Fuller's Fantastic Geodesic Dome

This lesson was created as a supplement to the *Fuller's Fantastic Geodesic Dome* program at the National Building Museum. It is designed to be used in your classroom independently, or as an activity before or after a school program at the Museum. For more information about and to register for the National Building Museum's school programs, visit http://www.nbm.org/schools-educators/school-visit/.

The *Fuller's Fantastic Geodesic Dome* program teaches fifth through ninth grade students about principles of engineering and design. Through studying geodesic domes, students are exposed to an innovative solution to the ongoing challenge of creating structures—how to maximize space while creating a strong, cost-effective, people-friendly structure. By studying the geodesic dome and its construction, students learn about materials, structures, and forces present in all buildings.

National Building Museum

Created by an act of Congress in 1980, the National Building Museum explores, celebrates, and illuminates achievements in architecture, design, engineering, construction, and planning. Since opening its doors in 1985, the Museum has become a vital forum for exchanging ideas and information about such topical issues as managing suburban growth, designing and building sustainable communities, and revitalizing urban centers. A private, nonprofit institution, the Museum creates and presents engaging exhibitions and education programs, including innovative curricula for school children.

Over the past two decades, the Museum has created and refined an extensive array of youth programming. Each year, approximately 50,000 young people and their families participate in hands-on learning experiences at the Museum: 2-hour-long school programs for grades K–9; major daylong festivals; drop-in family workshops; programs helping Cub and Girl Scouts earn activity badges; and three innovative outreach programs, lasting between 30 and 60 hours, for secondary school students. The Museum's youth programming has won the Washington, D.C., Mayor's Arts Award for Outstanding Contributions to Arts Education and garnered recognition from the National Endowment for the Arts.

NATIONAL BUILDING MUSEUM
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202.272.2448/www.NBM.org
Red Line Metro, Judiciary Square

Understanding Forces at Work: Compression and Tension

In any structure, there are always two forces at work—compression and tension. Architects and engineers must consider these forces when they design or construct buildings.

Domes, like all built structures, rely on unseen forces that hold them together and enable them to support additional weight, or loads. It can be difficult to visualize forces acting on an object or structure that appears to be at rest. This activity is designed to help students imagine these unseen forces and, thereby, better understand the mechanics of domes.

OBJECTIVES

Students will:

- examine how forces act upon an everyday object, a chair; and
- define compression and tension and find elements under these forces in their classroom or school building.

NATIONAL STANDARDS OF LEARNING

Mathematics . . . . Connections, Problem Solving

Social Studies 4

Science. . . . . B, E

DURATION

Two class periods, 45–60 minutes each

MATERIALS (for students)

- Chair
- Magic markers
- Soft kitchen sponges, at least 1” thick (1 per 2 students)
- Rulers
- Hardcover books

LESSON PROCEDURE

1. Define and demonstrate forces using an everyday object, such as a chair.

2. Define and demonstrate compression and tension. In teams, students search for elements under compression and tension in the classroom or school building. Compare the findings.

3. Investigate how forces act on a surface using a sponge.

TEACHER PREP

- Scope out several places in your classroom and school building that have elements under compression and tension.

GEODESIC DOME VOCABULARY

Compression, Force, Structure, Tension

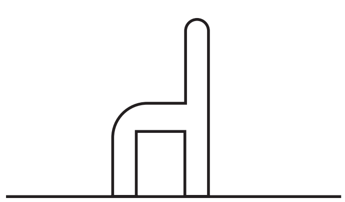
LESSON PLAN

PART I. Define and Demonstrate Forces (10 minutes)

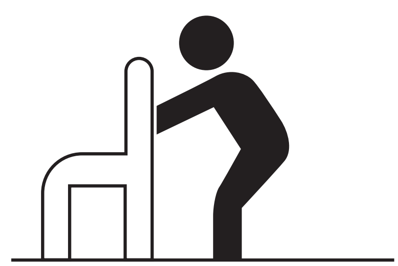
Discussion and Demonstration

1. Explain that a force is a push or pull on an object. When an object is at rest (not moving), the forces acting on it are balanced.

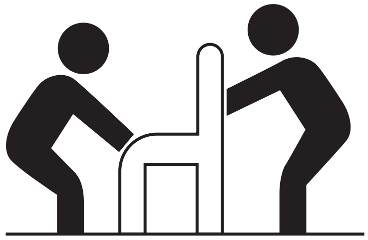
2. Place a chair in the middle of the floor. Ask students whether there are any forces acting on this chair. Even without anyone pushing on the chair, there are forces acting on it. The force of gravity is pulling down on the chair, but it does not collapse because it supports its own weight.



3. Have a student push the chair a short distance across the floor. Ask what force just acted on the chair. **Answer:** Pushing the chair unbalanced the forces on it, enabling it to move.



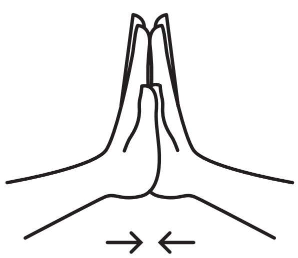
4. Have two students face each other on either side of the chair and push it so that it does not move. Ask students whether there are any forces acting on the chair. If so, why doesn't it move? Although two forces are acting on the chair, they balance each other, causing it to remain in place.



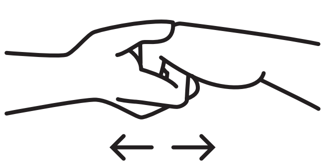
PART II. Define and Demonstrate Compression and Tension (30 minutes)

Discussion and Analysis

1. Explain to students that compression is the act of being pushed or pressed together. Have students place their hands with their palms together and elbows bent. Tell them to press their palms together. This pushing force is called compression.



2. Explain that tension is the act of being stretched or pulled apart. Have students place their hands in front of them and clasp curled fingertips together. Tell them to pull on their hands. This pulling force is called tension.



Action: Force Search

1. Divide the class into two teams.

2. Ask each team to search for building elements under compression and tension in the classroom or school.

3. Give the class a time limit of 15 minutes to find:
   - 5 elements under tension
   - 10 elements under compression.

4. Appoint one group member from each team to write down the information.

5. When the time is up, compare the lists.

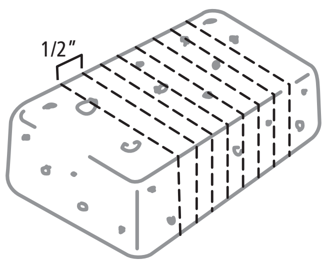
   Examples of elements under compression:
   - walls
   - vertical sides of doors or window frames
   - columns
   - piers

   Examples of elements under tension:
   - cables or strings hanging from the ceiling with an object attached to it, such as a map, poster, or screen
   - arches and triangular structures are in both tension and compression

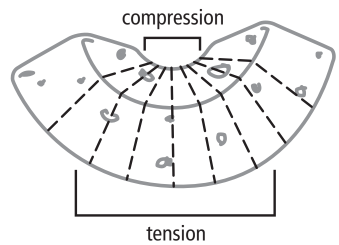
PART III. Investigate How the Forces of Compression and Tension Act on a Surface (30 minutes)

Discussion and Demonstration

1. Arrange students in pairs and give each pair a large soft kitchen sponge. (New sponges work best for this activity because they are flexible.) Have the students draw a series of lines approximately 1/2 inch apart crosswise around the sponge.



2. Next, have the students take turns bending the sponge into a U-shape and observe what happens to the lines. Let them describe what they observe. The lines inside the U-shape get closer together, while the lines outside the U-shape spread farther apart.



3. Ask where the sponge is in compression. **Answer:** the inside of the U-shape. Where is the sponge in tension? **Answer:** the outside of the U-shape. How could students balance out the forces of compression and tension acting on the sponge to make it stronger? **Answer:** Some ideas include using a stiffer material for the beam, or adding supports, such as knitting needles or pencils, to the sponge.

4. Show students the images of the domes (page 22). Based upon the exercise with the sponge, ask them where the compression and tension might be in the domes.

NOTES: