$F = kq_1q_2$

Potential energy of 2 charge system

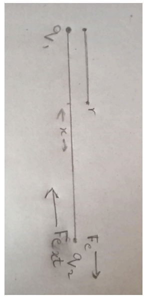
$U = kq_1q_2$

Derivation(Imp)

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:

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

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

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

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

$\int x^n dx = x^{n+1}/n+1$]

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

$= -1/x$

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

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

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

$\Rightarrow W = kq_1q_2/r$

This work is stored as potential energy of system

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

Potential difference

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

$W = U_p - U_i$

$W = \Delta U$

Potential energy of multiple charge system

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

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

Potential

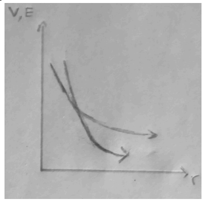
Potential energy per unit charge = V

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

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

Electric potential due to a single charge

V = kq/rGraph of E_{field} & Potential due to a point charge



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

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

Unit and DF of potential

Si unit = J/C = volt

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

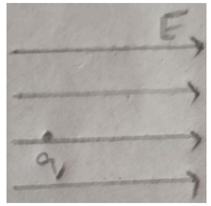
Electric potential due to a system of charges

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

Sum of potential of potential of all charges

Relation between E and V

$E = -dv/dr$



Electrical field is the negative of potential gradient

$V = Ed$

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

Equipotential surface

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

- Properties
  a. Potential difference between 2 points= 0 [Δv = 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

Potential energy of a dipole in uniform E_{field}

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

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

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

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

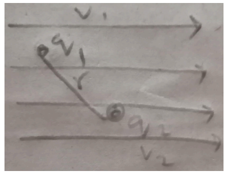
```***$V\varnothing = -P\bullet E$*** ```

Potential energy of a charge in external E_{field}

$U = qV$

Potential energy of 2 charges in external E_{field}

$U = q_1V_1 + q_2V_2 + kq_1q_2/r$



Potential due to dipole

Potential @ P

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

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

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

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

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

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

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

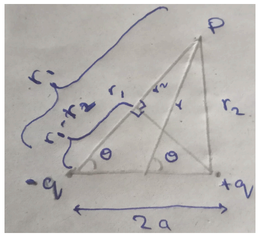
If ‘p’ is on equitorial line

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

$r_1 - r_2 = 2\cos\varnothing$

$\varnothing = 90°$

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



Capacitor

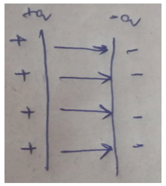
Charge storing device

Capacitance (c) is the ability to store charge

Defined as charge stored per unit potential

$C = q/ v$

Si unit : e/v or Farad



Parrelel Plate Capacitance

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

$= \varepsilon_0 qA/qd$ [σ=q/A]

$C= \varepsilon_0 A/d$

A = plate area; d = distance between plates

Effect of inserting dielectric

$C_m = k\varepsilon_0 A / d$

$C_m = KC_{air}$

Parrelel combination

$C = c_1 + c_2 + c_3$

Series combination

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

Potential energy of a capacitor

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

$U = Q^2/2c$

$U = ½CV^2$

$U = ½QV$

Electrical energy(energy per unit volume)

$U = ½ \varepsilon_0 E^2Ad$

$M= ½ \varepsilon_0 E^2$

Electrostatics of conductor

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 = > $E = \sigma /\varepsilon 0$
```