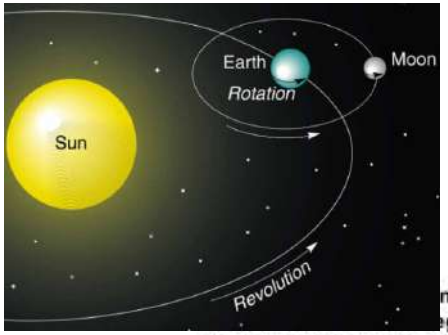
Review:



1. Does Earth rotate or revolve?

It does both: 1 rotation = ???

1 revolution = ???

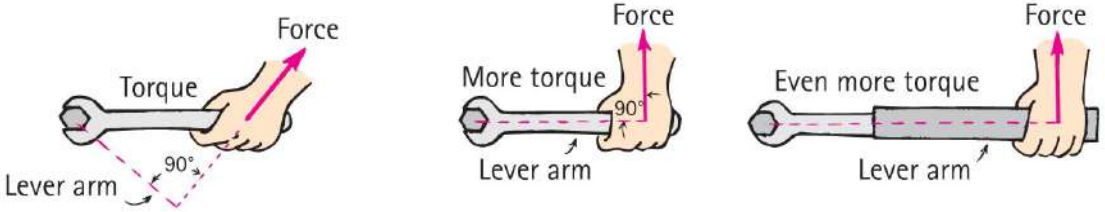
2. Why do you bend your legs to run?

To bring your leg mass closer to your hips.

This decreases the rotational inertia of your legs.

3. How is torque different from force?

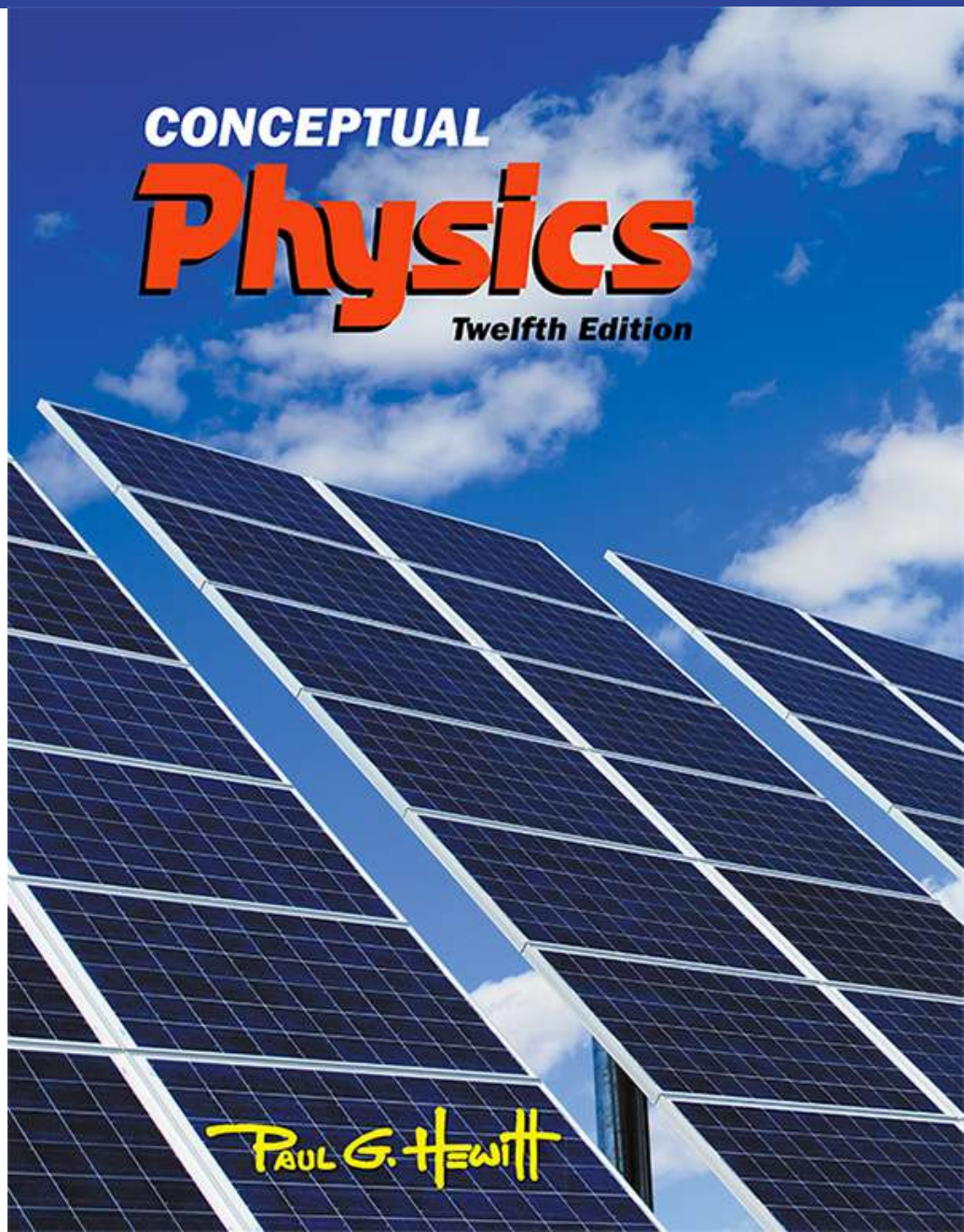
Torque depends on how far the force is from the axis of rotation and what angle it is applied at.



Chapter 8: Rotational Motion

Section 8.4

Center of Mass and Center of Gravity



What will you learn today:

Where to balance a broom or boomerang.

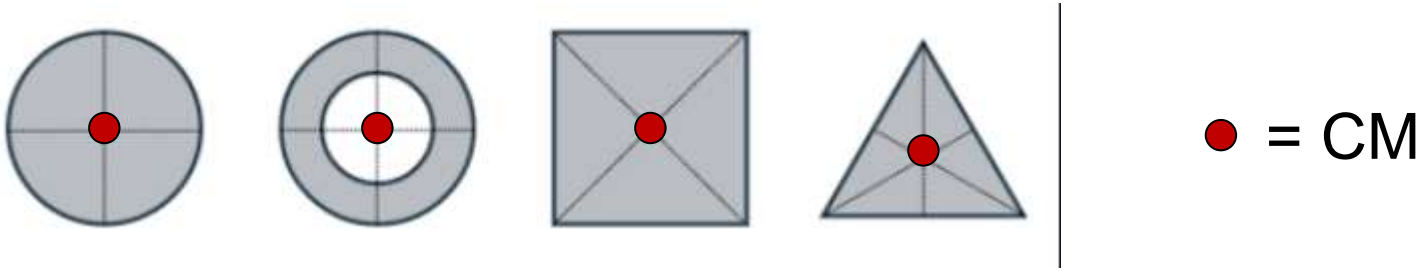
Why cars may or may not fall over.

Why balls spiral and spin.

Why the solar system wobbles.

Center of Mass

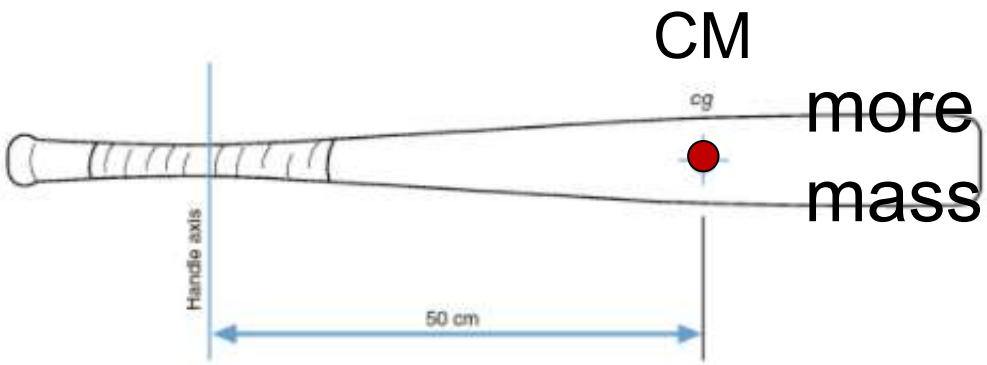
- **Center of mass** is the average position of all the mass that makes up the object.
- For symmetric objects, the CM is in the "center"



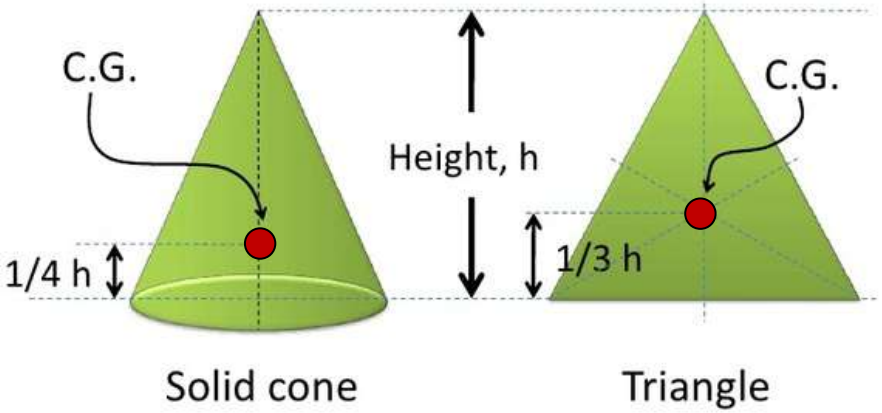
- Where is the CM of a donut? in the hole
- Of a basketball? in the center
- Must there be mass at the center of mass? no

Center of Mass

- ”For asymmetric objects, the CM is closer to the end that has more mass:



Why is the CM (CG) in different places here?→

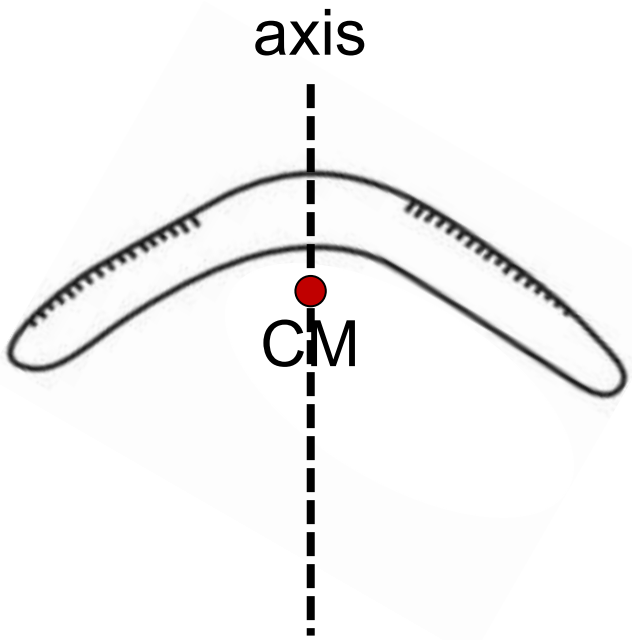


solid cone has more mass at bottom

Ex: Boomerang: Somewhat symmetric

A boomerang is symmetric about this axis:

same mass on each side



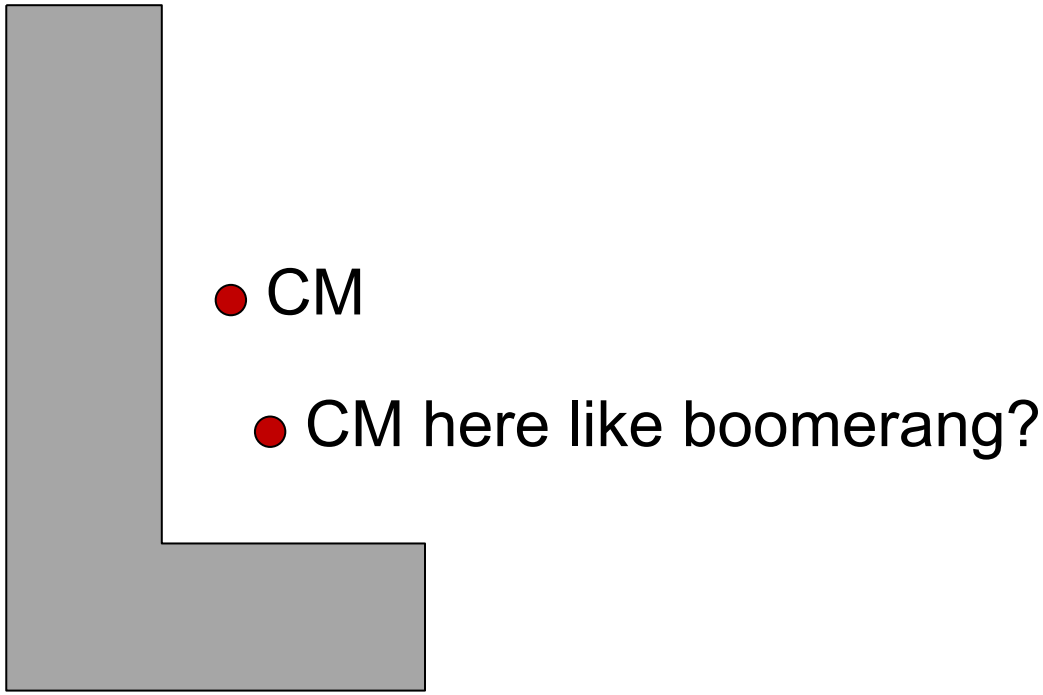
same mass on each side

Its CM must be on the axis, but where?

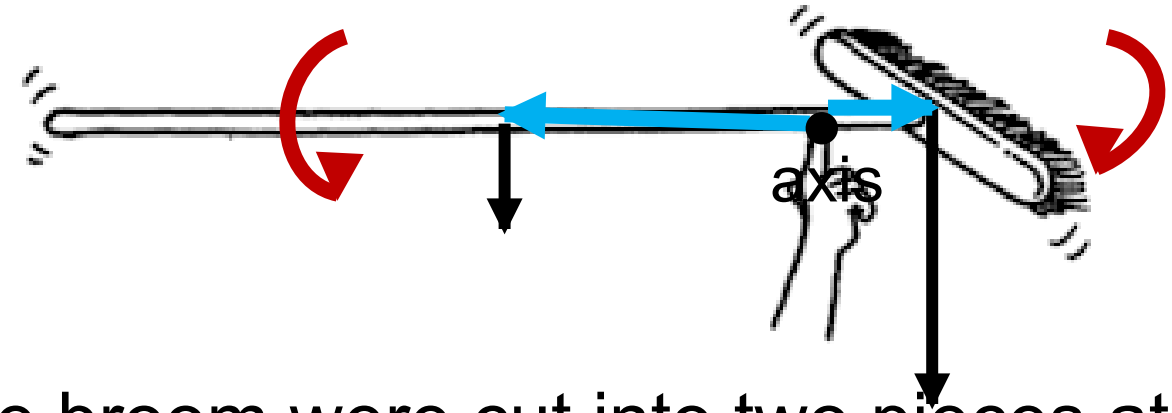
Ex: CM of an "L" shape

- Similar to boomerang, but no symmetry.
- The CM is shifted up towards longer side:

more mass
on this side



The Center of Mass is the balance point:



If the broom were cut into two pieces at the CM, which piece would weigh more?

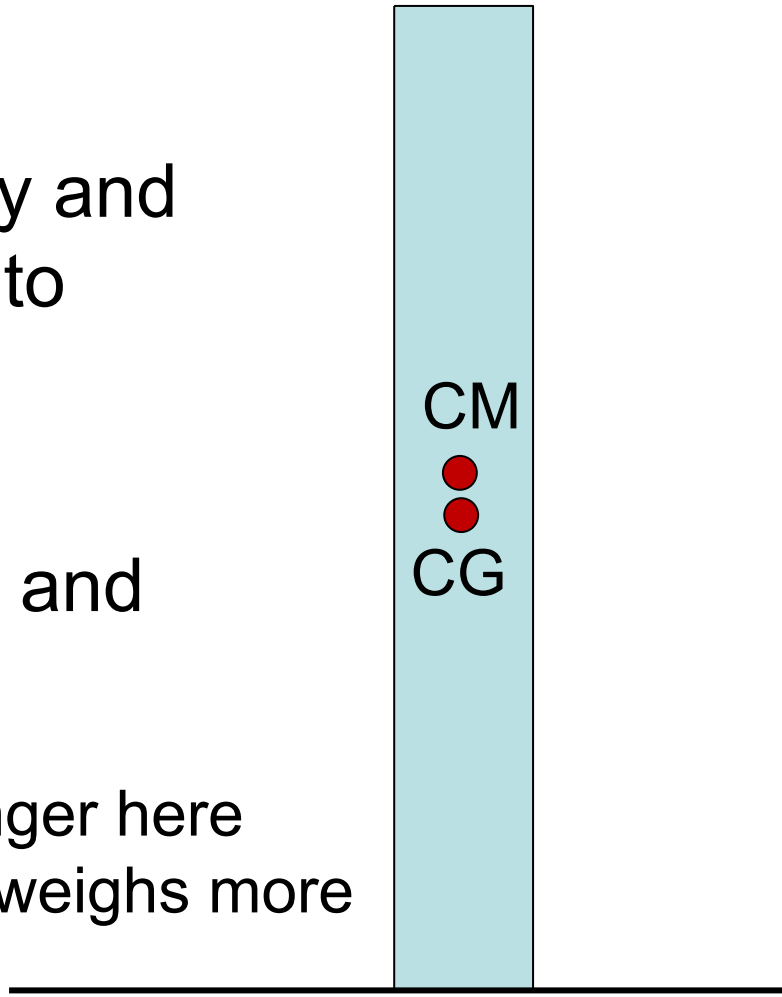
CCW torque = CW torque

lever arm x F = lever arm x F

long x (little weight) = short x (heavy weight)

The right side

- **Center of gravity (CG)** is the average position of weight distribution.
  - Since weight and mass are proportional, center of gravity and center of mass *usually* refer to the same point of an object.
  - But for tall buildings, the CM and CG are not the same.



Motion of the center of mass

If no net force acts on an object, its CM moves in a straight line.

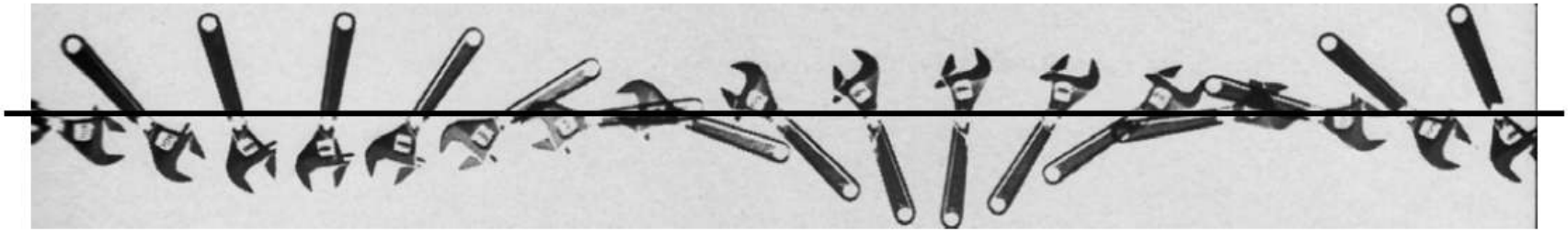
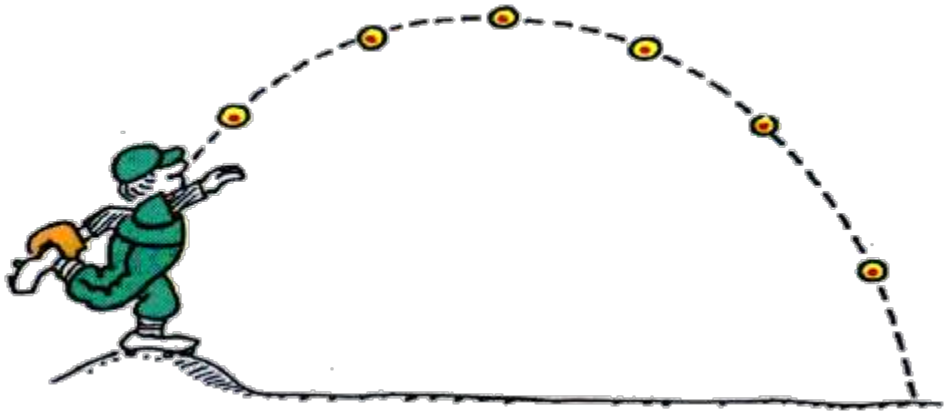
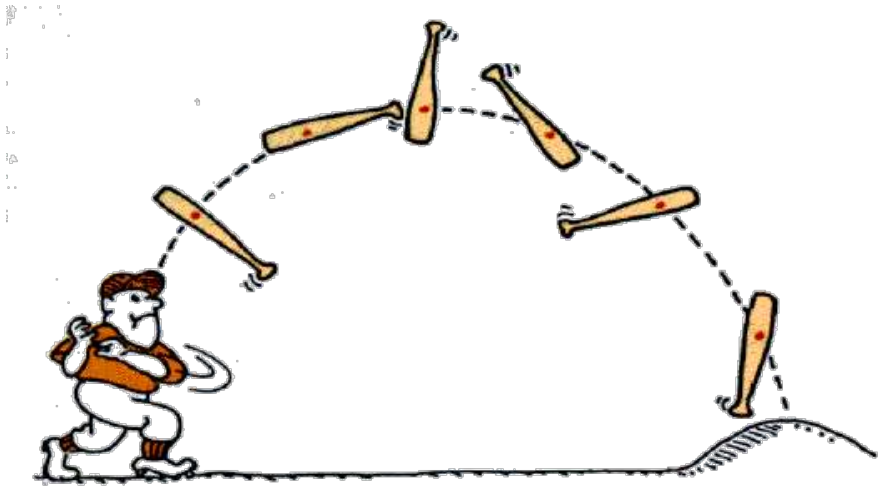


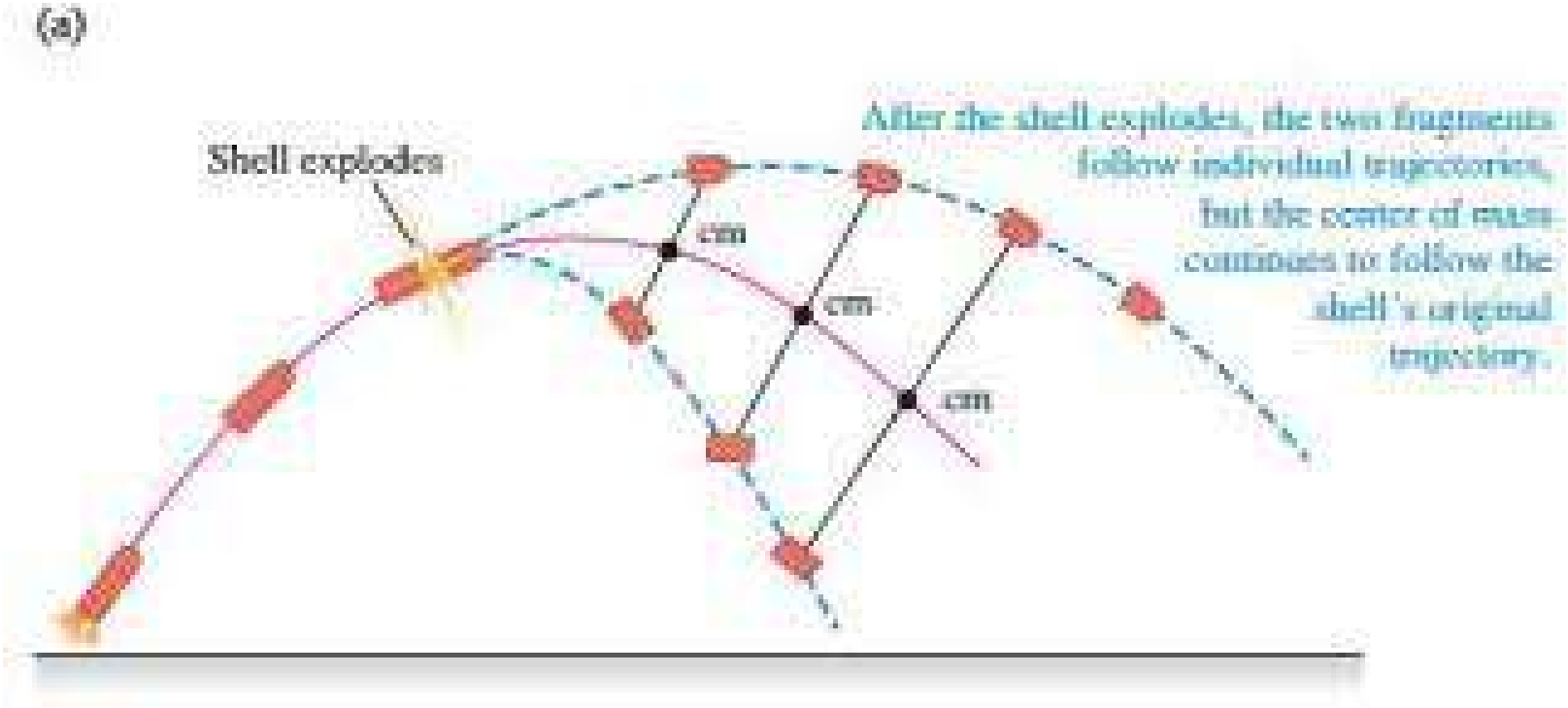
Figure 3

If a net force does act on an object, its CM moves as if all the mass were concentrated at that point.





This even works for exploding shells:

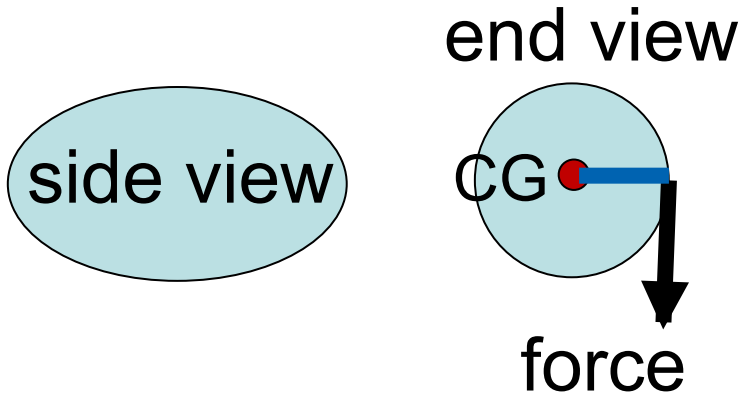


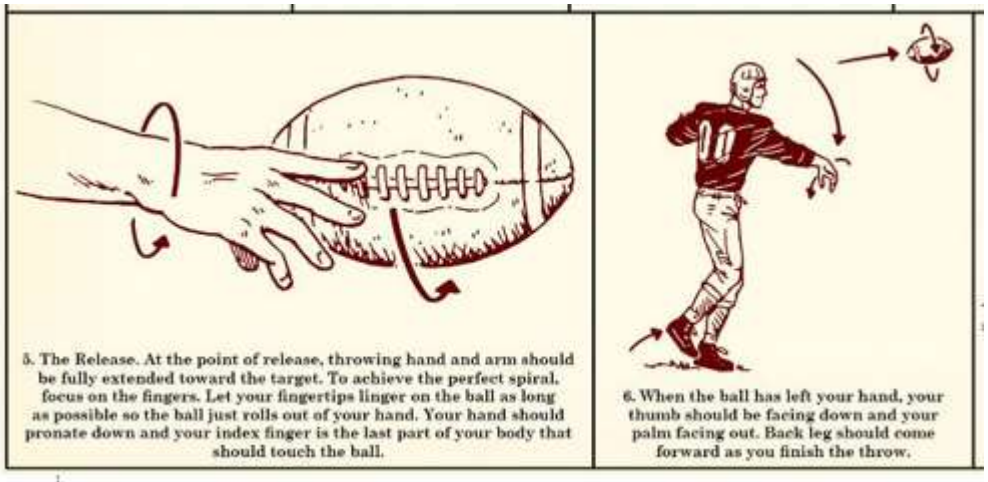
If allowed to spin freely, objects spin around their center of mass:

Football spiral:

First you torque it to get it to spin.

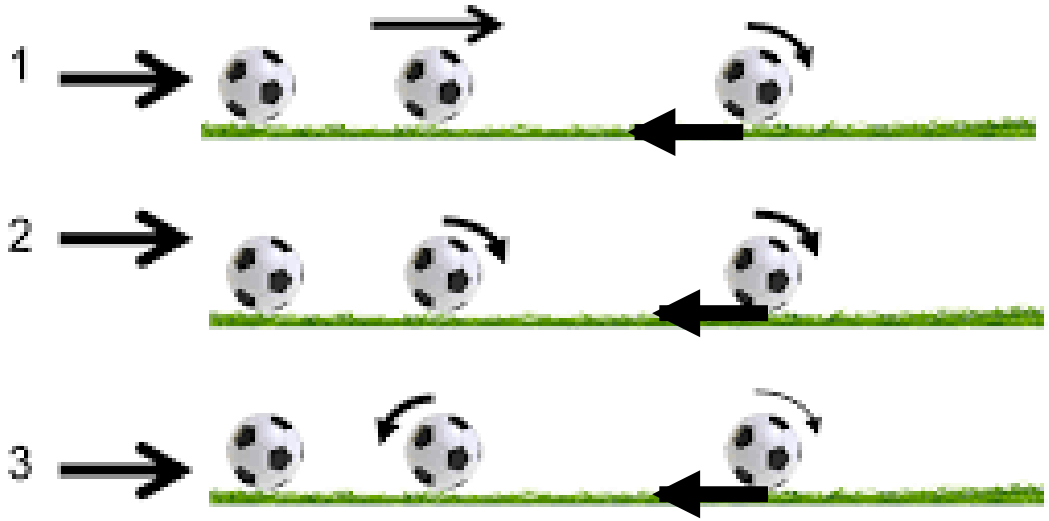
Then it spins about an axis through its CM





Putting spin on golf, soccer, volleyballs, etc

How does where you kick effect the movement of the ball?



Why does it end up spinning CW after a few bumps?

The ground torques it in that direction

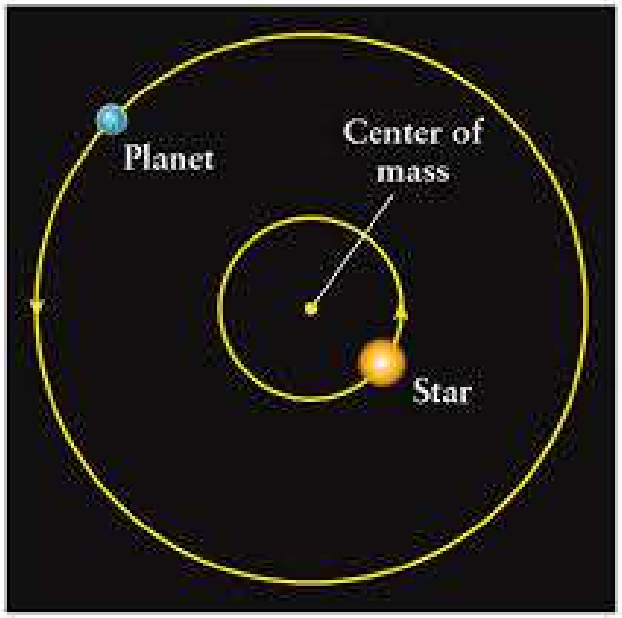
Which way does it spin, if you kick it

A) in the CG? it doesn't

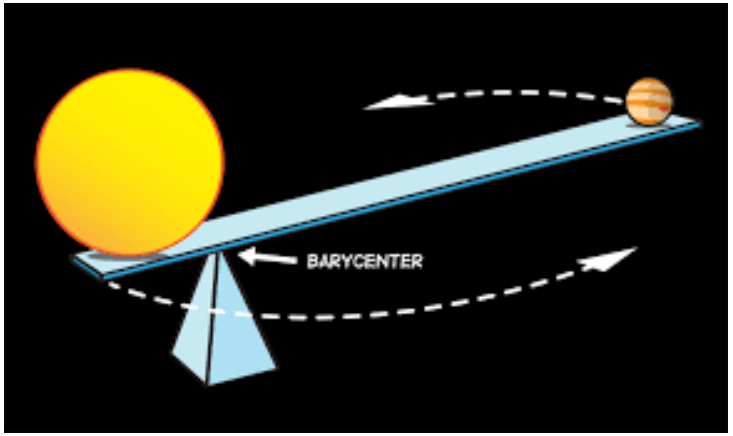
B) above the CG? CW

C) below the CG? CCW

Planets revolve about the CM between them and the star they orbit:



a

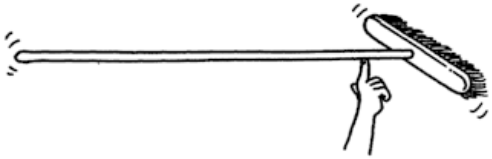


- Why is the barycenter (center of mass) closer to the star?

The star has more mass

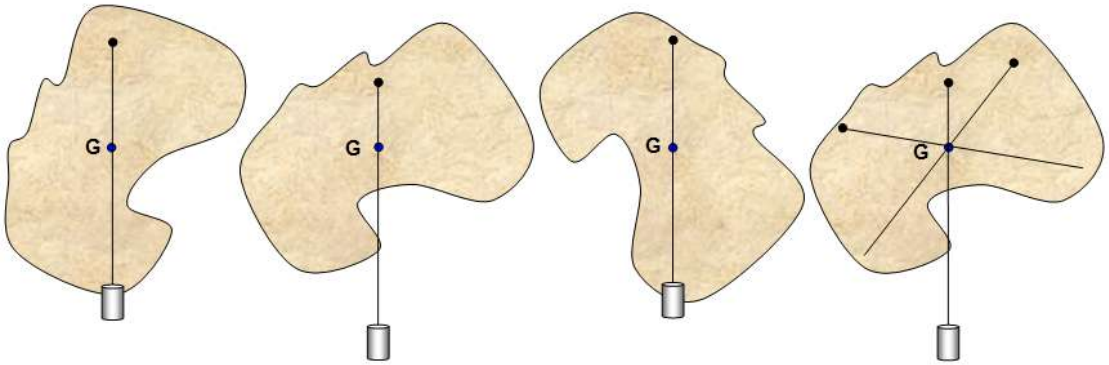
How to find the Center of Mass (Gravity)

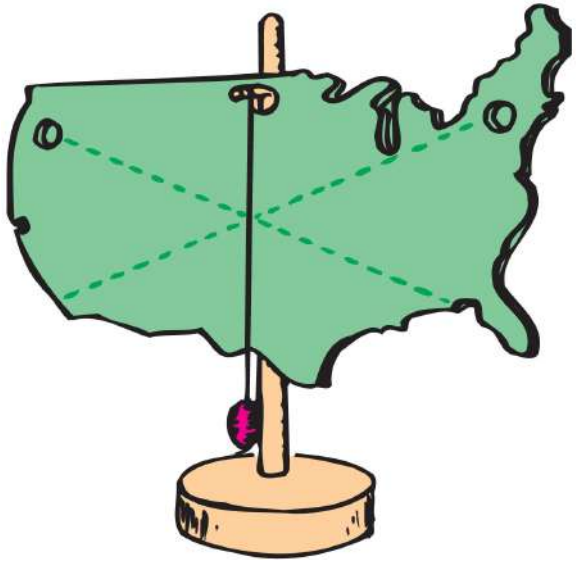
1) Balance the object – easiest way:



2) Another way:
   - suspend the object from a point and draw a vertical line from suspension point.
   - repeat after suspending from another point or two.

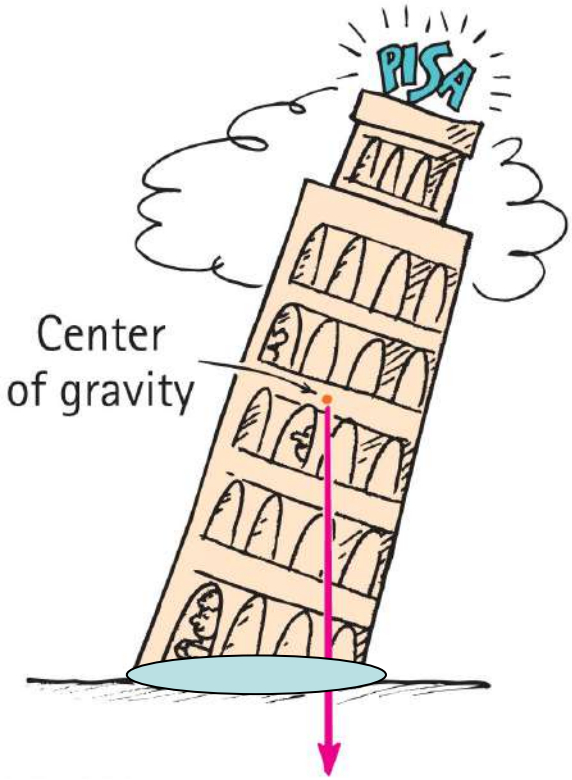
- The center of gravity lies where the two lines intersect.





Center of Gravity—Stability

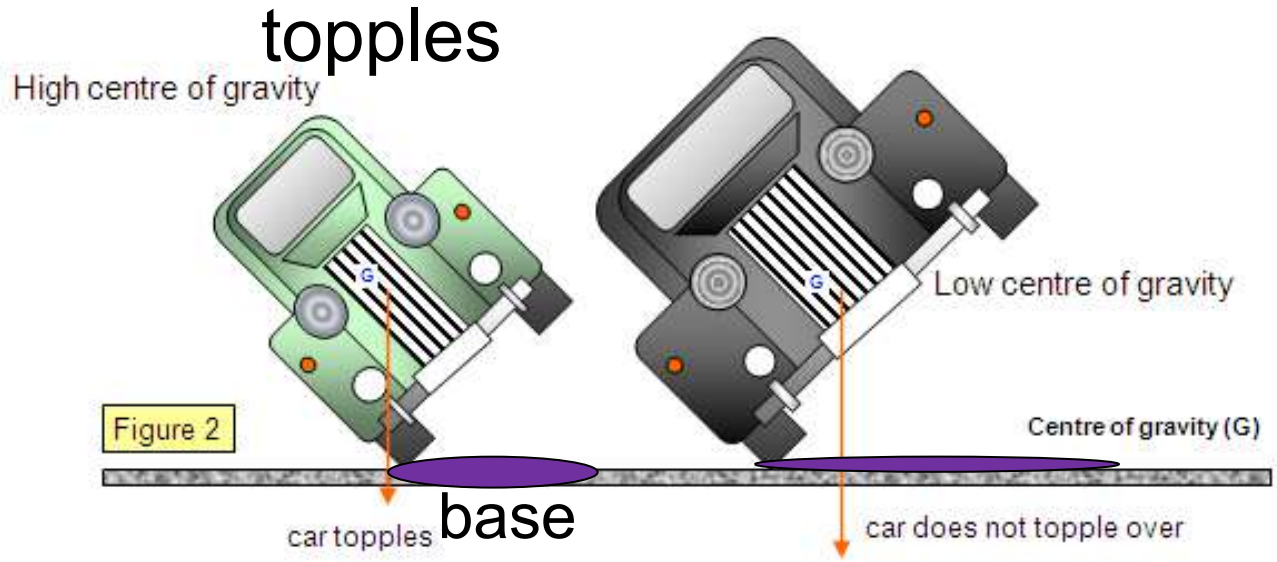
- The location of the center of gravity is important for stability.
  - If we draw a line straight down from the center of gravity and it falls inside the base of the object, it is in **equilibrium;** it will balance.
  - If it falls outside the base, it is unstable.

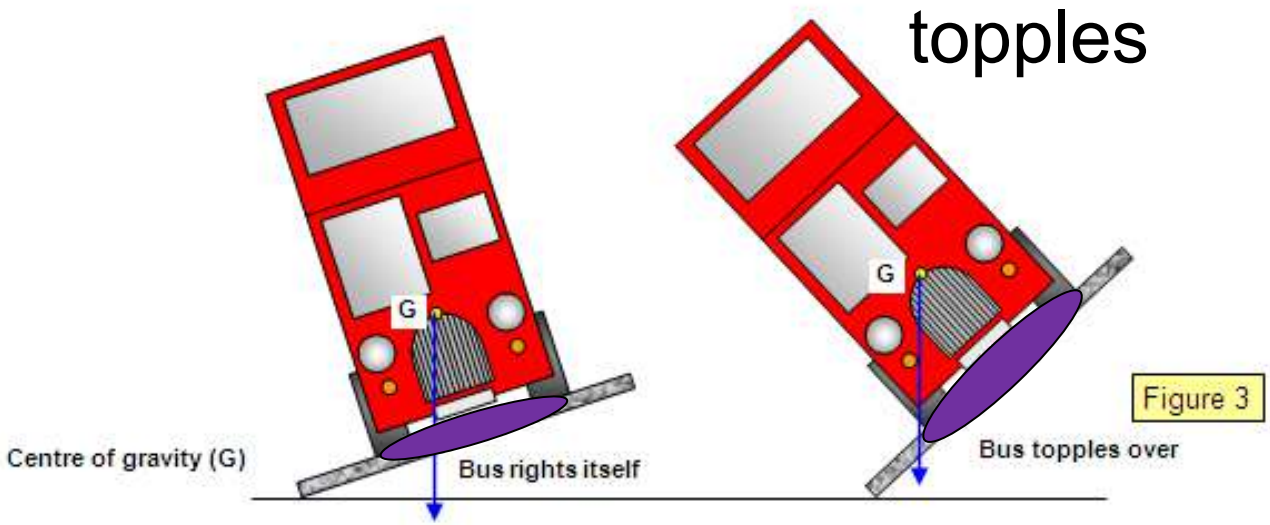


Where is the CG of all these objects?

Why is one car more likely to topple?

- Higher CG
- more likely to not be over the base
- (where tire touches the road)

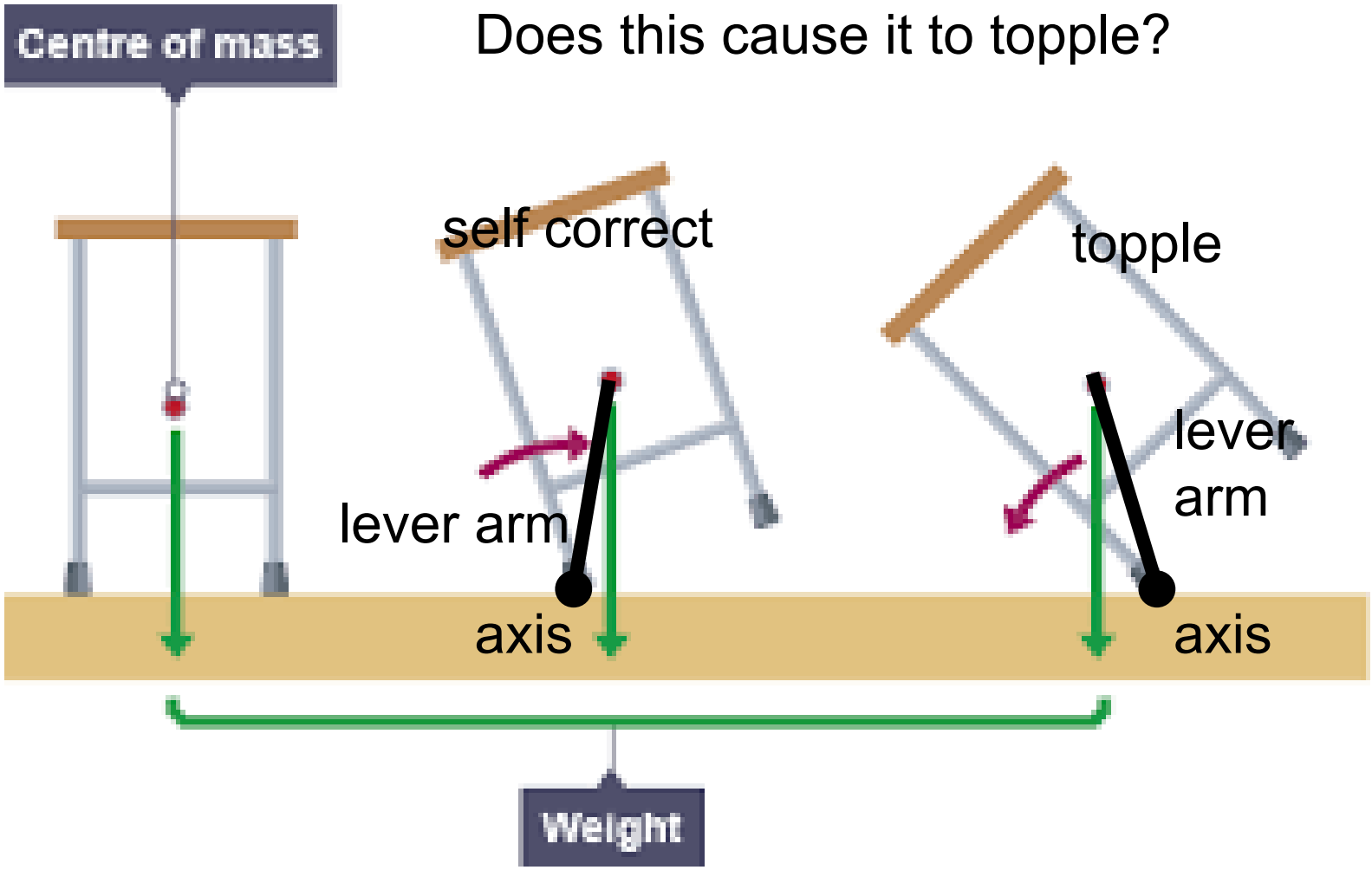




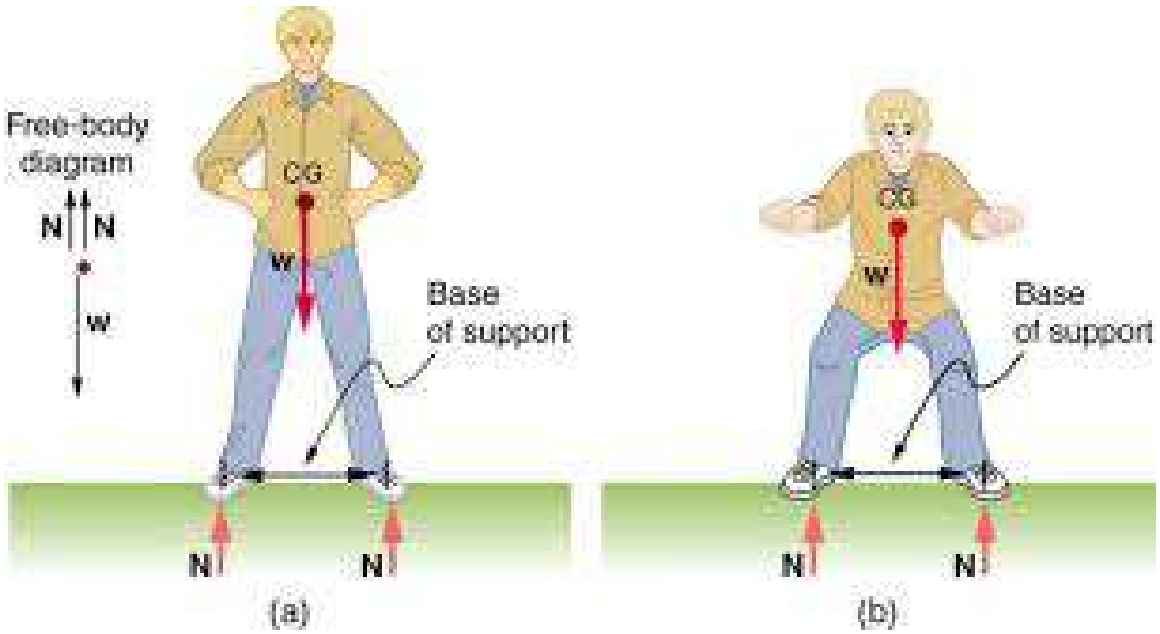
Gravity's torque causes toppling:

Which case produces a CW torque?

Does this cause it to topple?



To make yourself more stable:



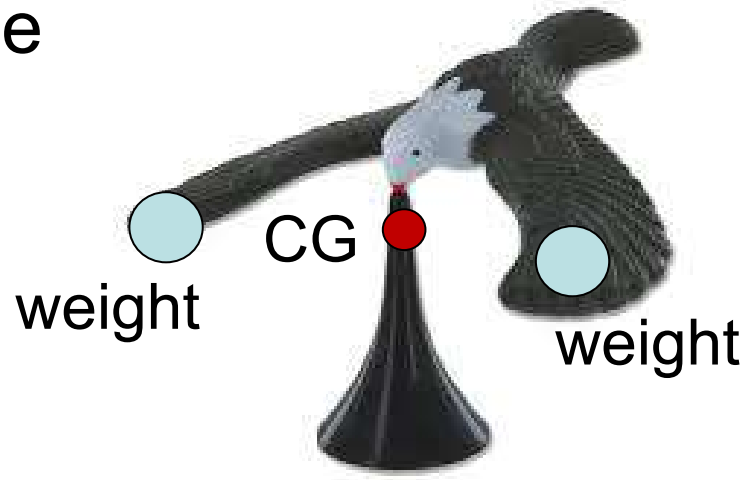
What are 2 ways to make yourself more stable.

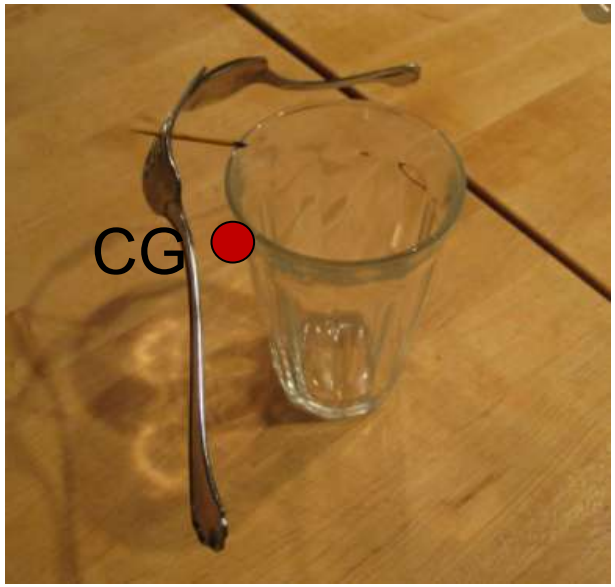
Move feet further apart.

Crouch down.

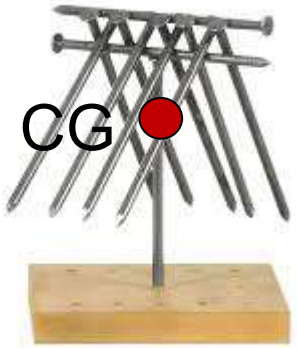
Stability the lower the CG, the more stable

The CG of the bird is below the balance point because there are weights in its wings.

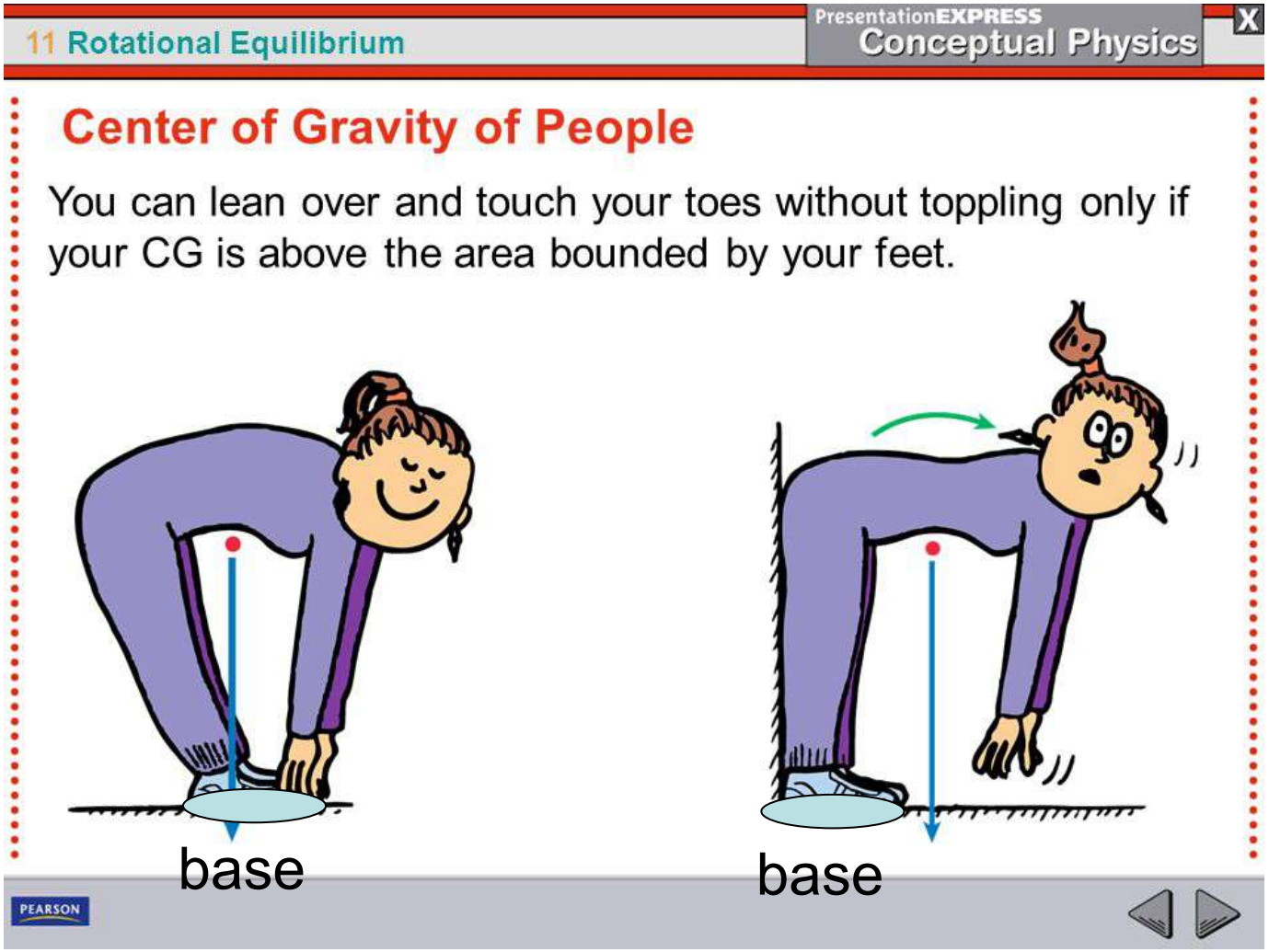




Where is the CG in these photos?

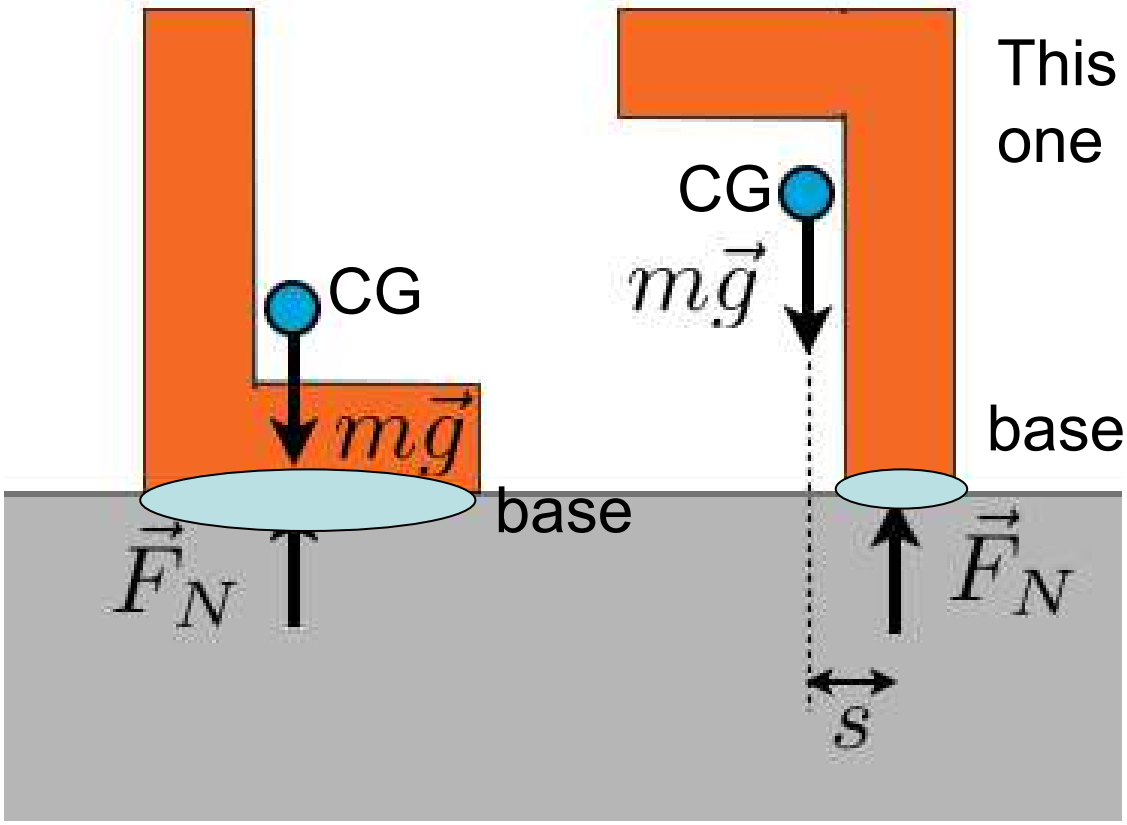


Stability



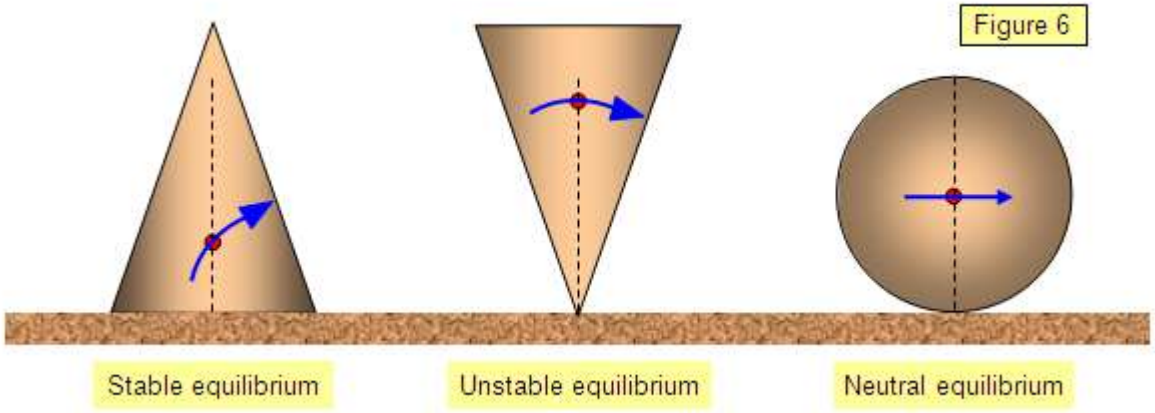
Why is right hand picture unstable?

Ex. Which L will topple?



Why? CG not over base

Stability: Tendency to return to original position if disturbed slightly



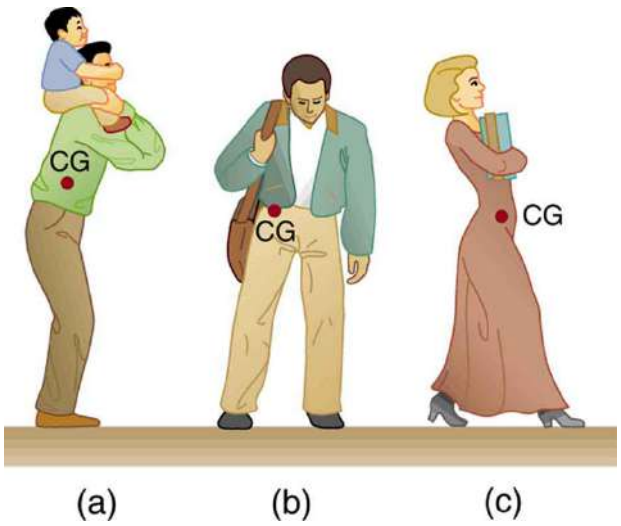
An object, when "disturbed," will be in…

…*stable* equilibrium if its CG rises

…*unstable* equilibrium if its CG lowers

…*neutral* equilibrium if its CG stays same height

Body shape affects CG:



In general, men have more mass in the shoulders, and women have more in the hips.
Who has a higher CG?

men

Try this:

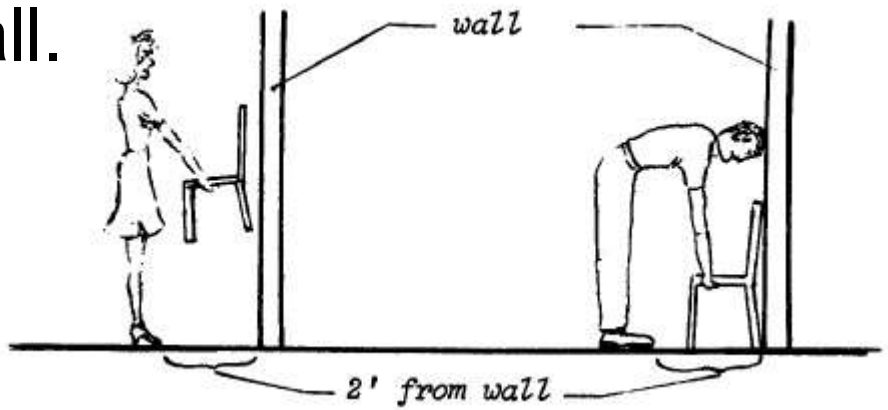
Stand 2 feet lengths from wall.

Bend over and grab chair.

Stand up (if you can.)

Women usually can.

Men usually cannot.



Homework due MONDAY by 7 pm

page 153: # 15-21