Angular Momentum

Linear momentum

- ______________

Angular momentum

- ______________
- Unit: ______________
- ω must be in ______________rad/s
- When you rotate something you exert a ______________.
- ______________ torque = faster ______________ in ______________ momentum
- $\tau_{net} = \frac{\Delta L}{\Delta t}$
  - Like $F = \frac{\Delta p}{\Delta t}$

Conservation of Momentum

Linear momentum of a system is ______________ if ______________

- $p_0 = p_f$

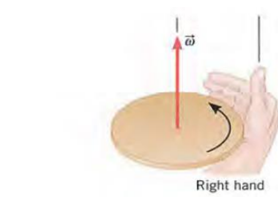
Angular momentum of a system is also ______________ if ______________

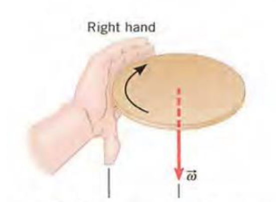
- $L_0 = L_f$

A 10-kg solid disk with r = 0.40 m is spinning at 8 rad/s. A 9-kg solid disk with r = 0.30 m is dropped onto the first disk. If the first disk was initially not rotating, what is the angular velocity after the disks are together?

What was the torque applied by the first disk onto the second if the collision takes 0.01 s?

- Angular Momentum conserved if net external ______________ is ______________
- Linear Momentum conserved if net external ______________ is ______________
- Kinetic Energy conserved if ______________ collision





Direction of angular quantities

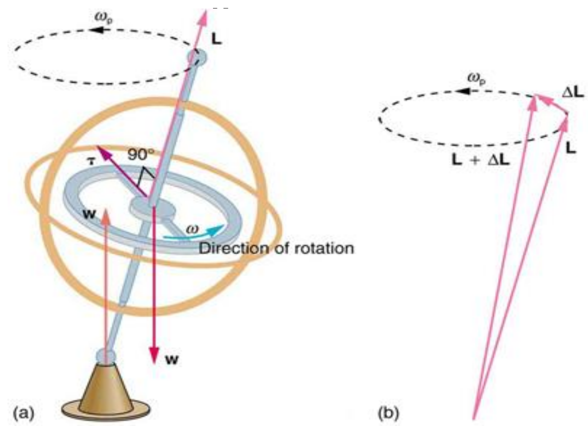
Right-hand Rule

- Hold hand out with ______________ out along ______________
- Curl your ______________ in direction of ______________ (you may have to turn your hand upside down)
- Vector in ______________ of ______________

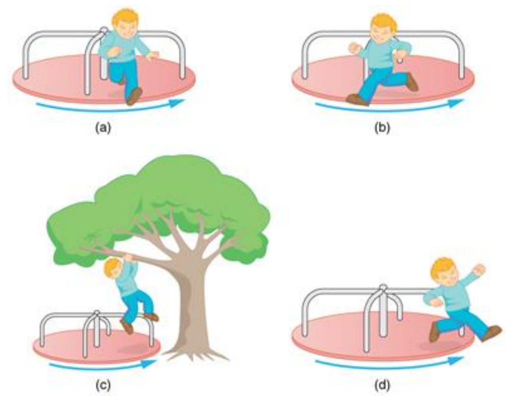
A person is holding a spinning bicycle wheel while he stands on a stationary frictionless turntable. What will happen if he suddenly flips the bicycle wheel over so that it is spinning in the opposite direction?

Gyroscopes

- ________________ forces acting on a spinning gyroscope. The torque produced is ________________ to the ________________ momentum, thus the ________________ of the torque is changed, but not its ________________. The gyroscope ________________ around a vertical axis, since the torque is always horizontal and perpendicular to L.
- If the gyroscope is not spinning, it ________________ angular momentum in the direction of the ________________ (L = ΔL), and it rotates around a horizontal axis, ________________ over just as we would expect.



Homework



1. Suppose a child walks from the outer edge of a rotating merry-go-round to the inside. Does the angular velocity of the merry-go-round increase, decrease, or remain the same? Explain your answer.
2. Helicopters have a small propeller on their tail to keep them from rotating in the opposite direction of their main lifting blades. Explain in terms of Newton's third law why the helicopter body rotates in the opposite direction to the blades.
3. When there is a global heating trend on Earth, the atmosphere expands and the length of the day increases very slightly. Explain why the length of a day increases.
4. Nearly all conventional piston engines have flywheels on them to smooth out engine vibrations caused by the thrust of individual piston firings. Why does the flywheel have this effect?
5. Suppose an ice hockey puck strikes a hockey stick that lies flat on the ice and is free to move in any direction. Which quantities are likely to be conserved: angular momentum, linear momentum, or kinetic energy (assuming the puck and stick are very resilient)?
6. (a) Calculate the angular momentum of the Earth in its orbit around the Sun. (b) Compare this angular momentum with the angular momentum of Earth on its axis. (OpenStax 10.36) $\mathbf{2.66 \times 10^{40}\ kg \cdot \frac{m^2}{s}, 7.07 \times 10^{33}\ kg \cdot \frac{m^2}{s}}$
7. (a) What is the angular momentum of the Moon in its orbit around Earth? (b) How does this angular momentum compare with the angular momentum of the Moon on its axis? Remember that the Moon keeps one side toward Earth at all times. (c) Discuss whether the values found in parts (a) and (b) seem consistent with the fact that tidal effects with Earth have caused the Moon to rotate with one side always facing Earth. (OpenStax 10.37) $\mathbf{2.89 \times 10^{34}\ kg \cdot \frac{m^2}{s}, 2.37 \times 10^{29}\ kg \cdot \frac{m^2}{s}}$
8. Suppose you start an antique car by exerting a force of 300 N on its crank for 0.250 s. What angular momentum is given to the engine if the handle of the crank is 0.300 m from the pivot and the force is exerted to create maximum torque the entire time? (OpenStax 10.38) $\mathbf{22.5\ kg \cdot m^2/s}$
9. A playground merry-go-round has a mass of 120 kg and a radius of 1.80 m and it is rotating with an angular velocity of 0.500 rev/s. What is its angular velocity after a 22.0-kg child gets onto it by grabbing its outer edge? The child is initially at rest. (OpenStax 10.39) $\mathbf{2.30\ rad/s}$
10. Three children are riding on the edge of a merry-go-round that is 100 kg, has a 1.60-m radius, and is spinning at 20.0 rpm. The children have masses of 22.0, 28.0, and 33.0 kg. If the child who has a mass of 28.0 kg moves to the center of the merry-go-round, what is the new angular velocity in rpm? (OpenStax 10.40) **25.3 rpm**
11. (a) Calculate the angular momentum of an ice skater spinning at 6.00 rev/s given his moment of inertia is 0.400 kg · m^2. (b) He reduces his rate of spin (his angular velocity) by extending his arms and increasing his moment of inertia. Find the value of his moment of inertia if his angular velocity decreases to 1.25 rev/s. (c) Suppose instead he keeps his arms in and allows friction of the ice to slow him to 3.00 rev/s. What average torque was exerted if this takes 15.0 s? (OpenStax 10.41) $\mathbf{15.1\ kg \cdot \frac{m^2}{s},\ 1.92\ kg \cdot m^2,\ -0.503\ N \cdot m}$