Work-Energy Theorem

OBJECTIVES

Students will…

- Analyze the relationship between the work done on an object and the change in the object's kinetic energy.

MATERIALS

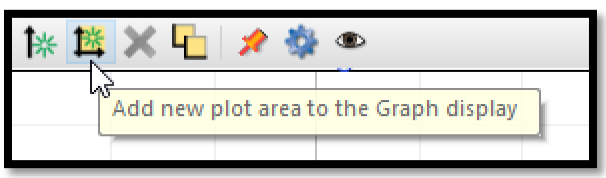
- PASCO Smart Cart with a hook attachment, track, force bracket, spring

SAFETY

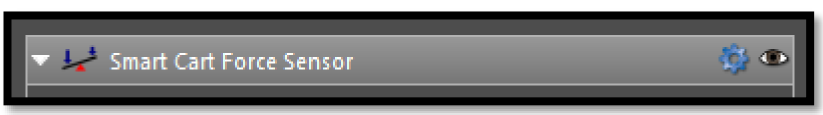
- Please follow the usual safety procedures regarding use of the SmartCart and track. In addition, please do not stretch the spring except for use during the experimental trials.

PRO-cedure:[*]

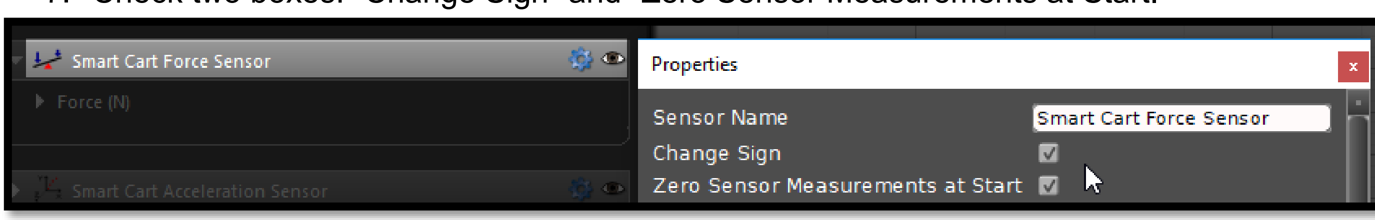
1. Set up your track with a force bracket at one end. Attach the spring to the force bracket.
2. Turn on Capstone, connect your car to the Bluetooth, and pull one graph onto the screen. **Put your car upside-down on your track and do not attach the spring yet.**
3. Click the button shown below to add a second graph. (Be sure to follow this step exactly as written.)



4. Set the top graph's y-axis to velocity and the bottom graph's y-axis to force.
5. Now for some weirdness: Set the x-axis to position.
6. On the left side of the screen select "Data Summary." Then click on the gear by the Smart Cart Force Sensor.

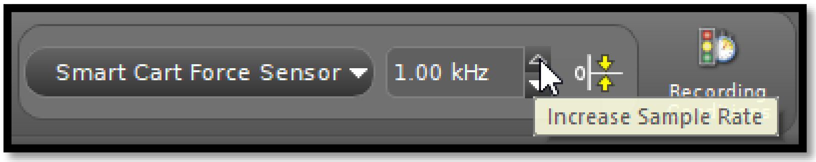


7. Check two boxes: "Change Sign" and "Zero Sensor Measurements at Start."

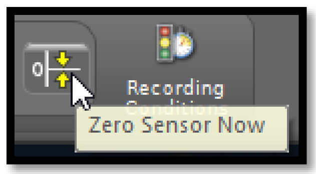


[*] Because you're such a PRO now

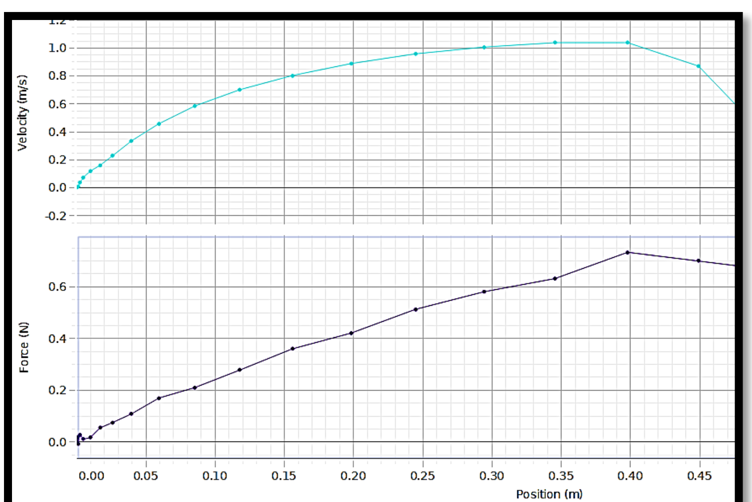
8. We need to increase the sample rate of the force sensor on the Smart Cart. This means that we need for the Smart Cart to take more data measurements in a given amount of time. We do this by increasing the frequency of measurements. At the bottom of your screen use the drop-down menus to select the Smart Cart Force Sensor and then click the appropriate arrow to increase the sample rate to 1.00 kHz. (This means it will take measurements 1000 times per second. It was originally set at 20 Hz, meaning it was only taking 20 measurements per second.)



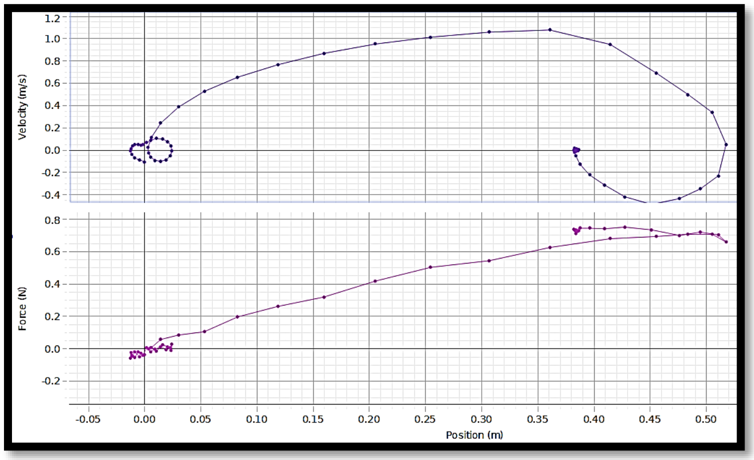
9. Click record and zero the force sensor by clicking this little gem of a button at the bottom of the screen. Then stop recording.



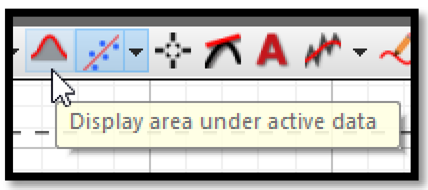
10. Read this entire step, because it will happen fast, and you have to do it exactly right.
    a. Person #1: Place your car on the track with the front at position 70 cm.
    b. **Person #2: Position yourself near the bracket to stop the car when the front exactly reaches position 30 cm. Do not let your car jump the track.**
    c. Person #3: You will run the computer. Start the recording while the car is perfectly stationary at 0.70m. THEN person #1 should release the car from 70 cm and stop the recording exactly at the moment that person #2 catches the car at 30 cm. You may need to do this multiple times and develop a countdown system. If you did this step right, your screen should look something like this image. Note that the velocity is zero at the beginning, and the velocity peaks when the car reached position 0.40 m. That's essential. LOOK AT THE NEXT PAGE FOR AN EXAMPLE OF A BAD GRAPH.



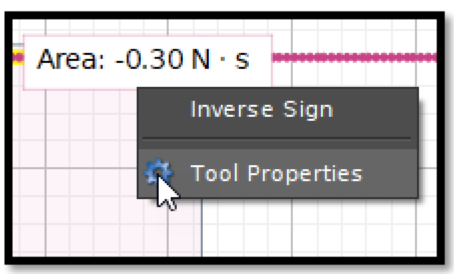
If your graph has curls or jumps at the ends, like in the following run, you'll need to re-run.



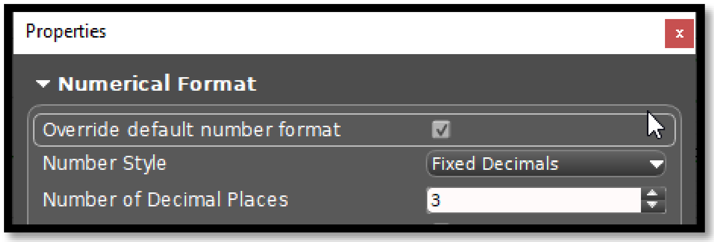
11. Use the coordinates tool to measure the velocity when the car has reached maximum velocity. (This may occur before the car reaches a displacement of 0.40m. That is ok.) This is the final velocity. Record it.
12. Highlight the curve on the Force vs Position graph over the displacement from 0.00 m to exactly the same position where the car reached maximum velocity. The click the following icon to find the area under the curve.



13. Pro-tip: Many times people do this step wrong. Don't be those people. ☺
    We need to set the precision of the measurement so that it shows the area measured to the three digits after the decimal. To do this, right-click on the box that shows the area and select "Tool Properties."



Then click on "Numerical Properties" and check the box that reads "Override default number format." Next increase the "Number of Decimal Places" to three. Then close the dialog box. (See image on the next page.)



Record the area under the curve. (Be sure to include units.) The area under the curve equals the y-axis variable multiplied by the x-axis variable. In this case that means that the area under the curve equals FΔx, or work! ☺

DATA TABLES & GRAPHS

Include the following:

- The mass of the Smart Cart
- The initial velocity of the Smart Cart (which is 0.000 m/s.)
- The final velocity of the Smart Cart from step eleven.
- The work done on the car by the spring. (This is area under the Force vs Position curve from step thirteen.) Remember units!
- Remove all highlighting and tools, zoom so that all relevant data fills the display, and take a screenshot of the display (Display > Copy Display.) Include this screenshot in your lab report. (Remember to title it first. There are two graphs, so include two titles.)

CALCULATIONS

Show your work for the following:

- Calculate the change in kinetic energy when the spring pulled the car.
- Calculate the percent difference between the change in kinetic energy of the car and the work done by the spring.

$$\%\ difference = \left\{ \frac{(A-B)}{\left(\left[\frac{(A+B)}{2}\right]\right)} \right\} x\ 100$$

CONCLUSION

Analyze your data in order to draw a conclusion about the objective of the lab.