Newton's Third Law

Equipment

1	Dynamics System	ME-6955
2	Force Sensor	PS-2189
2	Compact Cart Mass	ME-6755
	Required, but not included:	
1	Rubber Band	

Introduction

Newton's Third Law states that for every force (the action) there is an equal and opposite force (the reaction).

The purpose of this experiment is to determine the relationship between forces forming an action-reaction pair. Two Force Sensors are used to measure the paired forces in a rubber band tug-of-war (shown here) and the paired forces in a collision of two carts.

Setup

1. Connect two Force Sensors to the 1 and 4 PASPORT inputs on the 850 Universal Interface. In PASCO Capstone, set the sample rate of both Force sensors to 200 Hz.

2. Attach the hooks to the Force Sensors. 3. Open the Calibration at left and choose to calibrate one of the force sensors. Hang the force sensor up on a rod with the hook end hanging down.

3. Choose to calibrate with two points. Set the first point to zero. With nothing connected to the force sensor, press the "ZERO" button on the force sensor and click accept in the calibration window.

4. For the second point, hang a 100 g mass from the force sensor hook. Enter the value of mass times the acceleration due to gravity (in newtons) for the expected value. Click accept.

5. With nothing connected to the Force Sensors, press the "ZERO" buttons on the Force Sensors.

6. Hook the Force Sensors to the ends of a long rubber band as shown in Figure 1.

7. In PASCO Capstone, create a graph of "Force, Ch.P1" vs. Time. Then click on the "Force, Ch.P1" on the vertical axis and select Add a Similar Measurement. Then add "Force, Ch.P2". Click on the measurement selector on the vertical axis again and choose

a QuickCalc of (–F). Normally, the Force Sensor records a pull as negative value, but the QuickCalc will make these values positive.

Figure 1: Tug-of-war Setup

Procedure – Tug-of-war

1. Click on Record to start collecting data.

2. Play a small-scale game of tug-of-war with neither person "winning", but try to vary the force. Do not exceed 50 N.

3. After 10 seconds or so, click Stop. To delete unwanted data, click the Delete Last Run button.

4. Examine the two curves to see if the forces exerted by person A and person B are the same. You will probably have trouble seeing the two sets of data at the same time. The best way is to toggle back and forth between the two data sets. In the Graph Legend, click on the icon under "F, P1" (force at the PASPORT 1 input) to highlight the data in channel 1. Then click on the icon under "F, P4" to highlight that data. Go back and forth to see if you can detect any difference.

5. Are the action/reaction forces equal in magnitude (size)? Even if one person is winning the tug-of-war? Was the force exerted by person A opposite in direction to that exerted by person B? Explain how you know.

Cart Setup

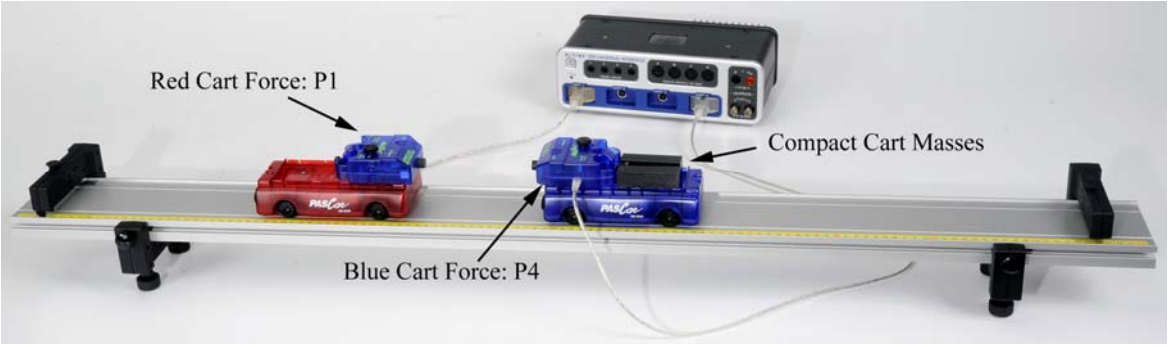

Figure 2: Carts Setup

1. Set up the track as shown in Figure 2. Place the carts on the track and level the track enough so that the carts don't begin to roll. Exact level is not necessary.

2. Remove the hooks from the Force Sensors. Replace them with the rubber bumpers.

3. Using long thumbscrews, attach the Force Sensors to the carts as shown in Figure 3. Force Sensor 1 should be on the Red Cart, and Force Sensor 4 should be on the Blue Cart.

4. Place both Cart Masses in the Blue Cart.

5. With nothing touching the bumpers on the Force Sensors, press the "ZERO" buttons on the Force Sensors.

Figure 3: Fasten Force Sensor

Push Red Cart:

6. Change the sample rate of both Force sensors to 1 kHz.

7. With the two carts touching, click on Record to start collecting data.

8. Push on the Red Cart as shown in Figure 4, pushing both carts to the right. Try and keep the two bumpers in contact as long as possible, but catch the cart before it hits the endstop.

9. Click on Stop.

10. Open the Data Summary and re-name this run Red Push.

11. You can also change the color of each trace, so that the Red Cart Force Sensor data (P1) is red and the Blue Cart Force Sensor data (P4) is Blue. This makes it easier to keep track.

Figure 4: Pushing on Red Cart

Push Blue Cart:

12. With the two carts touching, click on Record to start collecting data.

13. Push on the Blue Cart as shown in Figure 5, pushing both carts to the left. Try and keep the two bumpers in contact as long as possible.

14. Click Stop.

15. Open the Data Summary and re-name this run Blue Push. You can also change the color of each trace, so that the Red Cart Force Sensor data (P4) is red and the Blue Cart Force Sensor data (P1) is Blue. This makes it easier to keep track.

Figure 5: Pushing the Blue Cart

Analysis

1. Use the Run Select tool on the Graph tool palette and select the "Red Push" run.
2. Examine the two curves to see if the forces exerted by the two carts are the same.
3. Now repeat steps 1-2 for the "Blue Push" data set.
4. Are the action/reaction forces equal in magnitude (size)? Even if one car is more massive?
5. If a low mass car (Volkswagon) has a head-on collision with a high mass car (Suburban), which car will experience the larger force?