Newton's Laws, Friction, and Hovercraft

A Carolina Essentials™ Activity

Overview

Students can engineer a simple hovercraft that illustrates Newton's laws of motion and frictional force. Newton's laws explain how the craft "hovers" above a surface and how the craft reacts to an applied force. Introduce frictional force when the hovercraft is inflated, as it glides over the floor on a cushion of air, and after it rests on the floor.

Physical Science and Physics
Grades: 6–12

Essential Question

How can Newton's laws of motion and friction explain the motion of a hovercraft?

Activity Objectives

1. Build a working model hovercraft using inexpensive household items.
2. Observe the effect of friction on a mechanical system.

Next Generation Science Standards* (NGSS)

PE HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations • Plan an investigation individually and collaboratively, identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.	**PS2.A: Forces and Motion** • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion.	**Stability and Change** • Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales.

Safety Procedures and Precautions

Glue guns are a source of heat. Hot glue can stick to fingers and burn the skin. Follow all directions carefully.

Continued on the next page

TIME REQUIREMENTS

PREP	ACTIVITY
30 min	30 min

Teacher Prep: 30 min
Student Activity: 30 min

SAFETY REQUIREMENTS

MATERIALS (PER GROUP)

1 compact disc

1 balloon

1 dish soap bottle cap (push-pull)

Hot glue gun and glue sticks

REFERENCE KITS

Investigating Force Kit

Carolina® Introduction to Force and Motion Kit

Friction Board

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Student Procedure

1. Position the soap bottle cap over the center hole of the CD. Draw a circle around the cap.
2. Using the drawn circle as a guide, attach the soap bottle cap to the CD with hot glue.
3. Make sure the hot glue provides an airtight seal around the edge of the cap.
4. Allow the glue to dry.
5. Make sure the soap bottle cap is closed and pushed downward.
6. Inflate the balloon.
7. Twist the neck of the balloon to stop the air from escaping.
8. Stretch the neck of the balloon over the plastic tip of the cap. Make sure the balloon is securely attached to the cap so that no air can escape.
9. Place the balloon on a flat surface, such as a lab table or a tile floor.
10. Pull up on the cap so that air escapes from the balloon through the cap and the hole in the CD.
11. Gently push the hovercraft and observe how it moves across the floor.
12. When the balloon is completely deflated, push the hovercraft again.
13. Sketch the motions of the hovercraft.

Teacher Preparation and Tips

The soap bottle cap must be one that pulls up to open.

Prepare hot glue guns early so students do not have to wait for them to heat up. Reinforce that the glue is hot and will stick to their skin.

You may want to purchase balloon pumps so students do not have to put their mouths on the balloons.

Physics students should sketch free body diagrams for the hovercraft.

For a more complete study on friction, have students observe the hovercraft on several surfaces, such as carpet, a wood floor, a waxed tile floor, water, grass, or asphalt.

Data and Observations

Students should sketch and describe the motions of the hovercraft.

Descriptions and sketches will vary.

Analysis and Discussion

1. Explain in detail which of Newton's laws were illustrated in this activity.

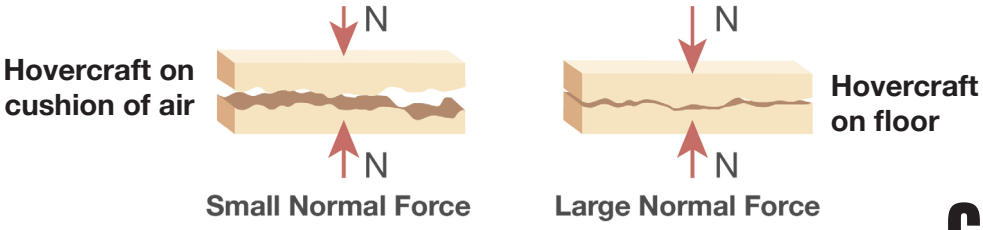
   Students must include inertia, F = ma, and action/reaction. Some may use the second law to explain how the force they exert on the CD can change the velocity at which the hovercraft travels. They should also note that friction is the force that slows or stops the motion of the hovercraft.

2. Explain differences in the force of friction between the hovercraft on a smooth surface and on a rough surface.

   There is more friction when the CD is pushed along the floor than when the CD is moving through the air.

3. Use a diagram illustrating the microscopic view of the surfaces to generate a model for friction in this activity.

   A hovercraft generates a cushion of air that prevents the solid surface of the hovercraft from making contact with the ground surface, thereby reducing friction.



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