Bridges: Primary Types and Engineering Principles
Lesson Plan

Grade Level: 9-12	**Curriculum Focus:** Technology and Society	**Lesson Duration:** Three class periods

Student Objectives

- Bridges are categorized into three primary types: suspension, beam, and arch.
- Each is designed and built according to certain principles of engineering.

Materials

- Discovery School video on *unitedstreaming*: *Understanding Bridges*
  Search for this video by using the video title (or a portion of it) as the keyword.

  Selected clips that support this lesson plan:

  - The Complexity of Building Bridges: A Multifaceted Task
  - Suspension Bridges: "Kings of the Bridge World"
  - Cable-Stayed Bridges: Combining Form and Function

- Research materials on bridge engineering
- Computer with Internet access

For each group:

- Twenty drinking straws
- One meter of masking tape
- Two stacks of books or blocks of wood
- Meterstick
- Jar of pennies

Procedures

1. Divide your students into groups, provide each group with the necessary materials, and challenge each group to build a bridge that will span 25 centimeters.
2. Set the following rules:
   - For the two ends of the span, students will use two stacks of books or wood blocks placed 25 centimeters apart.

- The only materials students may use for the bridge itself are 20 drinking straws and 1 meter of masking tape.
- The straws may be shortened, bent, or cut.
- No part of the bridge may touch anything between the two ends of the span.

3. Allow each group one class period to research bridge engineering. In their research, ask them to describe the basic principles of the three main kinds of bridges: suspension, beam, and arch.
4. Allow each group another class period to brainstorm ideas, make sketches, and choose a final design for their bridges.
5. Students will use a third class period to build their bridges with the materials provided.
6. After all bridges have been completed, have students test their bridges by seeing how many pennies they will hold. Students may modify their bridges, at this point, and then see if they will hold more pennies.
7. Have groups present their bridges and testing results to the class. Ask students to speculate about why some bridges were more or less successful than others. What factors went into the strength or weakness of each bridge? What flaws were inherent in the building materials? How were those flaws overcome?
8. Students who enjoyed this activity can try a more challenging level by increasing the span to more than 25 centimeters.

Discussion Questions

1. Suppose all the bridges in a large city such as New York City were closed. What effect would that have on that city? What are some specific ways that people would adapt to not using bridges?
2. Discuss how each of the three basic types of bridges—suspension, beam, and arch—transfers loads from the bridge to the ground. Describe where tension and compression occur on each type of bridge.
3. Many bridges are icons for their city or region. Why do you think people associate certain bridges with certain cities, while other bridges seem unremarkable?
4. Compare and contrast a beam bridge and an arch bridge. List at least three ways they are similar and three ways they are different.
5. The U.S. government requires states to inspect and rate all bridges at least once every two years. Describe ways that technology can be used to make monitoring and inspection of bridges more efficient and effective.
6. The earthquake in October 1989 in the San Francisco Bay area caused great structural damage to many of the bridges in the area. What features would you design as part of a bridge to make it better able to withstand an earthquake? Explain your ideas.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Students worked cooperatively in their groups; carefully prepared plans and sketches; thoroughly researched principles of bridge engineering and applied principles learned.
- 2 points: Students worked cooperatively in their groups; prepared plans and/or sketches; researched and applied some principles of bridge engineering.
- 1 point: Students had difficulties working cooperatively in their groups; failed to prepare plans or sketches; research insufficient; only a few principles of bridge engineering applied.

Vocabulary

composite

Definition: Made up of distinct parts.

Context: Chemists and engineers are creating strong yet lightweight composite materials that are now being used in everything from tennis rackets to airplanes.

resonance

Definition: A vibration of large amplitude in a mechanical or electrical system caused by a relatively small periodic stimulus of the same or nearly the same period as the natural vibration period of the system.

Context: The magnified sways and twisting of the Tacoma Narrows Bridge were caused by the resonance of 40-mile-per-hour winds and the natural oscillations of the bridge.

stay

Definition: A large, strong rope usually of wire used to support a mast.

Context: One of the diagonal steel stays that supported the bridge broke, but the structure remained standing.

tension

Definition: Either of two balancing forces causing or tending to cause extension.

Context: The heavy weight of concrete and steel causes a great deal of tension on the cables that support a bridge.

viaduct

Definition: A long elevated roadway usually consisting of a series of short spans supported on arches, piers, or columns.

Context: In Europe, there are still viaducts over deep valleys that were built by the Roman Empire.

Academic Standards

Mid-continent Research for Education and Learning (McREL)
McREL's Content Knowledge: A Compendium of Standards and Benchmarks for K-12 Education addresses 14 content areas. To view the standards and benchmarks, visit http://www.mcrel.org/compendium/browse.asp.

This lesson plan addresses the following national standards:

- Science—Physical Science: Understands forces and motion.
- Science—Nature of Science: Understands the scientific enterprise.
- Technology: Understands the relationships among science, technology, society, and the individual.

National Academy of Sciences
The National Academy of Sciences provides guidelines for teaching science in grades K-12 to promote scientific literacy. To view the standards, visit this Web site:
http://books.nap.edu/html/nses/html/overview.html#content.

This lesson plan addresses the following national standards:

- Physical Science: Motions and forces

Support Materials

Develop custom worksheets, educational puzzles, online quizzes, and more with the free teaching tools offered on the Discoveryschool.com Web site. Create and print support materials, or save them to a Custom Classroom account for future use. To learn more, visit

- http://school.discovery.com/teachingtools/teachingtools.html