

Electric Charges and Fields

Coulomb's Law
 $q_1 \quad r \quad q_2$

$$\vec{F} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2} \hat{r}$$
 $Q = \pm ne$

Gauss's Theorem
 $\phi_e = \oint \vec{E} \cdot d\vec{S} = \frac{Q}{\epsilon_0}$

Charge density
 linear $\lambda = \frac{Q}{L}$
 surface $\sigma = \frac{Q}{A}$
 volume $\rho = \frac{Q}{V}$

EF due to infinite Sheet of charge
 $\vec{E} = \frac{\sigma}{2\epsilon_0} \hat{n}$
EF due to infinite long charged wire
 $E = \frac{\lambda}{2\pi\epsilon_0 r}$

Electric Field
 $\vec{E} = \frac{\vec{F}}{q_0}$
Due to Point Charge
 $E = \frac{kq}{r^2}$ $k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$
Electric Dipole moment $\vec{P} = q \cdot 2\vec{a}$
Electric Field due to dipole
 on axial line $E = \frac{2P}{4\pi\epsilon_0 r^3}$
 on equatorial line $E = \frac{P}{4\pi\epsilon_0 r^3}$

Torque $\vec{\tau} = \vec{P} \times \vec{E}$ or $\tau = PES \sin\theta$
Due to charged Conducting Sphere

 $E = \frac{kq}{r^2}, r > R$ $E = \frac{kq}{R^2}, r = R$ $E = 0, r < R$

Potential due to Non Conducting Sphere
 Uniformly charged sphere
 Outside $r > R$ $V = \frac{q}{4\pi\epsilon_0 r}$
 On the shell $r = R$ $V = \frac{q}{4\pi\epsilon_0 R}$
 Inside $r < R$ $V = \frac{q}{4\pi\epsilon_0 R} \left(\frac{3R^2 - r^2}{2R^2} \right)$

Current Electricity

Electric Current
 $I = \frac{Q}{t}$
Current density
 $J = \frac{I}{A}$

Principle of Wheat Stone
 $\frac{P}{Q} = \frac{R}{S}$
Principle of Meter bridge
 $\frac{R}{S} = \frac{L}{100-L}$

Drift Velocity
 $V_d = \frac{eE\tau}{m} = \frac{eV}{ml}$
Relation b/w I & V_d
 $I = Anev_d$
Principle of potentiometer
 $K = \frac{V}{L} = \frac{IR}{L}$
Power $P = VI = I^2 R = \frac{V^2}{R}$
Energy $W = Vq = VIt = I^2 Rt = \frac{V^2 t}{R}$

Electric Potential & Capacitance
Electric Potential $V = \frac{q}{4\pi\epsilon_0 r}$
 Potential due to dipole
 Axial $\rightarrow V = \frac{P}{4\pi\epsilon_0 r^2}$
 Equatorial $\rightarrow V = 0$
Electric Potential Energy [for two charge]
 due to dipole in external field
 $U = -\vec{P} \cdot \vec{E} = PE(\cos\theta_2 - \cos\theta_1)$ or $U = -\vec{P} \cdot \vec{E}$
Capacitance
 Relation between E & V
 $E = -\frac{dV}{dr}$ or $V = -\int \vec{E} \cdot d\vec{r}$
 Series combination $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$
 Parallel Comb. $C_p = C_1 + C_2$
Capacitance of Parallel Plate Capacitor
 Air filled $C = \frac{\epsilon_0 A}{d}$
 Partially filled with dielectric $C = \frac{\epsilon_0 A}{d} \left(1 + \frac{k}{2} \right)$
 Completely filled $C = K\epsilon_0 \frac{A}{d}$
 Filled with metal $C = \frac{2\pi\epsilon_0 ab}{(d-t)}$
Capacitance of Isolated Sphere

 $C = 4\pi\epsilon_0 r$

Energy stored in a Capacitor
 $U = \frac{1}{2} CV^2 = \frac{1}{2} QV = \frac{1}{2} \frac{Q^2}{C}$
Common Potential
 $V = \frac{q_1 + q_2}{C_1 + C_2} = \frac{C_1 V_1 + C_2 V_2}{C_1 + C_2}$
Energy loss
 $= \frac{1}{2} \frac{C_1 C_2 (V_1 - V_2)^2}{(C_1 + C_2)}$
Force between plates of Capacitor
 $F = \frac{Q^2}{2A\epsilon_0}$

Moving Charges and Magnetism

Magnetic force
 $\vec{F}_m = q(\vec{v} \times \vec{B})$
 Pitch (P) = $\frac{2\pi m v \cos\theta}{qB}$

Motion of charge in Uniform Transverse Magnetic Field
 $F_m = qvB = \frac{mv^2}{r}$
 Time period $T = \frac{2\pi R}{v} = \frac{2\pi m}{qB}$
 Radius of Circular path $r = \frac{mv}{qB} = \frac{P}{qB} = \frac{\sqrt{2mK}}{qB} = \frac{\sqrt{2mqV}}{qB}$

Biot Savart's Law
 $dB = \frac{\mu_0}{4\pi} \frac{Idl \sin\theta}{r^2}$
Force b/w two Current Carrying parallel straight Conductor
 $F = \frac{\mu_0}{4\pi} \frac{2i_1 i_2 l}{r}$
Magnetic force on a Current Carrying Conductor
 $\vec{F} = i(\vec{l} \times \vec{B})$
Ampere's Circuital Law
 $\oint \vec{B} \cdot d\vec{l} = \mu_0 i$
 Magnetic field due to an infinitely long straight wire of radius 'a' carrying current 'i' at a point -
 $B = \frac{\mu_0 i}{2\pi a^2}, r < a$ $B = \frac{\mu_0 i}{2\pi a}, r = a$ $B = \frac{\mu_0 i}{2\pi r}, r > a$
MF at Centre of a Circular coil
 $B = \frac{\mu_0 i}{2a}$
MF at a point on the axis of Current Carrying coil
 $B = \frac{\mu_0 2\pi N i a^2}{4\pi (a^2 + x^2)^{3/2}}$

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