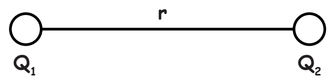
ELECTROSTATICS

PHYSICS WALLAH

ELECTROSTATIC POTENTIAL ENERGY

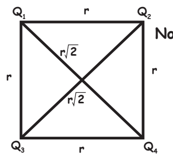
2 point charges



$\Delta U = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r}$ — like charges - positive (repulsive energy); Unlike charges - negative (attractive energy)

System of charges

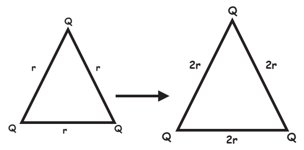
$\Delta U_{system} = \Sigma\, \Delta U_{pair}$ No. of pairs $= \frac{n(n-1)}{2}$



No. of pairs $= \frac{4\times 3}{2} = 6$

Total P.E $= \frac{KQ_1Q_2}{r} + \frac{KQ_1Q_4}{r\sqrt{2}} + \frac{KQ_2Q_3}{r\sqrt{2}} + \frac{KQ_2Q_4}{r} + \frac{KQ_3Q_4}{r} + \frac{KQ_1Q_3}{r}$

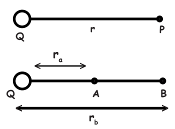
WORK DONE IN REARRANGEMENT OF THE SYSTEM



$W = U_f - U_i = \frac{3kQ^2}{2r} - \frac{3kQ^2}{r} = -\frac{3kQ^2}{2r}$

$U_i = \frac{3kQ^2}{r}$ $U_f = \frac{3kQ^2}{2r}$

ELECTROSTATIC POTENTIAL



$V_p = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$

$V_{AB} = V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_b} - \frac{1}{r_a}\right]$

WORK DONE

$w = q[V_B - V_A]$

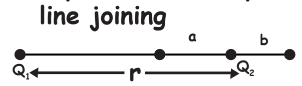
$w = 1 \times (-500-500) = -1000J$

Superposition of potential - Algebraic sum of all potentials

ZERO POTENTIAL

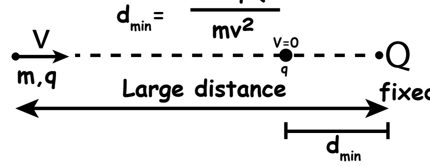
a) Like charge-no zero potential point

b) Unlike charge- 2 points of zero potential on line joining

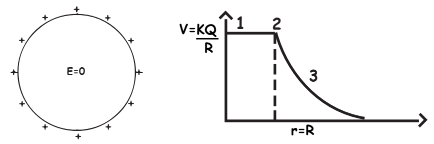


Inside point $= a = \frac{Q_2 r}{Q_1+Q_2}$ Outside point $= b = \frac{Q_2 r}{Q_1-Q_2}$

$d_{min} = \frac{2kqQ}{mv^2}$

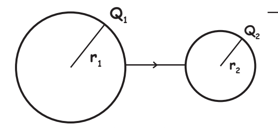


POTENTIAL OF CHARGED CONDUCTING SPHERE



case 1: V_{inside} =Const $= V_{surface} = \frac{KQ}{R}$ case 2: $V_{surface} = \frac{kQ}{R}$ case 3: $V_{outside} = \frac{kQ}{r}$

Redistribution of Charge when two Conducting sphere are connected



→ Charge flow from higher potential to lower potential. Final potentials of spheres are equal

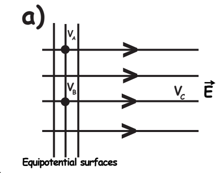
$\frac{1}{4\pi\varepsilon_0}\frac{Q_1'}{r_1} = \frac{1}{4\pi\varepsilon_0}\frac{Q_2'}{r_2}$

$Q_1' = \frac{(Q_1+Q_2)\, r_1}{r_1+r_2}$ $Q_2' = \frac{(Q_1+Q_2)\, r_2}{r_1+r_2}$

$\boxed{\frac{Q_1'}{Q_2'} = \frac{r_1}{r_2},\ \frac{E_1}{E_2} = \frac{r_2}{r_1},\ \frac{\sigma_1}{\sigma_2} = \frac{r_2}{r_1}}$

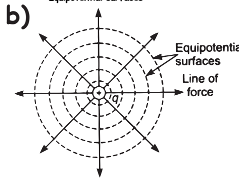
EQUIPOTENTIAL SURFACE

a)



$V_A = V_B > V_C$

b)



c) Field lines and equipotential surface are perpendicular to each other at every location.

d) work done in moving a charge on equipotential surface is 0

ELECTRIC FIELD & POTENTIAL

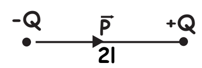
$E = \frac{-dV}{dr}$ $E_x = \frac{-\partial V}{\partial x}$ $E_y = \frac{-\partial V}{\partial y}$ $E_z = \frac{-\partial V}{\partial z}$

$\Delta V = -\int \vec{E}.\vec{dr}$

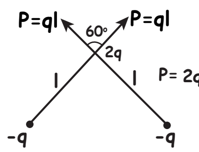
DIPOLE

Dipole moment

$\vec{P} = q\, 2\vec{l}$



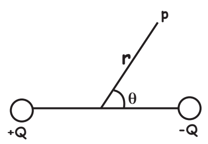
Direction is from -Q to +Q



$P = 2ql\cos 30° = 2\sqrt{3}ql(\uparrow)$

Q. Fine net dipole moment

ELECTRIC FIELD

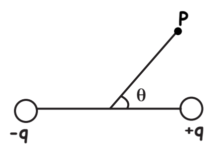


$E_p = \frac{Kp}{r^3}\sqrt{3\cos^2\theta+1}$

$E_{axial} = \frac{Kp}{r^3}\sqrt{3+1} = \frac{2Kp}{r^3}$ 0° with dipole moment, E_{net} from -Q to +Q

$E_{equitorial} = \frac{Kp}{r^3}\sqrt{0+1} = \frac{Kp}{r^3}$ 180° with dipole moment, E_{net} from +Q to -Q

ELECTRIC POTENTIAL

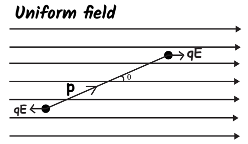


$V_p = \frac{kp\cos\theta}{r^2}$

$V_{axial} = \frac{Kp}{r^2}$ $V_{equitorial} = 0$

TORQUE

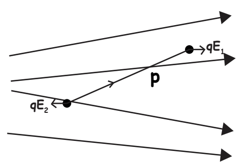
Uniform field



- Rotational motion only
- No translatory motion

$\vec{\tau} = \vec{P}\times\vec{E}$

$\tau = PE\sin\theta$



- Both rotatory and translatory motion

Non - Uniform field

$\tau_{max} = pE\sin\theta = pE,\ (\theta = 90°)$

$\tau_{min} = pE\sin\theta = 0, (\theta = 0°)$

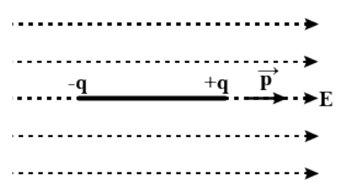
WORK DONE

$W = pE(\cos\theta_1 - \cos\theta_2)$

POTENTIAL ENERGY

$U = -pE\cos\theta$

1) $U_{minimum}$ (stable equilibrium)

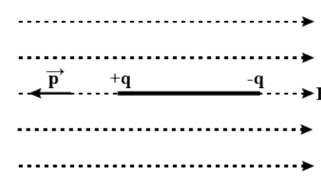


$\theta = 0°$

$\cos\theta = 1$

$U = -pE$

2) $U_{maximum}$ (Unstable equilibrium)

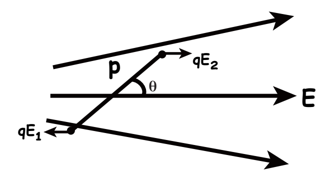


$\theta = 180$

$\cos\theta = -1$

$U = +pE$

Force in Non- Uniform field



$F_x = p\frac{dE}{dx}\cos\theta$

where, dE= small change in field at the two locations of the charges