Rotational Mechanics Review

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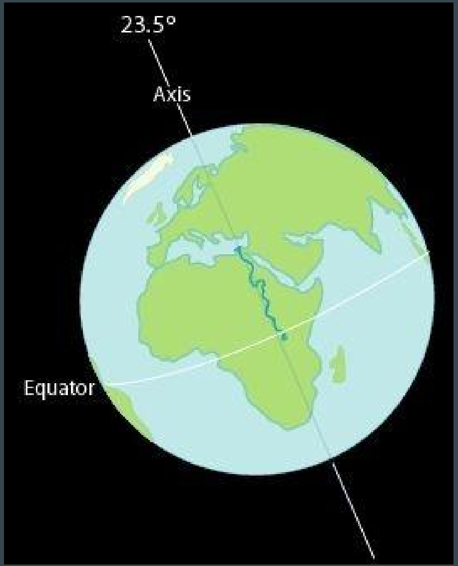
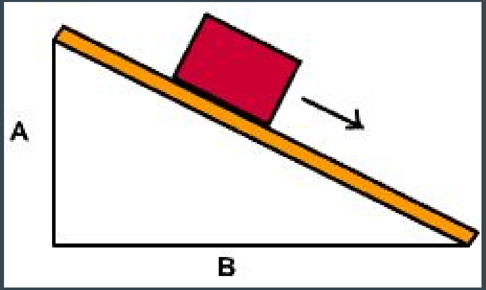
TRANSLATIONAL VS. ROTATIONAL MOTION

Rotational motion: the motion around an object's center of mass where every point in the body moves in a circle around the axis of rotation.

(ie. earth spinning on its axis)

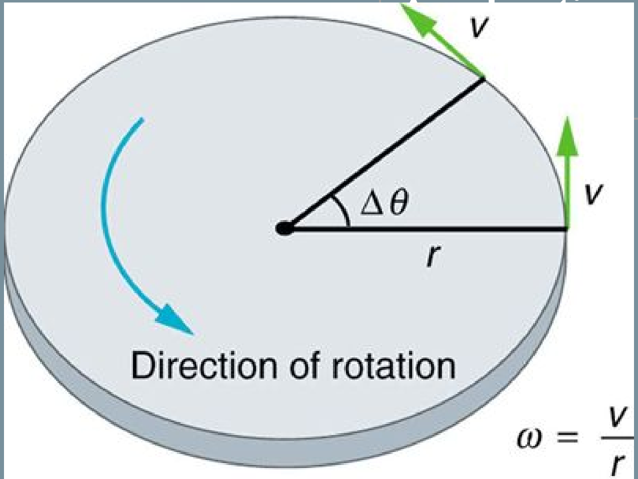


Translational motion: the movement of an object from one point to another through space, (ie. a block sliding down a ramp)



ANGULAR QUANTITIES

QUANTITY	LINEAR	ANGULAR	RELATIONSHIP
Position	*l* in meters	Θ in radians	Θ = *l*/*r*
Velocity	*v* in m/s	ω in rad/s	ω = *v*/*r*
[illegible]	*a* in m/s^2	α in rad/s^2	α= a/r =*d*ω /*dt*



LINEAR VS. ANGULAR VELOCITY

- Suppose we have 2 horses on a carousel. The black horse is 1 meter from the center, and the white horse is 2 meter from the center
    - Which horse has a greater angular velocity?
        - They have the same - they will each cover a full rotation (360 degrees) in the same amount of time.
    - Which horse “feels” like they are going faster
        - The white one, because it has a greater linear velocity.
            - It covers a greater distance (circumference) in the same amount of time

★ **NOTE: angular velocity should be in radians per second, NOT DEGREES!**

Centripetal Acceleration: the rate of change of tangential velocity.

$$a_c = r\omega^2$$

Tangential velocity: the velocity measured at any point tangent to a turning wheel.

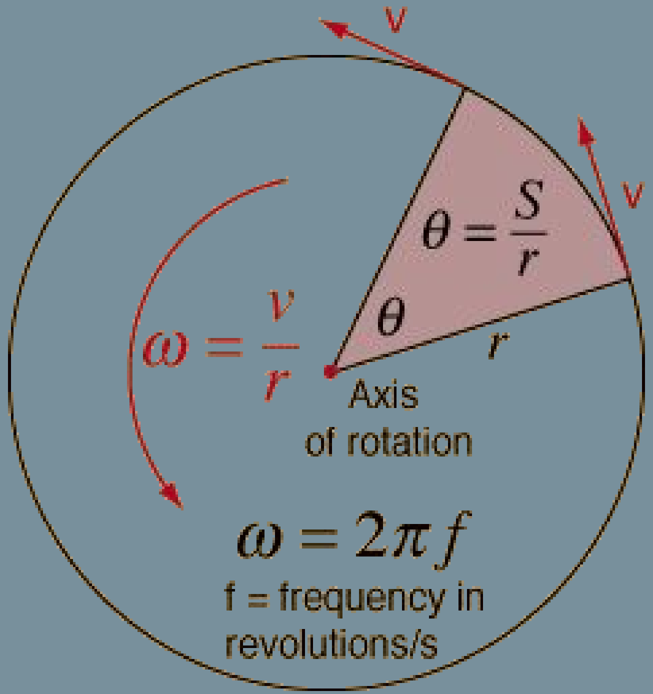
r is the is the radius

α is angular acceleration

ω is angular velocity.

Angular Frequency (or angular speed) is measured in rad/s^2

$\omega = 2\pi/T = 2\pi f$

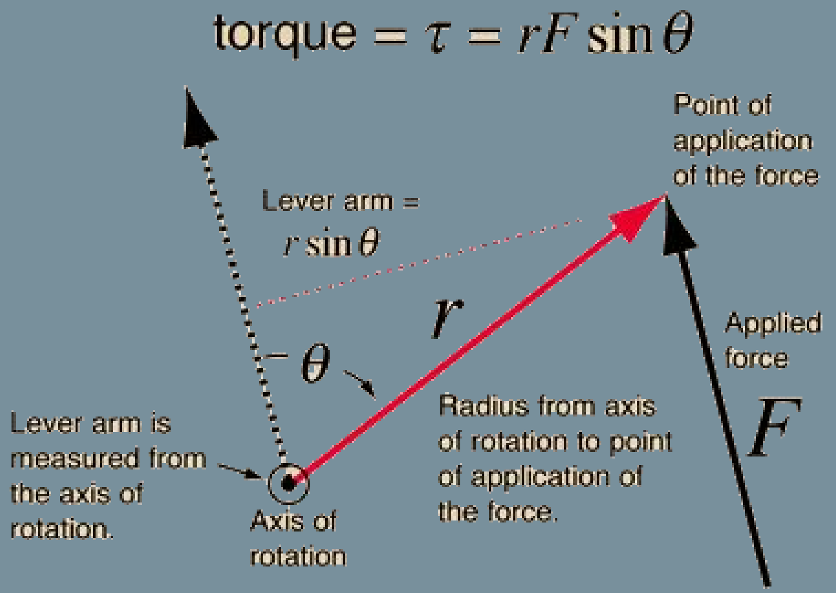


TORQUE

Torque is the ability of a force to cause a body to rotate about a particular axis. Net torque is the sum of the torques due to the individual forces.

Torque is **positive** if it tends to rotate the object counterclockwise, and **negative** if it tends to rotate the object clockwise around the axis of rotation. When the sum of all torques acting on an object equals zero, it is in rotational equilibrium.

- Only the perpendicular component of the force will contribute to rotation
- Measured in Nm (Newton meters)



Moment of Inertia (Rotational Inertia)

Rotational inertia is the tendency of a rotating object to remain rotating unless a torque is applied to it. This tells us how difficult it is to change the rotational velocity of the object around a given rotational axis. The bigger rotational inertia, the harder it is to move

Rotational Inertia is represented by I and is measured in units of kg x m^2

Angular Momentum

Angular Momentum is the quantity of rotation of a body, which is the product of its moment of inertia and its angular velocity. Units: **(kg m^2/s)**

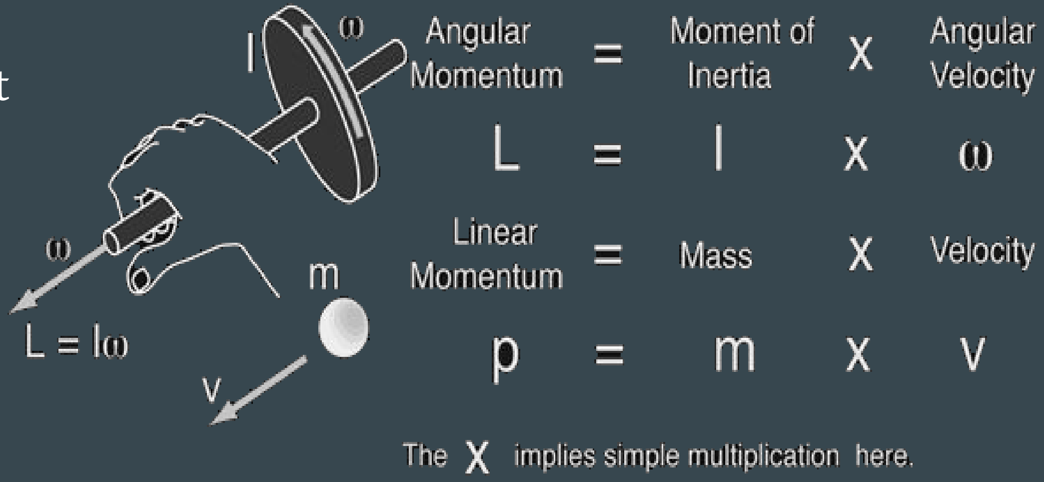
The Angular Momentum of an object will always remain constant unless acted upon by an external torque.

Equation for Angular Momentum

Angular Momentum = Moment of Inertia x Angular velocity

Or

$L = I \times \omega$



Rotational Kinetic Energy

Total Kinetic Energy = Rotational Kinetic Energy + Kinetic Energy of linear motion Units: J

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

Example: 2 cans going down a ramp. One is rolling and one is sliding. Which will reach the bottom first?

The sliding one, because part of the rolling can’s kinetic energy is used for rotation, and the rest is used for movement. The sliding can’s kinetic energy is not split.

Common Mistakes

Angular quantities are measured in radians, NOT meters or degrees.

Angular acceleration MUST be CONSTANT to use kinematics

Angular acceleration - There CAN'T be an external torque acting upon the system