



Determining wind direction

Grade Level:3rd-4th Grade**Lesson Time:**

45 minutes

Required Materials:

- This packet only

STEM Connections**Science** – Wind energy; meteorology**Technology** – Real-time data from sensors (wind speed and direction)**Engineering** – Wind turbine placement; construction**Math** – Directional degrees**Next Generation Science Standards**

4-PS3-4

Energy Literacy Principles

2.3; 4.1; 4.5

written by Christopher Petrone, Delaware Sea Grant, and Dr. Cristina Archer, University of Delaware College of Earth, Ocean, and Environment

This work was supported by a grant from the National Science Foundation (AGS-1564565). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the organizer(s) and do not necessarily reflect the views of the National Science Foundation.

Summary

Understanding compass directions is important to understanding where you are in the world, and how to navigate to another location. We hear weather people tell us about wind from all different directions, but what do those directions mean? In this activity, students will learn to read a compass rose, name wind directions, and manipulate directional degrees, and also understand the impacts wind has on our daily lives.

Activity Use

This activity can be used as part of a:

- Weather/Meteorology unit
- Renewable energy unit
- Climate change/Human impact unit

Objectives

After completing this activity, students will be able to:

- Name wind direction
- Read a compass rose
- Record and manipulate directional degrees
- Access and understand real-time, online wind data

Vocabulary

wind turbine, compass rose, wind directions (e.g. easterly, westerly, etc.), real-time data

Invitation

You hear the weather person on the radio say that today's forecast includes southwest winds at 20 miles an hour, which will make the air temperature a little warmer than usual. But how could it be really windy, but warmer? Usually when it's super windy, you feel colder? That's because those strong southwest winds carry warm air from the south up to where you are, making it warmer. So, what happens when winds are northerly (from the north) or easterly (from the east), does that have an impact on the air temperature? In the activity below, you will learn how to name winds, calculate wind direction degrees, and look at real-time (happening right now) wind direction and speed data from weather stations around the United States.

Essential Question

How do we name the wind direction?

Introduction

Wind energy

Using the wind to help humans is not a new technology. People have been using wind-powered sailboats since roughly 5,000 BC. In 200 BC China, wind-powered pumps were used to move water, and wind mills used to grind grain date back to 500-900 AD Persia. We then see bigger, more efficient wind-harnessing systems pop up all over the world, including China, the iconic Dutch windmills, and American farmland windmills, in the coming centuries to do similar tasks—grind grain and pump water.

Fast-forward to Cleveland, Ohio in 1888 when Charles F. Brush built what we believe to be the first electricity generating wind turbine (as opposed to a wind mill, which does not produce electricity), producing 12 kilowatts of electricity. This was followed in 1891 by Poul la Cour, a Danish scientists, inventor, and educator, who developed the first wind turbine with the ability to store power. Smaller, farm-scale wind turbines continue to grow in popularity until the 1930s when electricity was finally distributed out to rural areas via power lines. Oil shortages in the 1970s caused the reinvigoration of wind power, particularly in California, with larger-scale wind farms coming online in the 1990s and early 2000s.

Wind turbines and wind farms

In 2010, the University of Delaware installed a 2-megawatt wind turbine on its Lewes, Delaware campus (<https://publicutility.ceoe.udel.edu/lewesturbine/>). Not only has this wind turbine powered the small coastal campus and 100 homes in the city of Lewes, but it has also served as a research platform for numerous wind energy related research projects. Projects have included bird and bat interactions, metal corrosion, wind turbine tower vibration, component performance, and down-wind effects. This wind turbine has also served as the central figure in social science research on the public perceptions of wind energy, and visual and auditory impacts of wind turbines.

The average life of a wind turbine is approximately 25-years. Some wind turbines, depending on the materials that were used and the location, may last less than that, but most should last longer. A wind turbine built high on a mountain top is not subjected to the brutal saltwater and salt-air that an offshore wind turbine must endure. Therefore, through research such as the corrosion study on the Lewes turbine, better materials are being used now than 10- or 20-years ago.

A wind turbine is composed of four main parts:

- the tower, which supports the entire structure
- the nacelle (pronounced “nah-SELL”), which contains gears and the generator, which produces the electricity
- the blades, which are the long arms that are turned by the wind
- the hub, which attaches to the nacelle, holds the blades, and spins.

Unlike the singular wind turbine at the University of Delaware, most wind turbines are built in systems called wind farms. Whether it is located on a mountain, in a field, or in the ocean, wind farms utilize an economy of scale, where it is actually less expensive to build many of something at once versus fewer. The turbines are connected together and the power is delivered via one main line to a sub-station which is connected to the electrical grid.

In the United States, areas conducive to wind farms are leased to companies who build the farm. In order to maximize their investment, these companies place as many wind turbines as possible on the lease area. Extensive studies are carried out to not only determine the environmental impacts of the wind farm, but also the optimal arrangement of the turbines to maximize energy output, and get the best return on their investment. As wind turbine technology changes and we see larger wind turbines, fewer turbines fit in the lease area. However, these larger machines are more efficient at capturing wind and generating more electricity, so fewer wind turbines are needed to produce the same amount of electricity as more, smaller, less-efficient wind turbines.

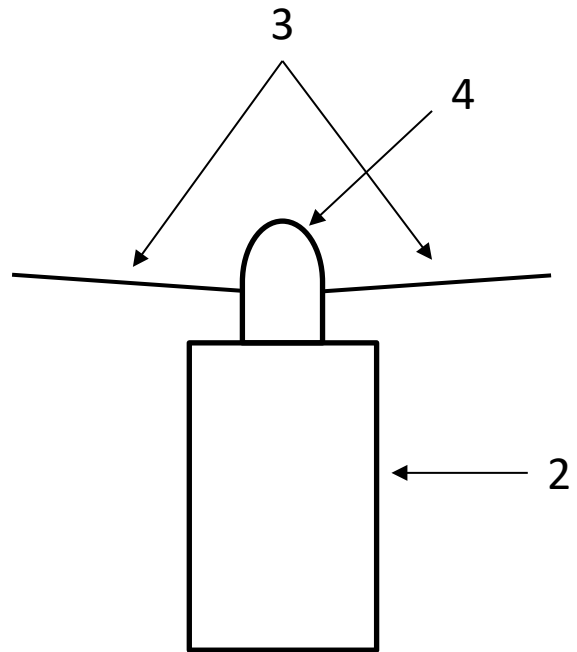
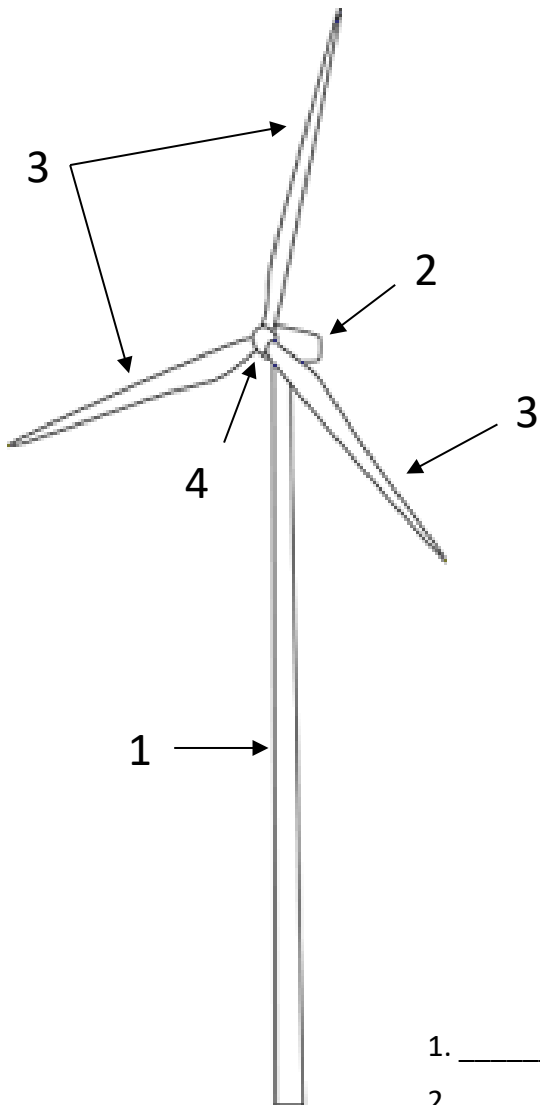
Compass rose

The compass rose was first published on a nautical chart in the year 1375. A nautical chart is a map of a waterway that includes water depth and other information important to navigation. At the very least, it shows the north direction, but can also include: south, east, west, northeast, southeast, southwest, and northwest.

Data Analysis

Part 1. Label the parts of a wind turbine using the word bank.

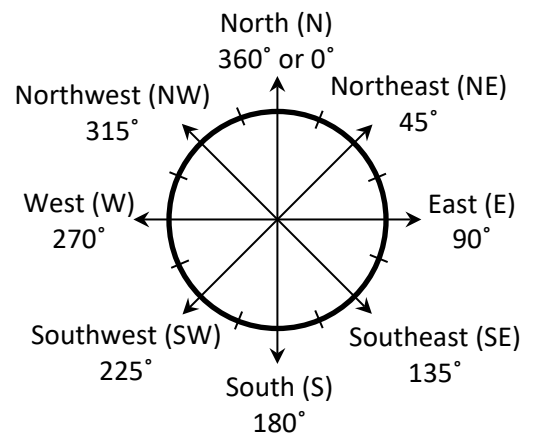
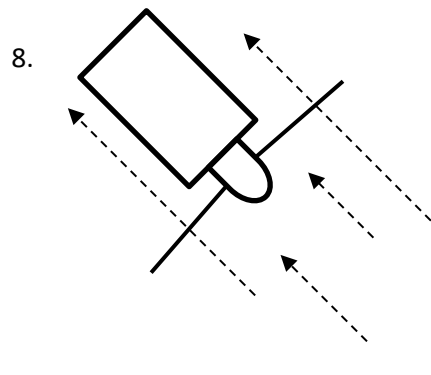
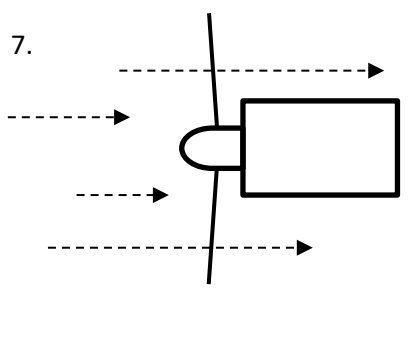
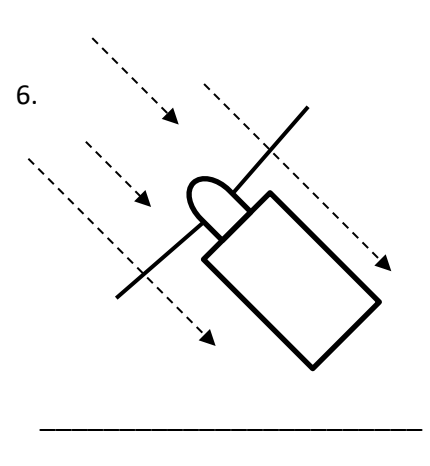
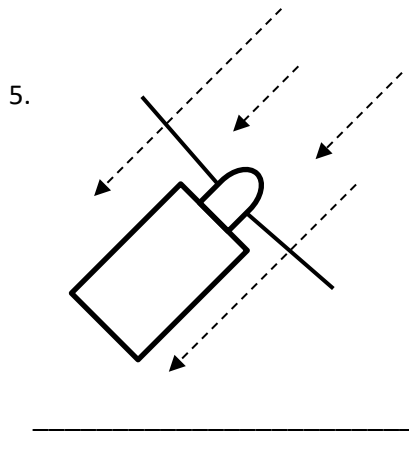
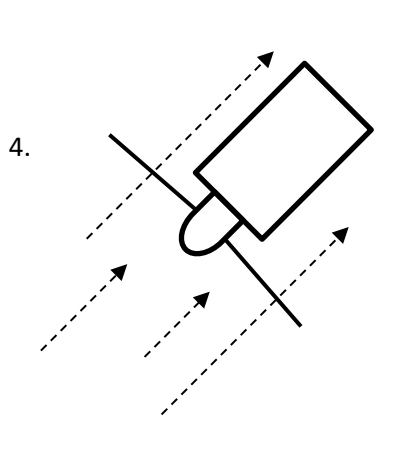
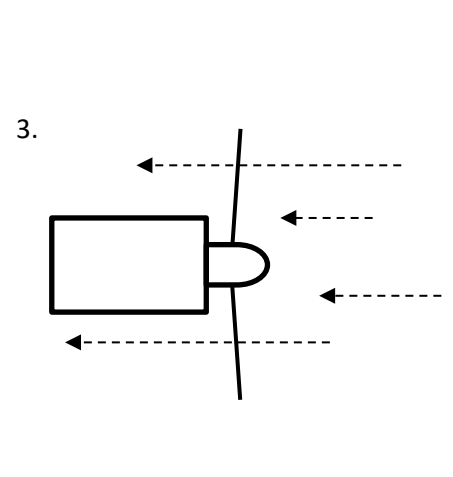
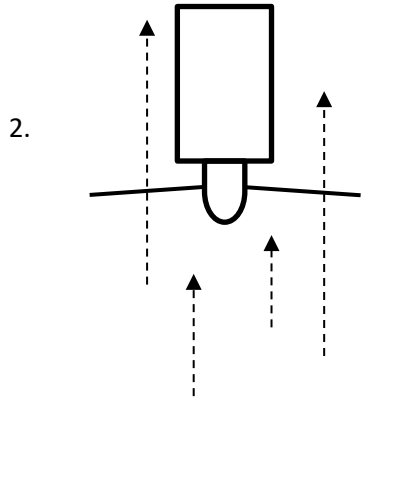
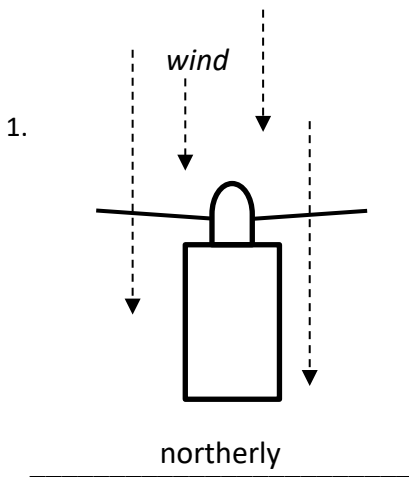
Word bank: blade, tower, hub, nacelle (pronounced nah-SELL)



This is the view of a wind turbine from above, looking down on to it. The part labeled #1 in the drawing on the left is not visible from this perspective. This is the view you will see in the next activity (Part 2).

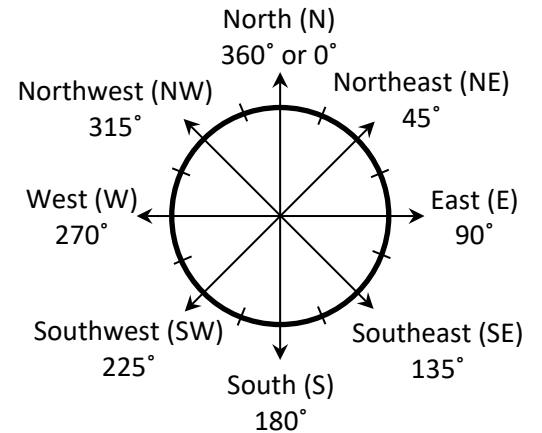
- 1. _____
- 2. _____
- 3. _____
- 4. _____

Part 2. Using the compass rose in the bottom-right corner of the page, name the wind direction. The wind is indicated by the dotted lines. The first one has been completed for you. Note that the wind turbine always faces into the oncoming wind, and winds are always named for the direction FROM which they blow and have the suffix “-erly,” for example a “southerly wind” blows from the south to the north.



Part 3. Using the compass rose on the right, calculate directional degrees. Please show your work.

1. If an easterly wind (90-degrees) shifts to a westerly wind (270-degrees), how many degrees did the wind shift?
2. If a northerly wind (360-degrees) shifts to a northwesterly wind (315-degrees), how many degrees did the wind shift?



3. If a southerly wind shifts to a westerly wind, how many degrees did the wind shift?
4. If a southwesterly wind shifts to a easterly wind, how many degrees did the wind shift?
5. If a wind shifts from 315° to 135°, what is the name of the new wind?
6. A nor'easter is a type of storm that often affects the east coast of the United States (Maine to Florida), causing heavy rain, strong winds, and tidal flooding. What is the directional degree of these strong winds?

Part 4. Discover real-time (happening right now) wind direction. You will visit three websites to see what direction the wind is currently blowing. Fill in the wind direction and speed in the spaces below the website address.

1. University of Delaware wind turbine, Lewes, Delaware: <http://www.ceoe.udel.edu/lewesturbine>

Current wind direction: _____

Current wind speed: _____

2. NOAA weather station PRDA2, Prudhoe Bay, Alaska:
https://www.ndbc.noaa.gov/station_page.php?station=prda2

Current wind direction: _____

Current wind speed (1 knot = 1.15 miles per hour): _____

3. NOAA weather stations OOUH1, Honolulu, HI:
https://www.ndbc.noaa.gov/station_page.php?station=ouuh1

Current wind direction: _____

Current wind speed (1 knot = 1.15 miles per hour): _____

4. Zoom in on the map and choose your own weather station (a yellow diamond; you may need to look at a few to find one with wind data): <https://www.ndbc.noaa.gov/>

Station name: _____

Station location: _____

Current wind direction: _____

Current wind speed (1 knot = 1.15 miles per hour): _____

Discussion Questions

Students should defend their answers with evidence from the data above.

1. What do you think a strong northerly wind does to the air temperature?
2. What are some activities that rely on fast/strong wind?
3. If a storm was forecasted to bring strong winds, what are some things you can do to protect yourself and your house?
4. In Part 4, what was the fastest wind direction you/your class found? Where was it located?

Assessment

Performance: Did the student actively participate in the independent and discussion portions of the activity, clearly demonstrating a grasp of the material? Was the student engaged during the activity?

Product: Did the student answer the data analysis questions coherently and provide evidence for their answers?

Standards

Next Generation Science Standards

4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

Energy Ocean Literacy Principles

2.3 Earth's weather and climate are mostly driven by energy from the Sun.

4.1 Humans transfer and transform energy from the environment into forms useful for human endeavors.

4.5 Humans generate electricity in multiple ways.

Determining wind direction

TEACHER ANSWER KEY

Part 1. Parts of a wind turbine

1. tower
2. nacelle
3. blade(s)
4. hub

Part 2. Naming wind directions

1. northerly
2. southerly
3. easterly
4. southwesterly
5. northeasterly
6. northwesterly
7. westerly
8. southeasterly

Part 3. Calculating directional degrees

1. $270 - 90 = 180$ degrees
2. $360 - 315 = 45$ degrees
3. $270 - 180 = 90$ degrees
4. $225 - 90 = 135$ degrees
5. Southeasterly
6. 45 degrees

Part 4. Real-time data exploration

Because this activity uses real-time data, students' answers will vary according to when they explored the websites.

Discussion Questions

1. What do you think a strong northerly wind does to the air temperature?
It will bring cooler air from the north.
2. What are some activities that rely on fast/strong wind?
Student answers will vary, but some examples include: sailing, kite flying (to an extent), and kite boarding

3. If a storm was forecasted to bring strong winds, what are some things you can do to protect yourself and your house?

Student answers will vary, but some examples include:

- Put away or secure outside furniture, basketball hoops or soccer/lacrosse goals, trash cans, or anything else that can blow away or become a projectile.
- Make sure windows are closed and locked.

4. In Part 4, what was the fastest wind direction you/your class found? Where was it located?

Because this activity uses real-time data, students' answers will vary according to when they explored the websites and the location(s) they choose.