Ready Set Create!

Design Challenges for Kids

Span-tastic Bridges

Activity Guide

A product of the Science-Technology Activities and Resources for Libraries (*STAR Net*) program.
Visit our website at www.starnetlibraries.org for more information on our educational programs.
April 2018

Special thanks to the staff and families from African-American Research Library and Cultural Center and High Plains Library District Centennial Park Library for their input on this activity.

This material is based upon work supported by the National Science Foundation under Grant No. DRL-1657593. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Span-tastic Bridges

Overview

Participants use commercially available building sets to "go long" or "reach high" with their own designs for model bridges.

Activity Time

This activity is flexible and open-ended; it can be done in 1 hour but children can take up to 2 hours, if desired.

Intended Audience

Families or other mixed-age groups, including children as young as 5 years old *with assistance from an older child, teen, or adult*
School-aged children ages 7 and up
Tweens
Teens

Type of Program

- [x] Facilitated hands-on experience
- [x] Station, presented in combination with related activities
- [x] Passive program (if instructions are provided)
- [ ] Demonstration by facilitator

Key Concepts

- **Bridges make our lives easier — they help us create shortcuts across waterways, help traffic flow more smoothly, allow us to reach hard-to-get-to places, and help people travel to see each other.**
- **Children, like engineers, can improve their designs through the creative process of thinking, building, testing . . . and doing it again!**

STAR net
Science-Technology Activities & Resources For Libraries

Materials

For a group of 10 children and their caregivers:

☐ Building sets, such as:
- ☐ 400 (or more) KEVA® planks (maple is recommended for durability)
  OR
- ☐ 1000 K'NEX® building pieces AND "Introduction to Structures: Bridges," K'Nex Education from https://www.knex.com.

Many commercially available building sets are appropriate for this activity. The following sets were successfully piloted with this activity:
- Keva planks (maple)
- K'NEX Education – Introduction to Structures: Bridges
- K'NEX 100 Model Imagine Building Set
- K'NEX Mighty Makers – World Travels Building Set
- Zometool Creator 1 Construction Kit

Looking for a traditional, low-tech spin on this activity? Try Build a Straw Bridge, featured on the STEM Activity Clearinghouse at http://clearinghouse.starnetlibraries.org.

☐ 5 copies of Engineering Design Process, preferably printed in color, double-sided, and laminated (below)
☐ 5 copies of Diagrams of Bridge Types, preferably printed in color (below)
☐ 5-10 rulers or measuring tapes
☐ 5-10 tennis balls or model vehicles for testing bridge height
☐ Optional: 5-10 larger balls – baseballs, softballs, volleyballs, soccer balls, and basketballs – to add greater challenge
☐ Optional: supports and foundations such as books, sturdy pieces of cardboard, or plastic tubs

For the facilitators:

☐ Facilitator background information:
- ☐ Brief Facilitation Outline (below)
- ☐ Facilitator Background Information (below)
- ☐ "Introduction to Structures: Bridges," K'Nex Education from https://www.knex.com
- ☐ "Teacher's Guide: Bridges," K'Nex Education from https://www.knex.com
- ☐ KEVA Educator's Guide: Activities and Lesson Plans for KEVA Planks, MindWare from http://www.kevaplanks.com

Preparation

- Arrange for three or more teens and/or adults to help facilitate this activity.

Reach out to professional engineers and technicians, makers, or engineering students in your community to help facilitate this activity. Find partnership opportunities listed at www.starnetlibraries.org/stem-in-libraries/collaboration/partnership-opportunities/.

- Well in advance of the program, facilitators should build a bridge using one or more building sets and review the Brief Facilitation Outline (below) to familiarize themselves with the activity.
- Optional: create a model triangle, arch, and square using index cards. See the activity, Strongest Shapes, from http://clearinghouse.starnetlibraries.org, for details.
- Optional: Plan to facilitate steps 2-3 of the activity, Human Suspension Bridge from http://clearinghouse.starnetlibraries.org.
- Set up materials for one or both engineering design challenges: Go Long and/or Reach High.

Activity

1. Opening Discussion: Share ideas and knowledge.

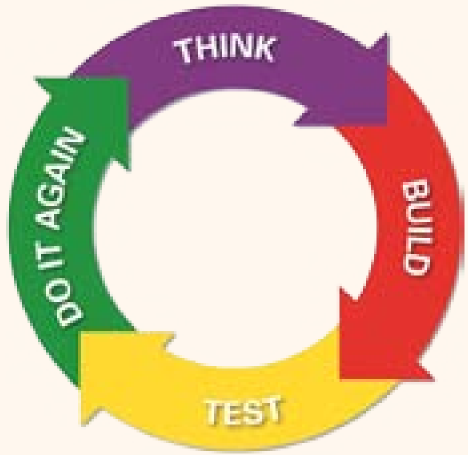
- Introduce yourself. Help the participants learn each other's names (if they don't already know each other).
- Frame the activity with the main message: Bridges make our lives easier — they help us create shortcuts across waterways, help traffic flow more smoothly, allow us to reach hard-to-get-to places, and help people travel to see each other.
- Show a video clip about how engineers create bridges to make our lives easier.

Video options:

- Collapse of the Tacoma Narrows Bridge, "Galloping Gertie"
- Simple Solutions Solve Big Problems — Building a Footbridge. Short Interview with Maria Gibbs
- Simple Solutions Solve Big Problems - Building a Footbridge. Long interview with Maria Gibbs
- Overnight Bridge Replacement

- Explain that the group will create model bridges using the engineering design process:
Think – Build – Test – Do It Again.

Activity (continued)



Guide the participants through the engineering design process as they work. Adjusting and retesting their ideas is the best way to experience the ongoing work of an engineer! As time allows, emphasize this stage of the engineering design process as much as possible. They will be rewarded by seeing improvement.

Reassure the participants that there isn't a "right" answer that they must arrive at on the first try. Furthermore, failure is an essential part of figuring out what works and what doesn't. It is OK to fail — and try again . . . and again . . . and again!

- Provide bridge-building tips through one or more short activities.

Introductions to bridges and model bridge building:

- Demonstrate how triangles are stronger than arches and squares using models of each shape. Apply pressure by hand to each shape to show how they respond (see Strongest Shapes).
- Kinesthetically demonstrate that the forces in a bridge can either push or pull (see Human Suspension Bridge).
- View additional video clips about the basics of bridge design and/or instructions for building model bridges:
  - "KEVA Planks Block Activity," Hingham Public Library
  - "STEM Kits: Bridge Building," Skokie Public Library
  - "What Makes Bridges So Strong?," SciShow Kids
- Get ideas from what others have built! Look at diagrams and photos of bridges and model bridges:
  - Diagrams of Bridge Types (below)
  - "Buildings and Bridges," KEVA planks
  - "Introduction to Structures: Bridges," K'Nex Education
  - "Bridge, Tower and Building models," K'Nex User Group

2. Design Challenge.

Invite participants to undertake one or both engineering design challenges: **Go Long** or **Reach High**. Explain the goal – for example, provide a minimum height and/or length for the bridge. Explain the constraints – for example, limit the number of pieces used or set a time limit. Encourage participants to work with each other collaboratively instead of competitively. Allow plenty of time for participants to redesign their bridges.

Design Challenge A: Reach High
Raise the platform of the bridge to allow traffic to pass under it.

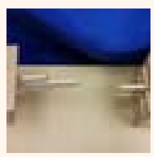
Sample design solutions: Use K'Nex to create a bridge that would allow a tennis ball to pass underneath it. (Increase the challenge with larger balls, such as baseballs or softballs – or, volleyballs, soccer balls, and basketballs for advanced builders.) See full-color, step-by-step instructions in "Introduction to Structures: Bridges," by K'Nex Education for "Cantilever," "Bascule Bridge," "Arch Through," "Suspension," and "Cable-Stayed, Double Tower" designs for inspiration.

Design Challenge B: Go Long:
Use towers or other strategies to build a bridge that it could connect people over long distances.

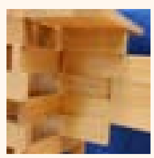
Sample design solutions: Use KEVA planks to collaboratively build a bridge that connects each participant, following the KEVA activity, "Interconnected Building."

1. Provide each child with 40 planks.

2. Invite them to construct a 6"-tall tower.



3. Then, work together to bridge the towers.



4. Use gaps in the towers to extend pieces out from each side of the tower, horizontally.

3. Test the bridges and make modifications – one change at a time – to the designs.

Encourage participants to give each other ideas or extra pieces – or even to combine their designs into one bridge!

Activity (continued)

A. Reach High.
Use a standard object (e.g., ruler, tennis ball, or toy vehicle) to test whether or not traffic could flow underneath the bridge. Change the design to make the bridge platform raise higher, provide more stability, use fewer pieces, etc.

B. Go Long.
Use a measuring tape to measure the distance that the bridge spans. Change the design to span a greater distance, provide more stability, use fewer support structures, etc.

4. Conclude.

Celebrate the participants' efforts and persistence in working with the materials to iterate on their designs.

Extensions

Allow additional time, per the instructions provided on these external websites, if incorporating these activities.

Build a Straw Bridge
http://clearinghouse.starnetlibraries.org/engineering/157-build-a-straw-bridge.html
This engineering design challenge relies on drinking straws, tape, and pennies to create bridges.

KEVA planks: STEM Any Time, Any Place
http://www.kevaplanks.com/lesson-plans-challenges-games-activities
Find additional bridge challenges, as well as a listing of fun games and challenges, in this KEVA planks guide.

Lego Structures
www.DiscoverE.org
Participants are challenged to build a structure in 12 min. or less using a provided bag of building materials.

Marshmallow Challenge
www.marshmallowchallenge.com/Instructions.html
Participants work in groups to build a structure out of spaghetti and balance a marshmallow on its top. With teens and adults, consider showing the TED 2010 talk, "Marshmallow Challenge" (marshmallowchallenge.com/TED_Talk.html) and using the design process concepts discussed there to launch a discussion about engineering and ways to tackle the world's problems. Appropriate for children ages 6 and up.

Next Generation of Science Standards

Assessment Standard

Engineering Design

Students who demonstrate understanding can:

- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

Structure and Properties of Matter

Students who demonstrate understanding can:

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Different properties are suited to different purposes.
- A great variety of objects can be built up from a small set of pieces.

ESS3.A Natural Resources

- Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.

ESS3.B Natural Hazards

- A variety of hazards result from natural processes; humans cannot eliminate hazards but can reduce their impacts.

ETS1.A: Defining and Delimiting Engineering Problems

- Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

ETS1.B: Developing Possible Solutions

- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

Science and Engineering Practices

Asking Questions and Defining Problems

- Define a simple problem that can be solved through the development of a new or improved object or tool.
- Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

Next Generation of Science Standards

Developing and Using Models

- Develop a simple model based on evidence to represent a proposed object or tool.

Using Mathematics and Computational Thinking

- Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.

Crosscutting Concepts

Structure and Function

- The shape and stability of structures of natural and designed objects are related to their function(s).

References

NGSS Lead States (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

Facilitator Background Information

Bridges Unite People

Bridges cut down on travel time, reduce traffic congestion, allow us to reach hard-to-get-to places, and help bring people closer together.

Széchenyi Chain Bridge in Budapest, Hungary.
Credit: Alex Brudaâ.

Train traversing the Wiesen Viaduct in Switzerland.
Credit: Kabelleger / David Gubler.

Si-o-se Pol bridge in Isfahan, Iran.
Credit: Wikimedia Commons.

Bridges in Amsterdam.
Credit: Wikimedia Commons.

Facilitator Background Information

In rural areas people still travel by foot to school, to the doctor, and to the market. Not every village can afford to have a doctor or school, and wading a river or climbing down a mountain gorge can be dangerous at the best of times. down on travel time, reduce traffic congestion, allow us to reach hard-to-get-to places, and help bring people closer together.

Photocredit: "Image provided courtesy of Bridges to Prosperity"

The organization, Bridges to Prosperity, builds footbridges over impassable rivers in order to give isolated communities access to opportunities and resources.

Photocredit: "Image provided courtesy of Bridges to Prosperity"

Photocredit: "Image provided courtesy of Bridges to Prosperity"

Built in 1566 in the city of Mostar, Bosnia-Herzegovina, this graceful pedestrian arch bridge connected people divided by religion and ethnicity. In 1993, during the country's bitter civil war, the bridge was deliberately destroyed. Reconstructed in 2004 using historic techniques, Stari Most ("Old Bridge") once again unites the city and serves as a symbol of hope and reconciliation.

Credit: Báthory Péter

Brief Facilitation Outline

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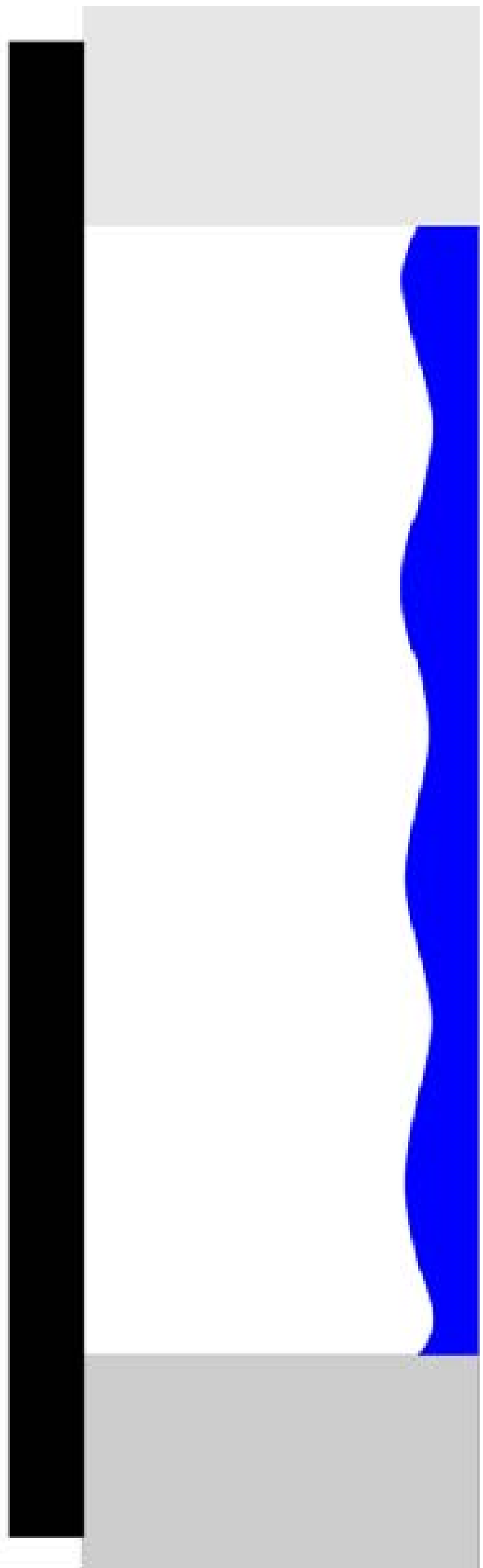
Activity Materials to Print

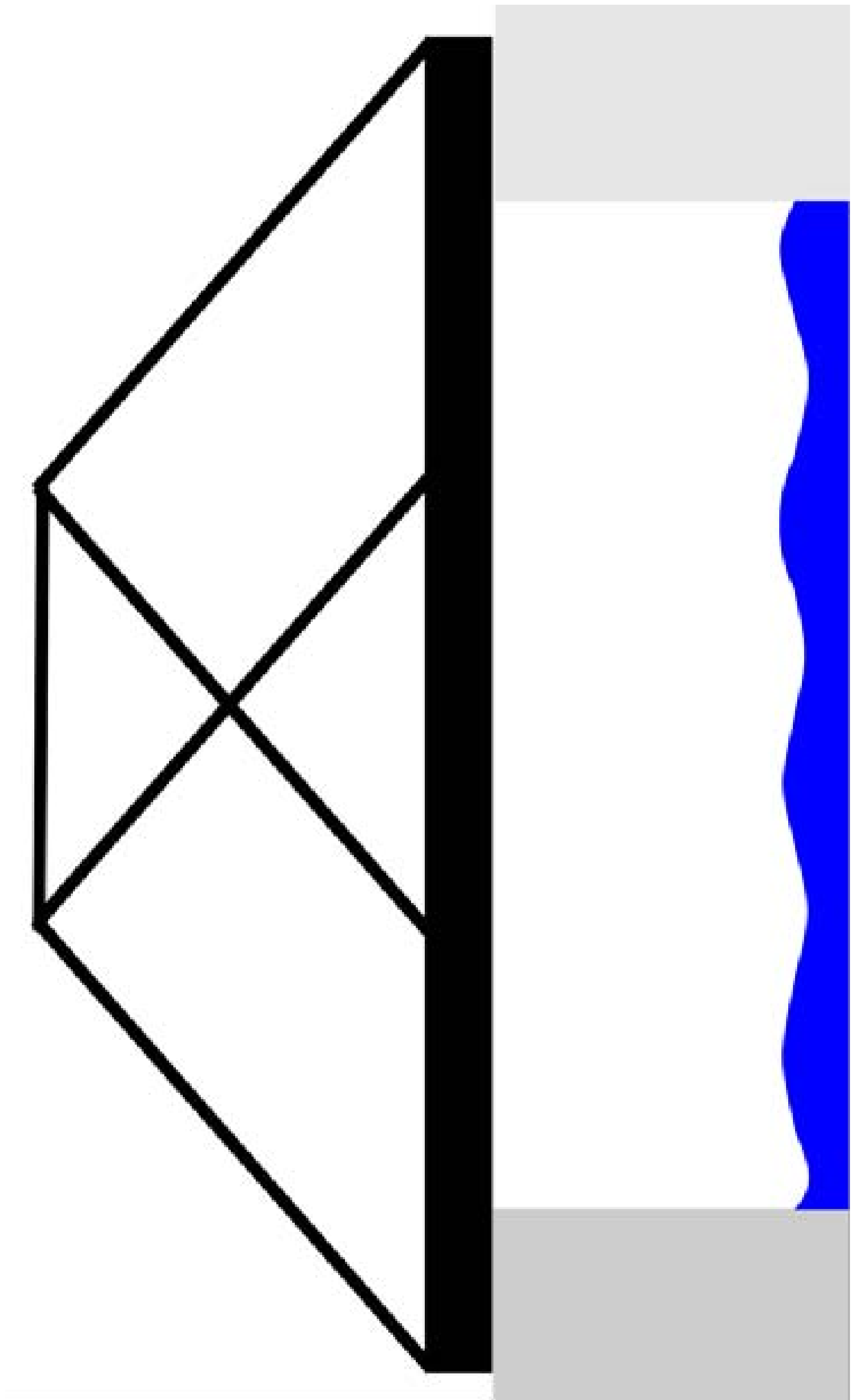
Beam Bridge



Creative Commons artwork credit: Themightyquill

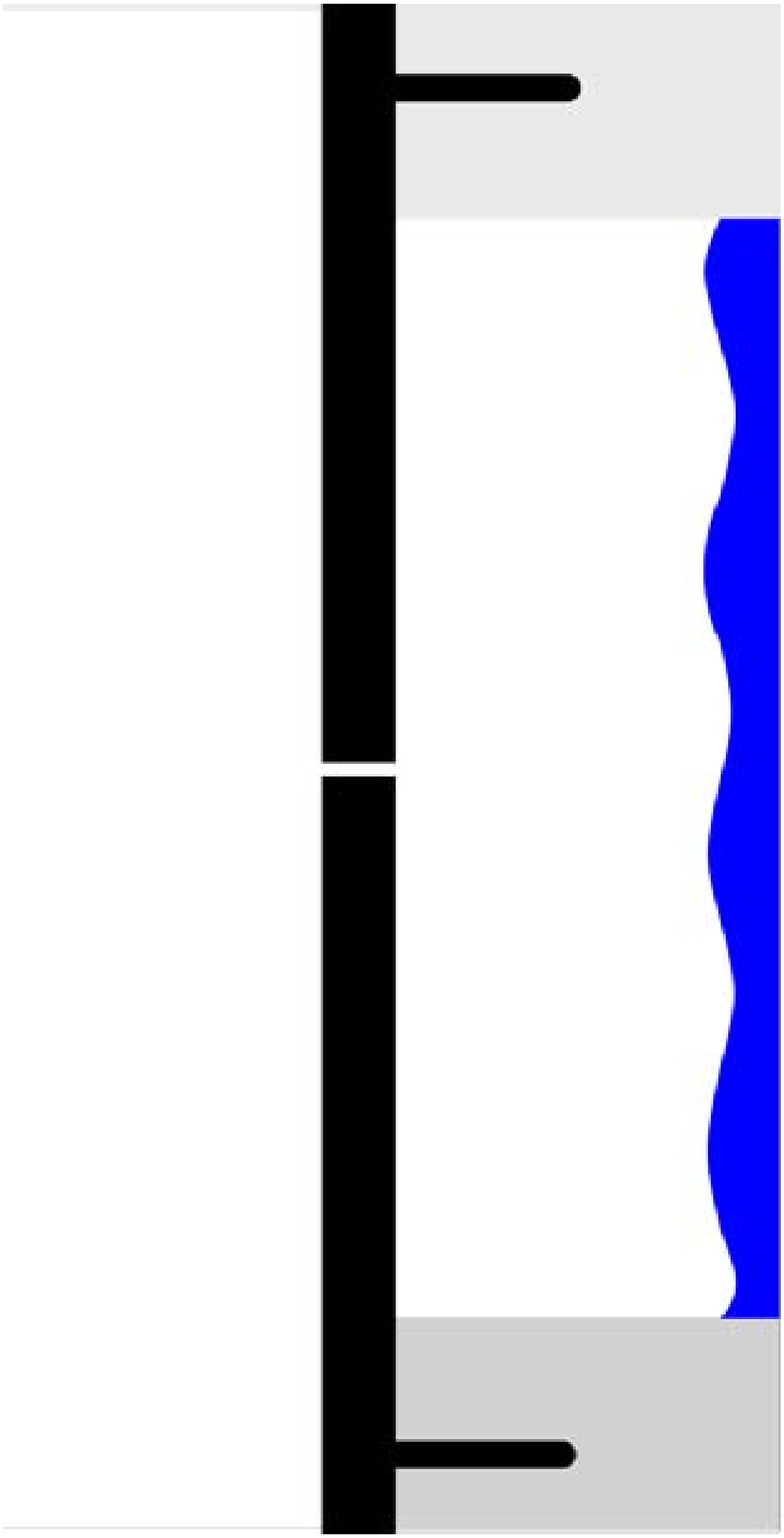
Activity Materials to Print

Truss Bridge



Creative Commons artwork credit: Themightyquill

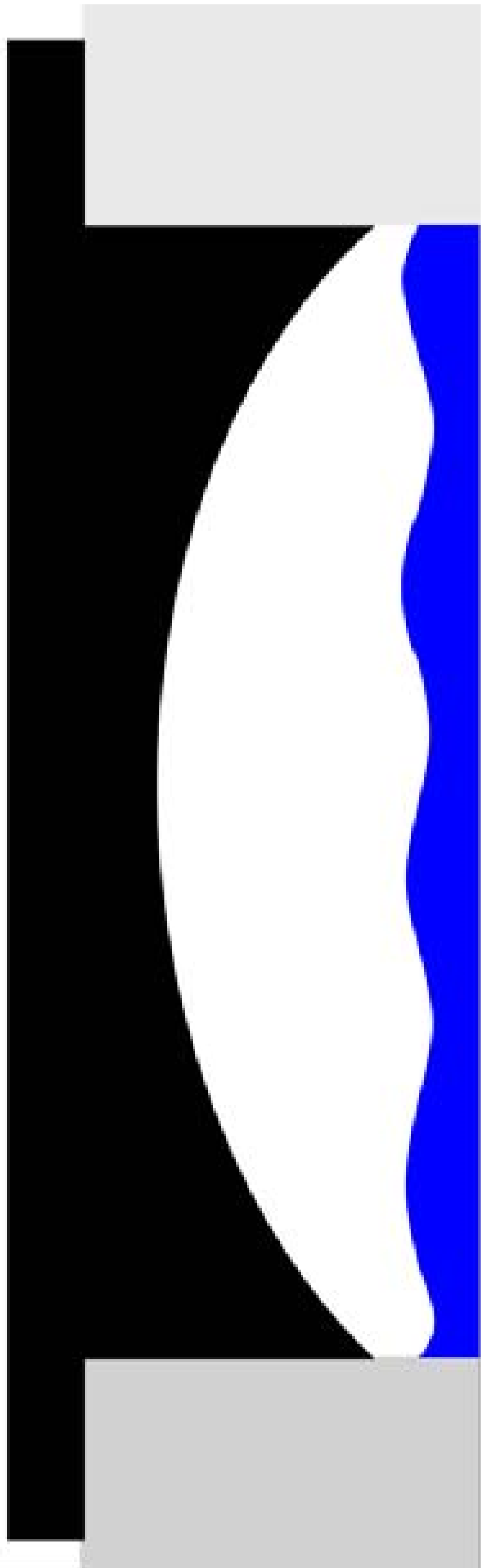
Activity Materials to Print



Cantalever Bridge

Creative Commons artwork credit: Themightyquill

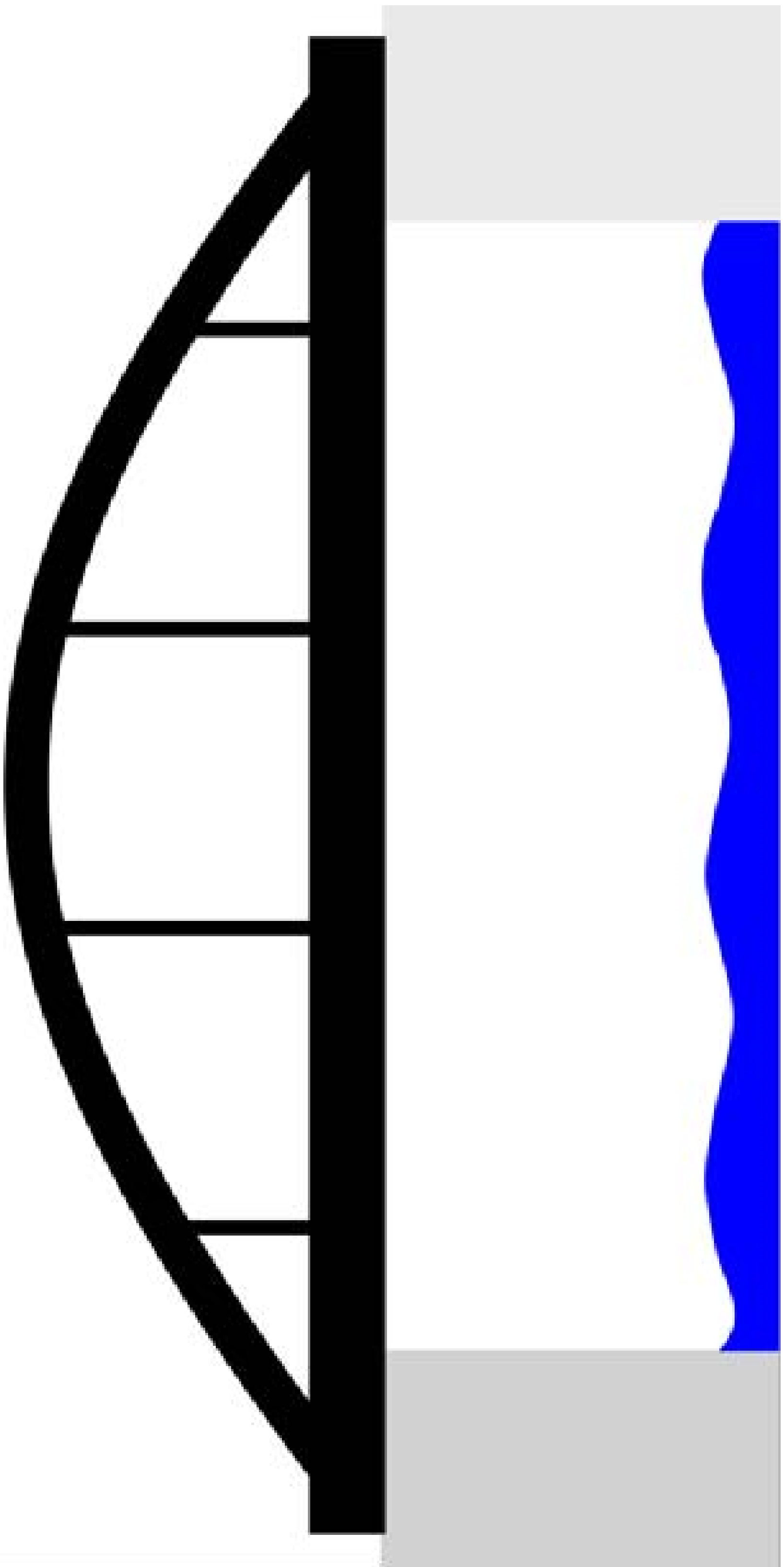
Activity Materials to Print



Arch Bridge

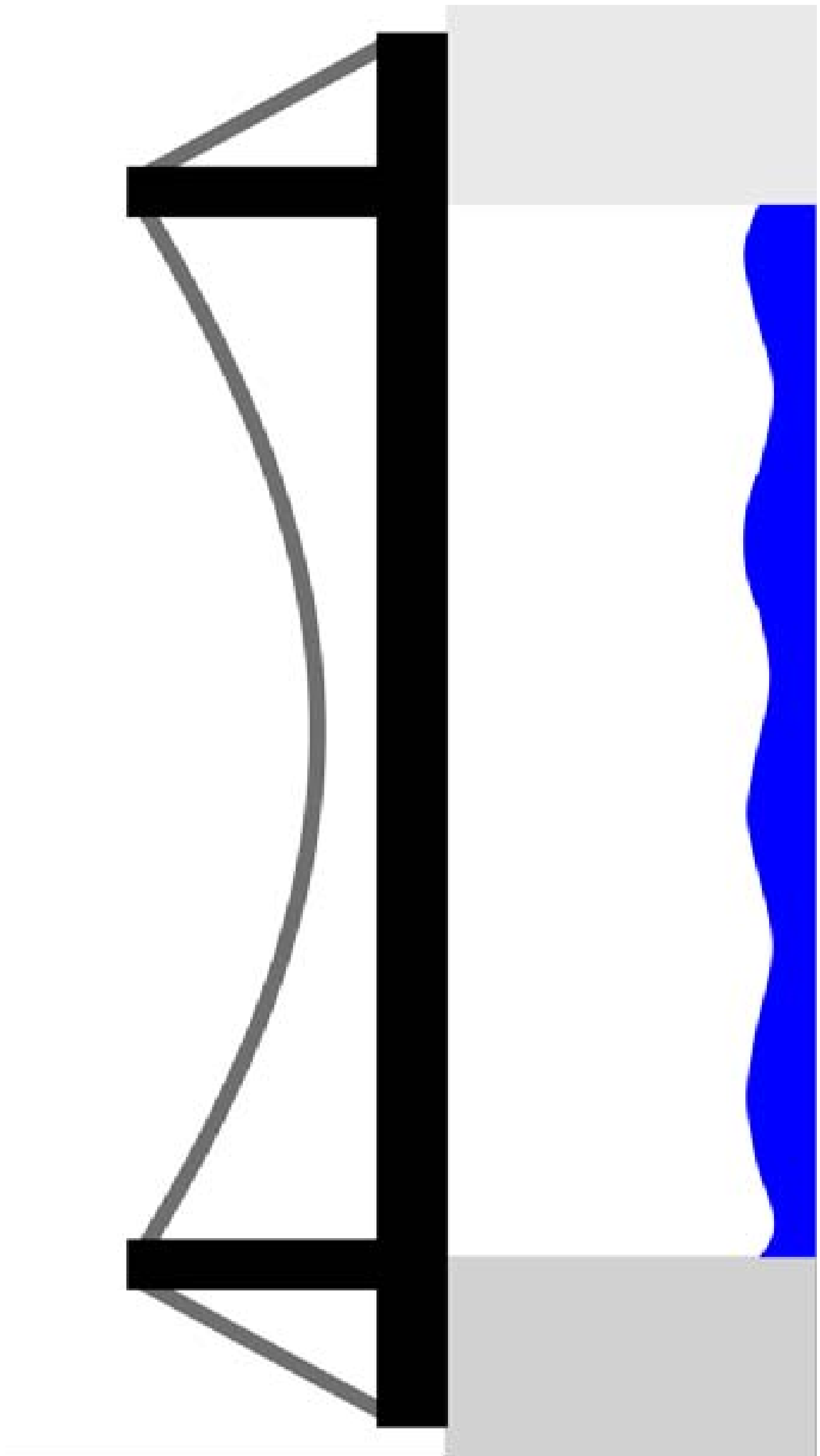
Activity Materials to Print

Tied Arch Bridge



Activity Materials to Print

Suspension Bridge



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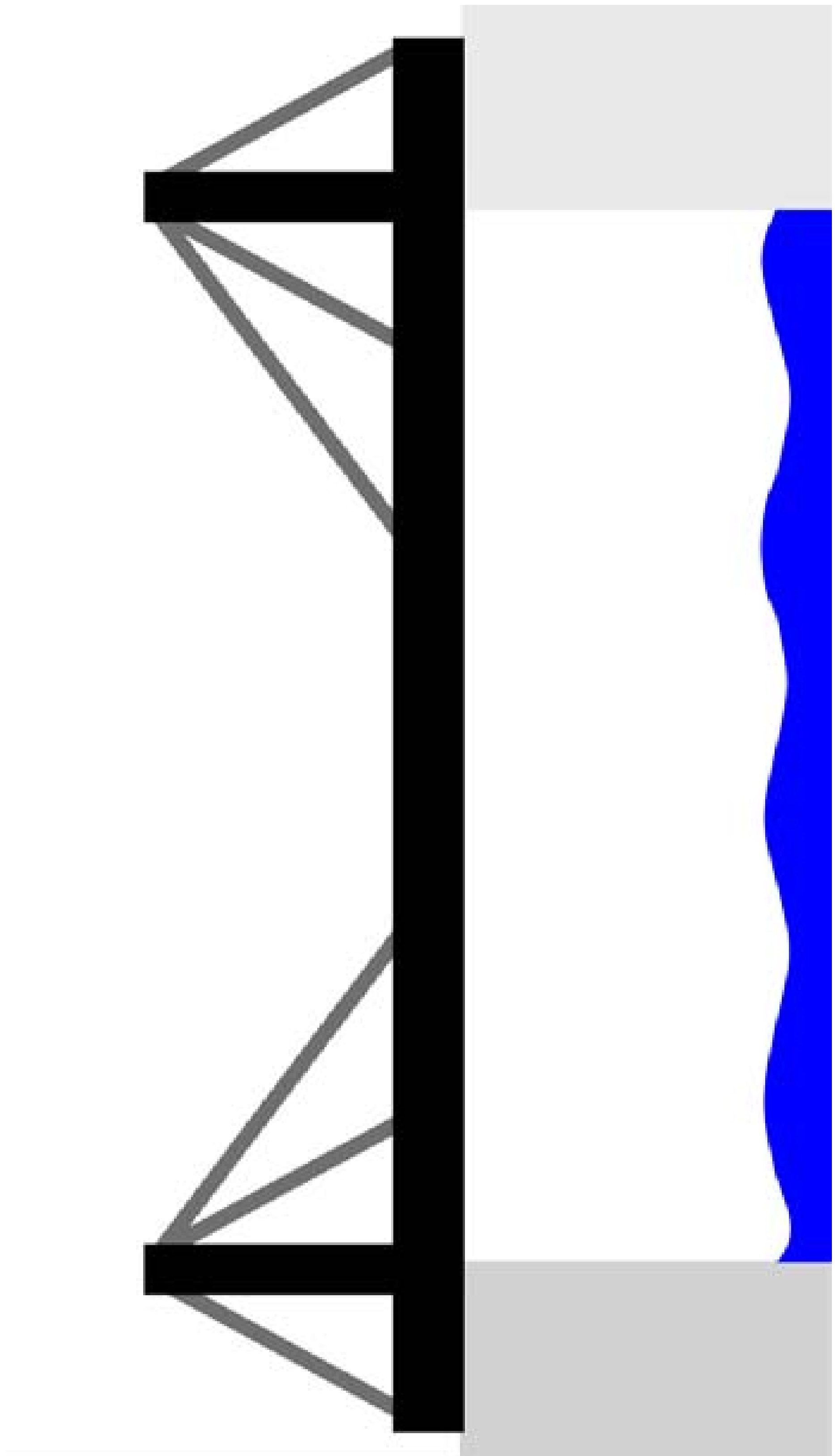
Activity Materials to Print



Cable-stayed Bridge

Creative Commons artwork credit: Themightyquill