$$G = 6.67\times10^{-11}\ \frac{\mathrm{Nm}^2}{\mathrm{kg}^2} \qquad k = \frac{1}{4\pi\varepsilon_o} = 8.988\times10^{9}\ \frac{\mathrm{Nm}^2}{\mathrm{C}^2} \qquad \varepsilon_o = 8.854\times10^{-12}\ \frac{\mathrm{C}^2}{\mathrm{Nm}^2}$$

$$e = 1.602\times10^{-19}\ \mathrm{C} \qquad \mu_o = 4\pi\times10^{-7}\ \frac{\mathrm{Wb}}{\mathrm{Am}} \qquad c = 3.00\times10^{8}\ \frac{m}{s}$$

$$F = G\frac{m_1 m_2}{r^2} \qquad \vec{g} = G\frac{M}{r^2}\hat{r} \qquad U = -G\frac{m_1 m_2}{r} \qquad \vec{F} = m\vec{g}$$

$$v = \lambda f \qquad f = \frac{1}{T} \qquad \omega = \frac{2\pi}{T} \qquad k = \frac{2\pi}{\lambda} \qquad y(x,t) = A\cos(\omega t \mp kx) \qquad v = \sqrt{\frac{T}{\mu}}$$

$$\vec{E} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}\hat{r} \qquad d\vec{E} = \frac{1}{4\pi\varepsilon_o}\frac{dq}{r^2}\hat{r} \qquad F = \frac{1}{4\pi\varepsilon_o}\frac{|q_1 q_2|}{r^2}$$

$$\vec{E} = \frac{\vec{F}_o}{q_o} \qquad p = qd \qquad \vec{\tau} = \vec{p}\times\vec{E} \qquad U = -\vec{p}\cdot\vec{E}$$

$$\Phi_E = \int \vec{E}\cdot d\vec{A} \qquad \Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_o} \qquad E = \frac{1}{2\pi\varepsilon_o}\frac{\lambda}{r}$$

$$E = \frac{\sigma}{2\varepsilon_o} \qquad E = \frac{\sigma}{\varepsilon_o} \qquad E_\perp = \frac{\sigma}{\varepsilon_o} \qquad E = \frac{1}{4\pi\varepsilon_o}\frac{Qr}{R^3}$$

$$W_{a\to b} = -\Delta U \qquad U = \frac{1}{4\pi\varepsilon_o}\frac{qq_o}{r} \qquad U = \frac{q_o}{4\pi\varepsilon_o}\sum_i \frac{q_i}{r_i} \qquad U = \frac{1}{4\pi\varepsilon_o}\sum_{i<j}\frac{q_i q_j}{r_{ij}}$$

$$V = \frac{U_o}{q_o} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r} \qquad V = \frac{1}{4\pi\varepsilon_o}\sum_i \frac{q_i}{r_i} \qquad V = \frac{1}{4\pi\varepsilon_o}\int\frac{dq}{r}$$

$$V_a - V_b = \int_a^b \vec{E}\cdot d\vec{l} \qquad V = \frac{\lambda}{2\pi\varepsilon_o}\ln\frac{r_o}{r} \qquad V = \frac{\lambda}{2\pi\varepsilon_o}\ln\frac{R}{r} \qquad V = \frac{1}{4\pi\varepsilon_o}\frac{Q}{\sqrt{x^2+a^2}}$$

$$C = \frac{Q}{V_{ab}} \qquad C = \frac{A\varepsilon_o}{d} \qquad C = 4\pi\varepsilon_o\frac{r_a r_b}{r_b - r_a} \qquad \frac{C}{L} = \frac{2\pi\varepsilon_o}{\ln\left(r_b/r_a\right)}$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots \qquad C_{eq} = C_1 + C_2 + C_3 + \ldots$$

$$U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV \qquad u = \frac{1}{2}\varepsilon_o E^2 \qquad \varepsilon = K\varepsilon_o$$

$$I = \frac{dQ}{dt} \qquad \rho = \frac{E}{J} \qquad \rho(T) = \rho_o\left[1+\alpha(T-T_o)\right] \qquad R = \frac{\rho L}{A} \qquad V = IR$$

$$R(T) = R_o\left[1+\alpha(T-T_o)\right] \qquad \xi = V_{ab} \qquad V_{ab} = \xi - Ir \qquad P = V_{ab}I = I^2R = \frac{V_{ab}{}^2}{R}$$

$$R_{eq} = R_1 + R_2 + R_3 + \ldots \qquad \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \qquad V_{rises} = V_{drops} \qquad I_{in} = I_{out}$$

$$q = C\xi\left(1 - e^{-t/RC}\right) \qquad i = I_o e^{-t/RC} \qquad q = Q_o e^{-t/RC} \qquad \tau = RC$$

$$\vec{F} = q\vec{v} \times \vec{B} \qquad \Phi_B = \int \vec{B} \cdot d\vec{A} \qquad \oint \vec{B} \cdot d\vec{A} = 0 \qquad R = \frac{mv}{|q|B}$$

$$v = \frac{E}{B} \qquad \vec{F} = I\vec{l} \times \vec{B} \qquad d\vec{F} = Id\vec{l} \times \vec{B} \qquad F = ILB\sin\theta$$

$$\tau = IAB\sin\phi \qquad \vec{\tau} = \vec{\mu} \times \vec{B} \qquad U = -\vec{\mu} \cdot \vec{B} \qquad \vec{B} = \frac{\mu_o}{4\pi}\frac{q\vec{v} \times \vec{r}}{r^3}$$

$$d\vec{B} = \frac{\mu_o}{4\pi}\frac{Id\vec{l} \times \vec{r}}{r^3} \qquad B = \frac{\mu_o I}{2\pi r} \qquad B = \frac{\mu_o I}{4\pi}\frac{2a}{x\sqrt{x^2 + a^2}} \qquad \frac{F}{L} = \frac{\mu_o I_1 I_2}{2\pi r}$$

$$B_x = \frac{\mu_o NI}{2a} \qquad B_x = \frac{\mu_o I a^2}{2(x^2 + a^2)^{3/2}} \qquad \int \vec{B} \cdot d\vec{l} = \mu_o I_{enc}$$

$$\xi = -N\frac{d\Phi_B}{dt} \qquad \xi = vBL \qquad \oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt} \qquad i_D = \varepsilon\frac{d\Phi_E}{dt}$$

$$\int \vec{B} \cdot d\vec{l} = \mu_o\left(i_C + \varepsilon_o\frac{d\Phi_E}{dt}\right)_{enc} \qquad \xi_2 = -M\frac{di_1}{dt} \qquad \xi_1 = -M\frac{di_2}{dt} \qquad \xi = -L\frac{di}{dt}$$

$$U = \tfrac{1}{2}LI^2 \qquad u = \frac{B^2}{2\mu_o} \qquad i = \frac{\xi}{R}(1 - e^{-Rt/L}) \qquad \tau = \frac{L}{R} \qquad \omega = \frac{1}{\sqrt{LC}}$$

$$i = I\cos\omega t \qquad I_{RMS} = \frac{I}{\sqrt{2}} \qquad V_{RMS} = \frac{V}{\sqrt{2}} \qquad V_R = IR \qquad V_L = IX_L$$

$$X_L = \omega L \qquad V_C = IX_C \qquad X_C = \frac{1}{\omega C} \qquad V = IZ$$

$$Z = \sqrt{(X_L - X_C)^2 + R^2} \qquad \tan\phi = \frac{X_L - X_C}{R} \qquad P_{av} = I_{rms}V_{rms}\cos\phi \qquad \cos\phi = \frac{R}{Z}$$

$$\omega_o = \frac{1}{\sqrt{LC}} \qquad \omega = 2\pi f \qquad \frac{V_2}{V_1} = \frac{N_2}{N_1} \qquad V_1 I_1 = V_2 I_2$$

$$v = f\lambda \qquad c = \frac{1}{\sqrt{\varepsilon_o \mu_o}} \qquad E = cB \qquad E(x,t) = E_{\max}\cos(\omega t - kx)$$

$$B(x,t) = B_{\max}\cos(\omega t - kx) \qquad \vec{S} = \frac{1}{\mu_o}\vec{E} \times \vec{B} \qquad I = S_{av} \qquad p_{rad} = \frac{I}{c} \qquad p_{rad} = \frac{2I}{c}$$

$$n = \frac{c}{v} \qquad \theta_r = \theta_i \qquad n_1\sin\theta_1 = n_2\sin\theta_2 \qquad \lambda = \frac{\lambda_o}{n}$$

$$\sin\theta_{crit} = \frac{n_2}{n_1} \qquad I = \tfrac{1}{2}I_o \qquad I_2 = I_1\cos^2\theta \qquad \tan\theta_p = \frac{n_2}{n_1}$$

$$f = \tfrac{1}{2}R \qquad \frac{1}{d_o} + \frac{1}{d_i} = \frac{1}{f} \qquad M = \frac{h_i}{h_o} = -\frac{d_i}{d_o} \qquad \frac{1}{f} = (n-1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$d\sin\theta = m\lambda \qquad d\sin\theta = \left(m + \tfrac{1}{2}\right)\lambda$$

$$\sin\theta = \frac{m\lambda}{a} \qquad I = I_0\left\{\frac{\sin[\pi a(\sin\theta)/\lambda]}{\pi a(\sin\theta)/\lambda}\right\}^2 \qquad d\sin\theta = m\lambda \qquad 2d\sin\theta = m\lambda$$