NAME PERIOD DATE

# WIND POWER 2: BLADE LENGTH, NUMBER, AND PITCH

## Driving Question | Objective

What number of wind turbine blades produces the most power? What is the optimal blade length? Which blade pitch is most efficient?

Some people think more wind turbine blades will produce more electricity, but blades can be expensive. The increase in electricity from 1 blade to 2 blades in an efficient system is about 6%. However, when you increase from 2 blades to 3, you only get a 3% increase. You must also factor in the additional cost of reinforcing the turbine and tower as more blades are added. Does the increase in electricity produced from each additional blade offset the higher cost of adding more blades?

## Materials

- Wind turbine with short blades (6) & long blades (6)
- Voltage sensor with red and black banana plug leads
- Current sensor with red and black banana plug leads
- Alligator clip adapters (2, black)
- Alligator clip leads (2, black and green)
- 33-Ω resistor
- Masking tape
- Meter stick
- Textbooks for weight (2)
- Box fan, 3 or more speeds (same fan as previous activity)

## Safety

Follow these important safety precautions in addition to your regular classroom procedures:

- Wear safety goggles throughout the experiment.
- Tie back long hair, remove dangling jewelry, secure loose clothing, and roll up long sleeves.
- Always make sure blades are properly inserted in the turbine and screws are secure before turning on the fan.

## Consider

1. Predict the blade length that will produce the highest power.

    a) Long

    b) Short

2. Predict the number of blades that will produce the highest power.

    a) Two

    b) Three

    c) Six

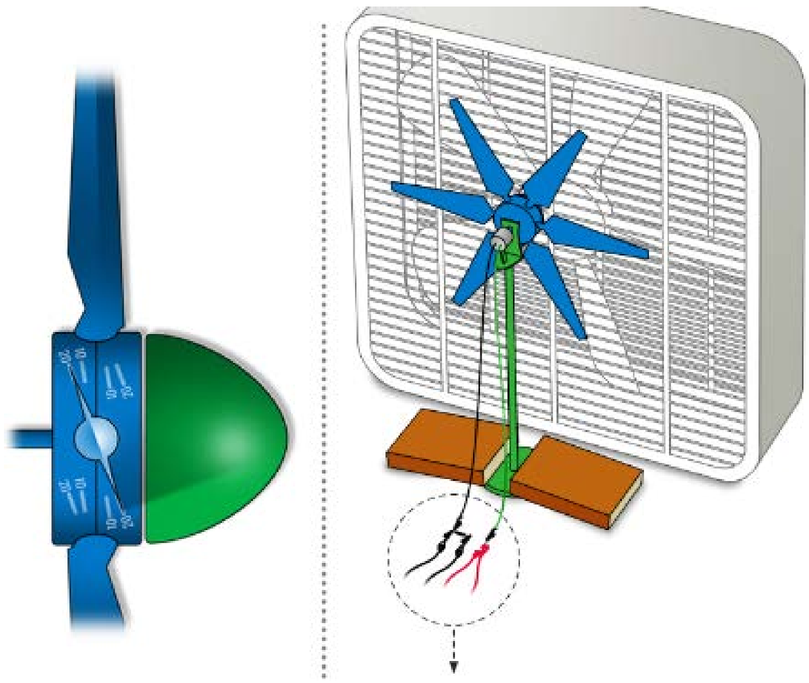
3. Observe the pitch angles printed on the blades. Predict the blade pitch that will produce the highest power.

   a) $10^{0}$

   b) $20^{0}$

   c) A combination of $10^{0}$and $20^{0}$

## Investigate Blade Length



1. Connect the voltage and current sensors. Use **Help (?)** if necessary.

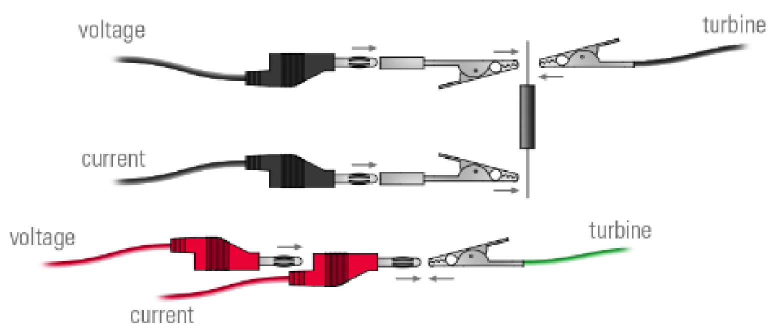
2. Select **Build** and choose a template that allows you to add two digits displays. Select Voltage (V) and Current (you **must** change units to mA) for the digits display measurements. Use **Help (?)** if necessary.

3. Remove the turbine cap and loosen the wing nut. Use the short blades to assemble the turbine according to the illustration. Set blades to $20^{0}$ with leaf logos facing the fan.

4. Place the turbine at the optimal distance, recorded on a piece of tape in a previous activity. Add textbooks to the base.

5. Insert banana plug leads into sensors if necessary. Use red for (+) and black for (-).

6. Attach alligator clip leads to the motor terminals. Assemble the red voltage sensor lead, red current sensor lead, and green turbine wire as shown.




7. Assemble the black voltage sensor lead, black alligator clip adapter, black turbine wire, and resistor as shown.

8. Assemble the open end of the resistor, black alligator clip adapter, and black current sensor lead as shown.

9. Turn the fan on to its optimal speed recorded in a previous activity.

10. Start collecting data.

11. Observe voltage and current over one minute. Record the highest observed values for each in Table 1.

Table 1: Highest Power for Blade Length

| Blade Length | Highest Voltage (V) | Highest Current (mA) | Power (mW) |
|---|---|---|---|
| Short | | | |
| Long | | | |

12. Turn the fan off.

13. Use the following equation to calculate power produced; show your work in the space provided. The units V x mA become mW. Enter your answers in the table.

    Power (mW) = Voltage(V) x Current (mA)

14. Remove the turbine cap and loosen the wing nut. Rearrange the turbine to have six long blades at $20^0$, leaf logos facing the fan.

15. Repeat steps 8-13; record results in Table 1.

16. Use power to identify the optimum blade length. Circle the optimum blade length in Table 1.

17. Rearrange the turbine to have 6 blades of optimal length (if necessary).

## Investigate Number of Blades

1. Set up the turbine with optimal blade length and distance, leaf logos facing the fan at $20^0$. Add textbooks to the base and turn on the fan to its optimal speed.

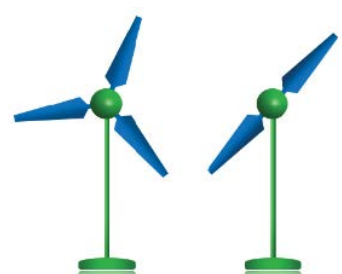
2. Observe voltage and current for 6 blades over one minute. Record the highest voltage and current in Table 2.

Table 2: Highest Power for Number of Blades

| Number of Blades | Highest Voltage (V) | Highest Current (mA) | Power (mW) |
|---|---|---|---|
| 6 | | | |
| 3 | | | |
| 2 | | | |

3. Turn the fan off.

4. Remove the turbine cap and loosen the wing nut. Repeat Steps 14-16 first with 3 blades and then with 2 blades arranged in the positions shown. Record results in Table 2.



5. Use the formula to calculate power for each number of blades in Table 2. Show work in the space below. Include units in your work and answers.

   Power (mW) = Voltage(V) x Current (mA)

6. Use power to identify the optimum number of blades. Circle the optimum number of blades in Table 2.

7. Rearrange the turbine to have the optimum number of blades before moving on.

## Investigate Blade Pitch

1. Place the turbine with the optimum number of blades at the optimum distance. Add textbooks.

2. Set all blades to $10^0$, leaf logos facing the fan. Turn the fan on at optimum speed.

3. Find the highest voltage and current over 1 minute. Record results in table 3.

Table 3: Highest Power for Blade Pitch

| Blade Pitch | Highest Voltage (V) | Highest Current (mA) | Power (mW) |
|---|---|---|---|
| 10° | | | |
| $20^0$ | | | |
| | | | |

4. Turn the fan off.

5. Repeat Steps 2-4 for $20^0$.

6. Enter a blade pitch combination of your own in Table 3, in the blank Blade Pitch cell. Repeat Steps 2-4 with your combination.

7. Use the the formula to calculate power for each number of blades in Table 2. Show work in the space below. Include units in your work and answers.

   Power (mW) = Voltage(V) x Current (mA)

8. Use power to identify the optimum blade pitch. Circle the optimum blade pitch in Table 3.

9. Record the optimum blade length, blade pitch, and number of blades on the piece of tape. Store the tape on the fan for future activities.

## Analyze

1. What number of blades produced the optimum power? How does your prediction compare to your results?

2. Propose an explanation for why 1, 4, or 5 blades were not tested.

3. How does your prediction for blade length compare to your results? Use data to support your answer.

4. How does your prediction for blade pitch compare to your results? Use data to support your answer.

## Extend

You were asked to explain why 1, 4, or 5 blades were not tested. Design an experiment to verify your explanation.