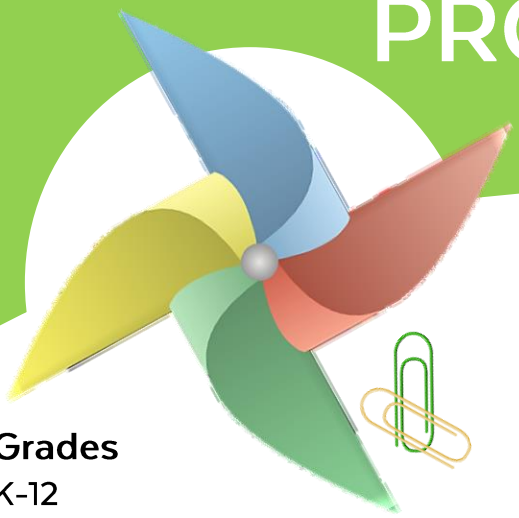
PROTOTYPE



Trade Winds Trap
Activity

Grades
K-12

Career Pathways
Mechanical Engineer
Turbine Design Engineer
Energy Systems Engineer
Turbine Technician
Field Specialist

Academics
Math: Surface Area, Measurement
Science: Energy, Forces, Structure, Function, Systems

Professional Career Skills
Collaboration
Creativity
Perseverance

Materials
Cardstock
String (Thread, Yarn)
Toothpicks
Drinking Straw
Paperclips (or washers/pennies)
Ziplock bags
Craft supplies: Scissors, Tape, Markers, Color Pencils

Optional -
Ruler
Hole Punch
Stopwatch
Scale (measure mass of objects)

Team Goal

Level 1

Construct a pinwheel that transforms kinetic energy from wind into mechanical energy.

Level 2

Design and construct a pinwheel that transforms kinetic energy into mechanical energy. Use your design to transfer this mechanical energy to an object through forces that will displace (lift) the object.

Level 3

With supplies as a constraint, design and construct a turbine that can transform energy into forces that will do the most work on an object.

Think like a Wind Turbine Design Engineer

Iterative Design

As you create your design, continue to think of new ideas and make improvements so it works better and looks great! Engineers and designers are always improving and modifying their ideas and models by cycling through the engineering design process.

Energy

Energy can be converted from one form to another, but cannot be created or destroyed. Wind energy comes from the uneven solar heating of molecules in the air. These air molecules move and this natural movement is what we feel as wind. A fan uses electrical energy (from a power plant) to push air molecules. This is an artificial way to create wind.

Renewable Energy

Wind and solar are sources of renewable energy, which are a kind of energy that will never run out. Windmills use wind energy and solar panels use the sun's energy to generate electricity. Your pinwheel can use renewable energy from wind to do work!

Precision

Engineers pay attention to the details of how components are shaped and connected. Measurements have to be precise so the final product they design works well. When you design and construct your pinwheel, you need to be precise! Precision in design and construction can help with reducing energy loss and increasing efficiency.

Criteria

You will know your pinwheel design is successful by how well it works. One criteria for success is designing a pinwheel that can lift the most mass. Modify your design to increase your pinwheel's ability use wind energy to do work!

Constraint

All designers and engineers are limited by resources or time. You may have a limited number of supplies or a limited amount of time to construct a design. You'll need to work with what you have to make the best pinwheel possible. Designing and engineering are very creative work!

Efficiency

Efficiency is important for designs that transfer or convert energy from one form to another. You must design your pinwheel to best use a fan or wind to lift mass. Reducing friction is one way to increase energy efficiency in your design.

Prototype or Model

Before putting too many resources, like time or money into a final product, you should sketch a plan and build a small model of your product first. Your pinwheel is a model of a simple wind turbine. You might create several pinwheel prototypes that lift mass.

Troubleshoot

When you assemble your pinwheel model, it may not work as well as you expected. Designers and engineers always test, modify and refine their designs so they work! Troubleshoot and modify your design so it lifts the most mass!

Component

Your pinwheel model has many parts that are needed to make it function and work. You might need to modify different components so they fit or work together better. The components need to all work together with efficiency to make your pinwheel do work!

Modular

Many engineers and designers create products with components that can be fixed or replaced without having to throw everything away. Many windmills are modular, so parts can be fixed, replaced or even removed. Are parts of your design modular? Modular products are good for the environment and a future budget!

Assembly

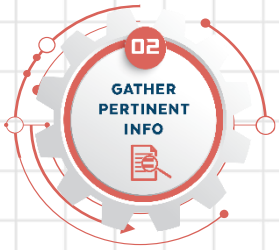
You need to be precise when you put all the components together. It is helpful to assemble a model in a certain order otherwise putting it together may be difficult or even impossible! During the construction of windmills, an assembly plan will save time, money and is very important for safety on the job site!

Engineering Design Process Directions:

STEMworks™ Energy:
Stabilizing the Grid
VR Experience

Define the Problem

Choose a goal to tackle with your team!



Gather Pertinent Information

Depending on your goal, you may either use a template or measure and design your own model. Either way, check out the **Design & Engineer a Pinwheel Prototype Tips** sheet to get started.

Generate Multiple Solutions

If you are designing your own model, consider the area of your pattern and the strength of materials you have to use! Even if you are using a pattern, there may be different choices of materials to use and multiple ways to assemble your turbine. Collaborate with your team and make predictions about what might work best. With a team to share the work, you might even have time to generate and build a few possible solutions!

Choose a Solution

Decide on a pinwheel design. If necessary, combine ideas from a few of the multiple solutions that your team may have created.

Design a Culturally Responsive Solution

As you build your solution, be sure to help your team. Assembly requires many helping hands, taking turns, and being patient with the time that building each step can take. Help each other manage construction responsibilities, supply needs, and material testing.

Test and Optimize

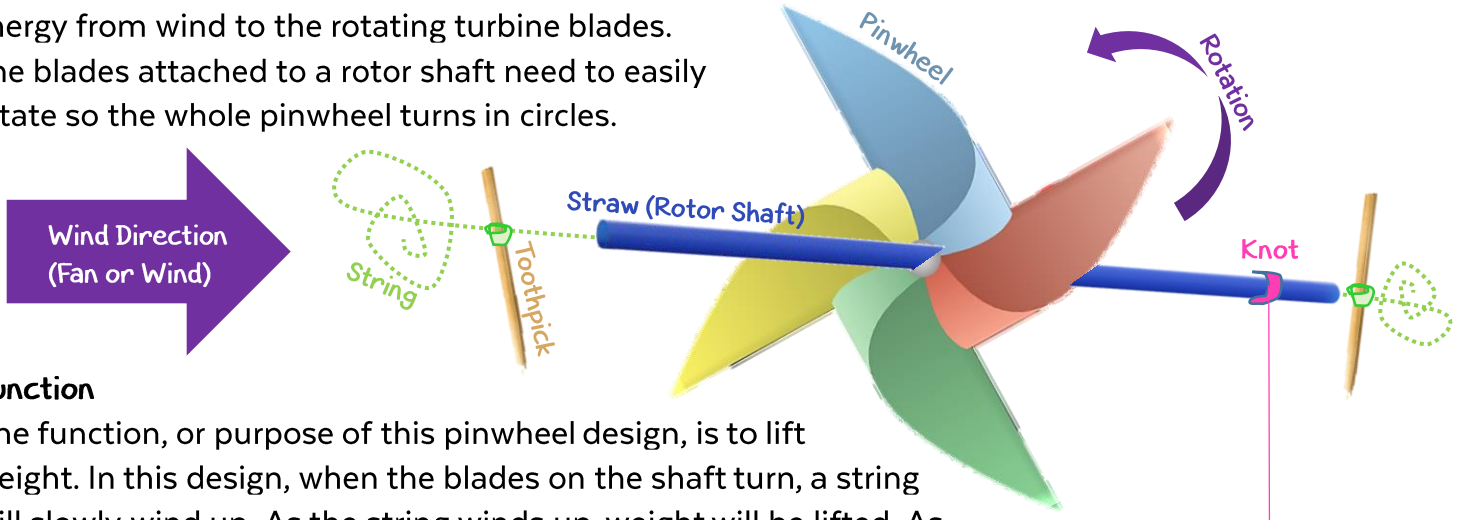
Test your pinwheel design. Does it work as well as you team predicted? How do you know, or how can you tell, that your design meets, or does not meet the goal? How can your design be improved? Use the feedback you gained from testing and from sharing with others to improve your solution.

Share & Reflect

How did you use feedback to improve your solution?
When did your team collaborate best? How did you practice perseverance?
Talk to your team: What went well? What could have gone better?

Design & Engineer a Pinwheel Prototype Tips

In design, both form and function are important. In the case of windmills, the structure or form of the turbine determines how well the turbine will work (function). Wind, or the kinetic energy from the molecules moving in the air, push the wind turbine's blades. The blades turn, transferring kinetic energy from wind to the rotating turbine blades. The blades attached to a rotor shaft need to easily rotate so the whole pinwheel turns in circles.

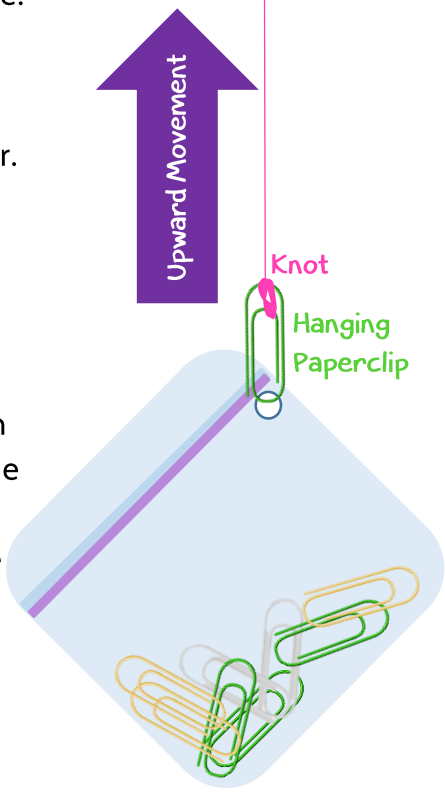


Function

The function, or purpose of this pinwheel design, is to lift weight. In this design, when the blades on the shaft turn, a string will slowly wind up. As the string winds up, weight will be lifted. As the weight is moved, your turbine will do work! Work is what happens when a force is used to move an object a certain distance. Your pinwheel will create an upward force on an object and lift it upward! The mechanical energy from the turning pinwheel blades will be transferred to mechanical energy in a winding string. This will pull a weight against gravity and lift it up in the air. This means that your design will convert kinetic energy (motion) into potential energy, as the weight is lifted higher and higher! The more weight you lift, the more work your pinwheel is able to do! The structure, or form, of a wind turbine is important for the function of the wind turbine.

Directions for the Pinwheel's Mechanical Design

1. Measure and cut out a perfect square. (Use the Pinwheel Template)
2. From each corner, make four cuts inward towards the paper's center.
3. Punch holes in every other corner and in the center.
4. Push the straw through the center hole.
5. Bring each of the four corner holes onto the straw.
6. Tape the paper pinwheel to the straw so both can turn together.
7. Cut string at least twice as long as the straw.
8. Push the string through the straw and knot it to a toothpick on both sides of the straw. Your pinwheel should be able to spin freely on the straw!
8. Cut another piece of string that is at least three times as long as the straw. Tie and/or tape one end of the string to the straw about 2-3 inches away from the paper pinwheel.
9. Knot the other end of the string to a paperclip.
10. Attach a bag to the hanging paperclip. Add weighted items to the bag.
11. How much can your turbine lift using the power of the wind?



Pinwheel Template

Turbine Design Engineers pay attention to the surfaces in their designs. This includes the surface area, angles, edges and more. In the template below, each quadrant has 100 square units. There are four quadrants and two sides of the paper. When built, what will be the total surface area of this pinwheel?

= 1 square unit