PENSACOLA BAY BRIDGE
REPLACEMENT PROJECT

Goes to School!

Popsicle Stick Bridge
Lesson Plan – Middle School

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Pensacola Bay Bridge Replacement Project Goes to School Program

2017/18 Middle School Edition

Version 1804

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Introduction to the Popsicle Stick Bridge Unit Series

Bridges 101: Since the first tree fell across a stream, bridges have been providing safe passage across bodies of water. When you consider how many bridges exist in Escambia and Santa Rosa Counties and their importance in connecting people to neighboring communities, it's easy to understand the importance of bridges in our everyday lives. The Pensacola Bay Bridge Replacement Project demonstrates this interconnectivity. For the next four years, residents will experience the magnificent construction of this project. Students and teachers will feel connected to the project as they engage in exciting and relevant hands-on activities and simulations, providing hours of classroom involvement through the duration of the bridge construction.

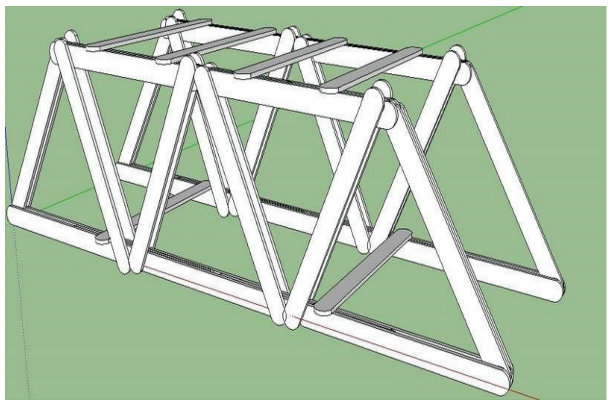
Modern bridges are vital structures. Most bridge construction requires the involvement of engineers (especially civil engineers), architects, scientists, mathematicians, and artists.

There are six main types of bridges: arch, beam, cable-stayed, cantilever, suspension, and truss (refer to the list at end of the lesson). For this unit series, the focus is on the four basic types of bridges used in transportation: beam, truss, arch, and suspension. To understand how a bridge functions, one must first understand how natural forces affect them. Two forces that constantly impact any bridge are compression and tension. Compression acts to push down or shorten the bridge. Tension (also referred to as tensile force) acts to expand or lengthen the bridge. The most effective way for a bridge builder to respond to these forces is to design the structure to balance the forces across sections of the bridge. This allows the bridge to resist the load from the weight of the bridge and the traffic, as well as the wind load, by transferring the load through the piers and into the foundations and the ground.

Lesson Series Overview: Middle-school students can explore an eight-unit curriculum on bridge building; this curriculum includes building a popsicle stick bridge. The lessons can be used together as a long-term project or used individually as stand-alone lessons. Regardless of the method by which the lessons are incorporated into the curriculum, building the popsicle stick bridge is the final activity in the curriculum.

In this eight-lesson unit on bridge building, teachers and students will:

- Construct a visual classroom project demonstrating simple bridge construction
- Apply bridge-building methodology
- Learn specific bridge types
- Understand bridge terminology
- Identify various careers related to bridge building.



Unit One-Introduction to Bridges: Walks students through the history of bridges and describes the types of bridges.

Unit Two-Bridge Construction and Design: Examines bridge design and construction, the forces of compression and tension, and how they work together.

Unit Three-Suspension Bridges: Details how bridge builders use suspension bridges to manage the natural forces of compression and tension.

Unit Four-Truss Bridges: Describes how the use of truss bridges manages the natural forces of compression and tension.

Unit Five-Arch Bridges: Demonstrates one of the basic principles in bridge design and shows how forces are applied in the structure.

Unit Six-Strength Testing of Materials: Teaches about the variety of materials used in bridge construction, and examines the advantages and disadvantages of the most common materials.

Unit Seven-Civic Engagement / Show Me the Money – Cost Estimation: Provides insight regarding the varying factors that influence bridge design and construction costs.

Unit Eight-Building a Popsicle Stick Bridge: The culmination of all the units; the teachers and students design and construct a popsicle stick bridge by applying the concepts from the previous lessons.

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PENSACOLA BAY BRIDGE
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Popsicle Stick Bridge Lesson Plan – Unit I

INTRODUCTION TO BRIDGES

Objective: "Introduction to Bridges" walks the student through the history of bridges and describes the types of bridges. It begins with an exchange of information between teachers and students to help students understand the complexity and the simplicity of bridge components.

As a result of this lesson, students will be able to

- describe four common bridge types: suspension, arch, beam, and truss;
- understand some of the basic design considerations that engineers take into account when building bridges;[1]
- understand the use and value of bridges in modern society; and
- understand basic vocabulary of bridge design and construction.

Summary: In the Unit 1 PowerPoint presentation, students will learn about six types of bridges while being presented with images, definitions each bridge type, and lists of the strengths and weaknesses of the bridges. The students will use websites to complete worksheets on each type of bridge. As a result of this lesson, students will become more aware of the variety of bridges and of their value in everyday life.

Materials:

- PowerPoint presentation – Unit 1 Bridge Types
- Activity 1 information and worksheet
- Activity 2 information and worksheet

[1]Source: https://www.wsdot.wa.gov/TNBhistory/Lessons/ManyKindsofBridges.htm

ACADEMIC STANDARDS

Objectives:

SC.6.P.13.1

Investigate and describe types of forces including contact forces and forces acting at a distance, such as electrical, magnetic, and gravitational.

SC.6.P.13.2

Explore the Law of Gravity by recognizing that every object exerts gravitational force on every other object and that the force depends on how much mass the objects have and how far apart they are.

SC.7.P.11.2

Investigate and describe the transformation of energy from one form to another.

SC.7.P.11.3

Cite evidence to explain that energy cannot be created nor destroyed, only changed from one form to another.

SC.8.N.1.1

Define a problem from the eighth grade curriculum using appropriate reference materials to support scientific understanding, plan and carry out scientific investigations of various types, such as systematic observations or experiments, identify variables, collect and organize data, interpret data in charts, tables, and graphics, analyze information, make predictions, and defend conclusions.

SC.8.N.1.5

Analyze the methods used to develop a scientific explanation as seen in different fields of science.

SC.8.N.1.6

Understand that scientific investigations involve the collection of relevant empirical evidence, the use of logical reasoning, and the application of imagination in devising hypotheses, predictions, explanations and models to make sense of the collected evidence.

s. 1003.41, Florida Statutes
Rule 6A-1.09441, F.A.C

Vocabulary:

Approach spans: Short spans over land that lead to the main spans

Beam: Thin, horizontal elements of the bridge that support the deck

Bent: Vertical support elements of the bridge (e.g., columns, piers, and abutments)

Chords: In a truss, the upper and lower horizontal (or arched) elements of the frame

Cross-bracing: Diagonal bracing that resists wind, earthquakes, and other forces

Deck: A slab of concrete or steel that rests on the floor-support system and is supported by beams; where traffic travels

Floor beams: Deck support beams that are perpendicular to the roadway's centerline

Footing: Support element at the bottom of a column or bent

Foundation: The underground base that supports the bridge columns (e.g. footings, drilled shafts, and piles)

Frame: A structural skeleton that is designed to resist collapse

Girder: A type of beam; see "beam"

Median: A barrier between opposing travel lanes that minimizes head-on collisions

Arch bridge: These arch-shaped bridges have abutments at each end.

Beam bridge: Beam bridges consist of horizontal beams that are supported at each end by piers. The earliest beam bridges included simple logs that sat across streams and similar simple structures.[1] In modern times, beam bridges include large-box concrete or steel girder bridges.[2] The weight on top of the beam pushes straight down on the piers at either end of the bridge.

Cable-stayed bridge: A cable-stayed bridge has one or more towers (or pylons), from which cables are attached to support the bridge deck. A distinctive feature are the cables that run directly from the tower to the deck, forming a fan-like pattern or a series of parallel lines.[3]

Cantilever bridge: Cantilever bridges are built using cantilevers—horizontal beams or trusses that are supported on only one end. Most cantilever bridges use two cantilever arms that extend from opposite sides of the obstacle, meeting at the center.[4]

Suspension bridge: Suspension bridges are suspended from cables. The earliest suspension bridges were made of ropes or vines covered with pieces of bamboo. In modern bridges, the cables hang from towers that are attached to caissons or cofferdams, which in turn are embedded deep in the floor of a lake or river.[5]

Truss bridge: Truss bridges have a solid deck and a lattice of pin-jointed girders on each side. Early truss bridges were made of wood, but modern truss bridges are made of metals such as steel.

[1] Source: https://en.wikipedia.org/wiki/Bridge
[2, 5] Source: https: http://ewh.ieee.org/r10/australia/council/TISP/pdf/paddlepopbridge.pdf
[3] Source: https://en.wikipedia.org/wiki/Cable-stayed_bridge
[4] Source: https://simple.wikipedia.org/wiki/Cantilever_bridge

Procedure:

1. Explain to students that several important elements must be considered before a bridge is built- These include
    - The proposed location of the bridge
    - The strength of the supporting soils at the proposed location
    - The practical bridge span lengths
    - The construction costs
    - The bridge's appearance
2. Explain that in addition to supporting their own weight and the weight of the cars and trucks (and the loads they carried by those vehicles) bridges need to be able to withstand strong natural forces such as wind (including wind and flooding from hurricanes).
3. Show students the Unit 1 PowerPoint presentation about the types of bridges. Explain that a bridge can be as simple as a log or as complex as the I-10 bridge..
4. Prior to beginning Activity 1 or Activity 2, have a brief discussion about bridges in everyday life using the discussion questions provided below as icebreakers.

    Discussion Questions. Ask the students these questions, and discuss them as a class:

    - One day, you are traveling through the woods, trying to travel in a straight line from one point to another. As you travel, you find yourself looking over a river. This river is obstructing your travel and is keeping you from reaching your destination. How do you fix this situation? How do you get back on your path and reach your destination? Answer: You hire a civil engineer, who will take the steps to design and build a bridge. But what kind of bridge do you build, and why?
    - Suppose all the bridges in Pensacola or Gulf Breeze were closed. What effect would that have on each city? What are some of the ways that we could adapt to not using bridges? (Be specific.)
    - Many bridges are gateways for their cities or regions. Why are certain bridges so remarkable, even as others are forgotten?
    - Compare and contrast a beam bridge and an arch bridge. List at least three ways in which they are similar and three ways in which they are different.
    - The Florida Department of Transportation inspects and rates all bridges at least once every few years. Describe ways in which technology can be used to make the monitoring and inspection of bridges more efficient and effective (e.g., drones or phone apps).
5. To have a visual understanding of the various bridge types, students will engage in activities to identify the types and will explore the many bridges in Florida using the selected websites.

    ACTIVITY 1 – Using the links provided on the Activity 1 worksheet, students will locate an example of each bridge type listed on that worksheet.

    ACTIVITY 2 – Using the link provided in Activity 2, students will use the Famous Bridges in the State of Florida page (Sheet 2 of the activity) to identify each bridge's type, location, and length (span).

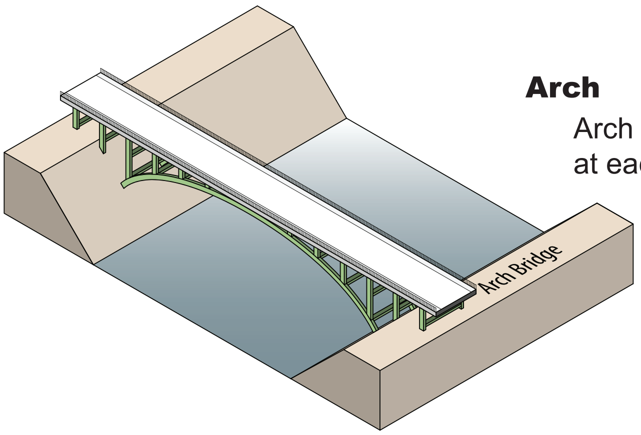
Research source: https://www.wsdot.wa.gov/TNBhistory/Lessons/ManyKindsofBridges.htm

ACTIVITY # 1

Find the Bridges

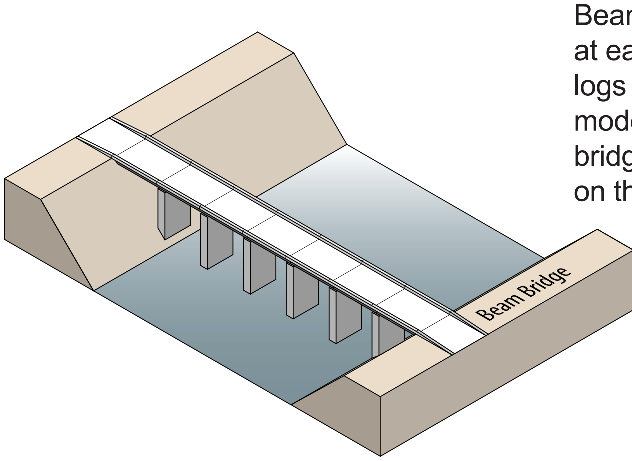
Using the links provided on the Activity 1 worksheet, locate an example of each bridge type listed below.

There are six main types of bridges: arch, beam, cable-stayed, cantilever, suspension, and truss.



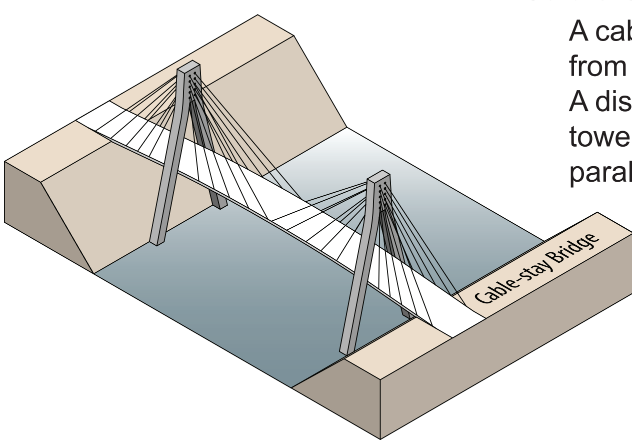
Arch

Arch bridges are arch-shaped and have abutments at each end.



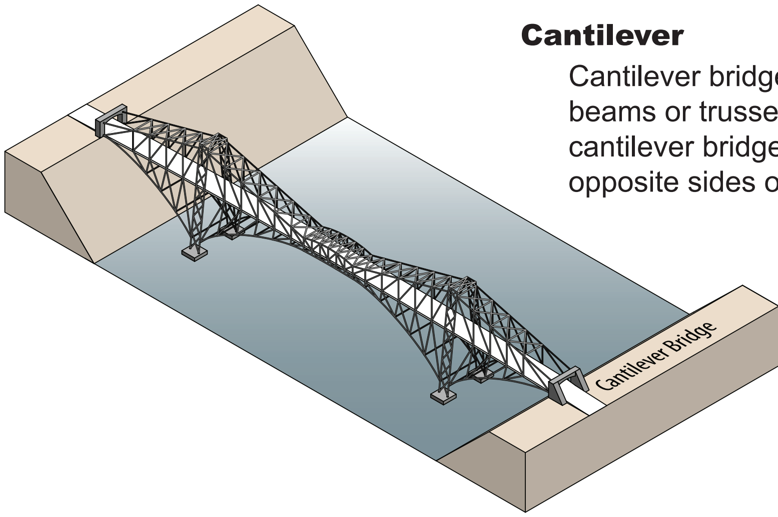
Beam

Beam bridges consist of horizontal beams that are supported at each end by piers. The earliest beam bridges were simple logs that sat across streams and other simple structures. In modern times, beam bridges include large-box steel girder bridges. The weight on top of the beam pushes straight down on the piers at either end of the bridge.



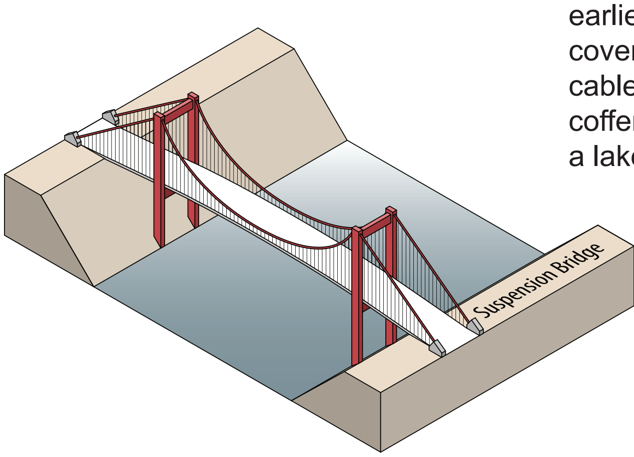
Cable-stayed

A cable-stayed bridge has one or more towers (or pylons), from which cables are attached to support the bridge deck. A distinctive feature are the cables that run directly from the tower to the deck, forming a fan-like pattern or a series of parallel lines.



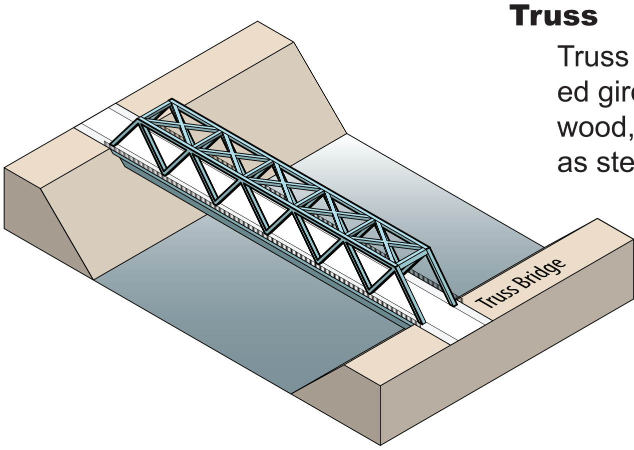
Cantilever

Cantilever bridges are built using cantilevers—horizontal beams or trusses that are supported on only one end. Most cantilever bridges use two cantilever arms that extend from opposite sides of the obstacle, meeting at the center.



Suspension

Suspension bridges are suspended from cables. The earliest suspension bridges were made of ropes or vines covered with pieces of bamboo. In modern bridges, the cables hang from towers that are attached to caissons or cofferdams, which in turn are embedded deep in the floor of a lake or river.



Truss

Truss bridges have a solid deck and a lattice of pin-jointed girders on each side. Early truss bridges were made of wood, but modern truss bridges are made of metals such as steel.

ACTIVITY #1 WORKSHEET

Bridges in Florida

Learn about famous bridges in the state of Florida. Give each bridge's name, location, and length (span). (Use an additional sheet of paper if necessary.)

Name	Location	Length (Span)

RESOURCES:

Outstanding Bridges of Florida
www.fdot.gov/construction/structures/OutstandingBridgesFlorida.pdf

List of bridges in Florida - Wikipedia
https://en.wikipedia.org/wiki/List_of_bridges_in_Florida

List of Famous Bridges in Florida - Ranker
www.ranker.com/list/bridges-in-florida/worldchap

ACTIVITY # 2

Find the Famous Bridges

Using the link below, find the famous Florida bridges that are listed on the Activity 2 Worksheet.

www.fdot.gov/construction/structures/OutstandingBridgesFlorida.pdf

ACTIVITY #2 WORKSHEET

Famous Bridges in the State of Florida

Bridge	Type	Location & Length
Isaiah D. Hart Bridge		
John T. Alsop, Jr. Bridge		
Hal Adams Bridge		
Myrtle Avenue Overpass		
Apalachicola River Bridge at Blountstown		
Seven Mile Bridge		
Napoleon Bonaparte Bridge		

LESSON CLOSURE

Can you think of any bridges in your community? They can be used for roadways, bike paths, or walking paths. Describe what they look like. What types of bridges are they? Countless types of bridges exist in the world. Natural bridges are made of trees or logs that cross over rivers or ravines. People have made bridges out of wood boards, rope, wire, metal, concrete, and any other material that might hold enough weight for a person or load of goods to pass.

Why do engineers design bridges? People might want a bridge to gain access to resources; to expand; for trade or industry; or to connect to another community, city, or region. Bridges can also bring money to a city through trade or tourism.

What must engineers consider when designing bridges? Civil and structural engineers think about the type of bridge that fits the situation, the available materials (What materials are needed to build the bridge?), the site conditions (What type of soil and rock will the bridge be built on?), the geologic and environmental factors (Are native animals and plants in the area? What is the weather like?), the budget (How much money do they have?), and the audience (Who will use the bridge, and for what purposes?)

TEACHER BACKGROUND INFORMATION

With countless numbers of these structures spanning rivers, canyons and great divides within our world, it's easy to take bridges for granted. From the ornate, historical bridges that can be found decorating the world's largest cities to the rustic bridges that have been connecting communities for generations, there are bridges everywhere, yet not many people take the time to consider how and when bridges came to be.

The history of the bridge dates back to the beginning of time, when nature introduced mankind to this concept.

Natural bridges and the beginning of this structural concept

The first bridges were not built but were created by nature. A tree that fell over a bubbling creek became a bridge that animals could use to navigate across the forest floor. A giant boulder that slid off the side of a mountain could bridge the gap of a crevasse, making a trail that native people could use to maneuver through the mountain range. As humans began to discover these natural phenomena and the ways that the bridge structure improve their lifestyle, they began to attempt to create these structures for themselves.

Ancient civilizations and bridge construction

Ancient civilizations from around the globe began to take notice of the concept of the bridge and began to create these structures within their own societies. One of the oldest surviving bridges dates back to the 13th century B.C. and was created by the ancient Greeks. However, it is assumed that humans were creating their own bridges long before this. There is evidence that early humans began creating bridges that were similar to the ones they found in nature — often using basic planks or wood beams to connect one point to another.

TEACHER BACKGROUND INFORMATION CONTINUED

As societies became more informed and advanced, the bridges they created became more structurally sound. For example, the ancient Romans used their expert architectural understanding to create arched bridges out of concrete. Many of these bridges — and the ruins of others — still exist today and can be admired by tourists who travel to Italy. On the other side of the world, the Incan tribes were creating the earliest forms of suspension bridges using rope. The ancient Chinese also mastered the art of creating stone arch bridges, which allowed them to build an enormous empire.

The structural bridges that were created by ancient civilizations laid the blueprint for many generations to come. For hundreds and thousands of years, humans improved upon these designs to create more magnificent bridges than ever before. Then, the Industrial Revolution began and completely changed the concept and capabilities of bridges.

The Industrial Revolution and the bridge

As the Industrial Revolution catapulted the civilized world into a new era of production and design in nearly every industry, bridge designers and constructors began to realize that steel would change everything about bridge design and capability. The strength and flexibility of steel allowed for larger, longer bridges to be built around the world. These bridges were no longer crossing simple streams and manageable rivers — they were able to connect people who had previously lived seemingly a world apart. The construction of these bridges led to further advances in trade, science, technology and more.

Some of the most famous bridges that resulted from the advances of the Industrial Revolution include the Golden Gate Bridge in San Francisco, the Mackinac Bridge in Michigan, the sea link bridge in Mumbai, and the Iron Bridge of Shropshire.

Today, advanced technology and systematic designs make it possible to create a bridge that spans nearly any divide. There's an innate trust between human beings and bridges — an understanding that these structures will safely transport people over seemingly impossible obstacles, including buzzing highways, rapid rivers and gaping canyons. It's important to understand that the history of the bridge is still evolving, as engineers, architects and other innovators continue to find new ways to connect travelers from one point to another.

Source: http://www.historyofbridges.com/bridges-history/

Source: http://www.bridgesdb.com/bridge-history-facts/historical-development-of-bridges/

Source: https://theconstructor.org/structures/history-of-bridges/5491/

ASSESSMENT
UNIT 1

The focus of this unit series is on the four basic types of bridges that are used in transportation: truss, arch, beam, and suspension. Unit 1 provides references that are specifically aligned to these types of bridges, which are widely used in transportation projects. The students will work independently and under teachers' supervision. The exciting and interesting experiences that students will have while exploring Unit 1 will open the door for them to develop a comfort zone and to enjoy the experience of STEM and STEAM as applied to bridge design and construction. The intent of this project is for middle-school students to fully grasp the general aspects of bridge construction and to acquire basic knowledge about bridge types, purposes, and design methods, including vocabulary that supports the activity.

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