The momentum principle:

$$d\vec{\mathbf{p}} = \vec{\mathbf{F}}_{net}dt$$

$$\vec{\mathbf{p}} = \frac{m\vec{\mathbf{v}}}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\vec{\mathbf{p}}_{new} = \vec{\mathbf{p}}_{old} + \vec{\mathbf{F}}_{net}\Delta t$$

$$\vec{\mathbf{r}}_{new} = \vec{\mathbf{r}}_{old} + \frac{1}{\sqrt{1+\left(\frac{p}{mc}\right)^2}}\left(\frac{\vec{\mathbf{p}}}{m}\right)\Delta t$$

Equations of motion in 1D for constant acceleration and low velocities ($v \ll c$):

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2$$

$$v(t) = \frac{dx(t)}{dt} = v_0 + at$$

$$a(t) = \frac{dv(t)}{dt} = a = \text{constant}$$

Requirement for uniform circular motion:

$$F_r = \frac{mv^2}{r}$$

Rotational motion:

$$d = \theta r$$

$$v = \omega r \qquad \omega = \frac{d\theta}{dt}$$

$$a = \alpha r \qquad \alpha = \frac{d\omega}{dt}$$

Gravitational force:

$$\vec{\mathbf{F}} = G\frac{m_1 m_2}{r^2}\hat{\mathbf{r}}$$

$$\vec{\mathbf{F}} = m\vec{\mathbf{g}} \quad \text{(close to the surface of the Earth)}$$

Electrostatic force:

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

Harmonic motion:

$$F = -kx$$

$$x(t) = x_{\max}\cos(\omega t + \phi) \quad \text{where } \omega = \sqrt{\frac{k}{m}}$$

$$T = \frac{2\pi}{\omega}$$

Damped harmonic motion:

$$x(t) = x_m e^{-\frac{bt}{2m}} e^{it\sqrt{\frac{k}{m}}}$$

Driven harmonic motion:

$$x(t) = \frac{F_0}{\omega_0{}^2 - \omega^2}\cos(\omega t + \phi)$$

Stress and strain:

$$\frac{F}{A} = Y\frac{\Delta L}{L}$$

$$Y = \frac{k_s}{d}$$

Work done by a force:

$$W = \vec{\mathbf{F}}\bullet\vec{\mathbf{d}} \qquad \text{constant force}$$

$$= \int_{\vec{\mathbf{r}}_1}^{\vec{\mathbf{r}}_2} \vec{\mathbf{F}}\bullet d\vec{\mathbf{r}} \qquad \text{variable force}$$

Work-energy theorem:

$$\Delta E_{system} = W$$

$$E_{system} = (E_1 + E_2 + E_3 + ...) + U$$

Relativistic energy relations:

$$E = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} = mc^2 + K$$

$$E^2 - \left(pc\right)^2 = \left(mc^2\right)^2$$

$$K = \frac{mc^2}{\sqrt{1-\frac{v^2}{c^2}}} - mc^2 \underset{v \ll c}{\rightarrow} \frac{1}{2}mv^2$$

Potential energy:

$$\Delta U = -W_{\text{internal}} = -\int \vec{\mathbf{F}} \bullet d\vec{\mathbf{r}}$$

$$\vec{\mathbf{F}} = -\vec{\nabla} U = \begin{pmatrix} -\frac{\partial U}{\partial x} \\ -\frac{\partial U}{\partial y} \\ -\frac{\partial U}{\partial z} \end{pmatrix}$$

$$U_{gravity} = -G\frac{m_1 m_2}{r}$$

$$U_{electric} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$$

$$U_{spring} = \frac{1}{2}kx^2$$