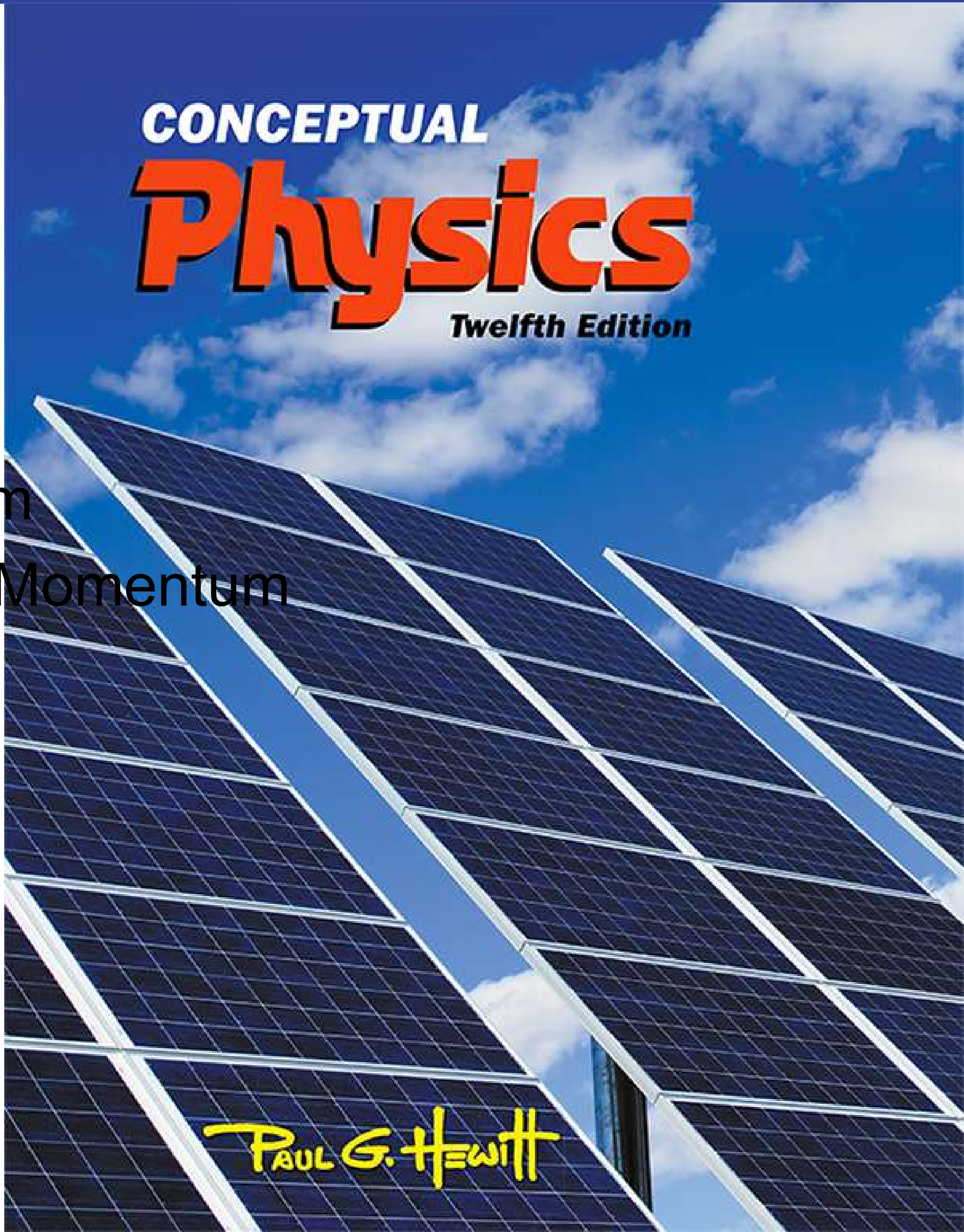
Chapter 8: Rotational Motion

Sections Angular Momentum

- Conservation of Angular Momentum



This lecture will help you understand:

- Angular Momentum
- Conservation of Angular Momentum

Review: Linear Momentum

Remember…. Momentum is like inertia in motion:

Linear momentum = mass x velocity

$$p = m \times v$$

Is momentum a vector?

Law of Conservation of Momentum

Angular Momentum

→The "inertia of rotation" of rotating objects is called **angular momentum.**

Angular momentum = rotational inertia x angular velocity

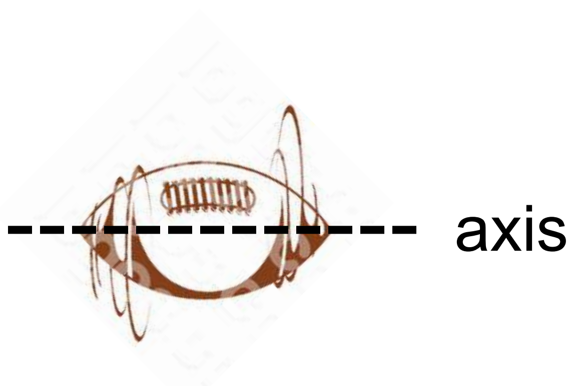
$$L = I \times \omega$$

mass x distance^2	revolutions per time or rpm

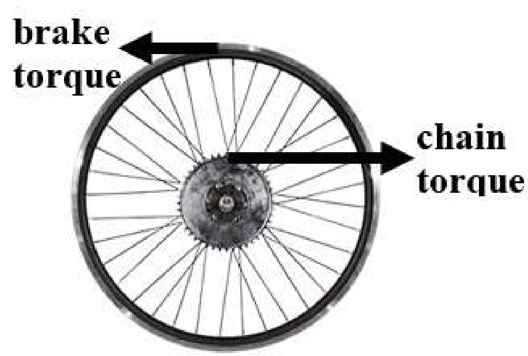
Angular momentum L is a vector that points along the axis of rotation.

Newton's Laws for Rotating Objects:

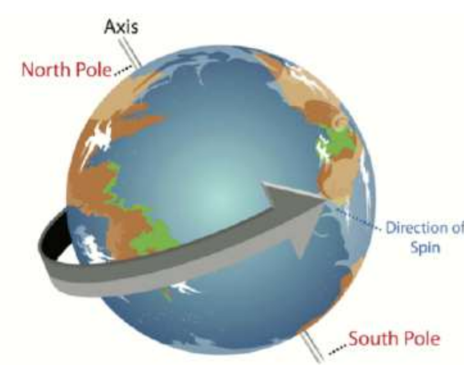
1. If there is no net torque acting on an object, the object keeps rotating at the same speed in the same direction.
2. If there is a net torque, either the speed changes or the direction (axis) changes.



no net torque

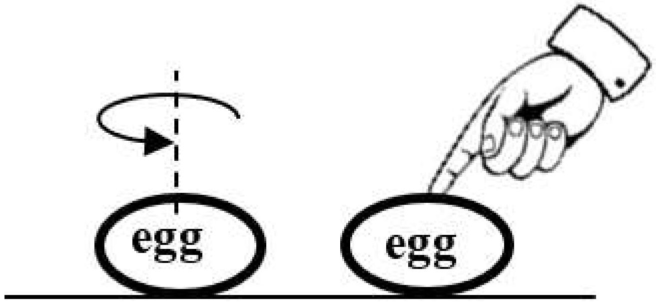


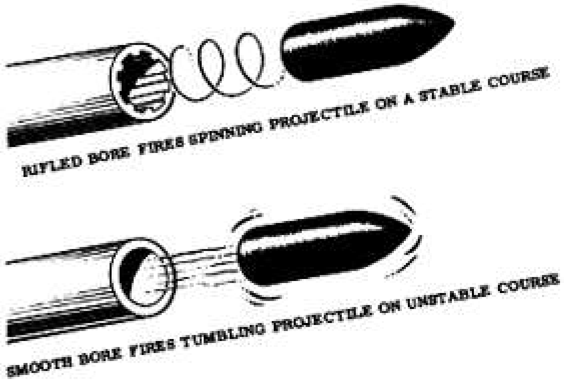
net torque: speed changes

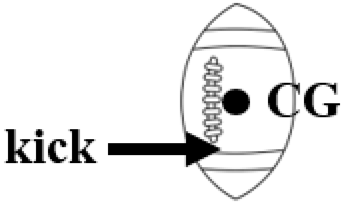


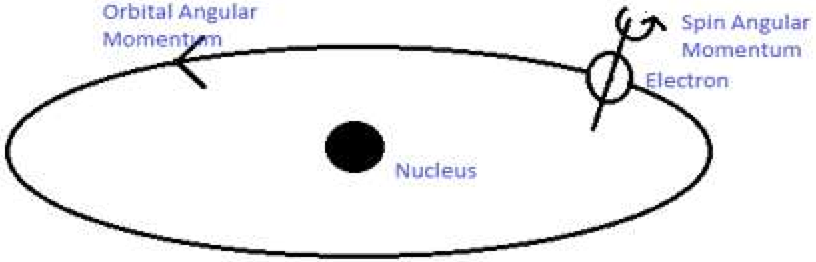
net torque: direction changes

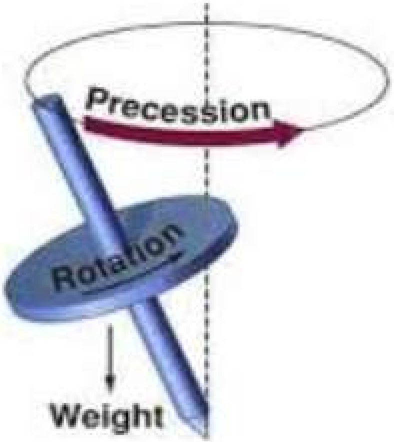

dime
table

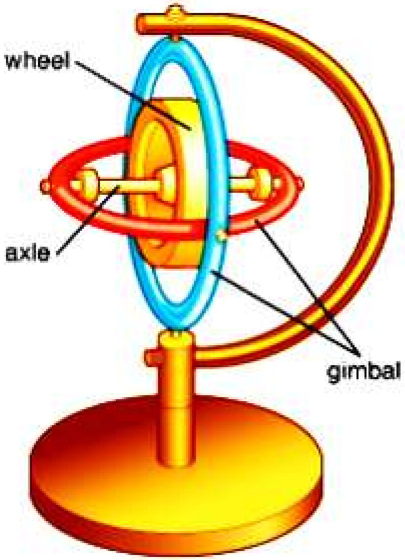

egg
egg

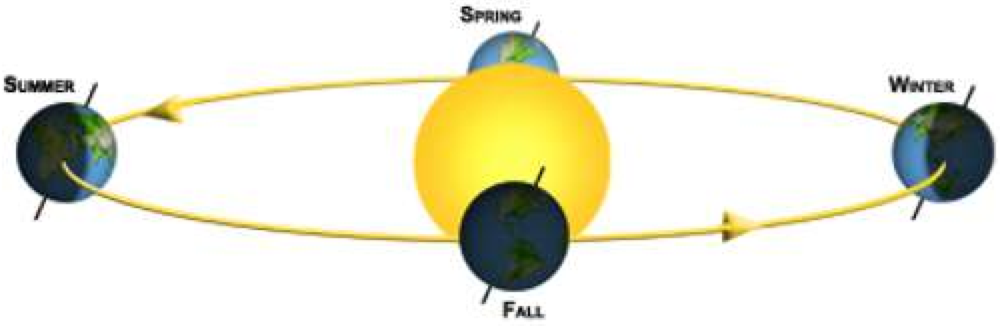

RIFLED BORE FIRES SPINNING PROJECTILE ON A STABLE COURSE
SMOOTH BORE FIRES TUMBLING PROJECTILE ON UNSTABLE COURSE


CG
kick


Orbital Angular
Momentum
Spin Angular
Momentum
Electron
Nucleus


Precession
Rotation
Weight


wheel
axle
gimbal


SPRING
SUMMER
WINTER
FALL

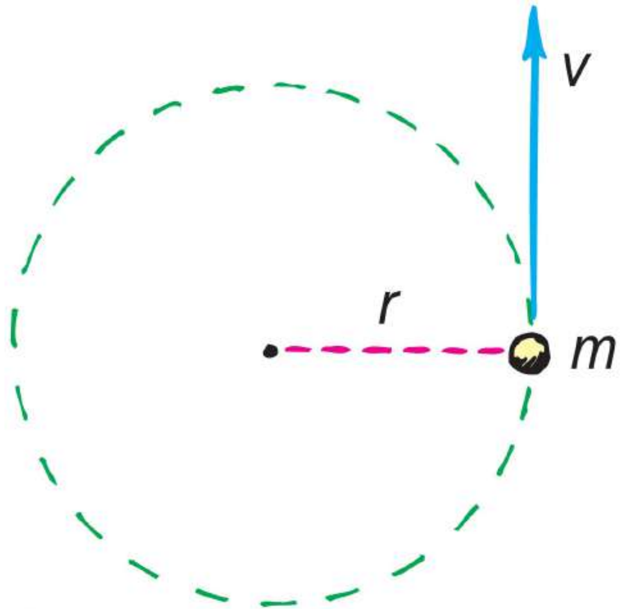
Angular Momentum, Continued

- For an object that is small compared with the radial distance to its axis, magnitude of

  Angular momentum = mass tangential speed x radius

  – This is analogous to magnitude of
    Linear momentum = mass x speed

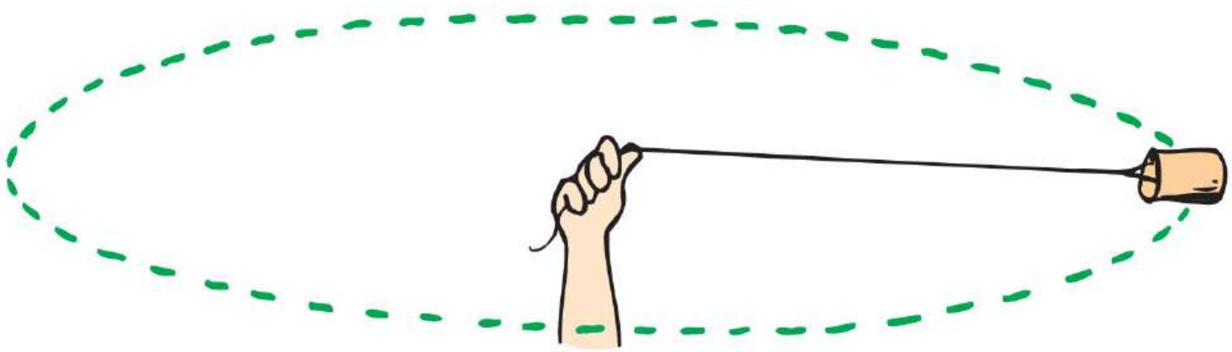
- Examples:
  – Whirling ball at the end of a long string
  – Planet going around the Sun



Angular Momentum
CHECK YOUR NEIGHBOR

Suppose you are swirling a can around and suddenly decide to pull the rope in *half*way; by what factor would the speed of the can change?

A. Double
B. Four times
C. Half
D. One-quarter



Angular Momentum
CHECK YOUR ANSWER

Suppose you are swirling a can around and suddenly decide to pull the rope in *half*way; by what factor would the speed of the can change?

A. **Double**

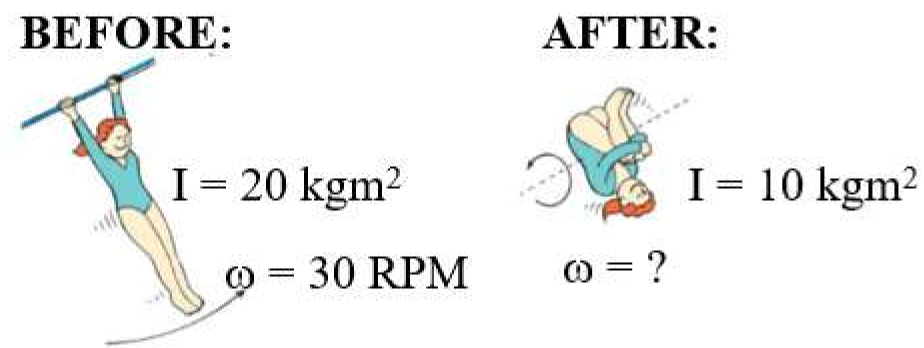
Explanation:
Angular momentum =
mass tangential speed x radius

Angular Momentum is proportional to radius of the turn.

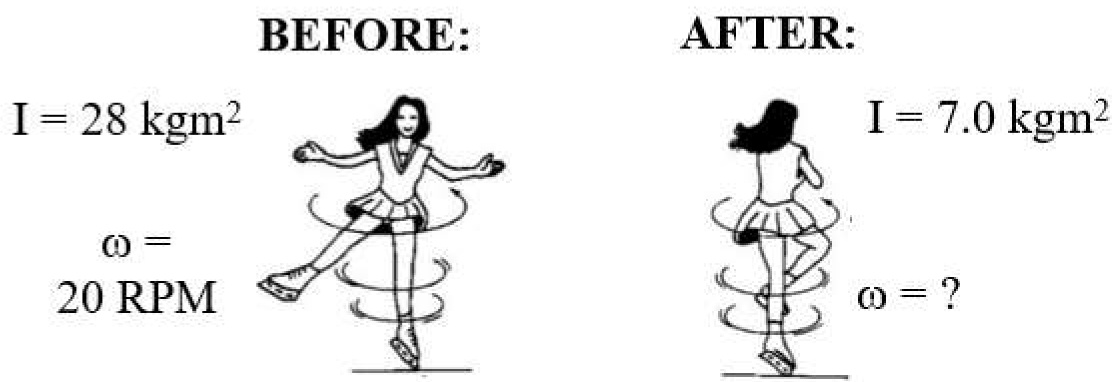
No external torque acts with inward pull, so angular momentum is conserved. Half radius means speed **doubles.**

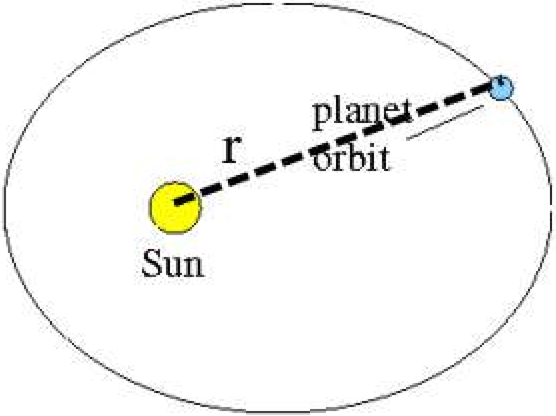
Conservation of Angular Momentum

- The **law of conservation of angular momentum** states:
  - If **no external net torque** acts on a rotating system, the **angular momentum of that system remains constant.**
- Analogous to the law of conservation of linear momentum:
  - If **no external force** acts on a system, the total **linear momentum** of that system remains constant.


BEFORE:
I = 20 kgm2
ω = 30 RPM
AFTER:
I = 10 kgm2
ω = ?

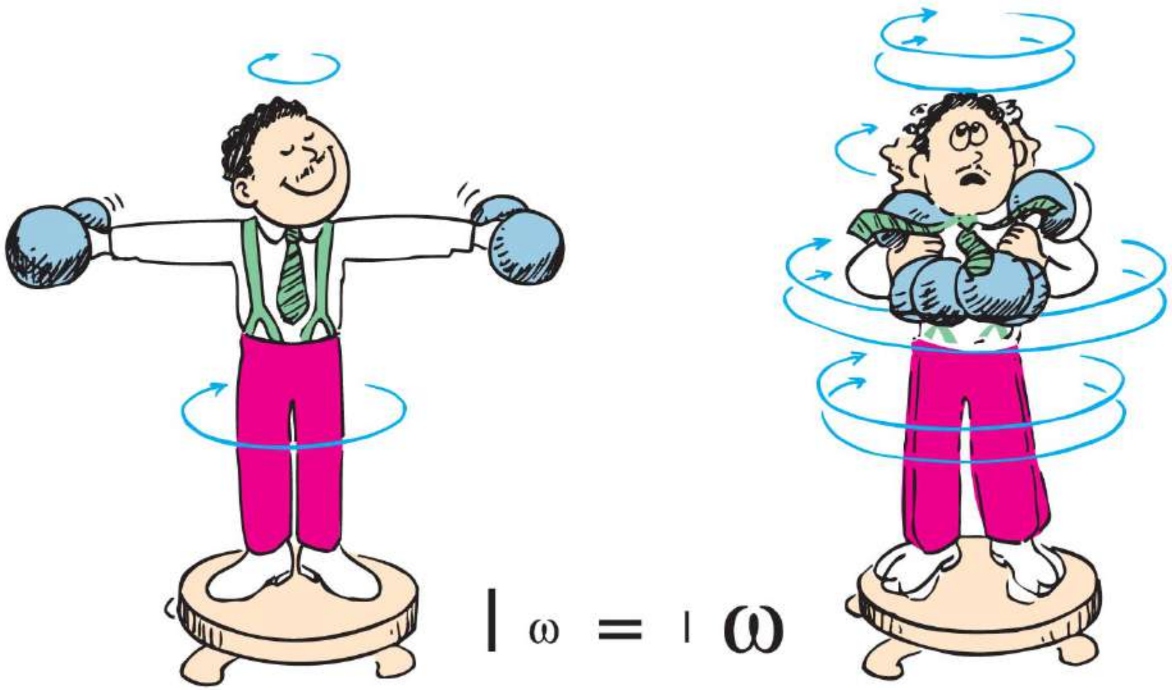

BEFORE
AFTER:
I = 30 kgm2
ω =
15 RPM
I = ?
ω =
45 RPM


BEFORE:
AFTER:
I = 28 kgm2
ω =
20 RPM
I = 7.0 kgm2
ω = ?


planet
r
orbit
Sun

Conservation of Angular Momentum, Continued

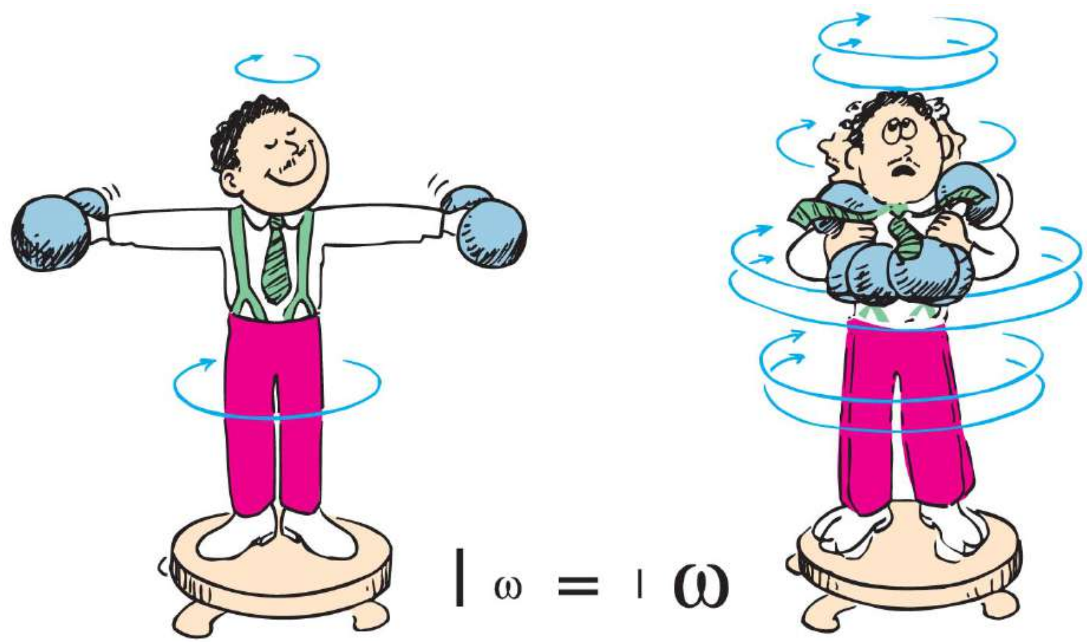
- Example:
  - When the man pulls the weights inward, his rotational speed increases!



Angular Momentum
CHECK YOUR NEIGHBOR, Continued

Suppose by pulling the weights inward, the rotational inertia of the man reduces to half its value. By what factor would his angular velocity change?

A. Double
B. Three times
C. Half
D. One-quarter



Angular Momentum
CHECK YOUR ANSWER, Continued

Suppose by pulling the weights inward, the rotational inertia of the man reduces to half its value. By what factor would his angular velocity change?

A. Double

Explanation:

Angular momentum = rotational inertia x angular velocity

Angular momentum is proportional to "rotational inertia."

If you *halve* the rotational inertia, to keep the angular momentum constant, the angular velocity would **double.**

Homework