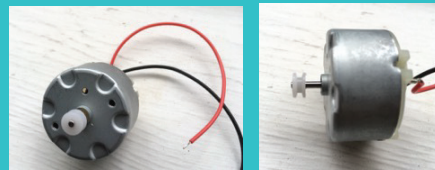


Make a **CARDBOARD FROG ROBOT**

MATERIALS

- Cardboard (Elmer's tri-fold display board measuring 22" W x 14" H was used for this example)
- Mini craft sticks
- Cooking skewers or dowel sticks (1/8" diameter)
- Mini duct tape
- Masking tape (optional)
- Electrical tape
- Soldering iron (optional, connecting the wires with electrical tape can be used as an alternative.)
- Googly eyes (23mm)
- Pony beads (optional)
- Rubber bands (1.75" or 1/5" diameter with 5-7 mm Motor Pulley. 1" rubber band with 16mm motor pulley)
- Acrylic paint (green)
- Small cup or bowl to hold paint
- Low-speed, high-torque DC motor (the following motor was used for this demonstration:
<https://www.homesciencetools.com/product/dc-electric-motor-low-speed/>



- Small motor pulley
https://www.amazon.com/gp/product/B00KHV0VN8/ref=oh_aui_detailpage_o00_s00?ie=UTF8&psc=1
- Mini rocker switch
- 9v battery connector with leads (Pangda I Type Long Cable Connection Hard Shell Black Red 9v Battery Clip Connector was used for this example)
- 9v battery
- Super glue
- Rubber gloves (optional)

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EXPERIMENTS

BEST FOR
Grades
4-12

Make a **CARDBOARD FROG ROBOT** (CONT.)

TOOLS

- Ruler (with centimeters and inches, clear plastic)
- Pencil
- Marker (optional)
- Compass
- American quarter (25¢ coin, optional)
- Glue gun
- Glue sticks for glue gun
- Drill with the following bit sizes: 1/16, 5/64, 3/32, 7/64, 1/8, 9/64, and 5/32
- Gimlets (3mm, 4mm, and 5mm)
- Nail
- Rubber Mallet or Hammer (optional)
- Block of Wood (optional)
- Utility scissors
- Box cutter or utility knife
- Handi-cut utility cutter (craftsman)
- Kobalt 8-in Home Repair Linesman Pliers (optional)
- Wire stripper and cutter
- Tiny paint brush
- Tweezers



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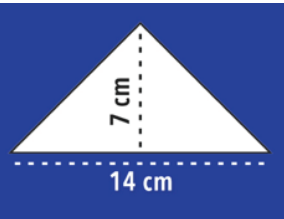


EXPERIMENTS

BEST FOR
Grades
4-12

Make a **CARDBOARD FROG ROBOT** (CONT.)

INSTRUCTIONS

PART 1: Prepare Frog Robot Parts

1. Draw and cut out four triangles from cardboard measuring 12 cm wide by 7 cm high. (Sides and Feet) I cut out one triangle and used it as a template to trace/draw four triangles of equal size and shape. Also, mark an "L" for "left" on the backs of two triangles and an "R" for "right" on the backs of the other two triangles. This will be useful in keeping things aligned when forming holes later on.
- 
2. Draw and cut out one rectangle from cardboard measuring 12 cm long by 7 cm wide. (Base)
 3. Using a compass, draw and cut out 2 circles from cardboard with a diameter of 6 cm each. (Outer sides for big cardboard pulley)
 4. Using the compass, draw and cut out one circle from cardboard with a diameter of 5.5 cm. (Inside middle of big pulley) Cover the outer perimeter of this inner pulley piece with a strip of mini duct tape. <https://youtu.be/2izbRRDDycl?t=1m10s>
 5. Using the compass, draw and cut out two circles from cardboard with a diameter of 2.5 cm each. Or trace an American quarter: 25¢ coin. (Eye supports)
 6. (Optional) Draw and cut out six little circles from cardboard with a diameter of 1.5 cm. (Inside and outer washers/spacers) *Form holes in circles before cutting them out* <https://youtu.be/2izbRRDDycl?t=1m33s>
 7. Cut 3 sticks (axles) from 1/8" cooking skewers/dowel sticks measuring 11.5 cm each. Then, with a pencil, draw two marks on each stick at 2.1 cm in from both ends. These marks will help keep things aligned when assembling the robot.
- 
8. Cut six short sticks from 1/8" cooking skewers/dowel sticks measuring 2.5 cm each <https://youtu.be/2izbRRDDycl?t=2m27s>
 9. Beginning at 2 cm from one end, mark two holes with a pencil in the middle of six mini craft/popsicle sticks spaced a 2 cm apart. <https://youtu.be/2izbRRDDycl?t=2m5s>
- 

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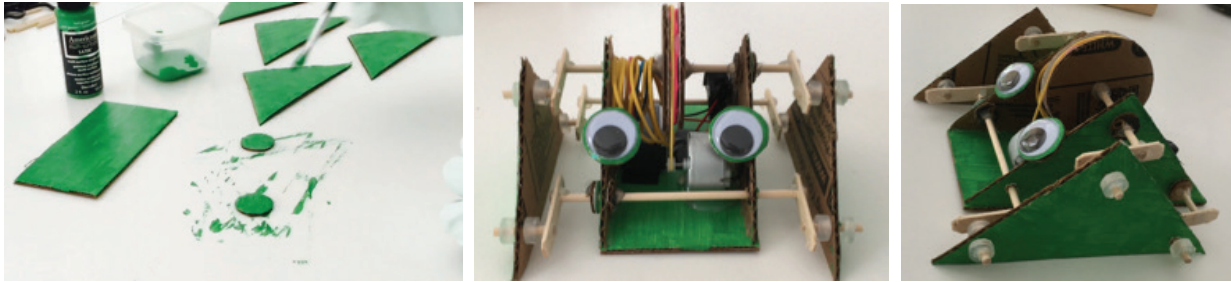
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INSTRUCTIONS (CONT.)

10. Paint any pieces where you wish to see color. I painted the top of the base, the outsides of each triangle, and the outsides of the eye supports.



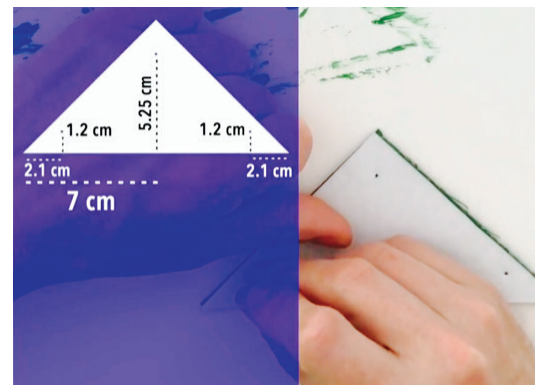
PART 2: Make the Holes

Triangle Holes

Begin by plotting holes on just one of the cardboard triangles. Once the holes are marked and formed, use the cardboard triangle as a template to mark the remaining three triangles. The quickest way to plot the initial three holes on a cardboard triangle is to print the provided SVG file containing a triangle with marked holes. Cut out the triangle from the printed SVG file to use as a template. Once it is aligned over the top of a cardboard triangle, poke the initial holes using a nail through the three plotted points on the template.

See video guide at <https://youtu.be/2izbRRDDycl?t=3m4s>




The goal is to get the size of each hole to be slightly bigger than the diameter of the skewer/dowel stick. This allows the top-middle stick/axle to rotate freely within the holes; and permits the bottom two holes of the feet-triangles to rotate freely around the front and back mini joint-axes. I like to start small and work my way up in size when forming holes so that I don't tear any of the cardboard. I started with a nail, then 3mm gimlet, and finally used the 5mm gimlet. The 5mm gimlet will provide the perfect size for each hole in the triangles.



To plot the holes yourself, without using the SVG file, measure 2.1 cm horizontally from the bottom left of the triangle, and then go 1.2 cm vertically to plot the first point. Next, measure 2.1 cm horizontally from the bottom-right of the triangle, and then go 1.2 cm vertically to plot the second point. Finally, measure 7 cm horizontally from either the bottom-left or bottom-right of the triangle (center), and then go 5.25 cm vertically from bottom-center to plot the third point.

See video guide at <https://youtu.be/2izbRRDDycl?t=3m17s>

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INSTRUCTIONS (CONT.)

TIP: I first plotted and formed my holes on one of the triangles marked "L." I used that triangle as a template for plotting holes on the other three triangles. Both triangles marked "L" were face-up when I traced with the "L" template triangle. Both triangles marked "R" were face-down when I traced holes using the "L" template triangle face-up. This helps keep the holes closely aligned on both sides so that the sticks/axles running through them are as straight as possible.

See video guide at <https://youtu.be/2izbRRDDycl?t=3m33s>



Pulley Holes

Form initial hole with nail and work your way up in size using the 3mm gimlet followed by the skewer, or dowel stick. Watch the video guide for more info: <https://youtu.be/2izbRRDDycl?t=4m3s>

Mini Craft Stick Holes

Start by drilling with the smallest drill bit (1/16) and work your way up in bit size. The goal is to get a hole the size of the 5/32 drill bit. Position the sticks on top of a wooden block when drilling. Try drilling through 3 sticks taped together with masking tape. It is difficult to drill the hole up to the desired size without splitting the stick. I often drill up to the 1/8 bit size and then gently form a bigger hole with the 4mm gimlet; followed by just the tip of the 5mm gimlet. Never force the gimlet when it meets resistance in the hole or the stick will split. Gently turn the gimlet back and forth, moving right and left as if taking great care to gently lock and unlock a door. Keep the clockwise motion sensitive to the resistance, working away at the wood a little bit at a time.



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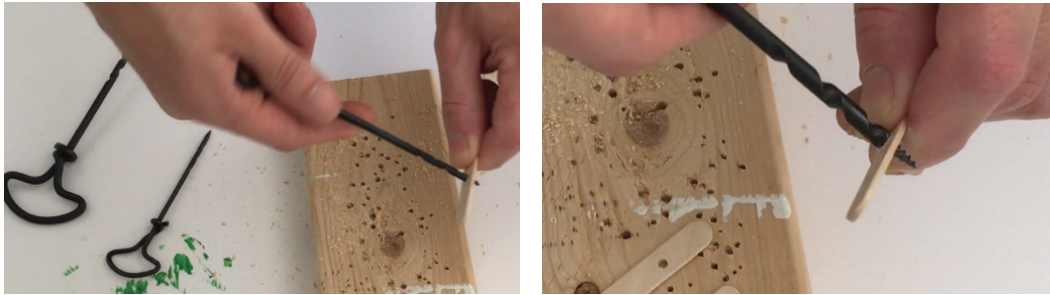
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INSTRUCTIONS (CONT.)

Mini Craft Stick Holes (cont.)



Work at forming the hole from both sides of the craft stick. These craft sticks are fragile with drill bits, so definitely have extras available because some will break.

See video guide at <https://youtu.be/2izbRRDDycl?t=4m58s>

PART 3: Glue Cardboard Pulley Circles Together

To align the cardboard circles when gluing together, place them on the skewer/dowel but do not glue them to the skewer/dowel stick yet. Start by gluing the inner pulley piece (5.5cm) to one of the outer pieces (6cm). I put the glue on the inner pulley piece when gluing it to the outer pieces.



See video guide at <https://youtu.be/2izbRRDDycl?t=4m18s>

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INSTRUCTIONS (CONT.)

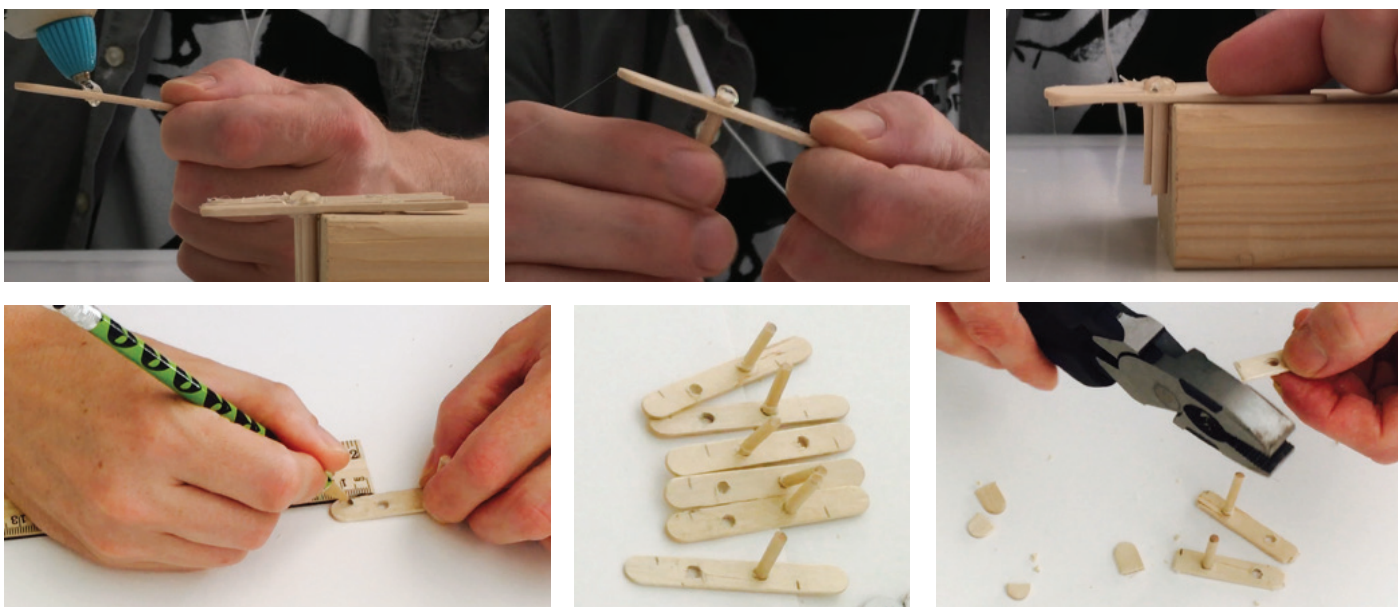
PART 4: Create the Joints

With the glue gun, put a drop of glue on top of the hole and insert the 2.5 cm stick from the bottom of the hole. Put the stick all the way through the hole, and then twist it back down into the hole so that it is almost flush with the upper rim of the hole. Try to keep the two parts in an "L" shape as they dry by placing on edge & side of wooden block; or at the edge & side of a tabletop. Once the initial glue dries, glue the other side of where the stick meets the hole to make the connection extra secure.

See video guide at <https://youtu.be/2izbRRDDycl?t=5m40s>

Next, draw a mark 8 mm away from the outer edges of each hole on the joints. Then cut at the 8mm marks, and clip the corners to make them more rounded.

See video guide at <https://youtu.be/2izbRRDDycl?t=6m5s>



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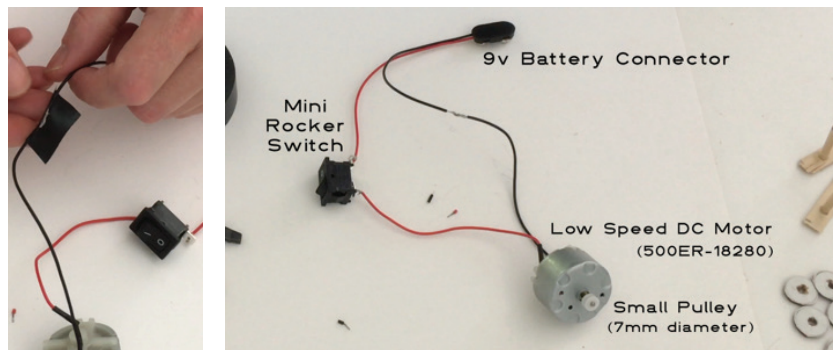
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INSTRUCTIONS (CONT.)

PART 5: Solder (or Tape) Motor Leads to Battery Connector & Switch

Strip the ends of each wire. Connect the positive (red) wire of the battery connector to the "O" (off) side of the mini on-off rocker switch. Connect the positive (red) wire of the motor to the "I" (on) side of the mini on-off rocker switch. Finally, connect the negative (black) wire of the battery connector to the negative (black) wire of the motor to complete the circuit. Secure the connections by either soldering or taping with electrical tape.

Watch the video guide for more info: <https://youtu.be/2izbRRDDycl?t=7m>

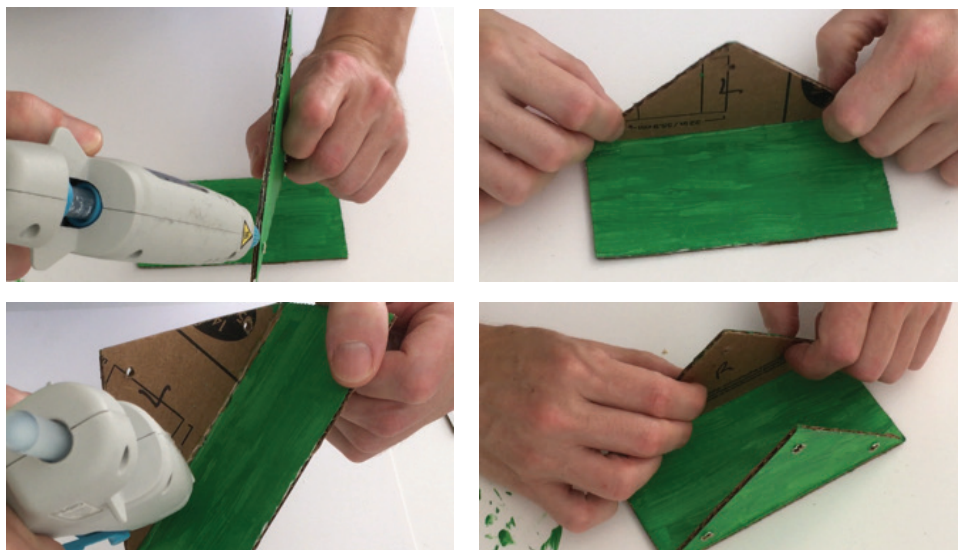


PART 6: Glue Sides to Base

Using the glue gun, apply glue to the bottom of one triangle and place it on top of the base so that it sits flush on the edge of the base. Hold triangle in place while glue dries.

Next, apply another line of glue where the inside bottom of the triangle meets the base.

See video guide at <https://youtu.be/2izbRRDDycl?t=6m28s>



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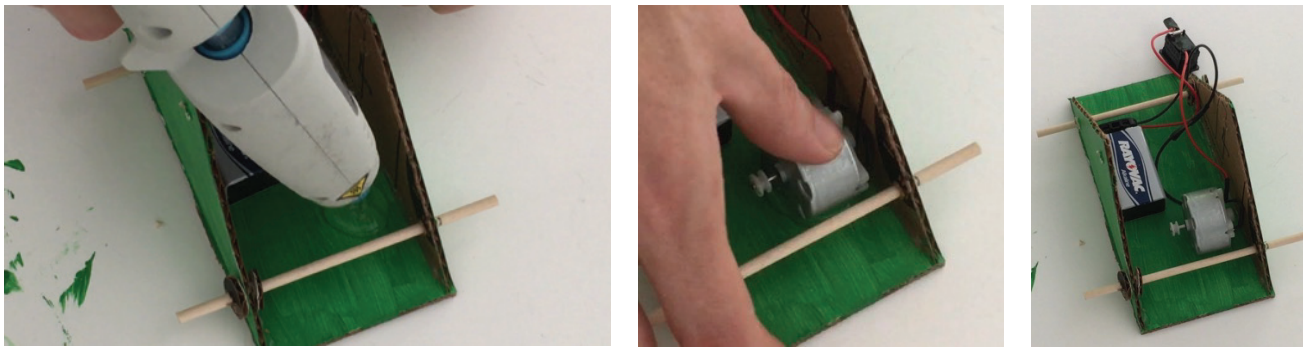
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INSTRUCTIONS (CONT.)

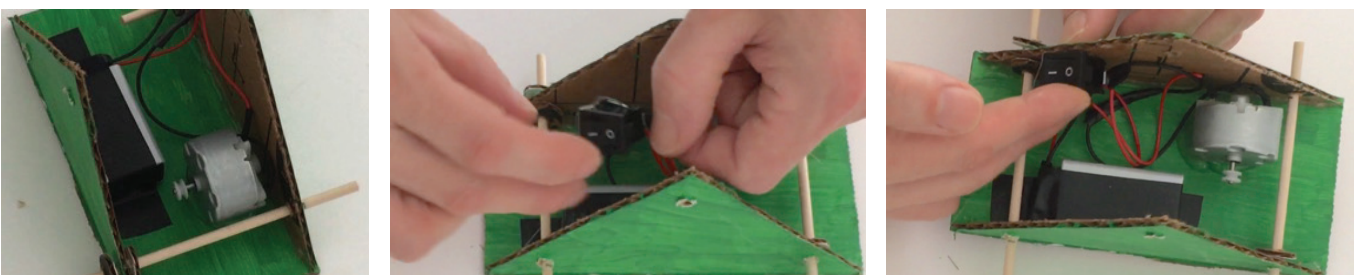
PART 7: Position Motor, Battery, and Switch

Insert the front and back axles before positioning the motor, battery, and switch. The motor is placed at the front-left with the switch on the back-left side. Make sure the motor does not touch the front axle before gluing in place. The battery will sit on the right side, between the back axle and the motor pulley.

Add a healthy portion of glue where the motor will sit. Place motor in glue. Apply pressure and hold in place while glue dries.



Tape the battery in position and add another healthy portion of glue to the bottom-right side of the motor (the side of motor facing the switch, or back of robot).



Put glue on the left side of switch. Position switch on back-left side of robot so that the switch is flush with the angle. Make sure the switch is placed high enough so that it is clear of the back-left washers. Apply pressure and hold in place while glue dries.

See video guide at <https://youtu.be/2izbRRDDycl?t=8m38s>

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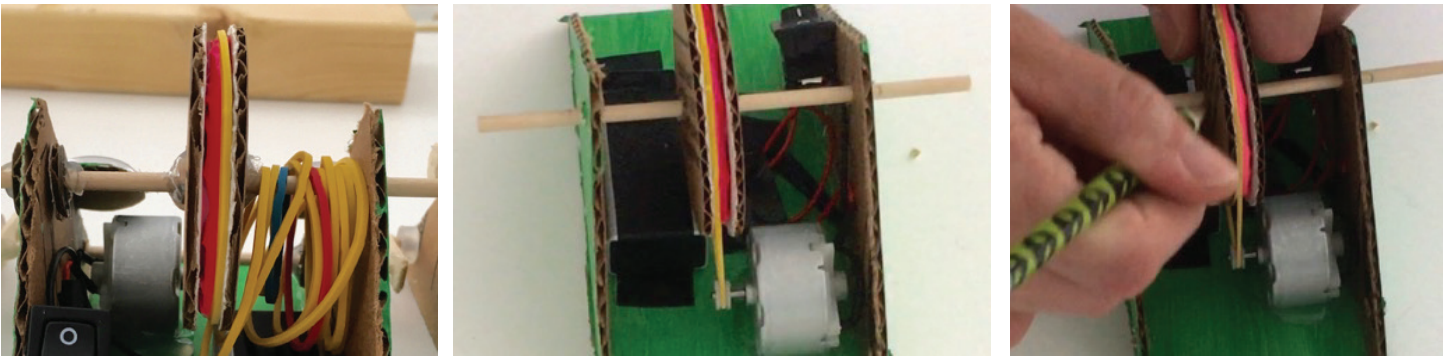
INSTRUCTIONS (CONT.)

PART 8: Align Cardboard Pulley with Motor Pulley

In preparation of gluing the cardboard pulley to the middle axle, wrap a rubber band around both the motor pulley and cardboard pulley. Position the cardboard pulley on the axle so that it is in direct alignment with the motor pulley. Be sure that the guides marked on the axle (Step 1, g.) are even on either side of the robot as the pulleys are aligned. Once pulleys are aligned, draw two marks on axle to plot the width and position of the cardboard pulley.

See video guide <https://youtu.be/2izbRRDDycl?t=8m52s>

Add rubber bands and the washer to the axle before gluing cardboard pulley to the axle. I added three 1", five 1.5", and five 1.75" rubber bands. It seems like a lot; however, the rubber bands will stretch and eventually break over time.



Use smaller rubber band with bigger pulley

16mm diameter pulley:
Use 1" rubber band



7mm diameter pulley:
Use 1.5" or 1.75" rubber band



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INSTRUCTIONS (CONT.)

PART 9: Glue Washers and Cardboard Pulley to Axles

Two washers are positioned on each axle: one outside and one inside the robot. This helps to keep all three axles in alignment. Both the middle and back axles have washers on the left side. The front axle has washers on the right side. Position the two washers on the axle so that they both slightly touch the outside and inside of the triangle. They should be able to rotate without rubbing too hard against the triangular side. Be sure the axle is even on both sides of the robot before gluing. Only glue the side of the washer that faces away from the triangle.

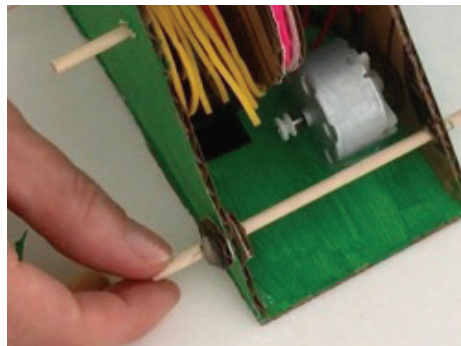
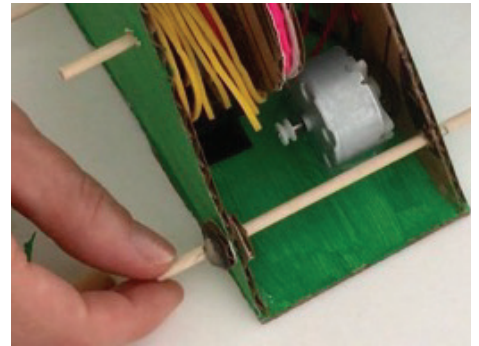
With the axle even on both sides of the robot, start by gluing the washers to the middle axle on the left side of the robot.

Double check the alignment of pulleys before gluing cardboard pulley to middle axle. Adjust position if needed. Glue the cardboard pulley on both sides where the pulley shaft meets the axle.

Glue washers on front and back axles.

See video guide at

<https://youtu.be/2izbRRDDycl?t=9m31s>



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INSTRUCTIONS (CONT.)

PART 10: Glue Joint to Axles

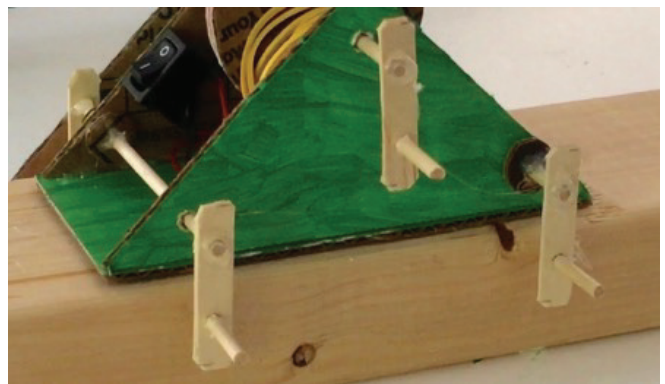
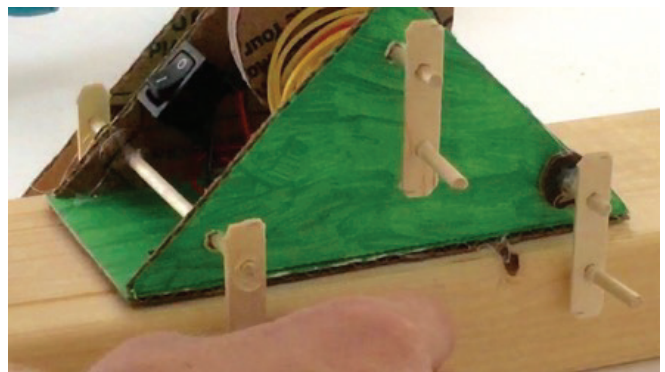
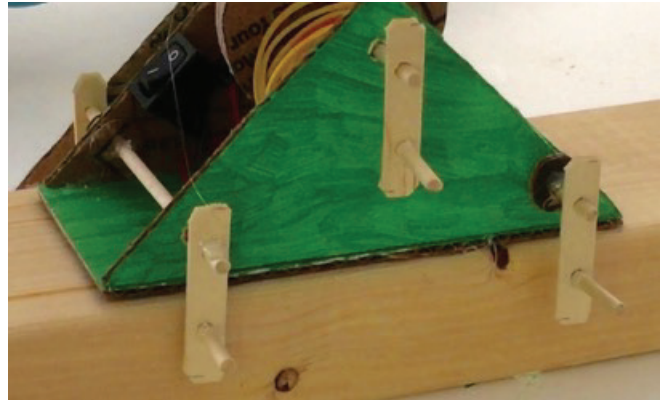
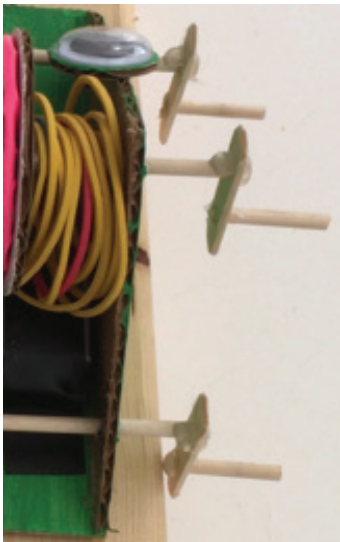
Attach joint to robot axle with joint being perpendicular to the robot; and mini-joint axle positioned below the robot axle; facing away from robot. Leave a little space from the axle's edge to apply a drop of glue. Once glue is applied to axle, rotate the joint; moving it towards the edge of the axle. Have the joint sit almost even with the edge of the robot axle. Be sure to have the glue dry with joint in original position; perpendicular to robot.

Once the initial glue dries, glue the other side of the joint where the axle meets the hole to make the connection extra secure.

Use a scrap piece of wood or small box as a lift so the joints cannot touch the surface when gluing. Having the joints hang off the edge of a table will work, too. Just be sure to glue all the joints in the same position on both sides of the robot.

See video guide at

<https://youtu.be/2izbRRDDycl?t=10m57s>



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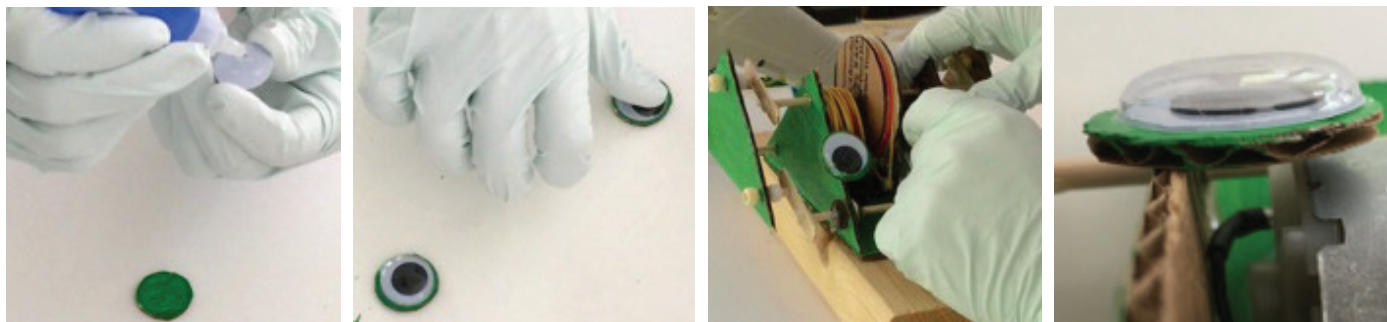
INSTRUCTIONS (CONT.)

PART 11: Glue Eyes

Add 3-5 drops of super glue to the bottom of the googly eye. Place googly eye with glue in the center of eye support. Hold and apply pressure while it dries.

Next, glue eyes to the robot. Apply super glue on the bottom of the eye support, a bit off-center, and place on the front perimeter of the triangle side. Hold in place while glue dries.

See video guide at <https://youtu.be/2izbRRDDycl?t=11m37s>

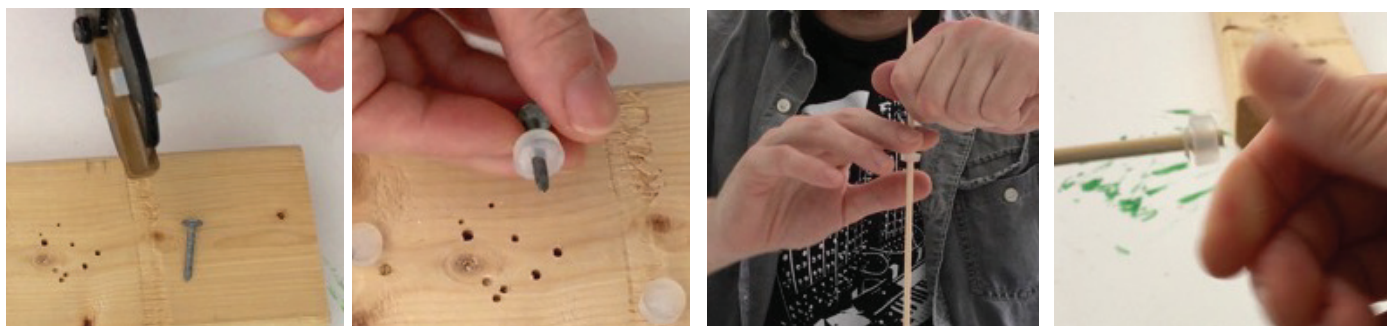


PART 12: Create 12 Stoppers/Washers from Glue Stick

Cut or slice 12 pieces from a glue stick, roughly 1/2 cm wide. Initiate a hole by forcing a nail through the center of the slice. Turn nail upside down with point facing up, and push the glue stick slice down into the nail with your thumbs on outer edges of slice.

Next, run a wooden skewer or dowel stick through the glue stick slice several times. Then rotate or twist the slice on and across the stick to remove pieces of glue from center.

See video guide at <https://youtu.be/2izbRRDDycl?t=12m15s>



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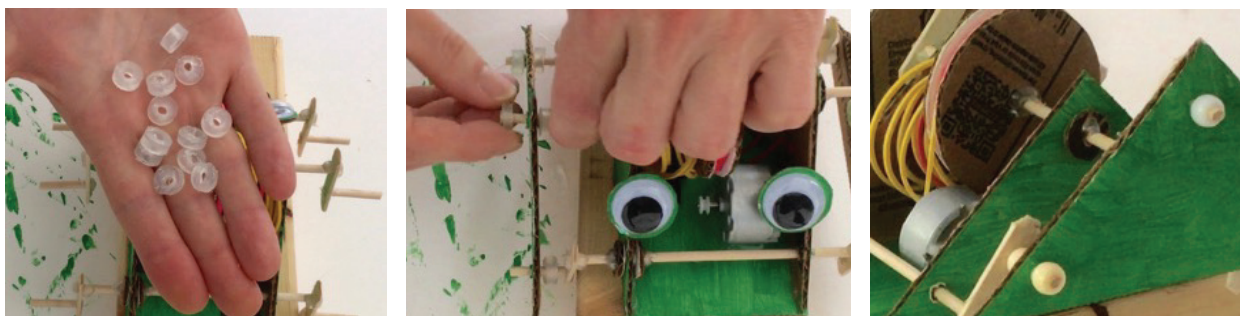
INSTRUCTIONS (CONT.)

PART 13: Attach Feet to Joints

Add a glue-stick washer to each little axle on the joint. Then attach the triangle foot, putting the little joint axles through each hole in triangle. Add a second glue-stick washer to each little axle on the outside of triangle to keep the foot straight and in place. Leave just a tiny bit of space between the triangle and washers.

See video guide at <https://youtu.be/2izbRRDDycl?t=11m37s>

Pony beads are an alternative to making the washers from glue sticks. Some pony beads fit the 1/8" dowel stick perfectly, while some are too loose. If they are a snug fit, I would highly recommend using the pony beads as an alternative.



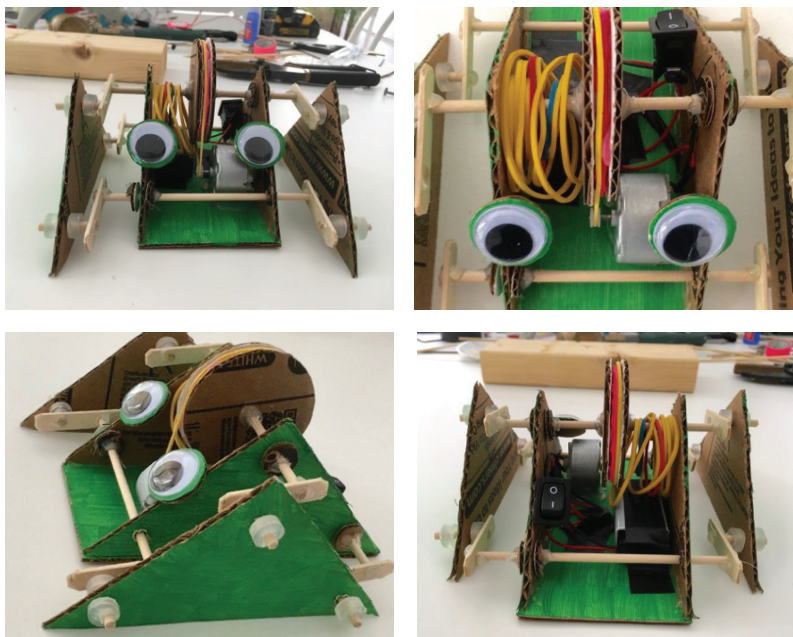
Attach the rubber band to both pulleys, flip the switch, and watch the robot do its thing!

Video Guide at

<https://youtu.be/2izbRRDDycl>

Instructable at

<https://www.instructables.com/id/How-to-Make-a-Cardboard-Frog-Robot/>



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