



**BRIDGE UP!
ENGINEERING**

LESSON 7 – GRADE 7

LESSON 7 – GRADE 7: Bridge Building



Big Idea

Engineers use a process when designing bridges. The process is used to create products, processes and systems that meet a need.



Essential Questions

What are the different types of bridges and what are basic strengths and weaknesses of each?

What are some factors that engineers consider when designing bridges?

How does the engineering process work?

Ask (What are the problems? What are the constraints?)

Imagine (Brainstorm ideas, choose the best one)

Plan (Draw a diagram, gather needed materials)

Create (Follow the plan, test it out)

Improve (Discuss what can work better, repeat steps to make changes)

Can you make predictions about how a design modification can change the results?



Background Information

Engineers need to consider the strength of materials used to create a bridge and the load capacity of the completed structure. This is necessary to make sure the structure is strong enough to provide a safe venue for those using it. You may see signs that specify the load limits before crossing a bridge.



Standards

Minnesota Science Standards

6.1.2.2 Practice of Engineering

Engineering design is the process of devising products, processes and systems that address a need, capitalize on an opportunity, or solve a specific problem.

Benchmark: 6.1.2.2.1 Applying a Design Process

Apply and document an engineering design process that includes identifying criteria and constraints, making representations, testing and evaluation, and refining the design as needed to construct a product or system that solves a problem.

6.1.3.4 Emerging Technologies

Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.



Benchmark: 6.1.3.4.2 Units of Measurement

Demonstrate the conversion of units within the International System of Units (SI, or metric) and estimate the magnitude of common objects and quantities using metric units.

8.1.3.4 Emerging Technologies

Current and emerging technologies have enabled humans to develop and use models to understand and communicate how natural and designed systems work and interact.

Benchmark: 8.1.3.4.2 Procedures for Investigations

Determine and use appropriate safety procedures, tools, measurements, graphs and mathematical analyses to describe and investigate natural and designed systems in Earth and physical science contexts.

8.1.1.2 Inquiry

Scientific inquiry uses multiple interrelated processes to investigate questions and propose explanations about the natural world.

Benchmark: 8.1.1.2.1 Reasoning based on Evidence

Use logical reasoning and imagination to develop descriptions, explanations, predictions and models based on evidence.

Wisconsin Standards

C.8.1 Identify questions they can investigate using resources and equipment they have available.

C.8.3 Design and safely conduct investigations that provide reliable quantitative or qualitative data, as appropriate, to answer their questions.

C.8.5 Use accepted scientific knowledge, models, and theories to explain their results and to raise further questions about their investigations.

C.8.6 State what they have learned from investigations, relating their inferences to scientific knowledge and to data they have collected.

C.8.7 Explain their data and conclusions in ways that allow an audience to understand the questions they selected for investigation and the answers they have developed.

C.8.9 Evaluate, explain, and defend the validity of questions, hypotheses, and conclusions to their investigations.

C.8.10 Discuss the importance of their results and implications of their work with peers, teachers, and other adults.

C.8.11 Raise further questions which still need to be answered.

Standard H (Science in Personal and Social Perspectives)

Content Standard: Students in Wisconsin will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.

Rationale

An important purpose of science education is to give students a means to understand and act on personal, economic, social, political, and international issues. Knowledge and methodology of the earth and space, life and environmental, and physical sciences facilitate analysis of topics related to personal health, environment, and management of resources, and help evaluate the merits of alternative courses of action.



Connections with Multimedia Program

Bridge Up! Geometry in Engineering and Fundamental Forces



Activity Description

Students will build a bridge using plastic straws and scotch tape – the span is set at 24 cm. Bridge strength will be tested using bolts. The initial build will be followed by one day of learning how bridges are designed and built. The final bridge will have more constraints: limited number of straws and less building time. Bridges strength of each will be compared.



Vocabulary

Engineer – A person who uses his/her understanding of math and science to create things for the benefit of humanity and our world.

Design – To form in the mind. Make drawings or plans for a work, make a new product or improve on current product or process.

Model – A representation of a person or thing or of a proposed structure, usually on a smaller scale than the original.

Bridge – A structure carrying a road, path, railroad, or canal across a river, ravine, road, railroad, or other obstacle.

Suspension bridge – A bridge made of a platform that is held up by wires or ropes strung from the tops of piers.

Truss bridge – This bridge type has a superstructure composed of elements connected to form triangles.

Arch bridge – A bridge made from one or more arches and abutments.

Cable-stayed bridge – A bridge in which the weight of the deck is supported by vertical cables suspended from larger cables that run between towers and are anchored in abutments at each end.

Beam bridge – Beam bridges are made of a flat piece, or beams, laid across two or more supports.

Tension – A stretching or pulling force that usually lengthens an object.

Compression – A pushing force that usually shortens the object.

Abutment – A mass receiving the arch, beam, truss, etc., at each end of a bridge.

Beam – A long, rigid horizontal support part of a structure.

Column – A long, rigid, vertical (upright) support part of the structure.

Bridge deck – The surface of a bridge where vehicles and pedestrians travel.

Span – The length of the a bridge from one pier to another.

Truss – Part of the structure frame based on the geometry of the strength of the triangle.



Materials

- Each group needs:
 - 20 non-bendy straws/group
 - Tape
 - Scissors
 - Measuring stick or ruler
 - Bridge Lab Report

Whole class needs to share:

- Large bolts
- Four textbooks

Procedure



Day 1 - Bridge Lab Report

- Each student should draw a plan of a bridge they might build on his/her Bridge Lab Report.
- Put students into groups of 4 and have them decide on the style of bridge they might like to build.
- Pass out the materials.
- Hypothesize the mass your bridge will hold. Record your estimation on your Bridge Lab Report.
- Set up desks to be 24 cm apart OR 2 books placed 24 cm apart (simulate the span for the bridge).
- 20 minutes to build the bridge using the 20 straws; they can be cut at any length. However, students will not be given additional straws.
- Test the load your bridge will hold and document the mass on your Bridge Lab Report.
- Reflection: What do you think went well?

Investigating Questions (as homework)

1. Describe the shapes involved in the bridge you constructed.
2. Why did you choose that type of bridge?
3. Did the bridge meet your load predictions? What do you think went well?
4. What made this activity difficult?
5. What would have made this activity easier?

Day 2 - Vocabulary Worksheet and Types of Bridges

- Have students share investigating questions with the class.
- Pass out vocabulary worksheet.
- Teacher provides definition and examples of bridge terms from vocabulary list.
- Students complete vocabulary worksheet. Assign as homework if not completed during class.

Day 2 – (continued)

- Have students note bridge types and brief pros and cons of each on board. Images available at <http://kids.britannica.com/elementary/art-88577/There-are-six-basic-bridge-forms>
 - Suspension
 - Truss
 - Arch
 - Cable-stayed
 - Beam
- Have students make plans (blueprint) for a new bridge to build the next day.
- Have them identify the terms as they relate to their bridge. Students are still limited to the same materials.

Day 3 – Improve

- Students collect materials.
- Now that students know a little more about bridge design, improve the current bridge they previously built. Mass the bridges and test the load capacity.
- Have students note the change in load the bridge can hold with the new design.
 - Take data showing the class average on change in load capacity after learning more about bridges.
 - Help students understand that each bridge that engineers design and build is done with an expansive amount of science and knowledge.

**Assessment**

- Show slides and have students identify different types of bridges and their parts. Images available at <http://kids.britannica.com/elementary/art-88577/There-are-six-basic-bridge-forms>
- Student-generated blueprints
- Investigating questions
- Improvements made to bridge
- Vocabulary sheet

**Extensions**

Home Project – Have students create a bridge using recycled materials at home to test strength of additional material. Optional - Take a field trip to a bridge construction site.

**Other Resources**

BUILDING BIG: Bridges

www.pbs.org/wgbh/buildingbig/bridge

ENGINEERING ENCOUNTERS: Bridge Design Contest

<https://bridgecontest.org/>

Name: _____

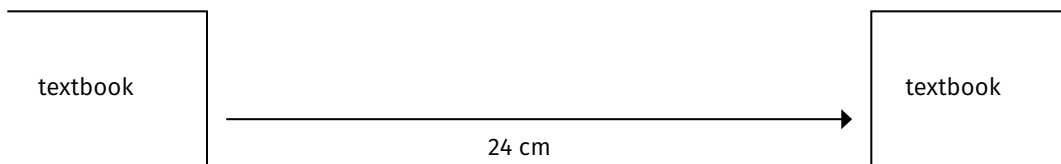
Bridge Lab Report

Day 1

ASK: What is the problem?

Supplies: meter stick for measuring, 20 straws, tape and scissors (optional).
Will need bolts later to test bridge strength.

1. **Imagine:** Draw a bridge to span 24 cm (use textbooks)



2. Have your teacher initial the diagram. Your teacher will give you supplies when you have initials.

3. Build bridge – you have as much time as you need, but shouldn't be more than 45 minutes. Put bolts on bridge. They only rest on span, not on the books.

4. **Estimate:** How many bolts do you think it will hold?

5. **Test:** Put bolts on bridge - they only rest on span - not on the books. Measure and record 3 times.

Test 1: _____ Test 2: _____ Test 3: _____

6. **Compare:** How did the two bridges compare? _____

Name: _____

Vocabulary Worksheet

Day 2

Vocabulary Term	Brief Definition <i>(Must be in your OWN words)</i>	Examples/Drawing
Engineer		
Design		
Model		
Bridge		
Tension		
Compression		

Name: _____

Vocabulary Worksheet

Day 2

Vocabulary Term	Brief Definition	Examples/Drawing
Abutment		
Cement		
Concrete		
Beam		
Deck		
Span		
Truss		

Name: _____

Types of Bridges: Day 2

Instructions: Draw each type of bridge. Use Wikipedia as a guide to draw.

Suspension Bridge	Truss Bridge
Arch Bridge	Cable-Stayed Bridge
Beam Bridge	

Name: _____

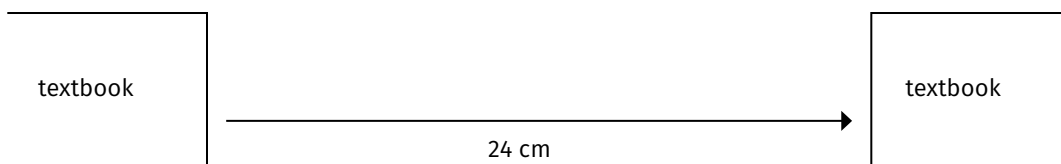
Improve Bridge Design Day 3

Instructions: Now that you know a little more about bridge design, you will try to construct a better one.

Supplies: Meter stick, 15 straws and tape.

Will need bolts later to test bridge strength.

1. **Imagine:** Draw a bridge to span 24 cm (use textbooks)



2. Have your teacher initial the diagram, then you can get your supplies.
3. Build bridge – you have as much time as you need, but shouldn't be more than 45 minutes. You may not tape bridge to textbooks or desks.
4. **Estimate:** How many bolts will it hold?
5. **Test:** Compare which parts of the bridge were stronger than the first? Weaker than the first? Measure and record 3 times.

Test 1: _____ Test 2: _____ Test 3: _____

6. **Compare:** Which parts of bridge were strong than the first? _____
Weaker than the first? _____