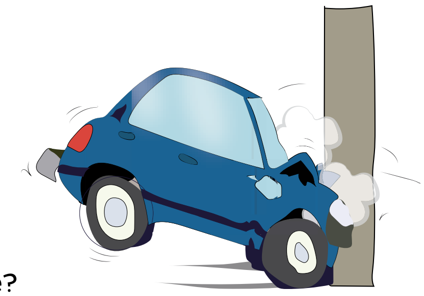
Name: ______________________ Class: __________ Date: ____________

STUDENT ACTIVITY

STRESSING SILLY PUTTY



MATERIALS NEEDED

DAY 1

For each group of 3-4 students

- 2 64-ounce (1.8L) plastic containers (such as storage containers without lids) for mixing
- 3 small plastic spoons
- 4 teaspoons of Borax powder in a small paper or plastic cup
- Approximately 10 ounces (300 ml) of water in a 12-ounce plastic cup
- 3 2-ounce (60 ml) condiment cups of white glue
- 1 100ml graduated cylinder
- 2 quart-size zipping plastic bags
- 1 permanent marker to label plastic bags
- Soap for cleaning
- **OPTIONAL:** Newspapers to work areas or desks

Per student

- 1 "Stressing Silly Putty" Student Activity Sheet
- 1 pair of safety glasses

Key Question

- How do crash forces apply stress to human tissue?
- How can stress-testing materials improve crash test dummy performance?

Purpose

- To investigate how different types of homemade slime/silly putty (simulated human tissue) respond to different types of stress forces

Did You Know?

Every material, whether it's concrete or a human tissue or organ, has a critical stress limit. Stay below the limit and there is no damage or failure. Go beyond a material's critical stress limit and there can be significant damage and/or failure (breakage). Trauma (stress) to human body parts including bones, tendons, ligaments, and organs like the heart, brain, or liver from a vehicle crash can lead to its failure just like stress to the concrete in a bridge support resulting from a vehicle crashing into it can cause the entire structure to fail and collapse.

Bioengineers study how human body parts, including bones, tissues, and organs, respond to different types of traumatic stress, such as the stresses experienced in a vehicle crash. In order to design more effective vehicle safety features and better protect the human body from the harmful effects of stress forces resulting from vehicle crashes, bioengineers must understand the critical stress limits of different human body parts. Since living human beings are not used in crash tests, crash test dummies made from synthetic materials must be used instead. When stressed, many man-made materials react in ways that are very similar to human body parts. A man-made material that behaves the same way many soft human tissues and organs behave when stressed is Silly Putty®. In this activity, you will investigate how different types of homemade slime/silly putty react to different stress forces to better understand how bioengineers design more realistic crash test dummies.

Procedure - Day 1

Part 1 — Making Homemade Silly Putty

1. If newspaper is provided, cover your work area with newspaper first. Lay out all of your group's Day 1 supplies and use two small pieces of scrap paper to make labels to place in front of each container. Label one container "Container 1-Borax Solution" and the other "Container 2-Glue Solution."
2. Make sure everyone is wearing their safety glasses and follow the instructions below to make three different batches of silly putty with different concentrations of Borax (low, medium, and high). Refer closely to Tables 1 and 2 and measure out all ingredients as precisely as possible when making the Borax and glue solutions.
3. In Container 1, make Batch 1 – Low Borax concentration solution by mixing 30 ml of water with ½ teaspoon of Borax. Stir well for 30-60 seconds. HINT: Use the class set of measuring spoons to measure 1 teaspoon of Borax into your plastic spoon. Then use this as a reference for your other measurements.

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MATERIALS NEEDED

DAY 2

For each group of 3-4 students

» Plastic bags of homemade silly putty batches 1, 2, and 3
» 1 metric ruler
» 1 stopwatch
» **OPTIONAL:** One sheet of graph paper

Per student

» 1 "Stressing Silly Putty" Student Activity Sheet

CONTAINER #1 - BORAX SOLUTION			
BATCH NUMBER	BORAX CONCENTRATION	BORAX AMOUNT	WATER AMOUNT
1	*Low*	*1/2 tsp*	*30ml*
2	*Medium*	*1 tsp*	*30ml*
3	*High*	*2 tsp*	*30ml*

CONTAINER #2 - GLUE SOLUTION	
GLUE AMOUNT (FILL 2OZ CLEAR CUP)	WATER AMOUNT
2ounces (60ml)	*60ml*
2ounces	*60ml*
2 ounces	*60ml*

Procedure - Day 1 (continued)

Tables 1 & 2 - Container #1 and Container #2 Solutions

1. In Container 2, make one batch of glue solution by first pouring in the 2 ounces of white glue from one of the condiment cups and then using the graduated cylinder to measure out 60 ml of water. Slowly pour the water into the container with the glue and use one plastic spoon to stir the glue and water together for 60 seconds until you have a uniform consistency and color. **It is important that this solution is uniform, with no areas of excess water, or it prolongs the mixing time in Step 5.**
2. After mixing the glue and water thoroughly, continue stirring the glue mixture and slowly pour the Borax solution from Container 1 into the glue solution in Container 2. Be sure that all of the Borax mixture is transferred into Container 2.
3. When the solution starts to thicken, mix it with your hands instead of the spoon. Continue to mix until a uniform solution is achieved and NO water is present.
4. Store this first batch of silly putty in a zip-lock plastic bag and use the permanent marker to write your team name and Low concentration on the bag. Squeeze all of the air out of the plastic bag before sealing it.
5. Thoroughly clean your hands and both containers with soap and water and discard the spoon.
6. Use the same procedure described in steps 3 through 8 above to make two more batches of silly putty, using 1 teaspoon of Borax (Medium concentration) for Batch 2 and 2 teaspoons of Borax (High concentration) for Batch 3. Make sure all three plastic bags of silly putty are labeled with the Borax concentration level and your team name and that the aire has been squeezed out of each bag.
7. Once all three batches of silly putty have been made, clean up your work area and set aside the silly putty bags containing batches 2 and 3 for use on Day 2. You only need to keep batch 1 for Part 2!

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Procedure - Day 1 (continued)

Part 2 — Observing the Properties of Homemade Silly Putty

1. Before making any formal observations of specific properties of your silly putty, make sure each member of your group is able to spend a few minutes handling and playing with the silly putty to get a sense of how it feels and behaves. Your teacher will tell you when to move on to step 2 and work with your group members

2. Complete the following three "tests" to learn more about the specific properties of your silly putty and record your observations and responses in the spaces below each item.

A. *Investigating Strain Rate*

Directions: Stretch the silly putty at different rates by grabbing a blob of putty with two hands and pulling it apart in opposite directions at different speeds. Try pulling it apart very slowly and then try again with a quick pull. This is called a strain rate test. The strain rate defines how fast the material is stretched.

Describe your observations and indicate whether the silly putty behaves more like a solid or more like a liquid for each strain rate.

Slow strain rate:

Fast Strain rate:

B. *Investigating Shape Changes*

Directions: Roll a small piece of silly putty into a ball (about the size of a large marble or a malted milk ball) and let the ball sit on a table for 1 minute.

Describe your observations and indicate whether the silly putty behaves more like a solid or more like a liquid while rolling it into a ball and then after it has been sitting on the table for 1 minute.

While rolling it into a ball:

After sitting for 1 minute:

C. *Investigating Creep*

Directions: Roll the silly putty into a cylinder shape and hold one end of it vertically above the table top. This stretching by a constant force (in this case, the constant force is the pull of gravity) is called creep.

Describe your observations while you hold the cylinder of silly putty above the table and indicate whether it behaves more like a solid or more like a liquid.

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Procedure - Day 2

Part 3 — Measuring Homemade Silly Putty Creep

1. Make sure your group has their 3 bags of silly putty and Student Activity Sheets from Day 1 as well as a ruler and a stopwatch.

2. Review the following group member roles and determine who is performing each role.

ROLE	DESCRIPTION
1	Putty Manager: Forms the cylinder (4 cm diameter) and holds the silly putty at the same height above the table (bottom of cylinder starting height of 20 cm above the table) for each trial
2	Measurer: Holds the ruler and checks the diameter of each cylinder and monitors the height of the silly putty above the table for each trial
3	Timer: Operates the stopwatch
4	Recorder: Records data (If working in groups of three, assign this role to everyone in the group.)

Note: It is very important that the diameter and shape of the putty be consistent for each trial and that each putty cylinder is held at exactly the same height above the table throughout each trial.

3. Follow this procedure for EACH trial:

a. The Putty Manager should form the silly putty into a 4 cm diameter uniform cylinder and have the Measurer check the diameter using the ruler.

b. The Measurer should then hold the ruler vertically so that the "0 cm" mark touches the top of the table.

c. The Putty Manager should hold the top and bottom ends of the silly putty cylinder vertically with two fingers of one handing holding the top and two fingers of the other hand holding the bottom so that the bottom of the silly putty cylinder is positioned exactly 20 cm above the table.

d. While still holding the top of the cylinder with 2 fingers, the Putty Manager should remove his/her other two fingers from the bottom of the putty while the Timer immediately starts the stopwatch. The Putty Manager needs to keep the hand holding the silly putty stationary and at the same height until the silly putty touches the table and the Timer should stop the stopwatch as soon as the bottom of the putty cylinder touches the tabletop.

e. The Recorder should record this time (creep time) on the Data Table.

4. Repeat this Procedure (a. through e.) with the same silly putty batch two more times and record the creep times for all three trials in the Data Table.

5. Write a descriptive title for your data table and identify the independent and dependent variables in the spaces provided. Be sure to include the units of measurement for each variable.

6. Follow the creep test procedure outlined above for the other two batches of silly putty and record all creep times in the Data Table.

STRESSING SILLY PUTTY

Table 3 - Title:

MY INDEPENDENT VARIABLE IS	MY DEPENDENT VARIABLE IS:			
	TRIAL #1	TRIAL #2	TRIAL #3	AVG. OF TRIALS

Part 4 — Analyzing Creep Test Results and Drawing Conclusions

Work with your group members to answer the following questions and complete the following tasks:

1. Looking at your creep test data, do you see a large or a small variation in the time it took each batch of silly putty to fall to the table during the three trials? If you have a large variation in the creep times for a particular batch, what factors could have caused this?

2. Use the data from your Data Table to construct a line graph comparing Borax concentration and creep time results. Borax concentration levels in teaspoons should be on the x-axis and average creep time in seconds should be on the y-axis. After plotting your data points, draw a best-fit line indicating the relationship between these two variables.

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CRASH SCIENCE IN THE CLASSROOM

STRESSING SILLY PUTTY

Title: ______________________________

3. Analyze the graph and describe the relationship between the variables in one sentence.

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4. As a review, name and describe three ways crash forces apply stress to human tissue.

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5. The human body is composed of both viscoelastic materials and a variety of other materials, including solids, such as bones, and liquids, such as blood. In your own words, explain how conducting stress tests on a variety of man-made materials (including viscoelastic materials, solids, and liquids) can help bioengineers design better crash test dummies.

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