

# A Bridge in Balance

## Chicago River Classroom Activity

### Summary

Students will make a model of a bascule trunnion bridge. They will then balance their bridge by calculating the weight of the necessary counter weight.

### Background

Built in 1920, the Michigan Avenue Bridge is a double leaf, double decker, fixed counterweight bascule trunnion bridge. The bridge's two leaves are the two spans that come from either bridge tower and meet in the middle. Each leaf is also double decker, allowing for traffic to move on two levels. The leaves are actually part of Michigan Avenue itself.

The word bascule is French for see saw. The bridge works in just that way. Each leaf balances on a trunnion (the same things used to fix a cannon to its stand). A trunnion is like a big pin sticking through the bridge leaf so it can pivot. Because the pivot point is not in the middle of the leaf, but rather close to one end, a counter weight is needed on the shorter end. The counter weight balances both sides. The counterweight not only makes up for the greater weight of the longer side, it takes into account the effect of gravity working on the two different length sides. The counterweight is stored in a great underground pit. The bridge is so accurately balanced that if a coat of paint is added, it needs to be rebalanced.

When the bridge opens to let boats through, each leaf moves up into an almost vertical position. Each leaf weighs 3, 750 tons. The bridge is lifted by a series of gears, which allow for a very small motor (108 horse power per leaf). The work is displaced throughout the gear system so that the bridge takes 1 minute to open, but since the force needed to lift it is spread out over the distance of the gear train, the motor can lift the bridge without burning out.

**Grade Level:** 3<sup>rd</sup> – 5<sup>th</sup>

**Duration:** 45 min

**Objectives:**

1. Students will understand how the Michigan Avenue Bridge works and the importance of it being perfectly balanced.
2. Students will recognize that the bridge leaf is similar to a lever.

**Materials:**

- ◆ Plastic straws (19.5 cm long) (3 per group of 2)
- ◆ Scissors (1 per group)
- ◆ Clay (one 5 inch cube per group of 2)
- ◆ Small paper plates (1 per group of 2)
- ◆ Sewing pins with plastic balls on the end (1 per group of 2)
- ◆ String or yarn (3 inches per group of 2)
- ◆ Lab scale
- ◆ Rulers (1 per group of 2)

**Standards:**

6.B.2, 6.C.2a, 8.A.2b, 8.D.2, 11.B.2a, 11.B.2c, 11.B.2d, 12.D.2b

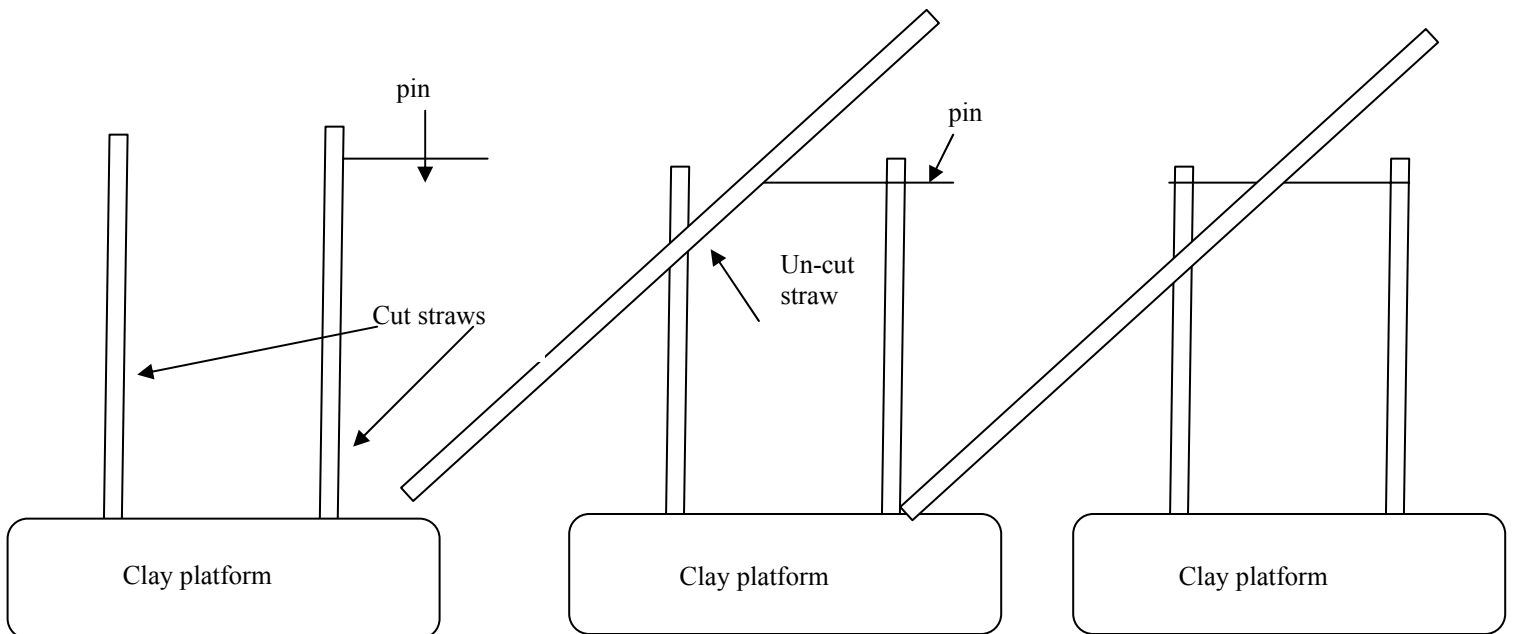
## Procedure

- ◆ Pass out the materials to the students.
- ◆ Pass out the student instruction sheet.
- ◆ After students make their bridge model, have a discussion about what they observe.
  1. If this was a real bridge, could cars cross over the bridge? *No, it's pointing down.*
  2. Why is the "bridge leaf" not able to stay horizontal? Why does it tip down? *Because the longer part of the straw is heavier than the shorter part so the part of the straw.*
  3. How can the bridge model be balanced and stay horizontal? *By placing a heavy object on the short side of the bridge model. This is called a counterweight.*
- ◆ Now have students work to calculate the weight of the counterweight and add it to their model.

# A Bridge In Balance: Student Instructions

## Make a Bascule Trunnion Bridge Model

1. Make a ball out of the clay. (Use most of your clay, but save a little piece for later.)
2. Press the ball of clay onto the paper plate so it sticks to the plate.
3. Flatten out the top of the ball.
4. Take one of the straws and cut it into two equal pieces.
5. Stick the two half straws into the clay ball so they stand up. The clay ball is acting as a platform.
6. VERY CAREFULLY stick the pin through one of the half straws, aiming the pin towards the other half straw stuck in the platform. (Figure 1)
7. Pick up the straw you did not cut in half and measure 12.5 cm from the top of the straw. Make a mark on the straw with a pen.
8. VERY CAREFULLY stick the pin through the straw at that mark. The straw should look sort of like a teeter-totter that has a longer and shorter side. (Figure 2)
9. Now stick the end of the pin through the second half straw stuck in the platform. (Figure 3)
10. Now the pin is through all three straws. Place the left over piece of clay over the sharp point of the pin to hold the pin in place.
11. The model you just made is of one leaf (or half) of the Michigan Avenue Bridge. The large straw is the leaf of the bridge and the pin is the pivot point (called a trunnion)



## Balance It!

Using the yarn and clay, you will create a counterweight for the bridge.

### How much should the counterweight weigh?

It's not just about mass being equal. Because the trunnion, or pivot point, is not in the middle you are going to have to consider distance as well. Here is how to do it:

### Using the last straw you have, find the following:

- a) In the model, the long side is 12.5 cm. Cut the straw at the 12.5 cm mark.
- b) The weight of the long part of the straw is \_\_\_\_\_
- c) The length of the short side of the straw is \_\_\_\_\_
- d) The weight of the short side of the straw is \_\_\_\_\_
- e) Half of the length of the long side of the straw is \_\_\_\_\_
- f) Half of the length of the short side of the straw is \_\_\_\_\_

### Now it is time to calculate!

To calculate the weight of the counter weight, use the following equation:

$$\text{Weight of counterweight} = ((a \times e) - (d \times f)) / f$$

**Note:** the letters refer to the letters in the instructions above. X means to multiply. / means to divide.

### Add the counterweight

1. Place your piece of string on the balance. Add small pieces of clay until the string and the clay are the weight of the counterweight you calculated.
2. Tie the counterweight to the short side of the straw in your model.
3. Is the bridge balanced now?

**Did you know:** The Michigan Avenue Bridge is so precisely balanced that it can be thrown off balance by an extra coat of paint!