

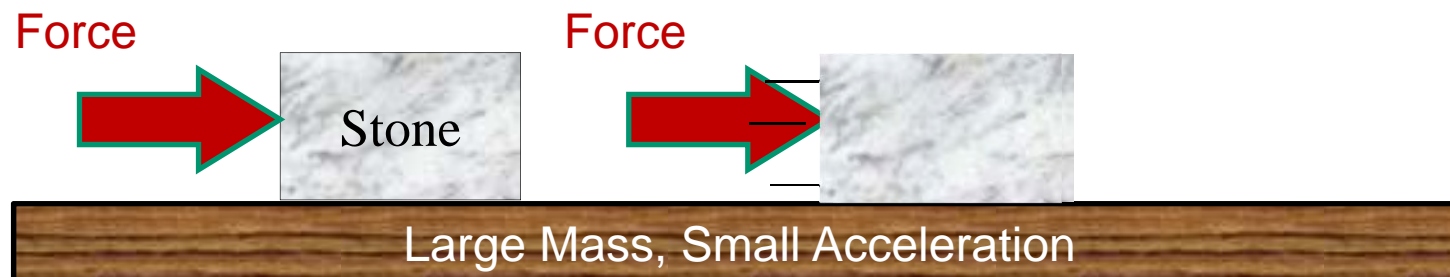
Rotational Inertia



National Science Foundation
WHERE DISCOVERIES BEGIN

Law of Acceleration & Forces

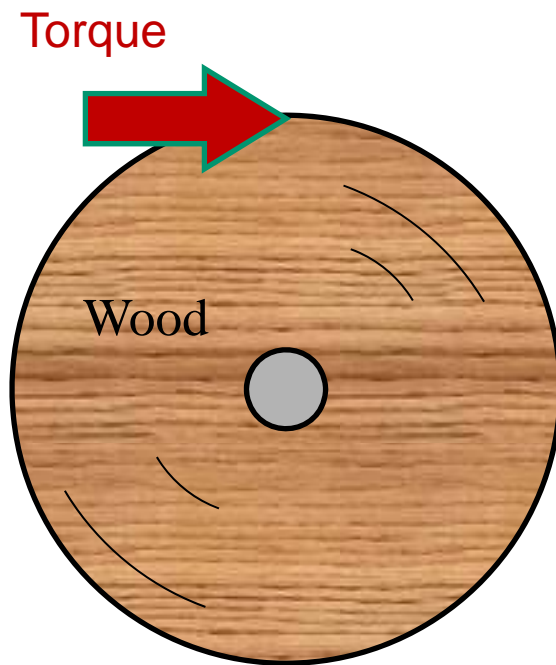
The greater the **mass** of an object, the less it accelerates when acted on by a **force**.



Large Weight \leftrightarrow Large Mass

Law of Acceleration & Torque

The greater the **rotational inertia** of an object, the less it accelerates when acted on by a **torque**.



Spins up quickly



Spins up slowly

Rotational Inertia

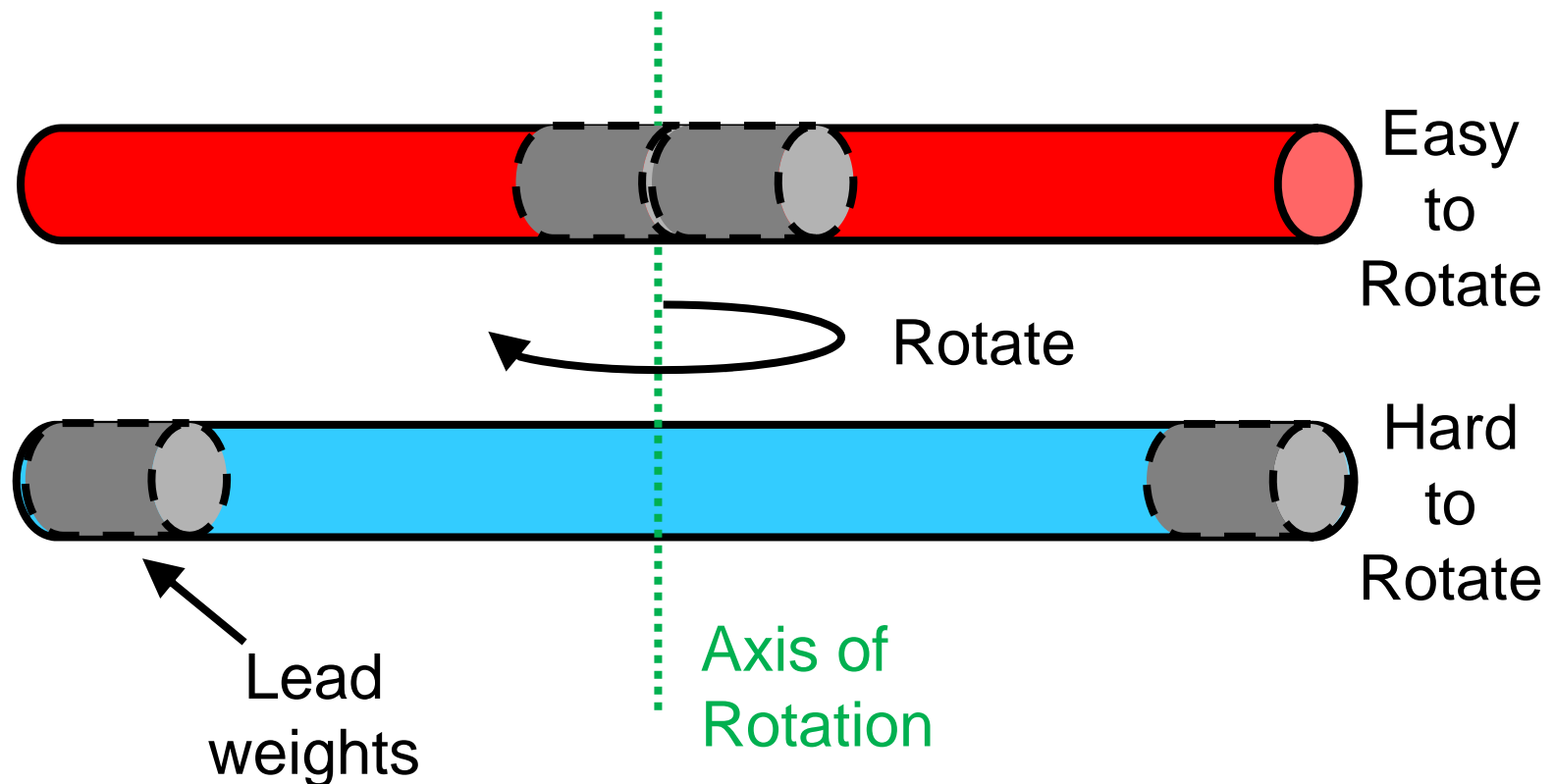
Rotational inertia depends on:

- Total mass of the object *and*
- How the mass is distributed

The farther the mass is from the axis of rotation, the larger the rotational inertia.

Inertia Sticks

Two metal pipes of the same mass but with different rotational inertia.



Inertia Sticks



Tightrope Walkers

Tightrope walkers carry a long pole to increase their rotational inertia, which slows their rotation when they're off balance.

Often have weights on the pole's ends.



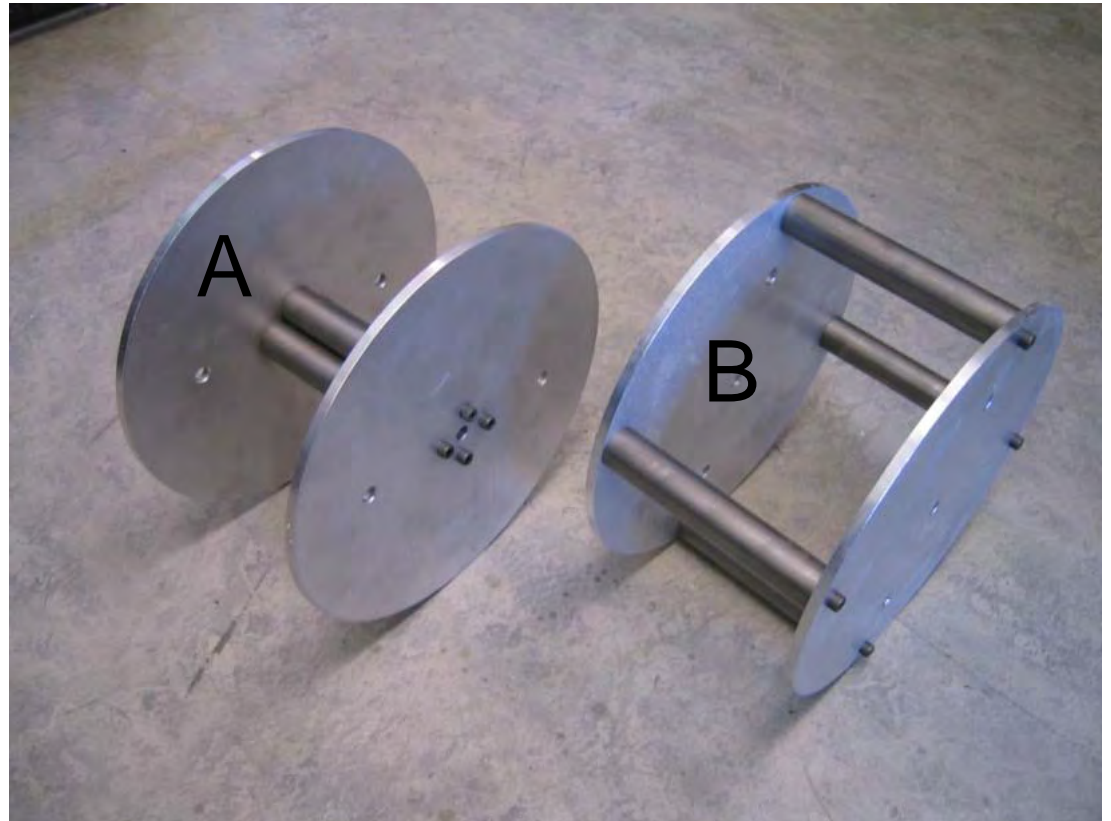
The Great Blondin Is First to Walk Across
Niagara Falls (June 30, 1859)

Rotational Inertia & Rolling

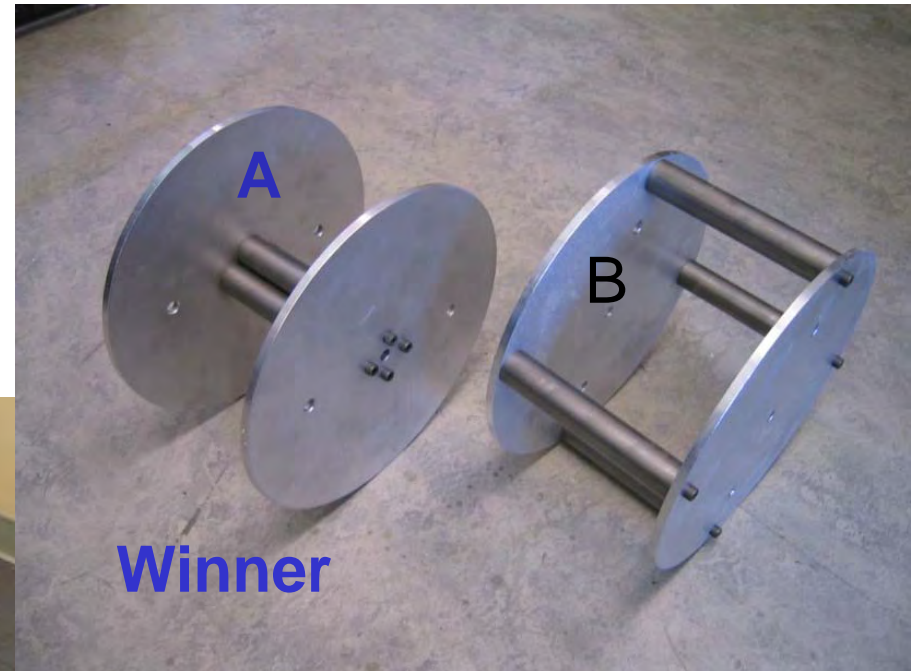
Two wheels are made from disks and rods that have the same mass but one has connecting rods near the center, the other has rods near the rim.

When rolled down a ramp, the wheel with the smaller rotational inertia wins the race.

So which wheel will win the race?



Rotational Inertia & Rolling



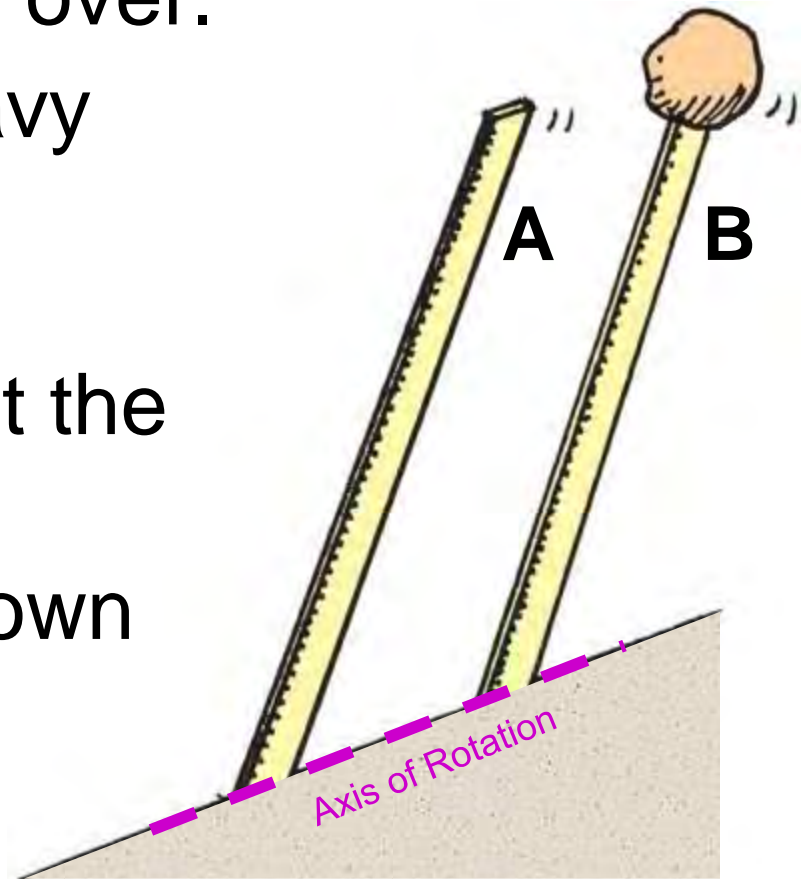
Rotational Inertia & Tipping

A pair of meter sticks tip over.

One stick has some heavy clay on the end.

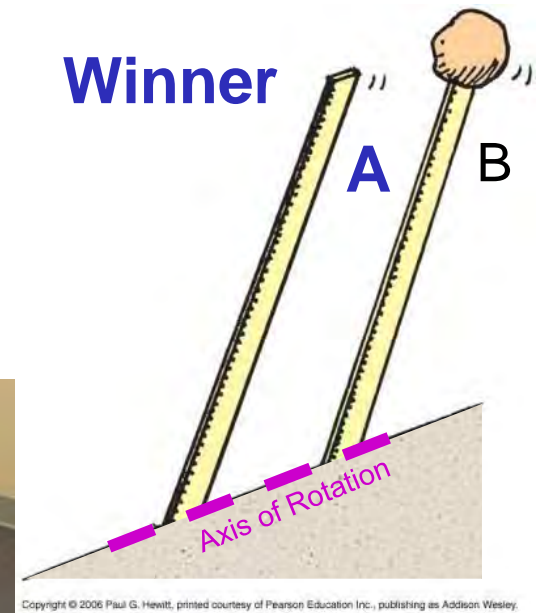
The stick with the lower rotational inertia will hit the ground first.

Which stick will swing down and hit the floor *first*?



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Rotational Inertia & Tipping



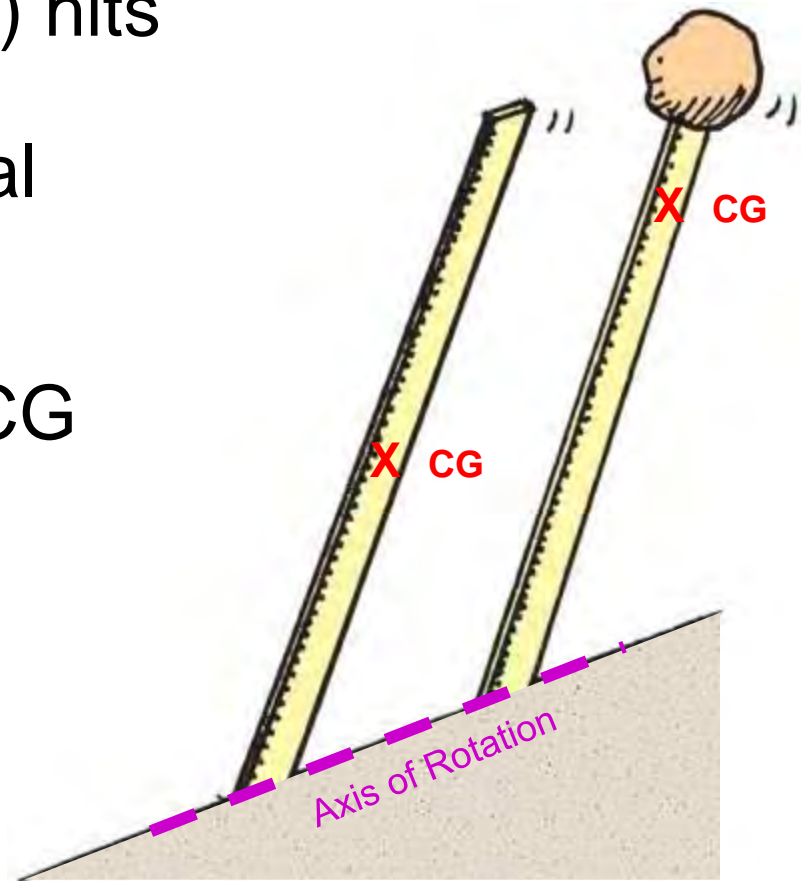
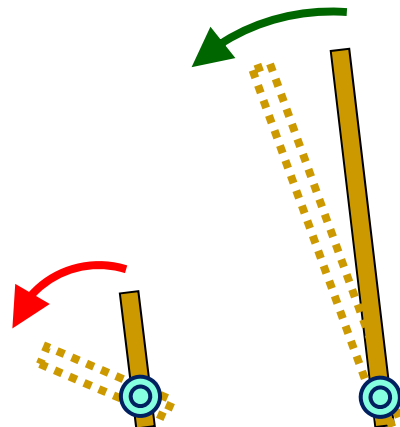
Rotational Inertia & Tipping

Stick A (No clay on the end) hits the ground first.

Stick B has higher rotational inertia so it rotates slowly.

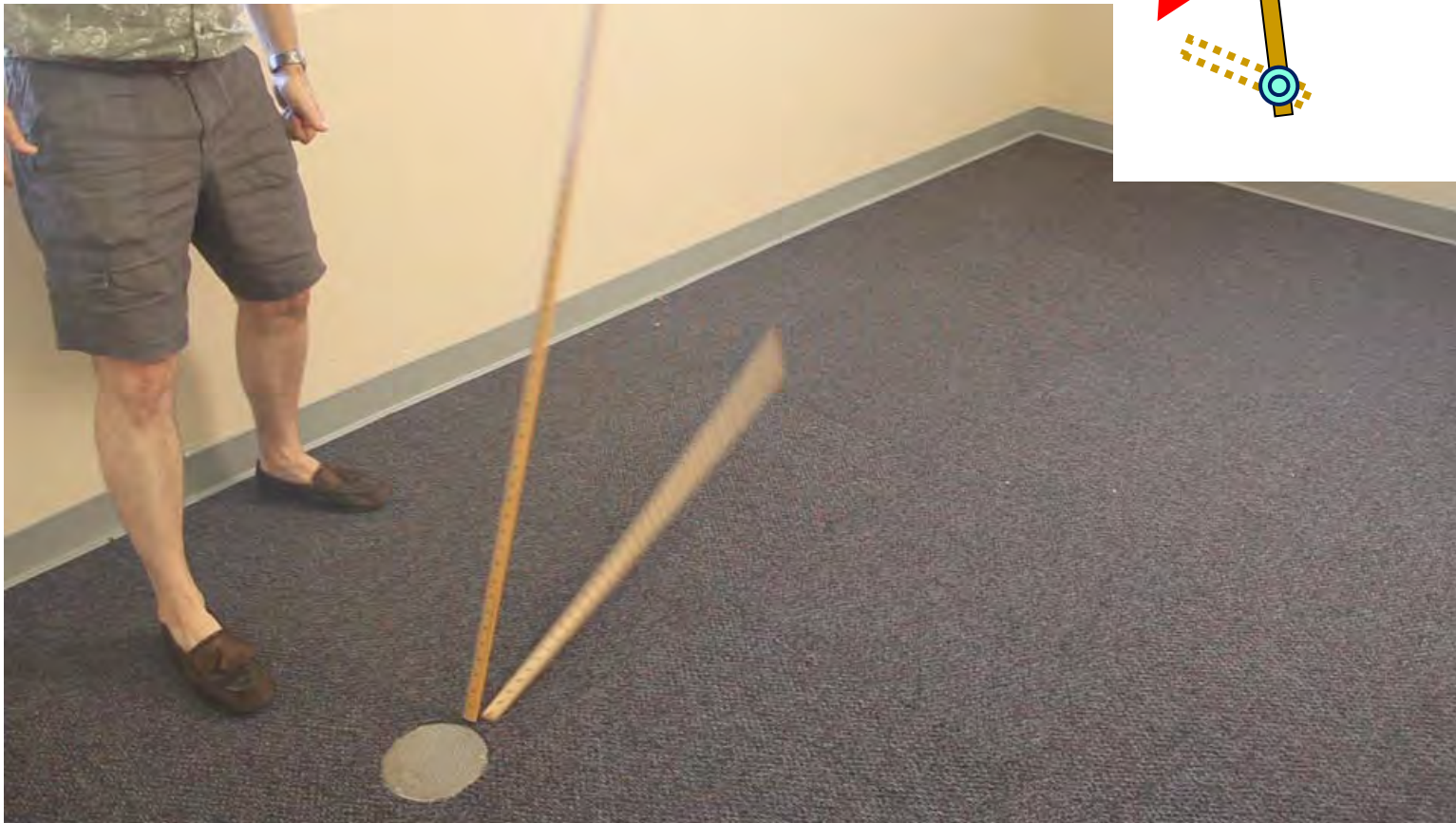
Can also think of it as the CG starting higher for Stick B.

Longer stick
tips over more
slowly

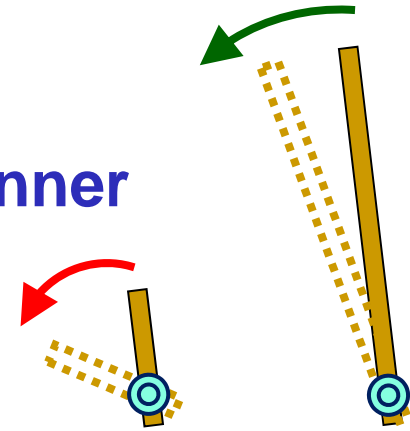


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Rotational Inertia & Tipping



Winner

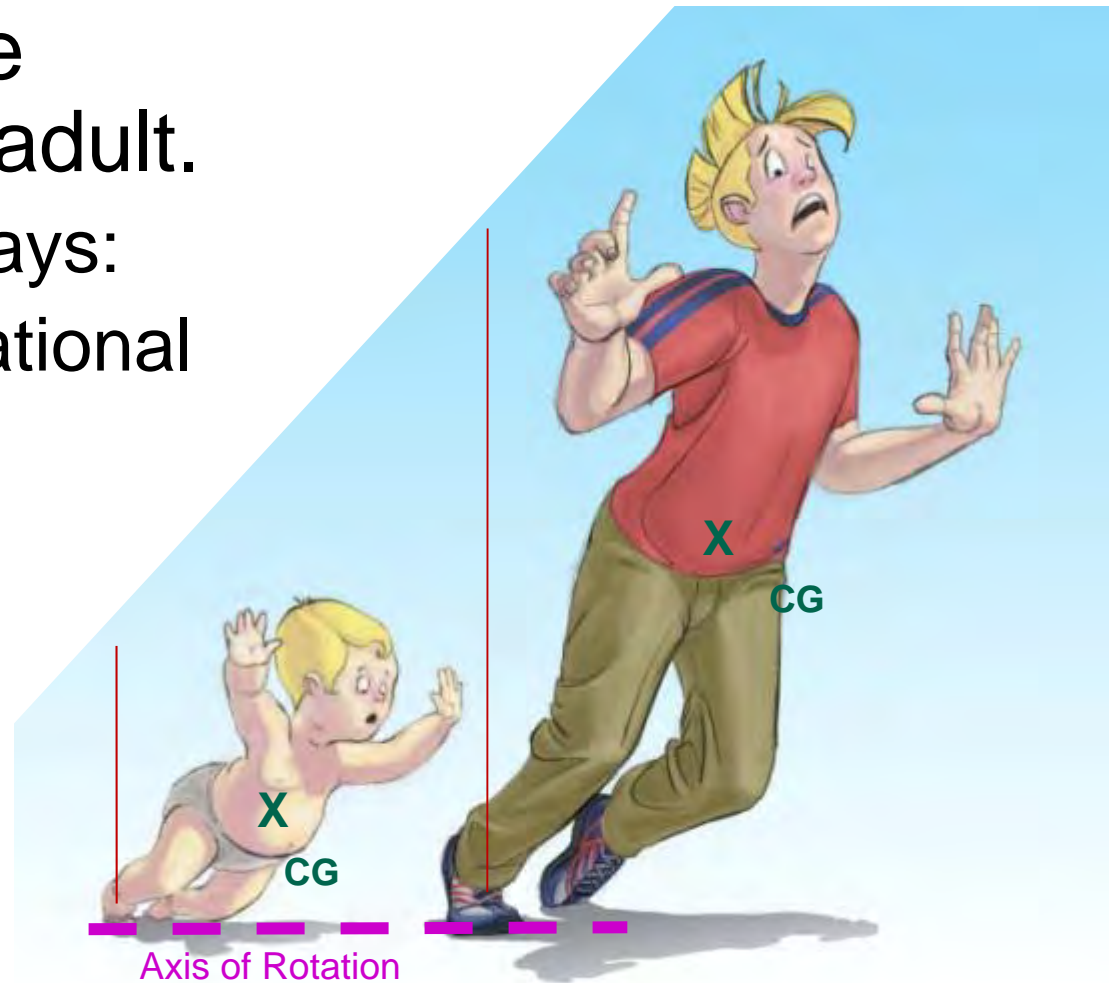


Tripping and Falling

If small child trips, he hits the ground more quickly than an adult.

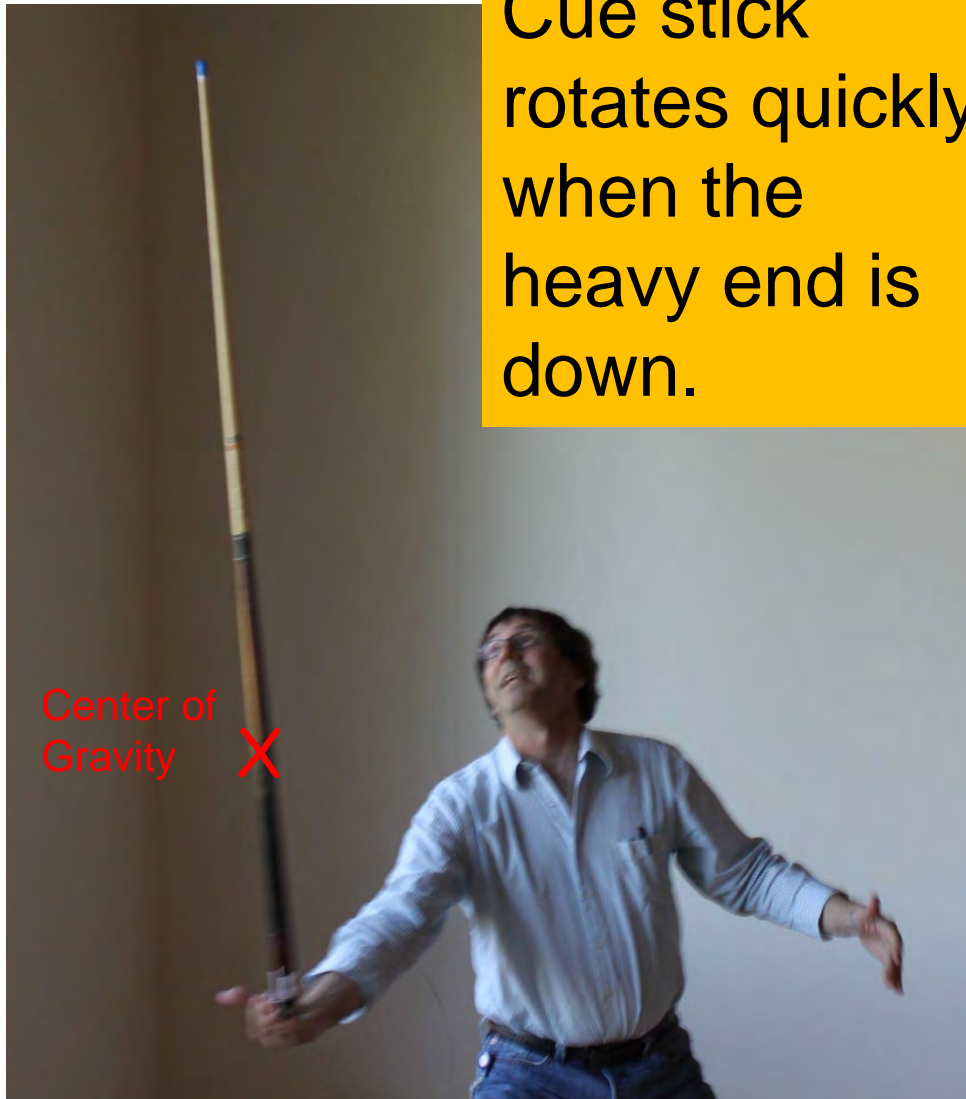
Can view this two ways:

- *Child has small rotational inertia.
- *Child's center of gravity is initially closer to the ground.

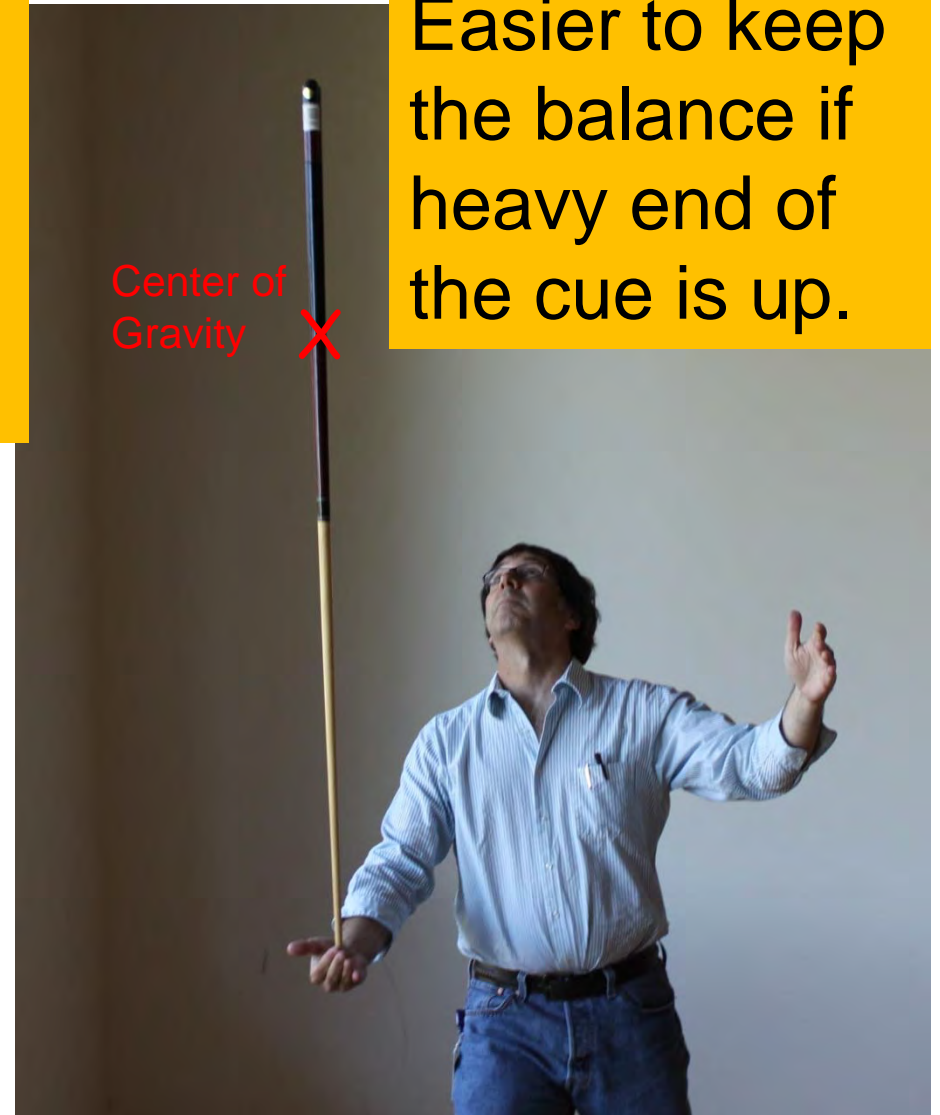


Balancing a Pool Cue

Cue stick rotates quickly when the heavy end is down.

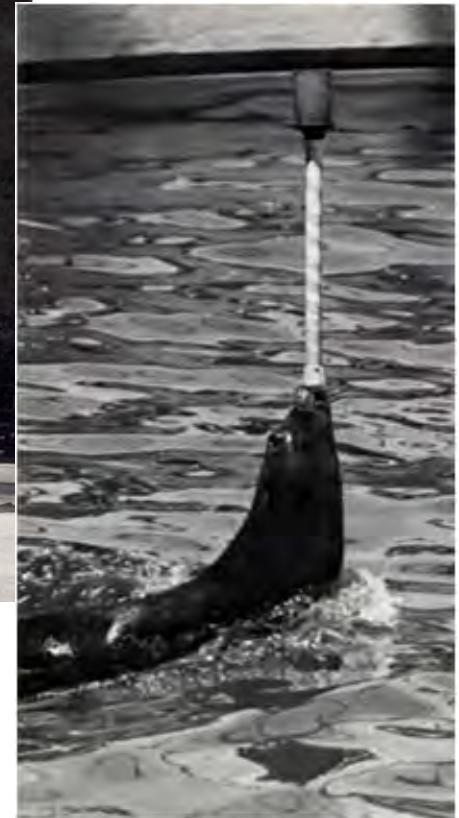


Easier to keep the balance if heavy end of the cue is up.



Circus Balancing Acts

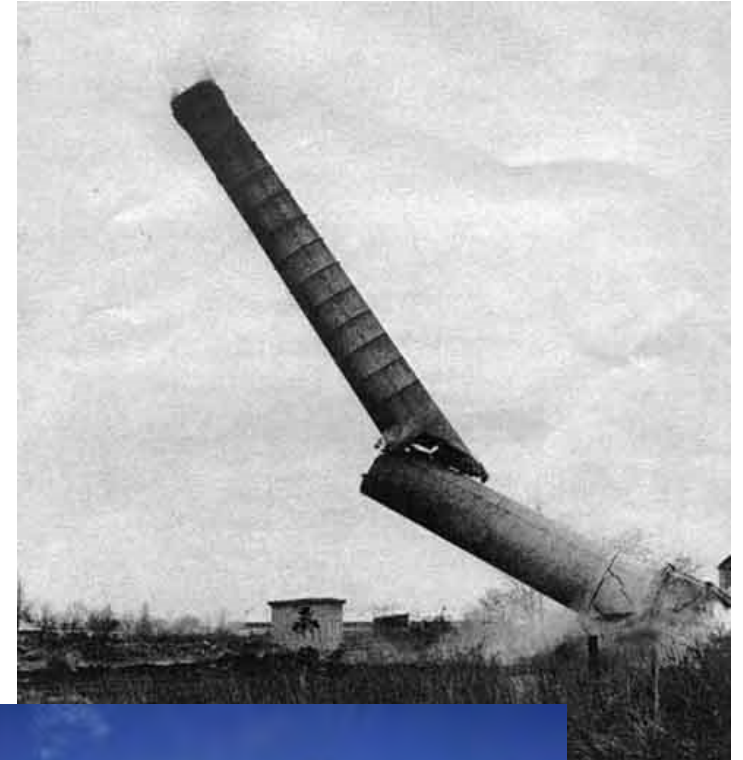
When the weight is high off the ground the larger inertia slows the tipping rotation.



Tipping & Breaking

When a tall structure, like a smokestack or chimney, tips over the lower part attempts to rotate faster than the upper part.

The resulting stress may cause it to break, typically near the center.



Summary

- The greater the rotational inertia of an object, less it accelerates when acted on by a torque.
- Rotational inertia depends on:
 - Total mass of the object *and*
 - How the mass is distributed
- The farther the mass is from the axis of rotation, the larger the rotational inertia.
- If an object or character is top-heavy or tall then it tips over slowly due to its large rotational inertia.