Rotational Mechanics

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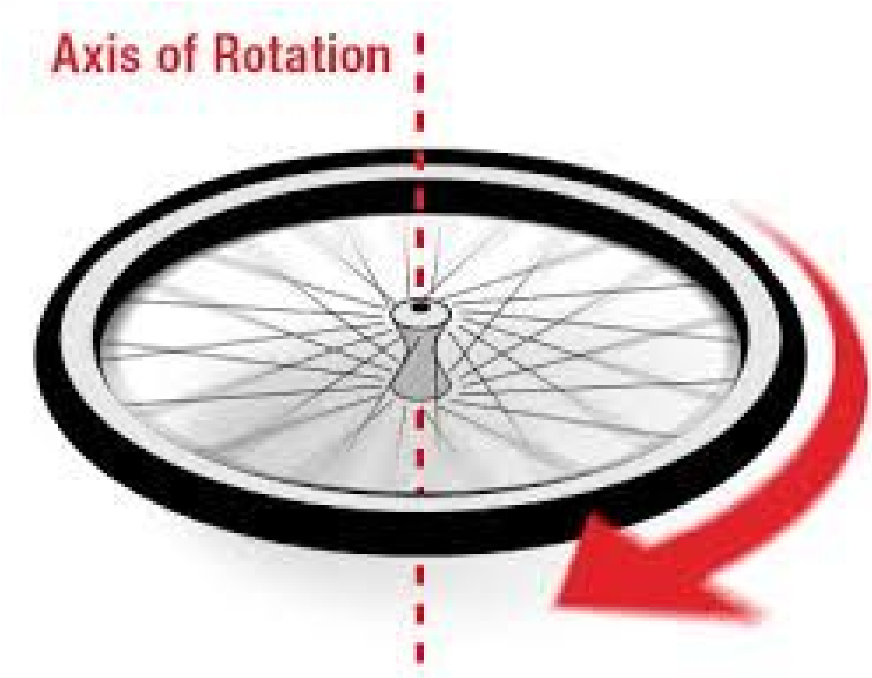
What is Rotational Mechanics

-Rotational Mechanics is the angular momentum; angular acceleration and kinetic energy of an object spinning on its axis.

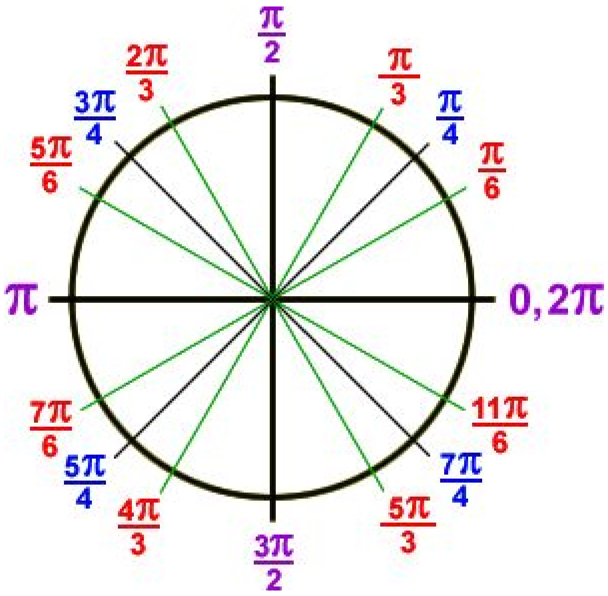
Tangential Velocity

- When a wheel rotates around an axis of rotation where the middle has 0 tangential speed but the outside of the wheel has more speed the further you go



Radians

- The Unit Circle is measured in a unit called a radian, in which 90 degrees translates into π/2, 180 into π, 270 into 3π/2, and 0 or 360 into 2π



Radians con.

- To convert Radians into degrees, you multiply your radians by 180/π

- To convert degrees into radians, you multiply your degrees by π/180

Degrees ⟺ Radians

$$360 = 2\pi$$

$$180 = \pi$$

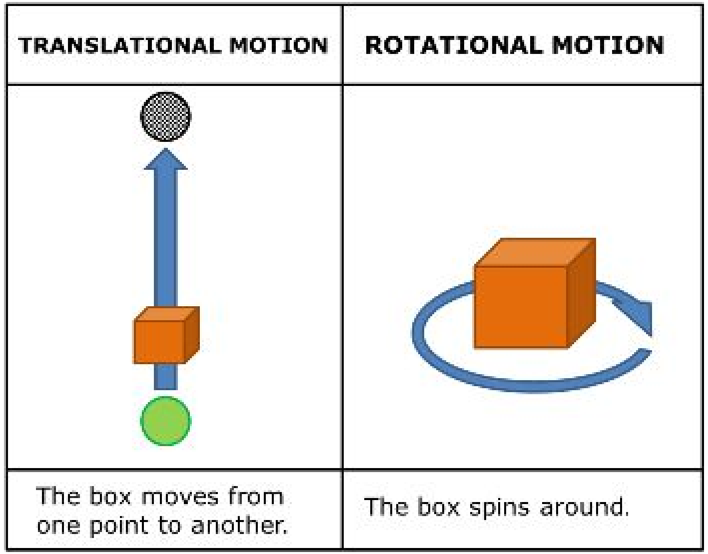
Ex. $\frac{\pi}{2}\text{rad} \cdot \frac{180}{\pi} = \frac{180\pi}{2\pi} = 90^\circ$

Ex2) $\frac{4\pi}{3}\text{rad} \cdot \frac{180}{\pi} = \frac{4 \cdot 180\pi}{3\pi} = 4 \cdot 60 = 240^\circ$

Linear Motion vs Rotational Velocity

- As linear motion is the measure of an object's change in position on a plane, Rotational velocity is the measure of an object's change in angle

- This is measured as Omega(ω) or its angular velocity



Linear and angular velocity

When we went to the field and spun in a circle with the large pole as the radius, who had the greater linear speed, the people at the inner end of the pole or the people at the purr end of the pole?

A. The inner end
B. The outer end
C. Both have the same linear speed

Answer

B. The outer edge

Linear and angular velocity

When we went to the field and spun in a circle with the large pole as the radius, who had the greater angular speed, the people at the inner end of the pole or the people at the outer end of the pole?

A. The inner end
B. The outer end
C. Both have the same angular speed

Answer

C. Both have the same angular speed

Angular Velocity vs Frequency

- Both of these units measure the same thing but in different units, Frequency being measured in revolutions per second and angular velocity measured in radians per second.

- 1 revolution is equal to 2π or the circumference of the circle

- This means to convert frequency to Radians, you multiply the frequency by 2π

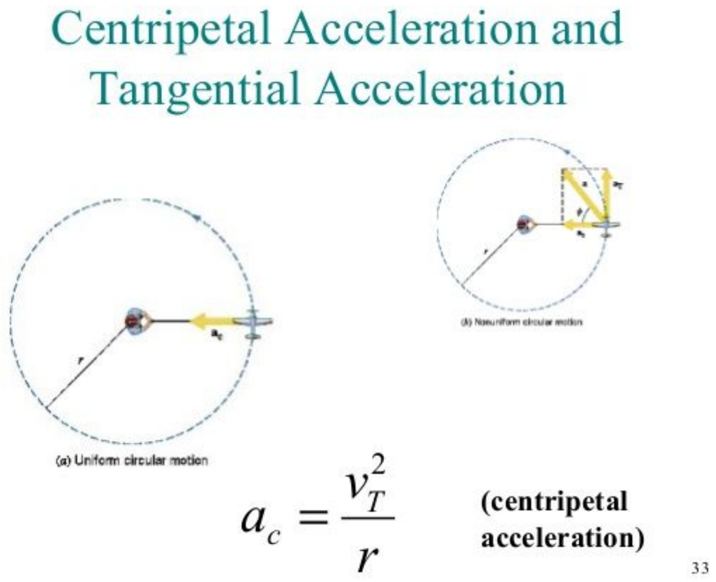
Angular and Tangential Acceleration

- Expressed as α, Angular acceleration is the angular velocity squared times the radius of the circle

-$\alpha = \omega^2 r$

- Expressed as a, Tangential velocity is equal to

-$a = \alpha r$



Angular Quantities

Angular quantities correspond to linear quantities

Quantity	Linear	Angular	Relationship
Position	*l* in meters	θ in radians	$\theta = l/r$
Velocity	v in m/s	ω in rad/s	$\omega = v/r$ $= \Delta\theta/\Delta t$
Acceleration	a in m/s^2	α in rad/s^2	$\alpha = a/r$ $= \Delta\omega/\Delta t$

Kinematic Equations

Angular Kinematics	Linear Equations
$\omega f = \omega i + \alpha \Delta t$	$Vf = Vi + a \Delta t$
$\Delta \theta = \omega i \Delta t + 1/2 \alpha \Delta t^2$	$\Delta X = Xi + Vi \Delta t + 1/2 a \Delta t^2$
$\omega f^2 = \omega i^2 + 2 \alpha \Delta \theta$	$Vf^2 = Vi^2 + 2a \Delta X$

Practice Problem

The Merry go round is going around once every 8 secs. The horse is 3m away from the center of the merry go round.

1. What's the horse’s Angular speed?
2. What is the horse’s angular displacement after 15 secs?

Work to practice problem

1. What information do you have?
2. Is the measurements in the right units? If not change it.
3. What formula are you going to use?
4. Use that formula and plug the information you have into the formula
5. Solve for the unknown

Torque

The “twisting force” that causes rotation

Only the perpendicular force is a component in torque

- $\tau = rF\perp$
- $\tau = rF\sin\theta$
- Measured in Nm

A common error that may occur is fogetting that only the perpendicular force is a component

Rotational Inertia

Moment of Inertia is a body's resistance to change in rotation

- $I = mr^2$

Rotational inertia depends on mass and how mass is distributed

The larger radius that an object has, the greater the rotational inertia will be

Which will have greater rotational inertia?

A. The man on the left
B. The man on the right

Answer

A. The man on the left

Angular Momentum

Linear Momentum:

- $p=mv$

Angular momentum:

- $L=I\omega$
- Measured in kgm^2

Newton's Second Law (Angular)

- $\Sigma\tau=\Delta L/\Delta t$

Conservation of Angular Momentum

The total momentum of a rotating body will remain constant if the net torque is zero