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BMW Suspension Systems

Initial Print Date:3/06 Revision Date:

Subject Page

BMW Suspension Systems

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Identify BMW Suspension Systems
- Understand BMW Suspension System design
- Locate suspension adjustments on the front and rear axle

Introduction

One of the most overlooked features on a vehicle is the chassis and suspension system. Most of the time, people who buy new vehicles are initially attracted to the style of the body. Some buyers are interested in the performance of the engine or the convenience features such as the audio system etc.

BMW vehicles are well known for having “cutting edge” engine technology. However, in order to be known as the “Ultimate Driving Machine”, it is the chassis that must provide the driver with comfort, safety and superior “road-holding” performance.

Since the most early development period of the automobile, chassis designs have had to keep up with the demands of the engine. The chassis and suspension system designs have also evolved with increasing demands of the driver and the road conditions.

As vehicles get more powerful and demands for ride comfort and driving safety rise, so do the demands placed on the modern chassis.

Requirements of a modern steering system:

- To ensure steerability in accordance with the driving conditions
- To provide function, comfort and safety
- To dampen vibration
- To convey a confident “road feel” by transferring road surface information to the driver
- To allow sufficient steering wheel return after cornering

The focus of this training module will be on BMW steering and suspension systems. This will include all front and rear axle designs as well as adjustments where applicable.

Front Axle

There are two basic front axle designs used on BMW vehicles:

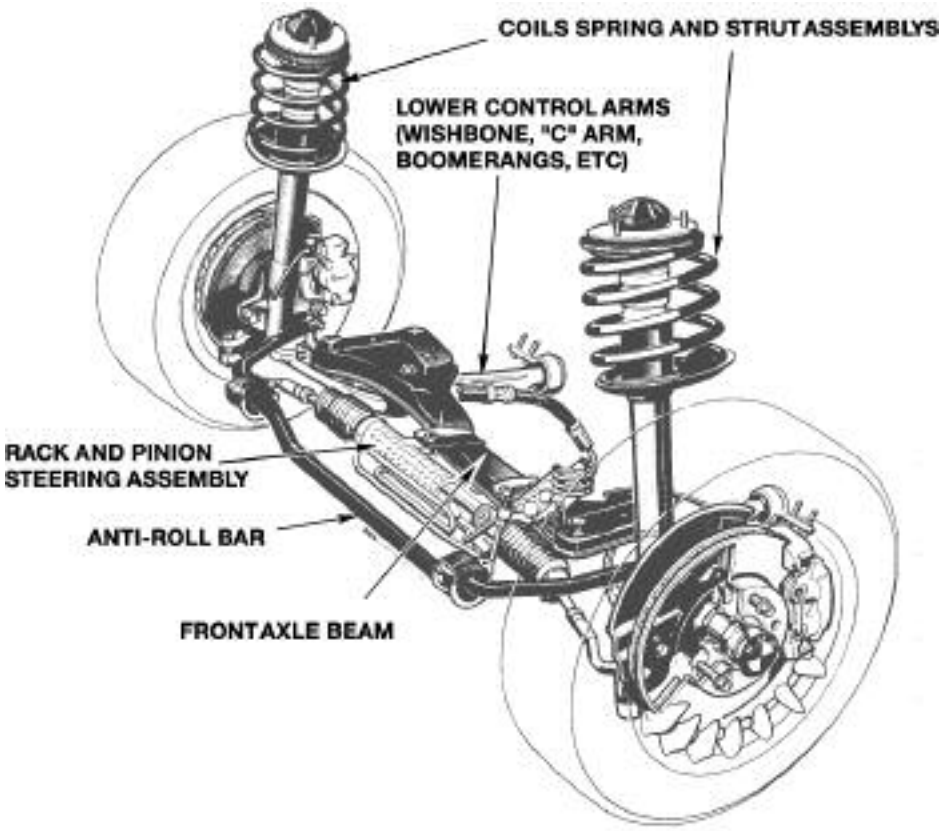
- Single-Joint Spring Strut Axle
- Double-Pivot Spring Strut Axle

Single-Joint Spring Strut Axle

The “Single-Joint” design has been in use since the introduction of the E30. It is used on the E30, E36, E46 and the E85. The design includes a steel axle carrier which allows the mounting of the engine mounts, steering rack, sway bar and lower control arm mount.

The axle carrier is bolted to the body structure via 4 bolts. There are two locating dowels which provide proper axle location as well as added strength. The “sickle-shaped” lower control arm is attached to the axle carrier via a ball joint, there is also an additional rubber mount which is attached to the body. The lower control arm also provides the “single-pivot” point for the steering knuckle.

The single-joint design has advantages due to it’s low weight and compact design. The geometry of the single pivot allows for a small positive steering offset, but the size of the brake rotor is ultimately limited. However, it is ideally suited for smaller cars such as the 3-series.



E46/E85 Front Suspension

The front suspension on the E46 and E85 is based on the single-joint front suspension used on the previous 3-series models (E30/E36). There have been some design changes to enhance ride quality and handling characteristics. The changes to the front suspension are as follows:

- A new forged aluminum lower control arm (except Xi). The lighter arm offers a lower unsprung mass.
- The rear lower control arm bushing is hydraulic.
- Hollow strut piston rods for reduced weight.
- The steering knuckles are “press-fit” to the strut tubes.
- The overall caster angle has been increased to improve “straight-line” stability.
- The track has been widened for improved cornering ability.
- The brake dust shield are made from aluminum.

Altogether there is a weight reduction of 5.72 pounds. The is “un-sprung” weight which enhances ride comfort and handling.

E46 Front Suspension

Adjustments

There are some limited adjustments on the “Single-Joint” front suspension. Front toe is adjustable on all models via the threaded outer tie rod. This can be achieved using standard hand tools.

There are no provisions for Caster adjustment. However, Caster should always be checked during the wheel alignment to ensure that there is no damaged components.

Camber is only adjustable on the E46 and E85. There is a slot in the upper strut tower which will allow small camber changes of up to .5 degrees. If the camber adjustment cannot be achieved, check for proper ride height and inspect for any suspension damage.

The illustrations above show the camber adjustment slots and special tool. The proper instructions for the camber adjustment can be found in WebTIS Repair Instructions under group 32.

To adjust the camber, loosen 2 of the nuts on the upper strut mount and remove the remaining nut. Drive out the pin in the strut plate. Install special tool # 323 140. Turn the adjusting nut as needed on the special tool to make camber the adjustment.

Note: It may be necessary to unload the suspension to make the needed camber adjustment. The weight of the vehicle on the strut plate may prevent movement while making the adjustment. Damage to special tool can result.

Double Pivot Spring Strut Axle

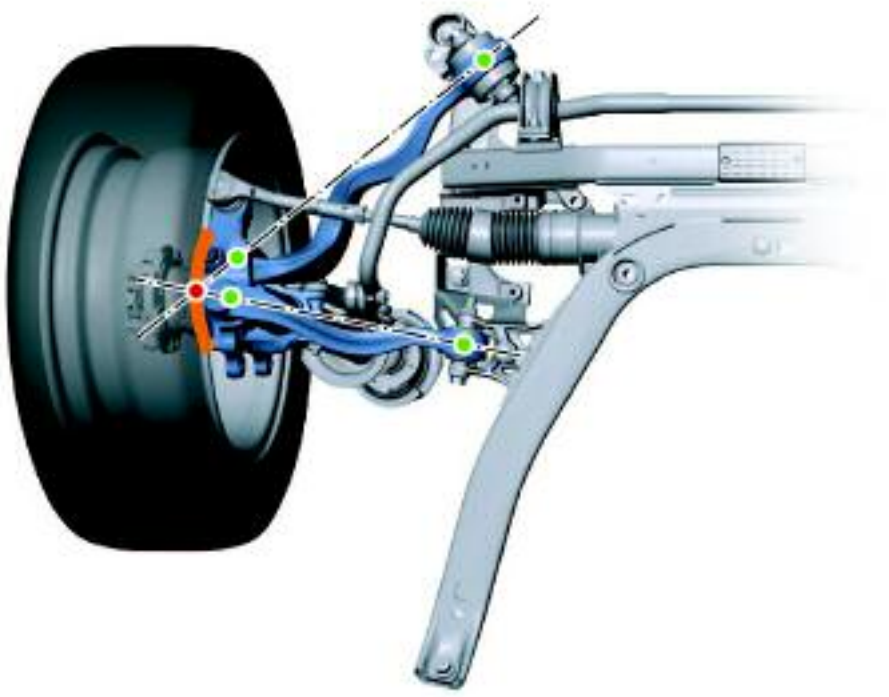
The double-pivot front axle configuration has been in use since the earliest 6 and 7 series vehicles were in production (E23/E24). This design is ideally suited for larger cars due to its rugged construction.

The double-pivot front axle is used on the following vehicles:

- 8 Series - E31
- 7 Series - All models from the E23 to the current E65/E66
- 6 Series - Both the E24 and the new E63/E64
- 5 Series - From the E28 through the current E60/E61
- 3 Series - This axle is used for the first time starting with the E90 (E91/E92 etc.)
- X Vehicles - Both the E83 and E53 use this axle with slight modifications for AWD

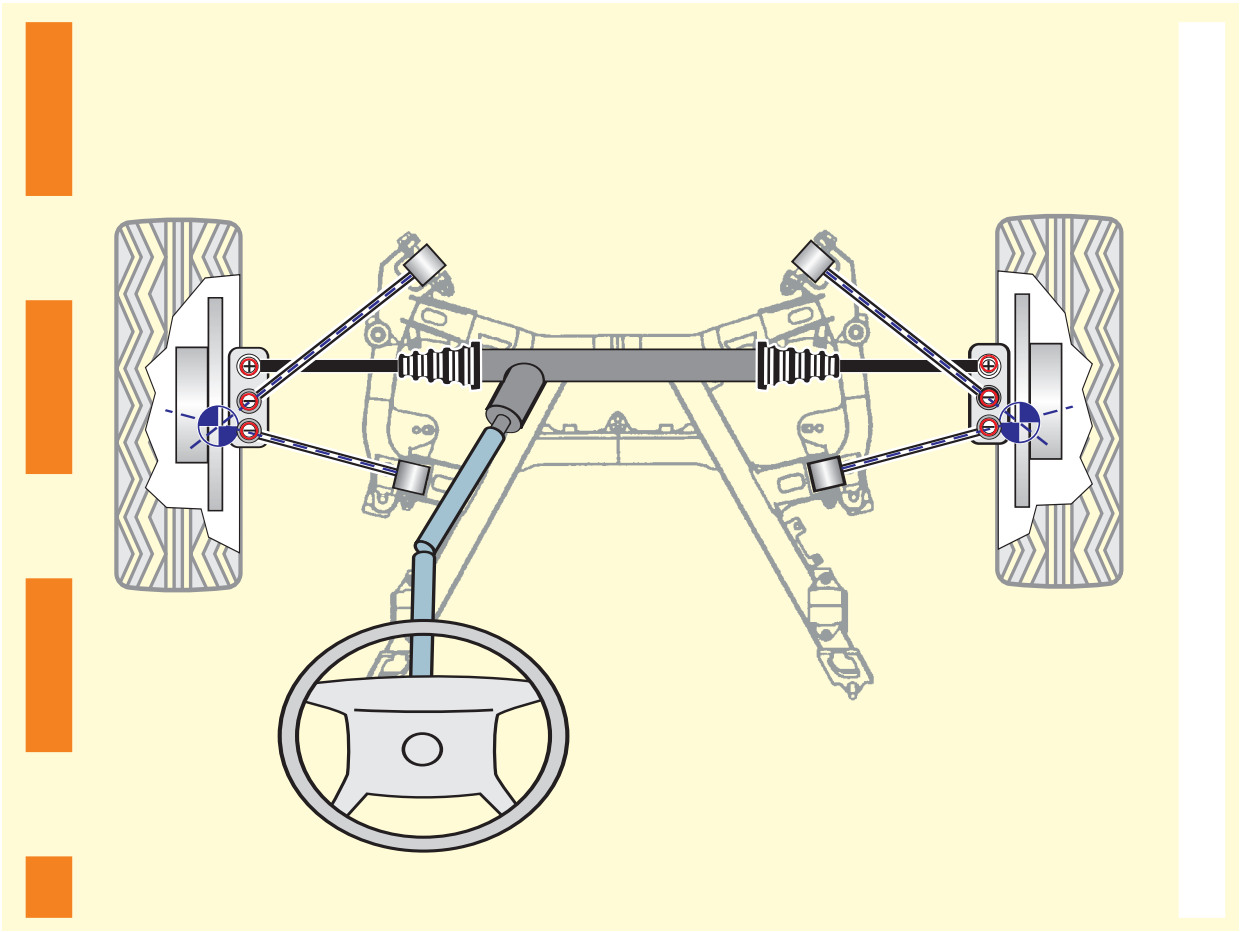
One of the primary features that separates this design from the single-joint front axle is the lower pivot point. This suspension design consists of one upper pivot (strut bearing) and two lower pivot points. The lower pivot is actually two separate points. These two points together create an imaginary pivot point or “axis”.

The design eliminates a single pivot (ball joint), which limits the size of the brake rotor and the amount of steering offset (scrub). The steering offset still remains positive, but less than that of the single pivot design.



Additional advantages of double pivot system are:

- Ability to reduce body roll while cornering.
- Reduces front end dive tendencies during severe braking situations.
- Utilization of a small positive steering offset, which offers improved handling. This is more evident when the friction levels differ while braking.
- Improved caster position, improving straight line stability at higher speeds, plus better steering return after small steering inputs.



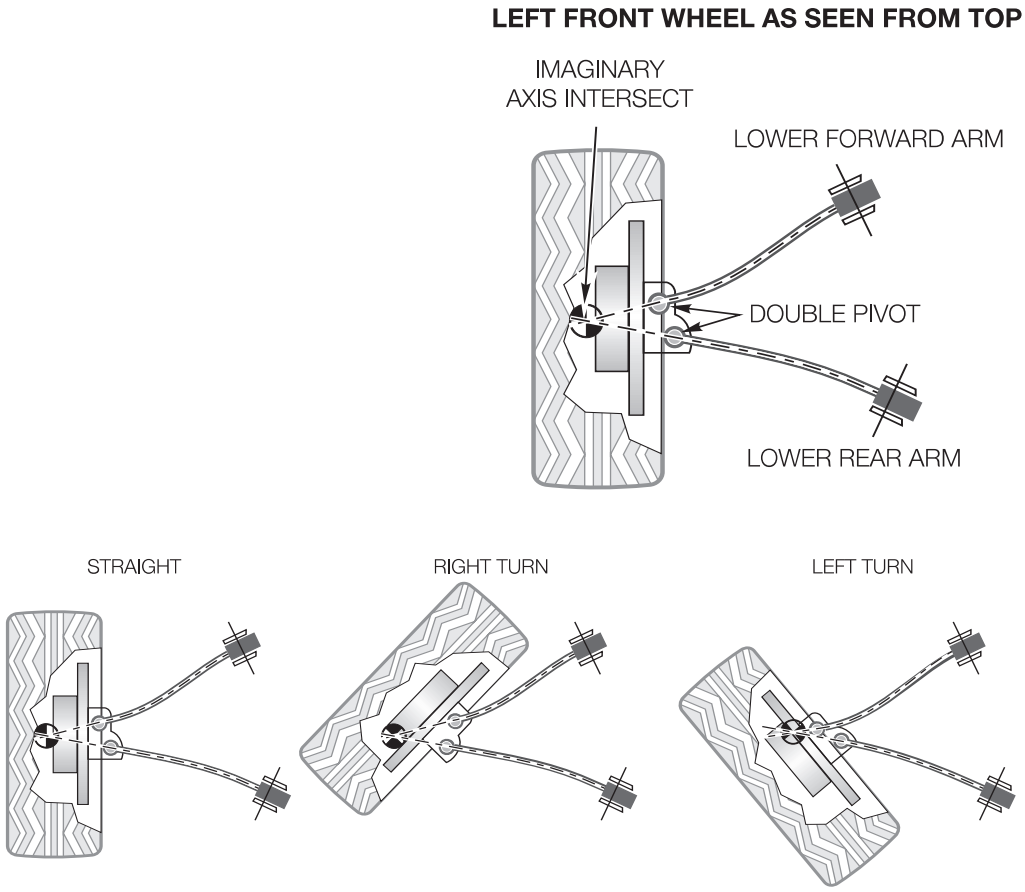
Double Pivot Operation

The true benefits of the double-pivot suspension become more evident during turns. On a traditional single-pivot design, the camber and caster remain static during steering maneuvers. On a vehicle with positive caster, the wheels tend to “flop over” during turns. This situation reduces the tire contact area with the road and increased the effort required for steering wheel return. The steering offset (scrub) also remains fixed which has a negative impact on steering wheel return as well.

The double-pivot design allows the the “imaginary” lower pivot point to change relative location during turns. The tire which is on the outside of the turn is carrying the majority of the load. Therefore it is the outside tire which must have the most contact area with the road surface.

On a turn, the double-pivot design causes the caster and camber on the outside wheel to become closer to zero. This allows the “contact patch” between the tire and the road to become optimized. This greatly enhances handling characteristics.

The body roll is also reduced by the caster change towards zero. One of the other benefits of this arrangement is the variable steering offset. The variable steering offset during turns provides for better “returnability” of the steering wheel.

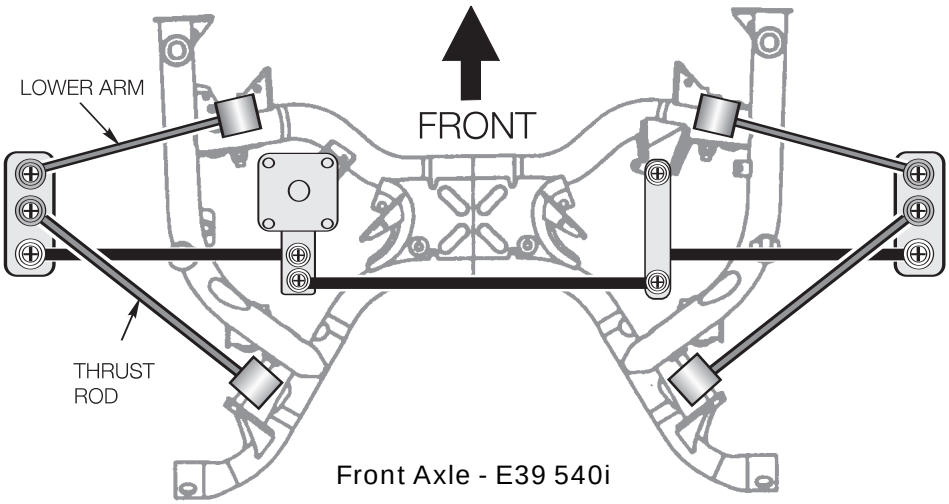


Double Pivot Front Axle Configurations

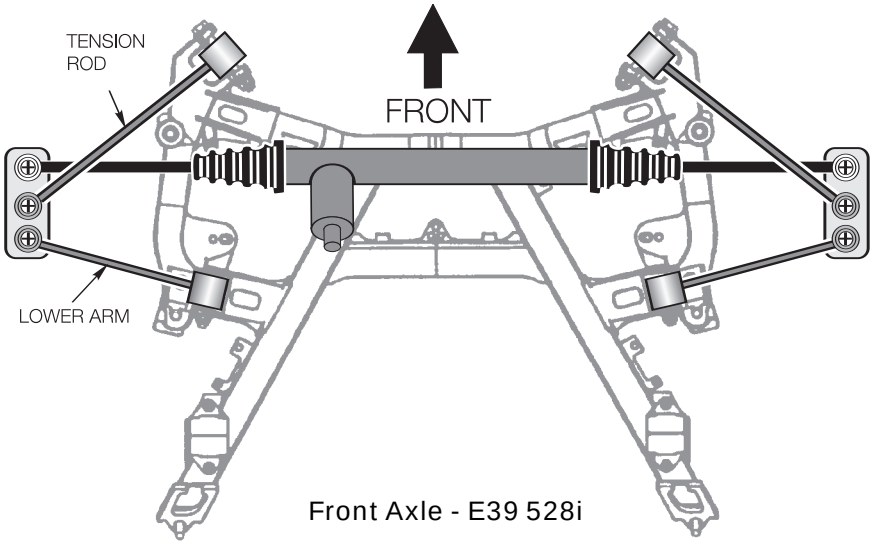
The double pivot axle features an axle carrier, to which the suspension components are attached. The carrier also provides the mounting points for the steering rack, stabilizer bar and engine mounts. The carrier is either steel (on the earlier models), or aluminum.

The aluminum carrier was first used on the E39 six-cylinder (528i) from 1997. The E39 was the first and only models to have both steel and aluminum carriers. The E39 540 featured a steel carrier with a steering box (instead of a rack and pinion. Aluminum components were used wherever possible on the 540i, except the suspension carrier. On the other hand, the E39 528i was equipped with an aluminum carrier and a steering rack.

Since then, all vehicles equipped with the double-pivot suspension utilized the aluminum carrier and steering rack configuration.



Front Axle - E39 540i

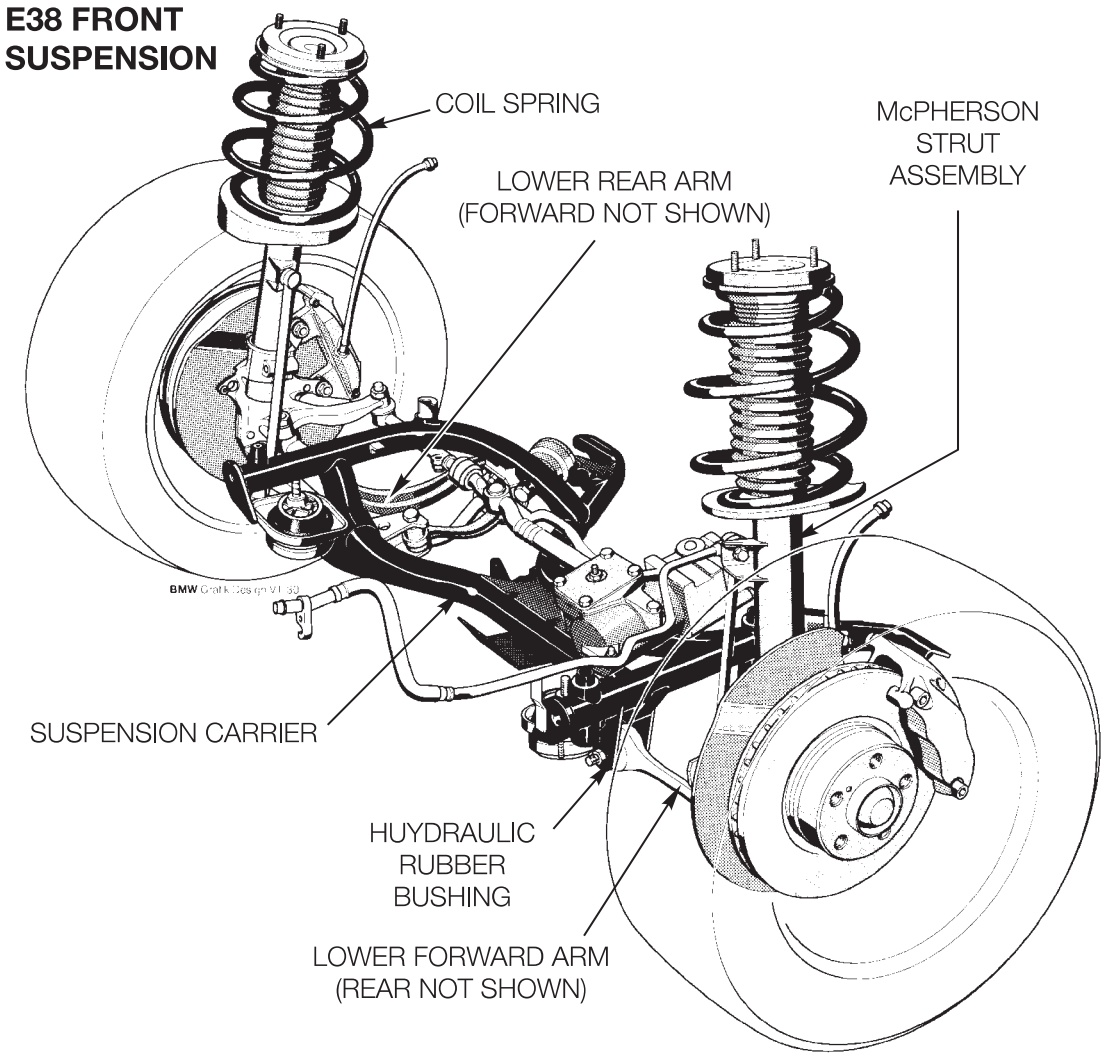


Front Axle - E39 528i

E38 Front Suspension

The E38 uses an updated version of the double-pivot suspension as compared to the previous 7 series designs (E23/E32). The features of the E38 suspension are as follows:

- Suspension carrier is made from tubular steel as opposed to stamped steel.
- Suspension carrier is lighter and can be removed as a complete unit.
- Design changes allow for larger front brake rotors.
- Slight difference in the configuration of the lower control arms.
- Lower forward control arms are made from forged aluminum.
- Variable diameter coil springs provide lower profile.



Front Suspension E6X Vehicles

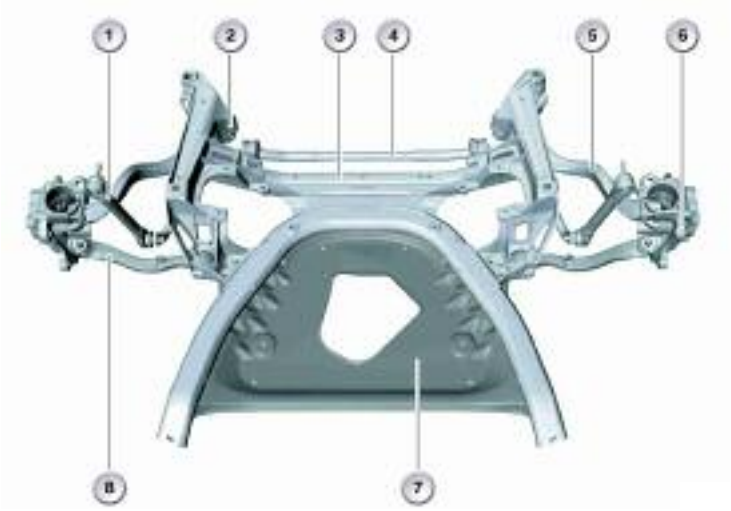
The double-pivot front suspension has been further enhanced since initially introduced. The materials used in the front axle carrier offer high tensile strength to support extreme loads. The front axle carrier is also manufactured entirely from aluminum. It consists of cast alloy preformed sections which are welded into the extruded sections. The front axle carrier accommodates the steering gear, control arms and tension struts, engine mounts, stabilizer bar, heat shield and the underbody panels.

An “thrust zone” panel is bolted on to increase the transverse rigidity of the front of the vehicle. This reinforcement has a positive effect on the handling, sound level and crash performance. The benefits as a result of the improved front axle include increased agility, improved comfort by the reduction of unsprung weight, a reduction in fuel consumption by lowering the gross vehicle weight and better axle load distribution.

The front double pivot suspension used since the introduction of the E65/66 includes the following:

- Aluminum front axle carrier
- “Thrust zone” panel for increased rigidity
- Aluminum suspension components
- Aluminum strut tubes

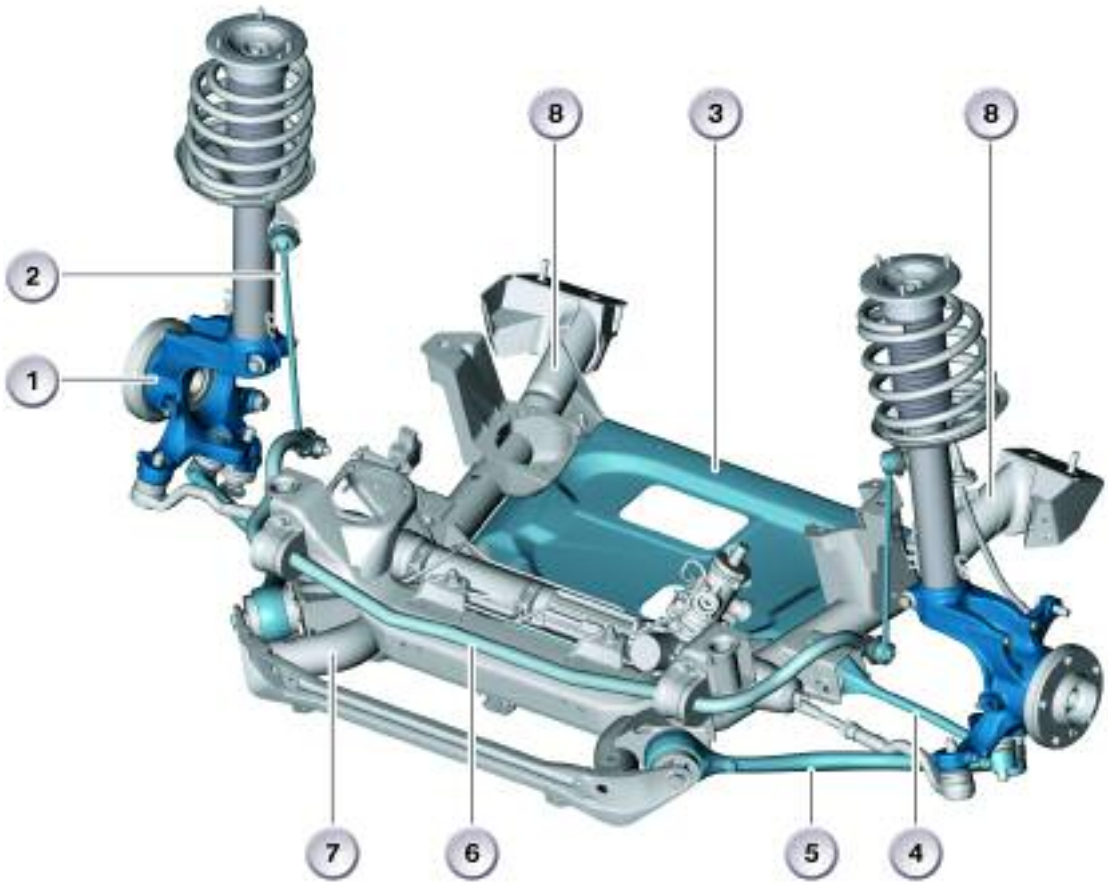
The front suspension on the E6X vehicles also includes accommodations for the Active Roll Stabilization (ARS) system.



Index	Explanation	Index	Explanation
1	Stabilizer link	5	Tension strut
2	Hydro-mount	6	Swivel bearing
3	Front axle carrier	7	Reinforcement plate
4	Stabilizer bar	8	Control arm

Sport Activity Vehicles (X3 and X5)

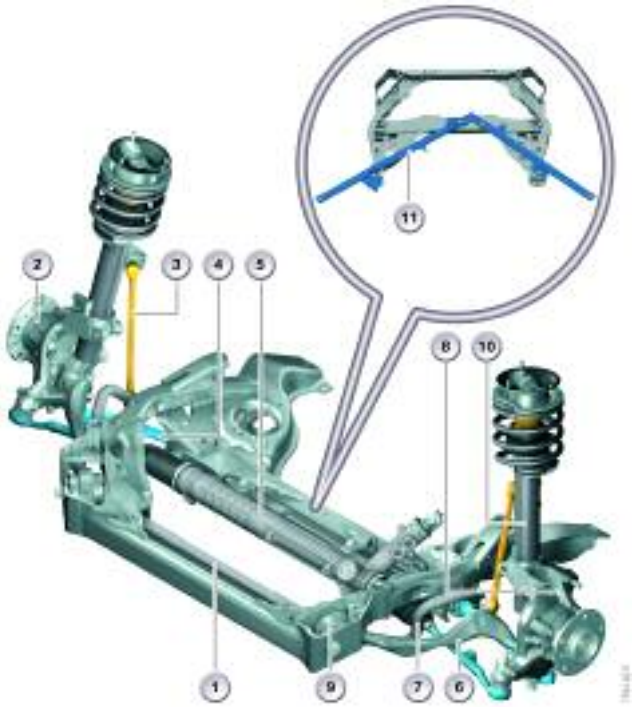
The X3 and X5 vehicles use a modified version of the double-pivot front suspension. There are modifications to accommodate the front drive axle components. Both the X3 and X5 use the rack and pinion configuration. There is an aluminum thrust panel which helps protect the oil pan and also provides additional stiffening properties for the front suspension carrier.



Index	Explanation	Index	Explanation
1	Swivel bearing	5	Tension arm
2	Anti-roll bar link (attached to strut tube)	6	Anti-roll bar
3	Thrust panel	7	Front axle carrier
4	Control arm	8	Axle carrier rear mounts

3 Series (E9X)

The E9X vehicles also take advantage of the double-pivot front suspension. Traditionally, the 3-series was associated with the single pivot design. This marks the first time that the double-pivot design has been used in the 3-series platform.



Index	Explanation	Index	Explanation
1	Front Axle Carrier	7	Stabilizer Bar
2	Wheel Hub	8	Swivel Bearing
3	Stabilizer Link	9	Hydro-Mount
4	Control Arm	10	Spring Strut
5	Rack-and-Pinion Steering	11	Reinforcing Strut
6	Tension Strut		

Suspension Adjustments (Double pivot front axle)

As with all BMW front suspensions, Caster angle is not adjustable. However, during an alignment, Caster should always be checked to rule out any damage to the chassis or suspension components.

Camber is adjustable by a slotted strut mounting holes. This adjustment is only available on newer vehicles from E53 production. Vehicles which are capable of this adjustment include, E53, E65/E66, E60, E63/E64, E90, E91, and E92.

As with other models, toe is adjustable via the threaded tie rod assembly.

NOTES PAGE

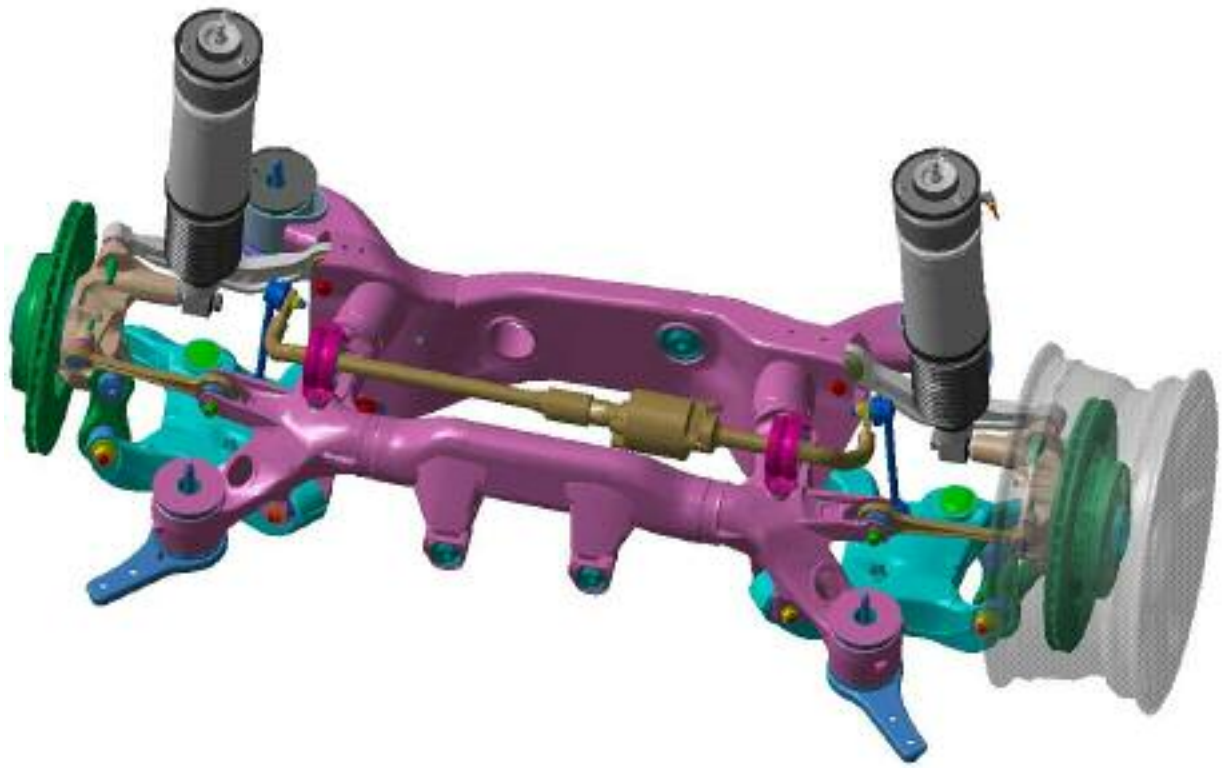
Rear Axle

As requirements for improved performance continue to increase, rear axle technology must also be continually enhanced. Throughout the development of various BMW Group vehicles, the rear axle has continually evolved to meet the overall needs of chassis design.

Throughout the various design changes, rear axles have allowed improvements in traction and stability. The rear axles have also been “weight optimized” which allows for an overall balanced chassis.

The rear axle designs have also made it possible to decrease changes in rear camber and toe during suspension travel. By limiting camber and toe changes, the tire can maintain a better contact patch, thereby improving rear end stability and improved tire wear.

E65/E66 Rear axle (Integral IV) shown with ARS and rear air suspension.



Some of the other improvements to rear axle design include the complete isolation of the rear axle through rubber bushings. This decreases the incidence of the transmission of road noise to the vehicle occupants and provides superior ride smoothness.

The chart on the opposing page list the various rear axle designs on BMW vehicles through the last few decades of production vehicles.

Development of BMW Rear Axles

Rear Axle Designation	Rear Axle Features	Models
HA 1	Semi-trailing arm axle	E12, E21, E28, E30, E36/5, E36/7
HA 2	Semi-trailing arm axle (with track-link)	E23, E24, E32 and E34
HA 3	Central “C” link rear axle	E36 (Except E36/5 and E36/7), E83 and E85
HA 4	Design Study Not used in production vehicles	N/A
HA 5	5-link rear axle (Dispersed double control arm axle)	E90 (E91, E92)
Integral I	Design Study Not used in production vehicles	N/A
Integral II	Design Study Not used in production vehicles	N/A
Integral III	Integral design with multi-link (5-link)	E31
Integral IV	Steel carrier, with spring on damper	E38
Integral IV	Aluminum carrier, spring on body, damper on axle carrier.	E39
Integral IV	Aluminum carrier	E39/2 (Touring)
Integral IV	Steel axle carrier, aluminum link with steel wheel carrier, spring and damper separated, but still supported on body. on body.	E53
Integral IV	Aluminum axle carrier, spring and damper on wheel carrier.	E65/E66
Integral IV	Aluminum axle carrier, spring and damper on wheel carrier.	E6X (E60, 61, 63 and 64)

Semi-Trailing Arm Axle (HA I)

The illustration below shows a semi-trailing arm axle used on some of the early BMW models. As with all of the rear axle designs covered in this training module, this is a type of independent rear suspension. The suspension consists of two trailing arms connected to rear axle beam (subframe).

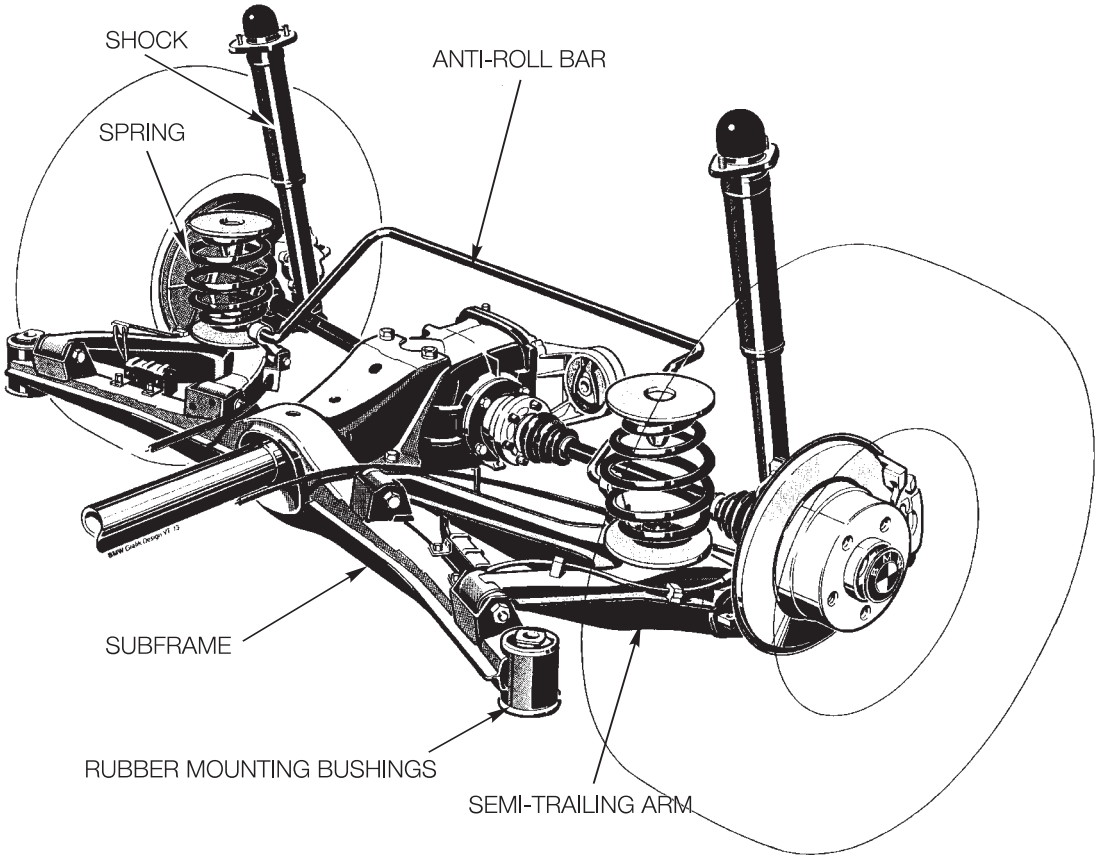
The final drive and rear axle beam are connected to the unibody structure via three rubber mounts. These mounts serve to insulate drivetrain and suspension noises from the body structure.

There are coil springs which are mounted on the trailing arms. The upper portion of the coil springs use a rubber insulating pad which rests on the body structure.

The dampers are mounted to the hub carrier and the upper end attaches to the body. There is an “anti-roll” bar which attaches to the control arms via links.

The trailing arms on this type of suspension travel in a circular path. This causes changes to rear camber and rear toe as the suspension travels through “jounce and rebound” motions.

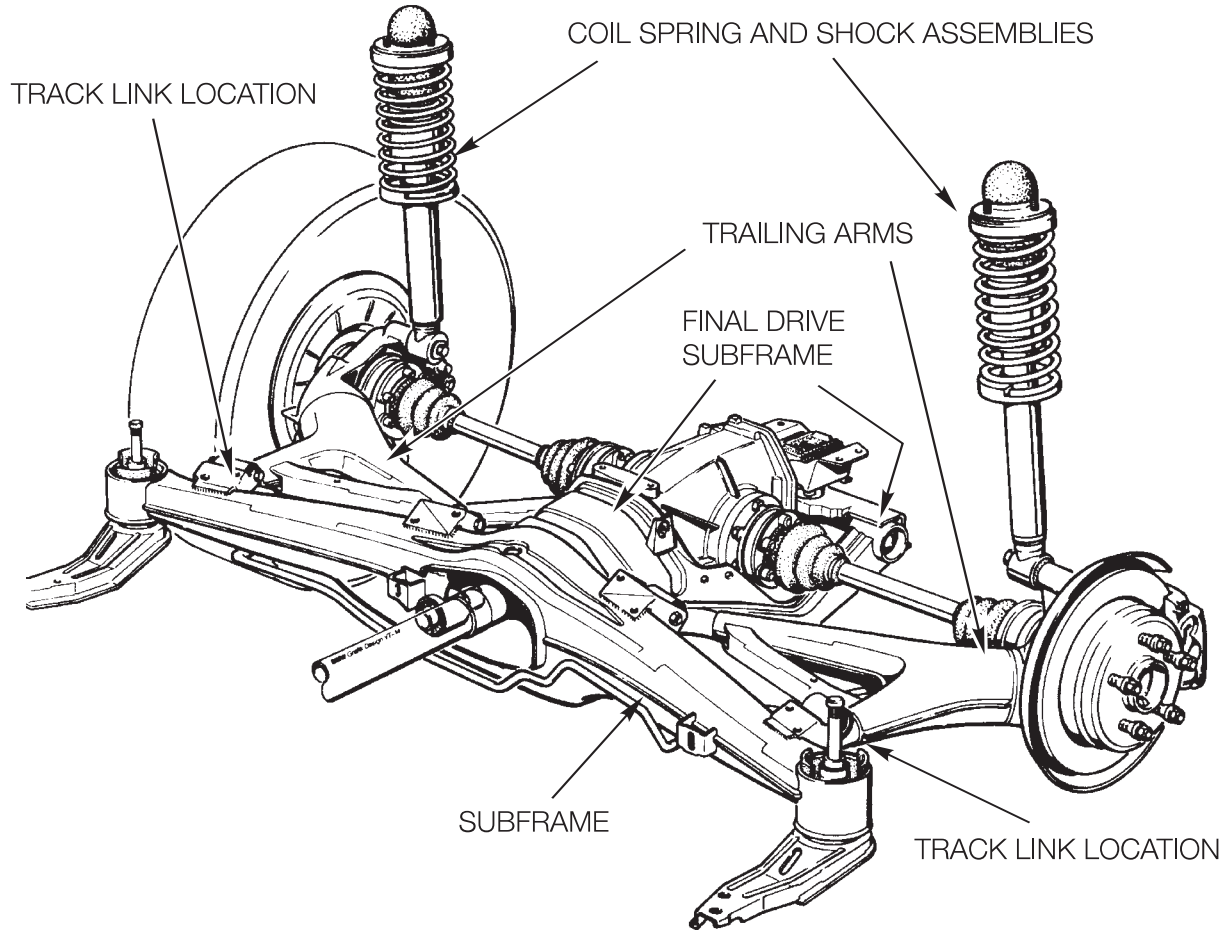
Future variations of BMW suspension system improve this action resulting in less camber and toe changes.



Semi-Trailing Arm Axle (with track link - HA II)

This rear suspension design is mostly similar to the previous Semi-trailing arm axle. It is sometimes referred to as the “screw-link” or “helical-link” axle. The primary change is the installation of a “track-link”. This limits the total travel arc of the trailing arm from 20 degrees to 13 degrees. This reduces the camber and toe changes.

Also, the spring and damper arrangement has been modified. The spring has been moved from the trailing arm to the damper. This rear axle is used on the E23, E24, E32 and E34.



Adjustment

Both versions of the semi-trailing arm axle cannot be adjusted via standard methods. If a toe correction is required, there are offset bushings available through parts. For more information, refer to repair instructions in WebTIS or the Alignment portion of this training course.

Central “C” Link Rear Axle (HA-III)

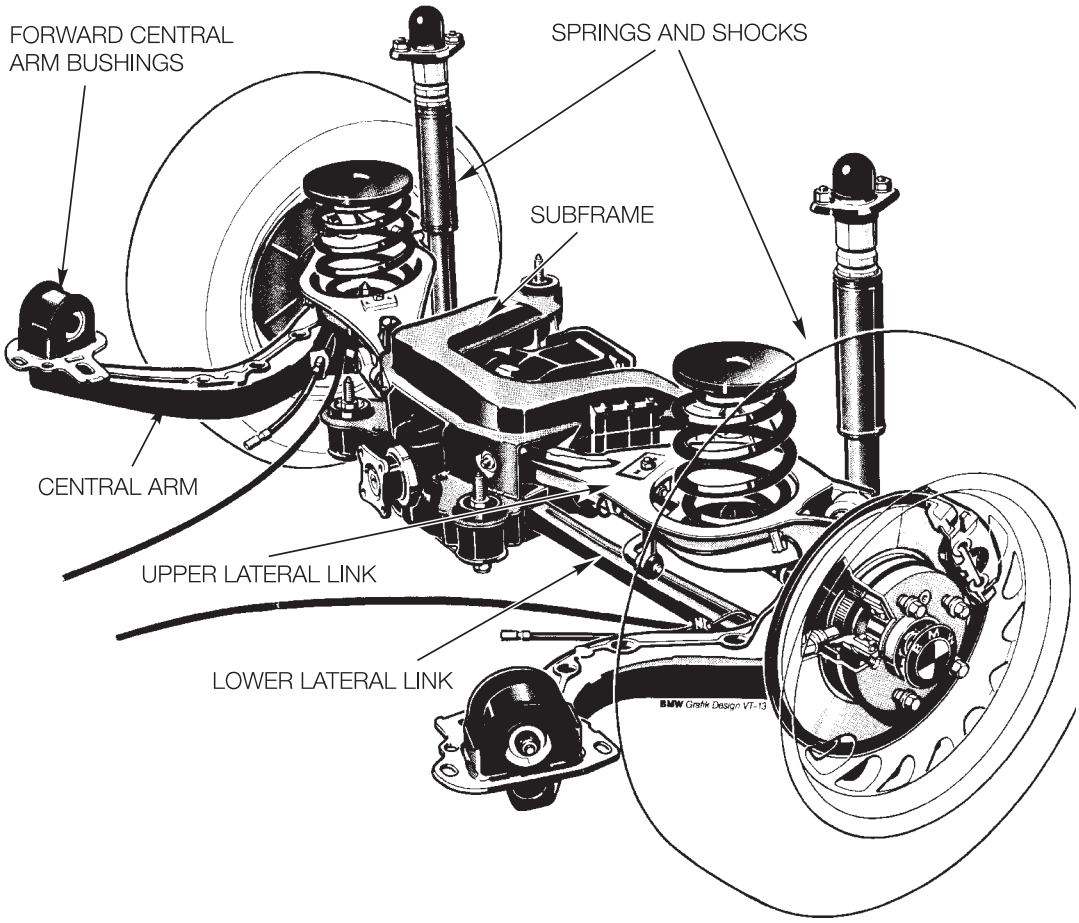
The Central-Link (HA 3) rear axle was introduced on the E36. Some of the other models which incorporate this design include the E46 (all), the E85 and E83. This suspension is a “multi-link” arrangement which consists of a cast-iron central arm on each side. The arm is connected to the body via a rubber bushing for noise and vibration dampening.

The hub carriers are connected to the suspension system via upper and lower lateral links. On the E36, the upper and lower lateral links are made from stamped steel. These links connect the hub carriers to differential carrier (subframe).

The coil springs and anti-roll bar are supported by the upper lateral link.

The design of this suspension allows for individual tuning of longitudinal and lateral forces acting on the vehicle. Longitudinal forces during acceleration and braking are absorbed by the central arm. Lateral forces during cornering, are absorbed by the lateral links.

This suspension design virtually eliminates toe changes while driving. Camber changes has also been greatly reduced over previous designs.



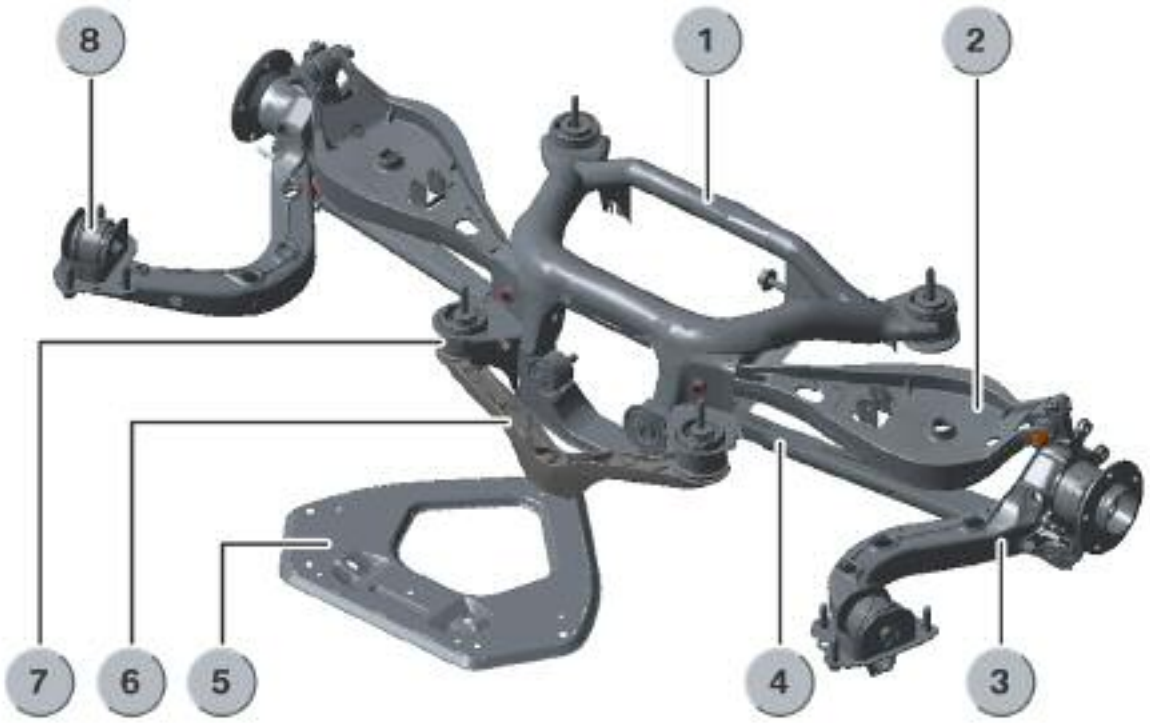
E46 Rear Suspension

The rear suspension design on the E46 is a further development of the “Central Link “ rear axle. The optimize weight reduction and improve noise characteristics, the following modifications have been carried out:

- The upper lateral link is now made from aluminum
- The subframe (rear axle carrier) is now made from tubular steel.
- The differential is mounted to the frame with a hydraulic mount

E85 Rear Suspension

The rear suspension on the E85 is taken from the E46 with some minor changes for the roadster. The track width has been increased by 30mm. 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 to help keep the differential within the proper temperature range.



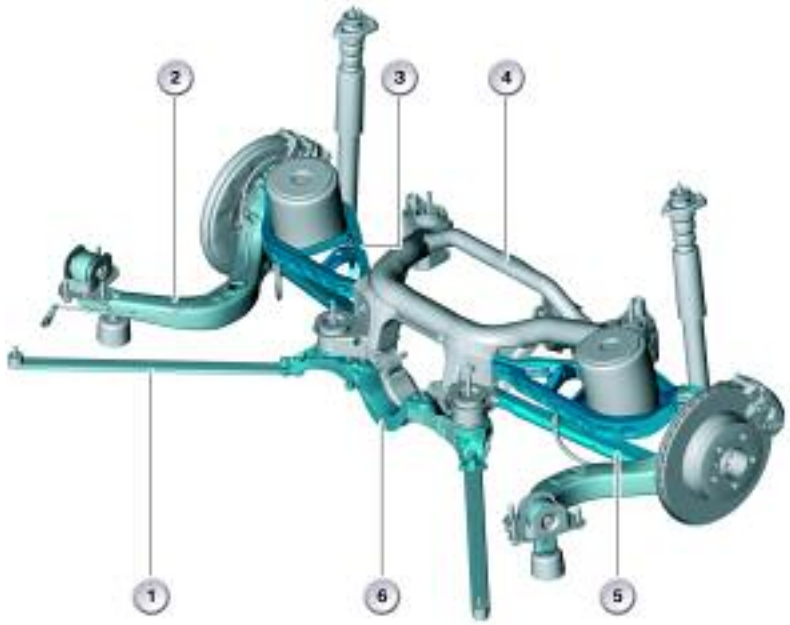
Index	Explanation	Index	Explanation
1	Rear subframe section	5	Reinforcement plate
2	Left upper control arm (lateral link)	6	Reinforcement support bracket
3	Central arm (left)	7	Rear subframe mounting bushings
4	Lower lateral link (left)	8	Central arm bushing (right)

E83 Rear Suspension

The Central Link rear suspension has been adapted to the E83. The rear suspension is a further modification of the design used on the E46/16 (AWD/xi).

The E46/16 rear suspension has been adapted to the E83 as follows:

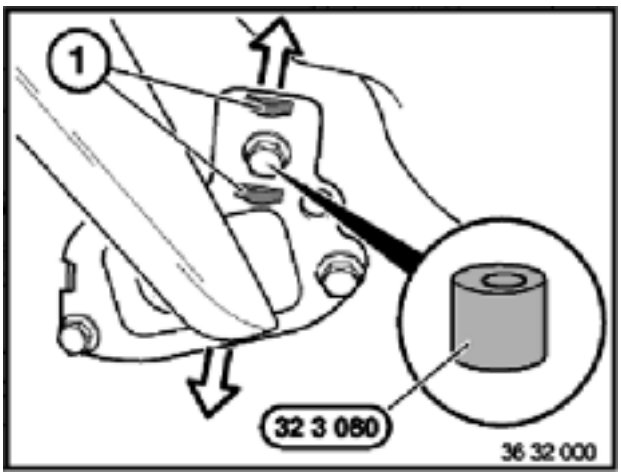
- Anti-roll bar secured to the rear axle carrier by clamps.
- Front of rear axle carrier suspension converted to special bolts with additional thrust washer.
- Thrust brace and tension arms.
- Surface of control arms are galvanized steel plates.
- Anti-roll bar link with ball joint attached directly to the control arm.
- Dampers with three point flange (bolt) plate.

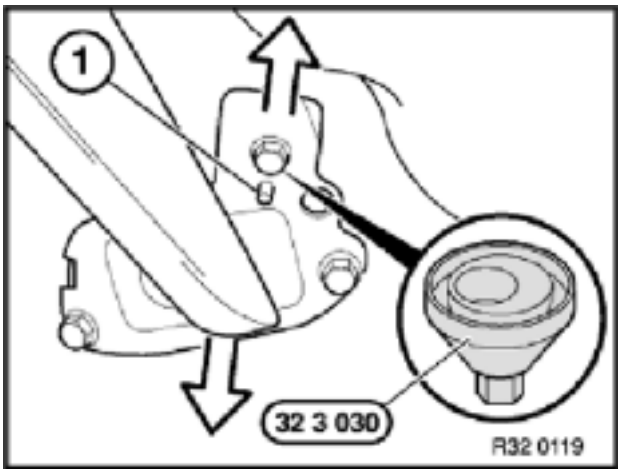


Index	Explanation	Index	Explanation
1	Tension arm	4	Rear axle carrier (subframe)
2	Central arm (right)	5	Lower lateral link (left)
3	Upper lateral link (right)	6	Thrust brace
4			

Note: When removing or lowering the rear axle, the handbrake cables (routed through the rear axle carrier and the body console) must be disengaged before the rear axle is lowered. This is to prevent shearing of the hand-brake cables.

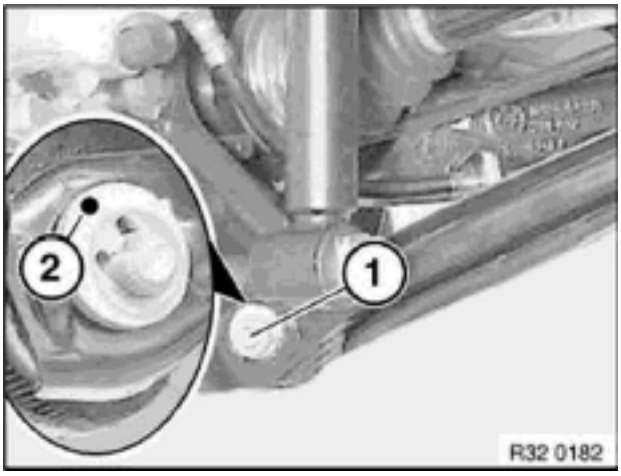
Rear Suspension Adjustments (Central Link Axle)

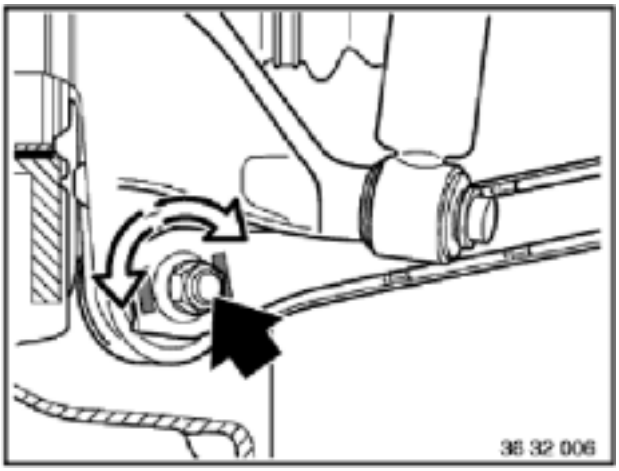




Rear Toe

Toe is adjusted by moving the forward central arm bushing mount with a special tool. The tool part number varies between models. Tool number 32 3 080 is used for the E36. The E46, E85 and E83 use tool # 32 3 030. These tools are not used for the 318ti and Z3 as the rear suspensions on the vehicles are different (HA-1).





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.

Integral Axle (III and IV)

The “integral axle” is a multi-link rear suspension which was introduced on the E31. Subsequent variations of this design have been utilized on the 5 and 7 series vehicles including the X5 (E53) and E39 Sportwagon. These suspensions incorporate what is called “elastokinematics” that allow each wheel to move and flex individually without loads and forces through the subframe to the opposing wheel.

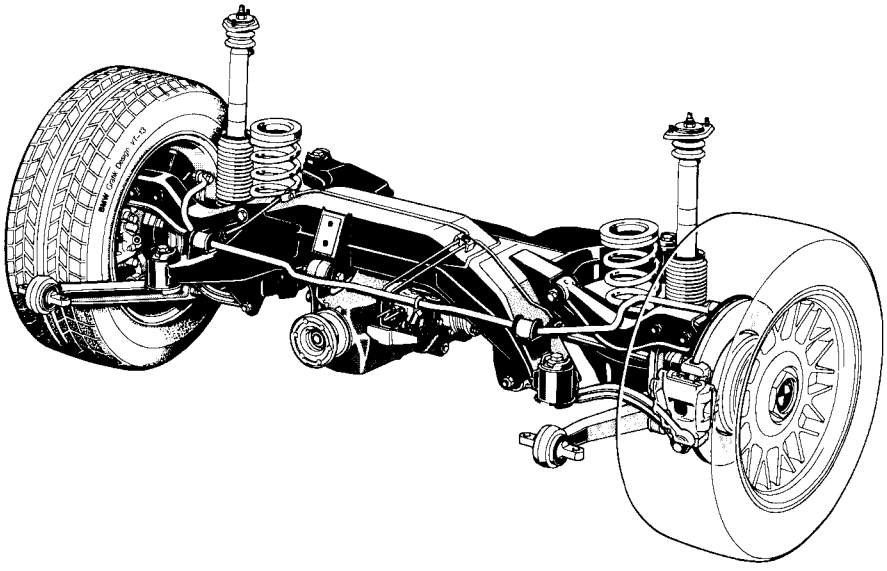
The integral axle has been used on the following vehicles:

- E31 (8-series all models)
- E38 (7-series all models)
- E39 (5-series all models)
- E53 (X5 all models)
- E52 (Z8)
- All E6X vehicles (including E65, E66, E60, E61, E63 and E64)

E31 Rear Suspension

The first BMW vehicle to use the “multi-link” integral rear suspension was the E31. The E31 version of this suspension uses a 5-link design rather than the subsequent 4-link design of later models.

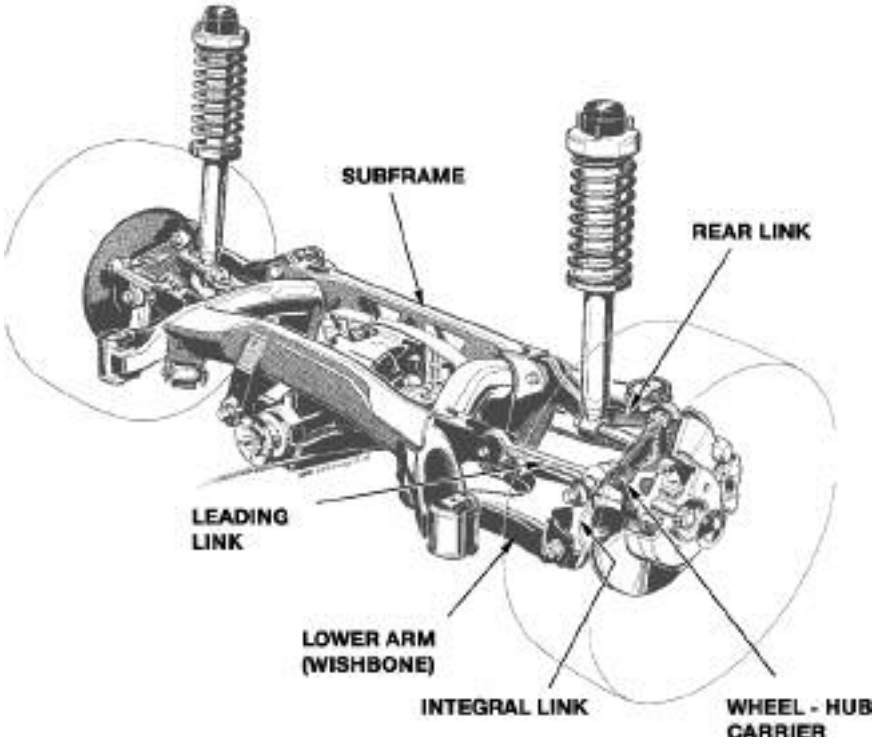
The “fifth-link” was the trailing arm which was deleted as of the E38 and E39 models. The E31 design placed the rear springs between the body and the upper lateral link. When introduced, this suspension was very innovative for it’s time and provided improved directional stability and marked an advance in driving comfort. Future models reaped many benefits from this suspension design.



E38/E39 Rear Axle

The E38 and E39 models 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.

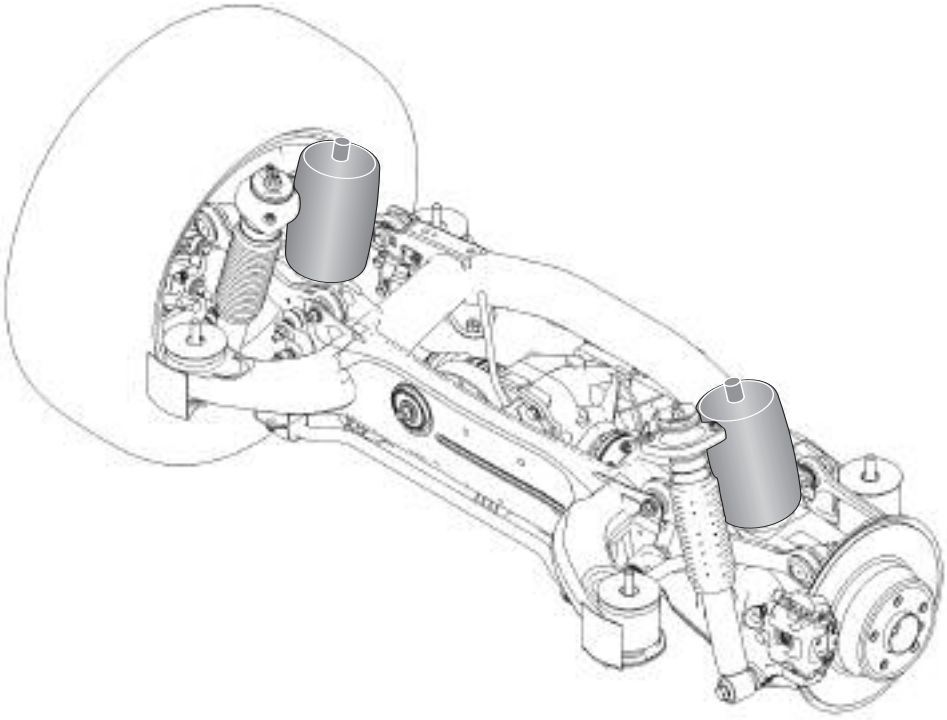
The trailing arm was eliminated and all suspension mounting is to the sub-frame of the vehicle. The springs were moved to the dampers. The changes from the E31 provided further improvements to the integral rear axle including weight savings and improved noise characteristics.



E39 Sportwagon and X5 (E53)

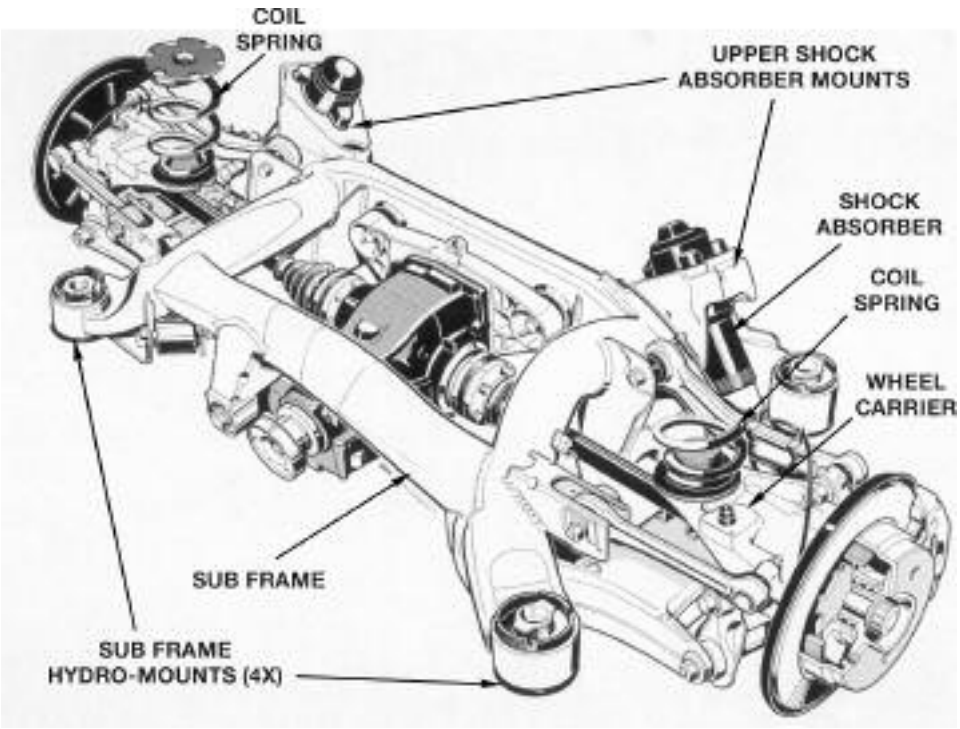
The rear suspension is the “integral” multi-link design taken from the E38/E39 vehicles. Several components are made from aluminum to reduce the unsprung weight. The X5 has the optional EHC or EHC II dual axle air suspension.

The rear axle sub-frame is mounted to the body through four bushings (larger than E38) for increased load and comfort. The rear differential is mounted through three rubber bushings two in the front and one hydromount in the rear. The wheel bearings are similar to the E39 but incorporate different seals - designed for off-road use.



The E39 Sportwagon shares the same basic rear suspension design as the E53 X5.

The standard rear suspension of the E39 Sport wagon follows the design characteristics of the four link elasto kinematic system of the E38/E39 sedan vehicles.



The main design difference is the separation of the coil springs and dampers.

- The coil springs are positioned between the perches of the wheel carriers and the underside of the rear floor pan.
- The shock absorbers are positioned diagonally between the lower lateral control arm and the rear axle sub frame.

This configuration provides the wide, uniform load space in the cargo area.

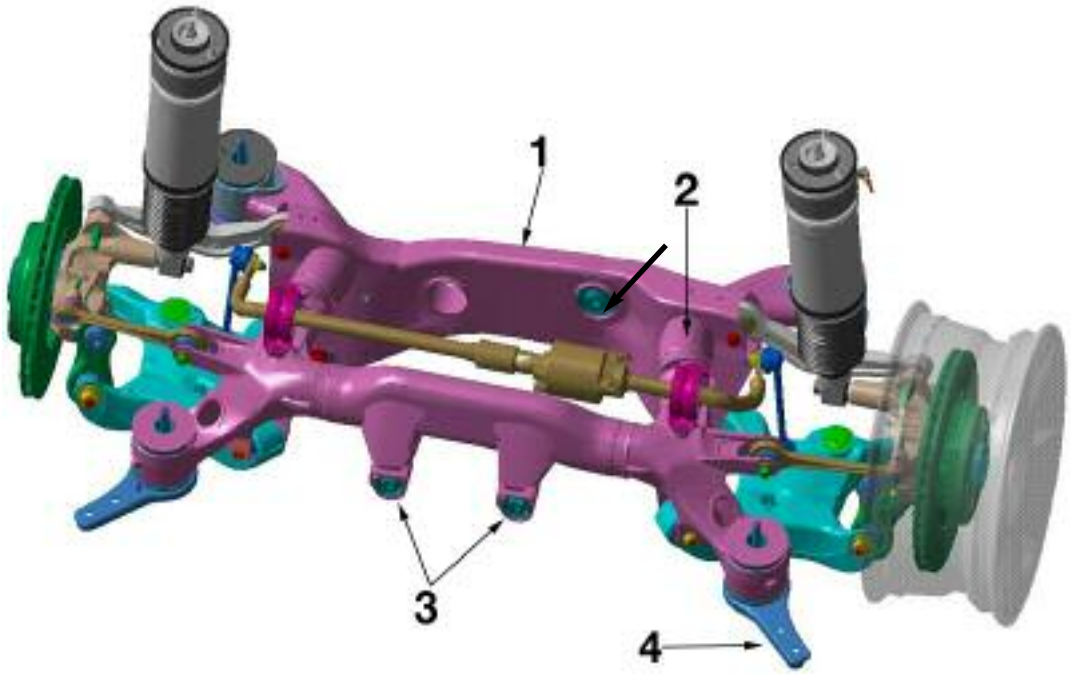
Since the shock absorbers are now mounted directly to the sub frame, the sport wagon requires unique sub frame hydro mounts. The hydro mounts contain a fluid that helps to suppress road/suspension noise and vibrations from transmitting into the vehicle body.

The hydro mounts require new special tools for removal and replacement. Refer to the special tools section of WebTIS for more information.

E6X Rear Suspension

The rear suspension of the E6X vehicles which include the 5, 6 and 7 series vehicles has remained mostly unchanged. The design is a slightly modified version of the Integral IV rear axle from the previous generation 5 and 6 series.

Provisions have been made to accommodate the Active Roll Stabilization System, the rear air suspension system (EHC) and the Electronic Damping Control System (EHC).



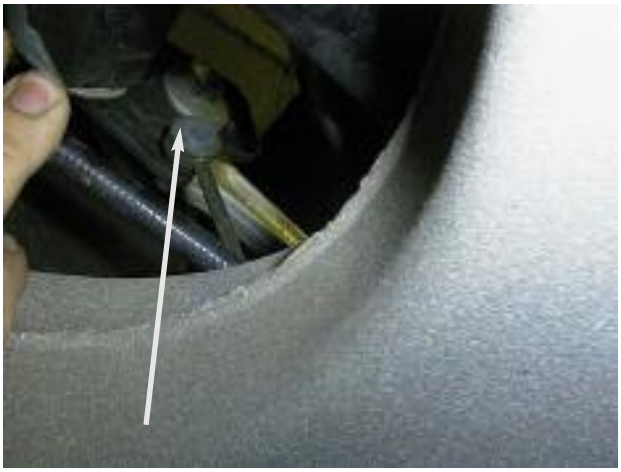
Index	Explanation	Index	Explanation
1	Rear subframe assembly	3	Front differential mounting
2	Rear differential mounting	4	Thrust plate

The subframe assembly continues to be made from aluminum. Otherwise, the rear suspension is very similar to previous designs.

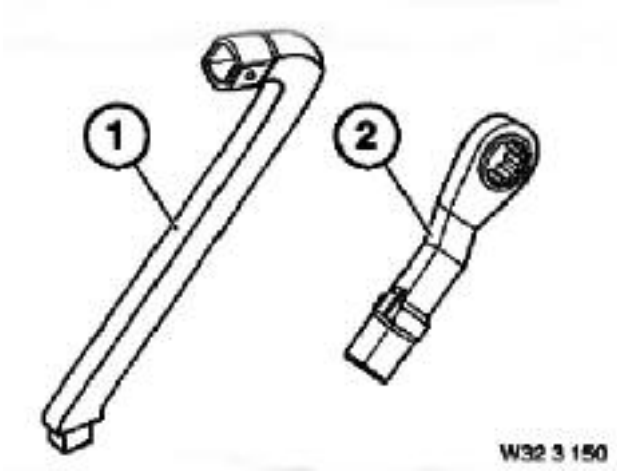
Suspension Adjustments (integral rear axle)

The integral rear axles (III and IV) have accommodations for the adjustment of both rear toe and rear camber angle. The adjustments consist of eccentrics that can be adjusted using standard hand tools. The only exception is the E53 X5, which due to space limitations needs special wrenches to access the toe eccentric.

E53 Camber Adjustment
(other integral axles similar)



E53 Toe Adjustment
(other integral axles similar)



E53 Rear toe adjustment tools

HA 5 Rear Axle

The new HA 5 rear axle is the newest development in rear axle technology. This design was first introduced on the new 3-Series (E90). Actually, the HA 5 axle was introduced on the E87 (1-Series). The E87 is currently not a model sold in the US market. It is designed as a multi-link independent rear suspension axle with 5 different link arms.

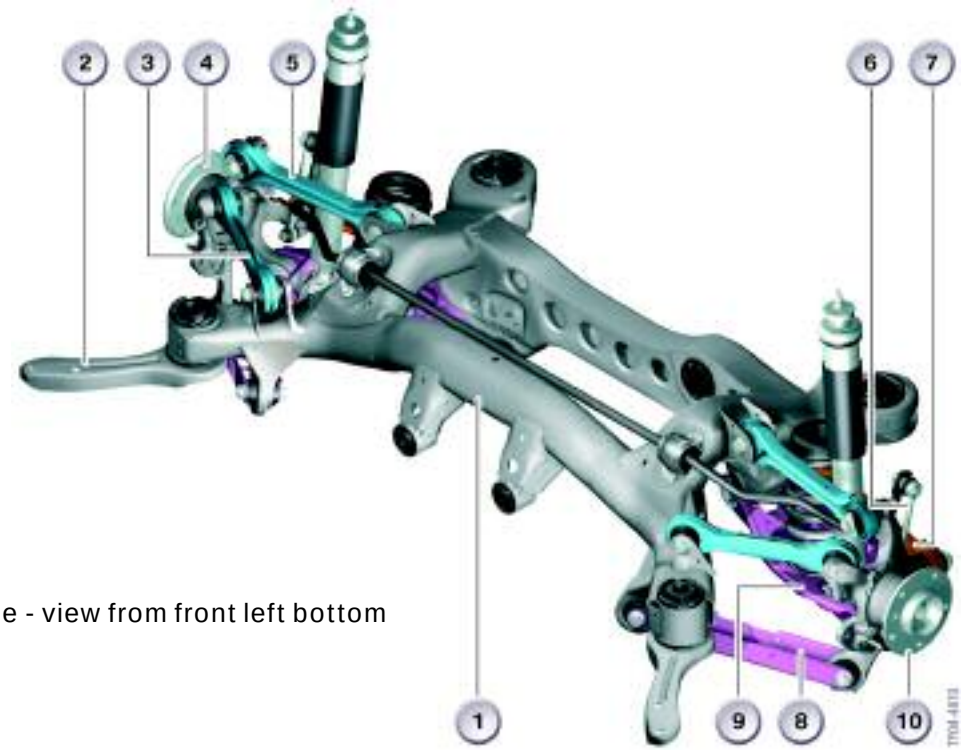
The designation "HA 5" does not refer to the five links but rather represents the consecutive development designation used at BMW.

As compared to the HA 3 and HA 4 rear axle, which were made mostly from aluminum, the HA 5 rear axle is made primarily from high strength steel. The wheel carrier is cast from GGG 40.

Minor differences exist between the HA 5 versions being used on the E90 variants.

- On the AWD version the wheel carrier is modified slightly as it utilizes bigger wheel bearings.
- In all variants the rear axle transmission mounting is matched to the relevant drivetrain.

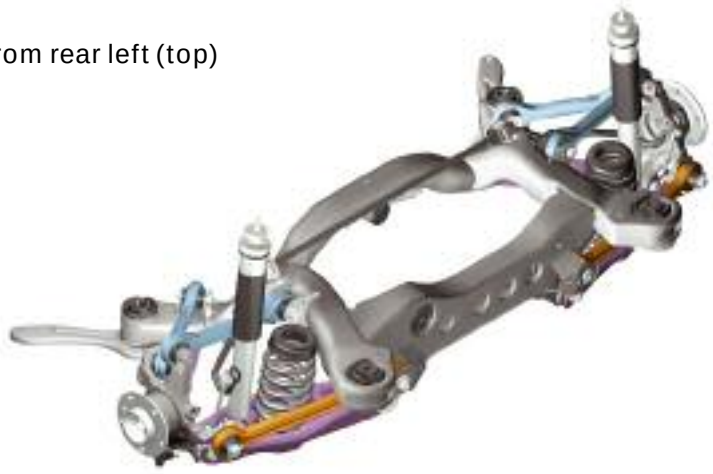
HA 5 Axle Layout



HA 5 Axle - view from front left bottom

Index	Explanation	Index	Explanation
1	Rear axle carrier	6	Stabilizer link
2	Thrust rod	7	Toe link
3	Traction strut	8	Semi-trailing arm
4	Wheel hub	9	Camber link
5	Control arm	10	Wheel carrier

HA 5 Axle - view from rear left (top)

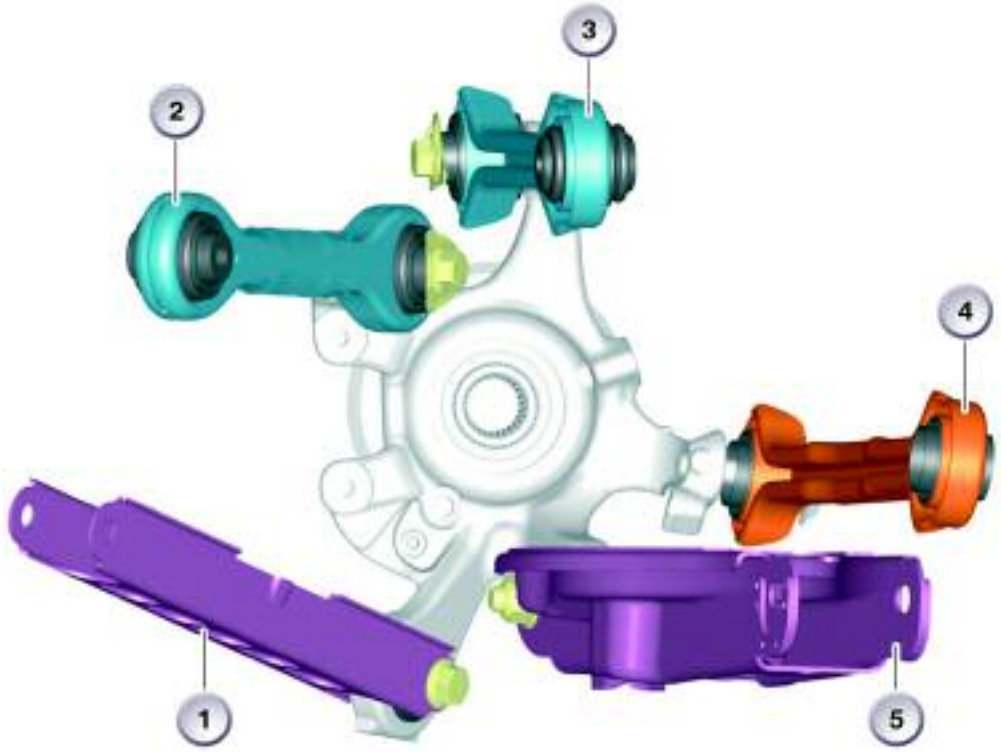


HA 5 Links

Top View of Left Rear Axle

The two upper links (blue in the illustration) form a triangle in the top view as do the two lower links (purple in the illustration).

The rear link (orange in the illustration) represents the toe rod.



Index	Explanation	Index	Explanation
1	Semi-trailing arm	4	Toe link
2	Traction strut	5	Camber link
3	Control arm		

Advantages

Compared to previous rear axles the HA 5 offers the following advantages:

Manufacturing Costs

The lower costs are attributed to the fact that the use of high strength steel has made it possible to reduce the wall thicknesses of the rear axle carrier and the links.

Compared to the integral IV, a considerable cost saving measure has been utilized by manufacturing the entire axle from high strength steel plus the weight of the HA 5 rear axle is not excessively high.

Light Construction

A bending moment occurs only in the camber link, as it provides the support function for the spring and damper. The remaining four links are not subjected to moments of force thereby enabling a lightweight and rigid design.

Thanks to the straight design of the links and the connection by means of ball joints, except for the camber link, the wheel control with this axle is subject to only minimal elasticity and is very precise.

Production

The HA 5 rear axle can be completely preassembled and adjusted with the brake system as well as the suspension and damping.

Kinematics

The very small positive kingpin offset guarantees less sensitivity to longitudinal forces even in connection with wide tires.

The relatively large caster ensures a defined degree of lateral force understeering and therefore improves vehicle handling/stabilization and offers faster response.

The change in toe as part of the suspension action enables outstanding directional stability with a relatively short wheelbase and exceptional self-steering characteristics while cornering.

The change in camber as part of the suspension action is selected in order to establish an optimum camber with respect to the road surface while cornering.

The long toe link has a positive effect on the toe-in characteristics over the spring travel range.

A low roll center has a particularly beneficial effect on the rolling motion.

The "propping" effect while cornering has been largely minimized by improving the roll center change rate.

The braking support has been set to 70%. Racing cars generally have a support angle of 0% in order to constantly achieve maximum contact force. On these vehicles, the disadvantage of a dive motion while braking and starting off is compensated by the taut suspension. The braking support (anti-dive) realized on the E90 represents an optimum compromise between comfort, safety and driving dynamics requirements.

The use of five links enables free selection of the pivot axle for the design layout. This means that the movement of the wheel in interaction with the suspension can be optimized without compromise under braking, acceleration and lateral forces. This largely determines all important variables such as toe, camber, brake support (anti-dive) angle, roll center and roll center change rate.

Crash Requirements

The HA 5 rear axle permits a considerably more favorable progression of the side member, resulting in specific advantages particularly at low impact speeds.

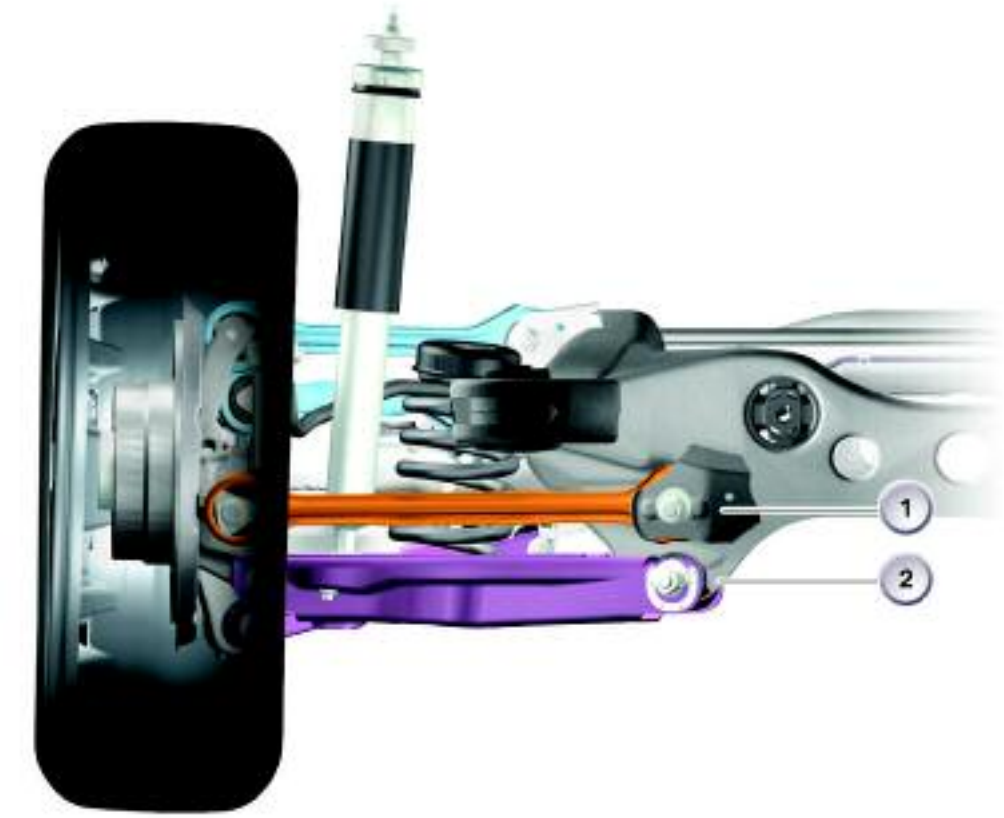
Added to this, the large rear axle carrier is connected directly to the rigid frame side member, allowing it to transmit the applied crash forces more favorably. The semi-trailing arm features crash beading (in the semi-trailing arm of the HA 5 rear axle) to ensure the fuel tank is not damaged.

Rigidity/Acoustics

The rear axle carrier of the HA 5 rear axle extends up to the rigid frame side members of the body with its axle mounting points and even up to the sill with its thrust rods. This provides a very large support face for the applied forces and moments. The resulting advantages include, considerably lower stress and strain on the body (rear axle breakaway) and the option of designing the rear axle bearing mounts relatively soft. This arrangement and the double flexible mounting, provide outstanding insulation against road noise and tire rolling noise.

Setting

Toe and Camber adjustment points:



Index	Explanation
1	Toe adjustment eccentric (no special tools needed)
2	Camber adjustment eccentric (no special tools needed)

Classroom Exercise - Review Questions

1. Name some of the disadvantages to the single-pivot front axle?

2. Of the vehicles that use the single-pivot front axle, which of these have camber adjustment capabilities?

3. On the front axle, which alignment angle is NOT adjustable?

4. Which suspension systems (front and rear) are used on the new 3-Series (E9X)?

5. On the HA 5 rear axle, what special tools needed for camber and toe adjustments?

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