Name: _____

Exploring Wind Turbine Blades

Blade design and engineering is one of the most complicated and important aspects of wind turbine technology. The blades of a wind turbine are the parts of the turbine that catch the wind. This causes the turbine to spin, which causes the generator to generate electricity. If the blades do not move, the wind turbine cannot generate electricity.

Blade design engineers try to design blades that efficiently capture wind energy. They also need to design blades that are durable, quiet, and affordable.

In this experiment, you will explore how blades interact with the wind and make the turbine spin. You will use data-collection equipment to measure the output of the wind turbine to determine how blade orientation affects the flow of electrons in a circuit. This information will allow you to set up your turbine correctly as you explore more advanced blade design in other experiments.

OBJECTIVES

- Explore how the orientation of a blade affects the direction in which the wind turbine spins.
- Measure current and potential difference (voltage) output of a wind turbine with an Energy Sensor.
- Explore how orientation of a blade affects the sign of the current and potential difference values.

MATERIALS

Chromebook, computer, **or** mobile device
Graphical Analysis 4 app
Go Direct Energy
KidWind MINI Wind Turbine
KidWind Wind Turbine Hub
2 wires with clips
safety goggles
multi-speed fan
centimeter ruler
2 premade blades **or** materials to make 2 blades:
    scissors
    hot glue
    wooden dowels
    blade material

VOCABULARY

Vocabulary term	Explanation
blade	the flat, wide section of a device such as an oar or a wind turbine
hub	the center piece in a turbine that connects all the blades together
hypothesis	an idea that can be tested through experimentation
meter	A meter is a unit used to measure distance. The symbol used to represent the meter is m. 1 m = 100 cm = 1,000 mm
orientation	direction

PRE-LAB ACTIVITY

The orientation of the blade, or the way that it faces, affects the way that the turbine spins. In Figure 1, the blade is facing to the left. In Figure 2, the blade is facing to the right.

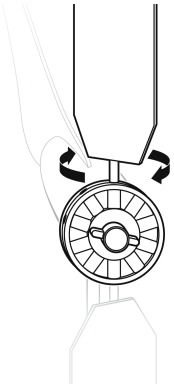

Figure 1 Left-facing blade

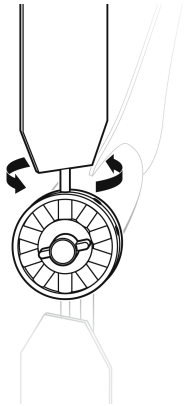

Figure 2 Right-facing blade

Hypothesis

Write a hypothesis about how the orientation of a blade affects the direction the turbine spins.

I think when the blade faces to the right, the turbine will spin (circle one)

clockwise **counterclockwise**

because

_____

_____

_____

PROCEDURE

Part 1 Blade direction

1. Get two blades from your teacher or make two blades for your turbine.
   a. If you are making blades, cut out two blades that are 12 cm long. They should be rectangular in shape.
   b. Attach the blades to wooden dowels with hot glue.

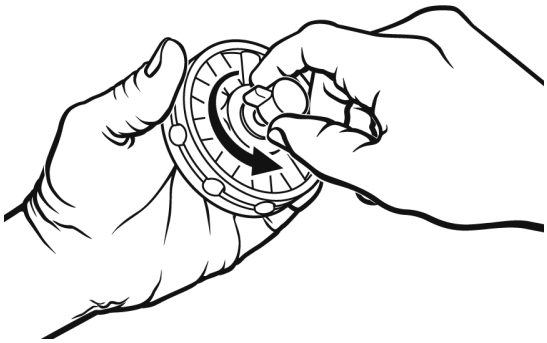

Figure 3

2. Assemble the blades and Wind Turbine Hub.
   a. Loosen the knob on the hub a little bit (see Figure 3). Do not loosen the knob too much or the hub will come apart.
   b. Gently create a space between the front and back pieces of the hub that is just big enough for the dowel and insert one of the blades.
   c. Insert the other blade on the opposite side of the hub.
   d. Tighten the knob on the hub to hold the blades in place.

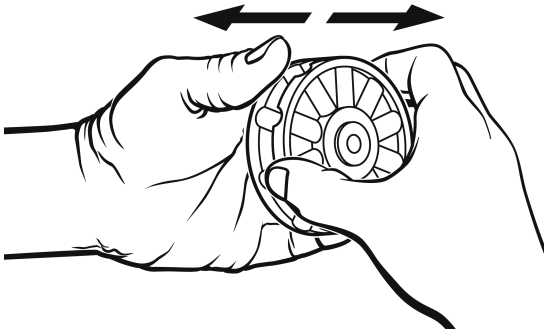

Figure 4

3. Connect the Wind Turbine Hub to the wind turbine.
   a. If the Red Blade Set is connected to the turbine, ask your teacher to remove it.
   b. Gently press the hub on to the turbine motor pin.

4. Face the blades to the right.
   a. To adjust a blade, rotate the Wind Turbine Hub so that the blade is positioned vertically at the 12 o'clock position.
   b. Slightly loosen the knob of the Wind Turbine Hub.
   c. Turn the wooden dowel so the blade faces to the right.
   d. Rotate the Wind Turbine Hub clockwise until the next blade reaches the 12 o'clock position.
   e. Turn the wooden dowel so the blade is facing to the right.
   f. When you have adjusted the blades so they face to the right, tighten the knob of the Wind Turbine Hub.
   g. Give the blades a gentle push with your finger to make sure it spins freely without hitting anything. If the blades hit the tower, adjust them until everything spins freely.

5. Position the fan so the center of the fan is in line with the center of the hub of the turbine. The fan should be 15 cm from the turbine. The distance needs to be the same each time you collect data.

6. Put on safety goggles and turn on the fan to the lowest speed setting. **CAUTION**: Do not stand in the plane of rotation of the wind turbine blades.

   If you are facing the front of the wind turbine, in which direction does the turbine spin (circle one)?

   clockwise **counterclockwise**

7. Turn off the fan and let the blades slow down until they stop. **Note**: Do not try to stop the blades with your hands.

8. Face the blades to the left.
   a. To adjust a blade, rotate the Wind Turbine Hub so that the blade is positioned vertically at the 12 o'clock position.
   b. Slightly loosen the knob of the Wind Turbine Hub.
   c. Turn the wooden dowel so the blade is facing to the left.
   d. Rotate the Wind Turbine Hub clockwise until the next blade reaches the 12 o'clock position.
   e. Turn the wooden dowel so the blade faces to the left.
   f. When you have adjusted the blades so they face to the left, tighten the knob of the Wind Turbine Hub.
   g. Give the blade set a gentle push with your finger to make sure it spins freely without hitting anything. If the blades hit the tower, adjust them so that everything spins freely.

9. Position the fan so the center of the fan is in line with the center of the hub of the turbine. The turbine should be the same distance from the fan as before.

10. Put on safety goggles and turn on the fan to the lowest speed setting. **CAUTION**: Do not stand in the plane of rotation of the wind turbine rotor.

    If you are facing the front of the wind turbine, in which direction does the turbine spin (circle one)?

    clockwise **counterclockwise**

11. Turn off the fan and let the blades slow down until they are stopped. **Note**: Do not try to stop the blades with your hands.

12. Data analysis for Part 1: Write a statement that summarizes what you have learned about blade direction and the direction the wind turbine spins.

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Part 2 Exploring turbine spin and output values

13. Set the switch on the Energy Sensor to Internal 30 Ω Load. Launch Graphical Analysis. Connect the Energy Sensor to your Chromebook, computer, or mobile device.

14. Connect the wind turbine to the Energy Sensor Source terminals.
    a. Connect the red wire from the turbine to the red Source terminal wire.
    b. Connect the black wire from the turbine to the black Source terminal wire.

15. Position the fan so the center of the fan is in line with the center of the hub of the turbine. Measure to make sure the fan and turbine are 15 cm apart.

16. Put on safety goggles and turn on the fan to the lowest speed setting. **CAUTION**: Do not stand in the plane of rotation of the wind turbine rotor.

17. Observe the current and potential difference values.

    Are the values positive or negative? _____

    If the values are positive, the electrons are moving in the direction we want them to and your equipment has been set up correctly. Show your circuit to your teacher.

    If the values are negative, the electrons are moving in the opposite direction. It is important that the electrons move in the other direction. In the next steps, you will create and test a plan to make the electrons move in the other direction.

18. Develop a plan to change the direction the electrons flow through the circuit. Record the plan and have it approved by your teacher.

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    _____

19. Test your plan. After you are finished, describe the relationship you observed between the direction the turbine spins and the current and potential difference (voltage) values.

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20. Someone is setting up a wind turbine and wants to set up the blades so the current and potential difference values are positive. In which direction should the blades face?

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