Cupcake Delivery

Grade Levels: 3-5

Duration: 60 min

Students will design and test a wind-powered device that can deliver a gift.

Outline

Frame the Activity	10 min total
Activate Prior Knowledge	5 min
Introduce the Challenge	5 min
Design Challenge	**50 min total**
Prototype (Create and Test)	35 min
Share	10 min
Debrief	5 min

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Concepts/Skills
Force, friction, surface area, balance

Objectives
Students will:
- Design and test a wind-powered device.
- Consider how characteristics of a payload may affect the design of their device.
- Use observations from their tests to compare solutions and iterate on their designs.

Materials and Preparation

Materials

Look for items that match the categories; see the suggestions below for ideas. Try to provide several different types of items for each category. Materials can vary among groups and do not need to be identical.

(per class of 32 students)

Wind Catchers *(25+ total)*	**Structural Pieces** *(50+ total)*	**Round Objects** *(25+ total)*	**Bases** *(25+ total)*	**Fasteners** *(100+ total)*
• Fabric	• Straws	• Cardboard tubes	• Strawberry baskets	• Masking tape
• Cardstock paper	• Craft sticks	• CDs	• Fry baskets	• Twist ties
• Cardboard scraps	• Chopsticks	• Bottle caps	• Paper cups	• String
• Recycled paper	• Bamboo skewers	• Plastic lids	• Pipette trays	• Rubber bands
• Foam sheets		• Paper plates	• To-go food containers	• Hair ties

□ Also needed: Supply bins or bags to organize materials

Tip: Don't use glue and limit the use of tape. This allows for faster iteration, more reuse of materials, and less mess.

(1 set per team) **Tools**	*(1 set per class)* **Test Area Supplies**
• Scissors	• Standing fan
• Hole punch	• Tape for securing power cords and marking test area
• Item for gift (payload)	• 3 x 8 ft (.91 x 2.44 m) smooth surface as the "track" (e.g., linoleum floor, table top)
• *Optional:* Heavier payload item (if including Challenge Card Extension)	
• *Optional:* Crop-a-dile® 1⁄4 in Power Punch (for punching holes in plastic and cardboard)	
• *Optional:* Stopwatch	

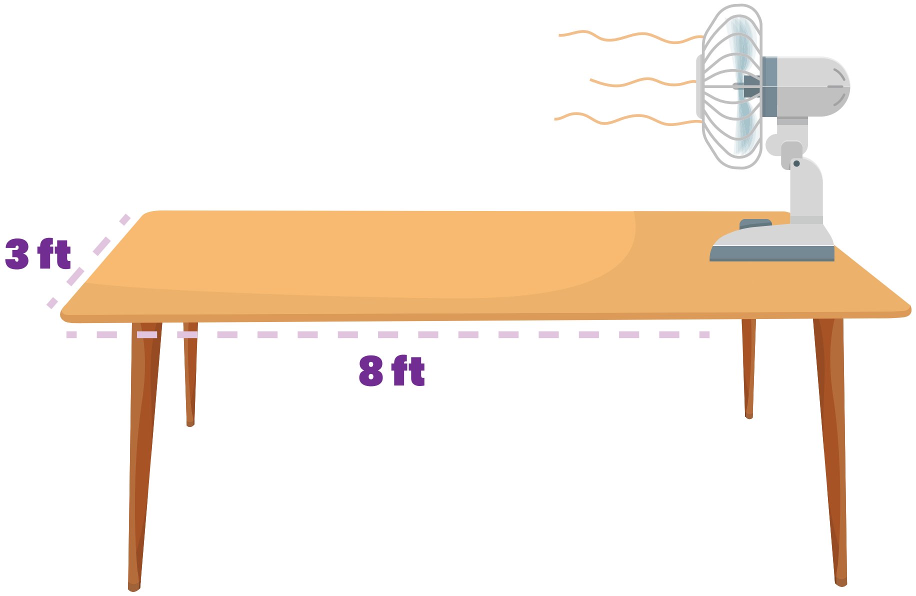
Materials Tech Tip

At The Tech Interactive, we generally set up the materials for this activity buffet-style so students can explore lots of options for building their devices. However, this can become chaotic in a classroom setting. To minimize material mess, try setting up categories of materials in different parts of the room to avoid congestion in one area, or limit the number of materials students can use at a time.

For more strategies on managing materials in design challenges, check out our **Tech Tip: Materials Strategies for Engineering Design** [PDF] and [Video].

Testing Set-up

1. Set up the testing area as far from the materials table(s) and building area as possible to avoid congestion. Allow enough space for students to line up to take turns when testing.
2. We recommend testing on a flat, smooth surface at least 6-8 ft (1.83-2.44 m) long. Testing on a carpet or rough surface will be more challenging due to the increased friction.
    - If you do not have a long enough table, mark off test track space to the floor using tape.
3. Locate a fan to act as your wind power. We recommend using a standing fan with different wind speeds so students can test under different wind conditions.
    - If you can't find a fan, a hair dryer set to the "cool" setting can be used as an alternative.
    - Secure any power/extension cords with tape to prevent tripping.
4. Place the fan behind the starting point and mark off where the finish line will be.



Preparation

1. Collect small items to act as the gift (payload). Make sure there are enough so each team (2-3 students) has one.
2. Gather, organize, and set out building materials.
3. Try out the activity yourself, with other educators, or kids you know. This will give you practice with the materials and tools to be able to anticipate student's questions.

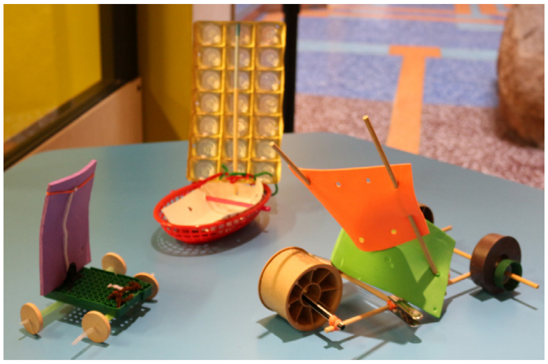
Tip: Choose items for the payload that match the scenario of your challenge and the type of "gift" you are delivering. *For example*, silicone/paper baking cups filled with playdough could represent cupcakes or small cardboard boxes could represent presents.

Although this challenge is a "cupcake delivery," we do not recommend using real food items as they will prevent students from iterating and improving on their designs. Imagination is part of the fun!

Adaptations for Distance Learning

For virtual learners designing devices from home, check out the **The Tech Interactive at Home version** of Cupcake Delivery.

Background Information



Cupcake Delivery is one of The Tech's favorite ways to theme the classic wind-powered delivery design challenge. When we feature the activity in The Tech Studio, students are challenged with delivering 3D printed cupcakes as their **payload**. Using fake cupcakes as the item being delivered helps students to not only consider the engineering aspects of their design, but empathize with the user, or person who is receiving the cupcake, as well. No one wants a cupcake that has been smashed during delivery, so students need to consider how to design their devices to keep the cupcake safe during the ride.

At The Tech, we are a big fan of incorporating whimsical narratives, like delivering cupcakes, into **Design Challenge Learning** activities. We have found that the addition of a narrative can lead to a more inclusive learning environment and can lower the barrier for entry for many students. In addition, the presence of empathy as part of the narrative or scenario leads to deeper engagement with engineering. Research conducted by The Tech, in partnership with other informal learning institutions, found that when empathy was present in a design challenge activity like creating wind-powered vehicles, on average, students displayed twice the number of engineering practices and participated in the activity three times as long. As you facilitate this lesson, think about how you can recreate this spirit of whimsy in your own setting. Frame the design scenario with a narrative that appeals to your student's interests and helps them empathize with the user.

For more information on the research mentioned above, check out the **practitioner's guide** for using narratives to support empathy and engineering practices at **InformalScience.org**.

Frame the Activity

Activate Prior Knowledge *(5 min)*

1. Introduce the concept of force as a push or pull on an object. Ask students if they can think of examples of objects that depend on the wind in order to function (pinwheels, wind turbines, kites, etc.).
2. Ask students for examples of vehicles that depend on the wind in order to move. Have them describe how these vehicles utilize the wind. Guiding questions can include:
   - *What kinds of vehicles use wind for power?*
   - *How do these vehicles use the wind to move forward?*
   - *What are some common or important parts of the vehicles that affect how they move?*

Terminology Tip

Use broader terms such as vehicle or device instead of specific terms like car in order to encourage students to think of a variety of different solutions. For this challenge, teams might create anything from a hamster wheel to a sled-like creation.

3. During the discussion, introduce relevant vocabulary and concepts.
   - They will need a way to capture the wind so it pushes their device forward, such as including a **surface area** (*For example*: the sails on a sailboat).
   - The force from the wind needs to be able to overcome the force of **friction** between the device and surface on which it is traveling.
     - Ask them to consider the difference between sliding across hardwood floors with socks — and without socks. This can help show how the force of friction changes with the use of different materials.
   - **Balance** can also play an important role in how a device moves. Distributing weight unevenly can cause a device to drift one direction or tip over.
     - Balance can also be affected by where the **payload** is located and how it is arranged inside the device.

Introduce the Challenge *(5 min)*

1. Introduce the design scenario:

   Your friend on the other side of town has been having a terrible day. You want to send them a gift to cheer them up. You're stuck at home and there are no delivery vehicles available. But it's a very windy day and you have everything you need to build a wind-powered delivery device!
   - Encourage students to keep adding to the narrative as they are building their device.
2. Introduce the design problem, criteria, and constraints.

Design Problem	Create a wind-powered device that can deliver a gift (payload) to a friend across town.	
Criteria	• Device must deliver the payload to the designated end point. • Device must remain intact during the test. • Payload must arrive undamaged.	 
Constraints	• Use only the materials available. • There's a time limit!	 

3. Ask students what would be important to them if they received a delivered gift.
   - *How would you feel if the gift arrived damaged?*
   - *How can you protect a treat that is easily smashed, like a cupcake?*
4. Show students the materials and testing area. Review the testing procedures listed below.
   - Students will place their devices at the starting point in front of the fan.
   - If the fan has varying speeds, let students know that they will choose which speed to use. Encourage them to try different speeds during testing and see if their device can work under different wind conditions.

Safety Note: If you are allowing students to test on their own, make sure to review how to operate the fan when introducing the test area.

Design Challenge

Prototype (Build and Test) *(35 min)*

1. Divide students into teams of two or three.
2. Have teams collect materials. Ask teams to spend a few minutes exploring the materials and discussing their design ideas before they start building.
3. Pass out a gift (payload) to each team while they are exploring materials.
   - Remind students that they will need to consider how to keep it safe as they plan their device design.
4. Encourage testing early and often. If students feel stuck or think their design will not work, they may learn something from seeing their device in action.
   - Challenge students to test at least three times during the allotted time.
   - After each test, teams should briefly discuss what they need to adjust on their device for their next iteration based on what they observed during testing.
5. During the prototyping time, support teams with open ended **Prototyping Questions** to guide the process:

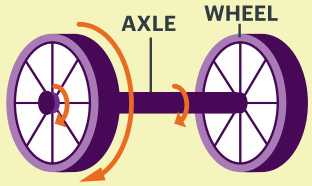
Just Getting Started	• *How will your device capture the wind? What materials could help you do this?* • *How does your device keep the gift safe during travel?*
Problem-Solving After Testing	• *Did your device drift towards the right or left? How can you adjust your device so it travels in a straight line?* • *How would increasing or decreasing the surface area affect the device's performance?* • *Did the gift shift in the device or fall over during the test? How can you adjust the design to keep it secure?* • *How might friction at the bottom of your device be affecting your design?*
Pushing Design Further	• *Does your device work if you were to add or take away some weight? What changes would you need to make, if any?* • *How can you alter your device's design so it can transport multiple gifts safely?* • *How can you alter your device's design so it can travel faster without compromising the gift?*

6. Encourage using key vocabulary and concepts as they discuss and reflect on testing.
   - *Did the force of the wind help or hinder the device's performance?*
   - *Do you think there was too much friction between the device and the surface?*
   - *Does the weight of the gift make a difference where it is placed in the device?*

Adaptations

Students often choose to design their devices with wheels, as these are usually the vehicles with which they are most familiar. However, wheels can be very challenging when designing wind-powered vehicles.

- Advanced engineers who want to include wheels can try creating an **axle** by connecting two round items to a long structural item at either end. The axle will need to be attached in such a way that it rotates freely, allowing the wheels to turn.
- Beginning engineers may want to stick with designing vehicles that slide, and focus on lowering the friction between the vehicle and the surface on which it is traveling.



Share *(10 min)*

1. Have the teams take turns sharing how their device performed during testing. Possible **Sharing Questions** could include:
   - *What did you notice worked well during testing? What did not work well?*
   - *Did your device work as you intended?*
   - *Did anything happen to the gift during the ride?*
   - *How would you change your device if you had more time?*
2. After each team shares, invite the other students to give positive feedback on their designs and encourage them to share suggestions.

Debrief *(5 min)*

1. Bring the conversation back to the concepts and what they learned. Possible **Debrief Questions** could include:
   - *What did you observe from your tests that helped you improve on your design?*
   - *How did you adjust your design so there was a balance between the weight distribution, friction, and wind speed?*
   - *Did the gift stay safe? Do you think your friend would be happy to receive the gift?*
   - *Did you make any changes to your design to keep the gift from being damaged?*

Extensions

With additional time, students can revise their designs and iterate with new criteria. Use the **Challenge Cards** included or try one of these specific extensions:

- Have students test their devices on other textured surfaces like carpet or, if possible, move outside and test on grass or concrete. Ask students what changes they would want to make to their devices to make them successful over different terrains.
- Discuss how changing the payload might affect their design. What if they were transporting something liquid, or very fragile items? Would the devices need different features?
- Have students run tests with different weight payloads. Fill small containers with items like marbles, paper clips, pennies, or dominos for the payload. Challenge students to design their devices so they can successfully transport items of different weight.

Tech Tips

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

- Prototyping - Test, Reflect, Iterate (**PDF**, **Video**)
- **Unpacking Design Challenges (Video)**: Get more tips for leading a cupcake delivery design challenge.

Next Generation Science Standards

Grades	Standard Description		Description
3-5	Performance Expectation	3-PS2-1	Plan and conduct an investigation to provide evidence of the effect of balanced and unbalanced forces on the motion of an object.
3-5	Performance Expectation	3-PS2-2	Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
3-5	Performance Expectation	3-5-ETS1-2	Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.

Vocabulary

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

- **Force:** The push or pull an object feels when it interacts with another object
- **Friction:** The force resisting the motion of two objects sliding against each other
- **Payload:** Item(s) being carried by the device
- **Surface area:** The area of the surface of an object
- **Balance:** An even distribution of weight
- **Axle:** A rod or shaft that rotates the wheels
- **User-centered design:** Iterative design process where designers focus on the users and their needs in each phase of the design process
- **Weight:** The force acting on an object due to gravity

Cupcake Delivery Challenge Cards

One Modification

Change one part of your design and see how it performs. (*Example*: add or get rid of wheels.)

Travel Faster

Try to get your device to reach its destination more quickly.

Larger Delivery

Increase the size or weight of the cargo being transported.

Dependable Design

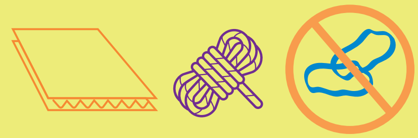
Make your device more reliable. (How many successful test runs can you do in a row?)

Innovator's Choice

Choose a new way to improve your device and challenge your engineering skills.

Materials Limit

Build with fewer materials. (*Example*: Build with only 2 different kinds of materials, or no rubber bands.)

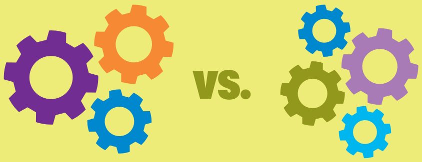


Rapid Redesign

How quickly can you revise your design? Set a timer for 5 minutes. (If you are on a team, make sure you are all involved and collaborating.)

Alternate Dimension

Create a second, totally different design to test. Compare the performance of each prototype.



Extreme Conditions

Increase the wind speed or change the surface. How well does your device deliver in a "storm" or bumpier terrain?