

PAPER TABLE

CHALLENGE 2

LEADER NOTES

The Challenge

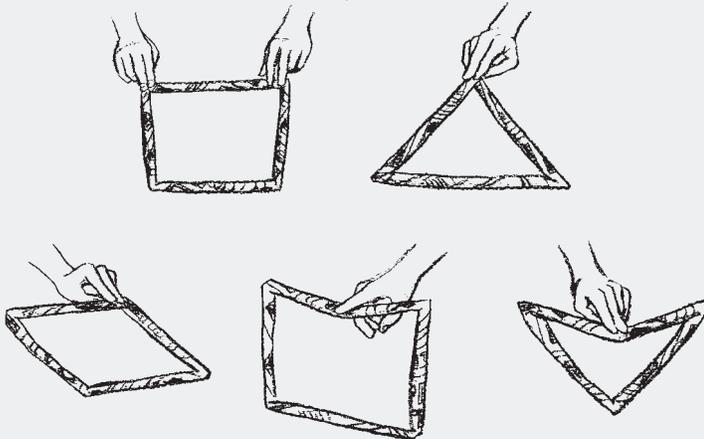
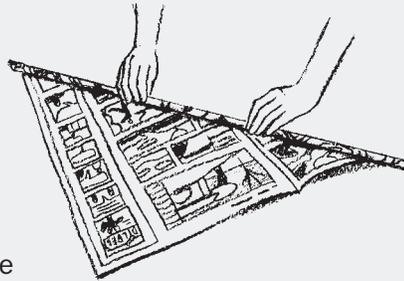
Use tubes of newspaper to make a table that's at least eight inches tall and strong enough to hold a heavy book.

In this challenge, kids (1) follow the design process to build a sturdy table out of paper tubes; (2) make paper support more weight by changing its shape; and (3) figure out ways to keep the table legs from buckling.

1 Introduce the challenge (5 minutes)

Begin by telling kids the challenge. Then get them thinking about ways to get paper to support a lot of weight. Ask:

- How can you make a piece of paper support a lot of weight? (You can fold, roll, layer, or reinforce it. In this activity, kids use sheets of newspaper rolled into tubes. To make a strong tube, roll it tight. Demonstrate how to do this. Start at one corner and roll diagonally toward the other corner. Your first roll should be about the diameter of a straw. Tape the tube closed with a strip or two of tape. Wave it around to show how stiff it is.)
- Tables and chairs have supports to keep their legs from tilting or twisting. Look at the furniture in this room. How would you describe the supports you see? (Table legs often use rods for support. The rods often form a triangle with the leg. Take two newspaper tubes. Bend one into a triangle and the other into a square. Tape them closed and set them on the floor. Push down on them and rock them side to side. The triangle will withstand more force and be more stable than the square. However, orientation matters. If you turn it so it rests on a point, the triangle will be weaker and less stable than before.)



2 Brainstorm and design (10 minutes)

Show kids the materials and ask, "How can you use these materials to make a paper table that's at least eight inches tall and strong enough to hold a book?" After discussing their ideas, have them sketch their designs on a piece of paper or in their design notebooks.



SHOW KIDS THE RELATED TV EPISODE



Photo: Anthony Tieuli

In Paper Table, kids figure out ways to use paper to make strong tables. Show them the Cardboard Furniture episode in which *Design Squad* teams compete to build cardboard furniture that is modern, comfortable, innovative, and functional. Get it online at pbs.org/designsquad.



Photo: Renée Mattier

It takes much more force to crumple paper when it's rolled into a tube than when it's in a flat sheet.



Photo: Ellen Robinson

In general, the more triangles kids use in their tables, the stronger and more stable they will be.



Photo: Renée Mattier

Changing the shape of a material affects its strength. Any shape that distributes the force of a load increases a material's strength.

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 table legs tilt or twist. *Support the legs by running tubes between them.*
- A tube buckles when weight is applied. *See if the tube is loosely rolled. If so, re-roll it tighter and tape it securely closed. Also, dents and creases weaken a tube. Add a support or reinforce the weak area or replace the damaged tube with a new one.*
- The table wobbles. *Make sure that the table isn't lopsided, that there are adequate supports, and that the tubes are undamaged. Also, a table becomes tippier as its height increases. If a table is very tall and reinforcing the legs doesn't work, suggest reducing its height.*
- The table collapses. *Check that the base of the table is truly sturdy. Remind kids that engineers often put materials together in triangular arrangements to increase their strength and stability. In general, the more triangles kids use to build their table, the stronger it will be.*

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—making paper support more weight by changing its shape, and designing a stable, strong table base—by asking questions such as:

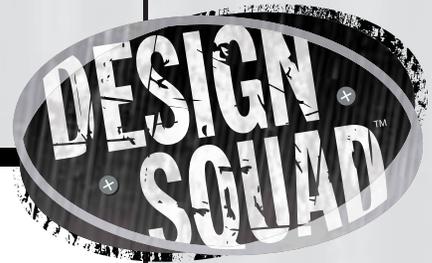
- How were you able to support a heavy book on just pieces of newspaper? *(Kids changed the paper's shape. A tubular shape distributes a load well and increases the amount of weight the paper can support. With a tube, the book's weight pushes on every part of the paper, not just one section of it. A tubular shape also resists buckling.)*
- How did knowing that certain arrangements of materials (like triangles) are stronger than others influence the design of your table? *(Answers will vary.)*
- What helped your table be especially strong? *(Kids may mention the use of good bracing, sturdy frames, triangles, and keeping the table as compact as possible.)*

FOR EVENTS

- Draw kids into your area by asking, "Do you think you can build a table out of newspaper?"
- To avoid spending time teaching each person how to make a tube out of newspaper, make samples that illustrate the process described in the Introduce the Challenge section. For example, take three pieces of newspaper. With the first, show how tight the first roll needs to be. With the second, show the paper rolled halfway up. With the third, show a finished tube. Tape these samples to a piece of poster board and label them accordingly.

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.

PAPER TABLE



YOUR CHALLENGE

Design and build a table out of newspaper tubes. Make it at least eight inches tall and strong enough to hold a heavy book.

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. How can you make a strong tube out of a piece of newspaper? (This challenge uses tubes because it takes more force to crumple paper when it's shaped as a tube.)
2. How can you arrange the tubes to make a strong, stable table?
3. How can you support the table legs to keep them from tilting or twisting?
4. How level and big does the table's top need to be to support a heavy book?



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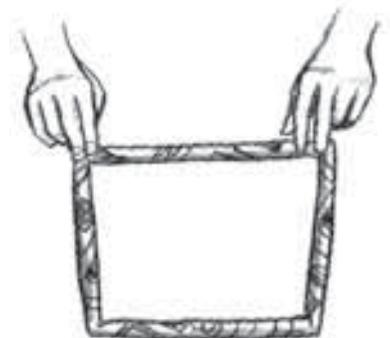
MATERIALS (per person)

- 1 piece of cardboard or chipboard (approximately 8 ½ x 11 inches)
- heavy book (e.g., a textbook or telephone book)
- masking tape
- 8 sheets of newspaper

BUILD, TEST, EVALUATE & REDESIGN

Use the materials to build your table. Then test it by carefully setting a heavy book on it. When you test, your design may not work as planned. If things don't work out, it's an opportunity—not a mistake! When engineers solve a problem, they try different ideas, learn from mistakes, and try again. Study the problems and then redesign. For example, if:

- the tubes start to unroll—*Re-roll them so they are tighter. A tube shape lets the load (i.e., the book) push on every part of the paper, not just one section of it. Whether they're building tables, buildings, or bridges, **load distribution** is a feature engineers think carefully about.*
- the legs tilt or twist—*Find a way to stabilize and support them. Also check if the table is lopsided, too high, or has legs that are damaged or not well braced.*
- a tube buckles when you add weight—*Support or reinforce the weak area, use a wider or thicker-walled tube, or replace the tube if it's badly damaged. Changing the shape of a material affects its strength. Shapes that spread a load well are strong. Dents, creases, and wrinkles that put stress on some areas more than others make a material weaker.*
- the table collapses—*Make its base as sturdy as possible. Also, a table with a lot of triangular supports tends to be quite strong. A **truss** is a large, strong support beam. It is built from short boards or metal rods that are arranged as a series of triangles. Engineers often use trusses in bridges, buildings, and towers.*



TAKE IT TO THE NEXT LEVEL

- If a little is good, a lot is better! Build a table that can hold two or more heavy books.
- The sky's the limit. Build a table that can hold a heavy book 16 inches above the ground.
- Matching furniture! Build a chair out of newspaper.

MAKE IT ONLINE

Paper guitar?

Build a great-sounding guitar out of a box, string, wood, and wire. See how on Make Magazine's project page at makezine.com/designsquad.

ENGINEERING IN ACTION

A paper house? Better leave your matches outside! Check out these items that engineers made out of paper. Then choose from the list and see if you can figure out the year each item was invented.

Years these items were invented: 1922; 1931; 1967; 1995; 2004; 2007

A. Paper Church

After a big earthquake in Japan, engineers quickly made a building by stretching a paper "skin" across 58 paper tubes, each over 16 feet long. The church was only meant to be a temporary place of worship. But it's still standing today.

B. Paper Video Disc

This disc holds more than three times as much data as a standard DVD and is much better for the environment. But you'll have to stay tuned—there's no release date set.

C. Paper House

An engineer built a vacation home out of newspaper. He glued newspapers into one-inch-thick slabs and then used them to make the walls. It's still standing!

D. Paper Towels

By mistake, a factory made rolls of paper that were too thick for toilet paper but too weak for most other uses. But where others see problems, engineers see possibilities. The paper was sold as "Sani-Towels," which soon became known as paper towels.

E. Paper Batteries

They're smaller than a postage stamp but can power a light bulb! And they decompose in landfills. Engineers are still figuring out how to get them to work with all our gadgets.

F. Paper Dresses

Engineers created paper outfits that could be printed with designs. They were sold in boutiques and in stationery stores, where you could get a tablecloth to match!

(Answers: A: 1995; B: 2004; C: 1922; D: 1931; E: 2007; F: 1967)



Watch the **DESIGN SQUAD** Cardboard Furniture episode on PBS or online at pbs.org/designsquad.



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