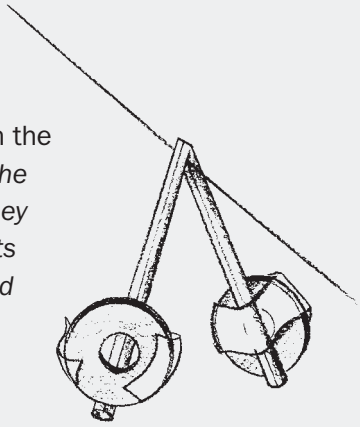
ZIP LINE

CHALLENGE 3
LEADER NOTES

The Challenge
Design and build something to carry a Ping-Pong ball from the top of a zip line to the bottom in four seconds (or less!).

In this challenge, kids (1) follow the design process to build a Ping-Pong ball carrier that slides quickly down a zip line string; (2) figure out how to keep something balanced; and (3) identify ways to reduce friction.

1 **Introduce the challenge** (5 minutes)
Before the session starts, run a four-foot length of fishing line between the back of a chair and a stack of books on the floor. Tie the line so that the chair end is about two feet higher than the book end. (It should slant at about 30 degrees.) Begin by telling kids the challenge and that the slanted fishing line is called a zip line. Then rest a straw on top of the zip line. Hold it across the line so that the line touches the straw at its middle. To get kids thinking about balance, ask:



- What will happen if I let go of this straw? (*It will fall. When the straw is straight, it's hard to balance it on the line.*)
- What can we do to help the straw stay balanced on the line? *(Try any ideas kids suggest, such as bending the straw in half and setting the crease on the line. If they don't suggest adding weight, show them how weights can balance the straw. Tape a washer onto each end of the straw. Bend the straw in half and set the crease on the line. The two washers will balance the straw.*)
- How do the washers help the straw stay on the line? (*The washers pull the straw down, keeping it firmly on the line. Also, when there is the same amount of weight on each side of the straw, the washers balance each other and keep the straw stable.*)

2 **Brainstorm and design** (10 minutes)
Show kids the materials and ask, "How can you use these materials to make a device that carries a Ping-Pong ball quickly down a zip line? The ball carrier should also be easy to put on and take off the line." After discussing their ideas, have them sketch their designs on a piece of paper or in their design notebooks.

3 **Build, test, evaluate, and redesign** (35 minutes)
Distribute the challenge sheet and have kids begin building. If any of the following issues come up, ask kids questions to get them thinking about how they might solve their problems.

- The ball carrier doesn't balance. *Check that each side is equally weighted and that the middle of the carrier touches the line. Also, make sure kids used enough weight. It can be hard to stay balanced if there's too little weight holding the carrier down, especially once there's a ball on it. Finally, the Ping-Pong ball carrier will be more stable the lower the weights hang, so make sure the weights hang well below the zip line.*

DESIGN SQUAD

SHOW KIDS THE RELATED TV EPISODE

Photo: Helen Tsai

In Zip Line, kids figure out ways to safely slide a Ping-Pong ball along a line. Show them the Backyard Thrill Ride episode in which *Design Squad* teams compete to build an exciting zip line-based amusement ride for a kid's backyard. Get it online at pbs.org/designsquad.

Photo: Lauren Feinberg

Open-ended challenges have no single right answer, so kids are inspired to come up with their own solutions.


Photo: Lauren Feinberg

Ball carriers go faster when they're evenly weighted and when there's little friction between the sliding surface and the line.


Photo: Lauren Feinberg

Kids can extend the activity by building a ball carrier that can hold several Ping-Pong balls.

- The ball falls off the ball carrier. *Make sure the carrier has a big enough place to hold the ball. Kids can use tape, a cup, several cups, or a platform to keep the ball on the carrier.*
- The carrier goes slowly or stops partway down. *See if kids have reduced friction as much as possible. To do this, they can: (1) make the part of the carrier touching the line as slippery as possible by using a smooth, hard material like plastic; or (2) adjust how hard the carrier presses on the zip line by hooking it on the zip line at two or more points.*
- The zip line sags. *Check the tension of the line. Tighten, if necessary. If a kid's carrier is very heavy, encourage him or her to find ways to lighten it.*

4 **Discuss what happened** (10 minutes)

Have kids talk about their designs and how they solved any problems that came up. Emphasize the key themes in this challenge—balance and friction—by asking questions such as:

- What helped your Ping-Pong ball carrier travel quickly down the zip line? (*Ball carriers go faster when they're evenly weighted and when there is little friction between the sliding surface of the ball carrier and the line.*)
- How did you minimize friction in your Ping-Pong ball carrier? (*Answers will vary.*)
- What was the hardest part of making a Ping-Pong ball carrier with good balance? With little friction? With a secure way to carry the ball? (*Answers will vary.*)

FOR EVENTS

- Draw kids into your area by asking, "How quickly do you think you can get a Ping-Pong ball to the bottom of our zip line?"
- Provide one zip line per eight kids.
- Four to five feet is the recommended length for the zip line. If it's much shorter, the ball carrier's ride goes too quickly. If it's much longer, the line begins to sag.
- Fishing line can be hard to see. Mark off the testing area so that people don't accidentally run into the lines you set up.
- To minimize distractions, give kids Ping-Pong balls only when they're in the testing area. Put out just a few at a time. Have kids leave them in the testing area once they've finished.

To determine how many materials you'll need for different-sized events, for information on obtaining large quantities of materials, and for other general event tips, see page 7.

ZIP LINE

DESIGN SQUAD™ PBS®

as built on TV™

pbs.org/designsquad

YOUR CHALLENGE

Design and build something that can carry a Ping-Pong ball from the top of a zip line string to the bottom in four seconds (or less!).

BRAINSTORM & DESIGN

Look at your materials and think about the questions below. Then sketch your ideas on a piece of paper or in your design notebook.

1. Using these materials, what can you design that can carry a Ping-Pong ball down a zip line?
2. How will your Ping-Pong ball carrier stay on the zip line as it goes from the top to the bottom?
3. What kinds of materials should be in contact with the zip line so that the carrier slides quickly?

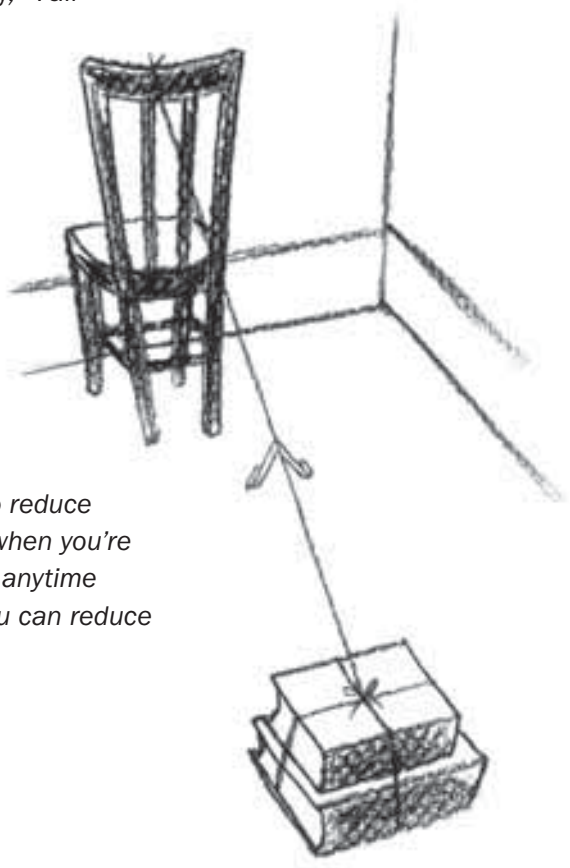
BUILD, TEST, EVALUATE & REDESIGN

Use the materials to build your Ping-Pong ball carrier. Then make a zip line. Run the line between the back of a chair and a stack of books. Make sure the high end is about two feet above the low end. Test the carrier by putting it on the line. When you test, your design may not work as planned. The design process is all about "if at first you don't succeed, then try, try again." On *Design Squad,* we say, "Fail fast—succeed sooner!" Study the problems and then redesign. For example, if your Ping-Pong ball carrier:

- keeps dropping the ball—*Check that it has a big enough place to hold the ball.*
- stops partway down—*Make sure there's nothing blocking your carrier where it touches the line.*
- doesn't balance well—*Adjust the weights. Add weights or move them so they are farther below the zip line. Doing this changes the carrier's* **center of gravity***, the point within an object where all parts are in balance with one another. See how changing the numbers and positions of washers affects the carrier's balance.*
- takes longer than four seconds to travel the zip line—*Find ways to reduce friction. Yes, there's* **friction***—the force that resists motion—even when you're dealing with something as smooth as fishing line. You'll find friction anytime things rub together. Experiment with different materials to see if you can reduce friction and speed up the Ping-Pong ball carrier.*

MATERIALS (per person)

- chipboard (from a cereal box or back of a notepad)
- 2–4 small paper cups (i.e., 3-ounce)
- Ping-Pong ball
- 4 plastic straws
- scissors
- single-hole hole punch
- 4 feet of smooth line (e.g., fishing line or unwaxed dental floss)
- tape (duct or masking)
- 4 standard, flat steel washers (1 inch in diameter or larger)
- 4 wooden skewers



TAKE IT TO THE NEXT LEVEL

- Slow down! Build a carrier that takes ten seconds to travel the length of the zip line.
- Piggyback time. Make a carrier that can hold several Ping-Pong balls at the same time.
- Blast off! Find a way to launch the Ping-Pong ball when the carrier gets to the end of the zip line.
- On your mark. Get set. Go! Set up two zip lines and race different ball carriers.

MAKE IT ONLINE

Travel by blimp, anyone? Build a jet-propelled blimp that can travel across a large room. Make it out of 2 balloons, 2 straws, and some clay and tape. See how on Make Magazine's project page at makezine.com/designsquad.

ENGINEERING IN ACTION

Ever want to zip up the side of a building like Batman or Spiderman? Now this superpower can be yours, thanks to engineer Nate Ball, host of *Design Squad*, and his friends. For a contest, they designed and built a climbing device that could carry a person 50 feet up the side of a building in less than five seconds. After months of work, the team tested their climber by lifting a 150-pound load of tires. Nate recalls, "After a few seconds, there was an awful sound. The gearbox exploded. The tires smashed to the ground with a huge crash." After analyzing the ruined climber, they made lots of changes and ended up winning third prize in the contest. Ultimately, they patented the climber and started a company to sell it. Today, soldiers, firefighters, and rescue workers around the world use the team's climber to fly up buildings. Now, those are *real* superheroes.

Watch the DESIGN SQUAD Backyard Thrill Ride episode on PBS or online at pbs.org/designsquad.

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