$$e = 1.602 \times 10^{-19} C.$$
$$m_e = 9.109 \times 10^{-31} kg$$
$$m_p = 1.673 \times 10^{-27} kg$$
$$c = 2.998 \times 10^8\, m/s$$

$$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 N \cdot m^2/C^2$$
$$\varepsilon_0 = 8.85 \times 10^{-12}\, C^2/(N \cdot m^2)$$
$$\varepsilon_0 = 8.85 \times 10^{-12}\, F/m$$
$$\mu_0 = 4\pi \times 10^{-7} T \cdot m/A \approx 1.26 \times 10^{-6} T \cdot m/A$$

| | | | | | |
|---|---|---|---|---|---|
| $10^{24}$ | yotta | Y | $10^{-1}$ | deci | d |
| $10^{21}$ | zetta | Z | $10^{-2}$ | centi | c |
| $10^{18}$ | exa | E | $10^{-3}$ | milli | m |
| $10^{15}$ | peta | P | $10^{-6}$ | micro | μ |
| $10^{12}$ | tera | T | $10^{-9}$ | nano | n |
| $10^{9}$ | giga | G | $10^{-12}$ | pico | p |
| $10^{6}$ | mega | M | $10^{-15}$ | femto | f |
| $10^{3}$ | kilo | k | $10^{-18}$ | atto | a |
| $10^{2}$ | hecto | h | $10^{-21}$ | zepto | Z |
| $10^{1}$ | deka | da | $10^{-24}$ | yocto | y |

$$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$$
$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\,\hat{r}$$

$$\lambda = \frac{Q}{L}$$
$$\sigma = \frac{Q}{A}$$
$$\rho = \frac{Q}{V}$$

$$dq = \lambda ds$$
$$dq = \sigma dA$$
$$dq = \rho dV$$

$$p = qd$$
$$\vec{\tau} = \vec{p} \times \vec{E}$$
$$U = -\vec{p} \cdot \vec{E}$$

$$\vec{E} = \frac{\vec{F}}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$$

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

$$E = \int \frac{1}{4\pi\varepsilon_0}\frac{dq}{r^2}$$

$$E_s = -\frac{\partial V}{\partial s}$$

$$W = -\Delta U = -(U_f - U_i)$$
$$\Delta V = V_f - V_i = -\frac{W}{q}$$
$$V_f - V_i = -\int_i^f \vec{E} \cdot d\vec{s}$$

$$E = \frac{qz}{4\pi\varepsilon_0(z^2 + R^2)^{3/2}}$$

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

$$V = \frac{U}{q}$$

$$K_i + U_i = K_f + U_f$$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$

$$V = \sum_{i=1}^{n} V_i = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\frac{q_i}{r_i}$$

$$\Phi_E = \sum \vec{E} \cdot \Delta\vec{A}$$
$$\Phi_E = \oint \vec{E} \cdot d\vec{A}$$

$$\varepsilon_0 \Phi = q_{enc}$$
$$\varepsilon_0 \oint \vec{E} \cdot d\vec{A} = q_{enc}$$

$$E = \frac{\sigma}{\varepsilon_0} \qquad E = \frac{\sigma}{2\varepsilon_0}$$
$$E = \frac{\lambda}{2\pi\varepsilon_0 r} \qquad E = \left(\frac{q}{4\pi\varepsilon_0 R^3}\right) r$$

$$q = CV$$
$$C = \frac{\varepsilon_0 A}{d}$$

$$C_{eq} = \sum_{j=1}^{n} C_j = C_1 + C_2 + \cdots + C_j$$
$$\frac{1}{C_{eq}} = \sum_{j=1}^{n}\frac{1}{C_j} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_j}$$

$$U_C = \frac{1}{2}CV^2$$
$$U_E = \frac{q^2}{2C}$$
$$u_E = \frac{1}{2}\varepsilon_0 E^2$$

$$C = \kappa C_{air}$$
$$\varepsilon_0 \oint \kappa\vec{E} \cdot d\vec{A} = q$$

$$v_d = \frac{i}{nAe} = \frac{J}{ne}$$

$$i = \int J dA = J \int dA = JA$$

$$i = \frac{dq}{dt}$$

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

$$R = \rho\frac{L}{A}$$
$$\vec{J} = \sigma\vec{E}$$

$$\rho - \rho_0 = \rho_0\alpha(T - T_0)$$
$$E = \left(\frac{m}{e^2 n\tau}\right) J$$

$$P = iV \qquad P = i^2 R$$
$$P = \frac{V^2}{R} \qquad P_{emf} = i\mathcal{E}$$
$$\tau_C = RC$$

$$V = iR$$
$$\mathcal{E} = iR$$
$$\mathcal{E} = \frac{dW}{dq}$$

$$R_{eq} = \sum_{j=1}^{n} R_j = R_1 + R_2 + \cdots + R_j$$
$$\frac{1}{R_{eq}} = \sum_{j=1}^{n}\frac{1}{R_j} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_j}$$

$$q = C\mathcal{E}\left(1 - e^{-t/RC}\right)$$
$$I_t = +\frac{\mathcal{E}}{R}e^{-t/RC}$$

$$q = q_0 e^{-t/RC}$$
$$I_t = -\frac{\mathcal{E}}{R}e^{-t/RC}$$

$$f = \frac{1}{T} = \frac{|q|B}{2\pi m}$$

$$T = \frac{2\pi r}{v} = \frac{2\pi}{v}\frac{mv}{|q|B} = \frac{2\pi m}{|q|B}$$

$$\omega = 2\pi f = \frac{|q|B}{m}$$

| | | | | | |
|---|---|---|---|---|---|
| $d\overrightarrow{F_B} = i\, d\vec{L} \times \vec{B}$ | $\overrightarrow{F_B} = i\,\vec{L} \times \vec{B}$ | $\tau = (Ni\pi r^2)B \sin\theta$ | $\mu = NiA$ | $\vec{\tau} = \vec{\mu} \times \vec{B}$ | |
| $d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\, d\vec{s} \times \hat{r}}{r^2}$ | $B = \frac{\mu_0 i}{2\pi R}$ | $B = \frac{\mu_0 i \Phi}{4\pi R}$ | $\vec{F}_{ba} = i_b \vec{L} \times \vec{B}_a$<br>$U_{(\theta)} = -\vec{\mu} \cdot \vec{B}$ | $\frac{F_{ba}}{l} = \frac{\mu_0 i_1 i_2}{2\pi a}$ | |
| $B = \frac{\mu_0 i N}{2\pi}\frac{1}{r}$ | $\vec{B}_{(z)} = \frac{\mu_0}{2\pi}\frac{\vec{\mu}}{z^3}$ | $\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc}$<br>$\overrightarrow{F_B} = q\vec{v} \times \vec{B}$ | $\Phi_B = \int \vec{B} \cdot d\vec{A}$<br>$\Phi_B = \sum \vec{B} \cdot \Delta\vec{A}$ | $\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$<br>$B = \mu_0 i n$ | |
| $\mathcal{E} = -N\frac{d\Phi_B}{dt}$ | $L = \frac{N\Phi_B}{i}$ | $M_{21} = \frac{N_2 \Phi_{21}}{i_1}$ | $\frac{L}{l} = \mu_0 n^2 A$ | $\mathcal{E}_L = -L\frac{di}{dt}$ | $i = \frac{\mathcal{E}}{R}\left(1 - e^{-t/\tau_L}\right)$ |
| $i = \frac{\varepsilon}{R} e^{-t/\tau_L} = i_0 e^{-t/\tau_L}$ | $\tau_L = \frac{L}{R}$ | $U_B = \frac{1}{2} L i^2$ | $u_B = \frac{B^2}{2\,\mu_0}$ | $\omega = \frac{1}{\sqrt{LC}}$ | $q = Q\cos(\omega t + \Phi)$ |
| $i = \frac{dq}{dt} = -\omega Q \sin(\omega t + \Phi)$ | $U_E = \frac{q^2}{2C} = \frac{Q^2}{2C}\cos^2(\omega t + \Phi)$ | $U_B = \frac{Q^2}{2C}\sin^2(\omega t + \Phi)$ | | | |
| $V_R = I_R R$ | $v_C = V_C \sin\omega_d t$ | $q_C = C v_C = C V_C \sin\omega_d t$ | $q = Q e^{-Rt/2L}\cos(\omega' t + \Phi)$ | | |
| $V_C = I_C X_C$ | $V_L = I_L X_L$ | $v_L = V_L \sin\omega_d t$ | $X_C = \frac{1}{\omega_d C}$ | $X_L = \omega_d L$ | $\mathcal{E} = \mathcal{E}_m \sin\omega_d t$ |
| $i = I\sin(\omega_d t - \Phi)$ | $I = \frac{\mathcal{E}_m}{\sqrt{R^2 + (X_L - X_C)^2}}$ | $Z = \sqrt{R^2 + (X_L - X_C)^2}$ | $\tan\Phi = \frac{X_L - X_C}{R}$ | | |
| $I_{rms} = \frac{I}{\sqrt{2}}$ | $P_{avg} = I_{rms}^2 R$ | $V_{rms} = \frac{V}{\sqrt{2}}$ | $\mathcal{E}_{rms} = \frac{\mathcal{E}_m}{\sqrt{2}}$ | $P_{avg} = \mathcal{E}_{rms} I_{rms}\cos\Phi$ | |
| $V_s = V_p\frac{N_s}{N_p}$ | $I_s = I_p\frac{N_p}{N_s}$ | $R_{eq} = \left(\frac{N_p}{N_s}\right)^2 R$ | $\oint \vec{E} \cdot d\vec{A} = q_{enc}/\varepsilon_0$ | $\Phi_B = \oint \vec{B} \cdot d\vec{A} = 0$ | |
| $i_d = \varepsilon_0\frac{d\phi_E}{dt}$ | $\oint \vec{E} \cdot d\vec{s} = -\frac{d\Phi_B}{dt}$ | $\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc} + \mu_0 i_{d,enc}$ | $E = E_m \sin(kx - \omega t)$<br>$B = B_m \sin(kx - \omega t)$ | | |
| $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ | $\frac{E_m}{B_m} = \frac{E}{B} = c$ | $\lambda = \frac{c}{f}$ | $\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}$ | $I = S_{avg} = \frac{1}{c\mu_0}[E^2]_{avg}$ | |
| $E_{rms} = \frac{E_m}{\sqrt{2}}$ | $I = \frac{1}{c\mu_0}E_{rms}^2$ | $u_E = \frac{B^2}{2\mu_0}$ | $I = \frac{power}{area} = \frac{P_s}{4\pi r^2}$ | | |