FORCES

Materials

- Forces - BLM 7.3.1
- Forces - BLM 7.3.2
- Toothpick Tower - BLM 7.3.3
- plasticine
- Styrofoam strips 2cm x 2cm
- newspapers
- elastic bands
- popsicle sticks
- glue
- plastic straws
- pipe cleaners
- glue sticks for glue gun
- masking tape
- corrugated cardboard
- nails
- spagetti noodles
- small boxes
- licorice
- pop cans
- toothpicks
- scissors
- books
- hacksaws
- safety glasses
- weights of 10g to 500g
- vice(s)
- tin snips or large garden shears
- mini-glue guns (low temperature type)

Overall Expectations: 2. Design and construct a variety of structures, and investigate the relationship between the design and function of these structures and the forces that act on them (7s21); 3. Demonstrate an understanding of the relationship between structural forms and the forces that act on and within them (7s22).

Structures and Mechanisms – Forms and Function -
– Forces –

Description: Students will perform several activities that will allow them to identify forces within a structure that are affected by forces outside the structure. After these activities, the students will then construct a tower to demonstrate that the effect of forces acting on a structure under a load depends on the magnitude, direction, and point and plane of the forces.

1. Use the following questions to engage students in a discussion of forces: What is force? Where do forces come from? What kind of forces effect structures? Are forces the result of natural occurrences or are they created by people?
2. Forces are present in the world around us all the time. Some forces such as wind, rain, ice and snow are part of our natural environment while other forces are created by people. Forces can be both internal and external. External forces act upon structures from outside. Strong wind, heavy snow and ice are examples of naturally occurring external forces. Internal forces are from within a structure and may be affected by external forces acting upon the structure. Shear, torsion, tension and compression are internal forces. These internal forces, for example within a bridge, are affected by external forces such as high wind or ice which may cause the bridge to twist or buckle.
3. Depending on available time, the following activities may be used as mini-experiments for the students or as teacher-directed demonstrations.
4. Compression: When a material does not hold up under compression, it buckles. Demonstrate compression by conducting the following experiments:
    a. Stand on a small box. Hold it up and show how it has buckled and folded in on itself.
    b. Tape a piece of uncooked spaghetti to the top centre of a book. As illustrated in Forces - BLM 7.3.1, lift the book using the spaghetti. Next place the book on a desk and slowly push down on the spaghetti. This downward force causes the spaghetti to compress. Continue to exert downward pressure until the spaghetti snaps. (See Forces – BLM 7.3.1).
    c. Place several books, one at a time, on a cylinder of plasticine, to demonstrate that some materials compress more easily than others. (See Forces - BLM 7.3.1).
5. Tension:
    a) Cut an elastic band in half and stretch it lengthwise. Have a student pluck the elastic band and note the sound. Stretch it to various lengths while plucking and have the students notice the various pitches produced as the tension on the elastic changes.
    b) Stretch a piece of licorice. Note any changes in its structure. Continue to stretch and stretch. What happens?
6. Tension/Compression Acting Together: Tension and compression often work together to counterbalance each other. When they work together they are called complementary forces. It is more common for tension and compression to work as complementary forces than it is for them to work in isolation.
    a. Make several small transverse cuts on the top and bottom of a strip of Styrofoam with a hacksaw. (See Forces – BLM 7.3.1). Press down lightly with your index finger on the top of the strip. Observe what happens to the cuts on the top and bottom of the strip. The top cuts are pushed together (compression) and the bottom cuts are pulled apart (tension).
7. Discuss and Note: Some materials will not resist. For example, some may withstand compression, but fail under the stress of tension (e.g., toothpick). This may be demonstrated using a toothpick (see Forces - BLM 7.3.1). Another example is the quill of a bird's feather which is a box-like structure with a foam-like core. This core is reinforced with longitudinal ribs on the tension side to provide strength for the feather on each downward beat. The compression side has no ribs (see diagram on Forces - BLM 7.3.2).
8. Shearing: Hold a page of newspaper in both hands. Pull with one hand and push away with the other to demonstrate the action of shearing (tearing). An example of a shearing force occurs on an aircraft's wings when it encounters heavy downdrafts of air on the upper wing and fuselage and uplift on the lower surface of the wing due to lift (see diagram on Forces – BLM 7.3.2).
9. 9. Torsion or Torque: Grip the upper top of an empty aluminum can with one hand and the bottom of the can with the other hand. Twist in opposite directions as shown in the diagram. Observe how the can is twisted out of shape (see diagram on Forces - BLM 7.3.2).

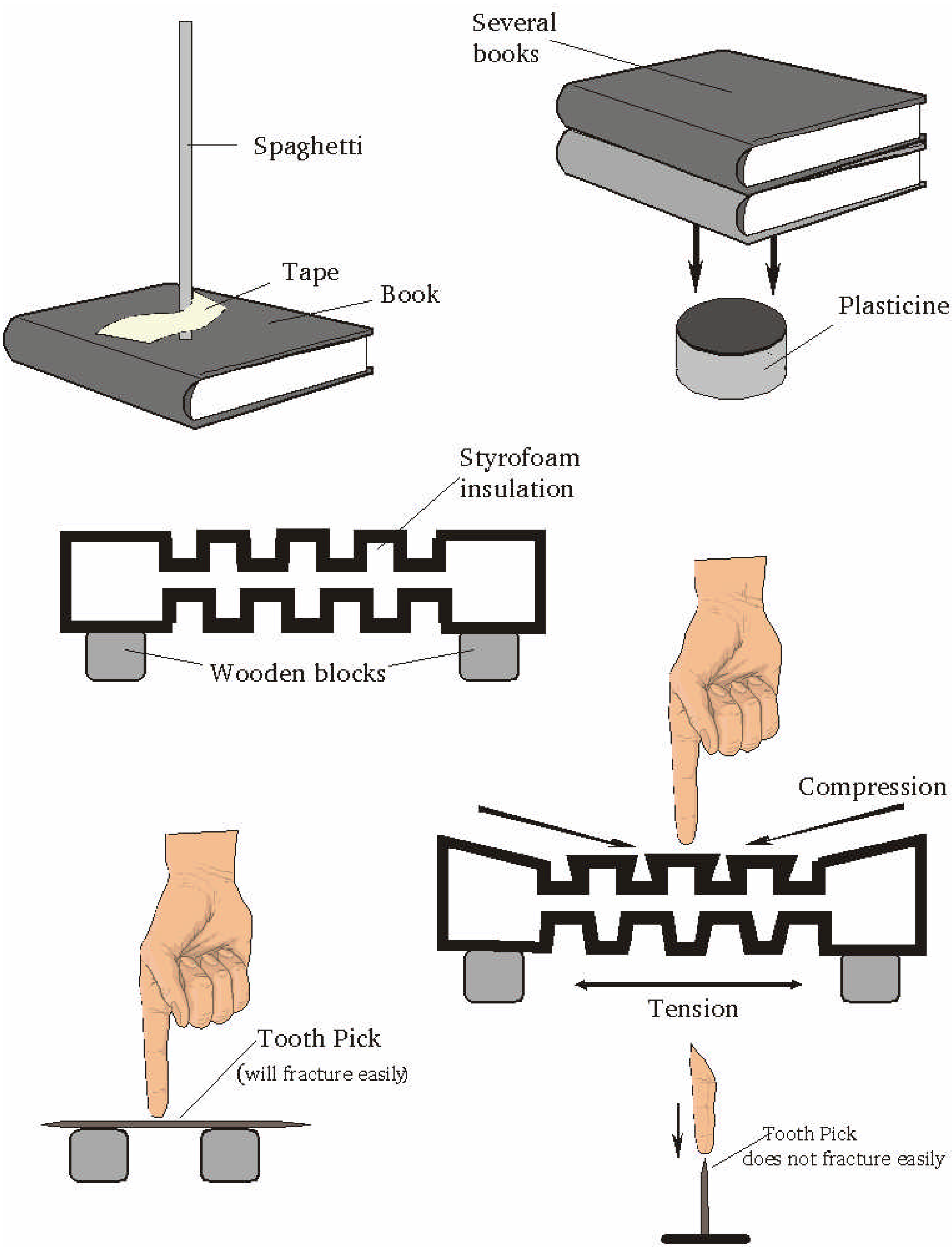
Part B (60 mins)

1. Investigating Internal Forces: Set up four stations as detailed in the following: Have students complete the activity at each of the stations. Note: Students will require][shaped beams for these activities. Each beam is constructed using three popsicle sticks. The beams should be constructed at least one day before the activity to allow sufficient time for the glue to dry.
    a. Station One – Twisting: Place one][shaped beam in a vice. Manually twist it until it breaks. Note where and how it breaks and the direction of force that was used to break it.
    b. Station Two - Bending: Place one][shaped beam in a vice in a horizontal position. Pile weights on it until it bends. Note where and how it breaks and the direction of the force that was used to break it.
    c. Station Three – Shearing: Place one][shaped beam in a vice. Use tin snips or garden shears to shear the][shaped beam in half. Describe the break and the direction of the force(s) used to break it.
    d. Station Four – Buckling: Place one][shaped beam in a vice in a vertical position. Place weights on the top of it until it buckles. Note where and how it breaks and the direction of the force that was used to break it.
2. Discuss with the students what they have discovered about internal forces and the affect they have on structures.

Part C (80 mins)

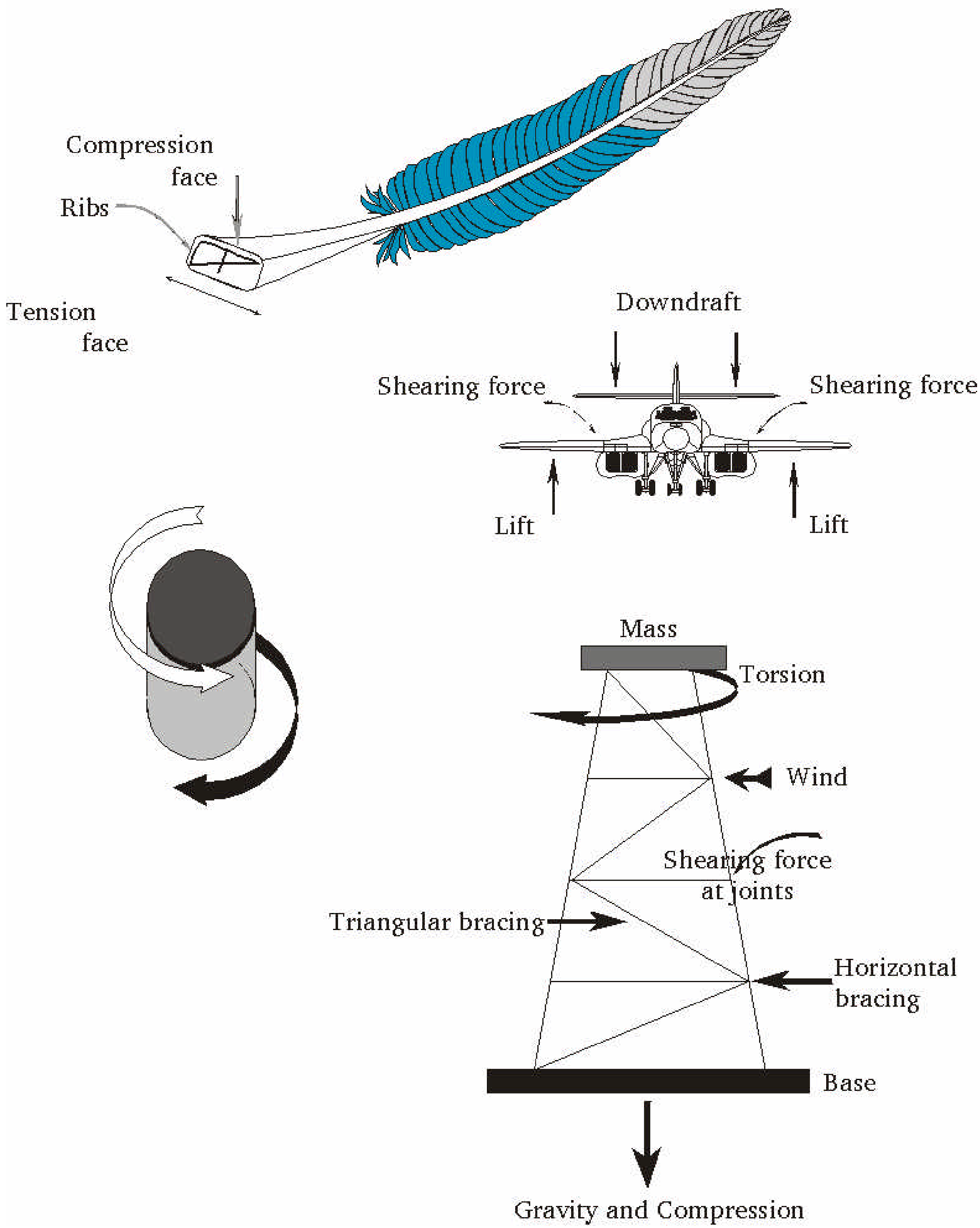
1. Have students working in small groups cut out a square f cardboard 8 cm X 8 cm.
2. Have the groups create a table using eight toothpicks. Place the cardboard on the toothpick table and add weights until the structure collapses.
3. Provide each group with enough toothpicks to create a table with legs that are two toothpicks in length. Place the cardboard on the toothpick table and add weights until the structure collapses.
4. Provide each group with enough toothpicks to create a table with legs that are three toothpicks in length. Place the cardboard on the toothpick table and add weights until the structure collapses.
5. For the second part of this experiment refer to BLM 7.3.3. Have students create the following structures using toothpicks: a single cube, a tower consisting of two cubes, a tower consisting of three cubes. (Note: 12 toothpicks are required for a simple cube.) To test each structure, place a piece of cardboard on top of the structure and add weight unit it collapses. Note the height of each structure, and the weight each supported before it collapsed. Record this information on BLM 7.3.3.
6. Discussion: Which tower could hold the most weight? Encourage the students to use the information they gathered during the experiments, as well as their observations, to support their answers.

Forces



BLM7.3.1

Forces

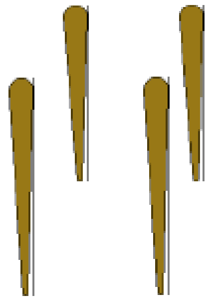
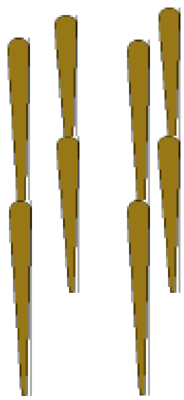
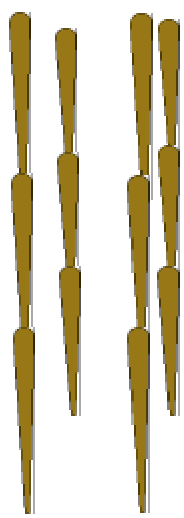


BLM7.3.2

Horizontal Braces

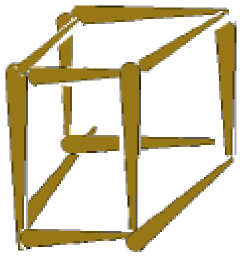
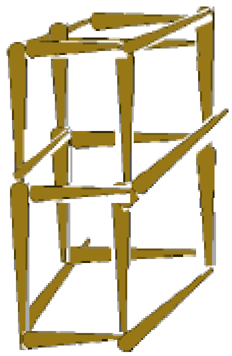
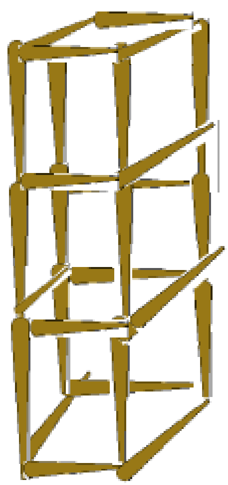
Part One

Method: Attach a square piece of bristol board to the toothpick (which act as "legs"). Place masses on the top of the bristol board until the structure collapses. Record the weight of the last mass supported before the collapse.

Height	Diagram	Mass supported
1		
2		
3		

Part Two

Method: Attach a square piece of bristol board to the toothpick cubes (which act as "legs"). Place masses on the top of the bristol board until the structure collapses. Record the last mass supported before the collapse.

Height	Diagram	Mass supported
1		
2		
3		

Part One and Part Two Conclusion:
