Balance Circus
Teacher's Lesson Plan

This classroom activity kit helps elementary school children learn about concepts of **balance** and **center of mass**. These ideas are used by **mechanical engineers** and **civil engineers** when they design and build machinery or structures. There are two teacher's demos, and two activities for the children to do that relate to engineering.

1. Background on Center of Mass

This section should help the teacher introduce concepts and field questions before and during the activities.

Mass vs. weight Mass is a number that represents how much matter (stuff, substance) is in an object. It's different from weight, which measures how strongly gravity pulls on the object. An object's mass is constant, no matter what its weight may be. For example, in the Earth's gravity, a car may weight a lot, but under the Moon's weak gravity, it weighs much less. The car, though, is still made up of the same amount of matter, or *mass*, on the Earth and on the Moon. Mass is part of the object itself.

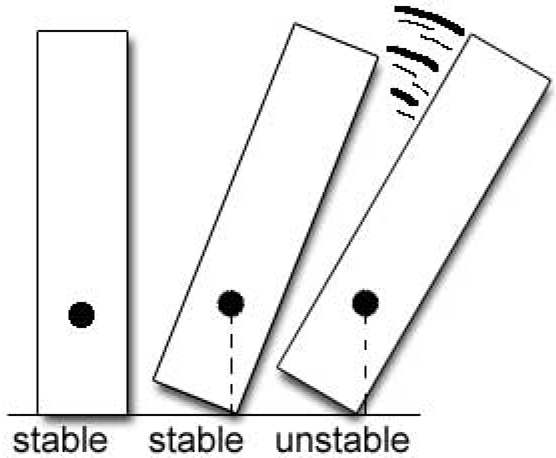
Center of mass Gravity acts on an entire object, all of its parts at once, regardless of its shape. A force like gravity, though, can be represented as acting on one point, the **center of mass**. Think of it as if the mass of all the object's parts were crunched together, or averaged out, into one point.

For example, the center of mass of a circle is at a point exactly in the circle's center. The center of mass of a three-dimensional sphere is at a point directly at the sphere's center. For a more complex object, like a bowling pin, you can imagine that the center of mass is again in the center, but located closer to the fat end (which has more mass) than to the little end.

Multiple objects, when gravity is acting on all of them, can share one center of mass between them. For example, two children riding a see-saw share a center of mass somewhere between them. If each child has the same mass, then their center of mass is directly in the middle of the see-saw. If the children have different masses, then their center of mass will be closer to the child who has more mass.

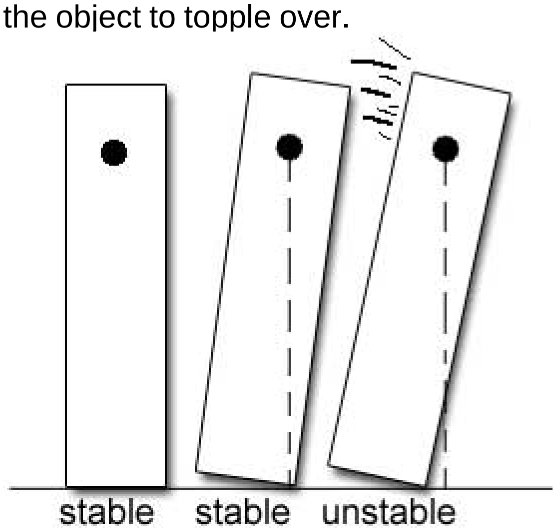
Balance & Center of mass Finding an object's center of mass can help you balance the object on a point. If you know where the center of mass is, you can pick a point on which to balance the object and have it be stable (won't tip over).

Imagine taking an object with lots of mass and balancing it on a single spot. If the object's center of mass is low down, close to the balancing point, the object will be very stable. You can tip the object over to very extreme angles, and it will not topple over, but rather will rock back upright.



Low center of mass

Imagine, though, if the object's center of mass were high up near the top of the object, far away from the balancing point: if you tip the object over to just a slight angle, the center of mass will be leaning out too far, and gravity will cause the object to topple over.



High center of mass

2. Classroom Activities – The Balance Circus

These activities use a circus theme to teach children about the concepts discussed in the **Background** section.

*****Before beginning the teacher's demos, have the children glue together popsicle sticks according to steps 1-3 of Children's Activity #2. The glue will have time to dry during the other activities.*****

Teacher's Demo #1: The Tall Clown

Materials:

- Tall Clown demo doll (pre-made, in activity kit)

The Tall Clown is built so his body (which contains lots of mass, and thus the whole Clown's center of mass) can be adjusted high or low, relative to his feet. Start the Clown with a low center of mass, and invite some children to gently tip him over by pushing on the top of his "leg" poles. The children should observe how stable the Clown is, and how far they must tip him over before he falls.

Next, adjust the Clown's body height so that his center of mass is at the top, far from his feet. Invite more children to gently tip him over again, and they will see how much easier it is to do so. The Clown is much less stable, and takes less tipping over to fall, when his center of mass is high.

Questions to ask:

- Why does a bowling pin have a low center of mass?
- Why does a crane, the large t-shaped ones used in construction, have a high center of mass?

Teacher's Demo #2: The Balance Beam

Materials:

- Balancing beam device, objects with masses (all included in kit)

This demonstrates the idea that a few objects can share a center of mass, and that knowing where that point is can help you balance those objects. Because the objects are being balanced *while* the children figure out their center of mass, the children should grasp the concept that center of mass and balancing point *work together* to make the objects balanced and stable.

First, the balance beam should be set up so that the balance point (or **fulcrum**) is in the center hole. Two objects of equal mass should be placed on the beam, one on each side of the fulcrum, in slots the same distance from the fulcrum.
Questions to ask:

- Why is the beam balanced? Where is the center of mass of the 2 objects?

Now move one object to a different slot, so that the objects are different distances from the fulcrum.

- Why is the beam *not* balanced? Where is the center of mass now?
- How can we fix this problem, so the beam is balanced? (Think about where the center of mass is, and how we can shift it so the beam balances.)

The children should learn that shifting objects will shift the location of their center of mass. They should use this idea to shift the second object over, or to add mass at other points, to shift the center of mass onto the balancing point.

Finally, remove the fulcrum from the beam and move it to a different hole, so that it is off-center. Now, the children have less slots on one side for shifting objects. If you place a more massive object on the longer side of the beam and a less massive one on the short side, the children should learn to move the more massive one toward the fulcrum to balance the beam, and the less massive one farther away if it still does not balance. If you place the more massive object on the shorter side, the children should learn to shift the less massive object farther away until the beam balances.

Activity #3: The Coat Hanger Circus

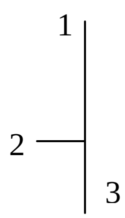
Student provided materials:

- Coat hanger
- 20 pennies
- scissors

Teacher provided materials

- paper clips
- cutouts – two of each type of animal

First the children need to cut out a pair of each type of animal. Each cutout has the following shape:



A pre folded example should be in the box.
The guideline is that the 3 end is folded up all the way.
The 2 is folded over top and around to wrap around the entire piece.
The 3 end is folded back down over the 2 end, revealing the animal, and creating a pouch
The 1 end is folded back, so that it can either be paper-clipped over the hanger, or to be a tab hung in the pouch

Once each student has all their pouches, they should add a penny to the jugglers, two to the clowns, three to the lions, and four to the jugglers.

The hangers can be hung from a ruler placed between desks.

The challenge is for children to balance their mobile. The children will generally start by placing equal weights at equal distances on each side, so to help them experiment, some of the following challenges are used.

1. No performer can be split up on different sides.
2. Elephants and lions have to go on the same side, because the jugglers and clowns are scared of them.
3. Lions scare the clowns, so lions and jugglers have to be on one side, and the elephants and clowns are on the other.
4. The circus doesn't have any lions.
5. We want to emphasize one act, so it should be all by itself on one side, with all the others on the opposite side.

Questions to ask:

- Does a weight have more or less impact when it is further out?
- What about when it is closer in?
- How can we make it balance when there are different amounts of weight on each side?
- Where do you think the center of gravity is?

Activity #4: The Finger Balancing Gizmo

Materials:

- Elmers glue
- Popsicle sticks
- Plasticene clay

The posicle sticks should have been glued in advance, so that they are dry now.

Taking the Popsicle stick gizmo so that it most resembles a "Y" the children should add equal balls of clay to the two top ends. Turning it upside down they should now be able to balance the gizmo on their finger. They can try to remove a little bit of clay from one side to see what happens.

Questions to ask:

- Where do you think the center of mass is?
- If the center of mass weren't below where it is being supported, what would happen?