Phoenix Chase Activity

STEM Lesson for TI-Nspire™ Technology

Objective: Students will use geometry to investigate NASCAR track designs and the speeds and g-forces caused by banking.

About the Lesson: Phoenix International Raceway has varied banking all around the track. Turns 1-2 are progressively are banked from 10 to 11 degrees while Turns 3-4 are progressively banked from 8 to 9 degrees. The backstretch goes from 10 to 12 degrees and the frontstretch is 3 degrees. There is even a roller coaster effect going through the "dog leg" following the exit of turn 2 due to an elevation change. It is quite impossible to have an optimal set-up for both ends of this track. The differential in the banking angle with the difference in radius from one end to the other allows you to have a great car in one end, but not both, or a compromise set-up for both ends. Crew chiefs and engineers have their work cut out for them. As for the drivers, their athletic ability is tested. If the cars exit Turn 2 at 130 ft/sec (~ 90 mph) then in 5.3 seconds down the back straight they can get up to about 250 ft/sec (~170 mph); but if they go around the high bank turn at that speed, the driver would experience slightly more than 12 g's--the max in fighter aircraft with pressurized suits to prevent blacking out is around 10 g's. The result would be a track that is harder on brakes than Martinsville and subjects the drivers to as much stress (centripetal g loading) as they can take so they need to slow down in Turns 3 and 4 to reduce the g loading. Estimated lap times would be on the order of 22.5 to 23 seconds on new tires, and they would wear very fast on the flat curve being subjected to blow-outs due to high g loads on the 60 degree banked turn. It would be physically exhausting for all but the most well conditioned drivers. Can you design a track more fascinating than Phoenix?

Materials: Student Worksheets

Prerequisite skills: The students need to be proficient in finding perimeter of rectangles and circumference of circles. Students also need to be proficient in converting units of measurement.

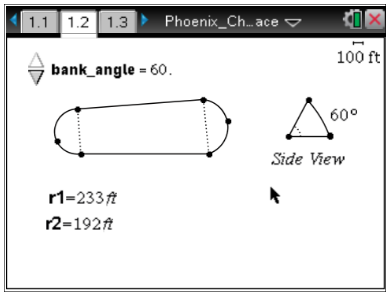
Analysis:

Using TI-Nspire Technology

1. Open the file named ***Phoenix_Chase_Activity.tns***.

2. Move to page **1.2**.

3. Drag the points around the track.



4. What do you notice about the radii **r1** and **r2**?

   Sample Answer: They increase and decrease.

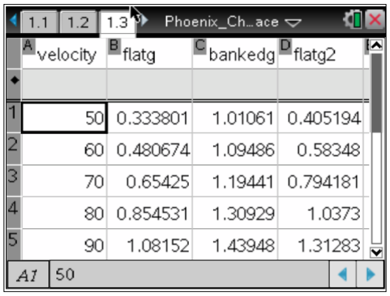
5. Click on the ▲ and ▼ at the top left of the page.

6. What do you notice about the banking angle?

   Sample Answer: It goes up and down.

7. Drag the points around the track until **r1** is close 100 and **r2** is close to 200. Set the banking angle to 10 degrees.

8. Move to page **1.3**. This table shows the g-forces at different speeds (velocity) for a flat track and your set degree of banking for each radius.



	A velocity	B flatg	C bankedg	D flatg2
1	50	0.333801	1.01061	0.405194
2	60	0.480674	1.09486	0.58348
3	70	0.65425	1.19441	0.794181
4	80	0.854531	1.30929	1.0373
5	90	1.08152	1.43948	1.31283

9. What is the g-force drivers will experience in a turn with a radius of 200 ft going 70 mph if the track is flat and if the track is banked 10 degrees?

   Answer: Flat will be 0.76 g's and banked will be 1.12 g's

Navigator Tip: *Quick Poll the students for their answers to #9 and show the results to make sure the students are on the right track.*

10. Move back to page **1.2**.

11. Create three different track designs and fill in the table below.

Radius 1	Banking Angle	g-force	Radius 2	Banking Angle	g-force

Answers will vary

Navigator Tip: *Do a screen capture of students' screens to see the different tracks created.*

12. Choose one of your track designs and find the perimeter around the track. Press (menu) then click **Measurement > Length**. Click the part of the track you want to measure and the length will appear. What is track length in feet.

    Answers will vary.

13. Most NASCAR races are about 400 miles long. How many laps will it take around your track to travel approximately 400 miles?

    Answers will vary. One way to calculate is 1 mile = 5280 feet, 400 miles = 2,112,000 ft, and 2,112,000 ft/perimeter in feet = # of laps.

Using spreadsheet software

1. Open the file named **Phoenix Chase Activity**

2. The table shows the different g-forces at the given radius for a flat track and a banked track. The graph shows *g-force vs. velocity*.

3. What is the g-force drivers will experience in a turn with a radius of 100 ft going 70 mph if the track is flat and if the track is banked 10 degrees?

    Answer: Flat will be 0.76 g's and banked will be 1.12 g's

4. Create three different track designs and fill in the table below. You can change the *r* and *bank angle* on the spreadsheet to help you out.

Radius 1	Banking Angle	g-force	Radius 2	Banking Angle	g-force

Answers will vary.

5. Make a sketch of each of your three designs above and correctly label all measurements.

Answers will vary.