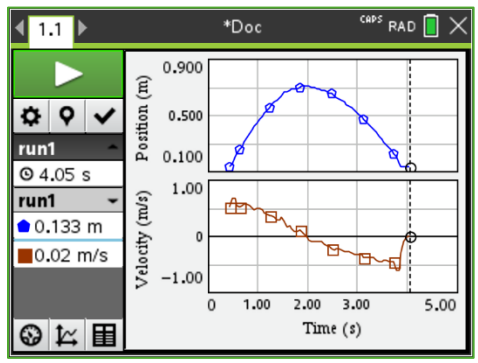
Just Rollin' Along: A CBR2 Exploration

Objectives:

- Use the area under a curve to determine total distance traveled
- Use derivatives to connect position, velocity and acceleration
- Use models to represent data from a list and scatter plot
- Use the capabilities of the graphing calculator to find cubic, quadratic, and linear regressions
- Use patterns to predict future behavior when given specific criteria (height of ramp & length of ramp)
- Use several data points to estimate the equation that would model the collected data
- Use conjectures and scientific method to predict wat happens as a certain parameter is changed (slope)

Vocabulary:

- Position
- Velocity
- Acceleration
- Regression
- Scatter Plot
- Quadratic
- Cubic
- Linear



Necessary Materials:

- ✓ 2 - Yardsticks
- ✓ 4 - Feet of Blue Tape
- ✓ 1 - Ping Pong Ball
- ✓ TI-Nspire Handheld or TI 84 +CE
- ✓ 1 - CBR2 Motion Sensor
- ✓ 1 - CBR2 to Handheld Cable
- ✓ 1 - Textbook (Or similar, to create a ramp)

Optional Materials:

- ✓ A variety of balls with varying densities, weights, textures, and sizes (Golf, Tennis, Lacross, Bouncy, Racquetball, Etc.)
- ✓ Protractor
- ✓ Video Recording Device

About the Lesson:

In this activity, the students will be able to collect data and analyze it using a variety of methods. When observing the data, multiple connections can be made between graphs, plots, and tables. Connections between cubic, quadratic, and linear functions will be explored. The applications range from Algebra to Calculus and can be used as a general process to collect, analyze and interpret data via the scientific method.

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Creating the Ramp:

• Begin by taping two yardsticks, along their long edge, and placing tape on each of the edges; see *Figure A*.

• Tape the base of the ramp to the table and set the top on a book, or something else that is about 2"off of the tabletop; see *Figure B1* and *Figure B2*.

• Place the CBR2 at the bottom of the Yardstick Ramp and make all necessary cable connections; see *Figure C*.

• It's time to start collecting some data by setting the ball at the base and blowing it up the ramp!

Figure A

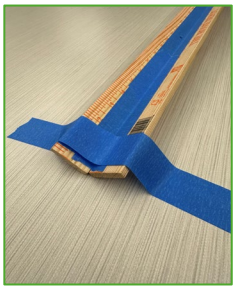


Figure B1

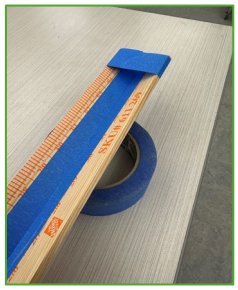


Figure B2

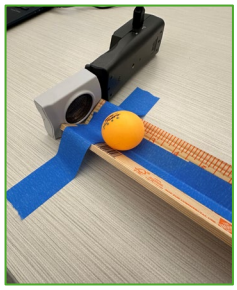
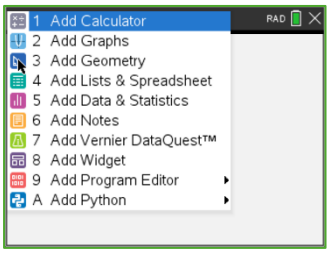


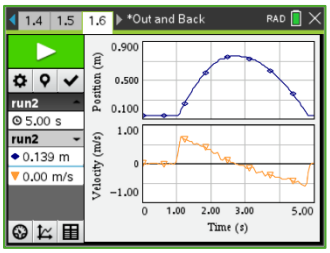
Figure C

Collecting the Data:

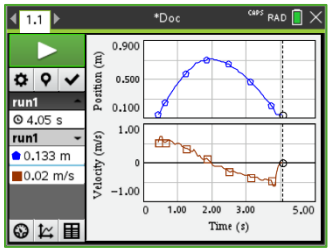
• Add a new page: "***Vernier DataQuest***"



• Run the program and start collecting data

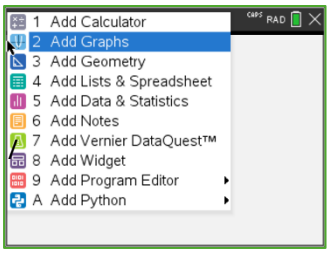


• To "Cut" the bad data, highlight the good data and use the **MENU**, **DATA**, **STRIKE** and then **OUTSIDE SLECTED REGION**

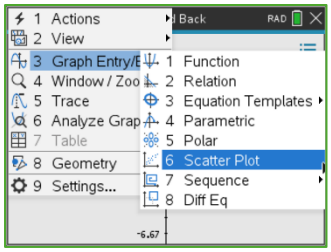


Seeing the Data - Scatter Plot:

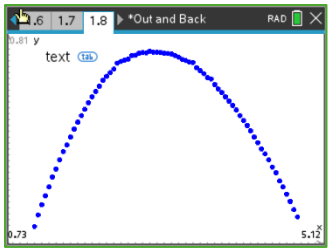
• Add a new page: "***Graphs***"



• Create a Scatter Plot **MENU**, **GRAPH ENTRY**, **SCATTER PLOT** "**run1.time** vs. **run1.position**"



• Change the Window size to see the collected data; **MENU**, **WINDOW/ZOOM**, **ZOOM-DATA**



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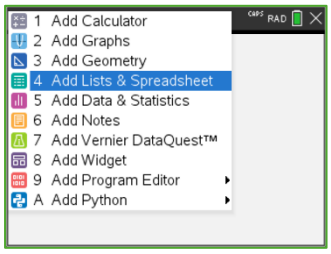
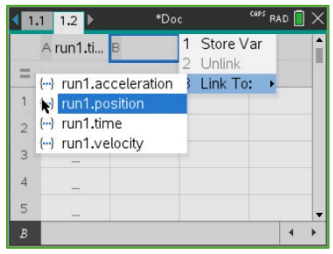
Seeing the Data - Lists & Spreadsheets:

It's worth noting that there are several ways to get the data collected from the CBR2 into a ***List & Spreadsheet*** but depending on what you plan on doing with that data in the spreadsheets may influence which method you use. For example, importing from the Vernier ***DataQuest*** page will transfer over the time, position, velocity, and acceleration and if you Strike any data, it will make your rows uneven which will make certain things more difficult. Which means I prefer the method below

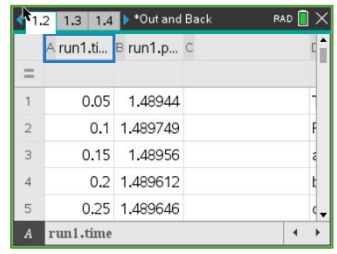
- Add a new page: "***Lists & Spreadsheets***"



- Input the labels for each column, this can be done through the **VAR** button

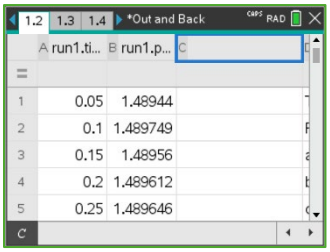


- The cells should populate with the collected data

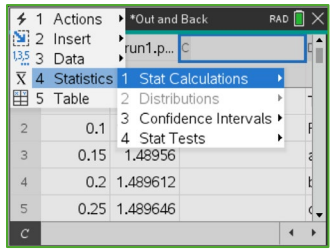


Analyzing the Data - Lines of Best Fit:

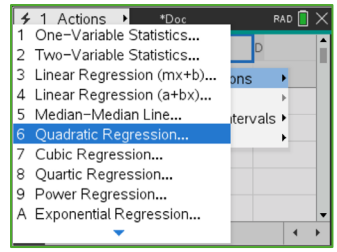
- From the current "**List & Spreadsheet**" page, go up to Column C and make sure it selected, but not highlighted



- Use the following progression when to find the line of best fit; still in the top of Column C, **MENU**, **STATISTICS STAT CALCULATIONS**, choose the appropriate regression model

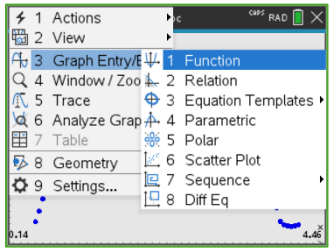


- When doing multiple regressions, simply repeat the process in different columns. By default, the model will be saved in the next available function.

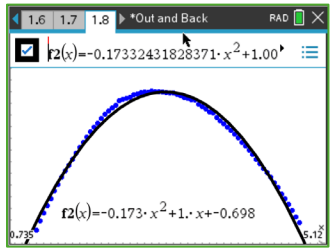


Viewing Lines of Best Fit Functions:

- From the "**Graphs**" page, pull down the function bar and open the **MENU**, **GRAPH ENTRY**, **FUNCTION**



- The regression functions will be input already, scroll up & hit **ENTER** to display them. Do this for each model



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<u>Discussion Topics & Follow Up Questions - To be carried out at any appropriate time</u>:

• Finding total distance traveled … Repeat the process of plotting the Velocity vs. Time scatter plot and line of best fit. Find the area between that line and the x-axis to get the total distance the ball traveled.

• When calculating the area under the curve, there is going to be a slight deviation from the actual value. Why is this? (Because the ball didn't start directly against the motion sensor)

• How can you fix this issue? (Plot a horizontal line that corresponds to the actual distance the ball begins from the sensor and go on to find the area between the velocity curve and that new line. You should record the starting distance before the ball is blown up the ramp)

• Why is better to use a cubic model when finding the line of best fit with the original position data? (Because the ball starts moving with two forces acting upon it, the blowing to get the ball started and also gravity. Compared to when the ball starts to descend the ramp and its only force is gravity)

• What should you look at when comparing whether a quadratic or cubic function best models the data of time vs. position? (Look at the R^2 value and see which is closer to 1)

• If a cubic is used as the regression model, does it make sense that the velocity data has a slight curve to it? Almost like part of a parabola. (Because the derivative of velocity represents the position and the derivative of a cubic function is a quadratic one)

• Can something similar be said between the velocity data set and the acceleration one? (Yes, for a similar reason)

• What happens when the height of the ramp changes or simultaneously, the slope of it changes? (Carry out the experiment with a variety of changes and compare the findings)

• When importing the data into a graph page, via a scatter plot, why is it necessary to change the window size?

• When carrying out this activity, what sort of considerations need to be factored in when looking at the error involved with this lab?

• How can you use three points from the time vs. position data to find a quadratic model in vertex form?

• Can you do the same thing if you wanted to use a cubic model? Why or why not?

• Convert the distance traveled found on the calculator and convert to inches, feet and yards. Does your answer make sense?

• Why is it important to "Strike" the data at the beginning of this lab? (It will provide a more accurate model by ignoring the very end when the ball hits the motion sensor and just sits there, not moving)