Start with a Book: Read. Talk. Explore.

Summer Science: Think Like an Inventor!

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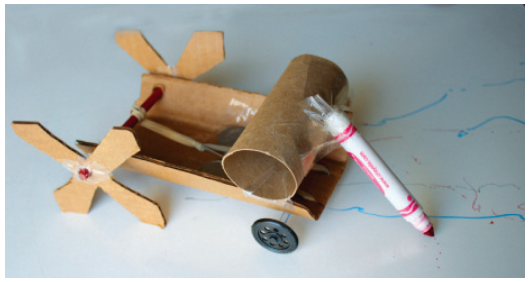


Random Robot

Build a rubber band-powered contraption designed to move across paper and create abstract art (and learn about friction while you're at it!).

Supplies: cardboard, pencil, markers, rubber bands, toilet paper tubes, ruler, scissors, tape, plastic straws, coins (weights), plastic wheels, and white paper.

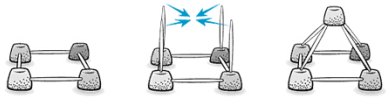
See PDF for instructions.

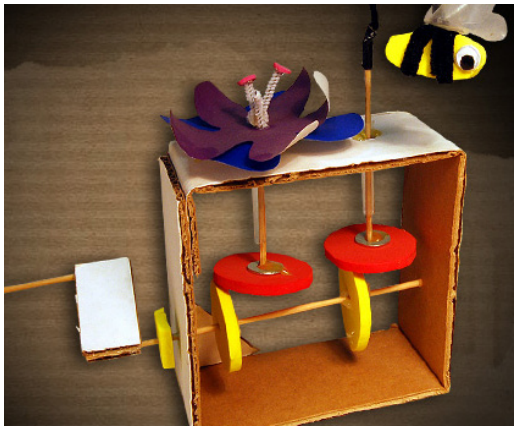
Geodesic Gumdrops

Make amazing structures with candy and toothpicks! Think like a builder and learn why triangles are so stable.

Supplies: bag of gumdrops (or mini-marshmallows), round toothpicks, paper and pencil (optional, for sketching out a design).

See PDF for instructions.





Cardboard"Automata"

Here's a playful way to explore simple machine elements like cams and levers.

Supplies: cardboard box, scissors, masking tape, nail, skewer, nut or washer, markers, pens, feathers, pipe cleaners, and Foamies™.

See PDF for instructions.

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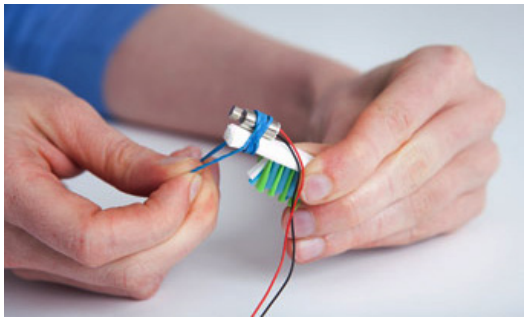


Bristle Bot!

Build a simple motorized bot that can really scoot! (Watch the video on Design Squad). And try some "bot bowling" with your gadget.

Supplies: 1 pager motor and 1 button cell battery (1V or 3V), toothbrush with angled bristles, rubber bands or tape, and pliers or wire cutter.

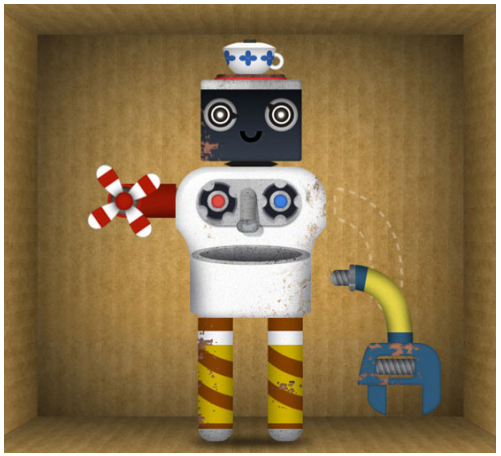
See PDF for instructions.

Tangrams

A tangram is a geometric puzzle with 7 peces: 5 triangles, 1 square, and 1 parallelogram. This ancient game originated in China — see how many different objects you can create using all the shapes.

Supplies: construction paper (any colors), pencil, ruler, scissors.

See PDF for template.



Cool Apps and Websites

APPS
- Robots
- Tinkerbox
- Toca Robot Lab

WEBSITES
- Design Squad (PBS)
- Exploring Leonardo
- Kids Think Design

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Fiction Books

Clever-Lazy by Joan Bodger

Clink by Kelly DiPucchio

If I Built a Car by Chris Van Dusen

Iggy Peck, Architect by Andrea Beaty

Marveltown by Bruce McCall

Oh No! (Or How My Science Project Destroyed the World) by Mac Barnett

Polo: The Runaway Book by Regis Faller

Randy Riley's Really Big Hit by Chris Van Dusen

Regards to the Man in the Moon by Ezra Jack Keats

Robot Zot! by Jon Scieszka

Nonfiction Books

The Boy Who Invented TV: The Story of Philo Farnsworth by Kathleen Krull

How Ben Franklin Stole the Lightning by Rosalyn Schanzer

Imaginative Inventions by Charise Mericle Harper

The Kids' Invention Book by Arlene Erlbach

Marvelous Mattie: How Margaret E. Knight Became an Inventor by Emily Arnold McCully

Neo Leo: The Ageless Ideas of Leonardo da Vinci by Gene Baretta

Pop! The Invention of Bubble Gum by Meghan McCarthy

Pop-Up House of Invention by Robert Crowther

Robot (Eyewitness Books) by Roger Bridgman

Robotics by Kathy Ceceri

So You Want to Be an Inventor? by Judith St. George

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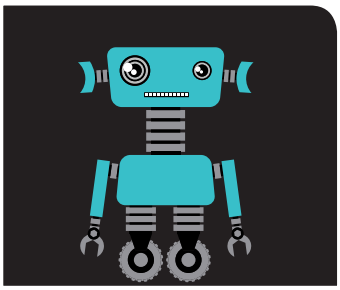
CREATIVE ACTIVITY : **ROBOTS**

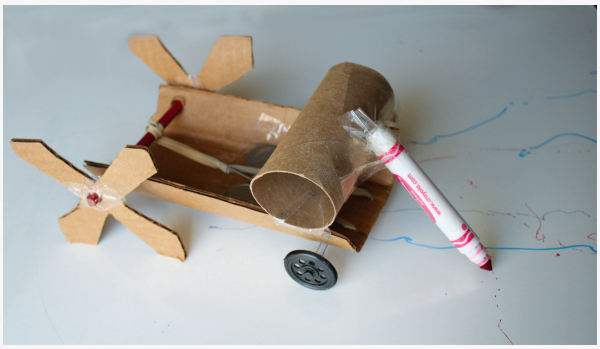
Random robot



Most robots are specifically designed to do a particular task, often one that would be tiresome or dangerous for humans. Creating art usually isn't tiresome or dangerous, but it is interesting to compare your child's own artwork to art created by a rubber band-powered contraption designed to move across paper and create abstract art! You'll need:

Supplies

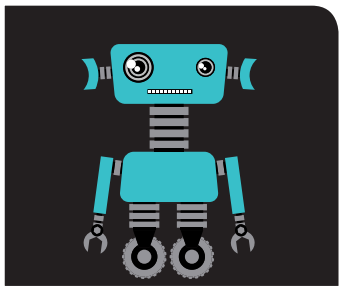
- Corrugated cardboard
- Pencil and different colored markers
- Rubber bands
- Hard, white, mint candies with a hole in the middle (or other items that work as wheels)
- Other items to test: old compact discs, washers, sticky foam, skewers, LEGO blocks, etc.
- Blank paper and an abstract drawing created by your child
- Toilet paper tubes
- Ruler, scissors, tape
- Plastic drinking straws
- Coins (or other items to use as weights)



Directions

1. Fold a 6-inch square of cardboard into thirds so it looks like a trough. This is the body.
2. Cut two 4-inch squares of cardboard and on each, draw an "X" from corner to corner. Then measure and mark ½ inch to the right and left of each line. Connect these marks so that your "X" is now 1 inch wide. Cut out the 4 smallest triangles created by your "X" and make a hole in the very center of each "X."
3. On the body, poke one hole close to the end of each folded side. Make sure the holes are directly across from each other and are big enough for a pencil axel to spin freely.
4. Put a pencil through the body and attach the "X" wheels on each end with tape.
5. On the other end of the body, tape the straw under the back end. Slip a candy onto each end of the straw and bend and tape the straw ends to stop the candies from coming off.
6. Loop two rubber bands together and then loop one end around the pencil axle. Cut two small slits into the back end of the body and slide the free end of the rubber bands into the notch.
7. Mount the toilet paper tube across the back end of the body, taping it to the sides.
8. Take the thin marker and attach it to the center of the toilet paper tube so that it drags behind the body like a tail. It needs to drag in order to draw. (*Continued on next page*)

Random robot



Directions (*continued from previous page*)

9. Put a large sheet of paper on the floor and uncap the marker. With the device on the paper, wind the rubber band by turning the pencil axle. The more you wind, the more energy the rubber band stores and propels your bot. Let go and see what it draws! How does it compare to what your child has drawn?
10. Change or add more markers, try other wheel types, use more or fewer rubber bands or experiment with other materials. If you have access to a small motor, you can also make a vibrobot that makes art: www.wired.com/geekdad/2012/05/ff_artbot

Other robots to make

5 Real Robots Made From Everyday Stuff
www.wired.com/geekdad/2012/08/robots-everyday-stuff

GoRobotics: How to Make a Robot
www.robotshop.com/blog/en/robots/gorobotics/tutorials/how-to-make-a-robot

American Society for Engineering Education: The BristleBot
http://teachers.egfi-k12.org/activity-do-it-yourself-bristlebot

Geodesic Gumdrops

Make amazing architecture with candy and toothpicks.

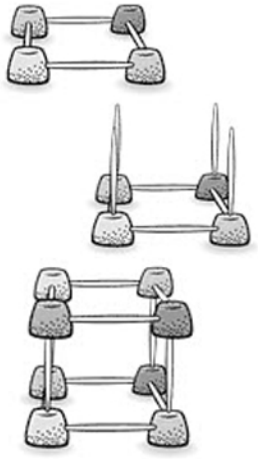
What do I need?

- A bag of gumdrops (If you can't find gumdrops, try using bits of rolled-up clay, mini-marshmallows, or partly-cooked beans. Be creative!)
- A box of round toothpicks

What do I do?

Making Squares and Cubes

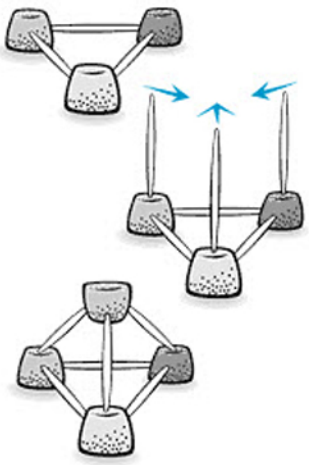
1 Start with 4 toothpicks and 4 gumdrops. Poke the toothpicks into the gumdrops to make a square with a gumdrop at each corner.



2 Poke another toothpick into the top of each gumdrop. Put a gumdrop on the top of each toothpick. Connect the gumdrops with toothpicks to make a cube. (A cube has a square on each side. It takes 8 gumdrops and 12 toothpicks.)

3 Use more toothpicks and gumdrops to keep building squares onto the sides of the cube. When your structure is about 6 inches tall or wide, try wiggling it from side to side. Does it feel solid, or does it feel kind of shaky?

Making Triangles and Pyramids



1 Start with 3 gumdrops and 3 toothpicks. Poke the toothpicks into the gumdrops to make a triangle with a gumdrop at each point.

2 Poke another toothpick into the top of each gumdrop. Bend those 3 toothpicks in toward the center. Poke all 3 toothpicks into one gumdrop to make a 3-sided pyramid. (A 3-sided pyramid has a triangle on each side. It takes 4 gumdrops and 6 toothpicks.)

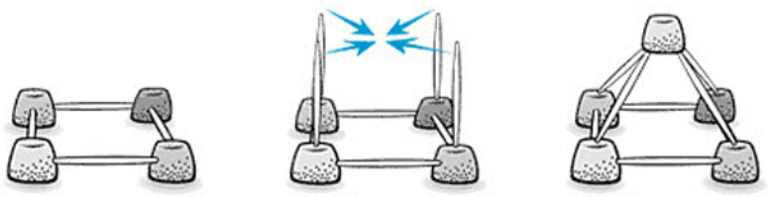
3 Use more toothpicks and gumdrops to keep building triangles onto the sides of your pyramid. When your structure is about 6 inches tall or wide, try wiggling it from side to side. Does it feel solid, or does it feel kind of shaky?

Making 4-Sided Pyramids

You can make a very big structure out of squares and cubes, but it'll be wiggly and will probably fall down. If you try to make a structure out of only triangles and pyramids, it won't be wiggly, but you'll probably run out of gumdrops and toothpicks before it gets very big. A 4-sided pyramid has a square on the bottom and triangles on all 4 sides. When you make a structure that uses both triangles and squares, you can make big structures that are less wiggly.

1 Build a square, then poke a toothpick into the top of each corner.

2 Bend all 4 toothpicks into the center and connect them with one gumdrop, to make a 4-sided pyramid.



3 What other ways can you use squares and triangles together? How big a structure can you make before you run out of gumdrops?

What's Going On?

Stretching and squashing -- some basic principles

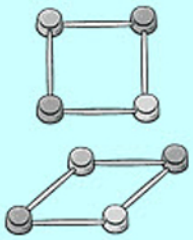
Even though your gumdrop structures are standing absolutely still, their parts are always pulling and pushing on each other. Structures remain standing because some parts are being pulled or stretched and other parts are being pushed or squashed. The parts that are being pulled are in tension. The parts that are being squashed are in compression.

Sometimes you can figure out whether something is in tension or compression by imagining yourself in that object's place. If you're a brick and someone piles more bricks on you, you'll feel squashedÑyou're in compression. If you're a long steel cable attached to a couple of towers and someone hangs a bridge from you, you'll feel stretched -- you're in tension.

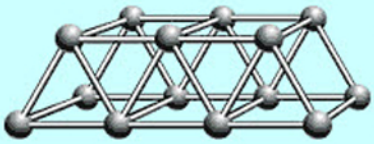
Some materials -- like bricks -- don't squash easily; they are strong in compression. Others -- like steel cables or rubber bands -- don't break when you stretch them; they are strong under tension. Still others -- like steel bars or wooden toothpicks -- are strong under both compression and tension.

What's the big deal about triangles?

As you've probably already discovered, squares collapse easily under compression. Four toothpicks joined in a square tend to collapse by giving way at their joints, their weakest points. A square can fold into a diamond, like this:



But if you make a toothpick triangle, the situation changes. The only way to change the angles of the triangle is by shortening one of the sides. So to make the triangle collapse you would have to push hard enough to break one of the toothpicks.



If you want to, you can use your gumdrops and toothpicks to build some strong structures that are made by combining triangles and squares. The pattern on the left is one that's similar to some used in modern bridge design.

Looking for other triangles in structures around you may give you ideas for other designs you can build with gumdrops and toothpicks.

THINGS TO TRY

Cardboard Automata

Cardboard Automata are a playful way to explore simple machine elements such as cams, levers, and linkages, while creating a mechanical sculpture.

Working with simple materials, this activity is easy to get started, and may become as complex as your mechanical sculpture ideas.

TRY IT! Collect these things:

Cardboard box 15x15cm (6"x6")
scissors, masking tape,

nail or screw, drinking straw, hot melt glue,
glue gun, skewer stick, thick (6mm) Foamies* nut or washer (optional),
materials for decoration, thin (2mm) Foamies* markers/pens, feathers,
pipe cleaners *(craftsuppliesforless.com)

The Cardboard Automata activity was inspired by

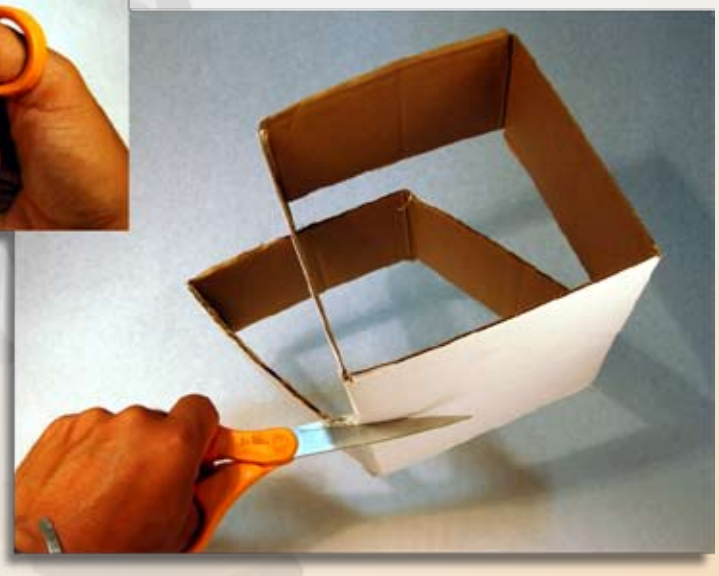
Cabaret Mechanical Theatre

PIE Institute shares a playful and inventive approach to teaching science, art, and technology.

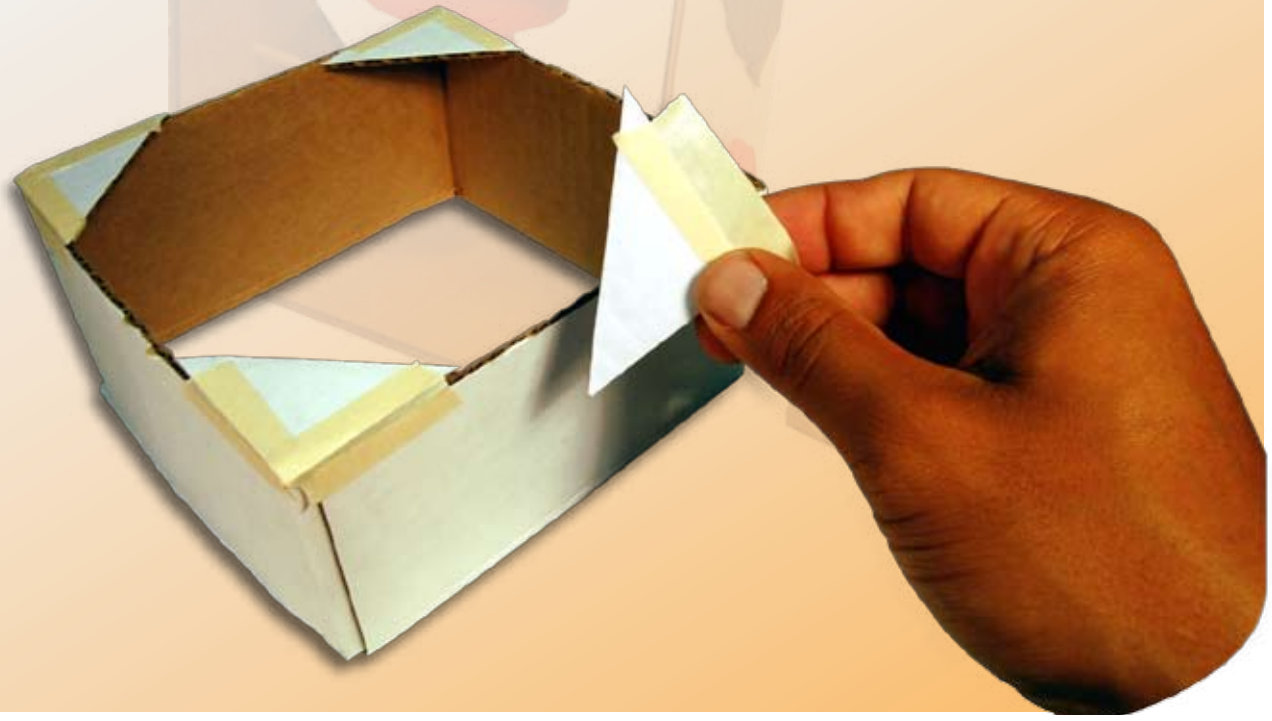
exploratorium

MAKE A FRAME

Cut the flaps off the box,
then cut the box in two pieces
(you get two frames from each box)

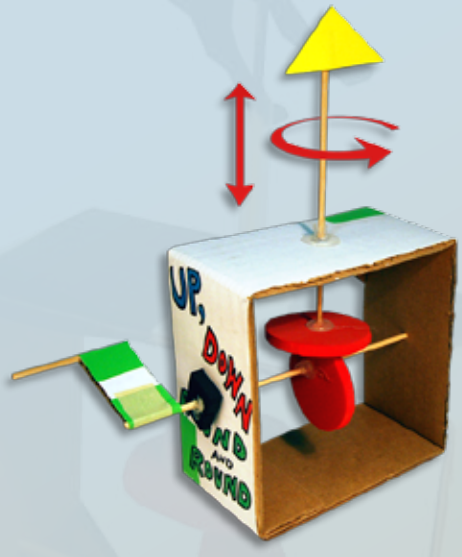


Cut triangles out of the
flaps and tape them into each
corner of the frame for support.

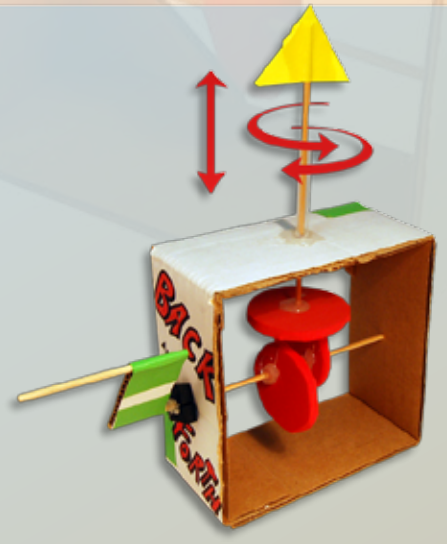


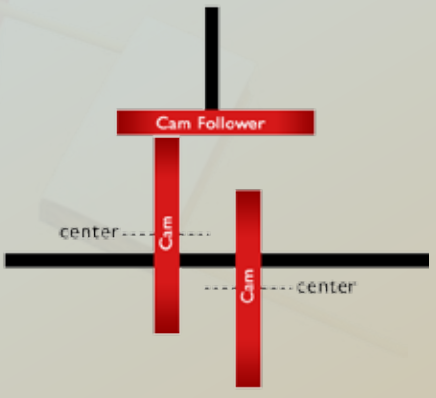
Choose a Motion

Round and Round



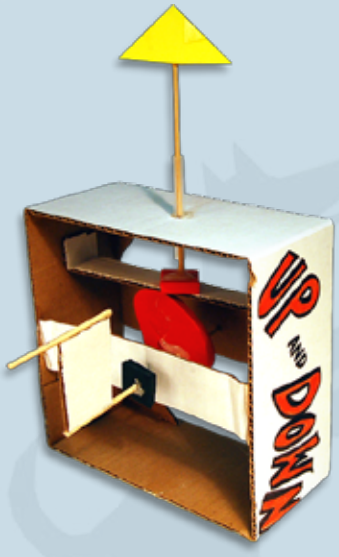
Up and Down, Round and Round

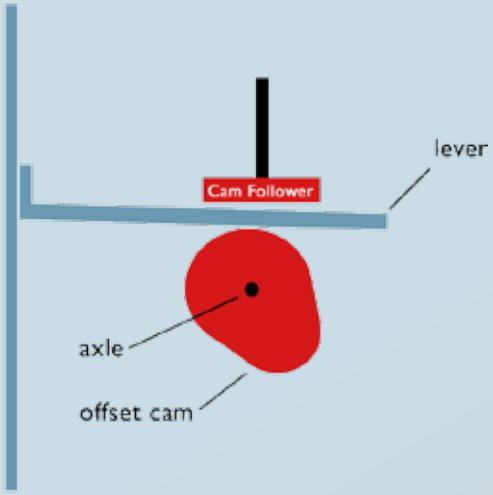




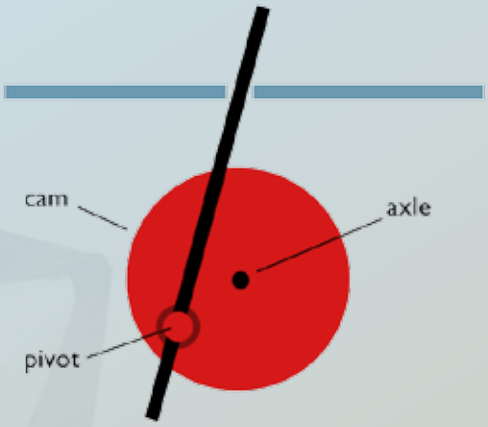
Up and Down, Back and Forth

More Options





Up and Down



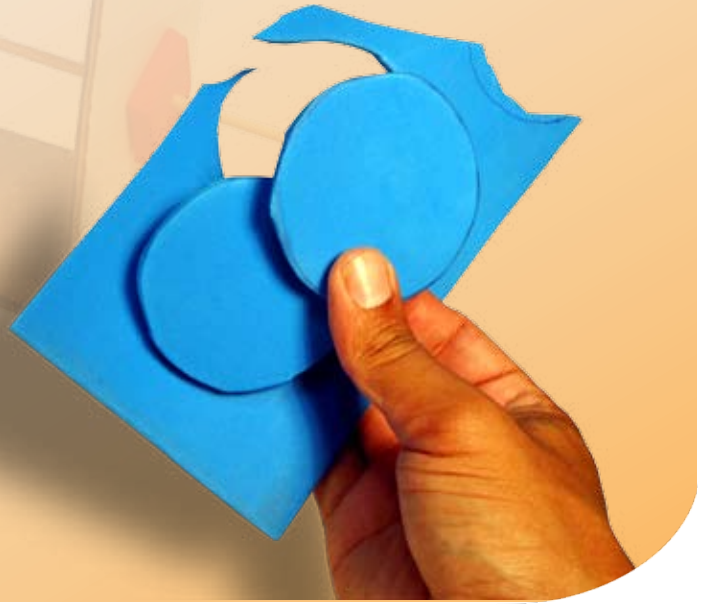
Side to Side

MAKE THE CAMS

Draw your cam and cam follower on the thick Foamie sheet, and cut them out.

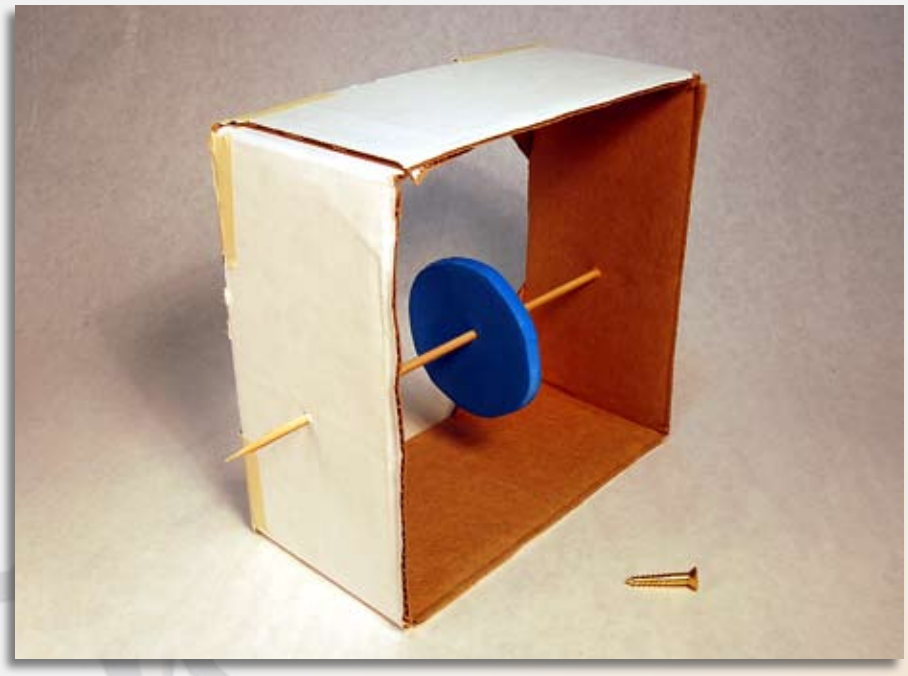
The cam should be about 2.5” (6cm) in diameter.

Tip: Cut the cams smoothly, and make sure the cam follower is a little bigger than the cam.

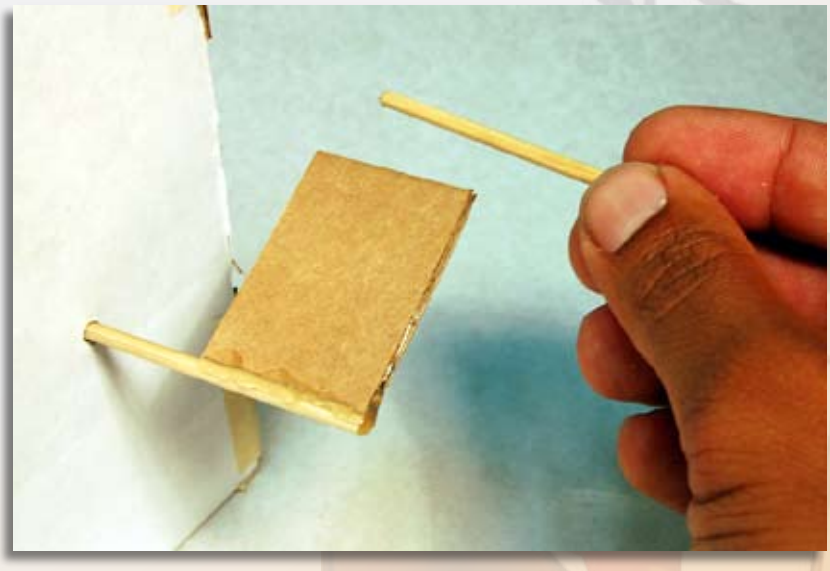


Make the Axle

Put your cam on a skewer stick inside the frame.



Tip: Start the holes in the frame using a nail or screw, and make sure the cam clears the top and bottom of the frame.



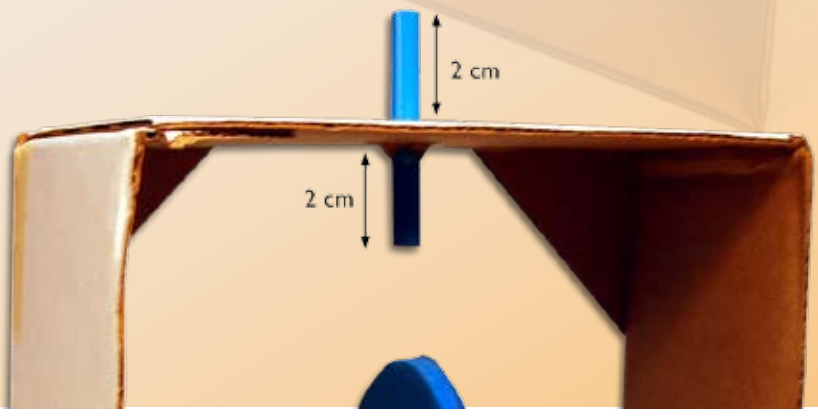
Make the Handle

Glue a small rectangle cut from the cardboard box flap to the skewer stick axle.

Glue a second piece of skewer stick to the end of the rectangle to make a handle.

Add the Cam Follower

Poke a hole in the top of the frame where you want your cam follower to be located, and insert a drinking straw. Carefully glue the drinking straw in place.



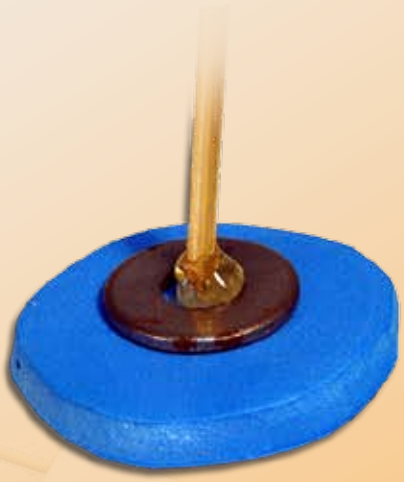
Tip: Use a pencil to make the hole large enough for the drinking straw.

Glue your cam follower on the end of a skewer stick and put it through the straw.

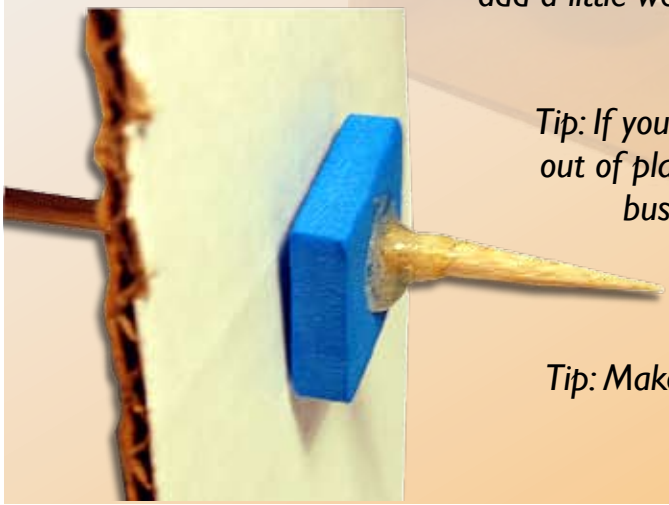
Tip: The straw will keep the skewer stick from falling over.

Test it!

Adjust your cam under the cam follower until you get the motion you like, then GLUE the cam into place on the skewer stick axle.



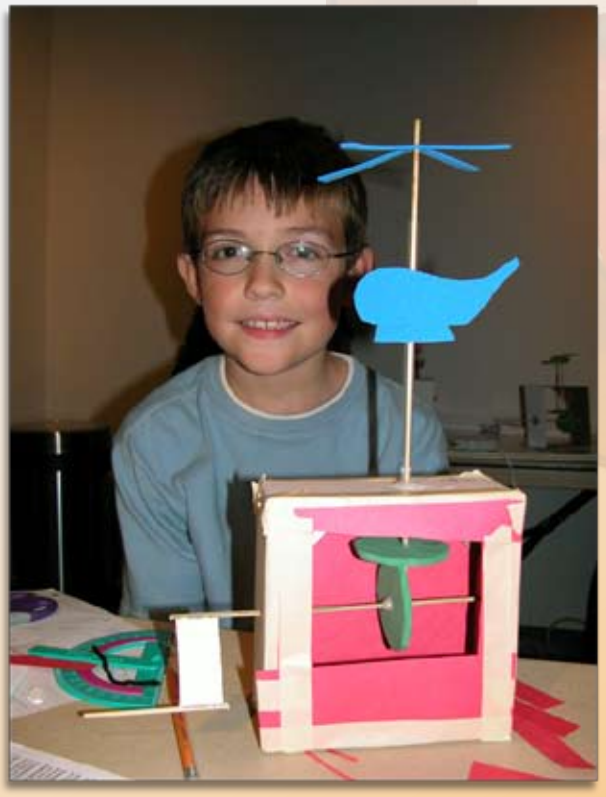
Tip: If the cam follower does not fall on the cam, attach a washer or nut to add a little weight.



Tip: If your cam and axle move out of place, add a small bushing made from a scrap piece of a thick Foamie.

Tip: Make sure to glue the bushing to the axle and NOT to the frame.

DECORATE YOUR AUTOMATA

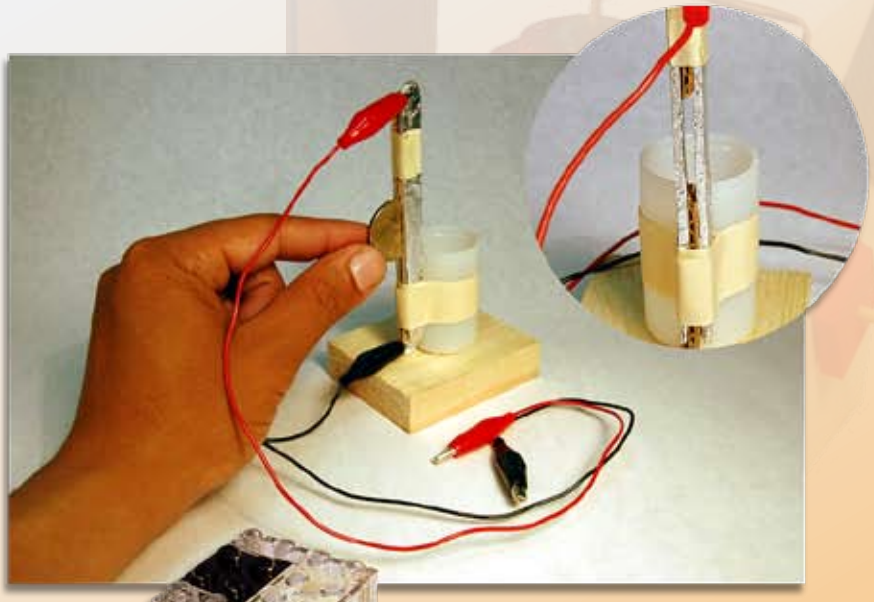


TAKING IT FURTHER

You can build automata out of a variety of everyday materials.

MAKE YOUR AUTOMATA COIN OPERATED:

Make a coin detector switch from three popsicle sticks, aluminum foil, masking tape, and a PicoCricket resistance sensor.
www.picocricket.com



Program a PicoCricket to send power to a LEGO motor when it detects a coin completing the circuit in a coin detector.

The skewer stick axle fits nicely into a LEGO motor.

WHY IS THIS A PLAYFUL AND INVENTIVE EXPLORATION?

• A playful and inventive approach to learning simple machines

This is a playful and inventive way of exploring levers, cams, cam followers, linkages, and other mechanisms.

• Science and art connections

Cardboard Automata are a good example of integrating science and art into an activity. For learners, the narrative, decorated aspects of the automata are as important as the mechanical elements.

• Connections to other activities and the real world

This activity is a good introduction to a variety of mechanisms and systems found in other PIE activities, and in the real world.

PBS KIDS GO!

DESIGN squad Nation

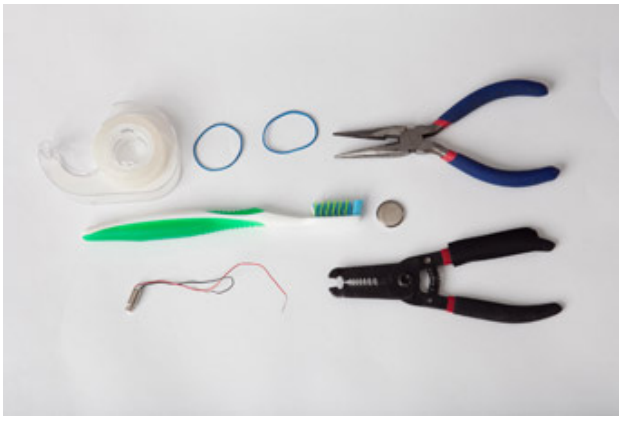
Dream It. Build It. Live It.
pbskids.org/designsquadnation

Bristle Bot

1

Here's what you need to build your own Bristle Bot!

- 1 pager motor with two wires (1-volt to 3-volt motor) No pager motor? Buy one at an electronics store or remove one from a broken electronic device that buzzes or vibrates (e.g., cell phone, electric toothbrush, pager, etc.).
- 1 button cell battery (1 volt to 3 volt, to match the pager motor)
- 1 toothbrush with bristles set at an angle. No toothbrush with angled bristles? Put a book on top of a head with straight bristles. After a few minutes, the bristles will stay angled back.
- Pliers/wire cutter

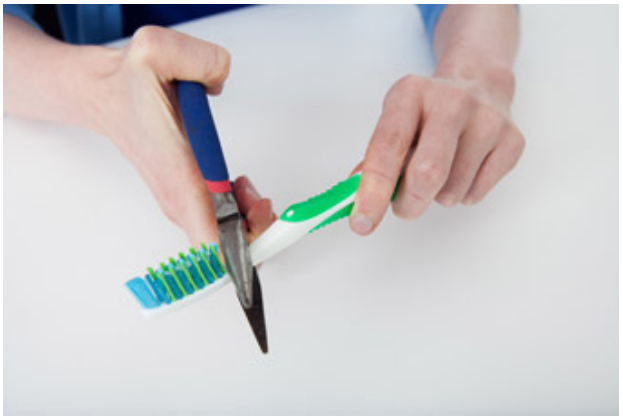


- Attachment materials (e.g., rubber band, twist-tie, zip-tie, tape, or double-stick foam tape)
- Wire stripper (optional)

2

Cut off the toothbrush head

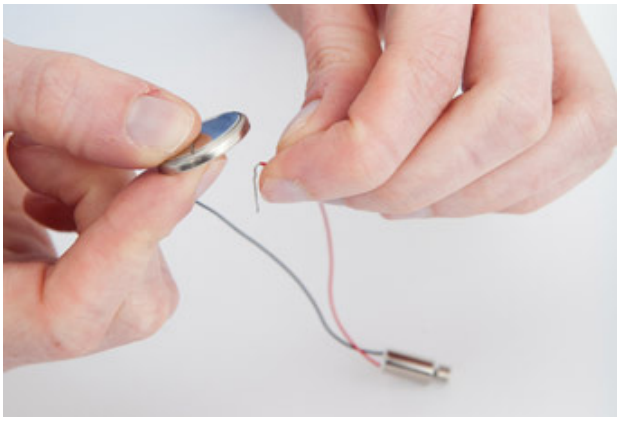
- Snip off the head, using pliers or wire cutters.
- Cut the handle close to the bristles.



3

Test the battery and motor

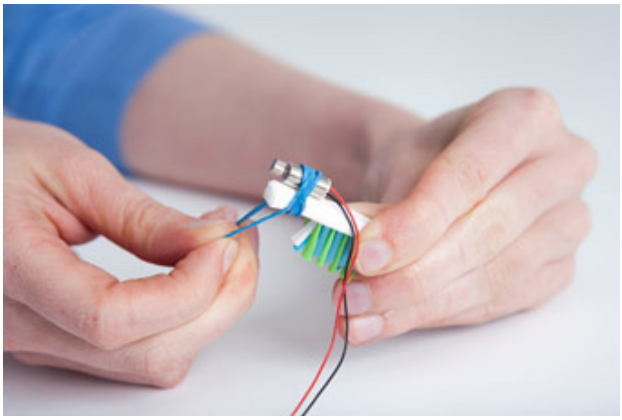
- Strip the end of the pager motor's wires so about half an inch of the metal wire shows.
- Touch one wire to the top of the battery and the other wire to the bottom.
- The motor should spin vigorously.



4

Attach the motor

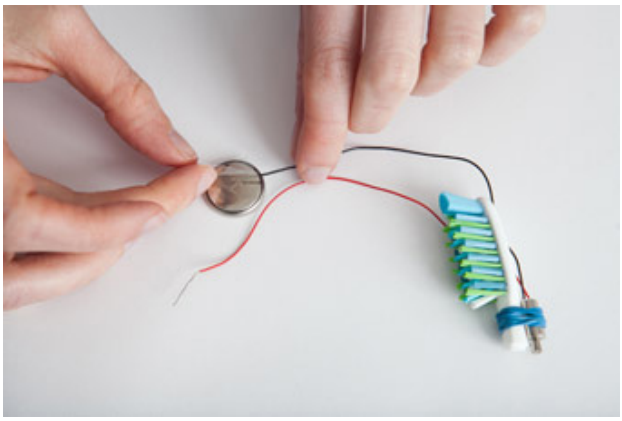
- Fasten the motor firmly to the top of the toothbrush head.
- Use a rubber band, twist-tie, zip-tie, or piece of tape or double-stick foam tape.
- Make sure the weight can spin without hitting the toothbrush.



5

Connect one wire

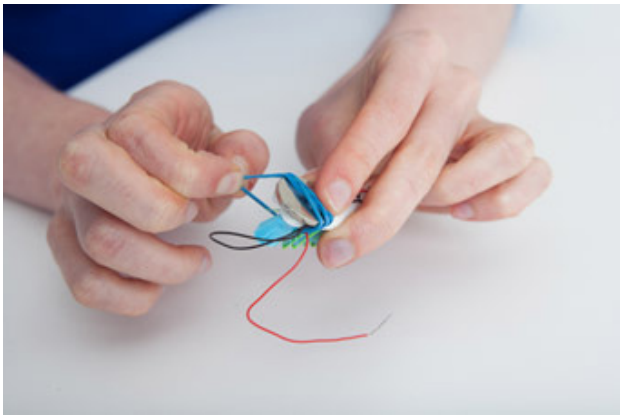
Tape one of the motor's wires to one side of the battery.



6

Attach the battery

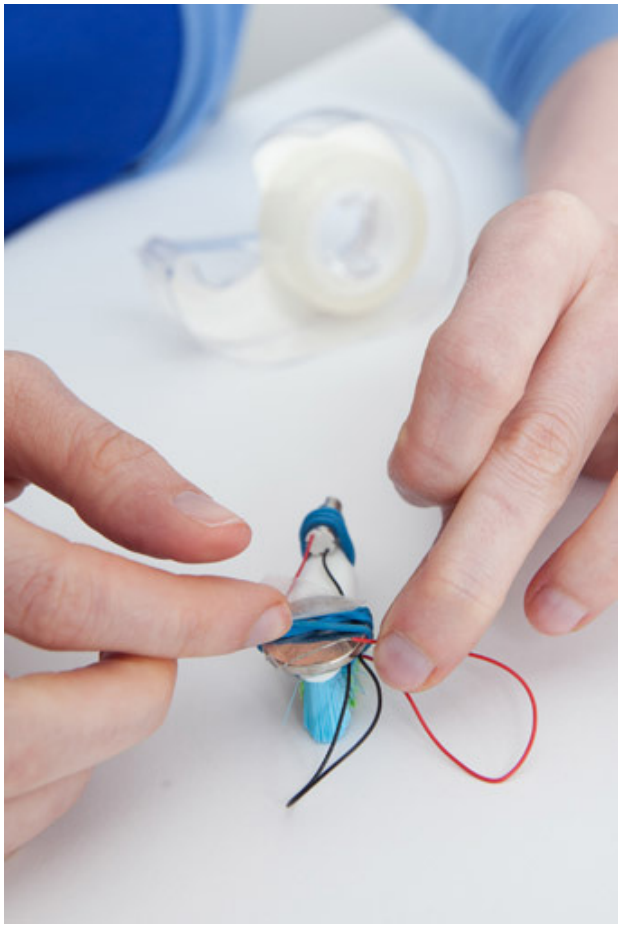
- Fasten the battery firmly to the top of the toothbrush, so the wire is on the bottom.
- Use a rubber band, twist-tie, zip-tie, or piece of tape or double-stick foam tape.



7

Connect the second wire

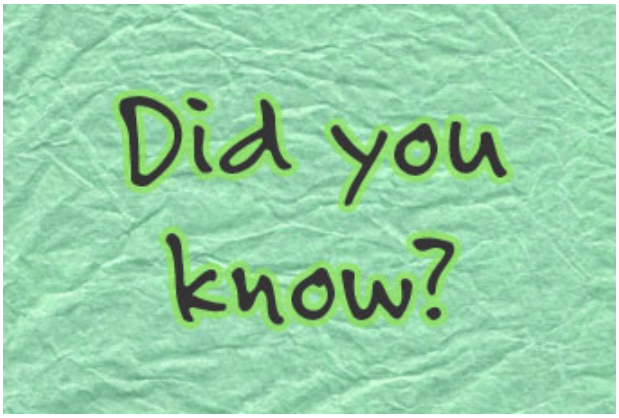
- Connect the second wire so it stays in contact with the top side of the battery.
- Not moving? Make sure the bristles are angled. The Bot moves in the direction that the bristles lean.
- Spinning or not going straight? Shift the weight. The position of the motor and battery affects how the bristles touch the surface. Move the battery and motor to put weight evenly on all the bristles.



8

Did you know?

A Bristle Bot is a lot like a Pogo Stick. For example, you bounce up and down on a Pogo Stick. The pager motor does the same thing with the toothbrush head—it bounces it up and down. To move forward on a Pogo Stick, you tilt it forward while bouncing. Similarly the Bot's bristles all tilt. Because the pager motor bounces the Bot up and down on the tilted bristles, the Bot scoots forward.



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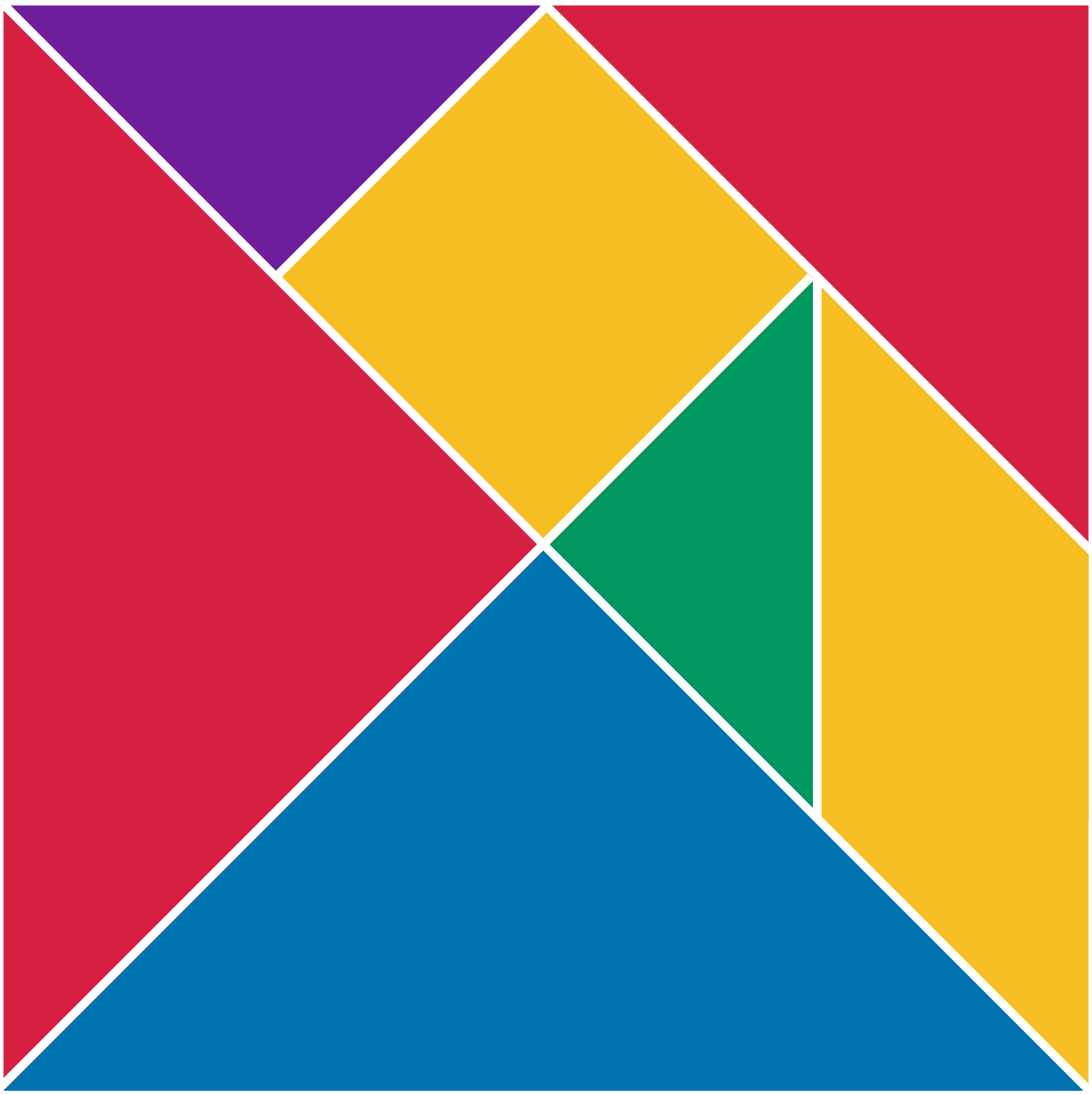
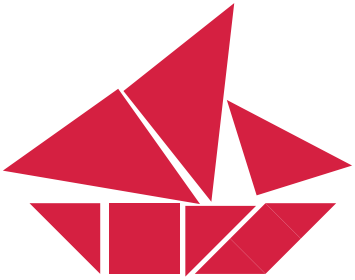
Tangram Grid

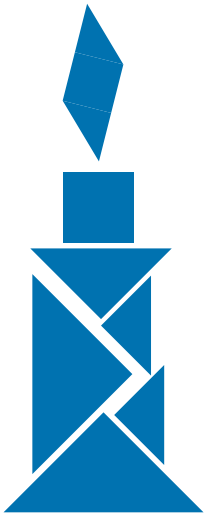


Tangram solutions

These are the solutions for the objects on the previous page. What other objects can you make?



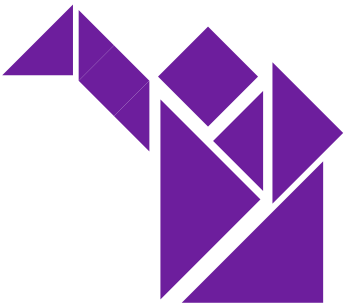
sailboat



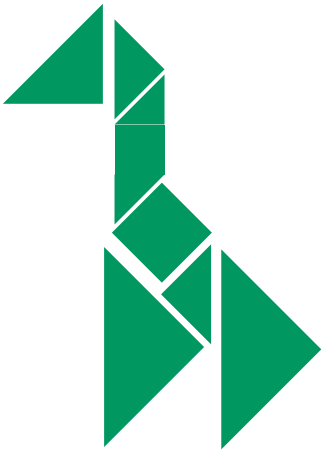
candle

rooster

shirt

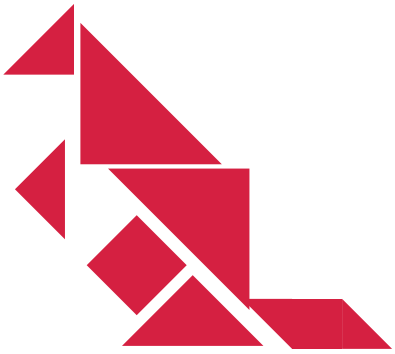


watering can

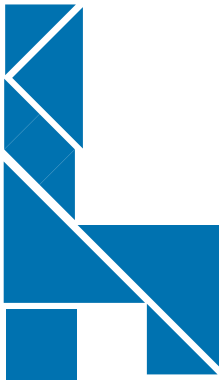


horse

boot



kangaroo



chair