

Speedster!!!



Analysis of Uniform Motion



Introduction: Uniform motion is motion in which velocity is constant. We can learn a lot about the motion of an object by examining Position vs Time graphs and Velocity vs Time graphs. We will do both in this experiment.

Objective: To be able to...

- discover a rule relating information from a Position vs Time graph to a Velocity vs Time graph.
- analyze graphs of Position vs Time to determine whether motion is uniform in each of three data runs.¹ (See footnote for help.)

Pro Tip: When writing your conclusion, be sure to use only the data specified in each objective to draw your conclusions. For example, when addressing the first objective, only analyze the Position vs Time graphs and do not refer to Velocity vs Time graphs.

Safety:

- **When not in use, turn your car upside-down so that it does not roll off the table.**
- Take care not to release the car's plunger in such a way that it strikes a person or lab equipment.
- Take care not to strike a person or computer with the track while moving it.

Materials:

- Capstone Software
- PASCO Smart Cart
- PASCO 1.20 m track

Procedure:

1. Set up: Place the car on the track (**upside-down** for now until you get to step six) and launch the Capstone software from the Desktop.
2. In the top left corner click on "Hardware Setup" and then click on the Smart Cart whose number matches the number on your actual Smart Cart in your equipment kit. Then click on "Hardware Setup" again to close the dialog box.

¹ In other words, is the motion uniform in run 1? Is the motion uniform in run 2? Is the motion uniform in run 3? You are not comparing run 1 to run 2 to run 3. Obviously the motion changes from one run to the next. You are determining whether in run 1 the motion was uniform. Then you are determining whether in run 2 the motion was uniform, and so on.

3. In the top right corner click on “Graph” and drag the icon to the center of your screen.
4. On the y-axis click “Select Measurement” and select “Position (m).”
5. Near the center top of the graph area look for a symbol that shows an x- and y-axis with a green gear on top of a yellow background. (See *Figure 1*.) Click that icon. A second graph should appear below your Position vs. Time graph. On the y-axis of the new graph click “Select Measurement” and select “Velocity (m/s).”

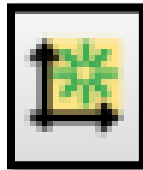


Figure 1

6. Now you're ready to roll! (pun intended) Push in the car's plunger one notch and place the plunger end of the car against the launch bracket at the end of your track with the car right-side-up. (If there is not a launch bracket on the end of your track, place a solid, sturdy object at the end of the track so that the plunger can push off of the object.) Hold the car steady so that it does not roll, and **read step 7 before doing anything else.**
7. **IMPORTANT: Station someone at the opposite end of the track to catch the car. It MUST NOT fall off of the track. It is very valuable and can break if it falls. DON'T LET IT FALL.**
8. At the bottom left of your screen click the red “Record” button to begin data collection. WAIT FIVE SECONDS after you click record and then release the plunger by pressing the black button on the Smart Cart. Allow the car to roll down the track until it reaches the other end. AFTER it reaches the other end, click “Stop,” which is at the same location as where the “Record” button used to be. (Note: If the car skidded out of the track grooves, or if anything bumped the car while it was running, click “Delete Last Run” in the lower right of your screen and repeat the trial.)
9. **Turn your car upside-down again to keep it safe.**
10. Click anywhere on the Position vs. Time graph. The graph should have a thin blue line around its edges now indicating that it is the graph you can actively work with.
11. At the top left of the graph toolbar look for a yellow highlighter symbol with three blue dots. (See *Figure 2*.) This is your highlighter tool. A colored box will appear on your graph. This box can be resized and moved, which we will do in step 12.

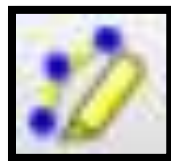


Figure 2

12. Move and resize the colored box so that it highlights just the portion of your graph during which your car was moving. You should have a little of the flat lines on each end of the slant included in this area. (See Figure 3.)

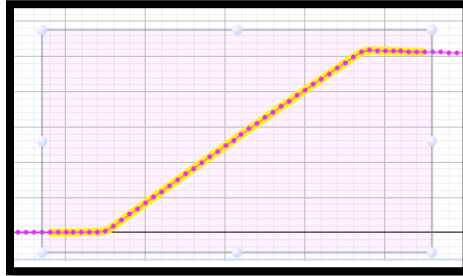


Figure 3

13. In the top left of the graph toolbar click on the symbol shown in Figure 4 to zoom in on the highlighted portion of your graph. (Note that the Velocity vs Time graph has also zoomed in as well.)

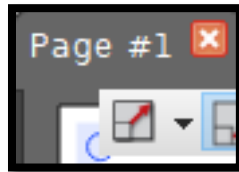


Figure 4

14. Now we need to resize the highlighter box. Since it's filling the screen, you may need to click and drag it down and right so that you can see the top left corner. Then place your mouse over the top left corner until it's a double arrow. Clicking and dragging now will allow you to resize the box. (See Figure 5.) Do the same thing with the lower right of the box so that the entire box is now visible on the screen. You'll need to resize and move the box so that it is highlighting just the straight portion of the data line. (See Figure 6.)

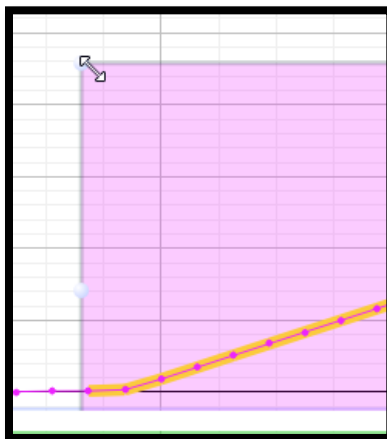


Figure 5

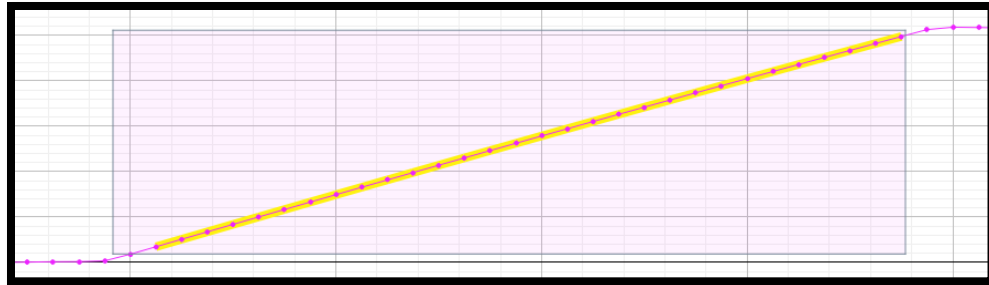


Figure 6

15. Let's take the slope of the line of best fit through this data. Click on the small black triangle to the right of the symbol that has a red slanted line with five blue dots (shown below in Figure 7 on the next page) to activate a drop-down menu. Select "Linear: $mt + b$ " and then click on the button with the red line and five blue dots. You should now see the slope (m) along with a \pm value, which gives the uncertainty of the measurement. Record this slope along with the uncertainty. Include the units of the slope, which are the y-axis units over the x-axis units.

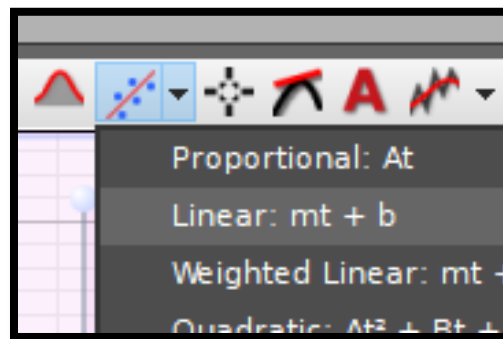


Figure 7

16. Now click on the bottom Velocity vs Time graph to activate it and highlight the portion of the graph that corresponds to the exact same time period as the portion you highlighted in the top graph. We need to find the mean y- value for this data, which will be the average velocity of the car during this time period. To find the mean, click on the sigma (Σ) button, which is to the right of the highlighter button. Record the mean along with the units. (Since this is the average of the y- values of the data points in the highlighted area, the units will be the units of the value on the y-axis.)
17. Let's remove all of the boxes and highlighting so that our data curve is the only thing on the graphs again.
- Click on the bottom graph. Next click the sigma button again to turn off the mean. Then click on the highlighter box and press delete on your keyboard. The only thing on your bottom graph should now be the data plot.

- b. Click on the top graph. Again, select the highlighter box by clicking on it. Then click the button that has the slanted red line with the five blue dots again. This will turn off the line of best fit and slope information box. Finally delete the highlighter box by pressing the delete key on your keyboard. Now the only thing on your top graph should be the data plot line.
18. Repeat steps 6-17 with the plunger pushed in two notches. **BE EXTRA CAREFUL TO CATCH THE CAR SO THAT IT DOES NOT FALL. IT WILL BE GOING MUCH FASTER.** (Be sure to clean up your graphs in step seventeen again.)
19. Repeat steps 6-17 with the plunger pushed in three notches.
20. Near the top-left of the graph area, look for a rainbow-colored triangle. FIRST click the rainbow triangle. THEN click the small, black triangle to the right of it for a drop-down menu. You should see all three runs. Click on all three so that there is a checkmark by each. (See Figure 8 on the next page.) LAST click the rainbow triangle again. You should see all three data runs on your graph. Stretch your x- and y-axis and reposition the origin as needed so that your data fills the graphs from left-to-right and top-to-bottom. (See Figures 9 and 10 for good and bad examples.)

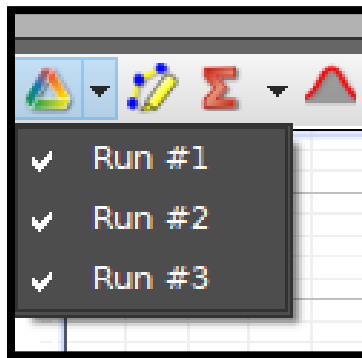


Figure 8

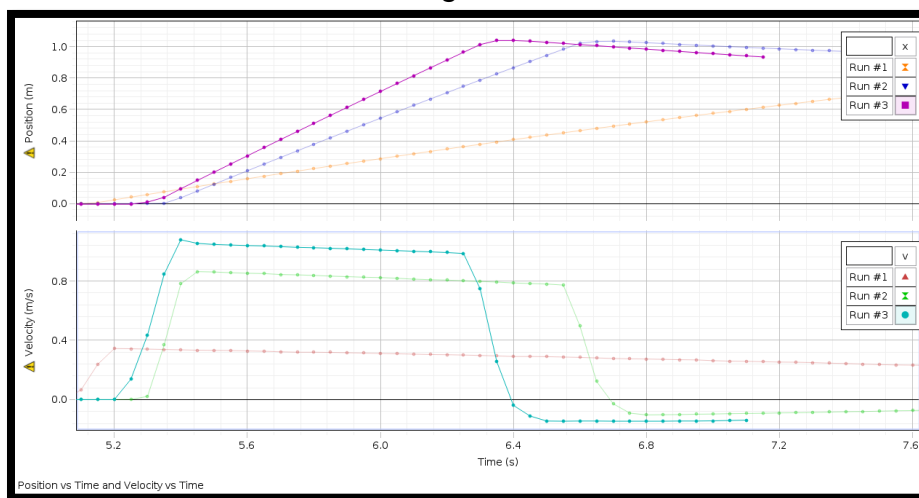


Figure 9 = Good 😊

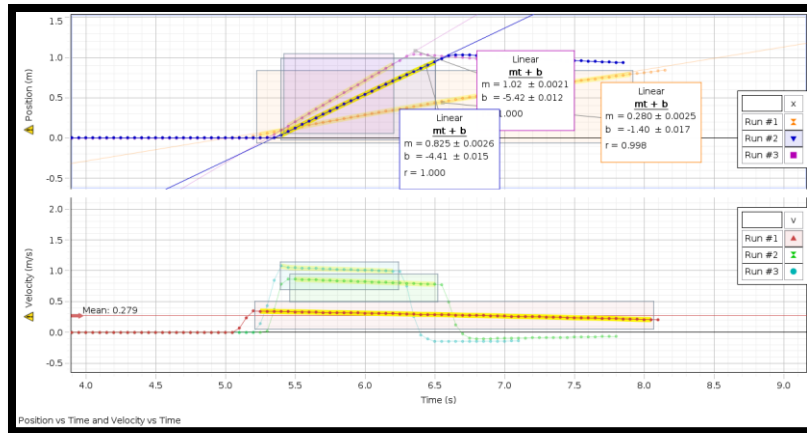


Figure 10 = A mess ☹

21. Now let's polish the graph up to prepare to export it to our lab document. In the bottom left of the graph area you should see a place to give the graph a title. Click and enter a title for both graphs. In this particular experiment you should type *Position vs Time and Velocity vs Time*. (Remember that graphs are always named *Dependent Variable vs Independent Variable*. In future experiments you'll need to title all graphs properly.)
22. At the top of the page, find the Display menu. Click on this menu and then select "Copy Display." (See Figure 11.) You can now paste the graph into a document. (For now it may be convenient to open a Word document and save the image there. Eventually you can move the image to another document as needed.)

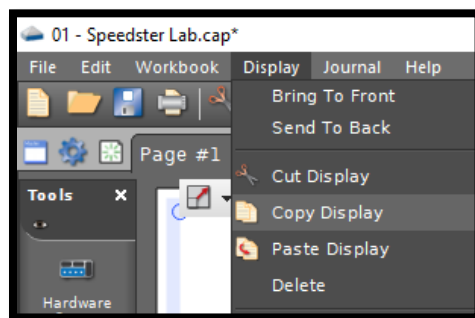


Figure 11

Data Tables & Graphs: This section should include:

- A clearly-labeled and well-organized data table that shows the slopes of the Position vs Time graphs and the means of the Velocity vs Time graphs for all three runs. Be sure to include units.
- Image the graph

Calculations: No calculations required for this lab

Conclusion: Write a conclusion summarizing what the results reveal about each of the objectives of the lab.