Wheel Alignment Basics Explained:
Shimmed Control Arms

By Joe Fisher

This brief article is not meant to teach someone how to align the front steering/suspension but to explain the three basic specifications that are set during a standard wheel alignment. It was explained to me by an old-timer back when *I wasn't* an old-timer. This article is not vehicle specific and the basics can apply to all cars.

The table at the end of the article can be used for any vehicle that uses shims at the upper control arm.

I will not get into four-wheel alignment (e.g., aligning all front and rear wheels on a C2 Corvette) in this article.

Toe-In, Toe-out:

"**Toe**" is a condition where the fronts of the tires are either pointed in toward one another, or pointed away from one another in a horizontal plane measured in a fraction of inches. If your toes are pointed toward each other then that is **toe-in**, if they are pointed away from each other then it is **toe-out**. So, if your tires are pointed inward you have a toe-in condition and if pointed outward then you have a toe-out condition. Normally, you want **1/16" to 1/8" toe-in**. A misadjusted toe setting will cause rapid tire wear and will sometimes cause tire squeal. If they are severely out of specifications the vehicle can become "darty" and the tire tread will become feathered.

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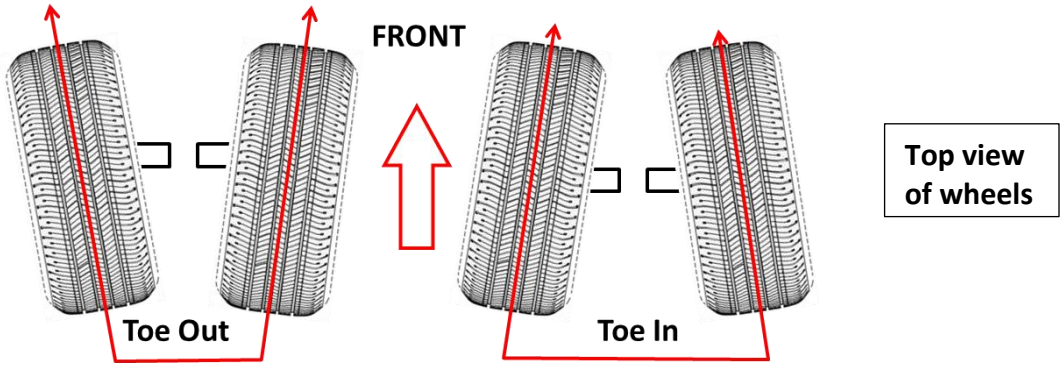
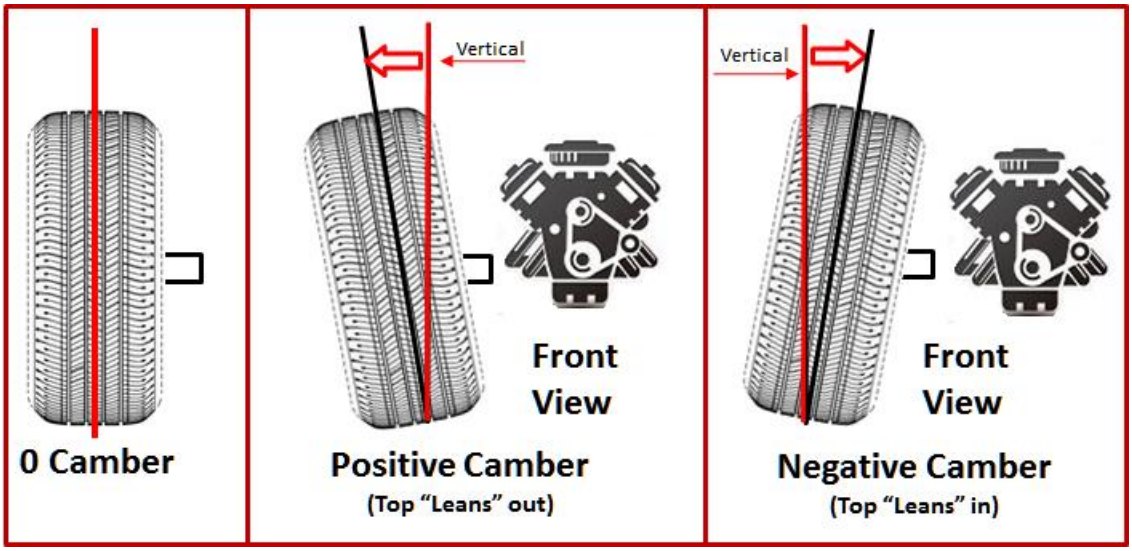


Camber:

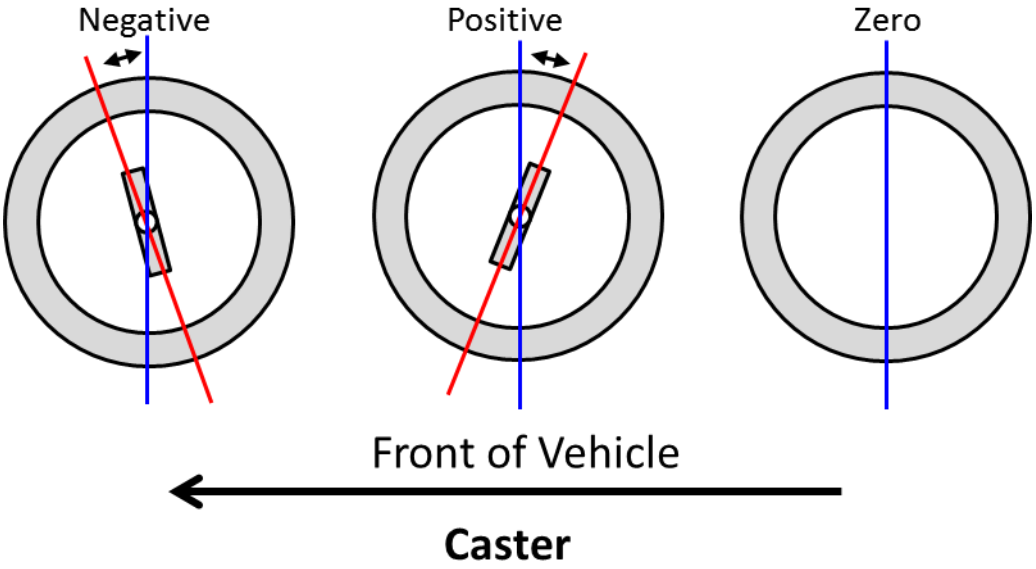
"Camber" is the tilt of the top of the tire, in a vertical plane toward or away from the engine; it is measured in degrees. If the top of the tire is tilted outward, it is called **positive camber**, if it is tilted inward, that is **negative camber**.

A poorly adjusted Camber setting will cause the tires to wear on one edge only. If you ever saw a car that has a raised front end, the tire normally goes toward negative camber.



Caster:

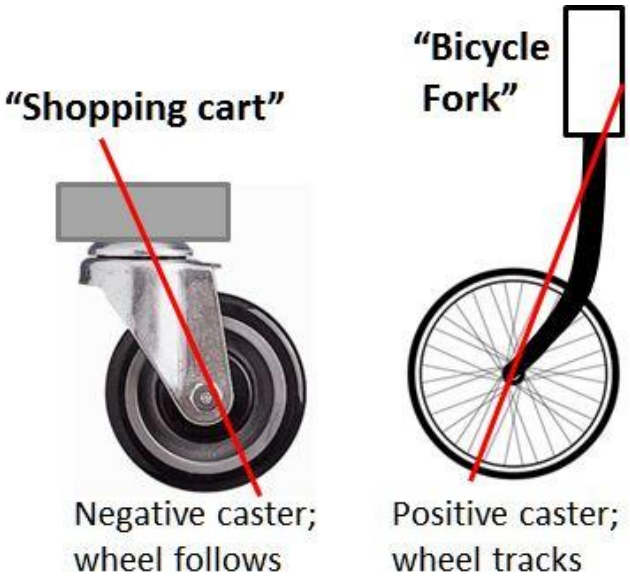
"**Caster**" is the most misunderstood part of an alignment. If you draw an imaginary line through the upper and lower ball joint and measure it in degrees (from the vertical), you are determining the caster setting.



Some analogies to describe positive and negative caster:

Picture a shopping cart's front wheel (below left), the wheel's axle lies behind the pivot and, when you push the cart; the wheel always follows. This is called **negative caster**.

Now, picture a bicycle fork (below right), its wheel axle is in front of the pivot point and, when you ride your bike and take your hands off the handle bars, the wheel tracks straight. It wants to stay forward – this is **positive caster**



Now, draw an imaginary line through the pivot point and the axle and imagine the axle is the lower ball joint and the pivot is the upper ball joint. In the case of the shopping cart, the line slopes front to back which is **negative caster**, and on the bicycle, it goes back to front which is **positive caster**.

If the upper ball joint is directly above the lower, you have **zero caster**. If the upper ball is more toward the rear of the car than the lower you have **positive caster**.

Keep in mind that negative caster wants to "follow" and positive caster wants to "track" (lead). Thus, the car will "pull" toward the side that has the lesser amount of positive caster.

This is why my mentor always told me to put ½ degree more positive caster on the right side then left to help counteract the crown in the road which wants to pull the car towards the curb.

Caster causes the car to pull to one side if all else is set up OK.

Also, I had cars with too much negative caster which **caused the steering wheel not to center itself** after making a turn.

Looking at the picture below of the left (driver side) control arm on a '64 Corvette you will notice the upper shaft is on the engine side of the support. On cars with the shaft on the outside of the support these explanations will be reversed.

To change the camber without changing the caster you would **install or remove equal amounts of shims at A and B from between the shaft and support.**

Adding shims will move the shaft toward the engine and, therefore, bring the top of the tire inward decreasing the camber and, if you remove shims from the shaft, it moves outward, moving the top of the tire out toward the fender thereby increasing camber.

To change the caster you will have to move the upper ball joint either toward the front or the rear of the vehicle.

On this set up if you move the front of the shaft toward the engine, i.e., add shims, or move the rear of the shaft away from the engine, i.e., removing shims, you will move the ball joint forward decreasing the caster, going toward negative.

Inversely, if you move the front of the shaft away from the engine, remove shims, or move the rear of the shaft toward the engine, add shims, you will move the ball joint rearward increasing the positive caster.

The table below shows the correlation between shim changes and resultant changes in the camber/caster setting.

Joe Fisher


1964 Driver-side upper control arm.
A
Support
Front
B

Effect of adding, removing or changing positions of upper control-arm shims on camber and caster setting.		
Action	Camber Change*	Caster Change*
Adding Shims to:		
Front only	Less	Less
Rear only	Less	More
Front and Rear, same size	Less	Same
Removing Shims From:		
Front only	More	More
Rear only	More	Less
Front and Rear, same size	More	Same
Switch Shim From:**		
Front to Rear	Same	More
Rear to Front	Same	Less

*__Less__ means the reading will move toward the negative and **More** will move the reading toward the positive.

**Taking a shim from one bolt and installing it on the other bolt, not adding or removing any shims.

Some suggested wheel alignment specs for C2 Corvettes with radial tires:

Corvette Forum post by John Hinckley (John Z):

Street specs for radial tires:

Front camber: zero
Front caster: 2^{o}-2.5^{o} positive (with P/S); manual 1.5^{o} positive
Front toe-in: zero-to-1/16" TOTAL toe-in

Rear camber: zero-to-$1/2^{o}$ negative
Rear toe-in: 1/16" TOTAL toe-in, split equally across the thrust centerline (**1/32" per side**).

"Midyear suspension geometry was designed in 1961 around 6.70-15 bias-ply tires; the camber gain doesn't respond well to extremely wide tires."