Chapeter 21

Coulomb's Law

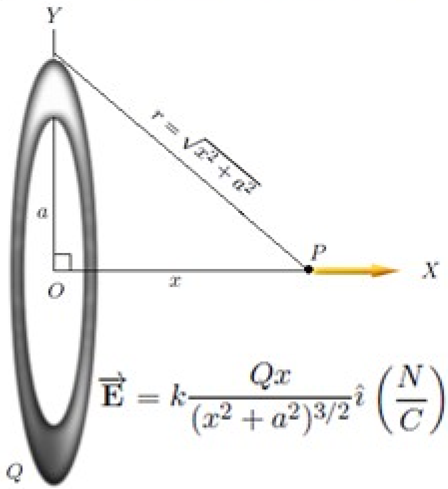
$$F = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2} \quad (N)$$

$$k = \frac{1}{4\pi\epsilon_0} \cong 8.988 \times 10^9 \quad \left(\frac{N \cdot m^2}{C^2}\right)$$

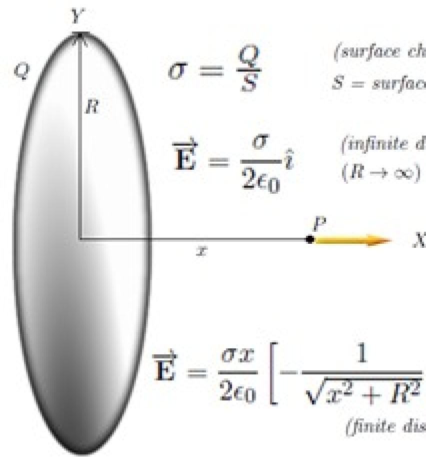
Electric Field

$$\overrightarrow{\mathbf{E}} = \frac{\overrightarrow{\mathbf{F_0}}}{q_0} = k\frac{q_0}{r^2}\hat{\mathbf{r}} \quad \left(\frac{N}{C}\right)$$

Electric Field Calculation (Common cases)



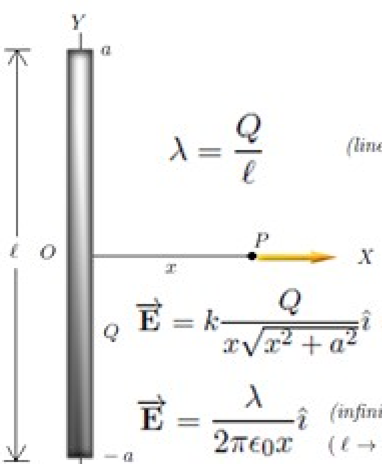
$$\overrightarrow{\mathbf{E}} = k\frac{Qx}{(x^2 + a^2)^{3/2}}\hat{\imath} \left(\frac{N}{C}\right)$$



$$\sigma = \frac{Q}{S}$$ *(surface charge density)* S = *surface area*

$$\overrightarrow{\mathbf{E}} = \frac{\sigma}{2\epsilon_0}\hat{\imath}$$ *(infinite disk/plane)* $(R \to \infty)$

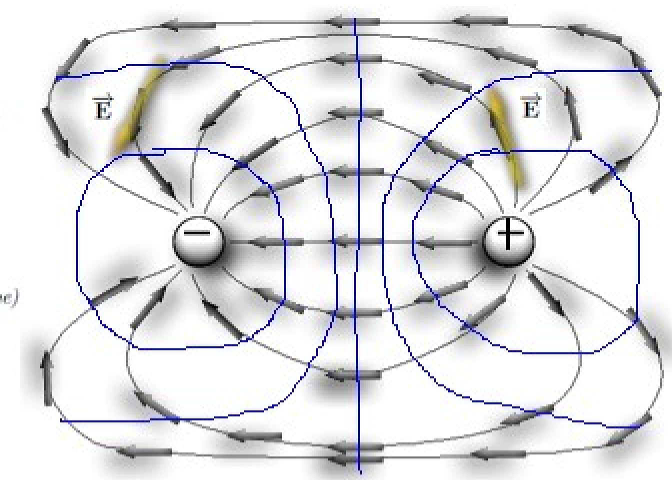
$$\overrightarrow{\mathbf{E}} = \frac{\sigma x}{2\epsilon_0}\left[-\frac{1}{\sqrt{x^2 + R^2}} + \frac{1}{x}\right]\hat{\imath}$$ *(finite disk/plane)*



$$\lambda = \frac{Q}{\ell}$$ *(linear charge density)*

$$\overrightarrow{\mathbf{E}} = k\frac{Q}{x\sqrt{x^2 + a^2}}\hat{\imath}$$ *(finite line of charge)*

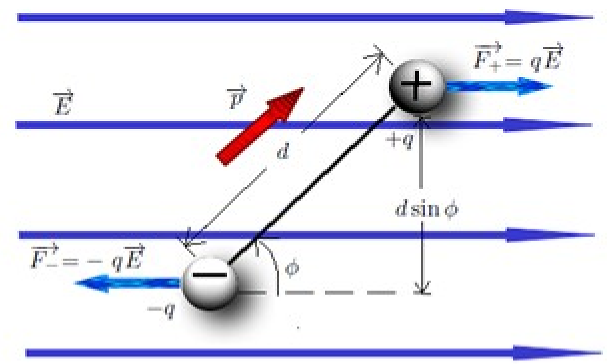
$$\overrightarrow{\mathbf{E}} = \frac{\lambda}{2\pi\epsilon_0 x}\hat{\imath}$$ *(infinite line of charge)* $(\ell \to \infty)$



Electric Dipoles

$$Torque = \overrightarrow{\tau} = \overrightarrow{p} \times \overrightarrow{E} = pE\sin\phi$$

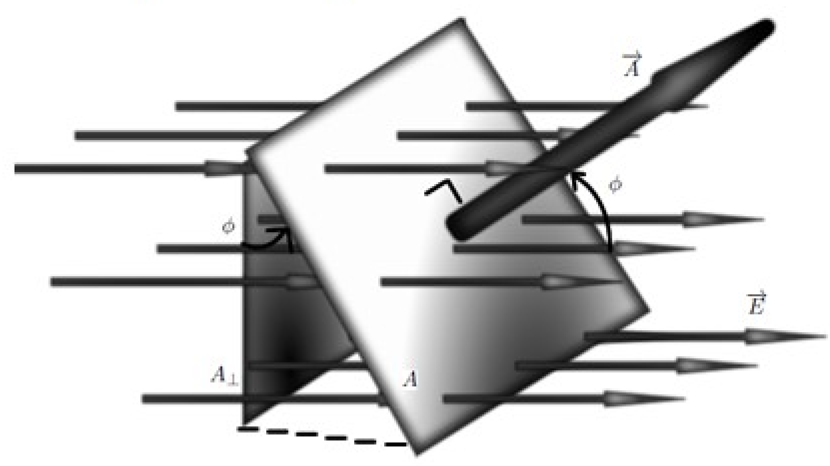
$$P.\ Energy = U = -\overrightarrow{p} \cdot \overrightarrow{E} = -pE\cos\phi$$



Chapeter 22

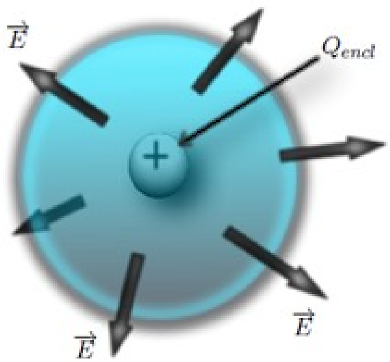
Electric Flux

$$\theta_E = \int \overrightarrow{E} \cdot d\overrightarrow{A} = \int E\cos\phi\, dA$$



Gauss's Law

$$\theta_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{encl}}{\epsilon_o}$$



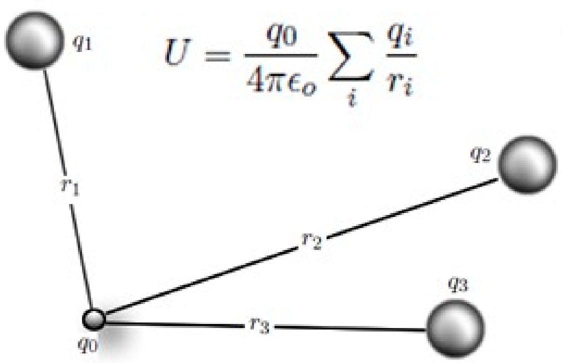
Electric field of various symmetric charge distributions

Charge distribution	Point in Electric Field	Electric Field Magnitude
Single point charge q	Distance r from q	$E = \frac{1}{4\pi\epsilon_o}\frac{q}{r^2}$
Charge q on a surface of conducting sphere with radious R	Outside the sphere, $r > R$	$E = \frac{1}{4\pi\epsilon_o}\frac{q}{r^2}$
	Inside the sphere, $r < R$	$E = 0$
Infinite wire, charge per unit lenght λ	Distance r from the wire	$E = \frac{1}{2\pi\epsilon_o}\frac{\lambda}{r}$
Infinite conducting cylinder with radious R, charge per unit lenght λ	Outside cylinder, $r > R$	$E = \frac{1}{2\pi\epsilon_o}\frac{\lambda}{r}$
	Inside cylinder, $r < R$	$E = 0$
Solid insulating sphere with radious R, charge Q distributed uniformly throughout volume	Outside sphere, $r > R$	$E = \frac{1}{4\pi\epsilon_o}\frac{Q}{r^2}$
	Inside sphere, $r < R$	$E = \frac{1}{2\pi\epsilon_o}\frac{Qr}{R^3}$
Infinite sheet of charge with uniform charge per unit area σ	Any point	$E = \frac{\sigma}{2\epsilon_o}$
Two oppositely charged conducting plates with surface charge densities $+\sigma$ and $-\sigma$	Any point in between the plates	$E = \frac{\sigma}{\epsilon}$

Chapeter 23

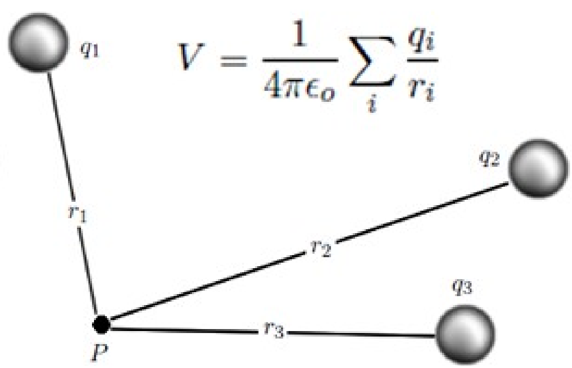
Electric potential energy

$$U = \frac{q_0}{4\pi\epsilon_o}\sum_i \frac{q_i}{r_i}$$



Electric potential

$$V = \frac{1}{4\pi\epsilon_o}\sum_i \frac{q_i}{r_i}$$



Electric potential of various charge distributions

$V_a = V_b + \frac{\lambda}{2\pi\epsilon_o}\ln\frac{r_b}{r_a}$	(Infinite line of charge)
$V = \frac{Q/2a}{4\pi\epsilon r}\ln\frac{\sqrt{x^2+a^2}+a}{\sqrt{x^2+a^2}-a}$	(Finite line of charge)
$V = \frac{Q}{4\pi\epsilon r}$	(Charged ring)
$V_x = E(d-x)$	(Parallel Plates)
$V = \frac{q}{4\pi\epsilon_o r}$ (Outside) $V = \frac{q}{4\pi\epsilon_o R}$ (Inside/Constant)	(Charged conducting sphere)

Potential gradient

$$\vec{E} = -\left(\frac{\partial V}{\partial x}\hat{\imath} + \frac{\partial V}{\partial y}\hat{\jmath} + \frac{\partial V}{\partial z}\hat{k}\right)$$