5.10: Force and Motion II

Name: ____

Date: ______________________

Partners:____

Equipment

• *LabPro* Interface • Motion detector • Two force sensors • *TwoForces* software file • Dynamics track • Two dynamics carts	• Pulley • Hanging masses • Short loop of string • Rubber band • Force probe rubber bumpers

I. Dueling Force Sensors

Open the file *TwoForces*.

Set each sensor to the ±10 N setting and securely attach it to the top of a cart. Place the carts at rest on the track.

Calibrate both sensors by selecting **Experiment/Calibrate** and then selecting either sensor. On the pop-up menu, check both sensors and select **Calibrate Now**. You will now perform a two-point calibration of both force sensors:

- For the first calibration point, do not apply any force to the sensors, enter 0 N, and hit **Keep.**
- For the second calibration point, hang a 200 g mass from each sensor. Enter the weight of this mass (1.96 N) and hit **Keep.**

When complete, place both sensors back on the track and zero both force sensors.

Connect the force sensors by a short loop of string. Press **Collect** and pull first on one cart and then the other. Sometimes hold the other cart in place and sometimes let it roll freely. Don't go crazy; keep the forces under 10 N.

Question: Describe the relationship between the two measured forces.

Replace the string with a rubber band. Press **Collect** and pull on both carts, then one and then the other. Sometimes hold the other cart in place and sometimes let it roll freely.

Question: Describe the relationship between the two measured forces.

Replace the rubber band with a rubber bumper. Press **Collect** and push on both carts, then one and then the other. Sometimes hold the other cart in place and sometimes let it roll freely.

Question: Describe the relationship between the two measured forces.

Question: Why are the forces displayed not equal in magnitude and *opposite* in direction? What algebraic sign does the sensor give to "pulls"? To "pushes"?

II. A Train

Create a "train" of two carts. The rear cart, closest to the motion detector, should be connected to the front cart by a short loop of string from the hook of the force sensor to a fixed point on the front cart.

The front cart should be attached to a 200 g mass by a string that passes, from the force sensor hook, over a pulley. Thus, you will measure both the force between the two carts and the force applied to the front cart.

Hold the rear cart in place about 20 cm in front of the motion detector, press **Collect**, and after about 1 second of data collection release the cart. Make sure that the force sensor cords do not drag behind the carts nor trigger the motion detector. Repeat until you have clean data.

Question: As you saw in a previous activity, your force vs. time graphs show a clear decrease in force when you released the cart. However, one of the forces decreases by a substantially larger amount than the other. Clearly explain which force decreases by the larger amount and why this larger decrease occurs. (It's probably useful to use Newton's Second Law in your explanation.)

Question: Imagine adding a 500 g mass to one of the two carts. To which cart should the mass be added in order to minimize the large decrease in force? Carefully explain.

Collect the following data from the relevant portion of each graph. **(Note: If your force probes do not both read close to 1.96 N before letting the carts go, something is wrong! Find and correct the problem.)**

Print out and attach one of your trials with the region analyzed highlighted and the relevant statistics displayed.

Trial	Rear Force (N)	Front Force (N)	Acceleration (m/s^2)
no 500 g mass	±	±	±
500 g on rear	±	±	±
500 g on front	±	±	±

Question: To which cart should the mass be added in order to minimize the large decrease in force? Does this agree with your prediction above? If not, provide a correct explanation for this phenomenon.

Question: Does the acceleration depend on which cart carries the 500 g mass? Should it? Explain.

Question: Does the front force depend on which cart carries the 500 g mass? Should it? Explain.

Question: Does the rear force depend on which cart carries the 500 g mass? Should it? Explain.

Measure the mass of each cart and sensor. Record it below.

mass of rear cart and sensor, m_{rear} = _____________ kg

mass of front cart and sensor, m_{front} = _____________ kg

Question: Draw a free-body diagram and apply Newton's Second Law to the rear cart, ignoring friction.

Question: For each of the three trials, substitute your experimental data into your equation above. Is your data consistent with Newton's law (i.e., is the left-hand side of the equation equal to the right-hand side of the equation, within experimental uncertainties)?

Trial	Left-Hand Side; F (N)	Right-Hand Side; ma (N)	Do LHS and RHS overlap?
no 500 g mass	±	±	
500 g on rear	±	±	
500 g on front	±	±	

Question: Is friction small enough to be reasonably ignored? Based on your results, would including friction make the agreement between your data and Newton's law better or worse? Explain.

Question: Draw a free-body diagram and apply Newton's Second Law to the front cart, ignoring friction.

Question: For each of the three trials, substitute your experimental data into your equation above. Is your data consistent with Newton's law (i.e., is the left-hand side of the equation equal to the right-hand side of the equation, within experimental uncertainties)? (Note: Be careful with the uncertainties on the left-hand side of the equation.)

Trial	Left-Hand Side; F (N)	Right-Hand Side; ma (N)	Do LHS and RHS overlap?
no 500 g mass	±	±	

500 g on rear	±	±	
500 g on front	±	±	

Question: Is friction small enough to be reasonably ignored? Based on your results, would including friction make the agreement between your data and Newton's law better or worse? Explain.

Question: Draw a free-body diagram and apply Newton's Second Law to the system of the two carts, ignoring friction.

Question: For each of the three trials, substitute your experimental data into your equation above. Is your data consistent with Newton's law (i.e., is the left-hand side of the equation equal to the right-hand side of the equation, within experimental uncertainties)?

Trial	**Left-Hand Side; F (N)**	**Right-Hand Side; ma (N)**	**Do LHS and RHS overlap?**
no 500 g mass	±	±	
500 g on rear	±	±	
500 g on front	±	±	

Question: Is friction small enough to be reasonably ignored? Based on your results, would including friction make the agreement between your data and Newton's law better or worse? Explain.