

# File

ΑΣΚΗΣΗ\_2Α\_EX-5503A Newton's 1st Law w Data.cap

File Edit Workbook Display Journal Help

New Experiment Ctrl+N  
Open Experiment... Ctrl+O  
Save Experiment Ctrl+S  
Save Experiment As...  
Preferences  
Import Data...  
Export Data...  
Recent Experiments  
Print Page Setup  
Print Preview...  
Print... Ctrl+P  
Exit

ory Setup 1 Procedure 1 Analysis 1 Setup 2 Procedure 2 Analysis 2 Conclusions

## Newton's First Law

### Equipment

1	Smart Cart Blue	ME-1241
1	Friction Block	ME-9807
1	Super Pulley with Clamp	ME-9448B
1	Mass and Hanger Set	ME-8979
1	Braided Physics String	SE-8050

### Introduction

The purpose of this experiment is to determine how external forces influence an object's motion. The following objects are pushed briefly: A cart and a friction block. An analysis of this motion yields Newton's First Law.

*Written by Chuck Hunt*

File → Print → Microsoft Print to PDF

The screenshot shows a software application window titled "Newton's First Law". The "File" menu is open, and the "Print..." option (Ctrl+P) is highlighted with an orange arrow. A "Print" dialog box (Εκτύπωση) is open, showing the "General" (Γενικά) tab. In the "Printer Selection" (Επιλογή εκτυπωτή) section, "Microsoft Print to PDF" is selected and highlighted with a blue bar and an orange arrow. Other printers listed include Fax, HP Laser 103 107 108, Microsoft XPS Document Writer, and Wondershare PDFelement. The status is "Ready" (Έτοιμο). The "Page Range" (Περιοχή σελίδων) section has "All" (Όλες) selected. The "Number of Copies" (Αριθμός αντιτύπων) is set to 1. The "Print" (Εκτύπωση) button is highlighted with a blue border.

**Equipment**

1	Smart Cart Bl
1	Friction Block
1	Super Pulley v
1	Mass and Han
1	Braided Physi

**Introduction**

The purpose of following object First Law.

Written by Chuck Hunt

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# File → Workbook → Lock – Unlock All Pages

ASIKH2H\_2A\_EX-5503A Newton's 1st Law w Data.cap

File Edit Workbook Display Journal Help

Add Page  
Delete Page  
Rename Page  
Lock All Pages  
Unlock All Pages  
Edit Master Page  
Show Tools Palette  
Show Displays Palette  
Show Controls Palette  
Show All Palettes  
Workbook Page Properties

Setup 1 Procedure 1 Analysis 1 Setup 2 Procedure 2 Analysis 2 Conclusions

## Newton's First Law

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New  
Experiment

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Open  
Experiment



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Save  
Experiment



Undo Insert snapshot

Undo

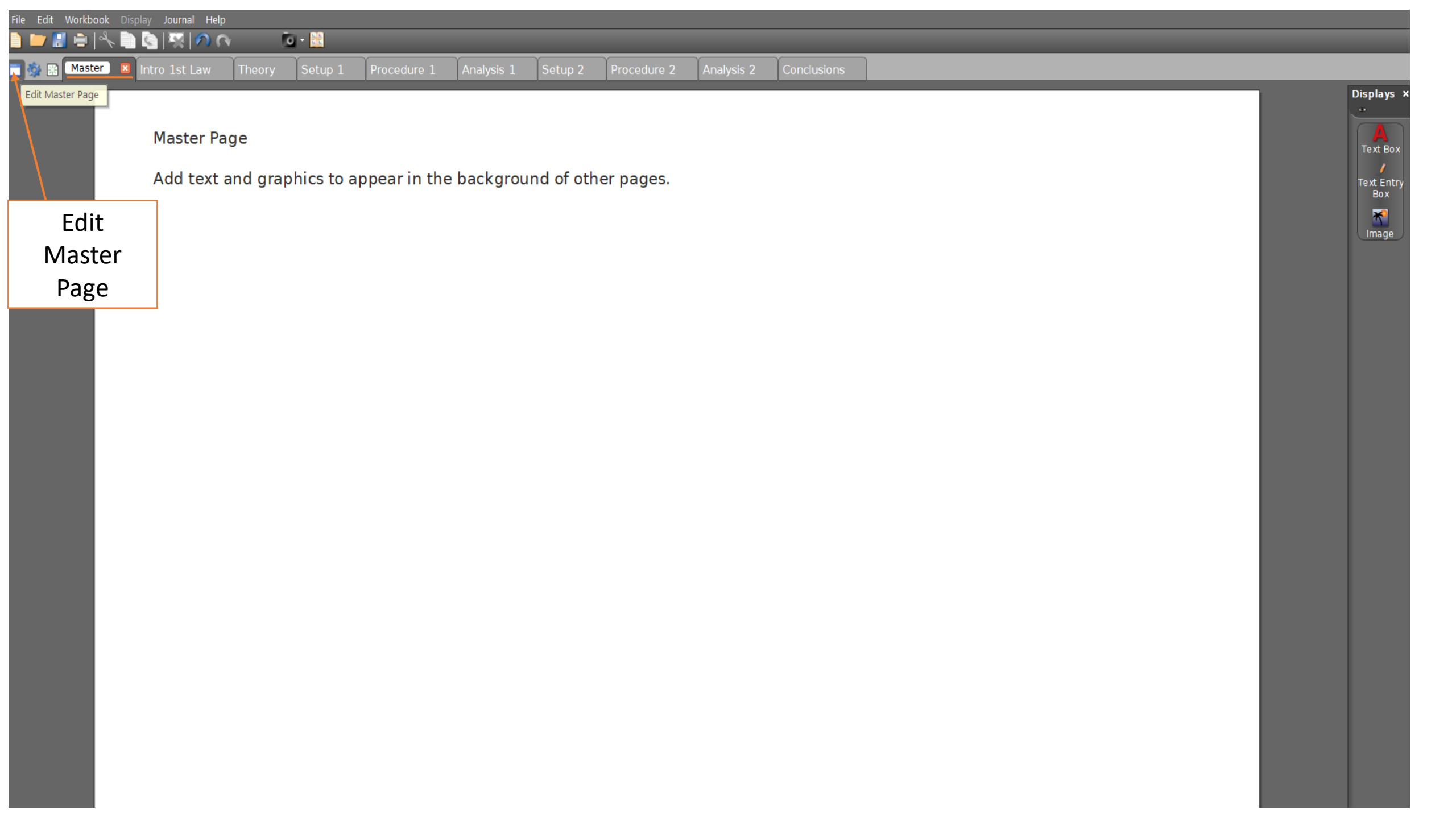
# Newton's First Law

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Edit Master Page

## Master Page

Add text and graphics to appear in the background of other pages.

Edit  
Master  
Page

Displays

- Text Box
- Text Entry Box
- Image





Change properties of current page and Tools Palette

Change Properties

## Equipment

1	Smart Cart
1	Friction Block
1	Super Pulley
1	Mass and Hanger
1	Braided String

## Introduction

The purpose of this experiment is to show how external forces influence an object's motion. The following object is used: a friction block. An analysis of this motion yields Newton's First Law.

Properties

- ▶ Page Options
- ▶ Tools Palette
- ▶ Workbook Options


Click on an item for a brief description.

OK

# 's First Law

how external forces influence an object's motion. The friction block. An analysis of this motion yields Newton's

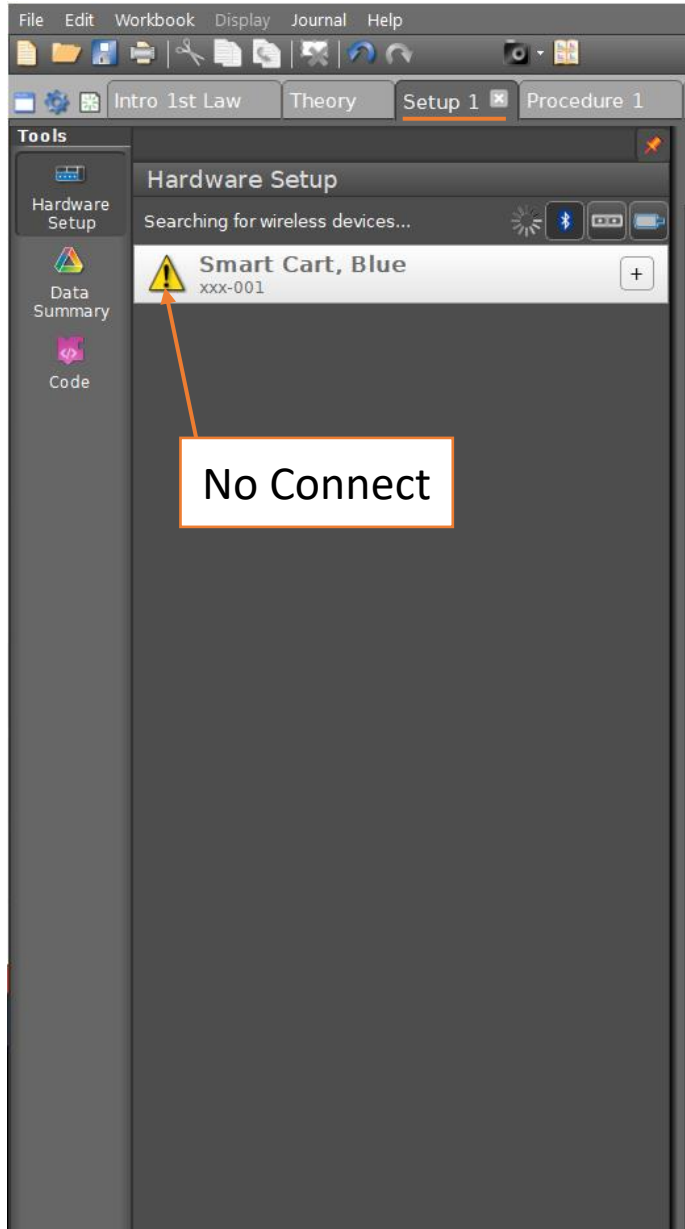
Drag a display onto the page or choose one of the QuickStart page templates below.



Add Page

- Hardware Setup
- Data Summary
- Calibration
- Calculator
- Code

- Graph
- Table
- Digits
- Scope
- FFT
- Meter
- Bar Meter
- Histogram
- Circuit
- Video Analysis
- Image
- Movie
- Text Box
- Text Entry Box
- Placeholder



File Edit Workbook Display Journal Help

Intro 1st Law Theory Setup 1 Procedure 1 Analysis 1 Setup 2 Procedure 2 Analysis 2 Conclusions

Tools

Hardware Setup


Searching for wireless devices...

Smart Cart, Blue  
xxx-001


No Connect

### Setup

1. Turn on the Smart Cart and connect to the Smart Cart via Bluetooth in the Hardware Setup.
2. Use adjustable feet on both ends to level the track. Give the cart a little push in one direction to see if it coasts to a stop or accelerates and then push it in the direction to see if the cart coasts to a stop equally in both directions.
3. Put the Friction Block on the track with the wood side down.
4. Put the Smart Cart on the track with the force sensor end (without hook) up against the Friction Block.



Smart Cart Alone



Smart Cart with Friction Block

Setup\_1 → Data Summary → Double click → Change Name

The screenshot shows a software interface with two 'Data Summary' windows. The left window shows a 'Sensor Data Summary' for a 'Smart Cart Position Sensor' with a '1.0 g' value highlighted. An orange arrow points from this value to the right window, where the same '1.0 g' value is highlighted with a white text box. The interface includes a menu bar (File, Edit, Workbook, Display, Journal, Help), tabs for 'Intro 1st Law', 'Theory', 'Setup 1', 'Procedure 1', 'Analysis 1', 'Setup 2', 'Procedure 2', 'Analysis 2', and 'Conclusions', and a sidebar with 'Tools' like 'Hardware Setup', 'Data Summary', and 'Code'.

connect to the Smart Cart via Bluetooth in the Hardware Setup.  
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and then push it in the direction to see if the cart coasts to a stop equally in both  
track with the wood side down.  
back with the force sensor end (without hook) up against the Friction Block.



Smart Cart with Friction Block

Setup\_1 → Calibration → Double click → Change

**Calibration**

1 Choose the type of measurement you would like to calibrate:

No measurements to calibrate

Back Next Cancel

**Figure 5: Frictional**

**Figure 6: String**

**Friction & String Mass Compensation:**

1. Add an additional 5 g to  $m_2$ . The two masses should now balance. If there were no friction and the string were massless, then if we gave  $m_1$  a push downward, it would continue at constant speed.
2. Move  $m_1$  to its highest point. Click RECORD. Give  $m_1$  a gentle push downward and release it.
3. When  $m_1$  stops moving or strikes the floor, click STOP. The masses may touch as they pass each other. If so, click the Delete Last Run button at the bottom of the screen and repeat the run.
4. Click the Data Summary button at the left of the screen. Double click on the current run (probably Run #1) and re-label it "Equal mass run". Click Data Summary again to close the panel.
5. Your Linear Speed vs Time graph should look like Figure 5. Answer Question 1 on the Conclusions page.
6. Add 0.5 g to  $m_1$  and repeat. Label this run "0.5 g run". Then add another 0.5 g and repeat again until you get a graph like Figure 6. Since you only have 0.5 g increments, your graph may not be quite as symmetric as

**Friction Compensation Runs**

Linear Speed (m/s)

Time (s)

1.0 g run v

**Tools**

- Hardware Setup
- Data Summary
- Calibration
- Calculator
- Signal Generator
- Code

**Calculator**

New Delete Accept

Calculations	Units
1 Total mass=[m <sub>1</sub> (g)]+[m <sub>2</sub> (g)]+[String Mass (g)]+[Fri...	g
2 m <sub>1</sub> -m <sub>2</sub> =[m <sub>1</sub> (g)]-[m <sub>2</sub> (g)]	g
3 Theory a=[Accel due to gravity (m/s/s)]*[m <sub>1</sub> -m <sub>2</sub> (g)]/...	m/s <sup>2</sup>
4 % high=100*((Theory a (m/s <sup>2</sup> ))-[Exp. a (m/s <sup>2</sup> )])/[Exp...	%
5 Corr Tot m=[Total mass (g)]+[Effect. Rot. m (g)]	g
6 Corr a=[Accel due to gravity (m/s/s)]*[m <sub>1</sub> -m <sub>2</sub> (g)]/[C...	m/s <sup>2</sup>
7 % diff=100*((Exp. a (m/s <sup>2</sup> ))-[Corr a (m/s <sup>2</sup> )])/[Corr a (...	%
8	

Measurement assignment OK

Total mass=[m<sub>1</sub>(g)]+[m<sub>2</sub>(g)]+[String Mass(g)]+[Friction Mass(g)]

DEG RAD

Scientific: sin, cos, tan, arcsin, arccos, arctan, x<sup>2</sup>, e<sup>x</sup>, 10<sup>x</sup>, √, LN, LOG, y<sup>x</sup>, 1/x, !, abs, EE, °

Simple: +, -, \*, /, π, (, )

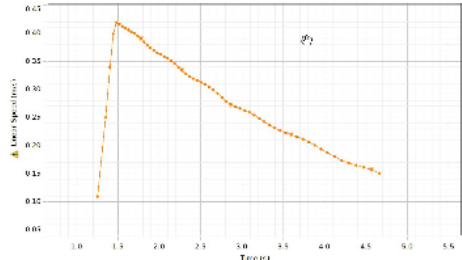


Figure 5: Frictional

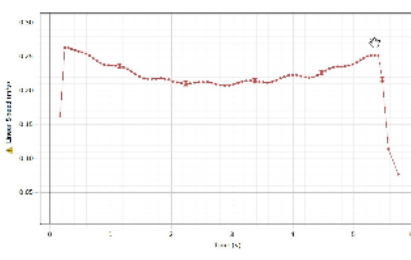
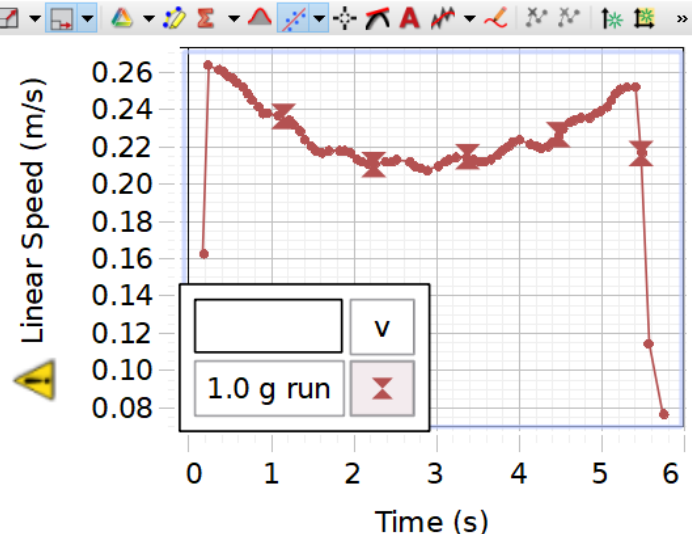


Figure 6: String

**Friction & String Mass Compensation:**

- Add an additional 5 g to m<sub>2</sub>. The two masses should now balance. If there were no friction and the string were massless, then if we gave m<sub>1</sub> a push downward, it would continue at constant speed.
- Move m<sub>1</sub> to its highest point. Click RECORD. Give m<sub>1</sub> a gentle push downward and release it.
- When m<sub>1</sub> stops moving or strikes the floor, click STOP. The masses may touch as they pass each other. If so, click the Delete Last Run button at the bottom of the screen and repeat the run.
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- Add 0.5 g to m<sub>1</sub> and repeat. Label this run "0.5 g run". Then add another 0.5 g and repeat again until you get a graph like Figure 6. Since you only have 0.5 g increments, your graph may not be quite as symmetric as



Friction Compensation Runs

Tools

- Hardware Setup
- Data Summary
- Calculator
- Curve Fit Editor
- Code

### Procedure A: Stretching the Spring

1. Start with the spring unstretched and slack in the string. Your hand should be on the end of the cart away from the Motion Sensor (so the sensor will not measure the position of your hand).
2. Click RECORD at the bottom left of the screen.
3. Push the cart until it is about 15 cm away from the Motion Sensor, then slowly back until it is back where it started from. Click STOP. The data on the Hooke's Law Graph should be very linear and the force should be zero at the right side.
4. Click open Data Summary at the left of the screen. Double-click on this run (probably Run #1) and re-label it "Weak Spring". Note that you can delete bad runs by using the Delete Last Run button at the bottom right of the screen, or the right of the button to delete specific runs. Click Data Summary again.
5. Push the car until the spring is stretched a certain amount. Click RECORD. Hold the car still for a few seconds.
6. Release the car. Press STOP after the car hits the bumper. The spring may come unhooked. If it does, try to prevent the car from striking the Motion Sensor.
7. Verify that you have good data for the speed of the car after the spring stops pulling on it and its speed is constant.
  - Open the "v Graph" tab.
  - Verify that the speed becomes constant before the car hits the bumper (speed rapidly becomes negative at the bumper). If you don't see a flat plateau (like the region between 1.70 s and 1.83 s in Figure 3) due to noise, delete the run, and do it again. If noise is a problem, make sure there are no objects near the track to reflect the signal. You may need to change the angle on the Motion Sensor.
8. Click open Data Summary and label this run as "15 cm".
9. Repeat steps 5-9 for initial stretches of 30 cm and 45 cm. Label them "30 cm" and "45 cm".
10. Replace the weak spring with one of the strong springs and repeat steps 1-4. Label the run "Strong Spring".

No Connect

Record

Select Sensor

Zero Sensor

Delete Last Run

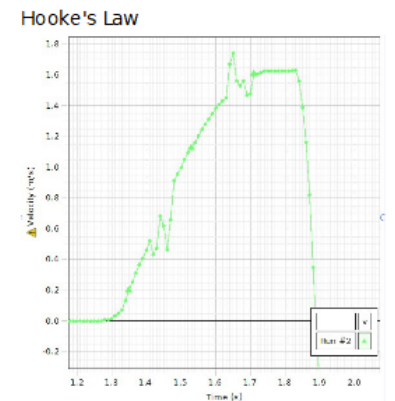
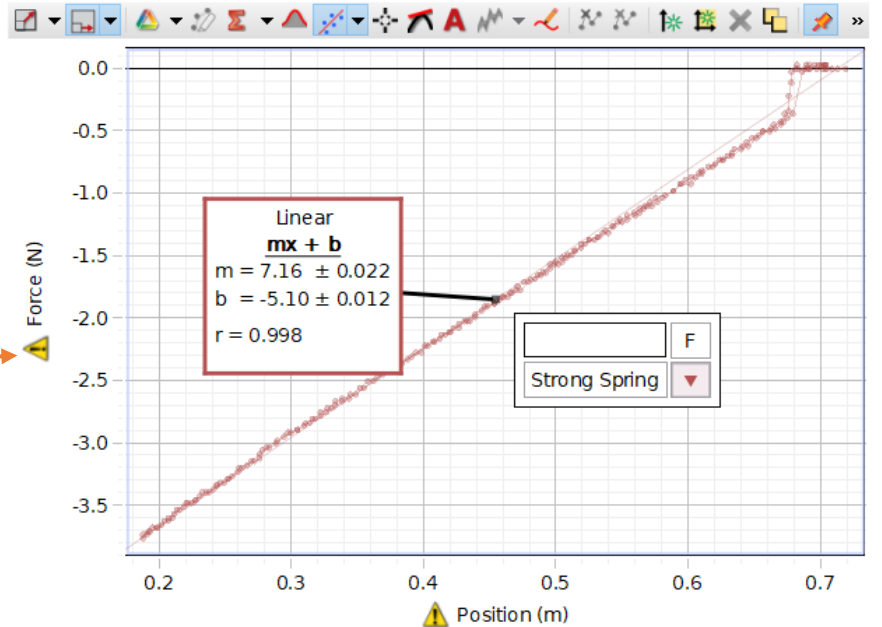


Figure 3: Constant Speed Plateau

Record Continuous Mode 00:00.00 Motion Sensor 100.00 Hz Recording Conditions Delete Last Run



## Analysis A

- Click on the black triangle by the Run Select icon on the graph toolbar and select "Weak Spring".
- Click the Scale-to-Fit icon at the left of the graph toolbar.
- Click on the Selection icon on the graph toolbar and when the selection box appears, drag the box handles to highlight all the data except the region where the force is zero because the spring is unstretched.
- Click on the black triangle by the Curve Fit icon and select Linear.
- From Equation 2 in Theory, the slope of the  $F$  vs.  $x$  plot is the Spring Constant,  $k$ . Enter the value and the uncertainty in the Spring Constant table on the Weak Spring line for  $k$  and  $\delta k$ .
- We need to determine the exact position where the spring is first unstretched,  $x_0$ . Click on the coordinates crosshairs box that appears and drag it until the vertical crosshair intersects the line (Linear) that you added with the Curve Fit tool crosses the  $F = 0$  horizontal line. Read the value in the coordinates box and enter it in the first line of the Spring Constant Table. Estimate the uncertainty in  $x_0$  by moving the vertical crosshairs a little bit (use the spread of the data to estimate how much is reasonable) left and right of the crossing point and see how much  $x$  changes in the coordinates box. Enter the value as  $\delta x_0$  in the Spring Constants table.
- Right click in the Coordinates tool box and select Delete Tool. Click on the black triangle by the Curve Fit icon and turn off "Linear". Click anywhere in the Selection box to highlight it and click the Remove Active Element icon.
- Repeat steps 1-5 and 7 for "Strong Spring".
- We need the start position,  $x_1$ , for each of the accelerated runs. Click the black triangle by the Run Select icon and select "15 cm". Click the Scale to Fit icon.
- If you don't see the coordinate crosshairs, click on the Coordinate tool icon. Grab the coordinate crosshairs and move it so the vertical crosshairs is directly above the start of the run (max force). It should be easy to see the start since you held the cart there for several seconds and the force sensor varies a bit and makes a short vertical line. Record the value of the start position and enter it in the Spring Constants table in the first row in the " $x_1$  15" column. Right click on the coordinate tool and delete it. Repeat for the "30 cm" and "45 cm" runs.

Table I: Spring Constants

	Spring	$k$ (N/m)	$\delta k$ (N/m)	$x_0$ (m)	$\delta x_0$ (m)	$x_1$ 15 (m)	$x_1$ 30 (m)	$x_1$ 45 (m)
1	Weak	3.44	0.01	0.681	0.002	0.524	0.375	0.232
2	Strong	6.86	0.01					
3								
4								





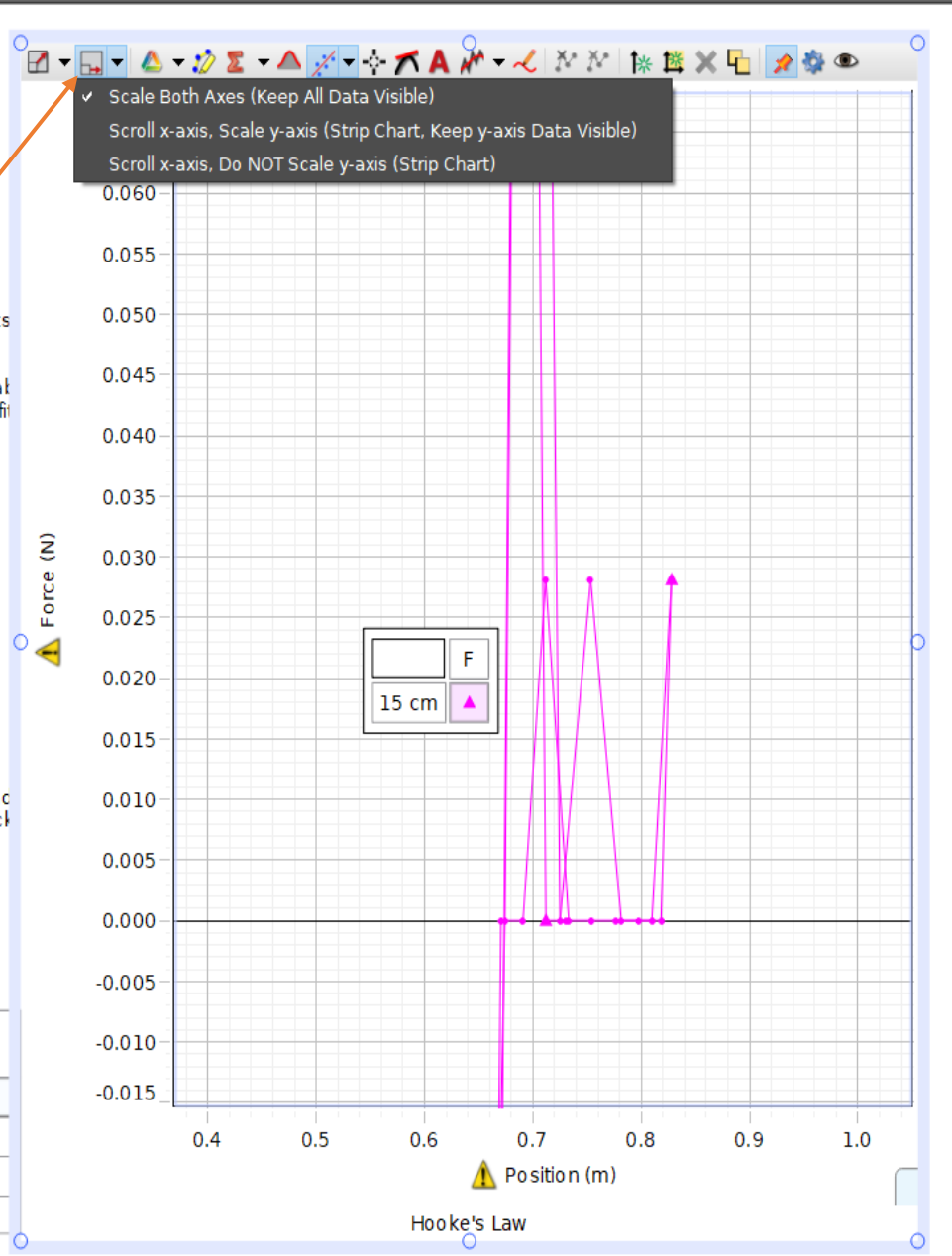
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- Click on the black triangle by the Curve Fit icon and select Line
- From Equation 2 in Theory, the slope of the  $F$  vs.  $x$  plot is the  $S$  and its uncertainty in the Spring Constant table on the Weak Spring line
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Scale Axes

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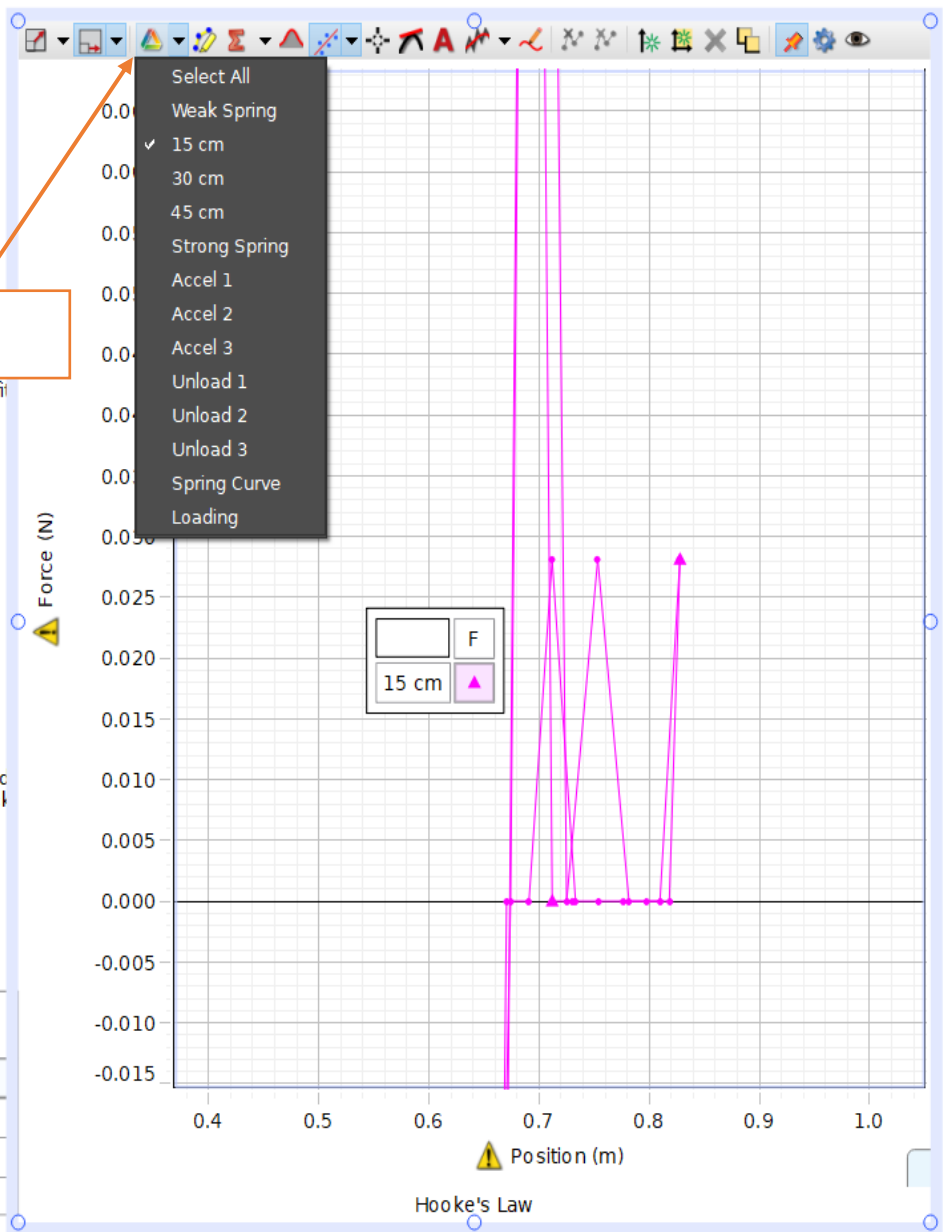
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Select Run



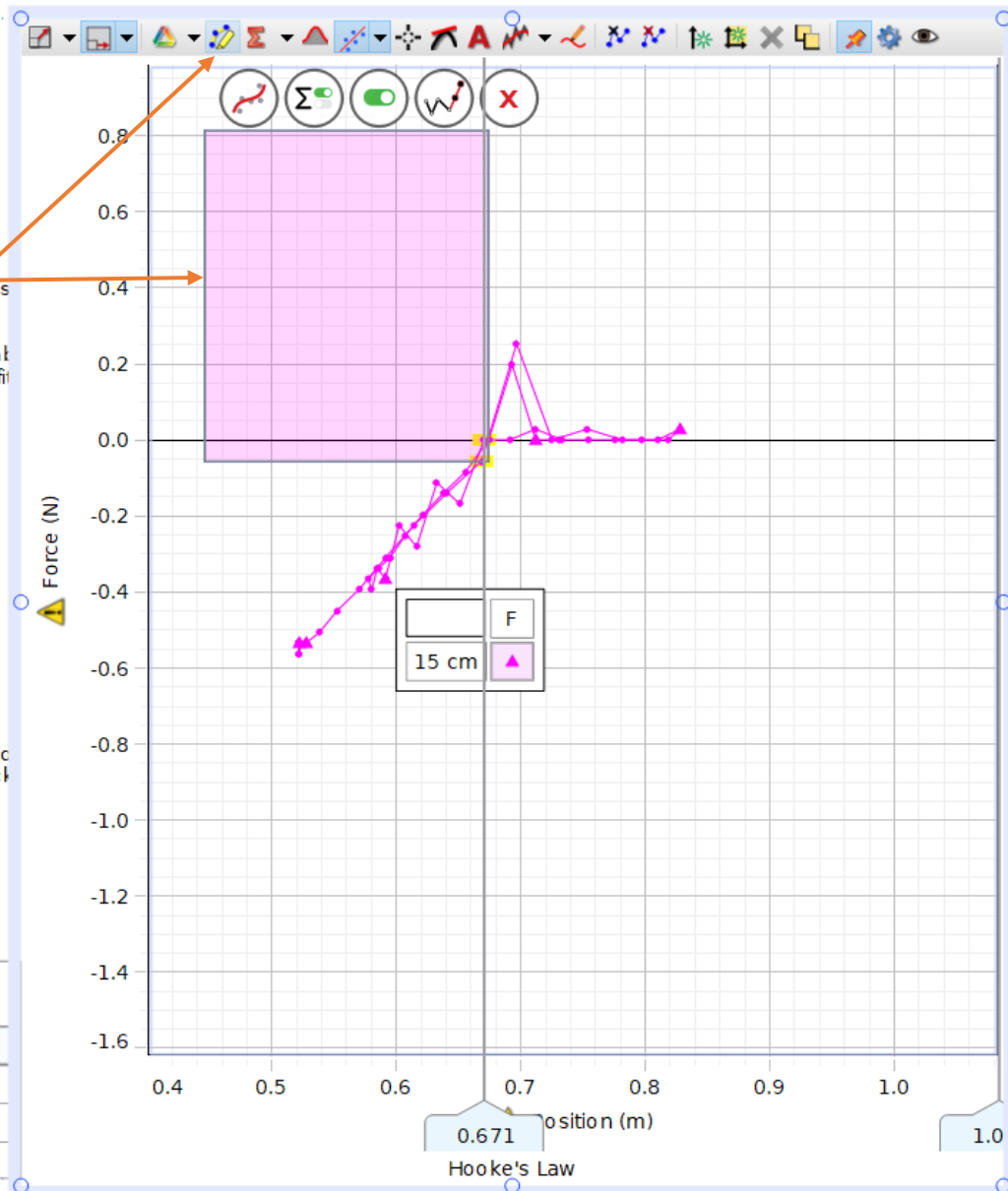
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Data Selection  
by square



**Tools**

- Data Summary
- Calculator
- Curve Fit Editor
- Code

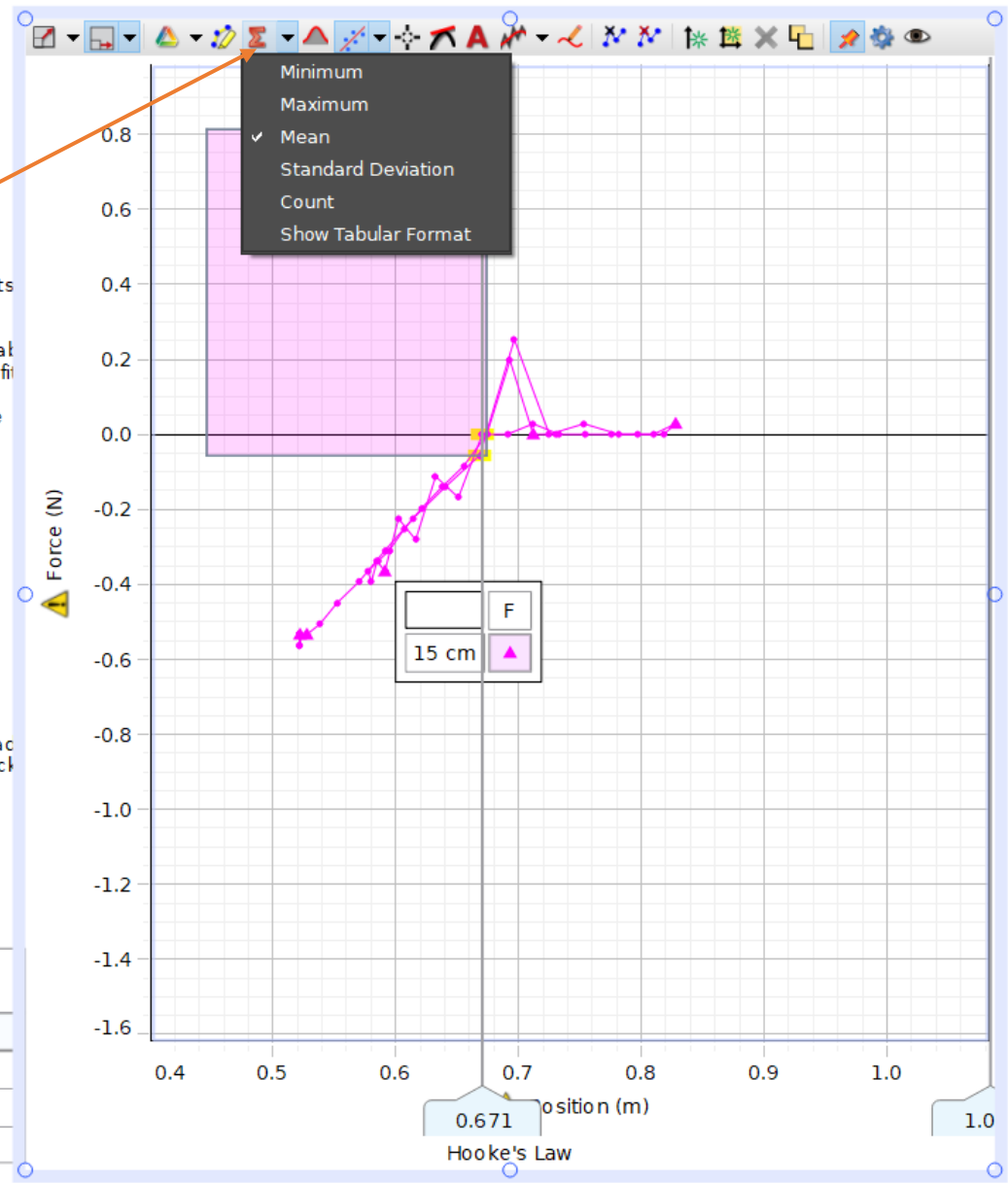
## Analysis A

1. Click on the black triangle by the Run Select icon on the graph toolbar and select "Weak Spring".
2. Click the Scale-to-Fit icon at the left of the graph toolbar.
3. Click on the Selection icon on the graph toolbar and when the selection box appears highlight all the data except the region where the force is zero because the spring is not stretched.
4. Click on the black triangle by the Curve Fit icon and select Linear.
5. From Equation 2 in Theory, the slope of the F vs. x plot is the Spring Constant, k. Enter the value of k and its uncertainty in the Spring Constant table on the Weak Spring line for k and  $\delta k$ .
6. We need to determine the exact position where the spring is first unstretched,  $x_0$ . Click on the Coordinates tool. Grab the coordinates crosshairs box that appears and drag it until the vertical crosshair intersects the point where the best fit line (Linear) that you added with the Curve Fit tool crosses the  $F = 0$  horizontal line. Read the value of  $x_0$  from the coordinates box and enter it in the first line of the Spring Constant Table. Estimate the uncertainty in  $x_0$  by moving the vertical crosshairs a little bit (use the spread of the data to estimate how much is reasonable) left and right of the crossing point and see how much x changes in the coordinates box. Enter the value as  $\delta x_0$  in the Spring Constants table.
7. Right click in the Coordinates tool box and select Delete Tool. Click on the black triangle by the Curve Fit icon and turn off "Linear". Click anywhere in the Selection box to highlight it and click the Remove Active Element icon.
8. Repeat steps 1-5 and 7 for "Strong Spring".
9. We need the start position,  $x_1$ , for each of the accelerated runs. Click the black triangle by the Run Select icon and select "15 cm". Click the Scale to Fit icon.
10. If you don't see the coordinate crosshairs, click on the Coordinate tool icon. Grab the coordinate crosshairs and move it so the vertical crosshairs is directly above the start of the run (max force). It should be easy to see the start since you held the cart there for several seconds and the force sensor varies a bit and makes a short vertical line. Record the value of the start position and enter it in the Spring Constants table in the first row in the " $x_1$  15" column. Right click on the coordinate tool and delete it. Repeat for the "30 cm" and "45 cm" runs.

Find\_Min-Max-Mean

Table I: Spring Constants

	Spring	k (N/m)	$\delta k$ (N/m)	$x_0$ (m)	$\delta x_0$ (m)	$x_1$ 15 (m)	$x_1$ 30 (m)	$x_1$ 45 (m)
1	Weak	3.44	0.01	0.681	0.002	0.524	0.375	0.232
2	Strong	6.86	0.01					
3								
4								



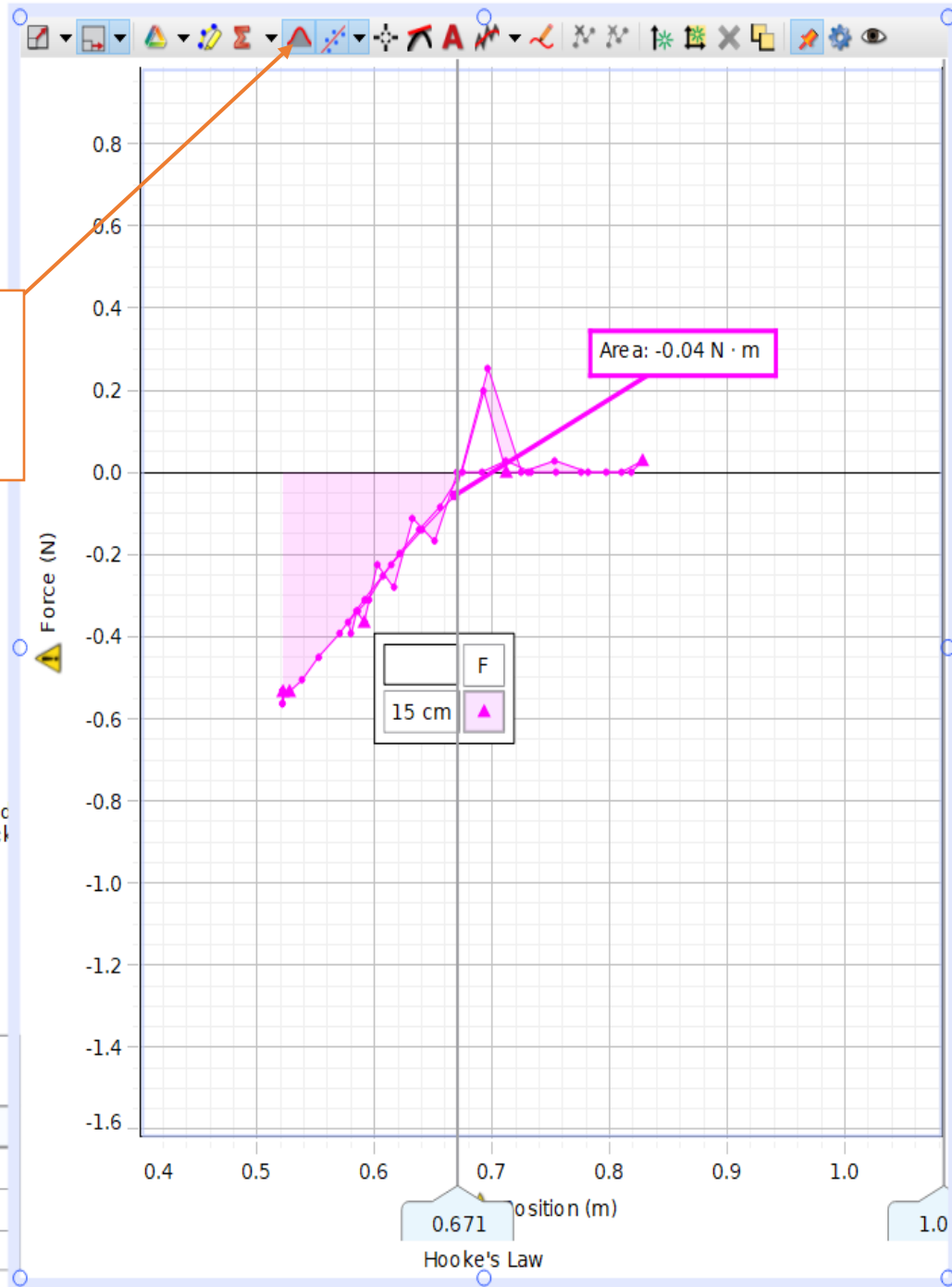
## Analysis A

- Click on the black triangle by the Run Select icon on the graph toolbar and select "Weak Spring".
- Click the Scale-to-Fit icon at the left of the graph toolbar.
- Click on the Selection icon on the graph toolbar and when the selection box appears, drag the box handles to highlight all the data except the region where the force is zero because the spring is unstretched.
- Click on the black triangle by the Curve Fit icon and select Linear.
- From Equation 2 in Theory, the slope of the  $F$  vs.  $x$  plot is the Spring Constant,  $k$ . Enter the value and the uncertainty in the Spring Constant table on the Weak Spring line for  $k$  and  $\delta k$ .
- We need to determine the exact position where the spring is first unstretched,  $x_0$ . Click on the coordinates crosshairs box that appears and drag it until the vertical crosshair intersects the line (Linear) that you added with the Curve Fit tool crosses the  $F = 0$  horizontal line. Enter the value in the coordinates box and enter it in the first line of the Spring Constant Table. Estimate the uncertainty in the vertical crosshairs a little bit (use the spread of the data to estimate how much is reasonable). Enter the value as  $\delta x_0$  in the Spring Constants table.
- Right click in the Coordinates tool box and select Delete Tool. Click on the black triangle by the Curve Fit icon and turn off "Linear". Click anywhere in the Selection box to highlight it and click the Remove Active Element icon.
- Repeat steps 1-5 and 7 for "Strong Spring".
- We need the start position,  $x_1$ , for each of the accelerated runs. Click the black triangle by the Run Select icon and select "15 cm". Click the Scale to Fit icon.
- If you don't see the coordinate crosshairs, click on the Coordinate tool icon. Grab the coordinate crosshairs and move it so the vertical crosshairs is directly above the start of the run (max force). It should be easy to see the start since you held the cart there for several seconds and the force sensor varies a bit and makes a short vertical line. Record the value of the start position and enter it in the Spring Constants table in the first row in the " $x_1$  15" column. Right click on the coordinate tool and delete it. Repeat for the "30 cm" and "45 cm" runs.

Table I: Spring Constants

	Spring	$k$ (N/m)	$\delta k$ (N/m)	$x_0$ (m)	$\delta x_0$ (m)	$x_1$ 15 (m)	$x_1$ 30 (m)	$x_1$ 45 (m)
1	Weak	3.44	0.01	0.681	0.002	0.524	0.375	0.232
2	Strong	6.86	0.01					
3								
4								

Display Area  
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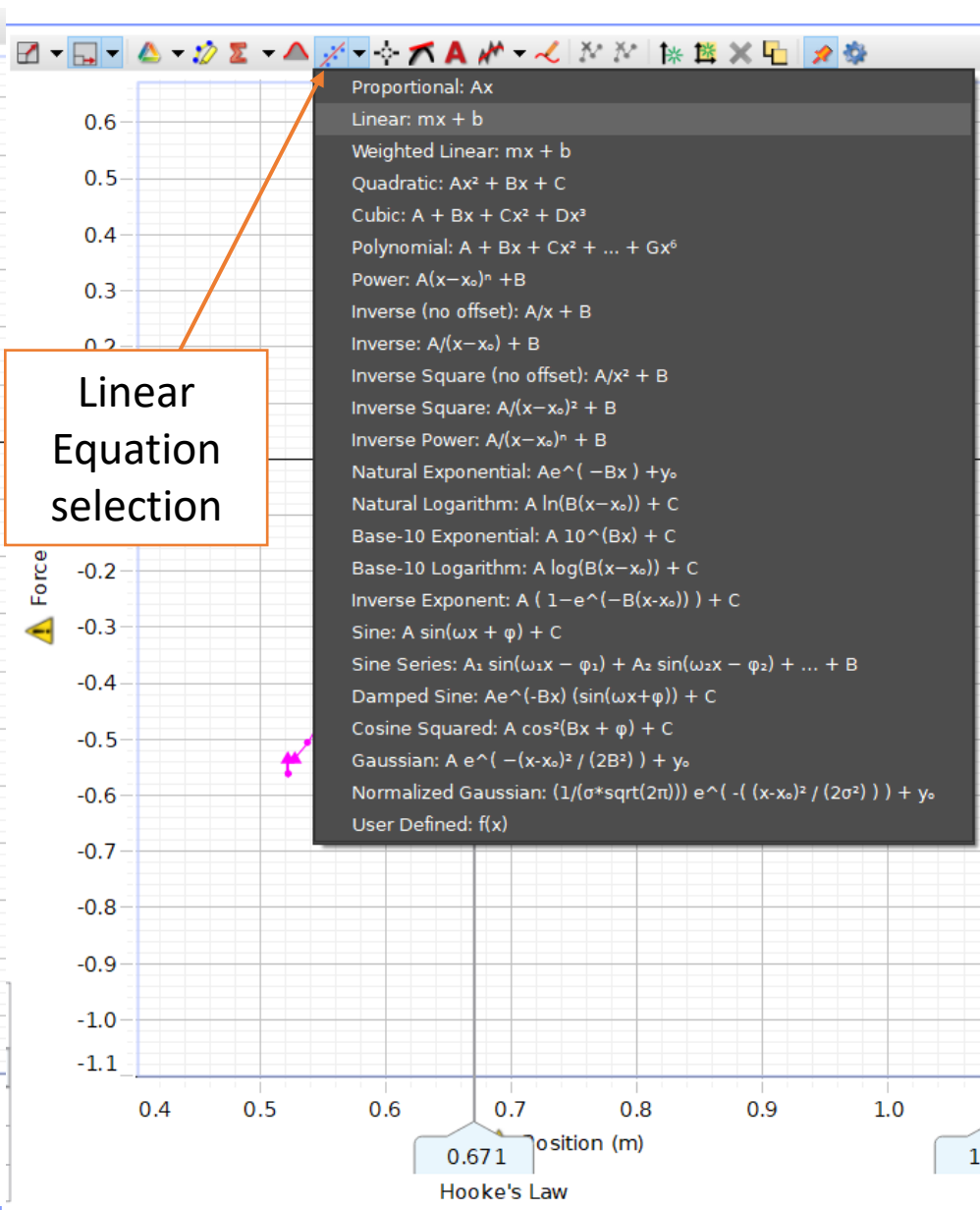
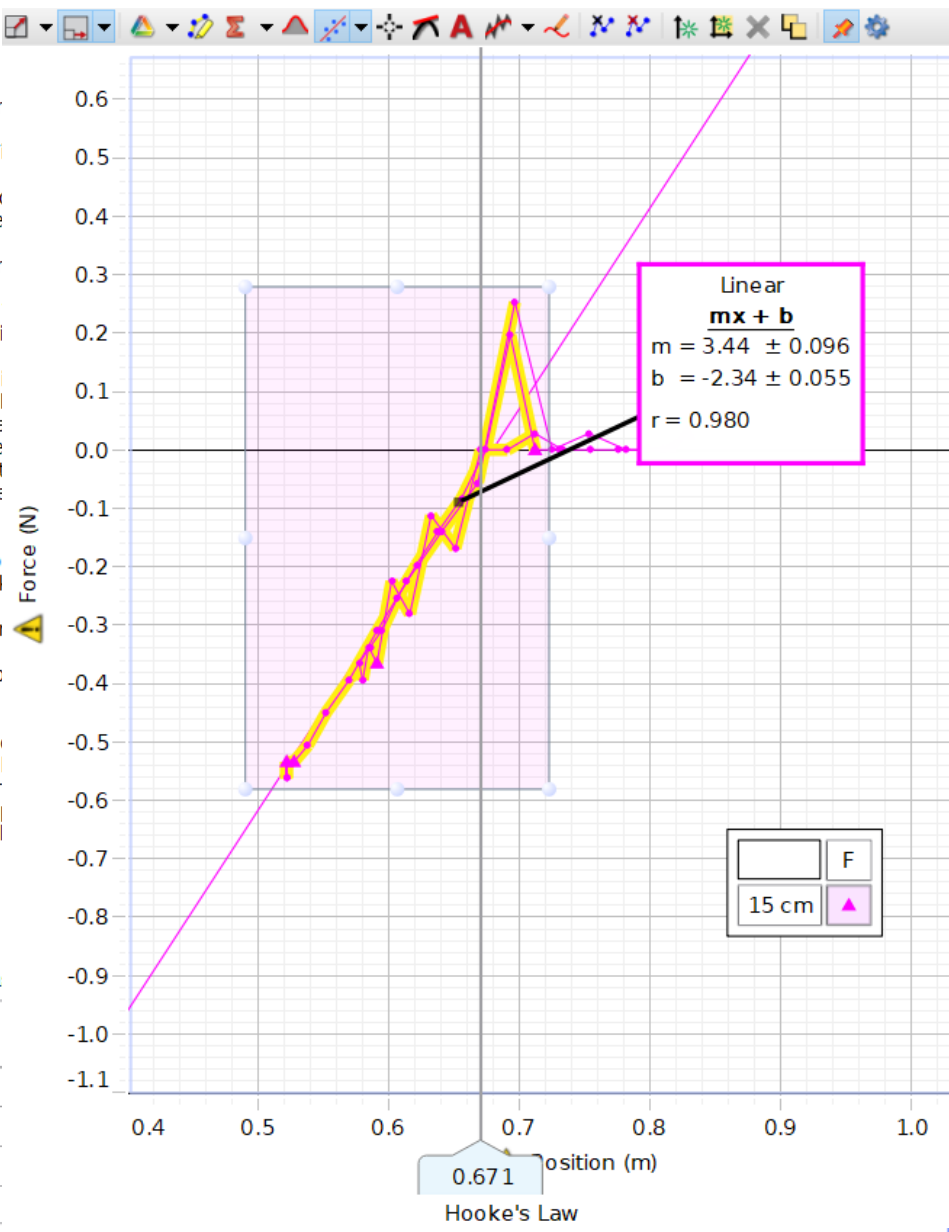
- Tools**
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  - Calculator
  - Curve Fit Editor
  - Code

### Analysis A

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Table I: Spring Con

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- Data Summary
- Calculator
- Curve Fit Editor

Multi-Coordinates Tools  
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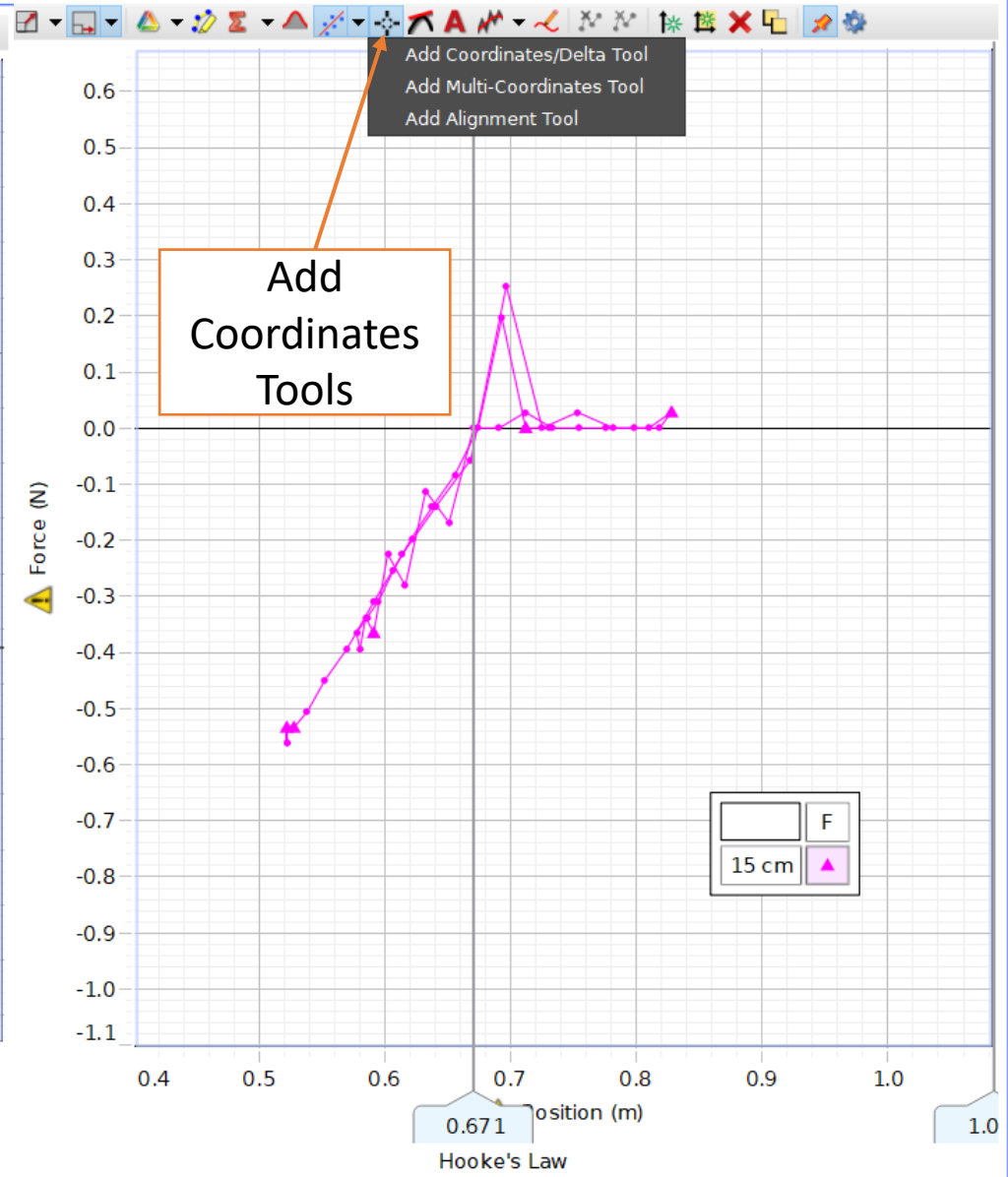
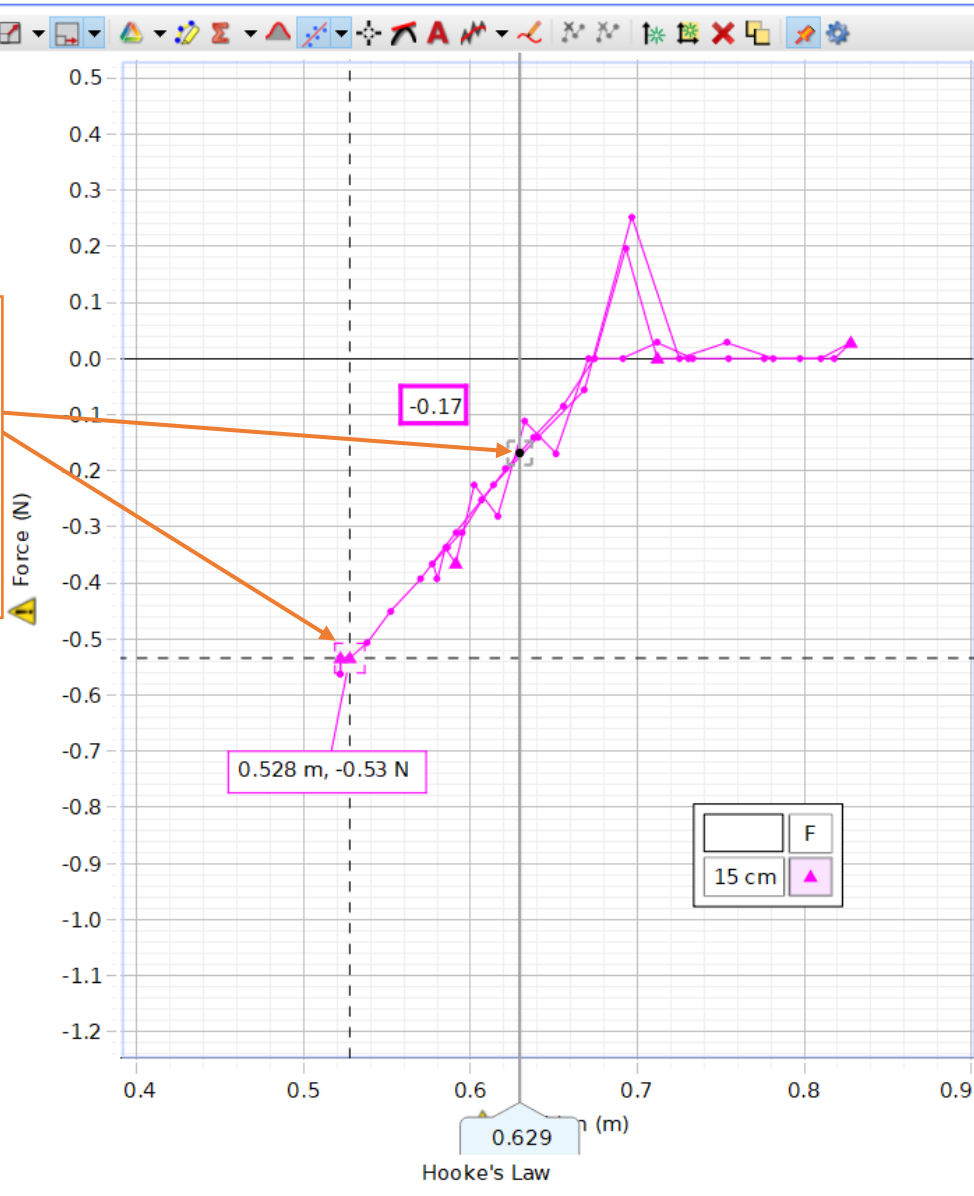
### Analysis A

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- Data Summary
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### Analysis

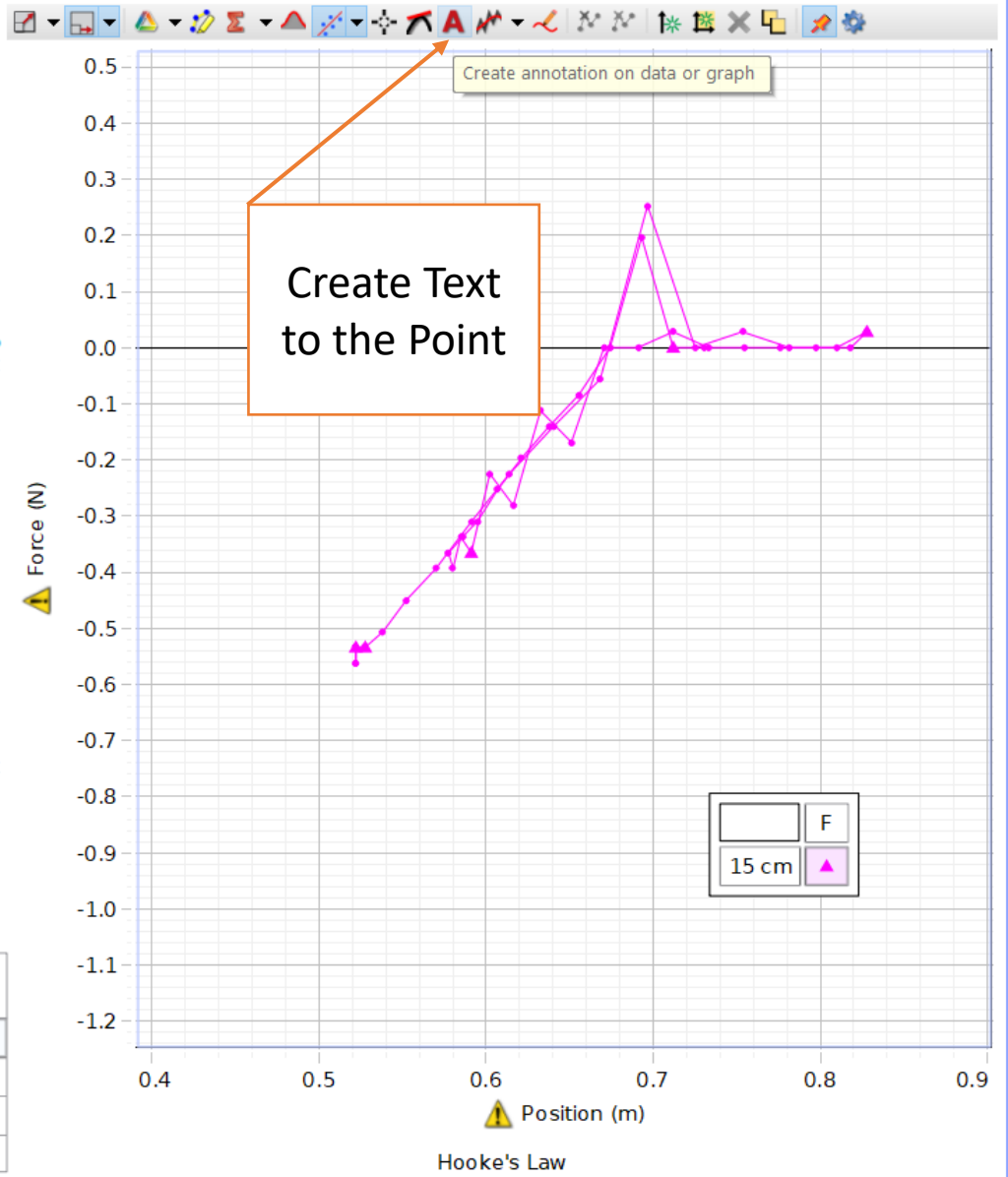
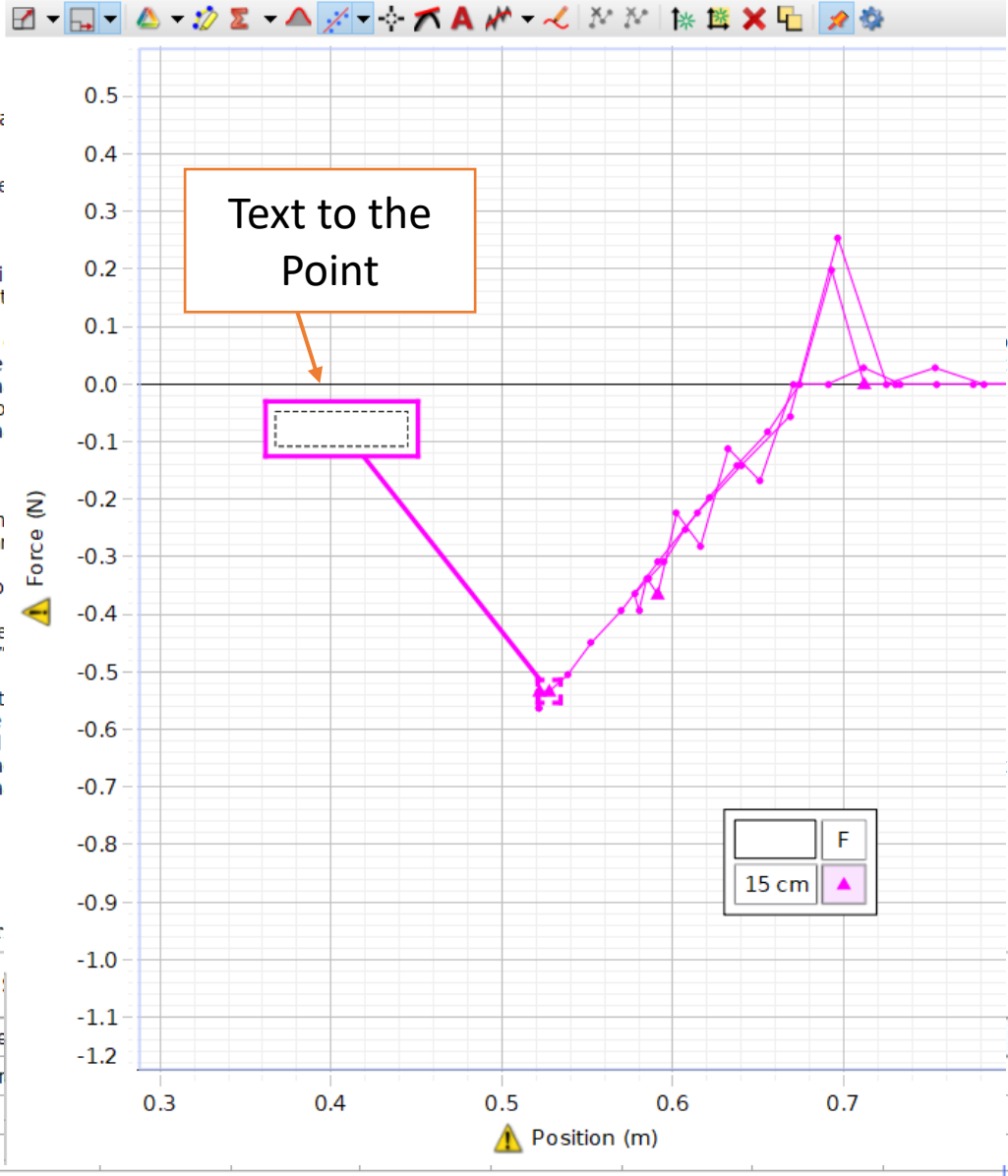


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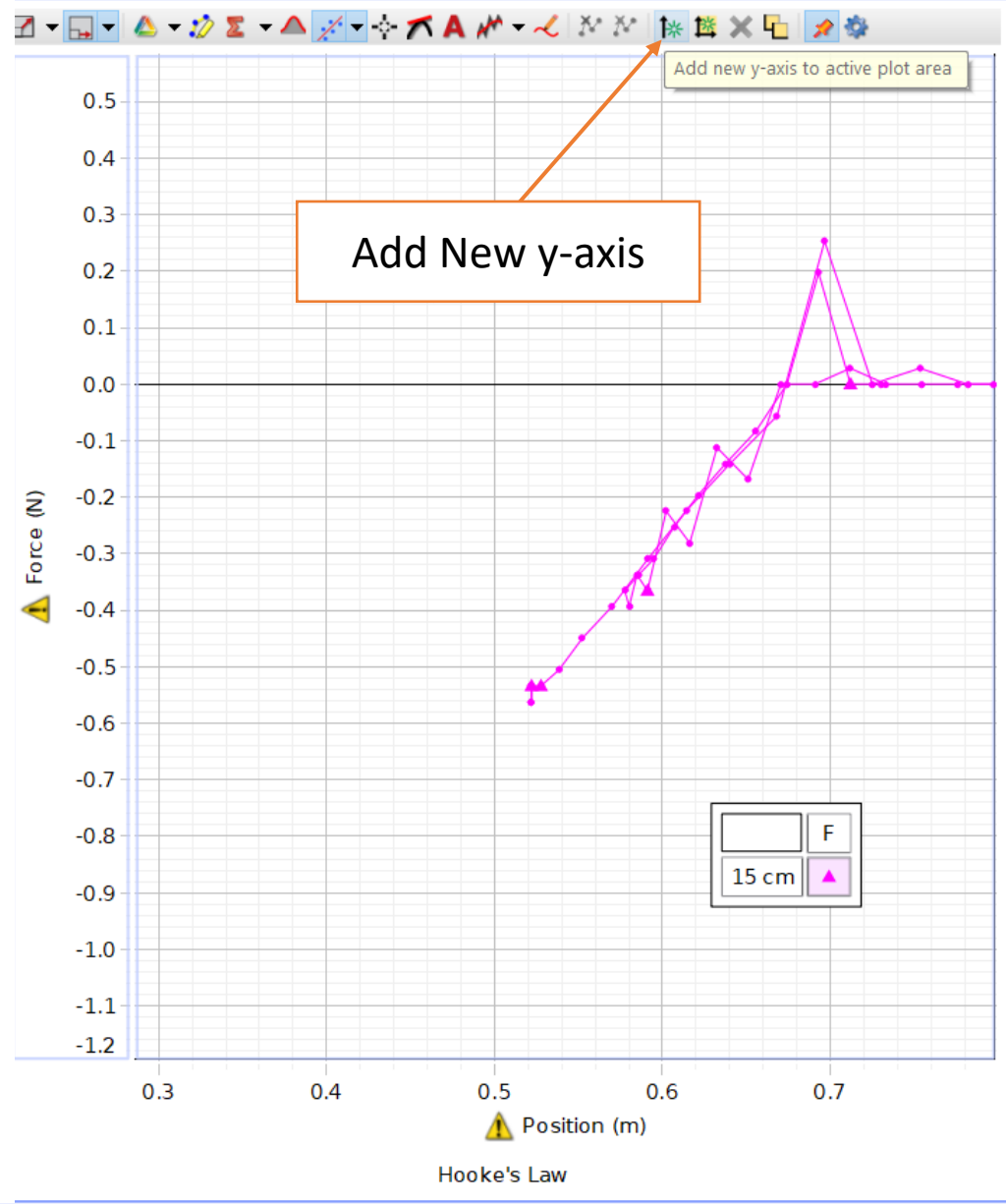
- Tools**
- Data Summary
  - Calculator
  - Curve Fit Editor
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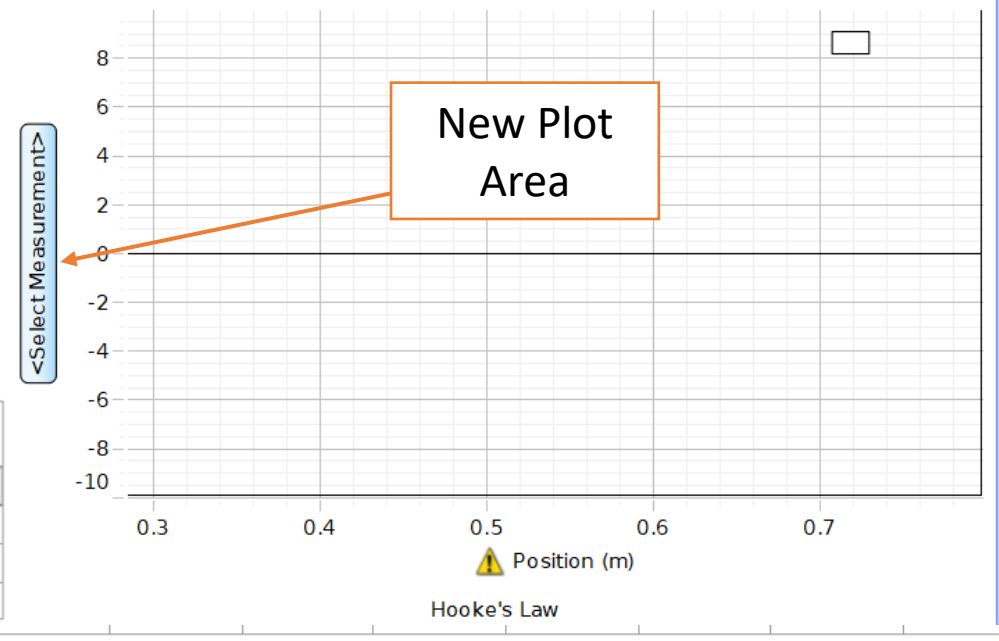
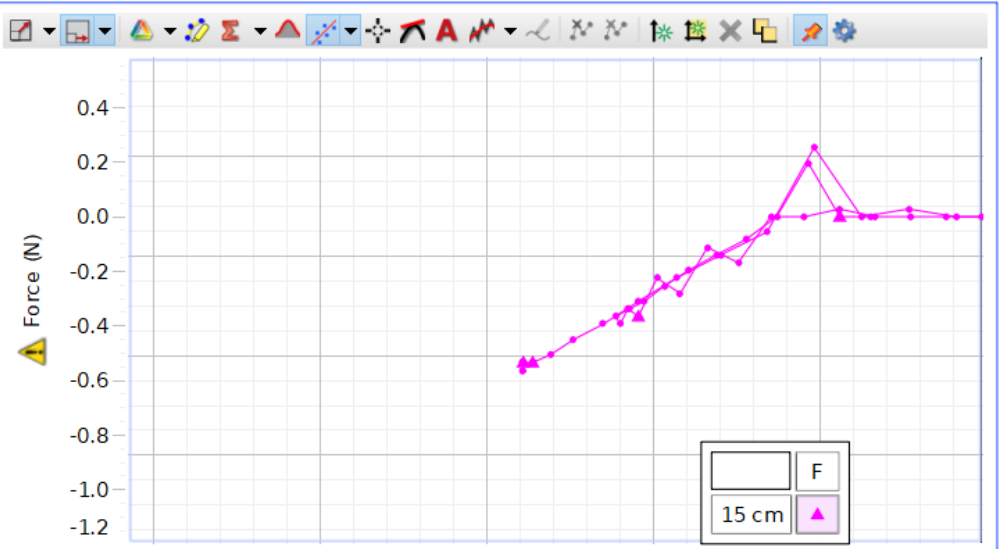
- Data Summary
- Calculator
- Curve Fit Editor
- Code

### Analysis

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### Graph

