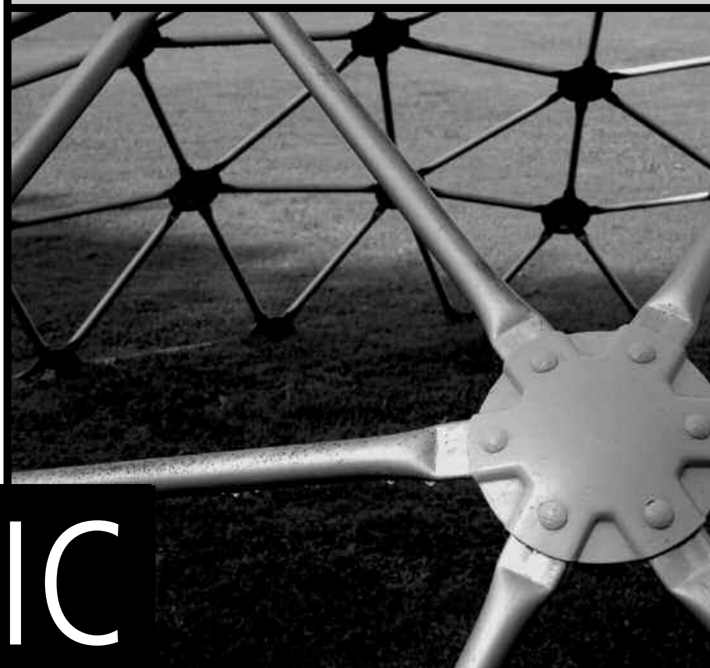
FULLER'S FANTASTIC GEODESIC DOME

EDUCATOR RESOURCE PACKET

GRADES 5–9

FULLER'S

NATIONAL BUILDING MUSEUM



FANTASTIC

GEODESIC

DOME

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, non-profit 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: several different, 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.

The National Building Museum is located in a historic landmark structure at 401 F Street, NW, Washington, DC 20001. To learn more about the Museum, visit www.nbm.org.

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To the Educator

Thank you for selecting the National Building Museum for your field trip. This Educator Resource Packet is designed to supplement the *Fuller's Fantastic Geodesic Dome* program and is intended to help both teachers and students, grades five through nine, recognize geodesic domes and discover their importance in the world around them.

The information, lessons, and activities found in this packet should help you teach structural design concepts to your students. The lessons suggested in this packet are designed for classroom use before and after your students visit the Museum. They encourage young people to explore the complexity of structural design in buildings and help them understand the basic engineering principles of the geodesic dome.

Why Study Geodesic Domes?

A geodesic dome is a system of triangular forms linked together to enclose a space. Of all structures it distributes stress and weight the most economically. Geodesic domes are unusual structures that intrigue students and offer teachers an opportunity to investigate interesting concepts in engineering, math, and environmental science. Geodesic domes are used in unique spaces—stadiums, theme parks, and playgrounds. They generally don't look like the buildings that people use in their everyday lives. 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 used in all buildings.

Why Use Design as an Education Model?

The *Fuller's Fantastic Geodesic Dome* school program and all other education programs at the National Building Museum inspire students to examine the people, processes, and materials that create buildings, places, and structures. All of the Museum's youth education programs use the design process as an educational model. This model requires young people to identify problems or needs, imagine solutions, test them before building a suitable design, and evaluate the product.

Learning by doing is central to design education in general and to the *Fuller's Fantastic Geodesic Dome* program in particular. After engaging in a variety of hands-on lessons that stimulate exploration of structural systems, geodesic domes, and the built environment, students gain a fresh perspective on their surroundings and begin to understand how design decisions impact the built environment.

What Are the Learning Benefits?

The *Fuller's Fantastic Geodesic Dome* program and supplementary lessons in this Educator Resource Packet meet national standards of learning in math, science, social studies, technology, and visual arts. The specific standards are described on page 6.

The lessons in this curriculum encourage young people to explore and recognize how, where, and why geodesic domes are used. Through hands-on, interdisciplinary lessons that address multiple learning styles, the *Fuller's Fantastic Geodesic Dome* program encourages and fosters life skills such as critical thinking, problem solving, team building, and communication.

The Educator Resource Packet Includes

- list of national standards of learning addressed in the program;
- matrix of optional lessons to enhance students' learning experience;
- introductory lessons to more fully prepare students for the *Fuller's Fantastic Geodesic Dome* program;
- reinforcement lessons for use after the Museum visit to help students continue their exploration of geodesic domes and design solutions; and
- vocabulary and lists of supplementary resources.

NOTES:

Program Description

American inventor, engineer, and architect R. Buckminster Fuller may be best remembered for developing the structurally-innovative geodesic dome that is one of the strongest, most cost-effective structures ever devised. The geodesic dome, a system of triangular forms linked together to enclose a space, distributes stress and weight in the most economical way. A geodesic dome's parts are interchangeable enabling it to be easily manufactured and constructed and increase in height while decreasing in width. Although the majority of geodesic dome experimentation and construction took place largely during the 1960s, its popularization and commercialization in the 1970s and 1980s allowed designers to span bigger and larger spaces than previously possible. These domes and other types of space framing are commonly used by architects and engineers and can be seen across America supporting signs, carports, stadium roofs, and concert halls.

Students participating in the *Fuller's Fantastic Geodesic Dome* program will consider traditional architectural structures including: post and lintel, arch, dome, and truss structures, as well as the modern geodesic dome. Working as a team, the students will construct a large geodesic dome in the Great Hall of the National Building Museum and individually assemble a geo ball, or icosahedron, to take home.

The *Fuller's Fantastic Geodesic Dome* Educator Resource Packet includes lessons for classroom use before and after a group's visit to the Museum. These lessons may be used to prepare students for their trip to the National Building Museum and to build upon what they have learned during the *Fuller's Fantastic Geodesic Dome* program. Each lesson includes objectives, connections to specific national standards of learning, list of materials, teacher prep notes, lesson procedures, and vocabulary words.

Goals, Objectives, and Skills Used in the Program

Goals

After completing the *Fuller's Fantastic Geodesic Dome* program and lessons in the Educator Resource Packet, students will:

- have an increased awareness of the geometric shapes and components that make up a geodesic dome;
- understand the basic structural engineering concepts that underlie geodesic dome construction;
- understand the advantages and disadvantages of modern building materials in dome construction; and
- have an increased awareness of more in-depth concepts relating to the study of architecture, geometry, and structures.

Objectives

After completing the *Fuller's Fantastic Geodesic Dome* program and Educator Resource Packet lessons, students will be able to:

- identify and understand the forces of compression and tension and how these forces affect structures;
- identify how triangles and tetrahedrons support and distribute weight;
- identify five roofing systems and understand the advantages and disadvantages of each;
- work cooperatively as a team to assemble a geodesic dome; and
- assemble a geo ball, or icosahedron (a 20-sided geometric shape), individually.

Skills Used

- Analysis
- Application of knowledge
- Cooperative learning
- Experimentation
- Evaluation
- Identification
- Problem solving

NOTES:

National Standards of Learning

The *Fuller's Fantastic Geodesic Dome* program and Educator Resource Packet lessons meet local and national standards of learning in several disciplines. The national standards are outlined below.

Standards for the English Language Arts
National Council of Teachers of English and International Reading Association

Students will	Standard
conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate and synthesize data from a variety of sources to communicate their discoveries in ways that suit their purpose and audience.	7

Principles and Standards for School Mathematics
National Council of Teachers of Mathematics

Students will	Standard
analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships;	Geometry
use visualization, spatial reasoning, and geometric modeling to solve problems;	Geometry
build new mathematical knowledge through problem solving; and	Problem Solving
recognize and apply mathematics in contexts outside of mathematics.	Connections

National Science Education Standards
National Research Council

Students will explore	Standard
properties of objects and materials;	B
form and function;	B, E
abilities of technological design; and	E
science and technology in society.	F

Curriculum Standards for Social Studies
National Council for the Social Studies

Students will	Standard
describe how people create places that reflect ideas, personality, culture, and wants and needs as they design homes, playgrounds, classrooms, and the like; and	3
work independently and cooperatively to accomplish goals.	4

Standards for Technological Literacy
International Technology Education Association

Students will develop an understanding of	Standard
technology and society, including the effects of technology on the environment;	4, 5
design, including the attributes of design and engineering design;	8, 9
the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving; and	10
the designed world, including the use of transportation and construction technologies.	19, 20

National Standards for Arts Education, Visual Arts Category
Consortium of National Arts Education Associations

Students will	Standard
intentionally take advantage of the qualities and characteristics of art media, techniques, and processes to enhance communication of their experiences and ideas;	1
generalize about the effects of visual structures and functions and reflect upon these effects in their own work;	2
employ organizational structures and analyze what makes them effective or not effective in the communication of ideas;	2
describe and place a variety of art objects in historical and cultural contexts;	4
analyze, describe, and demonstrate how factors of time and place (such as climate, resources, ideas, and technology) influence visual characteristics that give meaning and value to a work of art; and	4
describe ways in which the principles and subject matter of other disciplines taught in the school are interrelated with the visual arts.	6

Lessons Matrix

Use the following Lessons Matrix to prepare students for their visit to the National Building Museum and to build upon what they learn during the *Fuller's Fantastic Geodesic Dome* program.

Lesson	Purpose	Standards of Learning	Duration	Materials Needed
Building a Foundation Lessons				
Understanding Forces at Work: Compression and Tension **p. 26**	Introduce students to the forces of compression and tension and geodesic domes.	**Mathematics** Problem Solving, Connections **Social Studies** 4 **Science** B, E	2 class periods, 45 - 60 minutes each	For each student: ▪ a chair ▪ magic markers ▪ ruler ▪ hardcover books For every two students: ▪ 1 soft kitchen sponge
Shapes and Solids: Investigating Triangles, Squares, Pyramids, and Cubes **p. 30**	Experiment with two and three-dimensional shapes and forms to determine the strength of certain shapes.	**Mathematics** Geometry, Problem Solving **Science** B, E **Social Studies** 4 **Technology** 10 **Visual Arts** 1	2 class periods, 45 - 60 minutes each	For each student: ▪ 1 pair of scissors ▪ 3 index cards (4x6") ▪ 11 small brass paper fasteners ▪ photocopy of Triangles vs. Squares,Tetrahedrons vs. Cubes Worksheet **p. 34** ▪ photocopy of patterns **p. 35** For the class: ▪ several single hole punches
Reinforcement Lessons				
Architecture Investigation: Traditional and Geodesic Structures **p. 38**	Examine traditional structures used in buildings and identify these structures in their surroundings.	**Mathematics** Connections **Science** F **Social Studies** 3, 4 **Technology** 4, 5, 19, 20 **Visual Arts** 4	1 class period, 45 - 60 minutes, homework assignment	Structures Investigation Worksheet **p. 40**

Reinforcement Lessons (continued)				
Lesson	**Purpose**	**Standards of Learning**	**Duration**	**Materials Needed**
Geodesic Domes: Take a Closer Look **p. 44**	Connect geodesic domes to the larger society and other areas of the curriculum using these project ideas or homework assignments.	**Language Arts** 7 **Mathematics** Geometry, Connections **Science** B, E, F **Social Studies** 3 **Visual Arts** 2, 4, 6	Teacher's Choice	None
Fun Field Trips: Exploring Your Community **p. 45**	Connect the school work and Museum field trip to students' larger life and involve their families using these fieldtrip ideas or homework assignments.	**Mathematics** Geometry, Connections **Science** B, E, F **Social Studies** 3 **Visual Arts** 2, 4, 6	Teacher/ Family Choice	Teacher/Family Determine

1. Museum Orientation

The information found in this section provides all the logistical details for the field trip to the National Building Museum.

Getting Ready
- Before Visiting the Museum
- Directions
- Map

While You're Here
- Upon Arrival
- Touring the Building and Exhibitions
- Lunches
- Visiting the Museum Shop

The National Building Museum
- Facts About the Historic Home of the National Building Museum

Getting Ready

Before Visiting the Museum

1. Share this Educator Resource Packet with each participating teacher.

2. Select chaperones. *This program requires four chaperones, including the teacher.* Chaperones are expected to actively assist students. You will receive stickers for chaperones to wear while at the Museum in the confirmation packet. These stickers help Museum staff identify chaperones easily.

3. Arrange transportation and obtain permission slips.

4. Contact the Museum's assistant youth groups coordinator at 202.272.2448, ext. 3450, if the number of students changes by five or more.

5. Review the map and directions to the National Building Museum and bring a copy with you.

6. If you would like to tour the building or an exhibition, allow for extra time after your 2-hour program.

Prepare Your Students

1. Use the lessons in this packet to introduce domes and forces concepts to your students before attending the museum program.

Directions to the National Building Museum

The Museum is located between 4th & 5th and F & G Streets, NW in Washington, D.C. It is accessible by Metro and located immediately adjacent to the Judiciary Square Metro station (Red Line). Two-hour metered parking is available on all sides of the building. Buses may park in the G Street driveway (***drivers must remain with the buses***). Please distribute this sheet to the drivers and remind them that the National Building Museum is **NOT** on the National Mall.

From Northern Virginia on I-395

Follow I-395 north into the District.
Take either 14th Street or 12th Street exit northbound.
Follow either 14th or 12th Street north to Constitution Avenue.
Turn right on Constitution Avenue.
Follow Constitution Avenue east to 6th Street, NW.
Turn left on 6th Street, NW.
After several blocks, turn right on F Street, NW.
Follow F Street east to 5th Street, NW.
Turn left on 5th Street, NW.
Turn right on G Street, NW.
Pull into the G Street driveway.

From Northern Virginia on I-66

Follow I-66 east into the District, crossing the Roosevelt Bridge.
I-66 becomes Constitution Avenue.
Follow directions above from Constitution Avenue.

From Maryland southbound on I-95 / Baltimore-Washington Parkway (I-295)

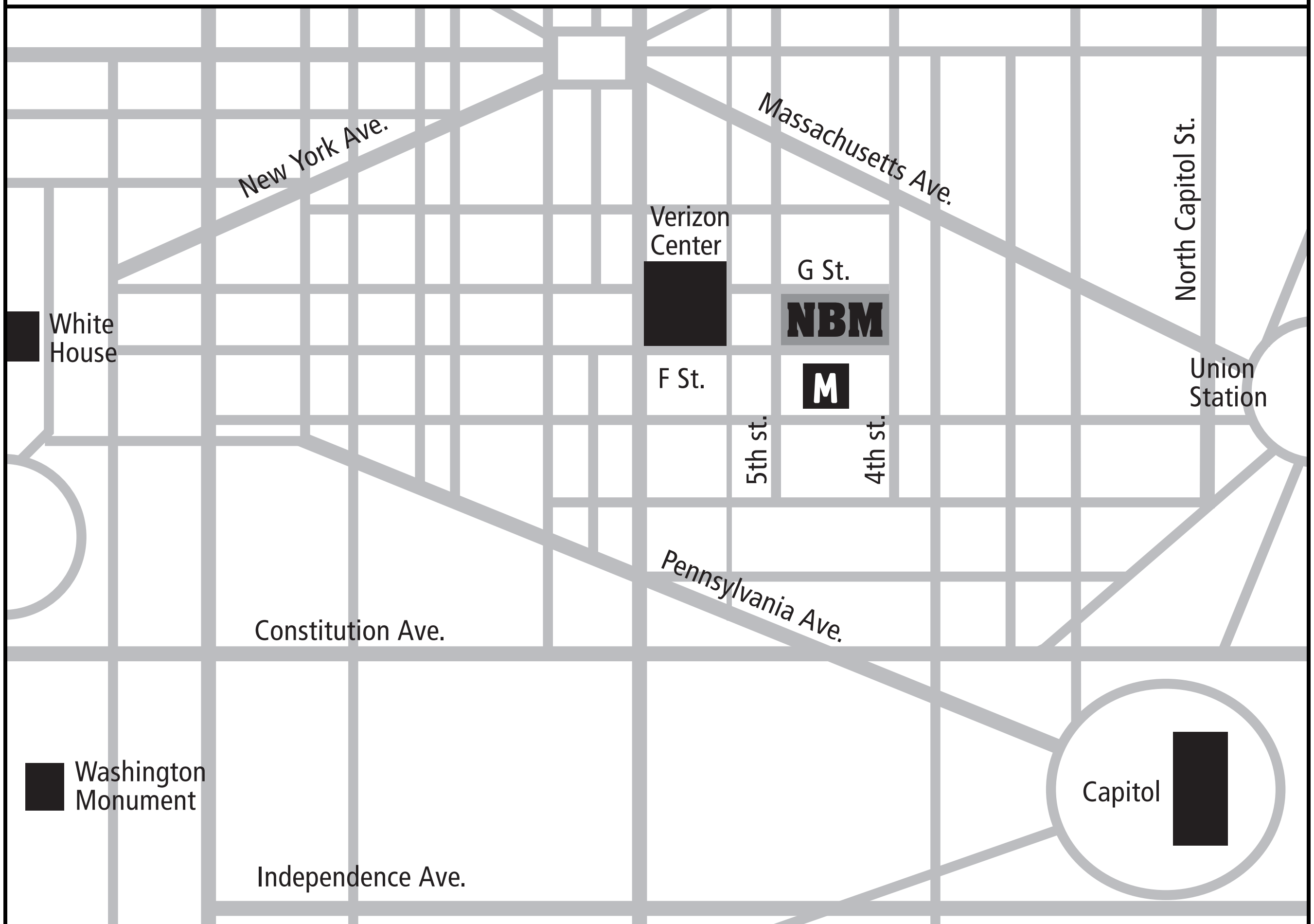
Follow I-95 to Baltimore-Washington Parkway southbound.
Take Baltimore-Washington Parkway to Rt. 50 westbound into Washington, D.C.
Route 50 becomes New York Avenue.
Follow New York Avenue several miles, eventually passing the I-395 southbound exit to your left.
Shortly after the I-395 southbound exit, turn left on 5th Street, NW.
Take 5th Street to G Street and turn left.

From Maryland southbound on I-270

Take I-270 to I-495 (Beltway) eastbound.
Take exit Route 355, Wisconsin Avenue southbound.
Follow Wisconsin Avenue into the District.
Turn left onto Massachusetts Avenue.
Take Massachusetts Avenue towards the Capitol, going through Dupont Circle.
Turn right onto 5th Street, NW.
Take 5th Street to G Street, and turn left.

NOTES:

Map to the National Building Museum



NBM

National Building Museum

401 F Street NW Washington, DC 20001

Between 4th and 5th and F and G Streets at the Red Line Metro; Judiciary Square.
Wheelchair access at 4th and G Street entrances.

Telephone: 202.272.2448
Facsimile: 202.376.3564
Website: www.NBM.org

While You're Here

Upon Arrival

- A Museum Teacher will greet you inside the entrance to the Museum.
- Please have a total count of students and adults ready for the guard at the entrance.
- Security measures require the checking of adults' bags.

Touring the Building and Exhibitions

We encourage you to bring your students to the Museum's exhibitions. All exhibition tours are self-guided. Please allow additional time for these activities, as the *Fuller's Fantastic Geodesic Dome* program does not include building or exhibition tours. Visit the Museum's website to learn about current exhibitions.

Lunches at the National Building Museum

Please note that there are no formal lunch facilities at the National Building Museum. Students may eat on the west lawn outside of the Museum, or eat in the Museum's Great Hall when space is available. However, please note that the Great Hall is frequently used for large events. When it is in use, students can eat outdoors or on their return trip to school. During the Museum visit, and especially during lunch, please ask your students and chaperones to observe the following guidelines:

- Dispose of trash properly. Please bring a garbage bag with you for this purpose.
- Stay with the group at all times. Forming a circle to the side of one of the large columns encourages the group to stick together.
- Keep away from the fountain, café tables (reserved for café patrons), and the information desk. TIP: Asking the students to stay on the carpet will help prevent them from falling into the fountain.
- Walk. Although children are often tempted to run and jump in the Great Hall, these actions are unsafe and not recommended. Climbing on the columns is not permitted.
- Talk and laugh, but please be considerate of other Museum visitors who may be enjoying a tour or exhibition.
- Restrooms are located at the southeast and southwest corners of the Great Hall.

Visiting the Museum Shop

The National Building Museum Shop offers a variety of items for children that range in price from $1.00 to $5.00 and up, including postcards, pencils, erasers, and puzzles. When visiting the Museum Shop, please keep these things in mind:

- Alert a shop staff member that a group of children will be visiting the Shop.

- All children should be reminded to behave appropriately when visiting the Shop.
- Students may visit the Shop in groups of ten at a time. At least one adult must accompany and supervise each group of students.
- Arrangements can be made to purchase pre-packaged goody bags in amounts of $1.00 and up. Please call 202.272.7706 for more information.

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Facts About the National Building Museum

Who designed the National Building Museum?
Montgomery C. Meigs (1816–1892), Quartermaster General in charge of provisions during the Civil War. He was a West Point-trained engineer. Meigs' design was inspired by Italian Renaissance architecture.

When was it built, and how much did it cost?
1882–1887 and $886,614.04

What was the building used for before it was a museum?
Until 1926, it was occupied by the U.S. Pension Bureau, which provided pensions to veterans disabled during wartime. The building was later occupied by several other government agencies before becoming the National Building Museum in 1980.

How big is it?
On the exterior, 400 feet by 200 feet, 75 feet to cornice level

What is it made out of?
15,500,000 bricks with brick and terra cotta ornaments

How long is the frieze on the building's exterior, and who designed it?
1,200 feet long, 3 feet high, made of terra cotta

Designed by Bohemian-born sculptor Caspar Buberl (1834–1899)

Features a continuous parade of Union Civil War units

What are some interesting facts about the Great Hall inside the Museum?
316 feet by 116 feet (a little larger than a football field)

159 feet—approximately 15 stories—at its highest point (The Statue of Liberty, without her base, could stand up straight if she were placed on top of the fountain.)

The Presidential seal has been in place since 1901—the only Presidential seal permanently affixed to a building other than the White House.

Presidential inaugural balls, from Grover Cleveland's in 1885 to the present, have been held in the Great Hall.

What are the Corinthian columns made from, and how tall are they?
Among the tallest interior columns in the world—75 feet high, 8 feet in diameter, 25 feet in circumference

Each one is built out of 70,000 bricks and covered by plaster.

Originally painted in 1895 to resemble marble. The present faux marble pattern was applied in 2000.

How many columns are part of the arcade, and what are they made of?
On the first floor, there are 72 Doric-style columns (terra cotta covered with plaster); and on the second floor, 72 Ionic-style columns (cast iron).

NOTES:

2. Geodesic Dome Essentials

The following information is designed to introduce you to geodesic domes and basic engineering principles. For additional information about geodesic domes, refer to the listings of books, videos, and websites found in the Resources section. For definitions of any unfamiliar terms used in this section, please refer to the Geodesic Dome Vocabulary in the Resources section.

Introduction to Domes

- Basic Engineering Principles
- Space Framing
- Geodesic Domes

Who was Buckminster Fuller?

Introduction to Domes

Basic Engineering Principles

A dome is defined as a large hemispherical roof or ceiling. Although many different types of domes exist, all domes share certain advantages, whether or not they are geodesic. Their compound-curved shape is inherently strong, giving a self-supporting clear span with no columns as supports. Domes are resource and energy-efficient because, of all possible shapes, a sphere contains the most volume with the least surface. A dome typically has a circular footprint. A circle encloses the most area within its perimeter. Thus, for a given amount of material, a dome encloses more floor area and interior volume than any other shape.

A dome's design is dependent upon many factors, including:

- needed area and span, or distance between supports;
- budget and building schedule;
- architect's and /or client's aesthetic preferences;
- forces, such as compression and tension, acting on the structure; and
- building materials.

Area and Span

The architect must consider the area to be covered by the dome and the needs of the structure in terms of space and uses. Span is the length of a structural element between supports. The materials used will impact how long the span can be and the budget along with the building schedule will also influence the span.

Forces of Compression and Tension

A force is a push or a pull on an object. Built structures, such as domes and buildings, rely on unseen forces that hold them together and enable them to support additional weights, or loads. In every structure, two invisible forces are at work: compression and tension. Compression is the act of being pushed or pressed together. Tension is the act of being stretched or pulled apart.

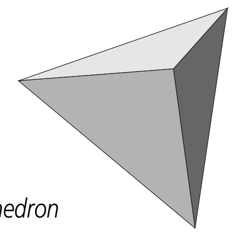
Materials

Engineers must consider the properties of building materials when making choices for any structure. When considering building materials for domes, engineers take into account the cost, proposed use of the dome, location, aesthetics, and durability.

Space-Framing

Space-framing (a network of triangular supports) is often used in dome construction. The most important element of a space frame is the triangle, which is also the strongest form used in architecture. Different types of geometric shapes (or polyhedra) are used in space framing. One common form is the tetrahedron—a four faced triangular shape, or a kind of pyramid with four faces and six struts. Six identical struts can form two triangles. But, when they are arranged synergistically, the same six struts make a tetrahedron of four triangles.

The connecting of triangles in this way provides a structural system that is strong and uses minimal amount of materials, all of which are interchangeable.



tetrahedron

Geodesic Domes

The aspects outlined about domes apply to all except the flattest domes, no matter what their structural system. Using space framing principles, geodesic domes have a major advantage over other domes: they are the strongest per pound of material employed. According to Webster's Dictionary, geodesic is defined as the "shortest line between two points that lies in a given surface." Further investigation revealed that the icosahedron (20 sided polyhedron or shape), with its 20 identical equilateral triangles, was the key. It didn't take R. Buckmister Fuller ("Bucky"), inventor of the geodesic dome, long to understand that a sphere made up of an icosahedral array of great circular geodesic lines represented the most efficient way to enclose space.

Positive Features of Geodesic Domes

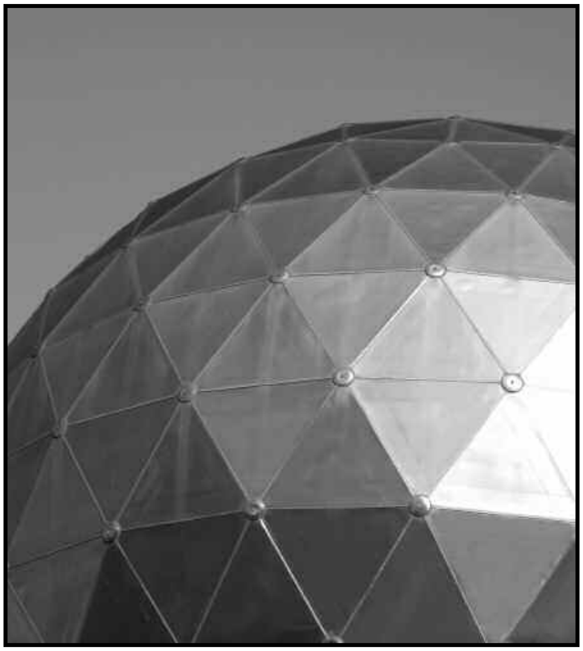
Nearly all advantages to geodesic domes are related to their efficiency.

Geodesic domes are:

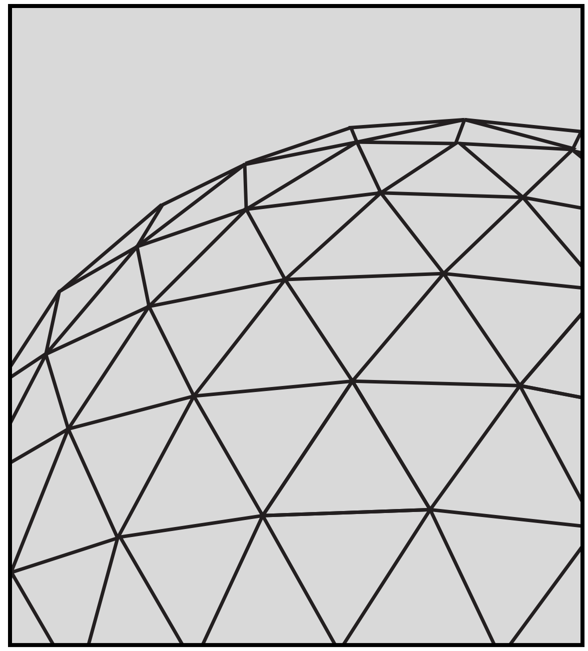
- The strongest structures per pound of material employed.
- Inherently strong and light; their curved form creates a span with no need for additional support (such as columns) and equally distributes stress throughout the structure.
- Resource- and energy-efficient because of all possible shapes, a sphere contains the most volume with the least surface area.
- Streamlined spherical forms let wind slide smoothly over their surface, thus helping to maintain a constant interior temperature with less need for heating and cooling systems.
- Structures that allow air to easily circulate, reducing heating and cooling costs.
- Easy to manufacture and construct due to interchangeable parts.

Negative Features of Geodesic Domes

- Do not fit certain lot shapes, particularly traditional rectangular city blocks.
- Do not gracefully accept additions.
- Difficult to enlarge by adding a second story.
- Often look identical to each other.
- Quickly distribute sound, smells, heat, cold, smoke, and fire because of their efficient circulation.
- Difficult to divide into separate spaces (such as rooms of a house or office).
- As its exterior becomes warm or cold with changes in weather, a dome's materials expand and shrink causing gaps where water can leak into the structure.



geodesic dome



geodesic dome outline drawing

geodesic dome photograph and outline drawing combined

Who Was Buckminster Fuller?

Architect, mathematician, engineer, inventor, visionary humanist, educator, and best-selling author, R. Buckminster Fuller, also known as Bucky, has been called "the 20th century Leonardo da Vinci." Born in 1895, he grew up in the northeast United States without automobiles, aircraft, radio, television, or computers.

Bucky attended Harvard University—the fifth generation of his family to do so—only to be expelled twice and never earn a college degree. His jobs included work in a cotton mill and meat packing plant. During World War I, he served as a naval officer, all the while learning about complex mechanical systems.

Bucky dedicated himself to a "lifelong experiment" to discover what he could do to help make humanity a success on Earth. He documented nearly everything he did and amassed an archive weighing 45 tons! It includes sketches, statistics, trends, models, even traffic tickets and dry cleaning bills.

Bucky's first inventions and discoveries were numerous. During the 1930s and 40s he created an aluminum car and house. They were radically different from structures known then or now. At the time, aluminum processing was expensive, so mass production of these inventions was impossible. Today, nearly all soda cans, and countless other designs, are made of inexpensive and recyclable aluminum.

Following the mixed success of a home constructed as a dome, Bucky began researching how to strengthen and enlarge such a shelter. He soon discovered that a sphere constructed of geometric shapes was the most efficient way to enclose a space. The first such structure to become known as a geodesic dome was built in 1922 by Walter Bauersfeld for a planetarium in Germany. However, Bauersfeld never patented his structure or developed the principles of building this way. Bucky likely knew of this earlier dome. His first large-scale outdoor model was attempted in 1949.

Geodesic structures can now be found everywhere. They are present in the structure of viruses and the eyeballs of some vertebrae. The soccer ball is the same geodesic form as the 60-atom carbon molecule C60, named buckminsterfullerene in 1985 by scientists who had seen Bucky's 250-foot diameter geodesic dome at the 1967 Montreal Expo. This dome was the largest of its time and still stands today.

Though he secured many patents for his designs, Bucky put his profits towards his research and never became wealthy. He was often disappointed that he did not receive more credit for his work. The geodesic dome at Disney's EPCOT center is familiar to much of the world, but its inventor is not.

Of all his contributions and creations, Bucky considered his World Game Institute, founded in 1972, to be one of his most important. This organization collects and shares comprehensive, world resource data. Bucky hoped that it would show that international cooperation was such an obvious advantage that war would become unthinkable. Thousands participate in World Game workshops, and the Institute is one of the largest of its kind.

Fuller was seen by his peers as both a genius and a failure because his ideas were so new and little understood by the time of his death. Over the course of his life, Fuller received 47 honorary degrees for his contributions in design science. After his death in 1983, appreciation for Fuller has continued to grow. The Fuller Institute in Santa Barbara, California, which opened in 1995, now educates the world about his life and work.

Information summarized from J. Baldwin's *Bucky Works: Buckminster Fuller's Ideas for Today*. New York: Wiley, 1996.

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3. Building a Foundation Lessons

Before visiting the Museum, these lessons may be used to introduce students to the basic engineering and geometry within building design and construction. These lessons are optional.

Understanding Forces at Work:
Compression and Tension

Shapes and Solids:
Investigating Triangles, Squares,
Pyramids, and Cubes
Shapes and Solids Student Worksheet
Patterns for Creating Cubes and
Tetrahedrons

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

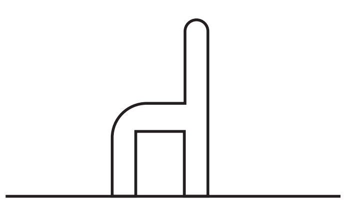
Compression, Force, Structure, Tension

LESSON PLAN

PART I. Define and Demonstrate Forces (10 minutes)

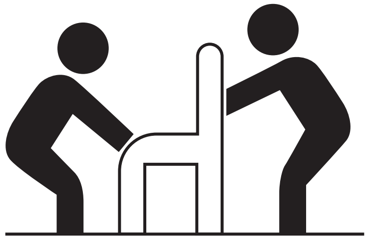
Discussion and Demonstration

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.

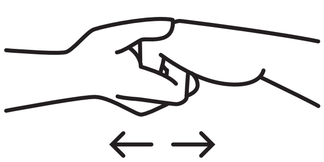


PART II. Define and Demonstrate Compression and Tension (30 minutes)

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.

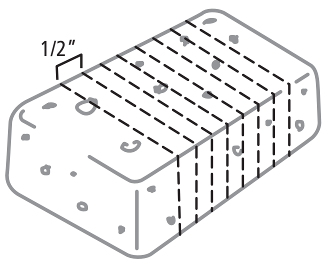
5. When the time is up, compare the lists.
   Examples of elements under compression:
   - walls
   - vertical sides of doors or window frames
   - columns
   - piers

   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

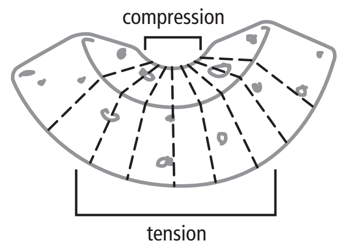
PART III. Investigate How the Forces of Compression and Tension Act on a Surface (30 minutes)

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:

Shapes and Solids: Investigating Triangles, Squares, Pyramids, & Cubes

In this lesson students will examine different shapes and materials to determine their strength and suitability when building structures. Students will come to understand that the strength of a material does not depend only on the composition of the material itself; changing a material's shape can also affect the way it resists forces. Likewise, a structure's location or function in a building may determine the shape it takes.

OBJECTIVES

Students will:

- create and examine three two-dimensional shapes — a square, a triangle, and a rectangle — and determine which is the sturdiest;
- discover how changing a material's three-dimensional shape can increase its strength; and
- identify points of compression and tension within geometric shapes.

MATERIALS (PER STUDENT)

- 1 pair of scissors
- 3 index cards (4 x 6")
- 11 small brass fasteners
- Shapes and Solids Student Worksheet, page 34
- Photocopy of Patterns, page 35

MATERIALS (FOR CLASS)

- Several single-hole punches (they can be shared among students)

NATIONAL STANDARDS OF LEARNING

Mathematics . . . . . . Geometry, Problem Solving

Science . . . . B, E

Social Studies 4

Technology 10

Visual Arts 1

DURATION

Two class periods, 45–60 minutes each

LESSON PROCEDURE

1. Create three two-dimensional shapes—a triangle, a square, and a rectangle—and determine the strongest shape.
2. Create two three-dimensional solids—a cube and a tetrahedron.
3. Evaluate the shapes and solids to determine the strongest ones.
4. Discuss geometric forms.

GEODESIC DOME VOCABULARY

Compression, Cube, Engineer, Form, Pyramid, Structure, Square, Tension, Tetrahedron, Triangle

LESSON PLAN

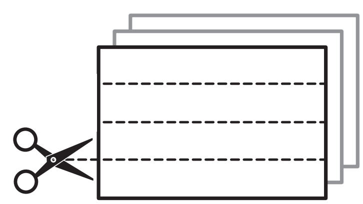
PART I. Create Three Two-Dimensional Shapes (30 minutes)

Discussion

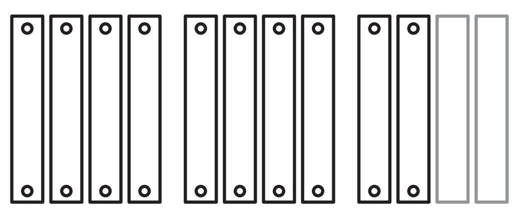
1. Explain to students the actual forms from which a structure is made contribute to its overall strength or weakness. Some shapes and solids are stronger or weaker than others.
2. Tell students that in this activity, they are going to examine three shapes—a square, a triangle, and a rectangle—and determine what makes the triangle the most rigid.

Action: Shape Comparison

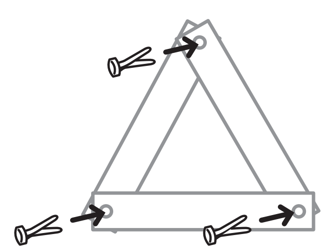
1. Instruct students to cut each index card into four 1-inch strips, lengthwise. They will now have 12 strips, although they will only need 10.



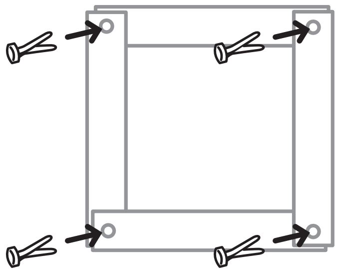
2. Next, have them punch a hole in each end of the 10 strips.



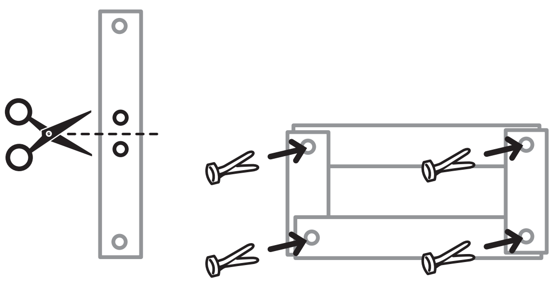
3. To make a triangle, have students connect 3 equal strips with the brass fasteners.



4. Ask them to connect 4 equal strips to make a square.



5. To make a rectangle, instruct students to cut 1 strip in half, widthwise, and punch a hole in the unpunch-ed ends. Have them combine these 2 shorter strips with 2 longer strips to make a rectangle.



6. Now ask students to take the triangle, square, and rectangle and push down on the corners and sides of each shape.

7. What happens? **Answer:** The square and rectangle should collapse; the triangle will keep its shape.

8. Why? **Answer:** The triangle is made up of the least number of sides possible for a geometric shape, locking its three sides into place.

9. Can students identify which parts of the triangle are in tension and which are in compression? **Answer:** If pressure is applied to any of the corners, the two sides radiating from that point will be in compression, while the side opposite that point will be in tension. If pressure is applied to any of the sides, that side will be in tension, while the other two sides will be in compression.

10. Can students add a longer strip to the square and rectangle so that they don't move? **Answer:** Take notice of the shapes they have made inside the square and rectangle; they are triangles.

Discussion

1. Based on the results of this experiment, which shape provides the most structural strength? **Answer:** Triangle

2. Explain to students that geodesic domes get their strength from triangles. Triangles can be arranged into many patterns, which can create different and unique structures.

PART II. Create Two Three-Dimensional Solids and Determine the Strongest Form. (30 minutes)

Just as some two-dimensional shapes are stronger than others, certain three-dimensional solids or forms are stronger than others. For example, a triangular pyramid, or tetrahedron, is more rigid than a square-based pyramid or cube.

Using the patterns for creating cubes and tetrahedrons, ask students to construct both a cube and a tetrahedron. Optionally, the structures can be covered with paper, newspaper, plastic wrap, or foil. Students can decorate their structures with paint, geometric shapes or other designs.

Patterns for creating cubes and tetrahedrons are available on page 35.

1. Copy patterns onto heavy paper.
2. Cut along solid black lines.
3. Fold along dashed lines.
4. Tape edges to create solids.

PART III. Evaluate the Shapes and Solids to Determine the Strongest Ones. (15 minutes)

Test the cubes vs. the tetrahedrons that the students have created. Have students complete the worksheet, page 34. Ask students which solids are sturdier and why. Answers to the worksheet are listed below:

1. Edges per structure:

triangle	3	square	4
tetrahedron	6	cube	12

2. Number of faces per solid, including the bases:

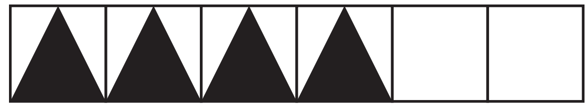
tetrahedron	4	cube	6

3. Surface area: answer can be determined by

(a) comparing the computed surface area of each structure:

triangle	.94	square	2.25
tetrahedron	3.75	cube	13.5

or (b) laying pieces of the structures against each other, in 2-D:



PART IV. Discuss Geometric Forms Conclusion (10 minutes)

- Discuss the students findings from the worksheet.
- Ask which structures they would select to build with and why?

To build structures as strong as possible, it makes sense to use triangular forms. However, because squares can provide additional area and blend with human surroundings, like city blocks and furniture, a mixture of both squares and triangles is often incorporated in buildings.

Ask students to consider what kind of buildings they might design if using triangles, squares, cubes, domes, etc. Would the building be a home, a space station, a roller coaster, or a school, etc. How do the answers differ for various structures?

- Domes have curved rather than flat surfaces. Geodesic domes are made of many flat surfaces, usually pentagons and/or hexagons that when combined form curves. The triangles in these forms make them inherently strong. See diagram on page 22.

Shapes and Solids Student Worksheet

NAME:

Which one will win?

It's a test of area, surface strength, and cost.

1. How many edges does your structure have?

________ triangle ________ square

________ tetrahedron ________ cube

2. How many faces does your structure have (don't forget the bases)?

________ tetrahedron ________ cube

3. Which structure has the least amount of surface area?

________ triangle ________ square

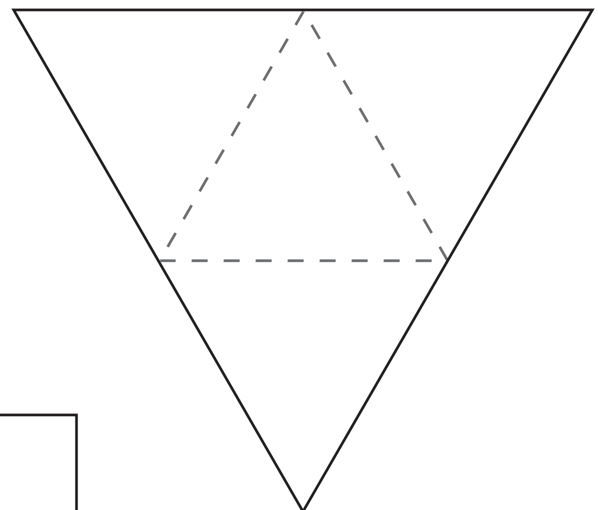
________ tetrahedron ________ cube

4. If you were constructing a building, which structures would you select and why?

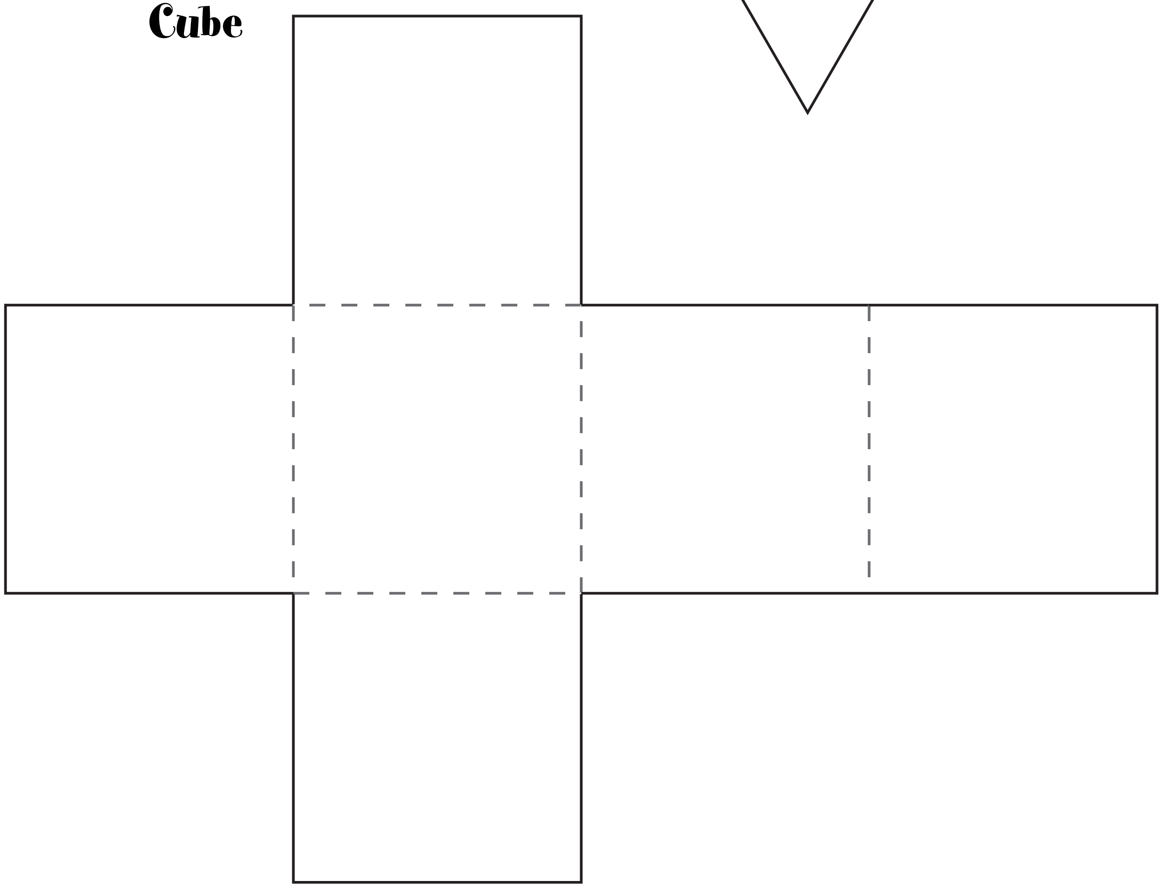
Patterns for Creating Cubes and Tetrahedrons

NAME:

Tetrahedron



Cube



NOTES:

4. Reinforcement Lessons

After visiting the National Building Museum, use these optional Reinforcement Lessons to strengthen the students' understanding of geodesic domes and build on the students' museum experience.

Architecture Investigation:
Traditional and Geodesic Structures
Structures Investigation Student Worksheet Part I
Structures Investigation Student Worksheet Part II

Geodesic Domes: Take a Closer Look

Fun Field Trips:
Exploring Your Community

Architecture Investigation: Traditional and Geodesic Structures

Now that students understand that different shapes and forms have varying strengths, they can further investigate traditional architectural structures. This lesson also encourages students to investigate their neighborhoods and communities and examine why architects might have chosen certain forms.

OBJECTIVES

Students will:

- understand that buildings today share many of the same structures as buildings built thousands of years ago;
- learn several different types of traditional building structures; and
- identify traditional building structures in their own neighborhood or in Washington, D.C.

NATIONAL STANDARDS OF LEARNING

Mathematics ....Connections

Science...................................F

Social Studies 3, 4

Technology 4, 5, 19, 20

Visual Arts 4

MATERIALS

- Structures Investigation Worksheet, page 40

DURATION

1 class period, 45-60 minutes

LESSON PROCEDURE

1. Discuss different types of structures used in buildings.
2. Investigate the structure of a building in the neighborhood or Washington, D.C.

GEODESIC DOME VOCABULARY

Arch, Dome, Geodesic Dome, Post and Lintel, Pyramid, Space-Framing, Structure, Triangle, Tetrahedron

LESSON PLAN

PART I. Discuss Different Types of Structures Used in Buildings (20 minutes)

- Ask students what shape most buildings commonly form **Answer:** cube or rectangular cube. Why? Explain to students that there are some structures in buildings that have been used for thousands of years, such as post and lintel, arch, and dome while some are a lot more recent like space framing and geodesic domes. Let them know they will be investigating some of these structures used in their school and their neighborhoods.

- Ask students to name examples of arches, post & lintel structures, and domes.

- Ask students from what materials buildings are made. Explain that traditional forms of architecture make use of a variety of natural materials such as stone, brick, and wood. Looking around the neighborhood or Washington, D.C., one can find many examples of buildings and monuments made using these materials.

- Not all triangular-formed structures are geodesic domes. Space-framing uses triangles and tetrahedrons to support roof systems, highway overpasses, and other spans. Their construction is not possible without modern materials that can be identically mass-produced for a given building.

- The Structures Investigation Worksheet, page 40, shows different types of structures and historic buildings where these structures are employed and examples of buildings in the Washington, D.C. area.

PART II. Investigate the Structure of a Building in the Neighborhood or Washington, D.C. (25 minutes in class or assign for homework)

- Using the Structures Investigation Worksheets, pp. 40–43, as a guide, have students consider why structures were built to look the way they do. Have students investigate their school building, a structure in their neighborhood, or a building in Washington, D.C.

NOTES:

Structures Investigation Worksheet Part I

NAME:

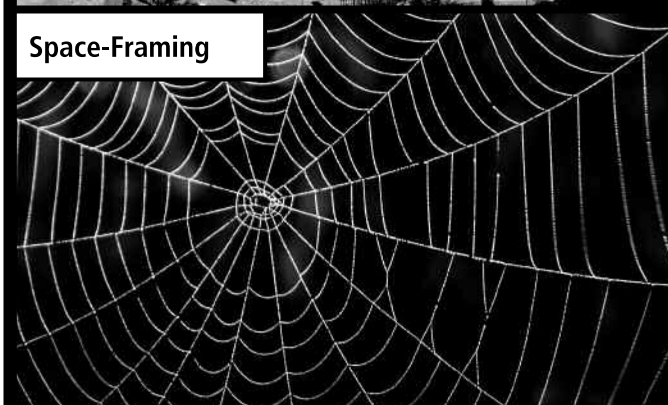
Take a look at these architectural structures. They will help you identify structures in other buildings.

Structure	Historical or Natural Model	Example in Washington, D.C.
Post & Lintel 	Greek Parthenon, Athens	Lincoln & Thomas Jefferson Memorials
Pyramid 	Egyptian pyramids	Top of Washington Monument
Arch 	Roman Coliseum, Rome Pont de Gard Roman aqueduct, France	Francis Scott Key & Arlington Memorial Bridges National Building Museum Washington National Cathedral

Structures Investigation Worksheet Part I

NAME:

Take a look at these architectural structures. They will help you identify structures in other buildings.

Structure	Historical or Natural Model	Example in Washington, D.C.
Dome 	Hagia Sophia, Istanbul Pantheon, Rome St. Paul's Cathedral, London	Library of Congress National Gallery of Art U.S. Capitol
Space-Framing 	Spider webs	Pentagon City Mall Thurgood Marshall Federal Judiciary Building (by Union Station)
Geodesic Dome 	Disney's EPCOT Center Crystals	Playground jungle gym

Structures Investigation Worksheet Part II

NAME:

Now that you've learned about types of architectural structures

it's time to investigate a building in your neighborhood or Washington, DC. Visit the building or view pictures of it to answer the questions below:

1. **Name and address of building:** ______________________________

2. **Building's use:** ______________________________

3. **Describe three types of structural systems in use.**

	Structure	Location	Purpose
Ex.	*post & lintel*	*entryway*	*provides a simple short span for doorway opening*

a. ______________________________

b. ______________________________

c. ______________________________

4. **Document your findings. Draw or paste a picture of your building here:**

Structures Investigation Worksheet Part II

NAME:

5. **How do you think these structures affect the building? Were they chosen…**
   - ☐ to save money
   - ☐ to appear grand or stately
   - ☐ to blend with their surroundings
   - ☐ to mimic a structure from the past
   - ☐ to appear modern and innovative
   - ☐ other ______________________________

6. **Do they appear to be…**
   - ☐ inexpensive
   - ☐ expensive
   - ☐ beautiful
   - ☐ functional
   - ☐ traditional
   - ☐ modern
   - ☐ historical
   - ☐ funky
   - ☐ utilitarian
   - ☐ other ______________________________

7. **What materials is this building made from? Do you think these materials are a good choice for the building? Why or why not?**

8. **If you could change this building by adding a different type of structure, which one would it be? Why?**

Geodesic Domes: Take A Closer Look

Now that you've been learning about geodesic domes and the forces at work in all structures, the following projects will help you investigate further.

Go to the Designer

Interview an architect or engineer about her/his work. How did s/he become interested in building structures? What does s/he build?

Innovative Architecture

Research an example of visionary design—a structure or object that uses geometry, physics, or materials in an innovative way. Consider what you like or dislike about the structure or object; how well it has stood the test of time; and the designer's methods of invention. Think about looking at one of these awe-inspiring designers:

- Leonardo da Vinci
- I. M. Pei: National Gallery of Art East Building and the Louvre Museum's pyramid
- Eiffel Tower: Iron trusses were previously used only in bridges
- Frank Lloyd Wright: The Solomon R. Guggenheim Museum and other structures with geometrical forms
- Parthenon and other Greek temples: Used geometric proportion for refinement and optical effect
- Frank Gehry: A modern architect who used materials in innovative ways

Creative Framing

Think of other ways space-framing can be used in buildings. Write an essay, draw a picture, or create a model of your new use for space-framing.

Redesign the World

Redesign a building of your choice using the architectural structures you just learned about. This could include creating a model or drawing of the building as it is now and how it will look with your new structure changes. Be sure to explain how your design is stronger or more effective than the previous one.

Fun Field Trips: Exploring Your Community

Families:

In school and at the National Building Museum, your children are learning about the geodesic dome and its strength in building design. Encourage them to explore homes and buildings in their community and have them teach you about the basics of structures.

1 When you and your child walk or drive around your community, notice the buildings and homes that you pass. What roof structures do they have? Which designs work best with the weather patterns in your area? Which roof designs require the greatest structural support?

2 Take a close look at the local school playgrounds and parks for jungle gym structures. Ask your child why triangles are so strong.

3 Learn more about engineering at the National Building Museum's annual day-long family festivals, which allow young people to explore hands-on engineering and other building activities. Check the Museum's website or call for more information.

4 Take a tour of the U.S. Capitol, which includes an impressive dome.

5 Visit www.pbskids.org to learn how your family can use newspaper and masking tape to create a geodesic dome at home.

Visit the National Building Museum, where families can discover the world we build for ourselves!

NATIONAL BUILDING MUSEUM 401 F Street NW Washington, DC 20001
202.272.2448 | www.NBM.org | Red Line Metro, Judiciary Square

Programs for Schools, Families, and Scouts, Outreach Programs, Discovery Carts, Exhibitions, Birthday Parties, Festivals, and Interactive Website

NOTES:

5. Resources

Information in this section comprises the following:

Geodesic Dome Vocabulary

Resources
- Books
- Websites
- Videos
- Activity Kits
- Organizations

Geodesic Dome Vocabulary

Arch
a curved structure, often semicircular

Architect
a professional who designs, plans, and coordinates the building of structures

Architecture
the art and science of designing and building structures

Barrel Vault
a roof constructed as a continuous semi-circular arch

Built Environment
human-made surroundings, such as buildings, structures, parks, streets, bridges, etc.

Column
a free-standing vertical support in architecture

Connector
something that joins or connects at least two other elements

Compression
the stress resulting from a pushing force on a structure; the opposite of tension

Cube
a regular solid of six equal square sides

Dome
an evenly curved structure of intersecting arches on a circular, elliptical or polygonal base

Engineer
a professional who applies mathematical and scientific principles to the design of structures, equipment, and systems

Equilateral Triangle
a triangle with sides of equal length and angles of equal degree

Face
a planar surface of a geometric solid; a side

Force
a push or a pull on an object; when an object is at rest (not moving) the forces acting on it are in balance

Form
a three dimensional object

Geodesic
made of light straight structural elements mostly in tension

Geodesic Dome
a lightweight dome supported by a grid of rigid members dividing the surface into regular facets

Perimeter
the boundary of a closed plane figure

Polyhedron
a solid formed by plane faces

Post and Lintel
a support fixed firmly in an upright position, especially as a stay or support with a horizontal architectural member spanning it and usually carrying the load above an opening

Geodesic Dome Vocabulary

Pyramid
a polyhedron consisting of a polygon base and triangular sides with a common vertex

Shape
spatial form or contour

Space-Frame
a three-dimensional framework that resists thrust from any direction

Span
the distance between two supports

Sphere
a solid that is bounded by a surface consisting of all points at a given distance from a point constituting its center

Square
a rectangle with all four sides equal

Structure
an object constructed of a number of parts that are put together in a particular way

Strut
a structural piece designed to resist pressure in the direction of its length

Tension
the stress resulting from a pulling force; the opposite of compression

Tetrahedron
a solid with all four faces made of triangles

Triangle
a polygon having three sides

Truss
a rigid support structure that is made up of interlocking triangles

Vertex
a point at which the edges of a solid figure intersect

Volume
the amount of space occupied by a three-dimensional object as measured in cubic units

Resources

Books

Baldwin, J. Bucky Works: Buckminster Fuller's Ideas for Today.
New York: John Wiley & Sons, 1996.
A thorough biography of Fuller's ideas and their relevancy today.

Hardhatting in a Geo-World.
1996: AIMS Educational Foundation.
Activities for grades 3-5. For information on AIMS call (209)255-4094.

Marks, Robert W. The Dymaxion World of Buckminster Fuller.
Reinhold, 1960.
A photo-essay of Fuller's work.

Richards, Julie. Stadiums and Domes.
Smart Apple Media, 2004. Ages 8-10.
Explains the construction and purpose of stadiums and domes. Part of "Smart Structures" series.

Van Loon, Borin. Geodesic Domes.
Tarquin Publications: Norfolk, England, 1994.
Provides basic insights into geodesic design of higher frequency structures from the fundamental icosehdral blocks. Cut out patterns provide some hands-on building.

Websites

Buckminster Fuller Institute
www.bfi.org/domes
Contains information on R.B. Fuller, photos of domes, articles on design science, a geodesic dome slide show, and information and pictures of the 10 largest domes in the world.

Geodesic Dome Photography
www.insite.com.br/rodrigo/bucky/house.html
Photos of geodesic dome houses.

Constructing a Geodesic Dome
www.insite.com.br/rodrigo/bucky/geodome.html
Middle School age friendly text describing the construction of a geodesic dome.

Buckminster Fuller Resources
www.worldtrans.org/whole/bucky.html
List of books by Buckminster Fuller as well as a bibliography of additional books and materials.

National Engineering Week
www.eweek.org
Includes information on engineering, libraries, science centers, and other resources. In addition, find information about annual National Engineers Week events for teachers and students.

Resources

Videos

Buckminster Fuller: Thinking Out Loud.
Produced by Kirk Simon and Karen Goodman. Available from Simon and Goodman Picture Company, 2095 Broadway, New York (212)-721-0919. (1996, color).
Biography of Fuller's life and work. Filmmakers were given wide access to the Buckminster Fuller Institute archives for footage and information.

Building Big With David Macaulay: Domes.
Produced by Tom Levenson.
Macaulay visits the world's greatest domes to tell their stories and the stories of the people who built them. Includes a mini dome building exercise. (2000).

Around the Universe in 90 Minutes.
A taped chat with Fuller introducing his most famous concepts and discoveries. Available from the Buckminster Fuller Institute, Santa Barbara, CA.

Activity Kits

Roger's Connectors.
Magnetic rods and balls that connect to create geometric structures (as used during Museum program).

Bridge Basics Program Kit.
National Building Museum curriculum and hands-on materials to teach about bridge engineering. www.nbm.org.

Organizations

Historic American Engineering Record (HAER)
U.S. Department of the Interior
1849 C Street, NW
Room NC 300
Washington, D.C. 20240
www.cr.nps.gov/habshaer/haer
Documents nationally and regionally significant engineering and industrial sites in the United States.

Historic American Building Survey (HABS)
U.S. Department of the Interior
1849 C Street, NW (2270)
Washington, D.C. 20240
www.cr.nps.gov/habshaer/habs
Documents historic architecture—primarily houses and public buildings—of national or regional significance.

Other School Programs at the National Building Museum

Be a Green Builder

Bridge Basics

City by Design

Green by Design

Lifecycle of a Building, a Street, and a City

Patterns: Here, There, and Everywhere

Washington: Symbol and City

For more information, or to obtain a school programs brochure, contact school programs at **youthgroups@nbm.org** or **202.272.2448**.

Other Youth Programs at the National Building Museum

Group Learning and Scout Programs

Outreach

Family Programs

Festivals

Birthday Parties

Visit the Museum's website at www.NBM.org for more information.

National
Building
Museum

401 F Street, NW
Washington, DC 20001
Telephone: 202.272.2448
Facsimile: 202.376.3564
Website: www.NBM.org

The National Building Museum, a nonprofit educational institution, was created by Congress in 1980 to celebrate American achievements in architecture, urban planning, construction, engineering, and design. It presents exhibitions and public programs, collects artifacts of the building process, and publishes books and a quarterly journal.

MUSEUM HOURS
Monday to Saturday, 10:00am – 5:00pm
Sunday, 11:00am – 5:00pm

ADMISSION
Admission is free.

LOCATION
401 F Street NW, between 4th and 5th Streets
at the Judiciary Square Metro Station (Red Line).
Wheelchair access at 4th and G Street entrances.

MUSEUM SHOP
The Museum Shop, located on the ground floor, is Washington’s finest source of design and building-related books and gifts, including jewelry, home furnishings, toys, and games. Museum members and teachers receive a discount on all purchases.

MEMBERSHIP
Museum membership offers such privileges as invitations to exhibition openings and special events; discounts on Museum Shop purchases, programs, workshops, and tours; and subscriptions to Blueprints and the Museum Calendar of Events.