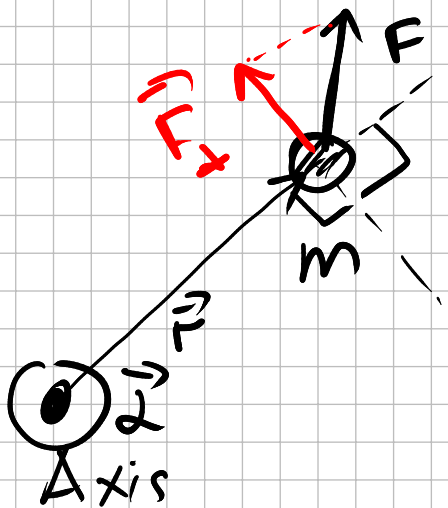


Torque



$$m a = F_t$$

$$m \alpha \cdot r \cdot r = F_t \cdot r$$

angular acceleration

$$m r^2 \alpha = r \cdot F_t$$

$$I \cdot \alpha = r \cdot F_t$$

$$I \vec{\alpha} = \vec{r} \times \vec{F} = \vec{\tau}$$

torque

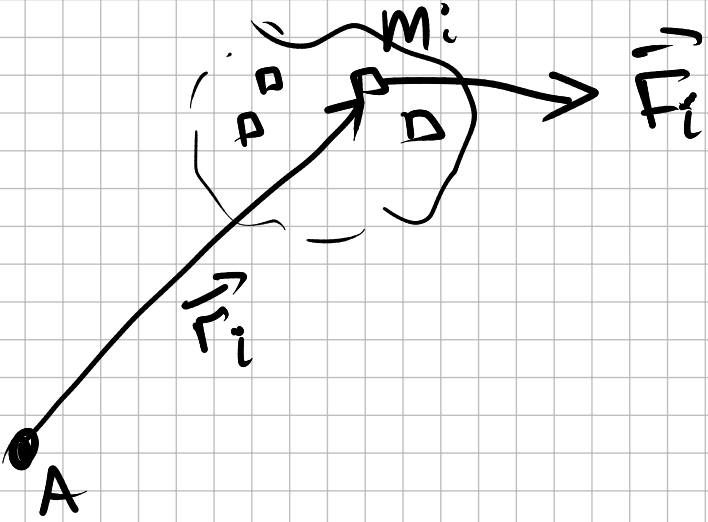
$$|\vec{r} \times \vec{F}| = r \cdot F \cdot \sin \theta$$

$$F_t = F \cdot \sin \theta$$

A diagram showing a vector r and a force vector F at an angle θ . The tangential component of the force, F_t , is shown.

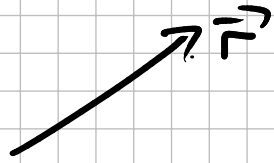
$$\vec{\tau}_{\text{net}} = \sum_i \vec{r}_i \times \vec{F}_i = I \cdot \vec{\alpha}$$

$$\sum_i m_i r_i^2$$



x, y, z

\vec{r}



\vec{v}

$$K = \frac{1}{2} m v^2$$

$$m \vec{a} = \vec{F}$$

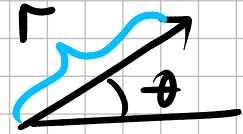
$$\vec{p} = m \vec{v}$$

$$\frac{d\vec{p}}{dt} = \vec{F}$$

momentum

Polar coordinates

r, θ



$\vec{v}_r, \vec{\omega}$

\vec{v}_r radial

for rigid objects with fixed axis of rotation

$$K = \frac{1}{2} I \omega^2$$

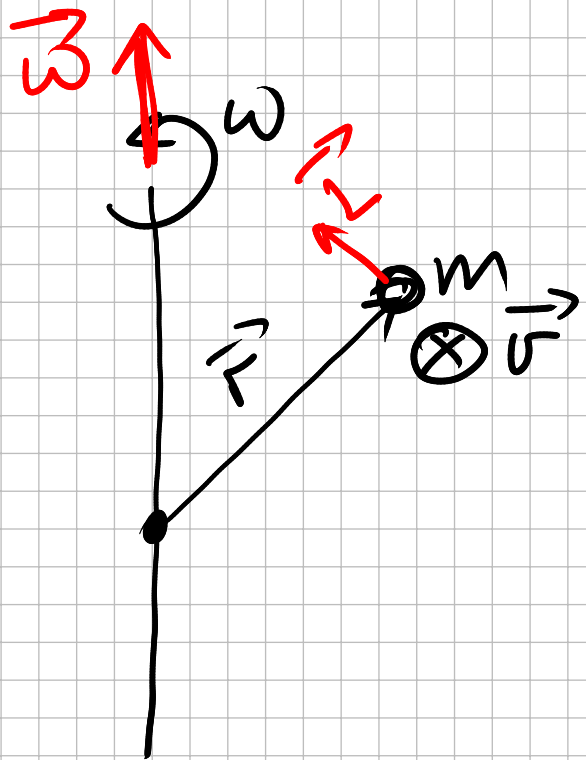
$$I \vec{\alpha} = \vec{r} \times \vec{F} = \vec{\tau}$$

$$\vec{L} = \sum_i \vec{r}_i \times \vec{p}_i = I \vec{\omega}$$

angular momentum

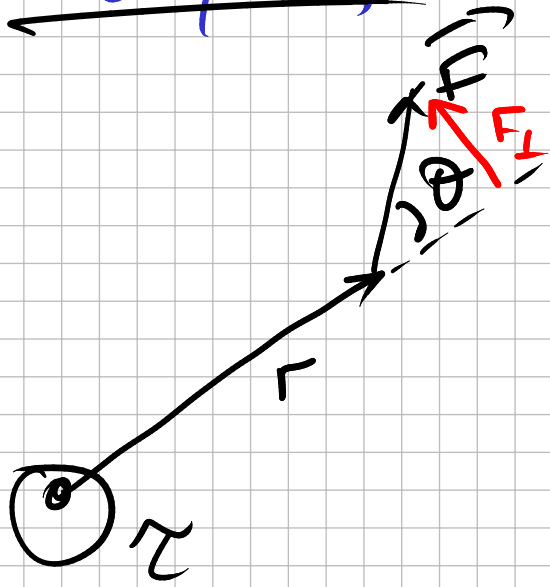
$\frac{d\vec{L}}{dt} = \vec{\tau}_{net}$

true only for symmetric objects



$$\begin{aligned}
 \vec{L} &= \vec{r} \times \vec{p} = \vec{r} \times (m\vec{v}) \\
 &= m(\vec{r} \times \vec{v}) = \\
 &= m \cdot r \cdot v \cdot \overrightarrow{\text{direction}}
 \end{aligned}$$

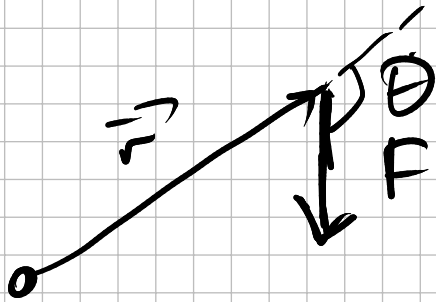
Torques



$$I \vec{\alpha} = \vec{z}$$

$$\vec{z} = \vec{r} \times \vec{F}$$

$$z = r \cdot F \cdot \sin \theta$$
$$= r \cdot F_{\perp}$$



$$= r \cdot F_{\perp}$$

