KANSAS CORN STEM

Kansas Corn: CornSTARh

This lab is made possible with the support and content contributions of the Kansas Corn Commission.

KANSAS CORN COMMISSION

kscorn.com

Overview

Cornstarch is an essential ingredient found in every household cupboard closely associating with the baking heavy hitters: sugar, flour and baking soda. It comes to us from the corn plant and is primarily used as a thickening agent in our sauces, soups and gravies among its many other uses. It is a starch that contains a lot of sugars linked together; sometimes in a nice straight-ish line and sometimes branched all over the place. These structures give cornstarch some unique properties. One of them is being able to absorb water and thicken things and another is to have a fluid behavior that is quite unexpected. It's these unique properties that we will be exploring in this mini-unit of multiple hands-on labs.

Kansas College and Career Ready Standards

- **HS-PS1-3.** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
- **HS-PS2-6.** Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
- **HS-PS1-5.** Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
- **HS-PS2-3.** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
- **HS-PS3-2.** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
- **HS-PS3-3.** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

Learning Objectives

After completing these activities the student will be able to:

- To observe and discover the unique properties of cornstarch
- To design experiments that determine the viscosity of everyday fluids
- To develop models to better understand how microscopic behavior influences macroscopic properties
- To take unique concepts and properties and apply them to real world applications

Materials

For the Instructor:

- CornSTARch PowerPoint presentation (available at kansascornstem.com)
- Bucket with water to wash hands
- Pitcher(s) of water
- Bucket or container of cornstarch (no label)
- Paper towels
- Trash bags
- Hammer
- Wood block and nails
- Large baking pan, tub or similar container filled with premade Oobleck mixture
- Large baking pan, tub or similar container filled with water or vegetable oil

For Each Student:

- 3-5 ounce paper or plastic cup
- Popsicle stick
- Safety glasses
- Mystery Mixture Student Sheet (pg. S1 and at kansascornstem.com)

Safety Considerations

- Wear appropriate clothing for the weather and outdoors.
- Students should wear safety glasses.
- Any mixture that ends up on clothes can be easily washed away with water.
- Any mixture that ends up on the ground can be rinsed with water or washed away in the rain.
- Be very careful with the hammer when hitting the mixture or the nail into the wood.
- Be sure to throw out mixture at the end of the day. The cornstarch is a great food source for microorganisms.

Viscosity Trails

- Off to the Viscosity Races (pgs. T 7 – T 9 and at kansascornstem.com)
- Graduated Cylinder Viscosity Test (pgs. T 10 – T 12 and at kansascornstem.com)
- Viscosity Cup Test (pgs. T 13 – T 15 and at kansascornstem.com)
- Oobleck Form and Function (pgs. T 16 – T 18 and at kansascornstem.com)

Procedures for Instruction

Length of Time for Preparation:

- 30 minutes for planning lesson, setup and making cornstarch mixture (Oobleck).

Length of Time for Classroom Teaching

- 50 minutes for discovery activity and discussion.

Preparation Procedure

- Print out copies of Mystery Mixture Observation Sheet for each student.
- Make a large batch of Oobleck in a large baking pan or similar container.
  - For every ¾ cup cornstarch add about ¼ cup water
  - Or add about 1/4 to 1/3 the amount of water compared to the amount of cornstarch.
  - Mixture should have the consistency similar to that of school glue.
  - Adjust with more water or cornstarch as necessary to get proper consistency.
  - The popsicle stick should easily move through the mixture when going slow and harden up when the popsicle stick tries to move fast. It will harder when you try to stab the mixture with the popsicle stick.
- Practice hammering a nail through a wooden block placed on top of the Oobleck mixture.
- Fill a bucket or multiple buckets with water. This will be used to have students wash their hands before going back inside the building.
- Fill pitchers with water. Students will use this water to make their mixture.
- Fill a couple containers or small buckets with cornstarch (no labels, it's a mystery!) and a spoon.
- Have plenty of paper towels available and a couple of trash bags.

Background Information

- This is an exploration, discovery activity.
- Background information can be found in the CornSTARch PowerPoint presentation.
- Newtonian Fluid – A fluid that responds linearly to a force. If a force is applied twice as hard, the fluid should move twice as fast. Examples – water, oils, and alcohols.
- Non-Newtonian Fluid – A fluid that responds non-linearly to a force. If a force is applied, the fluid will respond by getting thicker and more solid-like or thinner and more liquid-like.

Procedure for Lab

- Do not tell students the name of the mixture or the name of the mystery powder.
- Give a quick explanation on how to fill out the Observation Sheet.
- Give a quick explanation on how to make the mystery mixture.
- Have students help take the buckets of water, paper towels, trash bags, pitchers of water, the large batch of Oobleck and the hammer, block and nails outside the building.
- Students should wear safety glasses.
- Have students play with the mixture, let them explore and discover.
    - They can stir it slow and then fast.
    - They can pour it in their hands and play with it.
    - They can toss it in the air and catch it, or play "hot potato" with a classmate.
    - They can place it on the ground and hit it with a hammer.
    - Throw it against the wall (with permission!)
    - They can put their hands in the large baking pan mixture and squeeze it and scratch it.
    - They can place the wooden block on top of the mixture in the baking pan and try to hammer nails into the block.
    - Have students compare the properties of the mystery mixture with the properties of water from the buckets or pitchers.
- When finished students can throw away the mixture, cups, paper towels and popsicle sticks into a trash bag.
- Students can rinse off their hands in the wash bucket outside and then wash their hands in the bathroom on the way back to class.
- Have students fill out their Observation Sheets.
- Use the rest of the class time for discussion.

Classroom Discussion (After Activity)

- What properties did this mystery mixture display?
- Were any of these properties surprising? How so?
- What is the mystery powder?
- What applications can this mixture (or mixtures with these properties) be used for?

Teacher Tips

- Cornstarch and the Oobleck mixture are very MESSY. But, it easily washes out of clothes, carpets, etc.
- It is fine for the mixture to fall on the grass or the sidewalk. It washes away easily.
- Feel free for you or your students to come up with different ways to test the properties of this mixture.
- Have students list mixtures or substances that have similar properties to Oobleck.

- Have students brainstorm and list applications for a mixture with these properties.
- Have students compare the properties of Oobleck with other substances such as water, oil, honey, ketchup, etc.
- Have students experiment the perfect ratio of water to cornstarch.

Reflection and Conclusion

- Have students list all of the properties they came up with on a whiteboard at the front of the room.
- Discuss how cornstarch is used in baking.
- Discuss how observation of the world around them is the first step in the scientific process.

Assessments

- Students should have the Observation Sheet filled out with thoughtful and thorough observations.
- Students should be able to explain how the scientific process was used in discovering the properties of Oobleck.
- Students should be able to list many different properties used during observation to describe matter.

Extension Activities

- **Mystifying Mysterious Mixture:** (pg. S1 and at kansascornstem.com)
- **Disco Dancing Oobleck:** Using a speaker box with a subwoofer, certain frequencies will make it dance! (pg. S2 – S3 and at kansascornstem.com)
- **Perfect Oobleck Ratio:** Students will determine the "perfect" ratio of cornstarch to water by experimentation. (pg. S4 – S5 and at kansascornstem.com)
- **Oobleck Inc.:** Students will design and market a product that utilizes the properties of a Non-Newtonian Fluid. (pg. S6 – S7 and at kansascornstem.com)
  - Students can create a working prototype of this product.
  - The marketing presentations can be done in a "Shark Tank" style.
- **Oobleck Egg Drop Challenge:** Have students design a system that uses Oobleck to protect an egg from a drop. (pg. S8 – S10 and at kansascornstem.com)

Teacher Resources

Visit www.kansascornstem.com for videos and resources to assist with this lab.

Any educator electing to perform demonstrations is expected to follow *NSTA Minimum Safety Practices and Regulations for Demonstrations, Experiments, and Workshops*, which are available at http://static.nsta.org/pdfs/MinimumSafetyPracticesAndRegulations.pdf, as well as all school policies and rules and all state and federal laws, regulations, codes and professional standards. Educators are under a duty of care to make laboratories and demonstrations in and out of the classroom as safe as possible. If in doubt, do not perform the demonstrations.

Student Name: _____

Mystifying Mysterious Mixture

Purpose: To explore and identify the properties of a mystery substance.

Directions:

1. Obtain a small paper or plastic cup and popsicle stick provided by your teacher.
2. Put on your safety glasses.
3. Fill your cup about halfway with the white mystery substance.
4. Add about a quarter to a third the amount of water as your mystery substance.
5. Stir to combine until you have a homogenous mixture.
6. Your mixture should have the consistency of paste or school glue.
7. If not, add a little bit more water or mystery substance to your mixture.
8. Play around with it, use your imagination!
    a. Stir it slow and then fast. Pour it in your hands and play with it.
    b. Toss it in the air and catch it, or play "hot potato" with a classmate.
    c. Place it on the ground and hit it with a hammer. Throw it against the wall (with permission!)
    d. Put your hands in the large baking pan mixture and squeeze it and scratch it.
    e. Place a wooden block on top of the mixture in the baking pan and try to hammer nails into it.
    f. Compare the properties of the mixture with the properties of water from the buckets or pitchers.
7. Be sure to list as many properties and observations of this substance as you can.
8. Cleanup:
    a. Place cup, mixture, popsicle sticks, paper towels and any other trash into the trash bag.
    b. Cleanup any other mess. Rinse your hands in the wash bucket.
    c. Wash your hands in the restroom on your way back to class.

List your observations here:

*Describe what you are doing and how the mixture behaves. What makes this substance different or unique? How does it compare to the properties of water? Remember to use your senses (Do not taste or eat this substance).

Student Name: _____

Disco Dancing Oobleck

Purpose: To demonstrate how sound waves can display the properties of a Non-Newtonian fluid.

Materials:

- Speaker system with accessible cone
- Frequency generator app
- Plastic wrap
- Phone or camera with a slow-motion setting
- Oobleck

Directions:

1. Find a speaker system with a decent-sized subwoofer cone – the bigger the cone, the better!
2. Using plastic wrap, tightly and fully wrap the subwoofer box to protect it.
3. Get another piece of plastic wrap and place it over the cone of the subwoofer.
    a. Fill the plastic wrap above the cone with Oobleck. The mixture should settle inside the cone.
2. Feel free to color your Oobleck with food coloring. Color the water before mixing with cornstarch.
3. Hook up your subwoofer to a device that has a frequency generator.
    a. Frequency generators can be downloaded for free from any app store or played through a web browser.
2. Set the frequency to the lowest setting anywhere between 20 and 40 Hz.
3. Set the subwoofer power to its highest setting.
4. Slowly turn up the volume of your speaker system in small increments and observe the behavior of the Oobleck.
5. Adjust the volume and the frequency of your system to get the dance party going!
    a. See which settings give you the best show.
2. Have students record the demonstration using their phones or cameras.
    a. a. Have them set the video to the slow-motion setting for the best experience.
2. Cleanup: Oobleck can be wrapped up in the plastic wrap and throw it away.

Observations: Describe what you witnessed here:

What frequency (or range) best demonstrated Oobleck's Non-Newtonian properties? _____ Hz

Summary: Use the internet to explain how sound waves are able to "activate" Oobleck's Non-Newtonian Properties.

Student Name: _____

Perfect Oobleck Ratio

Purpose: To determine the "perfect" ratio that maximizes Oobleck's Non-Newtonian properties.

Directions:

1. Design an experiment that will determine the "perfect" ratio of cornstarch to water.
   a. How will you test it? What are the "perfect" properties are you looking for?
   b. Record these below.
3. Obtain a small paper or plastic cup and popsicle stick provided by your teacher.
4. Put on your safety glasses.
5. Mass the starting amount of your cornstarch. Record that in your data table.
6. Measure the volume of your water. Record that in your data table.
7. Combine your cornstarch and water into a container provided by your teacher.
8. Stir your mixture until it is homogenous.
9. Perform your test(s) to determine if it meets your "perfect" properties criteria.
10. If not, add more cornstarch or more water. Be sure to get its mass and/or volume. Record these.
11. When you determine your "perfect"ratio, add up the masses of your cornstarch and the volumes of your water.
12. Divide the total mass of cornstarch by the total volume of water to get the mass:volume of cornstarch:water.
13. Cleanup:
    a. Properly dispose of your materials according to your teachers guidelines.
    b. Wash any glassware and utensils. Clean your station.

Describe what your "perfect" Oobleck mixture would look like – it's properties, behavior, etc.

Write out your test procedure for determining your "perfect" Oobleck ratio:

Perfect Oobleck Ratio

Additions / Substance	Start	1	2	3	4	5	6	Total
Cornstarch (g)								
Water (mL)								

Ratio of Cornstarch to Water. Divide total mass of Cornstarch by the total volume of Water (Show your Work)

Cornstarch:Water

:

Student Name: _____

Oobleck Inc.: Real World Applications for a Non-Newtonian Fluid

Purpose: To come up with as many real world applications for a Non-Newtonian Fluid. Choose the best idea. Create a product and marketing campaign to present to the class.

Individual (15 minutes): List as many ideas/uses for Non-Newtonian products as you can

Partners/Groups (15 minutes): Discuss each individual's product idea. Choose the top two that interest you as a group.

1.

2.

Design (20 minutes): Sketch out a picture of each product. List the materials, its properties, its function and its name.

Oobleck Inc.

Market (1 – 2 class periods): Create a unique marketing campaign in order to pitch one of your products to the class. If it is possible, create a working prototype of your product. If not, make a model or design it using a software program. Outline your marketing ideas/methods/procedures here. Get approval and feedback from your teacher.

Student Name: _____

Oobleck Egg Drop Challenge

Purpose: To design a safety system that utilizes the properties of Oobleck to protect an egg from cracking when dropped from increasing heights.

Materials:

- Oobleck
- An area that allows incremental increases in height
- An egg for each group
- Plastic sheeting or trash bags cut open as a substitute
- Materials that students can use to design a safety cage – provided by the teacher and/or from the students' home

Directions:

1. Take time to brainstorm ideas for an egg drop safety system using Oobleck.
    a. The design should fall within parameters and guidelines set by your instructor as well as incorporate approved materials.
    b. Your instructor will show you the area where the drop test will take place and the possible heights.
3. Choose your best idea and sketch out the design you wish to use. Be sure to list all materials.
4. Get approval of your design from your instructor.
5. Build your Egg Drop Safety System within the time frame given by your instructor.
6. Your egg will be contained within your Egg Drop Safety System and will be dropped from incrementally increasing heights until your egg either breaks or you reach maximum height.
7. Good Luck and if possible, record each drop!

Date of Egg Drop Test: _____

Brainstorming Ideas/Sketches

Final Design – Include sketch, labeled parts and materials: Explanation of how your design will work:

Explanation of how your design will work:

Approval: Teacher Initials: _____ Date: _____

Height	Pass/Fail	Observations
Summary – What worked, what didn't, what would you do next time to improve?		

Off to the Viscosity Races – Place Your Bets!

For the Instructor:

- CornSTARch PowerPoint presentation
- Off to the Viscosity Races Student Handout (pg. S11 – S13 or at kansascornstem.com)

Possible Household Liquids:

- Oobleck
- Soaps
- Vegetable Oils
- Syrups
- Creamers
- Ketchup
- Sauces
- Honey
- Lotions
- Shampoos
- Detergents
- Rubbing alcohol
- Water

For Each Group:

- Small cups (1 – 2 ounces) of equal size for liquids
- 1 long, shallow pan, wood board, foam board or something similar – like a cookie sheet
- 1 deeper pan – to catch liquids – plastic wrap or paper towels could work too
- Sheet of paper to cover shallow pan – or butcher paper
- Ruler, Tape and Plastic wrap
- Stop watch or other timer
- Phone or camera to record trials

Safety Considerations

- Students should wear safety glasses.
- Any spilled liquids should be cleaned up immediately.
- Students should not ingest any of the liquids.

Procedures for Instruction

Length of Time for Preparation:

- 30 minutes for planning lesson, setup and making cornstarch mixture (Oobleck).

Length of Time for Classroom Teaching

- 50 minutes for lab and cleanup.

Preparation Procedure (Teacher Setup)

- Make a large batch of Oobleck.
  - For every ¾ cup cornstarch add about ¼ cup water
  - Or add about 1/4 to 1/3 the amount of water compared to the amount of cornstarch.
  - Mixture should have the consistency similar to that of school glue.
  - Adjust with more water or cornstarch as necessary to get proper consistency.
  - The popsicle stick should easily move through the mixture when going slow and harden up when the popsicle stick tries to move fast. It will harder when you try to stab the mixture with the popsicle stick.
- Have enough honey or corn syrup to provide a warm, room temperature and cold sample to each group.
  - Warm the honey or corn syrup on a hot plate – enough to make it less viscous
  - Cool another batch of honey or corn syrup in an ice bath – enough to make it more viscous

Background Information

- Background information can be found in the CornSTARch PowerPoint presentation.
- **Viscosity** – the thickness of a fluid. The internal friction between the molecules within a fluid that allow it to resist a force.
  - Higher viscosity = thicker fluid
  - Lower viscosity = thinner fluid
- **Flow Rate** – The rate at which molecules within a fluid are able to move past one another. The faster the fluid moves, the faster its flow rate.
  - Slower flow rate = higher viscosity = thicker fluid
  - Faster flow rate = lower viscosity = thinner fluid
- **Cohesive Force (Cohesion)** – The attraction of similar molecules to each other.
  - Stronger cohesive forces = slower flow rate = higher viscosity = thicker fluid
  - Weaker cohesive forces = faster flow rate = lower viscosity = thinner fluid

Classroom Discussion (After Activity)

- How are viscosity, thickness, flow rate and cohesive forces related to each other?
- What physical properties do you usually see in a liquid that has a high viscosity?
- What happens to the distance between molecules of a substance when they are heated and when they are cooled?
- Which substance has the weakest cohesive forces? A solid, liquid or a gas?

Teacher Tips

- Cornstarch and the Oobleck mixture are very MESSY. But, it easily washes out of clothes, carpets, etc.
- Have kids bring products from home that they would enjoy determining the flow rate.
- Corn syrup is a lot cheaper than honey. I would recommend using that for the warm/cold extension.
- The corn syrup/honey does not have to be too hot or too cod, just enough to see a difference.
- If students record video of their trials, they can go back and get a more accurate time.

Reflection and Conclusion

- Have students write the definitions of viscosity, flow rate, thickness and cohesive forces and show how they are related to each other.
- Have students research and explore practical applications for more viscous fluids as well as less viscous fluids. Where are they found? What are they used for?

Assessments

- Students should have the Data Tables and Lab Analysis sections of the Off to the Viscosity Races – Place Your Bets! lab sheet filled out.

Student Name: _____

Off to the Viscosity Races – Place Your Bets!

Purpose: To determine the flow rate of Oobleck compared to other household items and relate their flow rates to viscosity, thickness and cohesive forces.

Materials

Possible Household Liquids:

- Oobleck
- Soaps
- Vegetable Oils
- Syrups
- Creamers
- Ketchup
- Sauces
- Honey
- Lotions
- Shampoos
- Detergents
- Rubbing alcohol
- Water

For Each Group:

- Small cups (1 – 2 ounces) of equal size for liquids
- 1 long, shallow pan, wood board, foam board or something similar – like a cookie sheet
- 1 deeper pan – to catch liquids – plastic wrap or paper towels could work too
- Sheet of paper to cover shallow pan – or butcher paper
- Ruler, Tape, Plastic wrap
- Stop watch or other timer
- Phone or camera to record trials

Procedure

- On the sheet of paper or butcher paper, draw a horizontal line 2.5 centimeters from the top – the starting line.
- On the same sheet of paper, draw a horizontal line three quarters of the way down – the finishing line.
- Measure the distance from the starting line to the finishing line in centimeters.
- Tape the paper to the back of the shallow pan, board or foam board.
- Cover the paper with plastic wrap and tape that down as well.

Off to the Viscosity Races

- Fill each small cup with the same amount of liquid as the other fluids.
- You are now ready to pour each liquid down the pan and time how long it takes to cross the finish line.
- Have a student ready with their phone or camera to film each trial.
- Pour each liquid onto/from the top starting line. Start your timer!
- Stop your timer as soon as the liquid first crosses the bottom finish line.
- Determine your flow rate by dividing your distance traveled in centimeters by the time it took in seconds.
- Record your flow rate in the table below.
  - Rank in order the liquids from the fastest time (weaker cohesive forces = faster flow rate = lower viscosity = thinner fluid) to the slowest time (stronger cohesive forces = slower flow rate = higher viscosity = thicker fluid).
- Extension:
  - Obtain equal amounts of warm, room temperature and cold samples of either honey or corn syrup.
  - Repeat the procedure above and obtain the flow rate of each sample – try all three at the same time!
  - Record your results in the table below.

Data:

Distance from the top starting line to the bottom finish line: _____ cm

Liquid	Flow Rate (cm/s)		Liquid (Top = Faster Flow Rate)	Flow Rate (cm/s)

Off to the Viscosity Races

Honey or Corn Syrup	Flow Rate (cm/s)	Rank (1 = Faster Flow Rate)
Cold		
Room Temperature		
Warm		

Lab Analysis

Scenario: Liquid 1 had a flow rate of 0.76 cm/s and Liquid 2 had a flow rate of 1.12 cm/s

1. Which liquid has a higher viscosity? Liquid _____
2. Which liquid has weaker cohesive forces? Liquid _____
3. Which Liquid has a faster flow rate? Liquid _____

Explain why you would see a faster flow rate (a lower viscosity) when a liquid is heated compared to when it is cooled.

Graduated Cylinder Viscosity Test

For the Instructor:

- CornSTARch PowerPoint presentation (available at kansascornstem.com)
- Graduated Cylinder Viscosity Test (pg. S 1 – S 16 and at kansascornstem.com)

Possible Household Liquids (50 – 70 mL each):

- Oobleck
- Soaps
- Vegetable Oils
- Syrups
- Creamers
- Ketchup
- Sauces
- Honey
- Lotions
- Shampoos
- Detergents
- Rubbing alcohol
- Water

For Each Group:

- 4 – 5 50 mL or 100 mL graduated cylinders (must have the same volume graduated cylinders)
- 4 – 5 marbles
- 4 – 5 collection cups or beakers to collect marbles after test
- Stop watch or other timer
- Phone or camera to record trials

Safety Considerations

- Students should wear safety glasses.
- Any spilled liquids should be cleaned up immediately.
- Students should not ingest any of the liquids.

Procedures for Instruction

Length of Time for Preparation:

- 15 minutes for planning lesson, setup and making cornstarch mixture (Oobleck).

Length of Time for Classroom Teaching

- 50 minutes for lab and cleanup.

Graduated Cylinder Viscosity Test

Preparation Procedure (Teacher Setup)

- Make a large batch of Oobleck.
  - For every ¾ cup cornstarch add about ¼ cup water
  - Or add about 1/4 to 1/3 the amount of water compared to the amount of cornstarch.
  - Mixture should have the consistency similar to that of school glue.
  - Adjust with more water or cornstarch as necessary to get proper consistency.
  - The popsicle stick should easily move through the mixture when going slow and harden up when the popsicle stick tries to move fast. It will harder when you try to stab the mixture with the popsicle stick.
- Have enough honey or corn syrup to provide a warm, room temperature and cold sample to each group.
  - Warm the honey or corn syrup on a hot plate – enough to make it less viscous
  - Cool another batch of honey or corn syrup in an ice bath – enough to make it more viscous

Background Information

- Background information can be found in the CornSTARch PowerPoint presentation.
- **Viscosity** – the thickness of a fluid. The internal friction between the molecules within a fluid that allow it to resist a force.
  - Higher viscosity = thicker fluid
  - Lower viscosity = thinner fluid
- **Flow Rate** – The rate at which molecules within a fluid are able to move past one another. The faster the fluid moves, the faster its flow rate.
  - Slower flow rate = higher viscosity = thicker fluid
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- **Cohesive Force (Cohesion)** – The attraction of similar molecules to each other.
  - Stronger cohesive forces = slower flow rate = higher viscosity = thicker fluid
  - Weaker cohesive forces = faster flow rate = lower viscosity = thinner fluid

Classroom Discussion (After Activity)

- How are viscosity, thickness, flow rate and cohesive forces related to each other?
- What physical properties do you usually see in a liquid that has a high viscosity?
- What happens to the distance between molecules of a substance when they are heated and when they are cooled?
- Which substance has the weakest cohesive forces? A solid, liquid or a gas?

Kansas Corn: CornSTARch
Grade Level: Middle and High School

Teacher Tips

- Cornstarch and the Oobleck mixture are very MESSY. But, it easily washes out of clothes, carpets, etc.
- Have kids bring products from home that they would enjoy determining the flow rate.
- Corn syrup is a lot cheaper than honey. I would recommend using that for the warm/cold extension.
- The corn syrup/honey does not have to be too hot or too cold, just enough to see a difference.
- If students record video of their trials, they can go back and get a more accurate time.

Reflection and Conclusion

- Have students write the definitions of viscosity, flow rate, thickness and cohesive forces and show how they are related to each other.
- Have students research and explore practical applications for more viscous fluids as well as less viscous fluids. Where are they found? What are they used for?

Assessments

- Students should have the Data Tables and Lab Analysis sections of the Graduated Cylinder Viscosity Test lab sheet filled out.

Student Name: _____

Graduated Cylinder Viscosity Test

Purpose: To determine the flow rate of Oobleck compared to other household items and relate their flow rates to viscosity, thickness and cohesive forces.

Materials

Possible Household Liquids:

- Oobleck
- Soaps
- Vegetable Oils
- Syrups
- Creamers
- Ketchup
- Sauces
- Honey
- Lotions
- Shampoos
- Detergents
- Rubbing alcohol
- Water

For Each Group:

- 4 – 5 25 mL, 50 mL or 100 mL graduated cylinders (must have the same volume graduated cylinders)
- 4 – 5 marbles
- 4 – 5 collection cups or beakers to collect marbles after test
- Stop watch or other timer
- Phone or camera to record trials

Procedure

- Fill each graduated cylinder 25 mL, 50 or 75 mL (depending on size) with a different liquid to be tested.
  - Even though it is different liquids, the volume must remain the same.
- Hold marble just above the top of the graduated cylinder.
- Have a student ready with their phone or camera to film each trial.
- Let the marble drop and measure the amount of time it takes for it to reach the bottom of the graduated cylinder after contacting the top of the liquid.
- Determine your Flow Rate by dividing the volume traveled in milliliters (the volume of your liquid) by the time it took in seconds for the marble to reach the bottom.
- Enter the name of the liquid and its flow rate in the table below.
- Use a stirring rod/stick to fish out the marble or pour the liquid and the marble into a collection cup or beaker to retrieve the marble.
- Rinse off the marble and thoroughly dry it.

Graduated Cylinder Viscosity Test

- After all have been tested, rank the liquids in order from the fastest time (weaker cohesive forces = faster flow rate = lower viscosity = thinner fluid) to the slowest time (stronger cohesive forces = slower flow rate = higher viscosity = thicker fluid).
- Extension:
  - Obtain equal amounts of warm, room temperature and cold samples of either honey or corn syrup.
  - Repeat the procedure above and obtain the time for each sample – try all three at the same time!
  - Record your results in the table below.

Data:

Volume of liquid in graduated cylinders: _____ mL

Liquid	Flow Rate (cm/s)		Liquid (Top = Faster Flow Rate)	Flow Rate (cm/s)

Graduated Cylinder Viscosity Test

Honey or Corn Syrup	Flow Rate (cm/s)	Rank (1 = Faster Flow Rate)
Cold		
Room Temperature		
Warm		

Lab Analysis

Scenario: Liquid 1 had a flow rate of 0.67 s and Liquid 2 had a flow rate of 0.21 s

1. Which liquid has a higher viscosity? Liquid _____
2. Which liquid has weaker cohesive forces? Liquid _____
3. Which Liquid has a faster flow rate? Liquid _____

Explain why you would see a faster flow rate (a lower viscosity) when a liquid is heated compared to when it is cooled.

Viscosity Cup Test

For the Instructor:

- CornSTARch PowerPoint presentation (available at kansascornstem.com)
- Viscosity Cup Test (pgs. S 17 – S 19 and at kansascornstem.com)

Possible Household Liquids (50 – 70 mL each):

- Oobleck
- Soaps
- Vegetable Oils
- Syrups
- Creamers
- Ketchup
- Sauces
- Honey
- Lotions
- Shampoos
- Detergents
- Rubbing alcohol
- Water

For Each Group:

- 4 – 5 3-ounce plastic mouthwash cups
- 1 common nail
- 4 – 5 collection cups or beakers to collect running liquid
- Stop watch or other timer
- Phone or camera to record trials

Safety Considerations

- Students should wear safety glasses.
- Any spilled liquids should be cleaned up immediately.
- Students should not ingest any of the liquids.

Procedures for Instruction

Length of Time for Preparation:

- 15 minutes for planning lesson, setup and making cornstarch mixture (Oobleck).

Length of Time for Classroom Teaching

- 50 minutes for lab and cleanup.

Preparation Procedure (Teacher Setup)

- Make a large batch of Oobleck.

    - For every ¾ cup cornstarch add about ¼ cup water
    - Or add about 1/4 to 1/3 the amount of water compared to the amount of cornstarch.
    - Mixture should have the consistency similar to that of school glue.
    - Adjust with more water or cornstarch as necessary to get proper consistency.
    - The popsicle stick should easily move through the mixture when going slow and harden up when the popsicle stick tries to move fast. It will harder when you try to stab the mixture with the popsicle stick.
- Have enough honey or corn syrup to provide a warm, room temperature and cold sample to each group.
    - Warm the honey or corn syrup on a hot plate – enough to make it less viscous
    - Cool another batch of honey or corn syrup in an ice bath – enough to make it more viscous

Background Information

- Background information can be found in the CornSTARch PowerPoint presentation.
- **Viscosity** – the thickness of a fluid. The internal friction between the molecules within a fluid that allow it to resist a force.
    - Higher viscosity = thicker fluid
    - Lower viscosity = thinner fluid
- **Flow Rate** – The rate at which molecules within a fluid are able to move past one another. The faster the fluid moves, the faster its flow rate.
    - Slower flow rate = higher viscosity = thicker fluid
    - Faster flow rate = lower viscosity = thinner fluid
- **Cohesive Force (Cohesion)** – The attraction of similar molecules to each other.
    - Stronger cohesive forces = slower flow rate = higher viscosity = thicker fluid
    - Weaker cohesive forces = faster flow rate = lower viscosity = thinner fluid

Classroom Discussion (After Activity)

- How are viscosity, thickness, flow rate and cohesive forces related to each other?
- What physical properties do you usually see in a liquid that has a high viscosity?
- What happens to the distance between molecules of a substance when they are heated and when they are cooled?
- Which substance has the weakest cohesive forces? A solid, liquid or a gas?

Teacher Tips

- Cornstarch and the Oobleck mixture are very MESSY. But, it easily washes out of clothes, carpets, etc.
- Have kids bring products from home that they would enjoy determining the flow rate.
- Corn syrup is a lot cheaper than honey. I would recommend using that for the warm/cold extension.

- The corn syrup/honey does not have to be too hot or too cold, just enough to see a difference.
- If students record video of their trials, they can go back and get a more accurate time.

Reflection and Conclusion

- Have students write the definitions of viscosity, flow rate, thickness and cohesive forces and show how they are related to each other.
- Have students research and explore practical applications for more viscous fluids as well as less viscous fluids. Where are they found? What are they used for?

Assessments

Students should have the Data Tables and Lab Analysis sections of the Viscosity Cup Test lab sheet filled out.

Student Name: _____

Viscosity Cup Test

Purpose: To determine the flow rate of Oobleck compared to other household items and relate their flow rates to viscosity, thickness and cohesive forces.

Materials

Possible Household Liquids:

- Oobleck
- Soaps
- Vegetable Oils
- Syrups
- Creamers
- Ketchup
- Sauces
- Honey
- Lotions
- Shampoos
- Detergents
- Rubbing alcohol
- Water

For Each Group:

- 4 – 5 3-ounce plastic mouthwash cups
- 1 common nail
- 1 sharpie marker
- 4 – 5 collection cups or beakers to collect running liquid
- 50 mL graduated cylinder
- Stop watch or other timer
- Phone or camera to record trials

Procedure

- Measure 50 mL of water using a graduated cylinder.
- Pour the 50 mL into each of the 4 – 5 3-ounce mouthwash cups.
- Use the sharpie to mark the 50 mL level on each cup.
- Empty each cup.
- Use the nail to poke a hole in the bottom center of the cup.
- Use a finger to cover the outside of the hole to prevent leaking of the test liquids.
- Fill a cup with a test liquid to the 50 mL fill line.
- Hold the test cup over a collection cup.
- Have a classmate ready to start the timer.
- When ready, release your finger from the hole and begin the timer.
- Stop the timer when all liquid has drained (though some residual will be left for thicker liquids).

- Determine your Flow Rate by dividing the volume in milliliters (50 mL) by the time it took in seconds for the liquid to flow from the cup.
- Enter the name of the liquid and its flow rate in the table below.
- After all have been tested, rank the liquids in order from the fastest time (weaker cohesive forces = faster flow rate = lower viscosity = thinner fluid) to the slowest time (stronger cohesive forces = slower flow rate = higher viscosity = thicker fluid).
- Extension:
  - Obtain equal amounts of warm, room temperature and cold samples of either honey or corn syrup.
  - Repeat the procedure above and obtain the time for each sample – try all three at the same time!
  - Record your results in the table below.

Data:

Volume of liquid in cups: _____ mL

Liquid	Flow Rate (cm/s)		Liquid (Top = Faster Flow Rate)	Flow Rate (cm/s)

Honey or Corn Syrup	Flow Rate (cm/s)	Rank (1 = Faster Flow Rate)
Cold		
Room Temperature		
Warm		

Lab Analysis

Scenario: Liquid 1 had a flow rate of 3.21 s and Liquid 2 had a flow rate of 1.21 s

1. Which liquid has a higher viscosity? Liquid _____
2. Which liquid has weaker cohesive forces? Liquid _____
3. Which Liquid has a faster flow rate? Liquid _____

Explain why you would see a faster flow rate (a lower viscosity) when a liquid is heated compared to when it is cooled.

Oobleck Form and Function

Materials

For the Instructor:

- CornSTARch PowerPoint presentation (available at kansascornstem.com)
- Oobleck Form and Function Student Handout (pgs. S 20 – S 22 and at kansascornstem.com)
- Oobleck Observation Explanation Comic Activity (pg. S 23 and at kansascornstem.com)

For Each Group:

- Small container or 100-mL beaker
- Cornstarch
- Ketchup
- Water
- Sprinkles or Perler (waxy iron) Beads
- Golf balls
- Camera or phone – one with slow-motion setting if possible
- Spoons, popsicle sticks, toothpicks and/or wooden skewers
- Plastic wrap

Safety Considerations

- Students should wear safety glasses.
- Any spilled liquids should be cleaned up immediately.
- Students should not ingest any of the liquids.
- Use plastic wrap to keep the table and surrounding area clean.

Procedures for Instruction

Length of Time for Preparation:

- 15 minutes for planning lesson and setup

Length of Time for Classroom Teaching

- 50 minutes for lab and cleanup.

Preparation Procedure (Teacher Setup)

- Make a large batch of Oobleck.
  - For every ¾ cup cornstarch add about ¼ cup water

- Or add about 1/4 to 1/3 the amount of water compared to the amount of cornstarch.
- Mixture should have the consistency similar to that of school glue.
- Adjust with more water or cornstarch as necessary to get proper consistency.
- The popsicle stick should easily move through the mixture when going slow and hc arden up when the popsicle stick tries to move fast. It will harder when you try to stab the mixture with the popsicle stick.

Background Information

Background information can be found in the CornSTARch PowerPoint presentation.

- **Homogenous Mixture** – a combination of two or more substances in which those components are evenly distributed and have a uniform appearance.
- **Heterogeneous Mixture** – a combination of substances that do not have an even distribution and the different components can easily be seen.
- **Newtonian Fluid** – A fluid that responds linearly to a force. If a force is applied twice as hard, the fluid should move twice as fast. Examples – water, oils, and alcohols.
- **Non-Newtonian Fluid** – A fluid that responds non-linearly to a force. If a force is applied, the fluid will respond by getting thicker and more solid-like or thinner and more liquid-like.
- **Starch** – a macromolecule made from a long chain of sugar molecules. It can be a linear chain (amylose) or branched (amylopectin).
- **Thixotropic** – When a viscous fluid becomes thinner (less viscous) over a period of time or due to an outside force or agitation.
- **Dilatant (pseudoplastic)** – The viscosity of a fluid increases when a force is applied.
- **Hydrocluster** – When water between starch molecules gets squeezed out causing a lattice structure that has the properties of a solid.

Classroom Discussion (After Activity)

- What would be the best way to pour ketchup out of a glass bottle?
- If you want to make gelatin or gravy, what type of Non-Newtonian or Newtonian substance would you want to use?
- Name 5 Homogeneous Mixtures and 5 Heterogeneous Mixtures found in everyday life.

Teacher Tips

- The amount of sprinkles or beads needed in the Oobleck is kind of an art form. You can always add a bit more until you find a good model.
- The golf ball drop is going to be very messy. This one would best be done outside.
- Using skinny stirrers like popsicle sticks or thin wooden skewers seem to work better to see the behavior of the sprinkle particles.

Reflection and Conclusion

- What are other ways we can model or simulate how Oobleck behaves like a Non-Newtonian fluid?
- What other substances would have been good to use as a comparison to Oobleck, Water and Ketchup?

Assessments

- The terms for this unit would be good to attach to any unit when playing Kahoot! or Quizizz.
- Have students complete the Oobleck Observation Explanation Comic Activity for a visual summary.

Student Name: _____

Oobleck Form and Function

Purpose: To observe and simulate the structure and properties of Oobleck. To observe and compare the differences in properties between a Newtonian and Non-Newtonian fluid.

Materials

Part 1 - For Each Pair:

- Small container or 100-mL beaker
- Cornstarch and Water
- Sprinkles or Perler (waxy iron) Beads
- Camera or phone – one with a slow-motion setting if possible
- Spoons, popsicle sticks, toothpicks and/or wooden skewers

Part 2 - For Each Group:

- 3 - Plastic containers around the size of a cereal bowl
- Cornstarch and Water (Oobleck)
- Ketchup
- Water
- Golf balls
- Plastic wrap and/or Newspaper
- Camera or phone – one with a slow-motion setting
- A chair, stool or ladder that is tall and safe to stand on

Procedure

Part 1:

- Each pair of students will create a small batch of Oobleck with sprinkles:
  - Fill 3/4ths of the given container with cornstarch.
  - Add plenty of sprinkles (or beads) to the cornstarch powder – be generous.
    - The sprinkles will simulate the starch molecules of the cornstarch.
  - Add about 1/4 to 1/3rd the amount of water compared to the amount of cornstarch.
  - The mixture should have the consistency similar to that of school glue.
  - Adjust with more water or cornstarch as necessary to get proper consistency.
  - Your stirrer should easily move through the mixture when going slow and harden when the stirrer tries to move quickly through it. The mixture will act like a solid when you try to poke and stab it with the stirrer.

Oobleck Form and Function

- For the following procedures, be sure to take as much video as possible in order to go back, zoom in, slow down, etc. if needed.
  - Alternate between normal video speed and slow-motion capture.
- Really focus on the behavior of the sprinkles and how they move throughout the Oobleck mixture.
- Remember that sprinkles are simulating the starch molecules from corn.
- Gently, slowly move the stirrer around the mixture. Record your observations below.
- Then quickly pull upwards to force the Oobleck to solidify around the stirrer. Hold onto your container!
  - Pulling upwards instead of punching downwards allows us to bring that inside portion of the mixture outward for observation.
- Again, record your observations.
- Keep switching slow movements and fast movements, even scratch across its surface – observing the flow of the sprinkles; the clustering of the sprinkles; the moisture content at the spot of contact – the solid state versus the surrounding liquid mixture.
- Record as many observations as possible.

Part 2:

- Warning – this part is messy
- Each group will make a fresh batch of Oobleck that can fill the cereal bowl container ¾ full.
- Fill the other two cereal bowl containers ¾ full with Ketchup in one and Water in the other.
- Pick an open spot in the lab (or better yet, outside). Lay down newspaper and/or plastic wrap.
- Place a bowl with one of the three substances in the middle of the newspaper/plastic wrap.
- Have a camera or a cellphone record up close, the bowl with each substance.
- Gently, carefully set a golf ball on top of each substance. Watch and record each one's behavior below.
  - Let each golf ball set in the substance for at least 1.5 minutes
- Then set a chair next to a bowl containing one of the substances.
  - This is where you will stand to drop each golf ball.
- Hold and drop each golf ball from the same height onto the substance in the bowl – this is MESSY!
- Be sure to have the camera or cellphone in slow-motion mode and have it pointed at the bowl.
  - You want to capture how each substance behaves and spreads out on impact with the ball.
- Record your observations below.

Observations:

In your writing, include the proper terminology learned in this unit: Force, Newtonian, Non-Newtonian, Thixotropic, Dilatant, Heterogeneous, Homogeneous, Hydrocluster, Starch, etc.

Oobleck Form and Function

Part 1:

What is observed when you slowly move your stirrer through the sprinkled Oobleck? (Be specific, include details)

What is observed when you quickly pull your stirrer upwards? (Be specific, include details)

Using the proper keywords, describe Oobleck's properties:

Part 2:

Using the proper terminology from above, describe the characteristics of each substance (Ketchup, Oobleck and Water) when a force (a falling golf ball) is applied to them. Be sure to include your observations from the lab.

Describe how Oobleck gets its properties by generating hydroclusters.

Questions

Use Oobleck, Water and Ketchup as your answers, some can be used more than once, some not at all.

Which substance(s) are Newtonian? _____ _____ _____

Which substance(s) are Non-Newtonian? _____ _____ _____

Which substance(s) are Thixotropic? _____ _____ _____

Which substance(s) are Pseudoplastic? _____ _____ _____

Which substance(s) are Non-Newtonian? _____ _____ _____

Which substance(s) are a Homogeneous Mixture? _____ _____ _____

Which substance(s) are a Heterogeneous Mixture? _____ _____ _____

Student Name: _____

Oobleck Observation Explanation Comic Activity

Purpose: To visually summarize how Oobleck works as a Non-Newtonian fluid at the molecular scale.

Keyterms: Force, Newtonian, Non-Newtonian, Thixotropic, Dilatant, Heterogeneous, Homogeneous, Hydrocluster, Starch

Directions:

1. Use the panes below to **draw or sketch** you own Oobleck comic strip
2. Show **how Oobleck behaves as a Non-Newtonian fluid** at both the **macroscopic and microscopic scales.**
3. Be sure to incorporate the keyterms from above and remember that **comics are a form of visual storytelling.**

Science and Agriculture Careers

- Certified appraiser
- Crop adjuster
- Data processor
- Extension agent
- Grain buyer
- Geospatial analytics specialist
- Precision agriculture specialist
- Biosecurity manager
- Climate change analyst
- Ecologist
- Environmental engineer
- Environmental scientist
- Nematologist
- Nutrient manager
- Pest control advisor
- Produce inspector
- Irrigation specialist
- Aerial applicator
- Agronomist
- Crop advisor
- Crop scout
- Crop systems specialist
- Entomologist
- Horticulturist
- Microbiologist
- Plant biologist
- Plant breeder
- Plant geneticist
- Plant pathologist
- Field agronomist
- Row crop producer
- Soil scientist
- Weed scientist
- Seed production agronomist

Resources

- Cornstarch Lab Resources Playlist: https://youtube.com/