Rotational Motion Summary

Torque - Torque produces rotation. Torque is different from force. Forces make objects accelerate. Torques make things rotate.
A torque is produced when a force is applied with leverage. Torque is defined by the following formula: **torque = perpendicular force X lever arm distance**. Its units are Newton-meters (Nm).

Balanced Torques - Consider a seesaw. Balance is achieved if the torque that tends to produce counterclockwise rotation is canceled out by the torque that produces clockwise rotation.
Formula for Balanced Torques:

Counterclockwise torque = clockwise torque

OR in symbol form:

$$\textbf{(Force x distance)}_{\text{counterclockwise}} = \textbf{(Force x distance)}_{\text{clockwise}}$$

Example of Balanced Torques Problems:

1. A 500-g rock is suspended at the 25 cm mark on a meter stick that is balanced on a fulcrum at 50 cm. At what distance will a 350-g mass balance the rock?
2. A 140 lb. boy sits 4 ft from the fulcrum of a seesaw. If his little sister sits 6 ft away, what is her weight (in lbs.)?
3. Suppose that a meter stick is supported at the center, and a 20-N block is hung at the 20-cm mark. Another block of known weight just balances the system when it is hung at the 90-cm mark. What is the weight of the second block?

Rotational Inertia (also called *moment of inertia*) - measure of rotational laziness. It is the resistance of an object to changes in its rotational state of motion. It depends upon the *distance* of the mass from the center of rotation.
Examples:
pendulum - if the length of the string is increases, the RI of the system is increased as well
people with long legs - people bend their legs when running, to decrease RI, thereby increasing their speed.

Formula for **Rotational Inertia/Moment of Inertia**: $\mathbf{I = mr^2}$,
where **I** is the moment of inertia, **m** is the mass and **r** is the distance to the center of rotation or revolution.

3 axes of the body: longitudinal, transverse, and medial.
Longitudinal - RI is least about this axis. RI is increased by extending your legs or arms.
Transverse - somersault or flip. RI is also increased when arms/legs are extended.
Medial - cartwheel (less used axis due to great RI).

Angular Momentum - vector quantity.
Formula: **Angular Momentum = RI X RV**, where **RI** is the rotational inertia and **RV** is the rotational velocity.

Law of the Conservation of Angular Momentum: Angular Momentum is conserved if the sum of all external torques on the system is ZERO! In symbols:

$$\mathbf{RI_{before} \times RV_{before} = RI_{after} \times RV_{after}}$$

Precession - horizontal rotation of the axle/axis of a spinning object.
Example: bicycle wheel. A torque by the earth's gravity acts to change the direction of its angular momentum. Gravity tries to topple the wheel, but instead causes it to ***precess*** in a circular path about a vertical axis.