Electric Charge

$q = ne \quad e = -1.6 * 10^{-19} C$

Electric Force- Coulomb's Law

$F = k\frac{q_1 q_2}{r^2}\ N,\ k = 9x10^9 \left[\frac{Nm^2}{C^2}\right] \quad k = \frac{1}{4\pi\varepsilon_0} \quad \varepsilon_0 = 8.85x10^{-12}$

Electric Field

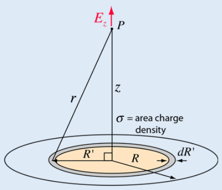
$E = k\frac{q}{r^2}\left[\frac{N}{C}\right] \quad E = \frac{F}{q}\left[\frac{N}{C}\right] \quad F = Eq[N] \quad q = \frac{F}{E}[C]$ r=distance, F=force, q=charge

One dimensional charge distribution – Line charge density : $\lambda = \frac{q}{l} \quad q = \lambda * l$

Two dimensional charge distribution – Surface charge density : $\sigma = \frac{q}{A} \quad q = \sigma * A$

Three dimensional charge distribution – Volume charge density : $\rho = \frac{q}{V} \quad q = \rho * V$

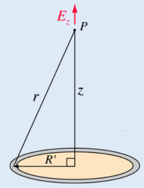
Electric Field Due to Disc Charge



$$E = k\sigma 2\pi \int_0^R \frac{R'dR'}{(z^2 + R'^2)^{3/2}}$$

$$E = \frac{\sigma}{2\varepsilon_0}\left(1 - \frac{z}{\sqrt{z^2+R^2}}\right)$$

Electric Field due to Ring of Charge

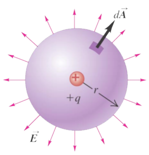


$$E = \frac{kqz}{(z^2 + R^2)^{3/2}}$$

or if z >>R

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

Applying Gauss's Law - Point Charge

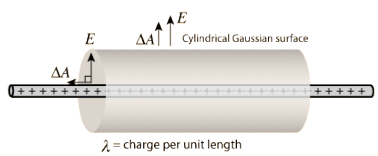


$$\Phi_E = \oint \vec{E}dA = \frac{q}{\varepsilon_0}$$

$$E(4\pi r^2) = \frac{q}{\varepsilon_0}$$

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

Applying Gauss's Law - Charged Wire (Line Charge)

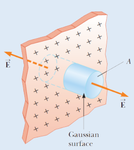


$$\Phi_E = \oint \vec{E}dA = \frac{q}{\varepsilon_0}$$

$$E\oint dA = E(2\pi rl) = \frac{\lambda l}{\varepsilon_0}$$

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

Applying Gauss's Law - Charged Plane Sheet

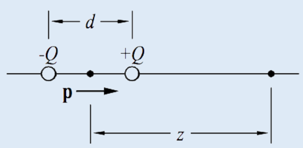


$\Phi_E = \oint \vec{E}dA = \frac{q}{\varepsilon_0} \quad \sigma = \frac{q}{A}, q = \sigma A$

$\Phi_E = E\oint dA = E2A$

$E2A = \frac{\sigma A}{\varepsilon_0}, E = \frac{\sigma}{2\varepsilon_0}$

Electric Field Due to an Electric Dipole

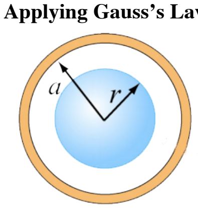


$E = \frac{2kp}{z^3} \quad E = \frac{1}{2\pi\varepsilon_0}\frac{p}{z^3} = \frac{p}{2\pi\varepsilon_0 z^3}$

$p = qd$

P=Dipole Moment d=Distance q=Charge

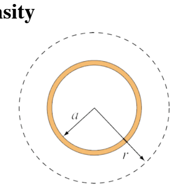
Applying Gauss's Law - Charged Spherical Shell - Surface Charge Density



if r < a

$$\Phi_E = \oint \vec{E}dA = \frac{q}{\varepsilon_0}$$

$$E = 0$$



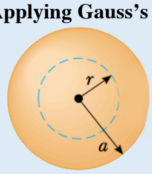
if r ≥ a

$\Phi_E = \oint \vec{E}dA = \frac{q}{\varepsilon_0}, \quad \sigma = \frac{q}{A} \quad q = \sigma A$

$E(4\pi r^2) = \frac{\sigma A}{\varepsilon_0} = \frac{\sigma(4\pi a^2)}{\varepsilon_0}$

$E = \frac{\sigma a^2}{r^2\varepsilon_0}, \quad A = 4\pi r^2$

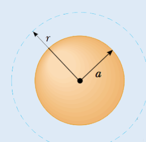
Applying Gauss's Law - Charged Solid Sphere - Volume Charge Density



if r < a

$\oint \vec{E}dA = \vec{E}(4\pi r^2) = \frac{q}{\varepsilon_0}, \rho = \frac{q}{V}$

$E(4\pi r^2) = \frac{\rho\left(\frac{4}{3}\pi r^3\right)}{\varepsilon_0} \quad E = \frac{\rho r}{3\varepsilon_0}$



if r ≥ a

$$\Phi_E = \oint \vec{E}dA = \frac{q}{\varepsilon_0}$$

$$E(4\pi r^2) = \frac{q}{\varepsilon_0} \quad E = k\frac{q}{r^2}$$

Electric Potential (and Due to Point Charge)

$V = k\frac{q}{r} = \frac{U}{q}[V] \quad \Delta V = V_f - V_i[V]$

$\Delta V = \frac{U_f}{q} - \frac{U_i}{q} = \frac{-W}{q}\left[\frac{J}{C}\right]$

Voltage from Electric Field

$\frac{dW}{q} = \frac{\vec{F}d\vec{s}}{q} = \vec{E}d\vec{s}$

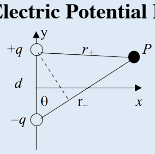
$V_f - V_i = -\int \vec{E}d\vec{s}$

Electric Field from Voltage

$dV = -\vec{E}d\vec{s} = -Eds$

$\vec{E} = -\frac{dV}{ds}$

Electric Potential Due to Dipole System



$V_{net} = V_+ + V_- = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_+}{r_+} - \frac{q_-}{r_-}\right) = \frac{q}{4\pi\varepsilon_0}\left(\frac{r_+ - r_-}{r_+ r_-}\right) \quad q_+ = q_- = q$

If r>>d $r_+ - r_- = d\cos\theta, \ r_+ r_- = \ r^2$

$V = \frac{q}{4\pi\varepsilon_0}\frac{d\cos\theta}{r^2} \quad p = qd \quad V = \frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$

Electric Potential Due to Charge Distribution

General

$$dV = k\frac{dq}{r} = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r}, dq = \lambda dl$$

For Line Charge

$$V = \frac{\lambda}{4\pi\varepsilon_0}\ln\left(\frac{l + \sqrt{l^2 + d^2}}{d}\right)$$

For Disk Charge

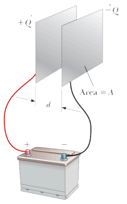
$$V = \frac{\sigma}{2\varepsilon_0}\left(\sqrt{z^2 + R^2}\right)$$

Calculating the Field from the Potential

$W = \vec{F}.d\vec{s} \quad W = q\vec{E}.d\vec{s} \quad q\vec{E}.d\vec{s} = qE\cos\theta ds \quad -qdV = qE\cos\theta ds \quad -dV = E\cos\theta ds$

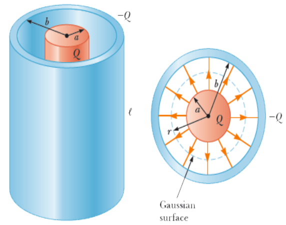
$E\cos\theta = -\frac{dV}{ds} \quad E_x = -\frac{dV}{dx} \quad E_y = -\frac{dV}{dy} \quad E_z = -\frac{dV}{dz}$

A Parallel-Plate Capacitor



$$q = \varepsilon_0 EA$$
$$E = \frac{V}{d}$$
$$C = \frac{q}{V}$$
$$C = \varepsilon_0 \frac{A}{d}$$

A Cylindrical Capacitor



$$\Delta V = V_b + V_a = -\int_a^b E dr = -2k\lambda \ln\left(\frac{b}{a}\right)$$
$$C = \frac{q}{\Delta V} = \frac{q}{\left(2k\frac{q}{l}\right)\ln\left(\frac{b}{a}\right)} = \frac{l}{2k\ln\left(\frac{b}{a}\right)} = 2\pi\varepsilon_0 \frac{l}{\ln\left(\frac{b}{a}\right)}$$

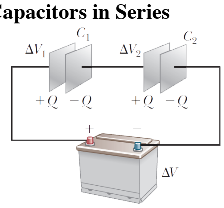
A Spherical Capacitor (Same Figure with Cylindrical)

$$C = 4\pi\varepsilon_0 \frac{ab}{b-a}$$

Isolated Sphere Capacitance

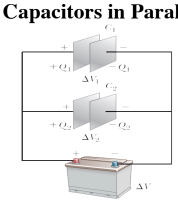
$$C = 4\pi\varepsilon_0 R$$

Capacitors in Series



$$Q_1 = Q_2 = Q$$
$$C_1 = \frac{q}{V_1},\ V_1 = \frac{q}{C_1},\ C_2 = \frac{q}{V_2},\ V_2 = \frac{q}{C_2}$$
$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$
$$V_T = V_1 + V_2 = q\frac{1}{C_{eq}} = \frac{q}{C_{eq}}$$

Capacitors in Parallel



$$\Delta V = \Delta V_1 = \Delta V_2$$
$$Q_{eq} = Q_1 + Q_1 = C_1\Delta V_1 + C_2\Delta V_2$$
$$Q_{tot} = C_{eq}\Delta V = \Delta V(C_1 + C_2)$$
$$C_{eq} = C_1 + C_2$$

Stored Energy in a Charged Capacitor

$$U = \frac{q^2}{2C} = \frac{1}{2}q\Delta V = \frac{1}{2}C(\Delta V)^2$$

Energy Density

$$u = \frac{U}{V} = \frac{1}{2}\varepsilon_0 E^2$$

u=Energy Density V= Volume U=Energy

Capacitance with Dielectric

For Parallel-Plates Capacitor

$$C_o = \varepsilon_0 k \frac{A}{d}$$

For Point Charge

$$E = k\frac{q}{r^2} \quad E_0 = \frac{1}{4\pi\varepsilon_0 k}\frac{q}{r^2} \quad E = \frac{E_0}{k}$$

Dielectrics and Gauss's Law

$$\Phi_E = \oint \vec{E} dA = \frac{q}{\varepsilon_0 k} \quad \Phi_E = \frac{q}{\varepsilon_0} \quad \varepsilon_0 \oint k\vec{E}\, dA = q$$

Current (Akım)

$$i = \frac{dq}{dt}\left[\frac{C}{s}\right][A]$$

Current Density

$$J = \frac{i}{A}\left[\frac{A}{m^2}\right]$$ J=Current Density, i= Current, A=Area

Drift Speed

$$q = (nAL)e,\quad L = V_d t,\quad t = \frac{L}{V_d},\quad i = \frac{q}{t} = \frac{q}{\frac{L}{V_d}} = \frac{(nAL)e}{\frac{L}{V_d}} \qquad J = \frac{i}{A} = \frac{(nAL)e}{\frac{L}{V_d}}\frac{1}{A} \qquad J = (ne)V_d\left[\frac{C}{m^2}\right] \qquad i = JA$$

Resistance (Direnç)

$$R = \frac{V}{i}\left[\frac{V}{A}\right][\Omega]$$

R=Resistance
V=Potential
i=Current

Resistivity (Özdirenç)

$$\rho = \frac{E}{J} = \frac{RA}{l}\left[\frac{\left[\frac{V}{m^2}\right]}{\left[\frac{A}{m^2}\right]}\right]$$

Unit=$[\Omega * m]$

ρ = Resistivity
E = Electric Field
J=Current Density

Conductivity (İletkenlik)

$$\sigma = \frac{1}{\rho} = \frac{J}{E}$$

σ = Condctivity
ρ = Resistivity

Relationship between Resistance and Resistivity

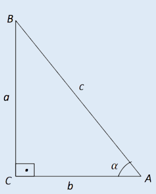
$$E = \frac{V}{l} \quad J = \frac{i}{A} \quad R = \frac{V}{i} \quad \rho = \frac{E}{J} \quad R = \rho\frac{l}{A} = \frac{V}{i} = \frac{V}{JA} = \frac{V}{\frac{E}{\rho}A} = \frac{El\rho}{EA} = \rho\frac{l}{A}$$

Ohm's Law

$$V = iR \qquad i = \frac{V}{R} \qquad R = \frac{V}{i}$$

Power in Electric Circuits

$$P = iV = \frac{W}{t}[\text{watt}]$$ P=Power $$P = iV = i(iR) = i^2R \quad P = iV = \frac{V}{R}V = \frac{V^2}{R}$$



$$\sin\alpha = \frac{a}{c} \quad \cos\alpha = \frac{b}{c} \quad \tan\alpha = \frac{a}{b} \quad \cot\alpha = \frac{b}{a}$$

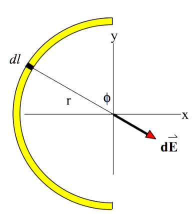
$\Phi_E = \oint \vec{E} dA = EA\cos\alpha$ for gauss's law flux

diameter=2r

1m = 100cm = 1000mm 1kg = 1000gr

Shape	**Area**	**Volume**
Disk	$2\pi r$	
Cylindir	$2\pi rl$	$\pi r^2 l$
Sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$
Cemberin Uzublugu	$2\pi r$	

Electric Fied due to Bent Rod



$$dE = k\frac{dq}{r^2} \quad E_{total} = \int dE\sin\theta$$
$$E = \int_0^\pi k\frac{\lambda dl}{r^2}\sin\theta = \int_0^\pi k\frac{\lambda r d\theta}{r^2}\sin\theta$$
$$E = \frac{k\lambda}{r}\int_0^\pi \sin\theta d\theta = \frac{k\lambda}{r}(-\cos\pi - \cos 0)$$
$$E = 2k\frac{\lambda}{r} = 2k\frac{\lambda}{\frac{l}{\pi}} = 2k\pi\frac{\lambda}{l} = 2k\pi\frac{\frac{q}{l}}{l} = 2k\pi\frac{q}{l^2}$$

$$\lambda = \frac{q}{l}$$
$$q = \lambda l$$
$$\frac{2\pi r}{2} = l$$
$$dl = rd\theta$$