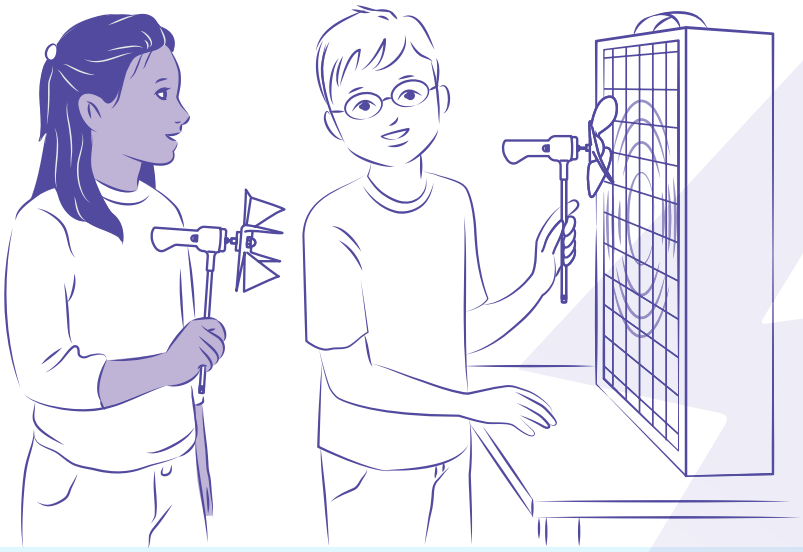
KidWind PROJECT

Firefly Activity



Grades

3–8

Concepts

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

Disciplinary Core Ideas

- PS2-A, PS2-B, PS3-A, PS3-B, PS3-C, ETS1-A, ETS1-B, ETS1-C

Time Required

45 minutes - 1 hour

Science and Engineering Practices

- Planning and carrying out investigations
- Analyzing and interpreting data
- Asking questions and defining problems

Cross Cutting Concepts

- Cause and effect
- Energy and matter
- Patterns

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

This activity guide was adapted from a prior REcharge lesson.

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Click to check out the NGSS Website, Full NGSS Standards, or Science and Engineering Practices in the NGSS

Materials

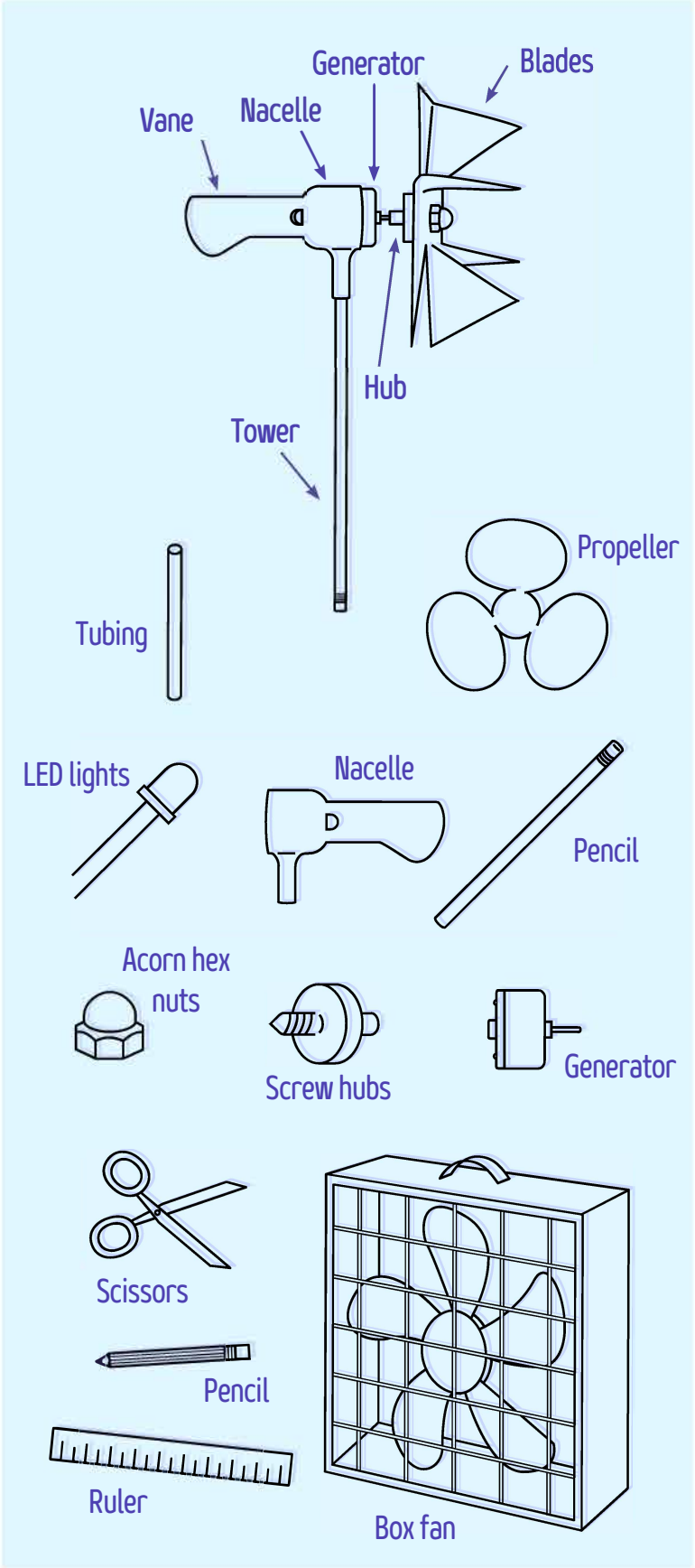
The illustration to the right is an example of the firefly wind turbine the students will be building. The students will mainly be problem-solving and performing tests on the blade portion of the firefly. Templates of different wind wheel designs are in the back of the guidebook. Copy and print those 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

Classroom materials to share

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

REcharge Labs & KidWind have been leaders in K-12 renewable energy education for over 15 years. Their library of materials and programming are now a part of Gale Force Education. Gale Force Education is a non-profit focused on fostering opportunities for students, educators, and the public to explore a future powered by renewable energy.



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.

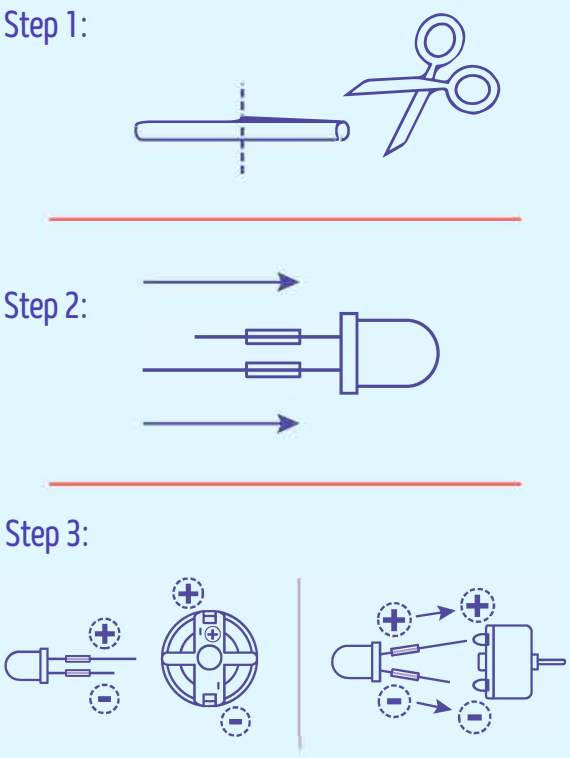
Getting Ready

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 min.

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 on page 5).

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.

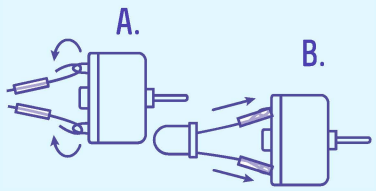
Step 9:

Print out the wind wheel templates on cardstock. Select a design and follow the steps on page 6 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.

Step 4:



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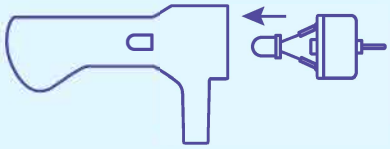

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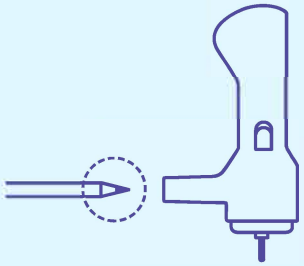

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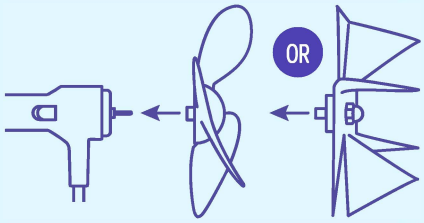

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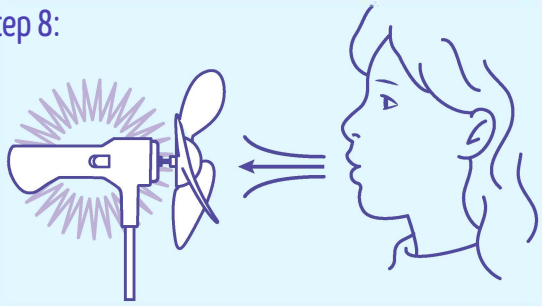


Making the Firefly Windwheel

Step 1: Beginning questions for students

2 min.

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 min.

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 3: Introduce the Fire Fly 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 goals students will achieve:

- 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 4: Designing the Wind

40 min.

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.

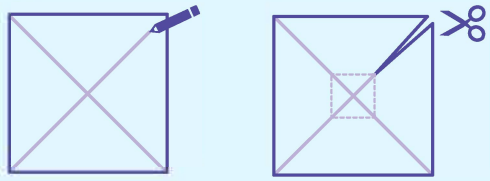
Part 4: Next, reposition the folded corners so they point up.

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.

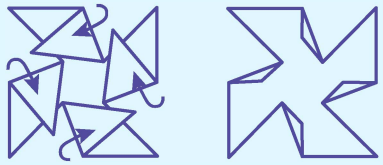
Part 6: Now attach the Wind Wheel with hub to the firefly.

Part 7: Test in the fan to see if it spins.

Part 2:



Part 3:



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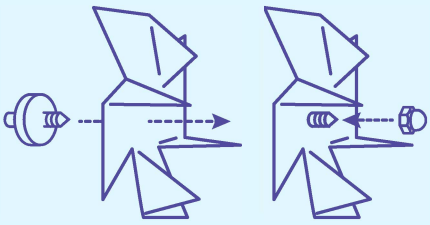

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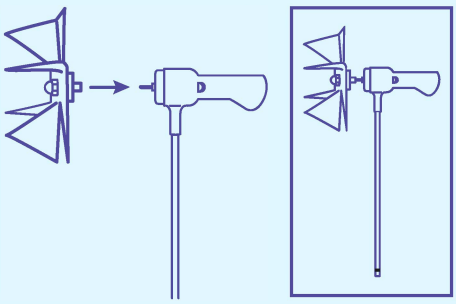


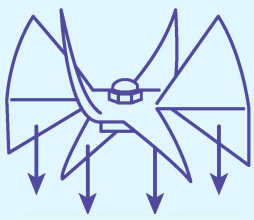
Act this out together:

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?



Step 5: Demonstration of tilt angle in the wind

3 min.

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 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 to the left). Emphasize how important the pitch angle is, and how much it affects whether the LED lights up.

Step 6: 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.

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 7: Activity close

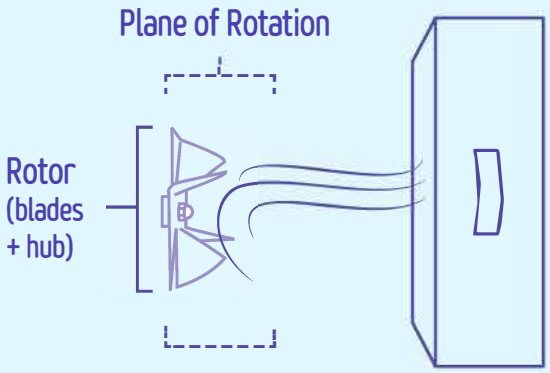
Give a couple minutes warning that testing time is almost over. When the testing time is over, shut off Wheel and fireflies to their tables and sit down.

Step 8: 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.

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.



Step 9: Evaluation discussion

10 min.

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

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.

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.

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.

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!

blades

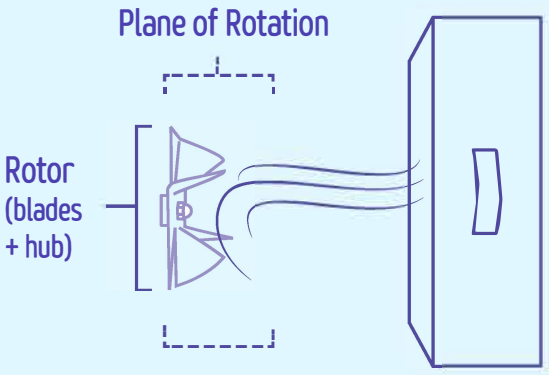
The blades on a wind turbine are the parts that spin because of the way they catch the wind.

hub

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

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.



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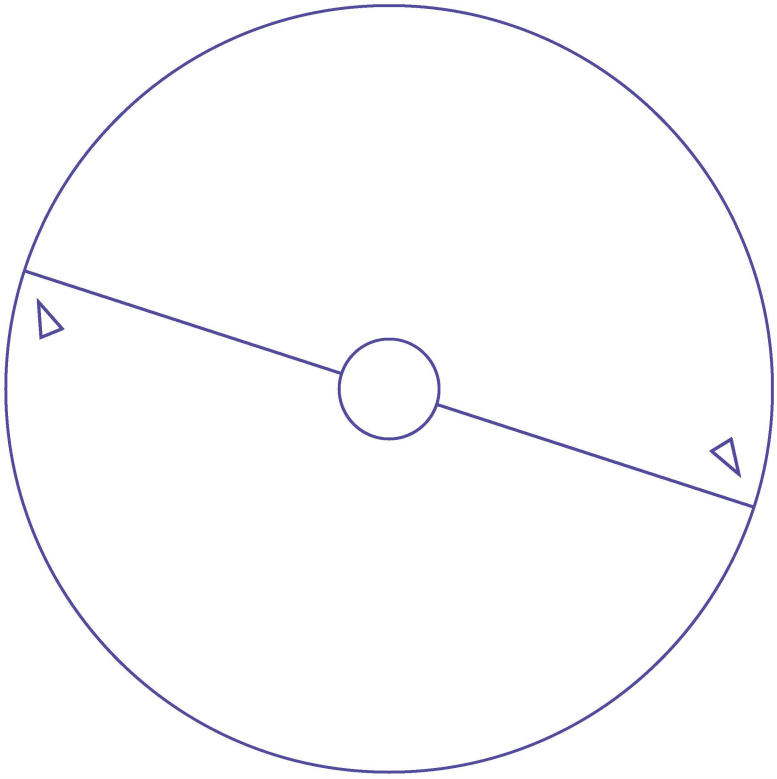
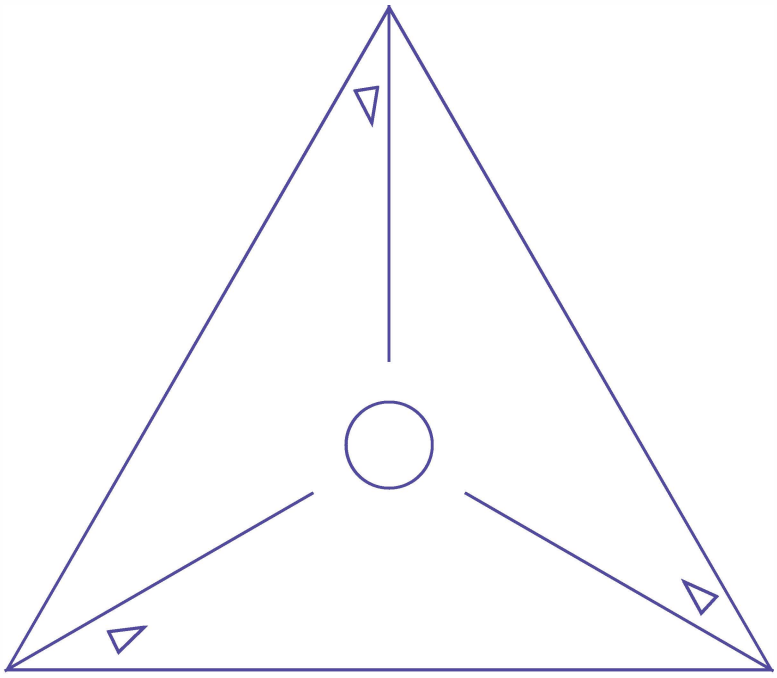
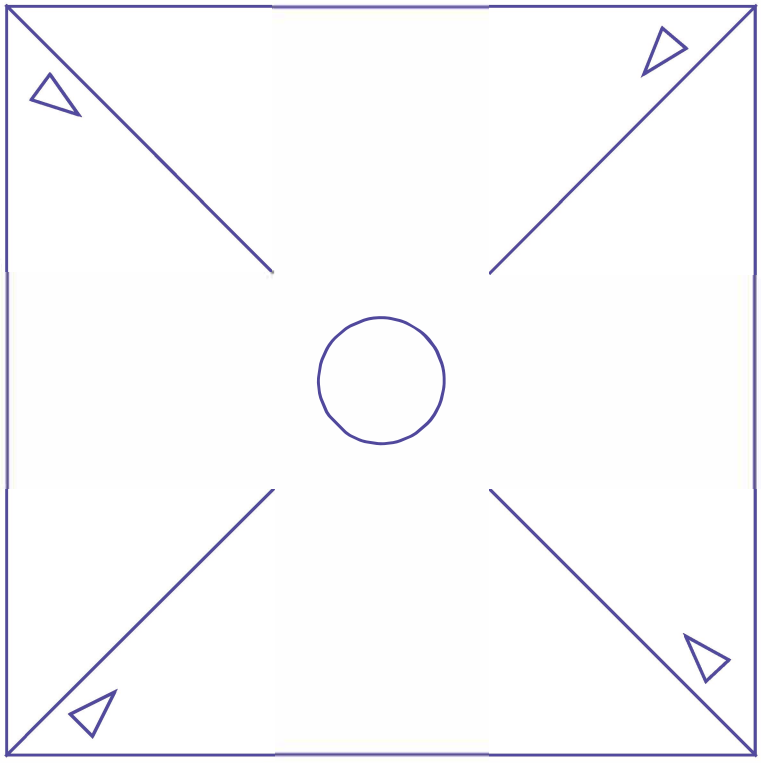
2 Blade



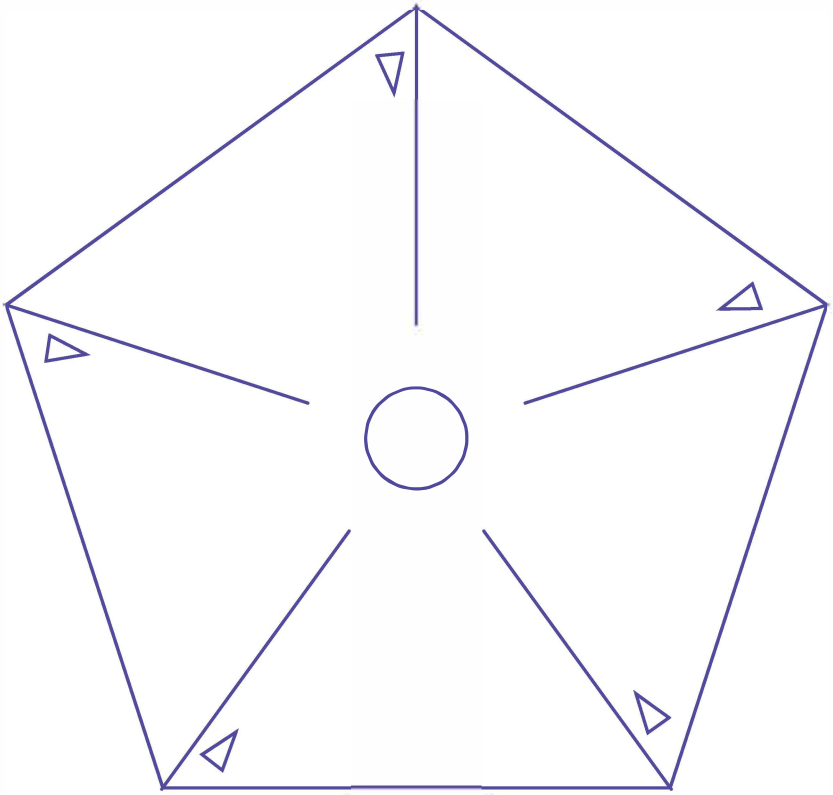
3 Blade



4 Blade



5 Blade



6 Blade