LESSON

Wind Maze

The Tech Challenge 2023
Grade Levels: 4-12
Duration: 90 min

Students will explore the elements by designing a wind maze, a device that can direct the wind along a specific path.

Outline

We recommend dedicating 90 minutes to this activity. However, if you only have 60 minutes, try facilitating the activity according to the outline below. This version skips the material investigation and shortens the other sections.

	90 min version	60 min version
Frame the Challenge	**15 min total**	**10 min total**
Activate Prior Knowledge	10 min	5 min
Introduce the Challenge	5 min	5 min
Design Challenge	**75 min total**	**45 min total**
Materials Investigation	10 min	N/A
Prototype (Build and Test)	40 min	35 min
Share Out	15 min	5 min
Debrief	10 min	5 min

Grade Levels: 4-12

Duration: 90 min

Concepts/Skills
Forces, wind, structural engineering, collaboration

Objectives
Students will:
- Design and test a wind maze.
- Consider how to direct the wind down an intended path by creating bends in the maze.
- Use observations from their tests to compare solutions and iterate on their designs.

The Tech Challenge

This lesson can be used to prepare students for the 2023 Tech Challenge: Survive the Storm, presented by Amazon.

This lesson will give students experience with...

- Exploring the elements of wind.
- Creating designs that maneuver the wind.
- Using wind power to create movement.

Materials and Preparation

Materials

Use the table below for inspiration and choose a couple items from each category. Don't limit yourself to the items on this list — be creative!

Maze Building Materials
(per class of ~32 students)

Large or Heavy *(40 total)*	**Flexible** *(50 total)*	**Structural** *(40 total)*	**Connectors** *(100+ total)*
□ Blocks	□ Bags	□ Binders	□ Binder clips
□ Full cans	□ Cardstock	□ Cardboard	□ Paper clips
□ Picture frames	□ Construction paper	□ Cardboard tubes	□ Pipe cleaners (chenille stems)
□ Stuffed animals	□ Fabric	□ File folders	□ Rubber bands
□ Text books	□ Folders	□ Food containers	□ String
	□ Index cards	□ Plastic cups	
	□ Tin foil	□ Poster board	

Testing Materials *(1 per group)*	**Wind Source**

□ 5-10 lightweight test objects (cotton balls, pom poms, etc.)
□ Tools
  □ Hole punch
  □ Scissors
  □ Masking tape
□ *Optional*: "recycling center" (cardboard box, netting from produce, etc.), friction items for **Challenge Card** (sandpaper, tape, etc.)
	□ Portable fan or hair dryer with cool setting
	
	Note: 1 per classroom is sufficient if you plan to move the wind source from group to group. Extension cord will be needed if it is plug-in.

Testing Setup

1. Designate a building area at least four feet long for each team on a table or a smooth floor.
   - Calibrate testing by setting the wind source at one end and seeing how far the testing objects (e.g. pom poms) blow without obstacles.
   - Use tape to mark a finish line about one foot in front of the farthest distance that any of the testing objects blew. This may be four to eight feet (or the end of a table) depending on the strength of your wind source.
   - Make sure each building area is at least two to three feet wide.
2. Use tape to create the starting line just in front of the wind source. This is where the testing objects will be placed to start.
3. *Optional*: Consider including an item to act as the "recycling center" on the other side of the finish line. We recommend including this to catch the testing objects, helping to prevent them from flying across the room.

Sample Setup

Each team will need their own building area. Tests will be conducted in this area. Calibrate the distance of the finish line based on the power of your wind source.

Note: If you only have one wind source, plan to move it between the building areas during the challenge.

Try these tips if you're concerned your classroom doesn't have enough space:

- Maximize the space of the room by having some teams work on arranged desks and some teams work on the floor.
- Look for an alternative space for several teams to build, such as a hallway or gym. (*Note*: This may require a cordless wind source for testing.)

Preparation

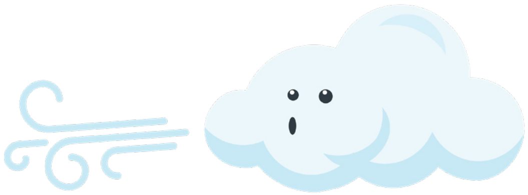
1. Collect, organize, and set up building materials.
   - Create materials kits for teams or set up materials at a central location where students can browse and choose their materials.
   - Calibrate and set up building areas for each team.
2. Draw a two column chart on the board or chart paper. Label the columns "advantages" and "disadvantages."
3. Try building with the materials ahead of time. This will give you practice with the materials and tools in order to anticipate student questions.

Frame the Challenge

Activating Prior Knowledge *(10 min)*

1. Let students know that today they are going to be exploring how to create designs that use wind to make something move.
2. Ask students, *When would you want to use wind to move something?*
   - *For power? (e.g. windmill)*
   - *To travel? (e.g. sailboat)*
   - *To move objects? (e.g. leaf blower)*
3. Bring their attention to the two column chart. Ask students to call out the advantages and disadvantages of using wind power. Write their ideas in the columns and fill in any missing information from the example chart below:

Advantages of Wind Power	Disadvantages of Wind Power
• Cost-efficient • Easily accessible • Clean fuel source • Sustainable	• Hard to control • Strength, duration, and direction varies



4. Next, turn their attention to one of the testing areas.
5. Ask students to make predictions about what will happen to the testing objects when the wind source is turned on. **Guiding Questions** could include:
   - *How much do you think the wind will move the objects?*
     - *A little? A lot? Not at all?*
   - *How do you think the objects will move?*
     - *In the same direction? Scattered?*
6. Turn on the wind source and have learners call out their observations.
7. Ask them to consider how they could use objects to force the wind to go the direction they want.

Career Connections: Wind Engineering

Wind engineering is a combination of mechanical engineering, structural engineering, meteorology and applied physics. It analyzes the effects of wind, including possible benefits and potential for damage. This includes studying extreme winds such as tornadoes, hurricanes, or heavy storms.

The flow of wind through cities is a real-world engineering challenge. In addition to addressing wind's effect on pedestrians, wind engineers have to consider how to build skyscrapers and other structures to withstand the wind.

Check out these resources to learn more about how wind engineers are making our world safer and more sustainable.

- **"Rosemary Barnes Wind Energy Engineer Career Profile,"** STELR Project, YouTube (2:45)
- **"Careers Portal: Wind Engineer,"** CareersPortal, YouTube (3:54)
- **"Catherine Gorle; How Cityscapes Catch the Wind,"** Stanford University School of Engineering, YouTube, (27:55)
- **"Dream Big: Engineering Our World,"** Dream Big Film website with resources for educators

Introduce the Challenge *(5 min)*

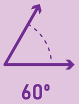
1. Introduce the **design scenario**.

You and your team of urban planners have been tasked with the the design of a new city block. It is located in an area that is usually very windy, and your team wants to plan the buildings so they can direct the wind to push trash to the recycling center outside of town. Your team will need to decide where to place buildings, tunnels, and other city elements.

2. Introduce the design problem, criteria, and constraints.

Design Problem	Design a model of the city that can act as a wind maze by directing the wind along a specific path.
Criteria	Wind mazes should... • Redirect the wind to move three to five objects across the designated finish line. • Have at least two bends that the wind must navigate.
Constraints	• Use only the materials provided. • Materials cannot be attached to the wind source.

3. Refer students back to the disadvantages column on the chart. Emphasize that in this scenario...
   - There are always strong **air currents** on this block.
   - Learners should focus on how to arrange buildings and other structures to force the wind to move down the path they create.
4. Let students know that before they begin their designs they will have a chance to test materials and see how they behave in the wind.



Content Connection: Angles

One of the ways learners are able to turn the direction of the wind is by adding angles to their maze. An **angle** is the space between two intersecting lines that meet at an endpoint. By directing the wind into an angle, learners can force the wind to move in a new direction. Encourage learners to think about how they can use the building materials to create angles in their maze.

Adaptations for Advanced Engineers

In addition to the criteria listed above, consider adding additional challenges for older or advanced engineers.

- Place the test objects inside the city rather than at the edge to start.
- Require that students incorporate additional bends for the wind to navigate.

Design Challenge

Materials Investigation *(10 min)*

1. Divide students into teams of three or four and assign them to one of the building areas.
2. Have teams collect materials.
3. Tell teams to spend a few minutes exploring the materials and discussing their design ideas before they start building.
4. Encourage them to set up items within the test area and see what happens when the wind hits them.
   - This is an opportunity for teams to explore the direction the wind moves and how certain materials resist or give in to the wind.
   - Teams should also observe how the test objects move and interact with various materials.
     - Remind teams that they will need to account for the **friction** between the test objects and the testing surface.
5. *Optional*: Have each team share one observation that they made about the materials and their movement in the wind before going on to prototyping.

60 Minute Version

If you are facilitating the 60 minutes version of this activity, skip the Materials Investigation and go straight to prototyping. Encourage students to "think with their hands" and explore the material's properties as they are building.

Prototype (Build and Test) *(40 min)*

1. Now that teams understand a little more about the materials and the wind, they should begin prototyping a design to direct their test objects toward the finish line.
   - Review the criteria and constraints as needed.
2. As they build, support teams by asking open-ended questions to guide the process:
   - *How could you use a narrow space to direct the wind? A wide space?*
   - *Are there any places in your maze where the wind might be escaping?*
   - *How can you use the materials to create bends for the wind to navigate?*
3. Encourage testing early and often. If students feel stuck or think their design will not work, they may learn something from observing a test.
4. If a team meets the goal with time to spare, give them a **Challenge Card** with an additional constraint.
5. Give students fifteen and five minute warnings. When time is up, have teams pause and leave their mazes set up. Bring the class back together for the share out.

Share Out *(15 min)*

1. Have the teams take turns sharing how their device performed.
   - One person from the team should briefly explain their process, including...
     - How they set up their city block originally.
     - What happened during testing.
     - What changes they made to their design after testing.
2. *Optional*: Have teams demonstrate their wind maze with the wind source.
3. Possible **Sharing Questions** could include:
   - *Did the device work as you intended?*
   - *Were you able to move the objects across the finish line?*
   - *What changes would you make to the design if you had more time?*

60 Minute Version

If you are facilitating the 60 minute version of this activity, try shortening the Share Out by just having students answer the **Sharing Questions** below.

Debrief *(5 min)*

1. Lead a short debrief with some of these questions. Possible **Debrief Questions** could include:
   - *How difficult was it to control the wind?*
   - *What were some elements that made the wind maze devices successful?*
   - *What did you observe during testing that helped you improve your design?*
   - *How could you use what you learned about how the wind moves to protect something or prevent potential wind damage in your city?*

Extensions

With additional time, students can revise their designs and iterate with new criteria. Use the **Wind Maze Challenge Cards** included — or try creating an entire city! Work in larger groups or as a class to build a large wind maze with at least five turns.

Standards Connections

Next Generation Science Standards

Grade	Standard		Description
3-5	ETS1-3	Engineering Design	Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
MS	ETS1-4	Engineering Design	Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
HS	ETS1-2	Engineering Design	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
Additional Standards		MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	

Related Standards

Common Core State Standards

Grade	Standard	Description
4	CCSS.MATH.CONTENT.4.MD.C.6	**Measurement & Data:** Measure angles in whole-number degrees using a protractor. Sketch angles of specified measure.
7	CCSS.MATH.CONTENT.7.G.B.5	**Geometry:** Use facts about supplementary, complementary, vertical, and adjacent angles in a multi-step problem to write and solve simple equations for an unknown angle in a figure.
HS	CCSS.MATH.CONTENT.HSG.CO.D.12	**Geometry- Congruence:** Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.).

Vocabulary

For more tips on vocabulary and common engineering terms see our **Tech Tip: The Language of Engineering**.

- **Angle:** The space between two intersecting lines that meet at an endpoint
- **Air currents:** Concentrated areas of wind
- **Friction:** The resistance that one surface or object encounters when moving over another
- **Repeatability:** The ability of a device to meet its goal multiple times in a row
- **Wind load:** Any pressures or force that the wind exerts on a building or structure

The Tech Challenge
Presented by Amazon

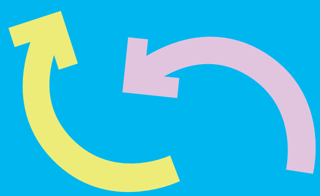
Wind Maze Challenge Cards

Target Practice

Choose a specific area within the finish line or recycling area. Can you get all of your test objects to land on that spot?

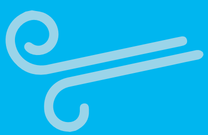
More Turns

Increase the number of turns the wind must navigate.



Less Wind

Have testing objects cross the finish line at a decreased wind speed.



Heavier Objects

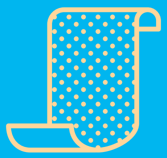
Change the testing objects to heavier items.

Bumpy Road

Have learners build on an uneven surface.

Added Friction

Include something like tape or sandpaper that adds friction for the testing objects to go over.

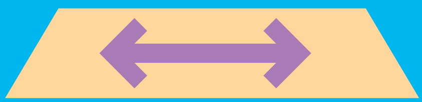


Reliable Design

Ensure the design works consistently by having three successful tests in a row.

Design a Different City Block

Give learners a different size building area. Try to make the building area longer or wider.



Skyscrapers

Make the building objects taller to represent skyscrapers. Have learners consider how the building height can affect the way the wind moves.