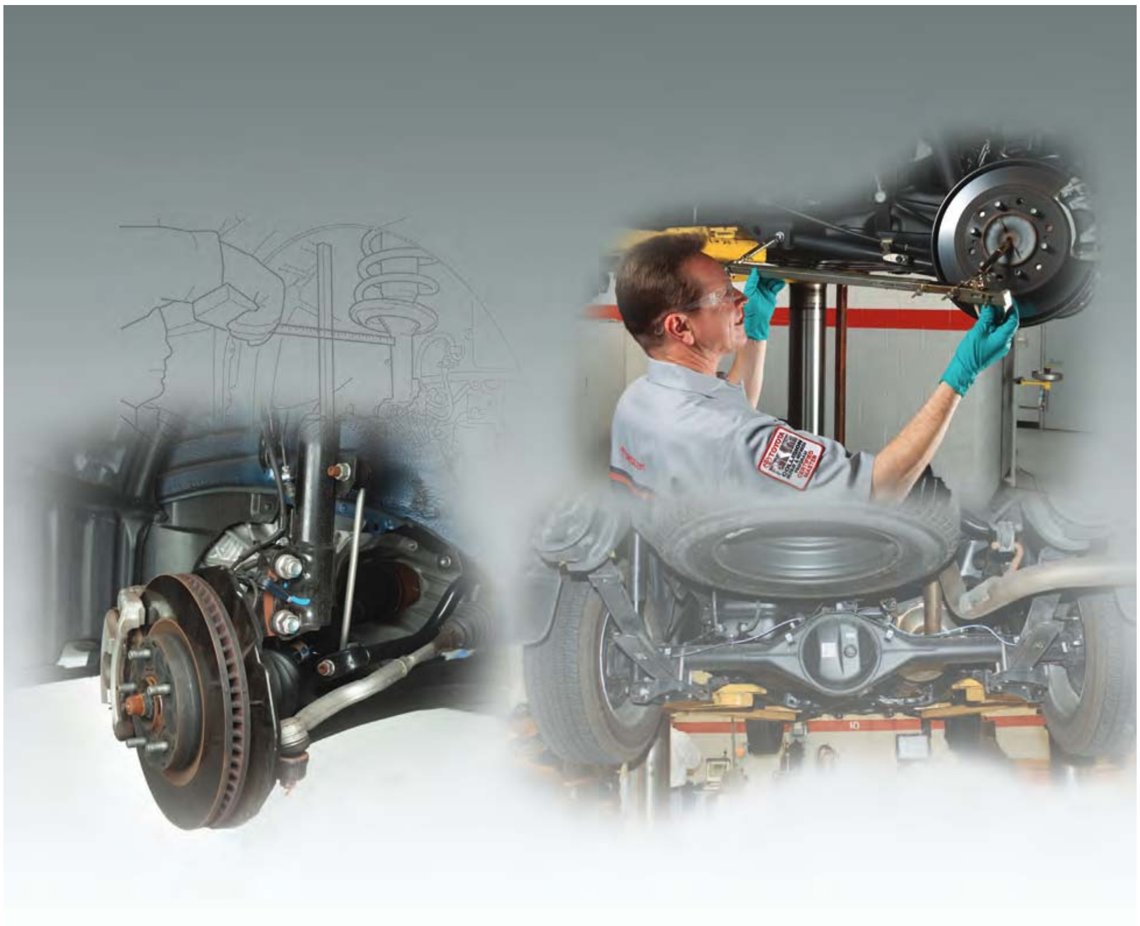
Steering and Suspension – Analysis and Repair
Course B503
Technician Handbook



Contents

What Is Steering and Suspension Alignment?

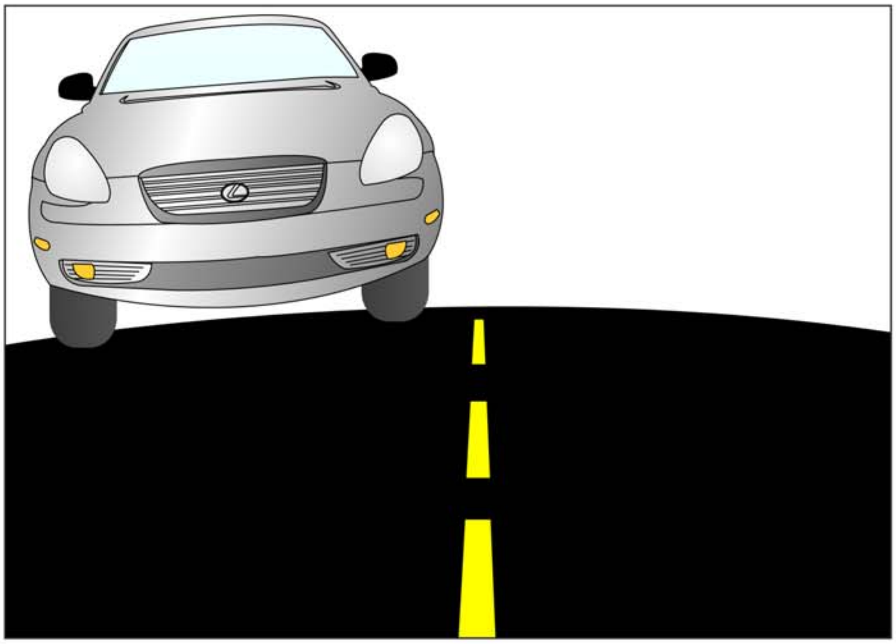
Introduction

Steering and suspension alignment is the correct positioning of the steering and suspension components in relation to each other and in relation to the structure of the vehicle. This positioning will ensure that these components will correctly function as a unit throughout their full range of motion. Although steering and suspension components may appear to be correct in a static position, they may not operate correctly under normal driving conditions unless they are correctly positioned in relation to each other and the vehicle. Steering and suspension alignment is accomplished in conjunction with structural repair and is dependent upon correct alignment of a vehicle's body or frame structure.

Steering and suspension alignment must not be confused with wheel alignment. Wheel alignment is the fine adjustment of caster, camber, and toe and can only be done after the correct positioning of the steering and suspension components has been achieved.

Steering and suspension alignment is the correct positioning of steering and suspension components in relation to each other and to the body or frame of the vehicle. It does not require the use of wheel alignment equipment.

The popularity of front-wheel-drive vehicles and rack-and-pinion steering has increased the need for an understanding of steering and suspension alignment. The structure of the vehicle must be within dimensional tolerance with correct length, width, and height at all of the suspension mounting points, and a square center section; otherwise, the correct steering and suspension alignment will not be possible.



Introduction ... continued

In order for the vehicle to be capable of having the same qualities that were engineered into it by the manufacturer, correct structural alignment must be achieved during the structural repair process. A vehicle with unusual handling problems like a lateral pull associated with bumps, braking, or acceleration and uneven or rapid tire wear could indicate steering and suspension misalignment. Front-wheel drive with rack-and-pinion steering has little-to-no adjustment for the necessary geometric angles, with the exception of toe. It has become increasingly important to diagnose and repair any misalignment that may affect steering and suspension components in order to repair the vehicle right the first time.

Steering Geometry

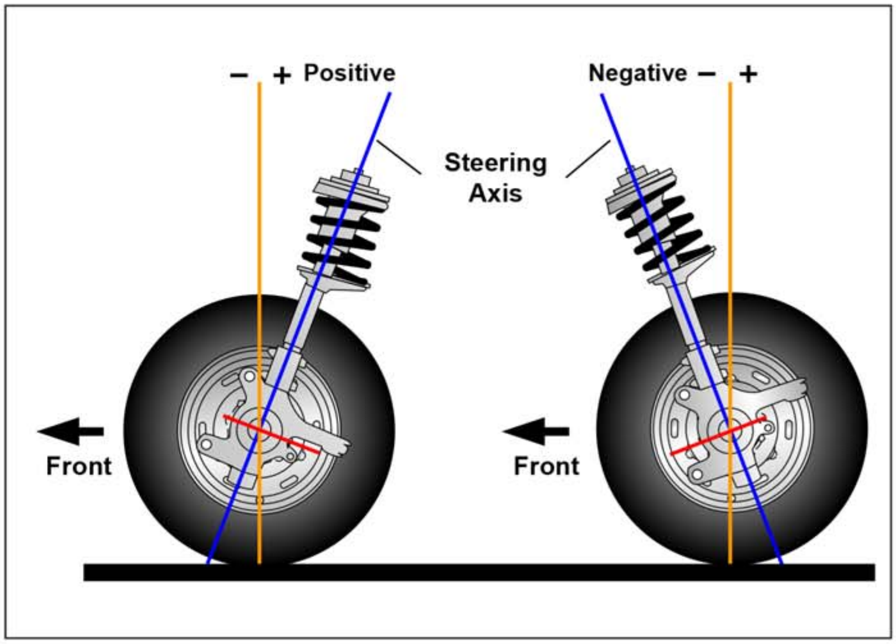
Introduction

The first step in being able to effectively diagnose and repair automotive steering and suspension problems is to have a fundamental understanding of steering geometry.

Five geometric angles are common to all vehicles. The importance of each will vary with the type of front suspension and the steering design that is being used. These angles are:

1. Caster
2. Camber
3. Toe
4. Steering Axis Inclination (SAI)
5. Toe-Out on Turns

These geometric angles position the steering axis and the components to control the directional stability, turning, and handling of the vehicle.

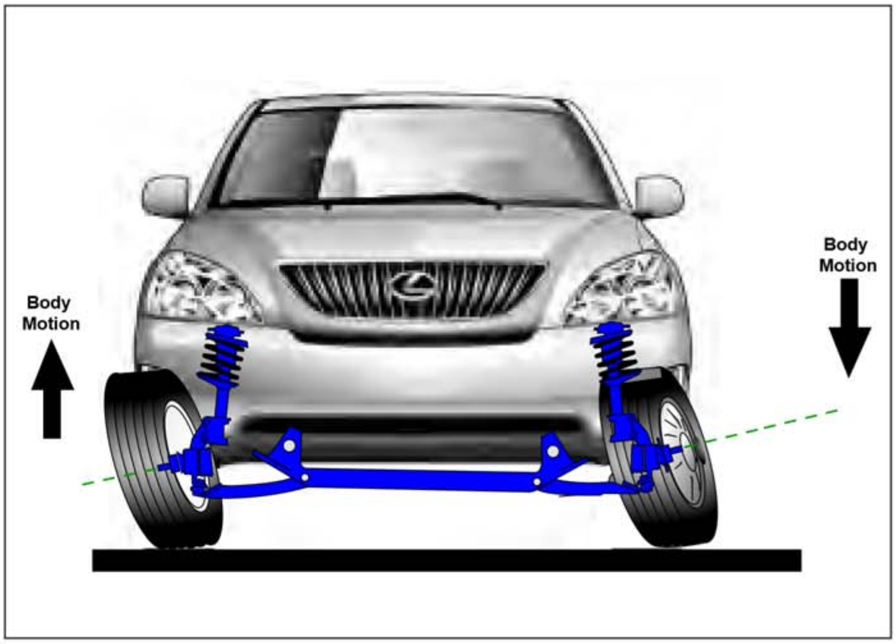


Caster

Caster is the angle formed by the forward or rearward position of the steering axis and an imaginary vertical line drawn through the spindle when the vehicle is viewed from the side. A backward tilt is positive camber, while a forward tilt is negative caster. Positive caster helps the front wheels track straight.

Caster influences the directional control of the steering but does not affect the tire wear and is not adjustable on some vehicles — but caster is affected by the vehicle height. Therefore, it is important to keep the body at its designed height.

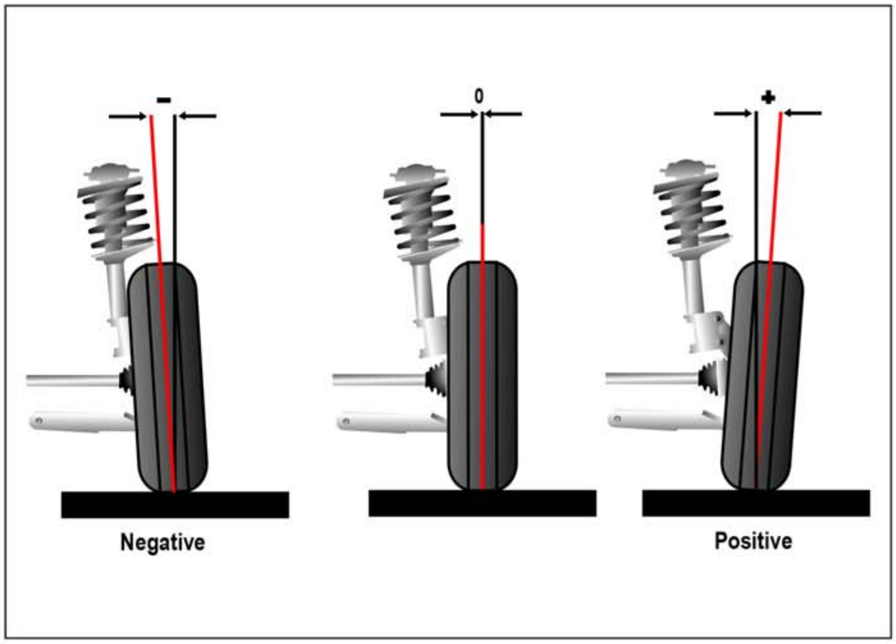
Caster is a directional-control angle. Caster prevents wandering and helps the vehicle return to a straight-ahead position after a turn. This is accomplished by creating a positive-caster situation. Positive caster positions the high point of the arc forward of the centerline of the wheel where it contacts the road surface. This causes the wheel to toe inward. As the wheels are drawn back and held in a straight-ahead position by the steering linkage, the weight of the vehicle tries to force the wheels to the high point of the arc. This creates an opposing force between the two front wheels, which results in stability and anti-flutter.



Caster ... continued

If caster is not equal from side to side, a lateral pull under straight driving conditions will most likely occur. The vehicle will pull towards the side with the least amount of positive caster. Positive caster results in good return ability because the high point of the arc is inward of the centerline of the wheel. As the wheels are drawn rearward to make them parallel, they are taken off the high point of the arc and held there. When the wheels are rotated to the left, the left side falls lower off the high point, causing the vehicle to lift on that side. The right wheel climbs higher on the arc, causing this side of the vehicle to lower. Since the inside of the vehicle is being lifted higher than the outside, the wheels are helped back to a straight-ahead position. When the wheels are rotated to the right, the opposite would take place. Motion also plays a part in the way caster works to achieve stability.

With a front-wheel-drive vehicle, caster is nullified under acceleration. Most front-wheel-drive vehicles use very little caster, and they usually have no caster adjustment. Correct caster is accomplished through proper location of the steering axis pivot points during the repair process.



Camber

Camber is the angle of the wheel — measured in degrees — when viewed from the front of the vehicle. If the top of the wheel is leaning out from the vehicle centerline, the camber is positive. If it's leaning in, the camber is negative. A vertical wheel has a zero camber angle.

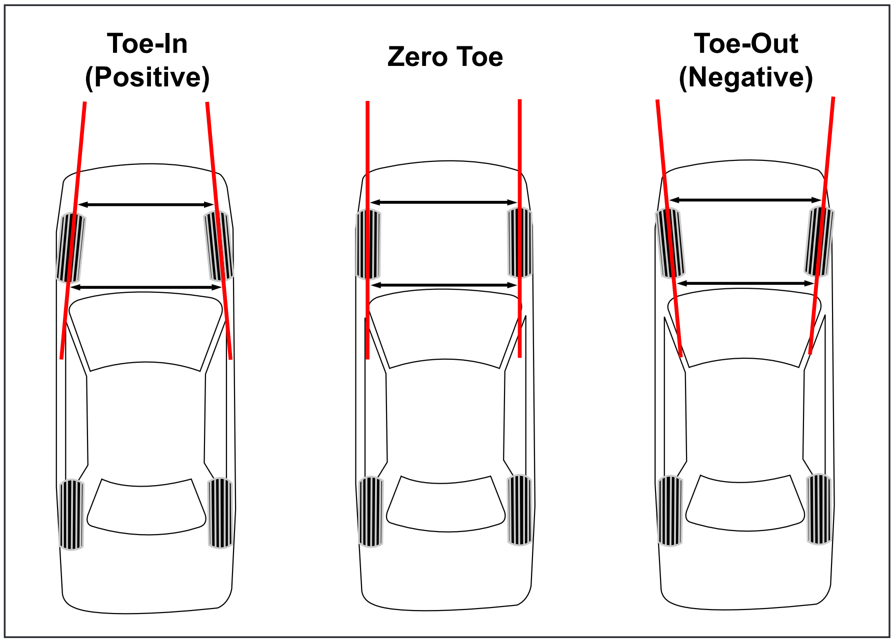
If the camber is out of adjustment, it will cause tire wear on one side of the tire's tread. If the camber is too far negative, for instance, the tire will wear on the inside of the tread.

The primary function of proper camber angle is to maintain maximum contact between the road surface and the tire tread. Incorrect camber can cause uneven tire wear and a lateral pull while driving. This is caused by the cone effect of a cambered tire. The diameter of the inside edge of the tire is larger than the diameter of the outside edge. This causes the inside edge of the tire to tend to travel farther than the outside edge, which creates a lateral pull toward the side of the smaller diameter.

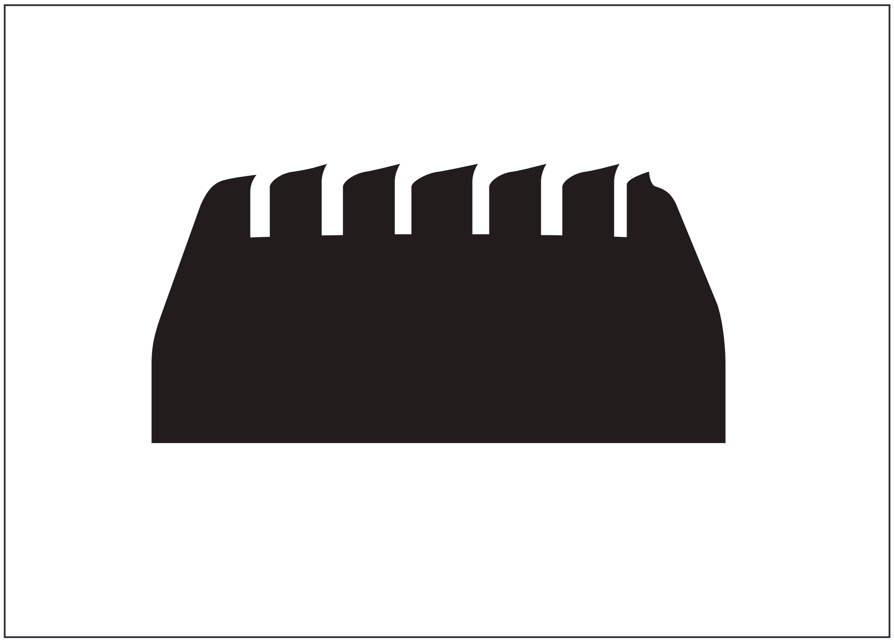
For a vehicle to maintain a straight line, a driver must hold the steering wheel through this pull. While traveling straight, the outside edge of the tire should travel a shorter distance than the inside edge. This is due to its smaller diameter. However, this cannot happen since both edges will travel the same distance. The outside edge is actually dragged along the surface slightly in order to travel the same distance as the inside edge. For this reason, excessive camber, positive or negative, may cause tire wear.

Like caster, camber is influenced by the ride height of the vehicle, so wheel alignment technicians typically check ride height *before* any geometric angles are adjusted.

Most front-wheel-drive vehicles with strut suspensions have few camber adjustments.



Toe The toe measurement is the difference in the distance between the front and the back of the tires when measured side to side. Toe is usually set close to zero, which means that the wheels are parallel with each other.

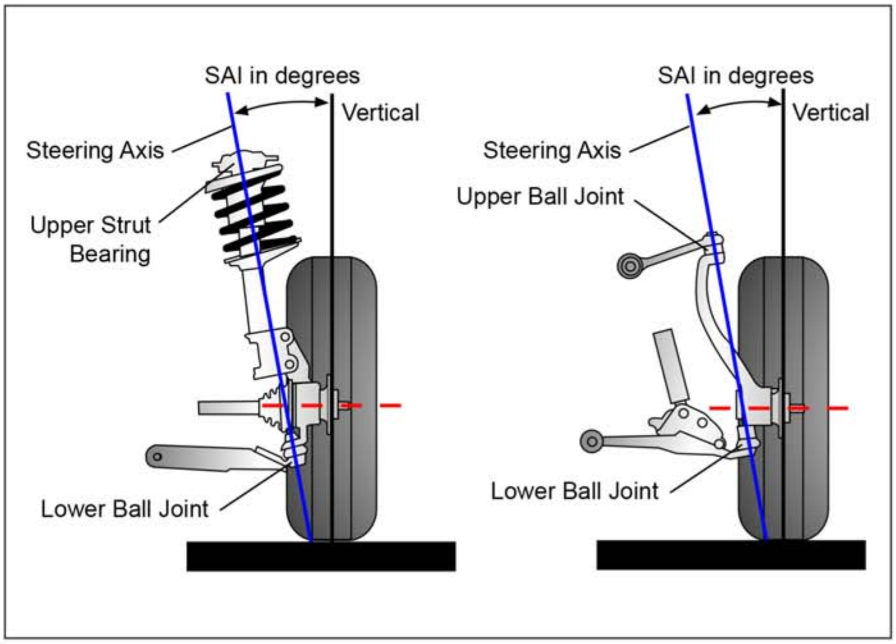


Toe
... continued

Incorrect toe is a leading cause of tire wear and will cause rapid wear to both tires equally. This type of tire wear is called a *sawtooth wear pattern*. If the sharp edges of the tread sections are pointing to the center of the vehicle, there is too much toe-in. If they are pointed to the outside of the vehicle, there is too much toe-out.

Toe is not considered to be a handling or directional-control angle. However, excessive toe-out can cause a wandering effect.

Toe is not a major concern in collision repair other than being an indicator of bent parts.



Steering Axis Inclination (SAI)

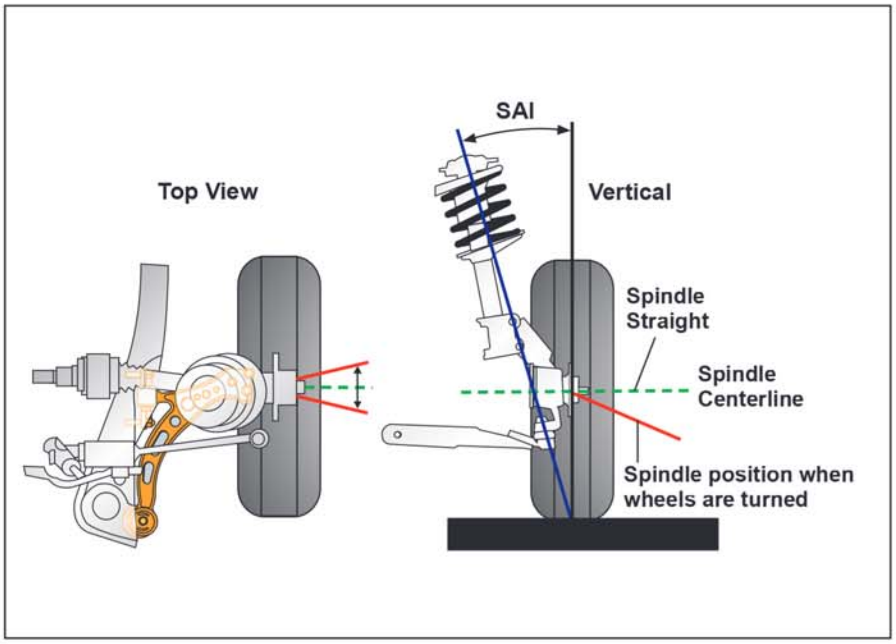
Steering axis inclination (SAI) is the angle formed between an imaginary line passing through the steering axis and a true vertical line at the center of the tire, when viewing suspension from the front of the vehicle. SAI is non-adjustable and is a non-tire-wear angle built into the suspension system. It is measured in degrees from true vertical to the steering axis at the top.

This angle, when added to the caster, causes the vehicle to lift slightly when you turn the wheel away from a straight-ahead position. This action uses the weight of the vehicle to cause the steering wheel to return to the center when you let go of it after making a turn.

Correcting SAI typically involves replacing damaged parts or repairing suspension-mounting points.

SAI promotes good handling characteristics by providing directional stability and appropriate weight projection. Directional stability refers to the tendency of the front wheels to return to the straight-ahead position and stay there without wandering after turning a corner.

The pulling effects of unequal traction, braking, acceleration, and normal contact between the tire and an uneven road surface are minimized by projecting weight to a point within the road contact area of the tire's contact patch.

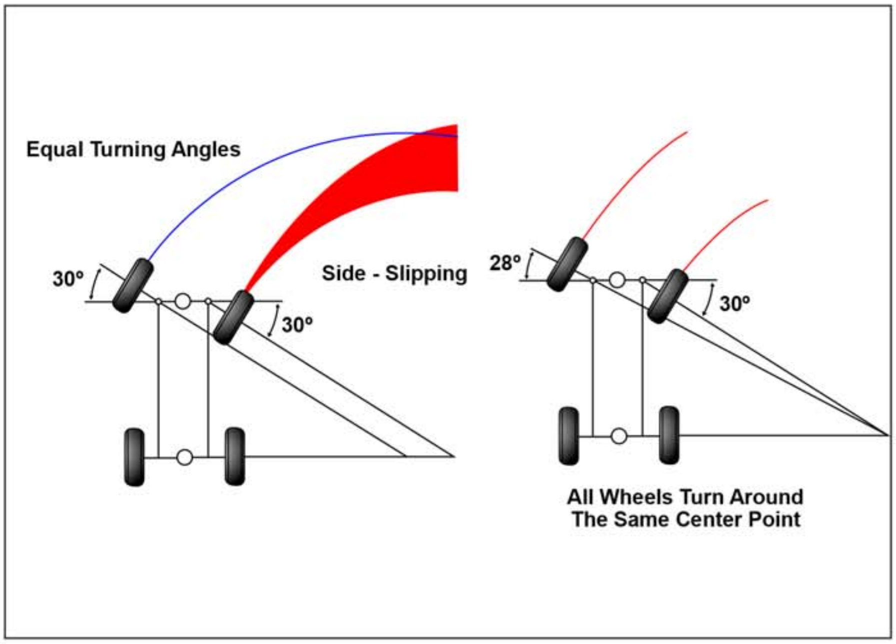


Steering Axis Inclination (SAI) ... continued

Vehicle-specific SAI is included in most Toyota, Lexus, and Scion wheel alignment specifications.

The projection of the vehicle's weight through the steering axis to the ground creates the wheel's pivot point.

A difference in SAI between sides may produce a lateral pulling condition under deceleration, which may not be present during normal driving conditions. It is critical to maintain correct SAI on a front-wheel-drive vehicle. SAI is the primary directional-control angle on this type of vehicle design, and it is non-adjustable.



Toe-Out on Turns

Toe-out on turns is the steering angle that controls the amount each wheel turns while cornering.

When you steer a vehicle through a turn, the outside front wheel has to navigate a wider arc than the inside wheel. For this reason, the inside front wheel must steer at a sharper angle than the outside wheel.

Summary

If alignment angles are not within specifications and tolerances set by the manufacturer, ride and handling will suffer. Misalignment can be caused by damage to the body or the frame structure or component attachment points — also referred to as control points — and worn or damaged steering and suspension components. This is why we strongly recommend thorough measuring of steering and suspension control points to make sure the vehicle structure and the component attachment locations are aligned.

A working knowledge of structural alignment — as well as these angles — is necessary to diagnose and repair steering and suspension misalignment properly.

Steering and Front Suspension Types

Introduction

Modern vehicles use a variety of steering and front suspension designs.

The two most common steering designs are:

- Rack and Pinion
- Recirculating-Ball Parallelogram

The engineering of each design had very specific goals. Some designs are better for light passenger vehicles, some for heavy trucks, and others for heavier passenger vehicles or light trucks. There are also specialized forms of suspensions for commercial vehicles, racing vehicles, and specialty vehicles.

The two most common front suspension designs are:

- Long Arm-Short Arm (also known as Double Wishbone)
- Strut (also known as MacPherson Strut)

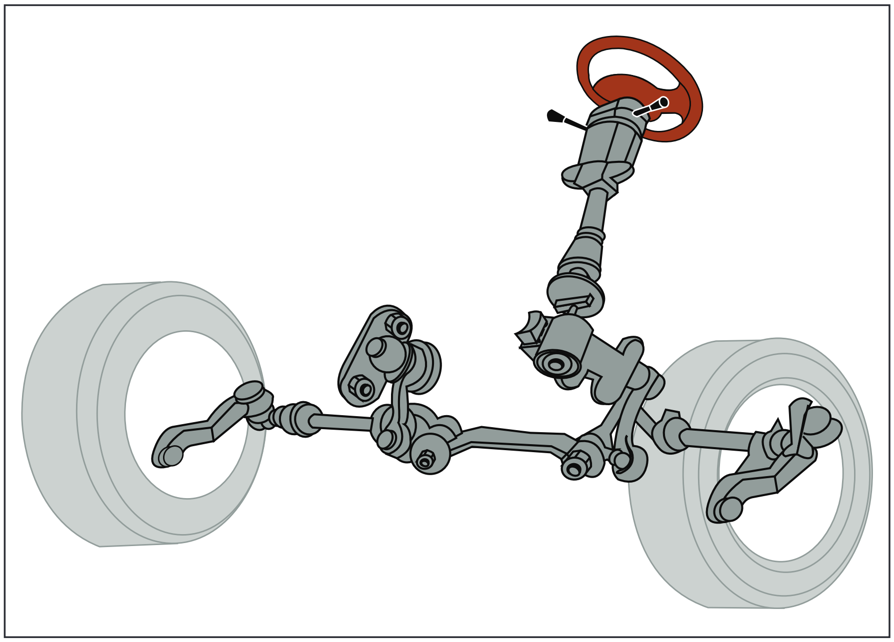
To be able to properly analyze steering and front suspension misalignment and damage, collision repair professionals must have a working knowledge of these different steering and suspension designs.

Steering Designs

The two most common steering mechanisms used on today's vehicles are:

1. Rack-and-Pinion
2. Recirculating-Ball Parallelogram

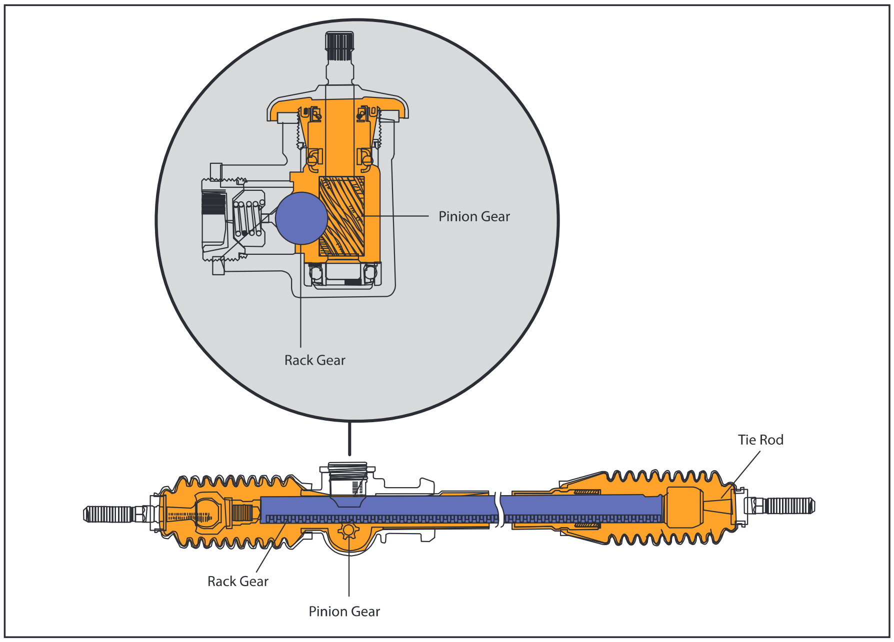
The function of the steering mechanism is to steer the vehicle through corners and to hold the wheels in a straight-ahead position. Regardless of which steering type is used, the gear and linkage must be aligned properly in order for the steering to perform these functions correctly.



Recirculating-Ball Parallelogram Steering

Recirculating-ball parallelogram steering consists of a steering box or gear, a pitman arm, an idler arm, a center link, and tie rods that connect to the steering arms at the steering knuckle.

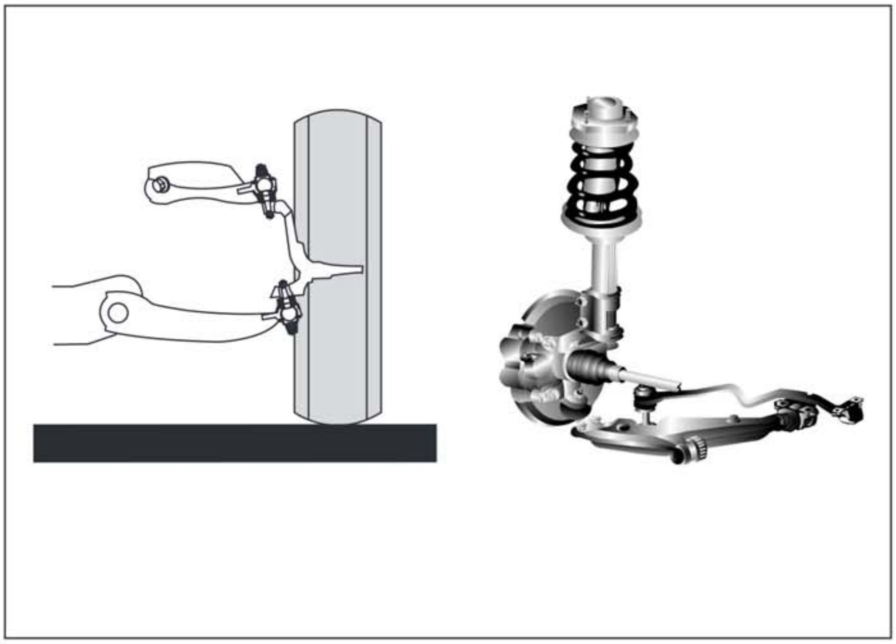
With this design, the steering shaft turns a worm gear that causes a toothed metal block to move back and forth, turning the front wheels. Ball bearings reduce friction between the worm gear and the metal.



Rack-and-Pinion Steering

A rack-and-pinion steering system is pretty much self-contained except for the outer tie rods. This design has fewer moving and connected parts compared to a recirculating-ball system. This design also saves space and reduces weight. This is the most common type of steering used for Toyota, Lexus, and Scion vehicles.

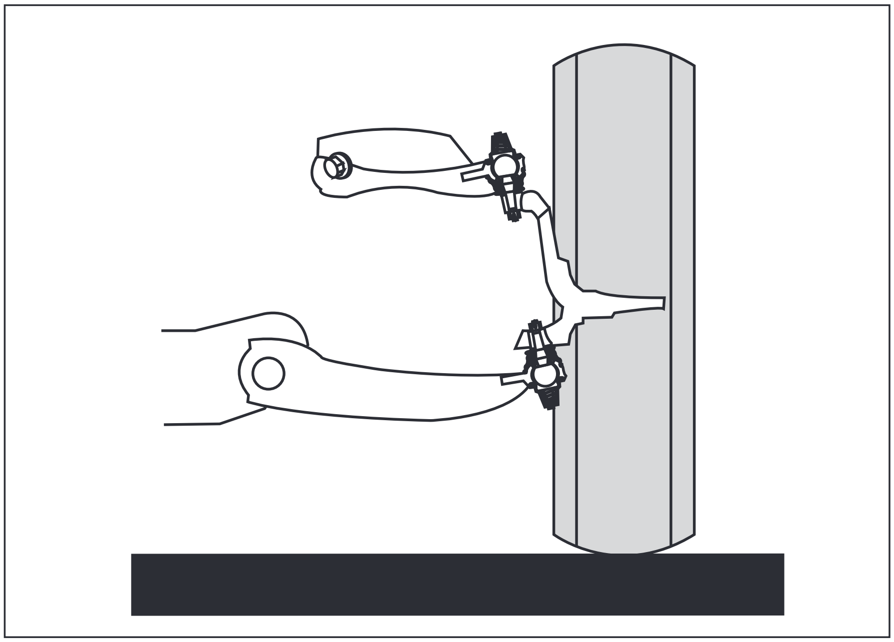
With rack-and-pinion steering, the steering wheel is connected to a pinion gear that meshes with a toothed bar that is called the rack or linear gear. As the pinion turns, the rack moves side to side, moving the steering linkage and causing the front wheels to turn left or right. The rack is linked to the steering shaft and the tie rods that attach to the steering arms.



Front Suspension Types

Modern vehicles have many variations in suspension design. The most common Toyota, Lexus, and Scion suspension design types are:

- Long Arm-Short Arm (also known as Double Wishbone)
- Strut (also known as MacPherson Strut)



Long Arm-Short Arm Suspension

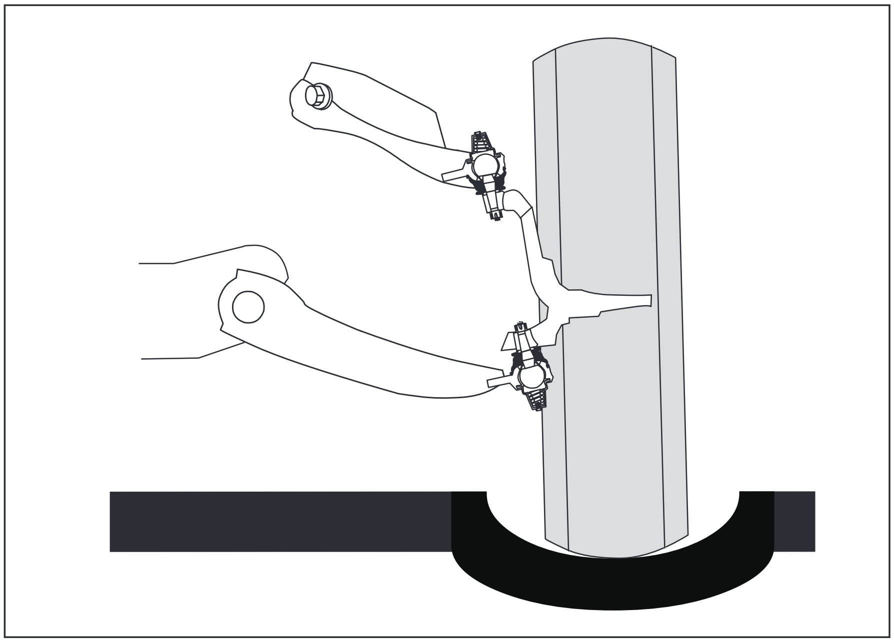
Long arm-short arm suspension is often referred to as double wishbone, A-arm, control arm, or multi-link suspension. This refers to the principal design feature where each wheel has a short upper control arm and a longer lower control arm to control the wheel position during suspension travel.

The reason for different length control arms is to help control tire wear and keep the tire in contact with the road. With this design, as the wheel unloads, minimal side shift of the tire occurs at the road contact area. In the loaded position, sideways movement of the contact area is also minimal. Camber angles change an acceptable amount during movement.

When in the loaded position, the longer lower control arm travels in a flatter arc, maintaining the sideways movement of the tire at the road contact area. The shorter upper control arm travels in a shorter radius, imparting some side shift to the position to the top of the tire. This has increased positive camber slightly.

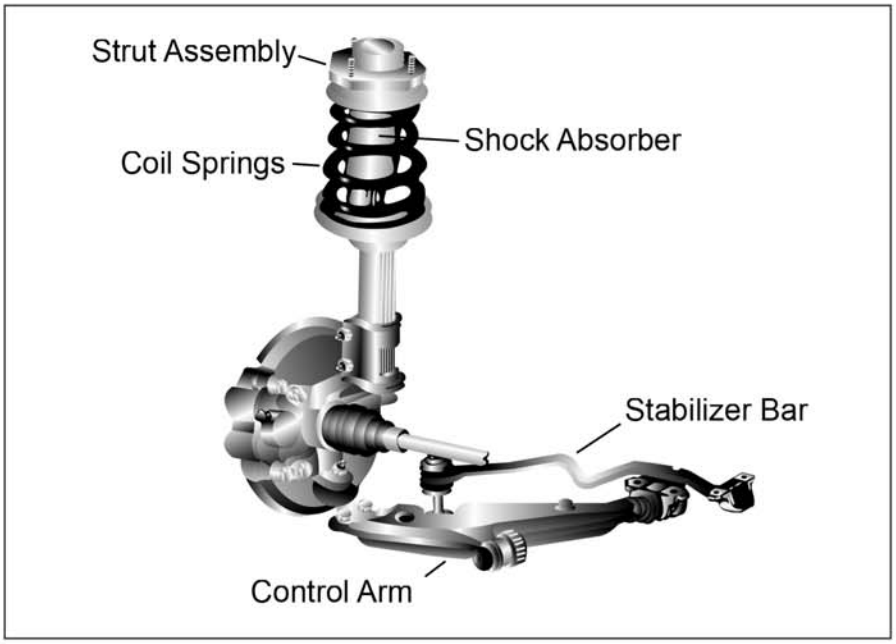
When control arms are of equal lengths and parallel to one another, the tire would retain a constant camber throughout the range of suspension travel, but the tire would move side to side considerably. This side-to-side movement would create rapid tire wear due to the scuffing action on the road surface. By using long arm-short arm control arms, some camber change is sacrificed to minimize the side-to-side scuffing action, thereby controlling tire wear.

Long arm-short arm suspension is a common suspension design used on Toyota and Lexus body-on-frame vehicles.



Long Arm-Short Arm Suspension ... continued

When the wheel falls away from the vehicle, as when going over a dip in the road, the longer lower control arm again travels in a flatter arc creating minimal side shift of the tire at the road contact area. Although a more pronounced camber change takes place (negative), it can be tolerated in this position, as there is less weight on the tire at this time.



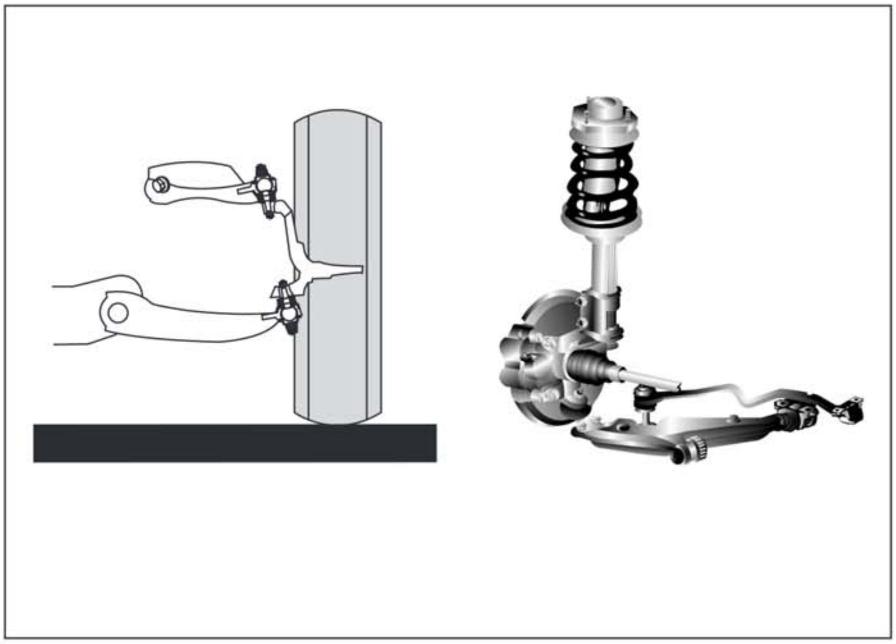
Strut Suspension

Strut suspension is the most common type of suspension on today's vehicles. It is popular because it saves space and reduces weight, and is used primarily for lighter and front-wheel-drive vehicles.

Strut suspension is less sensitive to caster misalignment. SAI is the main source of directional control in this type of suspension.

Commonly referred to as "MacPherson Strut" suspension, this design is typically composed of lower control arms, a stabilizer bar, and the strut assembly. Coil springs are mounted on the strut assembly, and the shock absorber is an integral part of the assembly.

Strut suspension is a common design used on Toyota, Lexus, and Scion vehicles.



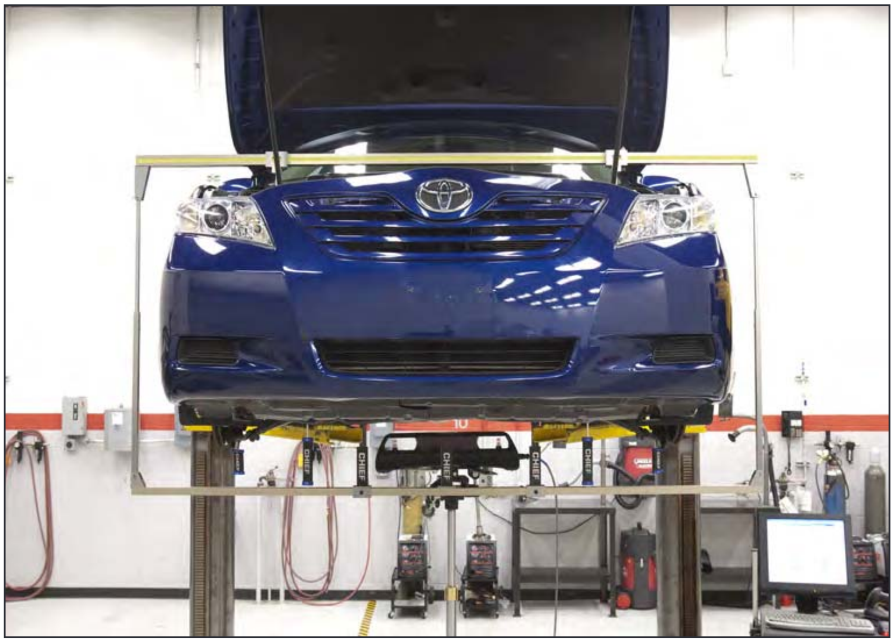
Summary

Each suspension type requires specific diagnostic techniques that are fundamental to properly diagnosing steering and front suspension misalignment and damage. In the next section we'll be taking a close look at how to analyze steering and suspension misalignment and damage.

Analyzing Steering and Suspension Damage and Misalignment

Introduction

Each steering and suspension type requires specific techniques to diagnose misalignment and damage. However, before you can accurately analyze steering and suspension components, you must first confirm the proper position of their control points.

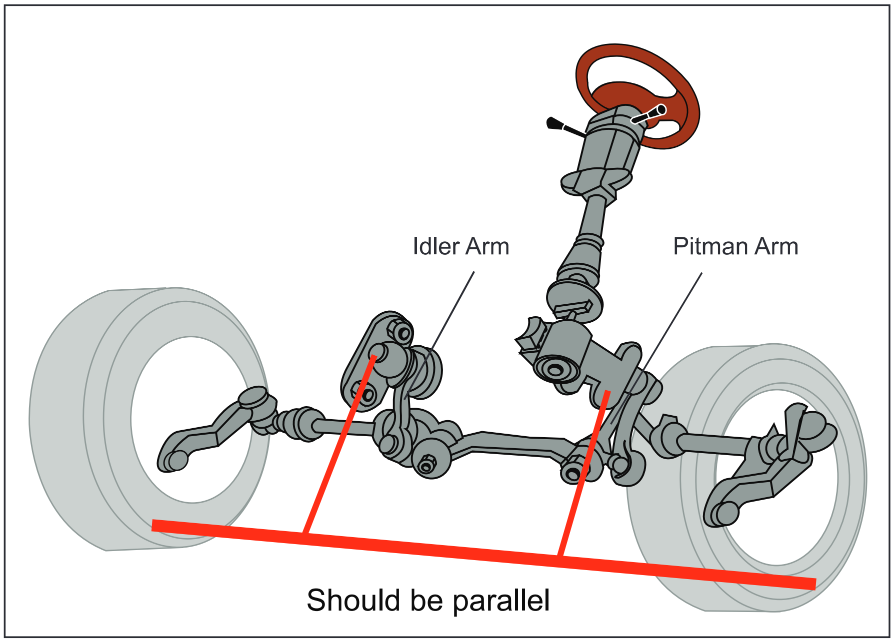


Control Points

For the front suspension to perform as designed, the mounting or control points where the suspension attaches to the structure of the vehicle must be in the correct position to each other and to the vehicle. These suspension mounting points help determine SAI, the caster, and the camber, and ensure correct steering linkage function.

The proper position of the steering and suspension control points is critical to proper function of suspension and steering. This can only be confirmed or accomplished through accurate measuring and proper structural body and frame alignment.

Therefore, it is very important to be able to accurately measure these control points. This is a key step in steering and suspension alignment analysis.

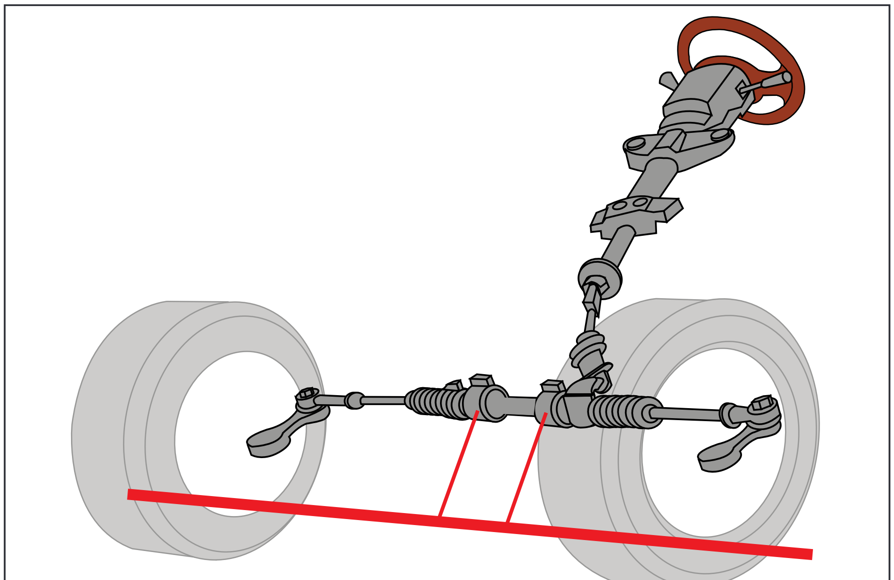


Recirculating-Ball Parallelogram Steering

On a recirculating-ball parallelogram steering design, the pitman arm and the idler arm must be at like angles with the gear centered. Control arms and tie rod ends must lie parallel to function properly. A misaligned lower control arm mounting point or steering linkage will cause a toe change.

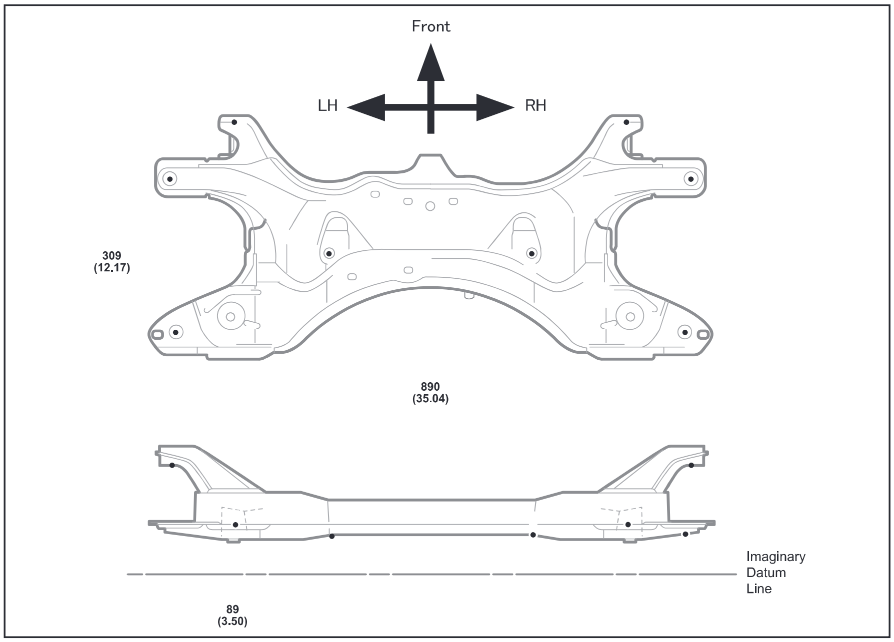
Misalignment could be caused by a twisted pitman shaft (sector shaft) or a steering gearbox being out of position.

After the linkage has been centered and parallelism of the idler arm and the pitman shaft has been verified, the steering arm must be checked for damage. Steering arm checks are explained later in this section.



Rack-and-Pinion Steering

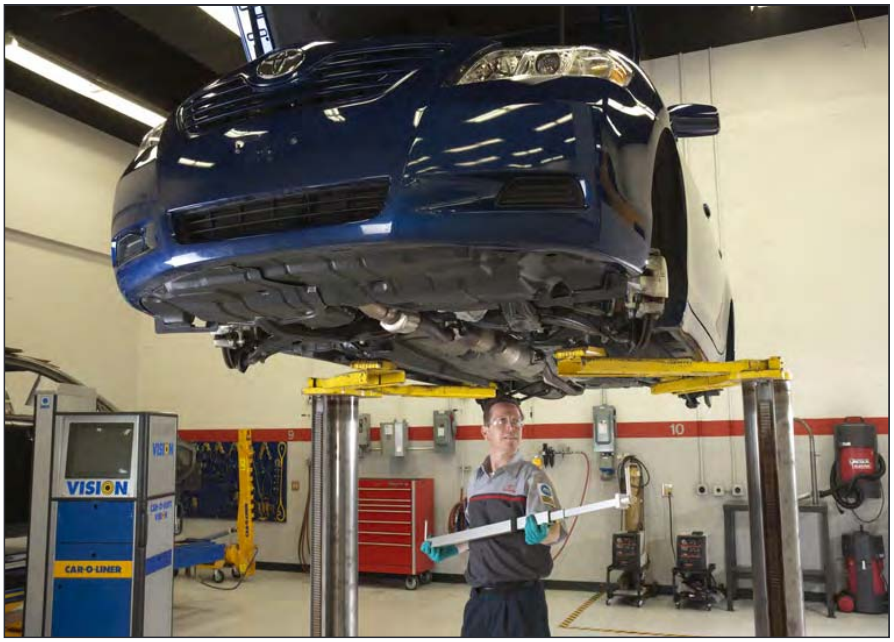
Rack-and-pinion steering must run parallel to the datum plane. If it is out of level, a condition known as “bump steer” may occur. Bump steer creates steering instability when going over bumps and while braking.



Analyzing Long Arm-Short Arm Suspension

Analyzing long arm-short arm suspension starts with determining if the main cross member is dimensionally correct.

Length, width, and height of the cross member or the sub-frame must be within dimensional tolerance. This requires accurate measuring equipment and dimension specifications.



Ball-Joint Position

Next, lower ball-joint position should be measured to ensure an equal length exists on each side.

Ball-joint measurements can be taken from an undamaged location in the vehicle center section.

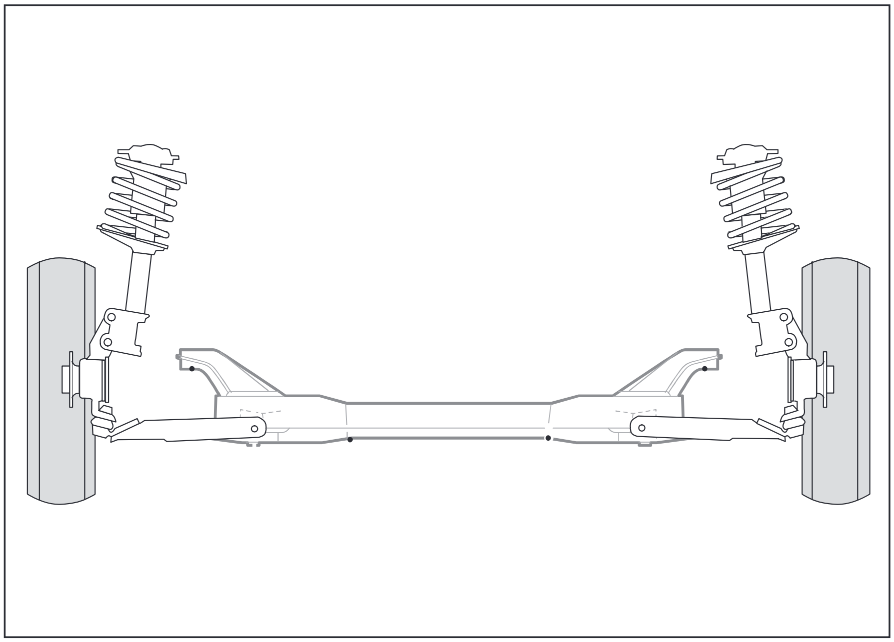
If these measurements are not equal, a caster problem will most likely occur. The cross member must also be level to the center section of the vehicle in order to maintain equal loading of the suspension on both sides.

Analyzing Strut Suspension

Analyzing strut suspension starts with making sure the upper and lower control points are where they belong.

The strut towers must be measured in all three dimensions — length, width, and height — and should be within tolerance of the factory-specified dimensions.

The strut towers must be at the proper width from centerline to ensure correct SAI and camber on both wheels. The strut towers must also be level to or parallel with the datum plane to ensure equal loading of the suspension. The position of the strut tower's upper and lower control points must be equal and within specification to ensure proper caster.

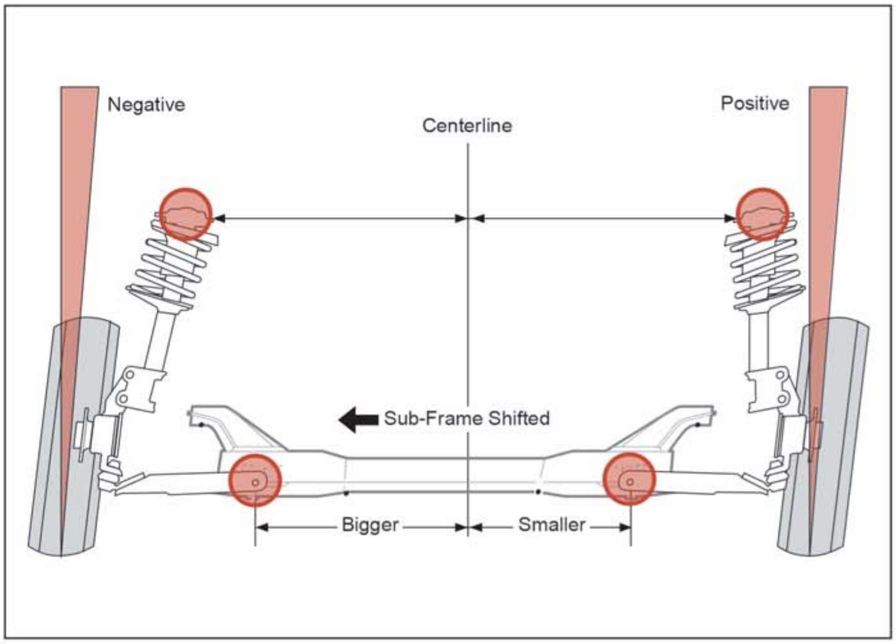


Analyzing Strut Suspension ... continued

On strut suspensions, lower control arm mounting points are the upper half of SAI and caster — and ultimately control camber — so they must be positioned correctly.

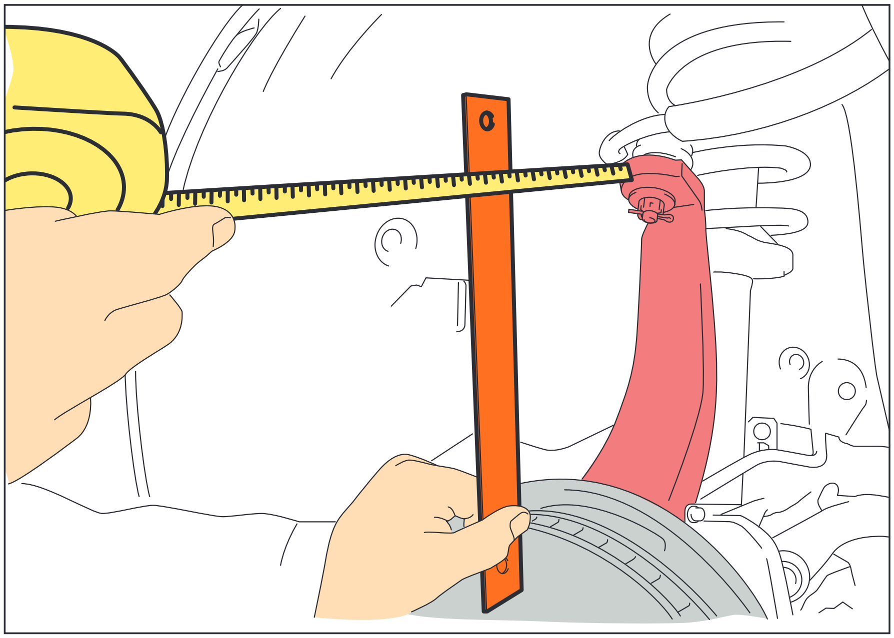
The lower position of the strut control points must also be equal from side to side to ensure proper caster. The distance of the lower mounting points from centerline must be equal to maintain proper SAI. These mounting points must also be level (parallel) with the datum plane to ensure proper load distribution.

If the vehicle's structure and all suspension mounting points have been verified to be in their correct position, any variance in camber will be an indication of a bent part — most likely a steering knuckle or a strut.



Analyzing Strut Suspension ...continued

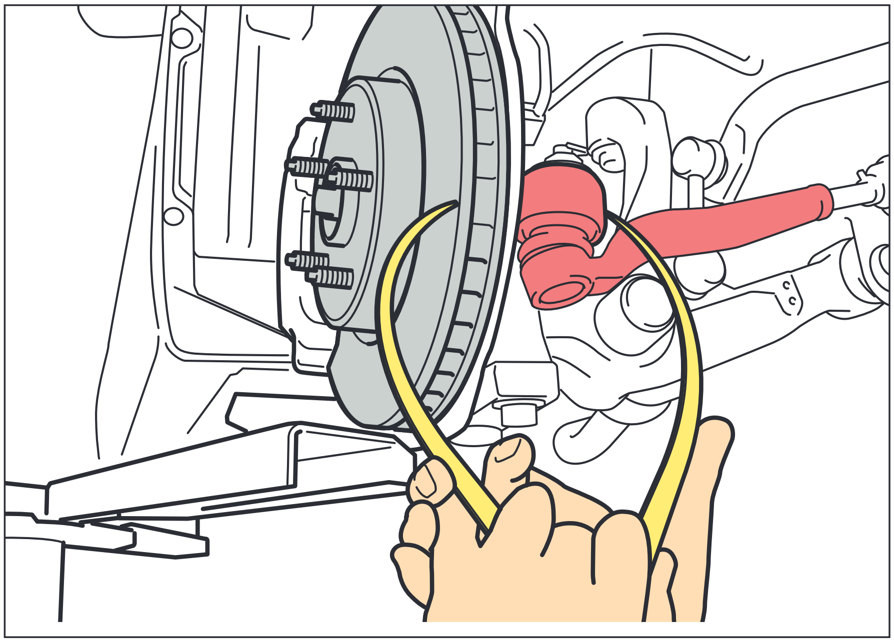
The upper mounting points may be at the proper position, but if lower mounting points are off one-quarter inch from centerline to one side, camber will be affected on each side. One wheel will be more positive and one wheel more negative. The combination of both wheels would cause a lateral pull in the same direction.



Checking for Bent Parts – Steering Knuckle

Checking for bent steering knuckles and struts can be done with basic tools, like an accurate straightedge and a tape measure.

Check for a bent steering knuckle by placing a straightedge vertically on the brake rotor. Measure from the straightedge, at a given height, to a point near the top of the steering knuckle. Compare this measurement with one taken in the same manner from the undamaged side. A difference may indicate a bent steering knuckle.



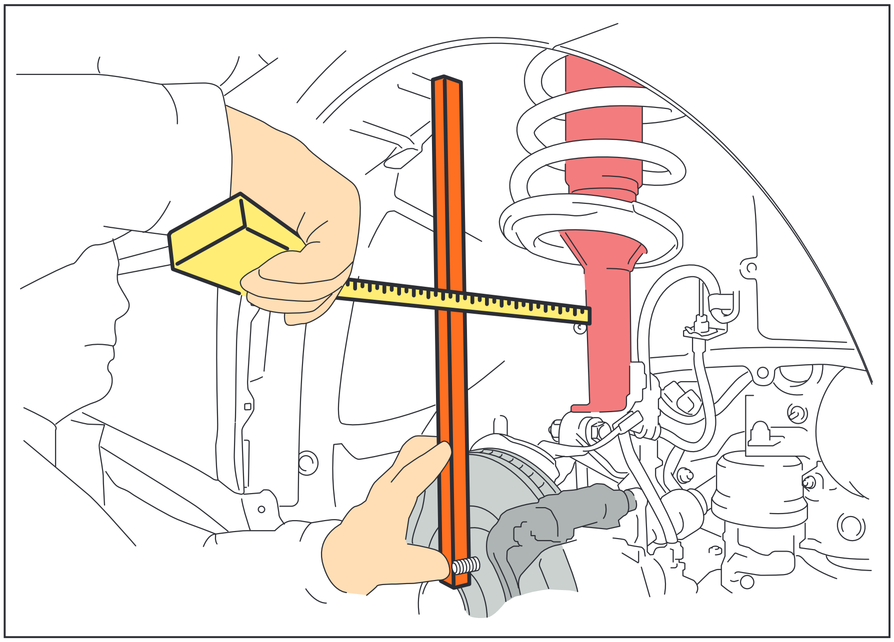
Checking for Bent Parts – Steering Arm

To check for a bent steering arm, measure from the brake rotor to the tie rod end. Compare this measurement with a measurement taken in the same manner from the undamaged side of the vehicle. These measurements should be equal.

A difference in this measurement may indicate a bent steering arm.

Checking for Bent Parts – Strut

Before proceeding, if the vehicle is equipped with a camber adjustment, the camber should be adjusted all the way in or all the way out on both sides of the vehicle.



Checking for Bent Parts – Strut ... continued

Then place a straightedge on the rotor, similar to the previous checks. Measure from a given point on the straightedge to a point just below the spring. Compare this measurement to a measurement taken in the same manner from the undamaged side of the vehicle.

A difference in this measurement may indicate a bent strut.

Checking for Bent Parts – Lower Control Arm

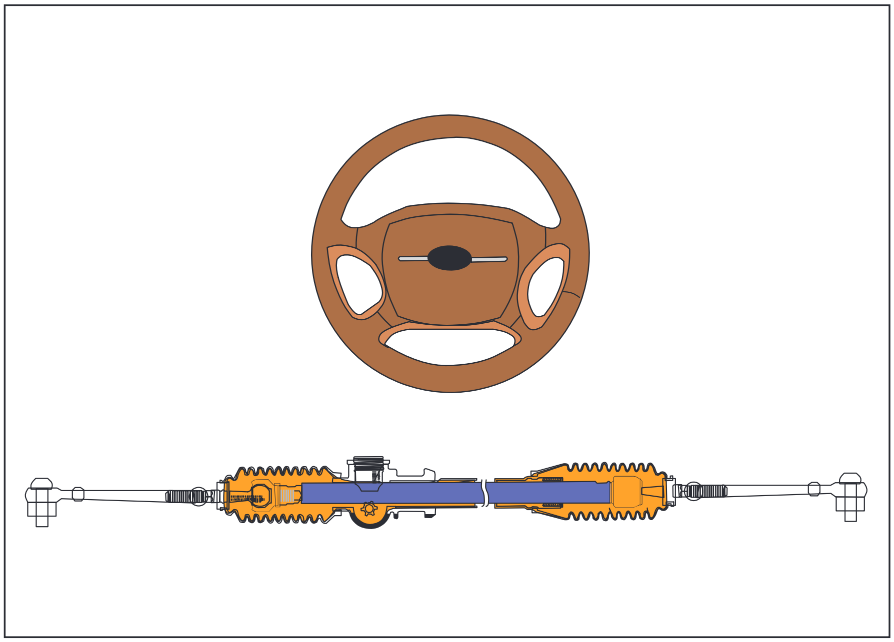
To check for a bent lower control arm on long arm-short arm suspension, measure the distance between the center of the lower arm pivot and the ball joint. Then compare these measurements to the undamaged side of the vehicle.

A difference in measurements may indicate a bent control arm.

Steering Linkage Lateral Check

Steering linkage lateral check is achieved by centering the linkage, and by verifying that steering geometry maintains the correct toe-out on turns.

Like suspension components, steering components and control points must be in their correct position.



Centering the Steering Linkage

To center the steering linkage, disconnect the tie rods from the steering arms to eliminate stops.

Turn the steering wheel all the way to the left and then all the way to the right, counting the total revolutions. Divide this number in half and bring the steering wheel to center, thus centering the steering gear.

Once the steering gear and the linkage are centered, you can begin to verify proper steering geometry.

Summary

It is very important to make sure the body structure and the control points are aligned before checking for bent parts. In addition, techniques for checking for damaged suspension parts are pretty straightforward, requiring only basic tools.

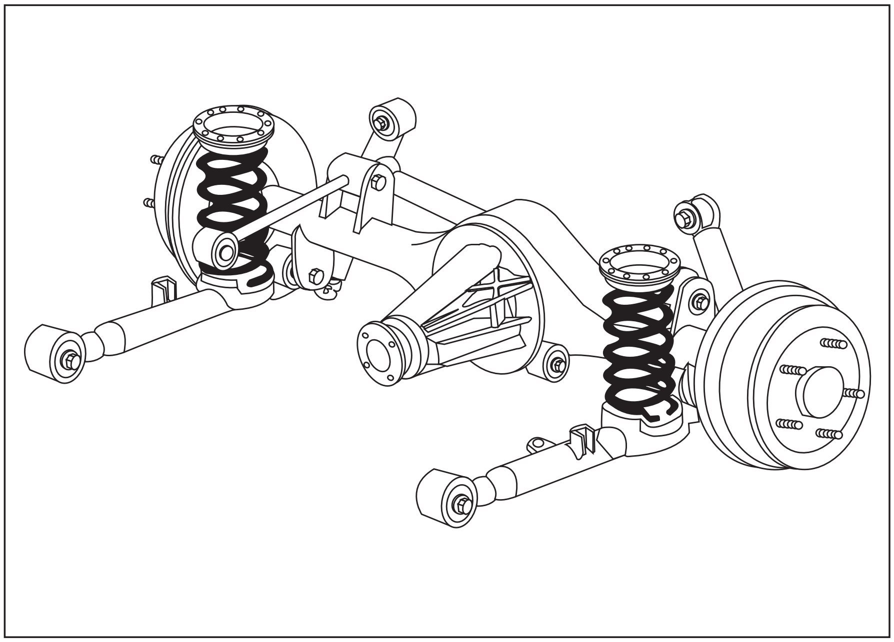
Rear Suspension and Tracking

Introduction

In this section we will examine rear-suspension design, tracking, and wheel alignment, and how they relate to one another.

The most common rear-suspension designs used in today's vehicles are:

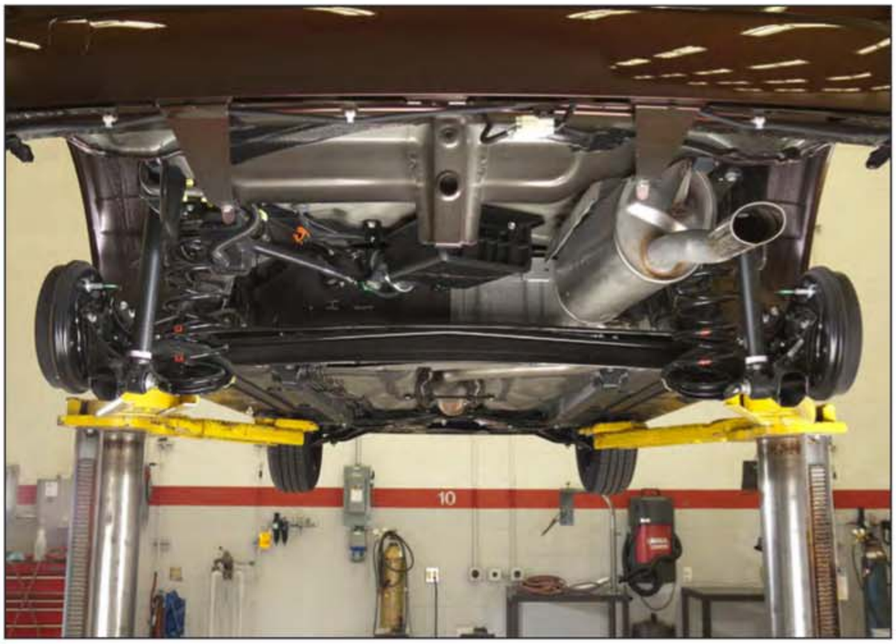
- Solid Axle
- Straight Axle
- Driven and Non-Driven Independent Suspension



Solid Axle

A solid axle has a one-piece housing that should be positioned correctly under the vehicle.

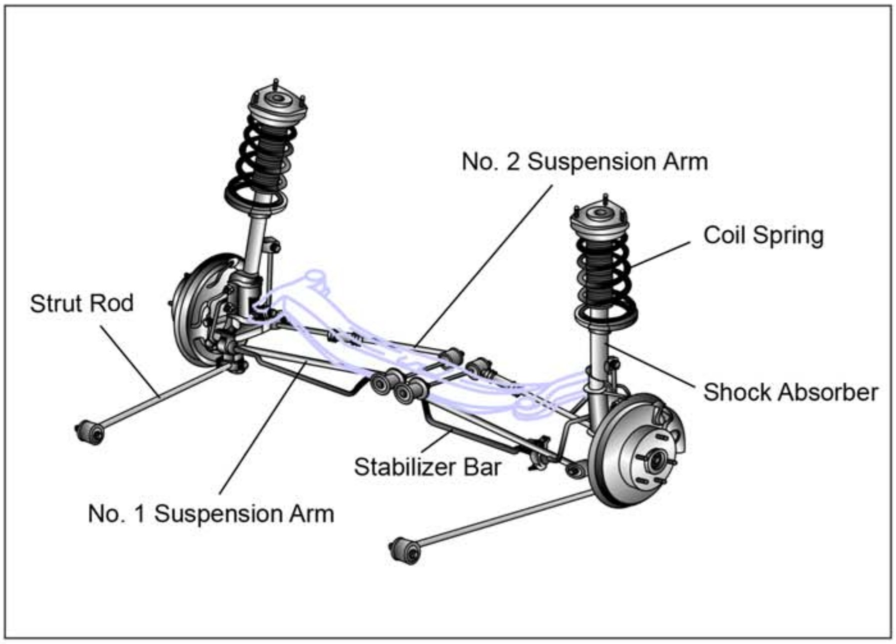
In addition to checking centering and setback, rear-wheel camber and toe should be checked on collision-damaged vehicles. If camber and toe are not near 0°, this may indicate a bent housing.



Straight Axle

A straight axle — sometimes referred to as a tag axle — is predominantly used as the rear axle on a front-wheel-drive vehicle.

A straight axle should also be positioned correctly, and camber and toe should also be near 0°.

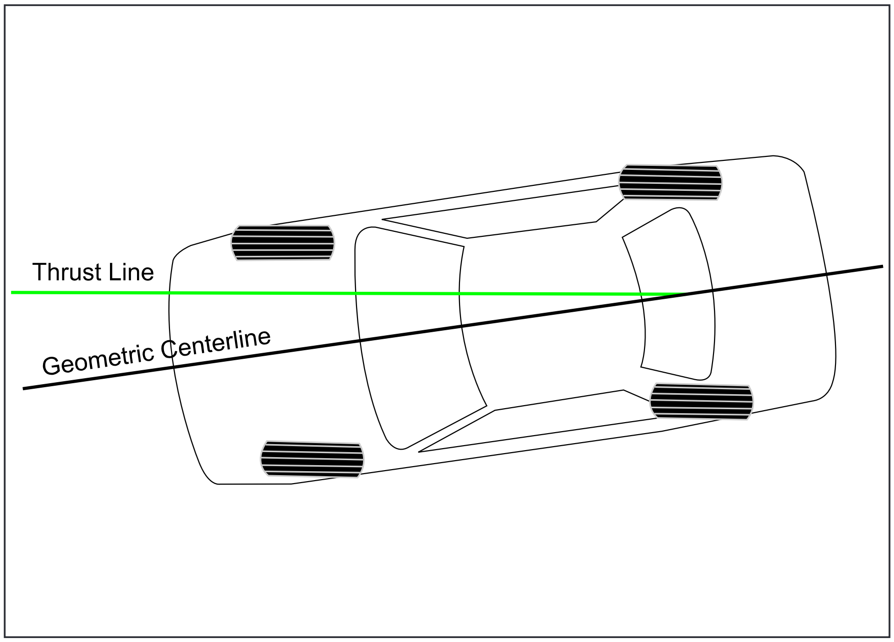


Independent Rear Suspension

Independent rear suspension provides improved ride quality and handling compared to solid-axle and straight-axle designs.

Independent rear suspension typically has camber and toe adjustments. Camber and toe specifications vary from solid and straight axles and may not be 0°.

Alignment of all types of rear suspension is critical to vehicle tracking.

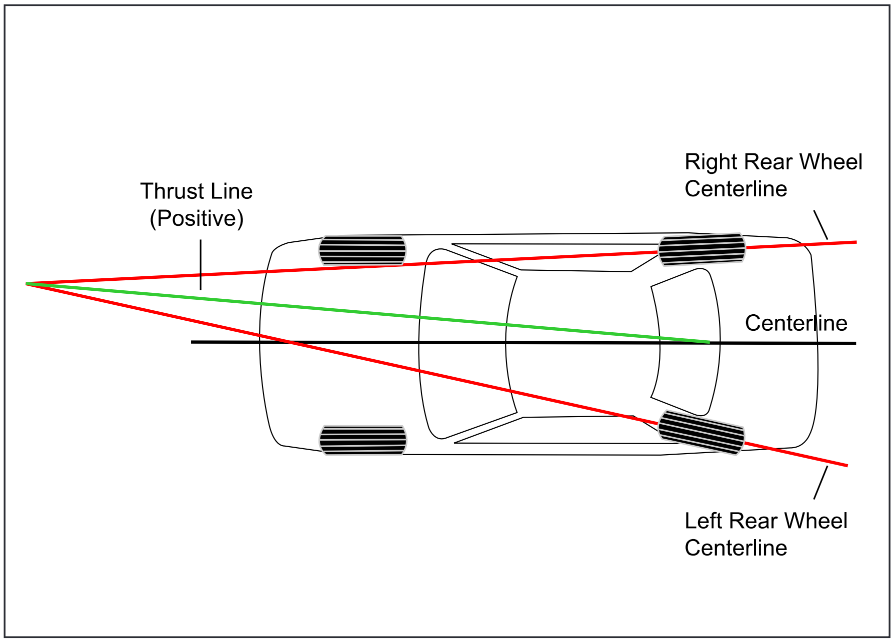


Tracking

Tracking refers to the alignment of the rear wheels with the centerline of the vehicle. Tracking is controlled 100% by the rear suspension.

If the rear wheels are not parallel to the centerline of the vehicle, the vehicle will "dog track," a term used to describe an angled vehicle during straight-ahead movement.

For correct tracking, thrust line and centerline must be the same.



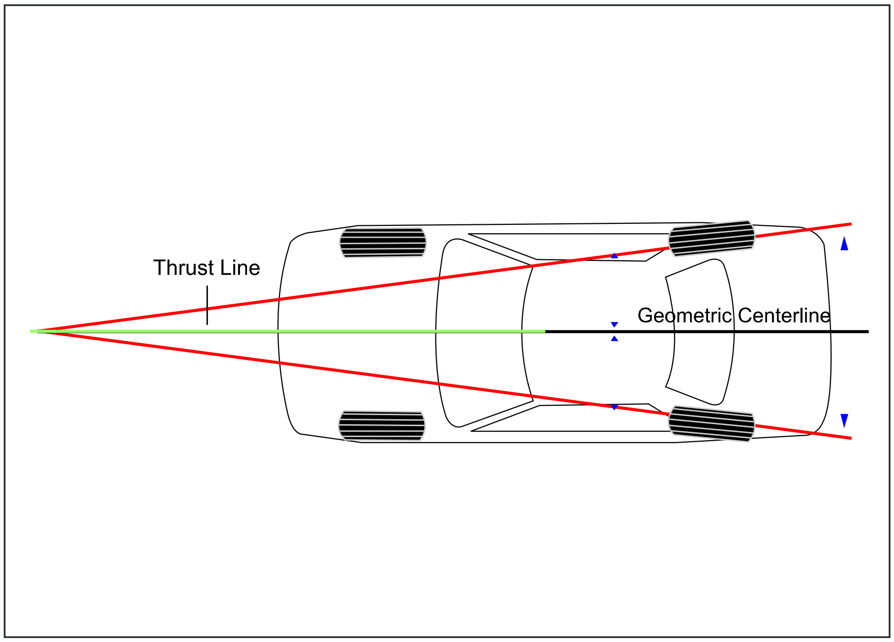
Thrust Angle

Tracking alignment is referred to as “thrust angle” or “thrust line.”

The thrust line can be thought of as a line midway between the lines representing the direction each rear wheel is aligned to travel. When a vehicle is traveling straight forward, the front wheels will always be parallel to the thrust line.

If the thrust line is to the right of centerline, the angle is positive ... and it’s negative if it’s to the left.

If the front wheels and the rear wheels are to follow the same track (correct tracking), the thrust line and the centerline must be the same.

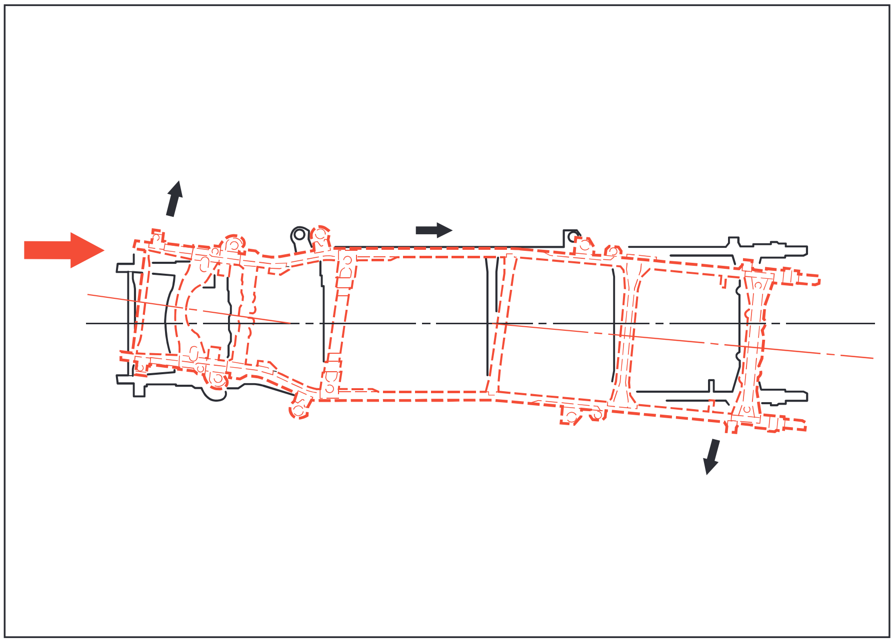


Thrust Angle ... continued

Thrust angle can only be changed by changing the direction of rear wheels relative to the centerline of the vehicle.

If rear toe is adjustable, then thrust angle is adjustable.

A wheelbase measurement may identify misaligned rear suspension.



Body-on-Frame Vehicles

Poor tracking of collision-damaged body-on-frame vehicles is usually a result of diamond frame damage. Diamond also affects centerline misalignment at both ends of the vehicle.

Since the rear-axle housing attaches to the rear section of the frame, centerline misalignment caused by diamond also causes a tracking problem.

Because the rear suspension controls tracking, rear-axle alignment is critical. It must be 90° to centerline and centered under the vehicle. This means both rear wheels should be an equal distance from the centerline.

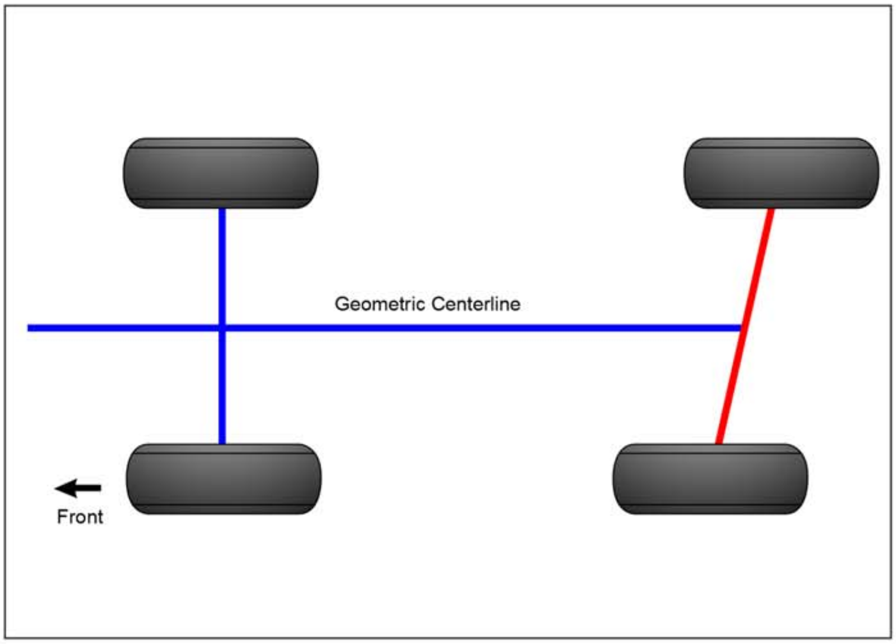
Check Tracking

To check tracking, measure to the front of the center section — not to the front wheels, as that *will not* determine which end is causing the problem.

Do this by projecting the thrust angle of the rear wheels forward with a tight string.

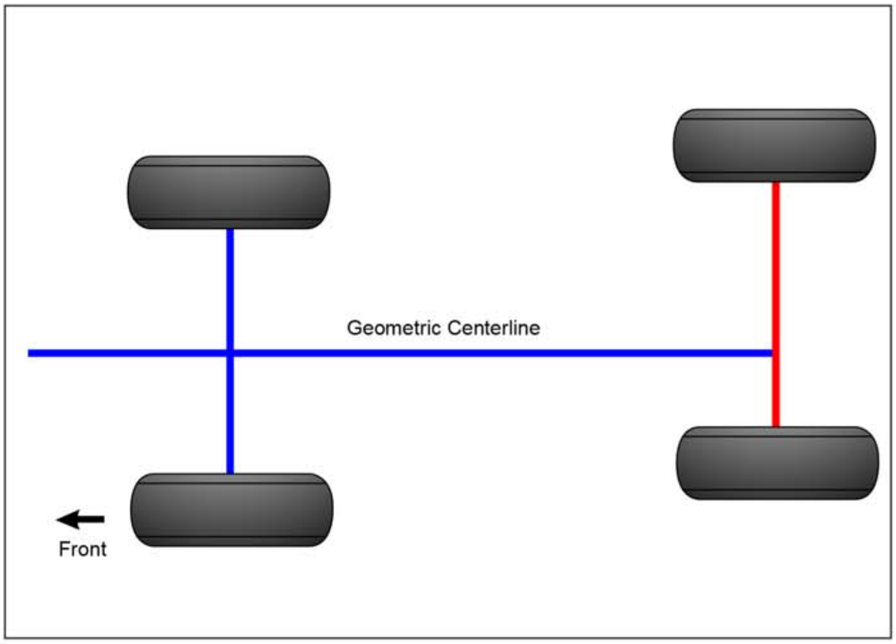
Measure the distance from the string to an identical point at the front of the vehicle's center section on both sides of the vehicle. For body-on-frame vehicles, measure to the frame. On unibody vehicles, measure to the rocker pinch-weld flange.

A difference in measurements indicates a misaligned thrust angle.



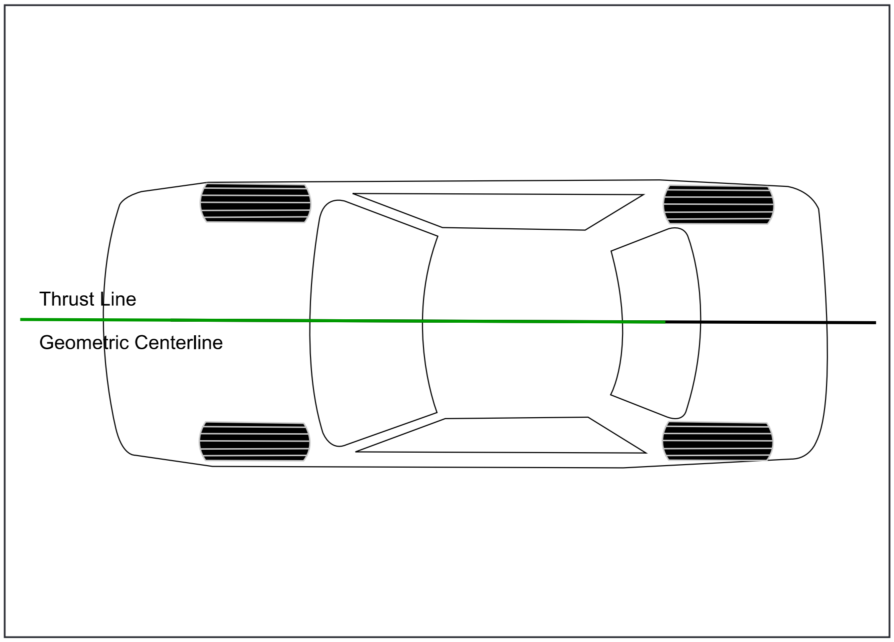
Setback Setback affects wheelbase and must be determined as being correct.

If measurements are not equal, look for misaligned or bent parts.



Offset Offset affects centering and must be determined as being correct.

If measurements are not equal, look for misaligned or bent parts.

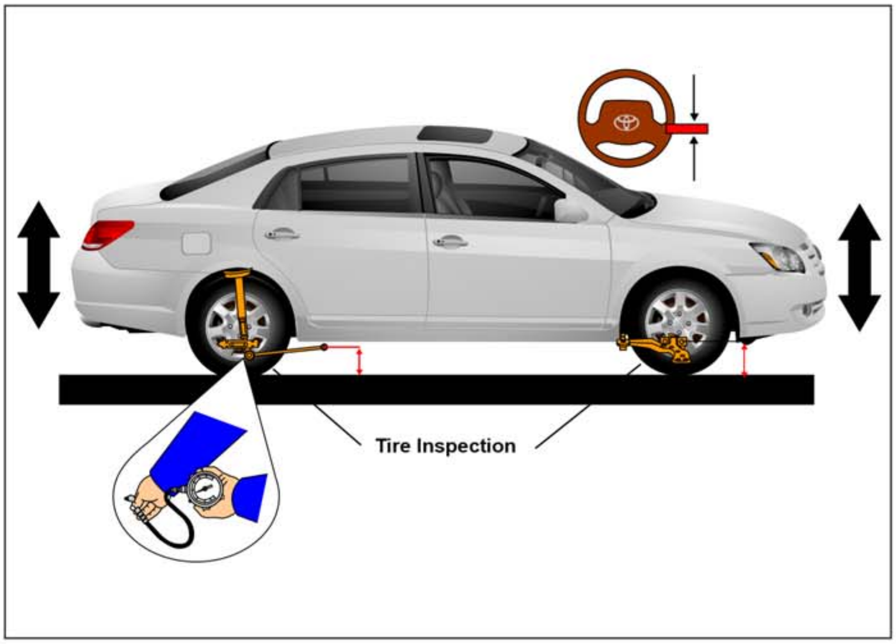


Thrust Angle or Tracking

Factors that may affect thrust angle or tracking are:

- Collision damage
- Worn or damaged rear-suspension components
- Misalignment of the rear suspension during assembly or reassembly

Besides correct front steering and suspension geometry, thrust angle must also be correct to achieve proper wheel alignment.



Wheel Alignment Preparation

Before a wheel alignment technician attempts to perform any wheel alignment adjustments, a series of checks are typically performed.

Tire sizes must match and tire circumference should match vehicle specifications. The tire pressure should be set to specifications, and tire wear must be within tolerance.

Ride height is also checked and, if adjustable, set to specification.

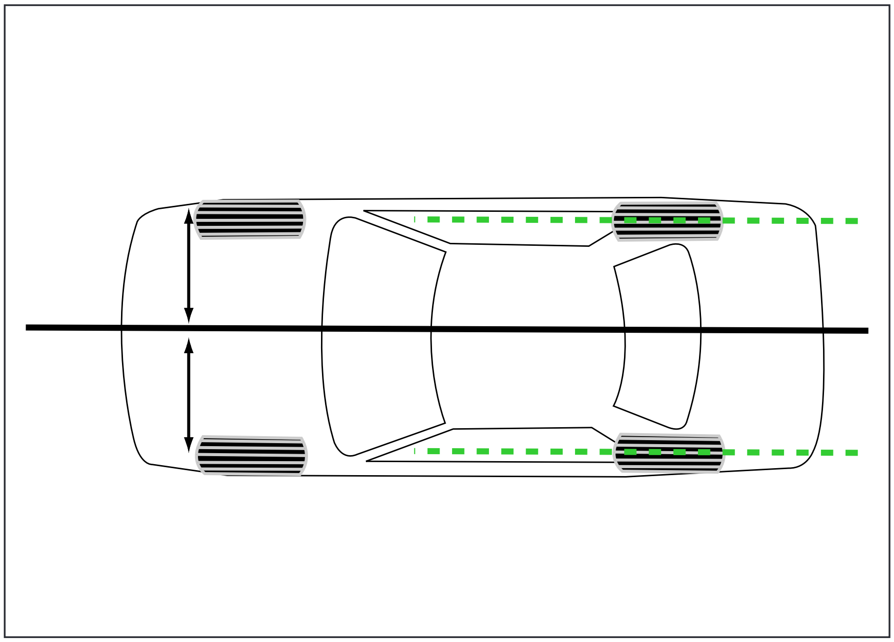
The technician may also do a quick wheelbase and steering check, and an inspection for worn and damaged parts.

The extent of any pre-alignment inspection may vary, so make sure you know what will be done and what you may need to check *before* sending a vehicle for wheel alignment.

Wheel Alignment Types

The role that thrust angle plays in the wheel alignment process may be better understood with a discussion of the different types of wheel alignment. The actual mechanics vary with the different types of equipment used and will not be discussed here. Three types of wheel alignment are commonly used:

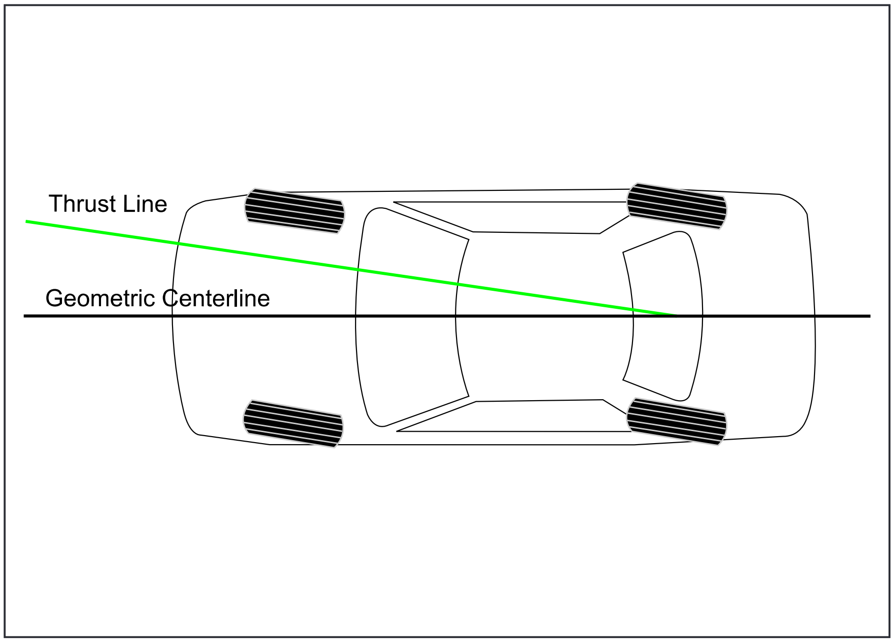
1. Two-Wheel Alignment
2. Thrust-Angle Alignment
3. Four-Wheel Alignment



Two-Wheel Alignment

A two-wheel alignment is achieved by aligning the front wheels to the geometric center of the vehicle, under the assumption that the rear wheels are set correctly.

This type of alignment is rarely done on today's vehicles with modern wheel alignment equipment.



Thrust-Angle Alignment

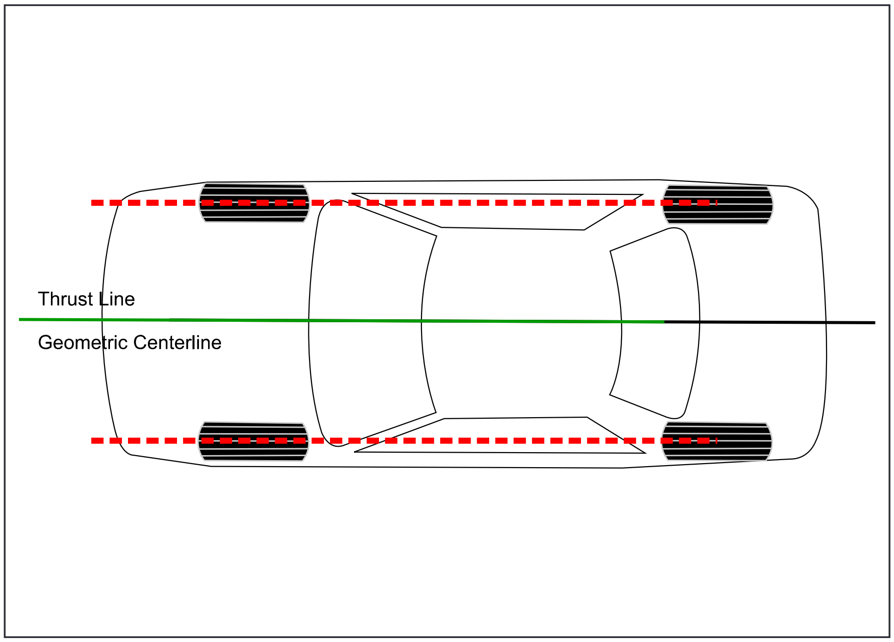
A thrust-angle alignment aligns the front wheels to the rear wheels instead of to the centerline. This type of alignment is done on vehicles with no rear-wheel adjustability.

Thrust-angle alignment is a misleading name for this type of wheel alignment. It implies that the thrust angle will be correctly adjusted or aligned. In fact, the thrust angle is not changed at all during a thrust-angle alignment.

A thrust-angle alignment is the same as a two-wheel alignment except that the front wheels are adjusted to the straight-forward position parallel to the thrust line instead of the centerline. In this manner, all settings are as intended when the vehicle is driven straight and the steering wheel remains centered as well.

If thrust angle exists, the vehicle will still “dog track,” even though the steering wheel may be straight. The amount of the tracking problem depends on the amount of thrust angle, but in most situations is unnoticeable or acceptable if the thrust angle does not exceed one-quarter degree in either the positive or negative direction.

The primary effect of a thrust-angle alignment is to ensure a centered steering wheel when traveling straight forward. If the rear wheels of a vehicle happen to be perfectly positioned and no thrust angle exists, a two-wheel alignment and a thrust-angle alignment are the same for that vehicle.



Four-Wheel Alignment

A four-wheel alignment aligns the front wheels and the rear wheels to the vehicle's centerline. The rear wheels are aligned first to eliminate thrust angle, and then the front wheels are aligned to the rear.

In recent years, more vehicles are being manufactured with rear suspensions that are adjustable for camber and toe, or aftermarket kits are available that permit those adjustments. These vehicles can receive a true four-wheel alignment.

A four-wheel alignment consists of the fine adjustments for front-wheel caster and camber and toe (where caster and camber are adjustable) along with adjustment for rear-wheel camber (where adjustable) and toe.

In a four-wheel alignment, any thrust angle can be eliminated by adjusting the individual toe of each rear wheel until the thrust line is parallel to or the same as the vehicle's centerline. Then, when all adjustments are correctly completed, the vehicle will have all four wheels tracking parallel to the vehicle's centerline (correct tracking) when traveling straight forward, and the steering wheel will be centered.

Conclusion

A solid grasp and working knowledge of the concepts presented in this training course are essential to sorting out and solving steering and suspension problems. Applying this knowledge while analyzing vehicles with potential damage to steering and suspension components will minimize or eliminate many of the stumbling blocks typically associated with guessing. In turn, this will reduce vehicle repair cycle time and contribute significantly to customer satisfaction, as well as profitability.