# SPAGHETTI TOWER

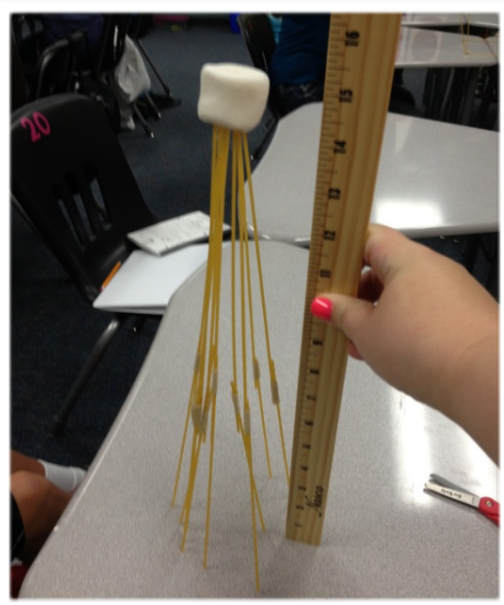
*Inspiring the scientist in every student!*

Students build the tallest freestanding structure they can that will support a regular-sized marshmallow for at least 15 seconds. Sounds easy, but solving this engineering problem requires curiosity, imagination, and patience!

A marshmallow might not seem like a difficult mass to support, but it can be when the only materials available are spaghetti sticks and tape. The same forces—gravity and wind—that engineers take into consideration when constructing a cellphone tower, highway bridge, or skyscraper also come into play when building a spaghetti structure.

Have fun and good luck!
Bill Earl and Sandra Shoshani, Santa Fe Alliance for Science

## Investigation Challenge



- *Goal and Materials*: Build the tallest free-standing structure you can using no more than 20 sticks of thick spaghetti, one yard of adhesive tape, 1 regular-size marshmallow, and a watch for tracking how much time it takes to complete the investigation. The tape is used to connect sticks of spaghetti (see photo at right).[1] If a regular marshmallow isn't available, use three soft gummy bears or any small object that weighs about the same amount and that can be placed on top of the tower. Your tower should be designed to support the marshmallow for at least 15 seconds.
- *Duration*: 30 minutes to design and build three different structures.

[1] Photograph from Live, Love, Math.

- *Rules and Procedures*:

  *Step 1: Read* all instructions and discussion questions.

  *Step 2: Collect* your materials and *plan* how to build your first structure.

  *Step 3: Build* your tower. The tower itself must stand on its own—it cannot be propped up by, or suspended from, another object. Break up the spaghetti sticks or tear apart the adhesive tape if you want smaller pieces. *Measure* the height of your first tower and write down the result.


  *Step 4: Test* the strength of your structure by carefully placing the marshmallow (or other object) on the very top of the tower. Do not change the marshmallow's shape. Does your tower design pass the 15-second test?

  *Step 5: Record* your results by photographing, videotaping, or drawing a diagram of the tower and marshmallow after the 15-second test period. *Write down* what happened even if the tower falls or breaks.

  *Step 6:* Based on what you learned from the first tower, *design and build* a second tower that you believe will be taller and stronger than the first. Write down the improvements you have made to your original design. Use a fresh set of materials to build the second tower. *Test* and *record* the results.

  *Step 7:* Brainstorm how the second structure might be further improved. How might the design or materials be changed so that the third tower is taller and better supports the marshmallow's weight? *Build* a third structure using your new ideas. *Test* and *record* the results.

- *Questions for Discussion*: In your record of investigation results, answer each of the following questions.

  1. What forces cause the tower to tip over?
  2. What changes did you make to the tower design when building the second and third structure?
  3. What building techniques make the tower stronger?
  4. How did using tape connectors add strength to the tower?
  5. What features of your design helped your tower reach new heights?

6. Could you have built a stronger (not taller) tower with more of the same materials? What alternative materials might have produced a stronger tower?
7. How does a change in the size of the tower foundation (base) change the strength of the tower?
8. Engineers early ideas rarely work out perfectly. How does testing help improve your design?

## TEACHER'S CORNER[2]

NGSS 3–5: Engineering Design Process ETS1-2

Many forces are at work on towers. Gravity and the dead load of the tower push down; the ground pushes back up, and small air movements push from the side. A tower foundation distributes the structural load into the surrounding ground material and can help balance the sideways wind force. The size of the foundation depends on the strength of the supporting ground. A foundation placed in rock can be smaller than a foundation placed in sand or mud.

### *KEY CONCEPTS*

- *Bending:* Combination of forces that causes one part of a material to be in compression and another part to be in tension.
- *Compression:* Force that squeezes material together.
- *Design Process:* Identify the problem, brainstorm, design, build, test, evaluate, share, redesign and rebuild.
- *Load-bearing members:* To support or strengthen a roof, bridge or other elevated structure with a network of beams and bars.
- *Mass:* The mass of an object is a measure of its resistance to acceleration. Mass is not the same as *weight*. An object on the moon would weigh less than it does on Earth because of the moon's lower gravity, but it would have the same mass on Earth as it does on the moon.
- *Tension:* A force that pulls material apart.
- *Truss:* Support something with a structure.

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[2] This activity is part of the National Aeronautical and Space Administration's Jet Propulsion Laboratory's *Engineering in the Classroom* tool for educators.

Watch the TED Talk "Build a Tower, Build a Team" in which designer Tom Wujec describes how the spaghetti tower activity is a revealing lesson in team (multi-person) collaboration.[3]

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[3] Source: This STEM Challenge was adapted from NASA Jet Propulsion Laboratory, California Institute of Technology: "Activities: Spaghetti Anyone? Building with Pasta".