

PUSH, PULL OR DRAG IT IN

3-5 STRUCTURES

Lesson 1

OVERVIEW

The next time the opportunity arises, carefully examine the type of materials used to construct a building, bridge, dam, roadway, tower, or other structure. You will discover that structures (buildings, bridges, etc) are typically built from concrete, steel, wood, or some combination of the three. City streets and highways are constructed using concrete or asphalt. Why is it that asphalt is used in highways but not for the bridges on a highway. Why is steel used in a building but not for a city street? Why are long bridges built from concrete and steel, but not with wood? The answer relates to the ability of a material to resist an applied force. Asphalt has very little resistance when it is pulled apart: a type of force that is very common in a bridge. Steel is too expensive and heavy to be used as a roadway, and wood can not resist the tendency to bend when used over long distances.

In order to determine how a material will respond to a certain type of load, civil engineers will test many samples to determine if there is a common result or a general trend. This information is then provided to a structural engineer who uses it to properly dimension a column or beam in a structure. Without the information gained from testing, the construction of a structure would be a trial and error process. No one would want to be on the error side of this experiment.

Three common forces that a structure might be subjected to are TENSION, COMPRESSION, and TORSION. Tension occurs when the ends of a piece of material are pulled apart. Compression occurs when the ends are pushed together. Torsion is the action of twisting the ends in opposite directions.

OBJECTIVES

The students will be able to:

1. understand the concept of a tension, compression, and torsion force
2. make a prediction and evaluate the accuracy of the prediction following an experiment
3. define and spell, as appropriate, the following vocabulary words
 - tension, compression, torsion, structure, construction, highway, concrete, steel, wood

MATERIALS

- Paper, string, yarn, tongue depressors, clay or play-doh, cleaning sponges, erasers, paper towel or toilet paper tubes, pencils, aluminum foil, straws, strips of cloth, or ceramic tiles.
- A piece of rope about 48 inches long
- A broom handle, or other similar length of ridged material
- Pencil, pen, or marker
- Chart paper
- A worksheet with rating scale and table to record results

ACTIVITY

1. Have two students come to the front of the class to assist with a demonstration. Have each student take one end of the piece of rope.
2. First, have the students PULL on their ends of the rope. Discuss what happens to the rope when it is PULLED.
3. Next, have them PUSH the rope toward each other. Discuss what happens to the rope when it is PUSHED together.
4. Lastly, have each student TWIST their end of the rope in a manner similar to using a screw driver. Again, discuss the result of TWISTING the rope.
5. Now, repeat Steps 1 through 4 with two new students and a broom handle instead of a rope.
6. Introduce the students to the terms TENSION - pulling, COMPRESSION - pushing, and TORSION - twisting.
7. On the chart paper, create a table with ROWS titled tension, compression, and torsion. Title the COLUMNS rope and broom. In the cells of the table, identify whether the rope/broom was STRONG or WEAK in tension, compression, and torsion. Note the differences between the two materials.
8. Now, divide the class into small groups of a manageable size.
9. Choose six to eight different items, such as those identified in the materials list, and provide a set for each group of students.
10. The groups will test each material to determine its ability to resist tension, compression, and torsion. Give each group a worksheet to record their results. See Table 1.

11. Before testing the materials, have the groups predict how well each material will resist tension, compression and torsion. Use the rating scale provided with Table 1. The groups are to record their predictions on the worksheet in Table 1.
12. The groups then test each of the materials and record the actual outcomes. If possible, have the students pull, push, and twist (each end in the opposite direction) each material until it breaks. Depending on the materials you select, it may be necessary for the students to use eye protection.
13. Use the rating scale that is provided on the worksheet to assess how each material resisted the three different forces.
14. After testing the materials and recording the results, have the students evaluate which of the materials performed as predicted and which did not. Also, have the students identify which materials were strongest/weakest in tension, compression, and torsion. Was any material strong or weak in all three cases?

Materials strong in TENSION

string, yarn, pipe cleaners, tongue depressors, ceramic tile, cardboard, straws, cloth, rubber band (strong, but very flexible), rubber eraser, paper towel tubes, and pencils.

Materials strong in COMPRESSION

tongue depressors, clay (limited), ceramic tile, rubber eraser, paper towel tubes (limited), and pencils.

Materials strong in TORSION

ceramic tile, rubber eraser (limited), paper towel tubes, and pencils.

15. After the groups have tested all of their materials, have them return to the large group and discuss the results of their tests. This discussion can be enhanced if there is some overlap in the materials that each group tested. However, make sure that each group also has some unique materials.
16. As a group, discuss which of the materials tested would be well suited for use in building structures such as foundations, buildings, bridges, and other similar projects.

Table 1. Worksheet for Recording Data

MATERIAL	TENSION		COMPRESSION		TORSION	
	Prediction	Result	Prediction	Result	Prediction	Result

RATING SCALE

- Weak Can withstand hardly any force.
- Fair Can withstand some force.
- Good Can withstand a lot of force.
- Strong Cannot be broken.