$

41. A point charge is surrounded by eight identical charges at a distance r as shown in figure. How much work is done by the force of electrostatic repulsion when the point charge at the centre is removed to infinity –



(A) zero (B) $\frac{8q2}{4\pi\varepsilon0r}$ (C) $\frac{8q}{4\pi\varepsilon0r}$ (D) $\frac{64q2}{4\pi\varepsilon0r}$

Answer: (B)

Work done $= -\Delta U = Ui - Uf$

$= \frac{8kq2}{r} - O$

$= \frac{8q2}{4\pi\varepsilon0r}$

42. An electric dipole of length 2 cm is placed with its axis making an angle of 30º to a uniform electric field 105 N/C. If it experiences a torque of 103 Nm, then potential energy of dipole –

(A) –10 J (B) –20 J (C) –30 J (D) – 40 J

Answer: (C)

$\tau = PE \sin 30$

$103 = \frac{PE}{2}$

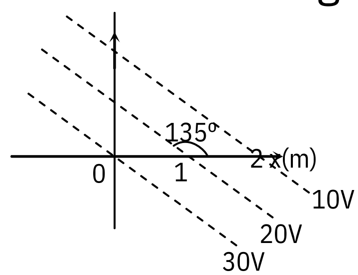
PE = $20\sqrt{3}$

Potential Energy = $-PE \cos 30$

$\therefore$ Potential energy = $-20\sqrt{3} \times \frac{\sqrt{3}}{2}$

$= -10 \times 3 = -30$ J

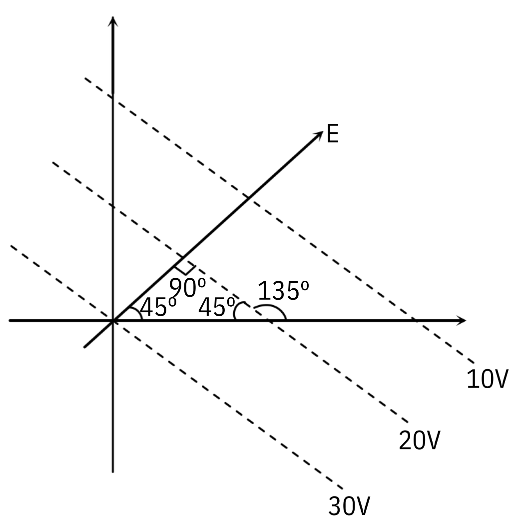
43. Figure shows a set of equipotential surfaces. The direction of electric field that exists in the region is -



(A) At 45° with x axis (B) At 135° with x axis

(C) Along x axis (D) Along y-axis

Answer: (A)



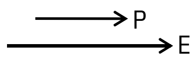
Electric field lines are $\perp$ to the equipotential surface and are directed from high potential to low potential.

44. An electric dipole has the magnitude of its charge as q and its dipole moment is p. It is placed in a uniform electric field E. If its dipole moment is along the direction of the field, the force on it and its potential energy are respectively -

(A) 2qE and minimum (B) qE and pE

(C) zero and minimum (D) qE and maximum

Answer: (C)

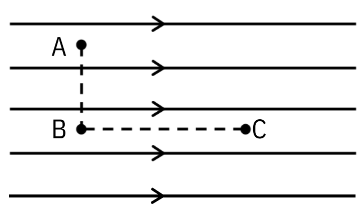


In uniform electric field, $F_{net}=0$ and

$U = -PE\cos\theta = -PE\cos 0^{o}$

$= -PE$ (minimum)

45. Figure shows three points A, B and C in a region of uniform electric field $\vec{E}$. The line AB is perpendicular and BC is parallel to the field lines. Then which of the following holds good?



(Where VA,VB and Vc represent the electric potential at the points A, B and C respectively)

(A) VA = VB = VC (B) VA = VB > VC

(C) VA = VB < VC (D) VA > VB = VC

Answer: (B)

Along electric field, potential decreases and perpendicular to field, potentials are same.

∴ $V_A = V_B > V_C$