week 3

Building Bridges

Build a sturdy bridge with a 2-foot span that can be transported from one spot to another.

Subjects and Skills

- Fundamental principles of engineering
- Various bridge designs

Materials Needed

- Index cards
- Paper
- Rulers
- Pennies
- Straws
- Self-adhesive labels
- Toothpicks
- Bridge test site (two stacks of books of equal height 2 feet apart)

Vocabulary

- Beam bridge
- Suspension bridge
- Anchorage

Purpose

Students can appreciate the engineering and design of bridges by understanding the physical laws and fundamental principles that guide the development and application of bridge conception and construction.

Objectives

Students will:

- understand the fundamental principles necessary in the development of bridges,
- analyze engineering of different types of bridges, and
- design and build a bridge.

Activity Preparation

1. Run off activity sheets.
2. Gather materials and place them in two different areas of the room.
3. Bookmark websites to be used in class.
   a. http://videos.howstuffworks.com/tlc/28828-understanding-history-of-bridge-construction-video.htm

b. http://videos.howstuffworks.com/tlc/29830-understanding-bridge-movement-video.htm
c. http://videos.howstuffworks.com/tlc/29829-understanding-bridge-designs-video.htm
d. http://videos.howstuffworks.com/discovery/35894-howstuffworks-show-episode-12-steel-bridges-video.htm
e. http://dsc.discovery.com/videos/we-built-this-city-new-york-the-brooklyn-bridge.html
f. http://www.pbs.org/wgbh/buildingbig/bridge/basics.html
g. http://www.brantacan.co.uk/bridges.htm

Activity Procedure

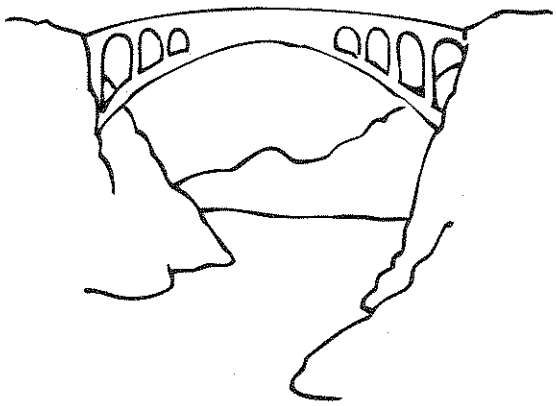
1. Begin the class discussion with the following questions: What types of bridges do we use today? What purposes do they serve? How are they made?
2. Watch some or all of the following videos online:
   a. Link a., History of Bridge Construction (02:41)
   b. Link b., Bridge Movement (01:28)
   c. Link c., Bridge Designs (02:08)
   d. Link d., Steel Bridges (02:54)
   e. Link e., The Brooklyn Bridge (01:55)
3. Share information found at two excellent sites on bridge basics, found at Link f. and Link g.
4. Summarize the video and website information. You could do this as a class, in partners, or in small groups, and you should use your method of choice for review (e.g., calling on students, writing paragraphs or questions).
5. Distribute the activity sheet to continue the discussion.
6. Have students highlight information and use what they have learned to draw sketches of the five different types of bridges.
7. While students are working on the individual section of the activity sheet, put students in small groups of three or four students and assign group numbers.
8. After students have used the allotted time to construct their bridges, begin the competition. It works well to erect two stacks of books of equal height 2 feet apart so that students can move their bridges to this test site and load their bridge with pennies.
9. After the competition, have students evaluate the construction and design of their bridges, and discuss the elements of the different bridges.
10. If you wish, assign one of the activities in Extend the Learning With Bridges: Activities.

Name: _____ Date: _____

Building Bridges

GOAL

- Build a sturdy bridge with a 2-foot span that can be transported from one spot to another.



MATERIALS

- Index cards
- Paper
- Ruler
- Pennies
- Straws
- Self-adhesive labels
- Toothpicks

TIME TO CREATE

- 20 minutes

INDIVIDUAL ACTIVITY

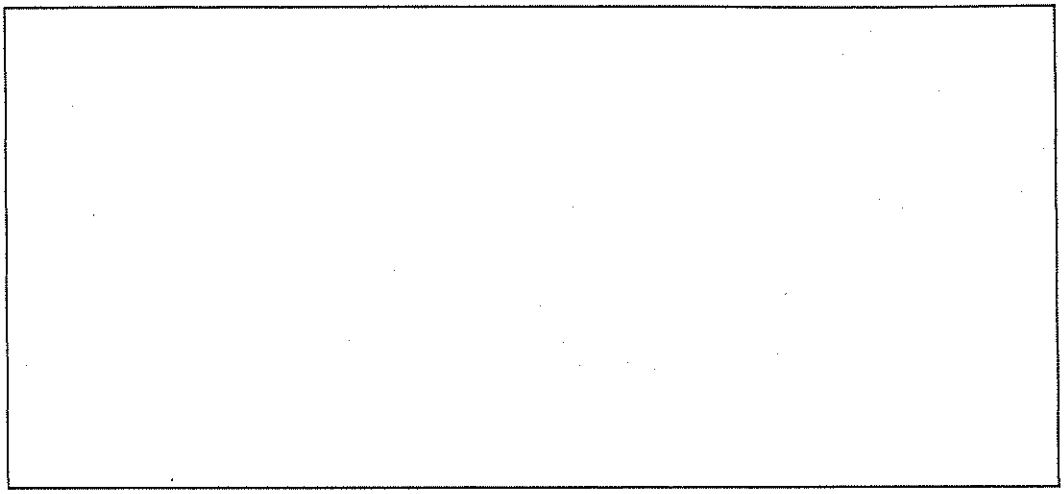
There are five types of bridges. Read the information about the different types of bridges, and draw a sketch of what each might look like.

A beam bridge is the simplest kind of bridge. A log that has fallen across a river or a board lain across a puddle forms a beam bridge.

SKETCH OF BEAM BRIDGE

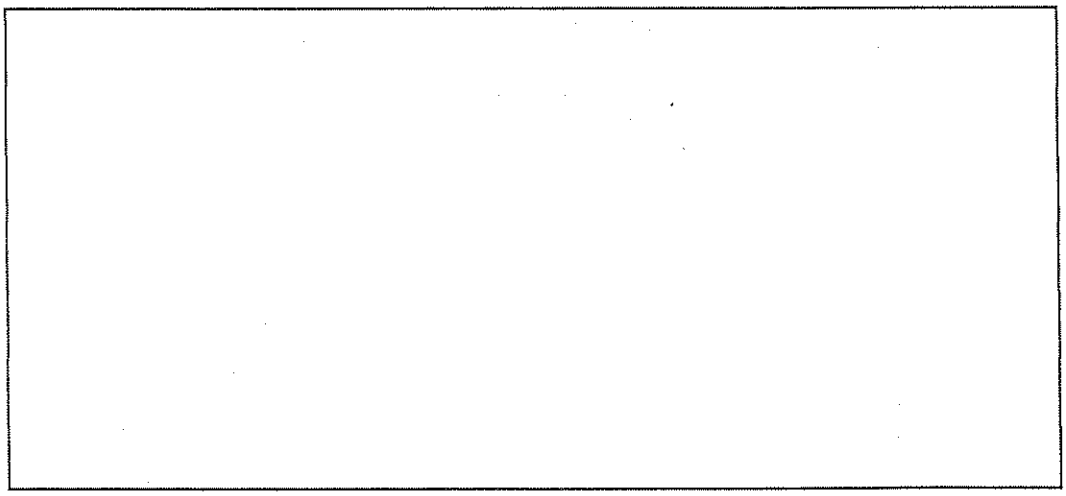
Arches have been common features in structures since 1,000 B.C., but they didn't appear in bridges for another thousand years. Roman roads were often supported by stone arches.

SKETCH OF ARCHES



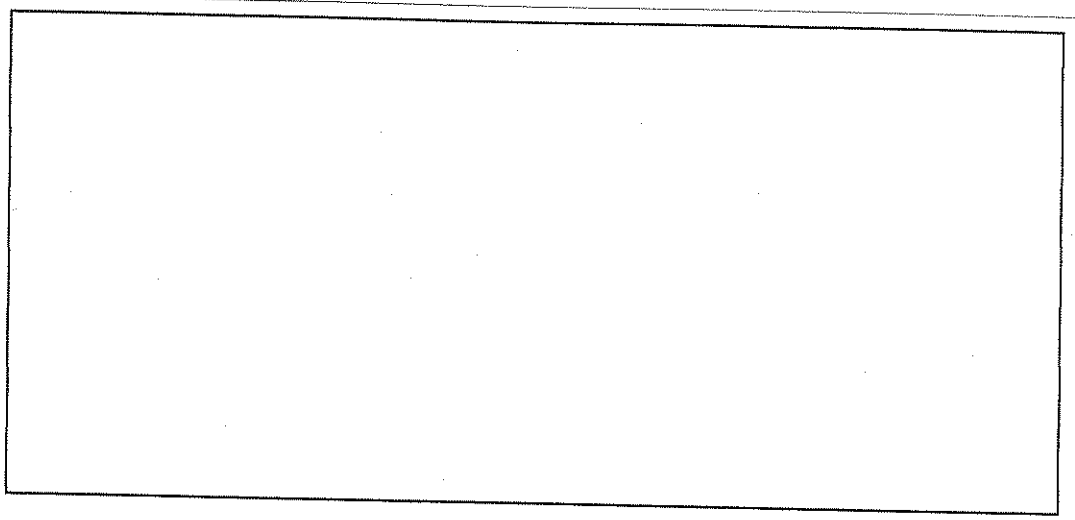
Suspension bridges, like the Golden Gate Bridge, rely on cables for their support. Each cable end must be anchored to a massive block of concrete called an anchorage. The cable pulls on the anchorages.

SKETCH OF SUSPENSION BRIDGE



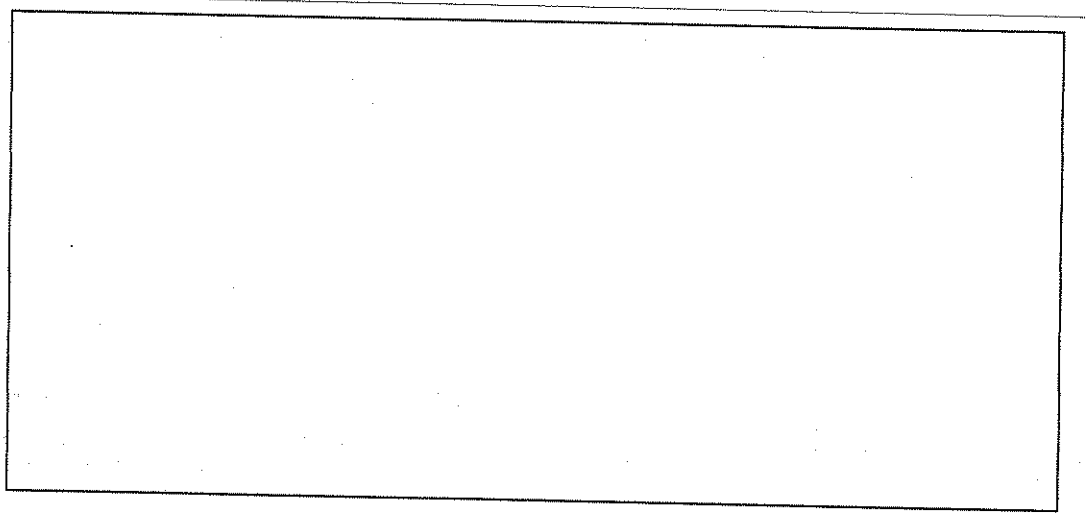
Cantilever bridges are supported by cantilevers, which are beams, or structural frameworks, that are fixed at one end and free at the other, much like diving boards. Most of the flexing, or bending, takes place in the middle of a cantilever bridge; therefore, the deepest part should be at the middle.

SKETCH OF CANTILEVER BRIDGE



Cable-stayed bridges are supported by a series of cables. Each forms the leg of a triangle and extends from a tower or towers. Cable-stays are straight and anchor directly into the roadway.

SKETCH OF CABLE-STAYED BRIDGES



Think about the following questions on your own before designing and building a bridge with your team.

1. What kind of bridge do you think would be the sturdiest? _____

   Why? _____

   _____

2. Which bridge would be the easiest to make? _____

   Why? _____

   _____

3. How could you change an index card and/or regular paper to make it sturdier?

_____

_____

_____

4. How might folding paper into pleats (like a fan) make paper stronger?

_____

_____

_____

TEAM CHALLENGE

Participants will work in small teams to design and build a bridge in 20 minutes. The bridge must have a 2-foot span and be able to be moved from one designated location to another without falling apart. You want your bridge to hold the most weight before collapsing. First draw the plan of the bridge to scale. Use one sheet of paper per team for the design, and label everything. Once the design is complete, begin constructing the bridge. Once the teacher has called time, stop working immediately. Any team that continues to work after time has been called may be disqualified.

Start Time _____:_____ + 20 Minutes = _____:_____ End Time

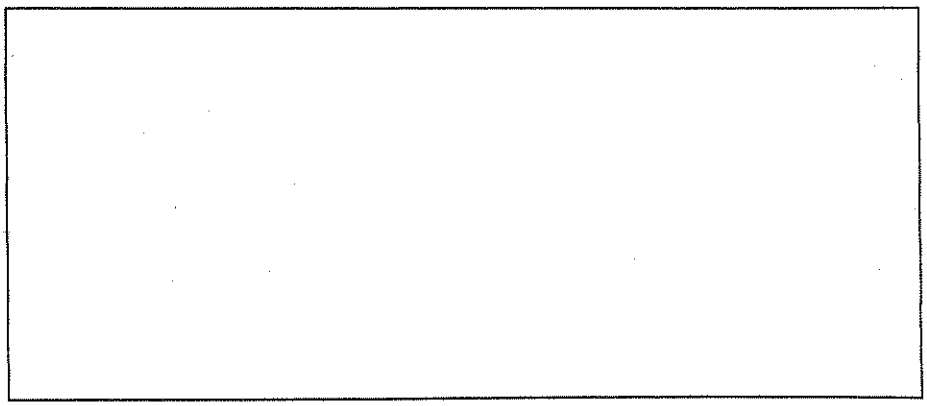
Before your group begins designing your bridge, think about the following questions:

1. What kind of bridge do you plan on making? _____
2. Explain why you decided on that type of bridge._____

_____

_____

3. Draw a sketch of your team's bridge.



4. Which of the available materials will you need to make this bridge? _____

_____

_____

After your bridge has been constructed, answer the following questions:

5. A roll of 50 pennies weighs 132 grams, which is a about 4.5 ounces. How many ounces are in a pound? _____
6. Approximately how many pennies would weigh 1 pound? _____
7. How many pennies do you think you can pile on your bridge before it collapses? _____

When the teacher signals that it is time to stop working, take the bridges to the test site. After the contest, answer the following questions:

1. How many pennies was your bridge able to hold before it collapsed? _____
2. What is the class record of pennies a team's bridge was able to hold today? _____
3. What contributed to the success of the bridge with the class record?

_____

_____

EXTEND THE LEARNING WITH BRIDGES: ACTIVITIES

1. **Bridges for the future.** The United States has more than 76,000 bridges. Technology today is more advanced and allows us to utilize unique methods for building smarter bridges. Visit http://www.pbs.org/wgbh/nova/tech/bridge-collapse.html to read about why some have failed. Design and draw a bridge for the future.
2. **Bridge projects.** Visit http://bridgepros.com/projects/index.html and investigate one of the bridge projects listed there. Write a paragraph explaining this project.
3. **Tacoma bridge collapse of 1940.** Visit http://bridgecontest.phys.iit.edu/public/help for a lecture and tutorial about this event. Skip ahead to minute 10:58 to watch the swaying of the bridge prior to its collapse. Write a paragraph explaining the reasons for the collapse and how such accidents are prevented now.
4. **Labs for understanding forces, materials, loads, and shapes.** Choose from among the following labs:
   - Complete the forces lab found at http://www.pbs.org/wgbh/buildingbig/lab/forces.html, which demonstrates real-life forces that affect structures and teaches about different forces that a bridge experiences.
   - Complete the materials lab at http://www.pbs.org/wgbh/buildingbig/lab/materials.html, which demonstrates the different materials used to build structures.
   - Complete the loads lab found at http://www.pbs.org/wgbh/buildingbig/lab/loads.html, which demonstrates the forces, or loads, that act on the structures.
   - Complete the shapes lab found at http://www.pbs.org/wgbh/buildingbig/lab/shapes.html, which demonstrates how the shapes of structures affect their strength.

5. **Build a bridge.** Complete one of the following build-a-bridge activities:
   - Interactive bridge: http://www.pbs.org/wgbh/nova/bridge
   - Spaghetti bridge: http://civil.camosun.bc.ca/spaghetti_bridge/Tips.htm
   - PBS bridge challenge: http://www.pbs.org/wgbh/buildingbig/bridge/challenge/index.html
   - Suspension bridge: http://www.pbs.org/wgbh/buildingbig/educator/act_suspension_ho.html