Figure 119-1 A pull is usually defined as a tug on the steering wheel toward one side or the other.

Figure 119-2 The crown of the road refers to the angle or slope of the roadway needed to drain water off the pavement. (Courtesy of Hunter Engineering Company)
Figure 119-3  Wander is an unstable condition requiring constant driver corrections.

Figure 119-4  Positive camber. The solid vertical line represents true vertical, and the dotted line represents the angle of the tire.

Figure 119-5  Negative camber. The solid vertical line represents true vertical, and the dotted line represents the angle of the tire.
Figure 119-6  Zero camber. Note that the angle of the tire is true vertical.

Figure 119-7  Excessive positive camber and how the front tires would wear due to the excessive camber.

Figure 119-8  Excessive negative camber and how the front tires would wear due to the excessive camber.
Figure 119-9  Positive camber tilts the tire and forms a cone shape that causes the wheel to roll away or pull outward toward the point of the cone.

Figure 119-10  Negative camber creates a pulling force toward the center of the vehicle.

Figure 119-11  If camber angles are different from one side to the other, the vehicle will pull toward the side with the most camber.
Positive camber applies the vehicle weight toward the larger inner wheel bearing. This is desirable because the larger inner bearing is designed to carry more vehicle weight than the smaller outer bearing.

Negative camber applies the vehicle weight to the smaller outer wheel bearing. Excessive negative camber, therefore, may contribute to outer wheel bearing failure.

Zero caster.
Figure 119-15 Positive (+) caster.

Figure 119-16 Negative (-) caster is seldom specified on today's vehicles because it tends to make the vehicle unstable at highway speeds. Negative caster was specified on some older vehicles not equipped with power steering to help reduce the steering effort.

TECH TIP: Think of a Bicycle

How caster affects steering stability and steering wheel returning to the straight ahead position after a turn is made easy by remembering how a bicycle acts. Caster allows a rider to travel straight ahead with their hands off the handlebars because the weight is behind the axis.
As the spindle rotates, it lifts the weight of the vehicle due to the angle of the steering axis. (Courtesy of Hunter Engineering Company)

Vehicle weight tends to lower the spindle, which returns the steering to the straight-ahead position.

High positive caster provides a road shock path to the vehicle.
TECH TIP: CASTER ANGLE TIRE WEAR

The caster angle is generally considered to be a non-wearing angle. However, excessive or unequal caster can indirectly cause tire wear. When the front wheels are turned on a vehicle with a lot of positive caster, they become angled. This is called camber roll. (Caster angle is a measurement of the difference in camber angle from when the wheel is turned inward compared to when the wheel is turned outward.) Most vehicle manufacturers have positive caster designed into the suspension system. This positive caster increases the directional stability. However, if the vehicle is used exclusively in city driving, positive caster can cause tire wear to the outside shoulders of both front tires. SEE FIGURE 119-22.

Figure 119-20 A steering dampener is used on many pickup trucks, sport utility vehicles (SUVs), and some luxury vehicles designed with a high-positive-caster setting. The dampener helps prevent steering wheel kickback when the front tires hit a bump or hole in the road and also helps reduce steering wheel shimmy that may result from the high-caster setting.

Figure 119-21 As the load increases in the rear of a vehicle, the top steering axis pivot point moves rearward, increasing positive (+) caster.
Figure 119-22  Note how the front tire becomes tilted as the vehicle turns a corner with positive caster. The higher the caster angle, the more the front tires tilt, causing camber-type tire wear.

OUTSIDE TURN SPINDLE MOVES DOWN

INSIDE TURN SPINDLE MOVES DOWN

Figure 119-23  Zero toe. Note how both tires are parallel to each other as viewed from above the vehicle.

Figure 119-24  Total toe is often expressed as an angle. Because both front wheels are tied together with the tie rods and steering gear, the toe angle is always equally split between the two front wheels when the vehicle moves forward.
Figure 119-25  Toe-in, also called positive (+) toe.

Figure 119-26  Toe-out, also called negative (-) toe. (Courtesy of Hunter Engineering Company)

Figure 119-27  This tire is just one month old. It was new and installed on the front of a vehicle. The tire has a 6 mm (1/4 in.) right of center. By the time the customer returned to the tire store for an alignment, the tire was completely bald on the inside, while the outer rim held on the outside.
Figure 119-28  Excessive toe-out and the type of wear that can occur to the side of both front tires.

Figure 119-29  Excessive toe-in and the type of wear that can occur to the outside of both front tires.

Figure 119-30  Feather-edge wear pattern caused by excessive toe-in or toe-out.
Figure 119-31  Rear toe-in (+). The rear toe (unlike the front toe) can be different for each wheel since the rear wheels are not tied together as they are in the front. (Courtesy of Hunter Engineering Company)

Figure 119-32  Incorrect toe can cause the tire to run sideways as it rolls, resulting in a diagonal wipe.

Figure 119-33  Diagonal wear such as shown here is usually caused by incorrect toe on the rear of a front-wheel drive vehicle.
Figure 119-34 Toe on the front of most vehicles is adjusted by turning the tie rod sleeve as shown. (Courtesy of John Bean Company)

Why Doesn't Unequal Front Toe on the Front Wheels Cause the Vehicle to Pull?

Each wheel could have individual toe, but as the vehicle is being driven, the forces on the tires tend to split the toe, causing the steering wheel to cock at an angle as the front wheels both track the same. If the toe is different on the rear of the vehicle, the rear will be steered similar to a rudder on a boat because the rear wheels are not tied together as are the front wheels.

TECH TIP: Smooth In, Toed-In; Smooth Out, Toed-Out

Whenever the toe setting is not zero, a rubbing action occurs that causes a feather-edge-type wear. SEE FIGURE 119-35. A quick, easy method to determine if incorrect toe is causing problems is to simply rub your hand across the tread of the tire. If it feels smoother moving your hand toward the center of the vehicle than when you move your hand toward the outside, then the cause is excessive toe-in. The opposite effect is caused by toe-out. This may be felt on all types of tires, including radial-ply tires where the wear may not be seen as feathered. Just remember this simple saying: “Smooth in; toe-in; smooth out; toe-out.”
While the feathered or sawtooth tire wear pattern may not be noticeable to the eye, it can usually be felt by rubbing your hand across the tread of the tire. (Courtesy of John Bean Company)

Figure 119-36 The left illustration shows that the steering axis inclination angle is determined by drawing a line through the center of the upper and lower ball joints. This represents the pivot points of the front wheels when the steering wheel is rotated during cornering. The right illustration shows that the steering axis inclination angle is determined by drawing a line through the axis of the upper strut bearing mount assembly and the lower ball joint.

Figure 119-37 The SAI causes the spindle to travel in an arc when the wheels are turned. The weight of the vehicle is therefore used to help straighten the front tires after a turn and to help give directional stability.
Figure 119-38 Included angle on a MacPherson-strut-type suspension.

Figure 119-39 Included angle on an SLA-type suspension. The included angle is the SAI angle and the camber angle added together.

Figure 119-40 Cradle placement. If the cradle is not replaced in the exact position after removal for a transmission or clutch replacement, the SAI, camber, and included angle will not be equal side-to-side.
A positive scrub radius (angle) is usually built into most SLA front suspensions, and a negative scrub radius is usually built into most MacPherson-strut-type front suspensions.

Figure 119-41

With negative scrub radius, the imaginary line through the steering axis inclination (SAI) intersects the road outside of the centerline of the tire. With positive scrub radius, the SAI line intersects the road inside the centerline of the tire.

Figure 119-42

With a positive scrub radius, the pivot point, marked with a + mark, is inside the centerline of the tire and will cause the wheel to turn toward the outside, especially during braking. Zero scrub radius does not create any force on the tires and is not usually used on vehicles because it does not create an opposing force on the tires, which in turn makes the vehicle more susceptible to minor bumps and dips in the road. Negative scrub radius, as is used with most front-wheel-drive vehicles, generates an inward force on the tires.

Figure 119-43
Figure 119-44  To provide handling, the inside wheel has to turn at a greater turning radius than the outside wheel.

Figure 119-45  The proper toe-out on turns is achieved by angling the steering arms.

Figure 119-46 (a) Positive setback.
Figure 119-46 (b)  Negative setback.

Figure 119-47  Cradle placement affects setback.

Figure 119-48 (a)  Zero thrust angle.
Figure 119-48 (b) Thrust line to the right.

Figure 119-48 (c) Thrust line to the left.

Figure 119-49 (a) Proper tracking.
Figure 119-49 (b) Front wheels steering toward thrust line.