The challenge: Build a tower that can support a tennis ball at least 18 inches off the ground while withstanding the wind from a fan.

In this challenge, kids (1) build a sturdy frame out of paper; (2) learn that a solid base helps stabilize a tower; and (3) use the design process to debug problems. This work prepares kids for the next challenge of building a tower with two parts that move in the wind.

1. Introduce the challenge, brainstorm, and design. (10 minutes) Tell kids the challenge for today and begin by asking:
   - What is a force? (A force is a push or a pull.)
   - Which forces will push on your tower and which will pull on your tower? (The wind will push on the tower and gravity will pull on it.)
   - How are tall structures different from low ones? (A tall structure can tip over if its base is too small or if it is not well anchored to the ground.)
   - How can we keep a tower from falling over? (Answers include: Make a wide base; attach string “cables” to steady a tower; make the base heavy; and make a massive, thick tower)
   - Let’s brainstorm some designs. How could you use flexible materials, such as paper and string, to make something tall? (Kids can stiffen paper by changing its shape [e.g., rolling or folding it] or by reinforcing it [e.g., building up layers]. As with a tent, string can stabilize a tower. Have kids sketch their ideas in their design notebooks.)

2. Build, test, and redesign. (40 minutes) Divide the group into teams of two or three. Distribute the Challenge Sheets and have kids begin building. During the activity, help them debug the following common issues:
   - The tower wobbles or falls over. Check to see if the base is heavy or wide enough.
   - The tower buckles with the tennis ball on top. Stiffen and reinforce the column.
   - The tennis ball falls off the tower. Increase the size of the platform under the tennis ball.

3. Discuss what happened. (10 minutes) Have the kids show each other their towers and talk about how they solved any problems that came up. Emphasize key themes in this challenge—how a solid base increases stability, how materials can be used to make a rigid frame, and how debugging can make a better tower—by asking questions such as:
   - What are some things all your tower bases have in common? (Many towers will have broad, wide bases. They may also be heavy. These designs help prevent a tower from tipping over in the wind.)
   - Paper is thin and flexible. How did you use it to make a tower? (Look for examples of where kids stiffened paper by changing its shape or reinforced it by building up layers.)
   - How was string useful in helping stabilize a tower?
   - What kinds of changes did you make between your first design and your final tower?
YOUR CHALLENGE

Build a tower that can support a tennis ball at least 18 inches off the ground while withstanding the wind from a fan.

MATERIALS*

- Building surface (tray, cardboard, or piece of wood)
- Electric fan
- Paper (copier paper and/or newspaper)
- Straws
- String
- Tape (masking or duct)
- Tennis ball
- Wooden skewers or Popsicle sticks

* For information on where to get these materials, see page 6 or visit pbskids.org/designsquad/engineers.

BRAINSTORM AND DESIGN

Divide into teams of two or three. Before you begin designing, brainstorm answers to the following questions. Record and sketch your ideas in your design notebook.

- How can we use our materials to make a tower that’s at least 18 inches tall?
- How can we use flexible materials, such as paper and string, to make a tower that is strong enough to hold up a tennis ball?
- How can we keep our tower from tipping over?
- How will we design our tower to resist the push of the wind and the pull of gravity?

As you brainstorm designs for your tower, think about other structures and how they stand up. For example, a tent combines flexible and rigid materials to make a frame and covering that can stand on its own.

BUILD, TEST, AND REDesign

Once you’ve got a tower to test, put it one foot away from the fan. (If your tower is hard to move, bring the fan over to the tower.) See how your tower responds when you turn the fan speed on low. When we made ours, we had to debug some problems. For example, our tower tipped over, our tennis ball kept falling off, and the weight of the tennis ball bent our tower. If any of these things happen to you, figure out a way to fix the problem so that your tower works as expected.
TAKE IT TO THE NEXT LEVEL

- Strengthen your tower so it can support a tennis ball when the fan speed is set to high.
- Build a tower that can support a baseball, softball, or soccer ball instead of a tennis ball.
- Make a tower that can support a tennis ball that’s 36 inches off the ground.

INSIDE THE ENGINEERING

WIPE OUT
When you’re schussing down the slope at 80 miles per hour, who’s got time to think about whether your snowboard will hold together? That’s where Chris Fidler comes in. He’s an engineer at Burton Snowboards®. Chris thinks a lot about snowboards so you don’t have to. Snowboarding since he was a kid, Chris now works with designers to build what he thinks makes the best snowboard. To make a board, Chris presses thin layers of fiberglass, metal, and plastic together—sort of like a club sandwich. Each material’s thickness and shape (e.g., corrugation, strips, tubes, and mesh) affects the board’s strength and flexibility. Chris then subjects his boards to a series of tough tests. Robotic instruments twist, bend, and pound the boards to see how much force they can take before breaking—something you definitely don’t want to find out when you’re catching air on a halfpipe!

The Design Squad cast tapped their “inner artists” as they designed and built wind-powered sculptures from recycled materials. One sculpture—the Aqu-AIR-ium—had a heavy steel base and sheet metal fins so the “bowl” full of fish could rotate in the wind.

WATCH Design Squad on PBS (check local listings). Download more challenges at pbskids.org/designsquad.

TAKE IT ONLINE

Want to avoid a mess? Select the best materials for different drink containers! Download Materials Choice from Intel’s Design and Discovery hands-on engineering program. intel.com/education/designanddiscovery
LEADER NOTES FOR CHALLENGE 2

KINETIC SCULPTURE

THE CHALLENGE: Build a tower that’s at least 12 inches high with two or more parts that move in the wind.

In general, a tower’s moving parts can spin (like a pinwheel), sway (like a branch or swing), or flap (like a flag). In this challenge, kids (1) design a system that allows at least two parts to move in the wind; (2) build a sturdy structure to support the moving parts; and (3) create a base that lets the tower stay up even when the parts shift their positions.

1 Introduce the challenge, brainstorm, and design. (10 minutes) Tell kids the challenge and begin by asking:
   - What are some different ways that wind can move something? (Parts can either move in circles—spin, twirl, or twist, or they can move back and forth—rock, sway, flap, or tip.)
   - What do you need to consider when designing a tower that has moving parts? (The tower needs to be stable enough to withstand the wind and to stay upright each time the parts move.)
   - In the last challenge, what did you learn about towers that might be helpful in this challenge? (A wide or heavy base helps stabilize a tower. Paper can be stiffened by changing its shape or by layering or reinforcing it.)
   - What kinds of materials would be good for the moveable parts? (Materials that can catch the wind while not adding too much weight to the top of the tower)
   - Let’s brainstorm some designs. How might you use the materials to make something that’s both tall but has parts that move? (Encourage kids to sketch their ideas in their design notebooks.)

2 Build, test, and redesign. (40 minutes) The wide selection of items in the materials list is intended to spark creative solutions to the challenge. You should also feel free to add other items. Distribute the Challenge Sheets and have kids begin building. During the activity, help them debug the following common issues:
   - The tower falls over in the wind. Widen or add weight to the base. Also, check how the weight is distributed—if most of it is near the bottom, the tower will stay up better.
   - The parts don’t move as expected. For spinning parts, make sure that the parts turn without catching and that kids have centered the axle and minimized friction. For swaying parts, make sure they’re wide enough to catch the wind and are attached in a way that lets them move back and forth easily.

3 Discuss what happened. (10 minutes) Have the kids show each other their sculptures and talk about how they solved any problems that came up. Emphasize key themes in this challenge—a stable base, a tower supported by a sturdy structure, and moving parts—by asking questions such as:
   - What do you think is the best feature of your design? Why?
   - How is the tower you built in this challenge similar to and different from the one you built last time? (They both have a rigid frame or column and a base that provides good support.)
   - What kind of moving part—spinning or swaying—is harder to build? Why? (Generally, friction issues and getting the axle system to work smoothly make spinning parts harder to build.)
   - How much would you have to change your design to add a third moving part?
YOUR CHALLENGE

Build a tower that’s at least 12 inches high with two or more parts that move in the wind. That’s what makes it kinetic—it moves.

MATERIALS*

- Aluminum foil
- Cardboard (corrugated or chipboard)
- Clay
- Electric Fan
- Foil baking dishes (disposable pot-pie-sized)
- Metal washers (various sizes)
- Paper (copier or newspaper)
- Paper cups (various sizes)
- Ping-Pong balls
- Plastic grocery bags
- Poster putty
- Rulers
- Scissors
- String
- Strips of colored paper or fabric
- Tape (duct or masking)
- Wooden skewers or dowels

* For information on where to get these materials, see page 6 or visit pbskids.go.org/designsqudad/engineers.

BRAINSTORM AND DESIGN

Looking for inspiration? Get your creative juices flowing by checking out the kinetic sculpture illustrations. Don’t worry, it’s not cheating! Being inspired by other people’s work and putting things you like together in new ways is a great way to come up with a unique creation of your own. Before you begin designing, brainstorm answers to the following questions. Record and sketch your ideas in your design notebook.

• How will my parts move? Spin? Sway? Flap? A combination?
• What kinds of materials would be good to use for the moveable parts?
• How will I attach the parts to the base or tower so they can move in the wind?
• How could having moving parts at the top of a tower affect how I design my tower?

BUILD, TEST, AND REDESIGN

Sculptors typically name their creations, which can add meaning to them. As you build your sculpture, think up a name for it. Try for a name that’s descriptive, funny, or mysterious. Test your sculpture by setting it in front of the fan. Do the parts move as you expected? When we made ours, we had to debug some problems. For example, the wind knocked our sculpture over. Also, our parts didn’t always move the way we wanted, especially the parts that turned. If things like this happen to you, figure out a way to fix the problem so that your sculpture works every time.
Kinetic Sculpture

Take it to the next level

- Add another moving part.
- Make your sculpture twice as tall.
- Build a sculpture that could work in either more or less wind.

Inside the engineering

Tower Power

What would make a tower stand up in typhoon-strength winds (74 miles per hour or greater)? That’s something the engineers who built one of the tallest buildings in the world—the Taipei 101 Tower of Taiwan (1,670 feet tall)—were worried about. Very worried! Typhoons regularly slam into Taiwan. To keep the building from being blown over, engineers made the skyscraper much wider at the bottom than at the top. They also used special materials, including strong, flexible steel, to make the building sturdy enough to withstand those typhoons. So next time you’re visiting the top of the Taipei 101 Tower during a typhoon, you don’t have anything to worry about. Right?

The Design Squad cast welded their kinetic sculpture out of heavy scrap metal. They set their “Urban Tornado” atop a steel pole and used metal fins to catch the wind and spin the sculpture.

Take it online

Like building things that move?

Make a unique mechanical toy!

Download Gears, Cranks, Crankshafts, and Belts from Intel’s Design and Discovery hands-on engineering program.

intel.com/education/designanddiscovery

Watch Design Squad on PBS (check local listings). Download more challenges at pbskidsgo.org/designsquad.