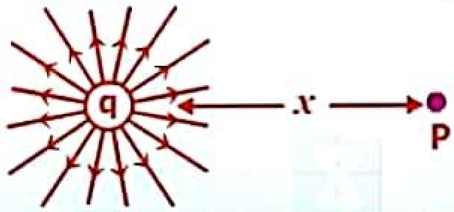
Part I


# ELECTRIC FIELD

## Electric Field due to Point Charge




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

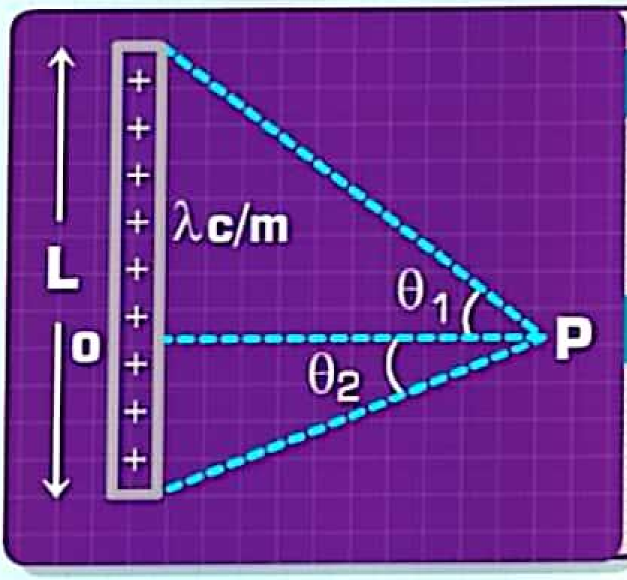
Vector Form $\vec{E} = \frac{kq}{x^3} \cdot \vec{x}$

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

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



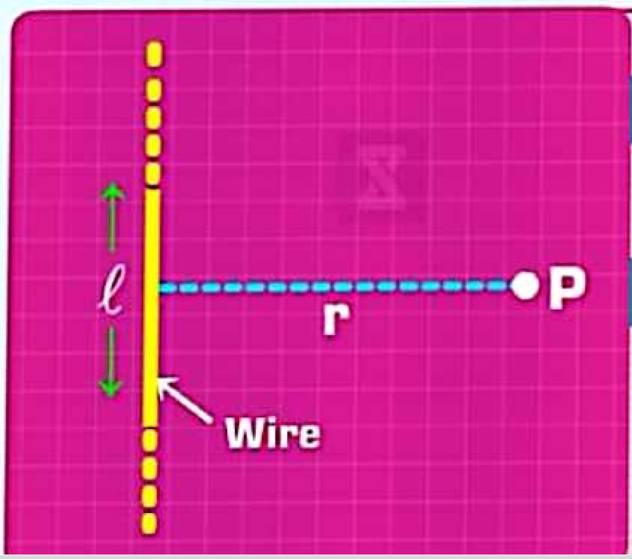

**PARALLEL**

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

**PERPENDICULAR**

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

## ELECTRIC FIELD DUE TO INFINITE WIRE ($\ell$>>r)




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

**PERPENDICULAR**

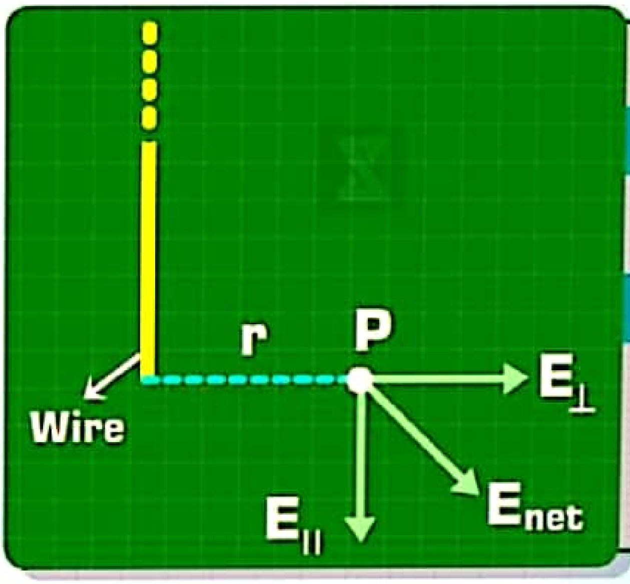
$$E_{\perp} = \frac{k\lambda}{r}(\sin 90^\circ + \sin 90^\circ) \Longrightarrow E_{\perp} = \frac{2k\lambda}{r}$$

**PARALLEL**

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

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

## ELECTRIC FIELD DUE TO SEMI INFINITE WIRE




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

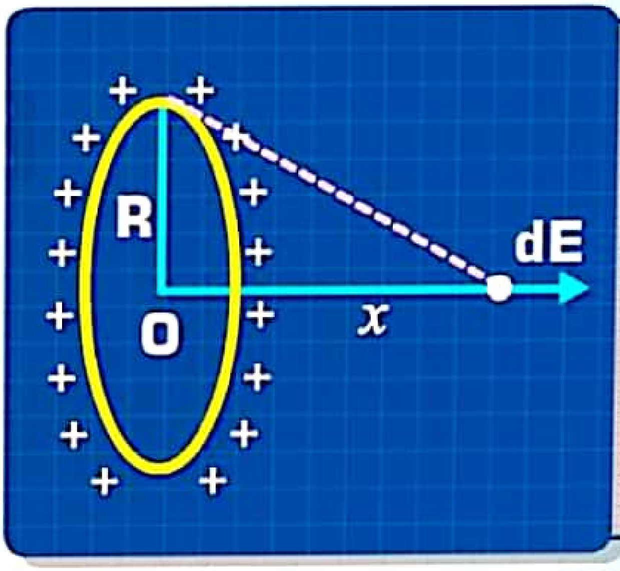
**PERPENDICULAR**

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

**PARALLEL**

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

## ELECTRIC FIELD DUE TO UNIFORMLY CHARGED RING

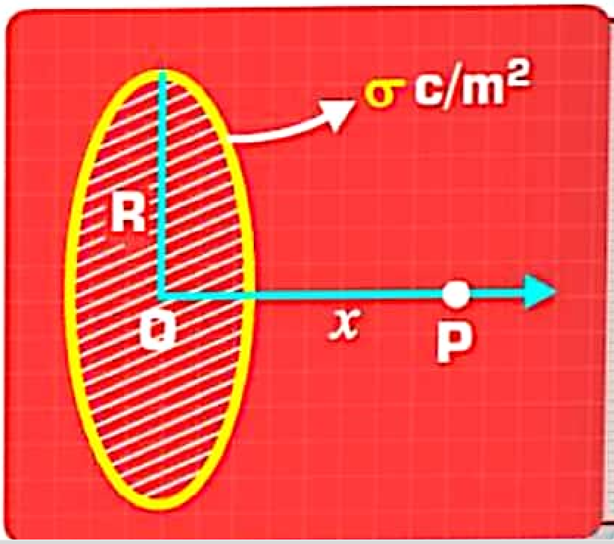



$$E = \frac{kQx}{(R^2 + x^2)^{3/2}}$$

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




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

If $x >> R$

$E = 0$

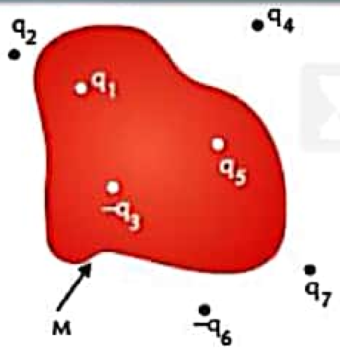
If $x << R$

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

# ELECTRIC FIELD STRENGTH

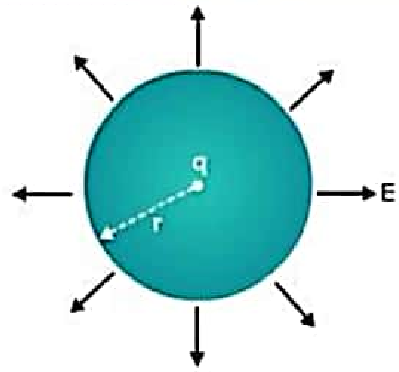
Part III

## Gauss's Law



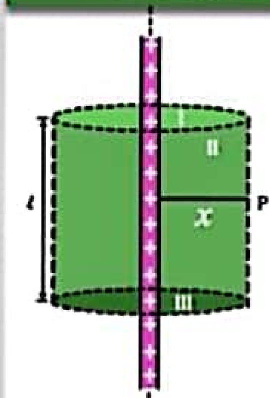

$$\oint_M \vec{E}\cdot d\vec{s} = \frac{q_1 + q_5 - q_3}{\varepsilon_0}$$

## 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

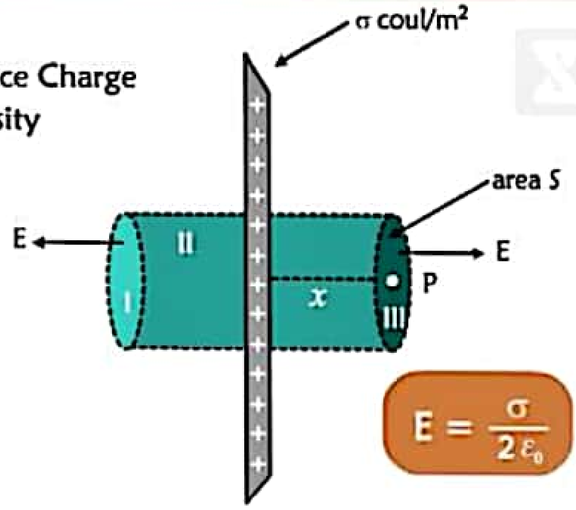



$\lambda$ = Linear Charge Density

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

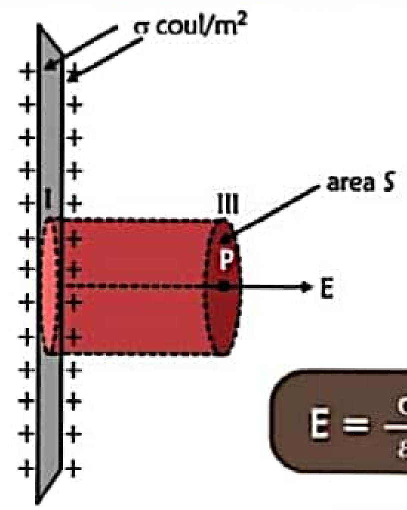
## Electric Field Strength due to Non-Conducting Uniformly Charged Sheet

$\sigma$ = Surface Charge Density




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

## Electric Field Strength due to Charged Conducting Sheet

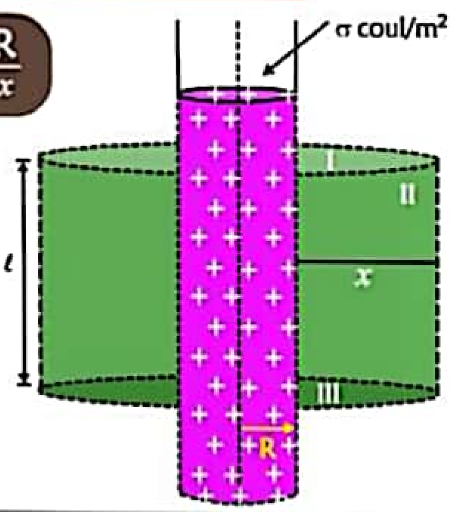



$$E = \frac{\sigma}{\varepsilon_0}$$

## Electric Field Strength due to a Long Uniformly Charged Cylinder

### Conducting Cylinder

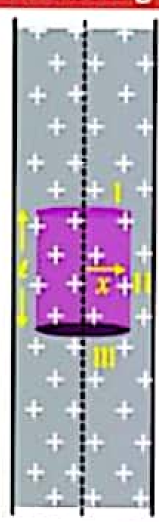
$$E = \frac{\sigma R}{\varepsilon_0 x}$$




### Uniformly Charged Non – Conducting Cylinder

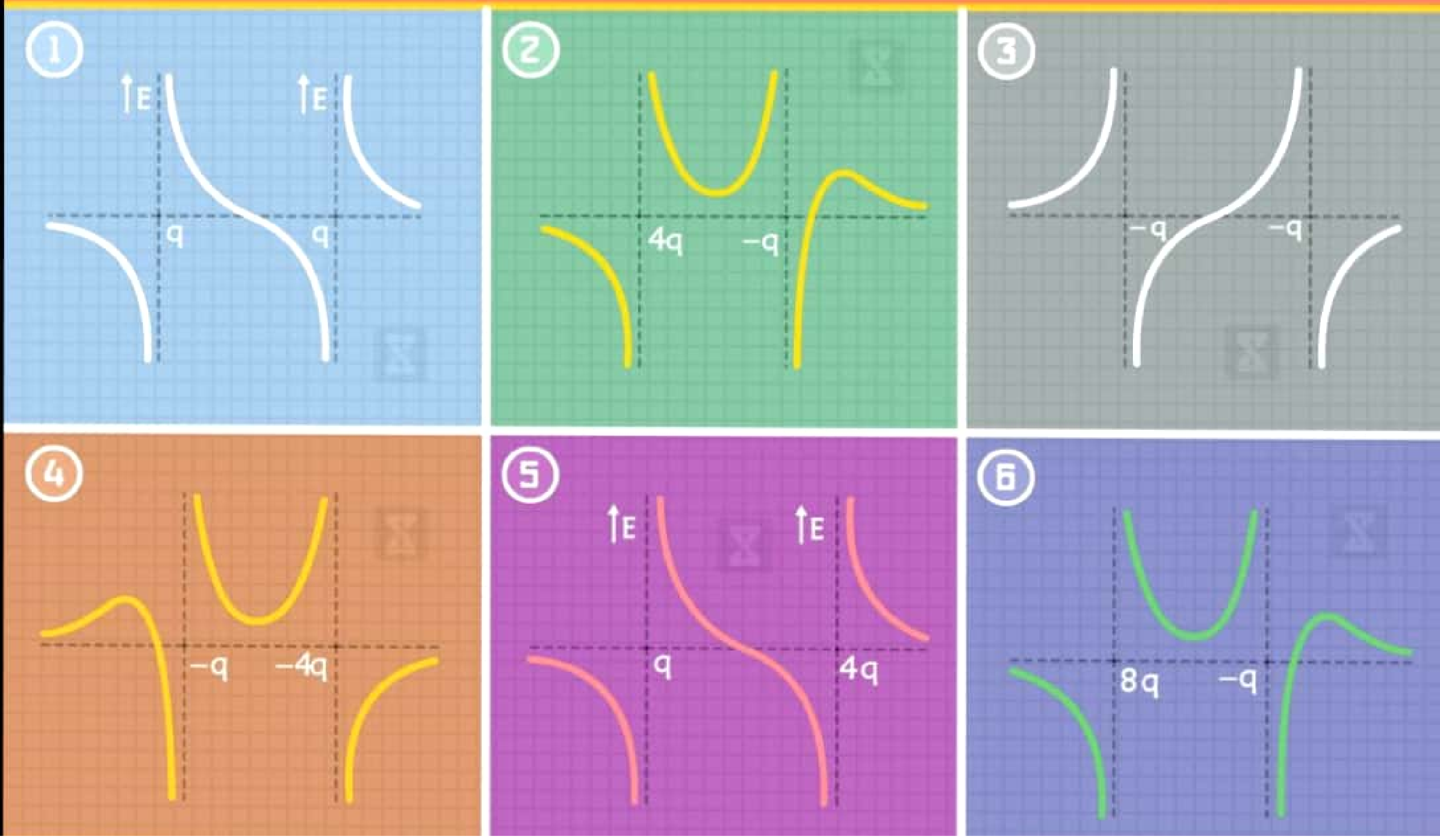
$$E_{inside} = \frac{\rho x}{2\varepsilon_0}$$

$\rho$ = Volume Charge Density



# GRAPH OF ELECTRIC FIELD DUE TO BINARY CHARGES

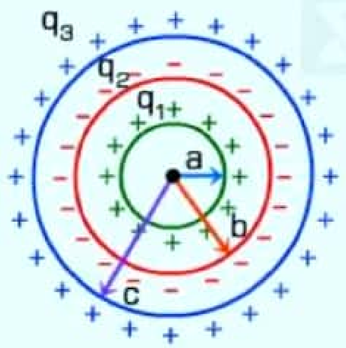
Part IV



# 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 $a < r < b$

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

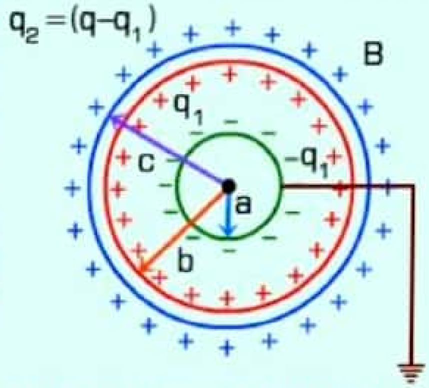
At a point $b < r < c$

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

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




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

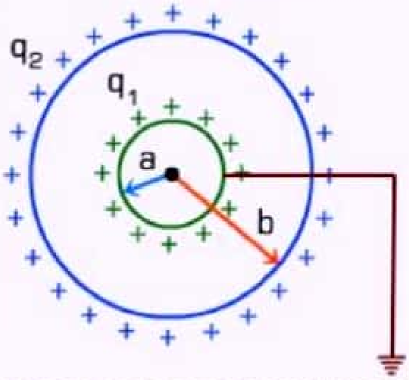
$$V_{out} = \frac{1}{4\pi\varepsilon_0}\left[-\frac{q_1}{b} + \frac{q_2}{b}\right]$$

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

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

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

## DIFFERENCE BETWEEN TWO CONCENTRIC UNIFORMLY CHARGED METALLIC SPHERES

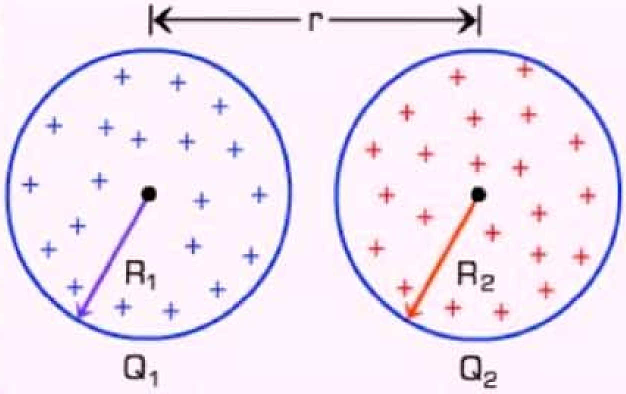



$$V_{in} = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{a} + \frac{1}{4\pi\varepsilon_0}\frac{q_2}{b}$$

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

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

## TOTAL ELECTROSTATIC ENERGY OF A SYSTEM OF CHARGES




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

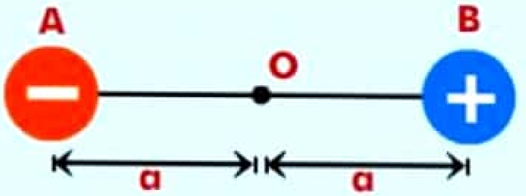
$$U = \frac{3KQ_1^2}{5R_1} + \frac{3KQ_2^2}{5R_2} + \frac{KQ_1Q_2}{r}$$

Part VI

# 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

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

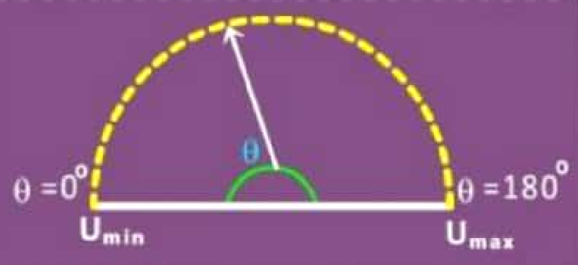
$E_{equatorial}$ is along the opposite direction of dipole moment

## DIPOLE IN A UNIFORM EXTERNAL ELECTRIC FIELD

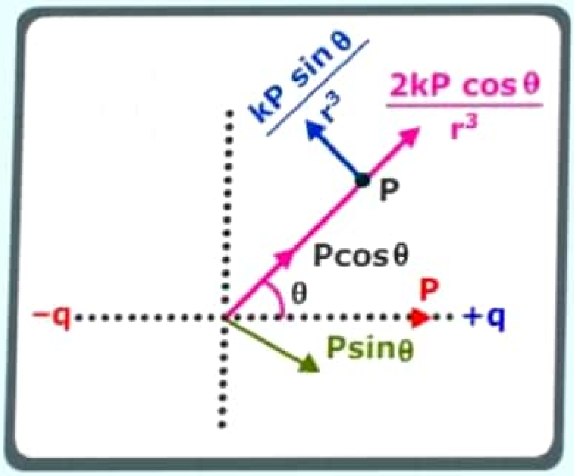
VECTOR FORM

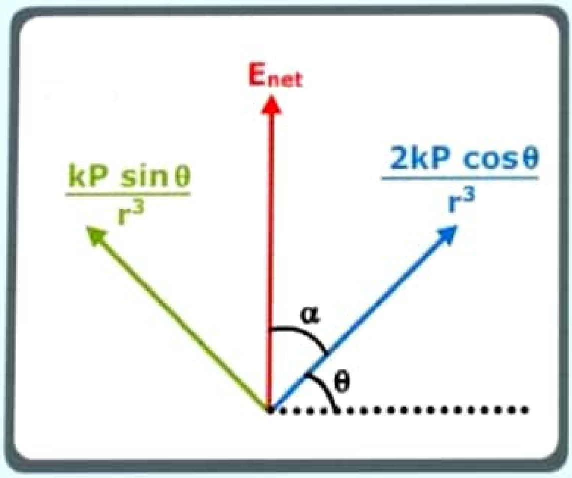
$\vec{\tau} = \vec{p}.\vec{E}$

$U = -pE\cos\theta$



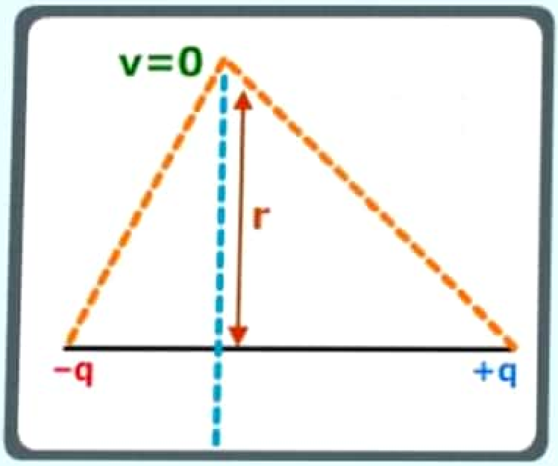
## ELECTRIC FIELD AT A GENERAL POINT DUE TO A DIPOLE

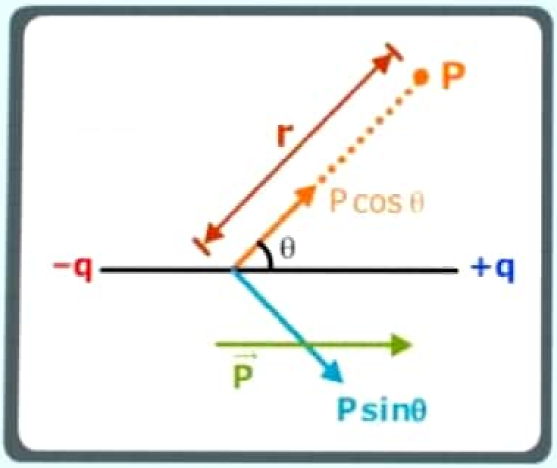



$$E_{net} = \frac{kP}{r^3}\sqrt{1+3\cos^2\theta}\ ,\ \tan\alpha = \frac{\tan\theta}{2}\ ;\ k = \frac{1}{4\pi\varepsilon_0}$$

## 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, $V_{net} = 0$