HOVERCRAFT LAUNCH

SCIENCE AND TECHNOLOGY

MISSION DESCRIPTION

Have you ever seen a hovercraft in a science-fiction movie and wished you could have one too? Well, it turns out hovercrafts are more real and widespread than you may think!

While they may not replicate our sci-fi dreams, hovercrafts on Earth are used to navigate rough and changing terrain in a variety of applications, from commercial to military. As well, hovercraft technology has been used in spacecraft landing systems. Also known as air-cushion vehicles, hovercrafts can travel as they are lifted by a pressure difference between the ambient air above it, and a higher-pressure air cushion below it. This air cushion is generally trapped within a flexible and durable rubber skirt.

In this challenge, participants will get to build their own hovercraft. They will start by building a basic hovercraft to understand the principles behind the motion, and the reasons why this kind of vehicle is used. Then, a group discussion will guide them in changing its structure to see how far it can go!

TIMELINE

Description	Duration
PART 1	
Background	5 minutes
Instructions	10 minutes
Basic hovercraft	20 minutes
Discussion	15 minutes
PART 2 (optional)	
Advanced hovercraft	35 minutes
Launch	10 minutes
Wrap-up	5 minutes
Total	**50-100 minutes**

Difficulty: **MODERATE**

Duration: **50-100 MINUTES**

Materials: **MODERATE**

GOAL

Participants will creatively apply Newton's first law and the principle of friction to design a functional hovercraft.

OBJECTIVES

By the end of this mission, participants will:

- Understand the forces at work in a hovercraft
- Apply critical thinking to engineer (plan and design) a hovercraft
- Work in groups to design, build and test a hovercraft

BACKGROUND

Hovercrafts, known by scientists as air-cushion vehicles, glide over land or water without wings or wheels, rather using a cushion of pressurized air. Usually equipped with a flexible rubber skirt, a hovercraft employs fans that can be as powerful as an airplane engine to fill it up and create a pressure difference, where the air cushion is highly pressurized while the ambient air around it has a much lower pressure.

A hovercraft travelling on water. Credit: Thomas Philipp

With no need for wheels, hovercrafts can navigate almost any terrain, including water, urban land, rocky mountains, and harsh deserts. As such, hovercrafts are used by many military organizations as a vehicle that can move quickly, carry large loads, and move easily between different environments. These qualities, along with the flexibility of the skirt, have also led to the investigation of hovercraft landing systems for spacecraft. A cushioned landing platform would increase spacecraft reusability, promote dry landing as well as ocean landings, and come at a relatively low cost. Hovercrafts are already used to test spacecraft on Earth, as they mimic frictionless motion similar to the environment in space.

While the applications of hovercrafts are impressive, they exploit a relatively simple principle that can be recreated with a basic understanding of the forces at play. While friction slows the hovercraft down and gravity pulls it toward Earth, both can be overcome with the appropriate pressure difference.

MISSION PREPARATION

DEFINITIONS

These will come in handy to understand the concepts being applied in this activity. Participants who are not yet learning about the principles of physics may be guided to focus more on the hovercraft principle instead, and its connection to space exploration.

Pressure difference: When there is a significant pressure difference between two things, such as a helium balloon and the air outside of it, a force is generated and can create motion.

Newton's first law: An object will remain at rest, or keep moving the way it is moving, unless an external force acts on it. For example, the hovercraft will not move until the bottle cap is opened, creating a force that moves it forward.

Newton's second law: The force on an object is equal to its mass times the acceleration of its motion. This is particularly applicable in understanding why a heavier hovercraft travels farther than a lighter one: the same acceleration will generate a larger forward force if applied to a heavier object.

Newton's third law: Every action has an equal and opposite reaction. If you push a door, it is pushing back on your hand with the same force. In the example of the hovercraft, it is less applicable than the first and second laws.

Static friction: The force between two surfaces which must be overcome in order for an object at rest to start moving.

Kinetic friction: The force between two surfaces when one is moving against it. Kinetic friction is what makes an object like a ball or hovercraft stop moving; if there is no driving force forward, the frictional force is too strong for the motion to continue.

MATERIALS

- Cereal boxes (half a box or one box per team)
- Scissors
- Balloons (at least one per team)
- Pop-top or sport caps from water bottles or dish soap bottles (at least one per team)
  - This can be substituted for regular bottle caps, with a sizable hole poked in the centre
- Hot glue gun

For the advanced hovercraft, additional materials may be gathered from home or from available scrap materials. A ramp may also be used – this may be, for example, a piece of wood reaching the floor from a chair.

SPACE REQUIRED

The hovercrafts will need a launch space! It should be long and quite smooth; any hardwood or laminate surface will do.

MISSION INSTRUCTIONS: PART 1

This activity should be completed in groups of 3 to 5 participants.

This is what the final product should look like! Credit: wikiHow

1. On the inside of one side of the cereal box, draw a circle, approximately 12 cm in diameter, and cut it out.
2. At the centre of this large circle, cut out a smaller circle, approximately 1 cm in diameter.
3. Place the disk cardboard-side up (i.e. you should not see the outside design of the box).
4. Use the hot glue gun to attach the bottle cap around the smaller circle, so that the hole in the bottle cap is in line with the centre of the smaller hole you cut. Be sure to close the pop-top if you are using one.
5. Blow up a balloon so it is about 2/3 full.
6. Attach the balloon to the bottle cap. If you are using a regular bottle cap, be sure to hold the balloon's edges in place around the bottle cap so the air is not let out yet.
7. Get into launch position (on the floor, or at the top of a ramp), hold the balloon, open the pop-top from inside the balloon, and push the cardboard disk!
8. Without adding anything to the hovercraft, try changing the angle, position, or surface of launch to see how far the hovercraft can travel.

MISSION DEBRIEF

As a group, try to answer some of the following questions (see PDF for answer key):

- What went well when you launched the hovercrafts? What didn't go well?
- How did the size of the disk impact the distance the hovercraft travelled? How do you think a smaller or larger disk would change this? Why?
- Would more air in the balloon make the hovercraft travel farther? Why?
- What is the ideal launch position for the hovercraft? Why?
- How did mass impact the hovercraft? Do you think a lighter or heavier hovercraft would travel a larger distance? Why?

MISSION INSTRUCTIONS: PART 2

In part two, construct a modified hovercraft with the same basic principles (cardboard disk, bottle cap, balloon) as in part one, but try to make it go farther by doing the following:

- Changing the size of the disk
- Increasing the mass of the hovercraft
- Changing the amount of air in the balloon
- Modifying the mass distribution on the hovercraft
- Using a fan (did this have the effect you expected?)

CONCLUSION

In this exercise, you built one or more hovercrafts and attempted to increase the distance they travelled. You may not have noticed, but you also learned lots about the forces at work in space exploration! You applied three main concepts: pressure differences, Newton's laws, and the force of friction. These are forces engineers must consider when designing real-life devices, including hovercrafts!

RESOURCES

The following external resources can be used to prepare for the activity, or to share with participants who are curious.

Pressure difference and associated concepts:
https://www.khanacademy.org/science/physics/fluids/density-and-pressure/a/pressure-article

Newton's laws: http://www.physics4kids.com/files/motion_laws.html

Friction: https://www.ducksters.com/science/friction.php

Applications of hovercrafts: https://schooledbyscience.com/purpose-hovercraft-technology/

ANSWER KEY

- How did the size of the disk impact the distance the hovercraft travelled? How do you think a smaller or larger disk would change this? Why?

  A larger disk (about 25 cm in diameter) will travel farther, as maximizing the surface area will create a larger pressure difference or “air cushion” underneath.

- Would more air in the balloon make the hovercraft travel farther? Why?

  Interestingly, the optimal hovercraft distance will be reached with a balloon that is two-thirds to three-quarters full! This is mostly just because an overly full balloon is more difficult to keep on the bottle cap, but in part because the air flow out of a larger balloon is less consistent.

- What is the ideal launch position for the hovercraft? Why?

  Generally, the ideal launch position will be from a ramp in order to exploit gravitational force and provide some initial speed to the hovercraft. This also helps overcome the force of static friction, which makes it harder for the hovercraft to start moving.

- How did mass impact the hovercraft? Do you think a lighter or heavier hovercraft would travel a larger distance? Why?

  While it may seen counterintuitive, a heavier hovercraft will travel farther than its lighter counterpart when launched with the same amount of air in the balloon. While it may be harder for a heavier hovercraft to overcome static friction and start moving, it gains more momentum and is less impacted by kinetic friction, the force that makes it stop moving.