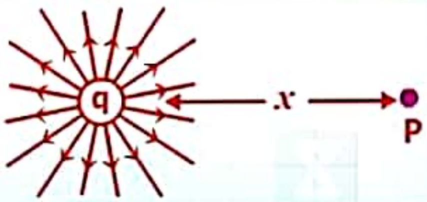
Part I

ELECTRIC FIELD

Electric Field due to Point Charge



$$E = \frac{kq}{x^2}$$

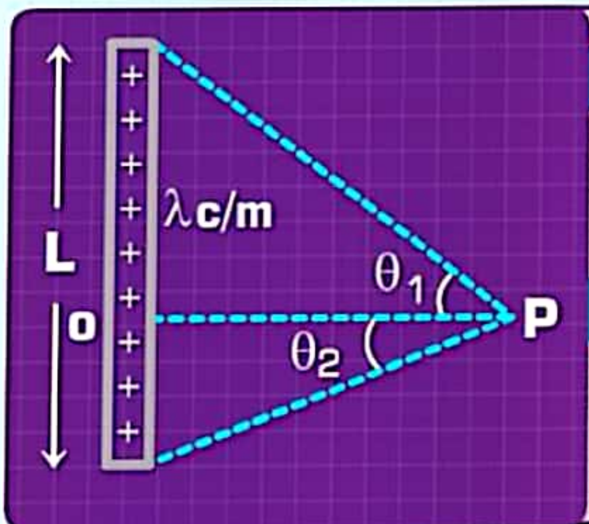
Vector Form $\vec{E} = \frac{kq}{x^3} \cdot \vec{x}$

$k = \frac{1}{4\pi\varepsilon_0}$

q = Charge ; x = Distance

If a charge q_0 is placed at a point in electric field, it experiences a net force $\vec{F}$ on it, then electric field strength at that point can be $\vec{E} = \frac{\vec{F}}{q_0}$

ELECTRIC FIELD DUE TO A UNIFORMLY CHARGED ROD



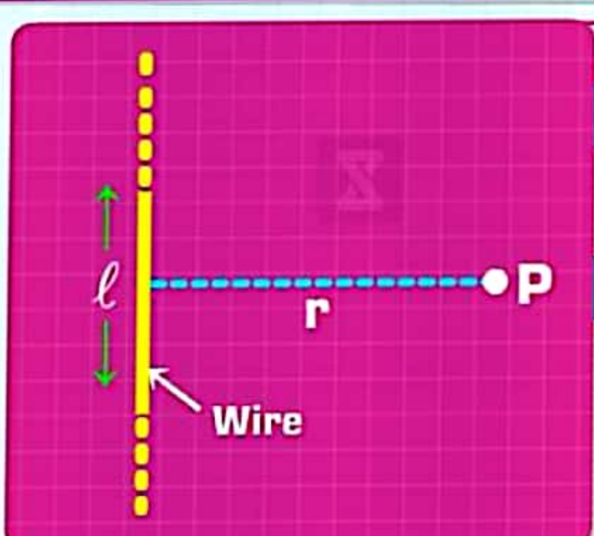
PARALLEL

$$E_{\parallel} = \frac{k\lambda}{r}(\cos\theta_2 - \cos\theta_1)$$

PERPENDICULAR

$$E_{\perp} = \frac{k\lambda}{r}(\sin\theta_2 - \sin\theta_1)$$

ELECTRIC FIELD DUE TO INFINITE WIRE (ℓ>>r)



Since $\ell >> r \Rightarrow \theta_1 = \theta_2 = 90^\circ$

PERPENDICULAR

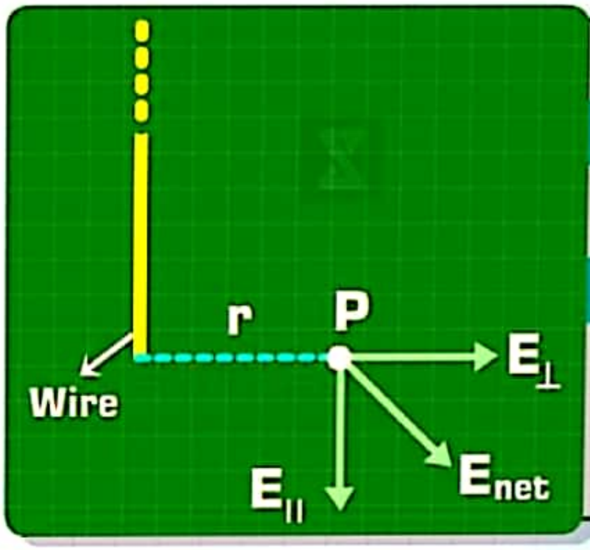
$E_{\perp} = \frac{k\lambda}{r}(\sin 90^\circ + \sin 90^\circ) \Rightarrow E_{\perp} = \frac{2k\lambda}{r}$

PARALLEL

$E_{\parallel} = \frac{k\lambda}{r}(\cos 90^\circ - \cos 90^\circ) \Rightarrow E_{\parallel} = 0$

At P, $E_{net} = E_{\perp} + E_{\parallel}$ $\quad E_{net} = \frac{2k\lambda}{r}$

ELECTRIC FIELD DUE TO SEMI INFINITE WIRE



$\theta_1 = 90^\circ$, $\theta_2 = 0^\circ$

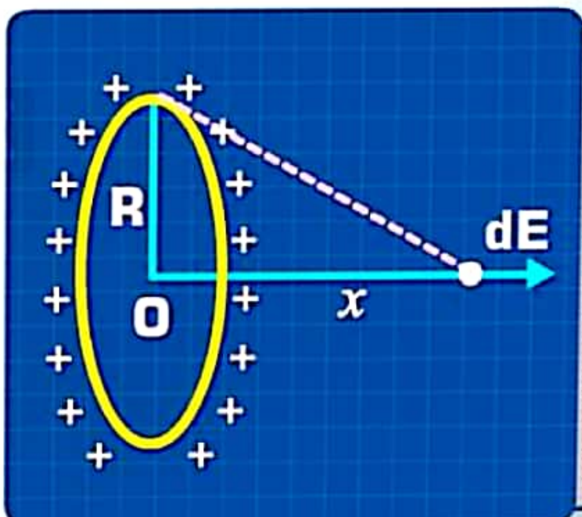
PERPENDICULAR

$$E_\perp = \frac{k\lambda}{r}(\sin 90^\circ + \sin 0^\circ) = \frac{k\lambda}{r}$$

PARALLEL

$$E_{||} = \frac{k\lambda}{r}(\cos 0^\circ - \cos 90^\circ) = \frac{k\lambda}{r}$$

ELECTRIC FIELD DUE TO UNIFORMLY CHARGED RING

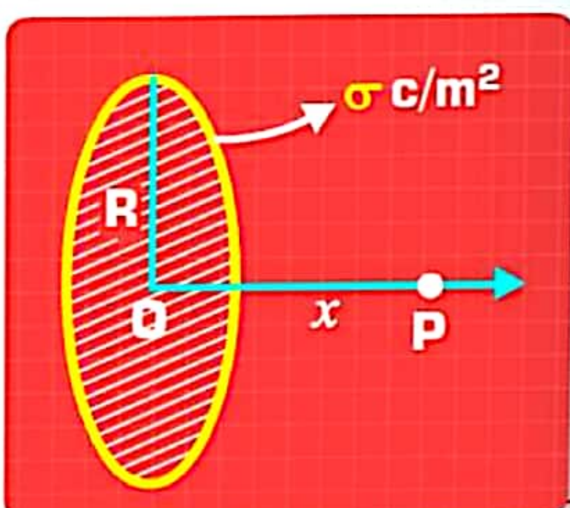


$$E = \frac{kQx}{(R^2 + x^2)^{3/2}}$$

For maxima, $x = \pm\frac{R}{\sqrt{2}}$

$$E_{max} = \pm\frac{2}{3\sqrt{3}}\frac{kQ}{R^2}$$

ELECTRIC FIELD ON THE AXIS OF DISC



$$E = \frac{\sigma}{2\varepsilon_0}\left[1 - \frac{x}{\sqrt{x^2 + R^2}}\right]$$ [along the axis]

If $x >> R$

$$E = 0$$

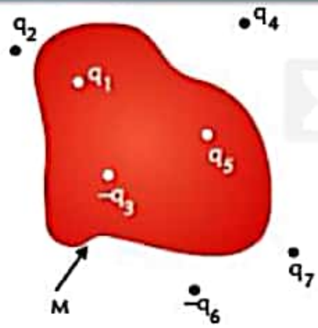
If $x << R$

$$E = \frac{\sigma}{2\varepsilon_0}(1 - 0) = \frac{\sigma}{2\varepsilon_0}$$

ELECTRIC FIELD STRENGTH

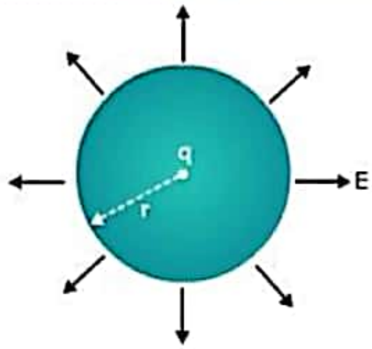
Part III

Gauss's Law



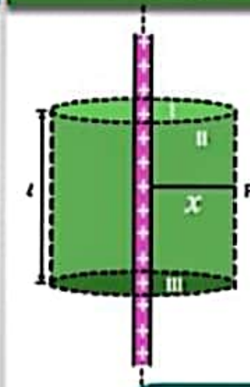
$$\oint_M \vec{E}\cdot d\vec{S} = \frac{q_1 + q_5 - q_3}{\varepsilon_0}$$

Electric Field due to a Point Charge



$$E = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r^2}$$

Electric Field Strength due to a Long Charged Wire

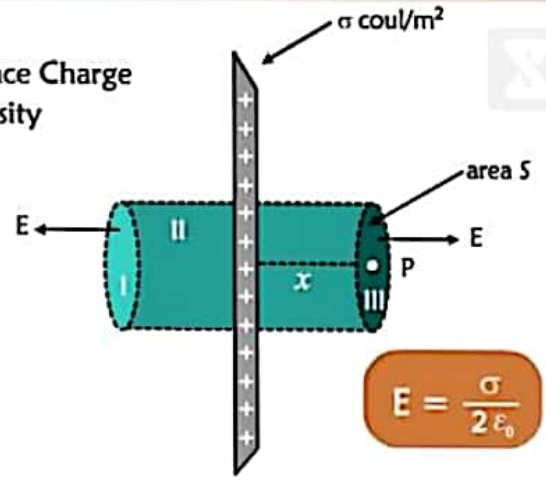


λ = Linear Charge Density

$$E = \frac{\lambda}{2\pi\varepsilon_0 x}$$

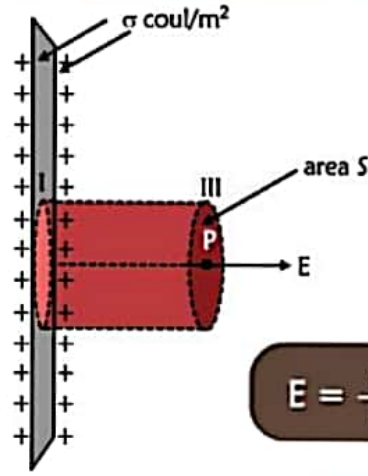
Electric Field Strength due to Non-Conducting Uniformly Charged Sheet

σ = Surface Charge Density



$$E = \frac{\sigma}{2\varepsilon_0}$$

Electric Field Strength due to Charged Conducting Sheet

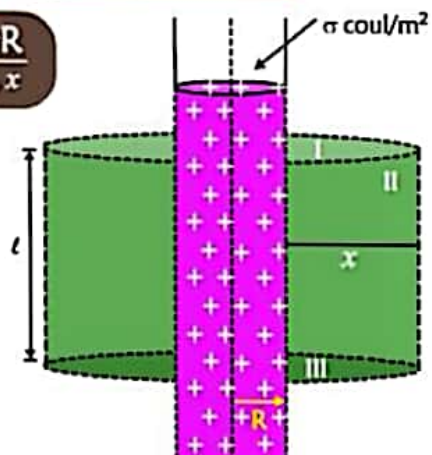


$$E = \frac{\sigma}{\varepsilon_0}$$

Electric Field Strength due to a Long Uniformly Charged Cylinder

Conducting Cylinder

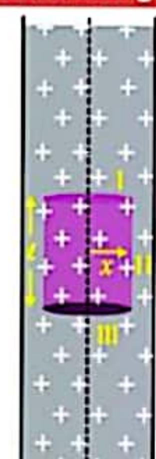
$$E = \frac{\sigma R}{\varepsilon_0 x}$$



Uniformly Charged Non – Conducting Cylinder

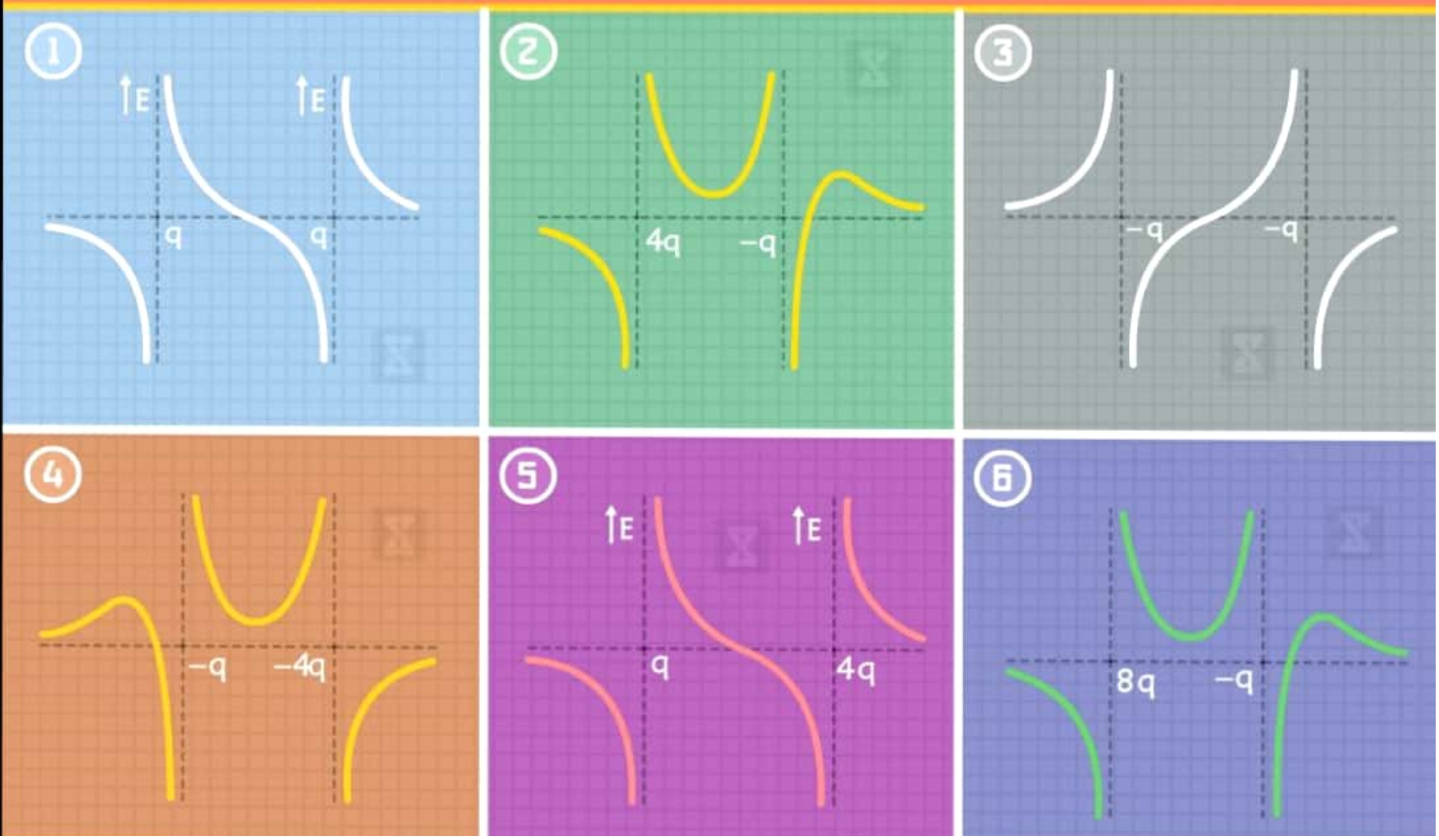
$$E_{inside} = \frac{\rho x}{2\varepsilon_0}$$

ρ = Volume Charge Density



GRAPH OF ELECTRIC FIELD DUE TO BINARY CHARGES

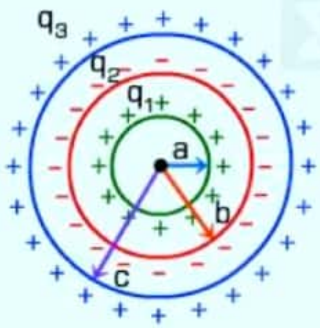
Part IV



ELECTRIC POTENTIAL

Part V

POTENTIAL DUE TO CONCENTRIC SPHERES



At a point r > c

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q_1 - q_2 + q_3}{r}$$

At a point a < r < b

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r} - \frac{1}{4\pi\varepsilon_0}\frac{q_2}{b} + \frac{1}{4\pi\varepsilon_0}\frac{q_3}{c}$$

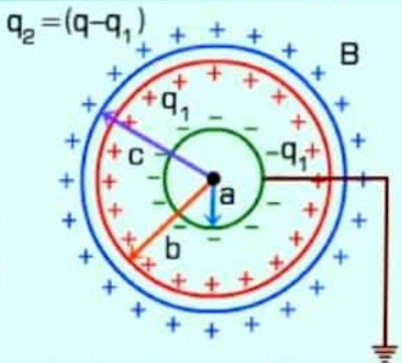
At a point b < r < c

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q_1 - q_2}{r} + \frac{1}{4\pi\varepsilon_0}\frac{q_3}{c}$$

At a point r < a

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{a} - \frac{q_2}{b} + \frac{q_3}{c}\right]$$

DIFFERENCE BETWEEN TWO CONCENTRIC SPHERES WHEN ONE OF THEM IS EARTHED



$$V_{in} = \frac{1}{4\pi\varepsilon_0}\left[-\frac{q_1}{a} + \frac{q_2}{b}\right]$$

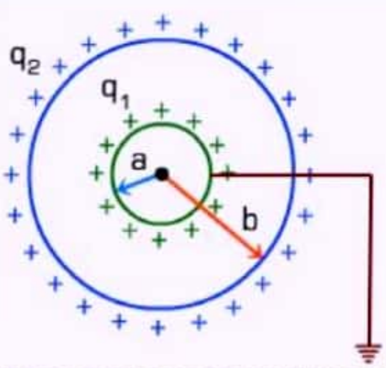
$$V_{out} = \frac{1}{4\pi\varepsilon_0}\left[-\frac{q_1}{b} + \frac{q_2}{b}\right]$$

$$\frac{q_2}{c} = q_1\left(\frac{1}{a} - \frac{1}{b}\right) \quad .....(i)$$

$$q_1 + q_2 = q \quad .....(ii)$$

Solving (i) and (ii) we can get q_1 and q_2

DIFFERENCE BETWEEN TWO CONCENTRIC UNIFORMLY CHARGED METALLIC SPHERES

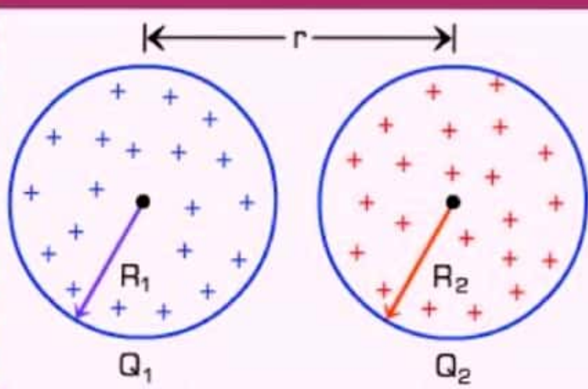


$$V_{in} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{a} + \frac{1}{4\pi\varepsilon_0}\frac{q_2}{b}$$

$$V_{out} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{b} + \frac{1}{4\pi\varepsilon_0}\frac{q_2}{b}$$

$$\Delta V = V_{in} - V_{out} \Rightarrow \Delta V = \frac{q_1}{4\pi\varepsilon_0}\left(\frac{1}{a} - \frac{1}{b}\right)$$

TOTAL ELECTROSTATIC ENERGY OF A SYSTEM OF CHARGES



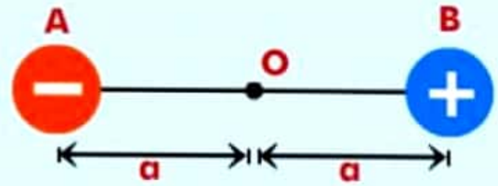
$$U = U_{self} + U_{interaction}$$

$$U = \frac{3KQ_1^2}{5R_1} + \frac{3KQ_2^2}{5R_2} + \frac{KQ_1Q_2}{r}$$

ELECTRIC DIPOLE

ELECTRIC DIPOLE

$\vec{p} = q.2\vec{a}$



SI unit : Coulomb - meter

It is a vector quantity

Direction of dipole moments ($\vec{p}$) is from negative charge to positive charge

ELECTRIC FIELD ON AXIAL LINE OF AN ELECTRIC DIPOLE

$$E = \frac{1}{4\pi\varepsilon_0} \frac{2qa}{(r^2-a^2)^2}$$

For a<<r

$$\vec{E}_{axial} = \frac{1}{4\pi\varepsilon_0} \frac{2\vec{p}}{r^3}$$

E_{axial} is along the direction of dipole moment

ELECTRIC FIELD ON EQUATORIAL LINE OF AN ELECTRIC DIPOLE

$$E = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{q.2a}{(r^2-a^2)^{3/2}}$$

For a<<r

$$\vec{E}_{equiatoral} = -\frac{1}{4\pi\varepsilon_0} \cdot \frac{\vec{p}}{r^3}$$

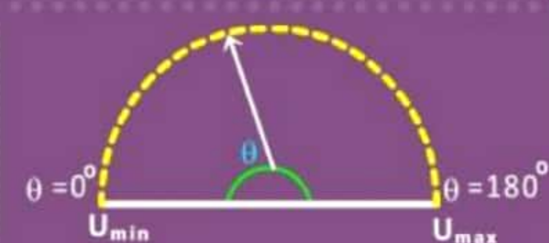
$E_{equatorial}$ is along the opposite direction of dipole moment

DIPOLE IN A UNIFORM EXTERNAL ELECTRIC FIELD

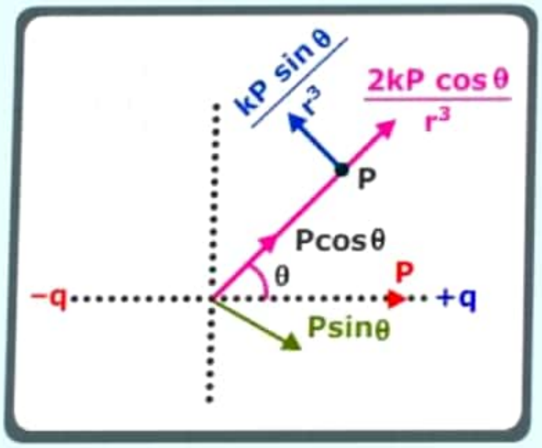
VECTOR FORM

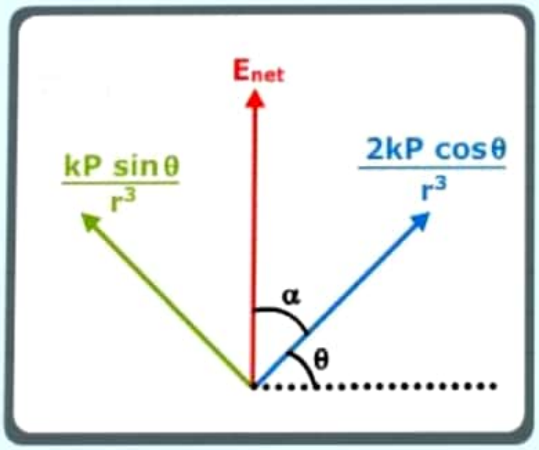
$\vec{\tau} = \vec{p}.\vec{E}$

$U = -pE\cos\theta$



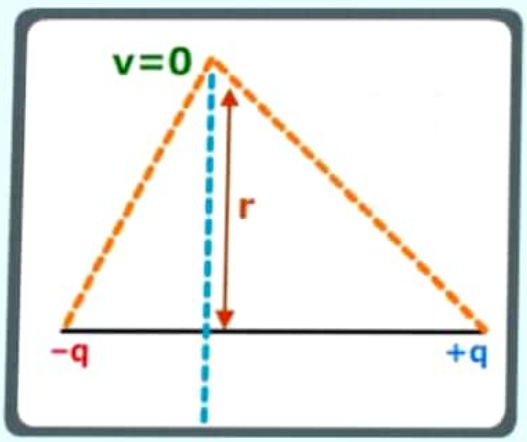
ELECTRIC FIELD AT A GENERAL POINT DUE TO A DIPOLE

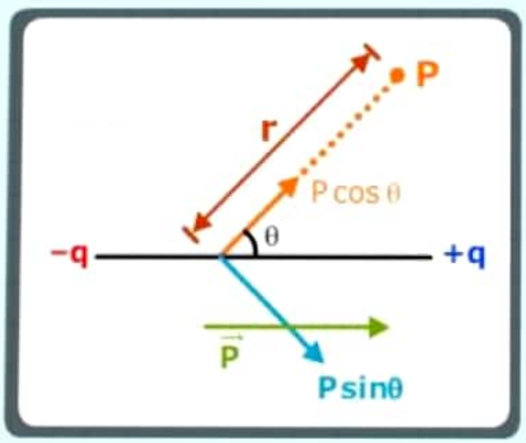




$$E_{net} = \frac{kP}{r^3}\sqrt{1+3\cos^2\theta}\ ,\ \tan\alpha = \frac{\tan\theta}{2}\ ;\ k = \frac{1}{4\pi\varepsilon_0}$$

ELECTRIC POTENTIAL DUE TO A DIPOLE





POTENTIAL AT 'P' DUE TO DIPOLE, $V_p = \frac{2kP\cos\theta}{r^2}$

AT AN AXIAL POINT, $V_{net} = \frac{kp}{r^2}$ (As $P = q.2a$)

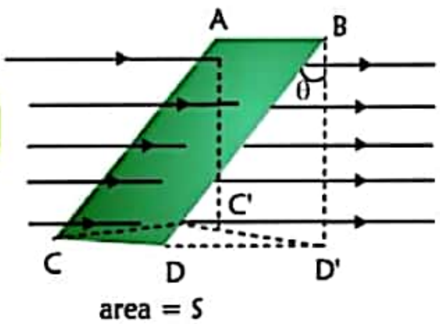
AT PERPENDICULAR BI-SECTOR, $V_{net} = 0$

ELECTRIC FLUX

Electric Field Strength in terms of Electric Flux

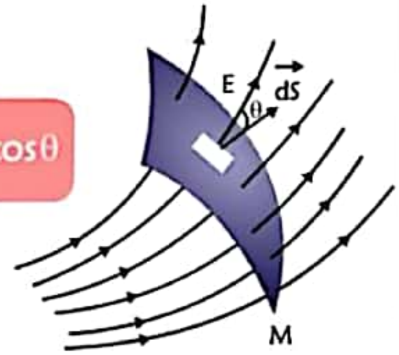
$$\phi = \vec{E}.\vec{S}$$

$$\phi = E.S.\cos\theta$$



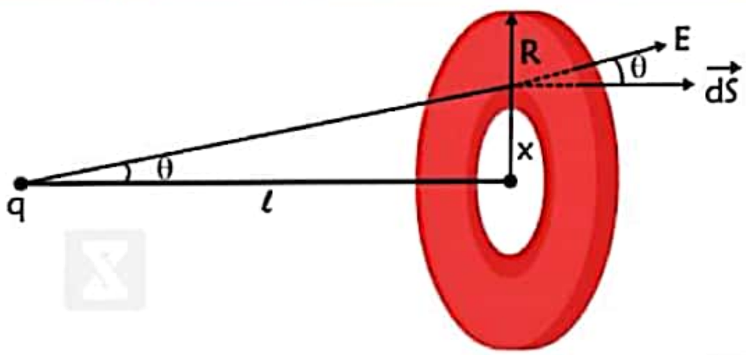
Electric Flux in Non-uniform Electric Field

$$\phi = \int d\phi = \int_M EdS\cos\theta$$



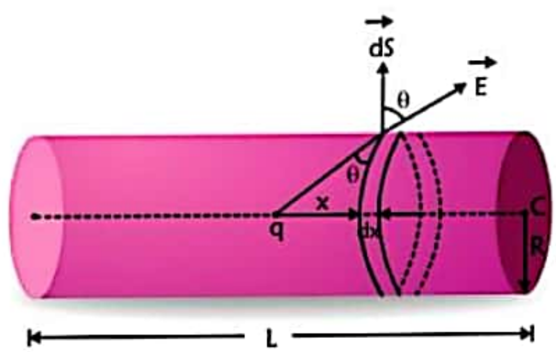
Electric Flux through a Circular Disc

$$\phi = \frac{q}{\epsilon_0}\left[1 - \frac{\ell}{\sqrt{R^2 + x^2}}\right]$$



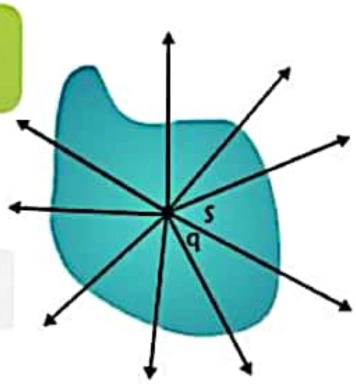
Electric Flux through the Lateral Surface of a Cylinder due to a Point Charge

$$\phi = \frac{q}{\epsilon_0} \cdot \frac{\ell}{\sqrt{R^2 + x^2}}$$



Electric Flux produced by a Point Charge

$$\phi_S = \frac{q}{\epsilon_0}$$



Flux Calculation in the Region of Varying Electric Field

$$\phi_{in} = E_0(2a)^2 . a^2 = 4E_0a^4$$

$$\phi_{out} = E_0(3a)^2 . a^2 = 9E_0a^4$$

$$\phi_{net} = 5E_0a^4$$