



Bringing science to life with the incredible, ERASABLE FriXion pens, markers and highlighters.

Grades 6–8



# BACK TO THE FUTURE: HOVERCRAFT STYLE!

Students gain firsthand experience on how friction affects motion. Using the thermo-sensitive ink in FriXion pens, students are going to look at how weight affects hovercraft flight. They will learn that a bed of air under an object significantly reduces the friction as it slides over a surface.

## LEARNING OBJECTIVES

After this activity, students should be able to:

- Explain that friction slows moving objects, but also allows them to be controlled
- Describe how a hovercraft moves and why it floats on a pillow of air
- Predict characteristics of surfaces that might influence the amount of friction
- Explain how having an understanding of friction helps engineers design moving objects so they can be controlled
- Explain how and why FriXion ink can be used as an indicator of the amount of friction created during the experiment



Developed by





## MATERIALS

### Each group needs:

- FriXion Pens or Markers
- 1 compact disc (CD)
- Gram
- Long or rolled paper
- 1 plastic bottle with a cap—16 oz. size, such as a soda bottle
- 1 balloon
- Masking tape
- Hacksaw, to cut the top off the plastic bottle
- Drill, to put holes in the bottle cap
- Hot-glue gun, to be shared among groups

## INTRODUCTION/MOTIVATION

Friction is a force that arises when things rub against each other. Friction can slow things down and eventually make the surfaces wear down. Different objects have different amounts of friction when they rub together. However, when surfaces do not rub against each other, there is no friction between them. The best way to reduce friction between two surfaces is to arrange them so that they do not touch!

Boat engineers and builders know that friction between a boat and water is one thing that slows the boat down. Over the years, they have discovered ways to design boats so that they do not touch water very much, but still float. Hovercrafts are so versatile that the Ford Motor Company even made a “hovercar” called the Glideair in 1959. Now, hovercrafts are used for rescue work on rapidly moving rivers and thin ice, cargo transport and ferrying work. Today you are going to create your own hovercraft and test how well it works with the help of the FriXion pens.

By design, FriXion erasable pens, markers and highlighters incorporate science, technology, and engineering. The unique, thermo-sensitive ink formula utilizes covalent bonding and PH to allow the ink to:

- **Write smoothly** and vividly in a variety of colors
- **Be ‘erased’ completely** by becoming invisible with erasing friction or when heated to temperatures higher than 140°F (65°C)
- **Be made to reappear** when cooled to extremely low temperatures of less than 14°F (–20°C)

The thermochromic chemistry in FriXion uses three types of chemical compounds that rely on acid-base interactions, temperature sensitivity, and covalent bonding. When you rub the ink with the hard rubber eraser, heat from the resulting friction causes the temperature-sensing compound to activate the acid compound, thus neutralizing the dye.

**The 3 compounds are:**

- A. The Color Pigment (which is stable at room temperature but changes color upon reaction with acids).
- B. A Color-Activating/Developer that acts as an acid to produce the color change that bonds.
- C. A Transparency/Color Change Regulator that controls the temperature at which the color transition takes place.

When A & B covalently bond you can see the ink color, when that bond is broken with heat, B & C bond and the ink becomes invisible. If the bond between A & B is reformed with cooling, the ink color will reappear.

**PROCEDURE****Before the Activity**

Gather supplies: Purchase or have the students bring in plastic soda or water bottles with caps and compact discs (CDs) before the activity.

Prepare materials: Using a hacksaw, cut the top of the bottle at the neck. Save the top and cap, discard the rest of the bottle. Drill 1-3 holes in each bottle cap, with a different number of holes in different caps, so that students can compare the results of hovercraft racers with different numbers of holes in the caps.

**With the Students**

1. Discuss with students the concepts of friction. Ask what happens when you roll an object across the ground over grass vs. the sidewalk. (Answer: Object rolls farther on the smooth concrete surface.) Which is easier to ride your bike on? (Answer: Sidewalk.) Why? (Answer: There is less friction between the bike and the sidewalk vs. the bike and grass.)
2. Invite teams of two students each to pick a bottle top and cap. Have them attach a balloon to the cap, over the cut neck.
3. Making sure they have caps that fit their bottle tops, have students use hot glue to attach the caps to the shiny side of their compact discs, with the holes in the caps centered over the holes in the middle of the CDs. Be sure to use enough hot glue to completely seal the space between the cap and the CD.
4. Once the hot glue cools, the hovercraft racers are ready for final assembly. Have the students blow up their balloon through the bottle tops, then pinch the neck so that air does not escape while they screw the top into their cap, which is attached to the compact disc.
5. Place the hovercraft racer on a smooth, flat surface and release the neck of the balloon, allowing air to escape. Tap the side of the hovercraft racer, and see how it glides over the surface!
6. Now attach masking tape to the bottom of the CD. Then color the masking tape using the FriXion pen or marker.



7. Lay out the white paper to test your flight.
8. To gather comparison data on the different hovercraft versions, set up a starting line, and collect measurements of distance and time traveled.
9. Students will add gram weights for each flight. What happens? How much FriXion ink is erased as the weight increases? What does this tell us about how weight affects friction?

## DISCUSSION QUESTIONS

- How well does the hovercraft racer slide when the balloon is out of air? (Answer: Not well.)
- How well does the hovercraft racer slide over rough surfaces, such as a carpeted floor? (Answer: Not well.)
- Why do you think that is? (Answer: The air can escape through spaces between the carpet fibers, and so does not hold up the compact disc as well.)
- What happens to the FriXion ink when weight was added? (Answer: It erased)
- Why? (Answer: Because the friction creates heat, which activates the heat-sensitive molecules in FriXion ink)
- What are the advantages of having only one hole? (Answer: Air escapes more slowly, and so lasts longer.)