LED Pinwheels

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LED Pinwheels

External

Developed by Peter Musk, 2016.

Summary

This workshop was developed by Peter Musk.

This set of instructions details how to construct a pinwheel that uses a rubber band to drive a low-voltage generator. When the current produced is passed through a Joule Thief circuit, the energy from a freely moving pinwheel spinner is sufficient to make an LED glow (red, yellow and green LEDs require a lower voltage, and are more successful).

Materials

For Aluminium can spinner version:

- 2 aluminium beverage cans (of equal size)
- 4mm drip irrigation T- joiner

For Polypropylene spinner version:

- laser cut 0.16mm polypropylene spinner

For both versions:

- 3 x 40mm cardboard hubs
- 1 x Acrylic hub kit, which contains
  - 1 x 30mm acrylic spoked hub
  - 1 x 10mm acrylic pinwheel cap
  - 1 x 10mm etched motor shaft outer hub
  - 1 x 5mm motor shaft inner hub
- 100 - 150mm straight 2mm wire axle (galvanized is OK)
- 4mm rigid poly irrigation riser tube
- 30 - 40cm (approx) x 1cm diameter bamboo garden stake handle
- 1 x plastic or metal clothing press stud (in two parts)
- 1 x size 19 rubber band
- 1 x Mabuchi 300-EA low rpm electric motor
- Joule Thief circuit parts kit:
  - 1 x wound toroid (10 - 13mm diameter)
  - 1 x NPN transistor (2N3904 or equivalent)
  - 1 x 1k resistor
  - 1 LED (red, yellow or green)
  - Joule thief circuit template (paper on polypropylene) with laser cut mounting holes
- Joule Thief box (laser cut 3mm white cardboard)

Tools

For aluminium can spinner version:

- Clear plastic right angle set square
- Felt-tipped marking pen (fine)
- Sharp screw or nail

For both versions:

- Craft knife
- Scissors
- Hot glue gun and glue
- Wire assembly stand
- Wire strippers
- Side cutters
- Small pliers
- Ruler
- Source of briskly flowing air (eg:fan, hair drier, ventilation outlet)
- Battery drill with 2mm bit (if needed to create holes in handles)
- Pencil sharpener

Before you Start

Consider safety aspects before you begin. This activity is not suitable for children younger than 12 without close adult supervision.

Hot glue, sharp knives and small pieces are used.

Instructions

PART 1: Making a Spinner from Recycled Cans

When cut, aluminium cans have sharp edges, and participants need to be warned not to slide hands or fingers along them. This version may be unsuitable for the less dexterous

Step 1 : Preparing the material for the pinwheel

Begin by selecting and washing out a couple of intact aluminium cans.

They need to be the same size, and the fatter, the better.

Avoid narrow cans (such as some energy drinks) as they will not give you a large enough piece of material to make the pinwheel.

Holding a can firmly with one hand, use a craft knife to slice around the end.

Follow the line where the bottom of the can begins to curve - the object is to cut out a flat cylinder.

Keep your fingers clear of the blade. Start by pushing the point of the blade into the can downwards (you might need to rock it back and forth a bit to get started).

Continue using slow sawing strokes, pushing down and away as the blade slices through the metal. Rotate the can before beginning the next stroke.

Finish cutting with scissors to separate the end of the can.
Turn the can around, and cut off the other end in the same way.

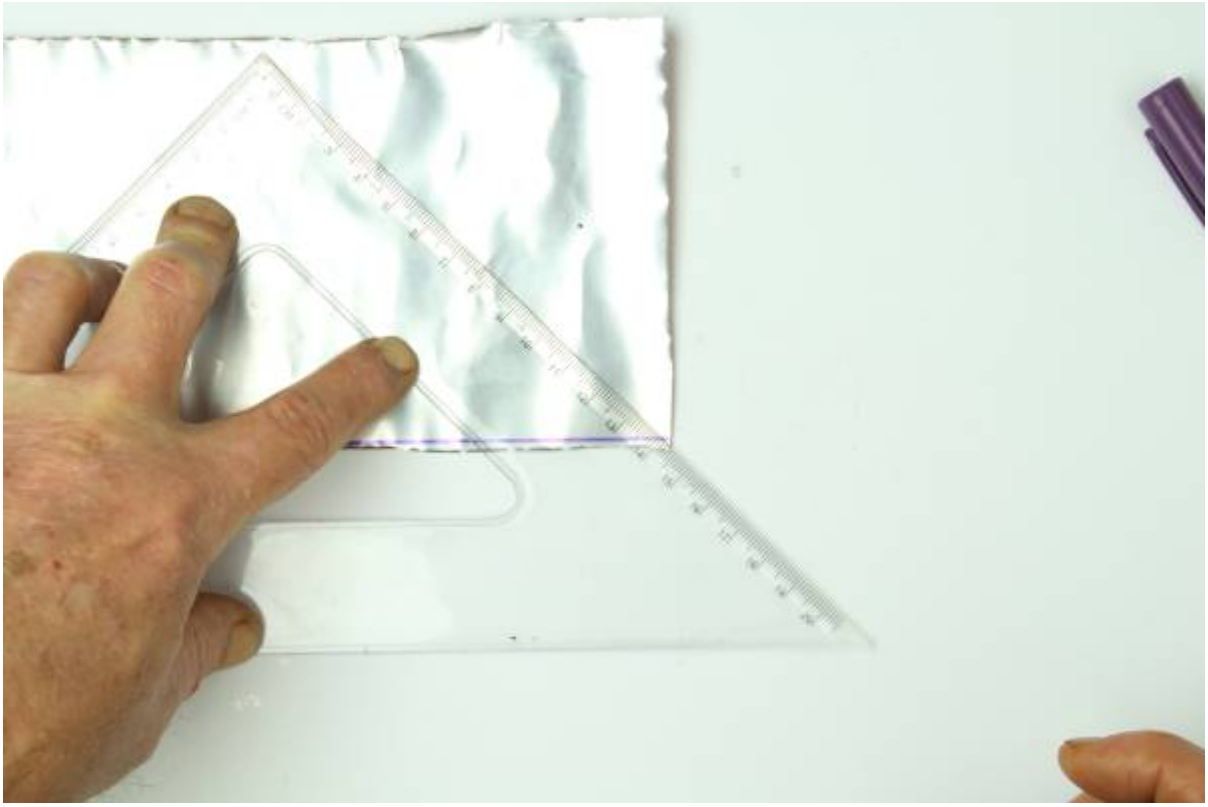
Use the scissors again to completely remove the top of the can.
Use the scissors to cut the remaining aluminium cylinder into curved sheet.

Find a line of text or the edge of an illustration to guide you to make a cut perpendicular to the ends of the opened can

Open the sheet of aluminium, and flatten it by bending gently against the curve.

Step 2: Marking out the Pinwheel

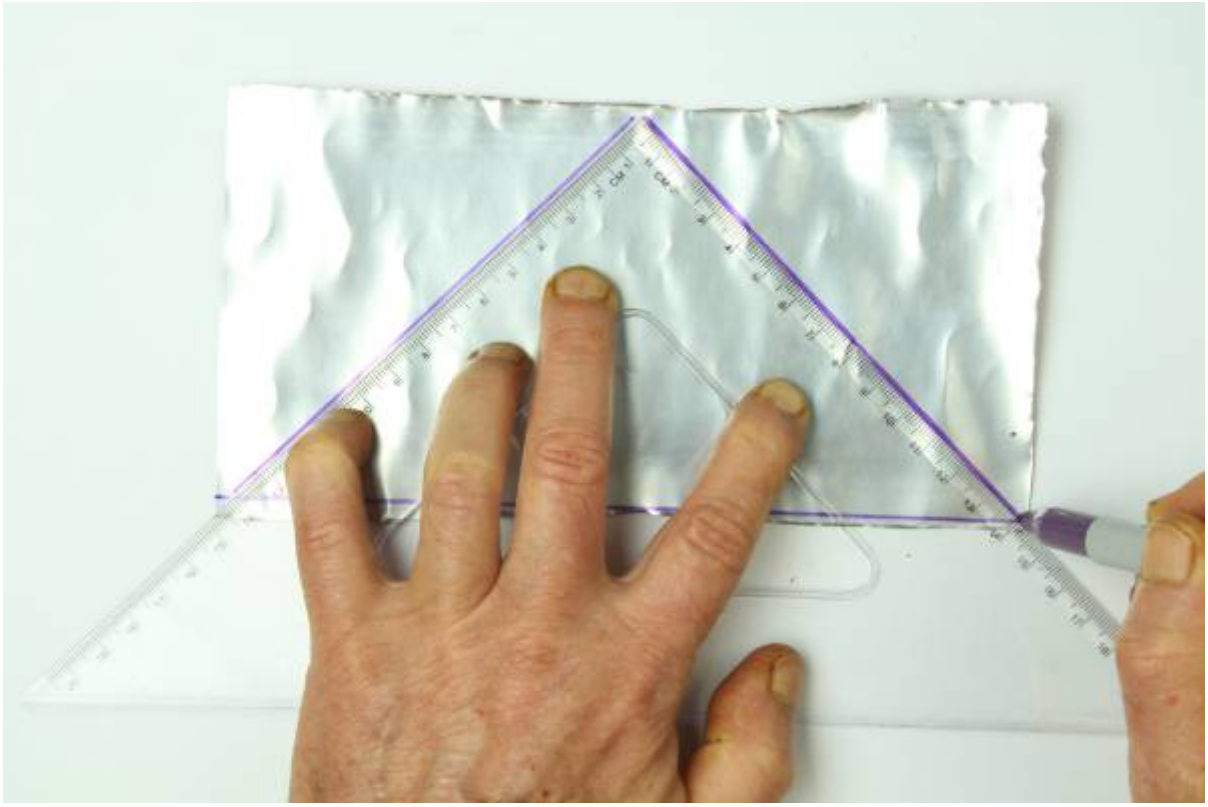
Turn over the sheet, and using a straight edge, mark a line along the long side about 5mm inside the ragged, cut edge.



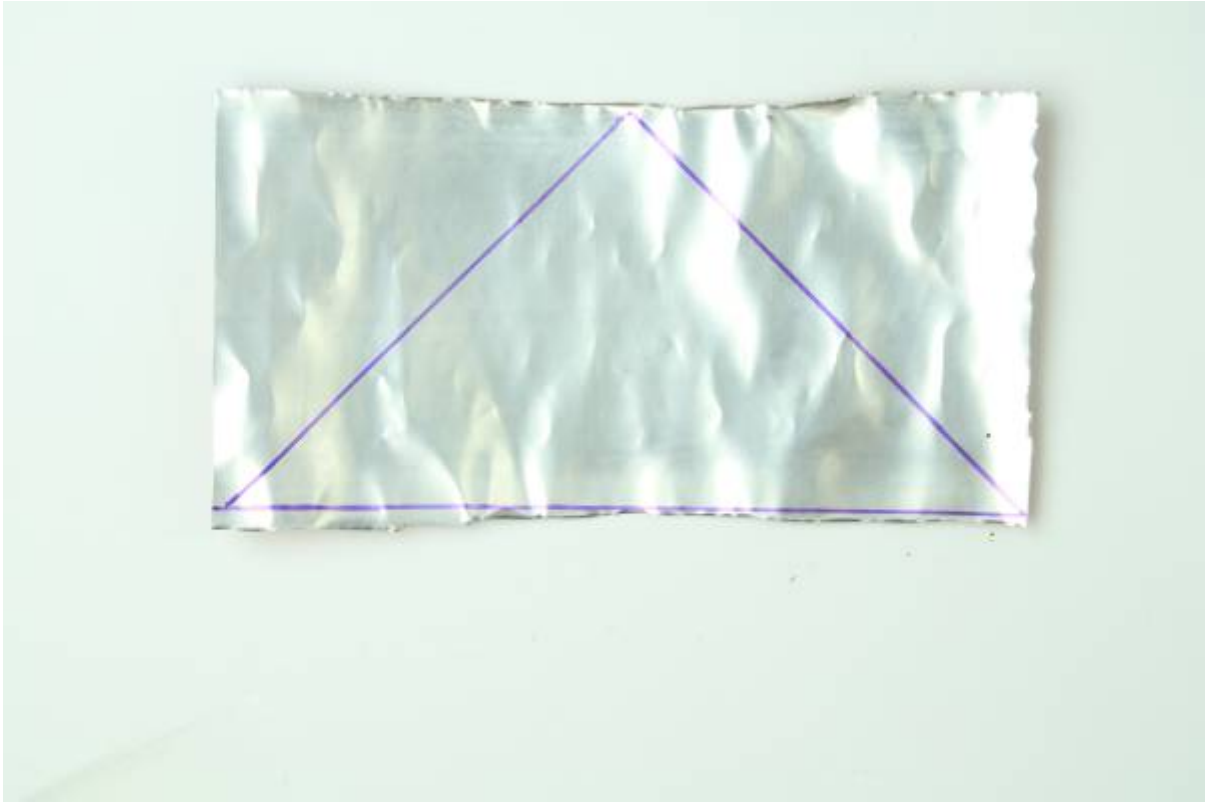
Place a right angled set square along the line, so that the point is close to the top edge.

Make sure the distance from the peak to the baseline on each side is the same.

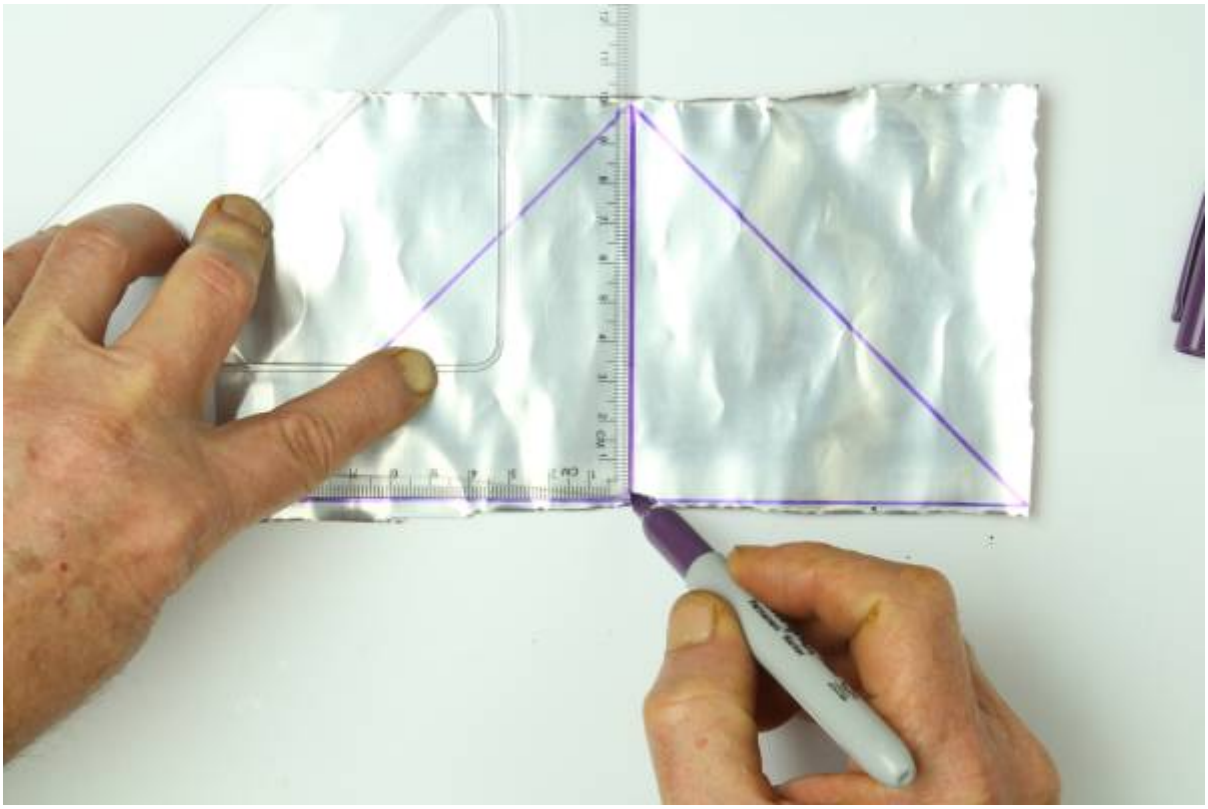
Use the scale on the sides of the set square to make sure the sides are equal



Draw a line around the set square using a marker

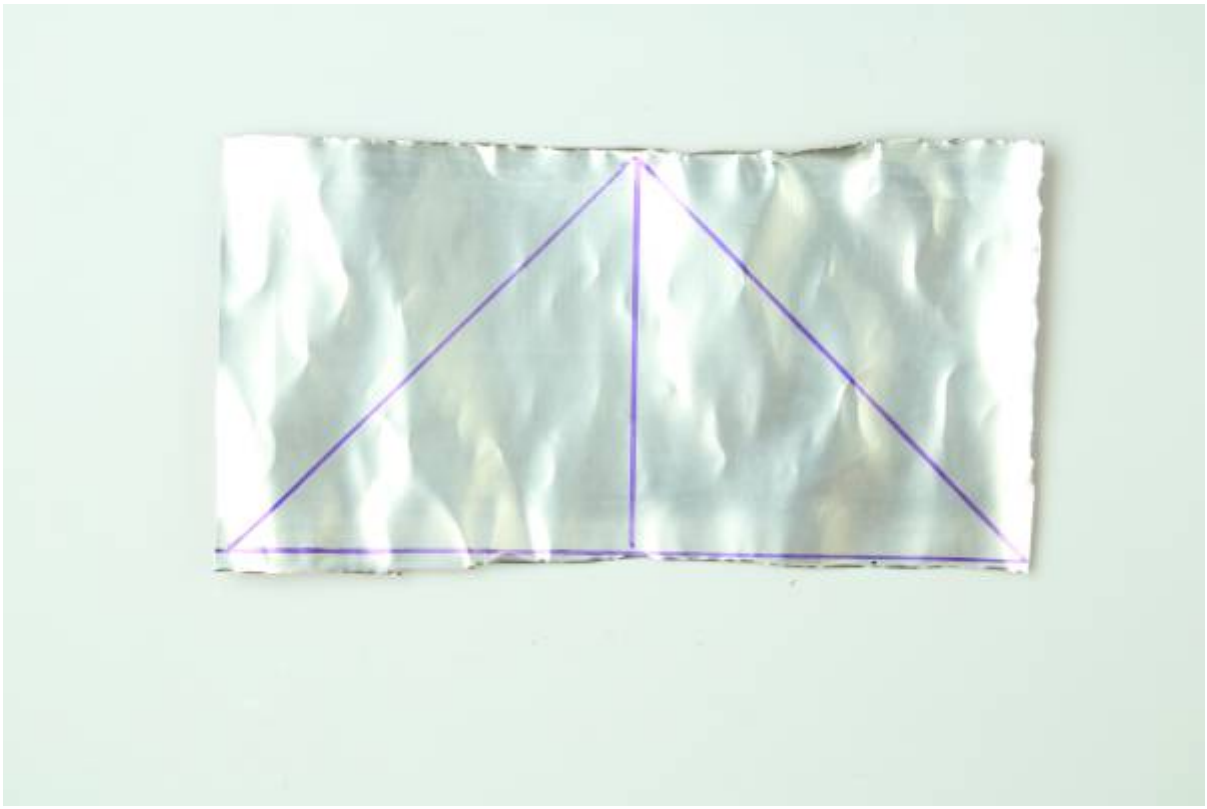


Check to see the line is complete, and touch up where necessary



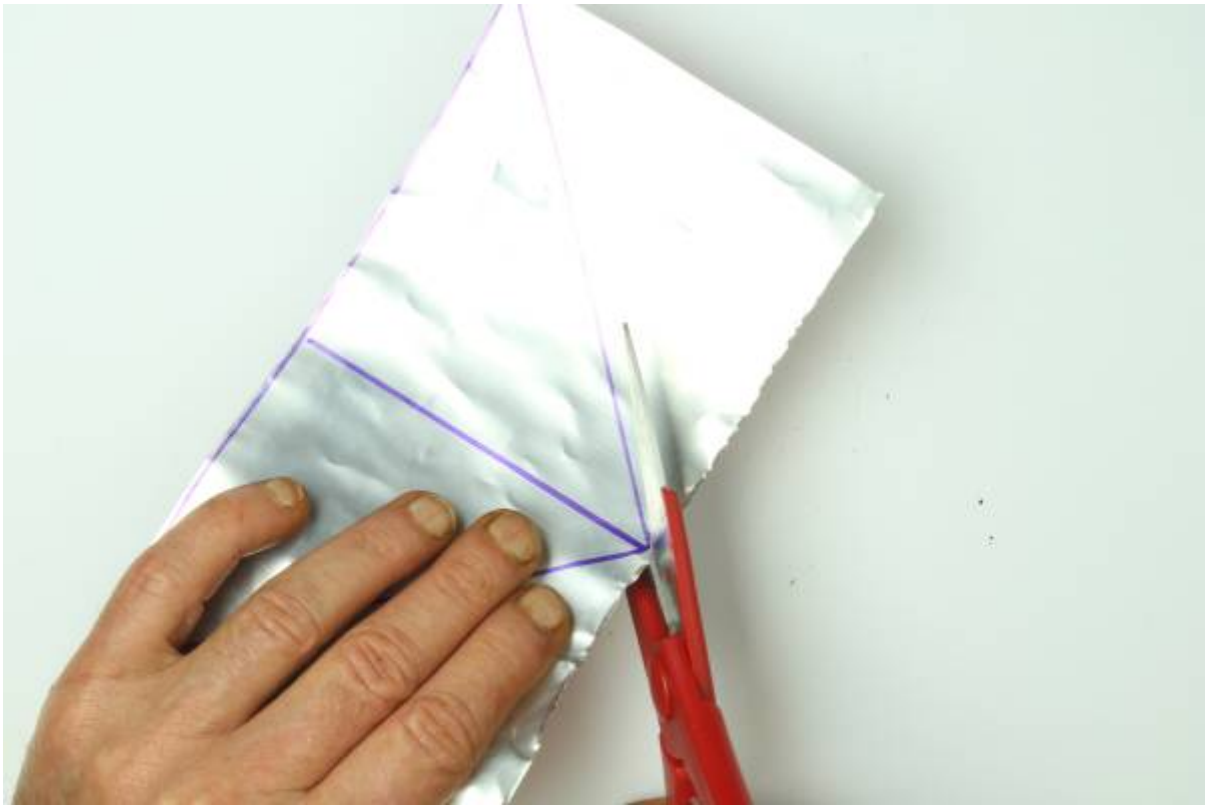
Place one side of the set square along the baseline, with the perpendicular passing through the peak of the triangle you have just drawn.

Now draw a perpendicular line from the point of the triangle drawn on the can down to the base



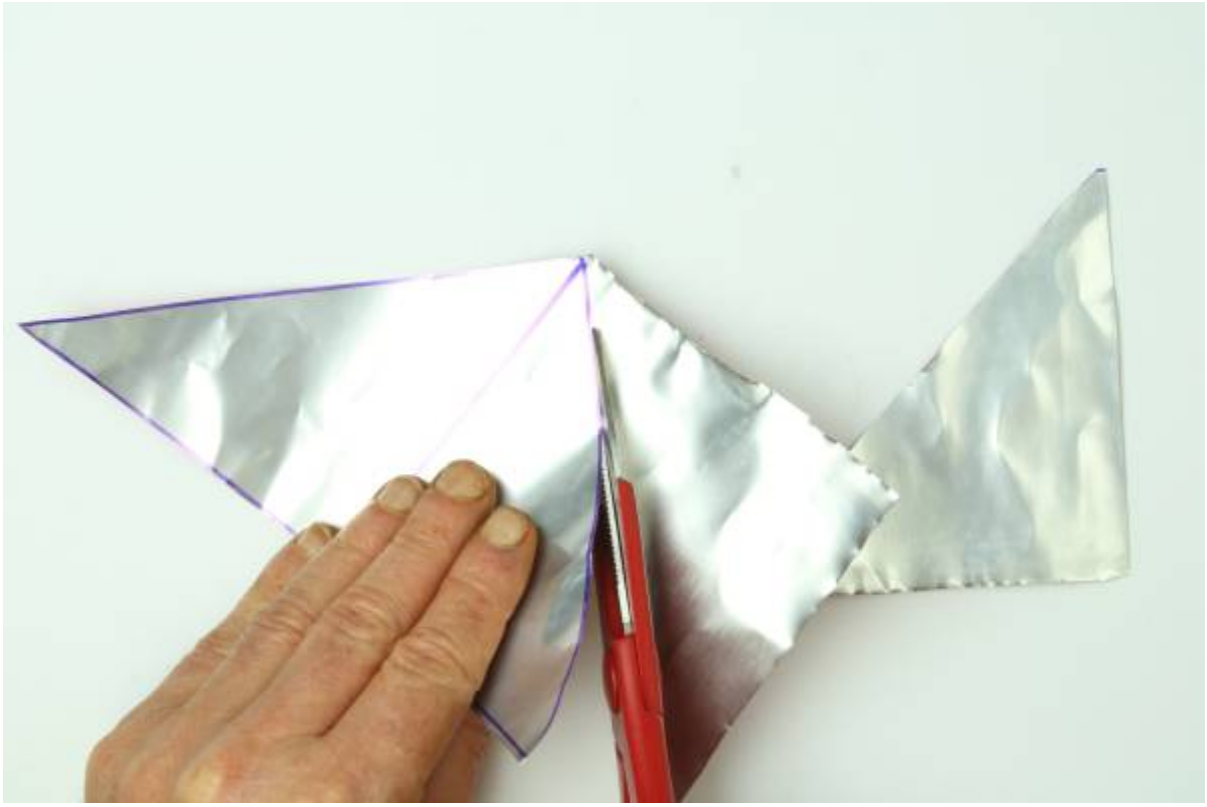
Your can should now look like this

Step 3: Trimming the material for joining

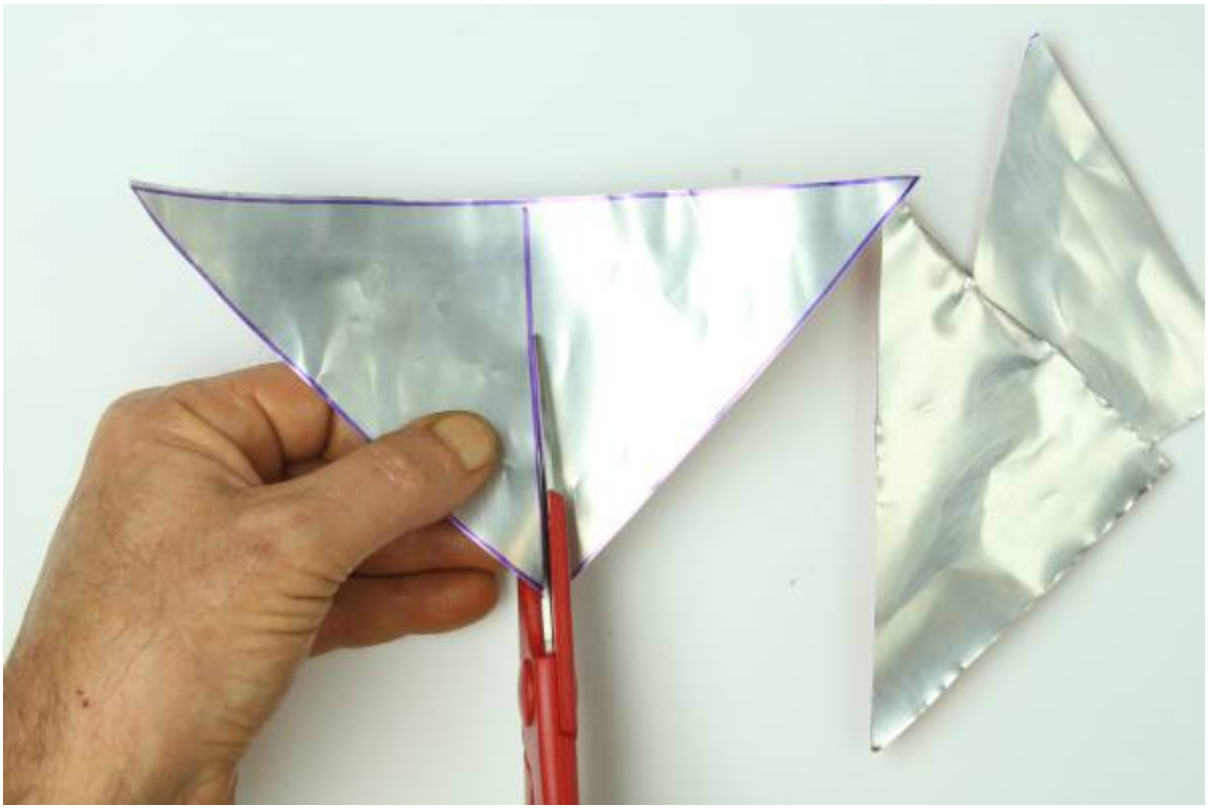


Use heavy scissors to cut along the sloping sides of the triangle drawn on the can.

Leave the excess material along the bottom.

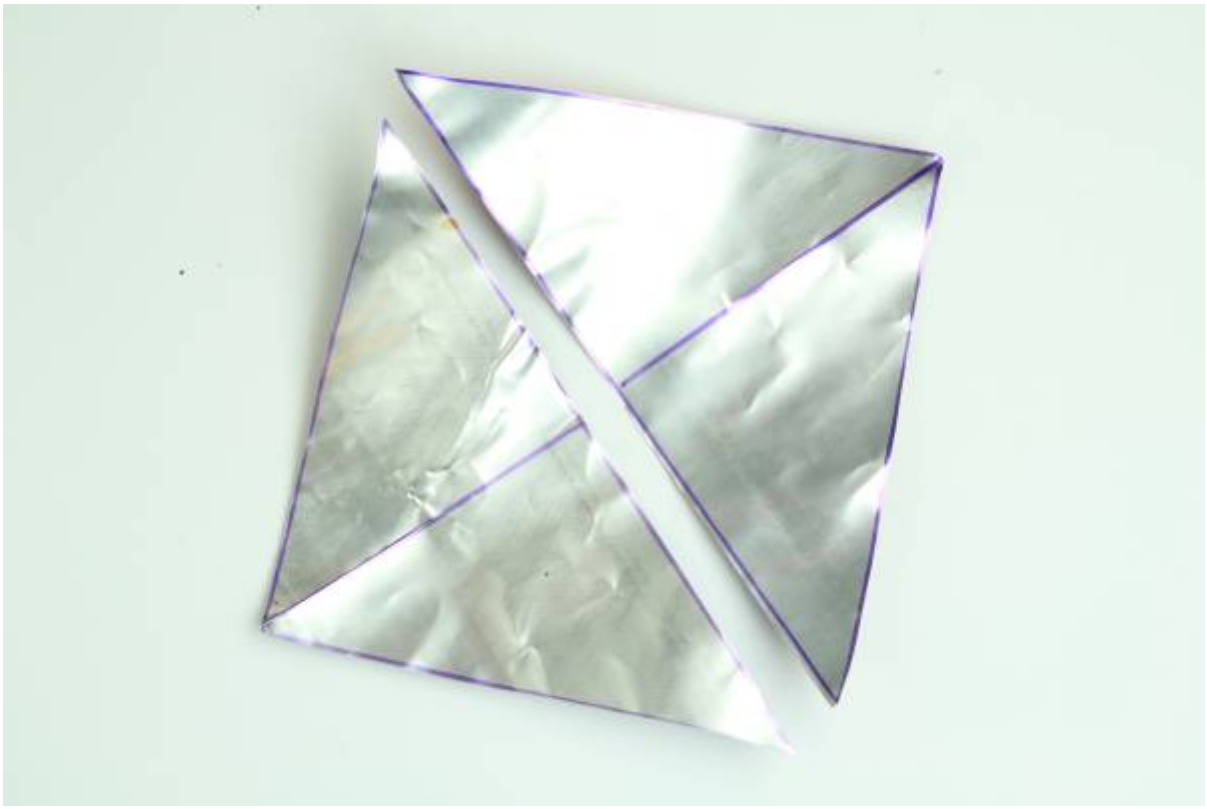


Now cut along the other side, to complete the triangular shape.



Cut about 2/3 down from the apex of the triangle along the perpendicular.

Don't cut down too far or the blades of the pinwheel will separate and getting the proper alignment will be difficult. If the halves fall apart, better to start again.



Now repeat the process with another can, so you have TWO identical triangles

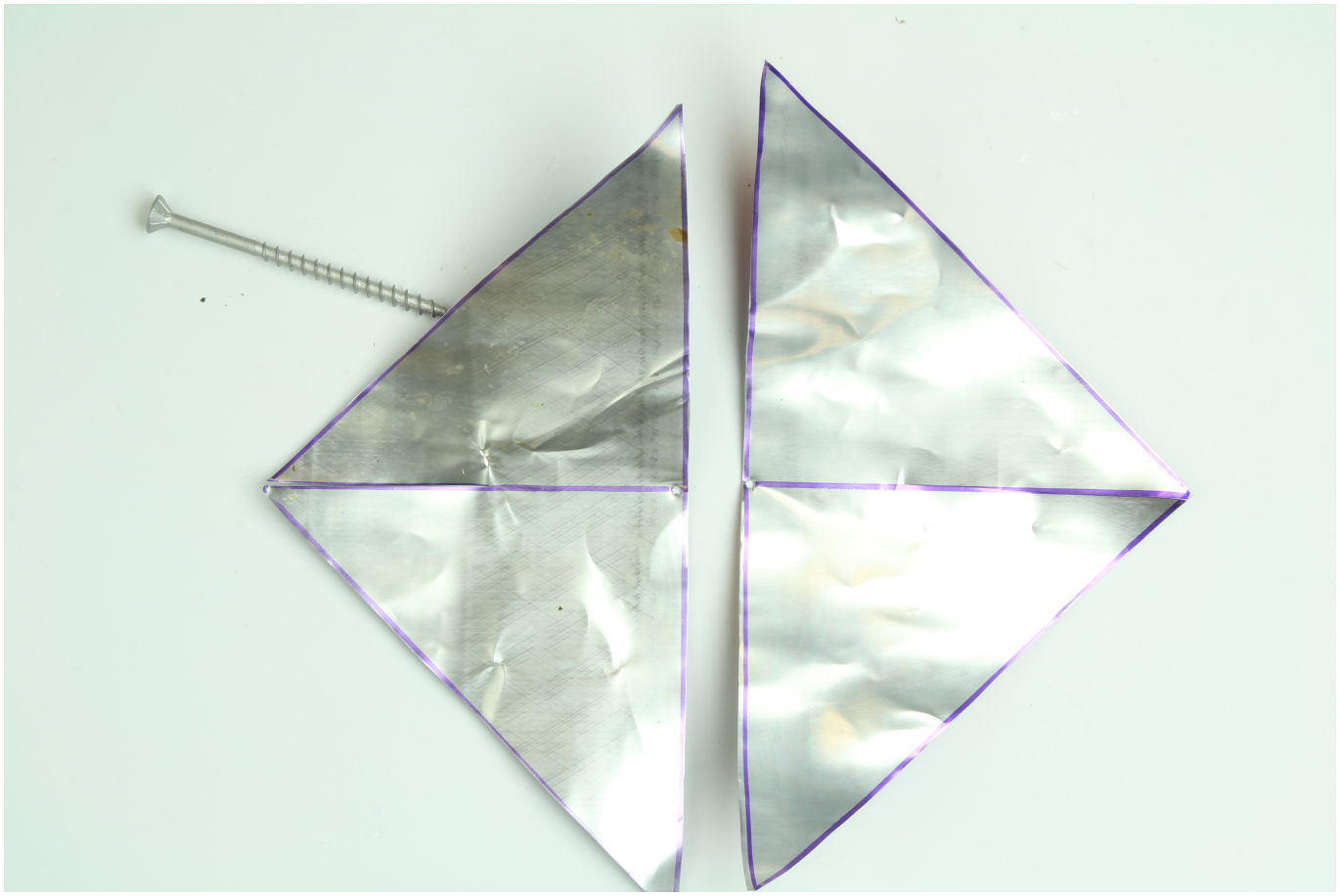
This is easily done if you use the measurements on the set square to make the sides of equal length for both triangles (see Step 9)

Step 4: Joining the halves

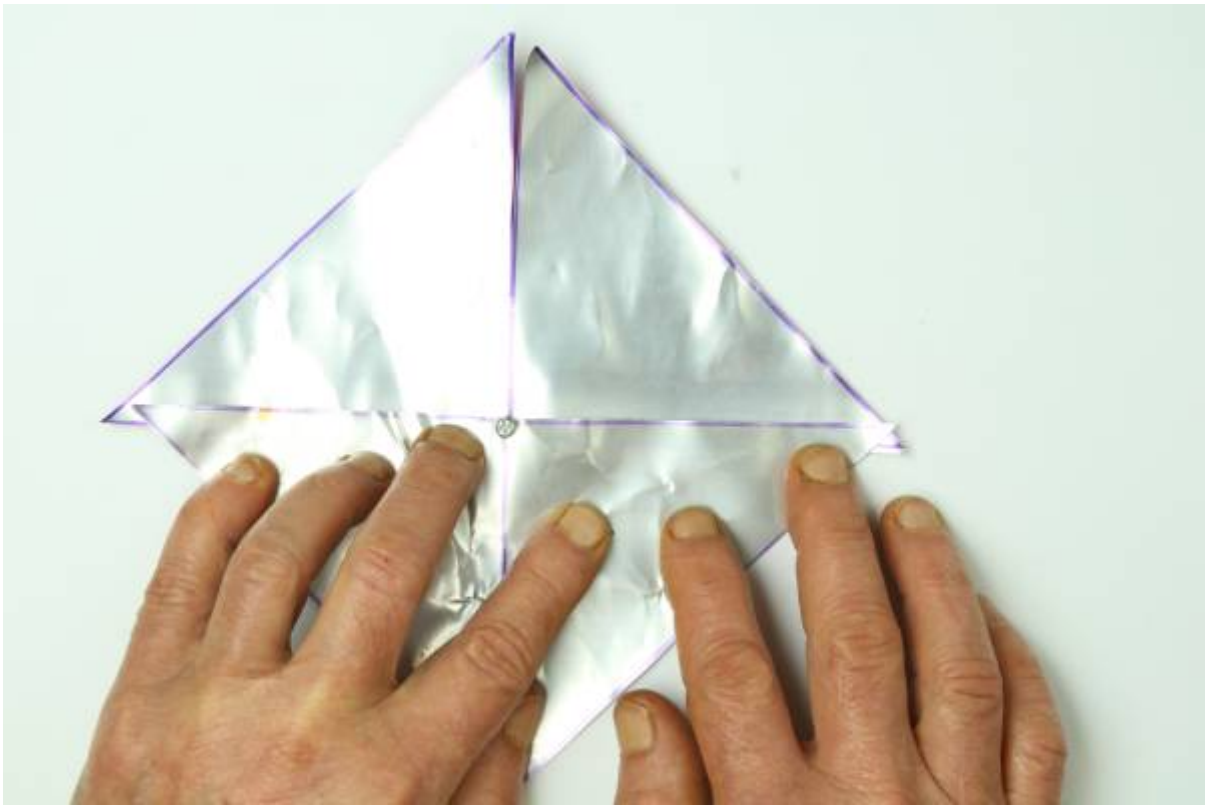
Use a nail or sharp screw to make a 2mm hole where the perpendicular meets the baseline of each triangle.

If you have left some excess material along the base, the hole should not tear through. Keep your fingers clear of the emerging point by placing them beneath and either side of the center, as in the picture.

If the hole tears through, the pinwheel will still work, but you will need to be careful when aligning the two halves later during gluing.

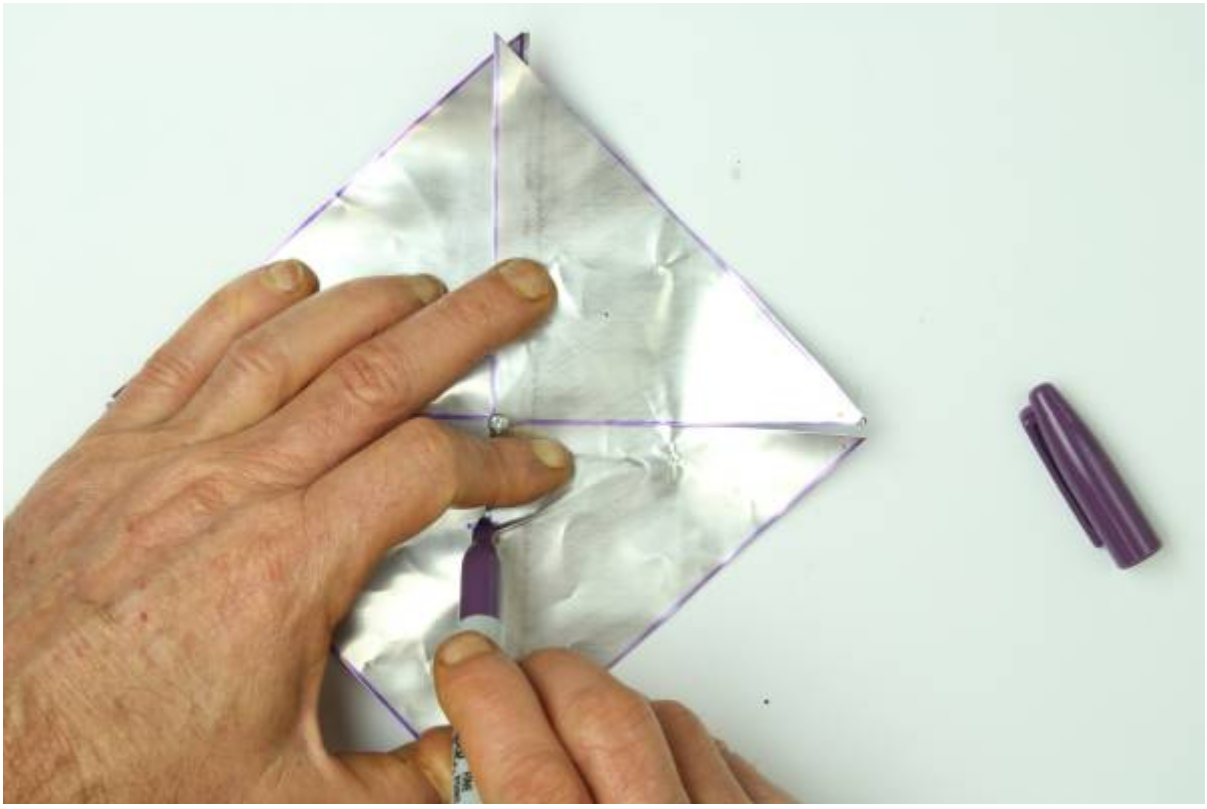


Now do the same with the other triangle, so both halves have a hole in the centre of the baseline.

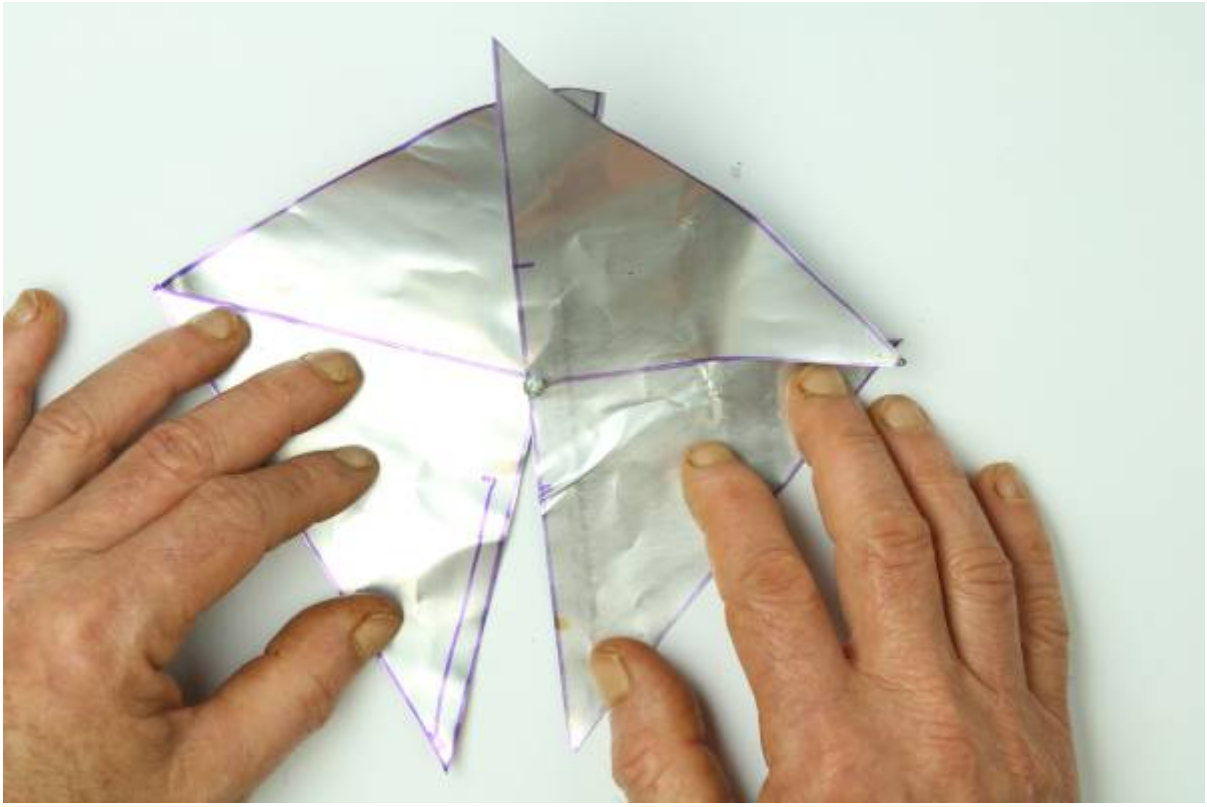


Lay one half on top of the other, making sure the holes you just made are aligned.

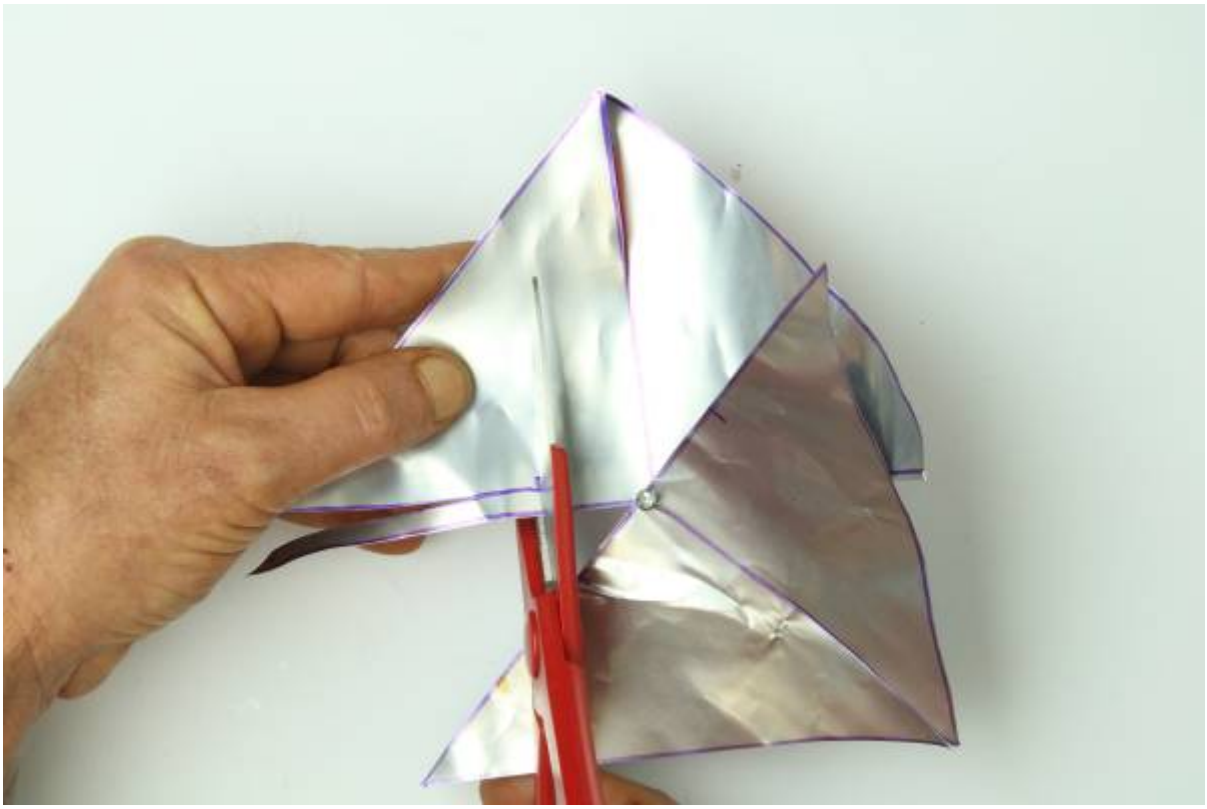
> You can use a pin or small screw pushed through the holes to keep the two halves in place.



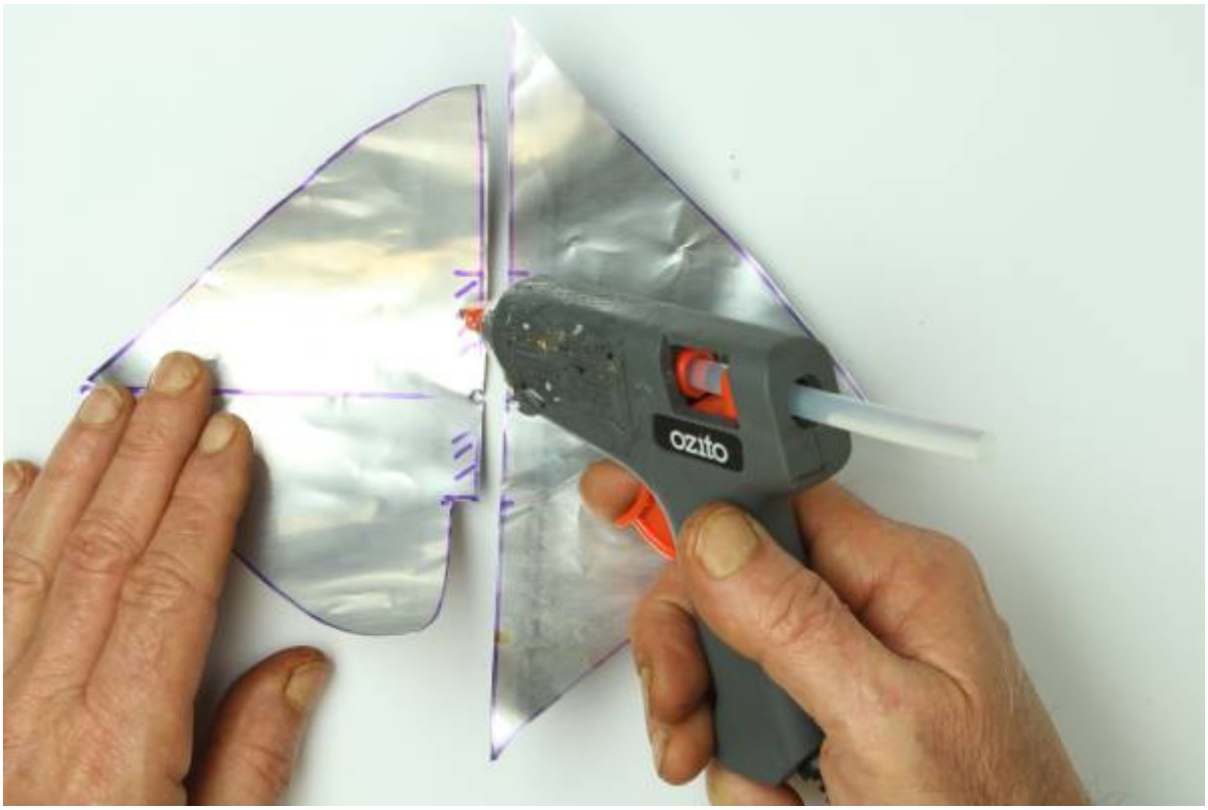
Make a mark one third from the centre along the baseline on the overlapping pieces closest to you. Make sure the mark is visible on the underlying piece.



Continue the mark along the edge of the top piece, so that when you move the overlapping pieces apart, you can see where the top half reaches over the bottom.



Cut along the lines you just made on the bottom piece, removing the part that is overlapped. This will allow the bottom piece to be folded up to make the pinwheel.



Use hot glue along the edge of the bottom piece to join the two halves together.

> Only glue down the central part of the overlap. Do not glue beyond the marks.

Step 5: Attaching the hubs

Use a craft knife to carefully cut the flanged end from the the centre of a T-shaped 4mm drip irrigation joiner.

Make sure the cut is a vertical as possible

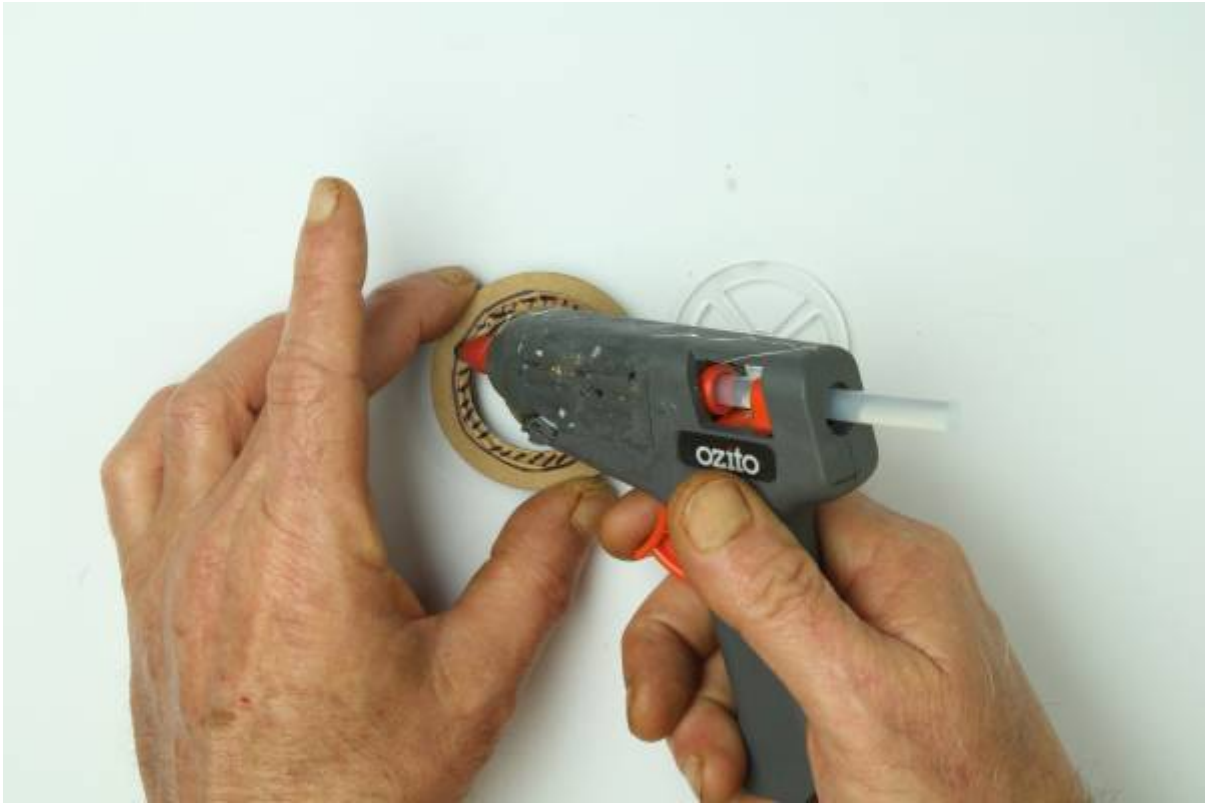
Set up the wire stand so that it is vertical, and slide the flange on to the wire. Have the narrow end uppermost. This will help to hold the hub assembly in place.

Locate the two cardboard hubs, and on one hub highlight the engraved circle with a marker.

Apply hot glue to the unmarked side of the hub, and glue them together with the marked circle on top. Make sure they are as evenly aligned as possible.

> The marked engraved circle needs to be still visible for the next step.

Locate the acrylic hub, which will be the same size as the engraved circle.



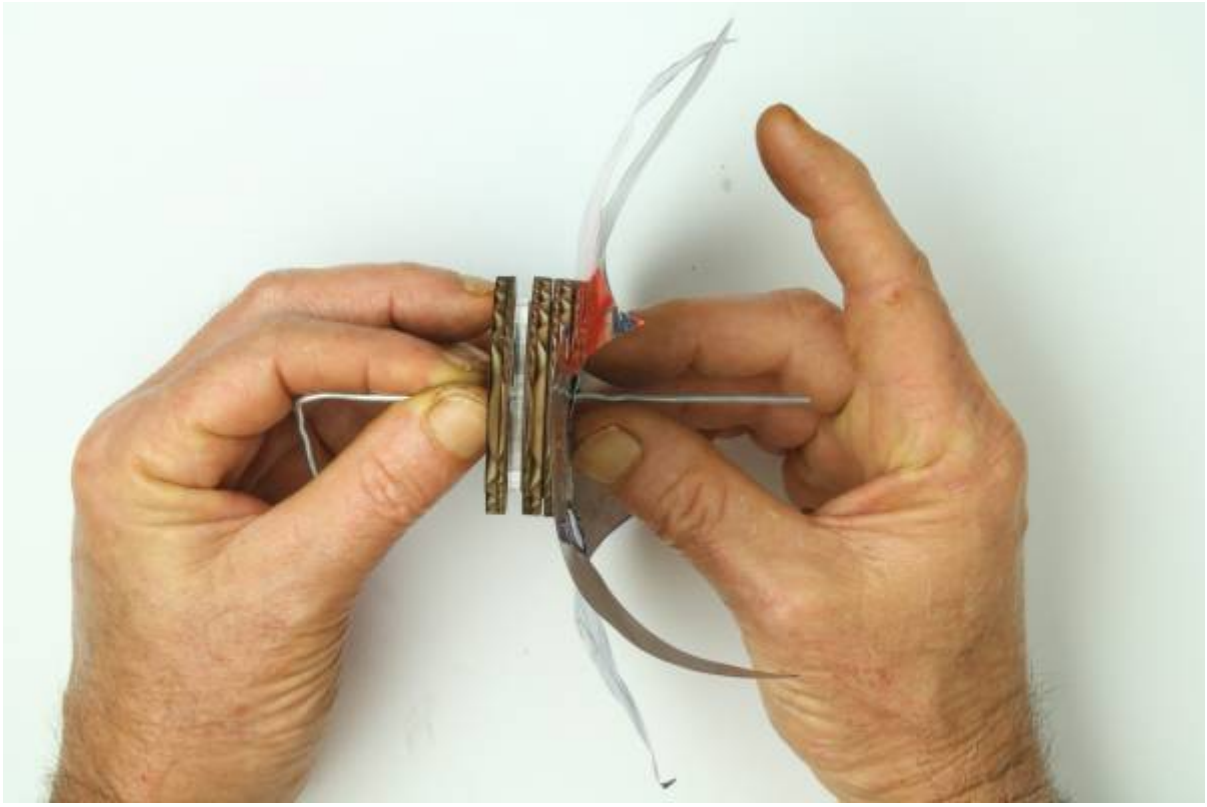
Apply glue to the marked area, and glue the acrylic hub to the cardboard ones, lining up the edges with the marked circle.

Now take the remaining cardboard hub, apply glue inside the etched area, and glue it to the acrylic hub.

Thread the sandwich of hubs onto the wire assembly stand, with the double hub uppermost.

> You must have the doubled cardboard hubs on top so that the pinwheel can align correctly with the motor

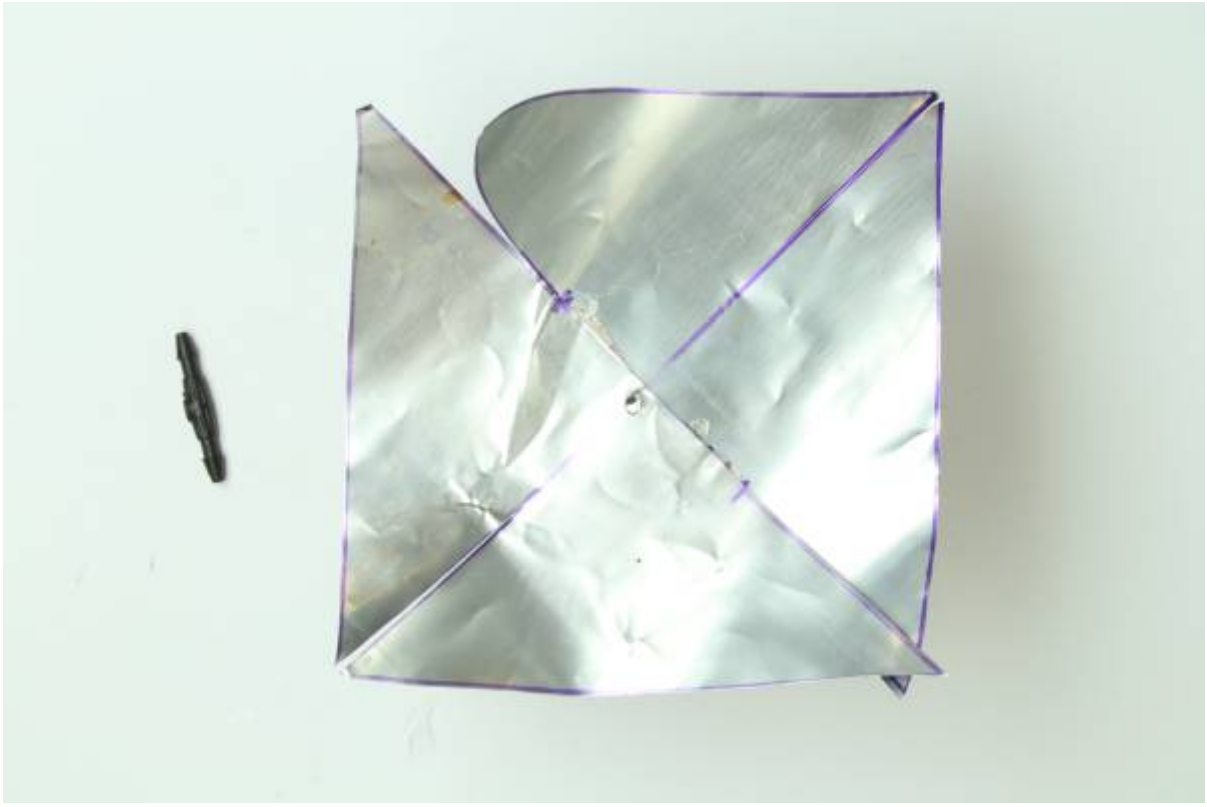
Add hot glue to the upper cardboard face of the hub assembly



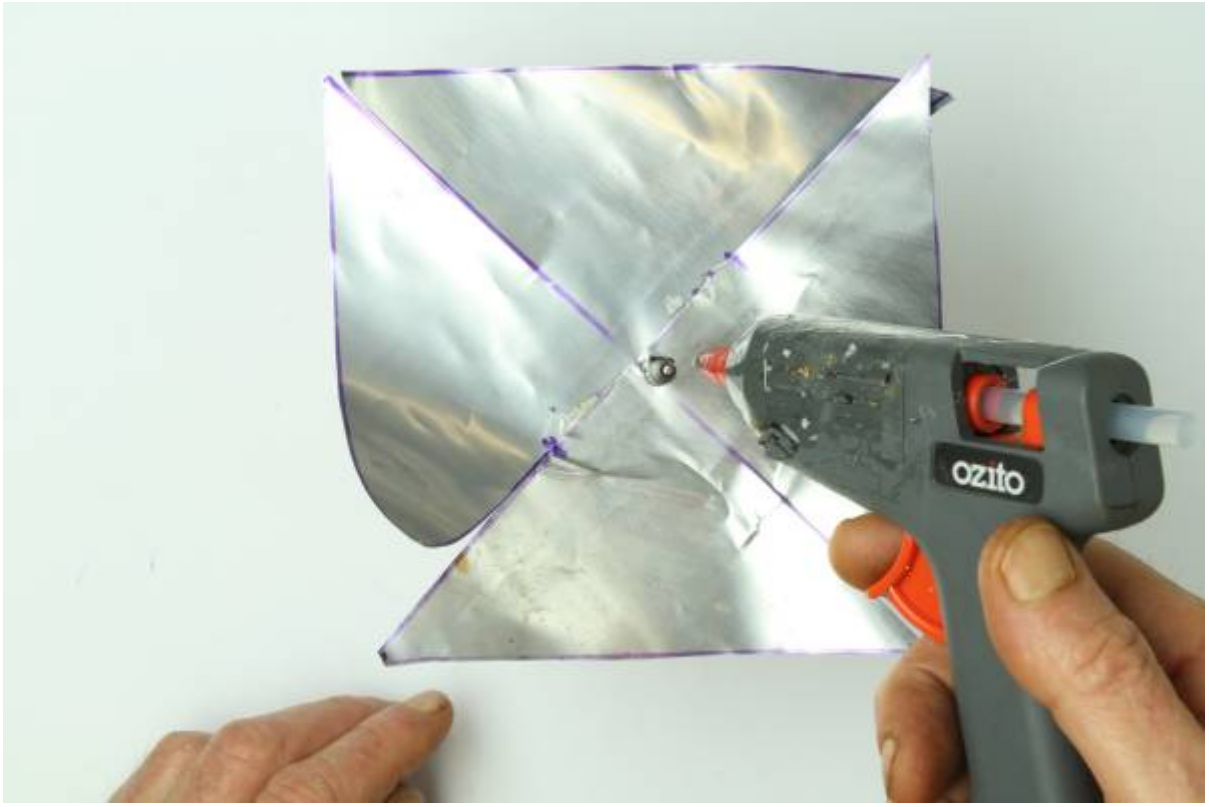
Thread the pinwheel onto the wire stand, and press together with the hubs until the glue sets.

> Press out from the center of the pinwheel, and avoid gluing to the acrylic hub.

Step 6: Folding the Pinwheel

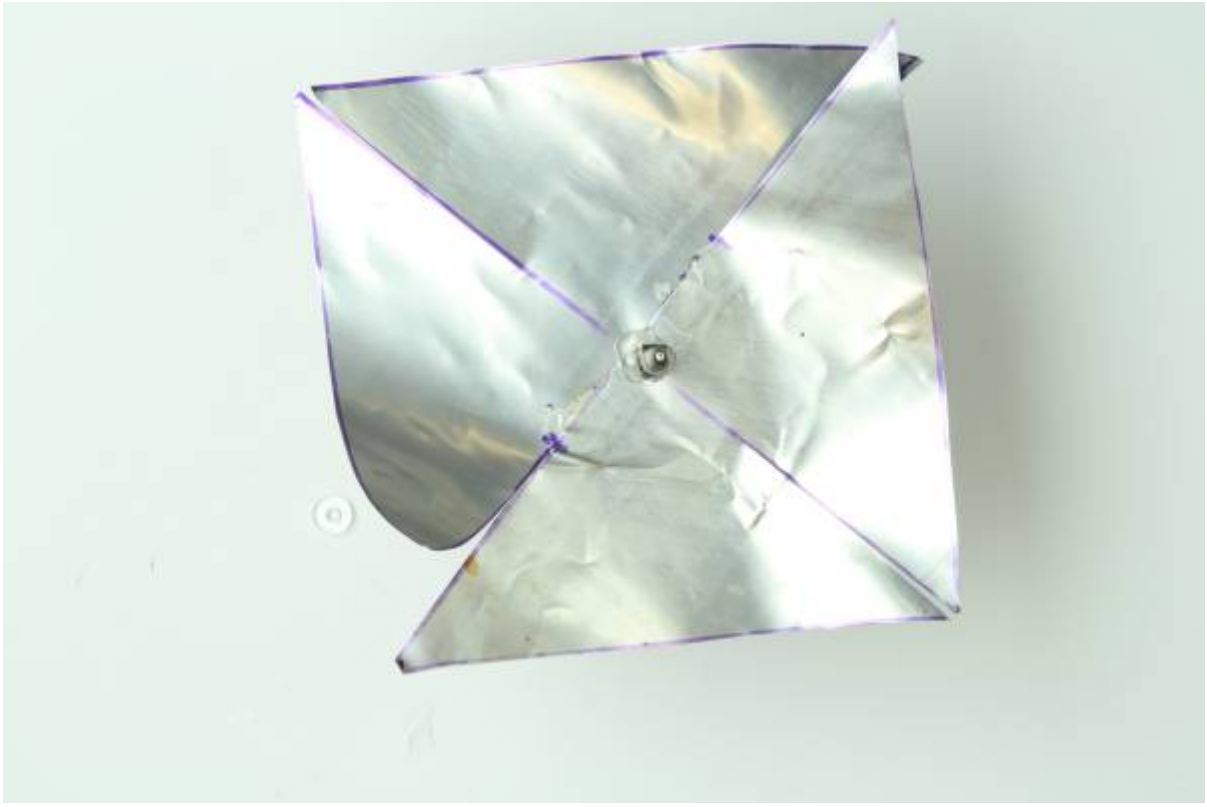


Locate the remaining straight part of the 4mm T-joiner and slide it on to the assembly wire. This will be a spacer to fix the height of the Pinwheel.



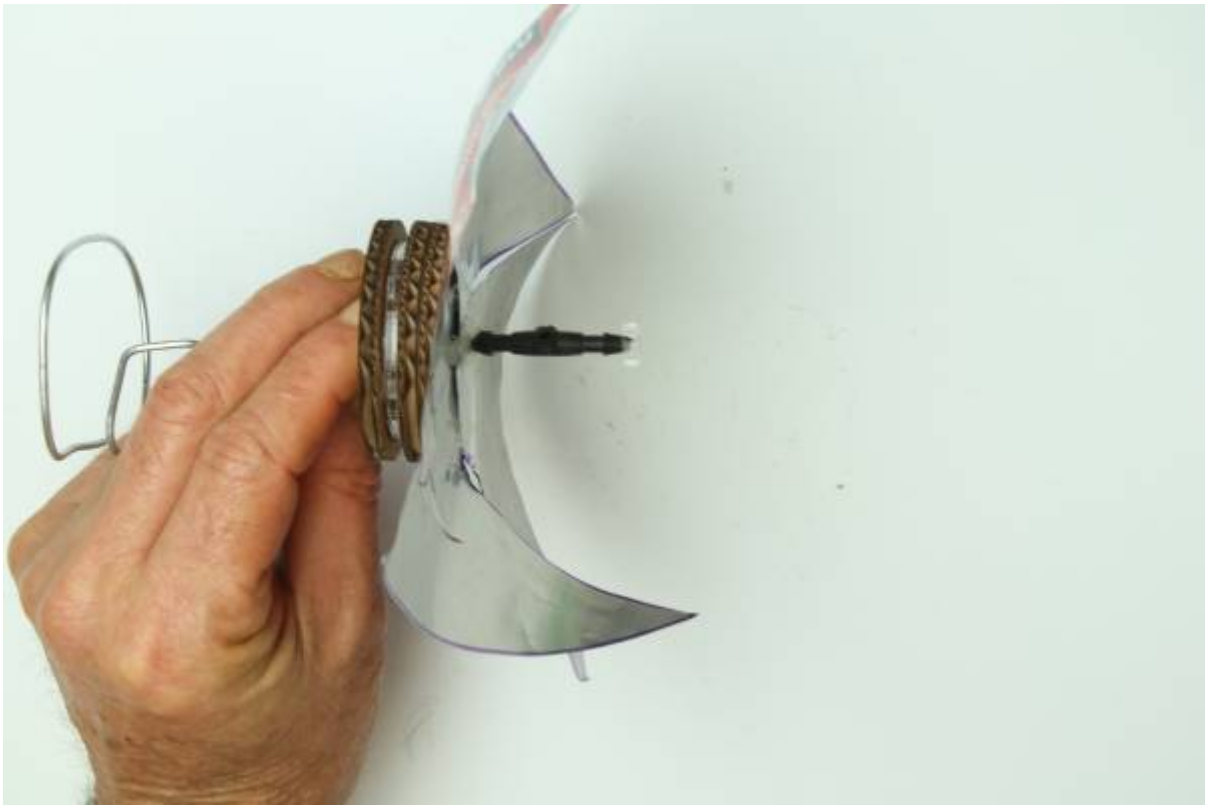
Glue the bottom of the spacer to the pinwheel.

Be careful to avoid getting glue INSIDE the spacer. It needs to be clear to spin freely. You might need to press down on the spacer as you add the glue, and hold it tight until the glue sets.



Locate the 10mm acrylic pinwheel cap (seen at left), slide it on to the assembly wire, and glue it on top of the spacer.

Again, avoid getting glue INSIDE the spacer by holding them together tightly while you apply glue to the outside of the join.

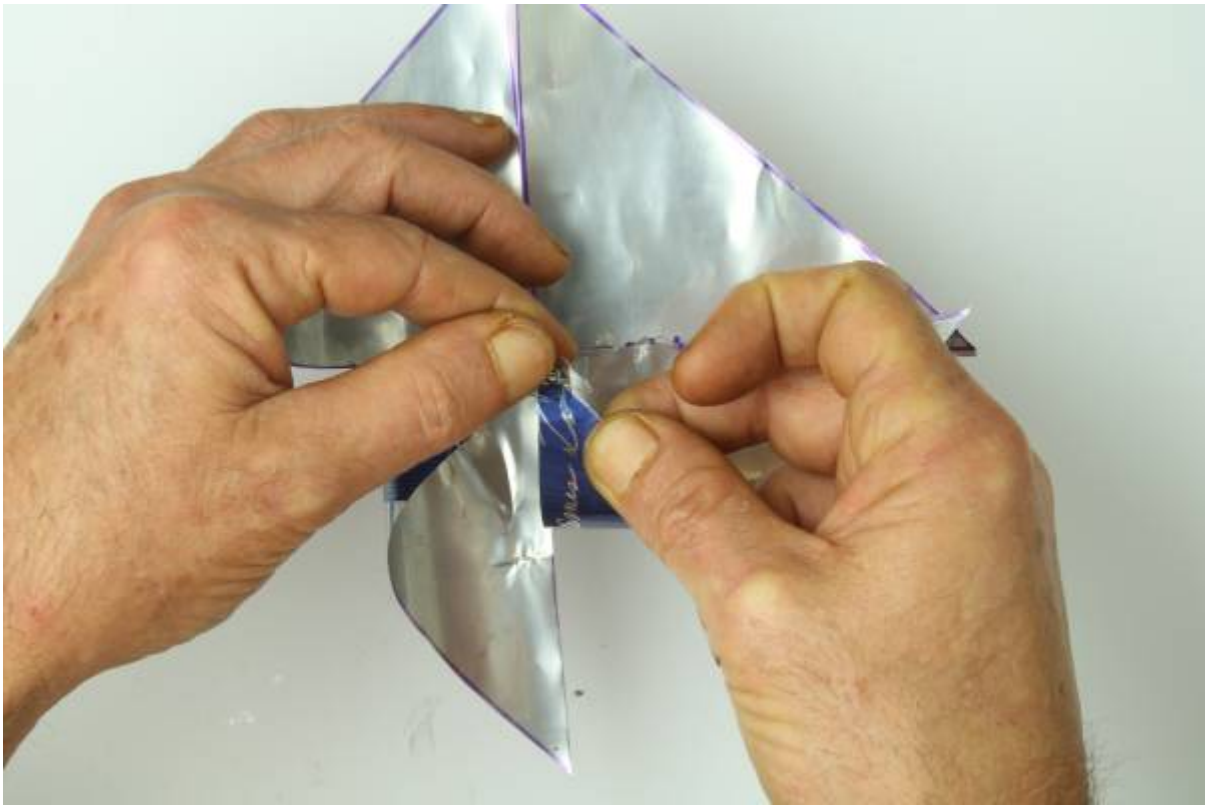


The assembly should now look like this

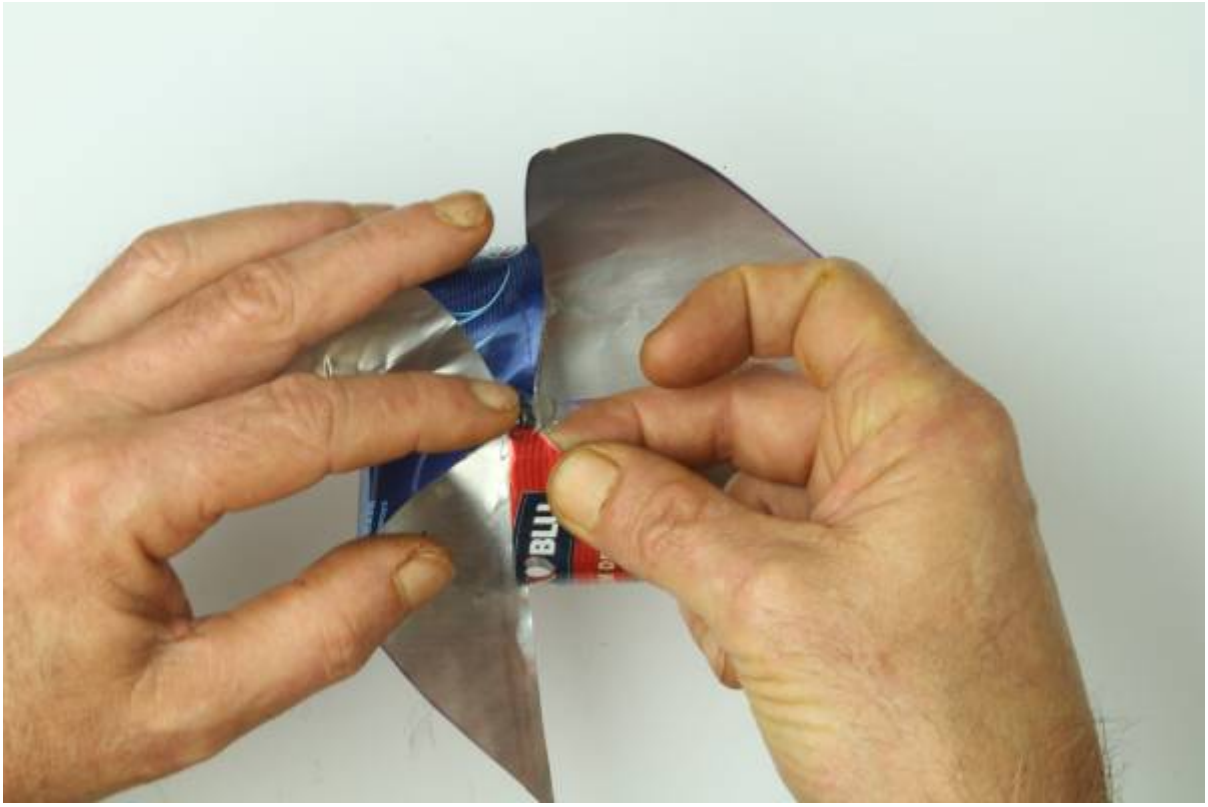
Find the corner of the lower half where you trimmed the overlying sheet.

Curve this corner towards you, and bend over the last 5mm of the tip, and apply glue.

> Be careful not to burn your finger on the hot glue. It helps if you crease the point at 90 degrees so the tip is pointing down the spacer. You can then push the angle into the join between the cap and the spacer

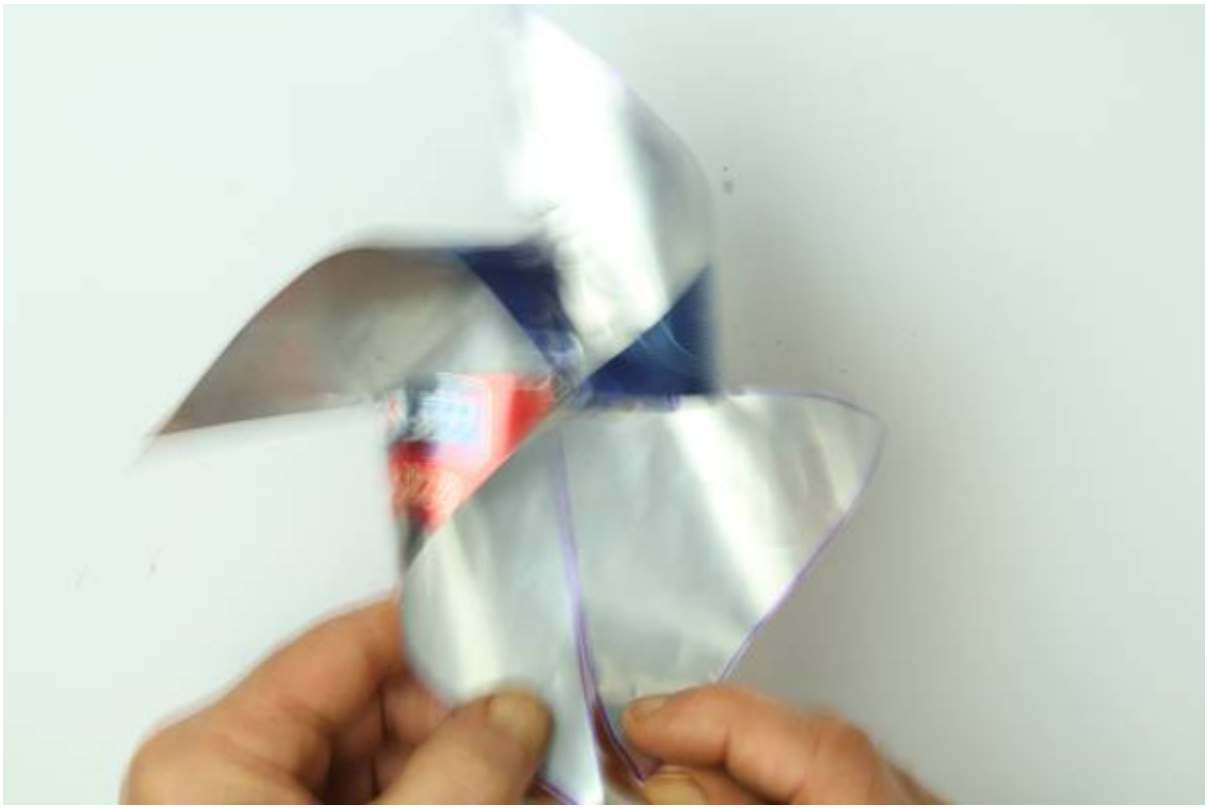


Push the tip in place against the spacer, and underneath the cap.



Check which side of the radial cut you have just glued to the cap (In the picture above, it was the right hand side)

Move around to the next corner of the square, and pick up the next point on the same side of the radial cut as you began, and repeat the process



Continue to the third side

And the fourth.

PART 2 : Making a Spinner from Polypropylene

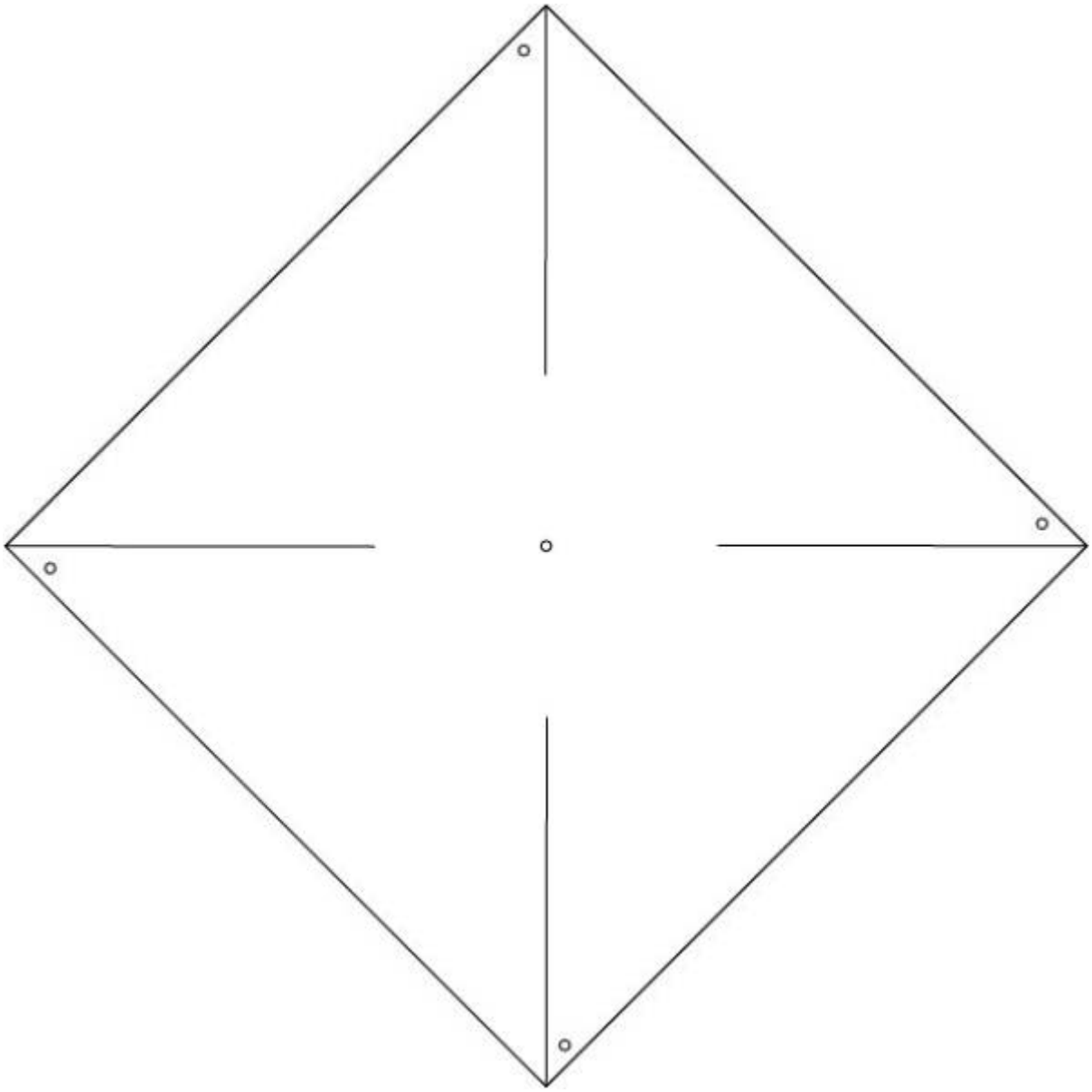
Step 1: Attaching the hubs

Glue two of the cardboard hubs together, making sure the guide mark is on the outside.

Now, glue the acrylic hub to the joined pair, using the guide mark to align to the centre.

Finally, glue the last cardboard hub on to the other side of the acrylic hub, as shown. The double hubs are necessary to achieve the correct alignment between the acrylic hub and the motor later in construction, so they glue on to the spinner.

Step 2



Place the joined hubs onto the assembly stand with the double hub at the TOP, and apply glue to the top surface.

Thread the flattened spinner onto the stand, making sure the corner holes are on the RIGHT of the cut when viewed from above as shown here.

If the corner holes are on the other side, then spinner will rotate anti-clockwise, and the circuit will not function correctly (the current will go in the opposite direction to that required by the LED).

Press the spinner onto the hubs, and allow the glue to set.

Step 3 : Folding the Spinner

Fold up the spinner arms on the side opposite to the hubs, inserting one half of a press stud through the hole from underneath.

Hold the stud in place as you work around the four arms until all the corners are hooked over the stud.

Top off with the other half of the press stud, and squeeze the halves together firmly.

PART 3: Aligning the Spinner and Motor

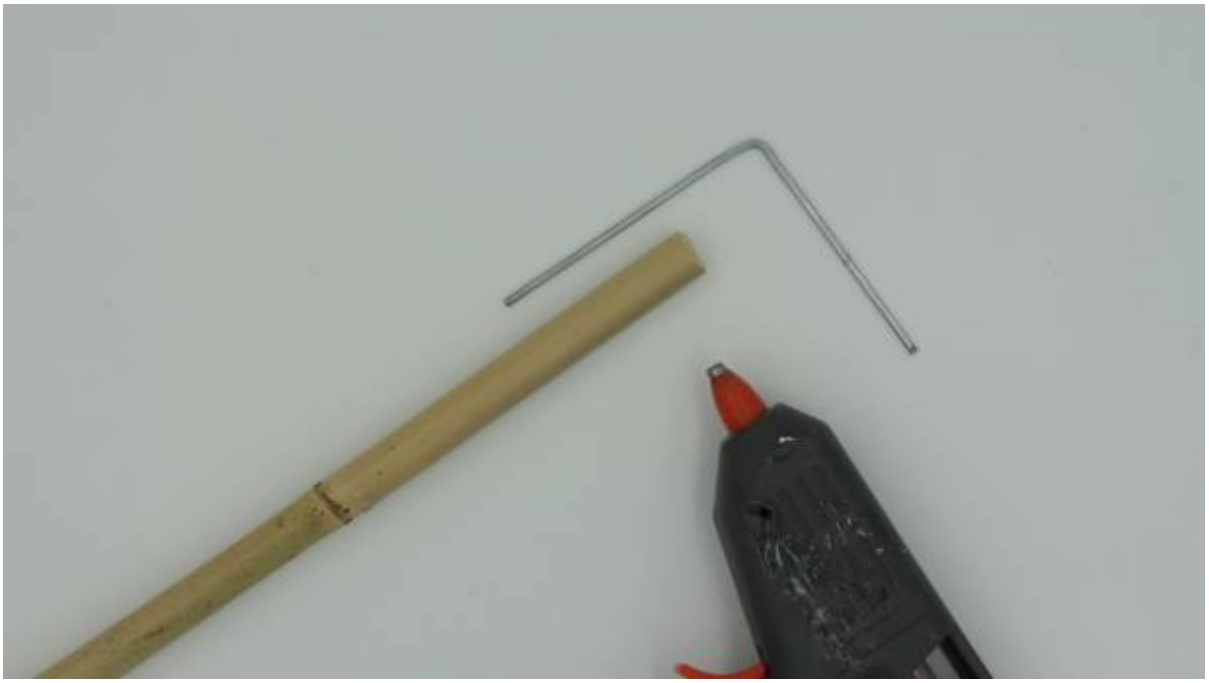
Step 1: Mounting the motor

Locate the two motor hubs - the larger one has an etched area to help locate the smaller one.

Push the small hub onto the motor shaft, and put a small dob of glue on the top. Push the larger etched hub onto the shaft, and press them together.

Now add another dob of glue to the top of the larger hub, to ensure it is fixed to the motor shaft.

Step 2

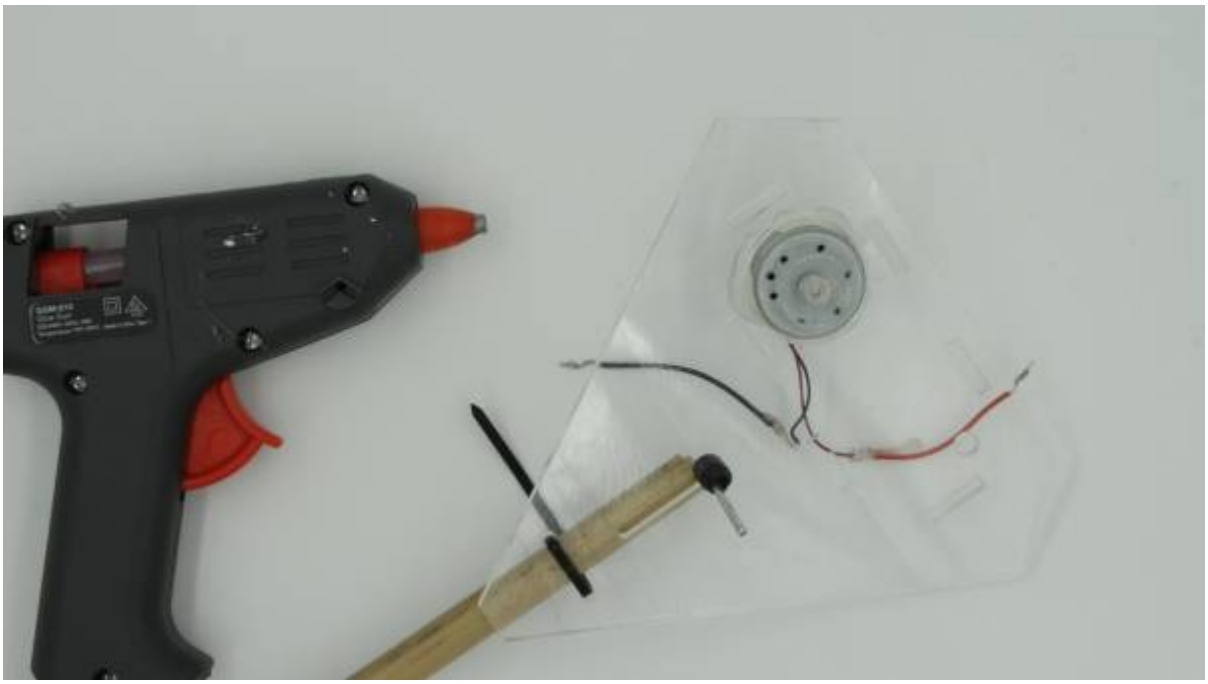


Holding the wire axle with some pliers about 50mm from one end, bend it to a right angle.

Inspect the end of the handle, and drill a 2mm hole down the centre if required.

Push the wire axle down the centre of the handle, and glue in place.

Step 3



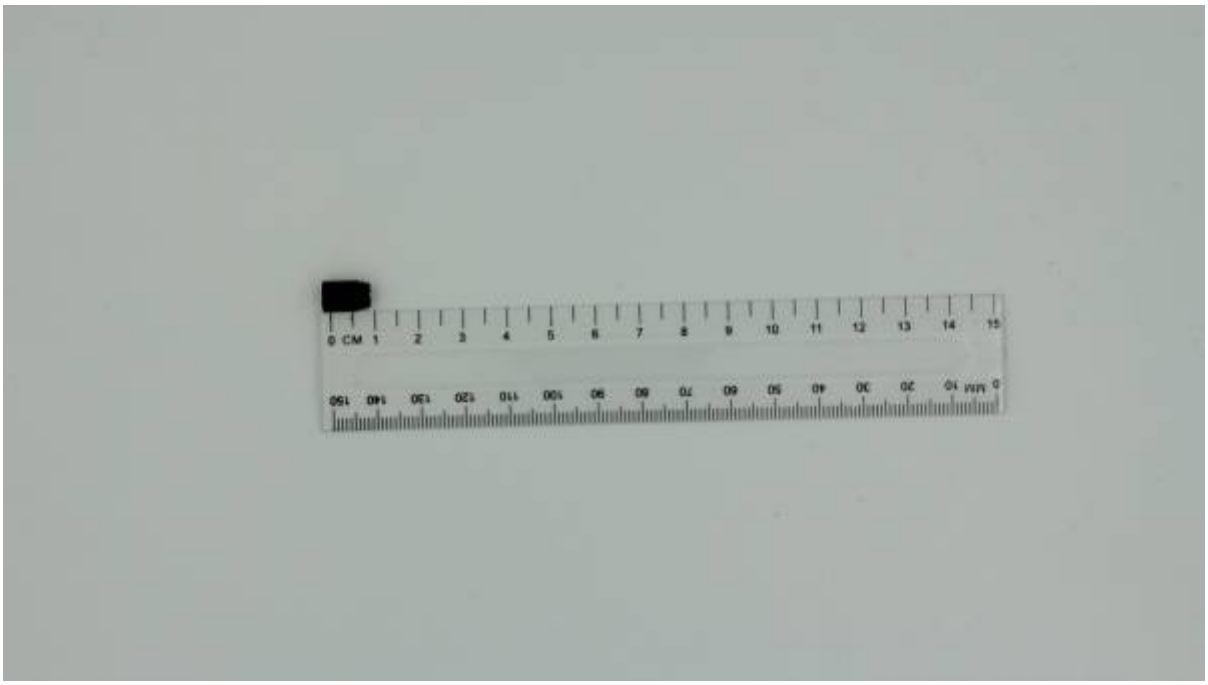
Glue the motor in the hole provided in the acrylic chassis with the shaft poking through (the motor should be on the left side, looking from the front).

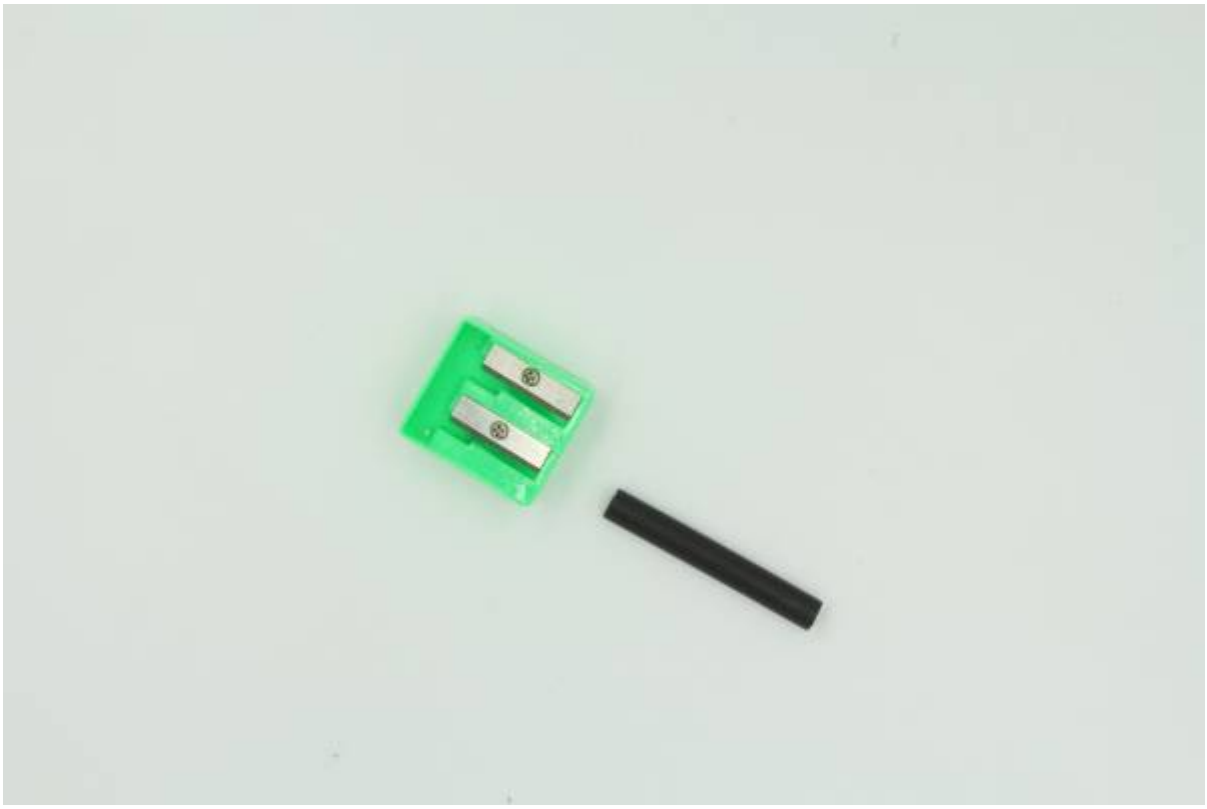
Push the motor most of the way through from the back, and keep it as perpendicular to the face of the chassis as possible. It is best if the wires are pointing to the right, as in the picture.

Insert the axle through the slot in the chassis from the back, and use a small zip-tie through the holes provided to hold the handle in place.

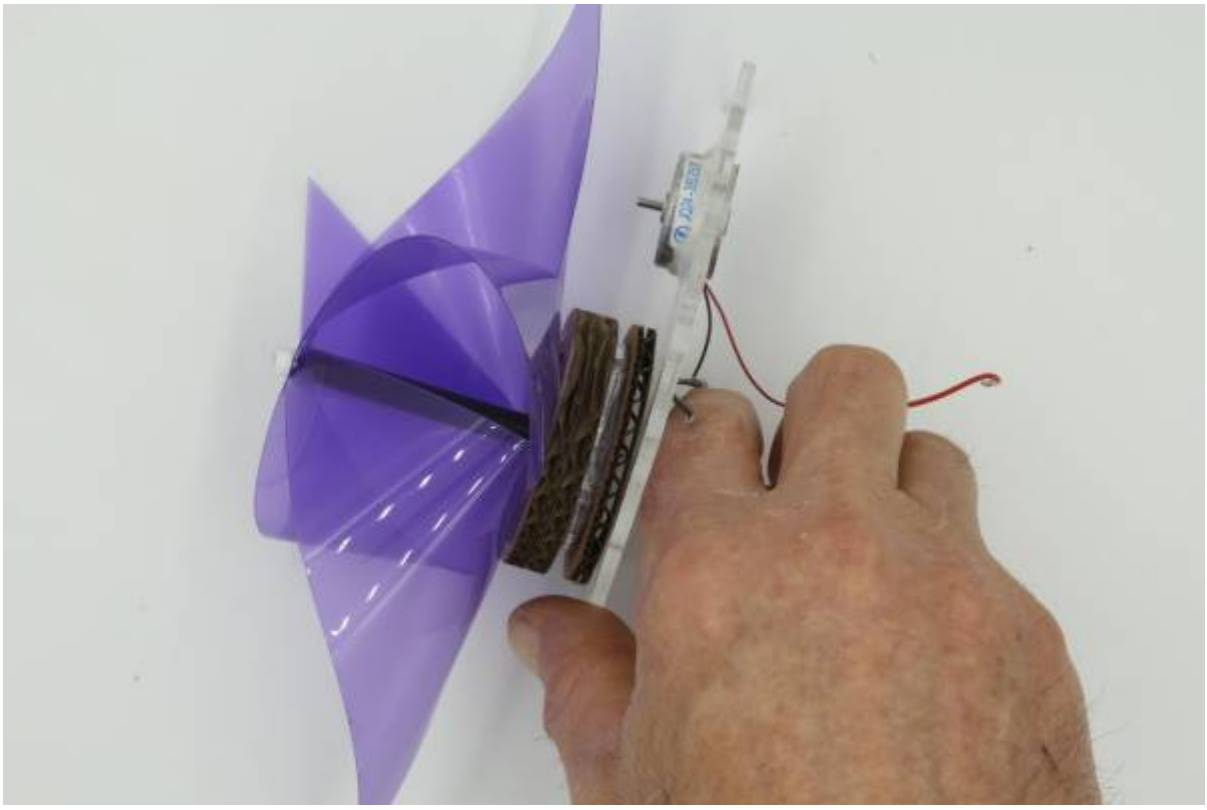
When the zip-tie is tightened, the handle should still be able to be pushed up and down a bit for fine tuning later.

Step 4





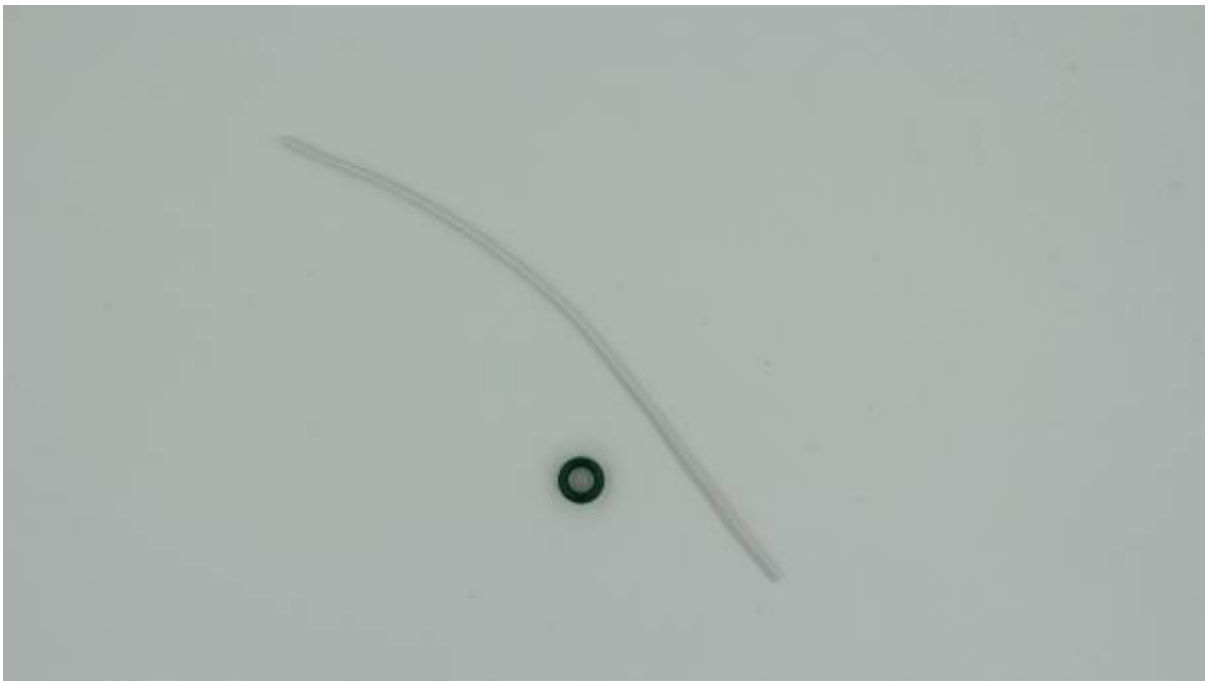
Cut a piece of tubing 10mm long. This will act as a spacer to hold the spinner hubs in alignment with the motor. Sharpen one end in a pencil sharpener before cutting it off. Trim the ends flat with a craft knife if necessary. Sharpening the end reduces friction with the acrylic hub, so make sure this end is towards the hubs.



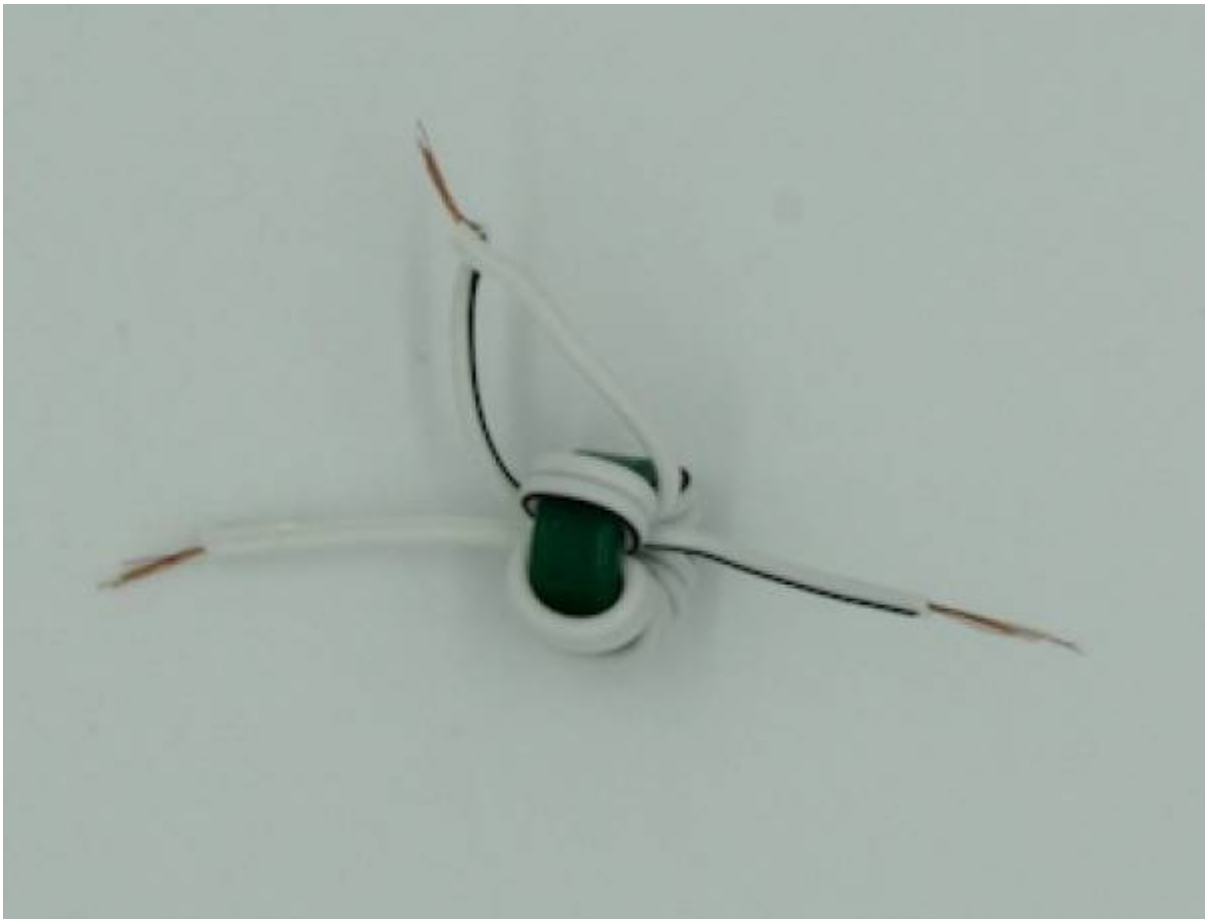
Slide the spinner onto the axle, and check that the acrylic spinner hub aligns with the motor. Trim the spacer if necessary.

PART 4: The Joule Thief

Step 1: Winding the toroid



Using about 150mm of double wire (this depends on the size of your toroid), thread through the toroid taking care to avoid crossing over the strands. 5 or 6 loops are sufficient.

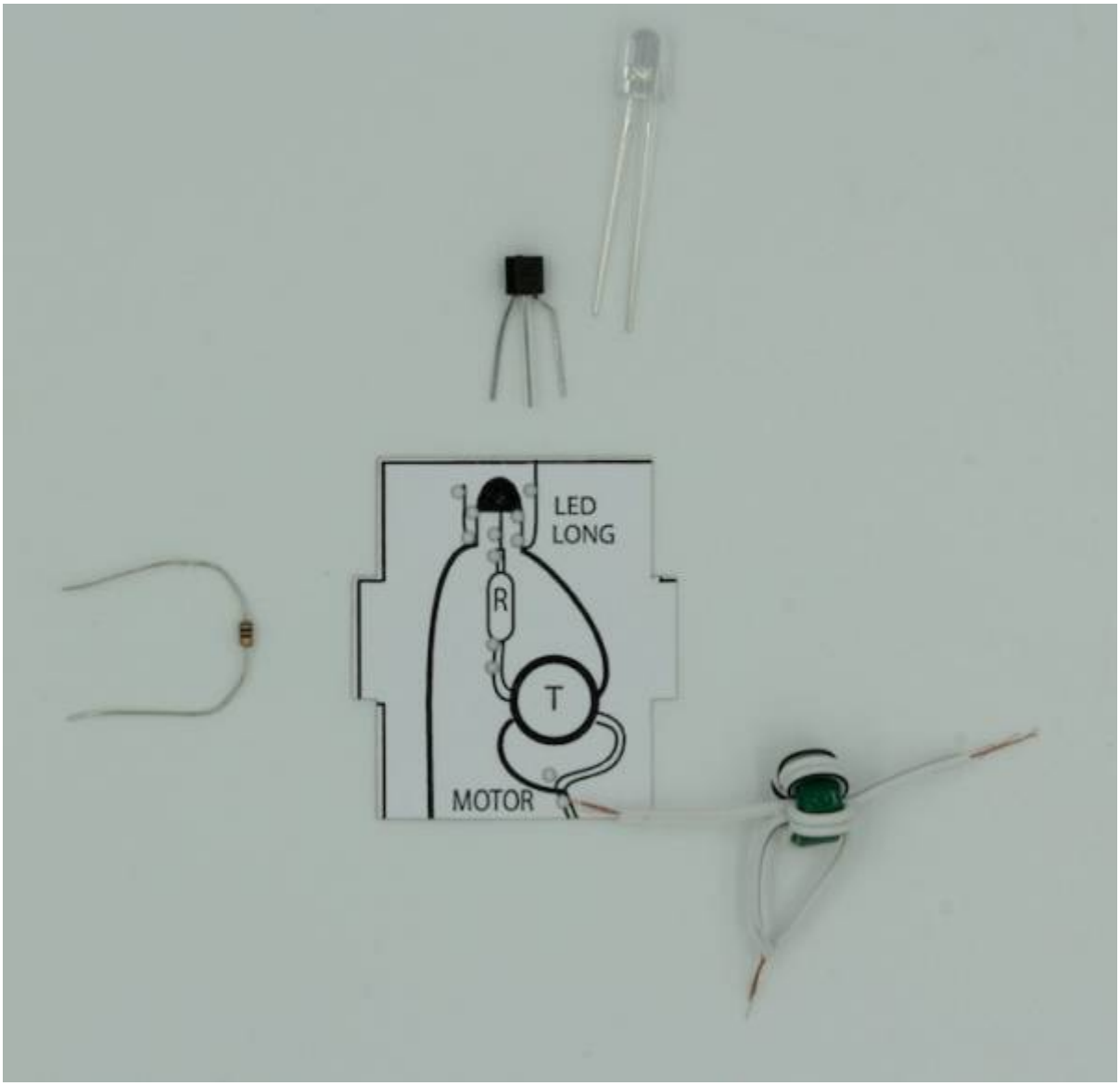


The toroid now has two pairs of wires emerging from either end of the winding.

Take the black wire from one pair, and twist it together with the white wire from the other pair.

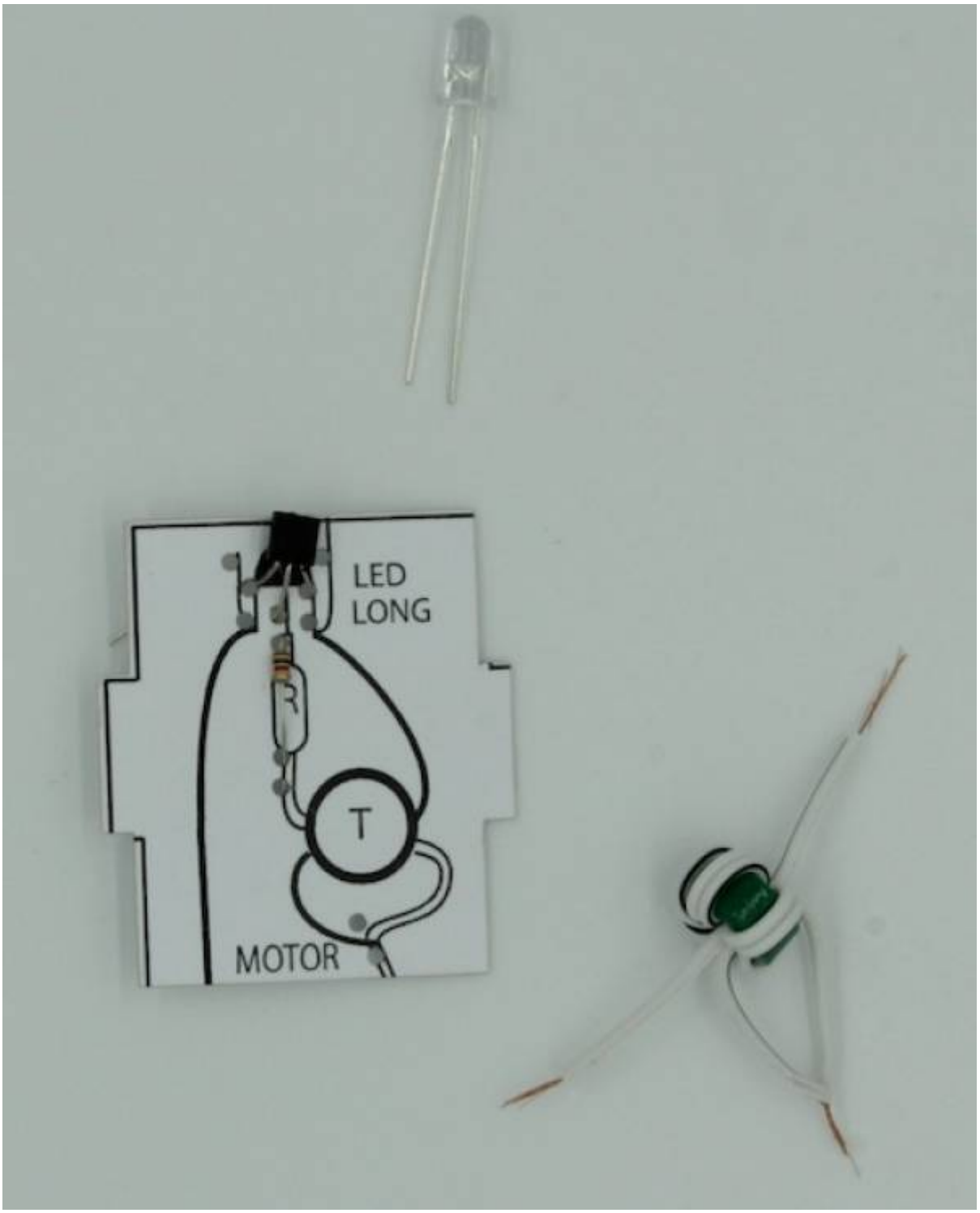
You should now have a toroid with two single wires and a joined wire coming from it.

Step 2: Assemble the Joule Thief circuit



The circuit requires a NPN transistor, a 1K resistor, the wound toroid and an LED. Red LEDs work best, but yellow or green will also suffice.

Step 3

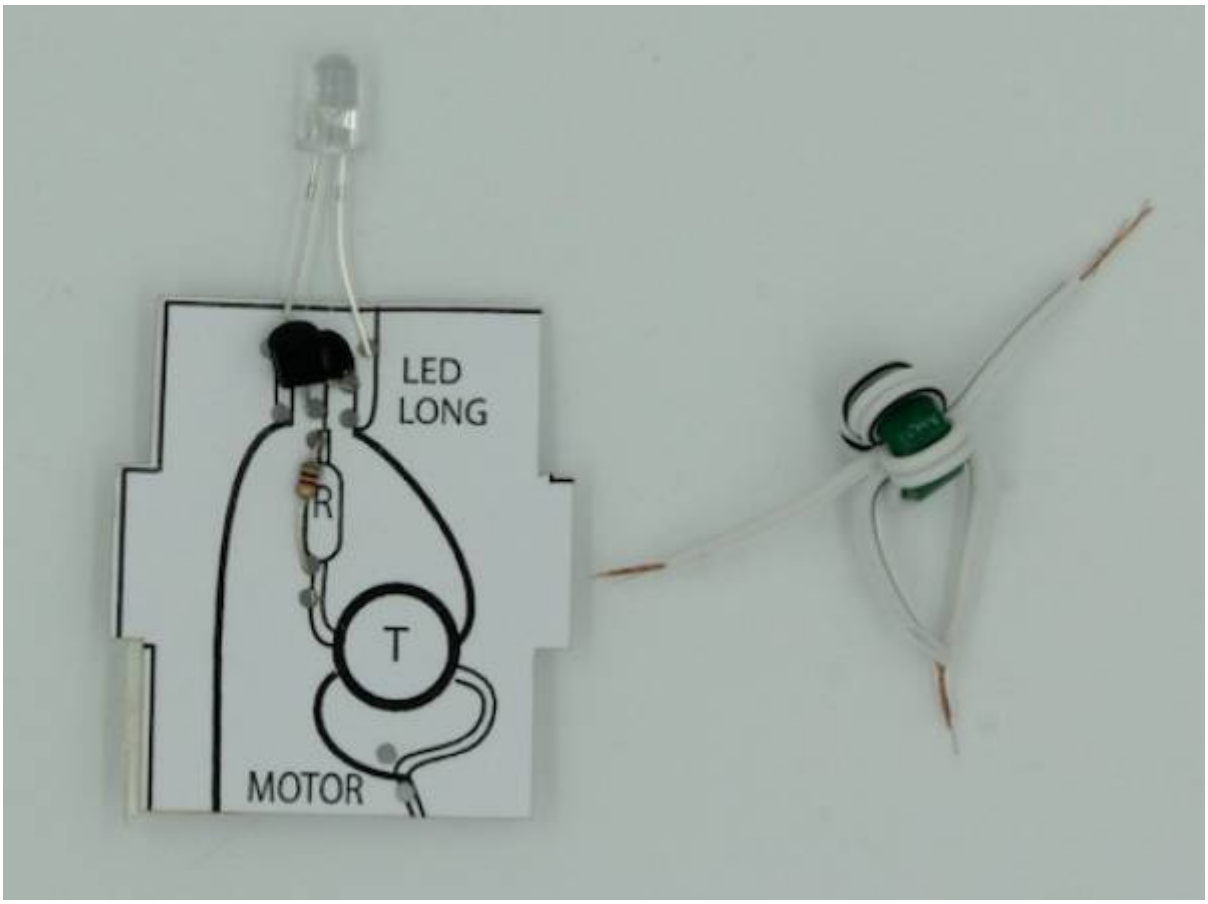


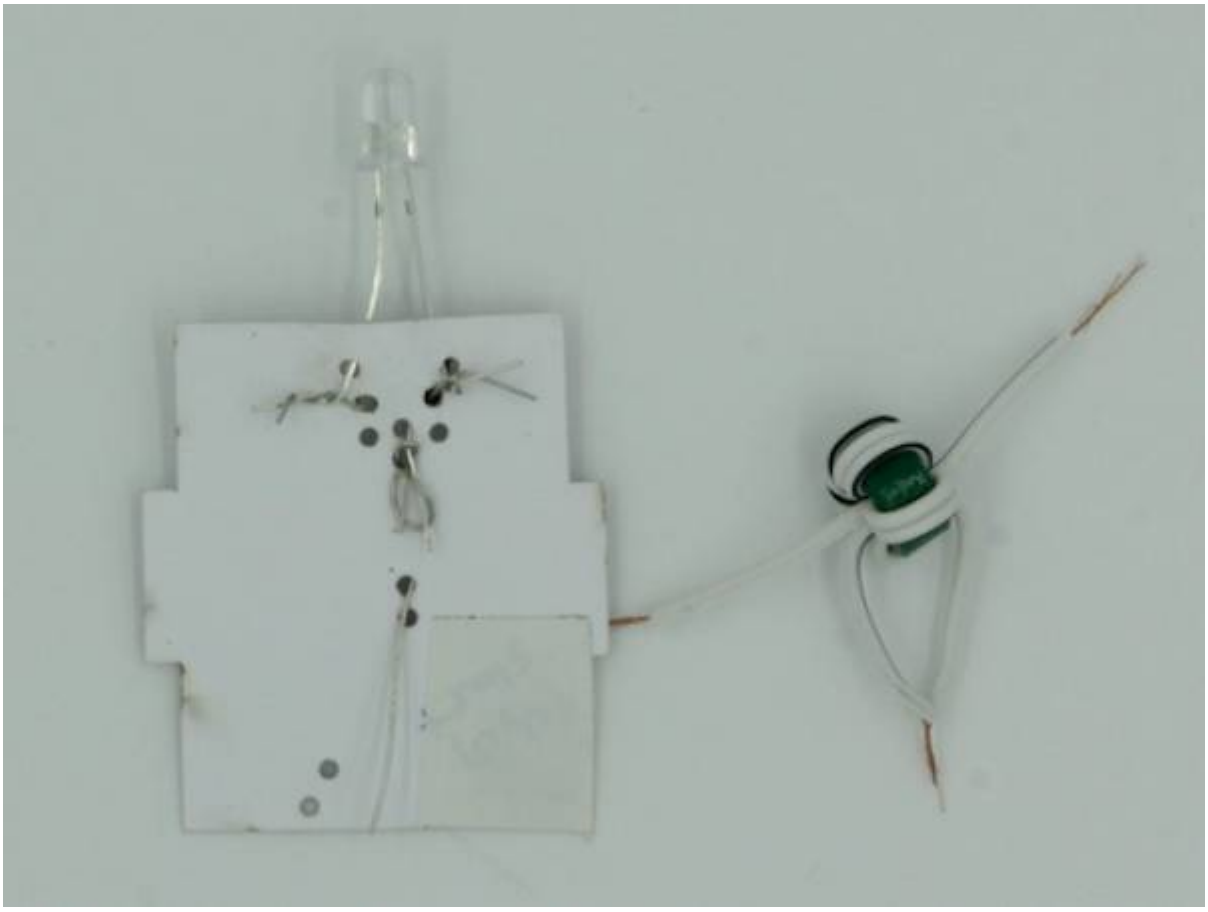
First insert the transistor through the holes in the template. It is important to orient the transistor correctly, so follow the diagram carefully.

The side legs of the transistor go through the middle holes of the three seen.

Next add the resistor and twist the leg and the transistor together at the back of the template. You can see the twisted wires from the back view here.

Step 4





Attach the LED, taking care to put the longer leg on the right side. Twist together with the transistor on the back of the template.

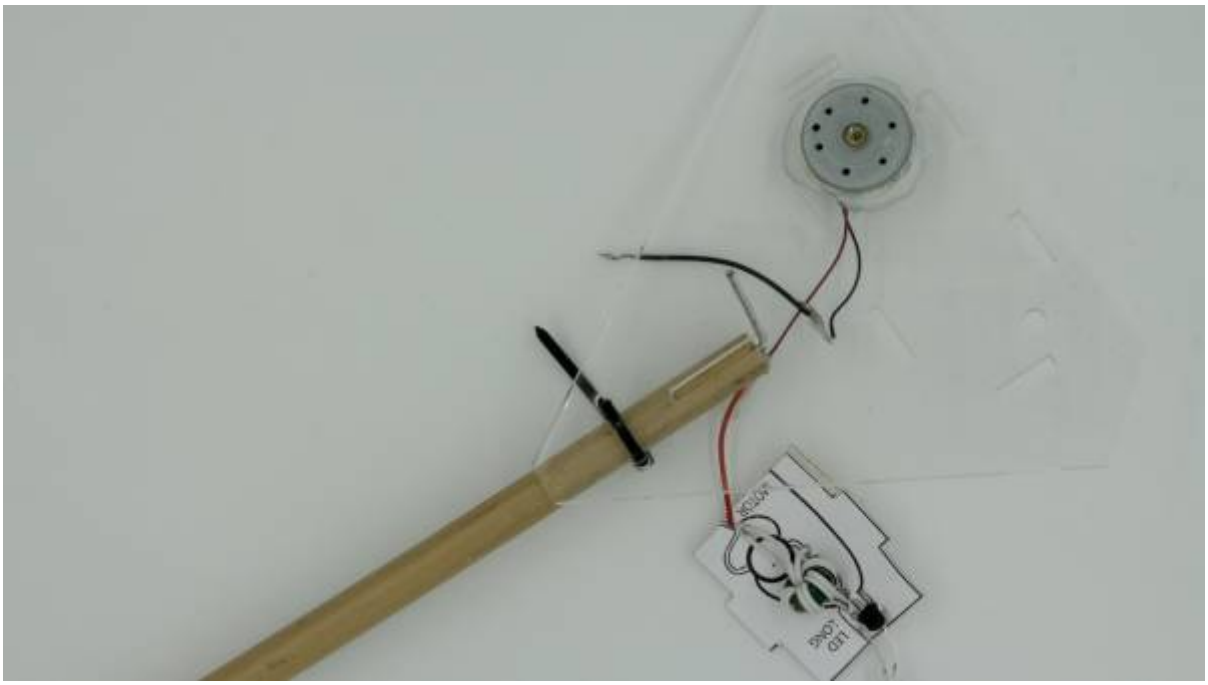
Use the ends of the LED legs to attach at a distance from the transistor so that it can be inserted into the locating hole later.

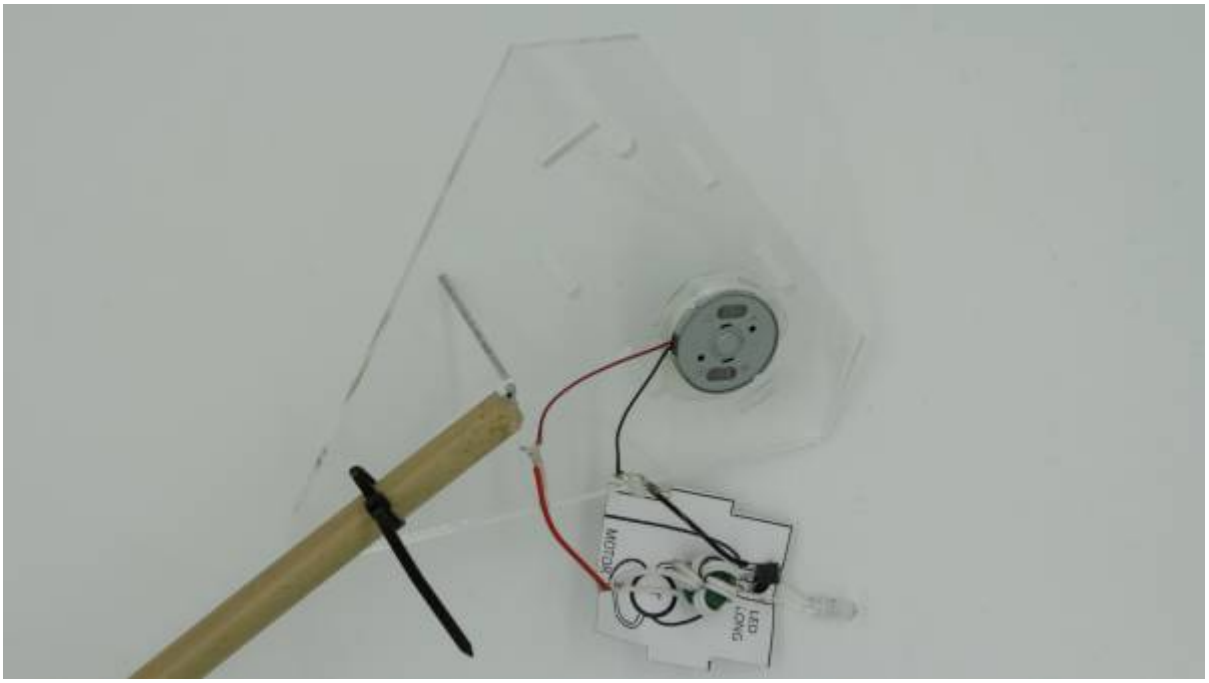
Step 5


LED
LONG
R
MOTOR

Finally , attach the toroid by pushing wires through the holes in the template and twisting together on the back.

Step 6





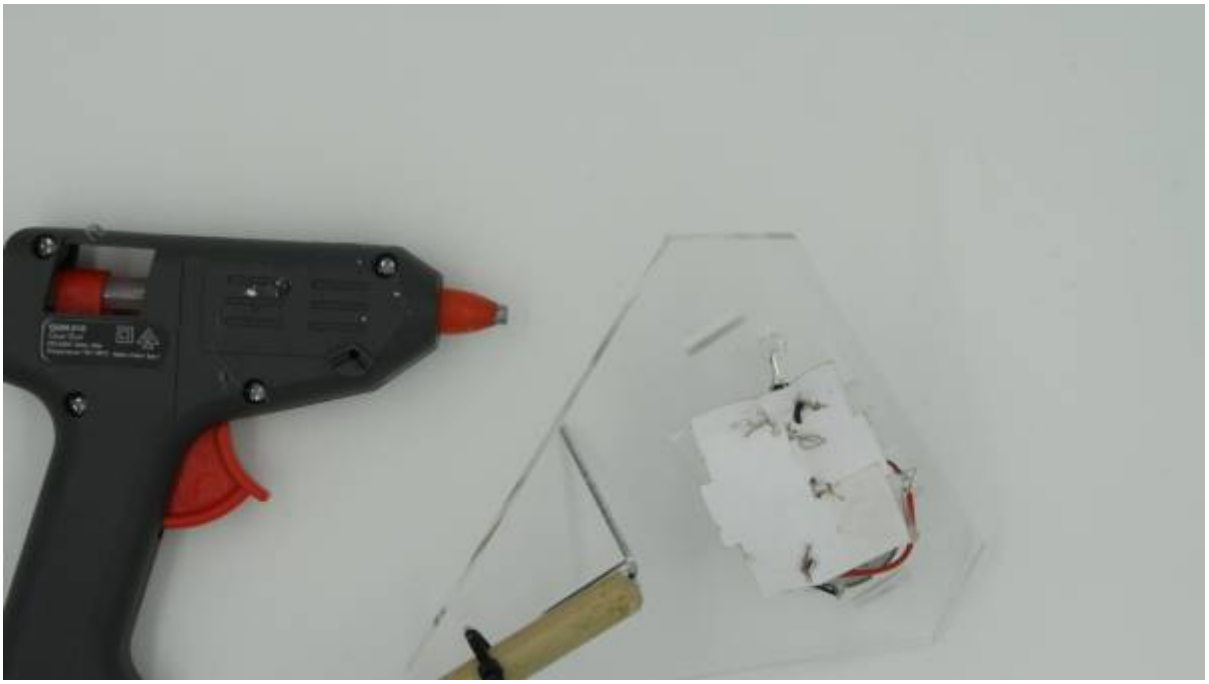
Now attach the motor wires as indicated: black wire to the transistor + LED, and red wire to the joined toroid wires.

Spin the motor in a clockwise direction with your fingers, and the LED should come on.

If not, check that the wires are twisted tightly, and no wires are touching that should not be.

PART 5: Installing the Joule Thief Circuit

Step 1: Attaching the Joule Thief circuit



From the back of the chassis, insert the LED into the hole provided, and glue it in place.

Step 2: Attaching the Enclosure

First, fold the enclosure along the scored line.
Now fold and fit the tabs into the slots in the chassis, enclosing the circuit.

Apply glue to the tabs on the cardboard enclosure, and hold in place.

Step 3: Attaching the spinner

Take the rubber band, and loop it over the hubs so that it sits in the groove made by the acrylic hub. Now slide the 10mm spacer on to the axle, and then the spinner with the double hubs closest to the chassis.

Holding the pinwheel vertically, loop the rubber band over the motor hubs, behind the larger one. Blow strongly on the spinner, and it should rotate freely (holding the pinwheel in front of a fan or hair drier works well, too).

The spinner needs to move as freely as possible, at the same time still causing the motor to turn.

Slide the chassis up or down the handle until this point is achieved. Now glue the handle in place by applying a line of hot glue to either side of the handle where it touches the chassis.

When the spinner rotates freely in a breeze, the LED will glow.

> Red LEDs work best, because they require the lowest voltage. Yellow, then green are the next best. Superbrights and flashing LEDs will probably not work at all.

References

led_pinwheel_workshop_instructions.pdf

This is a pdf powerpoint for facilitators to use during a workshop

http://www.talkingelectronics.com/te_interactive_index.html

Has a very good theoretical explanation of how the Joule Thief circuit works (find it under Joule Thief in the left hand table of contents)

Production notes

The design files for Pinwheel parts are here:

pinwheel_parts_designs.zip

, and the cutfiles in Corel format are here:

pinwheel_parts_cutfiles.zip

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The design files for the Pinwheel Joule Thief are here:

pinwheel_joule_thief_designs.zip

, and the cutfiles for the box are here:

pinwheel_joule_thief_box_cutfiles.zip