PRE-TRIP LESSON

THE GREAT BROOKLYN BRIDGE

LESSON OVERVIEW

OBJECTIVE

Students will learn the basic engineering and physics of bridges and how the forces of tension and compression help hold up a suspension bridge.

RECOMMENDED GRADE LEVELS

2-5

DURATION

45 minutes

MATERIALS

- Photos of NYC bridges & Brooklyn Bridge diagram (provided)
- Student worksheet (provided)
- At least 6 of the following item: yarn, popsicle sticks, pipe cleaners, clay, sponges, erasers, rubber bands, paper-towel tubes, pencils, cardboard, aluminum foil, drinking straws, tiles, or cloth.

TOPIC BACKGROUND

Before bridges in New York City existed, people relied on the waterways to get around and transport goods. The Brooklyn Bridge was the first steel-wire suspension bridge to be built in the world. A suspension bridge is a bridge that is held up by cables and usually suspended over water.

A suspension bridge has several key structures. The underground foundations of the Brooklyn Bridge are called caissons. The caissons were large, air–filled containers that were pushed deep under the East River. By working in the caissons, engineers were able to dig all the way down to the earth's solid bedrock. Towers were then built up from the caissons. The towers hold up the cables, which in return, hold up the deck, or roadway.

A force occurs when two materials in a bridge interact with each other. The cables in a suspension bridge experience pulling, or tension, because they are being pulled down toward the anchorage at either end of the bridge, as well as being stretched as they hold the deck up. The towers in the bridge are being pushed down into the ground by gravity and the heavy main cable, thus experiencing compression (see diagrams attached).

During your class' park visit, students will explore the history of the bridge, be challenged to build a model suspension bridge, and take a walking tour of the bridge. To prepare for your program, students can begin to understand why bridges are important, what they look like, and the simple physics behind building stable bridges.

GETTING READY

1. Print out NYC bridge photos and Brooklyn Bridge diagrams or project on screen/smartboard for students to see.
2. Make copies of "Testing Forces" worksheet for students.

GETTING READY CON'T

3. Gather as many of the following as are available for "Activity 2: Materials Test": yarn, popsicle sticks, pipe cleaners, clay, sponges, erasers, rubber bands, paper-towel tubes, pencils, cardboard, aluminum foil, drinking straws, tiles, or cloth.
   (At least 6 different materials is recommended. For this experiment,
   students should be split up into small groups and have access to 1 of each of the materials. i.e. having 6 student groups will require you to collect at least 6 rubber bands, 6 popsicle sticks, etc.)

PROCEDURE

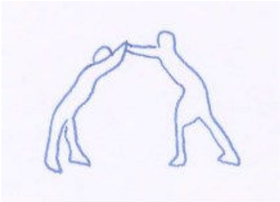
INTRODUCTION

1. Begin by showing students photo examples of several types of bridges found in New York City. (Alternatively: teachers may opt to read a short story about the Brooklyn Bridge. See recommended books on page 3)
2. Ask students to think about why a bridge is able to stay standing. Jot down on the board key words and ideas suggested,
   allow students to draw pictures to help explain their ideas.
3. Explain to students that many of the materials and parts of the bridge are experiencing pulling (tension) or pushing (compression). These two opposing forces help hold the bridge in place.

ACTIVITY 1: EXPERIENCING FORCES

1. Have students experience what tension and compression feels like by dividing students into pairs.
2. First have the students act out tension by holding both hands and leaning backwards slightly. Ask students to describe the type of pressure they feel. (pulling or stretching) Reiterate that an engineer calls this tension.

3. Next, ask students place their palms against the other person's and lean towards each other. Again ask students what they feel (pushing or pressing) and introduce the term compression.



ACTIVITY 2: MATERIALS TEST

1. Explain to students that they will now work in small groups to test different material's ability to resist damage under tension and compression.
2. Distribute materials and worksheets to groups. Go over with the students how to rank a material's strength under compression, tension, and (optionally: torsion, or twisting).
3. After students complete the experiments, explain that the materials used to build the Brooklyn Bridge

PROCEDURE CON'T

needed to be strong enough to withstand extreme amounts of tension and/or compression.

4. Ask students, based on their experiment results, if they were to build a bridge what materials would they use? Why or why not?

5. Show students a diagram of the Brooklyn Bridge. Notice that this bridge is a suspension bridge, which means the deck is held up by cables which rest over the top of the towers. Introduce new vocabulary such as foundation/caisson, tower, cable, deck, and anchorage.

6. Give students some time in pairs to think about what materials the bridge might be made of (granite rock, steel, cement, and wood) and what portions of the bridge might be in tension and compression. Next, have students share their theories with the class.

   Either draw or show students the diagram of bridge forces to reinforce this concept during the class discussion.

RECOMMENDED BOOKS

- *The Tiny Forces Make Things Move* by Kimberly Brubaker Bradley (Gr. K– 4)
- *Twenty-One Elephants* by April J. Prince (Gr. 1 +)
- *Brooklyn Bridge* by Lynn Curlee (Gr. 3 +)
- *The Brooklyn Bridge: The story of the world's most famous bridge* by Elizabeth Mann (Gr. 4 +)
- *Where Is the Brooklyn Bridge?* by Megan Stine (Chapter book; Gr. 4-8)
- *Historic Photos of the Brooklyn Bridge* by John B. Manbeck

RECOMMENDED WEBSITES

The History Channel– The Brooklyn Bridge

http://www.history.com/topics/brooklyn-bridge

PBS– Building Big

http://www.pbs.org/wgbh/buildingbig/lab/forces.html

PBS– Brooklyn Bridge for Educators

http://www.pbs.org/kenburns/brooklynbridge/educators/

Brooklyn Bridge Construction Timeline

http://www.brooklynexpedition.org/structures/buildings/bridge/bl_bridge_construct_b.html#one

TEACHER NOTES:

VOCABULARY

Anchorage: Part of the bridge that anchors it to the land. Heavy stone pillars used to anchor the ends of the cables of a suspension bridge.

Arch: A curved symmetrical structure spanning an opening and typically supporting the weight of a bridge, roof, or wall.

Bedrock: Solid rock that is part of the Earth's crust.

Bridge: A structure built over something (as a river or a railroad) so people can cross.

Cable: Entwined wires that hold up the deck of the bridge.

Caissons: Pressure filled wooden boxes used during the construction of the Brooklyn Bridge to dig through the silt to the bedrock below. (A waterproof chamber used by people working underwater.)

Compression: Pressing, pushing together (note the word press within compression).

Deck: Part of the bridge used for cars, bikes and pedestrians to cross.

Drawbridge or Bascule Bridge: A bridge that can be opened in the middle by raising a section of the roadway or deck.

Engineer: A designer or builder of complex structures such as bridges, highways, etc.

Ferry: A passenger boat that carried people and goods from Manhattan to Brooklyn before the Brooklyn Bridge was built.

Force: An interaction between two objects, usually resulting in a push or a pull.

Hanger/Suspender: Vertical cables that connect the main cable to the deck.

Pressure: The action of a force against an opposing force present in the caissons.

Roadway or Deck: The part of a bridge on which traffic runs.

Stay: Diagonal cables that help hold the deck in place.

Suspension Bridge: A bridge held up with cables, suspended over water or land. A bridge that is supported by strong cables running along its length (suspension cables) and by shorter, vertical cables (suspender cables) that hang down from the suspension cables.

Tension: Stretching, pulling apart.

Truss: A framework of wooden or metal beams used to support a roof, bridge, or similar structure.

Tower: A tall structure that holds up the cables and span of a bridge. The towers were the first part of the Bridge that was built.

STANDARDS

COMMON CORE ELA

- Literacy in Historical/Social Studies
- Speaking and Listening
- Literacy in Technical Subjects
- Literacy in Science

COMMON CORE MATH

- Number & Operations in Base Ten
- Geometry
- Ratios & Proportional Relationships

NYC K-8 SCIENCE & SOCIAL STUDIES SCOPE & SEQUENCE

- Our Community Geography
- New York City Over Time
- Humans in Their Environments
- Earth Materials

NEXT GENERATION SCIENCE STANDARDS

K-2. Engineering Design

3-5. Engineering Design

MS. Engineering Design

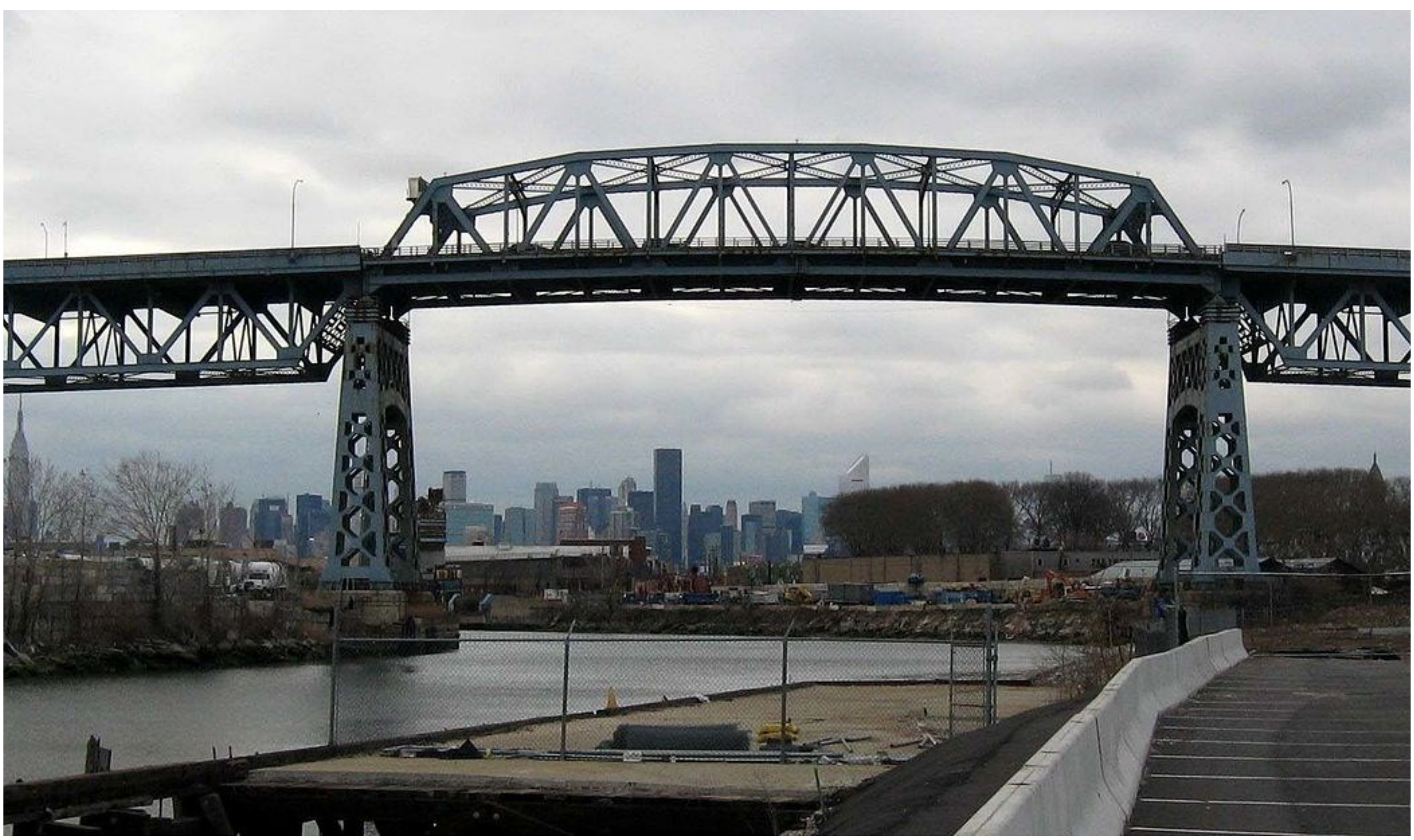
Brooklyn Bridge (Steel-wire suspension bridge)

Washington Bridge, Bronx (Two-hinged arch bridge)

Manhattan Bridge (Suspension bridge)

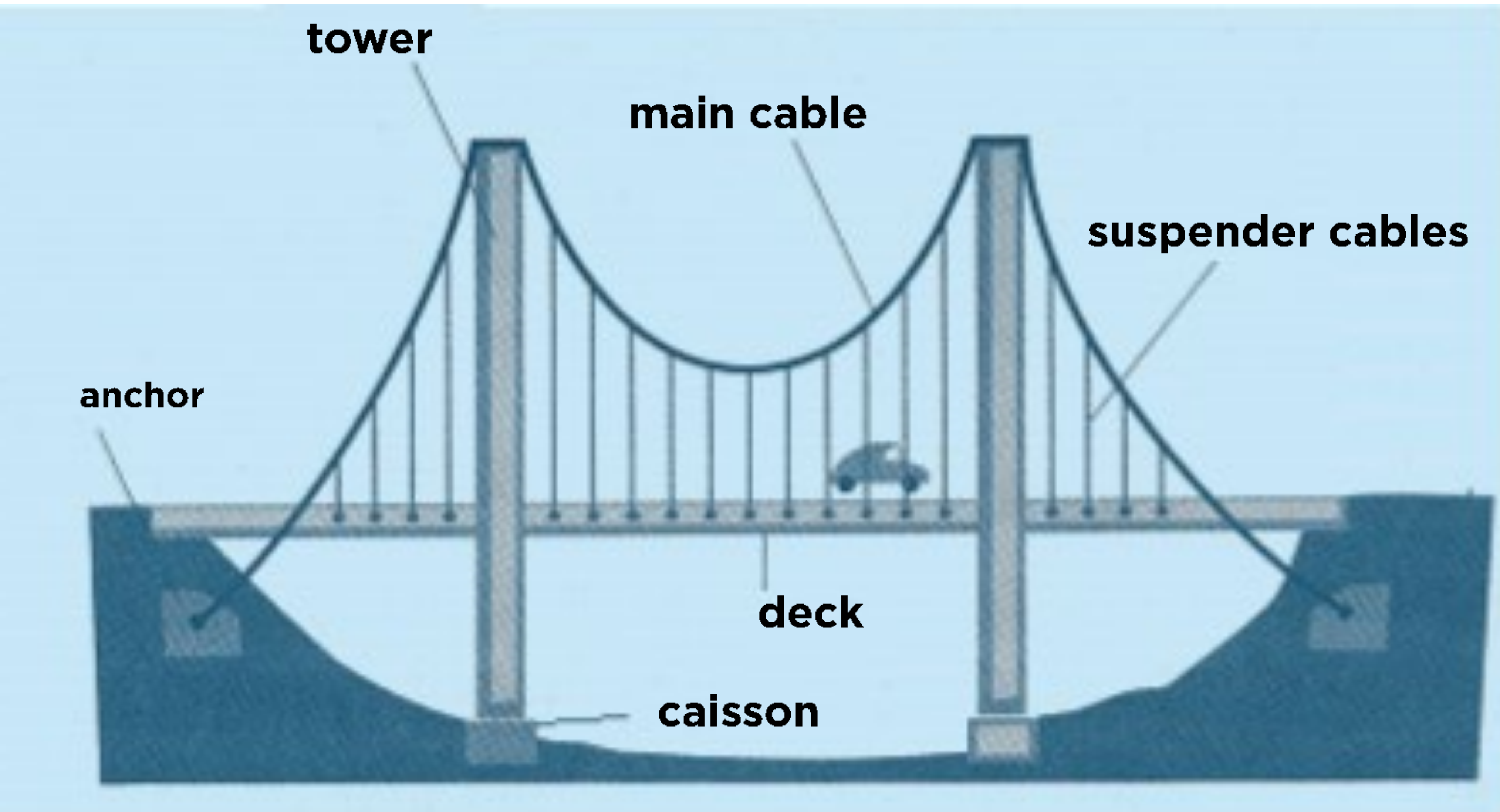
Williamsburg Bridge (Suspension bridge)

Queensboro Bridge (Cantilever bridge)

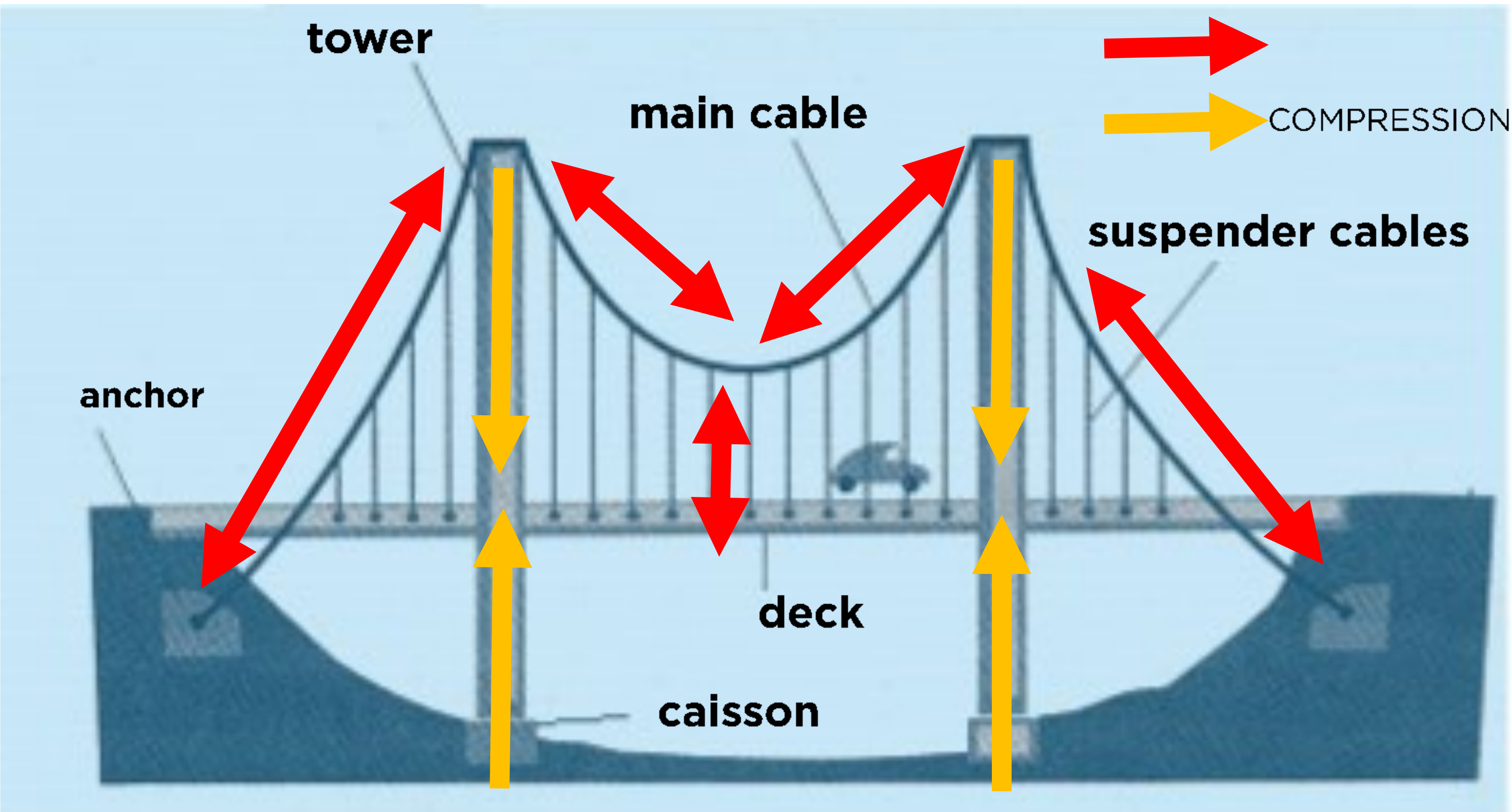


Kosciuszko Bridge (Truss bridge)

Parts of a Suspension Bridge



Forces in a Suspension Bridge



Name:____

Date:____

TESTING FORCES

1. **Make a Prediction**

Look at the materials on your table. Which do you predict will be the strongest (not break , bend or crumple) when placed under

Tension?________________________________ Compression? __________________________________

2. Try it Out

To test the material in <u>tension,</u> pull on it from both ends.

To test the material in <u>compression,</u> push it together from both ends.

To test the material in <u>torsion,</u> twist the two ends in different directions.

MATERIAL RATING GUIDE

1 Very weak! It crumples or breaks with hardly any force.

2 Only fair—it can't withstand much force.

3 Pretty good—it takes a lot of force to break it.

4 Super strong! We can't break it.

Using the guide above, rate your materials and record observations in the table below.

MATERIAL	TENSION	COMPRESSION	TORSION
Paper	3 (when we pull slowly)	1	1

Modified from PBS.org Building Big Tug-Push-Twist-O'War