FLOATING ON AIR

SIEMENS STEM DAY Science Technology Engineering Math

Level of Difficulty: 2
Grade Range: 9-12
Activity Time: 45-60 min
Career Path: Manufacturing
Topic: Transportation

OVERVIEW

Hovercrafts use pressurized air to travel smoothly on land or water. They are used for search and rescue efforts and to train astronauts for space missions. Hovercrafts can even transition from land to water, making them an exciting amphibious vehicle. In this activity, students will investigate the relationship between friction and motion by building a simple hovercraft.

STEM LESSON FOCUS

STEM incorporates Science, Technology, Engineering, and Mathematics to focus on real-world issues and problems guided by the engineering design process. This type of instruction supports students in developing critical thinking, collaboration, reasoning, and creative skills to be competitive in the 21st-century workforce.

Each Siemens STEM Day classroom activity highlights one or more components of the engineering design cycle and an essential 21st-century skill.

Engineering Design Cycle	**21st Century Skills**
• Creating or Prototyping	• Critical Thinking (Analysis, Synthesis, Flexibility, Evaluation)

OBJECTIVES

Students will be able to:

- explain the relationship between friction and motion
- apply Newton's Laws of Motion to build a working hovercraft out of household materials

MATERIALS

Used compact disks (CDs), strong glue, large balloon, sports bottle cap (push/pull closure), stopwatch

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OPTIONAL MATERIALS FOR EXTENSION

Cardboard, foam board, paper plates, scissors, tape, one-hole rubber stoppers, coins, paper clips, and small metal washers, scale/balance

HAVE YOU EVER WONDERED…

How is it possible for hovercrafts to glide over different surfaces while carrying people and heavy objects?

How does motion change when friction is greatly reduced, such as in a microgravity environment?

MAKE CONNECTIONS!

How does this connect to students?

Reducing friction is critical in different sports.

Example 1: In ice hockey, the puck rests on the slick surface with a tiny amount of friction. When the player strikes the puck, an unbalanced force greater than friction causes the puck to shoot away.

Example 2: In bobsledding, runner blades on the sleds reduce downhill friction to achieve high speeds but they increase horizontal friction to make steering around the turns easier.

How does this connect to careers?

- **First responders** use hovercrafts to reach various areas that are inaccessible by foot or conventional vehicles (e.g. floodwaters, swamps, marshes, deserts, etc)
- **Surveyors** use hovercrafts to scan the surface of large areas or to detect subterranean features for site mapping. Hovercraft can also fly above shallow, fast-moving water without getting snagged on obstacles or harming marine life.
- **Environmental researchers** also use hovercrafts for intertidal zone soil sampling, testing water quality, oil spill cleanup, and mosquito abatement.

How does this connect to our world?

Hovercraft technology holds great promise for future applications, as it is and will likely continue to be one of the safest methods for helping people in the most remote parts of the world.

Hovercrafts can be used for everything from border patrol to rescuing victims of a flood or those who have fallen through ice.

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If you want students to further explore career opportunities connected to this topic, please allow for more classroom time.

BLUEPRINT FOR DISCOVERY

1. Prior to starting the activity, ask students, "What are the forces acting on an object when it is resting on a surface?" and "What are the forces acting on the object when it is lifted off a surface?"

2. Next draw two free-body diagrams of a hovercraft. The first free-body diagram should show the hovercraft in a state of equilibrium with the vertical forces (downward force due to weight and the upward normal force from the surface balancing each other). The second free-body diagram should show unbalanced forces causing the hovercraft to accelerate upward. The lifting force vector should be greater than the downward weight vector. This imbalance in the force vectors causes motion in the upward direction. Any external force in the horizontal direction intended to produce motion while the hovercraft is flying would have to exceed the force of air resistance.

3. Engage the students in a discussion of how the hovercraft moves and why it floats on a bed of air. Also, discuss how friction acts as a resistive force to slow down objects. The lifting force on a hovercraft essentially reduces friction to zero by removing contact with a surface. If we totally eliminate all forms of friction in all directions, then the hovercraft would travel in a straight-line path, uninterrupted forever according to Newton's Law of Inertia (First Law).

4. Students will now begin to build their own hovercraft, individually or in small groups. Inform students that the goal is for the hovercraft to glide over the surface without touching down for an average (out of 3 trials) of at least 10 seconds. **No external force** can be applied to the hovercraft (e.g., pushing on it or pulling it up) while it is in the air.

5. Invite students to gather the materials they will be using to build the hovercraft.

6. Have students use strong glue (hot glue or Krazy Glue® with gloves) to attach the bottom of the sports cap over the hole in the center of the shiny side of the CD (labeled side down). Make sure the gap between the cap and the CD is completely covered to ensure an airtight seal.

   Safety Note: Hot glue can burn and Krazy Glue® can bond skin, so make sure to closely supervise students and have them put on gloves. Alternatively, the teacher can do the gluing for the students.

7. After the glue dries, have students stretch the balloon's opening over the sports bottle cap, open the valve, blow up the balloon through the bottle top, and then shut the valve.

8. Invite students to place the hovercraft racer on a smooth, flat surface and open the valve with two hands (one hand to hold down the bottle cap and the other to pull open the valve), allowing air to escape. Students will be amazed to see how the hovercraft glides over the

surface!

9. Have students collect time measurements for three trials and then take an average. Data can be recorded in a table such as the one shown below.

10. Allow time for students to experiment with different surfaces, different volumes of air in the balloon, and (if time permits) different construction materials.

11. Lastly, engage the class in a discussion of the reflection questions.

EXAMPLE OF DATA TABLE:

1st Trial Time (Seconds)	2nd Trial Time (Seconds)	3rd Trial (Seconds)	Average Time (seconds)

REFLECTION QUESTIONS

- Explain how **Newton's Laws of Motion** control the movement of the hovercraft.

  By Newton's First Law, the hovercraft remains in a state of equilibrium unless there is an external force that makes it change its state of motion. In this case, unbalanced forces are required to lift the hovercraft and propel it across the surface. By Newton's Second Law, the net force is determined by mass (amount of air released) and acceleration (how fast the air moves out of the hole). Newton's Third Law states that for every action there is an equal and opposite reaction. In this case, the action force is the air that is released from the balloon. The reaction force is the force that lifts the hovercraft upward.

- What allows the hovercraft to become **frictionless**? Explain your answer.

  The air escaping out of the balloon forms a thin cushion that the hovercraft floats on, thereby greatly reducing the friction.

- What **factors** are critical to consider when designing a working hovercraft? How do different surfaces affect the hovercraft?

  Some important factors to consider include: size of the balloon, smoothness of the surface, speed of air flow (depending on the size of the hole), material/shape of the hovercraft skirt,

etc. Smoother surfaces are easier to glide over than rougher ones because of decreased friction. For example, smooth table tops offer less resistance than carpets, smooth pavement offers less resistance than grass or gravel.

- How can hovercraft technology be used in the **real world**? Provide **THREE** real-world applications.

  Applications include rescue work, environmental testing, border patrol, agricultural spraying, entertainment purposes, etc.

TAKE ACTION!

Think about ways to improve the hovercraft design. Features that you may want to consider changing include: the construction materials used to build the hovercraft, the shape/size of the hovercraft, and the opening size of the lid.

Students can also investigate how much mass their hovercraft can lift off of the surface. Examples of items to add on top of the hovercraft skirt include coins, paper clips, small metal washers, etc.

NATIONAL STANDARDS

National Technology Standards	16: Students will develop an understanding of and be able to select and use energy and power technologies.
Next Generation Science Standards	**PS2.B: Types of Interactions** Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects.

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