Laws, Principles, Useful Relationships, and Other Information

Coulomb's Rule $\vec{F}_e = k\frac{q_1 q_2}{r^2}\hat{r}$ Def'n of E-Field $\vec{E} \equiv \frac{\vec{F}}{q}$ E-Field for Point Charge $\vec{E} = k\frac{q}{r^2}\hat{r}$

Electric Potential $\Delta V = -\int \vec{E}\cdot d\vec{s}$ Def'n of Potential $\Delta U \equiv q\,\Delta V$ Potential of a Charge $V = k\frac{q}{r}$

Def'n of Capacitance $C \equiv \frac{Q}{V}$ Cap. of Parallel Plates $C = \varepsilon_o\frac{A}{d}$ Energy in C's $U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2$

Energy in E-Fields $u \equiv \frac{U}{vol} = \frac{1}{2}\varepsilon_o E^2$ B-Field $u_m = \frac{B^2}{2\mu_o}$ C's: Series $\frac{1}{C_s} = \sum\frac{1}{C_i}$ Parallel $C_p = \sum C_i$

Dipoles: Def'ns $\vec{\mu} \equiv I\vec{A}$ and $\vec{p} \equiv q\vec{d}$ Torque $\vec{\tau} = \vec{p}\times\vec{E}$ or $\vec{\tau} = \vec{\mu}\times\vec{B}$ Energy $U = -\vec{p}\cdot\vec{E}$ or $U = -\vec{\mu}\cdot\vec{B}$

Def'n of Current $I \equiv \frac{dQ}{dt}$ Def'n of Resistance $R = \rho\frac{\ell}{A}$ Ohm's Rule $V = IR$ Power $P = IV = \frac{V^2}{R} = I^2R$

R's: Series $R_s = \sum R_i$ Parallel $\frac{1}{R_p} = \sum\frac{1}{R_i}$ RC: Charge $q = CV\left(1 - e^{-t/RC}\right)$ discharge $q = CV_o e^{-t/RC}$

Force Between Wires $F_m = \frac{\mu_o}{2\pi}\frac{I_1 I_2}{r}\ell$ Def'n of B-Field $\vec{F} \equiv I\vec{\ell}\times\vec{B}$ Force on a Charge $\vec{F} = q\vec{v}\times\vec{B}$

B-Field of Wire $B = \frac{\mu_o I}{2\pi r}$ Biot-Savart Rule $\vec{B} = \frac{\mu_o}{4\pi}\int\frac{Id\vec{s}\times\hat{r}}{r^2}$

Def'n of Flux $\Phi_B \equiv \int\vec{B}\cdot d\vec{A}$ or $\Phi_E \equiv \int\vec{E}\cdot d\vec{A}$ Def'n of Inductance $\mathcal{E} \equiv -L\frac{dI}{dt}$

Gauss's Law for E $\oint\vec{E}\cdot d\vec{A} = \frac{q}{\varepsilon_o}$ Faraday's Law $\oint\vec{E}\cdot d\vec{s} = -\frac{d\Phi_B}{dt}$ Gauss's Law for B $\oint\vec{B}\cdot d\vec{A} = 0$

Ampere's Law $\oint\vec{B}\cdot d\vec{s} = \mu_o\frac{dq}{dt} + \mu_o\varepsilon_o\frac{d\Phi_e}{dt}$ LC Circuit $Q = Q_m\cos(\omega t + \delta)$ where $\omega = \frac{1}{\sqrt{LC}}$

LR: "charging" $I = I_o\left(1 - e^{-\frac{R}{L}t}\right)$ "discharging" $I = I_o e^{-\frac{R}{L}t}$ Energy in Inductors $U_L = \frac{1}{2}LI^2$

LRC $Q = Q_m e^{-\frac{Rt}{2L}}\cos\omega_d t$ where $\omega_d = \sqrt{\frac{1}{LC} - \left(\frac{R}{2L}\right)^2}$ Transformers: $I_pV_p = I_sV_s$ and $\frac{V_p}{N_p} = \frac{V_s}{N_s}$

Def'n of Impedance $X \equiv \frac{\mathcal{E}_m}{I_m}$ Impedances: $X_R = R$ $X_C = \frac{1}{\omega C}$ $X_L = \omega L$

RLC Circuit: Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$ Phase Angle $\tan\varphi = \frac{X_L - X_C}{R}$ Resonance Freq. $\omega_o = \frac{1}{\sqrt{LC}}$

EM Waves: $c = \frac{1}{\sqrt{\mu_o\varepsilon_o}}$ $E_m = cB_m$ $k \equiv \frac{2\pi}{\lambda}$ $\frac{\omega}{k} = \lambda f = c$

The Def'n of Poynting Vector $\vec{S} \equiv \frac{1}{\mu_o}\vec{E}\times\vec{B}$ Average $I = \frac{E_m B_m}{2\mu_o} = \frac{E_m^2}{2\mu_o c} = \frac{c}{2\mu_o}B_m^2$

Complete Absorption: Momentum Transfer $p = \frac{U}{c}$ Radiation Pressure $P = \frac{I}{c}$

Physical Constants: $e = 1.60\text{x}10^{-19}\,C$ $m_e = 9.11\text{x}10^{-31}\,kg$ $m_p = 1.67\text{x}10^{-27}\,kg$ $c = 3.00\text{x}10^{8}\,\frac{m}{s}$

$\mu_o = 4\pi\text{x}10^{-7}\,\frac{T\,m}{A}$ $k = 8.99\text{x}10^{9}\,\frac{N\,m^2}{C^2}$ $\varepsilon_o = 8.85\text{x}10^{-12}\,\frac{C^2}{N\,m^2}$