Rotational Mechanics

Review

Main Concepts

- Circular Motion
- Angular Quantities
- Torque
- Rotational Inertia
- Rotational Kinetic Energy
- Angular Momentum

Circular Motion & Angular Quantities

- Rigid body is broken up between *translational motion* of its center of mass and *rotational motion* about an axis of rotation
  - has a definite, unchanging shape
- Angular quantities are similar to that of linear motion
  - $l = \theta r$ l = meters θ = radians r = radius
  - $v = \omega r$ v = velocity m/s ω = velocity rad/s
  - $a = \alpha r$ a = acceleration m/s^2 α = acceleration rad/s^2
- Centripetal acceleration of angular velocity
  - $a_c = \omega^2 r$ ω=angular velocity
- Frequency in terms of angular velocity
  - $\omega = 2\pi f$

Torque

- "twisting force" that causes rotation
- $\tau = r F_{\square}$
- Nm
- perpendicular component of force contributes to rotation
- $\tau = r F \sin\theta$

Rotational Inertia

- measure of a body’s resistance to changes in its rotation
- $\Sigma\tau = I\alpha$
- The rotational inertia of an object depends on its mass in addition to how its mass is distributed with respect to the axis of rotation.

Angular Momentum

- $L = I\omega$
- $kg \cdot m^2/s$
- Newton's Second Law
  - $\Sigma\tau = \Delta L / \Delta t$
- The total angular momentum of a rotating body remains constant if the net torque is zero.

Rotational Kinetic Energy

- Translational kinetic energy
  - $KE_{tran}=\frac{1}{2} mv^2$
- Rotational kinetic energy
  - $KE_{rot}= \frac{1}{2} I\omega$
- $KE_{total}=KE_{tran}+KE_{rot}$

Common Mistakes

#1: What do all these symbols mean?

- ω: angular velocity
- α: angular acceleration
- L: angular momentum

Common Mistakes

#2: Rotational Inertia

Unlike regular inertia, which depends only on the mass of the object, rotational inertia also depends on how the mass is distributed around the axis of rotation. In general, the rotational inertia will be greater if the mass is concentrated further away from the axis.

Common Mistakes

#3: Rotational Kinetic Energy

Rotational kinetic energy is not the same as rotational momentum. If a force is applied to a round object on a flat surface, some of the force will go towards rotating the object and some to moving the object forward. This only happens when the force is applied off the center of mass.

Strategies for Free Response Questions

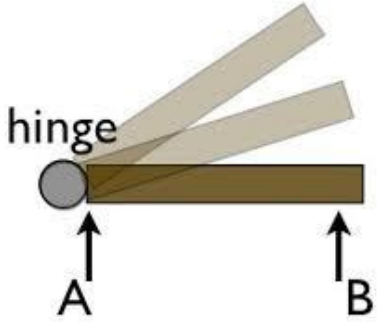
1. Change the units of the given information to the correct units
2. Define your variables *look for key-words like speed, radius, distance, torque, angular velocity, etc.
3. If needed, draw a picture to understand what the question if asking
4. Write the formula that will solve for the unknown variable
5. Solve for the unknown
6. Check math

*This unit is very similar to the linear motion, accept some of the variable are different and the object is moving in a circle. It may be easier to think of some of the questions like linear motion.

Multiple Choice

What component of force will contribute to rotation?

A. Parallel force
B. Perpendicular force
C. Horizontal force
D. Any Force



Multiple Choice

True or False

Rotational inertia (moment of inertia) is a measure of the body's *resistance* to changes in its rotation.

Multiple Choice

Which will have more rotational inertia, if they all objects have the same mass?

A. Large diameter cylinder
B. Small diameter cylinder

Multiple Choice

What is the formula of angular momentum?

A. $L = I\omega$
B. $p = mv$
C. $\omega = v/r$
D. $v = 2\pi r/T$

Multiple Choice

Which has greater linear speed, a horse near the outside rail of a merry-go-round or a horse near the inside?

A. The inside horse
B. Both have the same angular speed
C. The outside horse