# Hovercrafts and Newton's 3 Laws of Motion

## *Royal High School Physics, Fall 2007*

### Purpose

The purpose of this activity is to investigate Newton's 3 Laws of Motion using a PASCO force platform, motion sensor and hovercraft.

### Introduction to the Activity

The hovercraft provides many fun opportunities to do demonstrations and experiments involving brave student volunteers studying the concepts of momentum, collisions, velocity, vectors, and forces. There are many real-world applications to the hovercraft, as analogs of the laboratory model are used in daily life. Some everyday examples include air-cushioned vehicles (or ACV's) which travel atop a layer of compressed air and can travel over land or water. These carry people, vehicles or freight, and can move at speeds up to 80 mph.

The large PASCO hovercraft provides an excellent opportunity to investigate Newton's three laws of motion experimentally. The following exercise was adapted from the experiment and user's manual that came with the hovercraft. We have reproduced it and changed it slightly for this exercise. Some of the activity involves drawing vectors (you should complete the "Visualizing Vectors" exercise before starting this one…) and the use of the force platform (you should complete at least the first part of the "Forces, Motions, and Hovercrafts" exercise prior to starting this one…).

This activity meets State of Texas TEKS requirements from §112.42, IPC (c)(4)(A),(B); §112.47, Physics, including items (c)(4)(C) to (E) and (5)(B) to (D). **http://www.tea.state.tx.us/teks/.** More details about these and other national science education teaching standards can be found at websites such as **http://www.nsta.org/**

### Equipment

The equipment needed for this activity is as follows:

- 1 PASCO Hovercraft with air supply
- 1 Meter stick
- Masking Tape
- Stopwatch
- 2 PASCO Xplorer GLX hand-held data loggers, fully charged
- 2 Digital adaptors for the GLX
- 1 PASCO motion sensor
- 2 PASCO Force Platforms

## Procedure

In this experiment, we will investigate Newton's three laws of motion. The activity is adapted from PASCO's Experiment and User Guide for the Hovercraft. These can also be useful in exploring position, velocity and acceleration.

Newton's First Law

- Several students will observe the motion, one will be the "catcher" to stop the Hovercraft, and another will be the "marker" to mark the motion of the craft with tape placed on the floor
- Set up the motion sensor, connected to an Xplorer GLX, so it will be able to measure the distance and velocity of the person on the hovercraft. Press the Play button when you are ready to put the rider in motion.
- Provide a brief push to the rider, then start the stopwatch
- The marker will then mark the position of the hovercraft each second, as well as at the start and end of a 5-second interval
- After the last mark is placed, stop the Hovercraft
- Answer the questions in the final section.

Newton's Second Law

- Assign the same roles from Experiment 1 to different students, and give another student a chance to be the rider
- Place the motion sensor behind the rider, so as not to run over it when you pull the rider. Press the Play button when you are ready to start.
- Using a rope, provide a constant force to the rider for about 3 seconds.
- Have the "marker" mark the position of the Hovercraft each second
- After moving across the floor for 5 seconds, stop the vehicle, then stop the Motion Sensor
- Answer the questions in the final section

Newton's Third Law

- Assign the same roles from Experiment 1 to different students, and give another student a chance to be the rider (except that no markers will be needed in this case)
- The "pusher" should hold the Force Platform perpendicular to the ground
- The "rider" should place the second Force Platform up against the pusher's.
- The pusher should provide a force to the rider for about 1 second
- After moving across the floor for about 5 seconds, stop the vehicle
- Answer the questions in the final section.

### Questions-Newton's First Law of Motion

1. Describe the motion both during and after the push

2. Draw a force diagram for the rider both during and after the push

3. Describe the position versus time and velocity versus time graphs (you can print them out as well…). Based on the appearance of the velocity graph, is the rider traveling at a constant velocity?

4. Describe the spacing between the marks on the floor, and what is suggested about the motion of the Hovercraft? Make a plot of the distance versus time based on stopwatch and mark data. How does this compare with that of the Motion Sensor?

5. Describe the causes of motion that you observed throughout the motion of the Hovercraft

**Questions-Newton's Second Law of Motion**

1. Describe the motion both during and after the pull

2. Draw a force diagram for the rider both during and after the pull.

3. Describe the position versus time and velocity versus time graphs (you can print the graphs as well…). Based on the appearance of the velocity graph, is the rider traveling at a constant velocity?

4. Describe the motion of the hovercraft based on the spacing between the marks on the floor. Make a plot of the distance versus time based on stopwatch and mark data. How does this compare with that of the Motion Sensor?

5. Describe the causes of motion that you observed throughout the motion of the Hovercraft

**Questions-Newton's Third Law of Motion**

1. Describe the motion both during and after the push

2. Make a graph from the Force Platform data showing both the pusher's force and the rider's force

3. Draw force diagrams for both the pusher and rider during the push

4. Formulate a general rule about the size and direction of forces between two objects

## For Further Thought

You probably have done one or more activities in addition to this one which were meant to illustrate one or more of Newton's laws of motion. How are the activities similar? What is different about them? Specifically describe the common features of all the activities meant to show Newton's Laws of motion.