$$\oiint_S \vec{E} \cdot \hat{n}\, dA = \iiint_\tau \frac{\rho}{\varepsilon_0}\, d\tau$$

$$\oiint_S \vec{B} \cdot \hat{n}\, dA = 0$$

$$\oint_C \vec{E} \cdot d\vec{l} = -\frac{\partial}{\partial t} \iint_S \vec{B} \cdot \hat{n}\, dA$$

$$\oint_C \vec{B} \cdot d\vec{l} = \mu_0 \iint_S \bar{J} \cdot \hat{n}\, dA$$

$$\hat{p}_x = -i\hbar \frac{\partial}{\partial x}$$

$$\hat{H} = \frac{\hat{p}_x{}^2}{2m} + V(x)$$

$$\hat{\bar{L}} = \hat{\bar{r}} \times \hat{\bar{p}}$$

$$c = 3\times10^{8}\, m/s$$

$$k = \frac{1}{4\pi\varepsilon_0} = 9\times10^{9}\, Nm^2/C^2$$

$$\varepsilon_0 = 8.85\times10^{-12}\, C^2/Nm^2$$

$$\mu_0 = 4\pi\times10^{-7}\, Tm/A$$

$$q_e = -1.6\times10^{-19}\, C$$

$$m_e = 9.1\times10^{-31}\, kg$$

$$\vec{F} = \frac{kq_1q_2}{r^2}\hat{r}$$

$$\vec{E}(r) = \frac{kQ}{r^2}\hat{r}$$

$$\Phi_E = \int \vec{E}\cdot d\vec{A}$$

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enc}}{\varepsilon_0}$$

$$W_{a\to b} = U_a - U_b$$

$$K = \frac{1}{2}mv^2$$

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

$$V = \frac{1}{4\pi\varepsilon_0}\sum\frac{q_i}{r_i}$$

$$\Delta V = -\int_a^b \vec{E}\cdot d\vec{l}$$

$$I = \frac{dQ}{dt}$$

$$V = IR$$

$$R = \rho\frac{L}{A}$$

$$C = \frac{Q}{V}$$

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

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots (series)$$

$$C_{eq} = C_1 + C_2 + \ldots (parallel)$$

$$P = I^2R = \frac{V^2}{R} = IV$$

$$U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

$$R_{eq} = R_1 + R_2 + ...(series)$$

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + ...(parallel)$$

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

$$\vec{F} = \int I d\vec{l} \times \vec{B}$$

$$\vec{\tau} = I\vec{A} \times \vec{B}$$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v} \times \vec{r}}{r^2} = \frac{\mu_0}{4\pi}\int \frac{Id\vec{l} \times \hat{r}}{r^2}$$

$$\oint \vec{B} \cdot d\vec{A} = 0$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \mu_0 n I$$

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 (I_{enc} + I_D)$$

$$I_D = \varepsilon_0 \frac{d\Phi_E}{dt}$$

$$\mathcal{E} = -N\frac{d\Phi_B}{dt}$$

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$$

$$\mathcal{E} = -L\frac{dI}{dt}$$

$$L = \frac{N\Phi_B}{I}$$

$$P = \frac{E}{t}$$

$$I = \frac{P}{A}$$

$$c = f\lambda$$

$$I = I_0 \cos^2 \theta$$

$$V = \frac{c}{n}$$

$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$

$$E = Bc$$

$$\vec{v}_{ave} = \frac{\Delta \vec{r}}{\Delta t} \qquad \vec{\omega}_{ave} = \frac{\Delta \vec{\theta}}{\Delta t} \qquad v_{\tan} = R\omega$$

$$\vec{a}_{ave} = \frac{\Delta \vec{v}}{\Delta t} \qquad \vec{\alpha}_{ave} = \frac{\Delta \vec{\omega}}{\Delta t} \qquad a_{\tan} = R\alpha$$

$$v_s = v_{0s} + a_s t \qquad \omega = \omega_0 + \alpha_s t$$

$$\Delta s = v_{0s} t + \frac{1}{2} a t^2 \qquad \Delta \theta = \omega 0 + \frac{1}{2} \alpha t^2 \qquad s = R\theta$$

$$v_s{}^2 = v_{0s}{}^2 + 2a\Delta s \qquad \omega_s{}^2 = \omega_{0s}{}^2 + 2\alpha \Delta \theta$$

$$a_c = \frac{v^2}{R} \qquad a_c = \omega^2 R$$

$$\vec{F}_{net} = m\vec{a} \qquad \vec{\tau}_{net} = I\vec{\alpha} \qquad \vec{\tau} = \vec{r} \times \vec{F}$$

$$I = \sum_i m_i r_i{}^2$$

$$K = \frac{1}{2} m v^2 \qquad K_{rot} = \frac{1}{2} I \omega^2$$

$$\vec{p} = m\vec{v} \qquad \vec{L} = I\vec{\omega}$$

$$\vec{F}_{net} = \frac{\Delta \vec{p}}{\Delta t} \qquad \vec{\tau}_{net} = \frac{\Delta \vec{L}}{\Delta t}$$

$$W = \int \vec{F} \bullet d\vec{s}$$

$$E = K + U$$

$$W_{total} = \Delta K$$

$$W_{nc} = \Delta E$$

$$P = \frac{W}{t} = Fv$$

$$\vec{v}_1 - \vec{v}_2 = \vec{v}_2{}' - \vec{v}_1{}'$$

$$\vec{r}_{cm} = \frac{\sum_i m_i \vec{r}_i}{\sum_i m_i}$$

$$\vec{P}_{cm} = M_{total} \vec{v}_{cm} = \sum_i m_i \vec{v}_i$$

$$U_{spring} = \frac{1}{2} k x^2$$

$$U_{grav} = mgd$$

$$\vec{F}_{spring} = -k\vec{x}$$

$$F_{fk} = \mu_k F_N$$

$$F_{fs} \le \mu_s F_N$$

$$F_w = mg$$

$$f = 1/T$$

$$T = 2\pi\sqrt{\frac{m}{k}} \qquad = 2\pi\sqrt{\frac{l}{g}}$$

$$a = -\frac{k}{m}x \qquad = -\frac{g}{l}x$$

$$x = A\cos((2\pi f)t) \qquad v = -\omega A\sin(\omega t)$$

$$\frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

$$v = \lambda f$$

$$v = \sqrt{\frac{F_T}{m/L}}$$

$$y = A\sin(kx - \omega t)$$

$$k = 2\pi / \lambda \qquad \omega = 2\pi f$$

$$f' = f\left(\frac{v \pm v_0}{v \mp v_s}\right)$$

$$T_F = \frac{9}{5}T_C + 32$$

$$T_K = T_C + 273.15$$

$$\Delta L = \alpha L_0 \Delta T$$

$$Q = mC\Delta T$$

$$Q = \pm mL$$

$$PV = nRT$$

$$\Delta U = Q - W$$

$$e = W / Q$$

$$W = \int P\,dV$$

$$\rho = m/V$$

$$P = F / A$$

$$P = P_0 + \rho g h$$

$$P + \rho g h + \frac{1}{2}\rho v^2 = const$$

$$\frac{\Delta V}{\Delta t} = Av$$

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}}$$

$$y' = y$$

$$z' = z$$

$$t' = \frac{t - \dfrac{vx}{c^2}}{\sqrt{1 - v^2/c^2}}$$

$$T' = \frac{T_0}{\sqrt{1 - v^2/c^2}}$$

$$L = L_0\sqrt{1 - v^2/c^2}$$

$$u_x = \frac{dx}{dt} = \frac{\gamma(dx' + v\,dt')}{\gamma[dt' + (v/c^2)\,dx']} = \frac{u'_x + v}{1 + (v/c^2)\,u'_x}$$

$$u_y = \frac{u'_y}{\gamma[1 + (v/c^2)\,u'_x]}$$

$$u_z = \frac{u'_z}{\gamma[1 + (v/c^2)\,u'_x]}$$

where

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

The classical form for linear momentum is replaced by the special relativity form:

$$\mathbf{p} = \gamma m\mathbf{u} = \frac{m\mathbf{u}}{\sqrt{1 - v^2/c^2}} \qquad (2.47)$$

The relativistic kinetic energy is given by

$$K = \gamma mc^2 - mc^2 = mc^2\left(\frac{1}{\sqrt{1 - v^2/c^2}} - 1\right) \qquad (2.57)$$

The *total energy* E is given by

$$E = \gamma mc^2 = \frac{mc^2}{\sqrt{1 - v^2/c^2}} = \frac{E_0}{\sqrt{1 - v^2/c^2}} = K + E_0 \qquad (2.64)$$

Energy and momentum are related by

$$E^2 = p^2c^2 + E_0{}^2$$