Building BIG

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Activity: Building Challenges

General Tips

• The materials listed for each challenge are suggestions. You can limit or increase the choice of materials depending on what materials are available to you.
• Give kids the challenges ahead of time so they can think about possible solutions before the activity.
• Form groups of 3 or 4 kids for these activities. To ensure that all group members actively participate, assign roles such as "architect," "materials buyer," and "construction foreperson." Have kids switch roles during the activity.
• Incorporate a "design review" stage. Have kids present their plans to another group and trade feedback. Or, you can act as the City Engineer to provide comments and suggestions on each design. The finished projects can serve as outcomes for performance-based assessment.
• Any of these activities can be extended by adding the consideration of environmental loads such as earthquakes (shaking the table) or wind (using a table fan). Have kids test their structures, redesign them, and test them again.

Bridge Challenge

• This activity is a good follow-up to Tug-Push-Twist-O'War, Straw Shapes, Paper Bridge and Suspension Bridge.
• Remind kids that the span must be 45 cm (about 1.5 feet), so the bridge must be longer than that.
• Place the bridge across two desks to test its strength. Use the paper-cup load tester described in the Suspension Bridge Activity Handout to test each bridge.

Video Connection Afterward, use *Building Small: Bridges* to show how one family met this challenge. See Buy the Video for ordering information.

Web Connection: Interactve Bridge Challenge.

Dome Challenge

• This activity is a good follow-up to Tug-Push-Twist-O'War and Geodesic Dome.
• Remind kids to consider both geodesic and rib-style domes (as in Human Dome). A rib-style dome can be strengthened with buttresses or a tension ring around the bottom.

Video Connection Afterward, use *Building Small: Domes* to show how two kids built a newspaper dome. See Buy the Video for ordering information.

Web connection: Interactive Dome Challenge.

Skyscraper Challenge

• This activity is a good follow-up to Tug-Push-Twist-O'War, Columns, Newspaper Tower, and Straw Shapes.
• Encourage kids to incorporate cross-bracing in their skyscraper designs.

Video Connection Afterward, use *Building Small: Skyscrapers* to show how one family built newspaper towers. See Buy the Video for ordering information.

Web Connection: Interactve Skyscraper Challenge

Dam Challenge

• This activity is a good follow-up to Tug-Push-Twist-O'War and Under Pressure.
• Advance Preparation Combine water and sand in a trash barrel in a ratio of 1/2 gallon of water to 50 pounds of sand. Scoop wet sand into a sloping heap in one end of a clear plastic storage container. Kids can form a river channel in the wet sand and build a dam at one end of the channel.
• To get kids thinking about how they might use the materials, show "Dam Basics" from Dams (use the Program Description to locate this segment).

Video Connection Afterward, use *Building Small: Dams* to show how two kids met this challenge. See Buy the Video for ordering information.

Web Connection: Interactve Dam Challenge.

Tunnel Challenge

• This activity is a good follow-up to Tug-Push-Twist-O'War and Meeting in the Middle.
• Because they cannot use their hands, kids must find a way to dig out the sand and stabilize the sides of the tunnel before laying in the tunnel sections (the toilet-paper tubes). Or, they may model the "shield" method by covering the ends of the tubes with paper and burrowing into the sand.

Video Connection Afterward, use *Building Small: Tunnels* to show how one family met this challenge. See Buy the Video for ordering information.

Web Connection: Interactve Tunnel Challenge.

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Now that you've been exploring materials, shapes, and forces, it's time to put them together in a structure you design and build.

Choose a challenge, and think BIG!

Bridge Challenge
Design and build the strongest bridge you can that spans a distance of 45 centimeters (about 1.5 ft.), using any of these materials:

- drinking straws
- paper clips
- newspaper
- tape
- string or yarn

Dome Challenge
Design and build the widest dome you can that supports a dictionary, using any of these materials:

- drinking straws
- pipe cleaners
- tape
- string or yarn

Skyscraper Challenge
Design and build the tallest skyscraper you can that supports the load of a golf ball, using any of these materials:

- drinking straws
- paper clips
- newspaper
- tape
- 4 toilet-paper tubes
- salt or sand

Dam Challenge
Design and build a dam that blocks a river in a tub of wet sand, using any of these materials:

- popsicle sticks
- aquarium gravel
- 1/2 cup of modeling clay

Tunnel Challenge
Design and build a tunnel through a tub of sand, without touching the

sand with your hands. You can use any of these materials:

- plastic spoon
- 4 toilet-paper tubes
- paper
- tape
- paper cup

Activity: Columns

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Time
10 minutes

Materials
(per group of two)
• 2 empty toilet-paper tubes (but have lots of extras, as kids will want to try again and again)
• sand or salt
• dishpan, tray, or
• cardboard box lid to catch any spilled sand or salt
• masking tape
• sturdy chair
• funnel

Video Connection
After the activity, show "Chicago" from Skyscrapers to demonstrate how columns support loads in compression. (Check the Program Description to locate this show segment.)

Try the Forces Lab.

For more information, see Additional Resources.

Icebreaker
Hold up a toilet-paper tube and announce that you are going to stand on it. Ask: Do you think this tube will hold me up? (Kids will probably say no; if they say yes, ask what the maximum weight they think it can support is–a car? an elephant?). Now introduce the activity challenge–to find a way to make a toilet-paper tube support a person's weight.

Lead the Activity
• Supervise this activity carefully to ensure kids' safety. Limit testing to one person at a time. Have someone sit in the chair to hold it steady while the tester leans on the back of the chair.

• Instruct kids to step evenly on the top of the tube. They may observe on their own that a slight lean in any direction causes the tube to crumple more quickly on that side. Placing a piece of cardboard over the top of the tube may help distribute weight more evenly.

The Big Idea

Kids may find different solutions to increase the strength of the tube. Reinforcing the sides of the tube by wrapping it with bands of tape makes it a little stronger. The tape increases the stiffness of the sides of the tube and helps it resist buckling under the load.

Placing tape over the ends of the tube and filling the tube with sand or salt increases its strength enough to hold a person's weight. The load is distributed evenly by the material inside the tube. The sand's tendency to spread out is resisted by the sides of the tube, which hold it in and enable it to support the load. In construction, a thin-walled column can be filled with inexpensive material which still greatly increases the column's strength in compression.

Build on It
Supply additional materials (such as marbles or pebbles) for kids to test their predictions. Possible outcome: Kids may find that the smaller particles work better because they push out more evenly against the sides of the column.

Make Connections
Math Use the tubes to discuss circumference, diameter, and area of circles. Ask kids to predict which can support a greater weight: a single column with a circumference of 24 cm or three columns with circumferences of 8 cm each? Have them test their predictions. Possible outcome: Kids will probably find that the answer depends on how they arrange the columns. Three smaller columns arranged a small distance apart in a triangular shape may support more weight than a single large central column.

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Activity: Columns

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Can a toilet-paper tube support your weight?
Columns are often used to hold up heavy loads, such as the roofs of buildings. The heavy load pushes on the column, putting it in compression. So, a good column should be very strong in compression.

What You Need

- 2 empty toilet-paper tubes
- sand or salt
- dishpan, tray, or cardboard box lid
- masking tape
- sturdy chair
- funnel

Make a Prediction
Predict whether a toilet-paper tube can withstand the compression caused by your weight. Explain the reason for your prediction.

Try It Out
1. Place an empty dishpan, tray, or box lid on the floor. Stand an empty toilet-paper tube (the column) on one end in the pan.

2. While holding on to the back of the chair with both hands, gradually press straight down on the top of the column with one foot. Continue increasing your weight on the column until it collapses. Use this scale to rate the column's strength:

1	Very weak! It crumples or breaks with hardly any force.
2	Only fair—it canít withstand much force.
3	Pretty good—it takes a lot of force to break it.
4	Super strong! We can't break it.

3. Observe the collapsed tube to see where it failed. How can you make the column stronger, using only tape and sand? Repeat Step 2 using the second toilet-paper tube and your new design.

Explain It
How did the strength ratings for the two columns compare? Explain what you think accounted for any difference. Were you surprised by

the results of this activity? Why or why not?

Build on It

Is there any difference in strength between a column filled with small particles, like sand or salt, and a column filled with big particles, like marbles or pebbles? Make a prediction and test it.

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Activity: Geodesic Dome

Time
60–90 minutes
(depending on number of participants)

Materials
(for the whole group)
- many newspapers
- measuring tape
- masking tape (colored, if possible)
- markers, glitter, beads, and glue for decorating, if desired
- hand wipes for cleanup

Video Connection
Before the activity, show "Geodesic Domes" from Domes to introduce domes constructed from triangles. (See the Program Description to locate the show segment.)

See Dome Overview.

For more information, see Additional Resources.

Icebreaker
- Have kids form domes by bending a few sheets of newspaper into a bowl shape. They will quickly note that the domes cannot support much of a live load. Then show kids the video segment suggested above or pictures of geodesic domes (such as Epcot Center in Orlando). Ask: What shapes do you notice in these domes? Why do you think these shapes were used? (Triangles; they are a stable shape because compression acting at one joint is balanced by tension along the opposite side.)
- Have kids build miniature geodesic domes using gumdrops and toothpicks. Let them experiment on their own or direct them to build the model shown here.

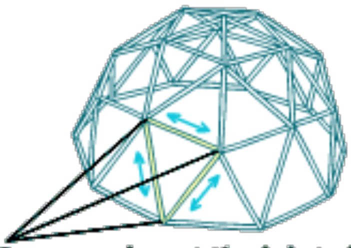
Lead the Activity
- Rolling the newspapers and measuring the tubes is time-consuming. This activity works best with large groups, so that each kid is only rolling a few tubes. Assign at least one adult "foreperson" to coordinate the dome assembly. Have kids decorate their tubes and attach them to the growing dome with an adult's help.

• The dome's joints are weak spots. Use plenty of tape to reinforce them.

• For safety, remind kids not to climb on the completed dome. Test the dome's strength by loading the top with magazines.

The Big Idea

A dome must support its own dead load as well as the live load of wind, rain, snow, or ice. The geodesic dome's strength is due to the fact that triangles are very stable shapes. It is difficult to distort a triangle; compression at one joint is balanced by tension along the opposite side (see Straw Shape). The geodesic dome's design distributes loads over all of the different triangles that comprise it.



Compression at the joints is balanced by tension in the sides.

Build on It
Possible outcome: Kids may add tension rings around the bottom of the dome or divide some or all of the triangular panels into smaller triangles.

Make Connections
Math Triangles are a shape that can be tesselated, or arranged to form a tiling pattern. Have kids predict what other shapes can be tesselated (hexagons, squares). Kids can cut the shapes out of paper and test their predictions.

Activity: Geodesic Dome

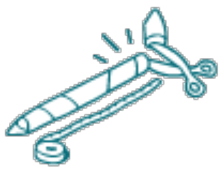
What's the strongest dome you can build out of newspaper?
A geodesic dome is a dome formed by joining triangles together. You can build a giant geodesic dome out of newspaper. First, gather some friends or family members to help you.

What You Will Need
• many newspapers
• masking tape
• measuring tape
• markers, glitter, beads, and glue for decorating

Make a Prediction
Predict how many magazines you think your newspaper dome will be able to support.

Try It Out
1. Stack three flat sheets of newspaper together. Starting in one corner, roll the sheets up together as tightly as you can to form a tube. When you reach the other corner, tape the tube to keep it from unrolling. Repeat until you have 65 tubes.

2. Now cut down the tubes to make 35 "longs" and 30 "shorts." Longs: Cut off both ends of a tube until it is 71 centimeters long. Use this tube as a model to create 34 more longs. Be sure to mark all the longs clearly in some way, such as with colored tape, so you can tell them apart from the shorts. Decorate the tubes if you like.



Shorts: Cut off both ends of another tube until it is 66 cm long. Use this tube as a model to create 29 more shorts. Decorate the tubes if you like.

3. First, tape 10 longs together to make the base of the dome.

4. Tape a long and a short to each joint. Arrange them so that there are two longs next to each other, followed by two shorts, and so on, as shown.

5. Tape the tops of two adjacent shorts together to make a triangle. Tape the next two longs together, and so on all the way around.

6. Connect the tops of these new triangles with a row of shorts. (The dome will start curving inward.)

7. At each joint where four shorts come together, tape another short sticking straight up. Connect this short to the joints on either side with longs, forming new triangles.

8. Connect the tops of these new triangles with a row of longs.

9. Finally, add the last five shorts so that they meet at a single point in the center of the dome. (You might need to stand inside the dome to tape them together.) To test your dome's strength, see how many magazines you can load on top.

Explain It
How strong is your dome? Did the results surprise you? Why or why not? What was the hardest part about creating the dome?

Build on It
How could you make your dome stronger without interrupting the space underneath it? Make a prediction and test it.

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Activity: Hang in There

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Time
25–30 minutes

Materials
(per group of four)
• 60 cm (about 2 ft.) each of several cables, such as yarn, thread, dental floss, and fishing line
• 2 empty 2-liter plastic bottles with caps, or a metal bucket with handle
• 2 pipe cleaners, or a metal "s"-hook
• broomstick or pole
• dishpan
• measuring cup
• funnel
• sand, salt, or water

Advance Preparation
For younger kids or kids with fine-motor difficulties, you may want to tie loops in the cables ahead of time to reduce the time needed for this activity.

Video Connection
After the activity, use "Golden Gate" from Bridges to show some ways to make cables stronger. (See the Program Description to locate this show segment .)

Web Connection
Try the Forces Lab

For more information, see Additional Resources.

Icebreaker
Introduce the term "cable" by discussing elevators. Hold up a piece of yarn, string, or fishing line. Ask: Would you ride in an elevator hung from cables made of this material? (Kids will probably say no.) To show that it is surprisingly difficult to break the material in tension, wrap the ends of the cable around two pencils and pull the pencils apart. (The pencils keep you from hurting your hands.) Now introduce the activity–measuring just how much weight different cables can support.

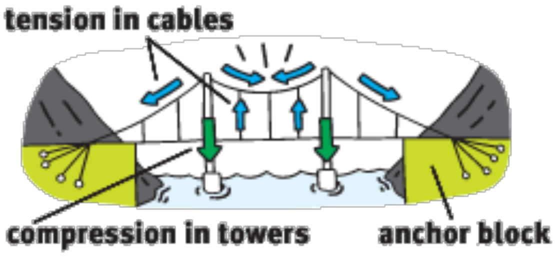
Lead the Activity

• Instruct kids to pour the sand only as fast as it passes through the funnel. This prevents clogging the opening and allows more accurate measurement of how much sand the cable can hold before it breaks. If you are using water, tell kids to support the bottle as they add each cupful of water, and then replace the bottle cap before letting go of the bottle again. This will prevent spills when the cable breaks.

• As the load gets heavier, have kids move the desks or chairs closer together to ensure that the broom handle doesn't break. If the soda bottle touches the floor before a cable breaks, the pole can be raised and held by hand.

The Big Idea

Unlike many other parts of structures, which experience combinations of compression and tension, cables support loads purely in tension. Thicker cables are not necessarily stronger than thinner cables. The particular material of the cable, as well as how the cable is formed, determine its strength and stretchiness. In this activity, kids will likely find that sewing thread is relatively weak and that fishing line is strong, with yarn and dental floss falling in between. Kids will probably be surprised at how much weight the different cables can support.



Different uses require cables with different degrees of stretchiness. For example, the non-stretchy wires that support tall radio towers keep the towers from moving too much. On the other hand, because ship mooring cables are stretchy, they can act as shock absorbers during storms. A fishing line's stretchiness allows it to absorb a sharp but short jerk that would snap a non-stretchy cable.

Build on It

Possible outcome: Kids may try twisting or braiding several lengths of cable or wrapping different kinds of cable together. Draw comparisons to the actual methods used in suspension bridges and elevator cables. (You may wish to show the video segment suggested above.)

Make Connections

Music In many musical instruments, putting metal or gut strings into different levels of tension creates a range of sounds. Kids can experiment with rubber bands stretched across pushpins on a board to find the right lengths to produce an eight-note scale.

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Activity: Meeting in the Middle

Time
15 minutes

Materials
(per group of two)
• large piece of corrugated cardboard or foam-core board
• 2 books or blocks
• 2 ballpoint pens
• paper
• ruler

Video Connection
After the activity, show "Hoosac Tunnel" or "The Chunnel" from Tunnels to emphasize the importance of measurement and communication to tunnel building. (Check the Program Descriptions to locate these show segments.)

Try the Tunnel Challenge.

For more information, see Additional Resources.

Icebreaker
Play a game of "Hot and Cold" to have kids locate an object in the room. Use the game as a starting point for a discussion about the best ways of communicating information and directions, including giving specific measurements.

Lead the Activity
• Kids may ask questions about what they are "supposed to" do in describing the location of their tunnel. Remind them that the goal is to enable their partners to draw a matching tunnel entrance (size and location) on the other side of the cardboard, and part of the challenge is to choose a way of communicating that information as completely as possible.
• Encourage kids to consider different ways of communicating the locations of their tunnel entrances using the materials they have.

The Big Idea

One challenge of tunnel engineering is making precise measurements to ensure that teams building from each end of the tunnel come together in the middle. This activity shows students the importance of choosing which measurements to make and communicating them accurately. Kids may measure points on the circle from different sides of the cardboard, or divide the cardboard into imaginary fractions.


David Macaulay demonstrates surveying equipent in 'Hoosac Tunnel' from Tunnels.

Build on It
Provide simple building materials, such as drinking straws and paper clips or toothpicks and gumdrops, for kids to use for their designs.

Make Connections
Language Arts Have kids write instructions for a simple task, such as making a peanut-butter sandwich or putting on a jacket. Remind them to use specific language and descriptive nouns, prepositions, and adjectives. Then have them trade instructions and carry them out to the letter to see what details are missing.

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Activity: Meeting in the Middle

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How good are your directions?
One major challenge of building a tunnel is making sure that the teams digging from each side meet in the middle. In this activity you will need to describe the location of a tunnel opening on one side of a piece of cardboard to your partner, who will try to recreate it on the other side.

What You Need

• large piece of corrugated cardboard or foam-core board
• 2 books or blocks
• 2 ballpoint pens
• paper
• ruler

Make a Prediction
Predict how close your partner will be able to get to your tunnel entrance. Why do you think so?

Try It Out
1. Stand the cardboard up on one edge between you and your partner. Place a book on each side of the cardboard to hold it up.

2. Holding onto the cardboard to keep it standing, draw a circle about the size of a penny somewhere on your side of the cardboard. Label the circle A. This is the entrance to Tunnel A. Your partner should draw a circle somewhere on the other side of the cardboard, and label it B (the entrance to Tunnel B).

3. Now describe the location of the Tunnel A entrance to your partner as precisely as you can. Your partner should describe the location of the Tunnel B entrance to you.

4. Based on his or her description, draw the other end of your partner's tunnel on your side of the cardboard. Your partner should do the same.

5. Use the pen to carefully punch a hole where you think your partner's Tunnel B is. Your partner should punch a hole where he or she thinks Tunnel A is. Now turn the cardboard around to see how well you both communicated!

Explain It
How closely did the two ends of each tunnel match up? If one tunnel matched more closely than the other, what do you think accounts for

the difference? How is this challenge like the challenge engineers face in digging a long underground tunnel?

Build on It
Sit back to back with a partner so that you are facing away from each other. As you build a simple structure, describe what you are doing. Your partner should follow your directions at the same time. When you are finished, see how closely the two structures match up.

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