A SCIENCE CURRICULUM GUIDE:
WHAT CAN THE HIGH LINE TEACH US ABOUT FORCES?

Grades 4 and 5

Materials:

Period 1:
- PowerPoint presentation
- Exploring forces question sheet

Period 2:
- Piece of 11" & 17" paper
- 4 or more Dixie cups
- Pennies
- Rulers
- Beam bridge construction info sheet
- Beam bridge question sheet

LESSON GOALS

Students will:

- Learn that the High Line was built in the 1930s to carry freight along Manhattan's west side
- Learn that the High Line is now open as a public park
- Learn to identify different types bridges
  - Suspension bridge
  - Beam bridge
  - Arch bridge

- Learn what a force is
- Learn about different forces
  - Tension
  - Compression
  - Balanced force
  - Imbalanced force
- Build a model of a beam bridge
- Learn the names of different parts of a beam bridge
  - Span
  - Continuous span
  - Pier
- Learn why some beam bridges are stronger than others

Duration: 2 periods

Period 1—PowerPoint presentation with exploration of different forces

Period 2—students build a beam bridge and test its strength

PERIOD 1:

Ask students to share their experiences of bridges. What is a bridge? What purpose does it serve? With which bridges are they familiar? Where do these bridges go? What type of traffic do these bridges hold? (e.g., vehicular, bicycle, pedestrian, train, etc.?) Are all bridges the same length as one another? Ask students to share their experiences of short and long bridges and the distances they span.

Set up the PowerPoint presentation.

Slide 1: The Brooklyn Bridge.
Ask students to name the bridge. Where is it? What body of water does it cross? (The East River.) What two bodies of land does it connect? (Manhattan and Brooklyn) Explain that the Brooklyn Bridge was built between 1869 and 1883 and was the longest bridge of its type at that time. Ask if any students know what type of bridge it is. Explain that it is a called a suspension bridge. What does suspension mean? Help students identify the part of the bridge that is being held up. (The roadway is being suspended by the suspenders, the vertical cables.)

Ask for two volunteers to come up to the front of the room. Have them face each other and join hands at waist level. Ask a third student to sit in the "seat" formed by the four hands/arms. Explain that the sitting student is being "suspended" by the arms or cables of the standing students. Ask what the standing students might represent in the actual suspension bridge? (The towers.)

Slide 2: Washington Bridge.
Ask the same types of questions about this bridge, i.e., where it is, etc. Students might be less familiar with this bridge. It crosses the Harlem River and connects Manhattan and the Bronx. It was built in 1889 and is an arch bridge. Ask students to describe how it looks different from the suspension bridge.

Ask for a volunteer to come up and be an arch bridge. The student may bend over and form an arch with his/her body. Ask another student to sit on top of the arch. What is supporting the sitting student? The arch.

Slide 3: The High Line.
Ask students to describe what they see. They might not think of it as a bridge. They might not be sure what it is. Explain. Students might share examples of elevated subway lines that they travel on. Ask if any students are familiar with what they are seeing. Briefly explain the history of the High Line and what is happening with it now. *(It was built in 1934 as part of a program called the West Side Improvement to ameliorate heavy shipping traffic on Manhattan's west side. At that time, the west side of Manhattan was NY's center of freight traffic—ship, train, and truck—and the streets were clogged with all manner of conveyance. Freight trains actually ran at grade along portions of 10th, 11th, and 12th avenues, and were a public nuisance as well as safety hazard. The High Line was built to get the freight trains off of the streets. It begins at 34th Street and runs to*

Gansevoort Street (a southern portion was previously demolished) between 10th and 11th Avenues. By 1980, the High Line had become defunct, and it sat idle for more than 20 years. In the late 1990s, threatened with demolition, a grass-roots organization, Friends of the High Line [FHL], formed to preserve this important piece of New York's industrial history. FHL was successful in saving the structure and it is now open as a public park. FHL now serves as a conservancy, raising funds and operating the park in a partnership with the New York City Department of Parks & Recreation.)

Do the students think the High Line is an arch bridge? A suspension bridge? (No.) Explain that it is a kind of bridge called a beam bridge. What makes the beam bridge stand up? (The piers—show students the piers and teach the name.) What supports the track bed? (The piers.) Ask if students can look around the room and find any examples of anything that is built on the same basic principle as a beam bridge? (A desk or chair could arguably be described as a type of beam bridge.)

Slide 4.
The High Line under construction. This image clearly shows the piers and the span above. Introduce these terms and have the students identify them in the image.

Introduce the word *force.* What is a force? (A force could be a push or a pull.) Bring a chair to the front of the classroom. What happens if it is just sitting there? Does it move? (No, because an extra force is not acting upon it.) Ask a student to come to the front of the room and push the chair. What is making the chair move? (The student is exerting a *force* upon the chair.)

Tell students that these bridges look different and function differently from one another because there are different *forces* that act upon them. Bridges would not stand up and would not do their job without forces.

Write the word *compression* on the board or chart. Ask students if they know the word. Some may. Explain that compression is a force that *pushes.* Go back to the chair. Ask if the chair is in compression. It is. It is pushing down upon the floor. But why doesn't it crash through the floor? There must be something pushing up, to balance the force. What might be pushing up? (The floor.) Explain that when objects don't move, the forces acting upon it are *balanced.* What will happen if the forces are *imbalanced?* (The object will move.)

Ask for two volunteers to come to the front of the room. Have them face one another and raise their hands over their heads, as in London Bridges. Have them lean into one another, so that nobody moves. Ask the class if they are acting a *balanced* force upon one another? (Yes.) Now ask one student to lean a little harder against the other. One student might lose his/her balance. Are the forces still balanced? (No, they are imbalanced.) Now ask the students to go back to a balanced force. Ask the class if they are pushing or pulling against one another? (They are pushing.) Explain that this force is called *compression*.

Ask two different volunteers to come to the front. Have them face each other, but keep their arms low, at hip level. Hold hands and lean back, so that nobody moves. Ask the class if they are pushing or pulling against one another? (They are pulling.) Explain that this pull is called *tension*. When the students are not moving, is the tension balanced or imbalanced? (Balanced.) What must happen for the tension to become imbalanced? (One student must pull a bit harder.)

Pass out the forces question sheet. Have students work in groups or pairs to answer the questions. Afterwards, they share their results.

Building a Beam Bridge

PERIOD 2:

Have the students work in groups of 3 or 4. Each group will construct a rudimentary beam bridge and test its strength. Begin by demonstrating at the front of the room how to construct a beam bridge. Then, give each group the materials they need, as well as the question sheet to experiment with the bridge's strength. Then, students will conduct the experiment.

How to build a beam bridge:

1. Take the piece of 11" X 17" paper. Fold it over three times the long way, so that you have strengthened the paper. Ask the students what part of the bridge this will probably be? (The road, also called the span.)
2. Use Dixie cups as the piers. Remind the students what the piers do. (They hold up the span.) Begin by positioning the cups far apart from one another. As students work through the worksheet, they will add additional cups to shorten the span.

Afterward, each group will share their results. Reinforce the notion that the High Line is an example of a beam bridge.

CONSTRUCTING A BEAM BRIDGE

—information for the teacher to demonstrate to the class. It is suggested that you demonstrate the construction of the beam bridge to the class, and then let them do it in their groups.

Materials:
Each group will need:

- Block of balsa wood for the bridge's span—1/4" X 4" X 12"
- Four blocks of balsa wood for the bridge's piers-- 2" X 2" X 6"

OR

- Oak tag, cut into a 4" X 12" rectangle
- 16 math manipulatives such as plastic cubes

- Weights such as pennies or scientific weights
- Scissors (if you are using oak tag)
- Scale
- Rulers
- Beam bridge question sheet
- pencils

Instructions:

1. Cut the oak tag (if necessary)
2. Weigh the oak tag or the balsa wood (whichever you are using)
3. Place two piers 11" apart. Place the span on top, so that ½" hangs off of either edge. The piers should be placed in the middle of the width of the span.
4. Start adding weights to the bridge. If you are using oak tag, you should add one penny at a time. If you are using balsa wood, you will probably want to use rolls of pennies.
5. Once the beam bridge is constructed, answer the questions.

EXPLORING FORCES
Grades 4 and 5

Group Member Names____

Date____

Directions: Answer these questions about compression and tension.

1. When your classmates *pushed* against one another, that is called _______________.

2. When your classmates *pulled* against one another, that is called ________________.

3. When one classmate lost his or her balance, this was because the forces were ______________________.

4. If the two classmates did not move, this meant that the forces were _______________.

5. With your partner, try out *compression.*

6. With your partner, try out *tension.*

7. Which is more fun? Why____

8. Do you think a bridge must have balanced forces or imbalanced forces acting upon it? Why?____

ANSWER KEY
EXPLORING FORCES
Grades 4 and 5

Group Member Names____

Date____

Directions: Answer these questions about compression and tension.

1. When your classmates *pushed* against one another, that is called compression.

2. When your classmates *pulled* against one another, that is called tension.

3. When one classmate lost his or her balance, this was because the forces were imbalanced.

4. If the two classmates did not move, this meant that the forces were balanced.

5. With your partner, try out *compression.*

6. With your partner, try out *tension.*

7. Which is more fun? Why____

8. Do you think a bridge must have balanced forces or imbalanced forces acting upon it? Why? Yes, so that the bridge is safe to carry people. If the forces are imbalanced, the bridge would be in danger of falling over.

BEAM BRIDGE QUESTION SHEET
Grades 4 and 5

Group Member Names____

Date____

Instructions: Construct a beam bridge. First, watch your teacher demonstrate. Then, build your own with your group. Fold the piece of 11" X 17" paper by folding it three times the long way. Use the Dixie cups as the piers (supports). Place the paper (the span) on top of the Dixie cups.

1. Use two piers (Dixie cups) to begin. Measure the distance between the Dixie cups. The piers are _______________ apart.

2. Add pennies. When the bridge begins to fail, or sag, stop. This is called the "live" load. How many pennies could you put on before the bridge failed?_____________

3. Add a pier (Dixie cup) to the middle of the bridge, so that it now has three piers. Measure the distance between each pier. Each pier is ____________apart from the other.

4. Add pennies. When the bridge begins to fail, or sag, stop. How many pennies could you put on before the bridge failed?_____________________________________

5. Now try again with four piers (Dixie cups). Measure the distance between each pier. Each pier is ___________________from one another.

6. Add pennies. When the bridge begins to fail, or sag, stop. How many pennies could your put on before the bridge failed?____________________________________

7. What made the beam bridge the strongest?______________________________

8. What made it the weakest?____

9. Is this beam bridge in compression or tension?___________________________

10. If you were building a train track to carry heavy freight trains, how would you make it strong?____

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