Formula sheet

Coulomb's Law: $\vec{F}_{12} = k_e \frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} = q_1\vec{E}_2$ $k_e = 9\times10^9 \frac{Nm^2}{C^2}$

Biot-Savard's Law: $d\vec{B} = \frac{\mu_o}{4\pi}\frac{Id\vec{s}\times\hat{r}}{r^2}$ $\vec{B} = \int d\vec{B}$ $\mu_o = 4\pi \times 10^{-7} \frac{Tm}{A}$

B field of an infinite wire: $\vec{B} = \frac{\mu_o I}{2\pi r}$ wrapping around the wire

Charge of electron: $e = -1.6\times10^{-19}\ C$

Gauss' Law: $\oint \vec{E}\,.\,d\vec{A} = \frac{q_{in}}{\varepsilon_o}$ $\epsilon_0 = 8.85\times10^{-12}\frac{C^2}{Nm^2}$

Ampere's Law: $\oint \vec{B}\cdot d\vec{s} = \mu_o I_{in}$

Faraday's Law: $\varepsilon = -\frac{d}{dt}\left(\int \vec{B}.d\vec{A}\right) = -L\frac{di}{dt}$

Potential: $\Delta V_{\mathrm{ab}} = -\int_a^b \vec{E}\,.\,d\vec{s}$

Potential from a point charge (when V=0 at infinity): $V = k_e\frac{q}{r}$

Capacitance: $C = \frac{Q}{\Delta V}$ Parallel plate capacitor: $C = k\epsilon_0\frac{A}{d}$

Parallel configuration: $C_{eq} = C_1 + C_2 + \cdots$ $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

Series configuration: $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$ $R_{eq} = R_1 + R_2 + \cdots$

Energy stored in a capacitor: $U_C = \frac{Q^2}{2C} = \frac{1}{2}C(\Delta V)^2$, Energy stored in an inductor: $U_L = \frac{1}{2}LI^2$

Ohm's Law: $R = \frac{\Delta V}{I}$

Power dissipated in a resistor (DC circuit): $P = RI^2 = \frac{(\Delta V)^2}{R}$

Kirchhoff's rules: 1) junction $\sum I_{in} = \sum I_{out}$ 2) loop $\sum_{loop}\Delta V = 0$

Current in a RL circuit: adding flux $I = I_{max}\left(1 - e^{-\frac{t}{\tau}}\right)$, $\tau = \frac{L}{R}$

removing flux $I = I_{max}e^{-\frac{t}{\tau}}$

LC circuit resonant frequency: $\omega = \frac{1}{\sqrt{LC}}$ and $\omega = 2\pi f$

AC circuits: $i = \frac{\Delta V_{max}}{Z}sin(\omega t)$, $\Delta v = \Delta V_{max}sin(\omega t + \varphi)$, $P_{avg} = \frac{\Delta V_{max}I_{max}}{2}cos\varphi$

$\varphi_L = +\frac{\pi}{2}$ rad, $\varphi_C = -\frac{\pi}{2}$ rad, $\varphi_R = 0$, $\varphi_{tot} = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$

$X_L = \omega L$, $X_C = \frac{1}{\omega C}$, $Z = \sqrt{R^2 + (X_L - X_C)^2}$ $\omega = 2\pi f$

EM wave average **intensity (power/area):** $I = S_{avg} = \frac{E_{max}B_{max}}{2\mu_o}$; $B_{max} = \frac{E_{max}}{c}$

EM wave average **pressure (force/area):** $P_{avg} = I/c$, where I is the intensity and c the speed of light

EM wave velocity: $c = 3\times10^8\ \frac{m}{s} = f\lambda$