DESIGN AN EFFICIENT TURBINE

Driving Question | Objective

Can a different turbine blade design perform as well as or better than the plastic blades provided?

In this activity, your goal is to create the most efficient turbine blades possible.

The blade engineering process will require applying what you learned about effective blade design and how to create the most optimal wind testing conditions with a fan. Trial-and-error testing will help you discover ways to improve the initial design of your product. Do not be discouraged if your first design fails to meet your expectations. When creating new products engineers may complete many cycles of the design process before they achieve their goals for the product.

Materials

- Wind turbine
- 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)
- Box fan, 3 or more speeds (same fan as previous activity, with tape)
- 33-Ω resistor
- Blade adapters (6)
- Dowels (6)
- Textbooks for weight (2)
- Disposable foil pans (2)
- Scissors
- Duct tape

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. Transfer the optimal turbine blade data from your piece of tape to the data table.

2. In your group brainstorm ideas to improve performance for each turbine factor. You will apply your ideas to create lightweight metal turbine blades. You may not use the plastic blades in your design, but they are available for you to inspect. Pick up and explore your materials to help you think of ways to design new blades. Use only the materials supplied and one foil pan for your first design. Use textbooks to stabilize the base.

3. Enter your best idea for each turbine factor in Table 1 on Page 2.

Table 1: Turbine Design Plan

Turbine Factor	Optimal Setting	What new design will you try?
Distance from fan		
Blade length		
Number of blades		
Blade pitch/angle		
Blade shape		

Investigate

1. Get instructor approval for your plan before moving on to Step 2.

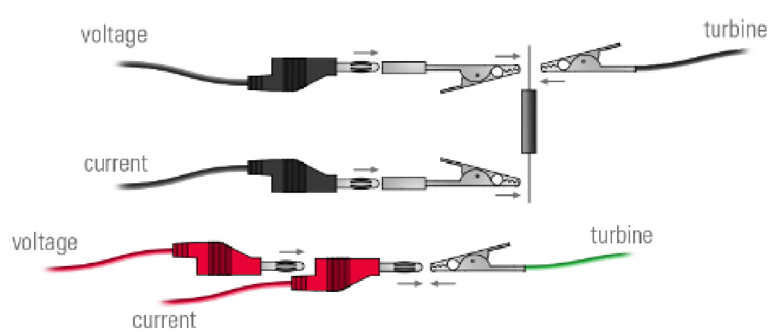
2. Connect the voltage and current sensors. Use **Help (?)** if necessary.

3. Select Build and choose a template that allows you to add two digits displays. Select Voltage and Current for the digits displays measurements. Change units for current from amps (A) to milliamps (mA). Use **Help (?)** if necessary.

4. In the Sampling Options menu, change Sampling Mode to Manual, change Sampling Rate to 2, and change Sampling Rate Units to seconds. Use **Help (?)** if necessary.

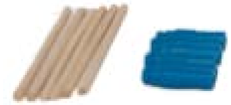
5. Insert banana plug leads into sensors if necessary. Use red for (+) and black for (-).

6. Attach alligator clip leads to the motor terminals. Connect the resistor and voltage and current sensors to the turbine as shown.



7. Remove the turbine cap and loosen the wing nut. Remove plastic turbine blades.

8. Use the dowels, blade adapters, scissors, one foil pan, and tape to create new turbine blades.



9. Insert the new blades into the turbine and secure all parts. Place textbooks on the base.

10. Get instructor approval before moving on.

11. Turn on the fan to the setting designated by your instructor.

12. Start collecting data. Observe the highest voltage and current reading over 1 minute. Enter the highest observed voltage and current for Trial 1 in Table 2.

Table 2: Results

Trial #	Voltage (V)	Current (mA)	Power (mW)
Trial 1			
Trial 2			
Trial 3 (optional)			

13. Turn the fan off.

14. Use the following equation to calculate power in milliwatts (mW). Enter your answer in Table 2.

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

15. Enter observations for Trial 1 and new revision ideas in Table 3.

Table 3: Trial 1 Results and Revisions

Turbine Factor	Describe first trial results	What revisions will you make?
Distance from fan		
Blade length		
Number of blades		

Blade pitch/angle		
Blade shape		

16. Get instructor approval for the revisions, then make the revisions.

17. Get instructor approval again after making revisions.

18. Repeat Steps 11-14.

19. Record observations and revision ideas for Trial 2 in Table 4.

Table 3: Trial 2 Results and Revisions

Turbine Factor	Describe second trial results	What revisions will you make?
Distance from fan		
Blade length		
Number of blades		
Blade pitch/angle		
Blade shape		

20. Check with your instructor to see if you need to complete and test the design revisions. If you complete a third trial, get instructor approval and repeat Steps 11-14. Create a table like Tables 2 and 3 on a separate piece of paper and record results and revisions for Trial 3.

Analyze

1. Review your results. Does it appear the optimal distance, angle, length, and shape settings for the plastic blades also work for the lightweight metal blades you designed? Why or why not?

2. Did your revisions improve turbine performance? Why or why not?

3. Estimate the number of revisions you think it would take to produce a turbine blade you are satisfied with. What is this number based on?

4. Which part of turbine design did you find the most challenging? What would make it easier to meet this challenge?

Extend

Your final goal is to explore hydroelectric power as a renewable source of energy. Design hydroelectric turbine blades to be attached to the motor where voltage output can be measured with the voltage sensor. Your water source for the water-powered turbine will be a classroom faucet. Get instructor approval before performing your experiment.

Compare results from solar, wind, and hydroelectric power. Write a recommendation to adopt one of the three sources of alternative energy that is the most reliable and environmentally-friendly power source for a small device such as an LED light. Support your recommendation with data.