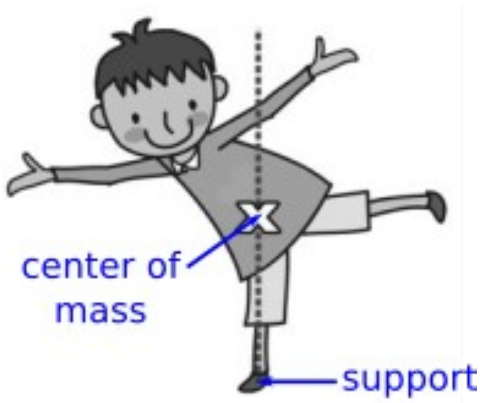
Center of Mass and Balance

- **Gravity** pulls down an object as if it were pulling on a special point called the "**center of mass**".
- To stay balanced, the center of mass has to be over the support of the object (or beneath it)
- The center of mass depends on the object shape and where the heaviest parts are.



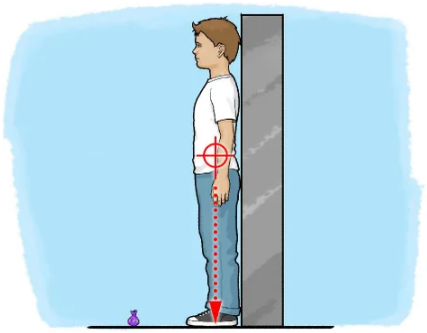
Part 1: Bet You Can't!

The following challenges may seem simple – but the Laws of Physics will be working against you. And they are not to be defied.

1. Bet you can't balance on one leg!
Stand sideways with your shoulder against a wall (or door). You right foot should be sideways up against the wall. Try lifting up your left foot to balance on one leg.

Could you do it? _____

2. Bet you can't pick up a coin!
Stand with your back and heels against the wall. Have a helper place a coin a couple inches front of your toes. Without moving your feet, try leaning over to pick up the coin.



Could you do it? _____

In order to stay balanced, the **center of mass** of an object has to be over its base of support. Otherwise the object topples over. As babies, we learn to shift our center of mass to be over our feet in order to stay balanced.

Discuss:
Why are the tricks above impossible?

Try balancing on one foot while sticking the other leg behind you. What happens to your torso? Why?

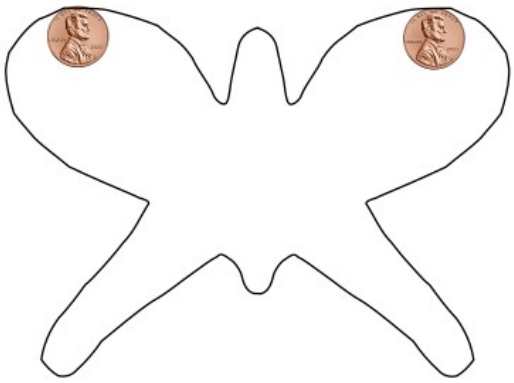
Part 2: Floating Butterfly

1. Cut out the butterfly shape printed on the cardstock.

2. Can you find the center of mass of the butterfly by balancing it on the eraser end of your pencil? The butterfly will balance when its center of mass is placed directly over the pencil.

Make a mark on your butterfly for where the center of mass is located.

3, Tape a penny at the tip of each wide wing of the butterfly, as shown. The pennies should be right at the edge.



Make a prediction:

Will the position of the center of mass shift? If so, where? Circle one.

shift forward (toward pennies) shift backward (away from pennies)
shift to the side not shift

Discuss: why do yu expect the balance point to shift, or not?

4. Try balancing your butterfly again on the pencil eraser. Mark the position of your new center of mass.

Was your prediction approximately right?

If extra time: Part 3, Stable Equilibrium
(work in pairs)

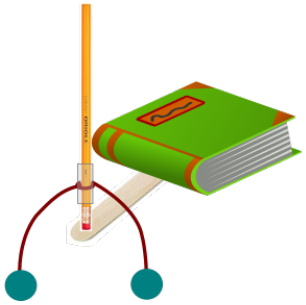
When the support is narrow, having your center of mass over the support is not enough to be stably balanced. Stable equilibrium means that when an object is pushed a little bit, it will respond by returning to where it was. A tiny push is not enough to make it fall.

1. Set your popsicle stick sticking out off the edge of a table, with a heavy book on the other end to keep it from falling.

2. Try balancing a pencil vertically on top of it. If you can get it to balance, try pushing the pencil the tiniest bit.

Could you get the pencil to achieve stable equilibrium?

Your pencil has a center of mass that is high above the popsicle stick. A tiny push will move that center of mass sideways off the stick and the pencil will fall. It is not stable.

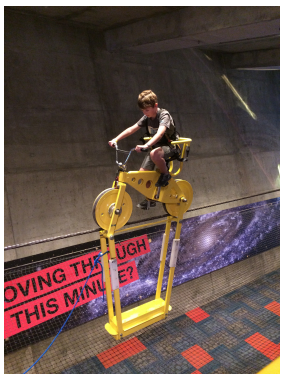


3. Twist 3 pipe-cleaners together to make a thicker wire.

4. Wrap the triple pipe-cleaner around the bottom section of your pencil. Use a piece of tape to keep it from sliding.

4. Make 2 identical balls of modeling clay, each about ½ inch across. Attach these balls to the tips of the pipe-cleaners.

5. Try making the pencil balance on the popsicle stick, with the clay balls hanging down below the stick. Adjust the pipe-cleaners and add or remove clay from the balls as need.



6. Try pushing the pencil a tiny bit with your finger.

Were you able to achieve stable equilibrium? _____

Where do you think is the center of mass of your pencil + clay "tightrope walker"?

_____

To be in stable equilibrium over a very narrow support, the center of mass has to be below the support. Then tilting the object slightly raises this center, and gravity pulls the center back down, bringing the object back to its equilibrium position. Stunt-men and science museums use this idea to ride bicycles on tight-wires!