February 14: Torque and Angular Momentum

Objectives

- Predict an object's response to a torque.

What's the point?

- Some things do not change!

Torque

Torque is an influence on an object to make it rotate. (More correctly, it is an influence that changes an object's angular momentum.) It is the rotational analogue of force. It is given by the formula $\vec{\tau} = \vec{r} \times \vec{F}$, where $\vec{r}$ is the lever arm (vector from the axis of rotation to where the force is applied) and $\vec{F}$ is the tangential force applied to the lever arm. Torque must be defined with reference to an axis.

Angular momentum

Angular momentum is the rotational analogue of momentum. It is given by the formula $\vec{l} = \vec{r} \times \vec{p}$, where $\vec{r}$ is the lever arm and $\vec{p}$ is the tangential momentum of the object. Angular momentum, as torque, must be defined with respect to an axis of rotation.

Just as force is the rate of change of momentum $\vec{F} = \Delta\vec{p}/\Delta t$, torque is the rate of change of angular momentum $\vec{\tau} = \Delta\vec{l}/\Delta t$.

Just as momentum is conserved in all interactions, angular momentum is as well.

Right-hand rule

Angular momentum and torque are vectors, directed along the axis of the rotation or torque. The direction along the axis is given by the right-hand rule: curling your fingers of your right hand along the direction of rotation (or change in rotation caused by the torque), your outstretched thumb will point in the direction of the $\vec{l}$ or $\vec{\tau}$ vector.