CENTER FOR ARCHITECTURE

BUILDING BRIDGES 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 *Building Bridges Vocabulary List* on Page 2 to your students so they can be active participants during our discussion at the Center for Architecture.
2	Read about it! Encourage your students to consider the context and history of bridges by reading a book from the *Bridge Book Resource List* on Page 3.
3	Help your students to identify various bridge types and to recognize their individual structural components with the *Building Bridges Flashcards* on Page 4 (front) and Page 5 (back). If available, photocopy these pages onto cardstock.

During Your Visit :

During this program, students will be asked to investigate the design and structural properties of four different bridge types (beam, arch, truss, and suspension) to learn how each works to support the load of traffic and span long distances. The design educator will facilitate a discussion about the relationship of materials, structures, and forces based on visual observations and hands-on demonstrations. For each bridge type, students will be challenged to draw and label a diagram showing the individual structural parts.

After this interactive presentation, students will work to create their own scale model of a suspension bridge by following a 10-step instruction sheet.

After Your Visit :

Continue the learning by facilitating these suggested extension activities.

1	**Symmetrical Structures:** Students can use the *Symmetrical Structures* worksheet on Page 6 to practice observational drawing and symmetrical logic. Answer Key on Page 7. For advanced students, build upon this conversation to discuss the concepts of balance and structural equilibrium as well as stability and instability in physical systems.
2	**Spanning Great Distances:** Challenge your students to use ratio and scale measurement to discover the relationship between specific bridge types and their relative spanning capabilities by completing the *Spanning Great Distances* activity on Page 8. Answer Key on Page 9. For advanced students, build upon this topic by challenging students to discuss or write about which factors (material, geometry, structural forces, etc.) affect the strength of different bridge types. Similarly, how can existing conditions (terrain, required distance, available material, etc.) affect how an architect or engineer might design a bridge?
3	**Writing Activities:** Have students write a "how to build a suspension bridge" piece about the bridge model they made at the Center, including the bridge terms introduced during the Building Bridges Student Day. Or have students research and write a report about a bridge using websites or books from the attached resource lists. Students should include the type of bridge, the length of its span, interesting facts, their own illustrations and at least four words from the *Building Bridges Vocabulary List* on Page 2 describe the bridge.

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Building Bridges Vocabulary List

Abutments	The massive structures at the end of a bridge that help to resist the lateral forces of a bridge and connect it to the ground.
Anchorages	The massive structures that secure the main cables of a suspension bridge, creating a tension force within the main cables.
Arch	A curved, symmetrical structure, often made from masonry (cut stone) or steel.
Beam	A horizontal piece of structure supported on both ends that spans across a distance, often supported by vertical piers.
Compression	A pushing or pressing force.
Dead Load	A force on a structure that is relatively constant. This is often the weight of the materials used to construct the structure itself.
Deck	The bridge roadway.
Deep Beam	A thick beam with greater ability to resist bending.
Footing	The bottommost portion of a pier or tower that secures the bridge underground.
Keystone	The central stone of a masonry arch. Typically larger or decorated to represent its role of locking and securing the entire structure in place.
Live Load	The force on a structure that can change or move. This force may be caused by the movement of cars and trains or by natural elements such as wind, rain, snow, earthquakes, etc.
Main Cables	The large cables of a suspension bridge that are held by the anchorages and supported by the towers.
Pier	A vertical support that carries the weight of the bridge down to the pier's footing and into the ground.
Shallow Beam	A thin beam that is more susceptible to bending.
Span	The measurement of distance between two supports in a bridge.
Suspender Cables	The vertical cables of a suspension bridge that suspend the roadway from the main cables.
Tension	A pulling or stretching force.
Towers	The tallest vertical structures of a suspension bridge that support the main cables.
Truss	A structure that is usually built from straight pieces of metal or wood to form a series of triangles. This structure functions like a deep beam and the triangles help to resist the forces of tension and compression.
Voussoirs	Wedge-shaped blocks that are used to build a stone or brick arch. Voussoirs work in compression, pressing on one another.

Additional Resources

Building Big: Bridges	http://www.pbs.org/wgbh/buildingbig/bridge/
Building Big: Educators' Guide	http://www.pbs.org/wgbh/buildingbig/educator/act_index.html
How Bridges Work	https://science.howstuffworks.com/engineering/civil/bridge.htm
Port Authority Bridges and Tunnels	http://www.panynj.gov/bridges-tunnels/
Technology Student: Structures	http://www.technologystudent.com/struct1/struindex.htm

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Bridge Books Resource List

Picture Books

Bridges Are To Cross
Philemon Sturges and Giles Laroche. Putnam Juvenile, 1998.

Bridges Go From Here To There
Forrest Wilson. The Preservation Press, 1993.

Brooklyn Bridge
Lynn Curlee. Atheneum Books for Young Readers, 2001.

The Brooklyn Bridge: The Story of the World's Most Famous Bridge and the Remarkable Family That Built It
Elizabeth Mann. Mikaya Press, 2006.

Famous Bridges Of The World: Measuring Length, Weight, and Volume
Yolanda Maxwell. Rosen Classroom. 2005

The Little Red Lighthouse And The Great Gray Bridge
Hildegarde H. Swift and Lynd Ward. HMH Books for Young Readers, 2003.

Pop's Bridge
Eve Bunting and C.F. Payne. HMH Books for Young Readers, 2006.

Twenty-One Elephants And Still Standing
April Prince. Houghton Mifflin, 2005.

The World's Most Amazing Bridges (Landmarks Top Ten)
Michael Hurley. Raintree Publishing, 2011.

You Wouldn't Want To Work On The Brooklyn Bridge!: An Enormous Project That Seemed Impossible
Tom Ratiff, David Salariya and Mark Bergin. Scholastic, 2009.

Activity Books

Bridges: Amazing Structures To Design, Build & Test
Carol A. Johmann and Elizabeth J. Rieth. Williamson Publishing Company, 1999.

Bridges And Tunnels: Investigate Feats Of Engineering With 25 Projects (Build It Yourself)
Donna Latham. Nomad Press, 2011.

Other Books

The Bridges Of Central Park
Henry Hope Reed. Greensward Foundation, 1990.

Bridging The World
Robert S. Cortright. Bridge Ink, 2003.

A Picture History Of The Brooklyn Bridge
Mary J. Shaprio. New York: Dover Publications, 1983.

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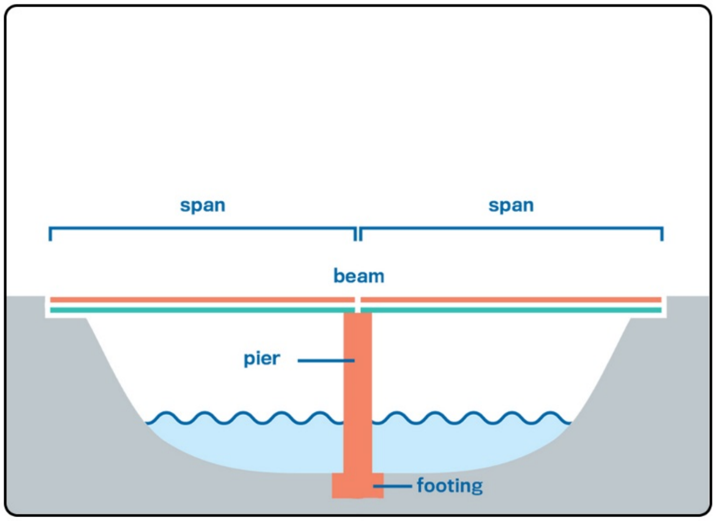
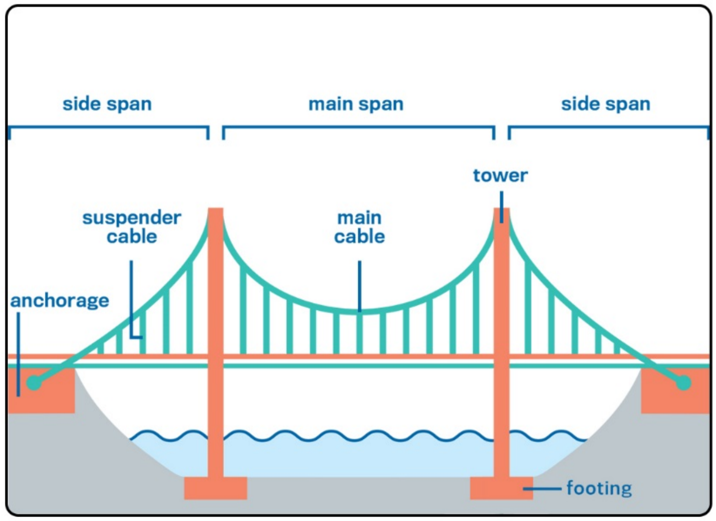
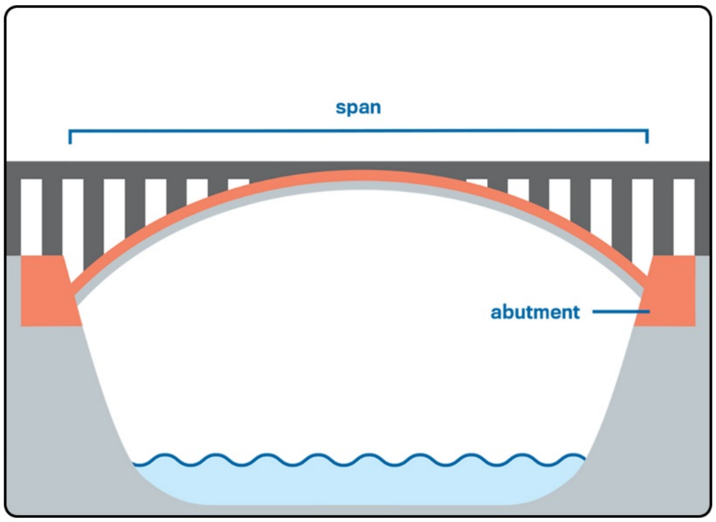
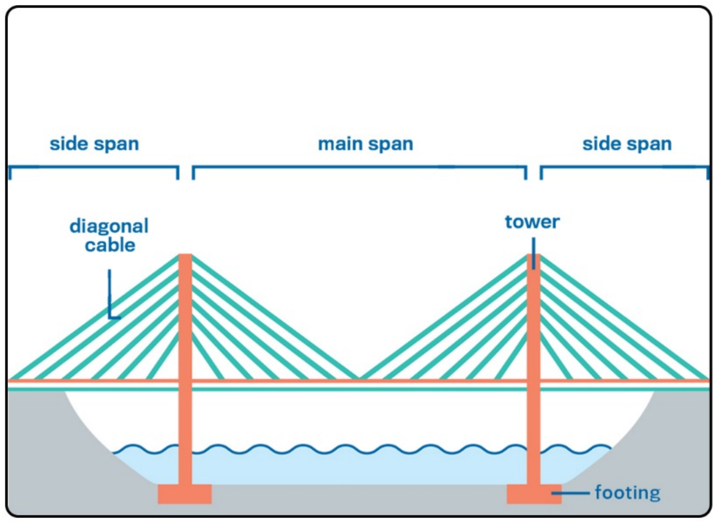
Building Bridges Flashcards

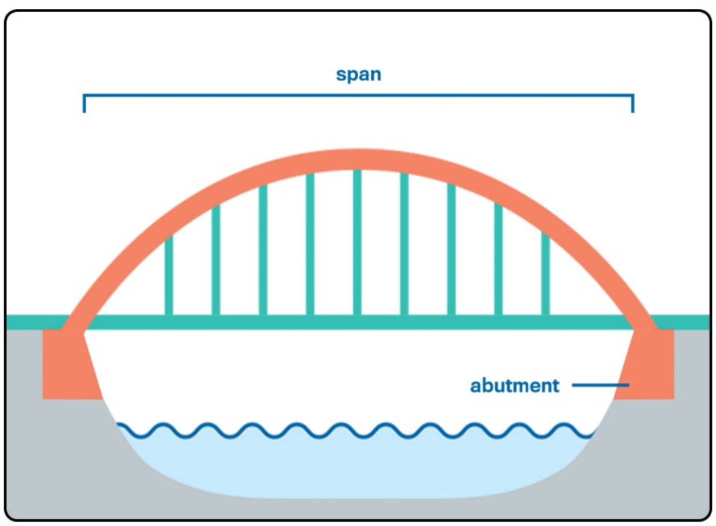
Use the flashcards below to learn about how different bridge types experience tension (turquoise) and compression (orange).

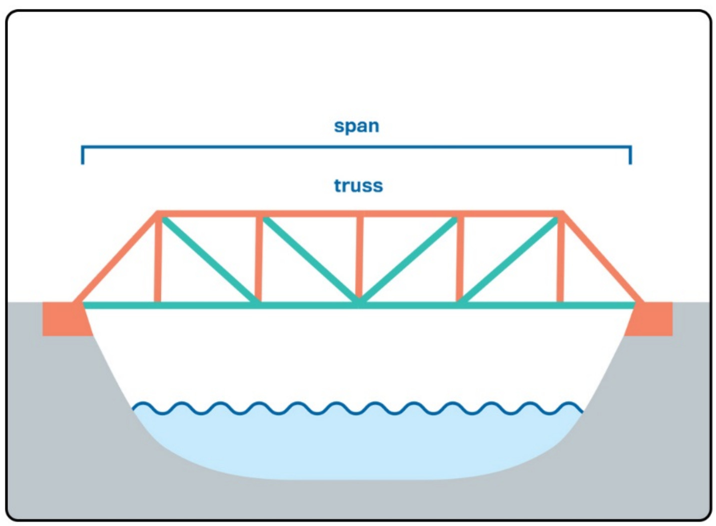












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Building Bridges Flashcards (Back)

Suspension Bridge

In a suspension bridge, strong towers support a main cable that is pulled tightly at each end by heavy anchorages. Straight suspender cables hang from the main cable and hold and lift the roadway along its span. This unique design allows suspension bridges to span the furthest of all bridge types. Trusses are often used to stiffen the long roadways of these bridges. Suspension bridge cables are always in ← tension → (pulling). The towers, however, are in → compression ← and must stand strong to resist the downward pull of the main cable.

Beam Bridge

A beam is a horizontal piece of structure that spans across an opening. A beam bridge is often supported by vertical piers that help carry the weight of traffic on the bridge and shorten the distance it must span. If the weight is too heavy, or the span too long, the beam will bend. This bending creates the forces of → compression ← (pushing) and ← tension → (pulling) in the beam.

Cable-Stayed Bridge

A cable-stayed bridge is a new form of suspension bridge that has diagonal cables stretching directly from a central tower to the roadway, with no main cable. These bridges don't span as far as classic suspension bridges, but use less material and are less expensive to build.

Arch Bridge

An arch is a structure shaped like a semi-circle. When a bridge roadway sits on top of an arch, the weight of traffic pushes down on the arch. This pushing force → (compression) ← is carried along the curve of the arch to the abutments at each end. Abutments are heavy supports that push back in from both sides to make sure the arch doesn't flatten out or collapse.

Truss Bridge

A truss is a structure made up of triangles. Triangles are naturally strong shapes, so truss bridges can carry more weight and span further than beam bridges. Each piece of a truss is either being pushed → (compressed) ← or pulled ← (tensed) →, but not both, so a truss doesn't bend easily. It is also much lighter than a beam since it is made up of individual pieces instead of solid material.

Bowstring Arch Bridge

When the roadway hangs down from the arch, it is called a bowstring arch bridge. The roadway takes the place of the abutments and works in ← tension →, pulling in on both ends of the arch to keep its shape.

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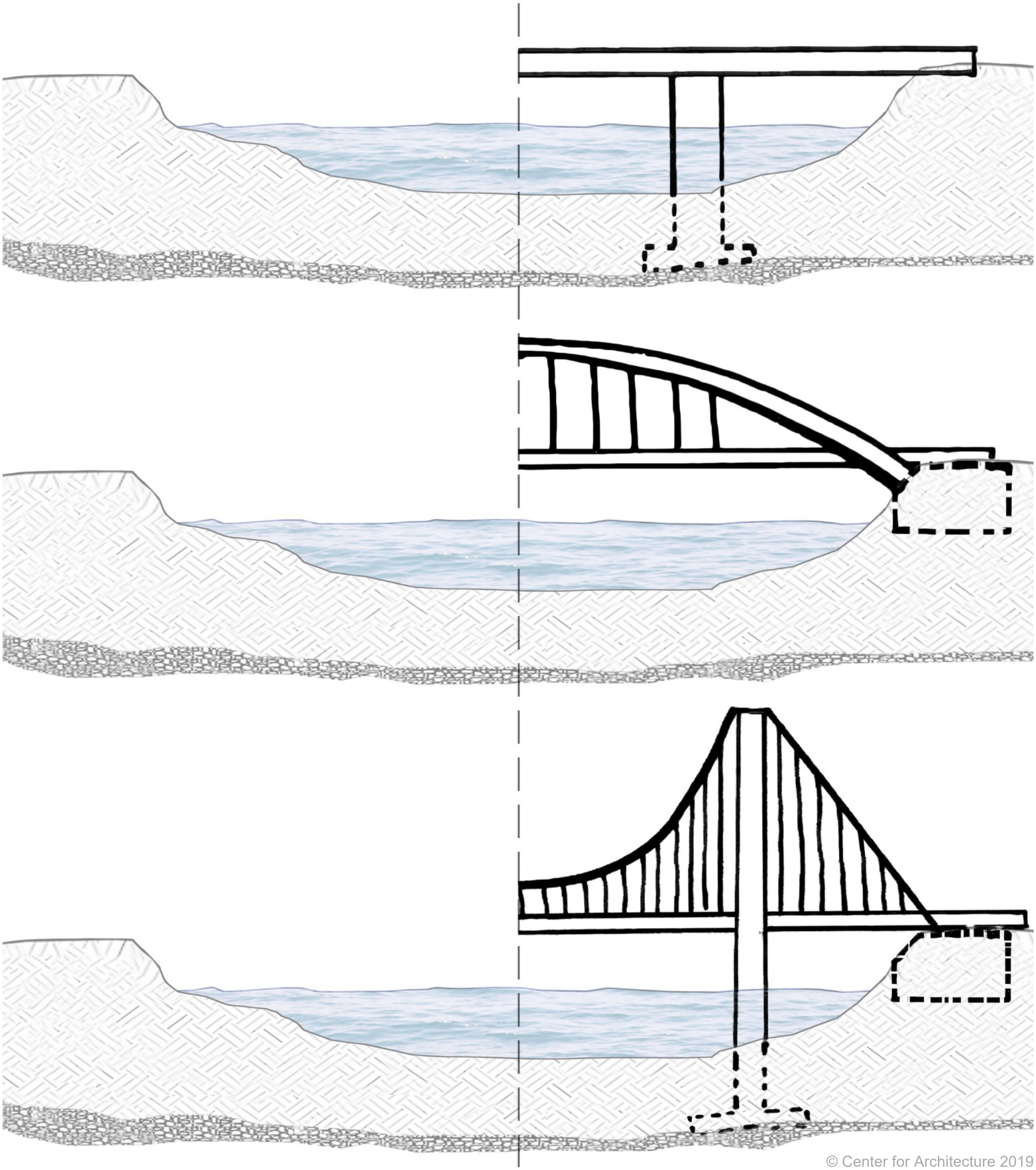
Symmetrical Structures

Bridges often use symmetry to help their structure stay balanced. Complete the diagram of each bridge below by drawing in the missing half. Use the *Building Bridges Vocabulary List* to label each piece of structure that you add or complete.



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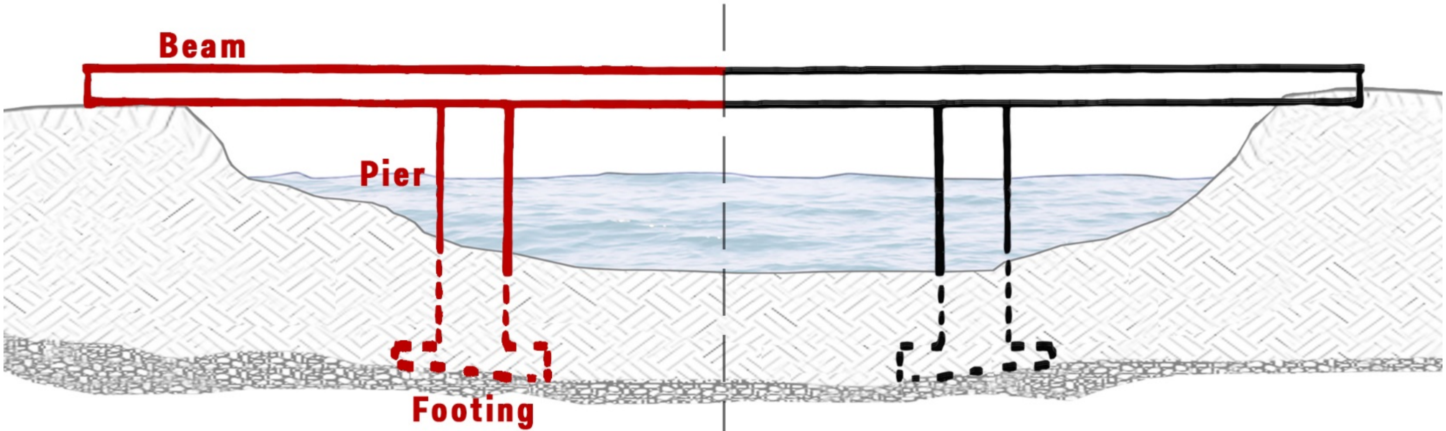
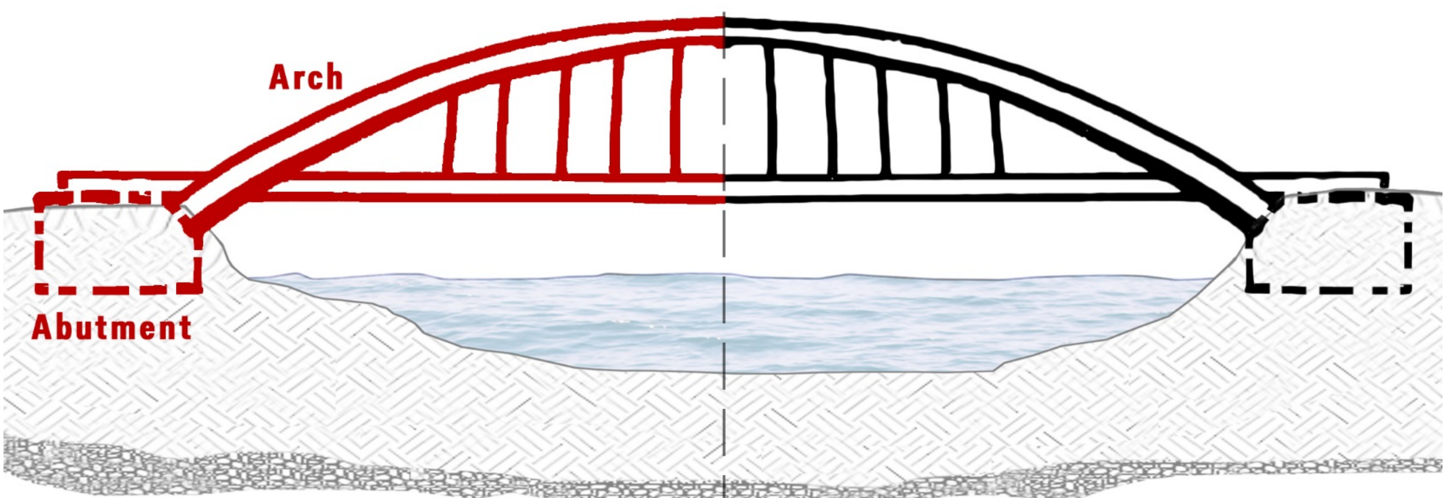
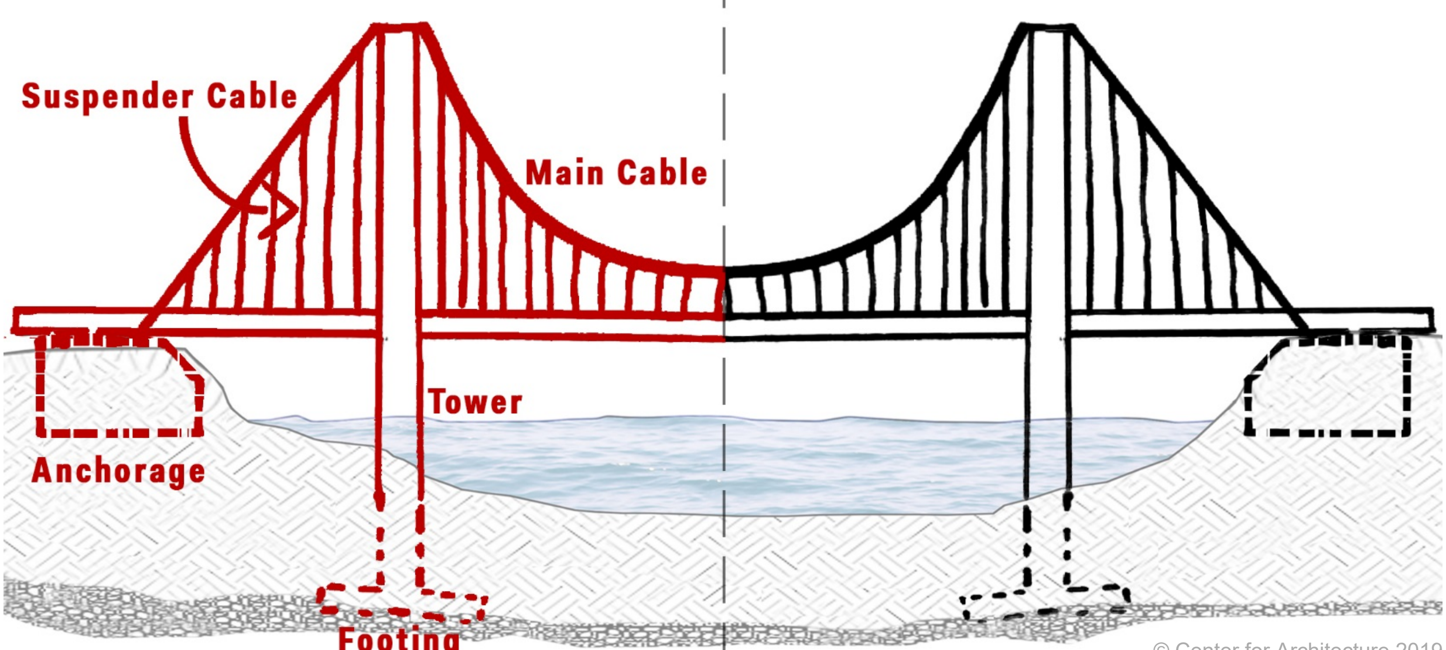
Symmetrical Structures (Answer Key)

Bridges often use symmetry to help their structure stay balanced. Complete the diagram of each bridge below by drawing in the missing half. Use the *Building Bridges Vocabulary List* to label each piece of structure that you add or complete.







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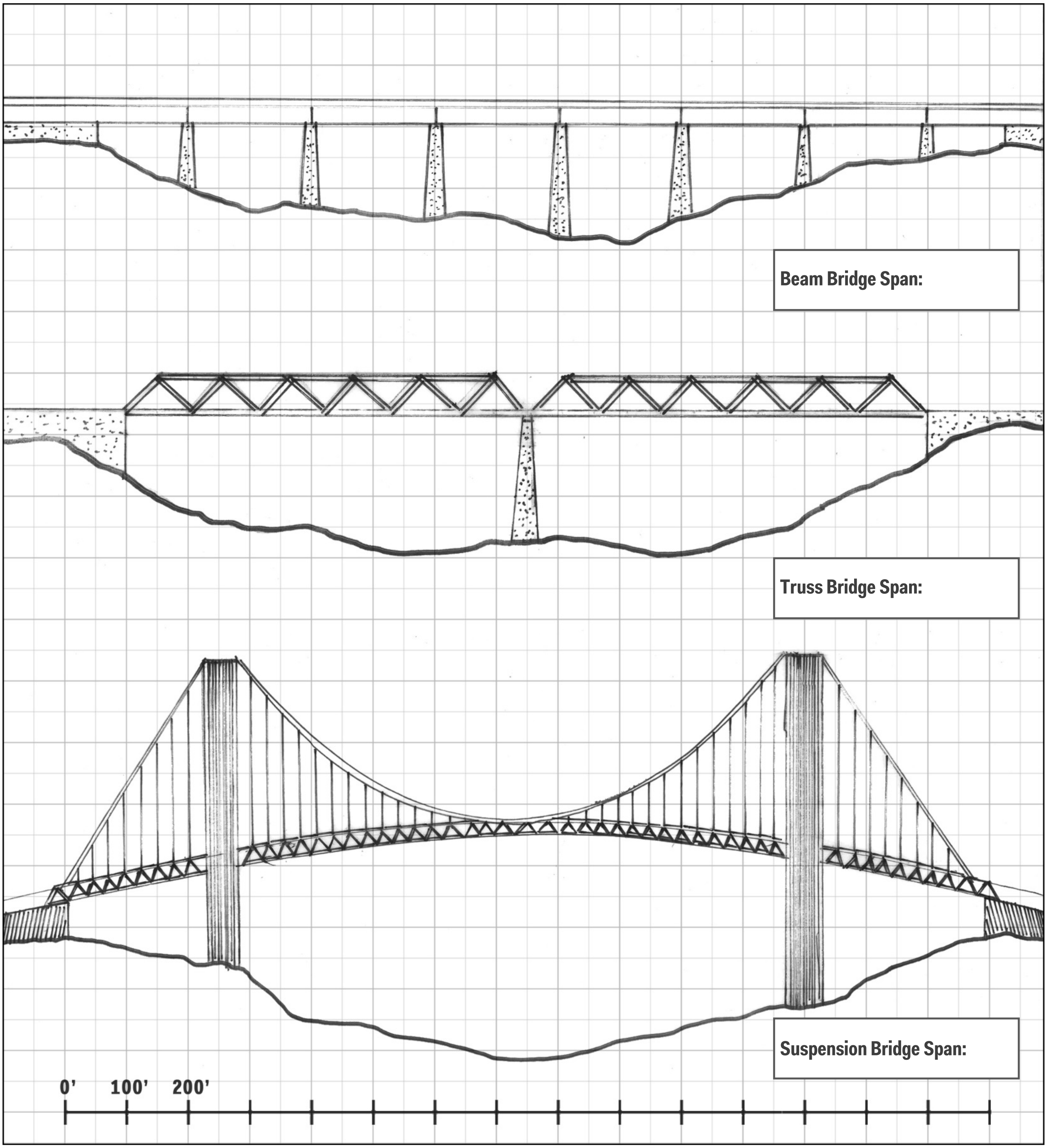
Spanning Great Distances

Use the grid to measure the span of each bridge below and discover which bridge can span the furthest distance. Remember, a span is the measurement of distance between two supports in a bridge— not the full length of the bridge.



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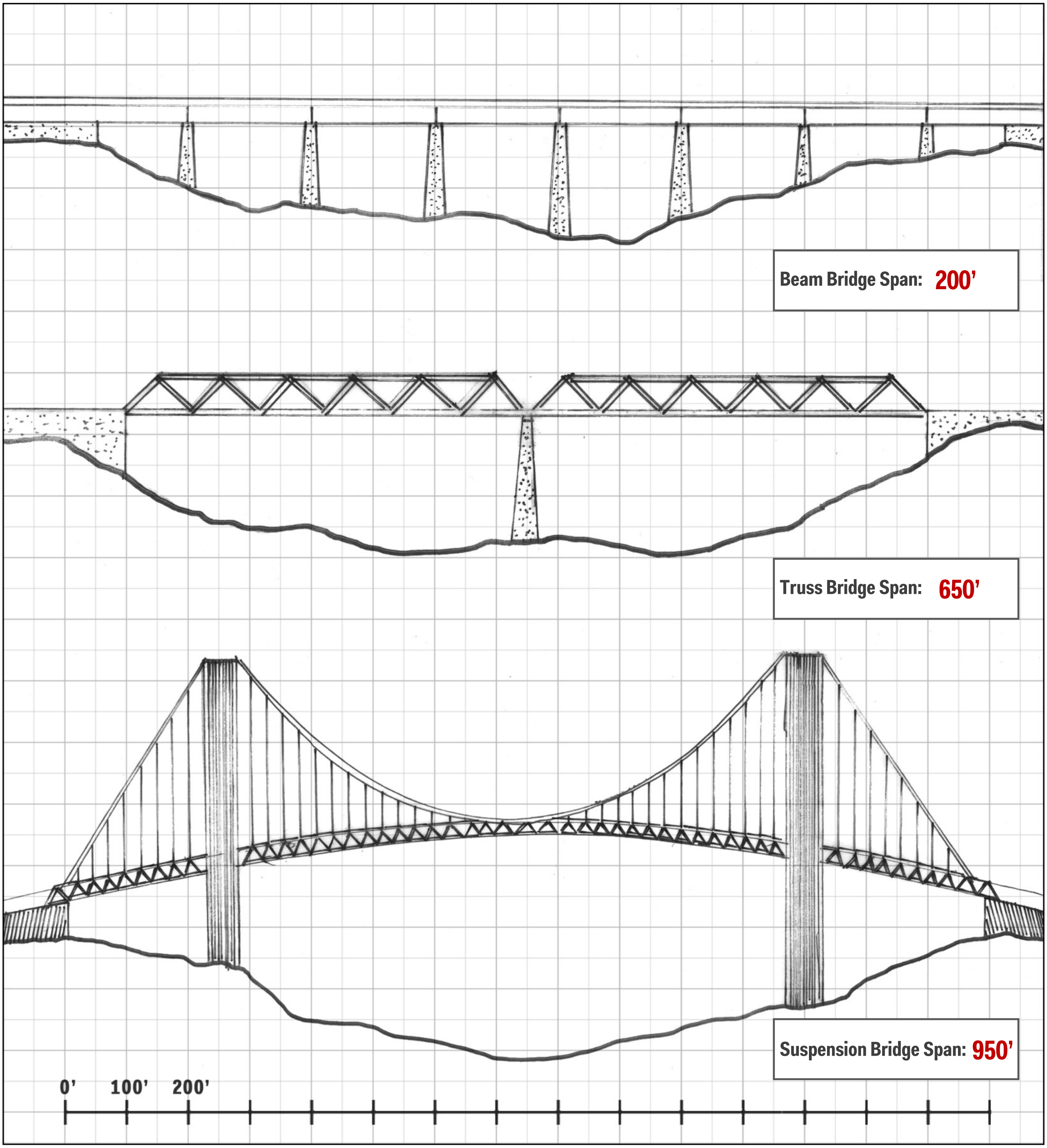
Spanning Great Distances (Answer Key)

Use the grid to measure the span of each bridge below and discover which bridge can span the furthest distance. Remember, a span is the measurement of distance between two supports in a bridge— not the full length of the bridge.



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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	■	■	■				■

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.	■	■	■	■	■	■	■

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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