**Wind Energy- Instructors Guide**

Created by: Daniel Henry for N.A.T.U.R.E Summer Camp 2017

**Description:**

In this lesson, you will explore a method for creating your own wind energy, find a

way to measure wind speed and explore the use of wind energy, and create your

own wind turbines and propeller design.

**Objectives:**

Explore the process involved in wind energy.

Create working wind turbines

Investigate how wind energy is used and the devices that harness wind energy

Create an Anemometer to measure wind speed

Convert units

**North Dakota State Standards:**

9-10.1.2. Describe the interaction of components within a system

9-10.2.1. Explain how scientific investigations can result in new ideas

9-10.2.2. Use appropriate safety equipment and precautions during investigations

9-10.2.6. Design and conduct a guided investigation

9-10.2.7. Maintain clear and accurate records of scientific investigations

9-10.2.8. Analyze data found in tables, charts, and graphs to formulate

 conclusions

9-10.6.1. Use appropriate technologies and techniques to solve a problem

9-10.6.3. Explain how emerging technologies may impact society and the

 Environment.

11-12.2.2. Select and use appropriate instruments, measuring tools, and units of

 measure to improve scientific investigations

11-12.2.5. Use technology and mathematics to improve investigations and

 communications

11-12.6.2. Identify examples of how new technologies advance science

**Schedule:**

9:00-9:30 Cultural Connection

9:30-10:30 PowerPoint and Activity 1: Pinwheels

10:30-11:30 Activity 2: Propeller design

11:30-12:00 PowerPoint and Activity 3: Horizontal and Vertical axis wind turbine’s

12:00-12:45 Lunch

12:45-1:30 Finish Activity 3

1:30-2:15 Activity 4: Wind Anemometer

2:15-2:45 PowerPoint and Activity 5: Debating Wind Power Industry

2:45-3:00 Wrap-up

**Activity 1- Pinwheels**

**Summary**

Students learn about wind energy by making a pinwheel to model a wind turbine. Just like engineers, they decide where and how their turbine works best by testing it in different areas of the playground.

**Engineering Connection**

Engineers use their understanding of natural forces to obtain energy from renewable resources such as the sun, wind, rivers and organic matter. For example, regions with forceful and steady wind are suitable for wind farms. Engineers design wind turbines to produce electricity from the force of the wind. Turbines look like pinwheels with angled blades connected to a gear box, which is connected to a generator. Engineers collect and analyze wind data to continually improve turbine technology and wind farm design.

**Learning Objectives**

**After this activity, students should be able to:**

* Understand different sources of energy and that wind is a renewable energy source.
* Understand how a wind turbine works.
* Understand how engineers work to monitor wind and design technology to capitalize on wind energy.
* Understand how to use angles and which angles are best for wind turbines.

**Materials List**

Each student should have:

A longer-length pencil (with an intact eraser) or 2 Popsicle®/craft sticks

1 straight pin

Scissors

Glue or tape (only if Popsicle®/craft sticks are used)

A copy of the KWL Chart (attached)

A copy of the Pinwheel Worksheet (attached)

A copy of the Pinwheel Template (in dropbox)

**Introduction/Motivation**

Engineers study the processes of the Earth to figure out how we can get energy to light up and heat our homes. Wind is a powerful force that can be used to produce energy. It is a renewable energy source, which means it can be used again and again without ever using it up. Another great thing about wind is that it does not emit any pollutants like fossil fuels emit. So, wind is Earth friendly!

How do engineers harness the wind? Have you ever seen a windmill? What does it look like? Well, engineers design machines called wind turbines that look a little like a windmill.

You may have seen wind farms or wind turbines in open fields or in bodies of water. They most often resemble tall, white pinwheels on a stick. A turbine has several parts (see Figure 1 on PowerPoint), the blades are connected to a gear box, which makes it spin faster and is connected to the generator. As the wind blows, the blades of the turbines spin, which turns a generator that creates electricity for our use. A turbine also has a brake in case the wind starts blowing too fast. Water turbines work in a similar way, except they use water instead of wind.

Today, we are going explore a pinwheel to model a wind turbine. We are going to make a part of a wind turbine (the blades). When the blades of a turbine turn in the wind, they make the generator turn, which then creates electricity.

**Procedure**

**Before the Activity**

* Gather activity materials.
* Make an overhead of the wind turbine diagram (Figure 1).
* Make enough copies of the [Wind Energy KWL Chart](http://content.teachengineering.org/content/cub_/activities/cub_earth/cub_earth_lesson04_activity2_chart.pdf), the [Pinwheel Worksheet](http://content.teachengineering.org/content/cub_/activities/cub_earth/cub_earth_lesson04_activity2_worksheet.pdf) and the [Pinwheel Template](http://content.teachengineering.org/content/cub_/activities/cub_earth/cub_earth_lesson04_activity2_template.pdf) (attached) for each to student to have one.
* Make a sample wind turbine/pinwheel to show the students.

**With the Students**

1. Pass out the [Wind Energy KWL Chart](http://content.teachengineering.org/content/cub_/activities/cub_earth/cub_earth_lesson04_activity2_chart.pdf). Ask students to write down in the "Know" column what they already know about energy created by wind. Hint: Think windmills.
2. Discuss with students the ways in which we get energy. (Answers: The Sun, the wind, water, fossil fuels and nuclear power plants)
3. Explain to students that they will be exploring a pinwheel to model a wind turbine. Ask the students if they have ever seen a wind turbine (tell them they are like windmills).
4. Explain to students what a wind turbine is, how it works and why we use it. Tell them that they will be making part of a wind turbine (the blades). Explain to students that when the blades turn in the wind, they make the generator turn, which then creates electricity.

**Making the Turbine**

1. Pass out the materials to build the wind turbine/pinwheel. Students should work individually (or may work in pairs if desired).
2. For the pinwheel handle, students may use a pencil or glue (or tape) two Popsicle®/craft sticks together end to end. If using Popsicle®/craft sticks, set aside to dry.
3. Pass out the [Pinwheel Template](http://content.teachengineering.org/content/cub_/activities/cub_earth/cub_earth_lesson04_activity2_template.pdf). Students should follow the directions listed in the Instructions.
4. If time permits, students can color their pinwheels. Explain that they will be folding the corners over, so both sides of the paper will be seen.
5. Have students poke their straight pin through all four corners of the paper (in order of lowest to highest number) and then through the center of the paper (position #5). Then, affix the paper blades — with the straight pin poked into the #5 position on the blades — to the eraser of the pencil or to one end of the Popsicle®/craft sticks.



**Testing the Wind Turbine/Pinwheel**



1. Discuss with the students that engineers must test everything they build to determine how well it works. Now the students will test the conditions in which their wind turbine will work the best. Discuss the factors that affect how well the turbine works. (Answers: the strength of the wind, direction of the wind and actual construction quality of the wind turbine.) Ask them where they think the wind is the strongest. (Answer: low to the ground or high up) Ask the students in what direction they should point their pinwheel. (Answer: into the wind, at an angle to the wind or away from the wind)
2. Have students record what they would like to know about how their wind turbine will work under the "Want to Know" column of the KWL chart. (They can use the questions discussed above.)
3. Pass out a [Pinwheel Worksheet](http://content.teachengineering.org/content/cub_/activities/cub_earth/cub_earth_lesson04_activity2_worksheet.pdf) to each student.
4. Take the students outside with their pinwheels and worksheets, and have the students face their pinwheels into the wind. What happens? (The pinwheels should turn.) What happens if the students turn their pinwheels at different angles to the wind? Have them turn 90 degrees and 180 degrees. Have students record their findings on their worksheets.
5. Have students test the pinwheel low to the ground, then try somewhere higher (a hill near the school or a playground structure), and record their findings.
6. Regroup and have students complete the remaining worksheet questions.
7. Next, have them record what they have learned under the "Learned" column of their KWL charts. Would they change anything on their wind turbine if they built it again? Can they think of anything that would improve the design of their wind turbines? Solicit responses, clarify, and record answers on the board.
8. Remind students that one very important task of engineers is to record their designs so that they may be duplicated. Have students write up the experiment. Be sure they include everything they need and everything they did. They should clearly write down each step in simple sentences so that others may understand their directions/steps.

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Wind Energy Activity – Wind Energy KWL Chart

|  |  |
| --- | --- |
| KNOW | WANT TO KNOW |
| LEARNED  |

**Wind Energy Activity – Pinwheel/Propeller Design Worksheet**

**Step 1. Find the Wind Direction**

To determine the current wind direction, lick your finger and

hold it up in the air. Feel which way the wind is blowing on

your finger (you should feel a coolness to the finger that

has been licked if the wind is blowing directly into your

finger).

**Step 2. Determining How Your Pinwheel/Propeller Works Best**

Hold your pinwheel into the wind (as determined in Step 1). Next, turn your pinwheel to a 90

degree angle from the wind. How fast does it spin? Fill your answer in the chart below.

Next, hold the pinwheel in a 180-degree angle (or opposite direction from the 90-degree angle)

from the wind. How fast does it spin? Fill your answer in the chart below.

Now go find a very high point. On top of a nearby hill (if available) or a playground structure.

(Note: remember to use caution when climbing playground equipment while holding onto your

pinwheels!) How fast does the pinwheel spin when up high?

|  |  |
| --- | --- |
| How You’re Holding Your Pinwheel/Propeller | How Fast It Spins(Fill in Fast, Slow or No Spin) |
| 0◦Into the wind |  |
| 90◦Against the wind |  |
| 180◦Against the wind |  |
| At a very high point |  |

At which angle did the pinwheel/propeller spin the fastest? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

At which angle would a wind turbine work the best? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Activity 2- Propeller Design**

**Context**

The blades of the rotor are designed to spin in the wind, driving the turbine generator. The design of wind propeller blades affects the efficiency of wind turbines. the blades need ‘capture’ as much of the wind as possible, transferring the movement of the wind into mechanical energy.

**Materials**

**•** Aluminum pie plates

• Pinwheel used in Activity 1

• Blu-tack or plasticine, glue, scissors, and paints or crayons.

**What to do**

Using the designs presented in PowerPoint, allow the students to freely experiment with different blade shapes to construct their own ‘windmill’ then test it under many wind speeds (e.g. the wind outside, their own breath, a fan). The pictures below show some patterns for propellers.

Try out some of these designs (or your own) and find which one’s spin best. Use the worksheet in Activity 1 to help with determining speed and efficiency.

You might hold a competition for the mechanically most efficient, or the best workmanship, and/or the best appearance. Have the students determine how the efficiency of the models could be tested. One way would be to have an electric fan provide a standard windspeed, and counting the revolutions per 10 seconds. (You will need to color or mark one blade to do this.)

**Activity 3- Presenting Horizontal and Vertical Axis Wind Turbines**

**Material**

* Computer
* Smart Board

**Procedure**

Break students up into groups of 5. Each group will research and create an 8 slide PowerPoint and give a 5-minute presentation on the subject they were assigned.

**Slide Assignments**

Title Slide

Intro Slide

Slide 1- Research and present on what Horizontal Axis Wind Turbines are and what land type is needed for maximum efficiency.

Slide 2- Research and present on what Vertical Axis Wind Turbines are and what land type is needed for maximum efficiency.

Slide 3- Research and present the Pros and Cons of Horizontal Axis Wind Turbines.

Slide 4- Research and present the Pros and Cons of Vertical Axis Wind Turbines.

Slide 5- Research and present the environmental impact (good and bad) of Horizontal and Vertical Axis Wind Turbines.

Conclusion Slide (WHAT DID YOU LEARN!) dhenry@tm.edu

**Activity 3 –Wind Anemometer**

**Introduction**
Have you ever wondered how wind is made? Wind is caused by a difference in air pressure. Air travels from areas of higher pressure to places where there is less pressure. And just as air flows out of the high-pressure inside an inflated balloon if the opening is not tied, air in the atmosphere will move to a lower pressure area, creating wind. The speed of that wind can be measured using a tool called an anemometer.

An anemometer looks like a weather vane, but instead of measuring which direction the wind is blowing with pointers, it has four cups so that it can more accurately measure wind speed. Each cup is attached to the end of a horizontal arm, each of which is mounted on a central axis, like spokes on a wheel. When wind pushes into the cups, they rotate the axis. The faster the wind, the faster the cups spin the axis. How fast will your homemade anemometer whirl?

**Materials**
•    Five three-ounce paper cups (such as Dixie Cups)
•    Paper hole punch or sharpened pencil
•    Ruler
•    Two straws
•    Pin
•    Stapler
•    Pencil with eraser
•    Fan with different speeds (optional)
•    Timer (optional)

**Preparation**
•    Prepare four cups this way: Punch one hole in the side of each cup, about one half an inch below the rim.
•    For the fifth cup, punch four equally spaced holes in its sides, about one quarter an inch below the rim. Also punch one hole in the center of the bottom.

**Procedure**
•    Take a single-hole cup and push a straw through the hole until about one inch of the straw is inside the cup. Make sure the straw is horizontal and staple it to the side of the cup. Repeat this with another single-hole cup and straw.
•    Push the empty end of each straw into one of the side holes in the five-hole cup and out the one across from it. Turn the cups so that they face the same direction. *Why do you think the cups should face the same direction?*
•    Push the empty ends of each straw protruding from the fifth cup into the other two single-hole cups until about one inch of the straw is inside each cup. Turn the new cups so all the bottoms of the cups face the same direction. Staple the ends of the straws to the side of each cup like you did for the first two cups.
•    After making sure all cups are about the same distance from the center of the five-hole cup, carefully push the pin through the two straws where they intersect, in the middle of the five-hole cup. Use caution when handling the sharp pin. *Why do you think it is important to use something as small as a pin for this?*
•    Push the pencil through the hole in the bottom of the five-hole cup, eraser-end first, until it reaches the straws. Carefully push the pin into the eraser.
•    The anemometer is now ready to measure wind speeds. While sitting down, try blowing very gently straight into one of the four open cups for a few seconds, then blow harder. *How did blowing harder change how the anemometer turns?* (If you feel light-headed or dizzy, stop and take a breather.)
•    **Extra**: If you have a fan that turns at different speeds, hold the anemometer in front of the fan and count the number of times one cup completely turns around for 15 seconds, then multiply that value by four. This number will be in revolutions per minute (rpm). Repeat this while keeping the fan at the same distance, but changing its speed. *How did the rpm change when you held the anemometer in front of the fan at a slow speed compared with a faster speed? Compared with the faster speed, do you think the rpm would be greater if you used your anemometer outside on a very windy day?*
•    *Why do you think a faster wind makes the anemometer spin faster?*
•    **Extra**: What is the speed of the wind outside? You can take your anemometer outside on a windy day or over multiple days to measure the wind speed. You could also take your anemometer to different locations, such as an open field, a narrow passageway, a beach by the ocean or a large lake, if you live near one, to measure and compare the wind speed in those places. *What is the windiest location? Why do you think it is so windy?*
•    **Extra**: *What is the actual speed of wind, in miles per hour (mph), that you are measuring?* To determine this, first calculate the circumference of the circle made by the rotating cups by measuring the distance around the circle that they make (using a tape measure or a piece of string you can measure with a ruler). Then convert this to miles by dividing the number of inches by 12 to get feet and then dividing that number by 5,280 (the number of feet in a mile). Multiply this number by rpm. Finally, divide your product by 60 (to convert minutes to hours) and you will have an approximation of the velocity at which the anemometer is spinning (in mph), although this does not take friction in to account.



**Observations and results**
Were you able to see wind make the cups on the anemometer spin around?

Did the faster winds make the anemometer cups spin faster compared with the slower winds?

**Activity 5- Debating Wind Power Industry**

**Material**

• Computer

• Smart Board

Procedure

Keep student groups from Activity 3. Each group will research and create an additional 4-6 slides to their PowerPoint on if Wind Energy is efficient, environmentally safe, and cost efficient as a renewable energy source.