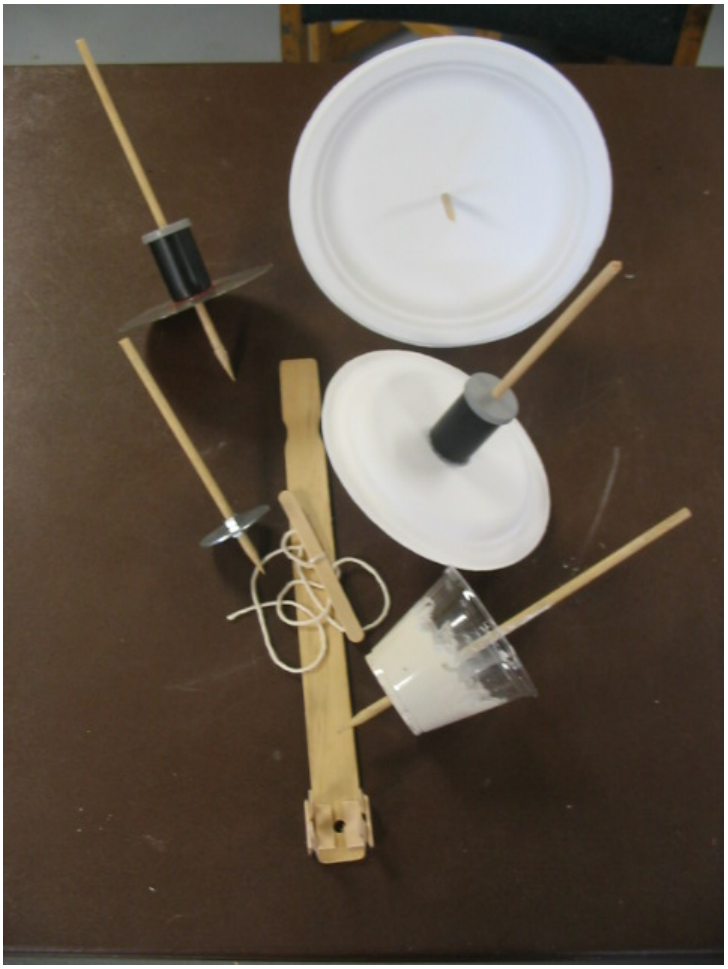
Tops

Some things only stand up while they're spinning.

Parts:

1	48" Dowel, ¼"
1	Stiff paper plate, big
1	Stiff paper plate, small
3	Film cans or salsa cups, with lids if possible
1	Flim can lid, for CD top
	String, strong
4	Popsicle sticks
1	Paint paddle
1	CD
1	¼ x 2 fender washer
2	7mm nuts
	Plaster
4	Little cup to measure plaster
1	Basin for water
1	Cup for plaster top
3	2 x 2 bases for plaster tops



Extra Tools:

Drill 15/64 drill bit Drill platform
Side cutter
Glue gun
Pencil sharpeners
Files to make point less sharp

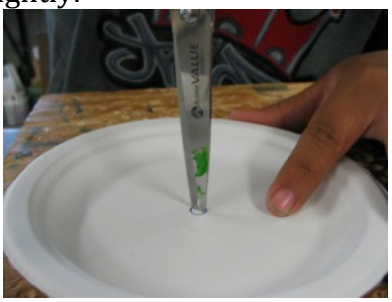
Concepts:

- Spinning things tend to be stable. Tops have to be spinning to stand up, and some bullets, rockets and satellites also spin to give them stability.
- The weight of a top is important. The heavier something is, the more momentum it will have, and the longer it will spin.
- The radius is also important. The bigger the radius, the more momentum it will have.

How To:

The Tops

There are five types of tops to make as well as a launcher. The 1st and 2nd tops involve paper plates. Find the center of the stiff paper plate by balancing it on the dowel. Then make a hole in the center big enough to drive the dowel through tightly.

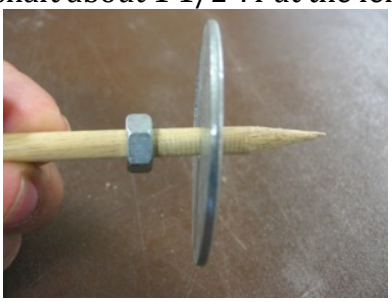
Cut about 8" of ¼ dowel. Sharpen the dowel with a pencil sharpener, but don't make it super sharp; it will work better with a small round tip. Drill a 15/64" hole in a film can or salsa cup. A lid is helpful but not required.


Insert the dowel through the hole. Try different lengths sticking out the bottom. Put hot glue around the hole in the paper plate.

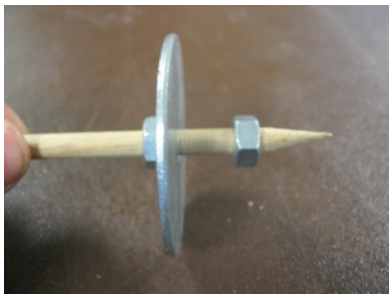

Insert the dowel through the hole until the film can contacts the glue on the plate. Hold it until it is glued firmly. Make another top just like the first with a different sized plate or bowl. Compare the difference in performance between the big one and the small one.


The 3rd top uses a fender washer. Make another sharp shaft from the ¼" dowel. Grip the7mm nut with a wrench or pliers to help you screw it onto the dowel. It should screw on tightly, but can be glued into position if it is a bit loose.


Screw the first nut onto the shaft about 1 1/2". Put the fender washer on the dowel.

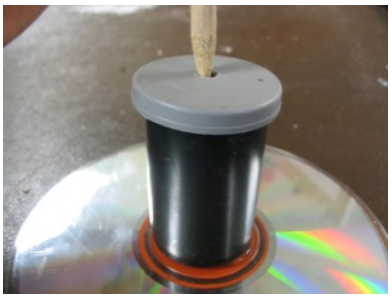
Screw the second 7mm nut on the dowel until it tightens snugly against the first. Hot glue around the 7mm nuts and the fender washers to make everything secure.



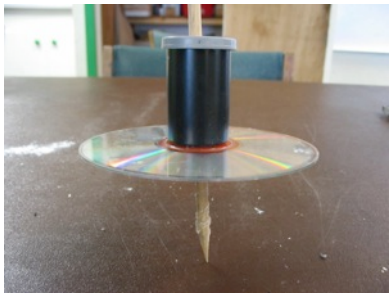
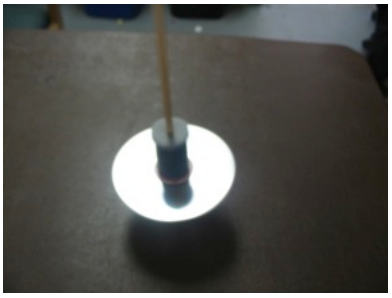

The 4th top uses a film can just as the 1st and 2nd, but now with a CD. Make another sharp shaft from the ¼" dowel. Drill a 15/64ths hole in the center of the film can and its lid.


Make sure the holes are exactly in the center of the film can and lid. Put hot glue on the bottom of the film can.

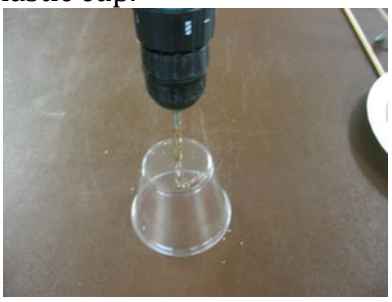

Glue the CD to the film can exactly centered around the hole. Insert the sharpened shaft through the hole of the film can.

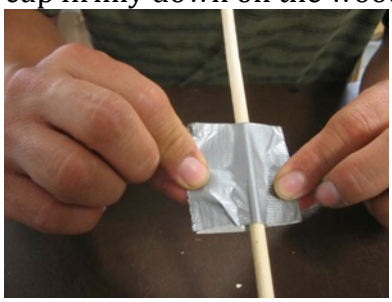
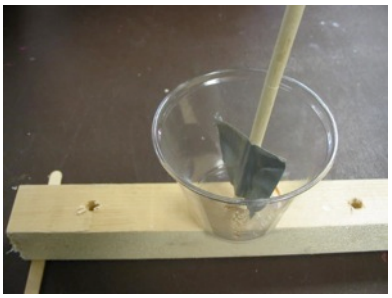
Start with pointy end extending out of the film can about 1 ½". Try different lengths sticking out the bottom.

The 5th top is the plaster top. Make another sharp shaft from the ¼" dowel. Drill a 15/64ths hole in the center of the bottom of the plastic cup.

Put some tape around the dowel near the point. This makes the plaster grasp the dowel better. Put the dowel down through the hole in the cup. Make a wood base out of a thick piece of wood by drilling a 19/64th hole exactly perpendicular to the surface of the wood. Insert the dowel in the hole and press the cup firmly down on the wood.

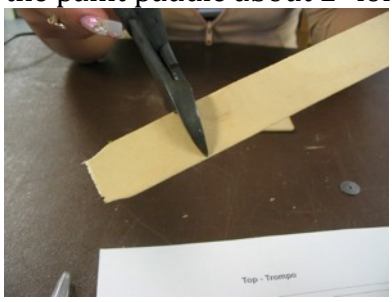



Measure out some plaster - 4oz will do, but you can try different amounts. Pour the plaster in the cup on the wood. Add the right amount of water.


Stir the water and the plaster together with a Popsicle stick. Let the top sit until the plaster is dry.

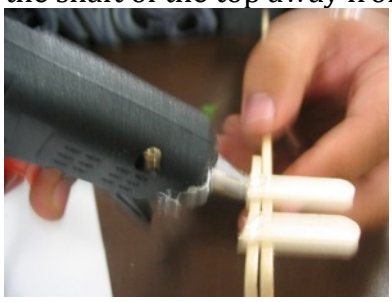

The Launcher

These tops can be spun at moderate speeds by squeezing the shaft between the palms of your hands, and then moving one hand forward and one back. To spin them faster, you'll need a launcher. Cut a piece of the paint paddle about 2" long. Glue the 2" piece to the end of the other piece.

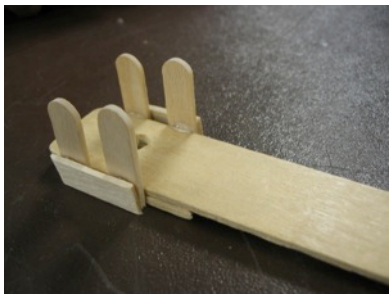
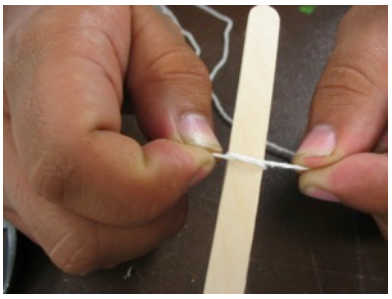



Drill a 15/64" hole through them both. Cut 2 popsicle sticks in half and in half again.

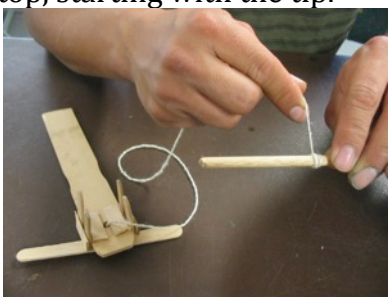

Hot glue two pieces of popsicle stick to one of the edges of the paint paddle about ¼" apart. Center them around the 15/64th" hole. Glue one more piece to span the first two. The purpose of this piece is to hold the shaft of the top away from the paint paddle so that the wound up string is free to rotate.



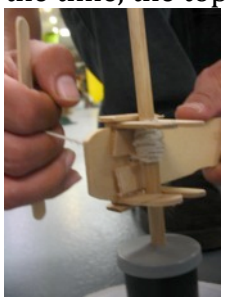
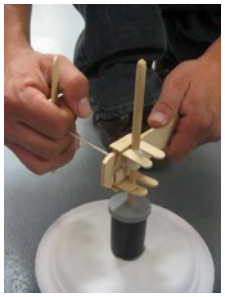

Do the same to the opposite edge of the launcher. Tie a string to the center of another Popsicle stick.

Pass the other end of the string through the hole in the paint paddle from the back. Wind the string tightly around the shaft of a top, starting with the tip.

When the string is all wound up, the top's shaft will rest in the notch made by the four sticks. To launch, hold the paint paddle firmly with one hand and with the other pull the Popsicle stick tied to the string. All the time, the top should be resting lightly on the floor. This takes some practice.

Focus Questions:

1. What could you do to make the top spin longer?
2. Why does the top fall over at the end?
3. How does the big plate spin differently than the small plate?
4. What do you think would happen if you made a top with very light plastic?

Elaboration:

Making all these different tops lets you find out which factors are most important in determining momentum. If a top is reasonably well balanced, its momentum can be roughly measured by how long it spins before falling over. The more momentum it has, the longer it will spin. An object's linear momentum – in a straight line – is simply its mass multiplied by its velocity. For spinning objects, the mass remains important, as does the distribution of this mass. If the mass is spread out farther from the center – a larger radius – the angular (or spinning) momentum will be greater.

According to these principles, the larger plate should spin longer than the smaller one; it has more mass at a larger radius. A top with two washers should spin longer than one with only one; they have the same radius, but one has twice as much mass. The plaster top should spin very long because it is the heaviest of all.

In reality, the balance and symmetry of the top as well as the surface it is spinning on and the smoothness of the release will all play into how long the tops spin. The more precisely symmetric you make the top, the longer it will go. The plaster top is the hardest to balance. Air resistance also plays a role. The large plate encounters a lot of air as it spins, whereas the washers and CD are smooth and thin so air won't affect them as much.

As it spins, a top loses its energy slowly to air friction and to friction between its point and the ground. It slows as it loses energy and eventually becomes unstable and falls over. Gravity and air friction are to blame. A top put to spin in orbit in a vacuum will continue spinning forever.

The launcher is an example of one of the simple machines of physics: the wheel. A wheel converts linear motion into rotational motion or vice versa. Here you pull straight on a string and the result is a rapidly spinning top.

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.