# Wind Energy

This experiment shows students how wind energy can generate electricity. Specifically, it shows how wind propeller design affects the efficiency of wind machines.

GRADES: 7–12

SUBJECT: science

TIME: one class period (45 minutes) for building wind machines; one to two class periods for experiments and discussion.

MATERIALS: Divide students into groups of two or three. Each group needs the following materials to build one generator and three wind propellers:

- small electric fan or hair dryer (you will need a two-speed fan for Experiment 4)
- DC motor (1.5 V or larger)
- three corks of the same size (at least 2 cm in diameter)
- DC voltmeter with a low rating (1 or 5 VDC minimum rating is fine)
- a stiff ruler or piece of wood
- 60 cm of connecting wire (about 22 gauge)
- large rubber band
- fast-drying glue
- 18 paper clips
- pliers or wire cutters
- a pair of scissors
- thin cardboard (less than 2 mm thick, paper pad backing works well)

PREPARATION:

1. If you have not studied electricity in your class, you may want to review basic concepts of electricity before this activity. You may also want to distribute the Beaufort Wind Scale handout (pg. 39) a week before this activity.

2. You may want students to glue the wind propellers (see the handout on pg. 38) during an earlier class, depending on how fast your glue dries (Elmers glue takes 20–30 minutes to dry).

3. Cut the connecting wire into 30 cm pieces before class.

PROCEDURE:

1. Ask students if they know what "wind energy" is and how it is harnessed. Ask them to name some uses of wind energy and/or ask them to sketch wind machines. Describe modern wind technology.

2. Review the basics of electricity and electricity generation. Explain to them how a magnetic coil motor works. Show them a small, disassembled motor. Explain that you can make a simple electric generator from a small motor.

3. Distribute instructions. They tell students how to build a generator and three wind-propeller models to power it. Review these instructions if necessary.

4. Supervise construction, helping if problems arise.

5. When students finish, ask them to do Experiments 1, 2, 3, and 4 below. Begin each experiment by writing the experimental question on the board. Describe each experiment to them.

*Note: You might also begin by simply showing, with your own model wind machine, that wind energy can produce a current. Alternatively, you could show that rotating a motor shaft produces a current, by pulling a rip cord around the motor shaft.*

EXPERIMENT 1: How does the blade angle on a wind propeller affect how much electricity it produces?

Procedure: Attach Model 1 wind propeller to the motor shaft. Tilt the blades so that they are perpendicular to the end of the cork (Figure A). Place the wind machine in front of a working fan or hair dryer. Does the propeller spin? If not, slightly rotate the blades so that they are at a small slant (Figure B). Place the propeller in front of the fan or hair dryer. Keep tilting the blades in small increments until the propeller starts spinning. When this happens, measure the voltage produced. Keep tilting the blades of the propeller to see which angle produces the greatest voltage.

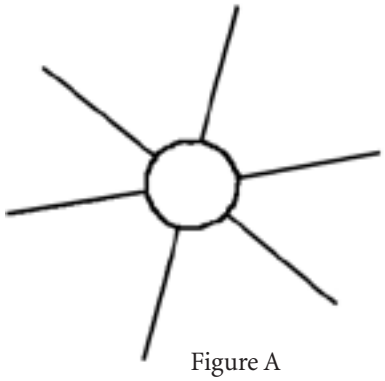


Figure A

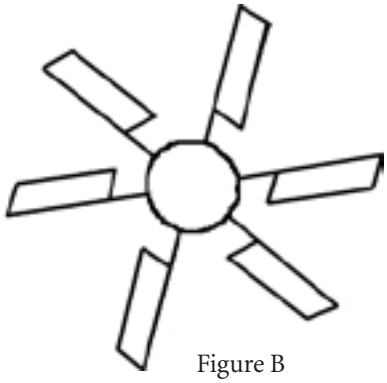


Figure B

Ask students to draw conclusions about how blade angle affects how fast a propeller can spin, and why.

EXPERIMENT 2: How does the size of the blades on a wind propeller affect how much electricity it can generate?

Procedure: Keep the wind blades on Model 1 at the angle at which they produced the greatest voltage. Measure the voltage again. Then, attach the Model 2 wind propeller to the motor shaft, with the blades at the same angle. Put it in front of the fan or hair dryer at the same distance as you did with the first propeller. Measure the voltage produced by this wind turbine.

Ask students to draw conclusions about how the size of wind blades affects how fast a propeller can turn, and why.

EXPERIMENT 3: How does the shape of the blades on a wind propeller affect how much electricity it can generate?

Procedure: Keep the wind blades on Model 2 at the same angle as in Experiment 2. Measure the voltage again. Then, attach the Model 3 wind propeller to the motor shaft, with the blades at the same angle as the Model 2 wind propeller. Measure the voltage.

Ask students to draw conclusions about how the shape of propeller blades affects how fast they can spin, and why.

EXPERIMENT 4: How does wind velocity affect the amount of electricity a wind machine can produce?

Procedure: Using any of the propellers created in previous experiments, place the wind machine in front of a two-speed fan. Turn the fan on low speed and measure the voltage. Then turn the fan on high speed and repeat the measurement.

Ask students to hypothesize about how wind speed affects the electricity output of wind machines. What conditions would probably be necessary for a good site for commercial wind energy generation?

You might end the activity by holding a contest to see who can produce the most efficient wind turbine. Give them identical corks and a total surface area that all their propeller blades must add up to, independent of their shape (6 sq. cm, for instance). Given this constant area, see which students can design the most efficient turbine.

FOLLOW-UP:

1. Ask students if they think they could build a wind turbine strong enough to power a flashlight bulb (average voltage: 2.5 V). How would they alter the turbine design to do this?

2. Ask students to picture what the ideal, most efficient wind turbine would look like, considering what they have learned in the experiments. Discuss the models they suggest. Show pictures of actual modern wind turbines.

3. Assign independent research projects on wind energy. Possible topics are:

   - different kinds of wind turbines
   - recent advances in wind turbine design
   - wind energy potential in the United States
   - problems with wind turbines
   - uses for wind machines other than electricity generation
   - wind energy storage
   - historical uses of wind power
   - current uses of wind power around the world

# Wind Machine Instructions

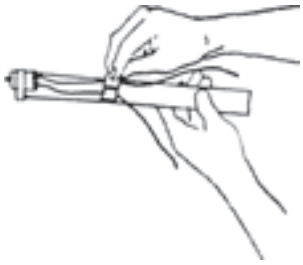
STUDENT HANDOUT

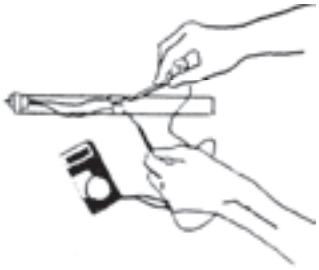
This sheet tells you how to build your own wind machine for generating electricity.

First, get a small motor and a ruler or piece of wood from your teacher. Attach the motor to the end of the ruler by wrapping it with a rubber band.

Second, cut two 30 cm pieces of electrical connecting wire. With a pair of scissors, take off 2 cm of rubber insulation from both ends of the two wires. Do this by pinching softly with the scissors on the rubber casing, cutting it slightly, then pulling the scissors toward the wire's end, removing the casing.

Next, attach one end of each wire to one of the motor's outlets. Tape the wires to the molding (at the end without the motor). Attach the other two ends of the wire to a voltmeter.





Now you're ready to build the actual wind propellers. There are three models you'll need to build.

# Wind Machine Instructions



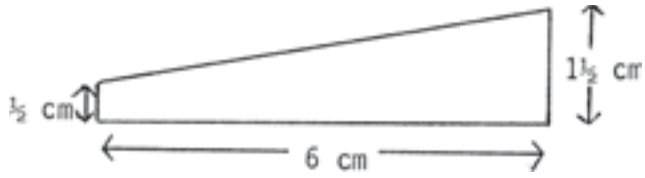
MODEL 1: Take six paper clips. Snip off part of each clip with pliers or wire cutters. Straighten out the bottom part of each clip.

Then cut out six pieces of cardboard 1 cm x 3 cm. Glue or tape the central part of each paper clip to the bottom of a cardboard piece. Leave time for glue to dry (20 minutes).

Take a cork and poke the six wind blades into it. Insert the blades about 5 mm from the end, spaced equally around the circumference of the cork. To loosen up a hole, you may want to stick a pin in beforehand.

MODEL 2: Follow the same directions as Model 1, but this time cut cardboard rectangles that are 1-1/2 cm x 4 cm.

MODEL 3: Follow the same directions as Model 1, but this time cut the cardboard in the following shape:




*Note: This shape has the same surface area as Model 2.*

To use a wind propeller, place the cork end furthest away from the wind blades on the motor's shaft. Make sure the shaft goes in the exact center of the cork and do not wiggle it (which will loosen its hold on the motor).

# Wind Machine Instructions

STUDENT HANDOUT

This is the Beaufort Wind Scale. It is used to measure wind speeds. It relies on human observations, not mechanical devices, to calculate the speed of the wind.

| BEAUFORT NUMBER | DESCRIPTION | OBSERVATION |
|---|---|---|
| 0 | calm (0–1 mph) | smoke rises vertically |
| 1 | light air (2–3 mph) | smoke drifts slowly |
| 2 | slight breeze (4–7 mph) | leaves rustle; windvane moves |
| 3 | gentle breeze (8–12 mph) | twigs move; flags extended |
| 4 | moderate breeze (13–18 mph) | branches move; dust and paper rise |
| 5 | fresh breeze (19–24 mph) | small trees sway |
| 6 | strong breeze (25–31 mph) | large branches sway; wires whistle |
| 7 | moderate gale (32–38 mph) | trees in motion; walking difficult |
| 8 | fresh gale (39–46 mph) | twigs break off trees |
| 9 | strong gale (47–54 mph) | branches break; roofs damaged |
| 10 | whole gale (55–63 mph) | trees snap; damage evident |
| 11 | storm (64–72 mph) | widespread damage |
| 12 | hurricane (73–82 mph) | extreme damage |

EXERCISES:

1. Measure the wind using the above scale. Measure it on three different days at three different times during the day, preferably in the morning, midday, and afternoon or evening. Record your observations.

2. At what time of day do the fastest winds usually occur? the slowest winds?

3. Any wind over 8 mph can be used to generate electricity. Currently, though, it only makes economic sense to build wind turbines in areas where the wind exceeds 15 mph most of the time. Could you generate electricity in your area?