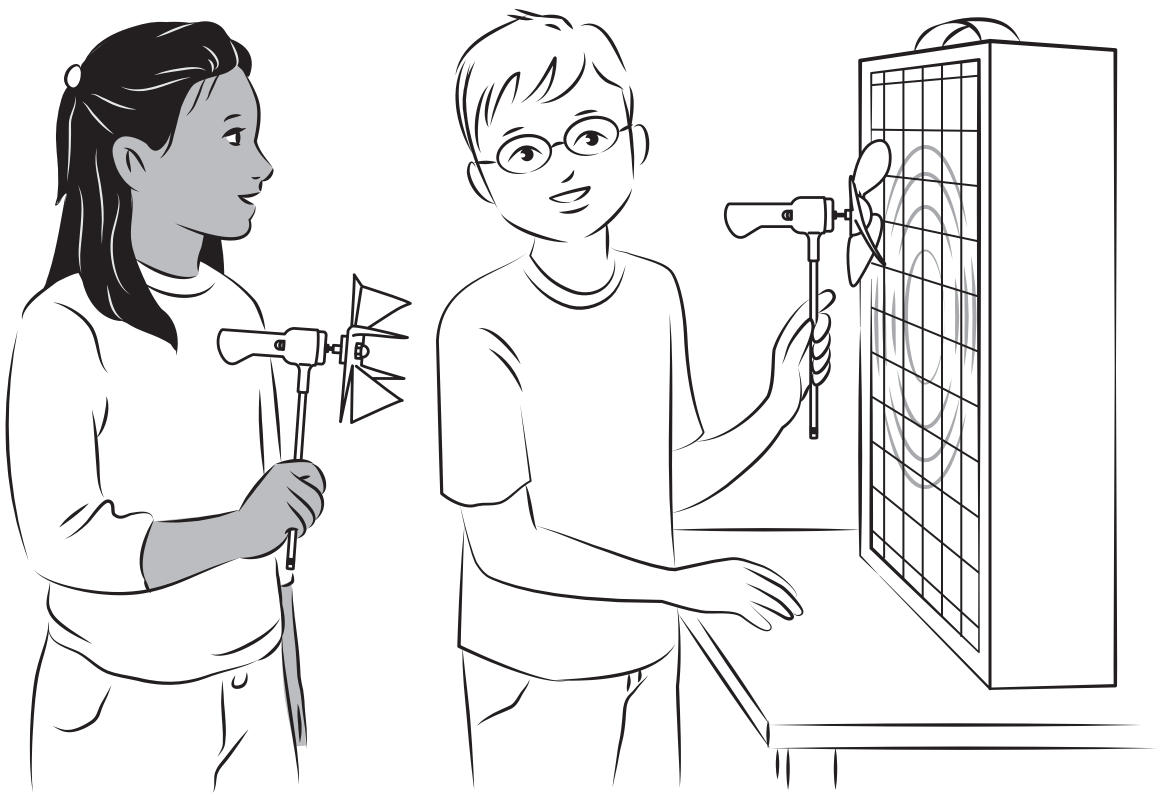
RECharge Labs®

firefly™ Class Pack
Activity Guide

Materials for 10 fireflies or 10–30 Students



Grades

- 3–12

Time required

- 45 minutes to 1 hour

Concepts

- Math
- Forces and Motion
- Earth Science
- Energy and Transformations
- Engineering, Art, and Design
- Using Basic Tools
- Collecting and Interpreting Data

Objectives

At the end of the lesson, students will:

- Know the fundamental parts of a wind turbine
- Be able to use the engineering design process and the scientific method to isolate and adjust variables while designing and testing wind wheels
- Understand energy conversions and transfers, and how a wind turbine converts moving air into electrical energy
- Design a Wind Wheel for the firefly wind turbine that can light up an LED

REcharge Labs®

Your REcharge Labs Classroom Kit

The materials enclosed in this kit will help you bring engaging lessons about renewable energy into your classroom. Consider attending a REcharge Training, if you haven't already done so, to enhance your experience using these materials.

About REcharge Labs

We believe that responsible and informed students of today will become our innovative renewable energy leaders of tomorrow. At REcharge Labs, our mission is to provide the resources to encourage this generation of informed thinkers, involved doers, and curious life-long learners.

REcharge Labs provide everything you need to teach renewable energy.

- **Professional development workshops** that prepare you to teach fun, hands-on project-based wind and solar activities.
- **Scalable activities** for different age groups and time frames.
- **Kits and resources** that fit educational standards and your budget.

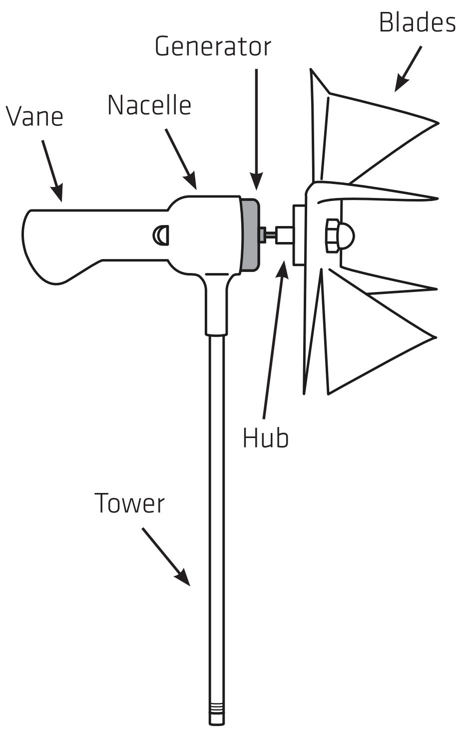
We recommend attending a REcharge Lab training workshop to enhance your experience using these kits.

REcharge Labs was born out of programming from the KidWind Project, and relies upon KidWind's resources and history to carry out its work. KidWind has been a leader in renewable energy education for over a decade. REcharge Labs, like KidWind, continues to be committed to bringing affordable, hands-on applications of our materials to teachers and students worldwide.

A note on reproduction

Find kits and sign up for training workshops at

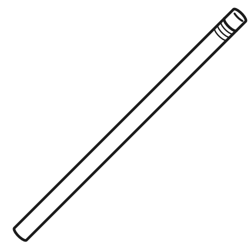
www.rechargelabs.org

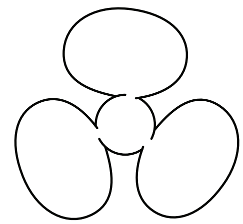


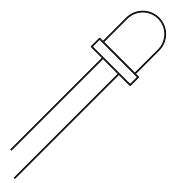
Materials

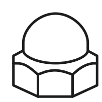
The illustration to the left is an example of the firefly wind turbine the students will be building. The students will mainly be problem-solving and performing tests on the blade portion of the firefly. Templates of different wind wheel designs are in the back of the guidebook. Copy and print those on colored cardstock for students to try different wind wheel shapes and number of blades. Small paper plates are perfect for blade material, but anything that catches the wind can be used, like paper cups, card stock, and cardboard.

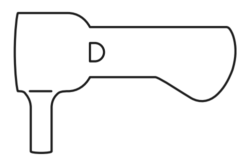

Tubing

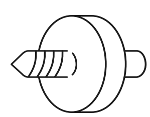

Pencil

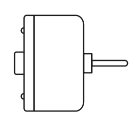

Propeller


LED lights


Acorn hex nuts

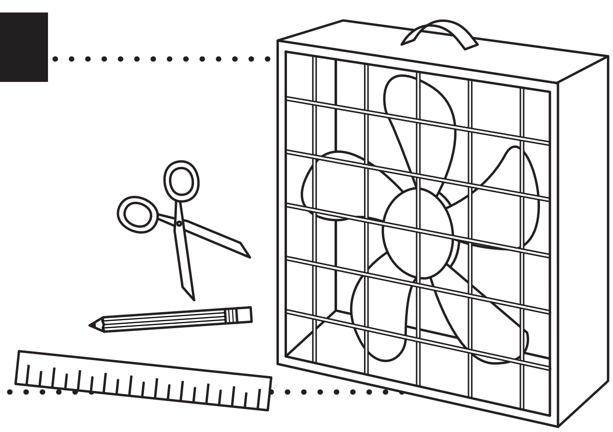

Nacelle


Screw hubs


Generator

You will need to supply the following materials:

- Rulers
- Pencils
- Scissors
- Pencil sharpener
- 20”x20” standard box fans
- Cardstock print outs of wind wheel templates



Topics for Discussion and Activity Integration

Forces and Motion

People use many kinds of forces to put objects into motion. Playing catch, swinging on a swing set, or riding a bike are ways that we use force to push and pull things to achieve motion. There are also forces constantly acting upon us that affect our movement, like wind, a hill, or something pushing or pulling us, like a dog on a leash. These forces cause us to slow down, speed up, or stop completely. Learning about forces and motion will help us understand how things work, and can help us understand how to make things work better in order to solve a problem. Students will gain a better understanding of forces and motion by testing a construction that moves with the wind.

Wind Power

Through experience, students are clearly very familiar with the wind and what it can do. They may not know where wind comes from, but they have seen how it can be helpful to society (kites, sailboats, windmills) and how it can be destructive (tornados, hurricanes). In this activity guide, we hope to show you some ways that we can harness the wind to do useful work in our daily lives (move objects, lift objects, etc.).

We understand that you may have a limited time to do these activities but when discussing wind power there are two important topics that may intersect with your exploration of this subject: energy and climate change. Below we offer some very brief guidance in talking with your students about these concepts.

Energy

When we are dealing with moving air molecules, gliding sail cars, rotating windmills, and turbines, we are exploring energy and the transformation of energy between different forms. While there are formal definitions of energy, such as the ability to do work, young (and older) students struggle with many of the basic concepts.

Young students understand energy from experience and not from textbooks and have a number of preconceptions about the topic. If you ask students to describe energy, you may hear the following concepts:

- Energy is a fuel that does work.
- Energy is linked to moving things.
- Energy is needed for living things to survive.
- Energy can move around in wires or be stored in a battery.
- Energy can be changed into different kinds of energy.

We are not worried about formal definitions of energy, understanding all the forms and sources, or technical aspects of energy transformations, although they can be easily incorporated into this lesson. It would be great if at the end of our activities students understand the following about energy:

- Energy is found in motion (and maybe light, heat, sound);
- Wind is the motion of air and has energy;
- The energy in the wind can be transferred to objects to make them move or rotate;
- We can use that movement or rotation to do useful work (make a car move, lift a weight or light a bulb)

Climate Change

When discussing wind power, one question that may come up is: why should we harness wind power to generate electricity? This is a very good question. It provides you an opportunity to discuss the delicate path we must walk between balancing our need for energy and the impact that generating electricity has on the climate.

Students of almost any age will be able to tell you something accurate about the weather. However, discussions about climate, and climate change, are more complex, and these conversations are probably more appropriate for students 3rd grade and above.

The first thing we can help students understand is that there is a big difference between weather and climate.

- Weather is the day-to-day state of atmospheric conditions like "Will it be hot tomorrow?"
- Climate is the weather of a place averaged over a period of time, often 30–40 years.

If young students can understand the difference between these two concepts, this will go a long way toward helping them understanding climate change as they become advanced students.

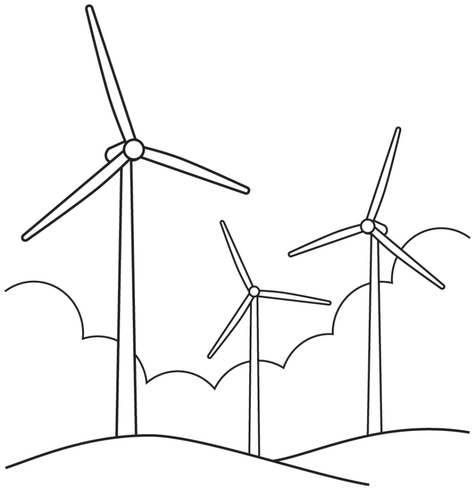
Discussing climate change can sometimes make students feel helpless. What can we do about such a big problem? While we do not want to scare students, we can tell them that scientists have discovered that our climate is changing in ways that may be different than in the past, and that on average, the planet is warming faster than it ever has throughout history.

Connecting climate change to electricity can be even more complicated. Most young students, and even older students and adults, do not know where or how their electricity is generated, but this can be a fun conversation! Currently, most of the electricity we consume in the US comes indirectly from burning fuel, such as coal or natural gas. These fuels are combusted to heat water, make steam, and drive a turbine which generates electricity that comes to our house over wires. The burning of these fuels generates CO_2 and pollution.

Most students understand that when we burn things, it creates smoke or pollution. We can ask students what they think could happen if there was a lot of pollution and tell students that the pollution created from electrical generation releases gases that are causing temperatures to increase over time. These temperature changes can impact all life on earth. More advanced students (4th grade and up) can explore mechanisms around how greenhouse gases heat up the earth.

This is a lot to digest for young elementary students, so here are a few major points when connecting energy and climate:

- All energy use has consequences.
- Current research informs us that the global climate is warming due human factors.
- As a society and individuals we can make choices that help reduce the climatic impact of electricity generation.
- Generating power with the wind is a choice we can make that reduces pollution and following climate impacts from electricity production.

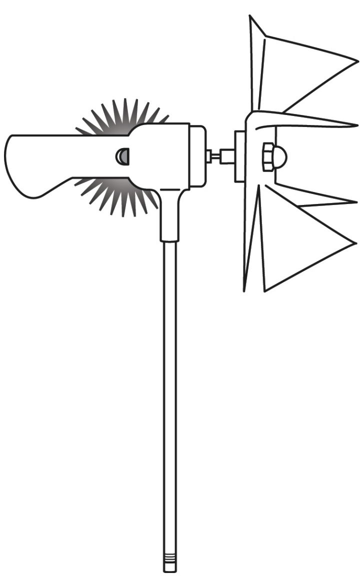


Background

Wind is a renewable energy resource. When we use wind to do work, it can never be used up and it doesn't produce harmful waste. Wind turbines are human-made structures engineered to capture the energy in the wind, converting it into usable electrical power. Large utility-scale turbines are used for producing electricity that goes onto the electric grid, which can power more than 300 homes, schools, and businesses. Wind turbines come in many sizes, from the small REcharge Labs firefly that can light an LED, to a large-scale turbine bigger than the Statue of Liberty that can power a village! Regardless of their shape and size, wind turbines are all descendants of windmills, which have been used for more than 1,000 years to grind grain and pump water. The American windmill, which was mostly used on farms to pump water, was commonplace and widespread in its peak during the 1930's. Artifacts of the American windmill can still be seen in rural areas today, sometimes within distance of large utility-scale wind turbines!

Learning Goals

Students will use a small wind turbine called a firefly to understand how rotational movement can be used to convert wind power into electrical energy, which can power a load like a light. Using the engineering design process and the scientific method, students will generate as much electricity as possible from their wind wheel designs.



Getting Ready

- For grades K–3rd build a classroom set of fireflies before the class begins. A classroom set provides one firefly for one to three students. Set up one box fan testing station per 10 students. For 4th grade and above, assembling fireflies can be an activity done in the classroom; just allow for more time, and assemble one before class to use as an example.
- Beforehand, prepare a few wind wheel examples that light the LED with the fan wind. Making a wind wheel example that works will take some adjustments, testing, and trials. This is a valuable preview to the challenges, problems, and success students will encounter.

Activity

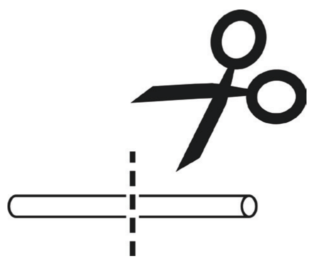
During the first half of the activity, students focus on understanding the fundamentals of a wind turbine through hands-on building and design. The second half of the activity is adjusting variables in design in order to accomplish two goals: 1) getting their Wind Wheel design to spin as fast as possible, and 2) to light the LED with the spinning Wind Wheel.

Assembling the firefly

5 MINUTES

Step 1

Cut off two pieces from the plastic tubing, one half inch each.

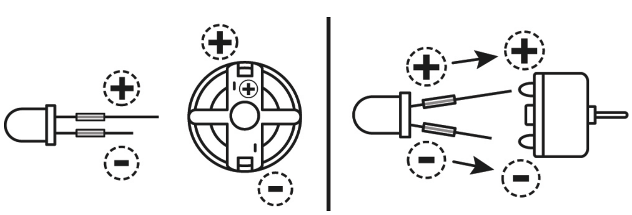


Step 2

Slide a piece of tubing onto each LED leg.

Step 3

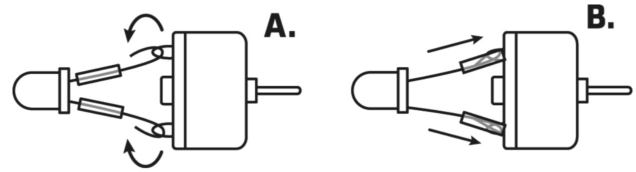
Look closely at the back of the generator. Next to the two metal leads are a positive and negative sign. Now look at your LED. One leg is longer than the other. Thread the longer LED leg through the positive generator lead, and the shorter LED leg into the negative generator lead. If this is done incorrectly, the firefly will not work. This is because the LED is polarity sensitive. In the firefly, the polarity is positive when the generator shaft spins clockwise. In the opposite direction the polarity is negative. When spinning in the negative direction, the LED will not light up.



Step 4

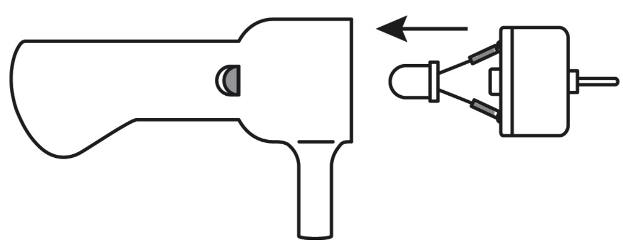
A) Bend the LED legs so they hook onto the generator connections.

B) Slide the plastic tube pieces over the junctions.



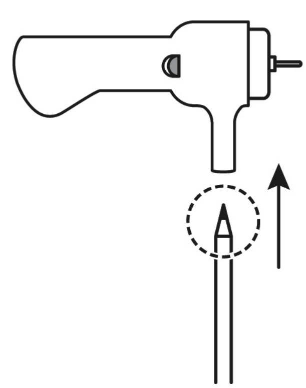
Step 5

Push the generator into the firefly until it fits snugly and the LED peeks through the window.



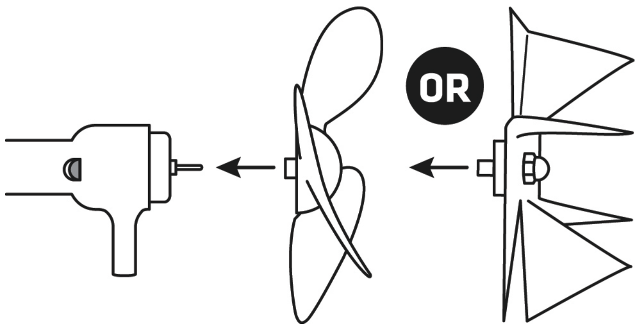
Step 6

Sharpen the pencil before placing it into the holder to help the firefly pivot into the wind. If pivoting is not required, use a piece of clear tape to secure the pencil to the firefly.



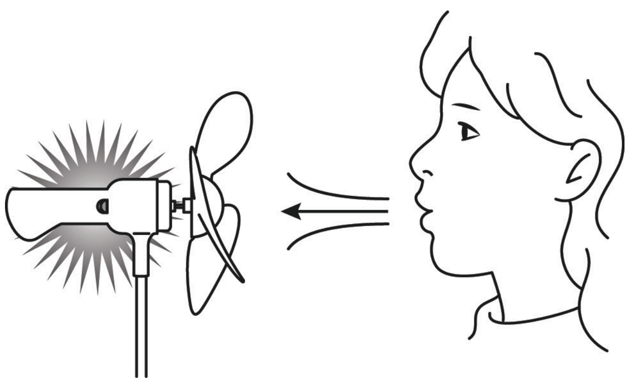
Step 7

Push the included propeller onto the generator shaft, or make your own Wind Wheel (see instructions beginning in next column).



Step 8

Holding the pencil upright, blow on the firefly and watch your LED light up! Or, test in front of a box fan, trying out different fan speeds. If it lights, the assembly was perfect. If it doesn't light, try stronger wind, or make sure the LED has been properly connected.



Step 9

Print out the templates from pages 13–15 on cardstock. Select a design and follow the steps on pages 9–11 for instructions on how to build and test a Wind Wheel.

Step 10

Test your Wind Wheel design in a box fan, and make adjustments until the LED lights up.

Making the firefly Wind Wheel

Step 1: Beginning questions for students

2 MINUTES

Gather students to sit in a circle on the floor. Ask them these prompting questions to get them to think about the concept of wind doing work. Having a box fan on nearby may help the students think about windy conditions!

- What are pinwheels?
- Have you seen a windmill before?
- Imagine it's windy outside. Is the wind doing anything to you or the things around you?
- Can you feel the wind? What does it feel like?

Step 2: Introduce the firefly and the main concepts and vocabulary

5 MINUTES

While the students are still sitting in a circle, pull out your firefly and Wind Wheel example and make sure the box fan is nearby. Go through the questions and vocabulary below, pointing to the different parts of the firefly, demonstrating when necessary. Be aware that fully understanding many of the components requires using more advanced explanations, so these are very basic definitions.

What is a wind turbine? A wind turbine is a human-made device engineered to spin in the wind in order to generate electricity. Our firefly is a small wind turbine that spins in the wind and lights up an LED!

What is an LED? LED stands for light emitting diode, which means it lights up like a light bulb.

The LED needs electricity to light. What is electricity, and how does the firefly generate it? Electricity is a form of energy. We use electricity to light lights, turn on pumps, blow air, and so much more. Have students give some ideas of where they use electricity daily. In the firefly, the generator makes the electricity.

A generator is made of magnets connected to a shaft and conductive wire (meaning electricity can flow through the wire). When magnets are moved next to wire quickly, a electrical charge is generated that can power lights or motors. The magnets can only generate a charge when the generator shaft is spinning. Students can spin the generator shaft with their fingers, or they can make the wind do the work!

What are blades? The blades on a wind turbine are the parts that spin in the wind because of the way they catch the wind. If students tilt the blades into the wind, they will catch the wind and move or spin.

Step 4: Introduce the firefly Wind Wheel Challenge

Tell students that they will be making their own Wind Wheels, just like the teacher's example, and testing to see if they can light the LED.

The firefly Wind Wheel Challenge has two problems students will solve:

- Spin the Wind Wheel as fast as possible using just the wind
- The Wind Wheel must light the LED while spinning in the wind

Step 5: Designing the Wind Wheels

40 MINUTES

Organize the students get in groups of one to three. Each group gets one firefly and hub.

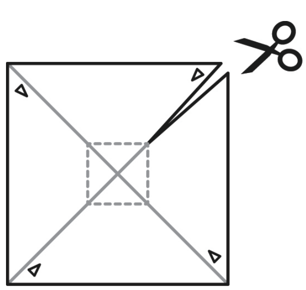
Place the cardstock templates and scissors on the groups' tables. Have one set of materials and tools with you in order to walk through the Wind Wheel process with the students.

Part 1: Choose a Wind Wheel pattern

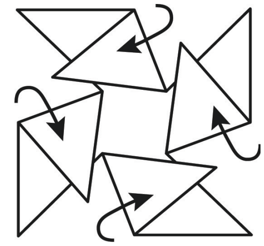
Notice the different designs and shapes of Wind Wheel patterns. Some are triangular with three sections. What other shapes are there, and how many sections do they have? Choose a pattern and cut it out, outside lines only.

Part 2: Cutting the blades

Cut the inside lines only to the where they are marked. Do not cut all the way to the middle.

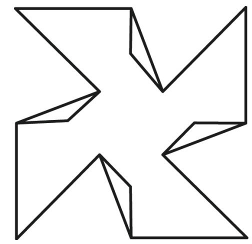


Part 3: Folding the blades to catch the wind.



Fold down the corners according to the diagram. On the top section, this is the right corner. You must fold these corners because the Wind Wheel must spin clockwise to light the LED. There is an arrow symbol on the corner of each section indicating which corner to fold inward.

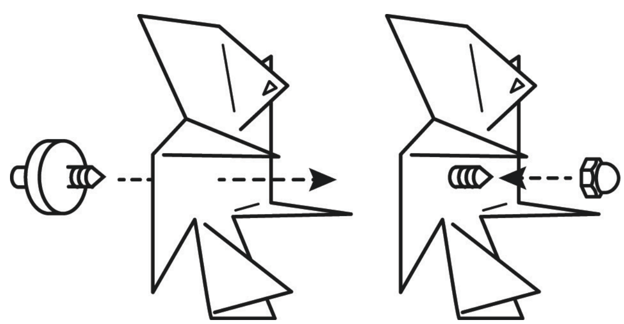
Part 4



Next, reposition the folded corners so they point up.

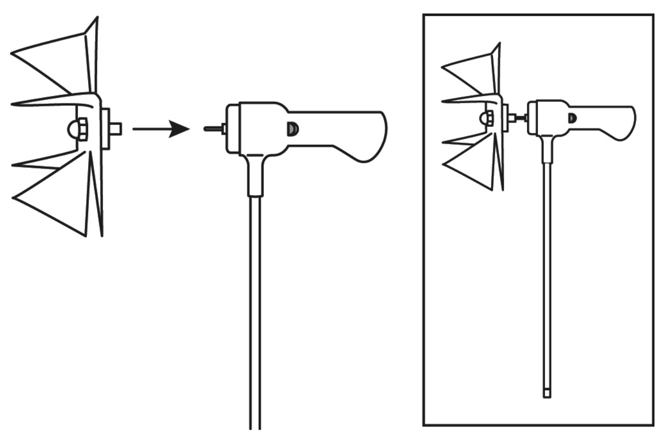
Part 5

Push the screw hub point through the center of the Wind Wheel from the back. Twist the acorn hex nut onto the screw hub, securing the Wind Wheel to the hub.



Part 6

Now attach the Wind Wheel with hub to the firefly.



Part 7

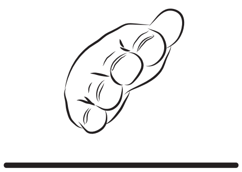
Test in the fan to see if it spins.

Step 6: Demonstration of tilt angle in the wind

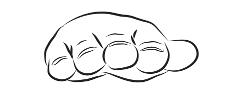
3 MINUTES

Allow the students some time to test out their Wind Wheel. During their first try, it will be difficult for them to light the LED. Call for students' attention to bring up this important information that will help them in their experiments. Shut off the fans because they can be loud and distracting.

Act this out together:

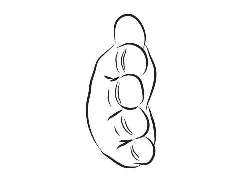


What happens if we tilt our hand, thumb pointing upward?



What if we move our hand flat, like it's cutting through the wind?

What happens if we tilt our hand, thumb pointing downward?



Now our hand is out, fingers together like we're making a wall. What happens to our hand?

Act out the following activity with students: have you ever played with the wind by sticking your hand outside a car window as the car is moving? Let's pretend we're doing that now. Stick your hand out to the side of you, being careful to give each other enough space to move. Let's pretend the wind is coming this way over our hands.

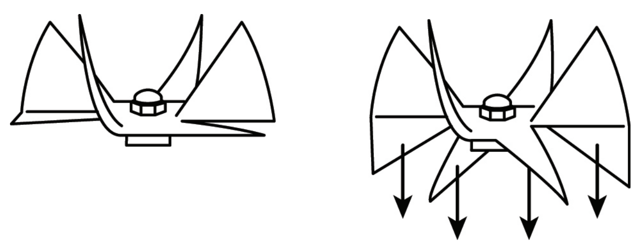
Have them act out with you how an airplane works. With arms out, demonstrate how when they tilt their hands up, their arms go up, similar to an airplane. When they tilt down, they go down. This tilt angle makes a big difference when using the wind to push something up or down.

Emphasize the function of the blades and how they tilt into the wind.

The Wind Wheel has folds sticking up that act as blades that catch the wind causing them to spin. The folds, which give the blades their tilt angle, are the most important part for students to investigate. The number of folded pieces and how much the folds are pointing up or down make a significant difference to how much the Wind Wheel spins.

Show them with your hands the way the folded pieces are tilting. This tilt angle is called pitch. While you have their attention, bend the folded pieces more in one direction, then ask them what they think will happen and why. Place the Wind Wheel in front of the fan and see if it spins faster or slower.

On each blade students should currently have the right corners folded up. To add more area to catch the wind, fold each left corner down (see illustration below). Emphasize how important the pitch angle is, and how much it affects whether the LED lights up.



Step 7. Engineering design process

Before the students go back to testing their Wind Wheels, walk them through the engineering design process.

Define the goals

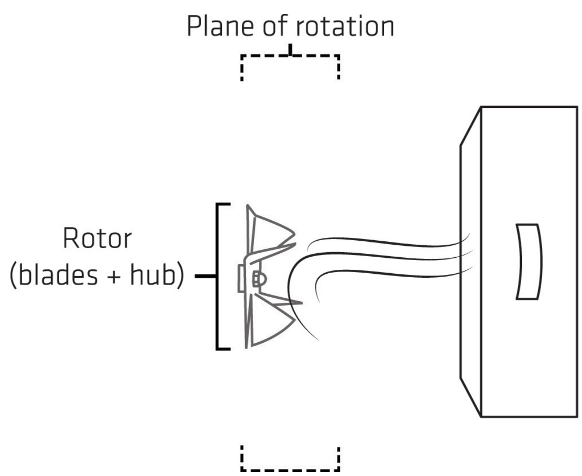
- Spin the Wind Wheel as fast as possible, using just the wind.
- The Wind Wheel must light the LED while spinning in the wind.

Plan solutions

The blades are what can make the Wind Wheel spin. Pitch angle determines how much the blades spin in the wind. It is up to the students to experiment with the pitch angle. What do they think will help their Wind Wheels spin faster? Now that they have a better understanding of pitch angle, ask them to make a pitch-angle adjustment to their Wind Wheel, and then move onto the next step in the process.

Test

The firefly needs to be within "arms length" of the fan. Ask students to get in line in front of each fan, taking turns within their group as they do their first test (see illustration below). After a first test is completed, students go back to their seats, and follow the next step in the process.



Reflect and redesign

Did the Wind Wheel design accomplish the goals? If not, or if it did not do so very well, then students need to figure out a solution, and make adjustments to the pitch angle.

Continue the testing cycle at least three times until the main goals are accomplished.

A determining factor of how well a Wind Wheel is designed is based on brightly the LED glows.

Bonus: Trying out different Wind Wheel templates

If there is time, the engineering design process can include testing different Wind Wheel templates. In the above section, students are just experimenting with pitch angle on the design of their choice. If students try out different Wind Wheels, they are experimenting with an additional variables: number of blades, and shape of blades.

Step 8. Activity close

Give a couple minutes warning that testing time is almost over. When the testing time is over, shut off the fans and ask the students to bring their Wind Wheel and fireflies to their tables and sit down.

Step 9. Label Wind Wheels, pack, and clean up

What happens to students' Wind Wheels and firefly is up to the educator. Ideally, the firefly stays with the teacher so that it can be used over and over again. The students may keep the Wind Wheel design they made by unscrewing the acorn nut and removing the screw hub, setting those parts aside for the teacher to collect. Students may then label their Wind Wheel to take home with them. Once the firefly and Wind Wheel parts have been figured out and collected, it's time to clean up! Then, ask students to gather in a circle on the floor.

Step 10. Evaluation discussion

10 MINUTES

As soon as all the students are situated on the floor, start the evaluation discussion with some prompting questions.

Prompt Questions:

- Raise your hand if you got your Wind Wheel to spin in the wind.
- Raise your hand if you were able to get your LED to light up.
- How did you make your Wind Wheel spin faster? What did you do to your Wind Wheel folds to make it spin more?
- Raise your Wind Wheels in the air. Everyone look around and see how different the designs are!
- If you tested out different Wind Wheel templates, was there a design that spun faster, or was more successful at lighting the firefly?

Vocabulary

Here are some important vocabulary for students to understand as they work through the activities.

LED

LED stands for light emitting diode, which means it lights up like a light bulb. A diode is an electrical component that only allows electricity to flow in one direction.

Blades

The blades on a wind turbine are the parts that spin because of the way they catch the wind.

Blade pitch

Blade pitch is the tilt or angle of the blades in the wind, with respect to the plane of rotation.

Drag

For a windmill, this is also called wind resistance. Drag is the friction of the blades against air molecules as they rotate. Drag works against the rotation of the blades, causing them to slow down.

Generator

A generator is made of magnets connected to a shaft and conductive wire. When magnets are moved next to wire quickly, a electrical charge is generated that can power things like lights.

Force

Force is a push or pull.

Friction

Friction is the "pull" of a force. Friction is a force that resists the relative motion of two things in contact.

Hub

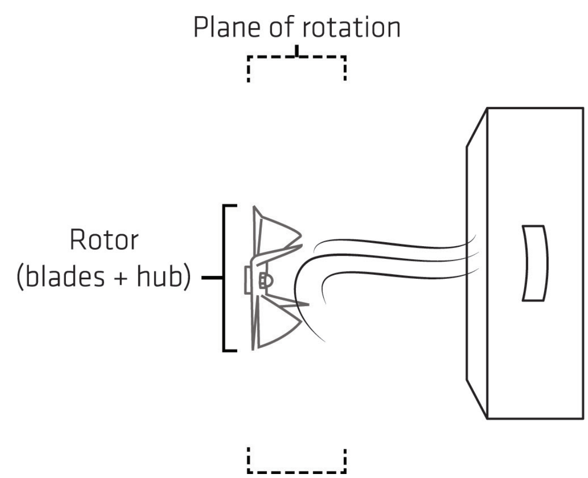
A hub is the central component connecting the blades to the generator shaft.

Motion

The action or process of something moving or being moved. Wind is air molecules in motion. Wind acts as a force on the Mini Windmill blades, causing them to move in rotation.

Plane of rotation

The plane of rotation is the area directly in line with the rotor. It is dangerous to stand in this area because a blade that is not securely fastened to the hub and detaches could hit any person standing in this zone.

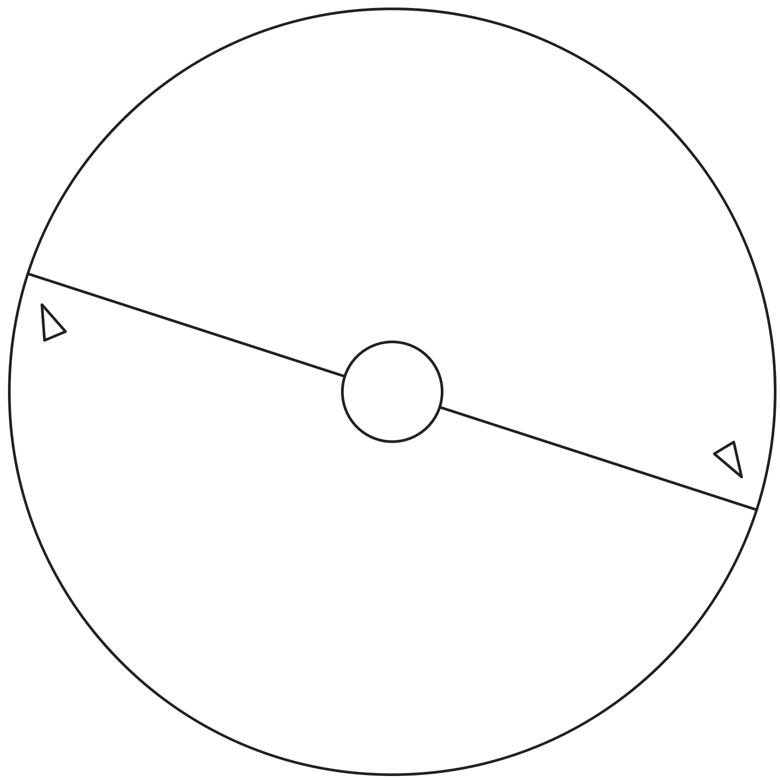


Wind turbine

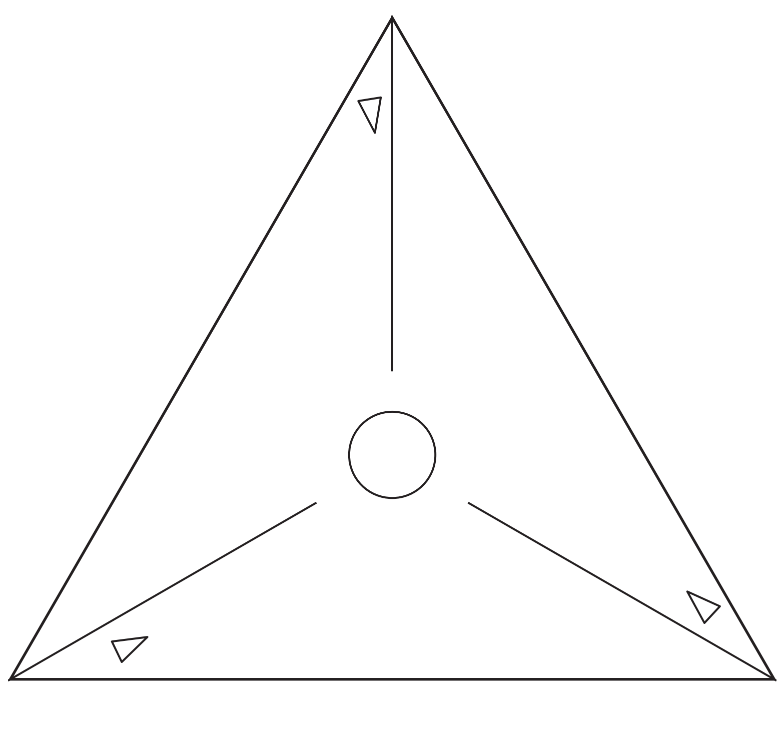
A wind turbine is a human made device that is designed to spin in the wind in order to generate electricity. Our firefly is a small wind turbine that spins in the wind and lights up an LED!

Wind Wheel Templates

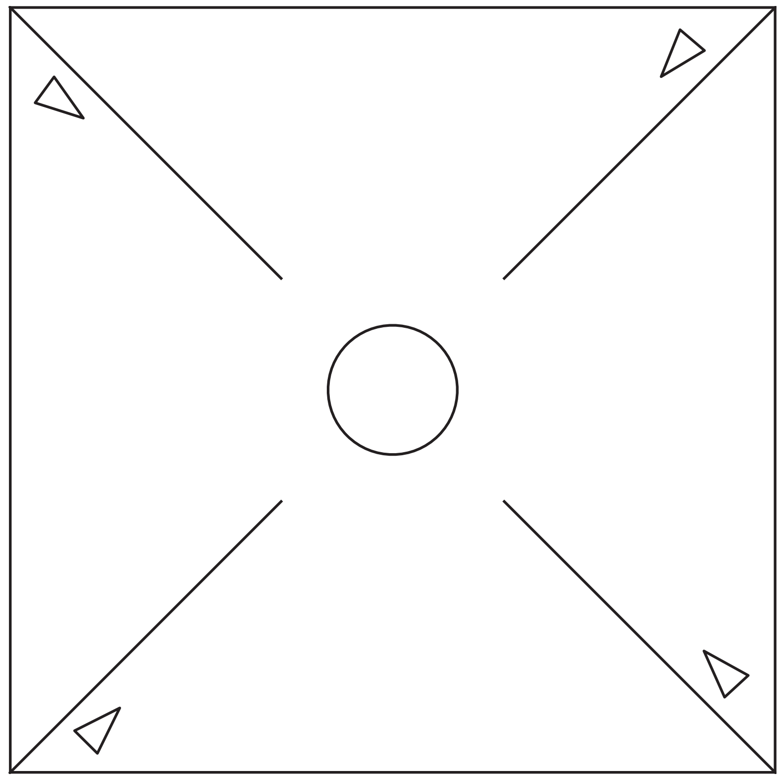
2 Blade



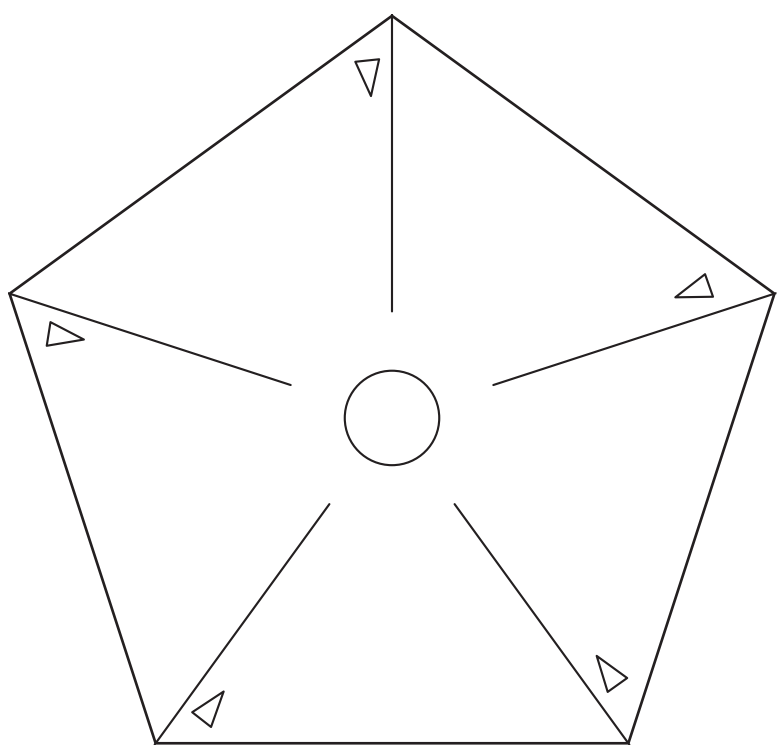
3 Blade



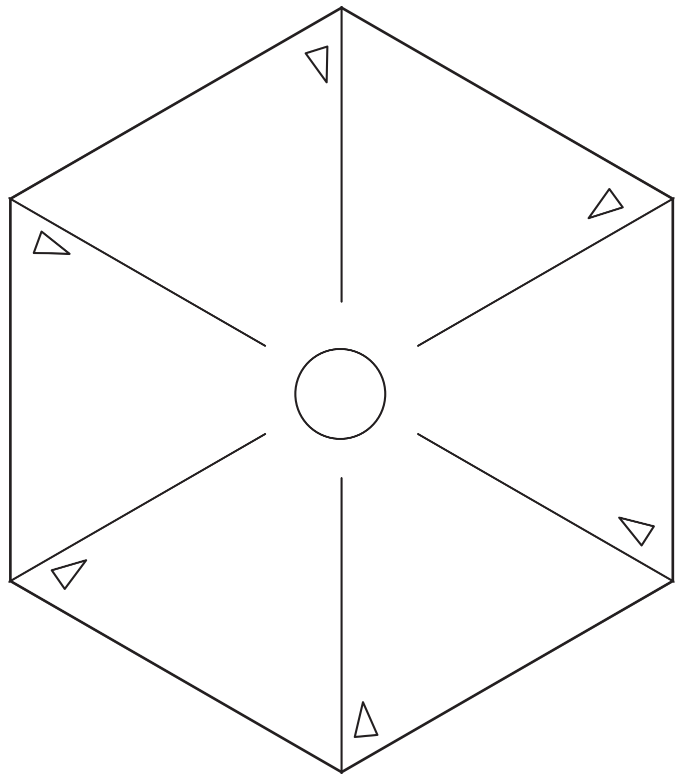
4 Blade



5 Blade



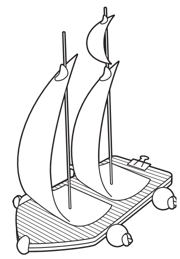
6 Blade



REcharge Labs®

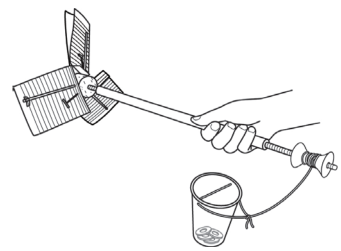
Did you like the **Firefly Class Pack**? Then you might be interested in these REcharge Labs classroom kits.

Sail Car Class Pack



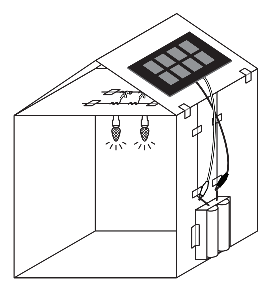
Build a Sail Car using inexpensive materials to demonstrate how wind can be used to propel an object. Gather measurements, record changes in variables, and use simple engineering design concepts to build sails that can push the car as far as possible.

MacGyver Windmill Class Pack



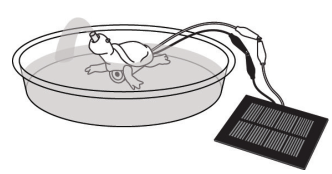
Students will use a limited amount of materials to design and build functioning windmill models. They will use these models to convert wind into mechanical energy in order to lift weights. Using the scientific method, they will conduct trials, change variables, and work to improve the performance of their windmills.

Solar Town Class Pack



Build a small solar powered house, then learn basic circuitry to wire it with lights, a motor, switches, power storage, and a solar panel. Use the model house to learn about energy consumption, efficiency, and conservation in an average household. A great activity to model real world applications. Connect with your neighbors to build a town!

Solar Fountain Kit



Learn how to use the power of the sun to build a creative electrical fountain. Discover how solar panels work, learn basic circuitry, and use this knowledge to build a custom solar powered fountain.

Visit **www.rechargelabs.org** for more.

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