
Table of Contents

Suspension Systems

Subject	Page
Purpose of the System	3
Basic Suspension Geometry	4
Caster	4
Camber	5
Toe	6
Steering Roll Radius	7
Steering Axis Inclination	8
Toe-out on Turns	9
Geometric Axis	10
Suspension Systems	11
Single Joint Front Suspension	11
Double Pivot Front Suspension	14
Rear Suspension Systems	16
Semi-Trailing Arm	17
Semi-Trailing Arm with "Track Link"	18
Central "C" Link	19
Multi-Link Suspensions	22
Alignment Procedures	28
Vehicle Inspection	29
Ride Height Measurement	30
Identification of Suspension	32
Vehicle Loading	34
Alignment Specifications	36
Alignment Checklist	38
Alignment Worksheets	39
Review Questions	40

Model: All Production BMW Vehicles

Production: All

Objectives:

After completion of this module you will be able to:

- Understand Basic Alignment Angles
- Understand Suspension Geometry
- Identify BMW Suspension Systems
- Understand Basic Alignment Procedures

Purpose of the System

The safety, stability, handling and performance of a vehicle depends on many factors. One of the most important aspects of these characteristics is the design of the suspension and steering systems. BMW vehicles are known for their superior handling and road performance. The design of the BMW suspension systems is a key factor in achieving these goals.

Suspension geometry is defined as: "The angular relationship between the suspension, the steering linkage and the wheels - relative to the road surface."

There are several alignment geometry angles which relate to the suspension components and steering linkages including:

- Caster
- Camber
- Toe-In/Toe-Out
- Steering Roll Radius (steering offset)
- Steering Axis Inclination (SAI) and Included Angle (IA)
- Toe Out on Turns
- Thrust Line and Thrust Angle

All of these angles influence:

- The ease with which the vehicle can be steered
- The steering stability (handling, tracking and safety)
- Tire wear

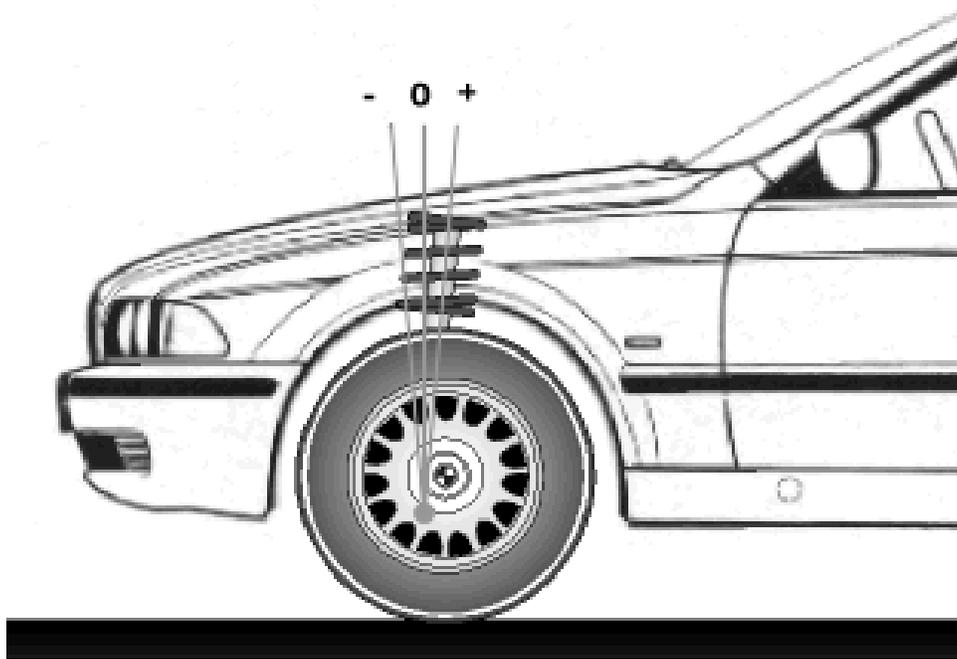
The suspension geometry for any given vehicle is a result of the design engineers development of the vehicle and the design criteria for that particular vehicle.

Basic Suspension Geometry

Caster

Caster is the forward or rearward tilt of the steering axis centerline, as viewed from the side of the vehicle, and is measured in degrees from a vertical. It is a directional control geometry angle that helps keep the vehicle moving straight ahead.

If the steering axis is tilted rearward, it is called "Positive Caster". A forward tilt is called "Negative Caster".



On BMW vehicles, Caster is always positive. Positive Caster increases stability at high speeds. Positive Caster also causes increased steering effort at low speeds. Systems such as Servotronic help minimize this negative effect. In addition to increased high speed stability, cornering is enhanced and steering wheel returnability is improved by positive Caster.

Caster is measured in degrees. On BMW vehicles, Caster is a non-adjustable angle. But Caster is influenced by damaged suspension components. When performing a wheel alignment, always check Caster to insure there is no hidden damage.

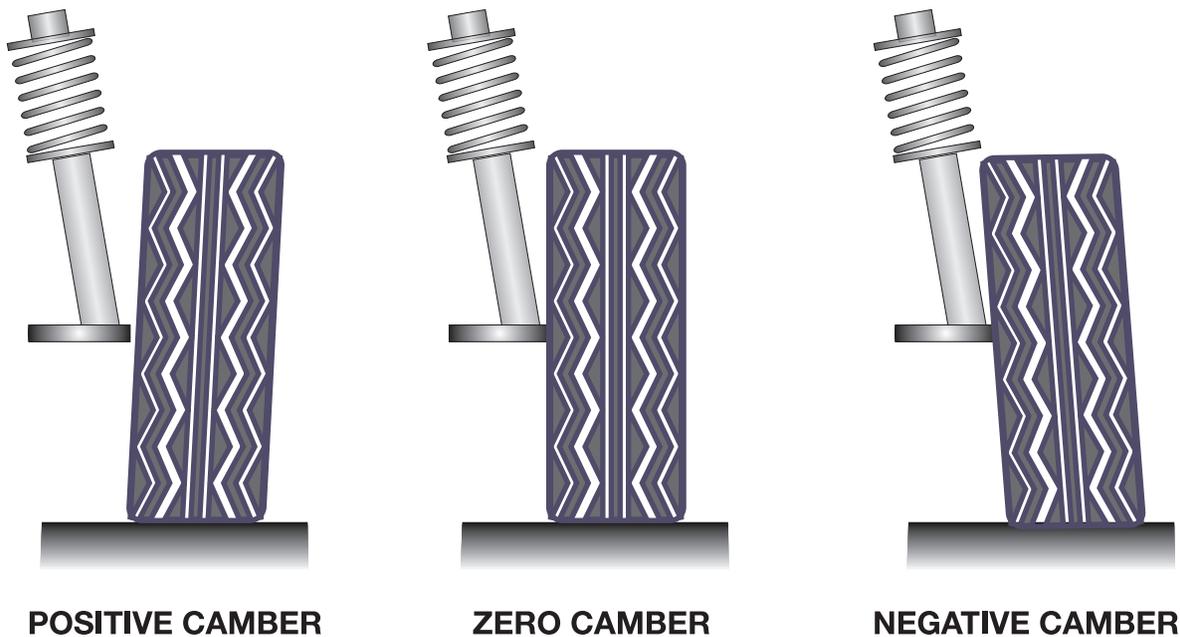
Cross Caster

Cross Caster is the difference in the Caster measurement from left to right. Excessive Cross Caster can cause the vehicle to pull to the side with the **least** positive caster.

Camber

Camber is the inward or outward tilt of the wheels when viewed from the front of the vehicle. The amount of tilt is measured in degrees from the vertical and is called the camber angle.

If the wheel tilts out at the top, the camber angle is positive and if the wheel tilts in at the top it is negative.



Excessive Positive Camber will cause abnormal wear on the outer edge of the tire.

Excessive Negative Camber will cause abnormal wear on the inner edge of the tire.

Camber is measured in Degrees and Minutes and is measured at the front and rear of the vehicle. Camber is adjustable on some BMW models.

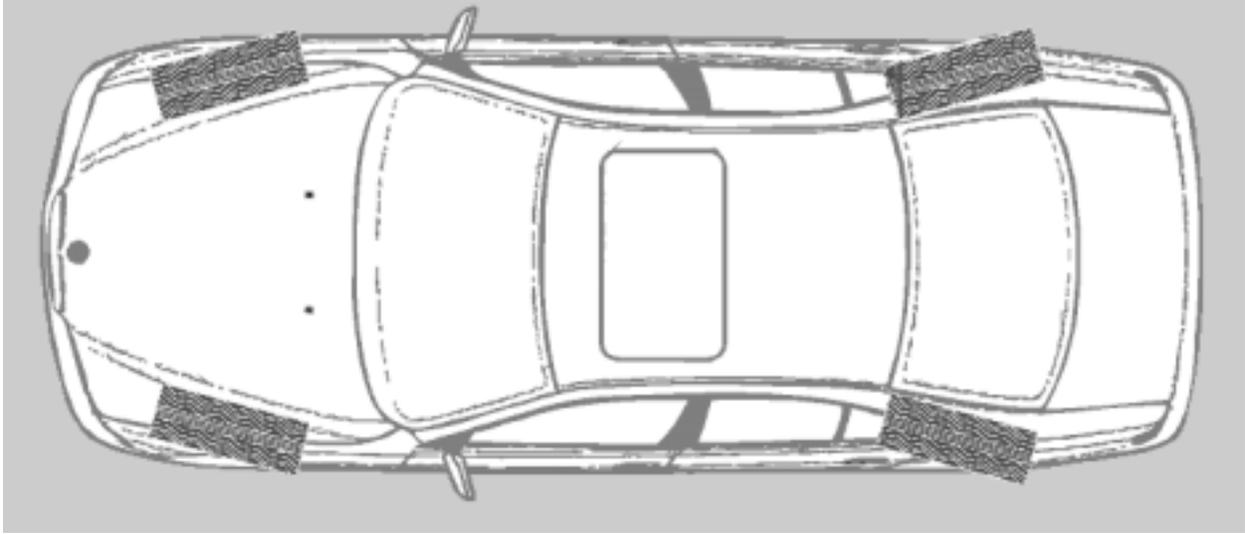
Cross Camber

Cross Camber is the difference between camber angles from left to right. If Cross Camber is excessive, the vehicle will pull to the side with the **most** positive Camber.

Toe in/Toe out

Toe is the difference in length by which the wheels of each axle differ from each other, front to rear, in the straight ahead position. The rear wheels are also subject to toe measurement.

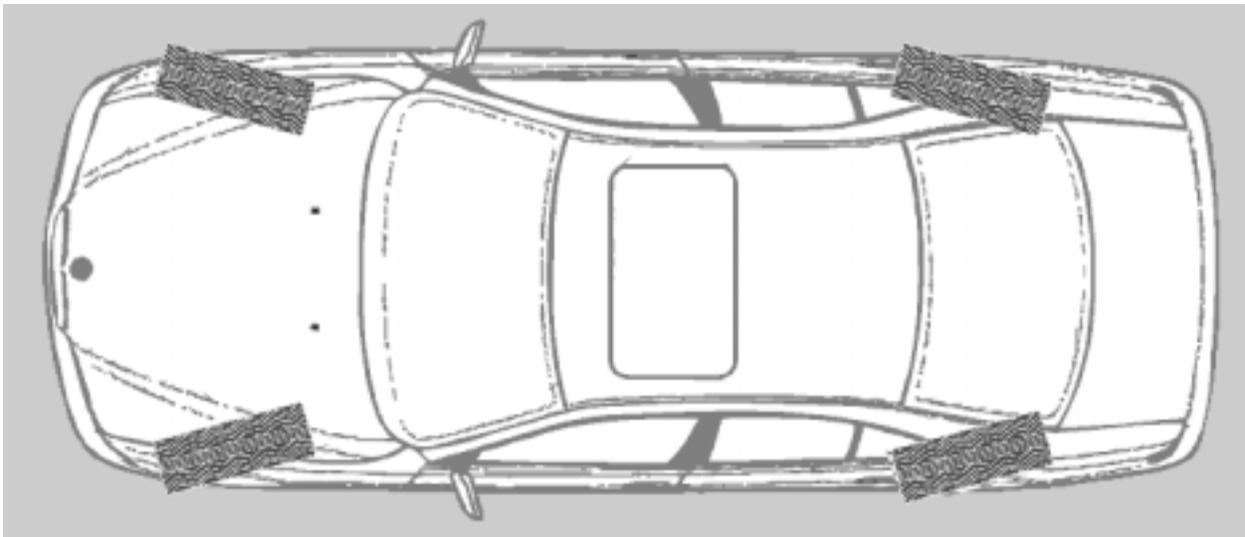
Toe is measured at the center of the wheels from one wheel rim to the other. When the distance is greater at the rear of the wheels, it is called toe-in.



When the distance is greater at the front of the wheels, it is called toe-out.

Rear wheel drive vehicles generally will have a small amount of toe-in at the front wheels. This will allow the wheels to toe out when rolling to achieve a zero running toe.

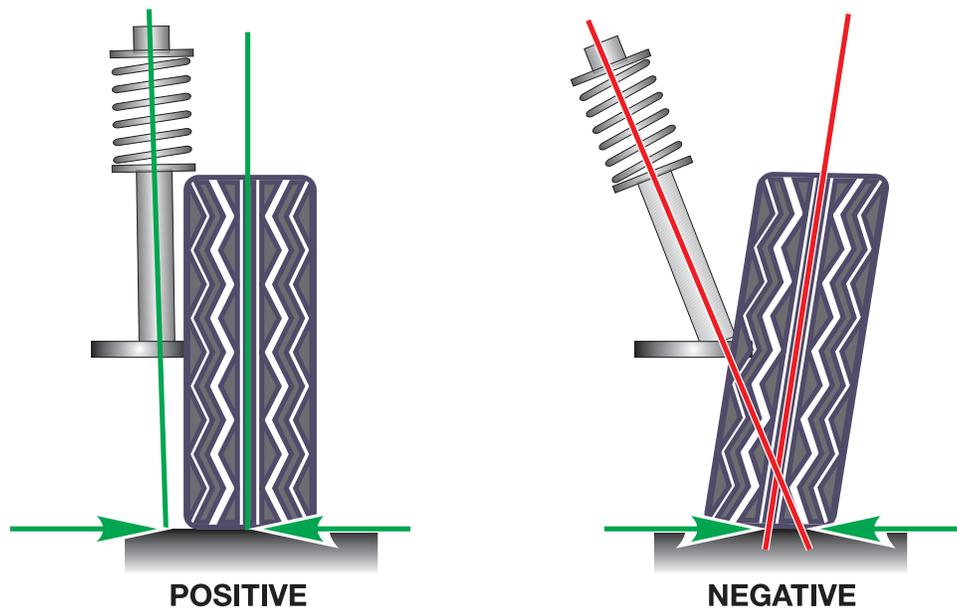
Toe is measured in Degrees when using BMW specifications. Front toe is adjustable on all BMW vehicles. Rear toe is only adjustable on some models.



Steering Roll Radius (Steering Offset)

The steering offset is the distance between the point of contact of the projected line drawn through the steering axis to the road surface and the center point of the tire contact area (foot print). The roll radius is the distance between these two lines.

- A **positive** roll radius exists when the steering axis line is **inside** the center line of the tire.
- A **negative** roll radius exists when the steering axis line is **outside** of the tire center line.



When the Steering Roll Radius is excessively positive, stability during braking is reduced. When the Steering Roll Radius is excessively negative, the directional stability is reduced and there is reduced feedback to the driver through the steering wheel. BMW vehicles are designed with a slightly positive Steering Roll Radius. This gives the driver a better “road feel” without compromising braking stability.

Steering Roll Radius is not adjustable, but can be influenced by improper tire and wheel combinations. Wheels with incorrect offsets can compromise handling characteristics. Scrub Radius is another term used to describe Steering Roll Radius.

Steering Axis Inclination (SAI)

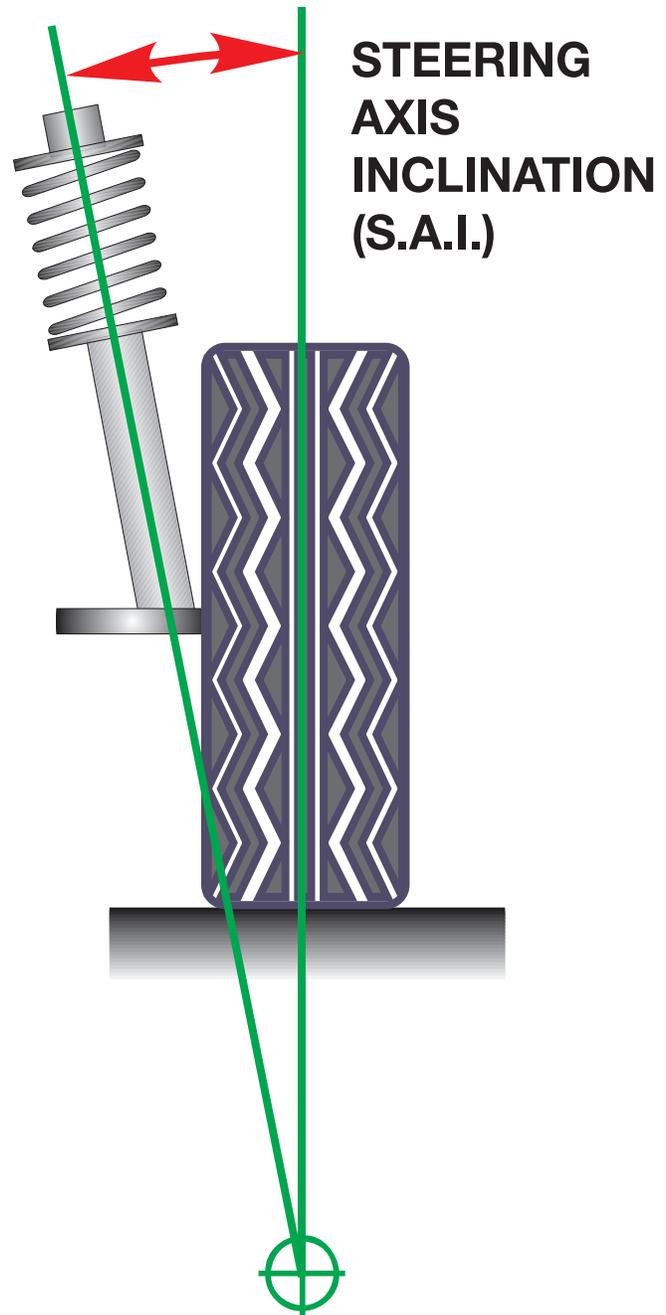
Steering Axis Inclination is the inward tilt (angle) of the strut assembly with respect to a vertical line to the road surface.

SAI results in self-correcting forces that cause the front wheels and steering wheel to return to a straight ahead position after cornering.

SAI is not adjustable, but is affected by damaged suspension components. Most current alignment equipment can measure SAI and can aid in the diagnosis of damaged parts. Bent strut or spindle assemblies are common causes of incorrect SAI readings.

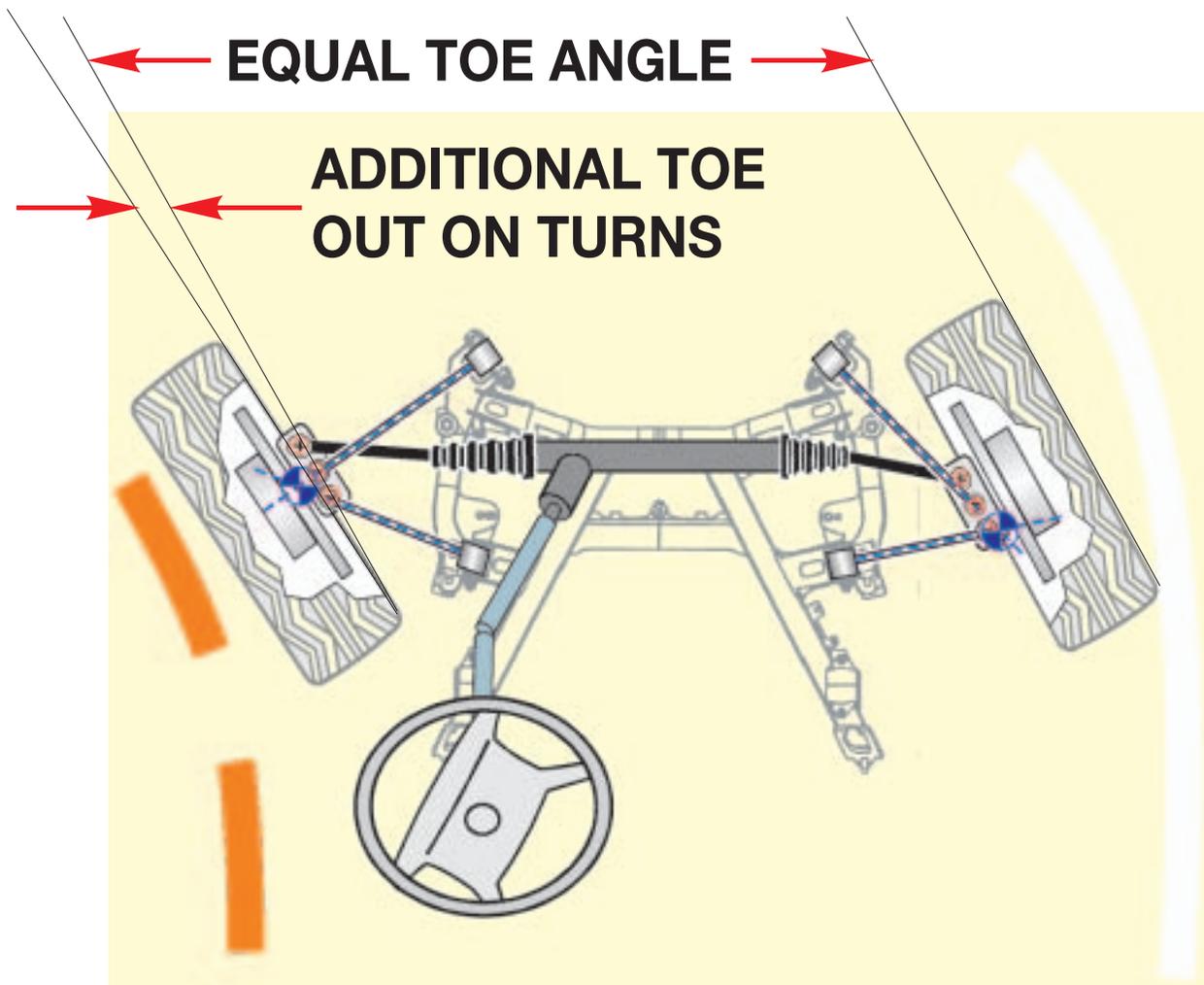
Included Angle (IA)

Included angle is the Camber angle and SAI combined. IA is also helpful when trying to diagnose bent suspension components. Knowing the IA and SAI is helpful when adjusting Camber. If the desired Camber angle cannot be achieved, then looking at SAI and IA could help determine the cause.



Toe Out on Turns

Also referred to as "Turning Angle", Toe out on turns results from the different angles (arcs) taken by the front wheels when driving through a corner. When turning a corner, the outside wheel must travel a greater distance than the inside wheel. The additional toe angle is determined by the steering arm design. Deviations from the specified value could indicate possible bent steering linkage. A typical complaint that would be associated with this condition would be excessive tire squeal or "scrubbing" on turns. When looking for this specification in TIS, look for the "Track Differential Angle" specification.



Geometric Axis

The Geometric Axis (Centerline) is an imaginary line that is drawn between the midpoints of both front and rear wheels. The Axis is perpendicular to front and rear axles at 90 degrees. This is an imaginary angle that is not adjustable.

Thrust Line/Thrust Angle

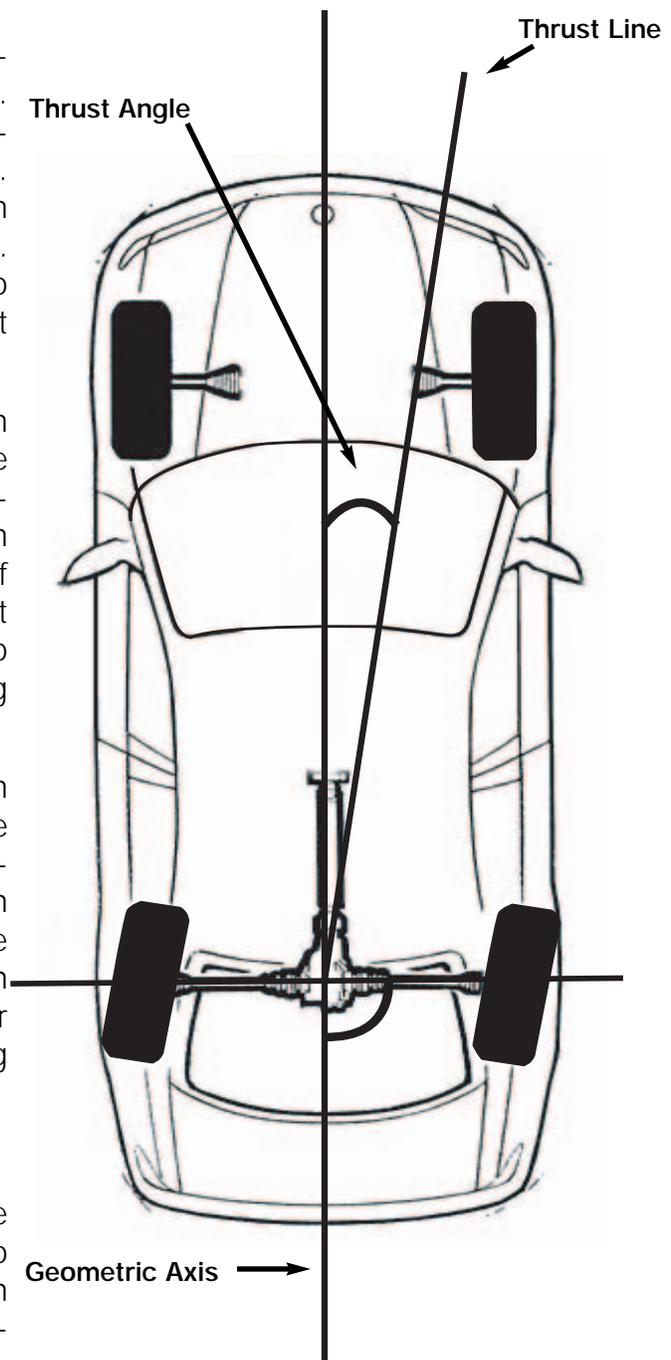
The Thrust Line is represented by an imaginary line that bisects the rear toe angle. This angle represents the overall "direction" in which the rear wheels are pointing. The Thrust Angle is the difference between the Geometric Axis and the Thrust Line. The optimum Thrust Angle is Zero Degrees, any deviation from this will affect the position of the steering wheel.

Positive Thrust Angle - is formed when the Thrust Line is to the right of the Geometric Axis (Centerline). When this situation occurs, the steering wheel position will be off to the right as well. The rear of the vehicle will tend to move to the right which will cause the front of the vehicle to steer left, the driver will move the steering wheel to the right to compensate.

Negative Thrust Angle - is formed when the Thrust Line is to the left of the Geometric Axis (Centerline). When this situation occurs, the steering wheel position will be off to the left as well. The rear of the vehicle will tend to move to the left which will cause the front of the vehicle to steer right, the driver will move the steering wheel to the left to compensate.

Alignment Procedures

When performing a wheel alignment, make sure that the thrust angle is as close to zero as possible. Failure to do so can result in a steering wheel that is not centered.



Suspension Systems

Front Axles

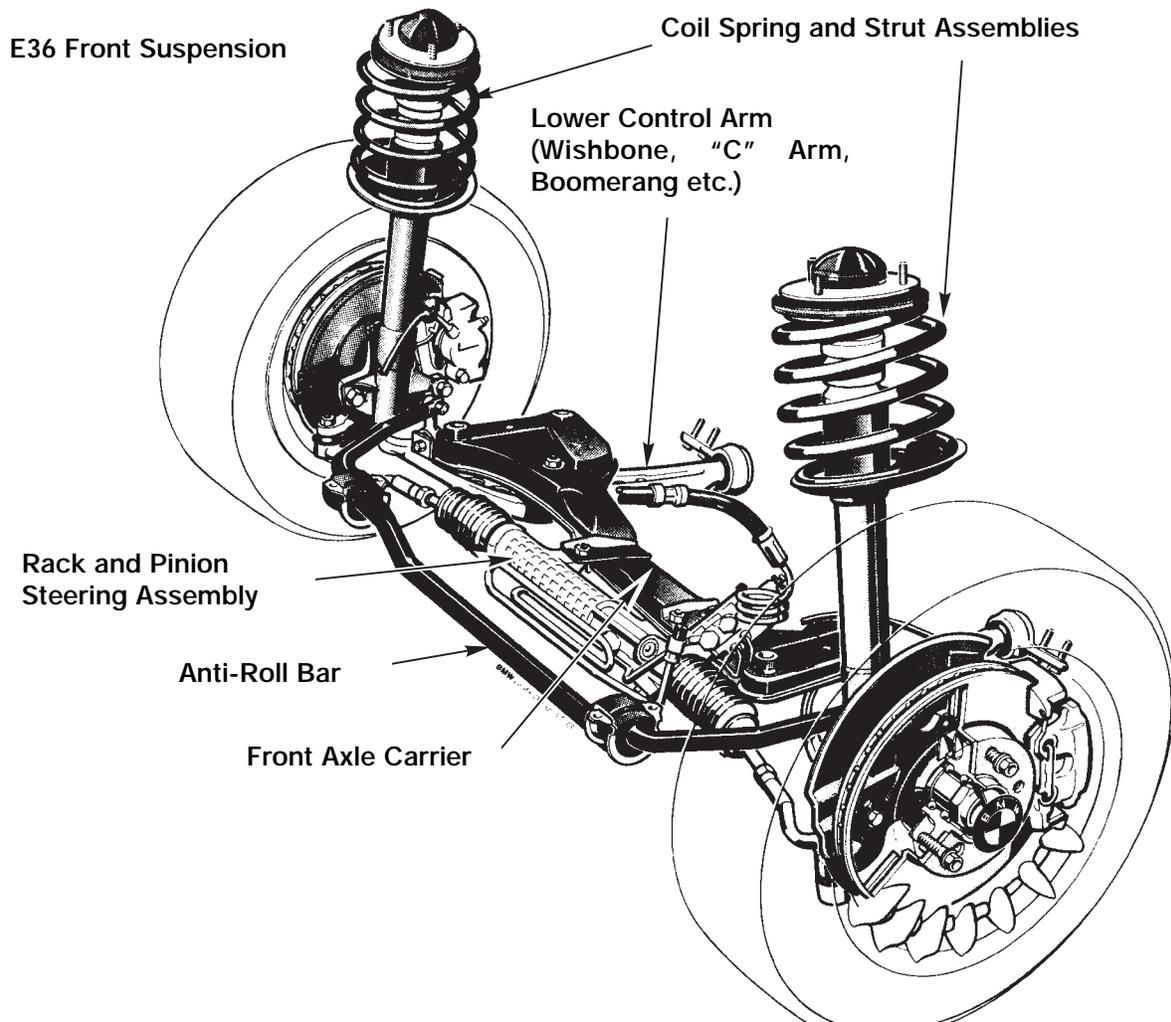
Two basic design front axles are used on BMW vehicles including:

- Single-Joint Spring Strut Axle
- Double Pivot Spring Strut Axle

Single Joint Spring Strut Axle

The single-joint spring strut axle is used on E30, E36 (all incl Z3 and 318ti) and E85 models. The axle beam is bolted to the body through four locating bushings. It supports the engine mounts, steering rack, anti-roll bar and lower control arm mount.

The "C" shape lower control arm is additionally mounted through a rubber bushing to the body and serves as the lower pivot for the steering system.

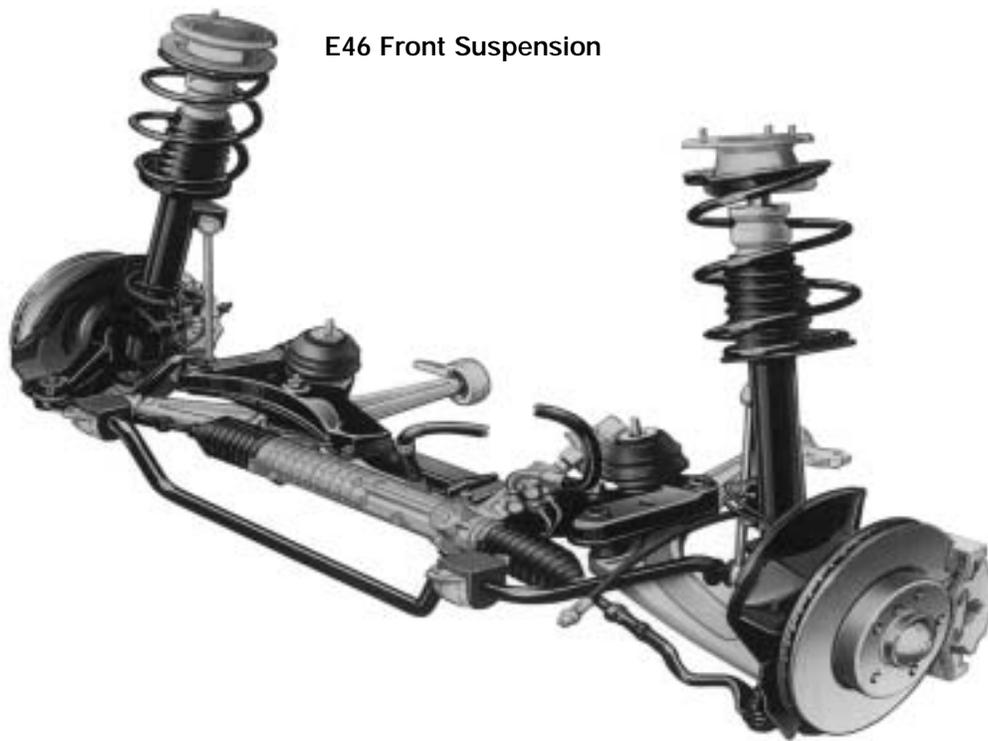


E46 Front Suspension

The E46 front suspension is based on the E36 design. There have been some design changes to improve ride quality and handling characteristics. The following changes were incorporated into the E46 front suspension system:

- A new forged aluminum lower control arm is used (Except iX all-wheel drive). It offers the advantages of weight reduction and lower unsprung mass.
- Hydraulic bushings are used for the rear lower control arm support.
- Hollow strut piston rods are used to reduce weight.
- The steering knuckles are press fit into the strut tubes which reduce the tolerances of the front suspension geometry.
- The Caster has been increased to improve straight line stability.
- The track has been widened for improved cornering
- Aluminum brake dust shields are used for weight reduction.

Altogether there is 5.72 lbs. less unsprung weight in the front suspension which enhances ride comfort and handling.



Adjustments

The “Single Joint” front suspension has some adjustments available.

Front toe is adjustable on all variants. Caster is **NOT** adjustable, but should always be checked during the wheel alignment to insure there is no damage.

Camber is adjustable on the E46 and E85. There is a slot in the upper strut tower which will allow small Camber changes. A pin must be driven down in order to allow the Camber changes. The upper strut plate can then be moved to make a slight Camber correction of up to .5 degrees.

If the Camber adjustment cannot be achieved, check for suspension damage. Make sure the vehicle is at the proper ride height.

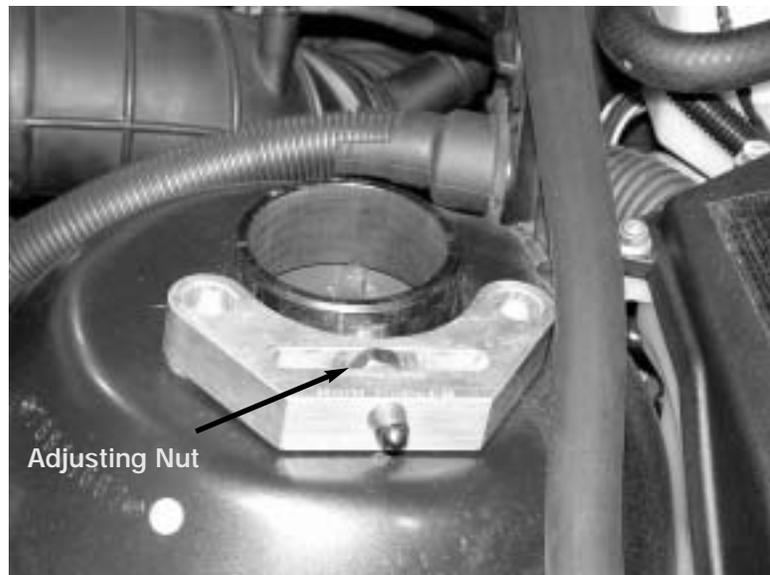
The instructions for making the Camber adjustment can be found in the Repair Manual in TIS under Group 32.

Use Special tool # 323 140 to make the Camber adjustment.

When using the Special tool:

- Drive out the pin in the upper strut mount.
- Loosen all 3 upper strut mounting bolts.
- Install tool and turn the adjusting nut to make camber corrections.
- Once desired value is reached, tighten upper strut mounting bolts to specification.

Tightening Torque specs can be found in TIS.



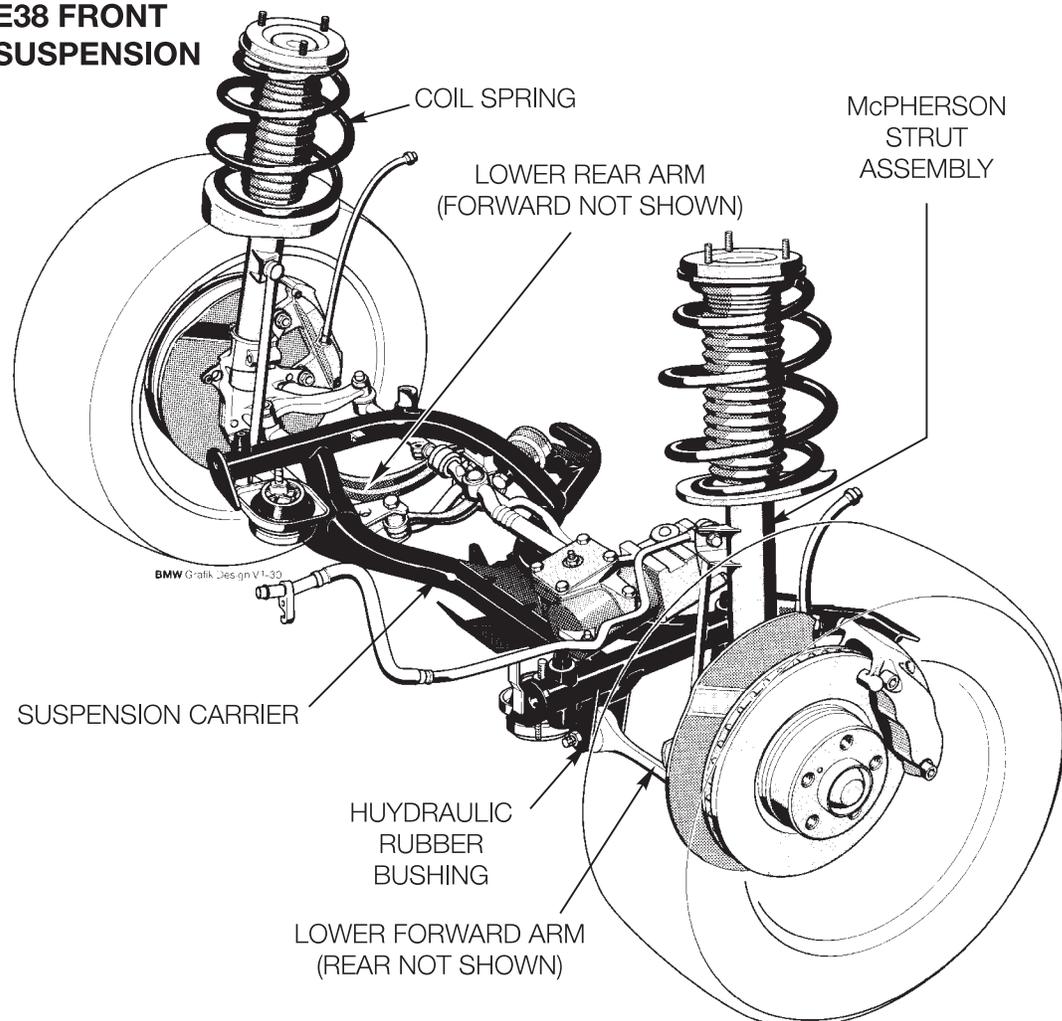
Double Pivot Spring Strut Axle

The "Double Pivot Spring Strut Axle" is used on the following vehicles:

- All 5 Series including E34 and E39
- E53, X5 All Models
- All 7 Series including E32, E38 and E65/E66.
- E31 8 Series

The axle beam of the double pivot is bolted to the sub-frame through three triangulated mounting bolts. The axle beam supports the steering box, engine mounting and lower control arms. The tubular cross member and compression struts complete the double pivot suspension frame work.

E38 FRONT SUSPENSION

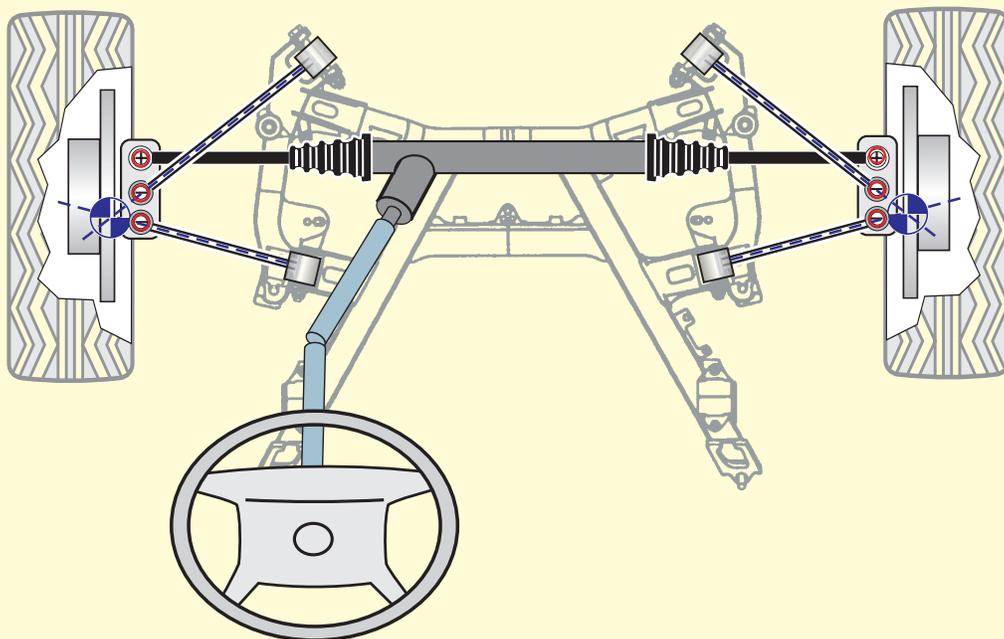
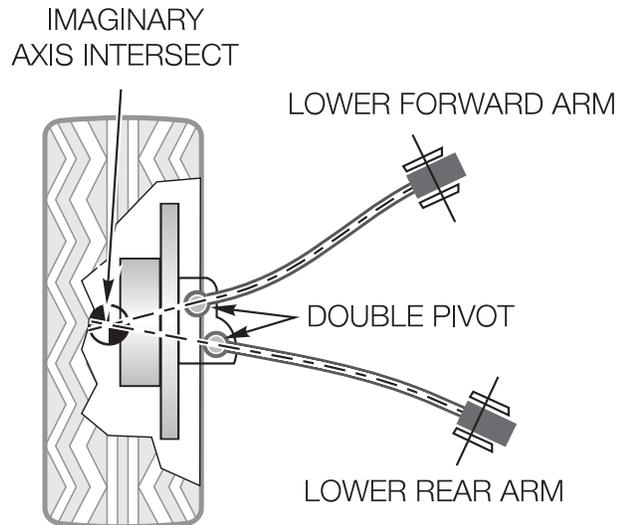


The double pivot refers to the lower mounting of the strut and spindle assembly around which the wheel turns.

The lower control arm and the compression strut form the two lower pivot points.

The lower pivot point is actually an imaginary point formed by the extension of the two lower mounting arms.

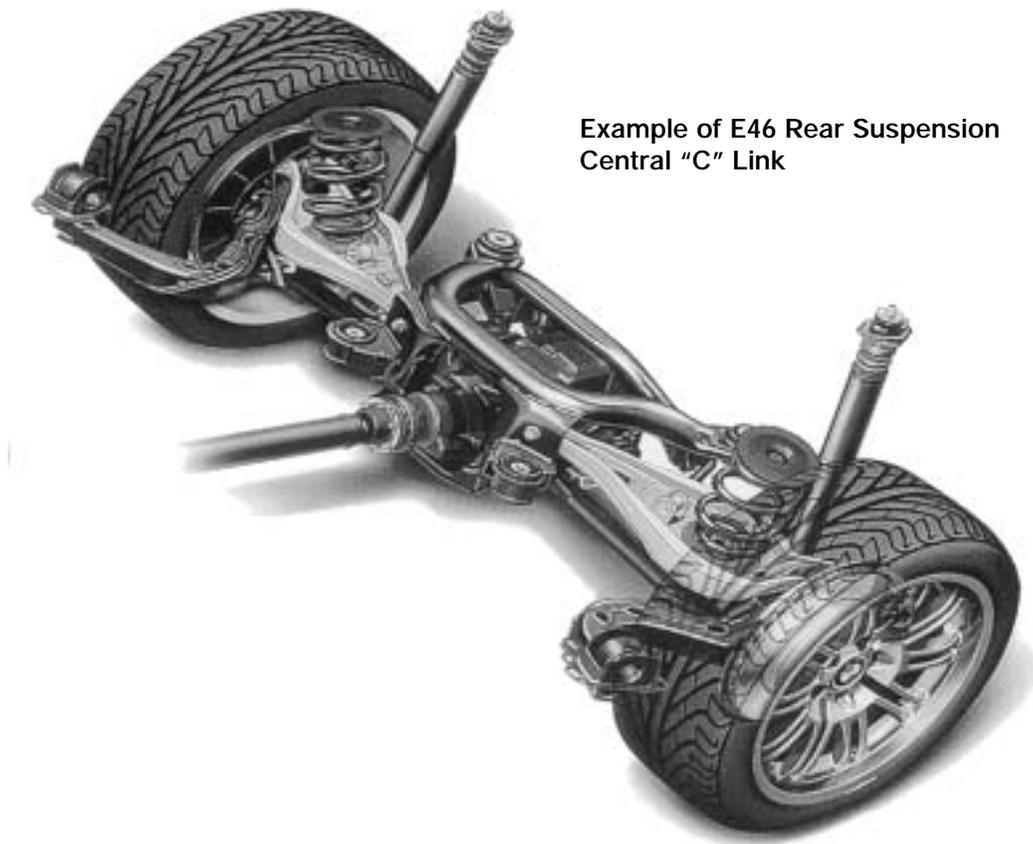
LEFT FRONT WHEEL AS SEEN FROM TOP



Rear Suspension Systems

BMW utilizes several different configurations for the rear suspension systems depending on the model and specific needs of the vehicle in terms of handling, ride and performance. Alignment angles are not adjustable on the early rear suspension systems. The Central "C" Link rear suspension and the Integral Link rear suspension have adjustable Camber and Toe. The different rear suspension systems used include:

- Semi-Trailing Arm - E30, E36/5 318ti and E36/7 Coupe and Roadsters
- Semi-Trailing Arm with Track Link - E32, E34, E28, E24
- Central "C" Link - E36, E46 and E85
- Integral Multi-Link - E38, E39, E31, E53, E65, E66 and E52.



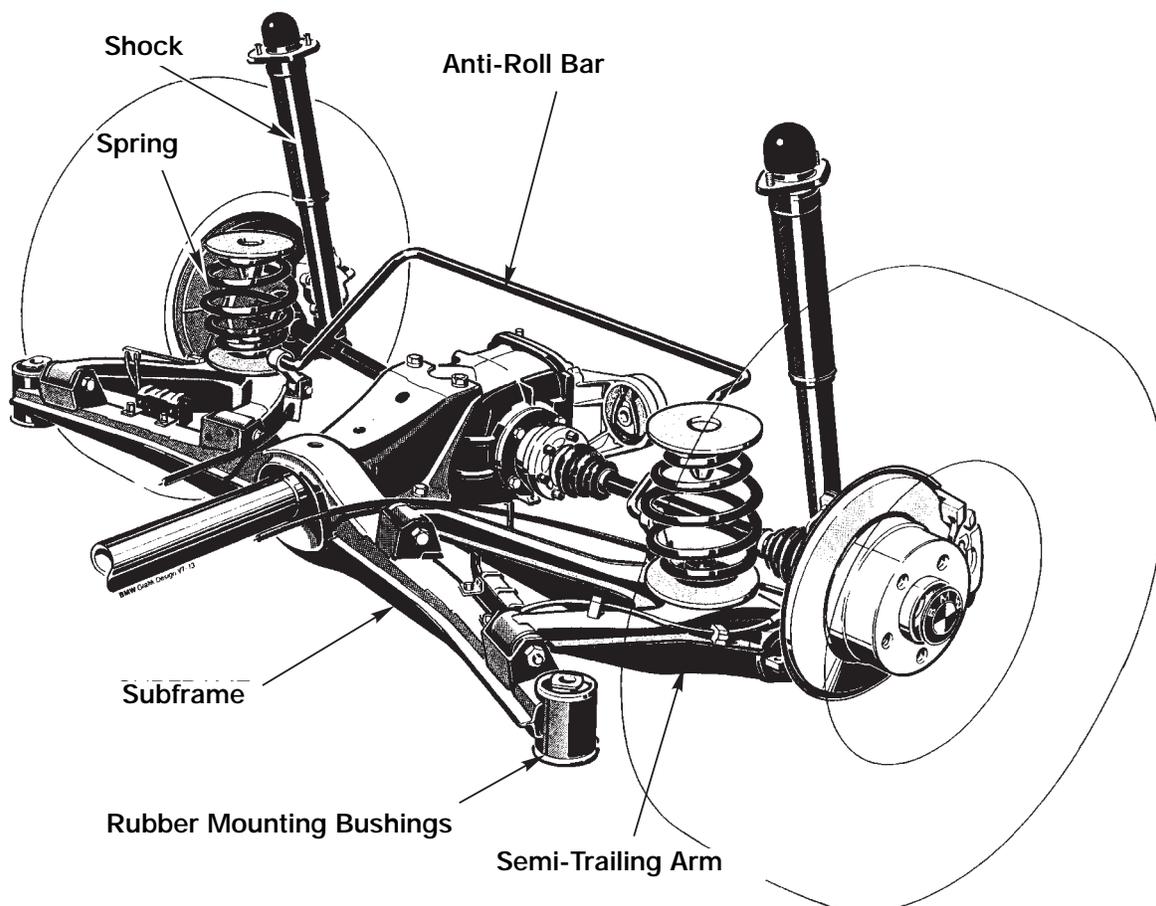
Example of E46 Rear Suspension
Central "C" Link

Semi-Trailing Arm

The Semi-trailing arm rear suspension is used on the following vehicles:

- E30 All models including convertible, M3 and iX
- E36/7 Z3 Roadster and Coupe including M Roadster and Coupe
- E36/5 318ti (Compact)

The semi-trailing arm is an independent suspension system. The axle geometry is such that all points on the hub carrier move in a circular path, on a single plane during bounce and rebound. As a result of this, the rear camber and track will vary with the up and down movement of the wheel. There are no adjustable angles on this suspension system. Rear Camber is influenced by ride height. In the event of an incorrect rear toe situation, offset bushings can be installed on the trailing arms to make slight corrections. Refer to TIS Repair instructions in Group 33.



Semi-Trailing Arm with "Track Link"

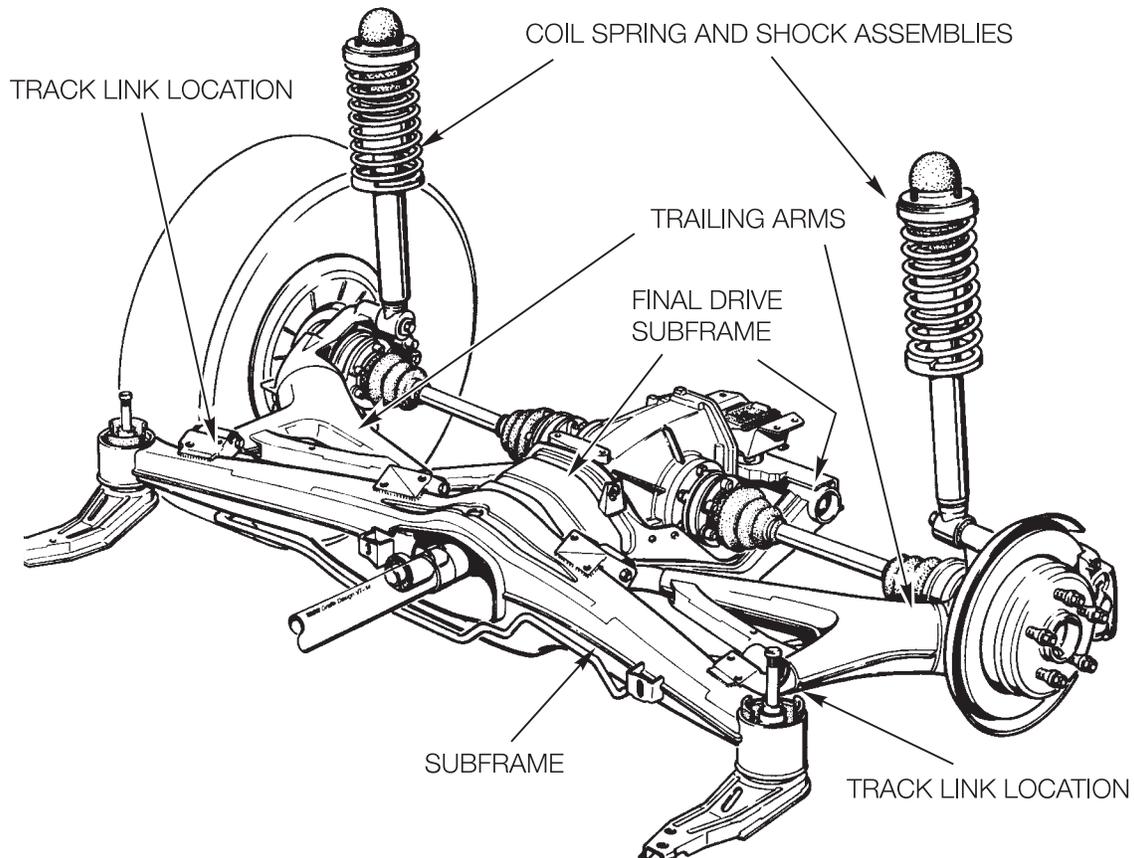
The "Track Link" rear suspension is used on the following vehicles:

- E24 All models including M6 and L6
- E28 All models including M5
- E32 All models
- E34 All models

The Track Link is a modified semi-trailing arm rear suspension. It incorporates an additional link that is mounted between the trailing arm and the rear axle carrier beam. The track link is mounted through rubber bushings that allow it to flex during bounce and rebound. The track link reduces the pivot axis from 20 degrees to 13 degrees which reduces the amount of camber and track change during bounce and rebound.

It provides better handling, reduces "squat" and "dive" tendencies and allows less camber change due to heavy loading.

There are no rear suspension adjustments, small corrections can be made with offset bushings. (see Repair Instructions in Group 33).



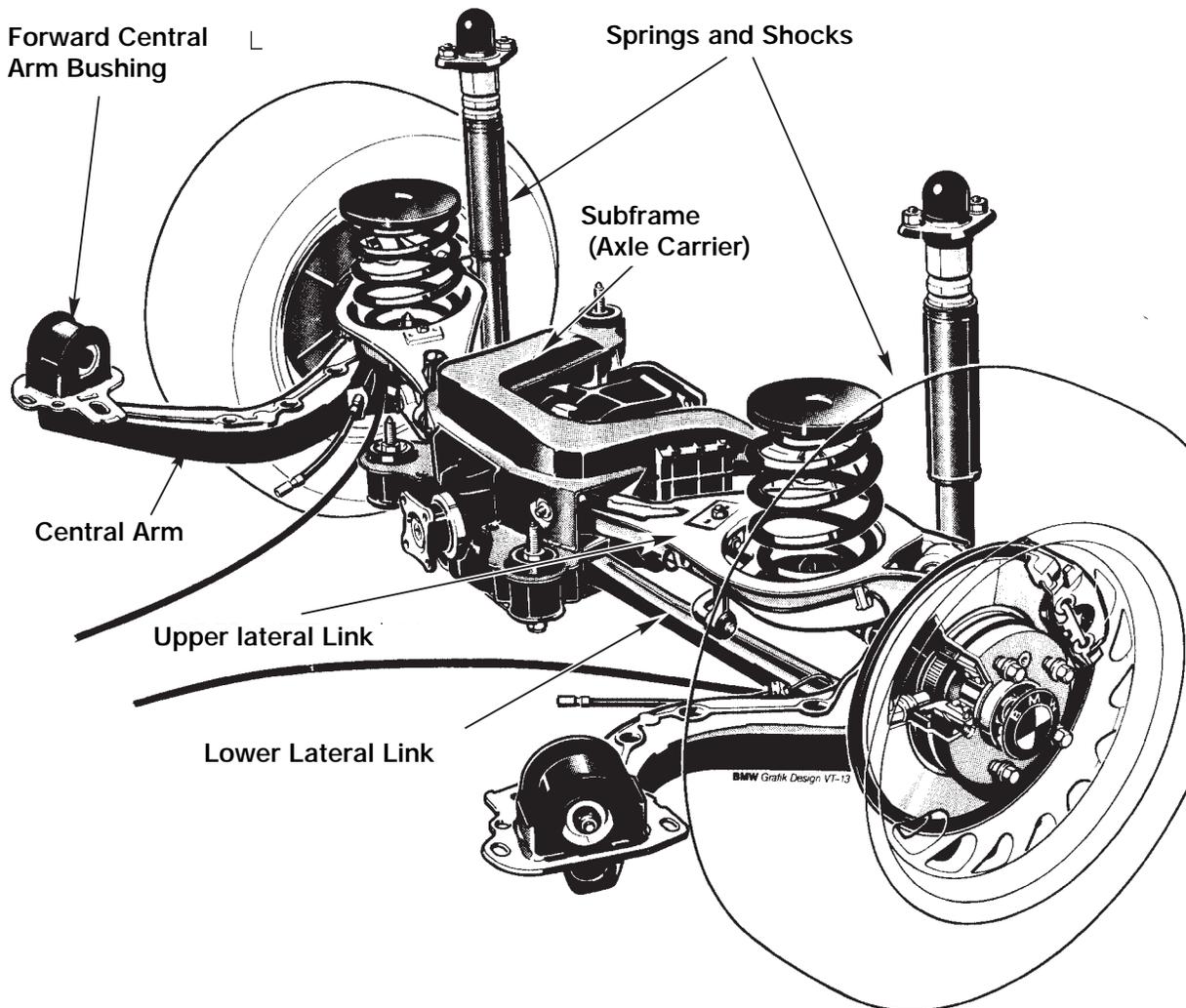
Central "C" Link Rear Suspension

The Central "C" Link rear suspension is used on the following:

- E36 All Models except E36/7 and E36/5.
- E46 All Models
- E85 Z4 Roadster

The Central Link rear suspension consists of a cast iron longitudinal arm that is bolted to the body through a rubber bushing. The wheels are additionally supported by two transverse arms that are connected to the rear axle sub-frame.

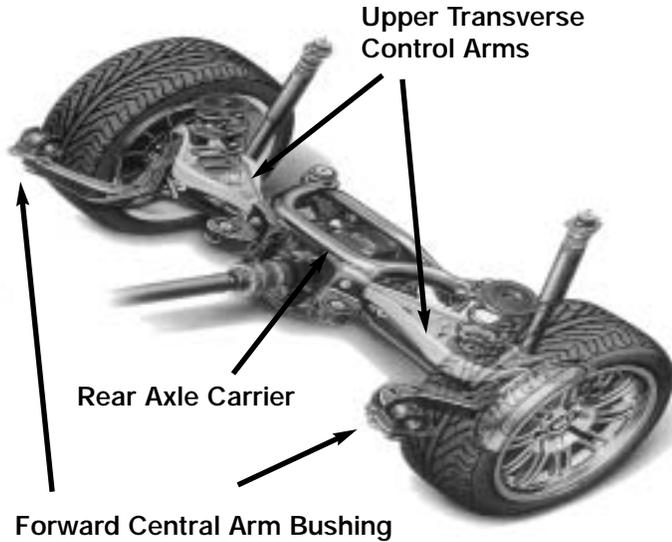
The design of this suspension allows for individual tuning of longitudinal and lateral forces acting on the vehicle. Longitudinal forces, such as starting and stopping are absorbed by the central arm. Lateral forces, such as cornering, are absorbed by the transverse links. The complete suspension exhibits little or no change in toe-in while driving.



E46 Rear Suspension

The Central "C" Link rear suspension on the E46 is almost identical to the E36 with some minor modifications:

- Upper Transverse Control Arms (Lateral Links) are made from aluminum.
- The Subframe (rear axle carrier) is of tubular steel construction.
- The differential is mounted to the subframe with a hydraulic mount.

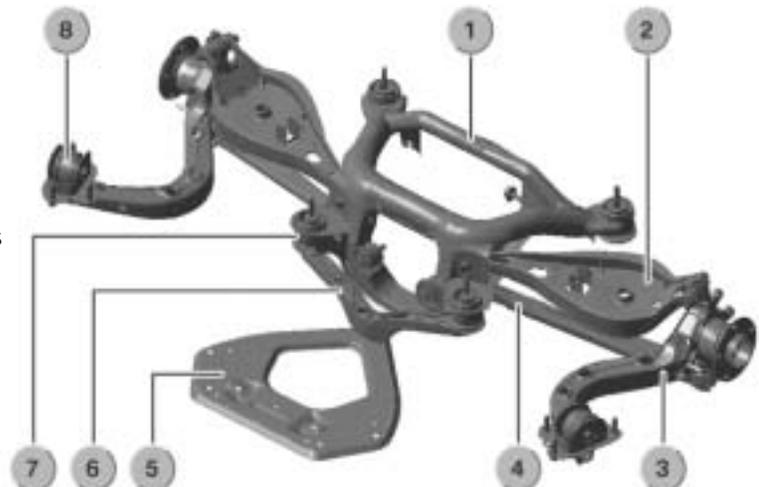


E85 Rear Suspension

The E85 rear suspension is taken from the E46 design with some minor changes for the roadster. The track width has been increased by 30 mm. A reinforcement plate has been added to increase rigidity. Due to underbody aerodynamics, a duct has been added to direct airflow to the differential. The differential cover has cooling fins which will help keep the differential within its operating temperature range.

E85 Rear Suspension

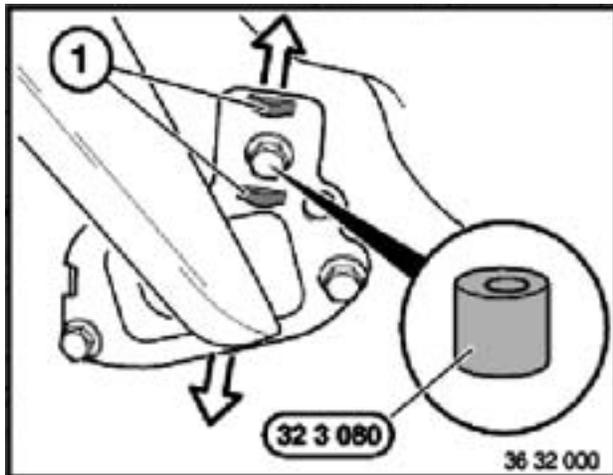
1. Rear Subframe Section
2. Left Upper Control Arm
3. Left Trailing Arm
4. Left Lower Control Arm
5. Reinforcement Plate
6. Reinforcement support bracket
7. Rear subframe mounting bushings
8. Right trailing arm bushing



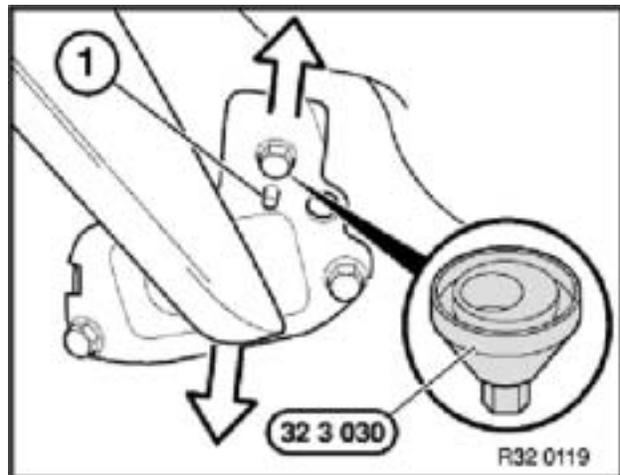
Rear Suspension Adjustments (Central "C" Link)

Rear Toe

Toe is adjusted by moving the forward central arm bushing mount with a special tool. The tool part number varies between models.



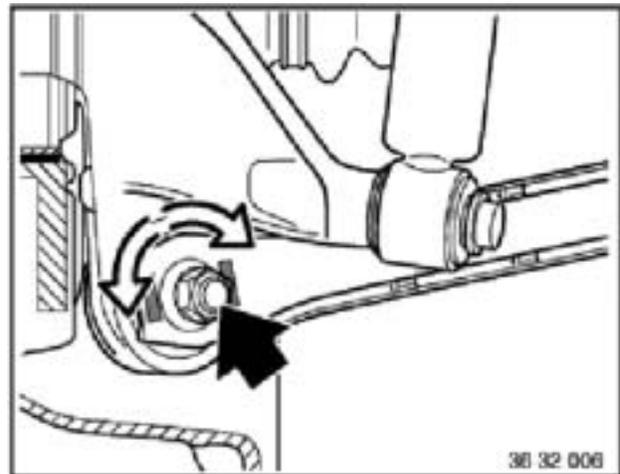
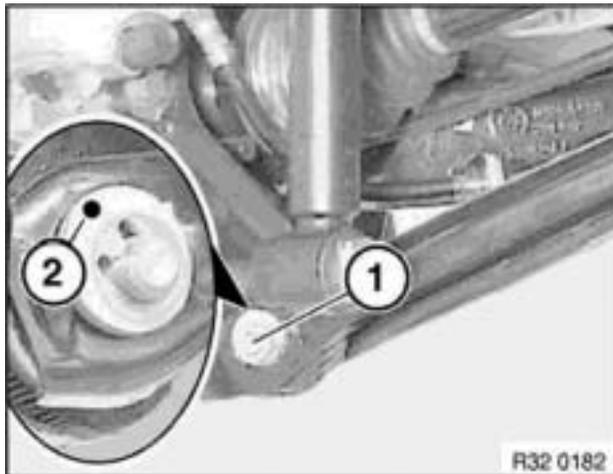
Tool # 90 88 6 323 080 for E36
Not Used for Z3 and 318ti



Tool # 90 88 6 323 030 for E46 and E85

Rear Camber

Rear Camber is adjusted by rotating an eccentric bolt located at the outer end of the rear lower lateral link. No Special tools are required to make the Camber adjustment.



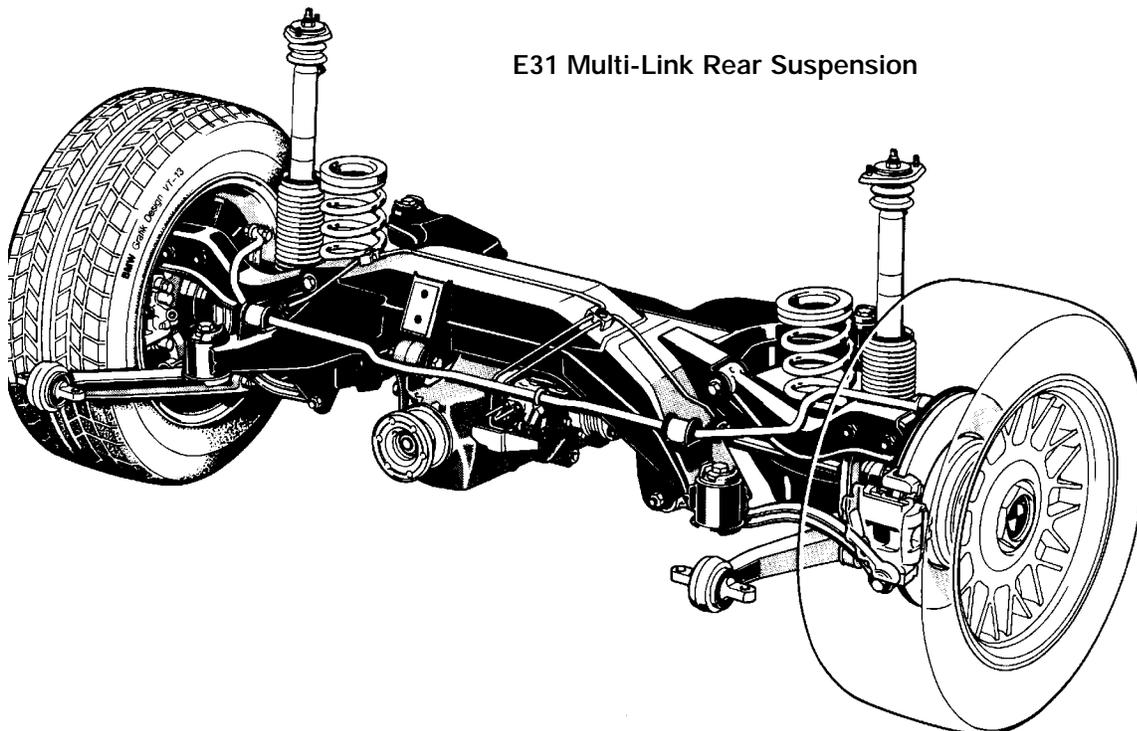
Multi-Link Rear Suspensions

Multi-Link Rear suspension systems are used on the following vehicles:

- E31 8 Series including 850i, 850Ci, 850CSi and 840Ci
- E38 7 Series - All models
- E39 5 Series - All models including M5 (Touring version is slightly modified)
- E53 X5 3.0i, 4.4i and X5 4.6is
- E52 Z8
- E65 and E66

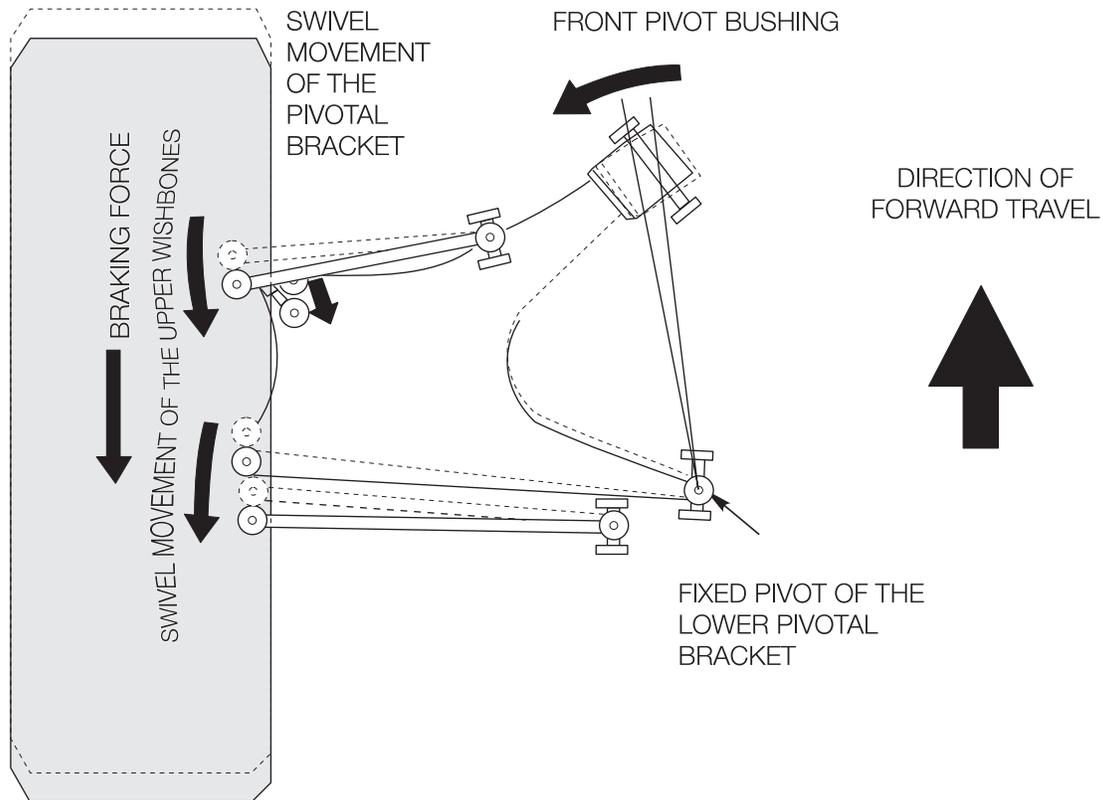
The "integral" multi-link suspension was introduced on the E31 and variations of it are used on the 5 and 7 series vehicles. Slightly modified versions are also used in the X5 and E39 Sportwagon with EHC. The multi-link suspensions incorporate what is called "elastokinematics" that allow each wheel to move and flex individually without transmitting loads and forces through the sub-frame to the other wheel.

These suspension systems incorporate anti-dive, anti-squat geometry which serves to keep the vehicle level during hard acceleration and braking.



Elasto-Kinematics

Elasto-kinematics relates to the suspension system design type. The term “elasto” implies stretching, which in fact the system does. Under extreme load (acceleration, turning, braking) the suspension changes its geometry to counteract inherent changes induced by the increased loads.

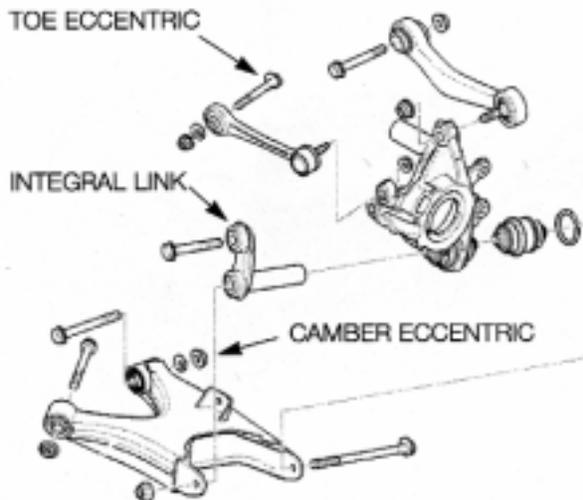
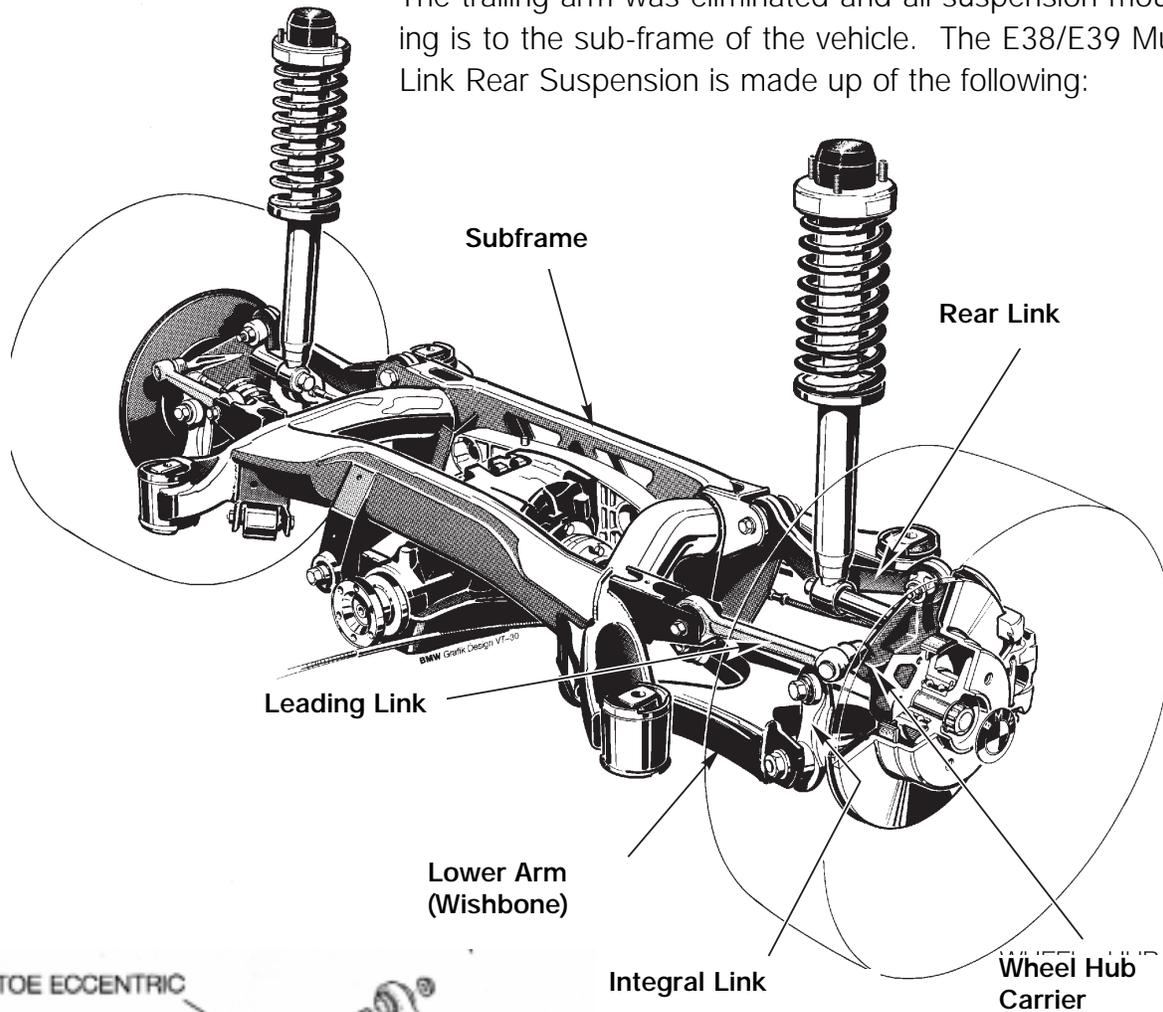


The system changes are pre-determined and built into the system. The geometry changes provided by this system correct for unwanted changes that occur under load in non- elasto-kinematic systems.

E38/E39 Multi-Link Suspension

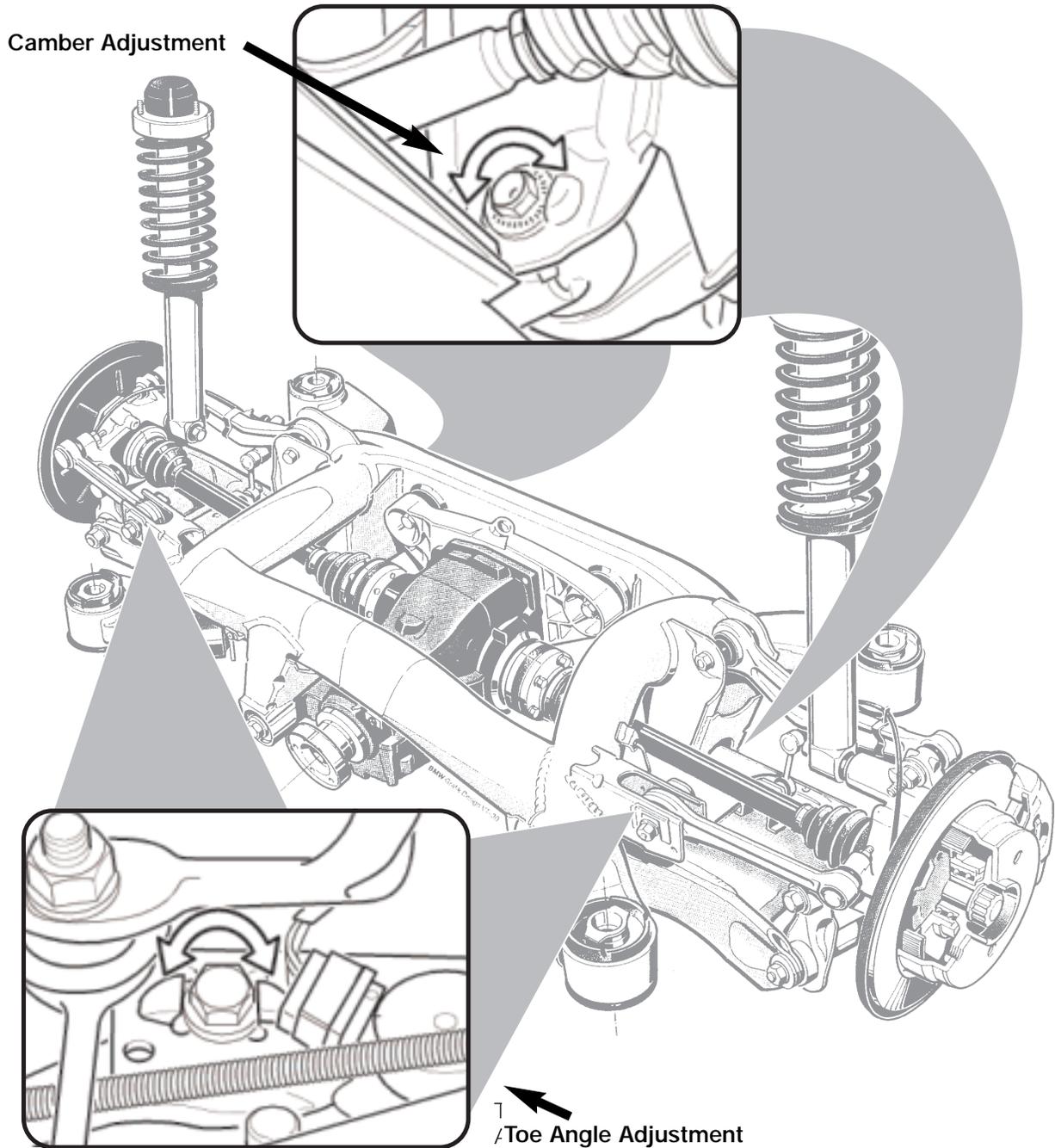
The E38 and E39s use a modified version of the E31 multi-link rear suspension system. The system was modified to be more compact yet provide the same handling and ride characteristics as the E31 system.

The trailing arm was eliminated and all suspension mounting is to the sub-frame of the vehicle. The E38/E39 Multi-Link Rear Suspension is made up of the following:



Rear Suspension Adjustments

Camber and toe angles are adjustable on the E38/39 rear suspension through two eccentric bushings. There are no special tools required to perform these adjustments.



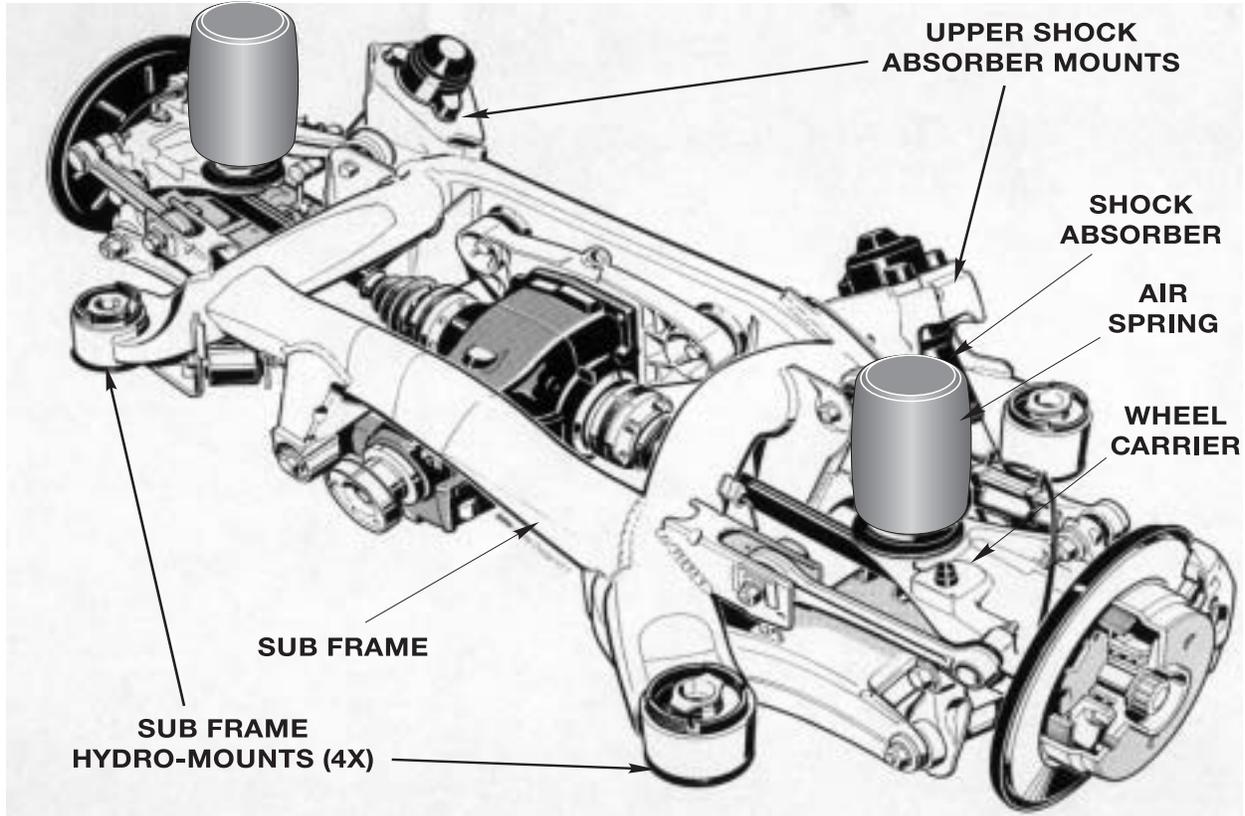
E39 Sportwagon and X5 Rear Suspension

With the introduction of the E39 Sportwagon and the E53 X5, the rear suspension system has been modified to accommodate the increased cargo capacity. The rear suspension is also modified to allow for the optional EHC system. The X5 and Sportwagon rear suspensions differ from the standard E38 and E39. The springs are now located on the perches that are part of the wheel carrier assembly. The E39 and E53 rear suspensions are also slightly different from one another, the E39 upper shock mounts are part of the subframe assembly. The E53 upper shock mounts are still located in the body.

Both the E39 and E53 are available with optional EHC, this means that the rear springs will either be coils springs or "air springs".

The E39 rear suspension also uses special "hydro Mounts". This modification is necessary due to the fact that the upper shock mounts are on the subframe. The "hydro mounts" are used to isolate the subframe to suppress road noise and vibrations from being transmitted to the body.

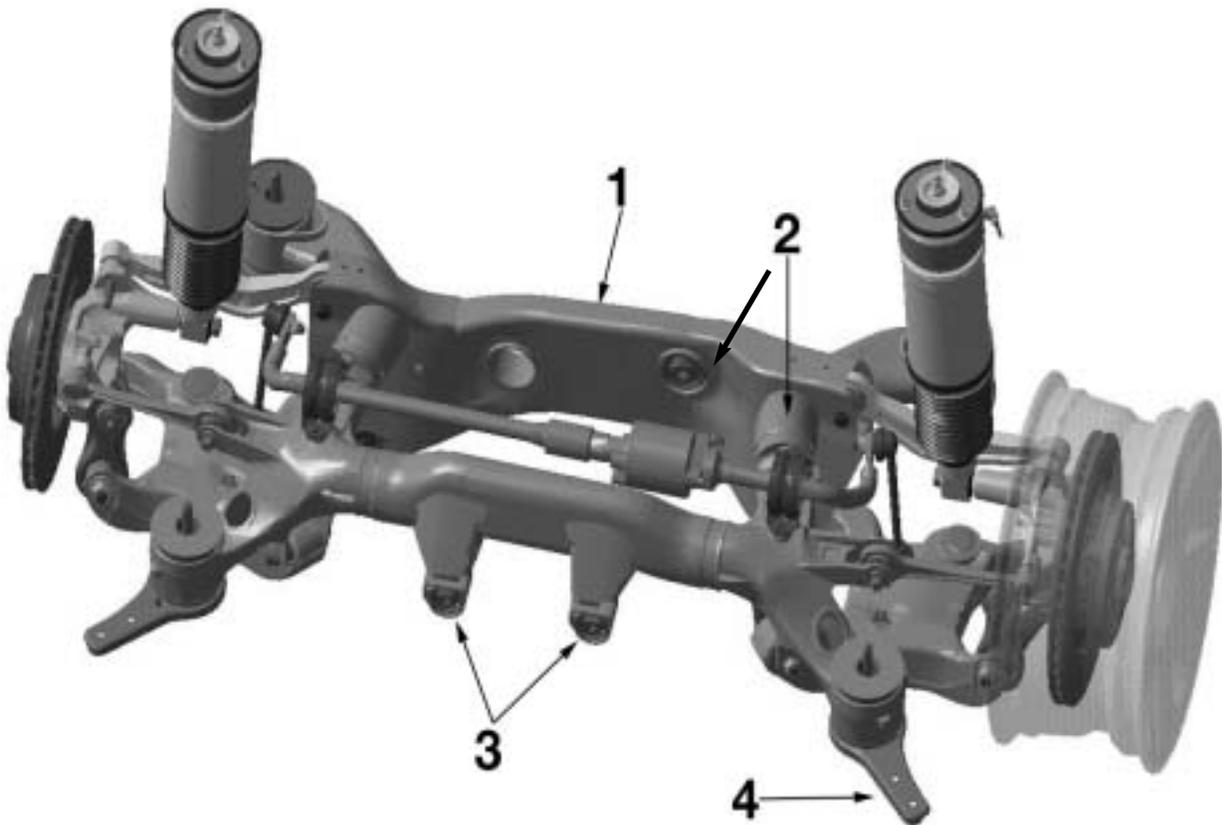
E39 Sportwagon Rear Suspension with EHC.



E65/E66 Rear Suspension

The rear axle on the E65/E66 is also the integral type. It is very similar to the E38/E39 rear suspension. The rear axle carrier (subframe) is made from tubular aluminum. The E65/E66 is also available with optional systems such as:

- EDC-K Electronic Damping Control (Continuous)
- ARS Active Roll Stabilization
- Air Suspension System



- | | | | |
|---|-------------------------------|---|------------------------------|
| 1 | Rear Cross Member | 2 | Differential Mounting (rear) |
| 3 | Differential Mounting (front) | 4 | Thrust Plate |

The Rear Toe and Rear Camber are adjusted by means of eccentric bolts. No special tools are needed to make these adjustments.

Alignment Procedures

The following procedure is an outline to follow based on BMW procedures. The actual alignment procedures will vary depending upon the alignment equipment being used. Refer to the alignment equipment manufacturers procedures for specific information. The steps listed below should be followed as closely as possible to perform a quality alignment.

- **Vehicle Inspection** - The vehicle inspection should include a road test before and after the alignment. Note any concerns during the pre-alignment road test and verify that the concern has been rectified during the post-alignment road test.
- **Install Specified Weight** - Check Group 32 Technical Data in TIS to determine the "Normal Position/ Inspection Conditions". Install Specified weight in vehicle and compensate for fuel by adding extra weight if needed.
- **Install Alignment Sensors** - Install alignment sensors as per the alignment equipment manufacturers recommended procedures.
- **Compensate Sensors** - Depending upon the alignment sensors being used, compensation may not be necessary. Compensation may require the vehicle to be lifted from the alignment rack. If so, be sure to remove the pins from the front and rear slip plates. If the sensors do not need to be compensated, the next step can be ignored.
- **Lower Vehicle and Jounce** - Make sure the pins are removed from the slip plates. Lower the vehicle back onto the alignment rack and jounce the vehicle. This will insure that the suspension has settled.
- **Check Ride Height** - Check ride height using metric tape measure. Ride height specifications can be found in Technical Data in TIS. Front ride height specs can be found under group 31 and rear can be found under group 33. Always check ride height after compensating the sensors. This will avoid having to check the ride height twice.
- **Perform Alignment** - There are various types of alignment equipment used in BMW workshops. Refer to the equipment manufacturers instructions for the next steps of the alignment.

When performing an alignment of a vehicle equipped with air suspension (EHC), disable the system by removing the fuse for the air supply system. This will insure that the ride height will stay consistent.

Vehicle Inspection

Before attempting to align any vehicle, it is important to inspect the vehicle completely to insure there are no damaged or loose suspension components. Regardless of the age or mileage of the vehicle, a complete inspection should be performed. The following items should be checked thoroughly:

- **Tires and Wheels** - Check tires for wear patterns that could indicate suspension problems. Make sure the tires are the correct size and type. Check for the correct inflation pressures. Look for wheel/rim damage which could indicate impact damage.
- **Wheel bearings** - Check to make sure there is no excessive wheel bearing play. This needs to be addressed for safety reasons, but loose wheel bearings will affect the quality of the alignment as well.
- **Steering Linkage**- Check the tie rods, center link, idler arm and pitman arm. On vehicles with rack and pinion steering, check for loose inner/outer tie rods etc. On vehicles with a center link, make sure the center link is level (see BMW TIS Repair Instructions). Check flexible coupling between steering shaft and rack and pinion assembly (or steering box).
- **Suspension Components** - Check Struts/Shocks for leakage or damage. Check springs and perform ride height measurements.
- **Subframe** - Check the front and rear axle carriers. Look for bent/twisted sub frames. Check the crossmembers for evidence of shifting or displacement. Check the mounting bolts for "clean spots" which could indicate shifting or movement.
- **Brakes** - Check braking system by road testing the vehicle. A road test could help to identify brake related issues such as pulling or brake induced vibrations.
- **Drivetrain** - While road testing the vehicle, observe and vibrations and/or noises and try to isolate the cause. Noises and vibrations under acceleration (rather than coasting) may be an indication of drivetrain issues.

Road Testing

Whenever possible, a vehicle should be road tested before and after an alignment. If time allows, drive on various road surfaces and note the vehicle behavior. Check for brake pull when stopping. And most importantly, note the position of the steering wheel before and after the alignment. These are important steps to avoid comebacks and unnecessary return visits.

Ride Height Measurement

When performing alignments on BMW vehicle, the ride height must be set and checked before proceeding with any measurement or adjustments. Ride height is measured from the lower edge of the wheel rim to the lower edge of the wheel housing. Ride height specifications are in millimeters. The specifications can be found in Technical Data. The front axle ride height is in Group 31 and the rear axle ride height is in Group 33. In order to obtain the correct specification, the vehicle and suspension type must be identified.

Ride height specifications depend upon rim size (15", 16", 17" etc.), engine size and the type of suspension. There are 4 different types of suspension packages:

- Series - Standard production vehicle
- Low Slung Sports Suspension - This is used on vehicle with Sports Package Option.
- Rough Road Package - For Eastern European Rough roads. Not used in US.
- M Sports Package - Used on Motorsport vehicles or those with M Package Option.

The example shown below is the ride height specifications for an E39 540i (Front Axle).

Series		
15" Rim	mm +/- 10	579
16" Rim	mm +/- 10	592
17" Rim	mm +/- 10	607
18" Rim	mm +/- 10	620
Low Slung Sports Suspension		
15" Rim	mm	559
16" Rim	mm	572
17" Rim	mm	587
18" Rim	mm	600
Rough Road Package		
15" Rim	mm +/- 10	599
16" Rim	mm +/- 10	612
17" Rim	mm +/- 10	627
18" Rim	mm +/- 10	640
M Sports Package		
15" Rim	mm +/- 10	562
16" Rim	mm +/- 10	575
17" Rim	mm +/- 10	590
18" Rim	mm +/- 10	603

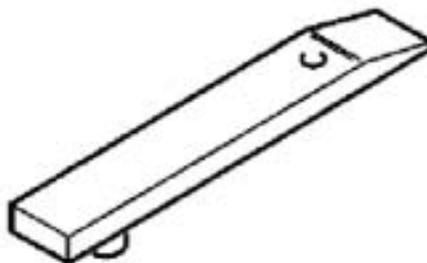
Ride Height

When measuring ride height, measure from the lower edge of the wheel rim to the lower edge of the wheel opening. Use a metric tape measure with divisions of 1 mm.



Z3 Ride Height Tool

When measuring ride height on the E36/7 (Z3), use special tool # 313 010. Due to the design of the hood on the Z3, this tool is used to simulate the lower edge of the wheel opening.



Special Tool # 313 010

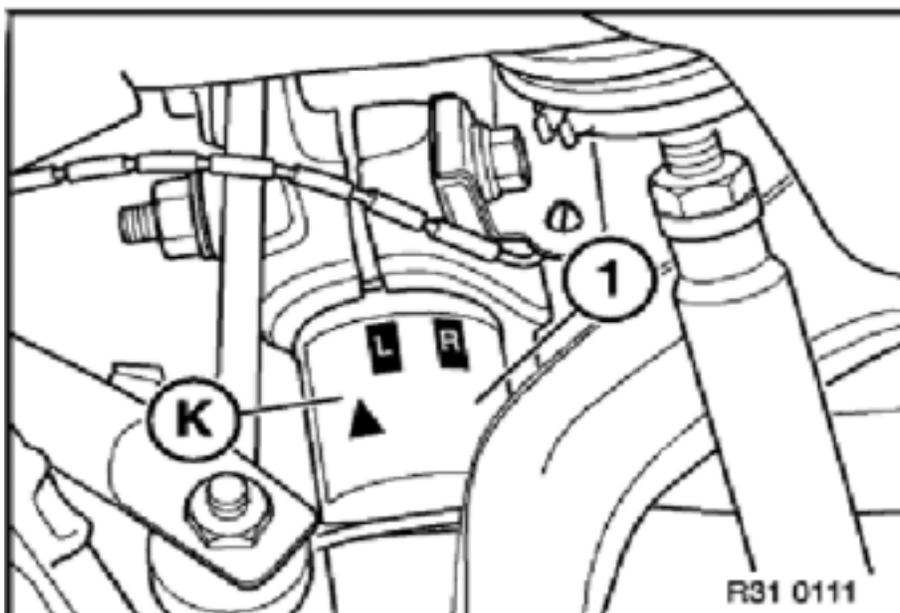
Identification of Suspension

When performing an alignment, the suspension variant must be identified. This insures that the correct alignment specifications are used and the ride height is correct. There are numerous suspension variants, there is the standard "series" production suspension, the "low slung" sports suspension, "M Sport Package" and the "Poor Road Surface" package. The latter term is for Eastern Europe, this is not used in the US.

There are various methods for determining the the suspension variant used. Refer to repair instructions in Group 32 for more information. The following is a summary of some common models:

- **E38** - The "Sports" suspension variant is identified by paint markings on the front springs or by a front sway bar diameter of greater than 21.5 mm.
- **E65/E66** - There is no additional identification needed to determine suspension variant (at this time).
- **E39** - There is a symbol (or code) located on the front strut assembly. There is a chart in repair instructions to match to the symbol found.
- **E36** - There is an auxiliary spring located on the front strut assembly. There is a measurement that needs to be made to determine suspension variant.. Refer to repair instructions for additional details.
- **E46** - There is a symbol (or code) located on the front strut assembly. There is a chart in repair instructions to match to the symbol found.

The following page shows the E39 suspension identification chart. Note the markings on the front strut housing below.



Identifying Symbol	Version	Model
Without	Volume production	Sedan
Solid Circle	Low slung sports Suspension	4 and 6 cylinder Sedan
Solid Triangle	Low slung sports Suspension	8 cylinder sedan
Solid Square	Poor road surface (Eastern Europe)	Sedan
M5	Volume production	M5 Sedan
M5	M sports package	8 cylinder Sedan
E39BAS.SP	M sports package	4 and 6 cylinder Sedan
Circle	Volume production	Touring
Triangle	Low slung sports Suspension	Touring
Square	Poor road surface (Eastern Europe)	Touring

Vehicle Loading

In order to obtain the correct ride height, the vehicle must be loaded with the specified weight. The normal specified weight for most vehicles is as follows:

- 68 kg. in each front passenger seat
- 68 kg in the rear seat
- 21 kg in the trunk
- Fuel tank full.

Not all vehicle need to be weighed down. Usually E39 M5 and E36/E46 M3 are measured without any weight. Always check TIS under Technical Data Group 32. The proper test conditions can be found under "Normal Position/Inspection Conditions".

If the vehicle fuel tank is not full, compensate by adding weight in the trunk. Fuel is approximately 7 pounds (about 3.2kg) per gallon. For example: If the vehicle has an 18 gallon tank and it is 1/2 full, add about 63 lbs. (about 28kg.)

Alignment Sensor Mounting

There are two types of alignment sensor mounting, this depends upon equipment used. The first type is the "Rim Clamp" Method which "clamps" on the edge of the wheel rim. This method of mounting requires that the sensor be "compensated" electronically to allow for wheel runout and mounting irregularities. The second type is the "Beissbarth" type clamp, this method allows the clamp to be indexed to the rotor hub through holes in the wheel rim. The clamp hold on to the tire tread with a spring loaded clamp. The "Beissbarth" clamping method does not have to be compensated due to the fact that the clamp is actually mounted to the rotor hub, theoretically this method eliminates the need for compensation. Always remember that the holes in the rim should be clean and free of excessive rust, this could cause irregular mounting and inaccurate alignment results.



"Rim Clamp" Mounting



Beissbarth Type Mounting

Alignment Adjustment Summary

	Front Caster	Front Camber	Front Toe	Rear Camber	Rear Toe
E30	No Adjustment	No Adjustment	Yes	No Adjustment	No Adjustment (Offset Bushing)
E36	No Adjustment	No Adjustment	Yes	Yes (Eccentric)	Yes Tool # 323 080
E36/7 Z3 E36/5 318ti	No Adjustment	No Adjustment	Yes	No Adjustment	No Adjustment (Offset Bushing)
E46	No Adjustment	Yes Tool # 323 140	Yes	Yes (Eccentric)	Yes Tool# 323 030
E34	No Adjustment	No Adjustment	Yes	No Adjustment	No Adjustment (Offset Bushing)
E39	No Adjustment	No Adjustment	Yes	Yes (Eccentric)	Yes (Eccentric)
E53	No Adjustment	Yes Tool # 323 145	Yes	Yes (Eccentric)	Yes (Eccentric)
E32	No Adjustment	No Adjustment	Yes	No Adjustment	No Adjustment (Offset Bushing)
E38	No Adjustment	No Adjustment	Yes	Yes (Eccentric)	Yes (Eccentric)
E65/E66	No Adjustment	Yes Tool # 323 145	Yes	Yes (Eccentric)	Yes (Eccentric)
E85	No Adjustment	Yes Tool # 323 145	Yes	Yes (Eccentric)	Yes Tool # 323 030
E31	No Adjustment	No Adjustment	Yes	Yes (Eccentric)	Yes (Eccentric)

Alignment Specifications

The alignment specifications can be found in Technical Data under Group 32. There is a slight difference in terminology between this information and the information found on most alignment equipment. The following text should be helpful in understanding the different terms used. The alignment specifications are shown on the opposing page:

- **Front Toe** - The Total Toe specification represents the left and right toe specs added together. Toe is measured in degrees and minutes.
- **Front Camber** - Camber is also measured in degrees and minutes. Camber is adjustable only a some vehicles. The maximum amount of Camber adjustment is approximately .5 +/- degrees.
- **Track Differential Angle with 20° lock on inside wheel** - This angle is also known as "Toe Out on Turns". With the inside wheel turned to 20 degrees on the front turn plates, the difference in the toe angle should be as specified.
- **Caster** - Caster must be measured by sweeping the wheel through an arc of 10-20 degrees. (Most alignment equipment requires at least 20 degrees). Ride height is crucial to this specification. If the vehicle is too high or low in the rear, the Caster measurement will be affected. Caster is NOT a "live angle", the wheels must be re-swept to check the measurement again. Although Caster is NOT adjustable, it should **always** be checked to insure there is no "hidden damage".
- **Front Wheel Displacement** - More commonly known as "Setback", this is a measurement of the angle formed between the front axle to the Geometric Axis. The front axle centerline should be at 90 degrees to the Geometric Axis. A quick check of setback is to look to see if the wheel is centered in the wheel opening. Setback is a good diagnostic angle, if the Caster is off, the Setback measurement could indicate the cause. Look for bent suspension components or damaged suspension carrier/subframe.
- **Maximum Wheel Lock** - Also known as "Maximum Steering Angle". This is the maximum angle of the wheels when turned to the inward and outward lock position. When this measurement is out of specification, check to see if the steering rack or steering box is centered. This can cause a hazardous condition and premature tire wear.
- **Rear Toe** - Just as with front toe, this is the combined measurement of the rear left and right toe. Rear Toe is also measured in Degrees and Minutes.
- **Rear Camber** - Rear Camber is always negative on BMW vehicles. Rear Camber adjustable on some models.
- **Geometrical Axis Deviation** - The Geometrical Axis Deviation is also known as the "Thrust Angle". The optimum angle is zero degrees. The Thrust Angle is the angle formed between the Geometric Centerline and the Thrust Line which is the imaginary line which bisects the rear toe angle. A Thrust Angle of Zero Degrees is Optimal.

Depending upon the type of alignment equipment used, the specifications can be expressed a number of ways. Whenever possible, set the alignment equipment to read in degrees and minutes. Some alignment equipment has this option, this is more desirable than trying to convert from inches to degrees etc.

The alignment angles are expressed in degrees and minutes. For example:

6° 30' is expressed as 6 degrees, 30 minutes.

There are 360 degrees in a circle and 60 minutes to each degree. There are also 60 seconds to each minute, but adjustments this fine are rarely used.

32 00 Wheel alignment E39 / M5

Observe test conditions		
Front axle:		
Total toe		0° 10' ±10'
Camber (difference between left/right max. 40' M5, M sports package max. 30')		- 30' ± 30'
Track differential angle with 20° lock on inside wheel		-1° 43' ± 30'
Caster (difference between left/right max. 30')		
With ± 10° wheel lock		6° 27' ± 30'
With ± 20° wheel lock		6° 49' ± 30'
Front wheel displacement		0° ± 10'
Maximum wheel lock		
Inside wheel	approx. °	41.5
Outside wheel	approx. °	32
Turning circle	approx. m	
Rear axle:		
Total toe		
Alignment check		0° 10' ±10'
Adjustment		0° 10' ± 8'
Camber (difference between left/right max. 15')		
Alignment check		-1° 50' ± 15'
Adjustment		-1° 49' ± 5'
Geometrical axis deviation		0° ± 12'

Alignment Checklist

Complete

1. Pre-Alignment Road Test

Notes: _____

2. Perform Complete Vehicle Inspection

Notes: _____

3. Check Air Pressure and Set to Specification

Notes: _____

4. Install Specified Weight

Notes: _____

5. Install Alignment Sensors

Notes: _____

6. Compensate Sensors - If Needed

Notes: _____

7. Lower Vehicle and Jounce - If Needed

Notes: _____

8. Check Ride Height

Notes: _____

9. Perform Alignment

Notes: _____

10. Calibrate Steering Angle Sensor (DSC III)

11. Post Alignment Road Test

Notes: _____

Alignment Worksheet

Vehicle: _____ Model Year: _____ Chassis #: _____

Front Suspension Type: _____

Adjustments: _____

Front Caster: Yes No Tool # _____ Front Camber: Yes No Tool # _____

Front Toe: Yes No Tool # _____

Rear Suspension Type: _____

Rear Camber: Yes No Tool # _____ Rear Toe: Yes No Tool # _____

Suspension Variant: (Circle One)

- A. Series B. Low Slung Sports C. Rough Road D. M Sports

Vehicle Loading (weight):

Front Right: _____ kg.

Front Left: _____ kg.

Rear Seat: _____ kg.

Trunk: _____ kg.

Ride Height Specification: Front _____ Rear _____

Ride Height Actual: Front _____ Rear _____

Tire Pressure Specification: _____ Tire Pressure Actual: _____

Wheel Bearing Play: _____

Alignment Equipment Type: _____

Alignment Head Type: _____

Notes: _____

Review Questions

1. What special tool is needed to adjust rear Toe on an E46? _____

2. What alignment angle represents the inward or outward tilt of the wheel at the top?
(When viewed from the front)

3. Where can the front and rear ride height specifications be found?

4. The "Geometrical Axis Deviation" angle is also known as _____
5. What angle is formed when combining Camber and SAI? _____

6. What vehicles use the "Single Joint" front suspension? _____

7. Ride height is measured from the _____ to the

8. When identifying the suspension variant of an E39, the technician finds a "Solid Triangle"
on the front strut housing. What is the suspension variant?

9. Which BMW vehicles have adjustable Caster? _____
10. What is Special Tool 313 010 used for? _____
