What I Instruct...

BY FRED PACK

"Porsche – there is no substitute.™" Probably everyone who reads this article is familiar with that tagline. Here's another one: "Fundamentals – there is no substitute," and it applies to most activities, including tennis, playing the piano and certainly track driving.

"Track driving" is very different from "Fast driving." There are certain fundamentals which must be learned (and hopefully mastered) to be a track driver. There is much more to track driving than strapping on your helmet and pressing the gas pedal. Fortunately, the Porsche Club of America provides classroom as well as in-car instruction to everyone starting Drivers Education, covering all the necessary topics so that the driver has a safe and fun experience. Plus, thoughtful people running the track event have placed cones around the track to guide us.

your car can generate cornering acceleration of 95% of gravity (32 feet/sec2)

But we often forget the fundamentals of an activity after we do it for a while, and a refresher on the basics is useful. So, why are those cones placed where they are? – Answer: to remind us of the fundamentals.

I strongly believe that the first thing which anybody driving on a race track must understand is the concept of the line. The line is the path through a corner which allows the maximum speed through that corner. It is determined by principles of physics. While the maximum speed a car can attain on a straight road is determined by the power of its engine, the speed on a sharp U-turn is obviously much less. Understanding the reason for the difference is the key to understanding the line. Fortunately, you can have an intuitive appreciation for the line without understanding the physics.

During a track session it is obviously not possible to explain the physics, so instructors talk about the cones as reference marks instead. However, it is useful to have an understanding of the underlying physical principles: Whenever an object changes direction a force is involved. A given tire on a given road surface can tolerate a certain amount of force; when it is asked to accept more than the maximum amount it can handle, it loses grip on the road and it starts to slide. Those who took high school physics may recall that in a turn centripetal force ('F') equals v2/r[1], where 'v' is the velocity and 'r' is the radius of the turn. In terms of calculating velocity, this can be written as $v=\sqrt{(F*r)}$. The meaning of this is that the maximum speed of a car (i.e., velocity) in a turn increases as the turn has a larger radius (i.e., gets wider or less sharp), which is no surprise, and that the maximum speed increases proportionally to the square root of the increased radius. Before your eyes glaze over too much, I'll give some concrete examples. You have a wonderful Porsche and you've read that it can corner at '.95 g.' You may not be quite sure what that means, but you know that .95 g is a lot, (and surely more than a lowly BMW can generate). What it means is that your car can generate cornering acceleration of 95% of gravity (32 feet/sec2), so your car can generate a maximum acceleration of 30.4 feet/sec2. Visualize a turn that you can drive through at a maximum speed of 65mph. Now increase the radius of that turn by 21%. You can speed up to 71.6mph! See the footnote below for the underlying math .

A road has width, so the driver Mr. Inside could hug the inside edge as he goes around a turn, while Mr. Outside could hug the outside edge; a third driver could take some other path. Let's visualize a smooth turn with an inside radius of 300 feet and a width of 40 feet, meaning that it has an outside radius of 340 feet. If the car hugs the outside of the road it can have a maximum speed 6.4% greater than if it stays on the inside .

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[1] a = m * v2/ r (where 'm' is the mass of the object) and F = m * a, so F = v2/ r .

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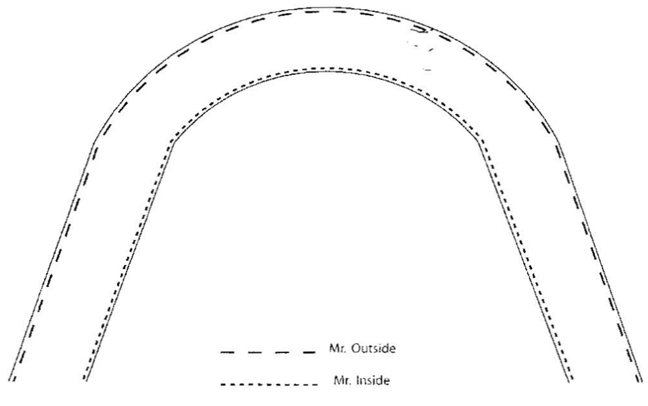
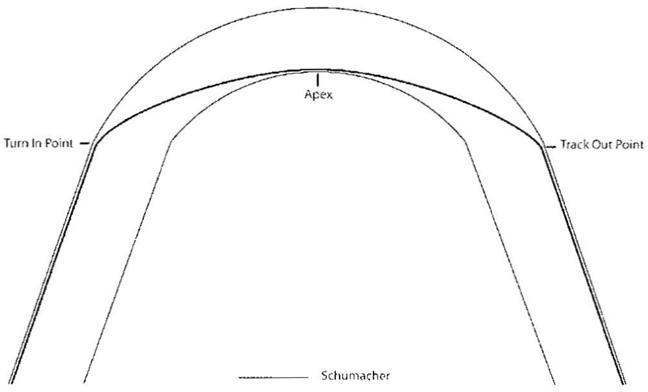
So if the car could go 65mph on the inside track it can go 69mph on the outside track. That is a major increase in speed. Mr. Outside will certainly win the race, won't he?



No, he will come out of the turn faster than Mr. Inside but he will be trounced by another driver who realizes that there is an even larger radius turn available to him. This guy, let's call him Schumacher, visualizes a turn with a radius of 420 feet where the other 2 drivers saw only 300 and 340 feet. How can Schumacher create such a large radius? He starts on the outside edge of the road and begins the turn at the 'turn-in point' (where the first cone is placed), smoothly moves to the inside edge of the road, at a location we call the 'apex'(where the second cone is placed), and arcs back to the outside, which we call the 'track-out point' (where the third cone is placed), making a radius of 420 feet. And with his radius of 420 feet he can maintain a speed of 77mph , which is much greater than 65 or 69. Now you should understand why the cones are placed where they are, and with experience you'll be able to sense the turn-in, apex and track-out locations without cones, and even without understanding the physics or the math.



So, the line is the path through the turn which creates the largest radius, since this line permits the greatest speed. It also, and this is a very important point, is the path with the greatest safety margin at any given speed, since it permits the highest potential speed. One more little piece of math to illustrate the importance of even a small speed increase: 2 identical cars enter a turn, one slightly behind the other. The trailing car exits the turn going 2mph faster than the leading car. This means he is going about 3 feet per second faster . which in turn means that on a straightaway lasting 10 seconds he will be 30 feet further down the track and can likely pass the leading car. (Even the short Lime Rock main straight takes longer than 10 seconds.) You can now understand why the line is so important to track driving and why I and all instructors pay so much attention to teaching it to our students.

A future article will discuss more about the line and its critical relationship to safety as well as speed. and some other topics. (For people who would like to learn more about the fundamentals, there are many fine books about track driving. "Going Faster" by Skip Barber is a good reference.)

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[2]The formula indicates that a 21% increase in the radius will permit the speed to increase by 10%, since the square root of 121 is 11, 11 is 10% greater than 10 and 71.6mph is 10% greater than 65mph.

[3]A radius of 340ft is 13.3% greater than a radius of 300ft and 6.4% is the percentage change between the square roots of those two radii. (In the interest of simplicity, this example ignores that the car itself has some width.)

[4](3600/ 5280) * √(32 * .95 * 420) = 77.04mph. (I traced Schumi's line with a piece of string and a pen on a diagram which had 300 and 340 sized arcs on it, and then measured its radius, which was 420.)

[5](5280 * 2 / 3600) = 2.933