Name \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Smart Cart Lab: Newton’s 2nd Law, Part II* – Distance Learning Version**

In this lab, we’ll use PASCO Smart Carts and SPARKvue software to experiments involving force, mass, and acceleration, investigating Newton’s 2nd Law of Motion.

(If you’re unable to get the data you need from SPARKvue via a shared session, see screenshots on the last page.)

Procedure:

1. Obtain a 1-m long track. Adjust the feet and use a bubble level to make sure the track is level. Attach a pulley to the end of the track.
2. Obtain a single Smart Cart. Turn it on, and make sure you see a blinking red light. This means it is blue tooth ready. Remove the magnetic “bumper” from the front of your Smart Cart and attach the hook to where the bumper had been screwed in. This hook now will be attached to the Smart Cart’s force sensor. Use a scale to determine the mass of your Smart Cart:

mCart = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Obtain a PC laptop, insert a Bluetooth adapter into a USB port, begin running SPARKvue, and connect your Smart Cart to SPARKvue.
2. Build an experiment with 3 pages. On the first page, have a data table with columns for time, force, and acceleration. On the 2nd page have a graph of acceleration vs. time. On the 3rd page have a graph of force vs. time.
3. Attach a roughly-meter-long string to the hook on the Smart Cart. Then add four 250-g masses to the top of your cart.
4. Before you can take data, you need to zero-out your force sensor. Click the “Show Hardware Setup” icon, then click the white gear symbol on the blue background next to “Smart Cart Force Sensor”. Then click “Zero Sensor Now”.
5. Run the string attached to your cart through the hole in the barrier at the end of the track and over the pulley. Attached a 50-g mass to the end of the string. You will allow the weight of the hanging 50-g mass to accelerate your system.
6. Draw a free-body diagram of the cart/hanging-mass system. Be sure to label all external forces acting on the system as a whole. (Assume any friction is negligible.)
7. Write a formula for the Net Force acting on the System in terms of the forces labeled in your diagram above

*Fnet, system* = *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

1. Now consider the *hanging mass only* and draw another free body diagram. Be sure to label all external forces acting on the hanging mass.
2. Write a formula for the Net Force acting on the Hanging Mass in terms of the forces labeled in your diagram above

*Fnet, hanging mass* = *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

1. Now consider the *Smart Cart only* and draw another free body diagram. Be sure to label all external forces acting on the Smart Cart.
2. Write a formula for the Net Force acting on the Smart Cart in terms of the forces labeled in your diagram above

*Fnet, Smart Cart* = *\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*

1. In terms of the various forces labeled in your diagrams, which force would you expect to be read by the force sensor in your Smart Cart?
2. Assuming negligible friction and using the known masses involved, calculate a predicted acceleration for your cart/hanging-mass system. Show all work below.

*asystem* = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Now calculated the theoretical value you expect to be reported by the Smart Cart force sensor during the experiment. Show all work below.

*Fsensor* = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. You will now perform a trial to see how close your theoretical values are to experimental results. Hold the cart at the far end of the track. Make sure the attached string is going over the pulley and has the 50-g mass hanging at the end. Click to start taking data. Release the cart. Click to stop taking data after the cart has hit the barrier on the other end of the track.
2. Highlight the relevant data points and determine average acceleration of the cart during the run. (You can get the average of your data by clicking “mean” under the statistics menu, which is found by pressing the button labeled Σ.) Take a snapshot of your graph indicating which point are highlighted and what their average value is and save it to your Journal.

*aexperimental* = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Determine the %-error between your theoretical and experimental values for acceleration:

*%-Error for Acceleration* = \_\_\_\_\_\_\_\_\_\_\_\_

1. Highlight the relevant data points and fit a linear curve to your force v. time graph. Determine the average force of recorded by the cart’s force sensor during the run. Take a snapshot of your graph, and save it to your Journal.

*Fexperimental* = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Determine the %-error between your theoretical and experimental values for force:

*%-Error for Acceleration* = \_\_\_\_\_\_\_\_\_\_\_\_

1. How do you account for your experimental error?