REVIEWED & RECOMMENDED
National 4-H Curriculum

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THE POWER OF THE *Wind*

YOUTH GUIDE

Acknowledgments

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The Office for Mathematics, Science, and Technology Education (MSTE) is a division of the College of Education at the University of Illinois at Urbana-Champaign. The goal of MSTE is to serve as a model-builder for innovative, standards-based, technology-intensive mathematics and science instruction at the K–12 levels. The Office serves as a campus-wide catalyst for integrative teaching and learning in mathematics, science, and technology education.

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Contents

THE POWER OF THE *Wind*

The 4-H Youth Development Program promotes learning by doing and focuses on developing skills for a lifetime. This project is designed to teach youth about the wind and its uses while introducing them to engineering and engaging them in doing and reflecting on the activities.

Wind has provided power for centuries.

Sail boats were one of the earliest uses of **wind** power, and windmills have been used throughout the world for more than 2000 years. The word "windmill" literally means "mill (or machine) powered by wind." Windmills have been used to pump water and grind grain. Some have been used to power saw mills and paper mills. In the late 1800's windmills began to be used to make electricity. In the 1970's when people started to be concerned about pollution and availability of fossil fuels, interest increased in windmills as a source of electricity.

As you **explore**

the activities in this book you will learn about the wind and its uses. You will learn how the **energy** of the wind is transferred to **machines** to do **work** for us. *(Note: bold words appear in the glossary on pages 52-53).*

You will also learn to design and improve your projects. There are photos of possible designs for some of the projects in this book, but these are not the only designs. Use your engineering skills to perfect designs of your own.

While working with your partners and helpers you may get some new ideas about using the power of the wind. Record your thoughts and ideas in your engineering notebook. (It's in the appendix.) Then as a final project create a wind powered device of your own.

Using the power of the wind!

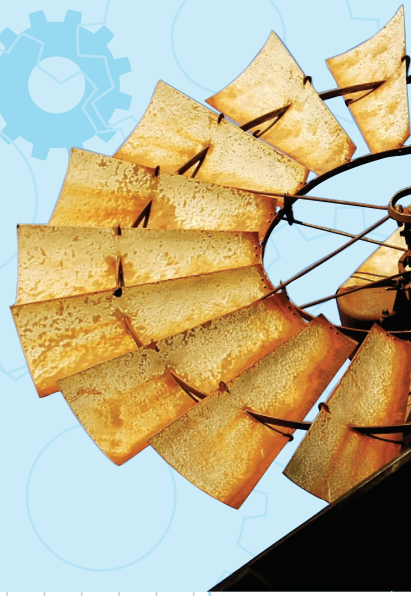
Use the **power** of the wind for your own creation!

If you could create anything using the power of the wind, what would it be?

List some of your best ideas here.

The possibilities are up to you!

How Can We Think Like an Engineer?



As you work through the wind power activities in this project book you will need to use your **engineering design skills** over and over again.

Learn to think like an engineer while you do these exercises.

Have you ever felt cold air coming in through a window or door on a cold windy day? How can you stop this air from entering? Putting tape around the edges of a window would help, but it wouldn't look nice, and tape around a door would make opening and closing the door tricky! How effective would it be to roll up a rug and put it next to the door? How effective would it be to cover a window frame with clear plastic?

Write or draw some of your solutions

It turns out that there are many solutions to the problem of air leaking into a building. Hardware stores sell weather stripping—strips of plastic that can be nailed to a door frame to help seal the space between the door and frame. Putting in new windows can take advantage of modern energy saving technologies. Even a simple fabric tube filled with sand placed against the bottom of the door can help stop cold air from coming in.

Think of more ways to stop cold air from coming into a house.

Engineering design with Sue Larson

Susan M. Larson is Associate Professor of Environmental Engineering and Assistant Dean and Director of the Women in Engineering Program in the College of Engineering at the University of Illinois at Urbana-Champaign.

www.engr.uiuc.edu

Have you ever made something you were extremely proud of?

Engineering Design
with Sue Larson

Maybe it was something that you really had to plan and think hard about. Perhaps you even had to change things as you were creating in order to make your idea work, but you ended up with something really great. If you ever made anything, especially if you planned it from scratch and adjusted it along the way, you have designed something.

Design is in practically everything people make.

Design is in practically everything people make. Some design is fairly simple, like planning and making a birdhouse or a tote bag. Some design is pretty complicated, like making an artificial heart or building a bridge. And some design looks simple, and is anything but, like making a doorknob, escalator, or water faucet.

There's a certain kind of designer called an engineer. Engineers use science and math and a lot of common sense to solve people's practical problems. When engineers talk about design, they're usually talking about how to make something that solves a problem. One interesting thing about design is that there's often more than one answer to a problem. To get a good solution, designers spend a lot of time thinking and asking a lot of questions. Designers may figure out many possible solutions to a problem before deciding on one to use. Engineers are no different.

Talk About It

Think about your day today. Was there something you used that was **developed or improved** by "engineering design."

What did you use or see today that **could be improved if it was re-designed**?

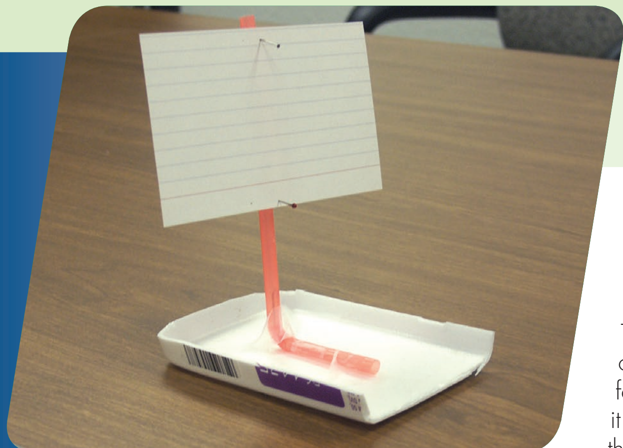
What skills do engineers use to solve problems?

CHALLENGE

How Can We Design a Wind Powered Boat?

Design and Build

a "sailboat" that will travel in a straight line a minimum of 75 cm on a smooth surface. Your **constraints** are to use a Styrofoam tray (see below for examples) for the body, and to attach a mast with a sail to the tray.



Try It

- Simulate the wind with a fan.
- Position the fan on the floor or a table top.
- Mark a starting line about 30 cm from the base of the fan.
- Fasten a tape measure to the table or floor.
- Place your boat at the starting line with the fan on low.

These photos show one possible design for this project, but it is probably not the best design. Use your engineering skills to invent and perfect a design of your own.

You Will Need:

- Small Styrofoam tray (part of an egg carton or a supermarket tray)
- Flexible straws
- Cardboard or index cards
- Tape
- Straight pins
- Scissors
- Tape measure
- Box fan

Other Possible Materials:

- Pencils
- Stop watch with second hand
- String
- Paper cups
- Paper clips
- Pennies
- Miscellaneous hardware and office supplies

In Your Engineering Notebook

write or sketch answers to questions you find important or interesting.

What forces influence your boat?

Where should you put the mast? How do you know?

Think about the best shape and size of the sail. Where should you attach it to the mast?

Take a picture of your best design and include it in your notebook.

Talk About It

- How far did your sailboat travel?
- How fast did it go?
- Did it go straight?

Try Something Else and Test Again

- Make the sail larger or smaller. What happens?
- Change the shape or material for the sail. What happens?
- What changes did you make in the design? What happened? What shape is the best sail?
- Where should the mast be attached to the body?

Learning from Others

- What ideas did you get from seeing the designs of others in your group?
- What other design changes could you make that might change the speed?
- How does the wind move a sailboat?

Wind Power for Sailboats

Early sailboats had square sails. These sails were pushed by the wind. The sailboat had to go in the direction of the wind's push. **Sails with larger areas were able to use more wind power.** Later triangular sails became popular. These sails were able to use the wind to push or pull the boat. Modern sailboats use different shapes and combinations of sails to maximize the **force** of the wind.

Some of the first wind powered machines for pumping water used cloth sails to catch the wind. Some of these are still in use today on the island of Crete.

Engineering Design with Sue Larson

Engineers design to solve problems—that means that engineers make things that serve some purpose or meet some objective. The solution has to meet certain **criteria**, but should be reasonable. For the previous problem of air infiltrating a leaky door or window, criteria could include: (1) must keep cold air from leaking in around the door, (2) must allow the door to be used and (3) must be attractive. You also want a solution that isn't too expensive. Restrictions like "not too expensive" are called the **constraints** on the design. Many constraints deal with performance, cost, and even the schedule of when a design will be completed. Anything an engineer designs will be the result of choices and trade-offs—balancing the criteria and the constraints.

In what other situations might you need to balance choices and trade-offs?

Wind Power Timeline

4000 BCE

3000 BCE — Evidence of sails on boats

2000 BCE

1000 BCE

Learn More About Engineering Design

How do engineers use design to solve problems?

Think About It

Think about the Wind Powered Boat activity as you discuss the Engineering Design Process and answer the questions on page 9.

Engineering Design Process

Step 1
What is the challenge?

Step 2
How have others solved this?

Step 3
What are the design criteria and constraints? Brainstorm possible solutions.

Step 4
Which of the possible solutions do you choose?

Step 5
Build prototype.

Step 6
How does it work? Try it and test again.

Step 7
How do you learn from the designs of others?

Step 8
How can you use your new ideas to improve your design?

Adapted from Massachusetts Department of Education (2006): *Massachusetts Science and Technology/Engineering Curriculum Framework.*

Talk About It

- What was the challenge?
- How did you get your first ideas?
- What were your constraints?
- Describe your first **prototype**.
- How did your prototype differ from your final result?

Restrictions like "not too heavy" or "not too expensive" are called constraints on the design.

Anything an engineer designs will be the result of choices and trade-offs – balancing the options and the constraints.

Engineering design always contains some "do-overs" (they're called **iterations**) where you learn something valuable from something that went wrong and you go back and fix it.

Learning from Others

- How did you use the ideas of others?
- Why do you think the **engineering design process** on page 8 is circular?

Part of design is testing what you've made to see how it works and being willing to adjust as necessary—even to the point of "going back to the drawing board."

It's all part of getting something that works just like you want it to.

EXPLORATION

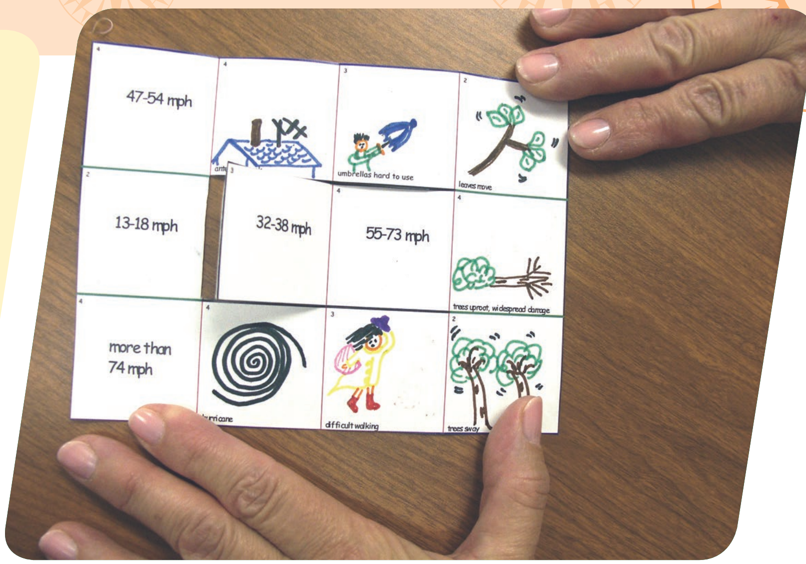
How Do We Observe and Measure the Wind (Part I)?

A method for estimating wind speed based on observations was developed in 1805 by Sir Francis Beaufort.

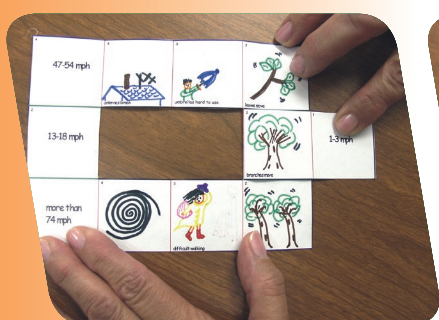
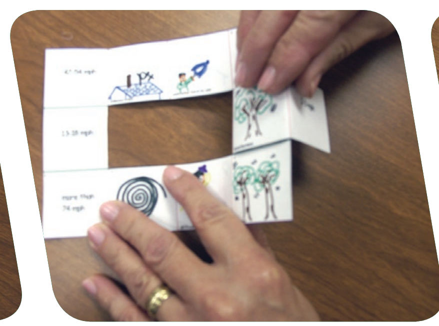
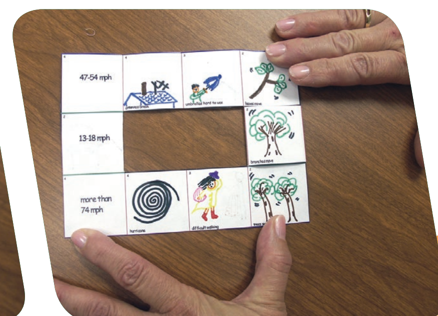
Learn about and use the Beaufort Scale

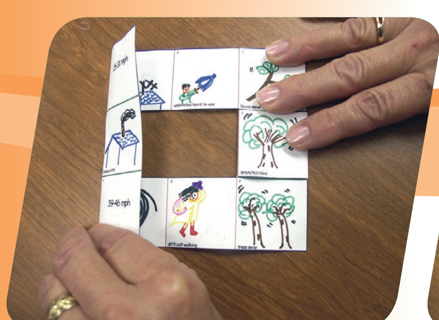
by making this tool. Cut out the tetraflexagon in Appendices D and E. Cut on the heavy black lines and crease on the red vertical lines.

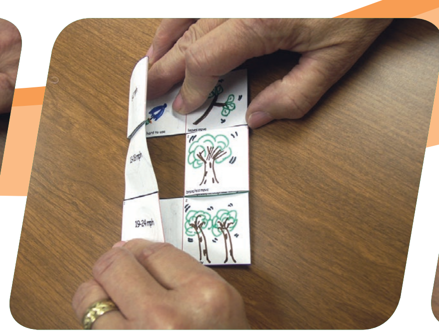
After you cut out the **tetraflexagon**, follow the instructions under the photos.

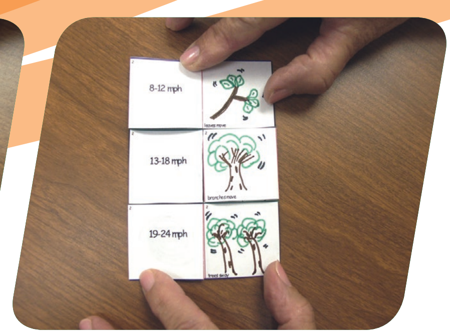


Draw illustrations in each of the squares that contain small print.




Fold the center flap over and under the right-most vertical column.


Fold the left-most column over the second column.

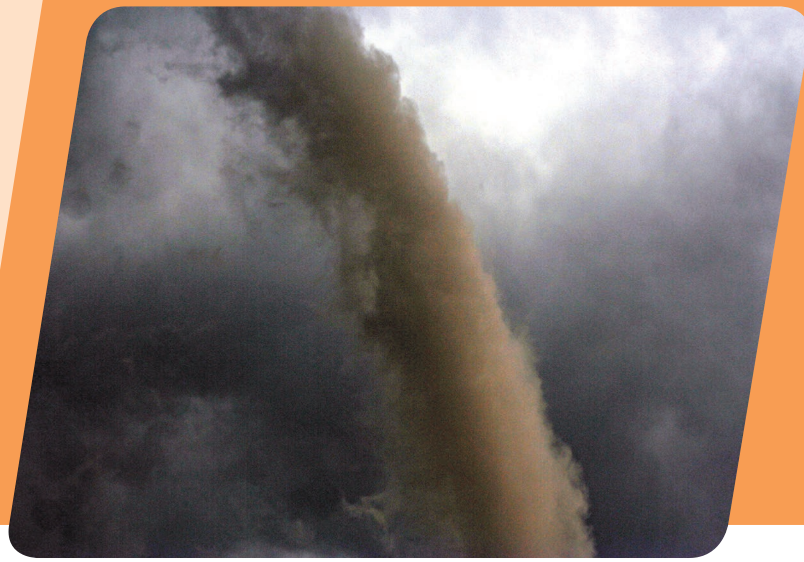

Fold both over onto the third column.

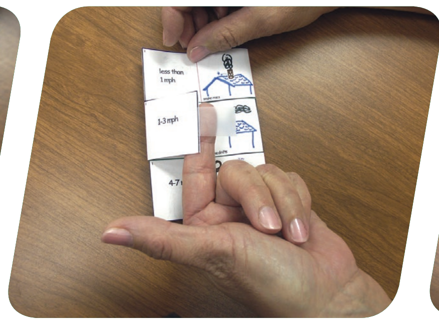


Now the wind speeds from the **Beaufort Scale** are matched up with their illustrations.

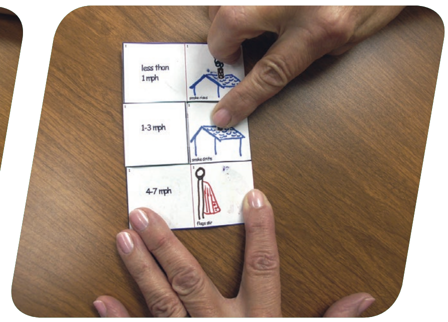
WIND FACT

Tornadoes make the highest wind speeds. **Scientists think some tornadoes may produce 400 mph winds**, but they don't know for sure because the tornadoes destroy their wind instruments.





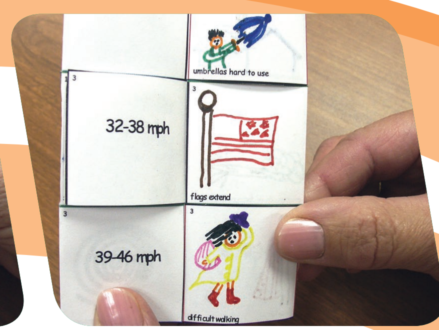
Flip the whole tetraflexagon over and tape.



The Beaufort Scale showing the least wind speeds is face up.

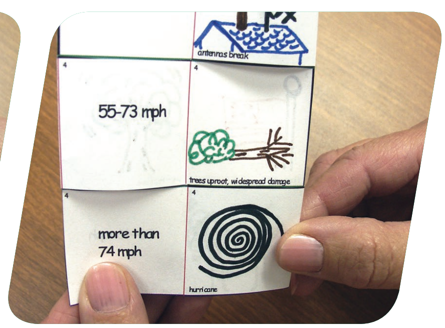
Turn the tetraflexagon over to show the next higher group of wind speeds.

Now the flexagon is ready to flex. Bend it in the middle.



Let the next group of wind speeds fall open.

Bend it in the middle again.



Open to see the highest group of wind speeds.

Flex your tetraflexagon to see all four sides showing the twelve Beaufort Scale categories and their illustrations.