Traction Pull Activity

STEM Lesson for TI-Nspire™ Technology

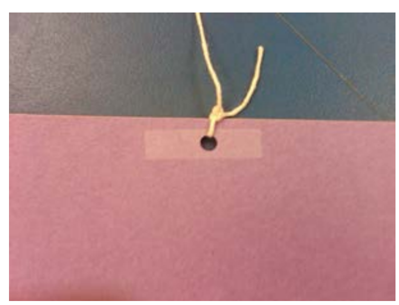
Objective: Students will collect data and analyze data using graphs. Students will also recognize patterns in graphing use the results to determine the winning strategy. Finally students will investigate the relationship between distance, time, velocity, and acceleration.

About the Lesson: If wheels spin, it means cars aren't moving forward. For race teams, that means they aren't on their way to winning. Loss of traction can also mean a potential crash so for them, maintaining "grip" is EVERYTHING. A leading question that NASCAR engineers ask is, "How fast can I go around this curve without spinning out?" NASCAR cars are so close to the edge of that limit that one shove from you or me would send them into the wall. If you aren't close, you don't qualify. If you're too far over the limit, you crash. Like everything else in racing, it is a trade-off engineers deal with in new ways for every race.

Materials: Small car such as the 1/16th scale RC car
String
Stiff paper such as construction paper
Tape
CBR 2
TI-Nspire
5 ft – 8 ft table or raised flat surface
Student Worksheets

Procedure:

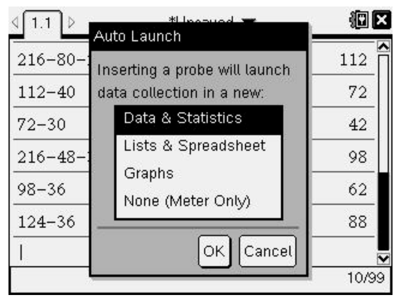
1. Place a small piece of tape on one end of the paper on both sides.
2. Punch a hole through the tape and paper.
3. Tie one end of the string through the hole around the paper as shown at the right.



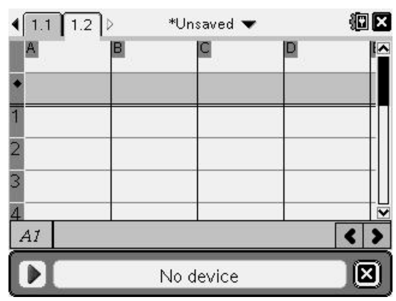
4. On the Nspire, create a new document.

5. Plug the CBR into the Nspire as shown at the right.

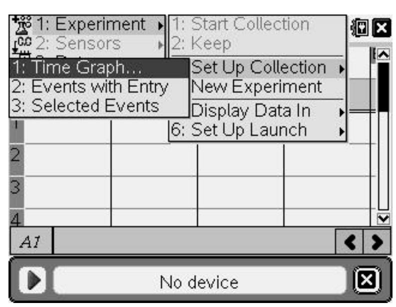
6. On the screen, a menu should pop up. Select **Lists & Spreadsheets** then click **OK**.



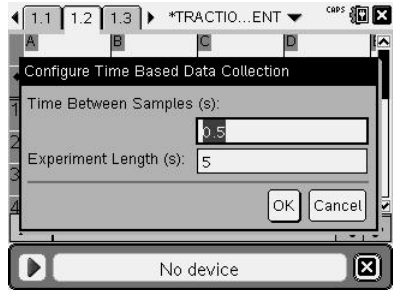
You will see a bar appear at the bottom of the screen with a play button, the distance to the object, and a close (X) button.



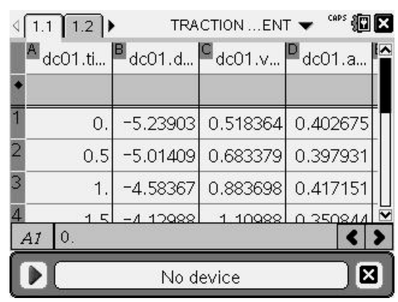
7. You need to set up the experiment before you begin. Press (menu) **>> Experiment >> Set Up Collection >> Time Graph**.



8. Choose the time intervals and the length of the experiment. A good setting is 0.5 sec for the intervals and 5 sec total for a 5 ft driving distance.



9. Now change the units. Press menu **>> Sensors >> Change Units** then press ▼ and select **ft**.
10. Press menu **>> Sensors >> Reverse** to tell the CBR2 that the car is coming toward it instead of away from it.
11. Choose one person to pull, one person to hold the CBR2, and one person to operate the Nspire handheld.
12. Place the car on the paper at one end of the table.
13. Hold the CBR at the other end of the table and line it up with the car. You know it is in line with the car when the length of the table shows at the bottom of the Nspire screen. It will be negative since the car is coming toward you.
14. Make sure everyone is ready and have another student give the "GO" signal.
15. On "GO", press the play button (bottom left corner) on the Nspire and pull the string speeding up at a constant rate about half way then staying at the same speed until the end.



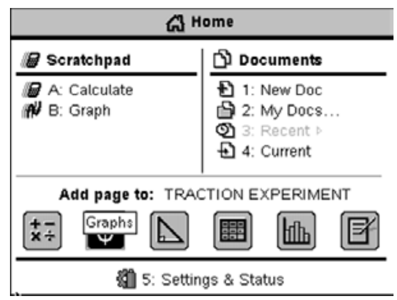
16. At the end of the run, numbers will appear on the screen. The first column is the time. The second column is the distance. The third column is the velocity, and the last column is the acceleration. Notice all of the titles begin with **dc01**. The Nspire will keep up with each run by increasing the number for each run. It also stores the columns as variables to use later.
17. Reset the car. Do the run again, but this time, speed up slowly the whole distance. When you push play or at the end of the run, the Nspire will ask you if you want to store the old data. Click on **Store**. If you make a mistake, click on **Discard** and the new run will save over the old run.

18. Reset the car. Do the run again, but this time, pull the paper as fast as possible without the car falling off. When you push play or at the end of the run, the Nspire will ask you if you want to store the old data. Click on **Store**. If you make a mistake, click on **Discard** and the new run will save over the old run.

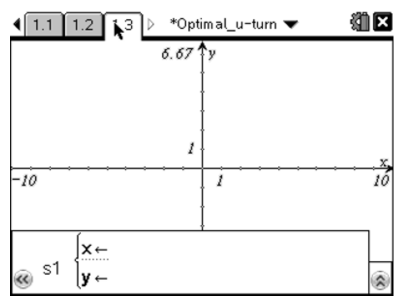
Teacher Tip: *If you have enough CBR2's, split the class into groups and make sure each person in the group has a job. If there is only one big group, rotate the students but use a different calculator to keep the data separate. Remember the data will only be on the calculators used in the investigation. You will have to have a student send you the file via the Navigator and distribute to the class for everyone to have the data.*

Analysis:

1. Now we need to graph our data to decide which strategy is the best. Graph **time** vs. **velocity** of each strategy. Press (on) and click on the graphs icon at the bottom of the screen.



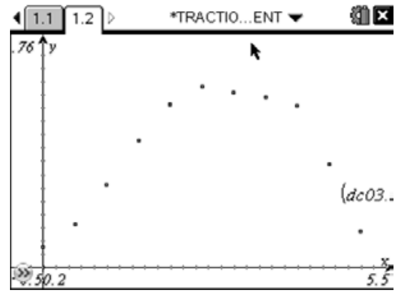
2. Press (menu) then choose **Graph Type > Scatter Plot**. Notice the function bar at the bottom of the screen changes from f1 to s1.



3. Which variable is the independent variable x?

4. Which variable is the dependent variable y?

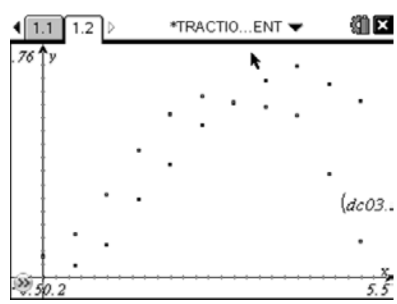
5. Press (var) and choose x. Press ▼ then (var) and choose y. Make sure it is for the first run. Press (enter). Now adjust your window to view the data by pressing (menu) then choosing **Window/Zoom > Zoom – Data**. An example of a set of data is shown at the right.



6. Describe what your graph says happened in the first run.

7. Based on this graph, which factor (distance, velocity, or acceleration) is the limiting factor for the first strategy?

8. Press (tab) to bring the function bar back and repeat steps 5 and 6 for the second run. You can move or delete the labels as needed. An example set of data is shown at the right.



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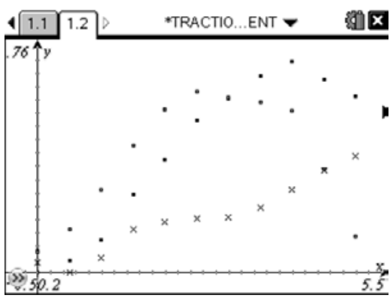
9. Describe what your graph says happened in the second run.

10. Based on this graph, which factor (distance, velocity, or acceleration) is the limiting factor for the second strategy?

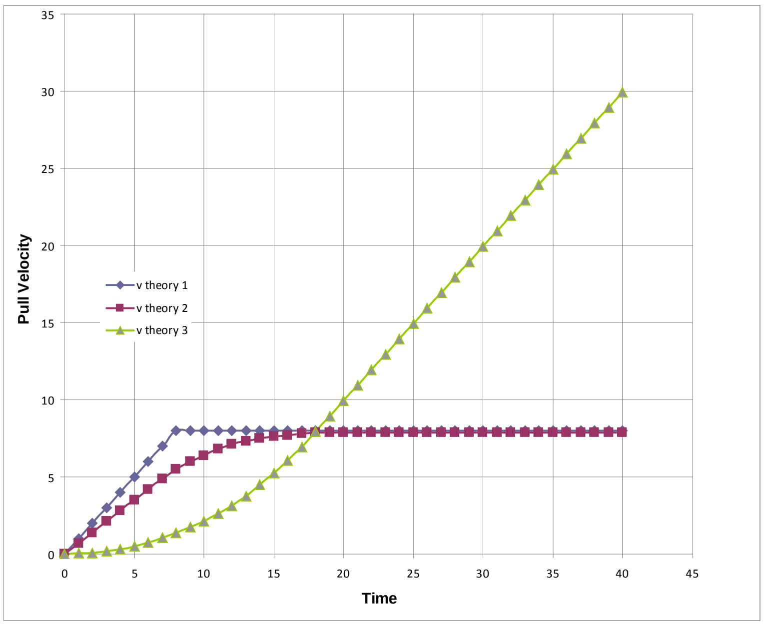
11. Press (tab) to bring the function bar back and repeat steps 5 and 6 for the third run. You can move or delete the labels as needed. An example set of data is shown at the right.



12. Describe what your graph says happened in the third run.

13. Based on this graph, which factor (distance, velocity, or acceleration) is the limiting factor for the third strategy?

Below is the theoretical data for the three strategies that you ran with the car.



14. How well do your graphs match these theoretical graphs?

15. Which strategy is the best strategy to go as fast as possible without wrecking?

The winning strategy is to realize the process is acceleration-limited. It isn't the speed that can't change too fast; it is the acceleration that can't change too fast.