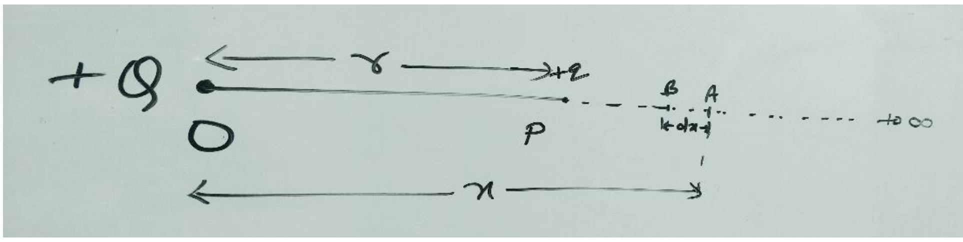
Electrostatic potential energy - Electrostatic potential energy of a charge in an electrostatic field is the amount of work done required to bring that charged body from infinity to that point . Its unit is joule per coulomb i.e. J

Let a charge Q is placed at point O as shown in figure , we have to find the potential energy at point 'p' which is 'r' distance away from the point 'O' .



Then the potential energy at point 'p' is equal to the work done to bring charge 'q' from infinity to point 'p' .

Let , at some instant charge is at point A which is 'x' distance away from the point 'O' .

Then , force at point 'O' is given by $F = KQq/x^2$ [where $K = 1/4\pi\epsilon_0$]

Let charge q cover a small distance 'dx' and reaches the point B , then work required to bring the charge q from A to B is $dW = F\,dx = (k\,Qq/x^2)\,dx$;

Integrating both sides we get $\int dw = \int \left(\frac{kQq}{x2}\right) dx$ with limit infinity '∞' to 'r'

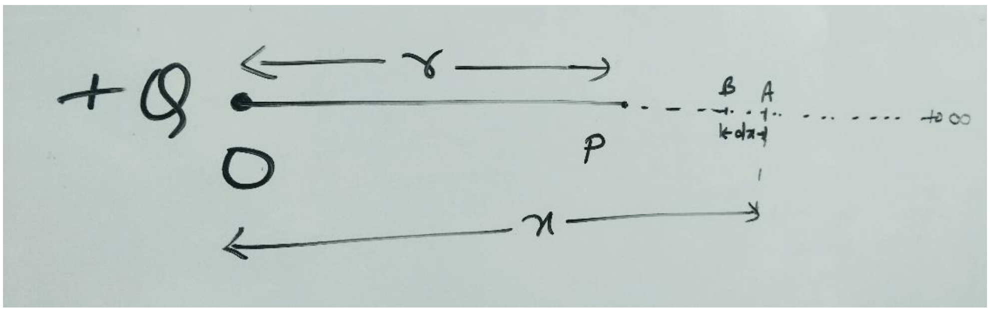
We get $W = K\,Qq\,[-1/x]^{r}_{infinity} = KQq/r$;

Or potential energy $U = W = KQq/r$;

Electrostatic potential – electrostatic potential at any point in a region of electrostatic field is the minimum work done required to carry a unit positive charge from infinity to that point .

We can write electrostatic potential $V = U/q$ i.e. electrostatic potential is equal to potential energy per unit charge . Its unit is J/c or JC^{-1} or NmC^{-1} and its dimension is $[M^1L^2T^{-3}A^{-1}]$

Let a charge Q is placed at point O as shown in figure , we have to find the potential e at point 'p' which is 'r' distance away from the point 'O' .



Then the potential energy at point 'p' is equal to the work done to bring charge '1c' of charge from infinity to point 'p' .

Let at some instant charge is at point A which is 'x' distance away from the point 'O' .

Then , force at point ‘O’ is given by $F= KQ/x^2$ [where $K= 1/4\pi\epsilon_0$]

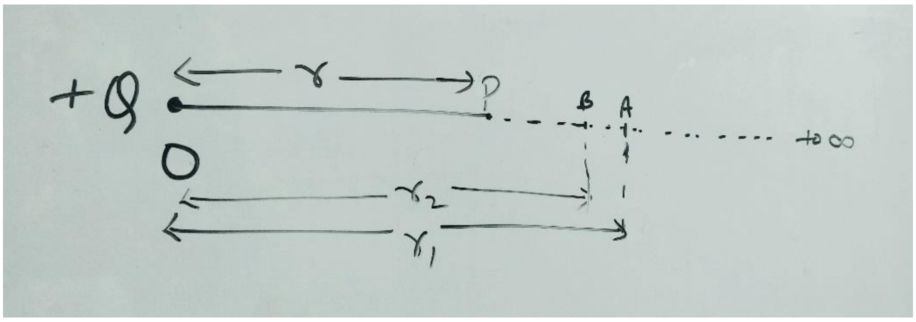
Let charge q cover a small distance ‘dx’ and reaches the point B , then work required to bring the charge q from A to B is $dW = F\,dx = (k Q/x^2)\,dx$;

Integrating both sides we get $\int dw = \int \left(\frac{kQ}{x2}\right) \mathrm{dx}$ with limit infinity ‘∞’ to ‘r’

We get $W = K Q [-1/x]^{r}_{infinity} = KQ/r$;

Or potential energy $V = W = KQ/r$;

Electrostatic potential difference - Electrostatic potential difference between two points is the amount of work done required to bring the unit positive charge from one point to another point .



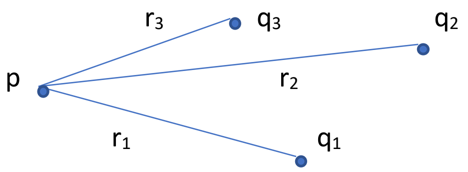
Suppose a unit positive charge is moving from infinity to point ‘A’ again it moves from ‘A’ to ‘B’ . suppose distance between AB is ‘dx’ then work done to bring the unit positive charge from A to B is $\int dw = \int \left(\frac{kQ}{x2}\right) \mathrm{dx}$ with limit ‘r_1’ to ‘r_2’

We get $W = K Q [-1/x]^{r2}_{r1} = KQ [(1/r_1) – (1/r_2)]$;

So , $V_{AB} = V_A – V_B = KQ [(1/r_1) – (1/r_2)]$;

Electrostatic forces are conservative are conservative in nature i.e. electrostatic force is independent of path followed , it only depends on initial and final position of the charge particle in an electric field .

Potential at a point due to group of electric charges . suppose there are numbers of charges q_1 , q_2 ,q_3 ,…………………… q_n are at distances r_1, r_2 , r_3 …………………r_n respectively from a point ‘p’ where we have to find the potential due to these charges .



Now , potential at p due to q_1 $V_1 = \frac{q1}{4\prod\epsilon 0\, r1}$

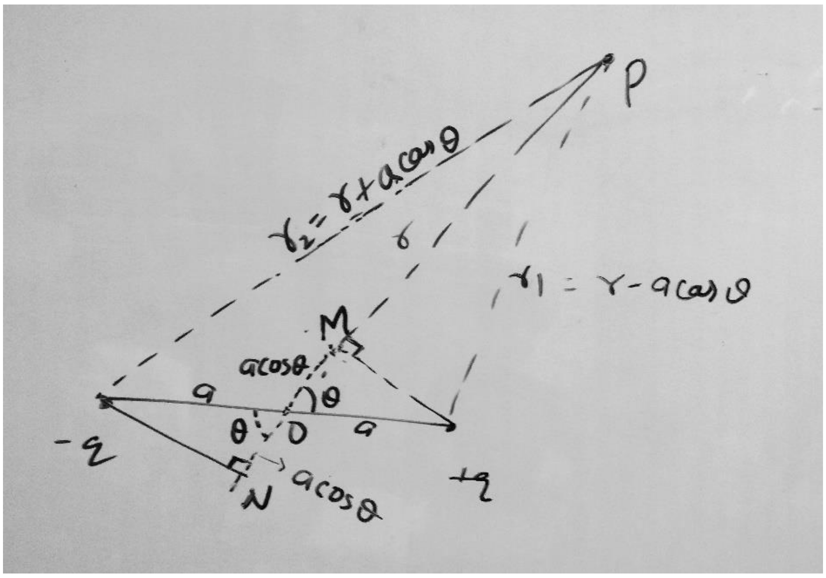
Similarly, potential at p due to q_2 $V_2 = \frac{q2}{4\prod\epsilon 0\, r2}$ and due to q_3 $V_3 = \frac{q3}{4\prod\epsilon 0\, r3}$

So net potential at p $V = V_1 + V_2 + V_3 \ldots\ldots\ldots\ldots V_N$

i.e. $V = \frac{1}{4\prod\epsilon 0}\,(q_1/r_1 + q_2/r_2 + q_3/r_3 + \ldots\ldots)$

so, $V = \frac{1}{4\prod\epsilon 0}\sum_{i=1}^{n} \mathrm{qi/ri}$

Electric potential due to a dipole at a point –



Suppose a dipole of charges -q and +q are separated by small distance ‘2a’ . We have to find the electric potential at point ‘P’ .

Potential at p due to ‘-q’ $V_1 = \frac{q}{4\prod\epsilon 0(\,r+acos\theta)}$;

Potential at P due to +q $V_2 = \frac{q}{4\prod\epsilon 0(\,r-acos\theta)}$;

Net potential at P $V= V_1 + V_2 = \frac{q}{4\prod\epsilon 0(\,r+acos\theta)} + \frac{q}{4\prod\epsilon 0(\,r-acos\theta)}$;

V= $\frac{q}{4\prod\epsilon 0}$ (2acosΘ/r^2) ; since r>>a

V = $\frac{pcos\Theta}{4\prod\epsilon 0}\frac{1}{r2}$

On the dipole axis Θ=0^0 i.e. cosΘ = 1 ; V= $\frac{p}{4\prod\epsilon 0}\frac{1}{r2}$

On the equatorial point Θ = 90^0 i.e. cosΘ =o V = 0 .