SLENDER TOWER CHALLENGE

Grades 3–5, 6–8, 9–12

45 minutes

DESIGN CHALLENGE

Build the tallest tower with the smallest footprint.

SUPPLIES AND EQUIPMENT

Per whole group:
- ☐ Tape measure

Per team:
- ☐ 1 pair of scissors
- ☐ 10 sheets of paper
- ☐ 1 roll of masking tape

GETTING READY

Choose a wide open building area. You may need to move tables or desks to the side of the room to provide adequate space. Some participants may try climbing on chairs or other structures to build the top of their tower—keep an eye out for unsafe behavior.

If possible, reuse scrap paper instead of using brand-new paper.

Create a chart on which to record each team's name, the base width of the team's tower, and the tower's height.

INTRODUCTION

Show participants the image included with this activity of the tallest US skyscrapers. Then show them the photo of 432 Park Avenue in New York. Ask, "What makes 432 Park Avenue different from other skyscrapers?" (It's extremely slender.) Introduce the term footprint. When talking about skyscrapers, a footprint is the area taken up by the building's base.

Get the participants thinking about slender towers with the following questions:

- What challenges might an engineer face in building a tall building? (Support, weight, wind, etc.)

INTRODUCTION (CONTINUED)

- What makes a building “slender”? (Width-to-height ratio.)
- What unique challenges do we face in making a tower slender? (Little support at the base.)

For young children:

- Is it easy or hard to balance on one foot? Why do you think so? (Smaller area to support you.)
- Imagine you are building a skyscraper. Would you make it skinnier at the top or bottom? Why?

INSTRUCTIONS

Introduce the design challenge: working in teams of 3–4, design and build the tallest tower possible with the smallest footprint.

- Each team gets 10 sheets of paper, 1 roll of tape, and 1 pair of scissors. Teams are not required to use all of their paper.
- Each tower must be at least 3 feet (1 meter) high.

Explain how each tower will be evaluated:

- Each tower will be measured for height and width (at the base). This information will be recorded on a chart.
- The width-to-height ratio of each tower will be calculated. (For young children who have not learned ratios, divide the height by the width to provide a simple score.)

Give each team 10 minutes to plan their designs. They can also think of a team name for you to write on the chart.

- During this time, teams should think about how tall they want to make their tower and how wide it will need to be.
- Participants should also think about the pros and cons of different building methods, like rolling, folding, and so on.
- Encourage teams to draw a quick sketch of what they plan to build, and think about where to use the tape and how (using it to strengthen the paper and/or to connect each piece of paper to the next).

Give teams 20 minutes to build their towers. During the build time, circulate and observe each team’s plan and teamwork. For fun, try interviewing team members as if you were a sideline reporter at a sporting event.

Evaluate each tower. Measure the widest part of the base and the tower’s height. Calculate the width-to-height ratio (or have the participants do this themselves). Record the data on the chart. Announce each team’s results. Share highlights of your observations.

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ACTIVITY VARIATIONS

Since a tower is a cantilever, pair this activity with Build a Diving Board. Compare the forces at play on vertical and horizontal cantilevers.

Provide different building materials, such as plastic bricks, wooden unit blocks, paper tubes, and so forth.

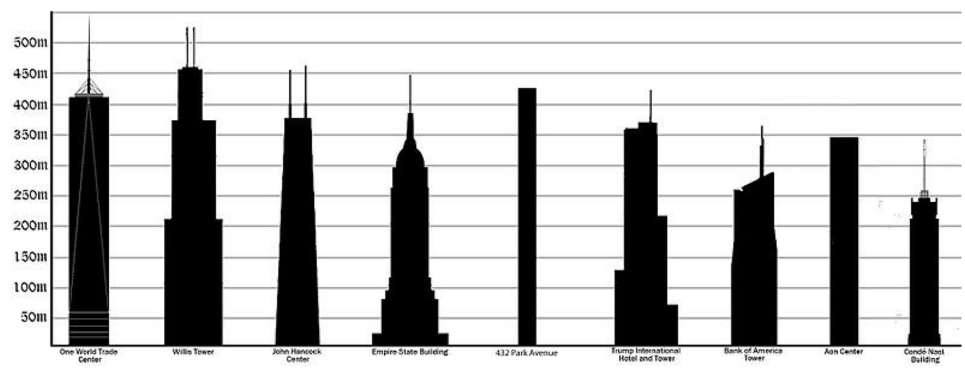
Have a contest with prizes for the tower that best meets the criteria of the design challenge. Create a leader board to show off the best structures.

Require the tower to support a certain amount of weight, or to withstand wind from a fan.

RELEVANT TERMINOLOGY

Footprint: The area taken up by a building's base.

Slenderness ratio: The ratio of a skyscraper's width to its height. Engineers consider buildings "slender" if they have a width-to-height ratio of at least 1:10 or 1:12.



US skyscrapers ranked by height. 432 Park Avenue in New York City (center) is 93 feet wide and 1,396 feet tall. This gives 432 Park Avenue a slenderness ratio of 1:15. Credit: Ali Zifan/Wikimedia Commons.

432 Park Avenue in New York City is a very slender skyscraper that towers over neighboring buildings. Credit: Alexander Caravitis/Wikimedia Commons.

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GUIDANCE FOR YOUNGER CHILDREN

QUESTIONS TO ASK AFTER THE ACTIVITY

- What problems might slender buildings face that regular ones don't?
- What other materials do you wish you had on hand to build your tower?
- Why is it important for architects and engineers to think about the height of their buildings? What about the size of the bottom of the building (the footprint)?
- Think of slender buildings that you have seen in your own city or a city near you. Does your team's tower look like them? How is your tower different?

ENGINEERING CONNECTIONS

Think about the tallest building you have ever seen. What did it look like? Did you wonder whether it was going to fall over? You probably didn't, but that is something that engineers must consider very carefully when designing skyscrapers or tall, slender buildings. Engineers who design buildings are called structural engineers. They work hard to solve problems, just as you did with this challenge. They have to think about what type of building is needed, how much space they have to build it, what types of materials are available, how to anchor the building to the earth, and how much time the design and construction will take. They also need to be sure that their skyscrapers will be safe and sturdy and be able to stand up to high winds. Cities are always growing and changing. To keep up with these changes, engineers develop new and stronger building materials. They also create new, modern, beautiful designs for buildings.

SCIENCE CONNECTIONS

Did you know that skyscrapers move? That's right: they move! Imagine a giant tree in the wind. To avoid breaking in strong winds, it sways. That is, it moves a bit with the wind without ever leaving its spot in the ground. Skyscrapers must be built to stand up to strong pushes from the wind, as well as other pushes and pulls, or forces, that occur during earthquakes, for example. These tall, slender buildings are designed to move just a little bit so that they don't break. They don't move enough that you would notice it if you were standing in the building—it's just an inch or so—but it's enough to help strengthen the skyscraper in rough or windy weather. Another way that these buildings keep their balance is through their base, or foundation, which works like the roots of the tree to anchor it to the ground. Try standing on one foot and swaying a little bit. It's pretty tough, right? Now try it on two feet. It's likely much easier. It's the same idea with skyscrapers: having a larger base that is firmly attached to the earth will help to support a tall building, even when it gets pushed around by wind, storms, or even earthquakes.

GUIDANCE FOR OLDER YOUTH AND ADULTS

QUESTIONS TO ASK AFTER THE ACTIVITY

- Why did you build your tower the way you did? If you had additional time, how would you modify your tower design?
- What materials would you have liked to use to help your team with this challenge?
- What might be some advantages to a slenderer tower design?
- What additional variables would an engineer have to consider when designing a skyscraper?
- Why is it important for engineers to consider the width-to-height ratio when designing buildings?

ENGINEERING CONNECTIONS

The Home Insurance Building, built in Chicago in 1885, is considered to be the first modern American skyscraper. It was the first building to feature a steel frame construction. Although it was a marvel in its time, it would be dwarfed by today's skyscrapers. Even though engineers still rely on steel and concrete for these massive buildings, a combination of creativity and technology have led to many developments in the design and materials of modern skyscrapers. Modern tastes and space restrictions demand that engineers develop towers that are taller than ever before, while also being attractive and innovative, to fit in with the existing urban environment while safely withstanding wind and other forces. In addition to all of those considerations, engineers must balance the need for state-of-the-art materials with the constraints of a given budget. Talk about a challenge! As a result, engineers have modified traditional designs and materials to produce ever-evolving building types that take into account aerodynamics and functionality. As towers become increasingly slender, various features must be added to strengthen the structure against the forces of high winds and to diminish or disperse wind resistance.

SCIENCE CONNECTIONS

Imagine carrying a friend on your shoulders. Supporting your weight and your friend's weight would be hard, but doable. Now imagine there is also a person on your friend's shoulders—you would have a tower made of three people. How would that feel? Heavy and unstable! Cheerleaders know how to make this work. They build a human pyramid to provide stability and to support the weight of the people at the top. Skyscrapers work the same way. They are usually widest at the base, which helps to distribute their weight over a larger area and make them more stable.

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