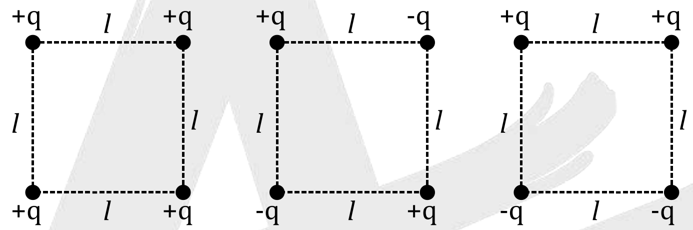
DPP - 7

Potential & Potential Energy

Q.1 Two charges, $+q$ and $-q$, each of mass m, are revolving in a circle of radius R, under mutual electrostatic force. Find (a) speed of each charge (b) kinetic energy of system (c) potential energy of the system (d) total energy of the system

Q.2 Calculate the work required to be done to make an arrangement of three particles each having a charge $+q$ such that the particles lie at the vertices of an equilateral triangle of side a. What work will be done by electric field when the particles are shifted away so that the side of triangle becomes 2a ?

Q.3 Determine the interaction energy of the point charges located at the corners of a square of side ℓ in the figures shown.

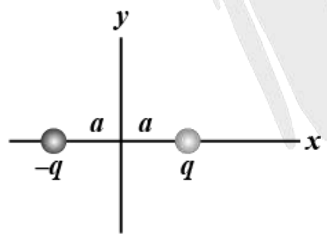


(a) (b) (c)

Q.4 Two charges $6\mu C$ and $-4\mu C$ are located 15 cm apart. At what point on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero.

Q.5 Consider a system of two charges shown in figure. The arrangement is also called an Electric Dipole. Find the electric potential at an arbitrary point on the x-axis and make a plot of

$\frac{V(x)}{V_0}$ Vs $\frac{x}{a}$ where $V_0 = \frac{q}{4\pi\varepsilon_0 a}$.



Electric dipole

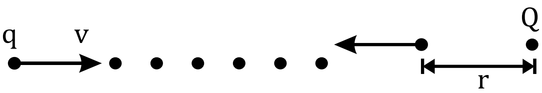
Q.6 On a thin rod of length $\ell = 1$ m, lying along the x-axis with one end at the origin $x = 0$, there is uniformly distributed charge per unit length $\lambda = Kx$, where $K = 10^{-9}\,Cm^{-2}$. Find the work done in displacing a charge $q = 1000\mu C$ from a point $A(0, \sqrt{0.44})$m to $B(0, \ell)$m.

Q.7 A thin spherical conducting shell of radius R has a charge q. Another charge Q is placed at the centre of the shell. The electrostatic potential at a point P at a distance $\frac{R}{2}$ from the centre of the shell is :

(A) $\frac{2Q}{4\pi\epsilon_0 R}$ (B) $\frac{2Q}{4\pi\epsilon_0 R} - \frac{2q}{4\pi\epsilon_0 R}$

(C) $\frac{2Q}{4\pi\epsilon_0 R} + \frac{q}{4\pi\epsilon_0 R}$ (D) $\frac{(q+Q)}{4\pi\epsilon_0}\frac{2}{R}$

Q.8 A charged particle q is shot towards another charged particle Q which is fixed, with a speed v. It approaches Q upto a closest distance r and then returns. If q was given a speed 2v, the closest distance of approach would be :



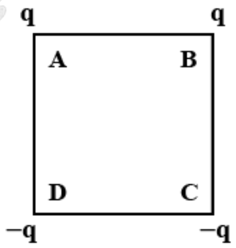
(A) r (B) 2r (C) r/2 (D) r/4

Q.9 Two thin wire rings each having a radius R are placed at a distance d apart with their axes coinciding. The charges on the two rings are +q and −q. The potential difference between the centres of the two rings is :

(A) $\frac{qR}{4\pi\epsilon_0 d^2}$ (B) $\frac{q}{2\pi\epsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$

(C) Zero (D) $\frac{q}{4\pi\epsilon_0}\left[\frac{1}{R} - \frac{1}{\sqrt{R^2+d^2}}\right]$

Q.10 Charges are placed on the vertices 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 change

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

Q.11 An electric charge $10^{-3}\,\mu C$ is placed at the origin (0,0) of X − Y coordinate system. Two points A and B are situated at $(\sqrt{2}, \sqrt{2})$ and (2,0) respectively. The potential difference between the points A and B will be :

(A) 9 V (B) Zero (C) 2 V (D) 4.5 V

Q.12 Two points P and Q are maintained at the potential of 10 V and −4 V, respectively. The work done in moving 100 electrons from P to Q is :

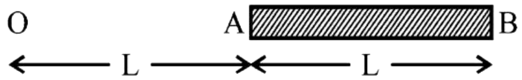
(A) -2.24×10^{-16} J (B) 2.24×10^{-16} J

(C) -9.60×10^{-17} J (D) 9.60×10^{-17} J

Q.13 A charge of total amount Q is distributed over two concentric hollow spheres of radii r and R(R > r) such that the surface charge densities on the two spheres are equal. The electric potential at the common centre is :

(A) $\frac{1}{4\pi\varepsilon_0}\frac{(R-r)Q}{(R^2+r^2)}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)Q}{2(R^2+r^2)}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)Q}{(R^2+r^2)}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{(R-r)Q}{(R^2+r^2)}$

Q.14 A charge Q is uniformly distributed over a long rod AB of length L as shown in the figure. The electric potential at the point O lying at a distance L from the end A is :



(A) $\frac{Q}{8\pi\epsilon_0 L}$ (B) $\frac{3Q}{4\pi\epsilon_0 L}$ (C) $\frac{Q}{4\pi\epsilon_0 L \ln 2}$ (D) $\frac{Q\ln 2}{4\pi\epsilon_0 L}$

Q.15 The potential (in volts) of a charge distribution is given by

$$V(z) = 30 - 5z^2 \text{ for } |z| \leq 1 \text{ m}$$

$$V(z) = 35 - 10|z| \text{ for } |z| \geq 1 \text{ m}$$

V(z) does not depend on x and y. If this potential is generated by a constant charge per unit volume ρ_0 (in units of ε_0) which is spread over a certain region, then choose the correct statement:

(A) $\rho_0 = 20\varepsilon_0$ in the entire region

(B) $\rho_0 = 10\varepsilon_0$ for $|z| \leq 1$ m and $p_0 = 0$ elsewhere

(C) $\rho_0 = 20\varepsilon_0$ for $|z| \leq 1$ m and $p_0 = 0$ elsewhere

(D) $\rho_0 = 40\varepsilon_0$ in the entire region

Q.16 Within a spherical charge distribution of charge density $\rho(r)$, N equipotential surfaces of potential $V_0, V_0 + \Delta V, V_0 + 2\Delta V, \ldots V_0 + N\Delta V (\Delta V > 0)$, are drawn and have increasing radii $r_0, r_1, r_2, \ldots r_N$, respectively. If the difference in the radii of the surfaceg is constant for all values of V_0 and ΔV then :

(A) $\rho(r) =$ constant (B) $\rho(r) \propto \frac{1}{r^2}$

(C) $\rho(r) \propto \frac{1}{r}$ (D) $\rho(r) \propto r$

Q.17 Three concentric metal shells A, B and C of respective radii a, b and c$(a < b < c)$ have surface charge densities $+\sigma, -\sigma$ and $+\sigma$ respectively. The potential of shell B is :

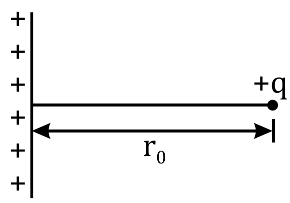
(A) $\frac{\sigma}{\epsilon_0}\left[\frac{a^2-b^2}{a} + c\right]$

(B) $\frac{\sigma}{\epsilon_0}\left[\frac{a^2-b^2}{b} + c\right]$

(C) $\frac{\sigma}{\epsilon_0}\left[\frac{b^2-c^2}{b} + a\right]$

(D) $\frac{\sigma}{\epsilon_0}\left[\frac{b^2-c^2}{c} + a\right]$

Q.18 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) $v \propto e^{+r/r_0}$

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

(C) $v \propto \left(\frac{r}{r_0}\right)$

(D) $v \propto \sqrt{\ln\left(\frac{r}{r_0}\right)}$

Q.19 Statement-1: For practical purposes, the earth is used as a reference at zero potential in electrical circuits.

Statement-2: The electrical potential of a sphere of radius R with charge Q uniformly distributed on the surface is given by $\frac{Q}{4\pi z_0 R}$.

(A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.

(B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.

(C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.

(D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

Q.20 Statement-1: Induced charge does not contribute to electric field or potential at a given point.

Statement-2: A point change q_0 is kept outside a solid metallic sphere, the electric field inside the sphere is zero.

(A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.

(B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.

(C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.

(D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

ANSWER KEY

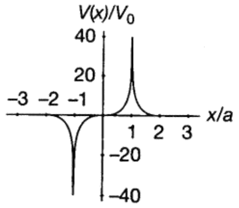
1. (a) $\sqrt{\frac{q^2}{16\pi\varepsilon_0 R}}$ (b) $\frac{q^2}{16\pi\varepsilon_0 R}$ (c) $-\frac{q^2}{8\pi\varepsilon_0 R}$ (d) $-\frac{q^2}{16\pi\varepsilon_0 R}$

2. $\frac{3q^2}{8\pi\varepsilon_0 a}$ **3.** (a) $\frac{q^2}{4\pi\varepsilon_0 l}(4+\sqrt{2})$ (b) $\frac{q^2}{4\pi\varepsilon_0 l}(-4+\sqrt{2})$ (c) $-\left(\frac{\sqrt{2}q^2}{4\pi\varepsilon_0 l}\right)$

4. (a) by between the charge $x = 5$ cm from $6\mu C$

(b) outside the charge $x = 45$ cm from $6\mu C$

5.



6. $W_{A\to B} = -1.1 \times 10^{-3}$ J

7.	(C)	**8.**	(D)	**9.**	(B)	**10.**	(C)	**11.**	(B)	**12.**	(B)	**13.**	(C)
14.	(D)	**15.**	(B)	**16.**	(C)	**17.**	(B)	**18.**	(C)	**19.**	(B)	**20.**	(D)