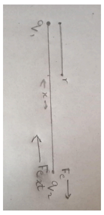
$F = kq_1q_2$

<u>Potential energy of 2 charge system</u>

$U = kq_1q_2$

<u>Derivation(Imp)</u>

let charge q1 and q_2 be at a distance n



Electrostatic force on q2 =

$F_e = kq_1q_2$ (F_e is positive)

External force to move q_2 is

$F_{ext} = (-kq_1q_2)/x2$

External work done to bring q2 from infinity to r is:

$W = \int F_{ext}dx = \int(-kq_1q_2 \cdot dx)/x2$

$= -kq_1q_2 \ {}_{\infty}\int^{x} dx/x^2$

$= \int(1/x^2)dx = \int x^{-2}dx$

$= \int(x^{-2+1}dx)/(-2+1)$ [$\int x^n dx = x^{n+1}/n+1$]

$= x^{-1}/-1$

$= -1/x$

$W = -kq_1q_2 [-1/x]^r_\infty$

$= kq_1q_2[-1/x]^r_\infty$

$= kq_1q_2[1/r - 1/\infty]$ [$1/\infty = 0$]

$\Rightarrow W = kq_1q_2/r$

This work is stored as potential energy of system

``` ***$U = kq_1q_2/r$*** ```

<u>Potential difference</u>

$W_{\infty \to P} = U$

$W = U_p - U_i$

$W = \Delta U$

<u>Potential energy of multiple charge system</u>

$U = k[(q_1q_2/r_{12}) + (q_1q_3/r_{12}) + (q_1q_4/r_{14}) + (q_2q_3/r_{23}) + (q_2q_4/r_{24}) + (q_3q_4/r_{34})]$

imagine u= 500J, work done to bring charge from infinity to configuration, $W_{\infty \to configuration}$

<u>Potential</u>

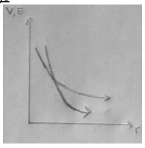
Potential energy per unit charge = V

``` ***$W = qV$*** ``` (from infinity to p)

``` ***$W = q\Delta V$*** ``` (for 2 points)

<u>Electric potential due to a single charge</u>

$V = kq/r$ <u>Graph of E_{field} & Potential due to a point charge</u>



$V = kq/r$; $v \propto 1/r$

$E = kq/r^2$; $E \propto 1/r^2$

<u>Unit and DF of potential</u>

Si unit = J/C = volt

DImentional formula = $[ML^2T^{-3}A^{-1}]$

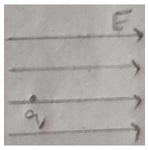
<u>Electric potential due to a system of charges</u>

$V = k[q_1/r_1 + q_2/r_2 + q_3/r_3]$

Sum of potential of potential of all charges

<u>Relation between E and V</u>

$E = -dv/dr$



Electrical field is the negative of potential gradient

$V = Ed$

If E_{field} is 0, i.e. potential is constant

<u>Equipotential surface</u>

A surface where electric potential is same @ all points is called an equipotential surface

- <u>Properties</u>
  a. Potential difference between 2 points= 0 [$\Delta v = 0$]
  b. Work done to move any charge = 0
  c. Two E_q surfaces can never intersect. (If they could, there will be 2 values of potential @ that point, which is more possible) [$W = q\Delta V = 0$]
  d. Efield must be proportional to $E_q$surface @ any point

<u>Potential energy of a dipole in uniform E_{field}</u>

Work done to rotate dipole by angle $d\varnothing$;

$dw = Fdx \Rightarrow Td\varnothing$ [T= torque]

$W = -PE[\cos\varnothing_2 - \cos\varnothing_1]$

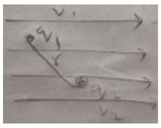
$V\varnothing_2 - V\varnothing_1 = -PE[\cos\varnothing_2 - \cos\varnothing_1]$

``` ***$V\varnothing = -P \cdot E$*** ```

<u>Potential energy of a charge in external E_{field}</u>

$U = qV$

<u>Potential energy of 2 charges in external E_{field}</u>



$U = q_1V_1 + q_2V_2 + kq_1q_2/r$

<u>Potential due to dipole</u>

Potential @ P

$V = v_{-q} + V_{+q}$

$= K\text{-}q/r_1 + k\text{+}q/r_2$

$= Kq[-1/r_1 + 1/r_2] \Rightarrow Kq[1/r_2 - 1/r_1]$

$= Kq[r_1 - r_2 / r_1r_2]$ [$r_1r_2 \approx r^2$]

$= Kq[r_1 - r_2 /r^2]$

$= Kq[2a \cos\varnothing] / r^2$ [$2aq = p$]

``` ***$V = kP\cos\varnothing / r^2$*** ```

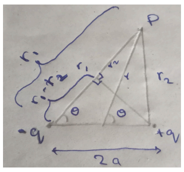
If ‘p’ is on equitorial line

$\cos\varnothing = b/h = r_1 - r_2/2a$

$r_1 - r_2 = 2\cos\varnothing$

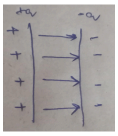
$\varnothing = 90°$

$V = 0$ [$\cos\varnothing = 0$]



<u>Capacitor</u>

Charge storing device



Capacitance (c) is the ability to store charge

Defined as charge stored per unit potential

$C = q/ v$

Si unit : e/v or Farad

<u>Parrelel Plate Capacitance</u>

$C = q/v = q/Ed = q\varepsilon_0$

$\varepsilon_0 qA/qd$ [$\sigma = q/A$]

$C = \varepsilon_0 A/d$

A = plate area; d = distance between plates

<u>Effect of inserting dielectric</u>

$C_m = k\varepsilon_0 A / d$

$C_m = KC_{air}$

<u>Parrelel combination</u>

$C = c_1 + c_2 + c_3$

<u>Series combination</u>

$1C = 1/c_1 + 1/c_2 + 1/c_3$

<u>Potential energy of a capacitor</u>

$W = Q^2/2c$; $V = Q^2/2c$

$U = Q^2/2c$

$U = \frac{1}{2}CV^2$

$U = \frac{1}{2}QV$

<u>Electrical energy(energy per unit volume)</u>

$U = \frac{1}{2} \varepsilon_0 E^2Ad$

$M = \frac{1}{2} \varepsilon_0 E^2$

<u>Electrostatics of conductor</u>

1) Fields inside a conductor material = 0
2) E-field is always proportional to conductor
3) Excess charge always reside on surface of conductor
4) Potential inside a conductor @ any point is same as surface
5) E- field inside a cavity of a conductor is always 0, electro static shielding
6) E-field @surface of conductor = > $E = \sigma /\varepsilon 0$
```