Name: _____ Class: ____ Date: _____

Examining Forces

Lerner Outcomes:

- Devise and use methods of testing the strength and flexibility of materials used in a structure (e.g., measure deformation under a load)
- Identify tension, compression, shearing and bending forces within a structure and describe how these forces can cause the structure to fail.
- Compare structural properties of different materials, including natural materials and synthetics.

Key terms:

Tension force	Torsion force	Live load
Compression force	Bending force	
Shear force	Dead load	

Background Information: If you know the types of internal forces that stress part of a structure, you can design that part with the strength it needs to resist the forces acting on it. In this investigation, you will identify the forces acting on a variety of structures and materials and the effect that each force has.

Investigative Question: What forces create stress in various structures?

Materials:

Black felt pen	10 x 15 cm block of blue polystyrene	Plastic bucket with handle
30 cm ruler	Small towel	Paper clips
Large mashmallows	Plastic bucket full of water	Assorted masses of known weight
Sharp scissors	Graduated cylinder	Metal bar or rod
Dull scissors	Gloves	Various types of threads and strings
Toothpicks	Retort stand	
Sheet of paper		

This investigation / activity has been adapted from:
Bullard J, Krupa G, Krupa M, et al. *Science Focus 7*. Toronto, ON: McGraw-Hill Ryerson.

Procedure:

Part 1: Stressed out Marshmallows

1. Use a felt pen and a ruler to draw a square grid pattern on the outside of 5 marshmallows.
2. Hold the marshmallow between two fingers (one finger on each end) and squeeze the marshmallow. Observe and record the changes in the vertical and horizontal lines.
3. Hold a second marshmallow by each of the two sides and pull outwards. Observe and record the changes in the vertical and horizontal lines.
4. Hold a third marshmallow on each side and bend the ends of the marshmallow upwards. Observe and record the changes in the vertical and horizontal lines.
5. Hold one end of a fourth marshmallow on the edge of a desk and push the other end downwards over the edge. Observe and record the changes in the vertical and horizontal lines.
6. Hold each side of a fifth marshmallow between two fingers and twist your hands in opposite directions. Observe and record the changes in the vertical and horizontal lines.

Part 2: Shear Excitement

1. Slowly tear a sheet of paper from top to bottom. Draw and describe what happened to the fibers that make up the paper as it was torn. Include arrows to show the direction of the forces acting on the paper.
2. Using sharp scissors, cut a sheet of paper from top to bottom. Record what happens.
3. Using the dull scissors, cut a sheet of paper from top to bottom. Record what happens.
4. Place two pieces of polystyrene together and connect them by pushing two or three toothpicks through both pieces. Slide the blocks apart, snapping the toothpicks and observe the broken ends of the toothpicks. Record your observations.

This investigation / activity has been adapted from:
Bullard J, Krupa G, Krupa M, et al. *Science Focus 7*. Toronto, ON: McGraw-Hill Ryerson.

Part 3: Twist That Towel

1. Soak the towel in water and hol the towel above the bucket of water until it stops dripping.
2. Squeeze as much water as possible into the empty bucket.
3. Use a graduated cylinder to measure the volume of water squeezed out. Record your observations.
4. Repeat steps 1-3 but twist the towel to squeeze out the water. Record your observations.

Part 4: Tug-o'-war

1. Loop the first materials being tested through the handle of the bucket and over the metal bar. Securely tie the loose ends together.
2. Gradually add masses to the bucket until your material breaks. Record the amount of mass required to break your thread.
3. Repeat steps 1 and 2 for the other materials.

Observations:

Stressed out Marshmallows

Action	Grid diagram	Changes in Grid	Type of force
Squishing			
Stretching			
Bend both ends			
Bend one end			
Twisting			

Shear Excitement

Action	Diagram	Description	Type of force

This investigation / activity has been adapted from:
Bullard J, Krupa G, Krupa M, et al. *Science Focus 7*. Toronto, ON: McGraw-Hill Ryerson.

Twist that Towel

Tug of War

Analysis:

1. Use your observations to decide whether each statement below is true or false. Explain which part of the investigation provides evidence for your decision.
   a. Only one force can act on one part of a structure at a time.

This investigation / activity has been adapted from:
Bullard J, Krupa G, Krupa M, et al. *Science Focus 7*. Toronto, ON: McGraw-Hill Ryerson.

b. Torsion forces reduce the size of the spaces between particles in a substance.

c. The top of a structure that is being bent may be placed under tension or compression.

2. For each type of force investigated (tension, compression, torsion, shear and bending), give two examples of materials that would be well suited to resist that particular force and two examples of materials that would be poorly suited.

Force	**tension**	**compression**	**torsion**	**shear**	**bending**
Well suited to resist					
Poorly suited to resist					

3. For each of the forces you investigated, give an example of a 'real life" structure or part of a structure that must be able to resist that force. Explain how these structures were designed to resist the forces.

This investigation / activity has been adapted from:
Bullard J, Krupa G, Krupa M, et al. *Science Focus 7*. Toronto, ON: McGraw-Hill Ryerson.

4. For each of the examples below, describe which force(s) would cause internal stress and explain how what the effect of too much stress would be.

Example	**Force(s)**	**Stress Caused**	**Effect of too much**
Playground swing set			
Playground seesaw			
Full garbage bag held shut with a twist tie			
Front bumper on a car			
Wrestler during a match			
Snowboard with bindings			

5. In part 4 of the experiment, did you notice a difference between the strength of natural fibers versus manmade or synthetic fibers? Explain.

This investigation / activity has been adapted from:
Bullard J, Krupa G, Krupa M, et al. *Science Focus 7*. Toronto, ON: McGraw-Hill Ryerson.

Extension:

Research two examples of structures that have failed because the forces they were exposed to exceeded the strength of the structures. Explain what forces caused the structures to fail and how the structures failed. Propose at least three changes in their design or materials that would make them stronger and less likely to fail again.

This investigation / activity has been adapted from:
Bullard J, Krupa G, Krupa M, et al. *Science Focus 7*. Toronto, ON: McGraw-Hill Ryerson.