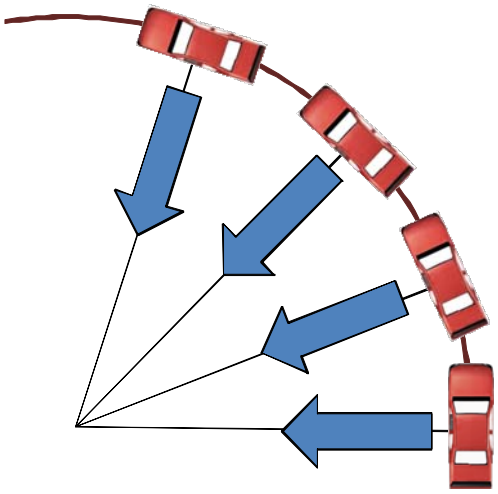
Turning on a Flat Track

They say that races are won and lost in the turns. At some tracks, drivers spend up to 60% of each lap turning, so if you can't get around the corners quickly, you won't be making the most important turn at the end of the race – the one that takes you into Victory Lane.

Background

If you put a tennis ball on a string and whirl it around your head, it moves in a circle. The force that makes it go in a circle instead of in a straight line is the centripetal force, which comes from the string. Race cars don't have strings – they have tires. The force needed to turn comes from the friction between the tires and the track.



The force that makes a car turn a circle always points perpendicular to the path of the car. Centripetal literally means "toward the center".

Most turns are not exactly circular, but they're close enough that we can approximate them as circular, which makes it much easier to calculate exactly how much force you need to turn.

This module asks you to calculate how much force you need to turn at a particular speed and radius. Track banking is a significant contributor to that turning force, as is aerodynamic sideforce and friction. Bristol is one of the most highly banked tracks, with twenty-four degrees of banking closest to the apron and thirty degrees of banking close to the wall. Banking helps the car turn, but it doesn't change how much force you need to turn.

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Start Your Engines…

SE.1. Bristol Motor Speedway has two slightly different turns, which we can approximate as semicircles. Turns 1 and 2 are 242 feet (73.76 m) and Turns 3 and 4 are 256 feet (78.03 m) in radius. The stock car plus driver weigh 3600 lbs (which corresponds to a mass of 1633 kg). The driver weighs 150 lbs (which corresponds to a mass of 68.0 kg). Sketch a picture of the track, indicating the track parameters on your diagram.

SE.2. How much force (in newtons) is required for the car and driver to takes turns 1 and 2 at 120 mph (53.6 m/s)?

SE.3. Convert your answer into pounds using 0.2248 lbs = 1.00 N

SE.4. What acceleration does this force correspond to?

SE.5. How many g's is this? (1 g = 9.80 m/s^2)

SE.6. The driver weighs 150 lbs (which corresponds to a mass of 68.0 kg). How much force does just the driver experience around turns 1 and 2?

SE.7. Divide the force the driver feels in lbs by the driver's weight. Where have you seen this number before?

SE.8. If a driver weighing 200 lbs went around the same curve at the same speed, how much force would the driver feel?

SE.9. How much force (in newtons) is required for the car and driver to takes turns 1 and 2 at 60.0 mph (26.8 m/s)?

SE.10. Compare the force needed to turn at 60.0 mph to the force needed to turn at 120 mph. When you double your speed, how does the force needed to make the turn change?

Extension A: Comparing Tracks

EA.1. Texas Motor Speedway has a turn radius of 750 feet (228.6 m), which is approximately three times that of Bristol Motor Speedway. How much force would the same car and driver you considered in SE.1. require to take the turn at 120 mph? (53.6 m/s)

EA.2. Calculate the ratio of the turn radius at Bristol (that you used in SE.2) to the turn radius at Texas.

EA.3. Calculate the ratio of the force needed to turn at Bristol (that you calculated in SE.2) to the force needed to turn at Texas that you just calculated.

EA.4. How are the two quantities in EA.2 and EA.3 related?

EA.5. Calculate Complete the following sentence: When you triple the turn radius, the amount of force needed to turn _____.

Extension B: Graphing Turning Force

EB.1. Texas Motor Speedway has a turn radius of 750 feet (228.6 m). A stock car plus driver weighs 3600 lbs, which corresponds to a mass of 1633 kg. Complete the table below to find the forces necessary to turn at different speeds and then plot force vs. speed using the graph paper on the next page.

Speed		Force
(mi/h)	(m/s)	
20.00	8.94	
40.00	17.88	
60.00	26.82	
80.00	35.76	
100.00	44.70	
120.00	53.64	
140.00	62.59	
160.00	71.53	
180.00	80.47	
200.00	89.41