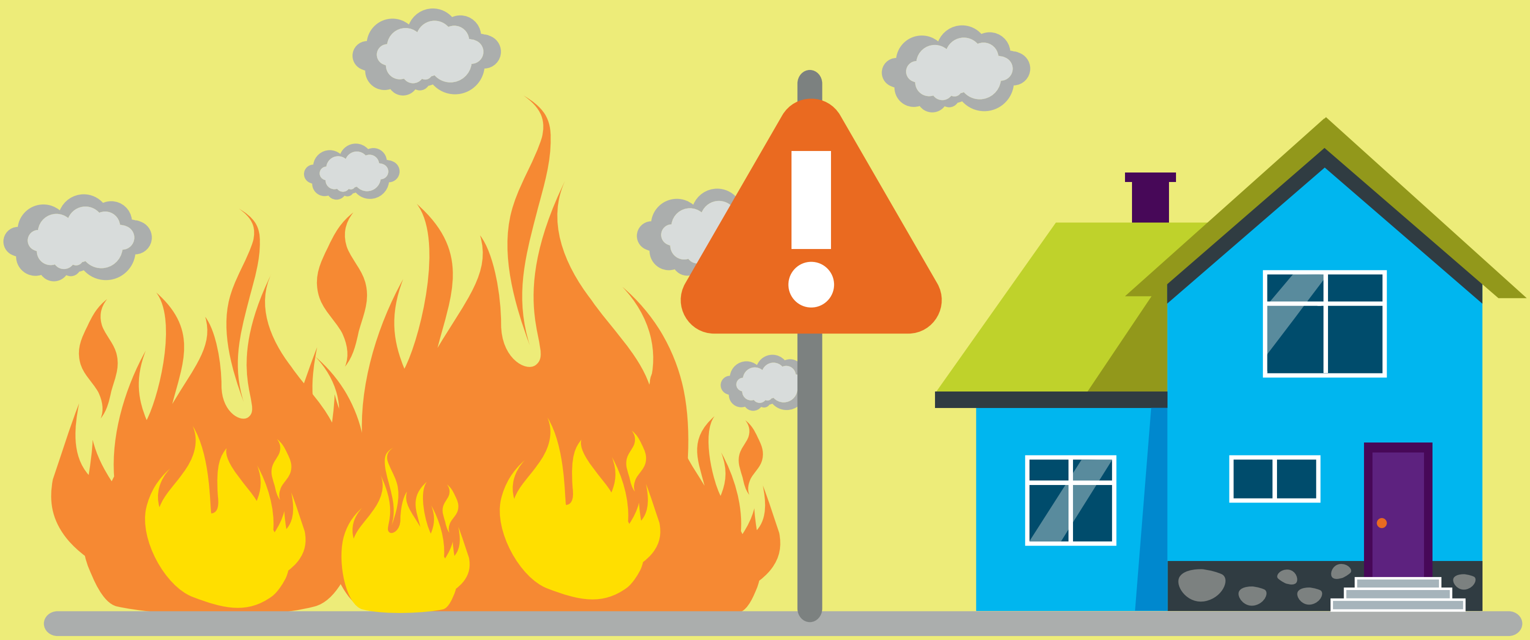
UNIT

Wildfire Warning

Grade Levels: 6-8
Duration: 150 min



Students will design a wind detection device, an anemometer, that could warn community members of the strength and direction of high winds during a wildfire.

Grade Levels: 6-8

Duration: 150 min

Concepts/Skills

Wind energy, natural hazards, anemometer, wildfires

Objectives

Students will:

- Build a device to measure the direction and strength of the wind.
- Evaluate how materials affect function.
- Use data to determine the success of a design.

Unit Plan

This unit plan is designed to be adaptable to any situation or setting. In addition to a detailed lesson plan, we have included supplementary resources and materials to help expand the content and do an authentic assessment.

Wildfire Warning Lesson

In this two-part design challenge, students design a wind detection device that could provide early warning to community members during a wildfire. After building a device that detects the strength of wind, students iterate to meet the additional criteria of wind direction in the second part of the challenge.

Frame the Challenge	**10 min total**
Activate Prior Knowledge	5 min
Introduce the Scenario	5 min
Design Challenge Part 1	**50 min**
Introduce the Design Challenge	5 min
Brainstorm: Materials Investigation	10 min
Prototype (Build and Test)	20 min
Share Solutions	15 min
Design Challenge Part 2	**30 min**
Introduce Changes to the Design Challenge	5 min
Prototype (Build and Test)	10 min
Share Solutions	10 min
Debrief	5 min

Authentic Assessment

Students will plan a social media campaign to advertise their device to community members with the goal of building a community data network.

This lesson is written to pair with **Science** standards around the concepts of **natural hazards and the development of technology to mitigate their effects**. To strengthen this connection, you might support students to build and practice these skills in the following ways:

- **Before this lesson**, students can study natural hazards and how scientists can analyze data to predict future events. Specifically, students might study the impact and behavior of wildfires.
- **Concurrent with this lesson**, students can study how wind contributes to fire behavior and review how red flag warnings are determined. Students might also learn about and evaluate existing wildfire warning systems for communities and make suggestions for improvements based on historical fire events.

Materials and Preparation

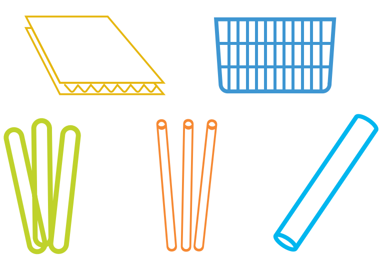
Materials

Choose 2-3 items from each category and collect the quantities needed. Don't limit yourself to the items on this list. Use whatever you have on hand — be creative!

Per class of 32

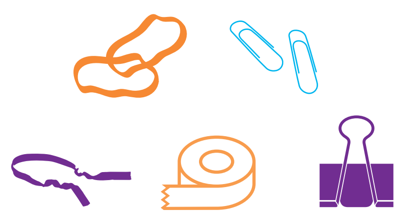
Structural *(50+ total)*

- ☐ Cardboard
- ☐ Craft sticks
- ☐ Chopsticks
- ☐ Paper towel or cardboard rolls
- ☐ Fruit baskets
- ☐ Paper cups/bowls
- ☐ Food containers
- ☐ Styrofoam
- ☐ Straws



Connectors *(100+ total)*

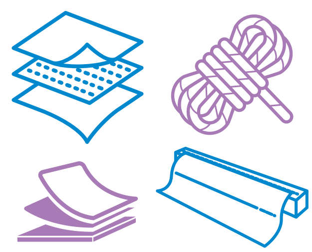
- ☐ Twist ties
- ☐ Pipe cleaners (chenille stems)
- ☐ Rubber bands
- ☐ String
- ☐ Paper/binder clips
- ☐ Clothes pins
- ☐ Paper fasteners
- ☐ Hair ties
- ☐ Push pins
- ☐ Tape (limit 1-2 inches per group)



Flexible *(5-10 total)*

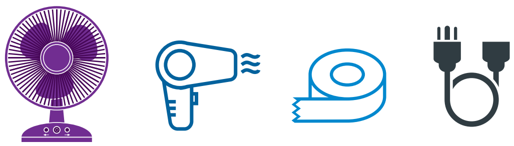
Find pieces approximately 10"x12"

- ☐ Fabric scraps
- ☐ Socks
- ☐ Ribbons/string/ thread
- ☐ Tissue paper
- ☐ Plastic bags or packaging
- ☐ Foil
- ☐ Paper
- ☐ Balloons



Test Area Materials *(per class)*

- ☐ 2 wind sources (electric fan, blow dryer or even waving a plastic tub lid to move the air)
  - A standard box fan produces a wind speed of 10-13 mph at close range
  - A standard blow dryer produces a wind speed of 40 mph on the highest setting
- ☐ Flat surface (at least 0.5 meters [1.5 ft] in each direction from the center)
- ☐ Painters' tape
- ☐ *Optional*: Extension cord



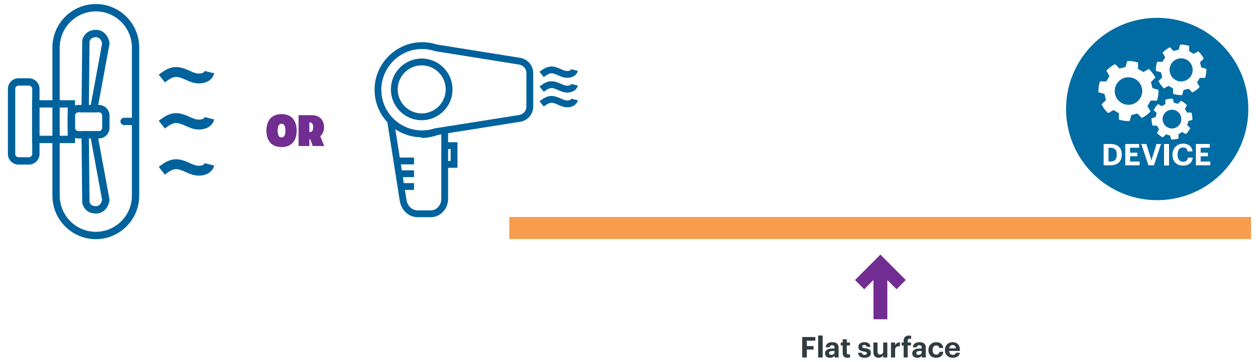
Tools *(1 per group)*

- ☐ Scissors
- ☐ Wildfire Warning Data Collection Student Handout (2 copies)
- ☐ Scrap paper (2-3 sheets)
- ☐ Pencil
- ☐ *Optional*: Tape measure or ruler

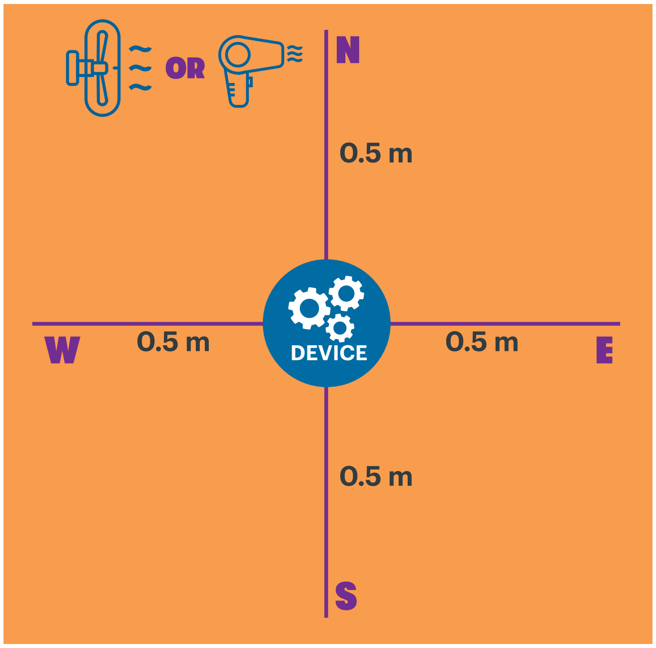
Test Area Set-up

1. Choose a flat surface for the test area. It will need to be available to students throughout prototyping time.
2. Place the wind source on a flat surface.
3. Measure a distance of about 0.5 meters (1.5 ft) and mark the location for student devices with tape.
   - The wind source and student devices will need to be at the same height.
   - Test this by holding a piece of paper at the device location. It should be moderately affected by the wind source.
4. During testing, groups will try different wind speeds/power settings to test their devices. (The distance of the wind source to the device will remain the same.)
5. During the iteration in Part 2, you will need to move the wind source to demonstrate a changing direction in wind.
   - It may be helpful to measure several locations (N/S/E/W) at the same distance (*0.5 meters*) around the device area. Make sure your wind source will be able to move to these locations safely, and that extension cords are able to be secured safely as needed.

Test Area Setup - Part 1



Test Area Setup - Part 2



Lesson Preparation

1. Build a solution (or solutions) yourself, with other educators or kids you know. This will give you practice with the materials and tools to be able to anticipate student questions.
2. Collect, organize and set up materials.
3. Set up the Test Area.

Adaptations for Distance Learning

For more tips on adapting Design Challenges to a virtual setting, see our Educator Tips for Remote STEM Learning.

- **Introduction:** Frame the challenge to students in a live video session. Model materials gathering with a Materials Treasure Hunt.
- **Prototyping & Testing:** Have students use materials from around their home to design the device asynchronously.
- **Sharing:**
  - Have students collect and share their results using an online tool (shared slide deck, Flipgrid, Padlet, etc).
  - Schedule a live video session, if possible, for students to share solutions, give feedback, and debrief.
- **Iterating:** Students can asynchronously revise and improve on their designs.

Frame the Activity

Activate Prior Knowledge *(5 min)*

1. Start by finding out what students already know about **natural hazards**. Lead the class in a brainstorm of wind-related natural hazards, natural events that cause harm to or endanger humans and some parts of the environment.
   - *How can high winds cause problems for human communities?*
   - *How might wind play a role in other natural hazards (ex: hurricanes, tornados, wildfires)?*
2. Let students know that, in this lesson, they will focus on the connection between wind and wildfires. Remind students that although **wildfires**, unplanned and destructive fire events, are a natural part of some ecosystems, they can be devastating to human communities.
3. Ask students: *How might communities prepare themselves in order to reduce the damage in a disaster like this?*
   - *Optional*: Show images of property destroyed in wildfires. If wildfires affect your community, find some examples at a local level.

Note: We do not recommend introducing the terms "weather vane" and "anemometer" unless they come up organically in discussion. During this first part of the lesson, let students discover how they might solve the problem on their own, without any external examples. During Part 2, these terms and examples can be introduced as content connections to inform iteration.

Introduce the Scenario *(5 min)*

1. Focus on the connection between wind and fire with students. Provide more background on the spread of wildfires with a video, article or other **Wildfire Resource**.
    - Wind aggravates fire conditions because it can increase the supply of oxygen to the fire while also pushing moisture away, which results in the fire burning rapidly.
    - Wind can also dictate the direction and speed at which the fire spreads.
2. Based on the background information/research have students share:
    - *What else do you wonder about how wind affects wildfire conditions?*
    - *How might collecting data about the speed and direction of wind during a wildfire event help fire crews to fight the fire?*

Wildfire Resources:

- Video: How do Wildfires Spread?, YouTube, uploaded by NOAA SciJinks, 2019.
- Video: California wildfires rage, fueled by forceful wind gusts YouTube, uploaded October 2019 by CBS This Morning.
- Article: NOAA's Ask the scientist: How can the weather spark and spread wildfires?
- Website: National Oceanic Atmospheric Administration (NOAA): fire weather warnings for the US.
    - A red flag warning is issued when weather conditions (hot, dry, windy etc.) over the following 24-72 hour period would make any fire especially dangerous.
- Article: These Wind Patterns Explain why California's Wildfires are So Bad

3. Introduce the design scenario.

Fast moving wildfires can affect whole communities, putting lives and property in danger. Especially in windy conditions, humans need the earliest possible warning to evacuate themselves and their pets or livestock well before the wildfires reach the community. Your engineering team has been tasked with creating a device that will alert members of the community about changing wind conditions.

Design Challenge Part 1

Introduce the Design Challenge *(5 min)*

1. Introduce the design problem, criteria and constraints.

Design Problem	Build a device that can detect the strength of the wind to alert members of the community about rapidly changing wildfire conditions.	
Criteria	• Must clearly show differences in wind speeds.	
Constraints	• Use only the supplies provided. • There's a time limit!	

2. Introduce students to the testing area.
   - Students will be using the Wildfire Warning Data Collection Handout to record observations of their device in the presence of varying wind speeds.
   - Ask students to consider: *What might we keep in mind about real-world wind or fire when testing our device?*
   - Clarify the process and address any questions students have.
3. If you have not already done so, group students into teams of 2-4.
4. Invite and encourage students to use the testing area throughout prototyping time to help them iterate as they go.
5. ***Note:*** A 15-20 minute time limit is suggested for this first round of prototyping.

Adaptation for Advanced Engineers

Students can suggest additional criteria or considerations for this challenge.

Brainstorm: Materials Investigation *(10 min)*

1. Have teams conduct an investigation of materials before beginning to build.
2. First, have them discuss some examples of material properties they might observe.
   - These might include: strength, size, weight, durability, visibility and flexibility.
3. Have students choose two or three materials at a time to investigate.
   - They should try to move, bend, connect and use the materials they selected.
   - They should also try placing them in the wind source to see how they behave.
4. *Option*: Students can make a simple chart to record their observations on the properties of the available building materials. This can be done on a scrap piece of paper or in an engineering journal.
5. Have a couple teams share something they noticed about the properties of their materials and how they worked. *For example*:
   - The chenille stems were flexible but didn't hold their shape for long.
   - The cardboard was strong but didn't catch the wind easily.

Prototype (Build and Test) *(20 min)*

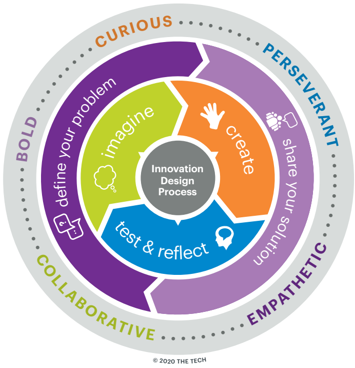
1. Set a timer to track the time remaining.
   - Give students occasional reminders on time, criteria and constraints to help them monitor their own progress.
2. During the prototyping time, walk around and support teams.
   - Help students focus on the process, rather than on the success of their designs. If their design fails, ask them how many things they have tried, what they notice about what isn't working and what they might try next.
3. Ask open-ended questions to encourage students to reflect on their process.

   Prototype Questions:
   - *What characteristics are you looking for in the materials you want to use?*
   - *How do the different materials used in your design work together to support the function of your design?*
   - *Which parts of your device keep it stable and which tell you about wind strength?*
4. Encourage teams to test 2-3 times while they build, even if their device is only partially built.
5. Encourage them to collaborate with each other and use the data collection sheet.

Innovator Mindsets

Remind students that failure is part of design challenge learning and that a rapid design process gives them an opportunity to learn quickly from each other and create more innovative designs.

See the Innovator Mindsets Tech Tip.



Share Solutions *(15 min)*

1. At the end of the time limit, students stop even if they don't have a completed device.
2. Sharing can be done by gathering around the test area as each team tests and demonstrates their device before they share.
3. Keep their sharing simple and focused on what they did and why.

Sharing Questions:

- *Tell us about your design.*
- *What characteristics does your design have that help it show wind speed? What would you change based on this test?*
- *How did the materials in your device behave as the wind conditions changed?*
- *What were the characteristics or properties of the materials that best displayed changes in wind speed?*
- *What are some similarities or differences you saw between the performance of your design and other teams?*

4. Have learners give each other positive feedback on their designs. Encourage them to tell the other team one thing they liked or noticed.

Adaptations for Beginning Scientists

- Have students learn about weather forecasts and plan to test their devices outside on a day when wind in the forecast.
- Study other ways that wind impacts communities or the geosphere more broadly.

Adaptation for Advanced Engineers

- Have students consider how their wind indicator may double as a green energy solution when weather hazard threats are low.

Content Connection Extensions

Before students build their next iteration, introduce some new information which they can use to inform their designs.

Science:

- Tell students that they are creating a specialized anemometer, a device used to measure wind speed and direction. Students can research how scientists use anemometers to monitor and predict weather patterns and mitigate the effects of natural hazards.

Career Connections:

- Look at the different careers involved in assessing wildfires and the technologies that professionals use to warn residents.
- Check out resources like NOAA's article, "Can Meteorologists help fight wildfires?" Have students consider the tools and resources these professionals use.

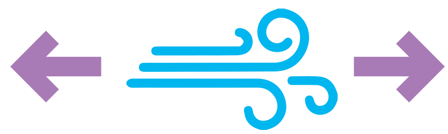
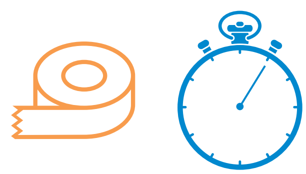
Social Science:

- Have students conduct research on the role of wind in a specific fire. *For example*: The 2018 Camp fire in Paradise, CA was especially destructive due to spotting embers carried by the wind.
- In addition, they can research the tools and resources that community members and officials used to get information about the direction and speed at which the fire was moving.

Design Challenge Part 2

Introduce Changes to the Design Challenge *(5 min)*

1. Iteration is an important part of the design process. In this next section, students will improve upon their design based on their experiences with prototyping, new content they were introduced to, as well as some new criteria.
2. In their first design, students were only looking at the speed of the wind; in this new iteration, their design will need to show the **direction of the wind**.
    - This information is critical in predicting the path of an active fire. Having this data in advance could help people to begin evacuating or be ready to evacuate before an official evacuation is called.
    - Spotting and embers which are blown around often start new fires, so knowing how the wind is changing direction is critical.
3. Introduce the new aspects of the design problem, criteria and constraints.

Design Problem	Build a device that can detect the **direction** and strength of the wind to alert members of the community about rapidly changing wildfire conditions.	
Criteria	• Must clearly show differences in wind speeds. • **NEW: Must show the direction of the wind.**	
Constraints	• Use only the supplies provided. • There's a time limit!	

4. In addition to new criteria, students will need to test their devices with changing wind direction.
    - Show students how to move the wind source around the testing area to test the different directions (ex: north, south, east, west). (See Test Area Set-up Part 2 in Preparation.)
5. Clarify the process and address any questions students have.
6. Students will work in the same teams they had during their first round of the challenge.
7. Invite and encourage students to use the testing area throughout build time to help them iterate as they go.

Prototype (Build and Test) *(10 min)*

1. Once again, during the prototyping time walk around and support teams.
2. Use open-ended questions to encourage students to focus on the process:

    Prototype Questions:
    - What characteristics did you notice about the designs that were successful in the first part of the challenge?
    - What materials seemed to help show how the wind was moving, both speed and direction? What were the properties of these materials?
    - How does your devicea djust to the direction of the wind allow someone to see the motion of the wind?
3. Encourage teams to test while they build and capture their data on the second copy of the **Data Collection Sheet**.
4. Encourage them to collaborate with each other and provide reminders on time.

Extensions

- **Challenge Cards:** If teams feel like they are "done" before time is up, try using the Tech's **Challenge Cards (English and Spanish)**.
- **Alert!:** Have students add a component to their device that will notify or alert the user.
  - *What types of signals might work for all community members?*
  - *What information would the community need? How far in advance of the hazard?*

Share Solutions *(10 min)*

1. At the end of the time limit, learners stop even if they haven't been able to complete their design.
2. Sharing can be done by gathering around the test rig as each team should test/demonstrate their device as they share.
3. Keep their sharing simple and focused on what they did and why.

   Sharing Questions:
   - *Tell us how your design works.*
   - *How did the properties of the materials you used help to meet the criteria?*
   - *What other characteristics of your design helped it meet the criteria?*
   - *What was different between this design and your first design? How did that change its performance?*
4. Have learners give each other positive feedback on their designs. Encourage them to tell the other team one thing they liked or noticed.

Debrief *(5 min)*

1. After students share their solutions, bring the conversation back to the engineering concepts and what they learned.
2. Lead a short debrief with some of these **Debrief Questions**:
   - *Which devices were able to measure a change in direction?*
   - *What do these devices have in common?*
   - *What was it about the materials they used that allowed these devices to measure wind direction?*
   - *What characteristics did you notice about the devices that clearly showed wind direction? And wind speed?*
   - *What other information would you want to collect before making another version of your design?*
   - *What changes would be needed to help your design function in a real world situation?*

Next Generation Science Standards: Engineering

Grades	Standard		Description
6-8	Performance Expectation	MS-ETS1-3	**Engineering Design:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
6-8	Disciplinary Core Idea	ETS1.C	**Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
6-8	Science and Engineering Practice	SEP 4	**Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.
6-8	Cross Cutting Concept	CCC	**Structure and Function:** Structures can be designed to serve particular functions by taking into account properties of different materials.

Vocabulary

- **Anemometer:** A device used to measure wind speed and direction.
- **Natural Hazards:** Natural events that cause harm to or endanger humans.
- **Weather vane:** A device to indicate the direction of wind flow.
- **Wildfires:** An unplanned, destructive fire that begins in a natural area.

Resources and References

1. Video: How do Wildfires Spread?, YouTube, uploaded by NOAA SciJinks, 2019.
2. Video: California wildfires rage, fueled by forceful wind gusts, YouTube, uploaded October 2019 by CBS This Morning.
3. Article: NOAA's Ask the scientist: How can the weather spark and spread wildfires?
4. Website: National Oceanic Atmospheric Administration (NOAA)- fire weather warnings for the US
5. Article: These Wind Patterns Explain why California's Wildfires are So Bad
6. Article: NOAA SciJinks: Can meteorologists help fight wildfires?

Tech Tips

See our educator guides and videos for more design challenge facilitation techniques.
For this lesson check out:

- Materials
- Data Collection

Student Handouts

Name: Date:

Wildfire Warning Data Collection Part

Draw diagrams of your **device**. Include labels for:

- ☐ All materials
- ☐ Measurements

Without wind source:

With wind source (include wind source and surface in diagram):

Material behavior observed during testing:	Material properties:
Similarities to other designs:	Differences from other designs:

Based on our observations of all of the designs tested, the characteristics of designs that performed the best were:

We might improve on our designs by:

Authentic assessment opportunities help students to make connections between what they are learning and how those skills may be useful in a future situation or even in a career. Use this assessment scenario to help students role-play what might happen after a design is finished.

Assessment Scenario:

Local government officials have asked your engineering team to create a citizen's weather data collection network to inform the community about potential weather hazards in your city. The device you have created will be available to anyone in the city to install on their property to deliver local data to the network. Now you need to create a social media campaign to convince members of the community to get a device and join the citizen network.

The presentation must include the following:

Observation data collected during device testing used to identify and describe:

- At least two similarities in the types and properties of materials that performed best on wind tests when comparing the test results with those of others.
- One finding that stands out as different from other results and what was learned from that finding.
- At least two characteristics of the design as well as properties of at least two included materials and how these characteristics and properties allowed the device to reliably determine wind speed and direction.

Tools Included for Assessment:

- ☐ Social Media Campaign Plan
- ☐ Rubric

Tech Tips

See our educator guides and videos for more design challenge facilitation techniques.
For this lesson check out:

- Materials
- Data Collection

Wildfire Warning
Social Media Campaign Plan

Name: ______________________________ **Date:** ____________________

Local government officials have asked your engineering team to create a citizen's weather data collection network to inform the community about potential weather hazards in your city. The device you have created will be available to anyone in the city to install on their property to deliver local data to the network. Now you need to create a social media campaign to convince members of the community to get a device and join the citizen network.

Your campaign plan needs to include:

- ☐ Observation data collected during device testing
- ☐ At least two similarities in the types and properties of materials that performed best on wind tests when comparing your test results with those of others.
- ☐ One finding that stands out as different from other results and what you learned from that finding.
- ☐ How characteristics of your design allow it to determine wind speed and direction:
  - ☐ At least one characteristic should be included.
  - ☐ At least two properties of at least two materials should be included.

Answer these questions to help you plan your campaign:

Which characteristics allow your device to solve the problem? How?	**What types of materials performed best in tests? What properties do these materials have in common?**

What is one test result that was surprising and different from other results? What did you learn from this result?

What materials did you choose to use in your final device? Why?

• What are the properties of those materials that allowed them to function well or better than other materials?	• How does this make your device a better option? (Remember that you need to convince the community to use your design)

Social Media Campaign Title or Slogan

Use these boxes to show how you will advertise your device to the community. Choose the words and images that will best convince people to get the device and join the weather data network.

A very visual platform (Instagram or Pinterest, etc.)	
The post:	How will this post build interest in your device?

An update-based platform (Facebook or Twitter)	
The post:	How will this post build interest in your device?

Next Generation Science Standards Performance Expectation				
• **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.				
	Below Standard	**Approaching Standard**	**Meeting Standard**	**Above Standard**
NGSS DCI **Optimizing the Design Solution:** Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.	*Areas that a student may need one-on-one support with:* • Making observations during testing to identify failure points and opportunities for improvement. • Isolating parts of solutions to identify parts that perform well. • Supporting observation conclusions with test data. • Testing materials to investigate their properties.	• Observation data recorded with some labeled characteristics. • At least 1 design characteristic that performed well during testing that is somewhat supported by test results.	• Observation data recorded with all relevant characteristics labeled. • At least 1 design characteristic that performed best in the wind speed or direction tests is aligned with observation data collected.	*Areas where a student may exceed:* • Diagram shows how the device indicates varying wind speed and direction.
NGSS SEP **Analyzing and Interpreting Data:** Analyze and interpret data to determine similarities and differences in findings.	*Areas a student may need one-on-one support with:* • Identifying and categorizing similar material properties. • Identifying results that are significantly different from other results.	• At least 1 similar property of materials used that was most effective at showing wind speed or direction. • 1 recorded test result or finding that was significantly different from other results.	• At least 2 similar properties of materials used that were most effective at showing wind speed or direction (in many devices). • 1 test result or finding that was different from other results and a lesson learned from this result.	*Areas where a student may exceed:* • Iterations of the design include changes based on observations of other devices.
NGSS CCC **Structure and Function:** Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used.	*Areas that a student may need one-on-one support with:* • Understanding how the properties of materials support the function of the device. • Making observations of how materials behave during testing.	• An explanation of at least 1 property of at least 1 material and how this property allowed the material to show wind speed or direction in words or visuals.	• A clear and logical explanation of at least 2 properties of at least 2 materials and how these properties allowed the materials to show wind speed or direction in words and visuals.	*Areas where a student may exceed:* • Recommendations are made for including other materials based on their known properties.

Assessment Rubric and Self-Reflection

Review your student's progress on the following tasks and ask them to reflect on their work and their mindsets.

Next Generation Science Standards Performance Expectation

- **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

	Task *Highlight or circle what was completed or observed*	**Score** ?	✓	★
Gathering test data	Records observation data and labels all relevant characteristics of the design.			
	Labels include at least 1 design characteristic that best met criteria accurately supported by observation data.			
Interpreting test data	Accurately identifies 2 similar properties of materials used that were most effective at showing wind speed or direction (in many devices).			
	Explains 1 test result that was different from other results and a lesson learned from this result.			
Explaining material properties	Words and visuals clearly and accurately explain how at least 2 properties of at least 2 materials allowed the materials to show wind speed or direction.			
	Overall Score			

Notes from the student:	**Notes from the educator:**

Student Self-Reflection

Ask the student to circle the face that shows how they feel about each question.

BOLD: Did you try new things?	? ✓ ★	PERSEVERANT: Did you keep trying even when it was not easy?	? ✓ ★	COLLABORATIVE: Did you work as a team?	? ✓ ★
CURIOUS: Did you ask questions today?	? ✓ ★	EMPATHETIC: Did you listen to others?	? ✓ ★	Did you enjoy this activity?	? ✓ ★

Which one of the mindsets above do you want to practice more? How will you practice it?