



# Classroom Connections

Surface  
Tension

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# Surface Tension

## Teacher Background



Grade Level: **6<sup>th</sup>-12<sup>th</sup>**



Suggested Time: **50 minutes**



Next Generation Science Standards (NGSS):

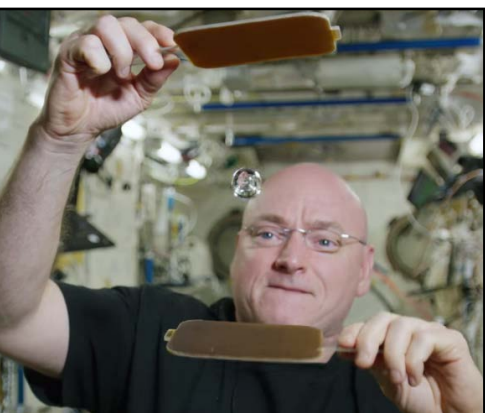
**HS-PS1-3. Matter and its Interactions:** *Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.*  
**Performance Expectation Grade:** High School (9-12)

**MS-PS1-2. Matter and its Interactions:** *Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.*  
**Performance Expectation Grade:** Middle School (6-8)

### Background

On the International Space Station, surface tension of water is much more obvious than on Earth due to the microgravity environment. In this lesson, students will explore the unique surface tension of water and see how water behaves on Earth and in space.

Surface tension is the result of an elastic-like force on the surface of a liquid. This property of liquids, in which molecules of one substance are more attracted to each other than to molecules of another substance, is what causes the curvature of water's surface on glass and we directly observe this when we see water bead up on glass. This force is referred to as cohesion or the intermolecular attraction between like molecules.



Water is unique in that it has a high surface tension compared to other liquids. Water is formed when two hydrogen atoms and one oxygen atom share electrons.

This is called covalent bonding. Because of the bent structure of the H<sub>2</sub>O molecule, the molecule has a slightly negative charge near the Oxygen atom, and a slightly positive charge near the Hydrogen atoms. This is called polarity - the presence of partial charges on different atoms within a molecule. Because water is a polar molecule, cohesive bonds are formed between the water molecules. These cohesive bonds are called Hydrogen bonds and are formed when the slightly positive (Hydrogen) end of one H<sub>2</sub>O molecule is attracted to the slightly negative (Oxygen) end of another H<sub>2</sub>O molecule, forming a series of water molecules that "stick" together and help produce water's high surface tension.

At the surface, water molecules are only attracted to other water molecules below and to the sides of them, and the inner cohesive forces are pulling these molecules together. So, the surface molecules of a body of water are experiencing a net inward force, creating a much more stable, stronger arrangement.



On the ISS, surface tension and capillary effects rule the day. Capillarity is the tendency of a liquid in a small tube or absorbent material to rise or fall as a result of surface tension. This concept creates opportunities to innovate with every day materials. For example, take the coffee cup pictured here. If a crew member were to use a traditional cup to drink their coffee, the fluid may not even reach their face due to surface tension - the coffee tends to cling to the walls of the cup. This zero-G coffee cup solves this problem by 'going with the flow': putting the strange behavior of fluid in microgravity to work. The liquid piles up right at the lip of the cup and keeps flowing as you sip. The drink comes out by the combined effects of the mouth extracting the fluid, the surface tension, and the particular shape of the cup. This feature, as well as many critical space station systems – air conditioning, refrigerators, toilets, cryogenic fuel tanks, medical treatments, the water supply, etc., depends on the ebb and flow of fluids. The capillary flow and fluid physics research conducted on the space station helps NASA improve the facilities on the station and future spacecraft.

### Objective

Following this activity, students will be able to:

- Describe why water has a high surface tension compared to other liquids.
- Identify the effects of surface tension with water on Earth and in microgravity.

## Materials

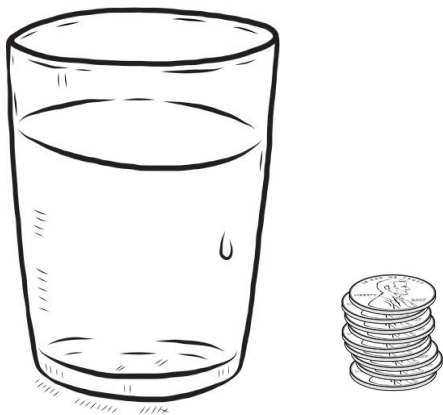
- Pennies (1 per group)
- Small disposable cups (1 per group)
- Water droppers (1 per group)
- Enough water to fill cups and droppers
- Water spray bottles (1 per group)
- Hydrophobic silicone polymer (any automotive windshield treatment for water repellent will work - 1 container should be enough for entire class to conduct experiment 1 time)
- Pen/paper to record data (1 per group)
- Paper towels (5 per group)

## Procedure

### • Exploration Activity 1

Students explore with disposable cups filled with water, pennies, and water drops. Students see how many drops they can add without causing the water to overflow. Let students explore with as little explanation as possible provided by teacher.

1. Have students work individually or in groups based on the amount of materials available.
2. Distribute materials.
3. Place cups on paper towel and fill cups to the very top with water.
4. Students will add drops of water to the cup to see how high they can get the water above the rim without spilling over. (Record results on paper)
5. Place penny flat on paper towel. Students will add as many drops as possible to the surface of the penny until it spills over. (Record results on paper)



### • Inquiry Discussion 1

Use the following questions and statements for discussion.

1. How many drops did it take to overflow the cup or spill over the sides of the penny?
2. Why were you able to add water drops higher than the top rim of the cup or higher than the surface of the penny without it flowing over at first?
3. Surface tension is a property of liquids in which molecules of one substance are more attracted to each other than to molecules of another substance.
4. Water is unique in that it has a high surface tension compared to other liquids. We observe this when water beads up on glass.
5. Water molecules are able to form Hydrogen bonds due to the polarity of the H<sub>2</sub>O molecule. The slightly positive ends of the Hydrogen atoms and the slightly negative end of the Oxygen atom attract other H<sub>2</sub>O molecules, forming a Hydrogen bond, and causing water to have high surface tension.
6. At water's surface, its molecules are only attracted to the water molecules below and to the sides of them, as there is only air above these molecules. So, the surface molecules of a body of water are pulled down, creating a much more stable, stronger arrangement.

### • Inquiry Discussion 2

Ask students the following questions and segue into the on-orbit video.

1. What would happen if you tried this experiment in microgravity?
2. Would the water behave differently in microgravity? Why or why not?
3. In microgravity, does surface tension exist?

- **Watch and Discuss Video**

Watch the video STEMonstrations: Surface Tension.

Make sure to reinforce that surface tension in microgravity is no different than on Earth. The chemical bonding mechanisms for water molecules do not change in microgravity. The variable was the amount of gravity acting on the water.

- **Exploration Activity 2**

Complete the following activity with your students.

1. Have students work individually or in groups based on the amount of materials available.
2. Distribute materials.
3. Go to the glass windows in your classroom or a close location in your school.
4. Use dry erase markers to create a line down the middle to separate the glass into two sections.
5. On the right, apply a hydrophobic silicone polymer to a cloth and rub on the glass until dry. Any automotive windshield glass treatment for water repellent will work.
6. Spray water on both sides of the glass.
7. Visually compare the sides. Record the results on how the water is behaving on both sides.

- **Final Discussion**

Discuss the following with your students.

1. Surface tension and lack of surface tension exists all around us.
2. Where do we observe surface tension everyday?
3. How does surface tension impact our lives?

- **Extension Activity**

- Conduct the cup and penny surface tension activity with a variety of liquids including milk, soda, juice, and soapy water. Compare the data to see which liquid has the highest surface tension.

- **Extension Research**

1. How does surface tension benefit water strider insects?
2. Can you engineer a coffee cup for space?
3. What is Marangoni convection and how does it relate to surface tension in space?
4. What other molecules are able to form Hydrogen bonds?
5. How does surface tension work inside the human body? Can you design an experiment involving biological surface tension to be tested in space?

- **Learn more**

Marangoni Convection

[https://www.nasa.gov/mission\\_pages/station/research/benefits/marangoni\\_convection](https://www.nasa.gov/mission_pages/station/research/benefits/marangoni_convection)

Capillary Flow Experiment

[https://science.nasa.gov/science-news/science-at-nasa/2013/15jul\\_coffeecup](https://science.nasa.gov/science-news/science-at-nasa/2013/15jul_coffeecup)

Astronaut Drinking From a Coffee Cup in Space

[https://science.nasa.gov/science-news/science-at-nasa/2013/15jul\\_coffeecup](https://science.nasa.gov/science-news/science-at-nasa/2013/15jul_coffeecup)



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