

Global Precipitation Measurement Mission

Building for Hurricanes: Engineering Design Challenge Teacher Guide

Overview:

This activity is a short engineering design challenge that can be completed by individual students or small teams. It can be done by students of all ages, although upper elementary school and above is best. The idea is to present a real-world problem, designing buildings for hurricane-prone areas, but in a simulated way that works in a classroom, after school club, or informal education setting.

Students are given simple materials and design requirements, and must plan out and build a tower as tall as possible that will hold up a tennis ball while resisting the force of wind from a fan. For an extra challenge, a spray bottle can be used to simulate rain.

After the towers are built, the group comes together to test them. This is also an opportunity to discuss how there are often different ways to solve the same problem. If there is time after testing, which can be observational or framed as a contest between teams, students can redesign their towers to improve their performance, or simply discuss what worked well and what didn't in their designs. Depending on how much time you give students to design and build (and possibly rebuild), this activity could be completed in as little as half an hour or up to an hour or more.

Objectives:

- Students will use given design criteria to build a tower out of simple materials, test it and potentially redesign and rebuild it to improve performance.

National Standards:

Core Idea ETS 1—Engineering Design

- MS-ETS1-2—Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem
- MS-ETS1-3—Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Materials:

Suggested building materials to provide each group (vary as needed based on what is available):

- index cards (4-8)
- straws (~10)
- craft sticks (4-8)
- string (~3 feet/~1 meter)
- chenille stems/pipe cleaners (4-8)
- tape (limited or unlimited amount –see *Teacher Notes* for tips)

Tools to provide each group to help them build (may not be part of the final tower):

- scissors
- ruler
- tennis ball
- [capture sheet](#) for planning and analysis of results (or just paper and pencil)
- fan and/or spray bottle with water for testing
- copy of challenge instructions
- copy of tower examples/structural elements from [Hurricane Towers PowerPoint](#) (optional)

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Teacher Notes:

- The accompanying PowerPoint presentation, [Hurricane Towers PP](#), outlines the instructions and gives a few examples of actual towers and structural components. It could be projected on a screen, or a copy made for each group.
- Instead of tape, consider giving each group part of a sheet of sticky mailing labels. They are easier to have ready to hand out to multiple groups (such as in pre-made supply bins), and ensure that each group gets the same exact same quantity if you are framing it as a competition. Alternatively, to make the challenge a bit easier, you could give each group a roll of tape and allow them to use as much as they'd like.
- For testing, ensure all towers are placed the same distance away from the fan—about a foot works well for most fans. If you are going to simulate rain with a spray bottle, you may want to do the testing outside, or put down plastic sheeting. Make sure to remind students that they will have to move their tower to the testing site, so it must be able to be moved (i.e. not taped down to the table).
- Be sure to remind the students that the height of the tower is measured from the ground to the bottom of the tennis ball as specified in the directions. This prevents designs that sit the tennis ball on the ground and built a tower around it, which defeats part of the purpose of the design challenge: to support weight. Also, this means that antenna-like protuberances on the top won't add to their height value. You can choose to allow them to attach tape to the tennis ball or just rest it on or in the tower—just be sure to specify which ahead of time.
- If you wish to make this a competition, here are a few possibilities for scoring:
 - With a single-speed fan, multiply the height of the tower (measured to the bottom of the tennis ball) times the amount of time the tower stands before collapsing or blowing over.
 - With a variable speed fan, you can start on the lowest speed and after a fixed period of time turn up the fan to the next level, then after the same length of time to the third level. The score could then be the level of the fan times the height times the amount of time withstood at the highest power the fan was on before the tower blew over or collapsed. For example, a tower that is 20 cm tall and stood for 15 seconds at level 2 (medium) power before collapsing would score $2 * 20 * 15 = 600$ points.

For either of the above options, you will probably want to determine ahead of time a maximum amount of time you will leave the tower in front of the fan—say 30 to 45 seconds. If several towers achieve that maximum, the tallest one wins!

Additional Resources:

- This activity is adapted from PBS Kids Design Squad: High Rise. The site has other interesting design challenges to check out.
http://pbskids.org/designsquad/parentseducators/resources/high_rise.html
- A similar activity using newspaper can be found here:
http://www.pbs.org/wgbh/buildingbig/educator/act_tower_ei.html
- For examples of different types and parts of structures, as well as additional activity ideas, visit: <http://www.technologystudent.com/struct1/struindex.htm>. On their list, numbers 36 ([frames](#)), 37 ([sections and beams](#)) and 38 ([struts and ties](#)) may be especially useful.

Building for Hurricanes Engineering Design Challenge Instructions

Whether you live in an area prone to hurricanes or not, you've seen images of the destruction caused by such storms. Data from satellites like the Tropical Rainfall Measuring Mission and soon the Global Precipitation Measurement mission have vastly improved our ability to forecast the track of storms, and has led to insights that allow us to know when a storm will intensify. Builders in areas at risk for hurricanes still need to plan for that in their designs. That is the role you will take on today—designing a building that can withstand a (simulated) hurricane.

Identify the Problem:

Your challenge is to build a freestanding tower that can support a tennis ball as high as possible off the ground (measured from the bottom of the tennis ball) while withstanding the wind from a fan. (Optional extra tough challenge: add a spray bottle to represent rain!)



The materials you will have available will be from the following list: index cards, straws, craft sticks, chenille stems, tape or other adhesive, string. Other materials may also be provided.

You will also have paper and pencil for brainstorming, scissors, a ruler (none of which may be part of your final tower) and a tennis ball to help you design, build and test your tower. Remember, the tower needs to be freestanding. That means you can't tape the tower to the table!

Generate Ideas:

Before you begin designing, think about answers to the following questions. Use the paper given for brainstorming to record your ideas.

- Which combination of materials will make the tower as tall as possible (measured to the bottom of the tennis ball)?
- What tower shapes could you use? Should your base be round? Square? Triangular?
- Can you be creative about using the materials in an unexpected way?
- How can you get the tower to be freestanding, not taped to the table, and yet not fall over?
- Think about the forces on the tower, wind from the side and gravity pulling down. How you will build your tower to resist them?

Develop and Test Solutions:

Once you've decided on your design, work as a team to build your tower! When everyone is finished, we'll share your designs and put them to the test with the fan. If you have time, try to redesign your tower with what you've learned from testing.

Adapted from http://pbskids.org/designsquad/parentseducators/resources/high_rise.html.