THE WATERMILL

Name of the object	Watermill
Recommended ages (from…)	From 10 years old
Thematic areas combined (STEAM)	Science (Physic forces, hydraulic energy) History
Materials needed	- Two same-size plastic bottle caps - Square - Marker - A precision knife or cutter - A heated screwdriver/a drill - 4 drinking straws (wide is better) - 1 wood skewer - 8 plastic or wooden spoons - A glue gun, or super glue - 8 ice cream sticks - An empty plastic bottle (with cap) - A bucket - An approximatively 20 cm-high box/can - Scissors - Water - (not mandatory) Micro Submersible Mini Water Pump + battery - Additionally: The support system can be done with 10 sticks and 14 small rubber gums, if you do not want to use a glue gun.

Instructions step by step	**Step 1**. Read all background information and instructions carefully in order to understand the materials needed and the time needed. **Step 2** Setting up all the materials **Step 3**. Prepare or create all components of the watermill system. **Part 1:** the water wheel **Part 2** the support system **Part 3** the water feed **Step 4** Assemble the watermill system

Step by step: how to make a watermill system out of everyday objects

Step 1. Read all background information and instructions carefully in order to understand the materials and time needed

Time needed: 5-10 minutes.

A watermill is a basic work energy generator. Created in ancient times, the watermill was originally attached to mechanical gears and shafts to drive grinders and mill wheels used for processing wheat and other types of grains. In the Industrial Revolution, watermills began to be connected to electrical generators to produce power. The basic concept of a watermill is simple, and you can create a small one with some basic materials and a water source.[1]

[1] https://www.ehow.com/how_10047629_make-miniature-watermill.html

Figure 1. Vitruvius' undershot-wheeled watermill (reconstruction).

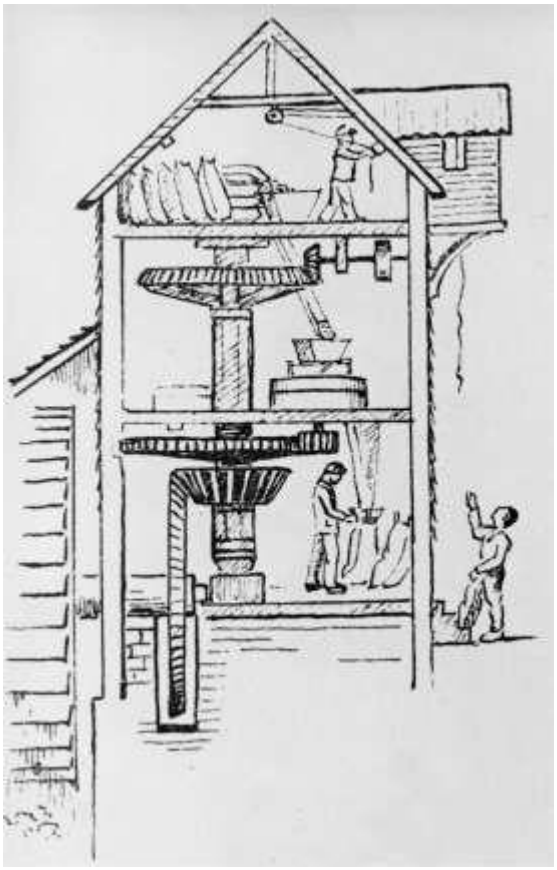


Figure 2: borrowed from Norfolk Mills (http://www.norfolkmills.co.uk/watermill-machinery.html)

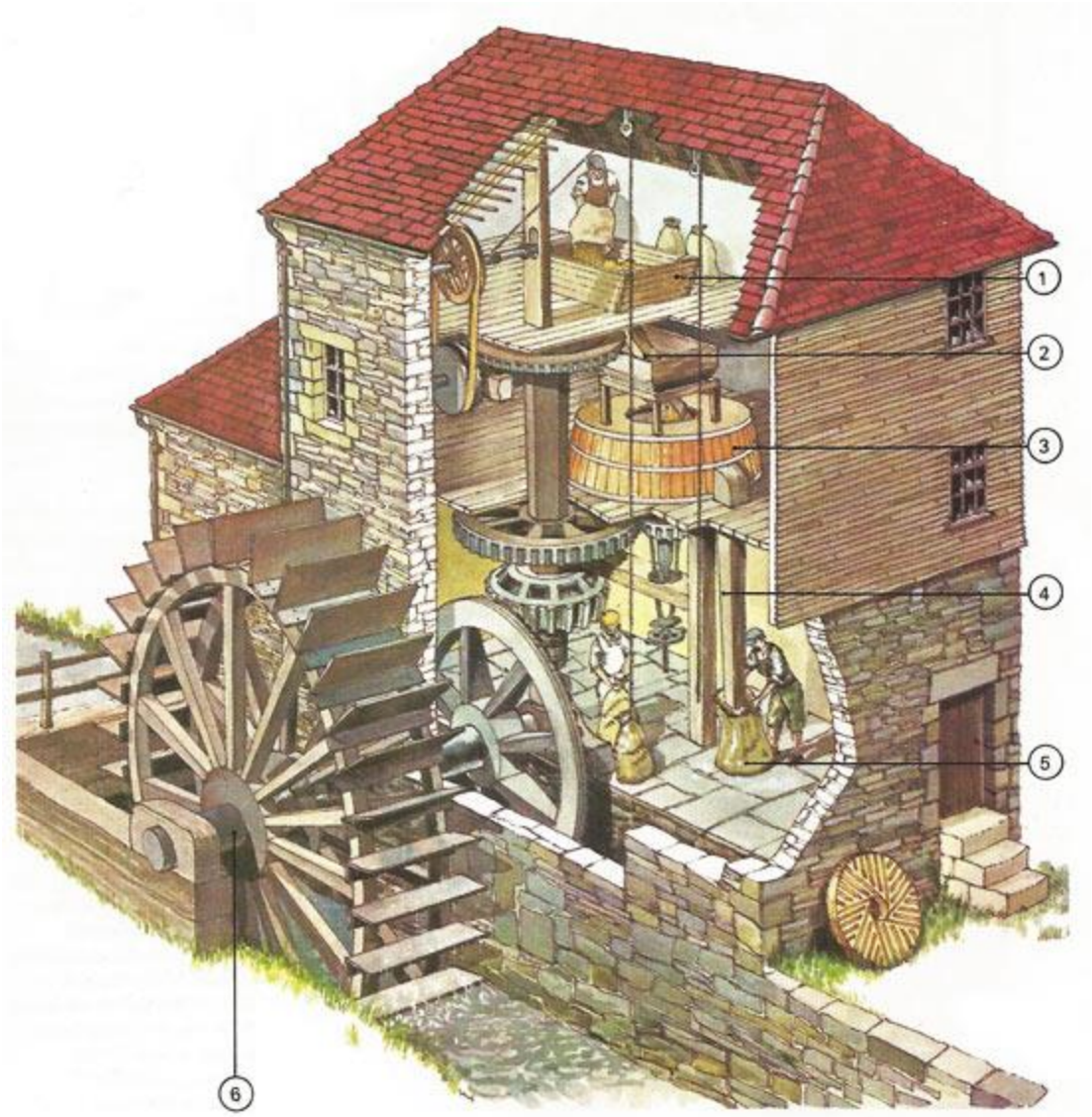


Figure 3: Consulted on https://www.daviddarling.info/encyclopedia/W/AE_water_wheel.html

Basic configuration of the machinery:

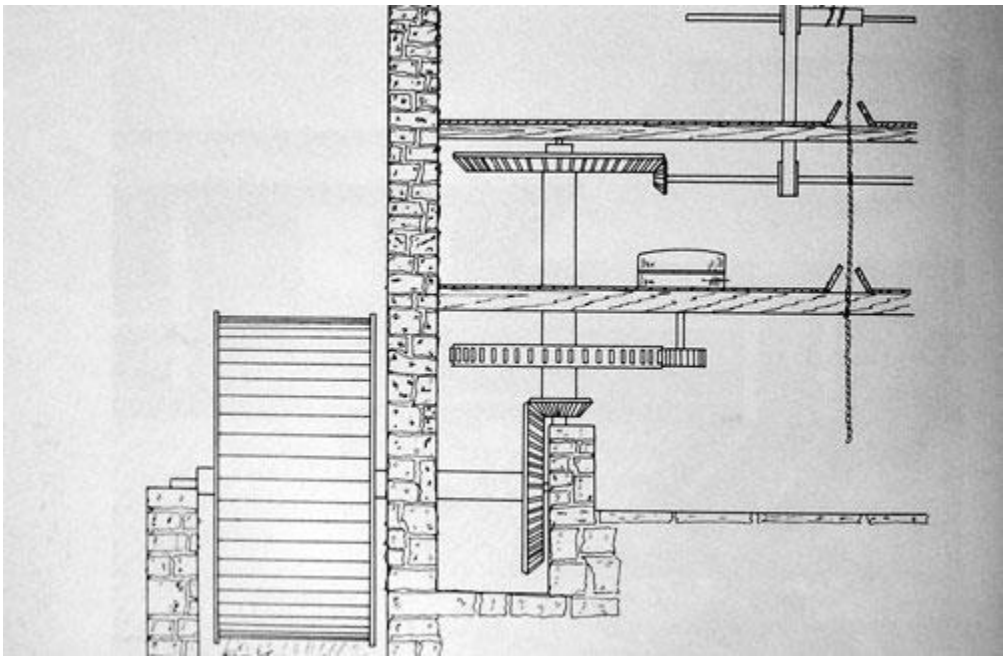


Figure 4, taken from http://www.norfolkmills.co.uk/watermill-machinery.html

Step 2. Setting up all the materials

Time needed: 5-10 minutes.

Checklist:

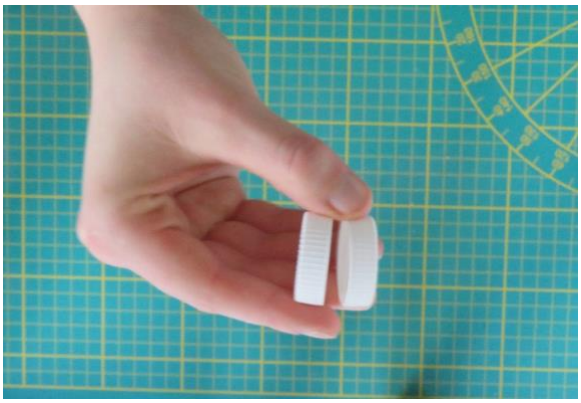
☐	Two same size plastic bottle caps
☐	Square
☐	Marker
☐	A precision knife,cutter or scissors
☐	A heated screwdriver/a drill
☐	4 drinking straws (wide is better)
☐	1 wooden skewer

☐	8 plastic or wooden spoons
☐	A glue gun, or super glue
☐	8 ice cream sticks
☐	An empty plastic bottle (with cap)
☐	A rectangle wide, low-height bucket
☐	An approximatively 20 cm-high box/can
☐	Scissors
☐	Micro Submersible Mini Water Pump + battery
☐	Water

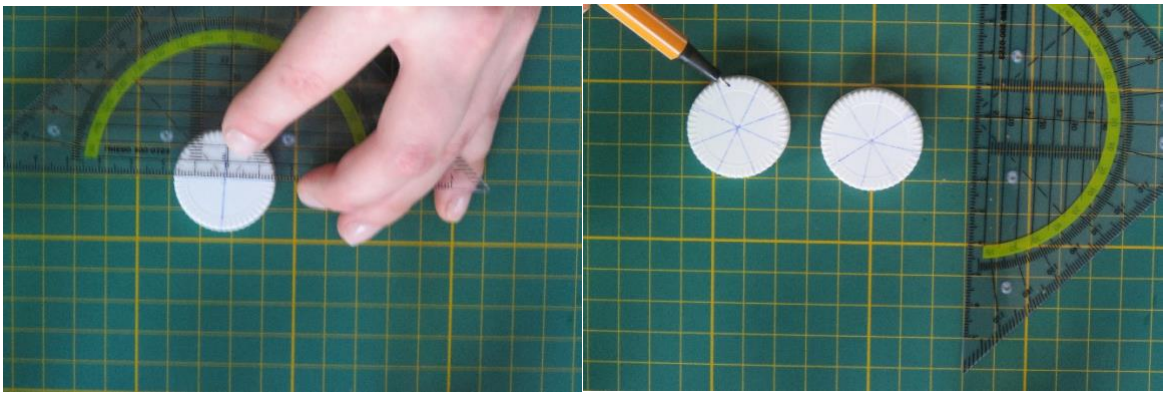
Step 3. Prepare or create all components of the watermill system

Time needed: 25 minutes

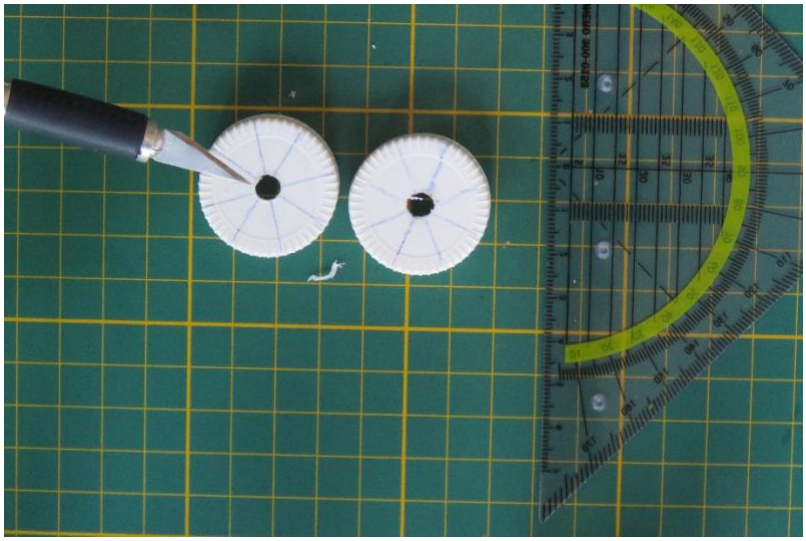
Part 1. The water wheel



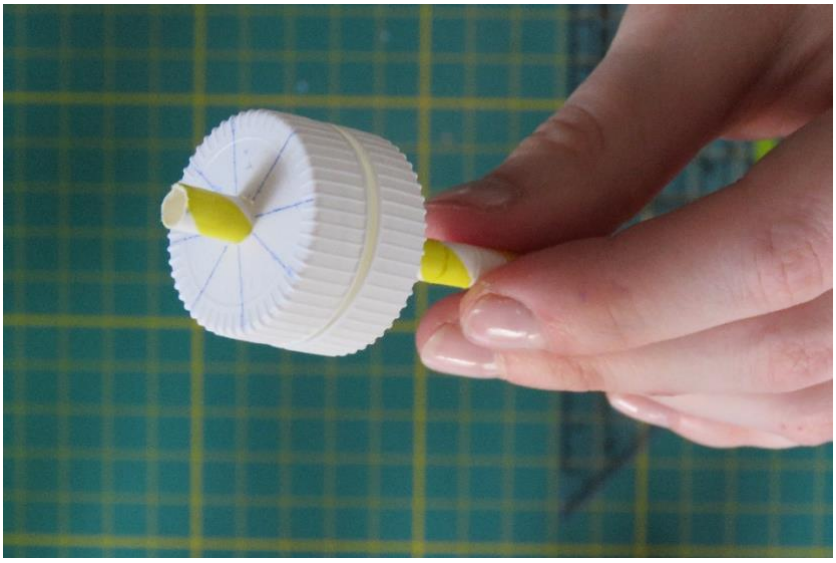
Take your two bottle caps and draw 8 equidistant lines from the centre out (in a star-like shape).



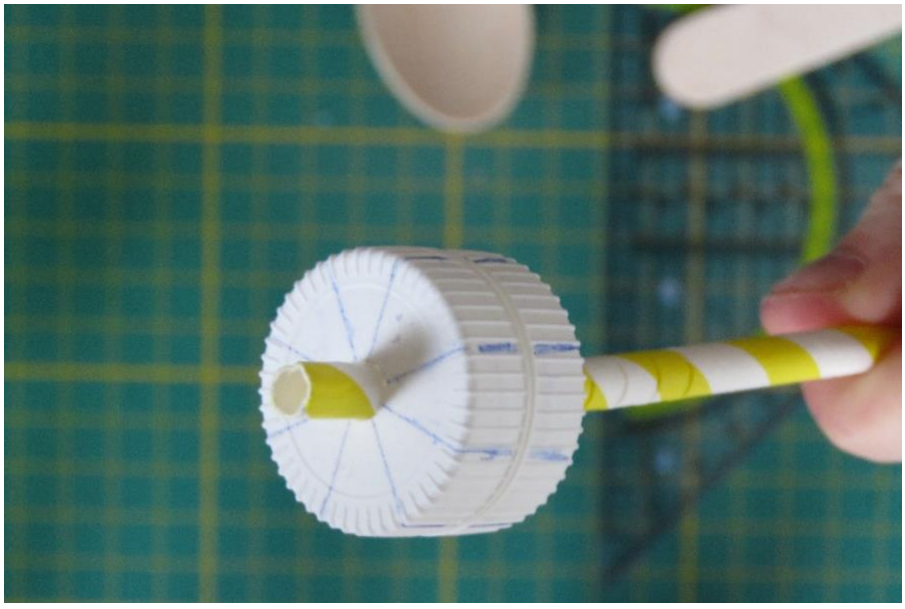
Then drill a hole in the centre of both caps that will allow your straw to go through.



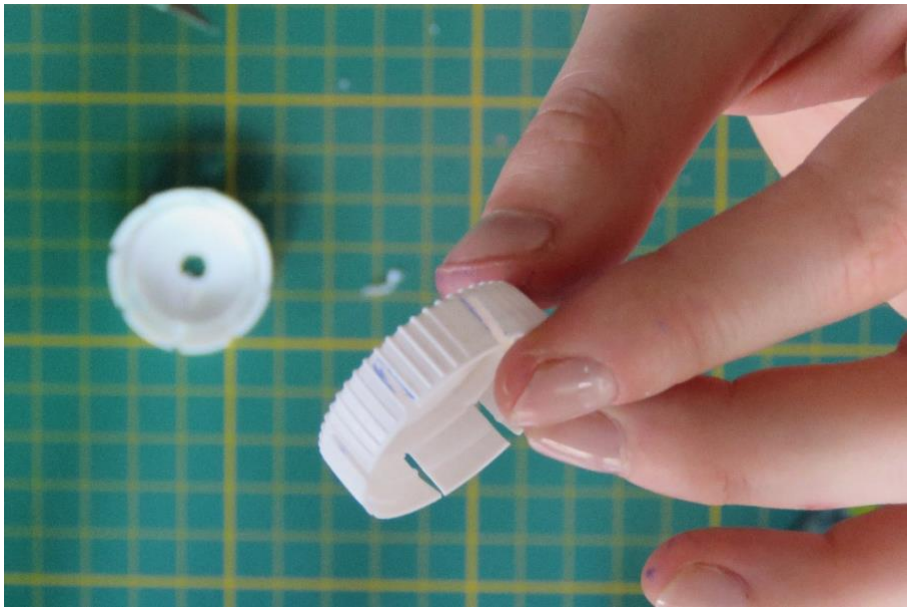
Take both caps and thread a straw through them, so that the drawn out parts (the top) can be seen from both sides.



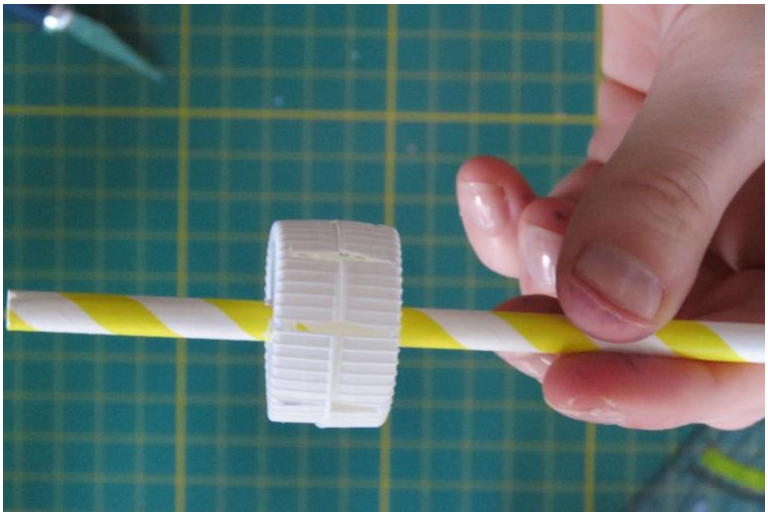
Once that is done, make your lines correspond and mark the place where they meet on the sides of the caps.



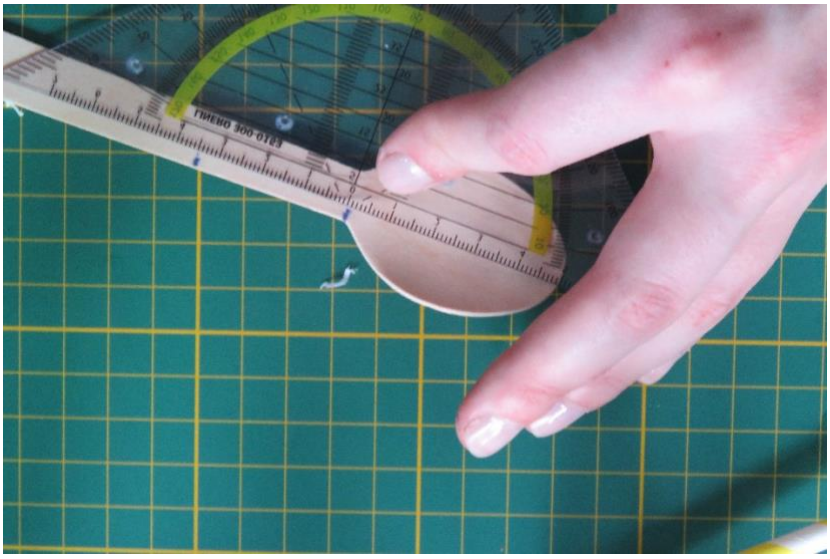
Take the caps back off the straw and use your precision knife or cutter to cut out the slabs where we marked the caps on their sides.



Thread the straw back through both caps the same way as before and make the holes correspond to one another.



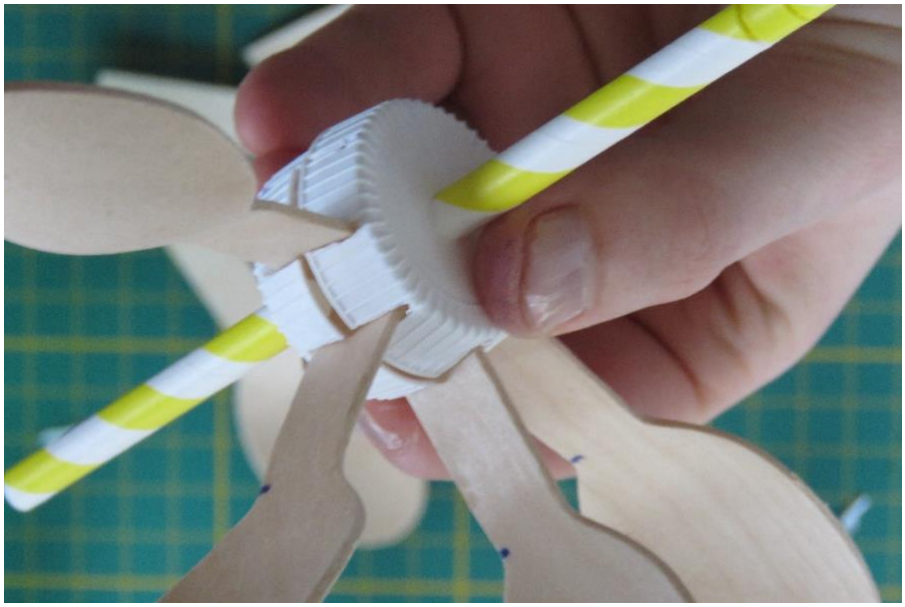
Leave that aside for now. The next step is to take your 8 spoons and to measure 3.5cm from the base of the hollow part and mark it.



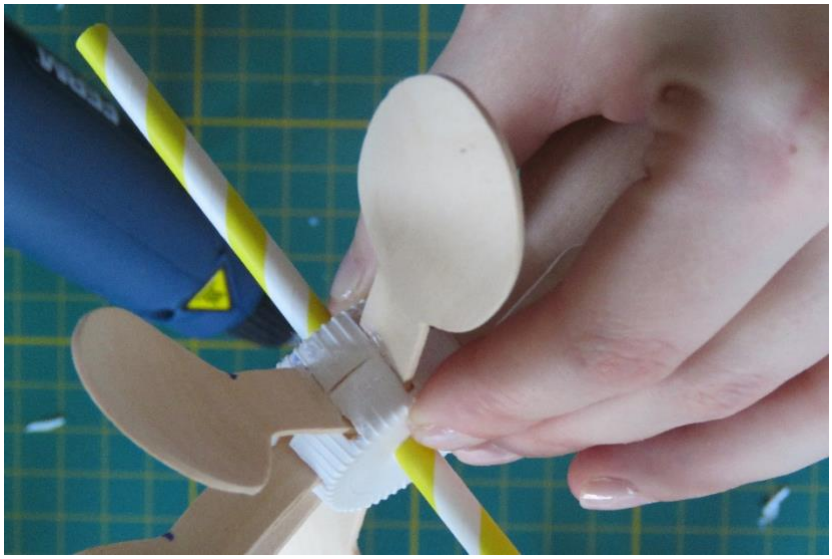
Repeat with all the spoons.

Now, using the cutter, precision knife or scissors, cut the excess off for each spoon.

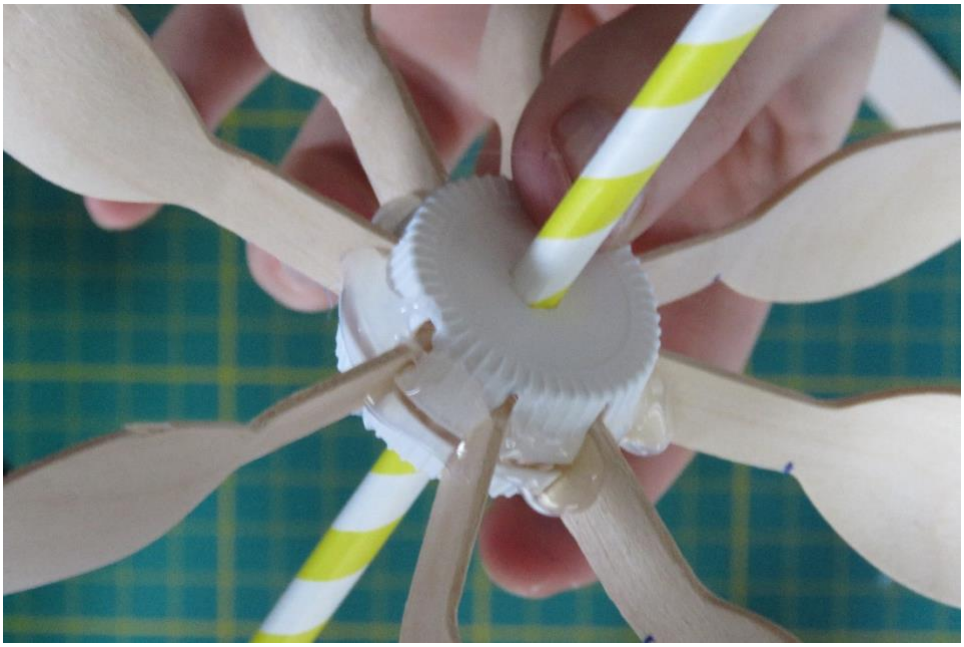
Take the short spoons and insert them in the grooves you created earlier (in the double cap). All spoons must face the same direction, and the small handle goes in until it touches the straw inside that will act as the dowel.



Now, take the glue gun, or super glue, and glue both caps' parts together, and glue the straws in place until everything holds together.



Be careful to leave enough time for the glue to set before manipulating or setting the wheel aside. It is also okay if it is not perfect-looking, as long as the “spokes” of the wheel are aligned and everything holds together.

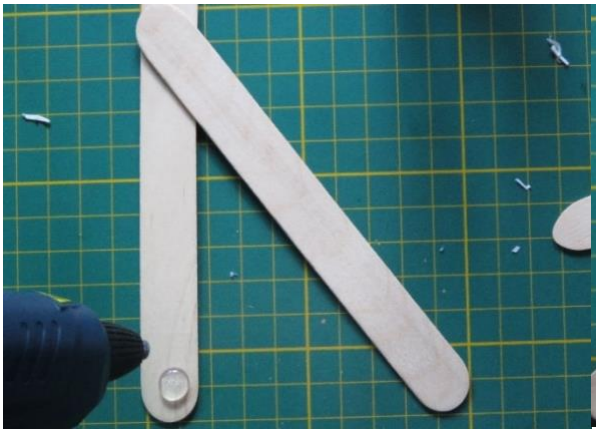


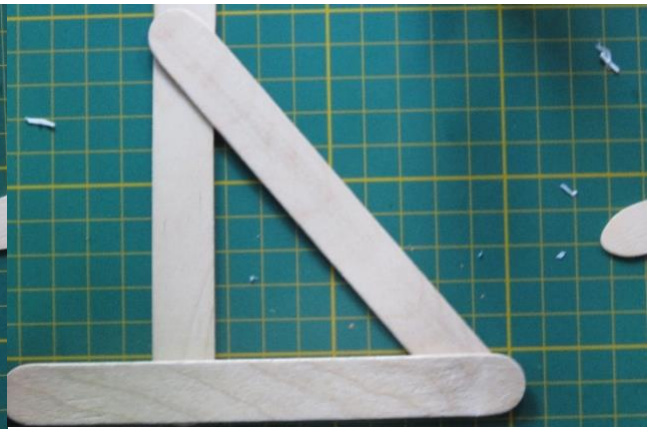
You now have your basic wheel.

Part 2. The support system

Time needed: 15 minutes

In order to create a simple support system, take your ice cream sticks and glue them together as so:

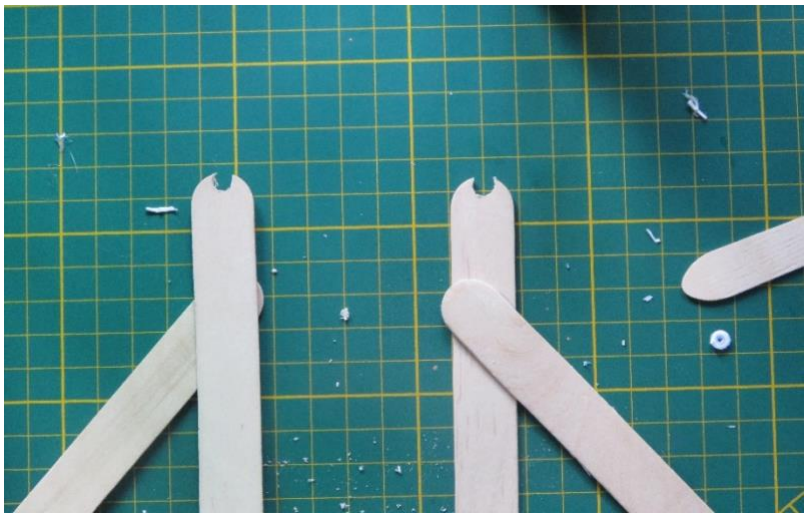




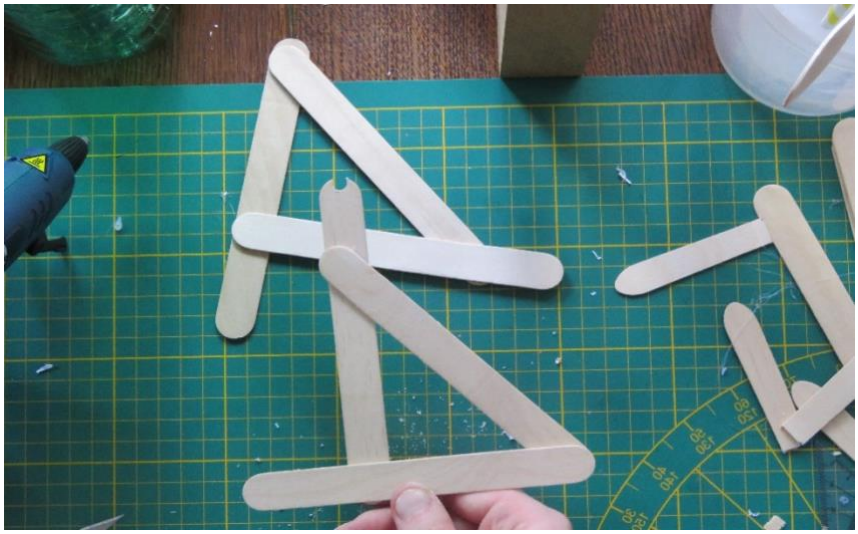
The central vertical stick will serve as the holder of the straw (dowel) of the wheel. Glue a second stick at an angle, leaving roughly 1.5 cm above it at the top of the central vertical stick, and aligning it on the same line as the bottom of the vertical stick.

The precise measures are not so important, except for one: The height of the vertical stick, as it needs to be superior to the full distance between the dowel and the top part of the spokes of your wheel. Otherwise, the wheel will not be able to turn on it.

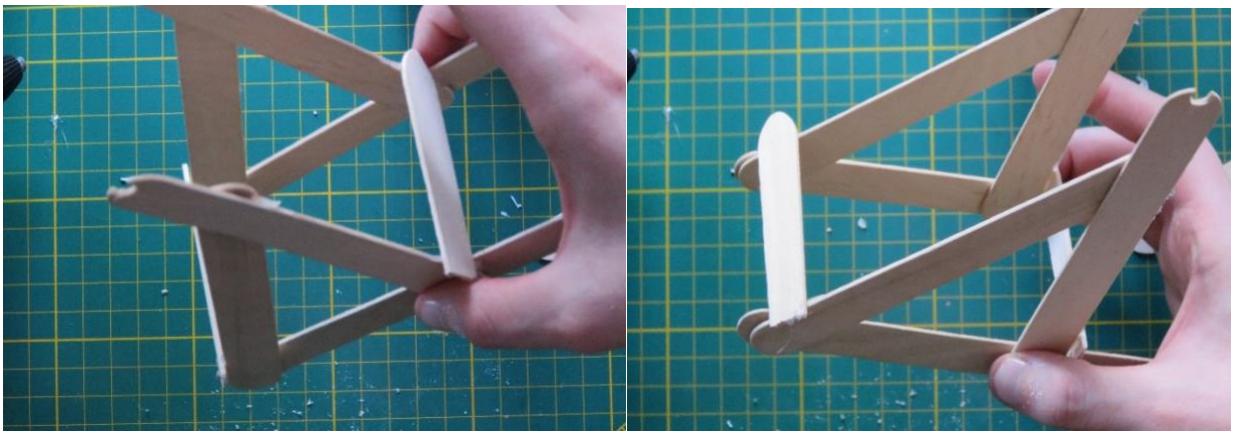
Then, link both bottoms with another stick while letting some of it go over on the other side. Repeat the procedure a second time and cut out grooves at the top of both support pieces to welcome the dowel later on.



The result should look something like this:



Now we need to hold them upright together. Use one of the leftovers from your cut off spoons or cut an ice cream stick in half. The size of it simply needs to allow the wheel to turn easily. Glue both pieces near the bottom of the structure in order to hold everything together:



Now, you can test your support system by inserting the wheel in it. If needed, open the grooves up so that the dowel of the wheel turns smoothly. Set everything aside.

Part 3. The water feed

Time needed: 10 minutes

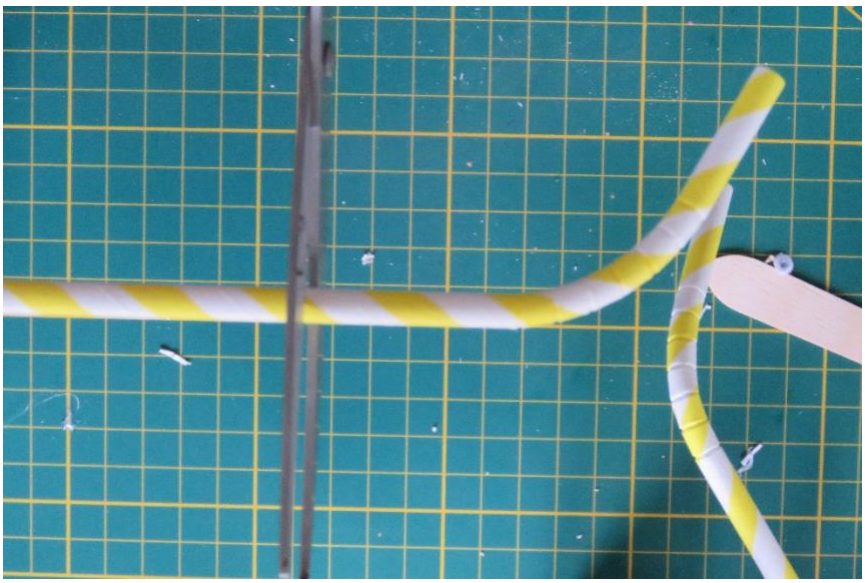
As we are not in nature, we will need to provide a continuous water feed to simulate a small stream. In order to do that, we will use a bottle and 2 straws.

Take your plastic bottle and drill a hole near the bottom of it. The hole just needs to let the straw go through.

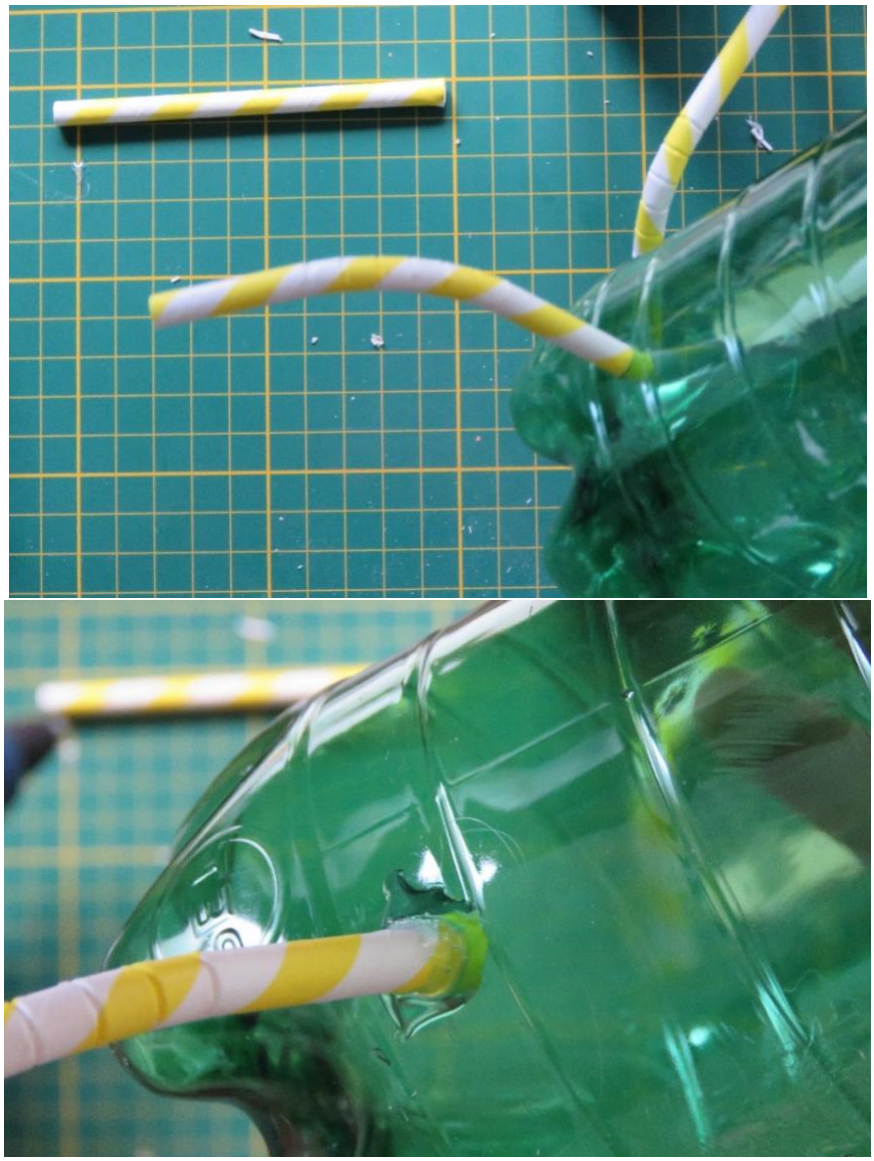
Once that is done, if you want to make it refill itself automatically (not mandatory), drill another hole towards the top of the bottle.

If you do it on the same side, as we do here, remember to offset it a little on the side in order to not have the first straw in the way. If your whole system will fit in your low-height flat bucket, you can drill this hole on the other side of the bottle (but still near the top).

Once that is done, you may cut a straw at roughly 4 cm long. Keep the folding part of the straw.



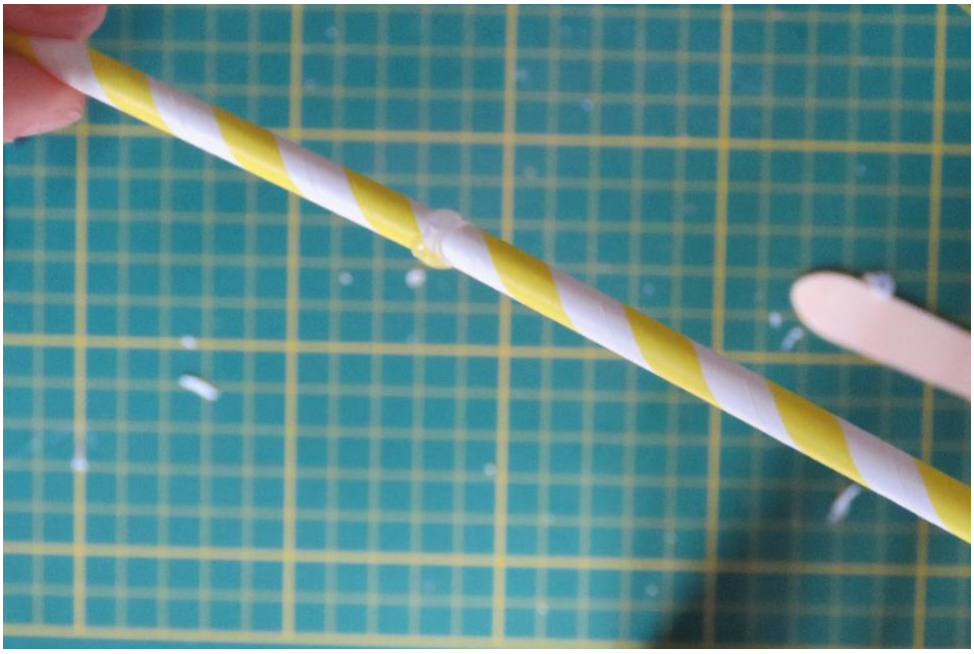
This small straw will let your water flow onto the water wheel. You may glue it in place in the bottom hole of your bottle, in a way that the fold turns the straw downwards.



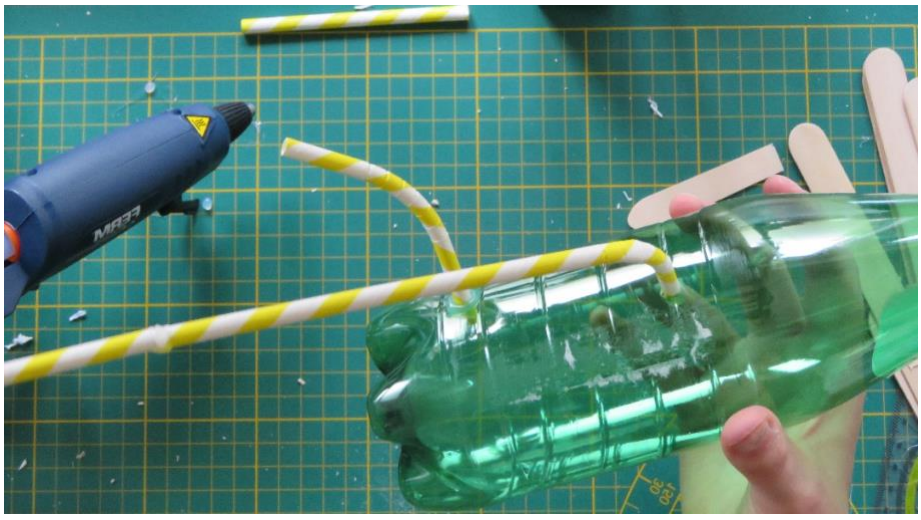
If you are using hot glue, be careful as the plastic of the bottle may tend to melt. The joint needs to be watertight.

Once that is done, if necessary, join two other straws together to make a super long straw (careful, it needs to be watertight. If you have a long tube instead, that works as well). This long straw will need to join the top hole of the bottle and the water in the bucket in which you will set the whole system. Depending on the height of your system, you may need a longer or shorter straw. The 20 cm high bucket will serve as a support

for your bottle. You may need to put everything in place in order to measure this distance.



Once you have your long straw prepared you may thread it in the top hole of the bottle and glue it in place so that the straw goes downwards as well.



Step 4. Assemble the watermill system

Time needed: 5 minutes

Once the previous parts are done, you may check that everything is of the right height.

You may now fill the receiving bucket with 1 or 2 cm of water. And you may fill the bottle with water as well. If you made the normal version, without refilling option, you may just fill the bottle up and keep you finger blocking the outlet straw, set it on the bucket and let the water flow once you are ready. Do not put the cap back on or the water will not flow. You may use a wooden skewer to strengthen your bottom straw if needed. The wheel will start turning as the bottle is emptying. You may need to refill the bottle quickly, or feed a small water source into it to not run dry.

If you made the automatic refill version, Keep your finger on the bottom straw so that you may fill it without difficulties and put the cap on tightly afterwards.

Be careful to attach your micro Submersible Mini Water Pump (with it's battery attached outside of the water) to the bottom end of the long straw, and to have the water pump properly submerged in the water of the receiving bucket and that your small straw aims at the spokes of your wheel.

Figure 31: image source https://www.amazon.com

Then you may let the water flow and turn the water pump on. The water will start to make the wheel turn by flowing out the bottom straw. At the same time, the emptying bottle will be filled by the water pump again that will suck the water from the receiving bucket back into the bottle with the long straw.

And there you have it. Your basic water wheel is done.

You may add a gear system on your dowel if you wish to.

Additional content:

- DIY. Simple Water Wheel at Home ! Water Fountain ! School Project. Experiment for Kids. Simple DIY. https://www.youtube.com/watch?v=EuUpZScza_Q
- Link to a micro submersible water pump (around 3 to 4$ on Amazon) : https://www.amazon.nl/SGerste-Waterpomp-Ultra-rustige-Horizontale-

Submersible/dp/B07HK69MTK/ref=sr_1_2?__mk_nl_NL=%C3%85M%C3%85%C5%BD%C3%95%C3%91&crid=14MG6T5BVAWBO&keywords=micro+submersible+water+pump&qid=1658335181&sprefix=micro+submersibe+water+pump%2Caps%2C60&sr=8-2