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BUILD A GEODESIC DOME Student Day Resource Packet

Pre & Post Visit Activities ▪ Vocabulary & Resource Lists ▪ Curriculum Connections

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Before Your Visit :
Prepare your students for their visit with these introductory pre-visit activities.

1	Introduce the *Build a Geodesic Dome Vocabulary List* on Page 2 to your students so they can be active participants during our discussion and construction process at the Center for Architecture.
2	Share the *Geodesic Dome Fact Sheet* on Page 3 with your students so they can discover some of the geometry involved in creating this important structure. This handout also provides a brief historical background.
3	Ensure your students understand the properties of a circle by completing the *Circles and Spheres Activity* on Page 4 These geometric relationships, diagrams, and calculations directly relate to the dimensions of the Geodesic Dome we will build at the Center for Architecture. An answer key can be found on Page 5.

During Your Visit :

The program begins by introducing students to various examples of Geodesic Domes from around the world. During this discussion, we will highlight ideas of modular construction and tessellation by identifying how triangles form larger shapes such as trapezoids, pentagons, and hexagons. We will discuss how this method of triangulation is derived from a sphere and can give strength to a structure to resist the forces of tension and compression. To make these ideas tangible, the whole class will work together to construct a 14-foot geodesic dome. This elegant structural form, made famous by engineer and inventor Buckminster Fuller, will offer a unique opportunity to experience the real-life applications of geometry and physics we had previously discussed. After a group photo inside the dome, students will be given the opportunity to test out their own structural ideas by creating individual scale models inspired by the dome's geometry.

After Your Visit :
Continue the learning by facilitating these suggested extension activities.

1	**Frequency and Tessellation Drawing Activity:** Use the *Frequency and Tessellation* activity sheet on Page 6 to encourage your students to practice measurement, proportion, division, and precision in drawing. Note that the higher the frequency they choose, the more challenging this drawing will become. On Page 7, you will find a completed version with a frequency of 2.
2	**Construct an Icosahedron:** Use the *Icosahedron Template* sheet on Page 8 to construct a physical model of an Icosahedron, the base geometry for the geodesic dome. If available, this sheet should be copied onto cardstock. Using this template as an example, challenge your students to design their own paper model of a triangulated structure.
3	**Writing Activity:** Using their experience of construction at the Center for Architecture and the *Geodesic Dome Fact Sheet* on Page 3 as a starting point, ask your students to research and respond to one of the following prompts: *What are the pros and cons of building with a geodesic dome? If you were designing a new piece of architecture for your neighborhood, how would you utilize this structure?* *How does the structure of a geodesic dome support Buckminster Fuller's notion of Spaceship Earth?*

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Build a Geodesic Dome Vocabulary List

Circumference	The perimeter or outside boundary of a circle.
Compression	A pushing or pressing force.
Diameter	A straight line passing through the center of a circle or sphere that divides it into two equal halves; measured as twice the radius.
Dome	A hemispherical structure typically forming a roof or ceiling.
Frequency	The rate at which something occurs or is repeated within a particular unit.
Geodesic	Relating to the shortest line between two points on a sphere; from the Greek word *geodaisia* meaning "division of the Earth."
Great Circle	A circle on the surface of a sphere that lies in a plane passing through the sphere's center.
Hexagon	A polygon with six sides and six angles; a regular hexagon has interior angles of 120°.
Icosahedron	A solid geometric figure with twenty triangular faces; typically equilateral triangles.
Pentagon	A polygon with five sides and five angles; a regular pentagon has interior angles of 108°.
Polygon	A two-dimensional shape with many straight sides.
Polyhedron	A solid three-dimensional figure with many planar faces.
Radius	A straight line from the center of a circle or sphere to the outside edge; measured as half the diameter.
Sphere	A perfectly round three-dimensional figure in which all points on the surface are equidistant from the center.
Structure	The parts of a building that hold up weight and provide support.
Surface Area	The total area of the surface defining of a solid figure.
Tension	A pulling or stretching force.
Triangulation	The use of a network of triangles to create a strong and rigid structure.
Volume	The measure of the amount of space inside of a solid figure.

Additional Resources

Buckminster Fuller in 3 Minutes Video by Prosocial Progress Foundation on YouTube

Buckminster Fuller Institute (www.bfi.org)

Building Big: Domes by PBS (www.pbs.org/wgbh/buildingbig/dome)

Geodesic Dome Article by Encyclopedia Britannica (www.britannica.com/technology/geodesic-dome)

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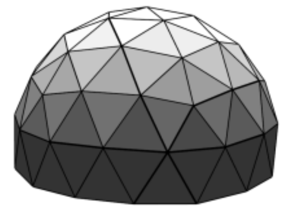
Geodesic Dome Fact Sheet

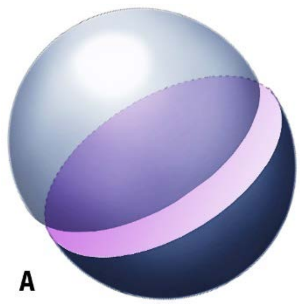
Definition

A ***Geodesic Dome*** is a curved, three-dimensional ***structure*** formed through a network of triangles. The more complex this network of triangles becomes, the closer it begins to approximate the geometry of a true ***sphere***, or any fraction of one. The word ***Geodesic*** comes from the Greek root *geodaisia,* meaning "division of the Earth."

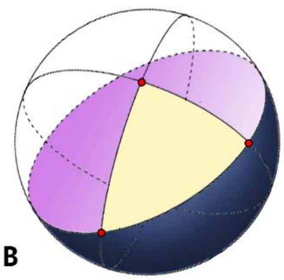


From Circles to Triangles

A ***great circle*** is a circle on the surface of a sphere that lies in a plane passing through the sphere's center. Another way to think of this is a circle that cuts a sphere perfectly in half, as shown in *Figure A*. The intersection of 3 great circles can define 3 points and a triangular surface, as shown in *Figure B*. Triangles are incredibly strong on their own but when used in a network, they work together to distribute stress (weight and other forces) across the entire structure. This ***triangulation*** is what makes a geodesic dome such an efficient and stable structure.



A



B

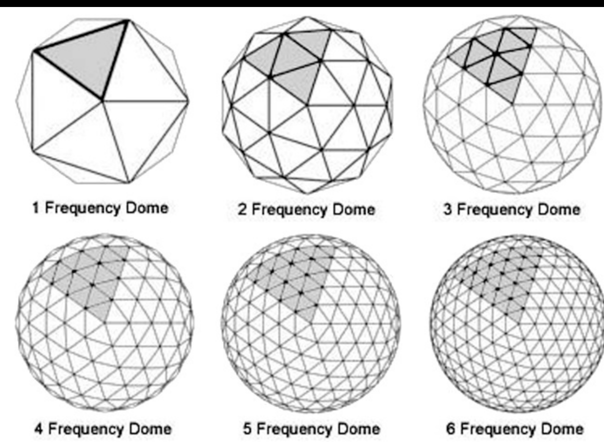
Fun Facts

The more triangles that are used in a dome, the rounder it becomes. The ***frequency*** of a dome indiciates this relationship such that the higher the number, the rounder the surface. See the diagram to the right.

A sphere is the geometric figure with the highest ratio of enclosed ***Volume*** to external ***Surface Area***. When building a structure, this means that a sphere, dome, or geodesic dome will allow you to create the most space with the least amount of material.

Because hot air rises, warm air inside of a dome can create a rising effect similar to that of a hot-air balloon. This phenomenon can actually lift the dome enough to noticeably change the weight of the entire structure. Larger domes that enclose more hot air experience a stronger lifting force.

One of the first domes presented to a wider audience was a pavilion at the 1964 World's Fair in New York City. This dome is now used as an aviary by the Queens Zoo in Flushing Meadows Corona Park.



A dome with the frequency of 1 is an ***Icosahedron***, a geometric solid with 20 triangular faces. Using tessalation, these faces can be broken up into smaller triangles. The more triangles, the more closely it approximates the true shape of a sphere.

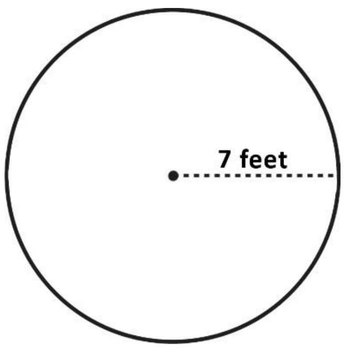
A Brief History

The world's first geodesic dome was built by Walter Bauerseld of Zeiss Optical Works in 1922 and was used as a planetarium on the roof. During the 1940's, inventor R. Buckminster Fuller investigated this type of structure further and named the dome "geodesic" from field experiments with Kenneth Snelson and others at Black Mountain College. Although Fuller was not the original inventor, he further developed this idea and received a U.S. patent for the Geodesic Dome. He worked hard to popularize the structure because he hoped that the geodesic dome could be used to help address the postwar housing crisis. Learn more about Fuller and his accomplishments by visiting the Buckminster Fuller Institute's website: www.bfi.org

Circles and Spheres Activity

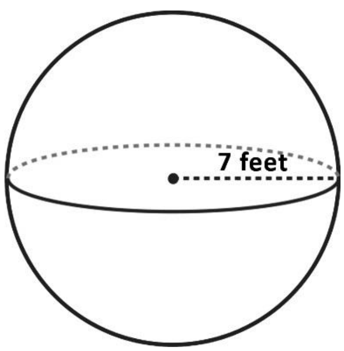
We can use the 2-D geometry of a circle and the 3-D geometry of a sphere to help us understand the properties of a geodesic dome. Use the formulas below to determine the values for each shape below. Round your answers to the nearest whole number.

Circle



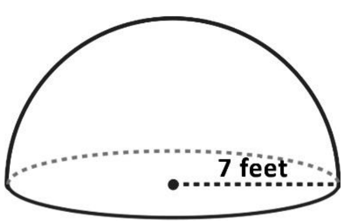
Radius	$r = 7'$	$r =$
Diameter	$d = 2r$	$d =$
Circumference	$C = 2\pi r$	$C =$
Area	$A = \pi r^2$	$A =$

Sphere

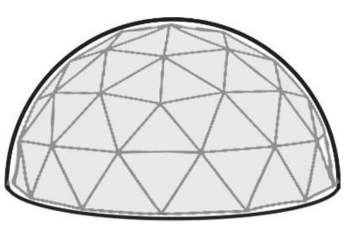


Volume	$V = \frac{4}{3}\pi r^3$	$V =$
Surface Area	$SA = 4\pi r^2$	$SA =$

Hemisphere (Dome)



Volume	$V = \frac{2}{3}\pi r^3$	$V =$
Surface Area	$SA = 2\pi r^2$	$SA =$

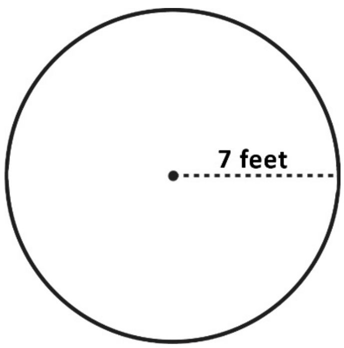


How does building a volume from triangles affect these calculations? How would the *Volume* and *Surface Area* of a Geodesic Dome compare to your calculations above? Explain your reasoning:

Circles and Spheres Activity

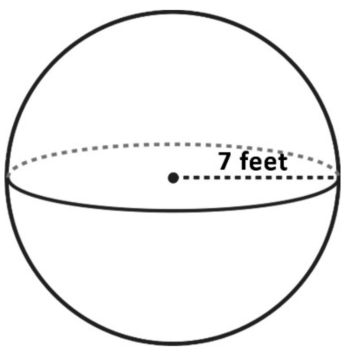
We can use the 2-D geometry of a circle and the 3-D geometry of a sphere to help us understand the properties of a geodesic dome. Use the formulas below to determine the values for each shape below. Round your answers to the nearest whole number.

Circle



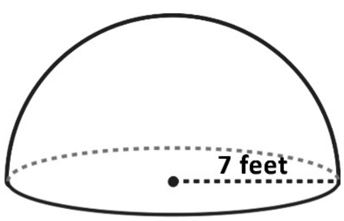
Radius	$r = 7'$	$r = \mathbf{7\ ft}$
Diameter	$d = 2r$	$d = \mathbf{14\ ft}$
Circumference	$C = 2\pi r$	$C = \mathbf{44\ ft}$
Area	$A = \pi r^2$	$A = \mathbf{154\ ft^2}$

Sphere

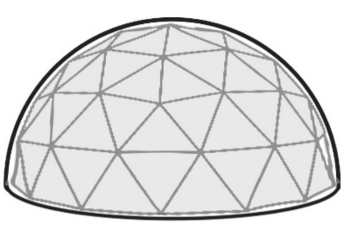


Volume	$V = \frac{4}{3}\pi r^3$	$V = \mathbf{1,436\ ft^3}$
Surface Area	$SA = 4\pi r^2$	$SA = \mathbf{615\ ft^2}$

Hemisphere (Dome)



Volume	$V = \frac{2}{3}\pi r^3$	$V = \mathbf{718\ ft^3}$
Surface Area	$SA = 2\pi r^2$	$SA = \mathbf{308\ ft^2}$

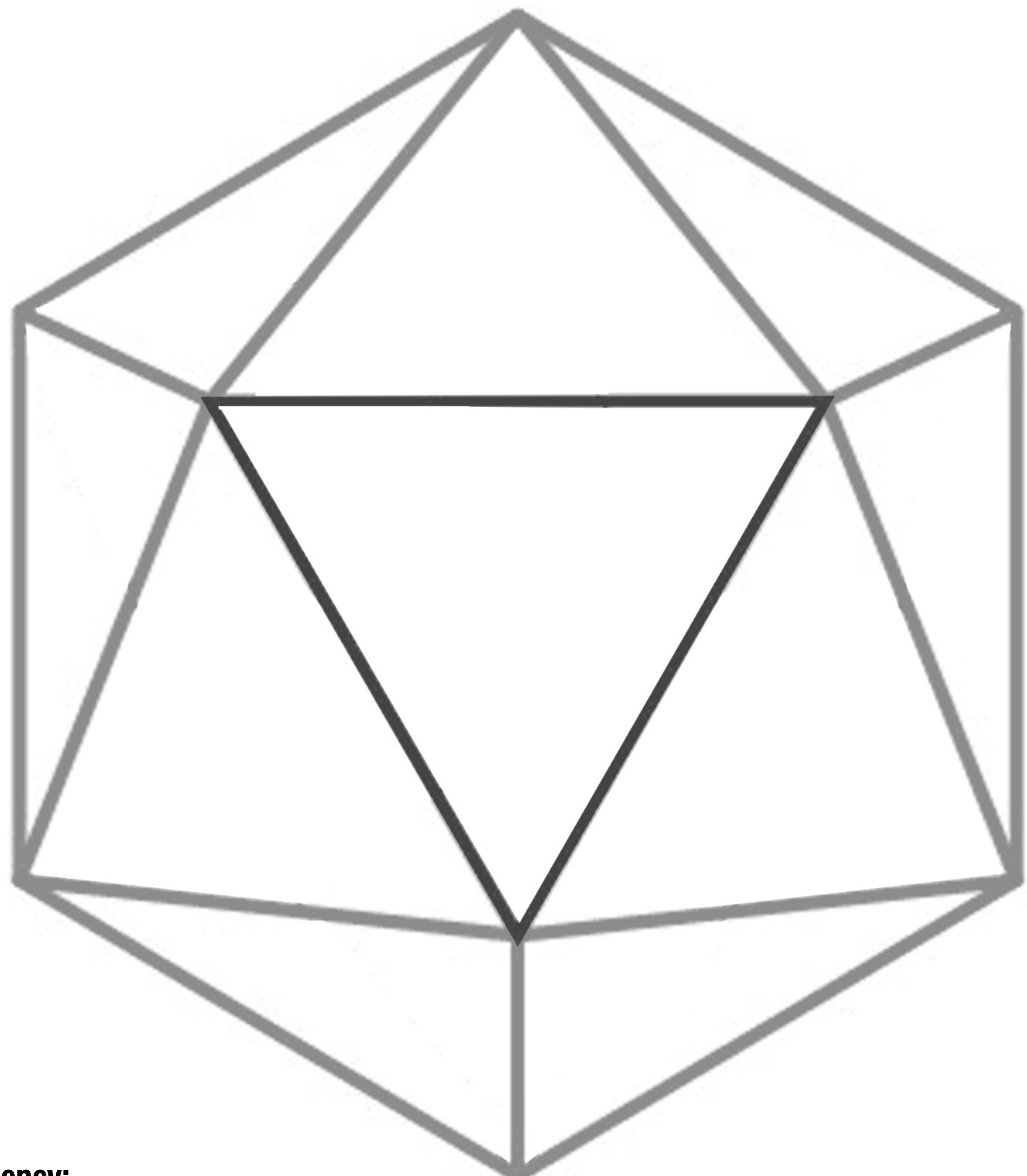


How does building a volume from triangles affect these calculations? How would the *Volume* and *Surface Area* of a geodesic dome compare to your calculations above? Explain your reasoning:

Calculating the true *Volume* and *Surface Area* of a geodesic dome would reveal smaller values than that of a perfect hemisphere because building a volume from triangles creates a smaller, planar approximation of the form.

Frequency and Tessellation

Complete the drawing below to create a geodesic dome with a ***frequency*** of 2 or greater. Measure and divide each triangular face to indicate the individual pieces needed to build this dome. Hint: You will need to measure each line in order to divide its length into the appropriate number of equal parts for that frequency (i.e. 2 equal parts for a 2-frequency dome.) Look for patterns to save time!



Frequency: ______

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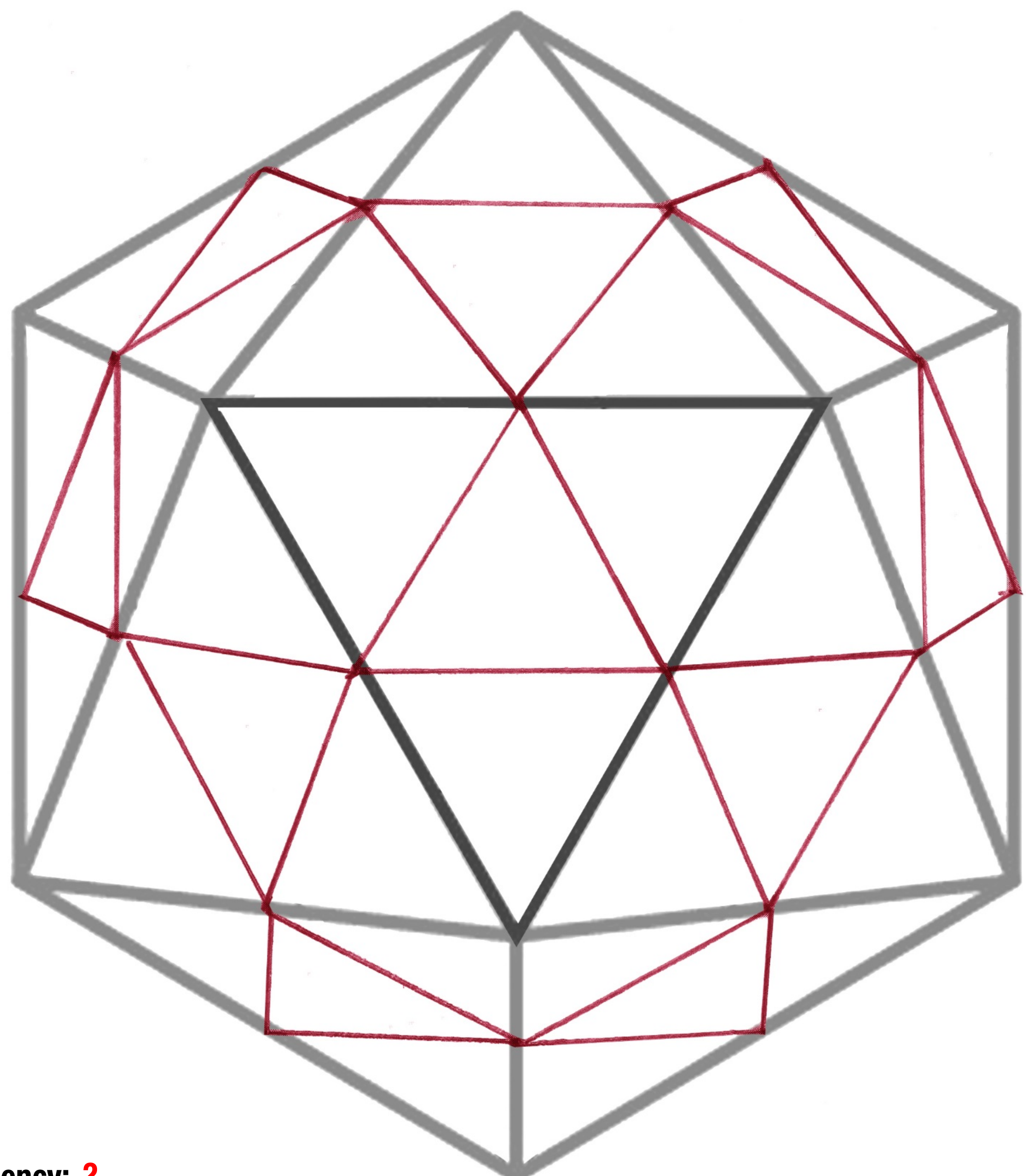
Answer Key for a Frequency of 2

Complete the drawing below to create a geodesic dome with a ***frequency*** of 2 or greater. Measure and divide each triangular face to indicate the individual pieces needed to build this dome. Hint: You will need to measure each line in order to divide its length into the appropriate number of equal parts for that frequency (i.e. 2 equal parts for a 2-frequency dome.) Look for patterns to save time!



Frequency: 2

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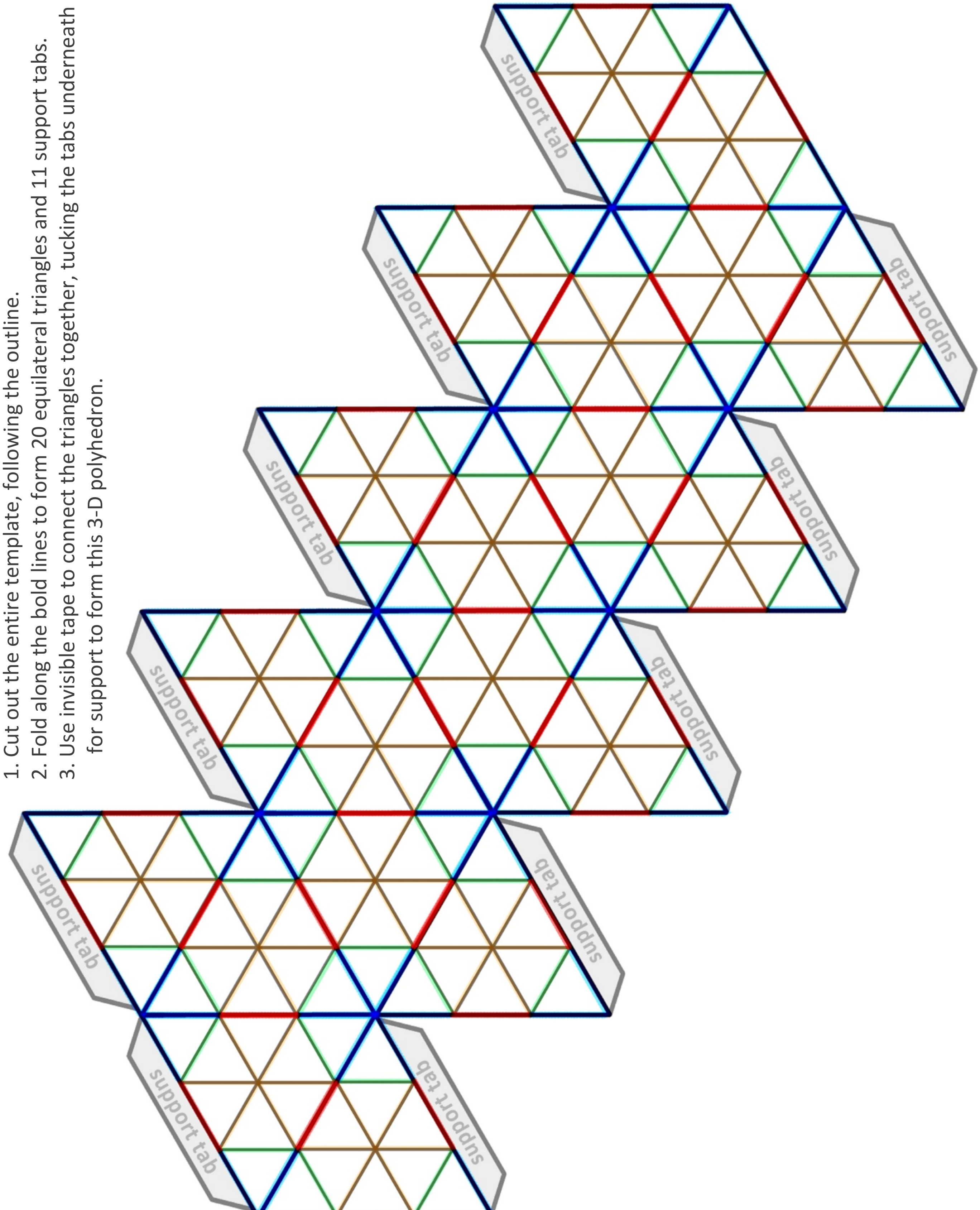
Icosahedron Template

Assembly Instructions

1. Cut out the entire template, following the outline.
2. Fold along the bold lines to form 20 equilateral triangles and 11 support tabs.
3. Use invisible tape to connect the triangles together, tucking the tabs underneath for support to form this 3-D polyhedron.



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Student Day Curriculum Connections

	New York State Learning Standards for the Arts: Learning Standards for the Arts at Three Levels	Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
1	Creating, Performing and Participating in the Arts	■	■	■	■	■	■	■
2	Knowing and using Arts Materials and Resources	■	■	■	■	■	■	■
3	Responding to and Analyzing Works of Art	■	■	■	■			■
4	Understanding the Cultural Dimensions and Contributions of the Arts	■	■	■	■			■

	NYC Blueprint For Teaching and Learning in Visual Arts: Five Strands of Art Learning	Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
I.	Art Making	■	■	■	■	■	■	■
II.	Literacy in Visual Arts	■	■	■	■	■	■	■
III.	Making Connections	■	■	■	■	■	■	■
IV.	Community and Cultural Resources	■	■	■	■	■	■	■
V.	Careers and Lifelong Learning	■	■	■	■	■	■	■

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	Common Core State Standards for Mathematics: Standards for Mathematical Practice	Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
1	Make sense of problems and persevere in solving them.	■	■	■		■	■	■
2	Reason abstractly and quantitatively.					■	■	
3	Construct viable arguments and critique the reasoning of others.			■	■	■		
4	Model with mathematics.	■	■		■	■	■	■
5	Use appropriate tools strategically.	■				■	■	
6	Attend to precision.	■				■	■	

	NYC K-5 Science Scope & Sequence + NYC 6-12 Science Scope & Sequence	Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
K Unit 2	**Exploring Properties** How do we observe and describe objects and the physical properties of objects?				■			
Grade 1 Unit 2	**Properties of Matter** How do we describe the properties of matter?				■			
Grade 2 Unit 2	**Forces & Motion** What causes objects to move?	■						■
Grade 3 Unit 2	**Energy** How does the use of various forms of energy affect our world?			■				
Grade 3 Unit 3	**Simple Machines** How do simple machines help us in our daily lives?	■						■
Grade 6 Unit 4	**Interdependence** What factors affect the interdependence of living and nonliving things?			■				
Grade 7 Unit 2	**Energy & Matter** What materials are best to conserve and efficiently use energy?			■				
Grade 8 Unit 4	**Humans and the Environment: Needs and Tradeoffs** How can energy resources affect the future planning for the continuity of life on Earth?			■				

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New York State P-12 Science Learning Standards		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
DIMENSION 1: SCIENTIFIC AND ENGINEERING PRACTICES								
1	Asking questions (for science) and defining problems (for engineering)	■	■	■	■	■	■	■
2	Developing and using models	■	■	■	■	■	■	■
3	Planning and carrying out investigations	■	■	■	■	■	■	■
4	Analyzing and interpreting data	PV		PV		PV		
5	Using mathematics and computational thinking	PV		PV		■	■	
6	Constructing explanations (for science) and designing solutions (for engineering)	■	■	■		■	■	■
7	Engaging in argument from evidence	■		■				■
8	Obtaining, evaluating, and communicating information	■		■		■		
DIMENSION 2: CROSSCUTTING CONCEPTS								
1	Patterns	■	■	■	■			■
2	Cause and effect: Mechanism and explanation	■		■				■
3	Scale, proportion, and quantity	■	■	■	■	■	■	■
4	Systems and system models	■	■	■		■		■
5	Energy and matter: Flows, cycles, and conservation			■				
6	Structure and function	■	■	■	■	■	■	■
7	Stability and change	■	■	■				■

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New York State P-12 Science Learning Standards (continued)		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
DIMENSION 3: DISCIPINARY CORE IDEAS								
Physical Sciences								
PS1.A	Structure and Properties of Matter				■			
PS2.A	Forces and Motion	■						■
PS2.C	Stability and Instability in Physical Systems	■	■					■
PS3.A	Definitions of Energy			■				
PS3.B	Conservation of Energy and Energy Transfer			■				
PS3.D	Energy in Chemical Processes and Everyday Life			■				
Life Sciences								
LS2.A	Interdependent Relationships in Ecosystems			■				
LS2.C	Ecosystem Dynamics, Functioning, and Resilience			■				
LS2.D	Social Interactions and Group Behavior					■		
Earth & Space Sciences								
ESS1.B	Earth and the Solar System			■				
ESS2.A	Earth Materials and Systems			■				
ESS2.D	Weather and Climate			■				
ESS3.A	Natural Resources			■				
ESS3.B	Natural Hazards							■
ESS3.C	Human Impacts on Earth Systems			■				
ESS3.D	Global Climate Change			■				

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New York State P-12 Science Learning Standards (continued)		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
DIMENSION 3: DISCIPINARY CORE IDEAS (continued)								
Engineering, Technology, and Applications of Science								
ETS1.A	Defining and Delimiting and Engineering Problem	■	■	■				■
ETS1.B	Developing Possible Solutions	■	■	■	■	■	■	■
ETS1.C	Optimizing the Design Solution		■	■	■	■	■	■
ETS2.A	Interdependence of Science, Engineering, and Technology	■	■	■	■	■	■	■
ETS2.B	Influence of Engineering, Technology, and Science on Society and the Natural World	■	■	■	■	■	■	■

Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR READING *								
1	Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textural evidence when writing or speaking to support conclusions drawn from the text.	■		■	■		■	■
2	Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.			■	■			
7	Integrate and evaluate content presented in diverse formats and media, including visually and quantitatively, as well as in words.	■	■	■	■	■	■	■
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR WRITING								
1	Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant and sufficient evidence.				PV	PV		

**At the Center for Architecture, we consider visual representations (i.e., photos, drawings, models, etc.) to be texts with their own set of vocabulary. Through this lens, we practice "reading a building" to consider its design and purpose.*

PV These standards are met by completing the suggested extension activities found in the Student Day Resource Packet.

Common Core State Standards for English Language Arts & Literacy in History/Social Studies, Science, and Technical Subjects (continued)		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR WRITING (continued)								
2	Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.			PV	PV	PV		
7	Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.	PV	PV	PV	PV	PV		PV
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR SPEAKING AND LISTENING								
1	Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	■	■	■	■	■	■	■
2	Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.	■	■	■	■	■	■	■
4	Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.					■		
5	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.					■		
COLLEGE AND CAREER READINESS ANCHOR STANDARDS FOR LANGUAGE								
4	Determine or clarify the meaning of unknown and multiple-meaning words and phrases by using context clues, analyzing meaningful word parts, and consulting general and specialized reference materials, as appropriate.	■	■	■	■	■		■
6	Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.	■	■	■	■	■	■	■

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New York State K-8 Social Studies Framework: Social Studies Practices		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
A	Gathering, Using, and Interpreting Evidence	■		■	■			■
B	Chronological Reasoning and Causation	■						■
C	Comparison and Contextualization				■			
D	Geographic Reasoning	■		■	■	■		■
F	Civic Participation					■		

NYC K-8 Social Studies Scope & Sequence + NYC 9-12 Social Studies Scope & Sequence		Building Bridges	Geodesic Dome	Green Architecture	Language of Arch.	Neighborhood Design	Scale Model Building	Skyscrapers
K Unit 3	**Geography, People and the Environment** What makes a community?				■			
Grade 1 Unit 3	**The Community** What is a community?				■			
Grade 2 Unit 2	**New York City Over Time** How and why do communities change over time?	■						■
Grade 2 Unit 3	**Urban, Suburban and Rural Communities** How are communities the same and different?	■			■			■
Grade 8 Unit 2	**A Changing Society and the Progressive Era** How do people, policies and technological advances shape a nation?							■
Grade 10 Unit 6	**Globalization and the Changing Environment** Is globalization a force for progress and prosperity?			■				

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