SCIENTIFIC AMERICAN FRONTIERS

TEACHING GUIDE

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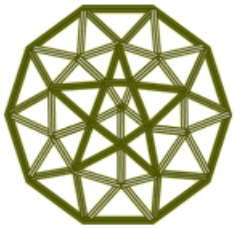
Forever Wild?

Activity 2: Grades 5-8

Geodesic Domes



As you watched the segment "The Second Earth," you observed how dome structures were used as containment areas for several ecosystems. Unlike traditional domes, these structures did not have a surface formed from solid building materials. Instead, there were assembled from a geometric framework of connecting rods. These open frame structures are called geodesic domes. They were invented by Buckminster Fuller over fifty years ago. If you examine the dome, you'd find that the basic unit of the frame is a triangle. As triangles are joined together, they form a pattern of increasing geometric complexity. The final result is a curved and sturdy surface that approaches spherical geometry.

This activity page will offer:

- Cooperative group activity in mathematics
- Experience in constructing a classroom geodesic dome
- An operational definition of geodesic dome geometry

Constructing a Geodesic Dome

Domes can be built at any size. It's all a matter of scaling the plans. The basic frame for a geodesic dome requires two lengths of connecting rods. It also requires a connection joint that can adjusted to the number and angle of intersecting rods. In this activity, you'll get to assemble a model dome using two lengths of newspaper rolls. The joints will be formed from masking tape. As you'll discover, even a paper and tape model forms a sturdy, reinforced structure.

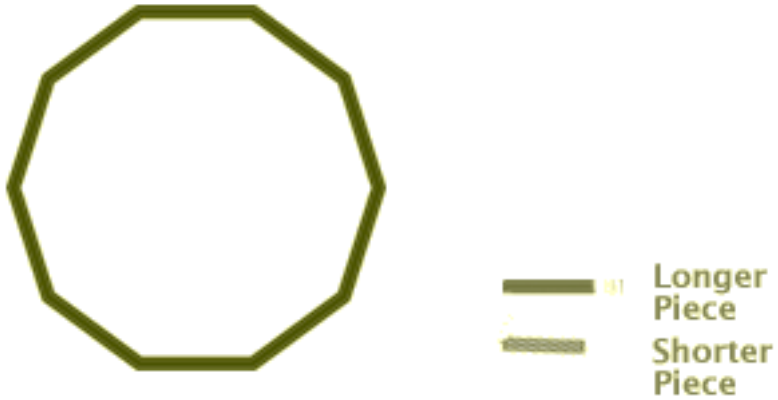
MATERIALS

- Scrap newspaper - Any size would work, as long as pages are consistent in size.
- Masking Tape
- Scissors

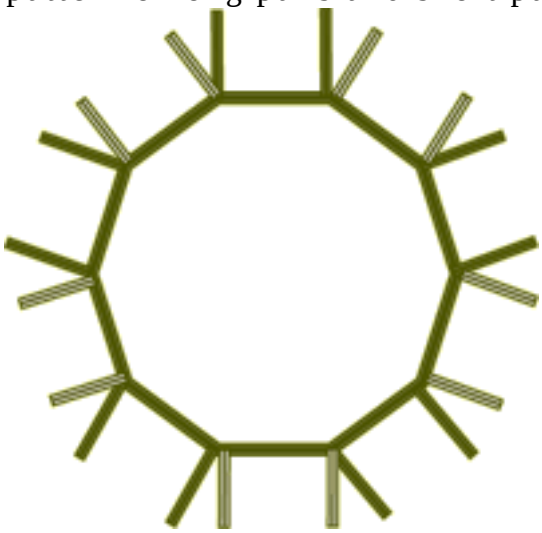
- Ruler marker

PROCEDURE

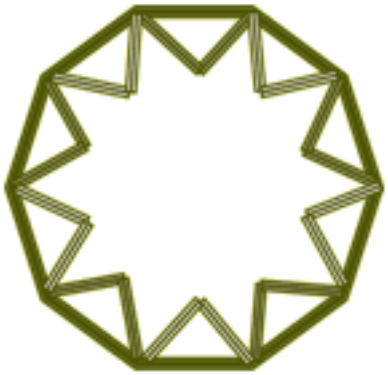
1. Work in teams of four. As a team you'll need to produce 65 tubes that form the framework of your geodesic dome. Each tube is formed from a stack of three newspaper sheets. Roll the stack from corner to corner to form a tight tube. Use masking tape to prevent it from unraveling.
2. Trim down your rolls to produce two tube sizes. The longer tubes are 26 inches (or 65 cm) long. You'll need 35 of these longer ones. The shorter tubes are 24 inches (or 60 cm) long. You'll need 30 of these shorter ones.
3. Create the base by taping ten of the long tubes (26 inches) together to form a closed geometric shape called a decagon.



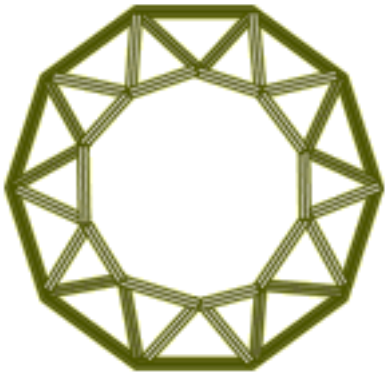
4. Tape a long tube and a short tube to each of the ten joints of the decagon. The tubes should be arranged to produce an alternating pattern of long pairs and short pairs.



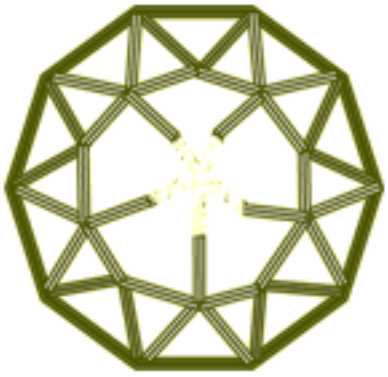
5. Use masking tape to secure the tops of the adjacent short tubes together to form a series of five triangles.



6. Likewise, form a series of five larger triangles by securing together the tops of the adjacent long tubes.
7. Connect the adjacent tops of these ten triangles together using a new row of short tubes. As you join these together, you'll form a zigzag like pattern that begins to curve the dome surface.

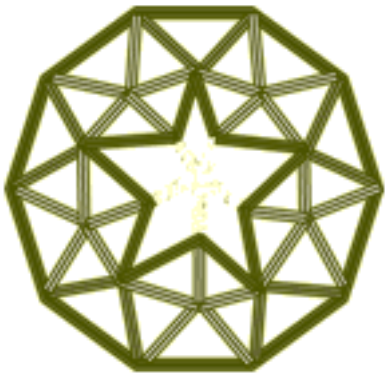


8. Locate the alternating joints where four short tubes come together. Tape a short tube to each joint and position it straight out from the joint as shown in the diagram.

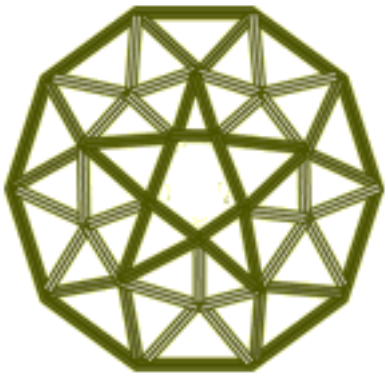


9. Connect the end of this tube to the adjacent joints using two longs. When this step is completed, you will have formed a distinct 5-sided

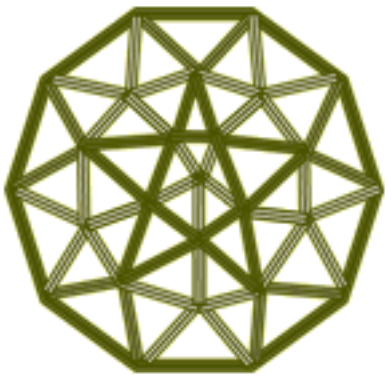
star pattern in the dome's framework.



10. Connect the tops of these triangles with a row of longs. This produces a pentagon.



11. Connect a short to each joint of the pentagon. These five shorts should meet in the center of the dome. Secure this final joint.



Questions

1. Did you need to use the ruler to measure the length of each tube?

2. What was the basic geometric shape of this frame?
3. What other shapes did you observe?
4. What was the maximum number of tubes that came together at any one joint?

EXTENSIONS

Think About It

How would increasing the number of component triangles affect the shape of the dome?

Small Scale Model

The plans for building a geodesic dome are scalable. In fact, you can use the steps above to build versions using either plastic straws or wooden toothpicks. Suppose you needed to scale the measurements to straws that are 20 cm long. If you opted to use the uncut length of the straw as the longer rod, what length would the shorter one need to be cut to? Explain.

Dome Support

The curved shape of the dome structure helps reinforce its integrity. This produces a lightweight structure that can withstand a good deal of force. You can explore this characteristic of domes using an empty and cleaned half shell of a chicken egg that has been prepared by an adult. Put on safety goggles. Position the shell on a tabletop so that its end points up. Carefully balance a textbook on the shell's pointed end. You'll probably need to support the book to prevent it form slipping off the curved shell surface. Slowly increase the size of the book stack until the egg cracks. To uncover the weight that eventually "broke" the egg, place the books on a bathroom scale. Apply your observation to the use of domes in architecture.

> **To prepare the egg:** The adult places the egg on a dish - remember this can get messy. The adult then uses a sharp modeling knife to score a ridge along the surface of the shell. The ridge should be positioned so that it divides the egg into two equal halves. To prevent the shell from premature cracking, use a new blade in a gentle back-and-forth sawing motion within the ridge until the shell separates into two halves.

Geodesic Dome Advantages

Compare and contrast a geodesic dome design with a more traditional dome built from reinforced cement. Think about the advantages of the geodesic style. You can learn more about dome structures on the Internet at sites such as:

World Domes and History *http://www.takenaka.co.jp/takenaka_e/dome_e/history/hisindex.html*

What are the advantages in material simplicity?

What are the advantages in illumination?

What are the advantages in placing and lifting supports?

WEB CONNECTION

Inventions by R. Buckminster Fuller
http://www.westnet.com/~crywalt/inventions/invtotal.html
This site presents an autobiography by Buckminster Fuller, the inventor of the geodesic dome.

Applied Synergetics - Geodesic Domes
http://www.applied-synergetics.com/ashp/html/domes.html
Here is a site that offers a freeware DOS utility program in which the user constructs geodesic domes.

The R. Buckminster Fuller FAQ: Geodesic Domes
http://www.netaxs.com/people/cjf/fuller-faq-4.html
The site offers a set of questions and answers that explores the geodesic dome as a housing unit.

The activities in this guide were contributed by Michael DiSpezio, a Massachusetts-based science writer and author of "Critical Thinking Puzzles" and "Awesome Experiments in Light & Sound" (Sterling Publishing Co., NY).

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Geodesic Domes

Questions

1. Did you need to use the ruler to measure the length of each tube?
   (No. The ruler was only needed to measure the lengths of one long and one short tube. These two tubes could then be used as templates from which to obtain the measures for the remaining tubes.)
2. What was the basic geometric shape of this frame? **(Triangle)**
3. What other shapes did you observe?
   (Pentagons, rhombus, hexagons)
4. What was the maximum number of tubes that came together at any one joint?
   (Six)

EXTENSIONS

Think About It

How would increasing the number of component triangles affect the shape of the dome?

(The more triangles that are used, the closer the shape resembles a true sphere.)

Small Scale Model

The plans for building a geodesic dome are scalable. In fact, you can use the steps above to build versions using either plastic straws or wooden toothpicks. Suppose you needed to scale the measurements to straws that are 20 cm long. If you opted to use the uncut length of the straw as the longer rod, what length would the shorter one need to be cut to? Explain.
(Using the ratio 26:24, we uncover a proportionality constant of about 0.92. When you multiply the 20 cm length by the constant, you arrive at a length of about 18.5 cm for the shorter support.)

Geodesic Dome Advantages

Geodesic Dome Advantages Compare and contrast a geodesic dome design with a more traditional dome built from reinforced cement. Think about the advantages of the geodesic style. What are the advantages in material simplicity?
(You need only three basic parts: two lengths of pipe and a connector.)
What are the advantages in illumination?
(The open frame allows daylight to spill into the dome)
What are the advantages in placing and lifting supports?
(The basic parts of the dome are relatively light)

CURRICULUM LINKS

Physics

Geodesic domes
Force distribution
Geometric shapes
Scale

NATIONAL SCIENCE STANDARDS (Grades 5-8)

Science as Inquiry - Content Standard A

Students will build and observe models in order to describe cause and effect relationships.

Students will use the tool of mathematics in the design of the their investigation..

Physical Science - Content Standard B

Students will understand that equal forces acting in opposite directions will cancel one another out.

Science and Technology - Content Standard E

Students will use criteria to consider costs and benefits of different design materials.