Smart Glove

MATERIALS

For the activity (per pair or team)

- 1 wide-mouth, clear plastic container, at least 3 inches deep (e.g., cylindrical cover from a small stack of CDs or DVDs, or a food storage container)
- 1 plastic cup
- 1 box cornstarch
- water
- 1 spoon, to stir
- 1 marble
- newspaper (to cover surfaces)
- paper towels
- activity sheet

For the group

- 2 wide-mouth, tall, clear plastic containers, at least 6 inches deep (e.g., cylindrical cover from a large stack of CDs or DVDs, or a food storage container)
- 1 box cornstarch
- water
- 1 marble
- 2 quart-sized ziptop freezer bags
- tape (masking, duct, or electrical)
- video clip available at pbs.org/nova/education/makingstuff
- video display equipment

Note: This activity can be messy, but the material (cornstarch and water) will dry, flake, and can be vacuumed up. It can also be washed off of clothes, hair, and skin.

Time: Prep:15 minutes; Activity: 45 minutes

Activity Description

Kids mix up a batch of a smart material and explore its unusual properties using a glove for a truly hands-on experience.

Learning Goal

To learn that materials vary in how they respond to forces and that some *smart materials* respond in unusual ways that materials scientists are using to design new products and materials.

Introduction

Materials respond to forces or changes in their environment. Most fluids follow Newton's Law of Viscosity. Viscosity is a property of a fluid that describes its resistance to flow. For example, syrup and molasses resist flowing; they have high viscosity. Simply stated, Newton's Law says that the harder or faster a fluid, like water, is pushed, the faster it flows. But some fluids do not follow Newton's Law—they are called *non-Newtonian fluids*.

This activity investigates a non-Newtonian fluid that is also a smart material—a mixture of cornstarch and water, often called oobleck. When a force is rapidly applied to oobleck, not only does it not flow faster—it suddenly turns solid! Its viscosity (resistance to flow) increases. Some other non-Newtonian fluids are latex paint, honey, mayonnaise, and ketchup. When sitting still, these fluids exhibit high viscosity (they resist flowing), but once they are moving, they flow easily. That's why a knife is sometimes needed to get the ketchup moving before it will flow out of the bottle. Latex paint is designed to thin out and flow as it is brushed onto a surface, but to resist flowing once in place, so there are fewer drips down the wall.

Advance Preparation

- Gather the materials.
- Spread newspaper on any surfaces you want to keep clean.
- Set up the introductory demonstration. Fill one tall container with about 4 inches of water and another with 4 inches of cornstarch.
- Build the "glove." Make a small batch of oobleck: mix 2 cups of cornstarch with 1 cup of water. Pour into a quart-sized resealable ziptop freezer bag. Turn another freezer bag inside out and insert into the first bag over the oobleck. Line up the opposite zipper seals on the two bags so they will seal. Zip the bags together and cover the seal with tape to prevent leakage.

1. TURN THE SECOND BAG INSIDE OUT AND INSERT IT INTO THE FIRST BAG, ON TOP OF THE OOBLECK.

2. LINE UP THE OPPOSITE SIDES OF THE ZIPPER SEALS, SO THEY WILL MESH.

3. SEAL BAGS AND PLACE TAPE OVER THE SEAL TO PREVENT LEAKAGE.

Procedure

1. Engage the kids.

Have you ever used a straw to drink water? What happens if you suck on the straw? (The water flows.) *What happens if you suck harder?* (The water flows faster.) Explain that how fast the water flows is proportional to how much force is applied. A force is a push or a pull. The scientist who discovered this was Isaac Newton. Kids may have heard that an apple fell on his head, leading him to discover gravity. He also figured out the laws that describe how fluids move and respond to forces, including the Law of Viscosity above. So we call fluids that obey those laws Newtonian fluids. Fluids that don't behave this way are called non-Newtonian fluids.

2. Demonstrate liquids and solids.

Explain that the containers hold water and cornstarch. The cornstarch is a solid in powder form. Ask for predictions of what will happen when you drop the marble into the cornstarch, then into the water. (The marble will stop in a solid, but will fall through a liquid.) Ask: *So how is a solid different from a liquid?* (A solid keeps its shape when a force is applied. A liquid flows and doesn't have a shape of its own.) *What do you think will happen when we combine these two materials?* (Accept all answers.)

3. Facilitate the activity.

Divide kids into pairs or teams. Have them mix small batches of oobleck and predict how it will respond when they perform the marble test on it. Have them record their observations on the activity sheet.

Pass around the glove that you made earlier and have them insert their hands in the inner bag to explore the mixture between the layers. Ask: *What happens when you squeeze, punch, or poke it?*

4. Discuss the results.

Ask kids: *What did you predict would happen in your marble test? What actually happened?* (The material flows like a liquid when you apply a force slowly, such as stirring it with a spoon, but hardens like a solid when you apply a force quickly, like dropping a marble on it.)

Ask kids: *Why do you think this happened?* (Accept all answers.) Explain that when force is applied quickly to the oobleck, the water is squeezed out from between the grains of cornstarch. This creates more friction between the grains as they rub against each other. The material becomes more viscous—the grains can't flow out of the way fast enough and the material behaves like a solid. When the pressure is released, the water flows back in between the grains, and the material behaves like a liquid again. It does not follow Newton's Law, which is why it's called a non-Newtonian fluid.

5. Explain smart materials.

Materials that respond to forces or changes in their environment in very specific, often unusual, ways are called smart materials. Materials scientists are using smart materials, and designing new materials that have smart properties, to make helpful products.

How could you use the cornstarch and water mixture in a new product? (Accept all answers.) Explain that a material with similar properties is being used in a prototype of a new lightweight bulletproof vest. The material allows the wearer more freedom of movement, but solidifies when impacted, offering protection when needed.

6. Conclude the activity.

Share some other applications of smart materials (in box on activity sheet). Show the video clip from the *Making Stuff: Smarter* episode, in which host David Pogue and a group of students mix a batch of oobleck in a cement mixer, fill a dumpster, and try to run across it, demonstrating its smart properties. The clip is available at pbs.org/nova/education/makingstuff.

MAKING STUFF

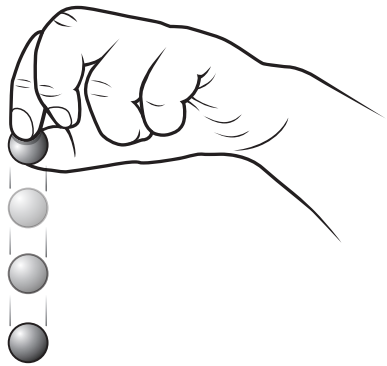
Smart Glove

NOVA PBS

MATERIALS

- 1 wide-mouth, clear plastic container, at least 3 inches deep (e.g., cylindrical cover from a stack of CDs or DVDs, or a food storage container)
- 1 plastic cup
- 1 box cornstarch
- water
- 1 spoon, to stir
- 1 marble
- newspaper (to cover surfaces)
- paper towels
- resealable plastic sandwich bag*

Viscosity is a fluid's resistance to flow. Water flows easily; it has low viscosity. Syrup and molasses resist flowing; they have high viscosity. Most fluids follow Newton's Law of Viscosity, which says that the harder or faster a fluid is pushed, the faster it flows—but some do not. They are known as non-Newtonian fluids. **Investigate a non-Newtonian fluid—a mixture of cornstarch and water, often called oobleck—that exhibits some strange properties.** Materials like oobleck that respond to forces in unique ways are called smart materials.



1. Set up the test.

Mix the water and cornstarch together in the container. What do you notice as you mix them?

2. Make a prediction.

Predict what will happen when a marble is dropped into the mixture, a combination of a solid and a liquid.

3. Do the test.

Hold the marble above the mixture and drop it. What happens when it hits the mixture? Use the spoon to get the marble out. Repeat the test to confirm your observations. Does the same thing happen again?

4. Explore the smart glove.*

Insert your hand into the inner bag and punch, pinch, poke, and probe the oobleck. Record your observations.

5. Think about the results.

How would you describe the cornstarch and water mixture—is it a liquid, a solid, or both?

- What properties does it have when it is being poured? When sitting still?
- What properties does it have when something impacts, or hits, it?

6. Think like a materials scientist.

Brainstorm some ways that you could use a mixture that behaves like a liquid until a force is applied to it quickly.

*If doing this activity at home, after the marble test, create a modified "smart glove" by pouring the oobleck from the container into a resealable plastic sandwich bag. Seal firmly and secure the seal with tape.

HOW DOES IT WORK?

When a force is applied quickly to the oobleck, the water is squeezed out from between the grains of cornstarch. This creates more friction between the grains of cornstarch as they rub against each other. The grains of cornstarch can't flow out of the way fast enough and the oobleck behaves like a solid. When the pressure is released, the water flows back in between the grains, and the oobleck behaves like a liquid again. Because it responds to forces in this way, oobleck is a smart material.

Some other smart materials are:

- a special kind of wire used in some dental braces that, when heated, bends itself into a memorized shape to keep teeth in line without painful tightening. Such materials are called *shape memory alloys*.
- a fluid containing iron used in the shock absorbers of some vehicles. It solidifies in response to a magnetic field to smooth out a car ride on very bumpy roads. The material is called a *magnetorheological fluid*.
- some salts and crystals such as quartz (which is common in sand) that produce electricity when squeezed. These materials are called *piezoelectric materials*. Piezoelectric sensors are used in airbags. They sense the impact and send an electric signal to deploy the airbag.

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