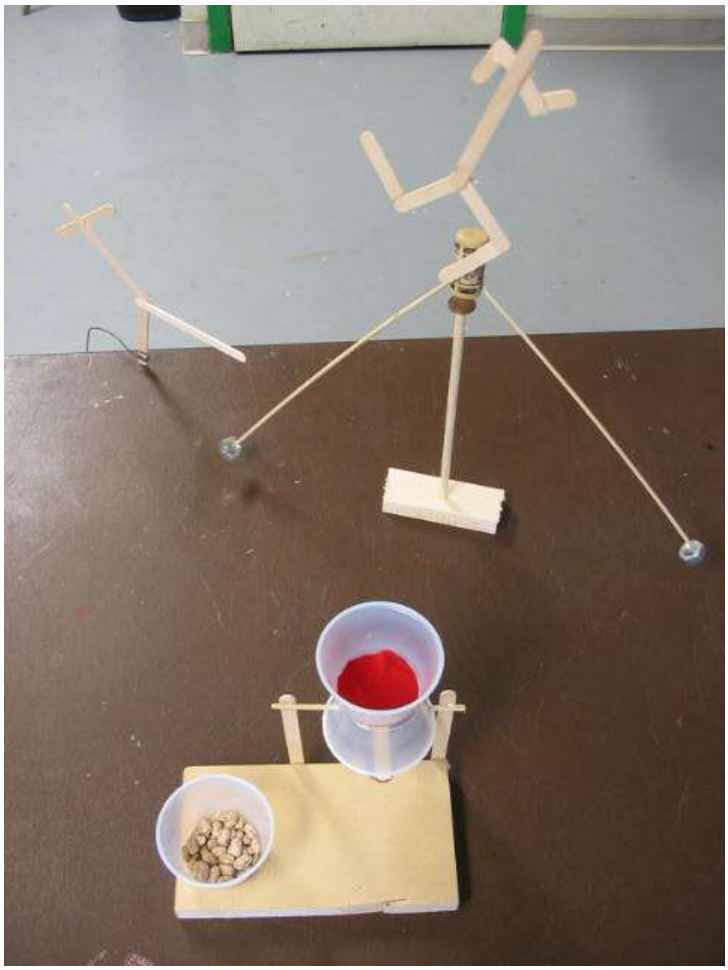
Balancing Acts and Spill the Beans

Watch your center of mass, or you'll fall over.

Parts:

Balancing Acts

1	1x2 Baseboard
1	Tack
2	Bamboo skewers
3	Nuts, 3/8" or larger
8"	Dowel, ¼"
	Popsicle sticks
	Baling wire



Spill the Beans

1	Cork
7	Pennies
3	Salsa cups
2	Popsicle sticks
1	Bamboo skewer
	Cloth
	Beans

Extra Tools:

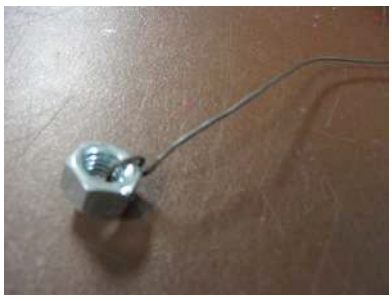
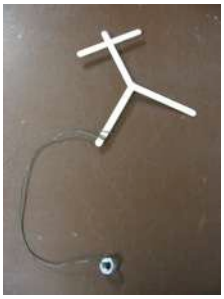
Drill Drill platform 15/64 bit for drill Nail bit, large for bamboo skewers
Hole punches
Duct tape
Markers
Colored paper
File folders or stiff paper

How We Build It:

Dancer on the Table

Construct a small person with Popsicle sticks and hot glue. Cut about 12" of baling wire. Wrap about 1"of the wire around the tip of one of the person's legs.

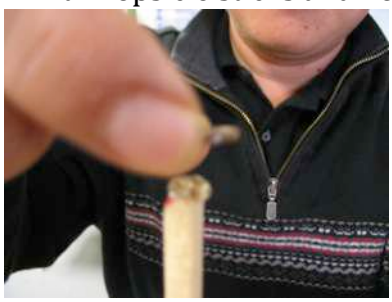
Connect a nut or something heavy to the other end of the wire. Bend the wire in a curve such that the popsicle figure stands up by itself. It can stand on either leg if you bend the wire correctly.


Dancer on a Tack

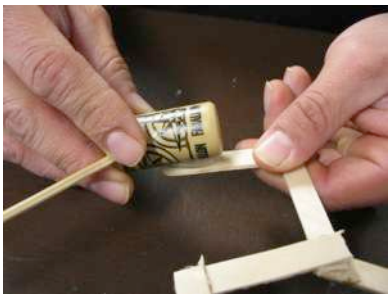
First, cut two small pieces of wood drill a 15/64th hole on each of them. Cut a piece of ¼" dowel about 8". Hammer it into the hole. If it is not tight, hot glue it.


Glue a penny on the tip of the dowel, Lincoln's memorial up. Make a figure – any shape, but not too heavy – with Popsicle sticks and hot glue.

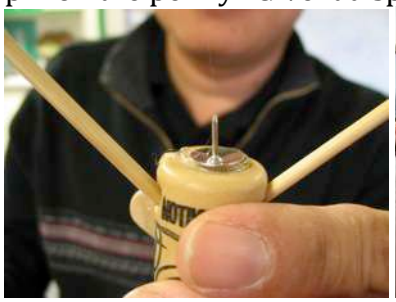
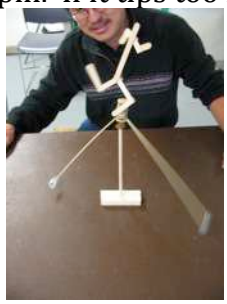



Use a nail as a drill bit and make two holes in opposite sides of the cork. The holes should be angled upwards. Insert the sharp ends into the holes in the cork.


Glue nuts to the unsharpened ends of two bamboo skewers. Glue the cork to the lower most stick on your figure.

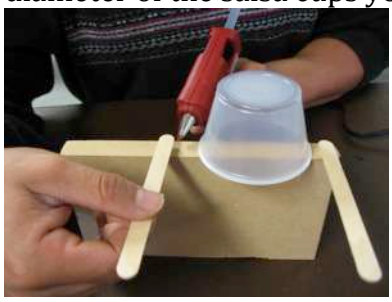



Glue a tack to the bottom of the cork so that the point is sticking out. Balance the figure by the tip of the pin on the penny. Give it a spin. If it tips too much, glue more weight on the ends of the skewers.

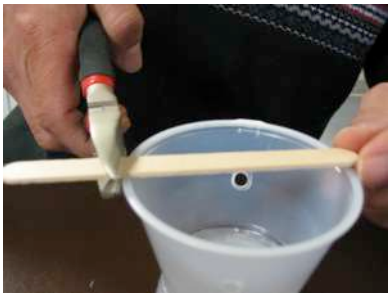
Spill the Beans

Hot glue two Popsicle sticks to the edge of the baseboard. They should be about 1" farther apart than the diameter of the salsa cups you are going to use.

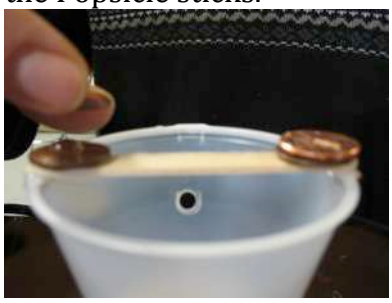
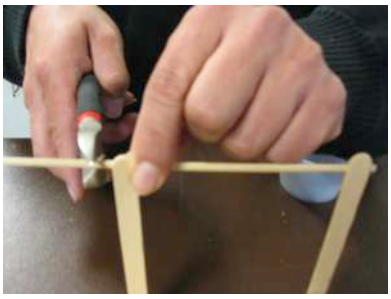


Punch a hole in the side of the cup as far in as your hole punch will allow. It helps to remove the paper bracket on the hole punch. Punch another hole directly opposite the first.


Glue another salsa cups to the bottom of the one with the punched holes. Cut a Popsicle stick a bit longer the diameter of the salsa cup.

Hot glue it on. Glue about six pennies to this Popsicle stick, one by one. Put them symmetrically around the center so that the cups stand vertically when you release them. The more pennies you glue on, the more beans will be necessary to tip the cups over. Cut a bamboo skewer to span the distance between the Popsicle sticks.

Insert the bamboo stick through the two holes on the salsa cup. Glue it to the tips of the two Popsicle sticks. Cut a piece of cloth the size of the bottom of a salsa cup.


Glue it in. This helps the beans not slide around. Hot glue the third salsa cup to the baseboard in a position that allows the other two cups to swing freely. Store the beans in this cup.


To play, two players take turns placing beans into the top cup one by one until the cup tips over spilling the beans.


Concepts:

- Everything has a point called the center of gravity, or center of mass. You can think of all the mass of the object concentrated there.

- An object standing on the ground will balance only if its center of mass is directly above a point that is within the boundaries of its support points. For example, if you lean too far, you'll fall over unless you move a foot or hand underneath you.
- An object hanging will fall and/or rotate until its support point is directly above its center of mass. For example, if you hang from your hands you'll hang straight down, but if you raise your legs out in front of your torso will swing back a bit.

Focus Questions:

If your Dancer on the Table doesn't balance right, what can you do to change it?
If a fat kid and a skinny kid use a seesaw, who should sit closer to the center?
Why might it be easier to carry two buckets of 20 pounds each than one bucket of 40 pounds?
Why is it harder to walk on high heels than on regular shoes?

Elaboration:

These projects are about optical illusions as well as center of mass. Since the nuts and pennies are small and the figures are large it looks like they should fall over. But the nuts and pennies are heavy for their size and the figures are light, so it makes sense that the heavy parts will swing to the bottom. If you made the figures from thick wood, they would probably fall over because they would be heavier than the nuts.

In the Spill the Beans project, the salsa cups are hanging from two points: where the skewer enters the bottom cup, and where it exits. The pennies are heavy, so the center of mass is near them and swings underneath the two support points. Then, as you add beans to the top cup, the center of mass of the two cups moves up bit-by-bit, bean-by-bean, until it rises above the points of support. At that point the system must turn so that the center of mass moves back under the support. But when it moves, the beans all fall out and it goes back to the original position.

Count how many beans it takes as you play. When it tips over, it will always be the same number of beans, within two or three, no matter how carefully they are placed. That's because the mass of that number of beans raises the center of mass of the entire system above the support points.

Your body has a center of mass too. While standing, your feet always stay directly under your center of mass. If you try to stand on your hands, you may notice that your hands are not as big as your feet, and

you will have to work harder to keep them under your center of mass. To walk on high heels can be hard because your points of support on the ground are so very small. It is easy for your center of gravity to move outside those points of support, at which time you'll stumble or fall. Similarly, if you want a table to be very stable, you'll put the legs far apart. Tall, slender tables with legs close together fall over easily.

If you try to hang from your hands, it will be easy. Gravity just pulls your center of mass directly under the pole you are hanging from. In physics this is called "stable equilibrium," and occurs whenever you hang something. Think of the exact same system upside down, that is, standing on your hands on a bar. There will still be a point of equilibrium – when your mass is balanced above the point of support on the bar, but it will not be very stable because the bar is so narrow. Instead, you will tend to fall and swing around until you reach stable equilibrium again.

If your Dancer on the Table is not working, you can bend the wire and weight around so that the center of gravity is below the point of support. A seesaw works because it is balanced on the center pivot. If one kid is a lot heavier, it will not be balanced, so that kid will always be on the ground. But if she moves toward the center, there will be a point where she is balanced with the other kid around the central pivot. Both mass and distance from the pivot are important when determining balance and equilibrium. If you carry 40 pounds of water in two 20 pound buckets, you can put one on each side of you, so that your center of mass is right above your feet. It is hard to get your feet under one bucket of 40 pounds, unless you put it on your head.

Links to k-12 California Content Standards:

Grades k-8 Standard Set Investigation and Experimentation
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other strands, students should develop their own questions and perform investigations.

Grades k-12 Mathematical Reasoning:
1.0 Students make decisions about how to approach problems:
1.1 Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
1.2 Determine when and how to break a problem into simpler parts.

2.0 Students use strategies, skills, and concepts in finding solutions:
2.1 Use estimation to verify the reasonableness of calculated results.
2.2 Apply strategies and results from simpler problems to more complex problems.
2.3 Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and

models, to explain mathematical reasoning.
2.5 Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.

3.0 Students move beyond a particular problem by generalizing to other situations:
3.1 Evaluate the reasonableness of the solution in the context of the original situation.
3.2 Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.
3.3 Develop generalizations of the results obtained and apply them in other circumstances.

Grade 2 Standard Set 1. Physical Sciences:
The motion of objects can be observed and measured.
1.c Students know the way to change how something is moving is by giving it a push or a pull. The size of the change is related to the strength, or the amount of force, of the push or pull.

Grade 8 Standard Set 2. Forces:
Unbalanced forces cause changes in velocity.
2.a Students know a force has both direction and magnitude.
2.c Students know when the forces on an object are balanced, the motion of the object does not change.
2.e Students know that when the forces on an object are unbalanced, the object will change its velocity (that is, it will speed up, slow down, or change direction).