Rigid Body Rotations:

\[ \omega = \frac{d\theta}{dt}, \quad \alpha = \frac{d\omega}{dt}. \]

Connection to linear quantities: \( v = r\omega \), \( a_t = r\alpha \), and \( a_r = r\omega^2 \).

Both \( \vec{\omega} \) and \( \vec{\alpha} \) are vectors, with direction defined by a right-hand rule based on sense of rotation, or sense of change in \( \vec{\omega} \).

Rigid Rotor Kinematics for constant \( \alpha \):

\[ \theta = \theta(0) + \omega(0)t + \frac{1}{2} \alpha t^2. \]

\[ \omega = \omega(0) + \alpha t. \]

\[ \omega^2 = \omega(0)^2 + 2\alpha(\theta - \theta(0)). \]

Vector Cross Product: \( \mathbf{A} \times \mathbf{B} = \mathbf{C} \).

The vector \( \mathbf{C} \) is perpendicular to the plane containing \( \mathbf{A} \) and \( \mathbf{B} \), and has magnitude \( C = AB \sin \theta_{AB} \).

Torque:

\[ \vec{\tau} = \mathbf{r} \times \mathbf{F}. \]
The big picture!

\[ F_I = F \sin \theta \]

\[ \tau = r F \sin \theta \]

\[ \tau = r F_I \]
The magnitude of the torque can be expressed three different ways:

\[ \tau = rF \sin \theta = r_{\perp}F = rF_{\perp}. \]

Rotational Inertia:

\[ I = \sum_{i} m_{i}r_{i}^{2} \]

\[ I = \int r^{2}dm. \]

Parallel Axis Theorem:

\[ I = I_{\text{cm}} + Md^{2}. \]

Second Law for Torques!

\[ \sum_{i} \vec{\tau}_{i} = I \vec{\alpha}. \]

Rotational Kinetic Energy:

\[ K_{r} = \frac{1}{2}I\omega^{2}. \]
Rolling Motion:

\[ v_{cm} = R\omega. \]

Conservation of Energy:

\[ E = K_{cm} + K_r + U_{cm}. \]