NASCAR® Pit Strategy

STEM Lesson for TI-Nspire™ Technology

Objective: Analyze data using graphs, regressions, and area under the curve; and use the results to asses the best pit strategy for the last 30 laps of a NASCAR race.

About the Lesson: NASCAR teams track lap times for their driver and other cars to find out who is gaining and losing. This information is critical to devising a pit strategy – when to come in and what to do. One of the most critical decisions a race team has to make is how many tires to change and when. In such harsh conditions, tires may only last about 100 laps. Worn tires slow the car down so it is up to teams to decide how to handle the trade-off: Changing tires requires time but not adding tires means your car goes slower.

Your team is in the last 30 laps of a race. Though your team is balancing many variables when making decisions (such as how much fuel to add and what tire pressure to use), you are only responsible for suggesting how many tires to change: 2, 4 or don't pit.

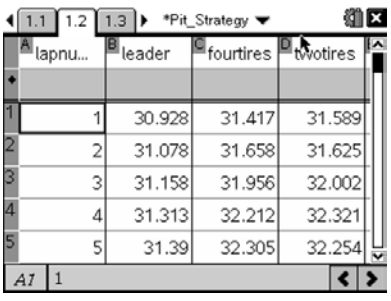
Materials: *Pit_Strategy.tns* TI-Nspire file
Student worksheets

Analysis:

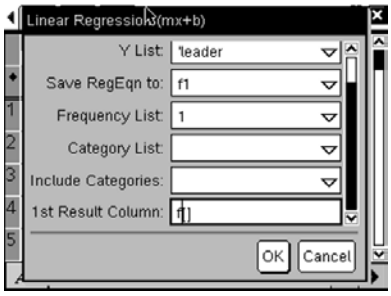
1. On your handheld, go to My Documents and open the file named *Pit_Strategy.tns.*

2. Use ctrl ▸ to move to page **1.2**.

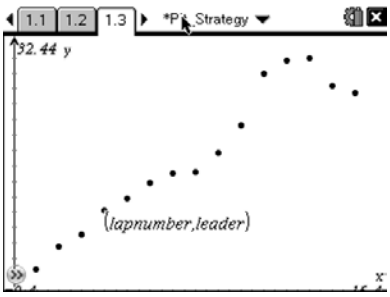
The data is 15 laps from the 2011 race at Las Vegas Motorspeedway. The first column is the lap number, and the second column is lap times for the race leader. The third and fourth columns are a 15th place car with 4 new tires and a 15th place car with 2 new right side tires.



3. Do a linear regression analysis on the leader data. Press (menu) then choose **Statistics > Stat Calculations > Linear Regression(mx+b)**. The regression template will pop up. Remember to press (tab) to switch boxes. Click the arrow at the right of each box to access the drop down menus. Choose *lapnumber* for the X List and *leader* for the Y list. Tab through the other options until you get to 1st Result Column. Click beside the letter and change it to 'f' if it isn't already. Click OK.

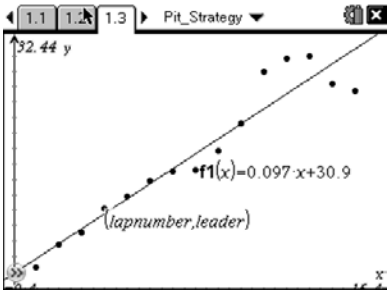


4. Move to page **1.3**. Press (menu) then choose **Graph Type > Scatter Plot**. Notice the function bar at the bottom of the screen changes from f1 to s1.

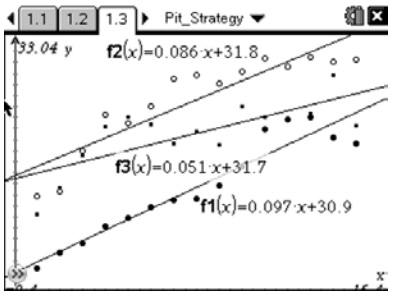


5. Press (var) and choose *lapnumber*. Press ▼ then (var) and choose *leader*. Press (enter). Now adjust your window to view the data by pressing (menu) then choosing **Window/Zoom > Zoom – Data**.

6. Now graph the regression line. Press (menu) then choose **Graph Type > Function**. Press ▲ to see your function in f1 then press (enter). You should see your line on top of your data points.



7. Repeat this process to analyze *lapnumber* vs. *fourtires* and *lapnumber* vs. *twotires*. Remember to change the column letter in the 1st Result Column box of the regression template. Always use the next **empty** column and don't overwrite data. Each scatter plot will use a different symbol. Hover over a label and press (ctrl) then (☉) to move the labels to see the data better. You can also click a label and press (del) to erase the labels completely.



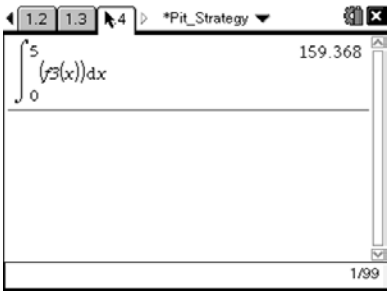
Notice how changing just the right side tires at Las Vegas yields similar lap times to changing all four for the first 5-6 laps, then starts to fall off and is slower than 4 fresh tires on a longer run.

8. It takes about 8 seconds to change 2 tires and 14 seconds to change 4 tires. If there were 10 laps left in a race and you had to make a pit stop, how many tires would take? Explain.

The predictive lap time equations can be used to help decide on tire strategy. The total predicted elapsed time for the car is defined as the area under the predicted lap time curve. The area under the curve can be calculated by taking the integral of the equation of the lap time curve.

9. Move back to page **1.2**. What is the actual total elapsed time for the first 5 laps of the race on 4 fresh tires? Press the (=) key to bring up the scratchpad for calculations.

10. Move to page **1.4**. Now calculate the predicted total elapsed time for the first 5 laps using an integral expression. Press (menu) then choose the definite integral template and enter 0 for the lower limit, 5 for the upper limit, and **f1(x)** for the expression. Don't forget the *x* after the *d* which tells the handheld to integrate with respect to *x*. Press (enter).



11. What is the difference between the predicted five lap elapsed time and the actual elapsed time for the first five laps of the race with 4 fresh tires?

12. What will the leader's elapsed time after 10 laps be? Write the integral you used.

13. Use the 4-tire data to predict a car's total elapsed time after 10 laps with a 4-tire pit stop? Write the integral you used.

14. How far (in seconds) behind the leader will you be after 10 laps? Show all work.

'Short pitting' is a pit stop procedure used by teams to try to makeup ground on the leader when they are not as fast as the leader. The car will run quicker lap times on new tires, so the team will pit well before they need fuel to put new tires on the car to make up time on the leader while the leader is running slower lap times. When the leader finally pits for fuel and tires, the chasing car will be much closer to the leader if not ahead. The risk with this strategy is that the pit stop takes a lot of extra time, and if the caution comes out before the leader pits later in the race, the chasing car is in jeopardy of going 1 lap down.

15. If the leader pits for 4 tires on lap 40, what is the best tire strategy if your car is going to pit on lap 20? For a four tire pit stop, add 37 seconds to your total elapsed time. For a two tire stop add 30 seconds to your total elapsed time.