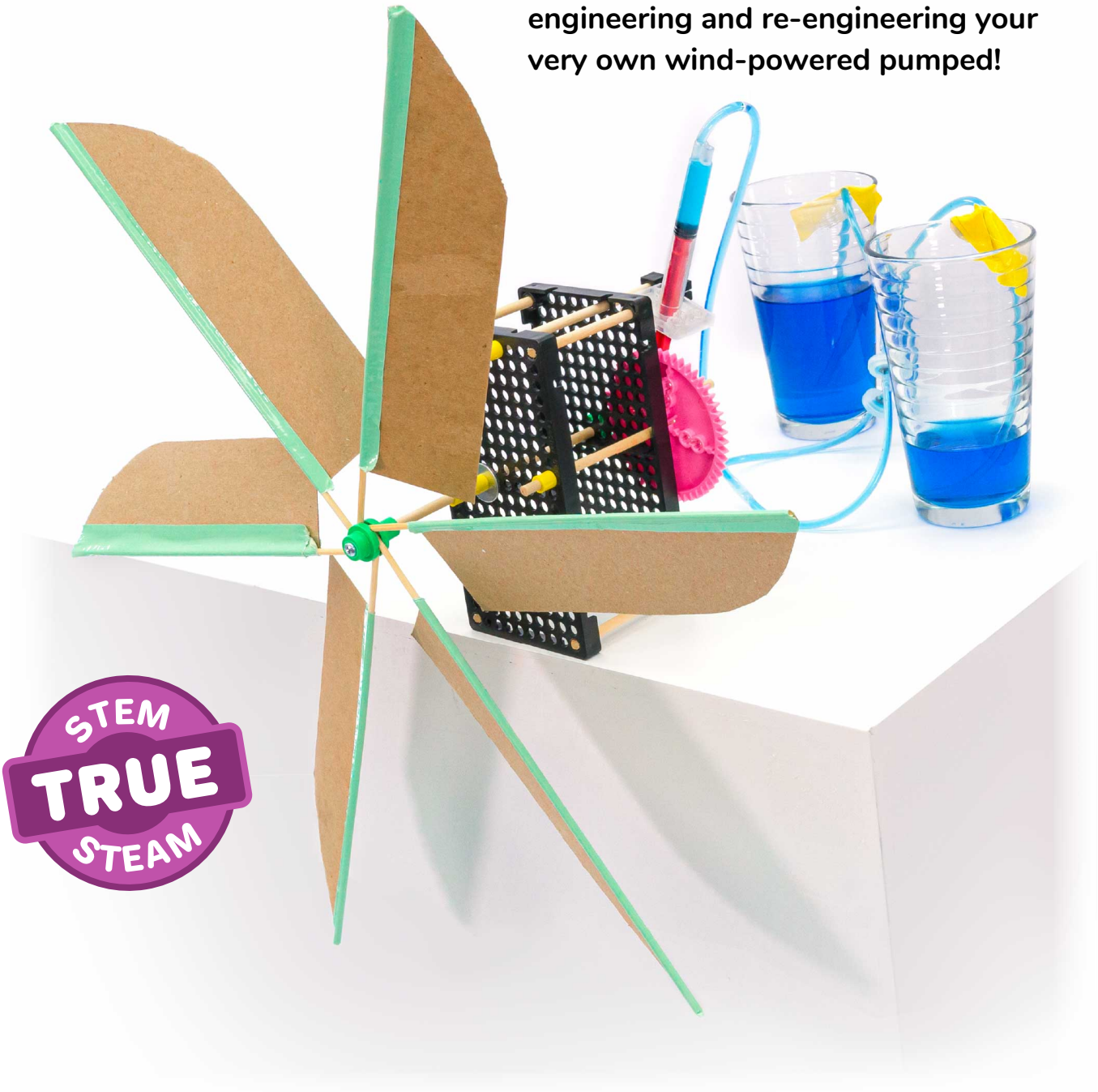
Go Guide Wind Pump 2.0

Learn about wind energy and power by engineering and re-engineering your very own wind-powered pumped!



STEM TRUE STEAM

You Are Here

Choose how you would like to complete this activity.
Download documents & videos at teachergeek.com/windpump

Go Guide

Start here! Build your Wind Pump, evolve your design, and begin the Steady Wind Challenge!

Optional Labs

-Energy & Power Lab (Ages 9+)

Optional Challenges

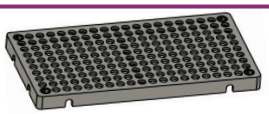
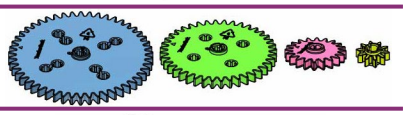
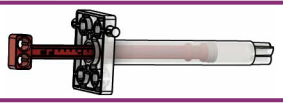
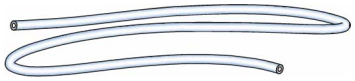
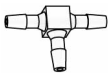
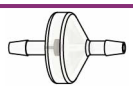
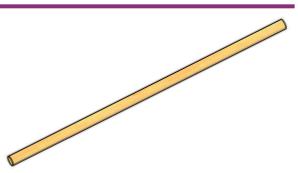
-Steady Wind Challenge*
-Variable Wind Challenge*
-Elevation Challenge*
-Environmental Challenge*

*See Page 10

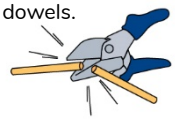
Go Guide Wind Pump 2.0

Supplies

PUMP PARTS These are the parts you need to build one Wind Pump, plus some extras, so you can make your own unique designs.

Name	Qty	Picture
Hole Plates SKU 1821-32	**2**	
Block SKU 1821-34	**1**	
Gear Set SKU 1821-28	**1** set (4 gears)	
Cylinder 4.5 ml SKU 1821-52	**1**	
Tubing 60 cm (24 in) SKU 1821-51	**2**	
T-Connector SKU 1821-56	**1**	
Check Valves SKU 1821-57	**2**	
Mini Hub Base Green SKU 1821-67	**1**	
Mini Hub Cover Green SKU 1821-67	**1**	
Mini Hub Screw SKU 1821-67	**1**	
Project Sticks 25 cm (10 in) SKU 1821-18	**10**	
Chipboard 22 cm x 5 cm (8.5 in x 2 in) SKU 1823-48	**6**	
Washers #10 size SKU 1821-24	**1**	
Slide Stop 8 cm (3 in) SKU 1821-49	**1**	
Dowels various sizes SKU 1821-20	**1** – 5 cm (2 in) **4** – 8 cm (3 in) **4** – 10 cm (4 in) **1** – 13 cm (5 in) **2** – 15 cm (6 in)	

Have a Maker Cart? Use Multi-Cutters to cut your own dowels.



INCLUDED TOOLS

TeacherGeek Reamer
SKU 1823-87

MATERIALS YOU SUPPLY

- **Phillips Screwdriver**
- **Scissors**
- **Duct Tape**
- **2 Cups** (one filled with water)
- **Fan**
- **Stopwatch**
- **Recycling Bin Materials**
  What can you use to make turbine blades?

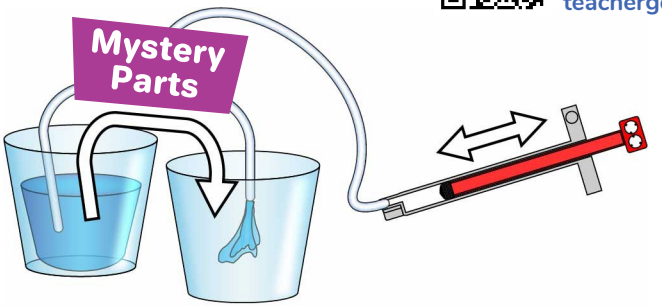
Optional Tools

Modify materials to make even more creative designs with the **Maker Tool Set**
SKU 1823-84

Make Your Pump

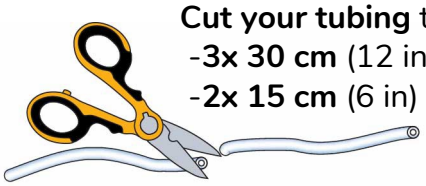
Check out the Scenario Video!
Play it by scanning the QR Code or going to teachergeek.com/windpump

You're going to engineer your very own hand pump! Later, you'll convert it to use wind power!

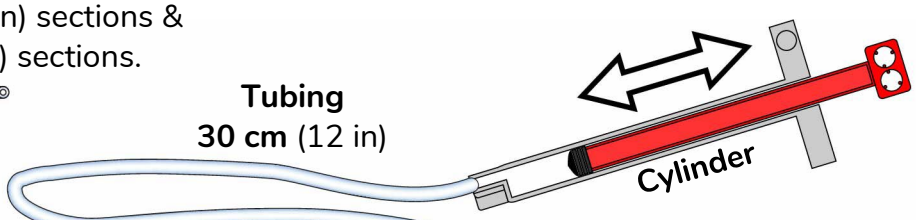


Your pump must move water from one cup to the other when you push & pull the cylinder.

Can you figure out how to use these parts to build your pump?

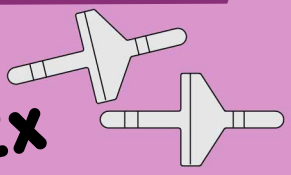


Cut your tubing to make
-**3x 30 cm** (12 in) sections &
-**2x 15 cm** (6 in) sections.

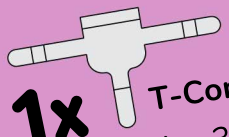


Tinker with the Mystery Parts! You will need to **use all of them** to make your pump!

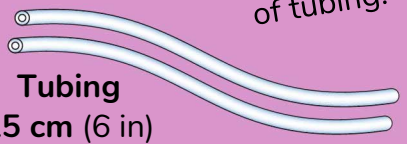
Mystery Parts



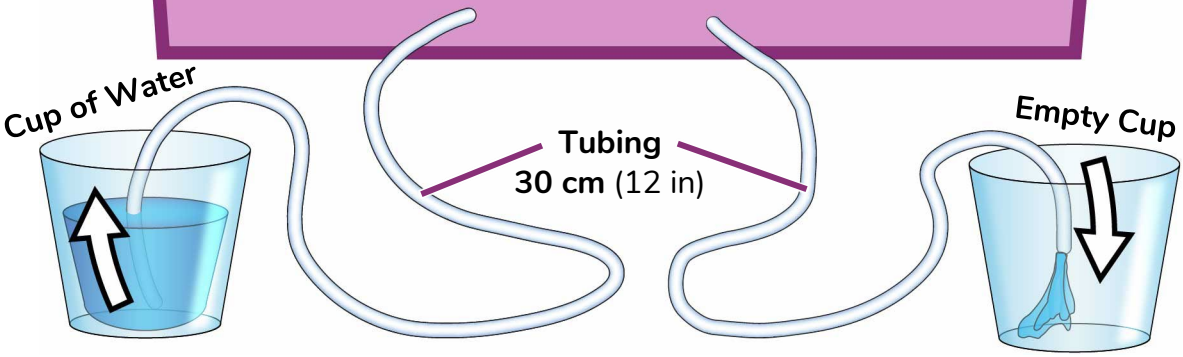
2x **Check Valves**
Only let water (or air) through in one direction.



1x **T-Connector**
Joins 3 sections of tubing.



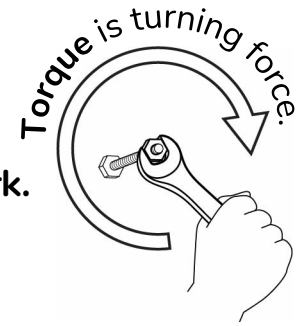
2x **Tubing**
15 cm (6 in)



Did you do it? Does your hand pump suck water from one cup and push it into the other? Awesome! You're ready to move on to the Gears.

Go Guide Wind Pump 2.0

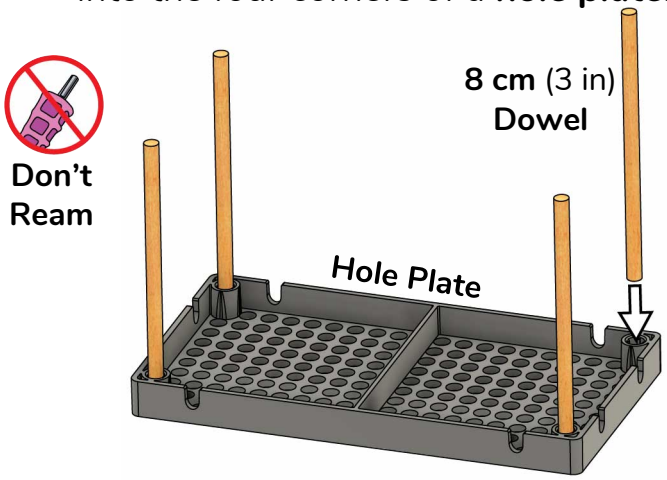
Gear Up



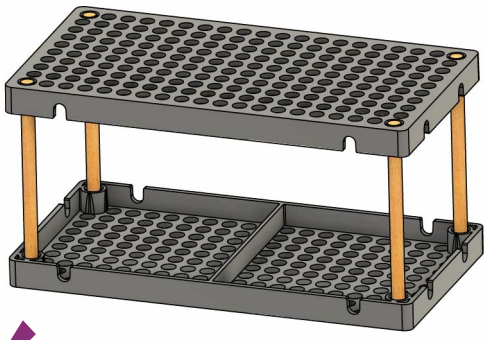
Your pump will use gears to pump faster or with more torque. Get your gears set up, then play with them to see how they work.

Build Your Frame

1. **Wiggle** or tap **four 8 cm** (3 in) **dowels** into the four corners of a **hole plate**.



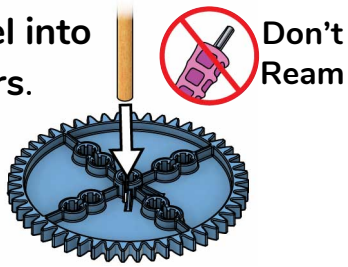
2. **Push** or tap another **hole plate** onto the dowels.



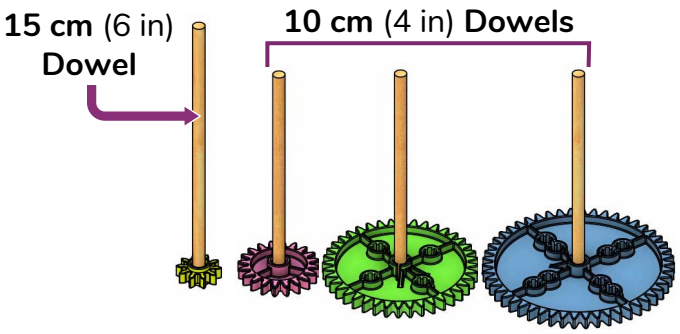
☑ **Your frame is done!**
Time to add gears.

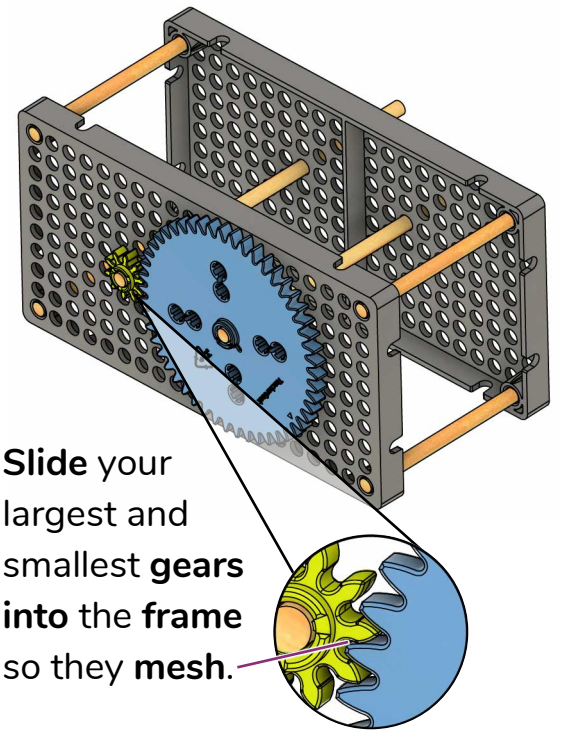
Make Your Gears

3. **Wiggle** or tap a **dowel into** each of your four **gears**.



Finished Gears



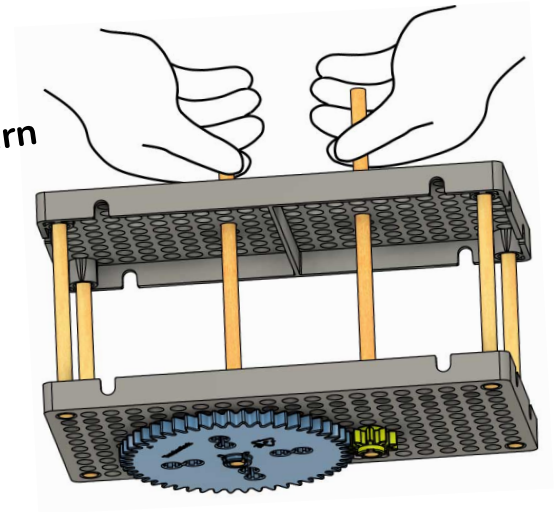


4. **Slide** your largest and smallest **gears into** the **frame** so they **mesh**.

Play with Gears!

Gears can trade speed for torque (and vice-versa)

Spin the dowels to turn the gears!



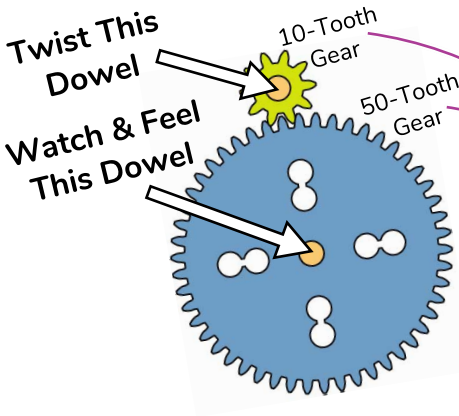
Feel the Torque

The easier it is to twist the dowel, the more torque its gear has.

See the Speed

Watch the gears to see which one revolves faster.

Speed for Torque -OR- Torque for Speed



Gear Ratio

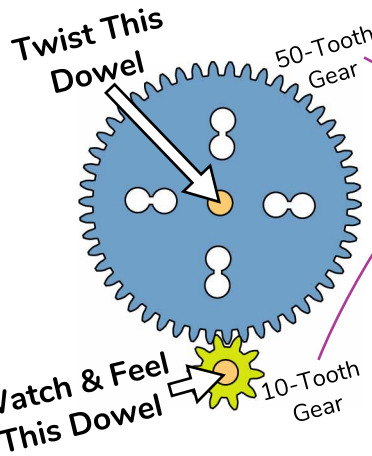
$\frac{10 \div 10}{50 \div 10} = \frac{1}{5}$

Speed Decreases

$\frac{1}{5}$ the speed

Torque Increases

$\frac{5}{1}$ = **5x** the torque



Gear Ratio

$\frac{50 \div 10}{10 \div 10} = \frac{5}{1}$

Speed Increases

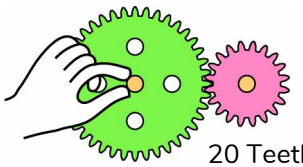
$\frac{5}{1}$ = **5x** the speed

Torque Decreases

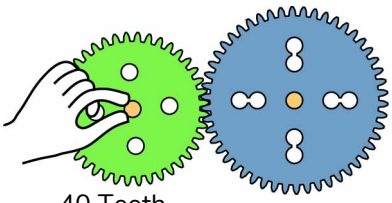
$\frac{1}{5}$ the torque

Try other gear combinations

10 Teeth 20 Teeth



40 Teeth 20 Teeth

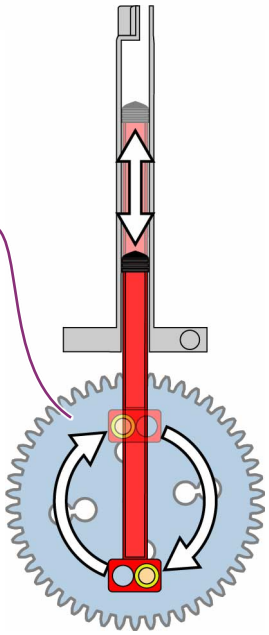


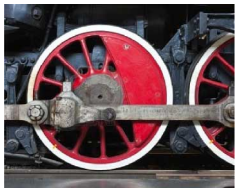
40 Teeth 50 Teeth

☑ **Now you have a feel for how gears work!** Next, you're going to use the gears to drive your pump.

Geared Pump

You're going to use your gear as a cam to convert rotational (circular) motion to linear (straight-line) motion.





Cams are used on train wheels and gasoline engines.

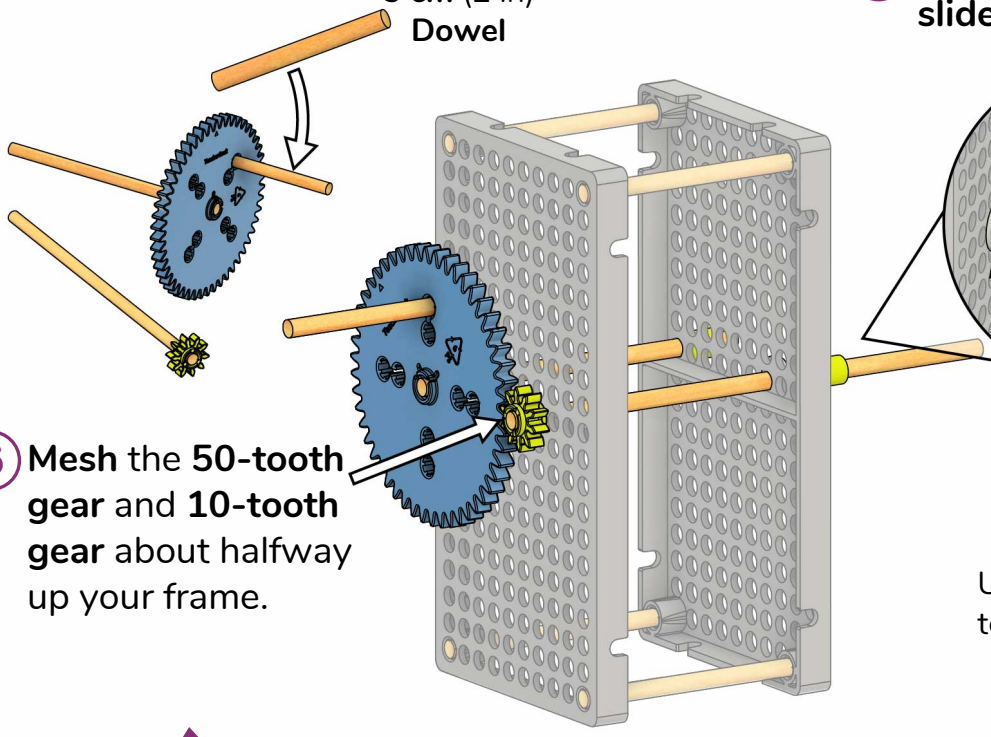
Attach the Cam

Start by connecting the cam to the frame; next, you'll connect the cylinder.

5 **Wiggle** or tap a **5 cm** (2 in) **dowel** into the **50-tooth gear**.

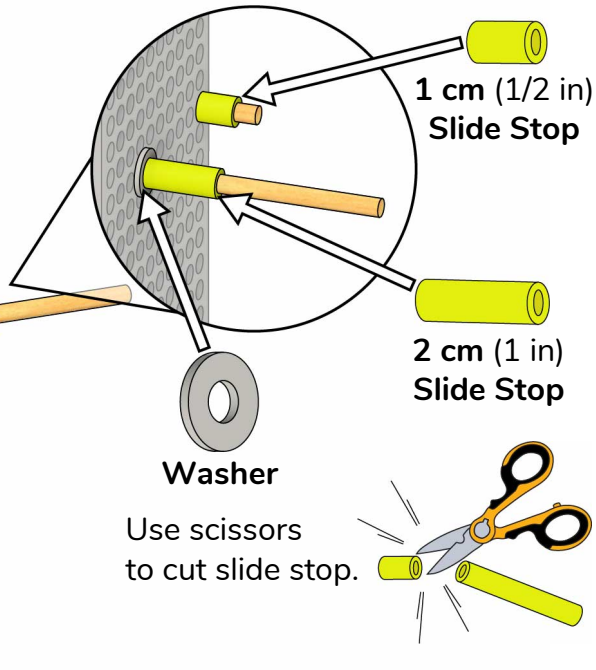
Don't Ream

5 cm (2 in) **Dowel**



6 **Mesh** the **50-tooth gear** and **10-tooth gear** about halfway up your frame.

7 **Secure** the **dowels** with **slide stop** and a **washer**.



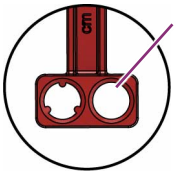
Use scissors to cut slide stop.

☑ **Test your gears!** If they don't spin freely, loosen the slide stop until they do. Now you're ready to add the pump!

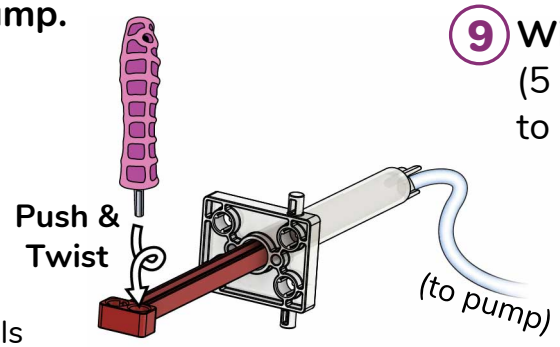
Attach the Pump

Connect you pump's cylinder to finish your geared pump.

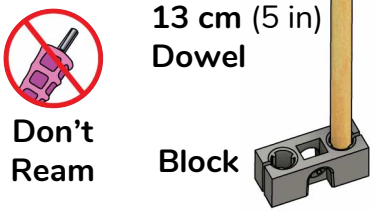
8 **Ream** one of the holes in the **cylinder**.



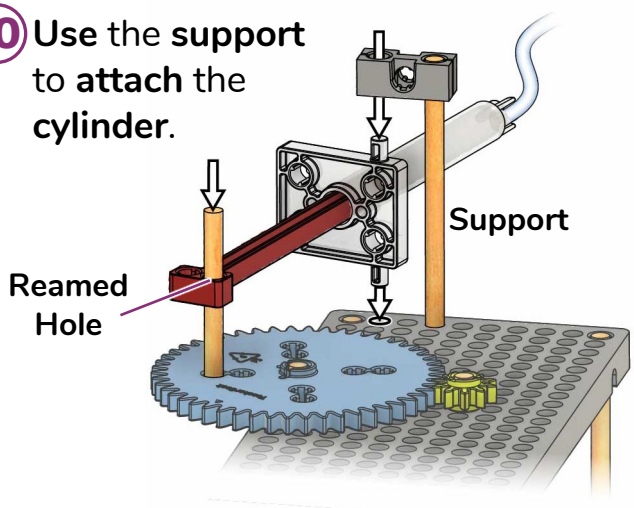
Reamed holes have no splines (teeth) so dowels can spin freely.



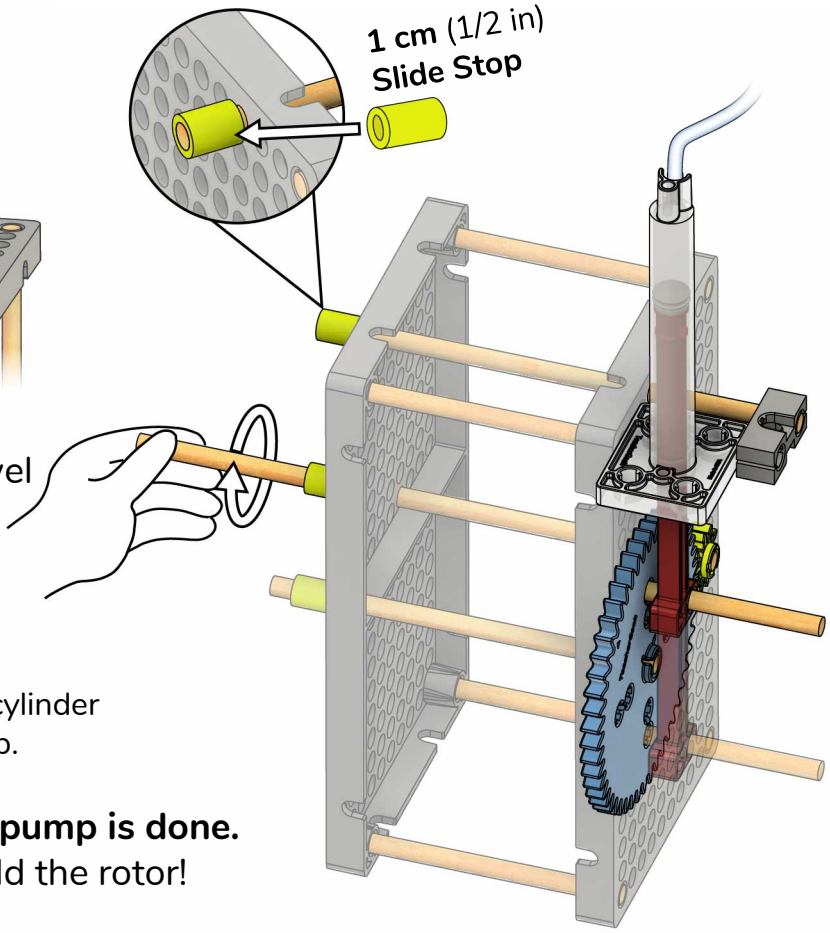
9 **Wiggle** or tap a **13 cm** (5 in) **dowel** into a **block** to make a **support**.



10 **Use** the **support** to **attach** the **cylinder**.



11 **Secure** the **support** with **slide stop**.



12 **Test it out!** Spin the longest dowel (10-tooth gear) to run your pump!

Not working?

You may need to move your gears or cylinder on your frame or loosen your slide stop.

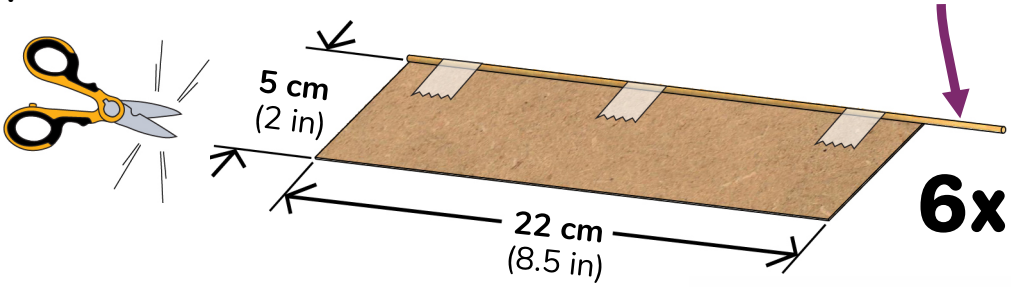
☑ **Your geared pump is done.**
It's time to add the rotor!

Ready the Rotor

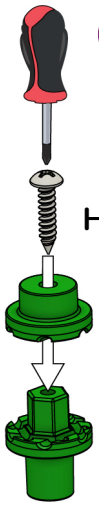
You're going to add a rotor to harness wind energy to turn the gears that drive your pump.

Build Your Blades

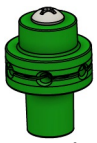
13 Get **six 22 cm x 5 cm** (8.5 in x 2 in) **pieces** of **chipboard**.



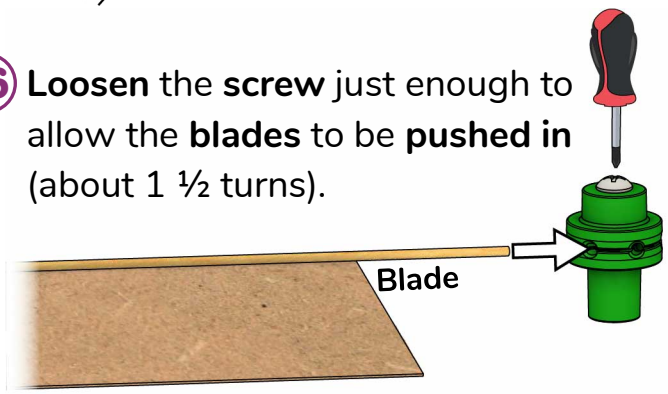
14 **Tape** a **project stick to** each **edge**, leaving the extra on one side.



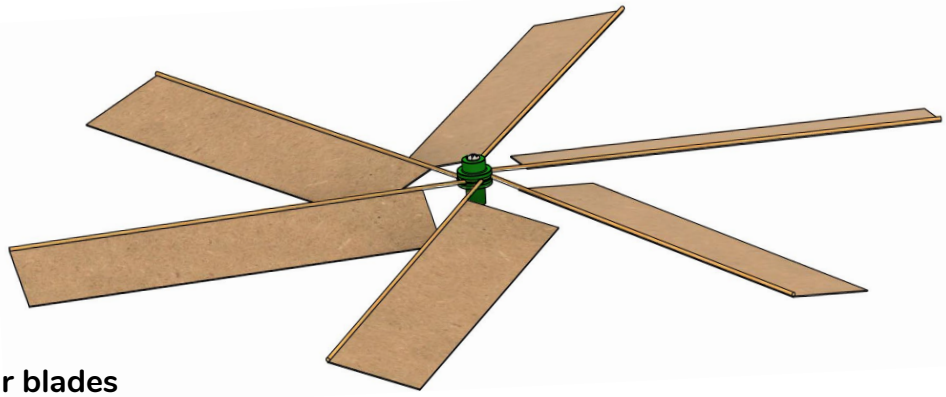
15 **Attach** the **hub cover** to the **hub base** with the **hub screw**.

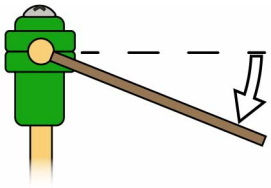


16 **Loosen** the **screw** just enough to allow the **blades** to be **pushed in** (about 1 ½ turns).



17 **Add** all the **blades** and **tighten** your **hub screw** to complete the rotor.





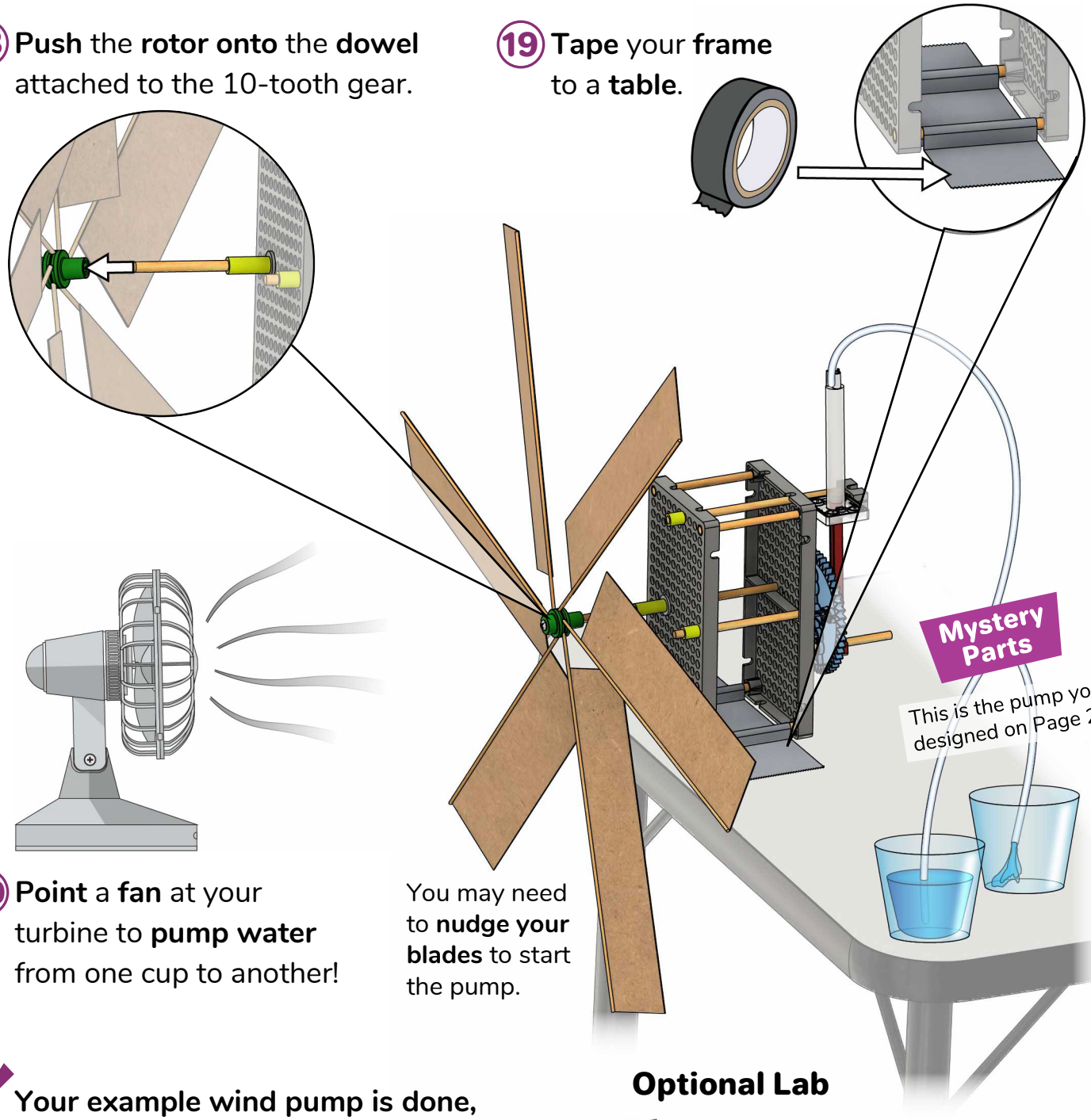
Angle your blades so they spin in the wind.

☑ **Your rotor is done!**
Time to mount it on the frame.

Test It Out

18 **Push** the **rotor onto** the **dowel** attached to the 10-tooth gear.

19 **Tape** your **frame** to a **table**.



20 **Point** a **fan** at your turbine to **pump water** from one cup to another!

You may need to **nudge your blades** to start the pump.

Mystery Parts

This is the pump you designed on Page 2.

Your example wind pump is done, but you aren't... Make it better, try a lab, or start a challenge!

Optional Lab

Energy & Power Lab (Ages 14+)

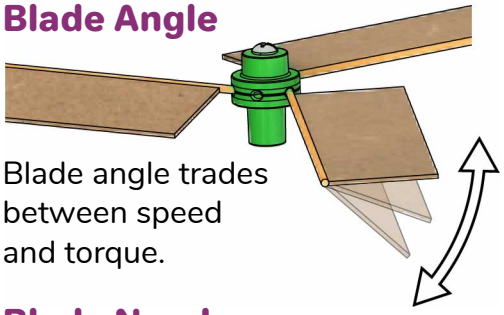
Get documents and more at teachergeek.com/windpump

Tuning Your Turbine

Pump water faster by harvesting as much wind energy as possible and getting the right balance between speed and torque. Your turbine needs *just enough* torque to get started – any extra torque should be traded for speed.

Experiment with the Blades

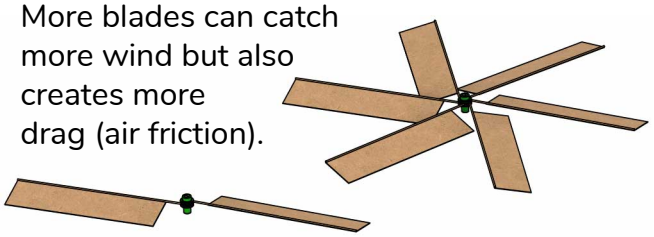
Blade Angle



Blade angle trades between speed and torque.

Blade Number

More blades can catch more wind but also creates more drag (air friction).



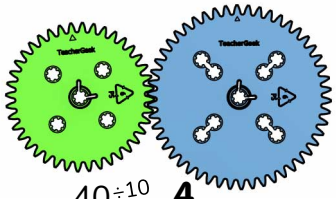
Blade Shape

Try all different shapes, sizes, and materials. What can you make into a turbine blade?

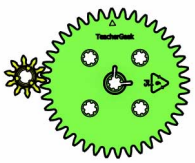
Experiment with the Gears

Swap the Gears

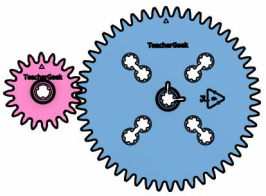
Try different gear ratios.
What works best with your blades?



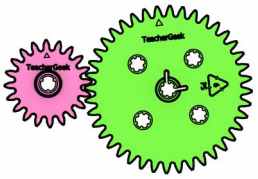
$\frac{40}{50} \overset{\div 10}{\underset{\div 10}{}} = \frac{4}{5}$



$\frac{10}{40} = \frac{1}{4}$



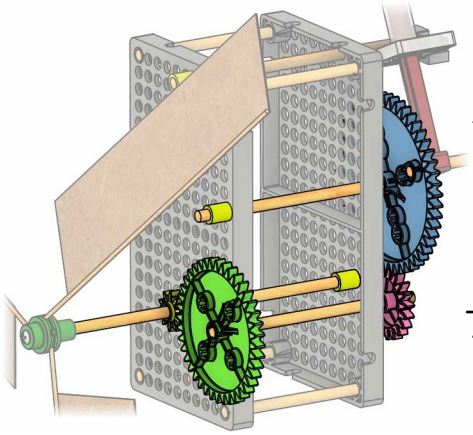
$\frac{20}{50} = \frac{2}{5}$

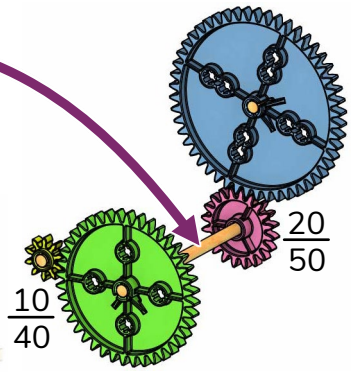


$\frac{20}{40} = \frac{1}{2}$

Compound Gears

Compound gears multiply the ratios of the other gears, giving you even more ratio options.





Gear Ratio:

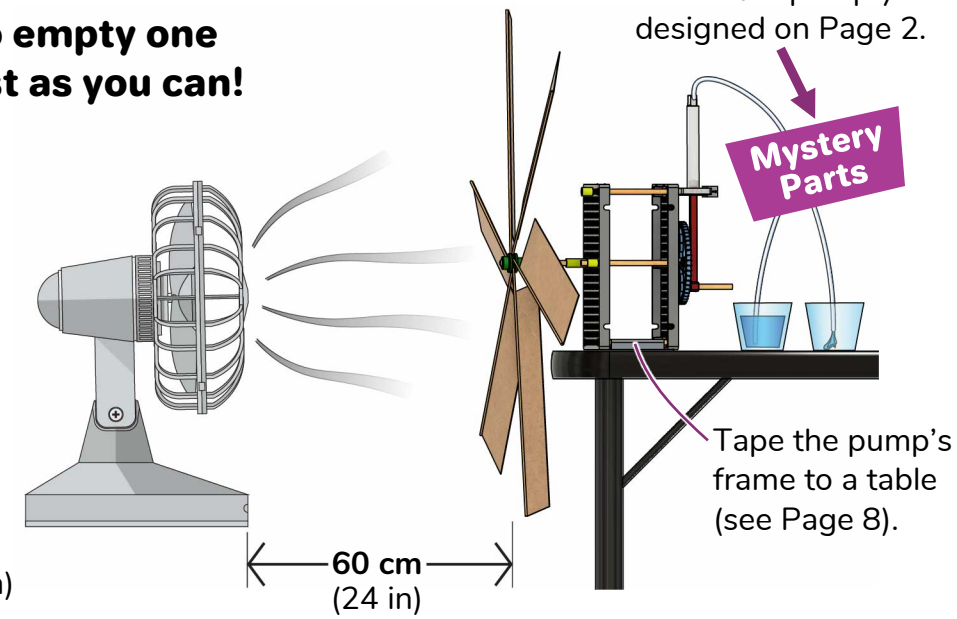
$\frac{10}{40} \times \frac{20}{50} = \frac{200}{2000} = \frac{1}{10}$

Steady Wind Challenge

Engineer your pump to empty one cup into another as fast as you can!

Criteria:
(what your design must do)

- **Pump 110 ml** (4 oz) of **water** from one cup to another in the **shortest time possible** to win!



Constraints:
(rules and limits for your design)

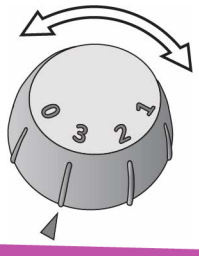
- **Only wind** can **power** your pump (but you can give it one small push to get it started).
- You may **only use** the **supplies** listed on **Page 1**.
- The **fan** must be **60 cm** (24 in) **from the blades**.
- There is **no limit** on **recycling bin materials**.

Additional Challenges

Use the Criteria & Constraints above for these challenges.

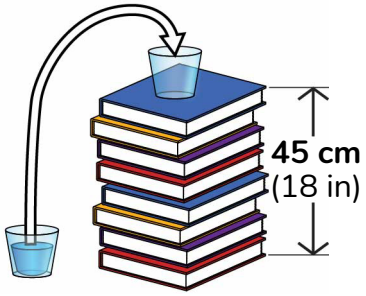
Variable-Wind Challenge

Do three trials, back-to-back, with **different fan speeds**. There's 1 minute between trials to swap gears/blades. The turbine with the **shortest total time** wins!



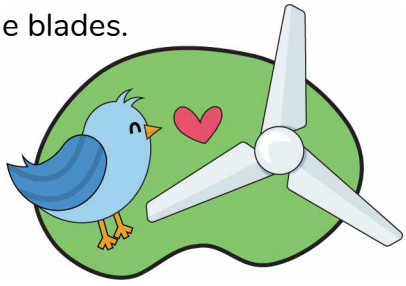
Elevation Challenge

Change setup so you **pump a vertical distance of 45 cm** (18 in).



Environmental Challenge

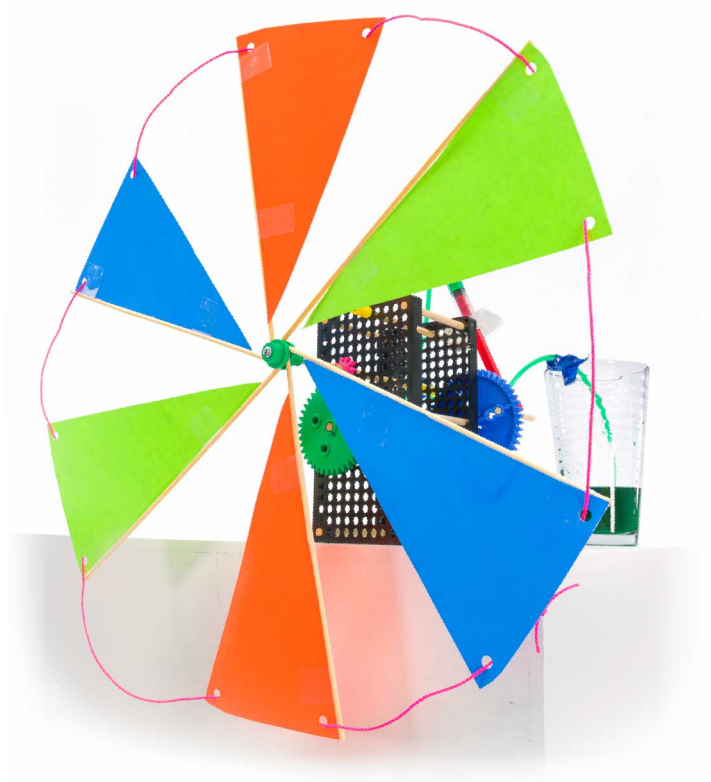
Modify your turbine to **look nice in nature** and have safety features to **protect birds** from the blades.



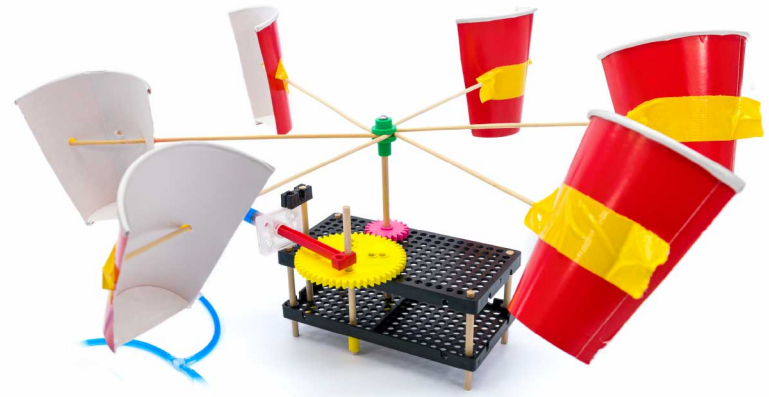
Inspiration

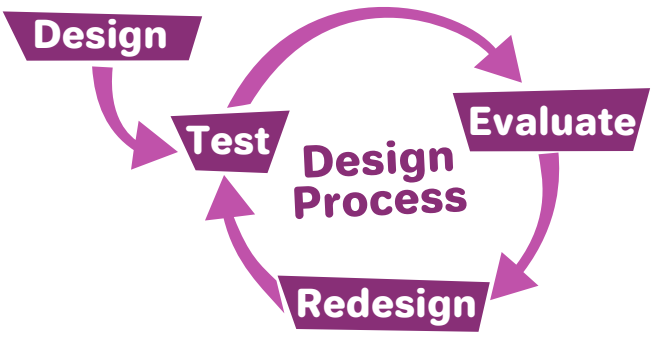
How else can you make your turbine?
What else can you make with the parts?

Try crazy blade designs!



Design a Vertical Axis Turbine – they work no matter what direction the wind comes from!





The Engineering Design Process never ends!
There is no perfect design.

Make a Kinetic Sculpture that uses the wind to make moving artwork.