Physics 101: Lecture 16
Rolling Objects and Angular Momentum

No checkpoints today.

Review session for Exam 2
Monday 3/25 6:00 PM
in Loomis 151 (here)
Print out/bring Exam 2, Fall 2005

Linear and Angular relations

	Linear	Angular
Displacement	x	θ
Velocity	v	ω
Acceleration	a	α
Inertia	m	I
KE	$\frac{1}{2} m v^2$	$\frac{1}{2} I \omega^2$
N2L	$F=ma$	$\tau = I\alpha$
Momentum	$p = mv$	$L = I\omega$

$x = R\theta$

$v = \omega R$

$a_t = \alpha R$

Today

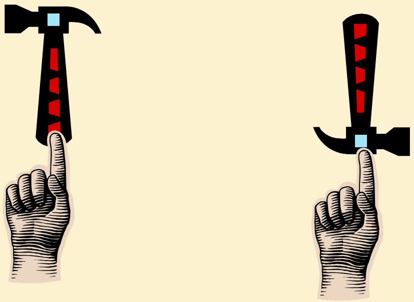
The Hammer!

You want to balance a hammer on the tip of your finger, which way is easier (the dot is the center of mass of the hammer)

A) Head up

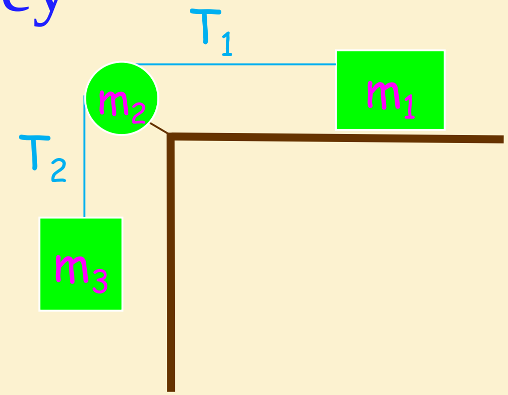
B) Head down

C) Same



Clicker Q: Tension and Pulleys With Mass

Hint: Consider the consequences for the pulley

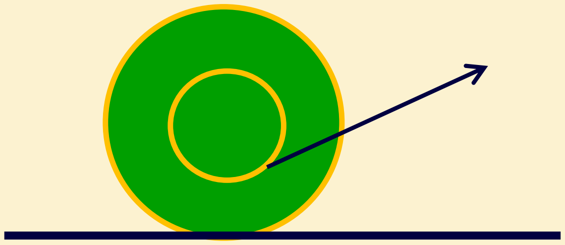


Compare the tensions T_1 and T_2 as block 3 falls

A) $T_1 < T_2$ B) $T_1 = T_2$ C) $T_1 > T_2$

Clicker question

A large spool with two outer disks and an inner solid cylinder has string wound around it. You now pull on the string as shown. In which direction does the spool move?



a. To the right

b. To the left

c. The spool does not move

Define Angular Momentum

Momentum

$p = mV$

$F_{net,external} = \Delta p/\Delta t$

conserved if $F_{Net,ext}\Delta t = 0$

Vector!

units: kg-m/s

Angular Momentum

$L = I\omega$

$\tau_{Net,external} = \Delta L/\Delta t$

conserved if $\tau_{Net,ext}\Delta t=0$

Vector!

units: $kg\text{-}m^2/s$

Right Hand Rule

- Since angular momentum is a vector we need a way to decide on its direction. We use the “right hand rule” for that.
- Wrap fingers of **right hand** around direction of rotation, thumb gives direction of angular momentum.
- What is direction of angular momentum for wheel

  A) Up B) Down C) Left D) Right

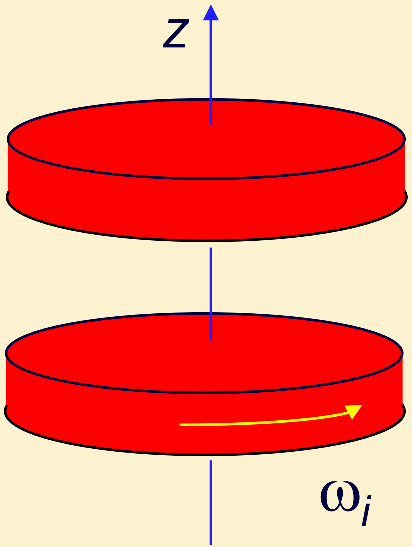
Clicker Q: Two Disks

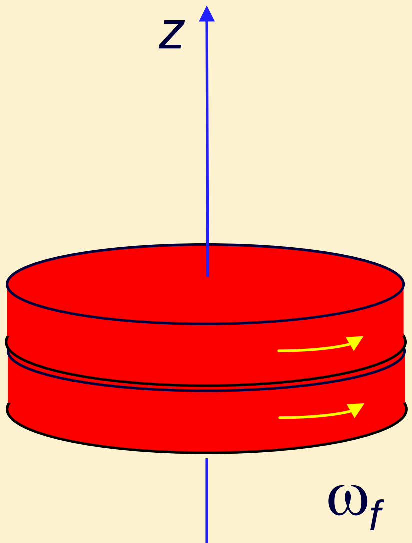
Wheel rim

Drop demo

- A disk ($I_{disk} = \frac{1}{2} MR^2$) of mass M and radius R rotates around the z axis with angular velocity ω_i. A second identical disk, initially not rotating, is dropped on top of the first. There is friction between the disks, and eventually they rotate together with angular velocity ω_f.

A) $\omega_f = \omega_i$ B) $\omega_f = \frac{1}{2}\,\omega_i$ C) $\omega_f = \frac{1}{4}\,\omega_i$

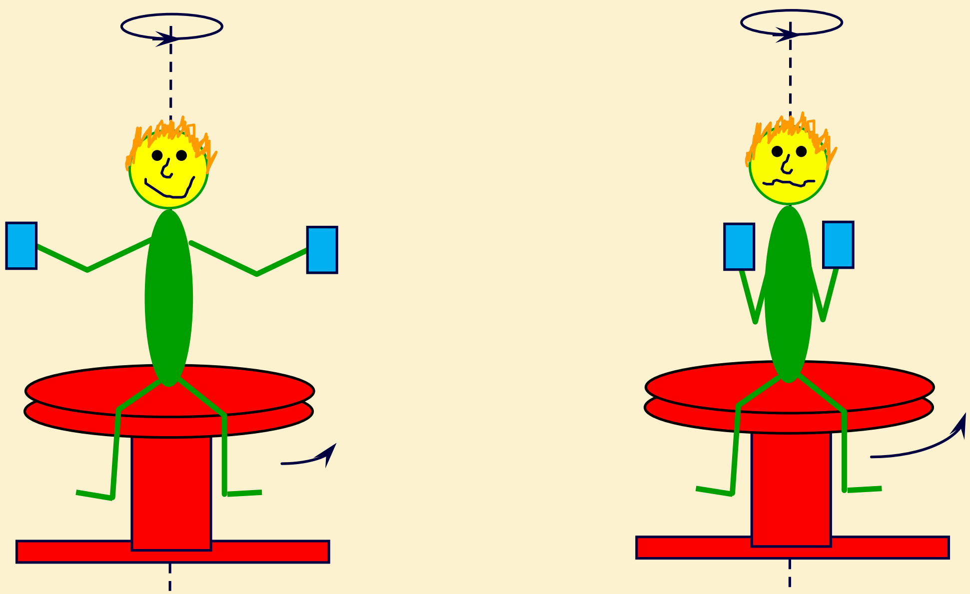




Clicker Qs

You are sitting on a freely rotating bar-stool with your arms stretched out and a heavy glass mug in each hand. Your friend gives you a twist and you start rotating around a vertical axis though the center of the stool. You can assume the bearing that the stool turns on is frictionless, and that there is no net external torque present once you have started spinning.

You now pull your arms and hands (and mugs) close to your body.

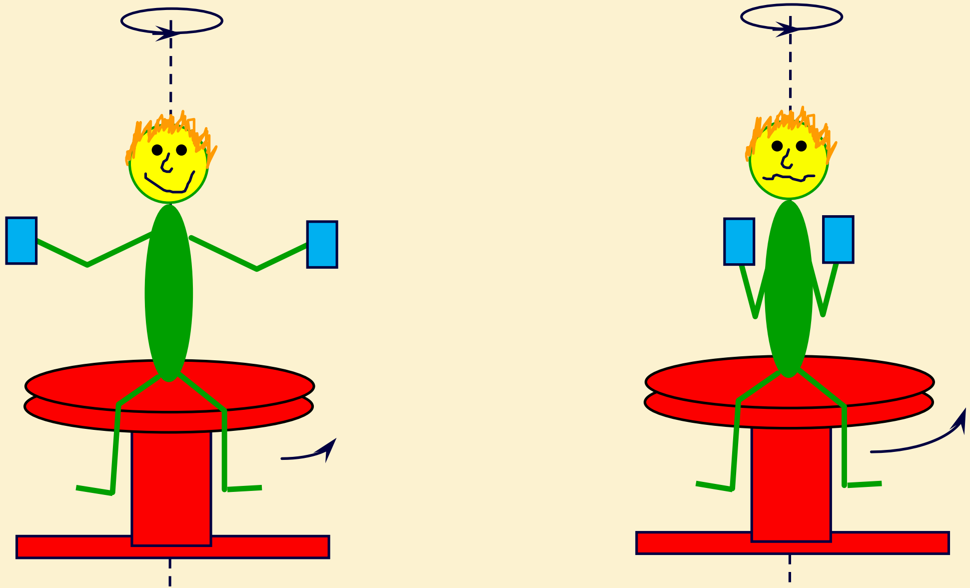


Preliminary Question!

Hint: Think before you answer!

- There are No External forces acting on the "student+stool" system.

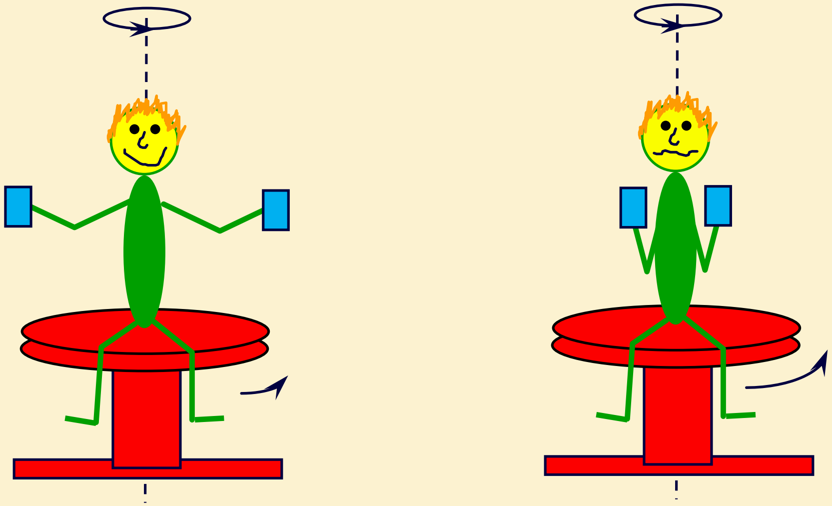
A) True B) False



Clicker Q1

What happens to the angular momentum as you pull in your arms?

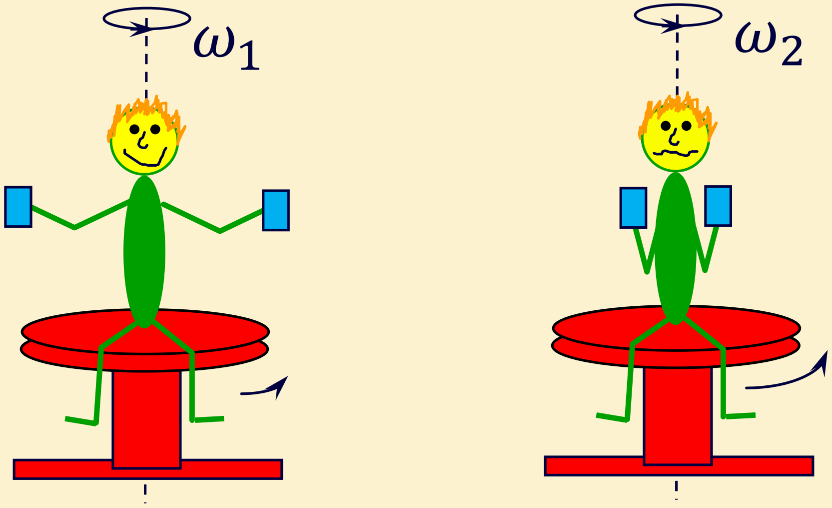
1. it increases
2. it decreases
3. it stays the same



Clicker Q2

What happens to your angular velocity as you pull in your arms?

1. it increases
2. it decreases
3. it stays the same

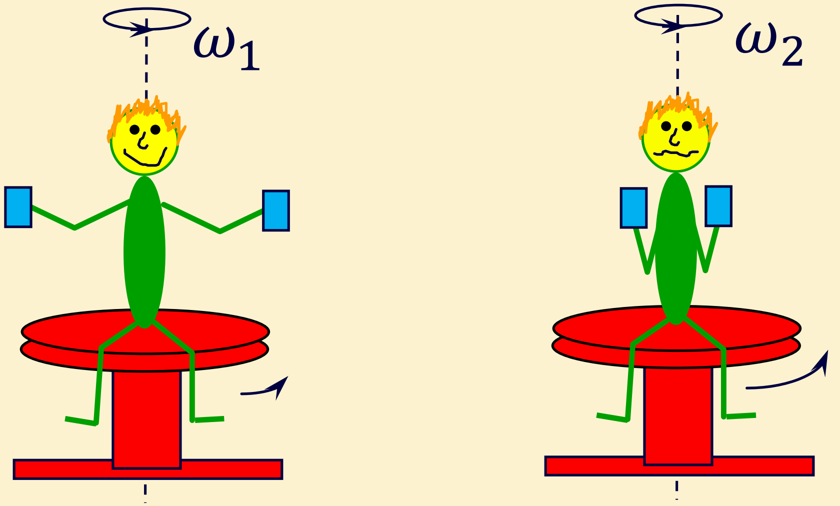


Clicker Q3

What happens to your kinetic energy as you pull in your arms?

1. it increases
2. it decreases
3. it stays the same

Hint: $K = \frac{1}{2} I\omega^2 = L^2/2I$



What about Energy Conservation?

A) Total Energy isn't conserved here

B) Extra energy comes from weights

C) Gravitational energy is being converted to rotational kinetic energy

D) Energy comes from you. You do work pulling in the mugs, and work=ΔK

E) I have no clue….

One more Clicker Q on this

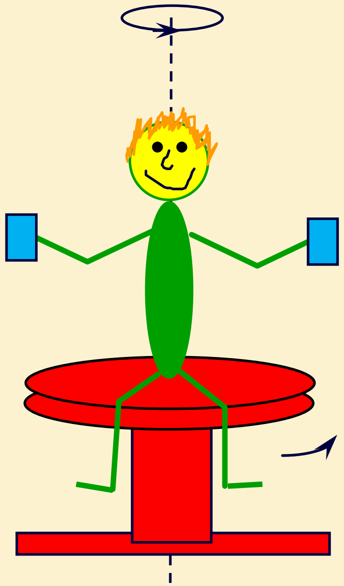
You are sitting on a freely rotating bar-stool with your arms stretched out and a heavy glass mug in each hand. Your friend gives you a twist and you start rotating around a vertical axis though the center of the stool. You can assume the bearing that the stool turns on is frictionless, and that there is no net external torque present once you have started spinning.

Now you drop the dumbbells while rotating counter-clockwise. What happens?

A. You spin faster

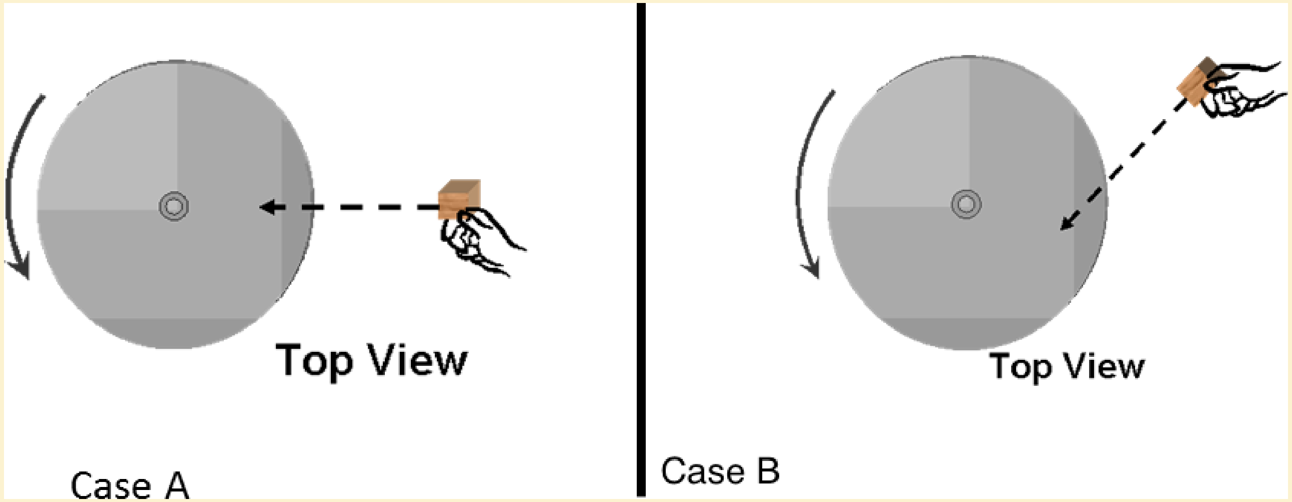
B. You spin slower

C. You spin at the same rate.



Checkpoint 3 / Lecture 15

The angular momentum of a freely rotating disk around its center is L_{disk}. You toss a heavy block horizontally onto the disk at two different orientations, but with the same speed, as shown in the figure. Friction acts between the disk and the block so that eventually the block is at rest on the disk and rotates with it. In which case is the magnitude of the final angular momentum of the disk-block system the greatest?

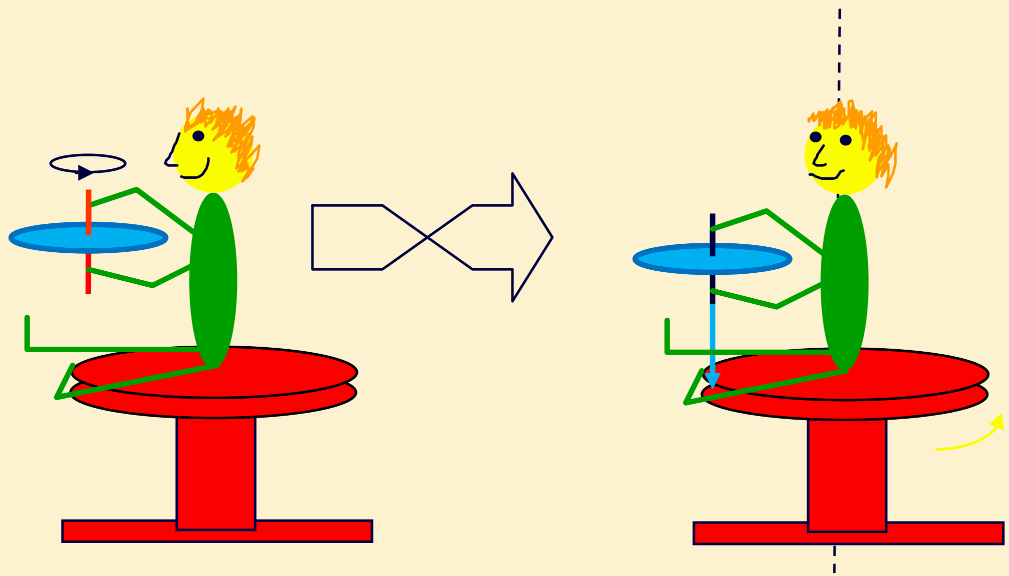


A) Case A B) Case B C) Neither

Turning the bike wheel

She is stationary sitting on the rotating platform holding a bike wheel that is spinning counter clockwise. What happens if she turns the bike wheel upside down from how it started.

A. She starts to spin CCW.
B. She starts to spin CW.
C. Nothing



Summary

- Angular momentum defined: $L = I\,\omega$
  - ➔ Right Hand Rule gives direction
  - ➔ If $\tau_{Net,external} = 0$, L is conserved