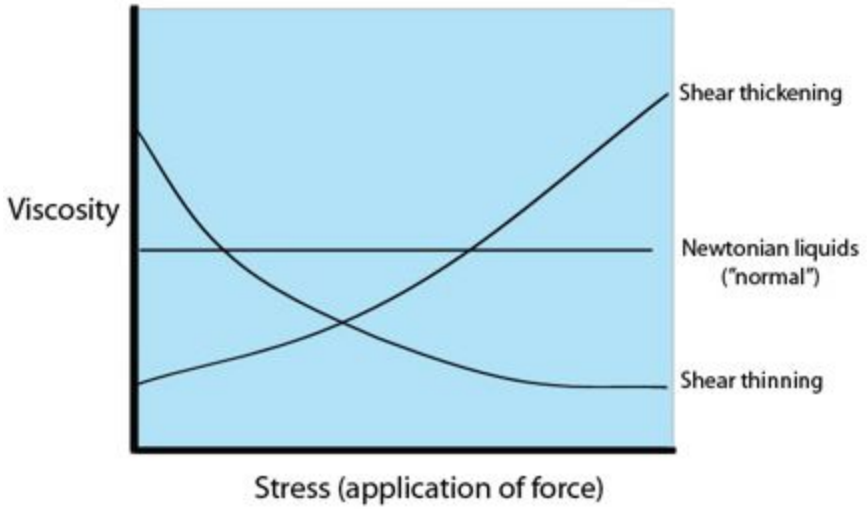
Student Name: _____ Date: _____

Non-Newtonian Fluids
How slow can you go?

Background

Have you heard of Sir Isaac Newton? Newton (1643-1727) is a famous scientist and mathematician who discovered gravity! In addition, he created the three laws of motion, contributed to creating calculus and predicted the shape of the earth. Newton also did a lot of work with fluids.

Newton described how "normal" fluids, like water, behave. For example, these fluids have a constant viscosity. For Newtonian fluids (or "normal" fluids), viscosity only changes with temperature. **Viscosity** refers to a fluid's resistance to flow. A highly viscous substance flows slowly. For example, peanut butter is more viscous than water because it is more difficult to pour. There are some fluids that do not have a constant viscosity, and these are called **non-Newtonian fluids**. These fluids can be affected by other factors besides temperature, such as stress. Applying a force to non-Newtonian fluids can cause them to get thicker and act like a solid or get thinner and less viscous than they were before. If the force or stress is removed, the fluid will return to its natural state.



Watch this clip to see an example of a shear thickening non-Newtonian fluid and to see someone walk on a liquid! https://www.youtube.com/watch?v=vcmMHQMSzBY

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Procedure:

Timer: _____ Measurer: _____

Reader/Recorder: _____ Handler: _____

1. Choose one version of Non-Newtonian fluid that you will test. Write that version on the line. _____

A.	B.	C.
Glue Borax Solution	Glue Borax Solution Water	Water Corn Starch

2. The measurer will measure how far the silly putty has fallen from its original spot on a vertical surface at 30 seconds, 1 minute, 3 minutes, 5 minutes and 3 additional times decided by your group. These times must be less than 10 minutes long. Write your three times in the boxes below.

3. Order your times from smallest to greatest in the table on the next page.
4. Create your version of the non-Newtonian liquid.
5. Place non-Newtonian liquid on a vertical surface (window, white board, chalk board) by holding the it against the surface for 10 seconds. BEFORE LETTING GO of the non-Newtonian liquid, MARK where the bottom of the non-Newtonian liquid is with a marker (make sure the line is wide enough that you can see it even after the silly putty drips over it). Once the handler let's go of the non-Newtonian liquid, the Timer starts the timer.
6. Measure the distance the non-Newtonian liquid has fallen from its starting point using a ruler at each designated time and record your results in the table.
7. Once you are done, throw out the non-Newtonian liquid, along with the cup, mixing stick, and any excess materials used to make the non-Newtonian liquid

Directions: Record how far your silly putty has fallen from it's original location. Be sure

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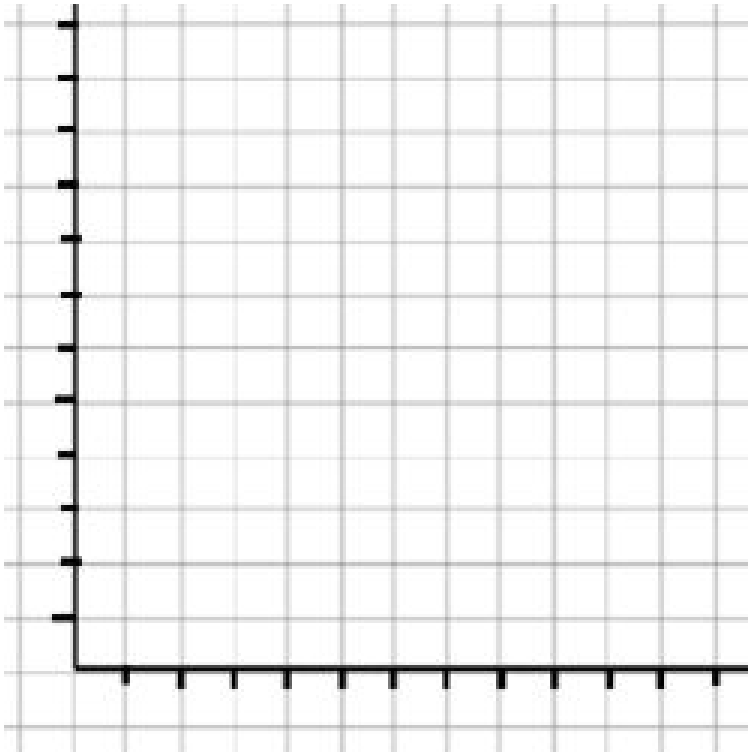
to include the time of your recording.

TIME	DISTANCE
0 minutes	0 cm

Directions: Plot the data on the graph below. Label your axis, scale and units.



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Analysis

1. If you did the experiment again, would you get the same results? Why or why not?

2. Compare your results to groups who measured the different versions of non-Newtonian fluids. Which version had the most viscosity? Support your answer with evidence.

3. Which version had the least viscosity? Support your answer with evidence.

4. In your own words, describe what a non-Newtonian fluid is. Include an example of a non-Newtonian fluid, and where you might find an example of one.

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Procedures for Silly Putty

Non-Newtonian Fluid Version A: Glue and Borax

1. Fill the cup half-way with glue.
2. Add one drop of food coloring to the glue and stir well with the craft stick.
3. Add one dropper full of sodium tetraborate (Borax solution) into the glue and stir. Notice what happens to the glue and Borax solution.
4. Continue adding a dropper full of sodium tetraborate (Borax solution) at a time and stirring well after each addition until the glue solution takes on a silly-putty texture (this should take 3-6 times). You will need to really stir it for about 2 minutes with the stick.
5. Remove the solid glob and roll it around in your hands to dry it off. It will remain sticky for one or two minutes and then will take on the elastic quality of putty.

Non-Newtonian Fluid Version B: Glue, Water, and Borax

1. Fill the cup ¼ of the way with glue.
2. Add one drop of food coloring to the glue and stir well with the craft stick.
3. Add water until the cup is ½ full. Stir with the craft stick until the glue and water are well combined.
4. Add one dropper full of sodium tetraborate (Borax solution) into the glue and stir. Notice what happens to the glue and Borax solution.
5. Continue adding a dropper full of sodium tetraborate (Borax solution) at a time and stirring well after each addition until the glue solution takes on a silly-putty texture. You will need to really stir it for about 2 minutes with the stick. Be careful not to add too much borax to the solution, or the silly putty will become too stiff. A good rule of thumb is to quit adding the borax solution when there is still a little glue-water mixture left in the bottom of the cup. This way you will not add too much borax.
6. Remove the solid glob and roll it around in your hands to dry it off. It will remain sticky for one or two minutes and then will take on the elastic quality of putty.

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Non-Newtonian Fluid Version C: Water and Corn Starch

1. Fill the cup half-way with water.
2. Add one drop of food coloring to the water and stir well with the craft stick.
3. Add one spoonful of cornstarch into the water and stir. Notice what happens to the water and cornstarch.
4. Continue adding a spoonful of cornstarch at a time and stirring well after each addition until the water solution takes on a gooey fluid-like/silly putty consistency. (You will need to add about twice the amount of cornstarch as water.) Notice what the new consistency of the water solution is like.