800 Wind Powered Generator

Purpose:

The Wind Powered Generator is an excellent device for studying wind as a source of energy. The generator will allow students an opportunity to measure the amount of electricity generated and to study the various factors affecting the performance of a windmill.

NOTE:
GENERATOR SHAFT SHOULD GO INTO HUB BY ½" ONLY BEFORE TIGHTENING THE LOCKNUT

Required Accessories:

Pliers
Hex (“Allen”)wrenches
Voltmeter/Ammeter
Electric fan (3 speed or variable) for the wind source
Phillips screwdriver
Protractor or Angle Templat

Assembly:

1. Locate the two wing nuts protruding from the underside of the generator housing. Loosen these and slip the slotted end of the tail support bar under the wing nuts. Tighten the wing nuts onto the tail support.
2. Screw the threaded end of the support post into the weighted base. Be sure this connection is tight. Place the pivot shaft (1/4-20 bolt extending from the underside of the generator) into the hole in the top of the support post.
3. The threaded generator shaft extends from the front of the generator housing. You should find a 1/4-20 nut already started on this shaft. Screw the hub/blade assembly onto the threaded generator shaft for ½” only. Turn the nut that was already on the shaft so that it tightens up against the hub/blade assembly. This will lock the hub onto the shaft.

Description:

To change the number of vanes or adjust the angle at which the blades are set, you must first loosen the three cap screws using an hexagonal (“Allen”) wrench. After the blades have been repositioned, tighten the cap screws securely.

The unit is equipped with a 1.5 volt electric bulb which provides a visual measure of electrical output; the brighter the bulb, the higher the voltage.

The unit is also equipped with a jack and binding posts

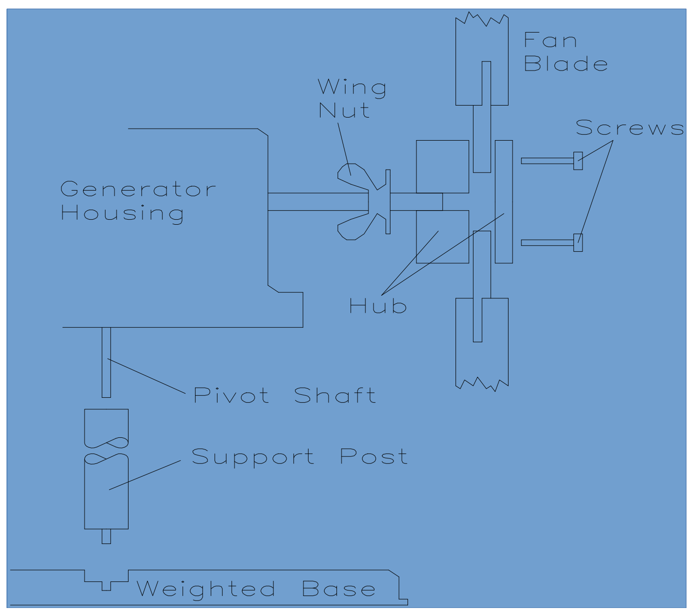

Figure 1 Cross Section of hub and blade assembly

for utilizing an ammeter or volt meter to precisely measure the current or voltage produced. To measure the voltage generated, connect the voltmeter to the red and black binding posts on the underside of the generator housing. The phono jack on the underside of the generator is provided for a convenient connection to measure current.

When using the resistor, disconnect the bulb by removing the red lead from the red binding post. Next, connect the resistor between the red and black binding posts. This provides a load of 100 ohms across the terminals of the generator. Always check the value of the resistance if you are recording quantitative data.

Background:

Wind is an ancient source of energy. Thousands of years ago people were using wind to propel their sailing ships. The invention of the sail was a great step forward for early mankind. Windmills were an important source of energy in Holland and played an important role in the industrial development of that country. Even in the United States, windmills were an important source of energy during the 19th century. As oil became an inexpensive, available source of energy, the use of windmills gradually declined. Today, as fossil fuels become more and more expensive, and we become more aware of their harmful effects on our environment, we are again looking to the wind to fill some of our energy needs.

Although it is not obvious, wind is a result of sunlight striking the surface of the earth, making it a form of solar energy. While sunlight is falling on one place on the Earth, another is in shadow. The warm air tends to rise and cooler air rushes in beneath it creating prevailing winds throughout the world. The same thing happens on a smaller scale in local areas. For example, at the seashore during the day, the land is warmer than the water, so the warm air rises above the land and the cool air above the water rushes in to take its place. This produces a wind blowing from the water to the land. At night, when there is no sunlight to heat the land, both the land and the water cools off, but the water cools more slowly. So the air over the water is warmer than the air over the land. The air over the water rises and is replaced by air moving to the water from the land. This produces a wind blowing from the land to the water.

The major problem with wind as an energy source is the fact that it is a variable quantity. The wind is not always blowing when we want it to, nor does it always blow with a sufficient velocity. On the other hand, when it does blow, it may produce energy for us in quantities that are too great for us to use immediately. A method is needed to store the energy so that it can be available when we need it. There are many methods currently under investigation to store wind energy.

As detailed below, you will perform experiments to study the various factors affecting the performance of a windmill.

General:

In all experiments requiring energy measurements, use a voltmeter with a range of 0 to 15 volts or something reasonably equivalent. Avoid putting your hands near the blades when they are spinning rapidly. If it is available, a three-speed window fan provides maximum versatility and should be used as a wind source.

Theory:

How does the windmill work? This windmill is actually an electrical generator. The basic principle of every electrical generator is the same. If a conductor moves near a magnet or if a magnet moves near a conductor, an electric current is produced in the conductor. In order to create the motion that will produce an electric current, some agent must supply a force that moves the conductor. There are many ways that this can happen; the gravitational pull of water falling over a dam, the pressure of steam produced by burning fuel, and ordinary wind can be used to turn the blades of a propeller. All of these methods and others can be used to turn a coil of wire between the poles of a magnet to generate electricity. Even a nuclear power plant is only a means of producing steam, which is used to turn electric generators.

Returning to the wind generator for a moment, if you remove its top cover, behind the blades you will see a small motor. Inside the motor are magnets and a coil of wire. When the blades turn, the coil of wire inside the motor turns between the magnets, producing electricity.

Experiment 1:

Attach a voltmeter (0 to 10 volts) to the red and black connectors on the underside of the generator housing. With your hands, spin the blades slowly and record the voltage. Spin the blades faster and finally as fast as you can. Record the voltage each time.

Spin Speed	Voltage
Slow	
Medium	
Fast	
Very Fast.	

How is the voltage output related to the speed of rotation of the blades? Based on your results, what do you think is the main objective in designing an efficient windmill?

Experiment 2:

In this experiment you will investigate the effect of varying the number of blades in the performance of the windmill. As a measure of performance, you will use the voltage output of the windmill. In this experiment set all blades at an angle of 15 degrees to the vertical. Set up the windmill using two blades in balanced configuration. Place a fan 15cm from the blades of the windmill. Turn it to the maximum speed. Let the fan run for about 60 seconds. Record the maximum voltage. Using the above procedure, complete the table below.

Number of Blades	Voltage
2	
3	
4	
5	
6	

What conclusion can you draw from your data? Do you think adding more blades would increase the voltage output? Is there any limit to the number of blades? Why?

Experiment 3:

In this experiment you will investigate the importance of blade angle in maximizing windmill output. Using 6 blades, set them on the windmill at the angles to the vertical indicated in table 3. Set your fan 15cm from the blades. Complete the table.

Angle	Voltage
0 degrees	
15 degrees	
30 degrees	
45 degrees	

From your data, what do you conclude is the most efficient blade angle? Would it help or hinder performance of the windmill if some of the blades were at one angle while others were at a different angle?

Experiment 4:

With a piece of chalk, or a suitable sticker, place a white spot near the tip of one of the blades. Repeat Experiment 2. With a PSSC- type hand strobe or an electronic strobe, if one is available, measure the number of rotations per minute made by the blades. Make a graph of RPM vs voltage output. Is your graph linear? Could you use your graph to predict the voltage output for RPM's higher than the highest you measured? In which predictions would you have the most confidence? disconnect the bulb and repeat the experiment. What effect does the bulb have on the rotational speed and the voltage output. Connect the 100 ohm resistor across the red and black binding posts. What effect does this have on the rotational speed and the voltage output? Explain your results.

Experiment 4A:

Remove the generator housing by unscrewing the two small Phillip head screws holding it down. Measure the size of the drive shaft pulley and the generator pulley. What is the ratio? Knowing the speed of the drive shaft from Experiment 4, what would you theorize is the speed of the generator shaft? Why? Can you develop a formula that ties RPM's and pulley diameters together? Knowing the pulley diameters and the drive shaft RPM's compute the generator RPM's. How might this knowledge be used in the design of a wind powered generator?

Experiment 5:

In this experiment you will investigate the effect of distance of the fan from the blades vs voltage output. Use a six blade configuration with each blade set at an angle of 15 degrees. Place the fan one meter from the blades. Turn the fan to high speed. Measure the voltage output. Move the fan closer to the blades in increments of 10 cm. until you complete the table below:

Distance, cm.	Voltage
100	
90	
80	
70	
60	
50	
40	
30	
20	
10	

What conclusions can you draw from the experiment? Does the “wind” speed change as the fan moves closer to the blades? Does any characteristic of the wind change as the fan moves closer to the blades? Can you explain the results?

Experiment 6:

In this experiment, you will investigate the effect of fan speed on voltage output. It is necessary to have a fan with at least 3 speeds. Set up your equipment in the usual way with six blades set at an angle of 15 degrees. Place the fan 15cm from the blades. Set the fan at low speed. Record the voltage output. Set the fan at medium speed. Record the voltage output. Set the fan at high speed. Record the voltage output.

Fan Speed	Voltage
Low	
Medium	
High	

What is the effect of increasing wind speed on voltage output. Would doubling the wind speed double the voltage output? Do you have enough data to answer the question? How could you obtain more useful data? You need a wider variety of speeds and the numerical values of those wind speeds. If you can't answer this question, turn to the next experiment.

Experiment 7:

Number of Blades	Voltage	Power

In this experiment you will determine the power produced by your windmill. Connect the 100 ohm resistor into the circuit in place of the bulb. Repeat Experiment 2. This time you will calculate the power in watts produced by your windmill. Use the formula

$$P = V^2/R$$

Where:
V is the output voltage
R is the 100 ohm resistance
P is the power produced by the generator in watts

An ordinary house light bulb requires anywhere from 50 to 150 watts. Could your windmill light one of these bulbs?

Experiment 8:

In all the previous experiments, you were using a fan as a wind source. Try taking your windmill outside everyday for a month to determine the voltage output of your windmill produced by the real wind. Can you devise a method to determine the wind speed each day using your windmill? Look up anemometer in an encyclopedia. How is an anemometer like your windmill? How is it different?

Date	Voltage	Wind Speed

Experiment 9 - Research Problem:

In all the previous experiments, rectangular blades were used. Scientists have been experimenting with windmill blades of various shapes in attempting to increase the efficiency of windmills. Curved blades have been used, cupped blades, and blades of a wide variety of shapes and curvatures. Using any materials that are available such as plastic, cardboard, wood, paper cups, etc., design your own blades and carry out a research project of your own to determine more efficient shapes than flat rectangles. You can insert wood dowels in the blade hub to carry your blades or attach them to the blades supplied.

Questions for Further Discussion:

1. What is an anemometer? How is it like your windmill?

2. Write an essay on the history of windmills in Holland. Are windmills still being used today in Holland?

3. Write an essay on windmill research in the U.S.

4. Are there any windmills where you live? Find out. Visit one if you can.

5. Are the winds where you live strong enough to produce practical levels of power? Get weather data from newspapers in your library or call your local weather bureau or better still, carry out your own actual observations.

6. At what time of the day do the winds blow the fastest in your area? Are the winds in your area steady or do they blow in gusts. How can you find out?

7. How many hours during the day are the winds strong enough to produce electricity?

8. How accurate is the weather bureau in predicting winds where you live? Make your own determinations of wind speed for a month and check them against the weather bureau predictions.

9. Look up Savonius rotors and helical rotors in the library. Write a short report of your findings.

10. Wind “farms” were established in various parts of the U.S. at the time of the energy crisis in the 70's. Most of them are no longer in operation. Find out their history. When do you think they will stage a comeback?

Time Allocation:

To prepare this product for an individual experimental trial should take less than ten minutes. Actual experiments will vary with needs of students and the method of instruction, but most are easily concluded within one class period.

Feedback:

If you have a question, a comment, or a suggestion that would improve this product, you may call our toll free number.