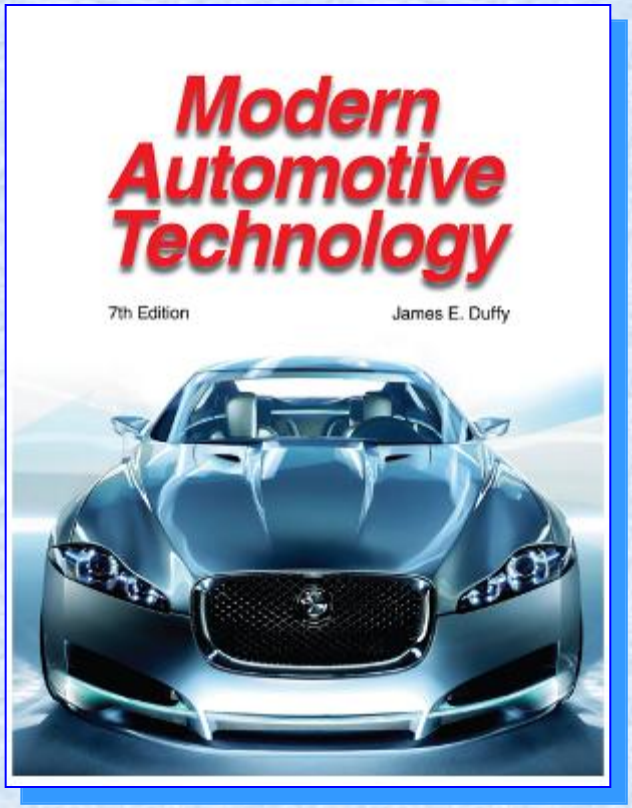
PowerPoint for

Modern Automotive Technology

by

Russell Krick



Publisher
The Goodheart-Willcox Co., Inc.
Tinley Park, Illinois

Chapter 67

Suspension System Fundamentals

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- Independent and nonindependent suspension systems
- Understeer and oversteer
- Suspension system springs
- Suspension system construction

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- MacPherson strut suspension
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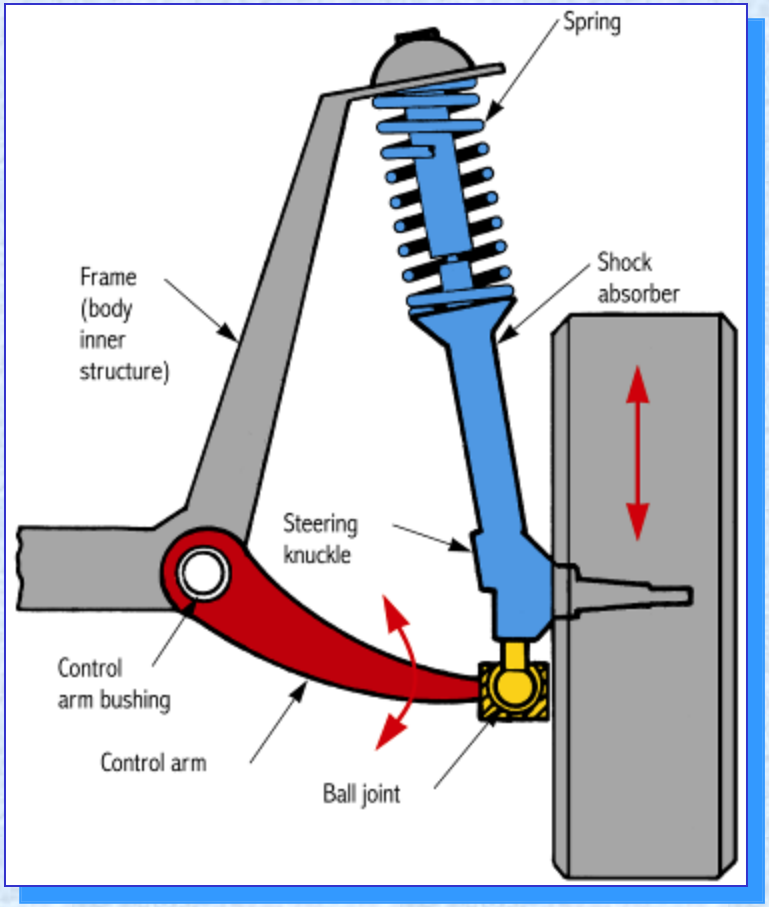
Functions of a Suspension System

- Supports the weight of the vehicle
- Allows the wheels to move up and down
- Allows rapid cornering without extreme body roll
- Keeps the tires in firm contact with the road

Functions of a Suspension System

- Prevents excessive body squat when accelerating or heavily loaded
- Prevents excessive body dive when braking
- Allows the front wheels to turn left or right for steering
- Helps keep the wheels in correct alignment

Basic Suspension System

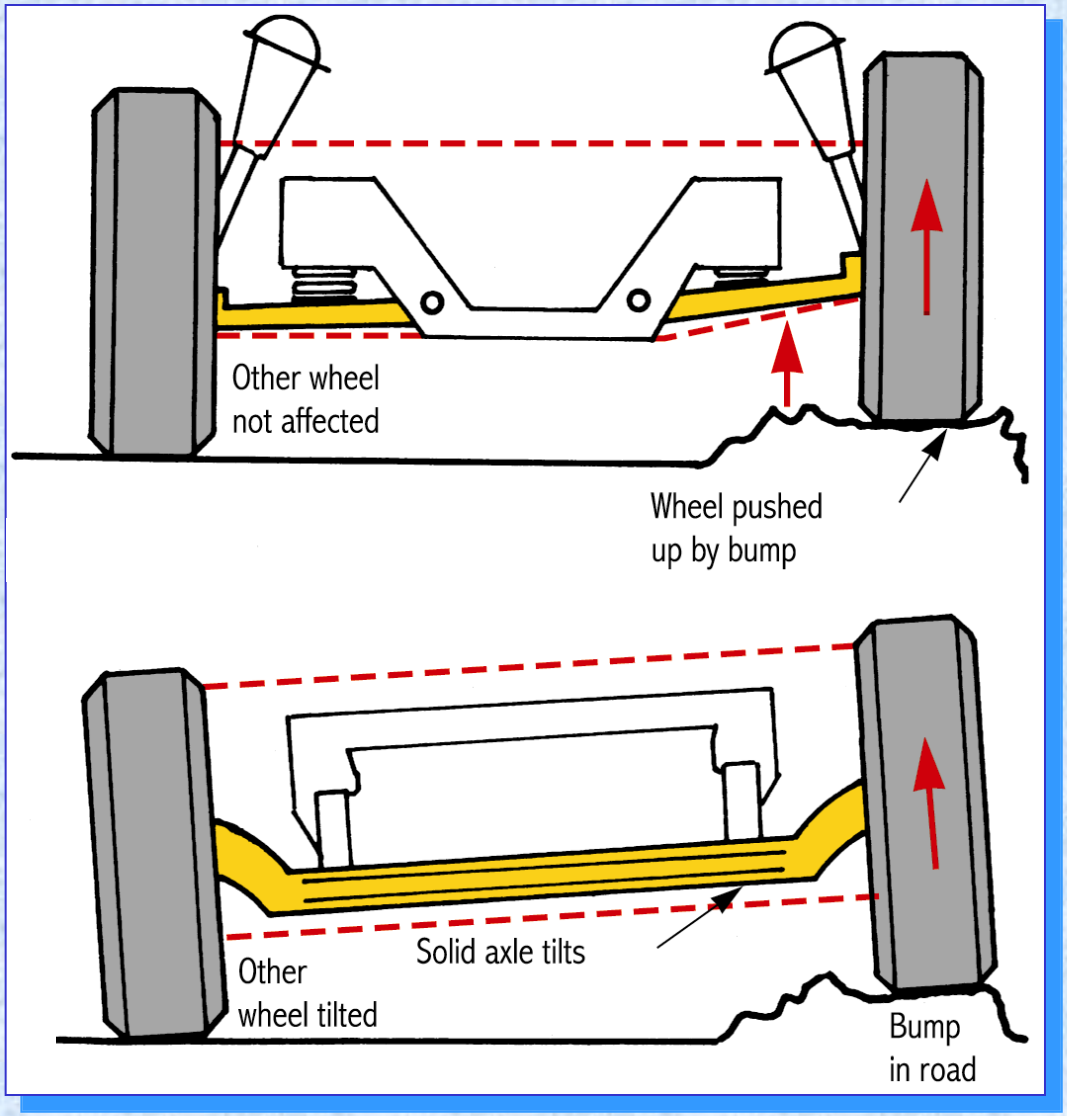


Independent and Nonindependent Suspension Systems

Suspensions

Independent

Nonindependent



Independent Suspension

- Allows one wheel to move up and down with minimal effect on the other wheels
- Each wheel is attached to its own suspension unit
- Movement of one wheel does not cause direct movement of the wheel on the other side of the vehicle

Nonindependent Suspension

- Both left and right wheels are attached to the same solid axle
- When one tire hits a bump in the road, its upward movement causes a slight upward tilt of the other wheel
- Neither wheel is independent of the other

Understeer and Oversteer

Understeer

- The vehicle is slow to respond to steering changes in a turn
  - the rear tires retain traction
  - the front tires may slip on the road surface due to lack of downforce or other factors

Oversteer

- The rear tires try to skid around sideways in a sharp or hard turn
- The front tires retain traction
- The rear tires skid

Neutral Steering

- Suspension systems are designed to balance understeer and oversteer
- Neutral steering is the result, where all four wheels have equal traction in turns

Lateral Acceleration

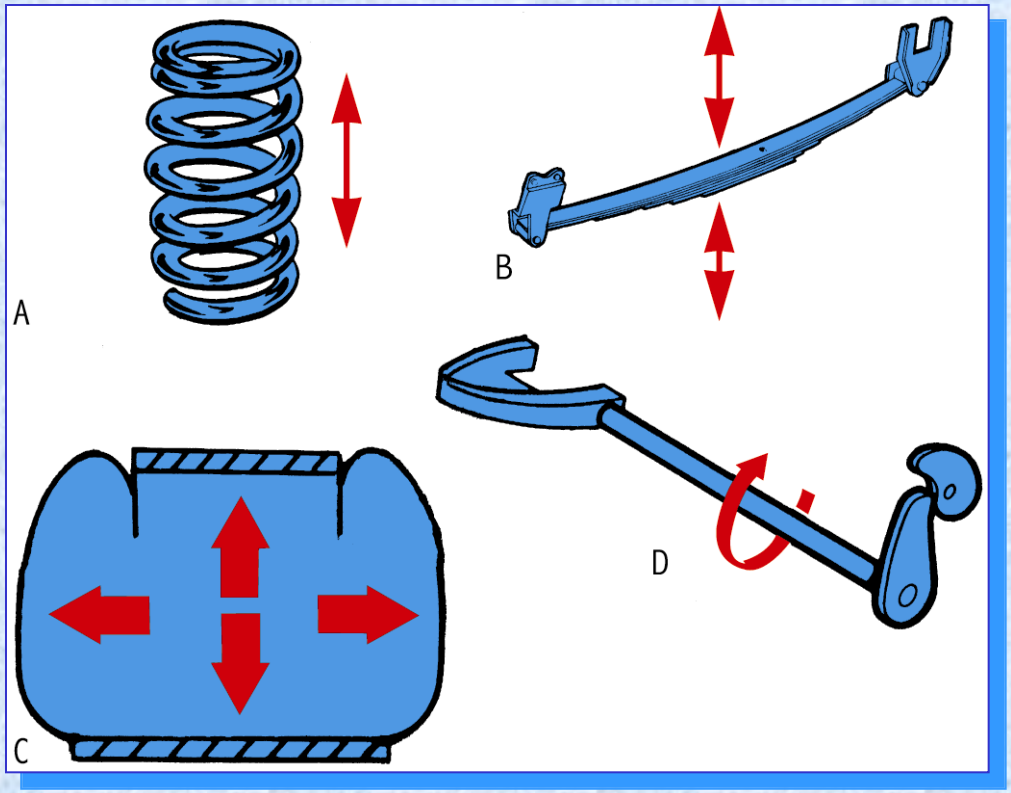
- Amount of side force a vehicle can achieve before its tires lose traction and skid in a sharp turn
- Measured in units of gravity (g-force)
- Passenger cars might achieve 1.0 g
- Race cars might achieve 3.0 g

Suspension System Springs

- Springs must jounce (compress) and rebound (extend) as a vehicle travels over bumps and holes in the road surface
- Springs must support the weight of the vehicle while still allowing suspension travel (movement)

Types of Springs

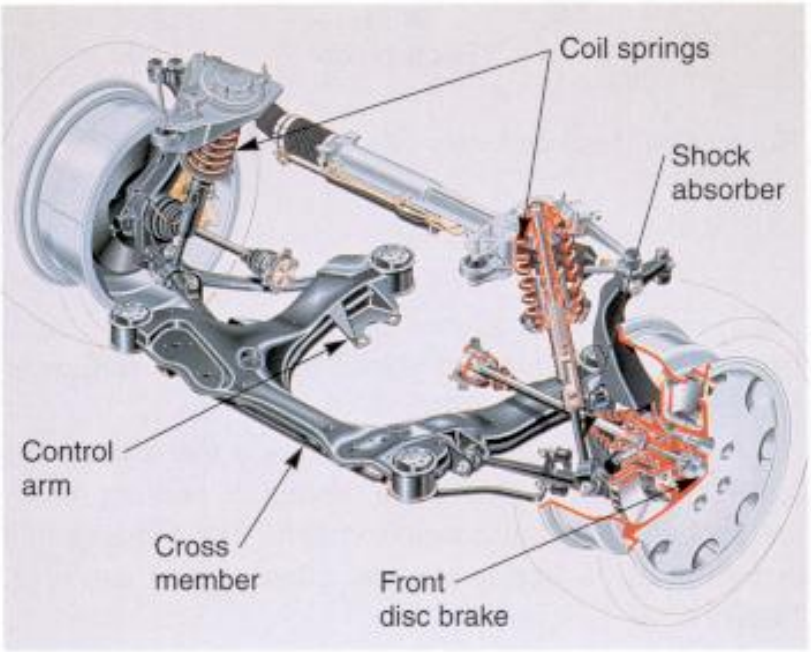
A. Coil spring
B. Leaf spring
C. Air spring
D. Torsion bar



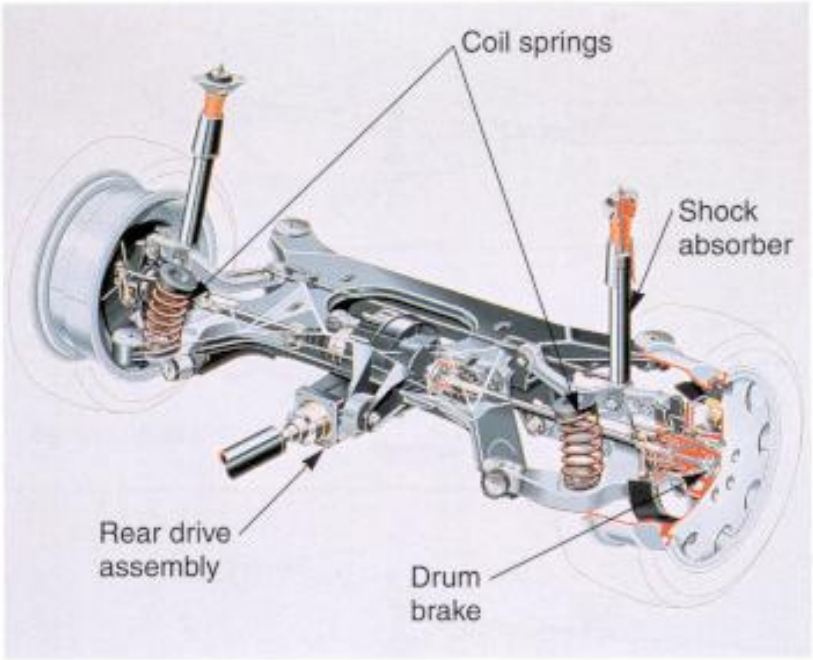
Coil Spring

- Length of spring-steel rod wound into a spiral
- Most common type of spring
- Used on front and rear suspensions

Coil Spring



Front suspension

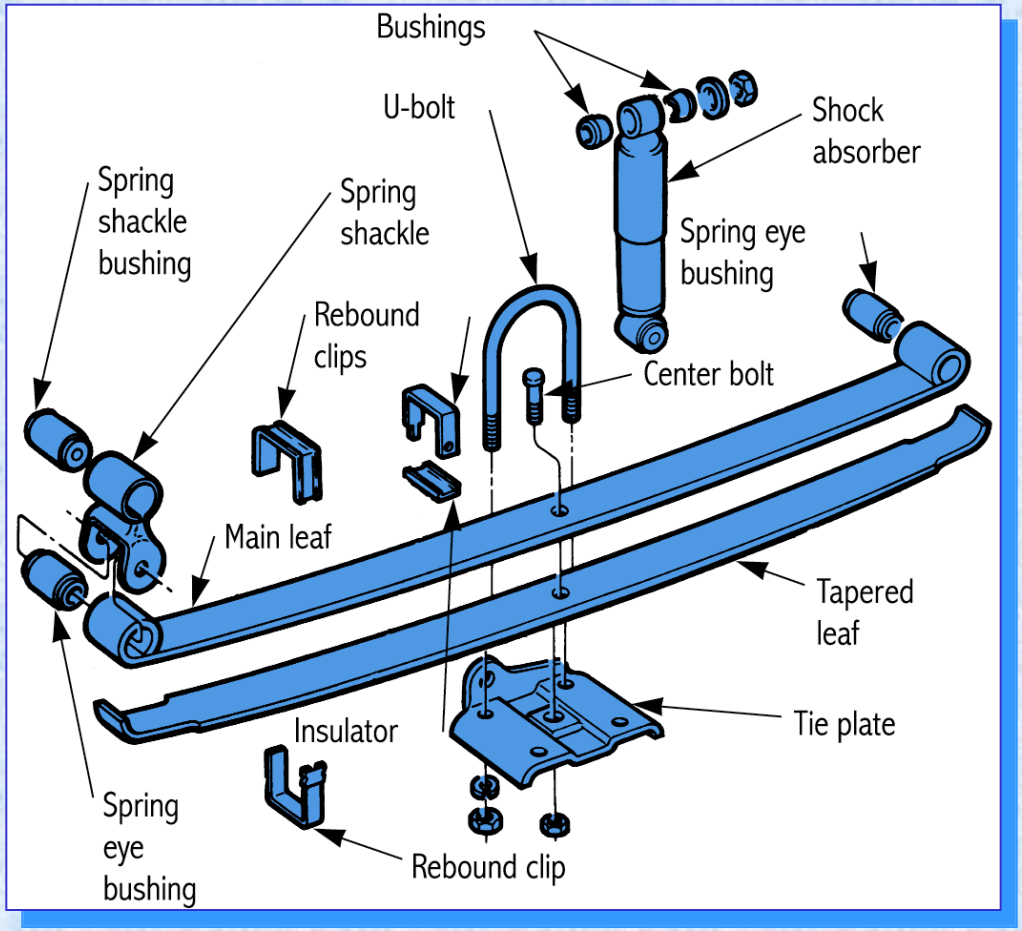


Rear suspension

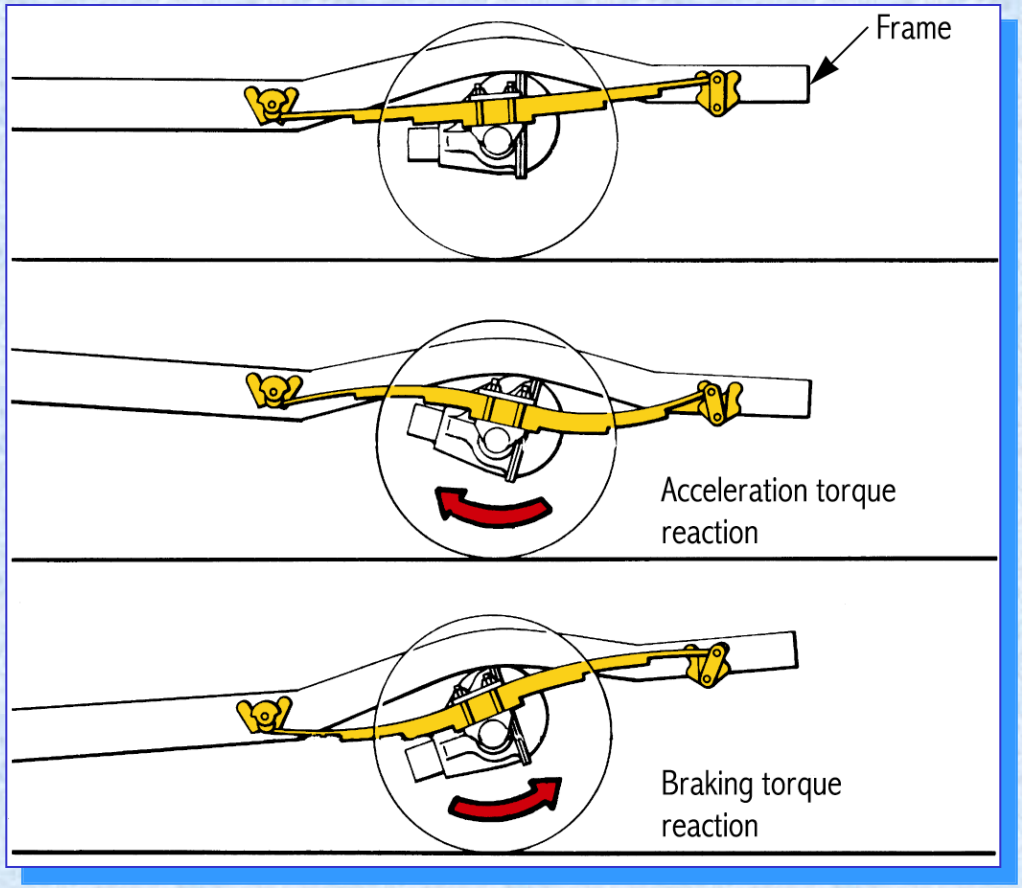
Leaf Spring

- Flat strips of spring steel bolted together
- Limited to the rear of some cars
- A monoleaf spring is made from a single, thick leaf of reinforced fiberglass
- A shackle fastens the rear leaf spring eye to the frame or body and allows the spring to change length when bent

Leaf Spring Assembly



Leaf Spring Windup

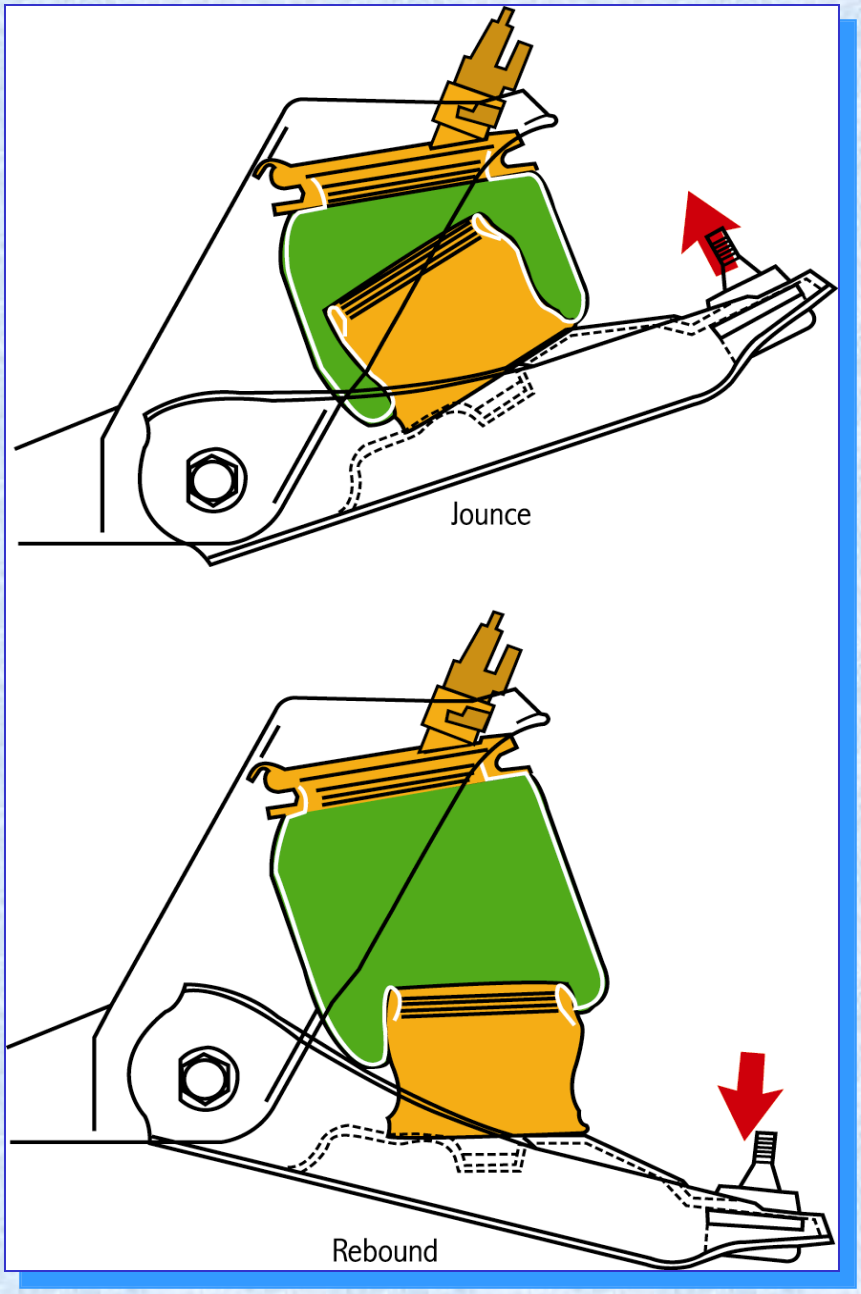


Rear leaf springs flex when driving or braking forces are applied

Air Spring

- Rubber cylinder filled with air
- End caps are formed on the ends for mounting
- Air pressure in the rubber cylinder gives the unit a spring action
- Special synthetic rubber compounds are used so the air spring can operate properly in cold weather

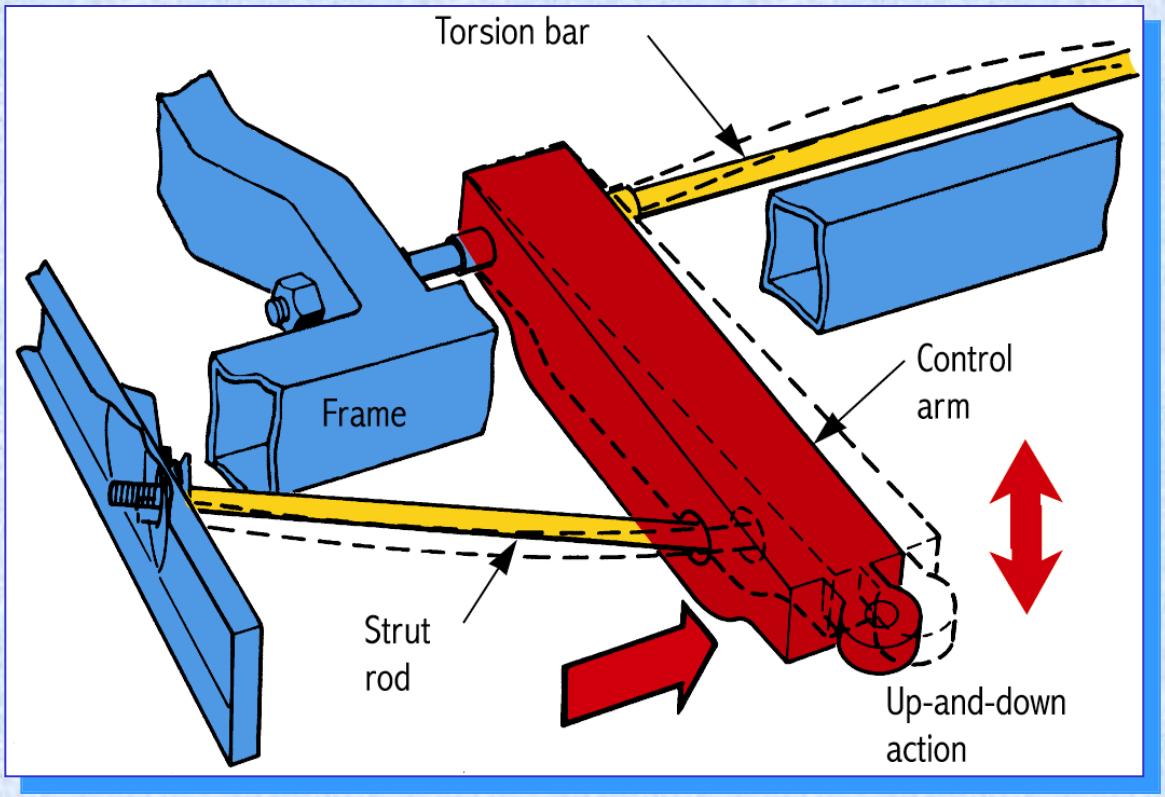
Air Springs



Torsion Bar

- Made of a large spring-steel rod
- One end is attached to the frame
- The other end is fastened to the control arm
- Jounce and rebound twists the torsion bar

Torsion Bar



The bar resists twisting action and acts like a conventional spring

Spring Rate

- Stiffness, or tension, of a spring
- Determined by the weight needed to bend the spring

Sprung Weight

- Weight of the parts supported by the springs
- Sprung weight should be kept high, in proportion to unsprung weight

Unsprung Weight

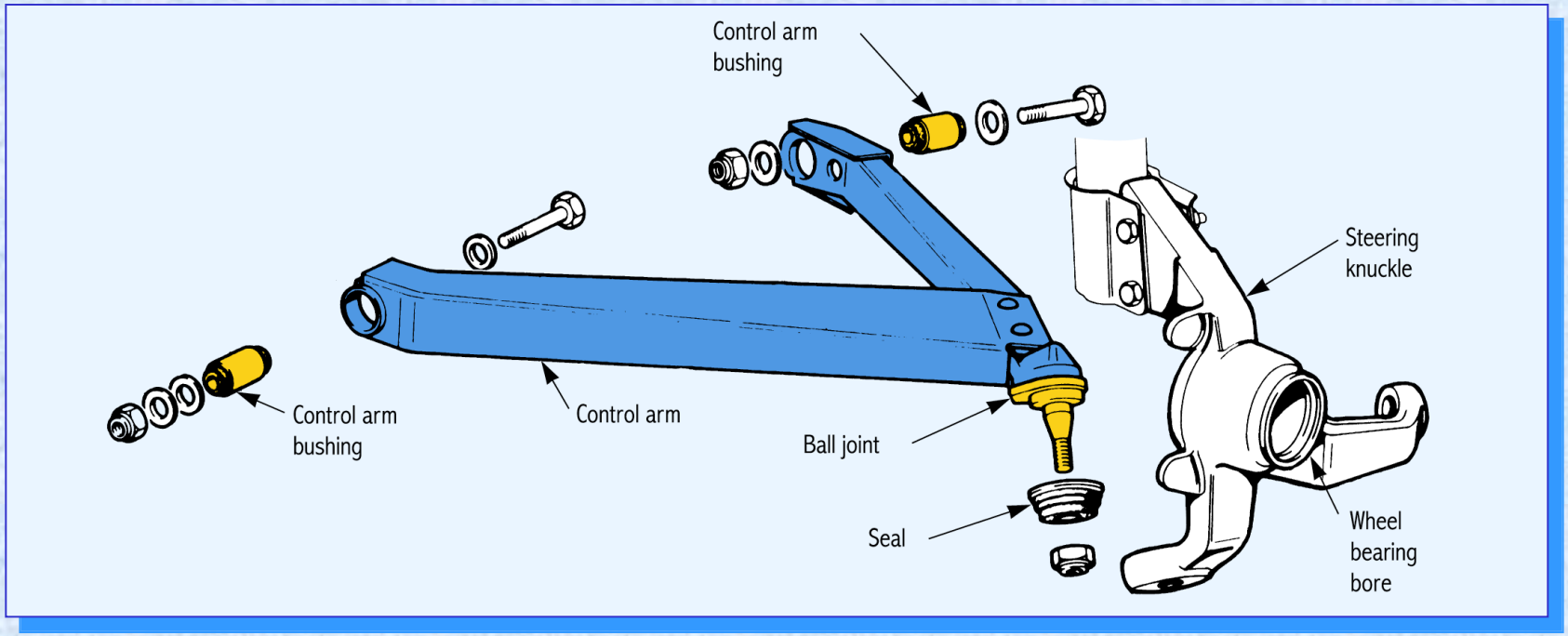
- The weight of the parts not supported by the springs:
  - tires and wheels
  - wheel bearings and steering knuckles
  - axle housing
- Unsprung weight should be kept low to improve ride smoothness

Suspension System Construction

Control Arms

- Used to hold the steering knuckle, bearing support, or axle housing in position as the wheel moves up and down
- The inner end contains bushings
- The outer end contains a ball joint (independent) or bushing (solid axle)

Control Arm Assembly



Control arm bushings act as bearings

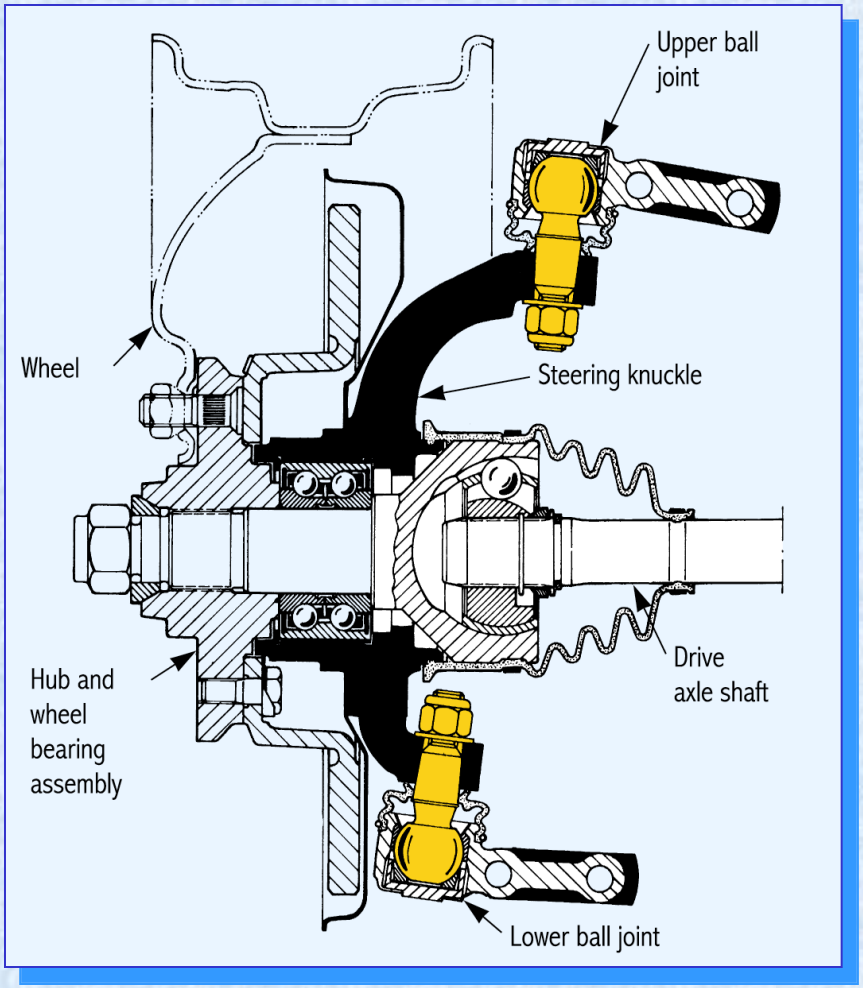
Strut Rod

- Fastens to the outer end of the lower control arm and to the body or frame
- Keeps the control arm from swinging toward the front or rear of the vehicle
- The rod ends contain rubber bushings that soften the action of the rod and permit a controlled amount of lower control arm front-to-rear flex

Ball Joints

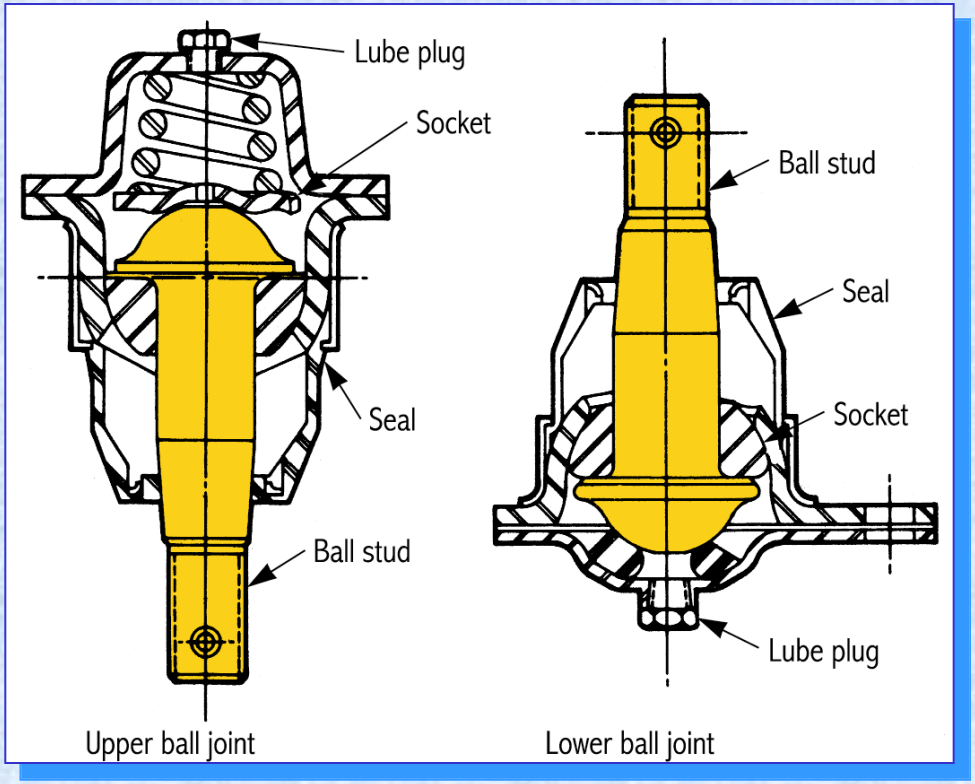
- Connections that allow limited rotation in every direction
- Filled with grease for lubrication
- A grease fitting may be provided
- A grease seal holds grease in and prevents water and contaminant entry

Ball Joints



Steering knuckle for front-wheel drive

Ball Joints



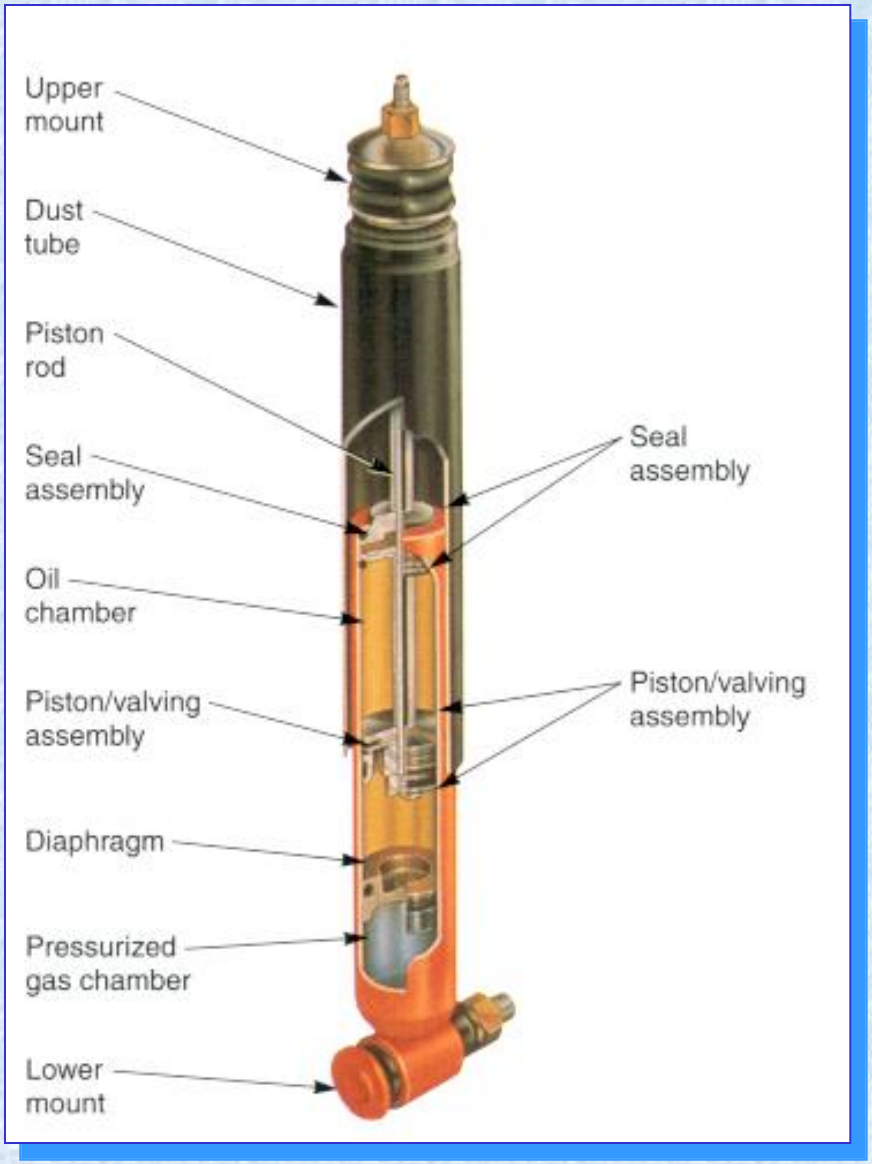
A tapered stud provides a force fit into the steering knuckle or bearing support

Shock Absorbers

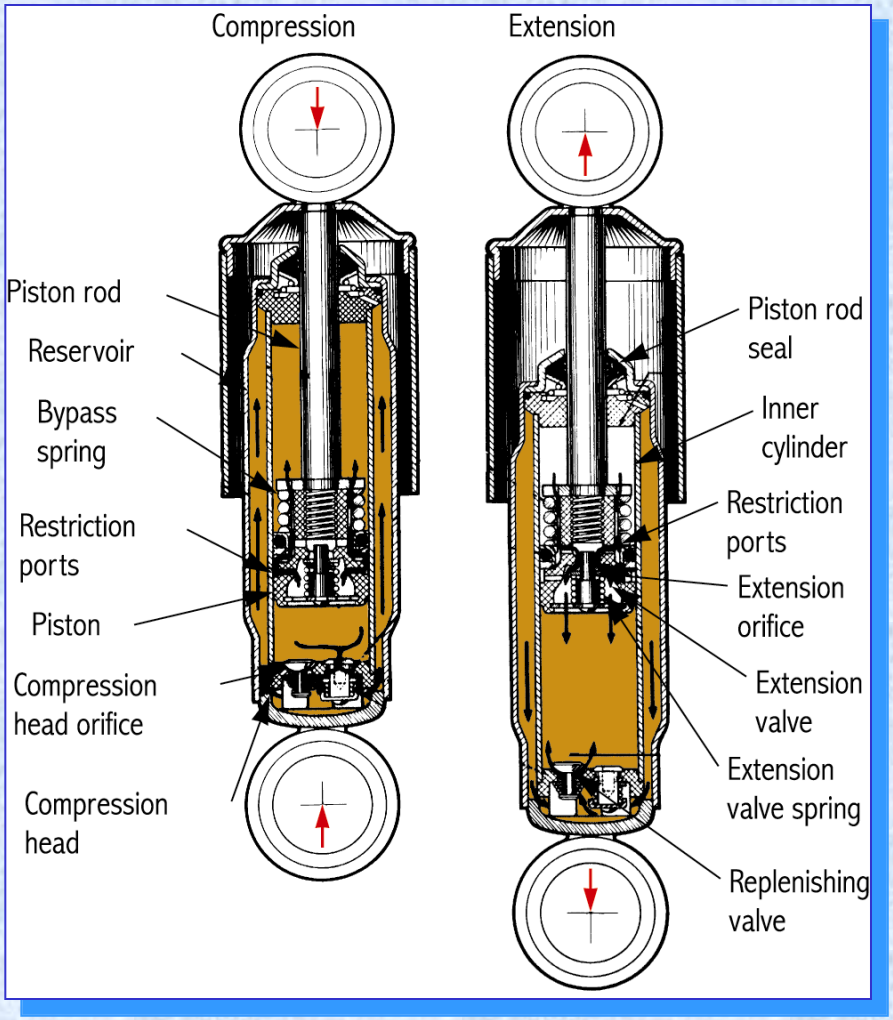
- Limit spring oscillations to smooth a vehicle's ride
- One end is connected to the body or frame, and the other is connected to the axle or control arm
- When compressed or extended, oil inside the shock is forced through small orifices, absorbing energy and dampening spring action

Shock Absorber

This shock uses pressurized gas to reduce foaming in the oil



Shock Absorber Action



Gas-Charged Shock Absorbers

- Use a low-pressure gas to help keep the oil in the shock from foaming
- Nitrogen gas is enclosed in a chamber separate from the main oil cylinder
- Gas pressure acting on the oil prevents air bubbles from forming

Self-Leveling Shock Absorbers

- The special design causes a hydraulic lock action to help maintain normal curb height
- A valve system in the shock retains hydraulic pressure when the shock is compressed near its minimum length
  - helps keep the shock rod at the same length with changes in force or curb weight

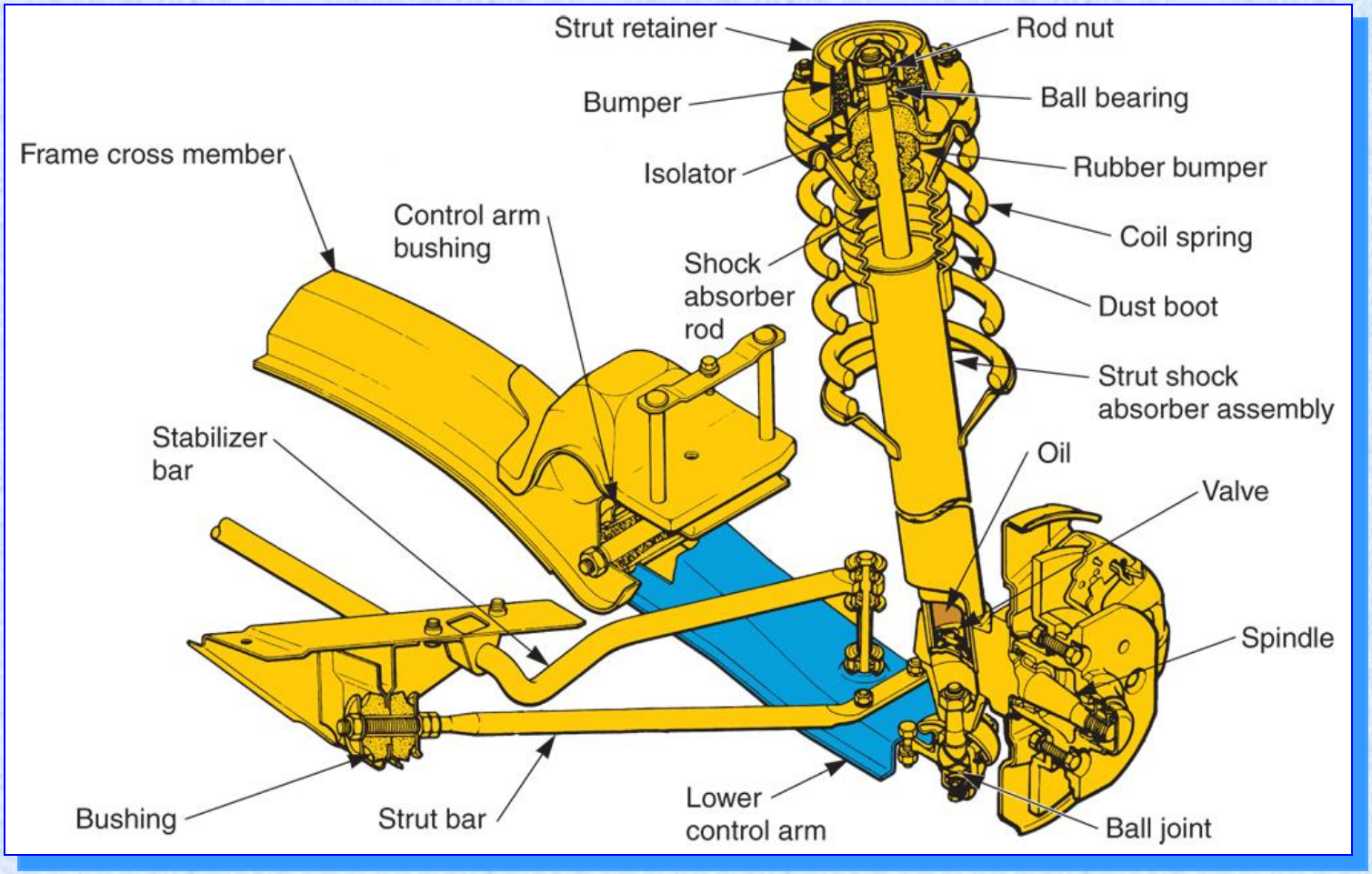
Adjustable Shocks

- Provide a means of changing shock stiffness
- The shock can be set for different dampening stiffness, usually by turning the shock's outer body

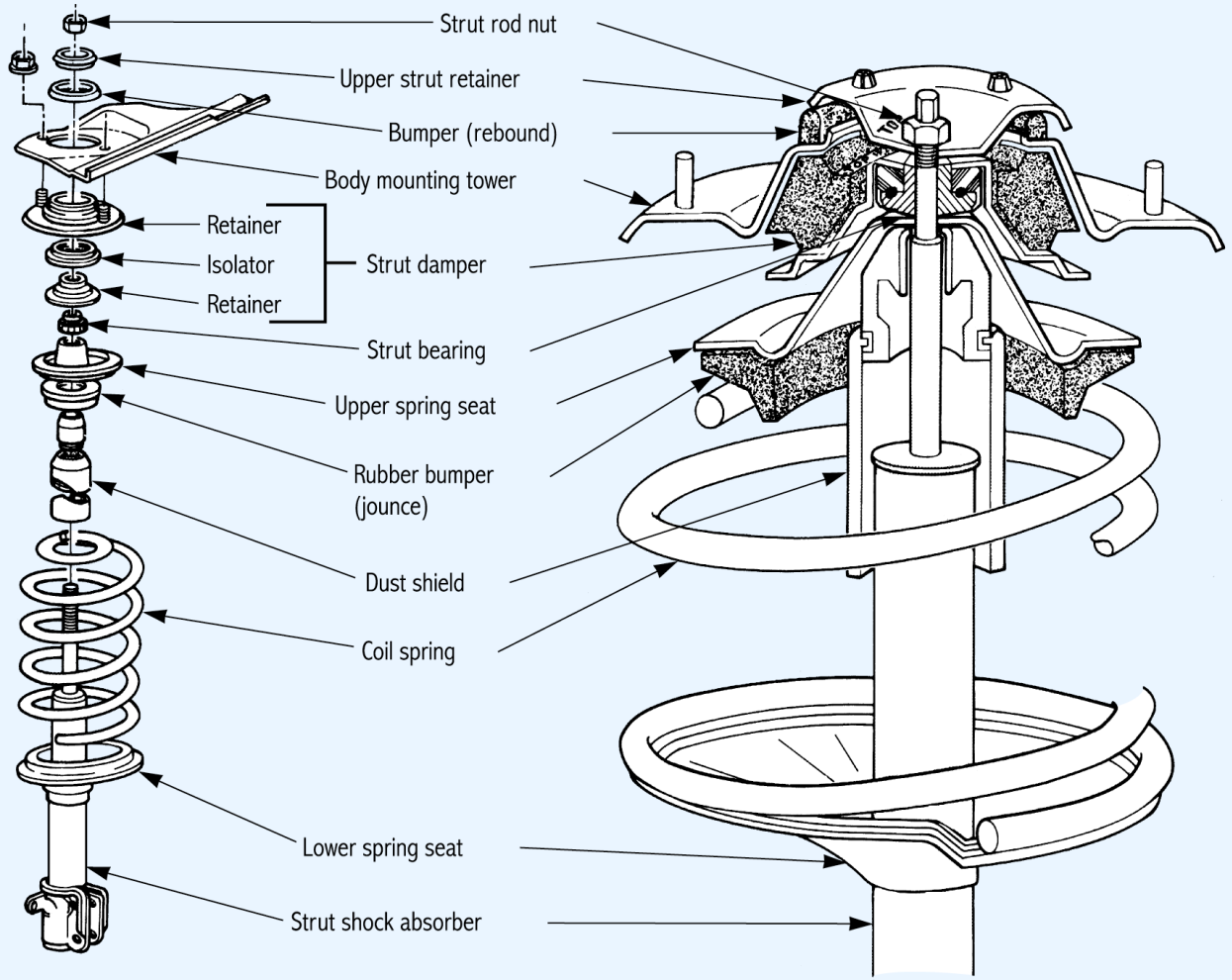
Strut Assembly

- Consists of a shock absorber, a coil spring, and an upper damper unit
- Replaces the upper control arm
- Only the lower control arm and the strut are needed to support the wheel assembly

Strut Assembly



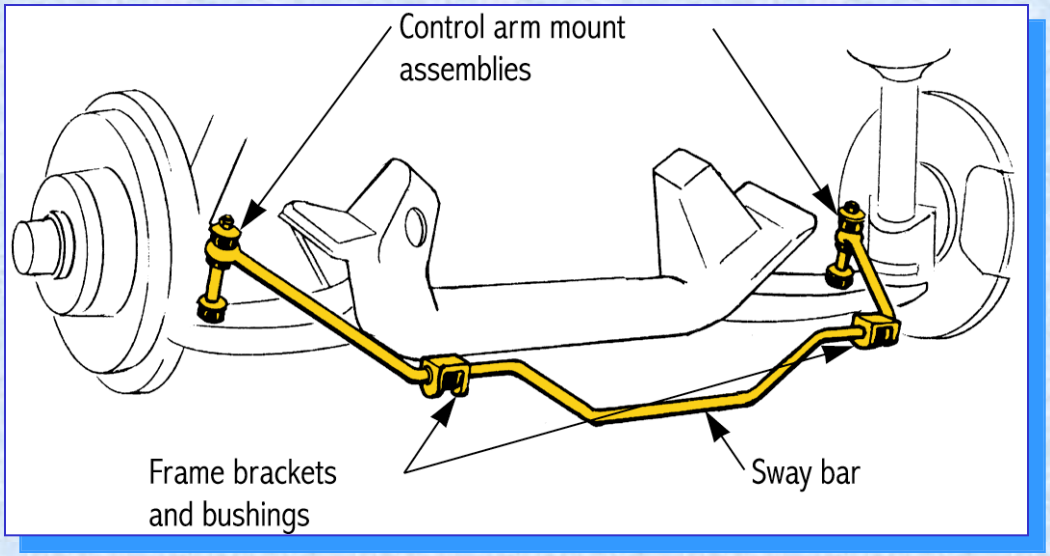
Strut Components



Sway Bar (Stabilizer Bar)

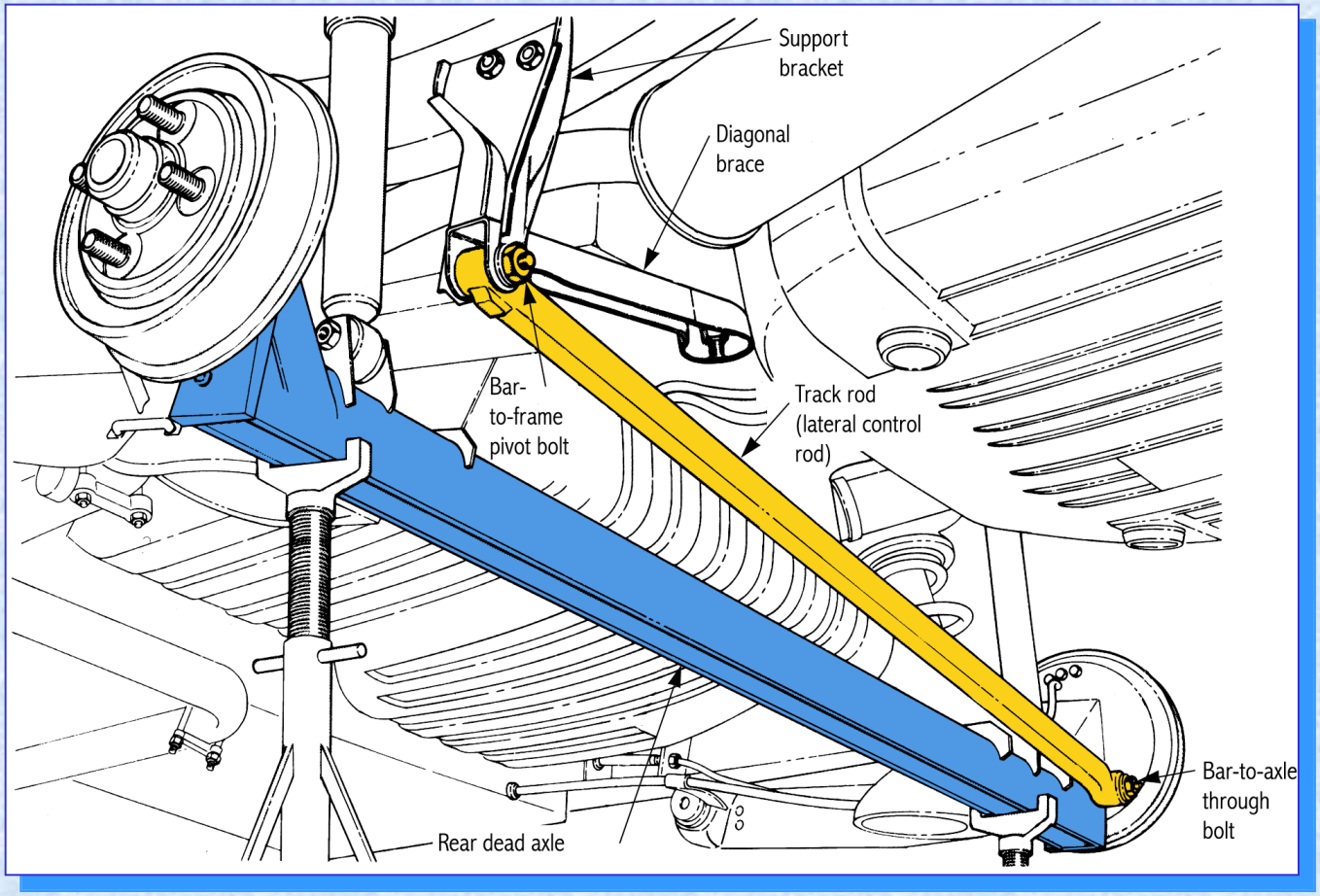
- Used to keep the body from leaning excessively in sharp turns
- Made of spring steel
- Fastens to both lower control arms and to the frame
- When the body leans, it twists the bar
- The bar's resistance to twisting limits body lean in corners

Sway Bar (Stabilizer Bar)



Sway bar links connect the bar to the control arms

Track Rod

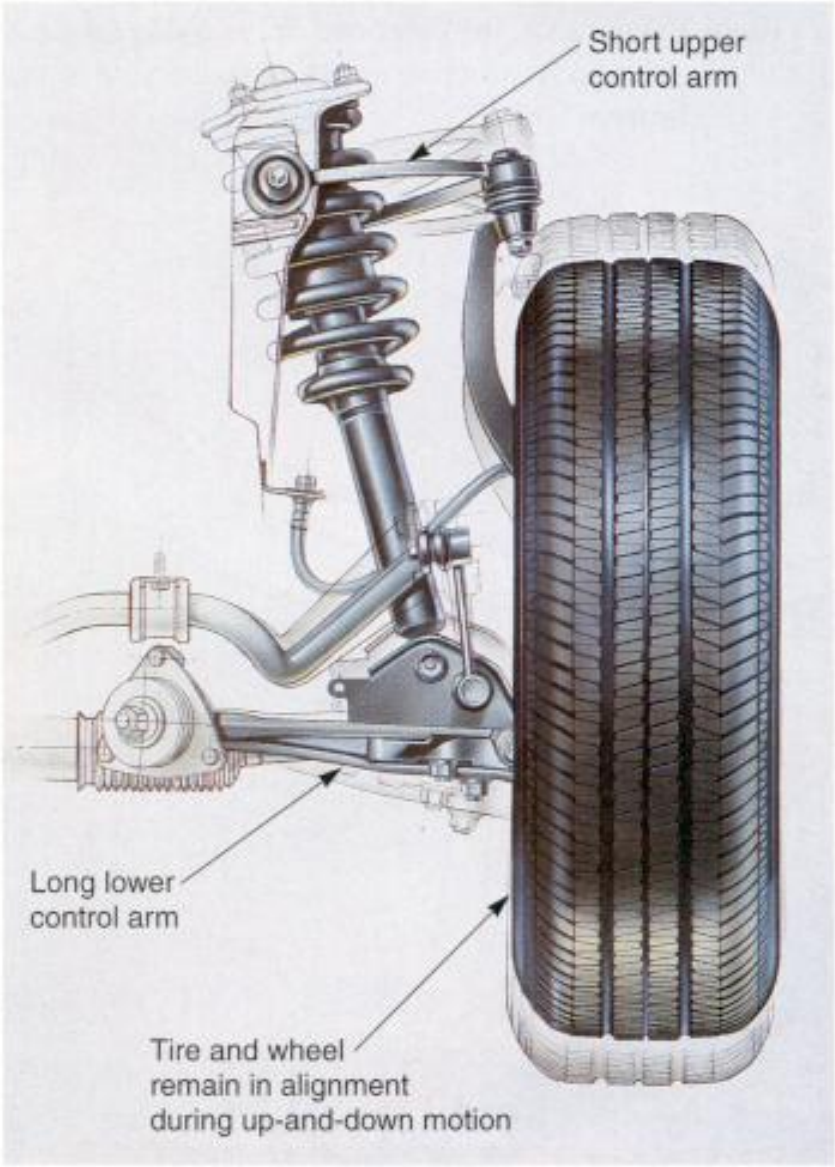


Used on the rear axle to prevent side-to-side movement during cornering

Long-Short Arm Suspension

- Uses control arms of different lengths
- Minimizes tire tilting (camber change) with suspension action
- Reduces tire scuffing and wear
- The upper control arms are shorter than the lower control arms

Long-Short Arm Suspension



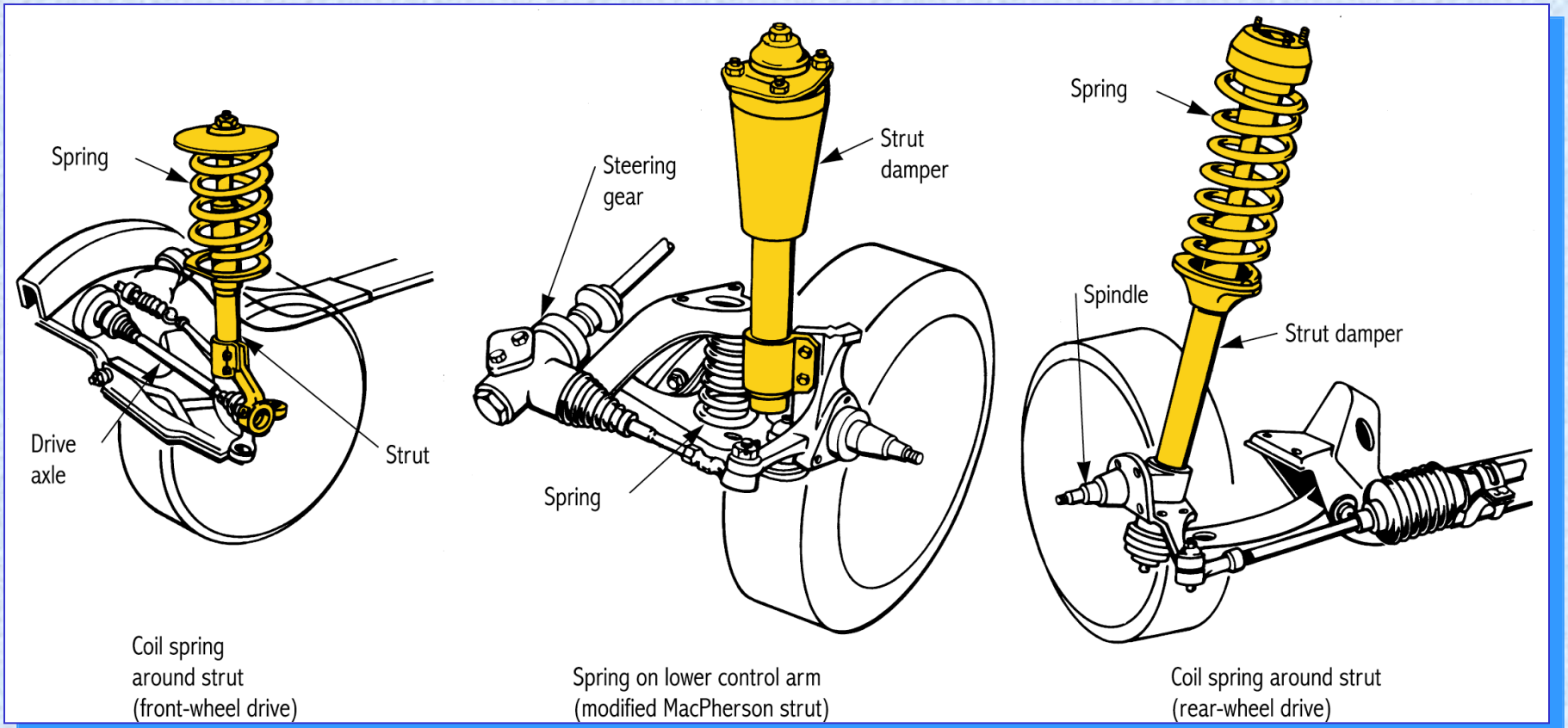
Torsion Bar Suspension

- Contains torsion bar springs instead of coil springs
- Most allow curb height adjustment
- By turning an adjustment bolt, you can increase or decrease the tension on the torsion bar, raising or lowering the vehicle

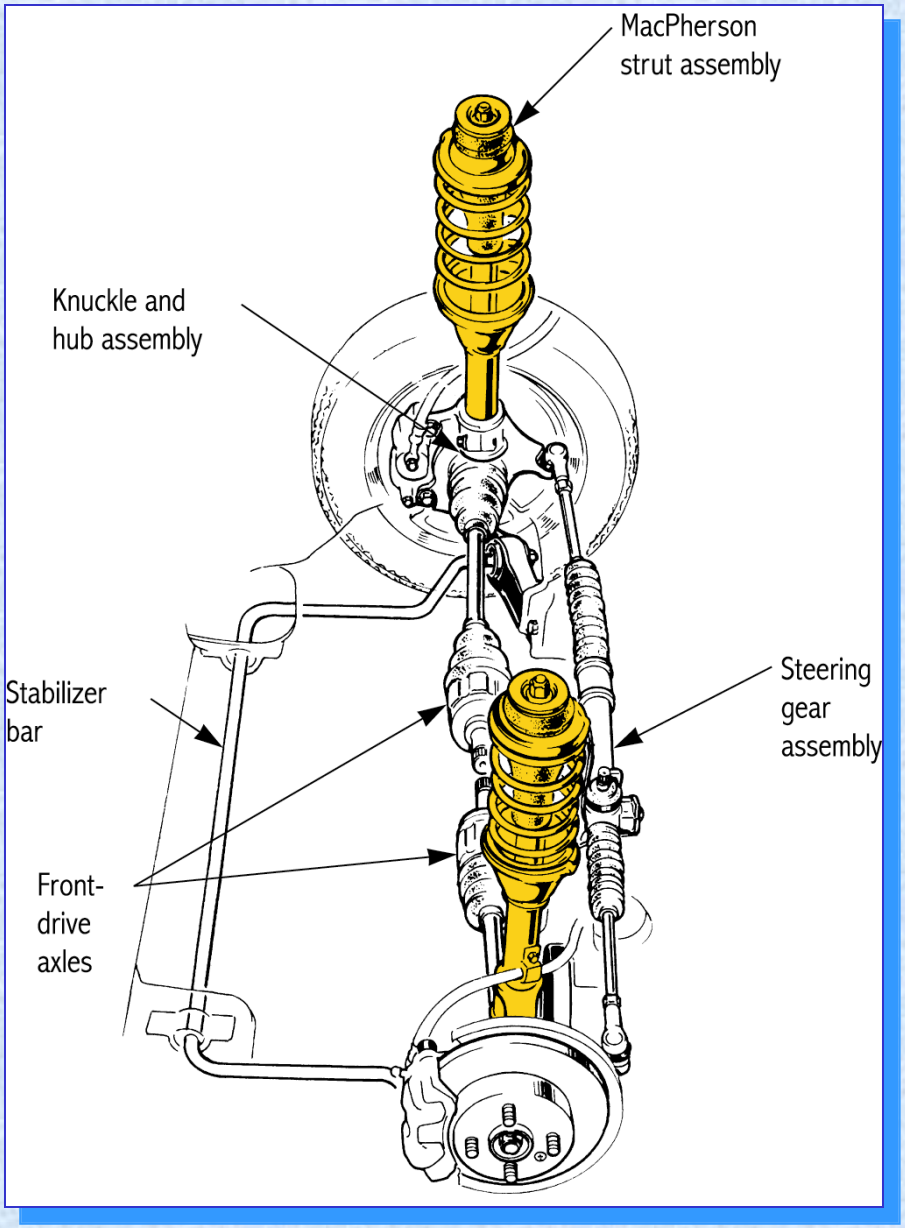
MacPherson Strut Suspension

- Uses only a lower control arm and a strut to support each wheel assembly
- The top of the strut is fastened to the reinforced body structure, which supports the weight of the car
- The most common system in use on late-model cars

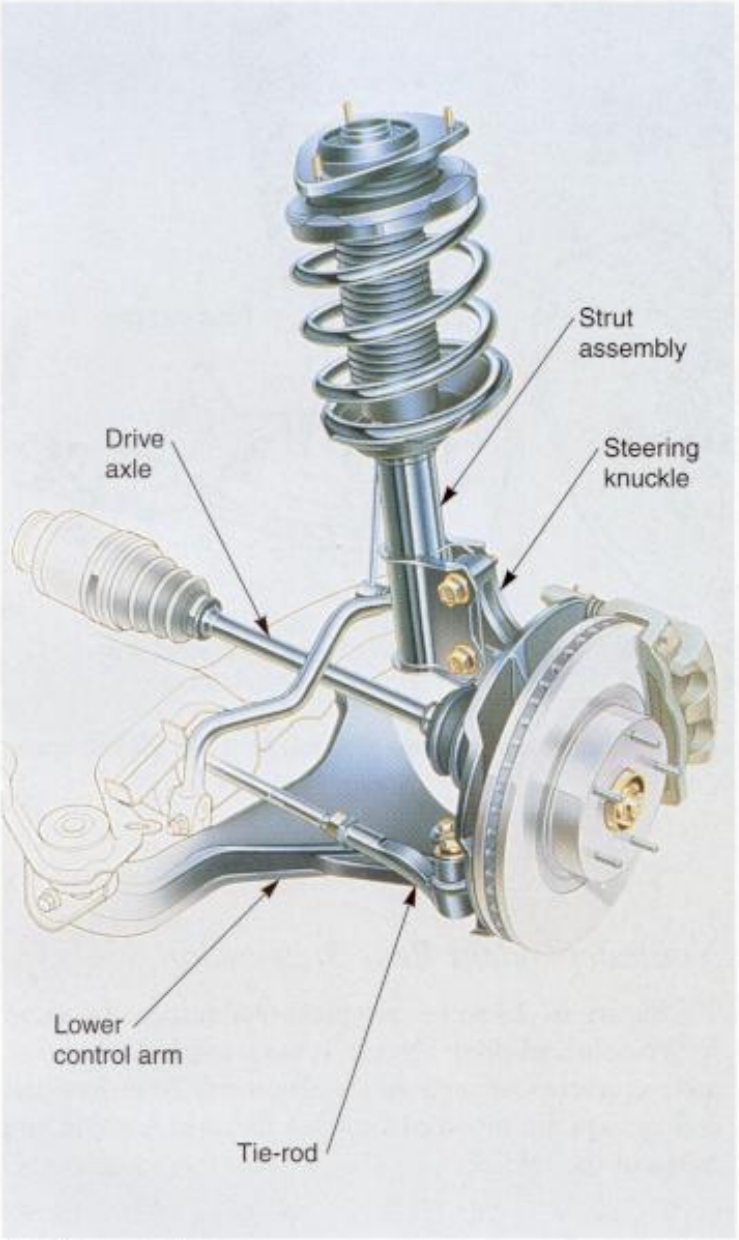
Front Suspension
(MacPherson Strut)



MacPherson Strut Suspension

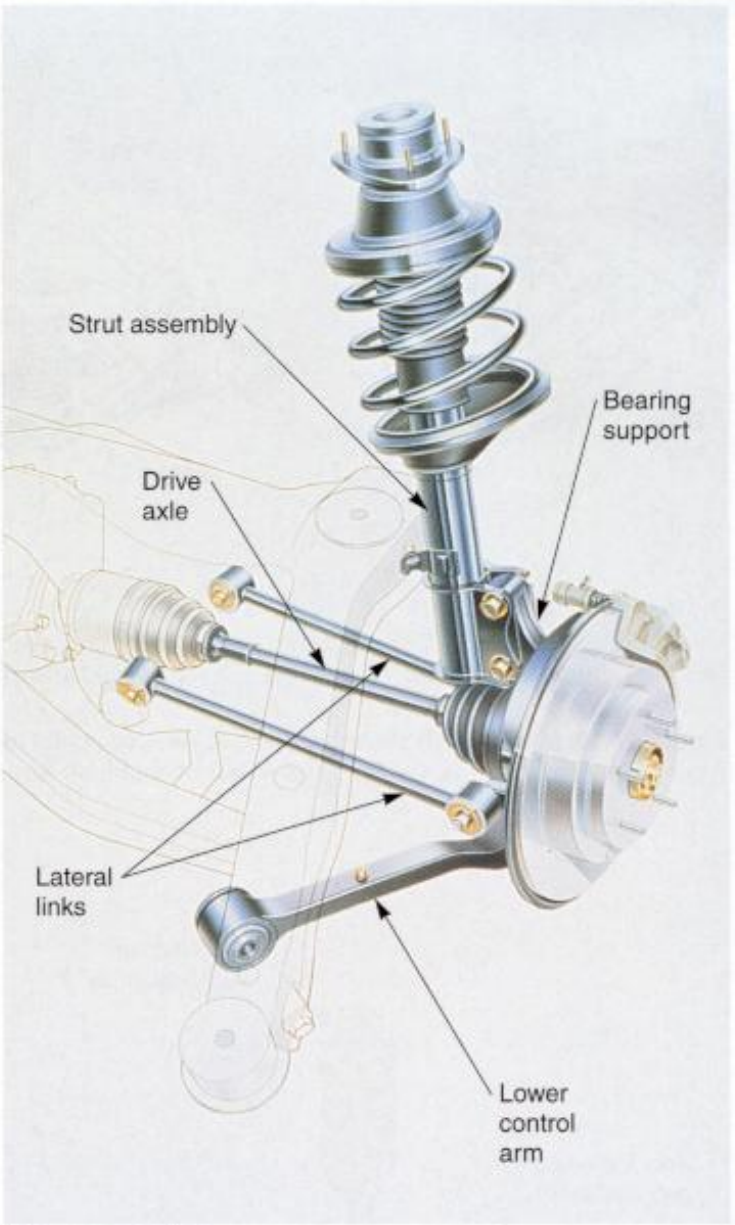


Front Strut Suspension



Front suspension

Rear Strut Suspension

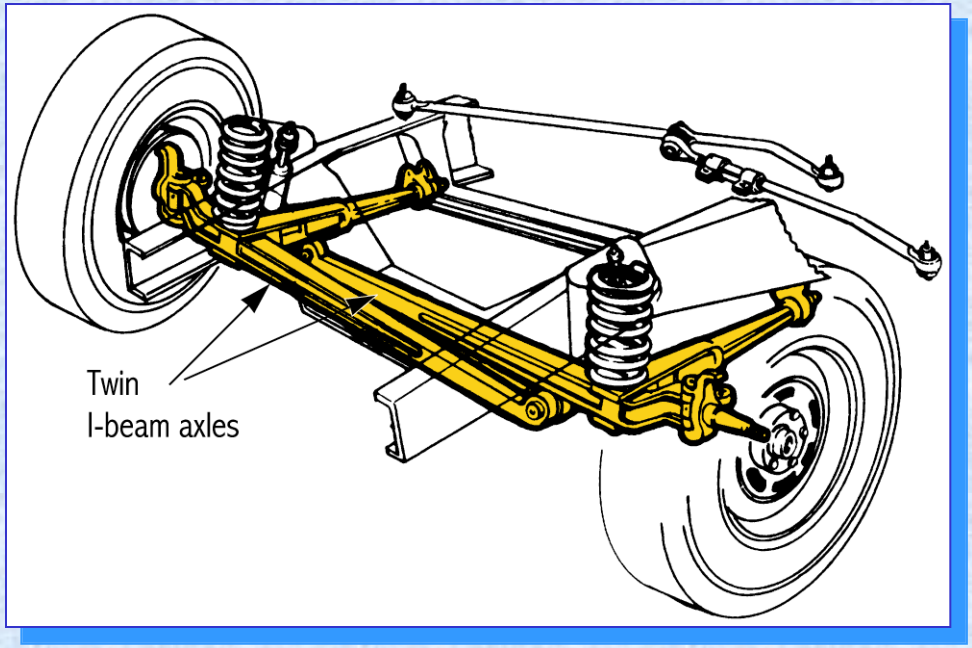


Rear suspension

Pickup Truck Suspension Systems

- Pickup trucks use numerous designs:
  - long-short arm
  - MacPherson strut
  - solid axle
  - twin axle (twin I-beam)
- A four-wheel drive truck can have a solid axle housing and differential in the front or independent front suspension

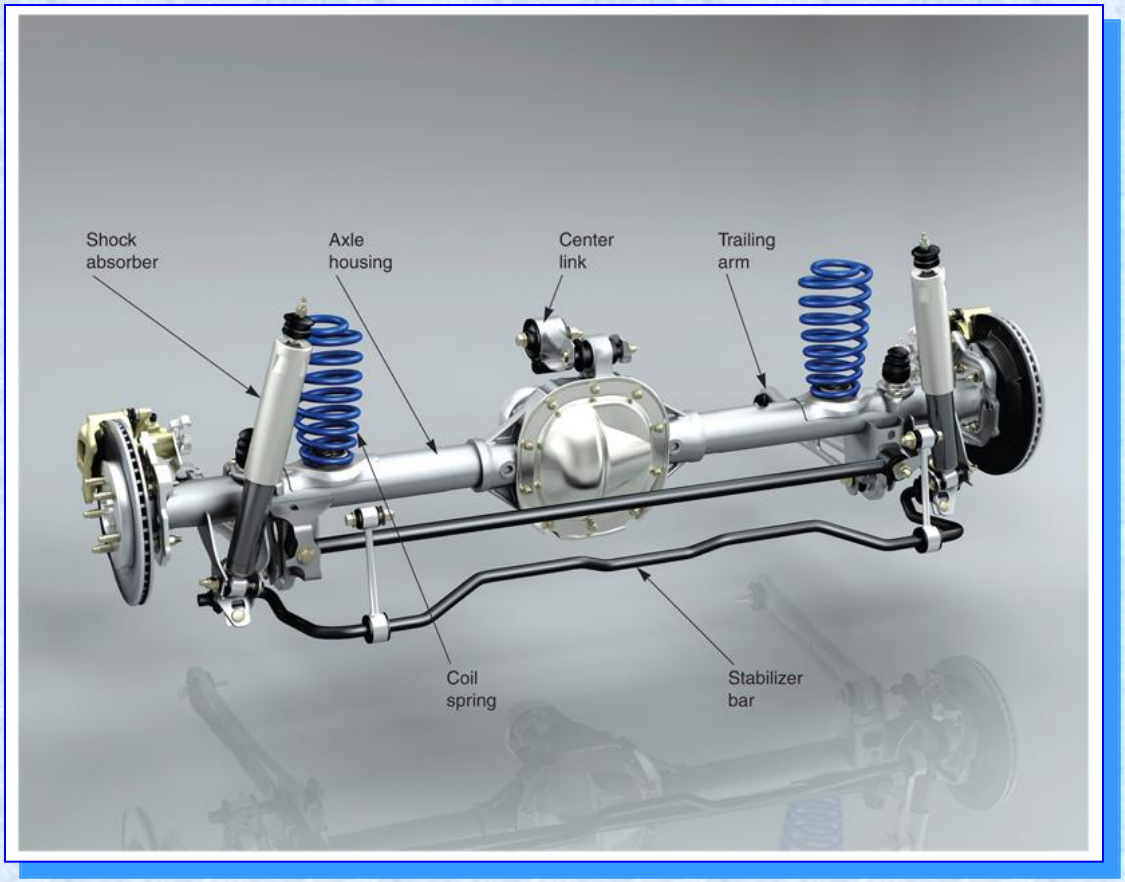
Twin I-Beam Suspension



Rear Suspension Systems

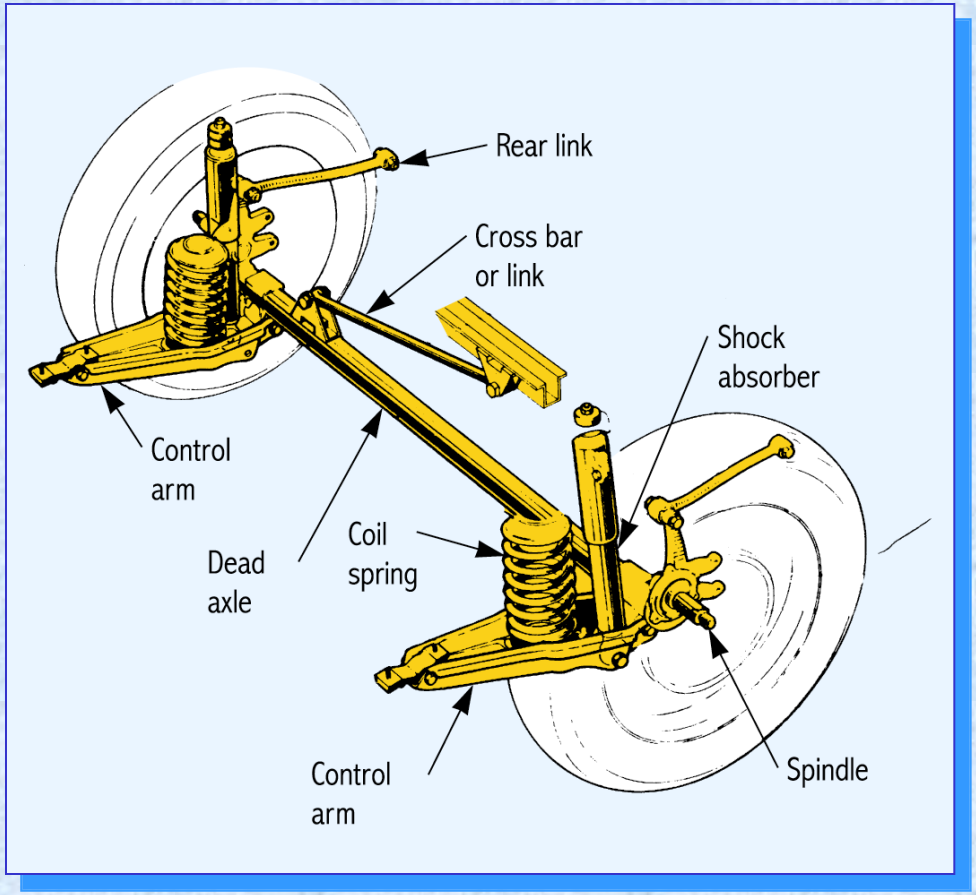
- The rear axle housing may be solid
  - nonindependent suspension
- Rear swing axles can also be used
  - independent suspension

Nonindependent Rear Suspension



Solid axle housing for a rear-wheel-drive vehicle

Dead Axle

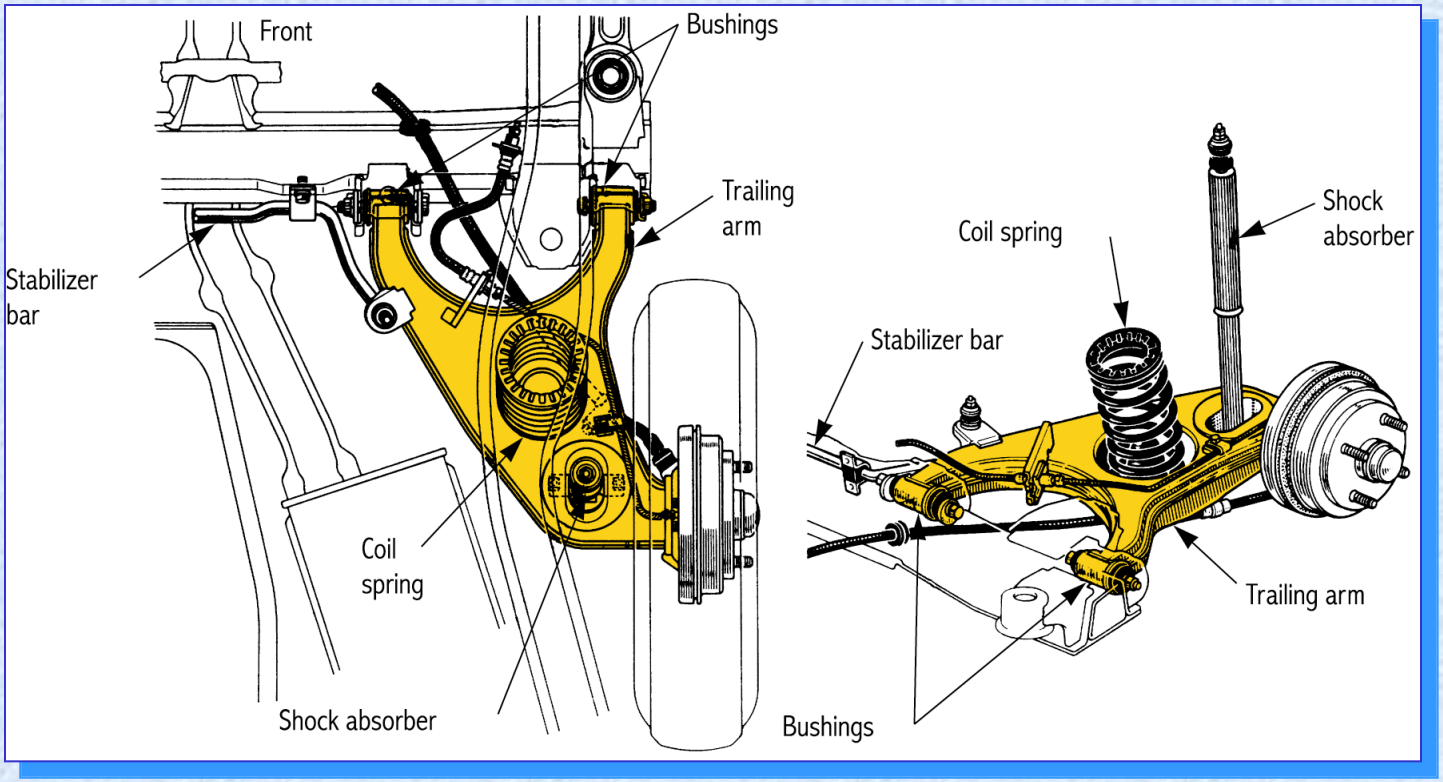


A solid axle that does not drive wheels

Semi-Independent Suspension

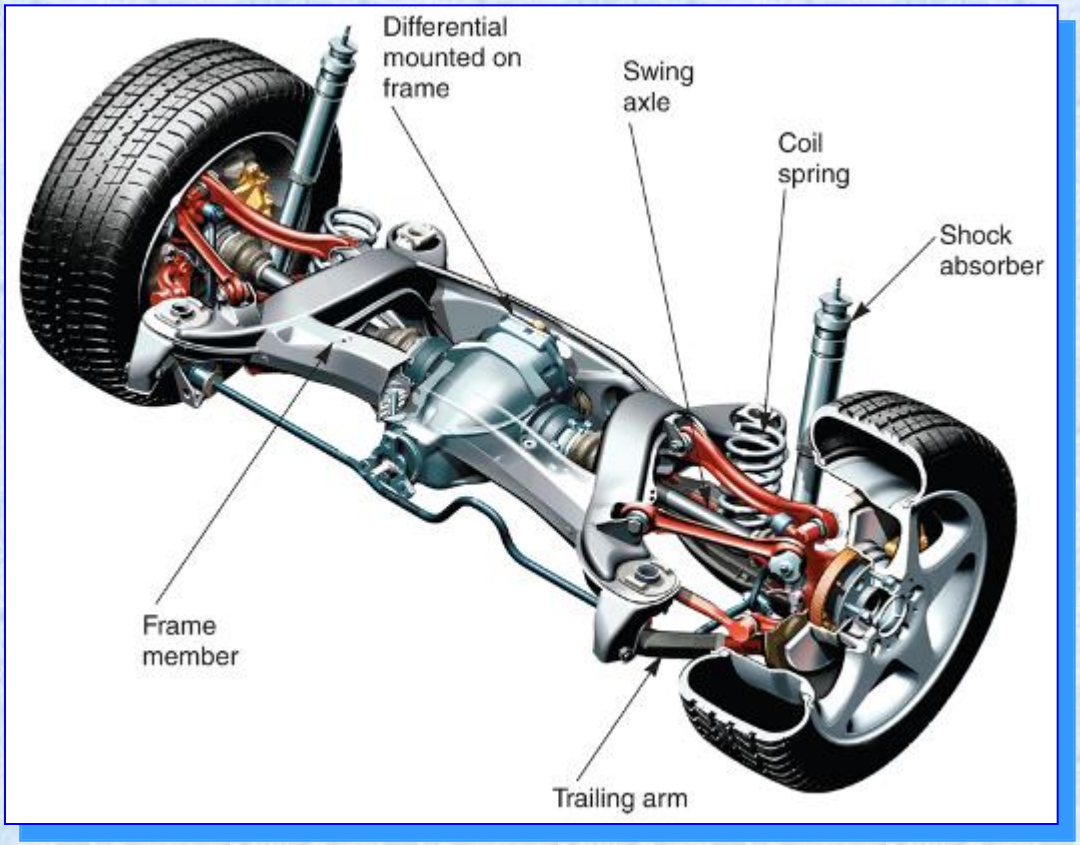
- Uses a flexible axle, allowing the right and left wheels to be partially independent of each other
- When one wheel hits a bump, its control arm moves up
- Since the axle can flex, the effect on the other tire is minimized

Independent Rear Suspension



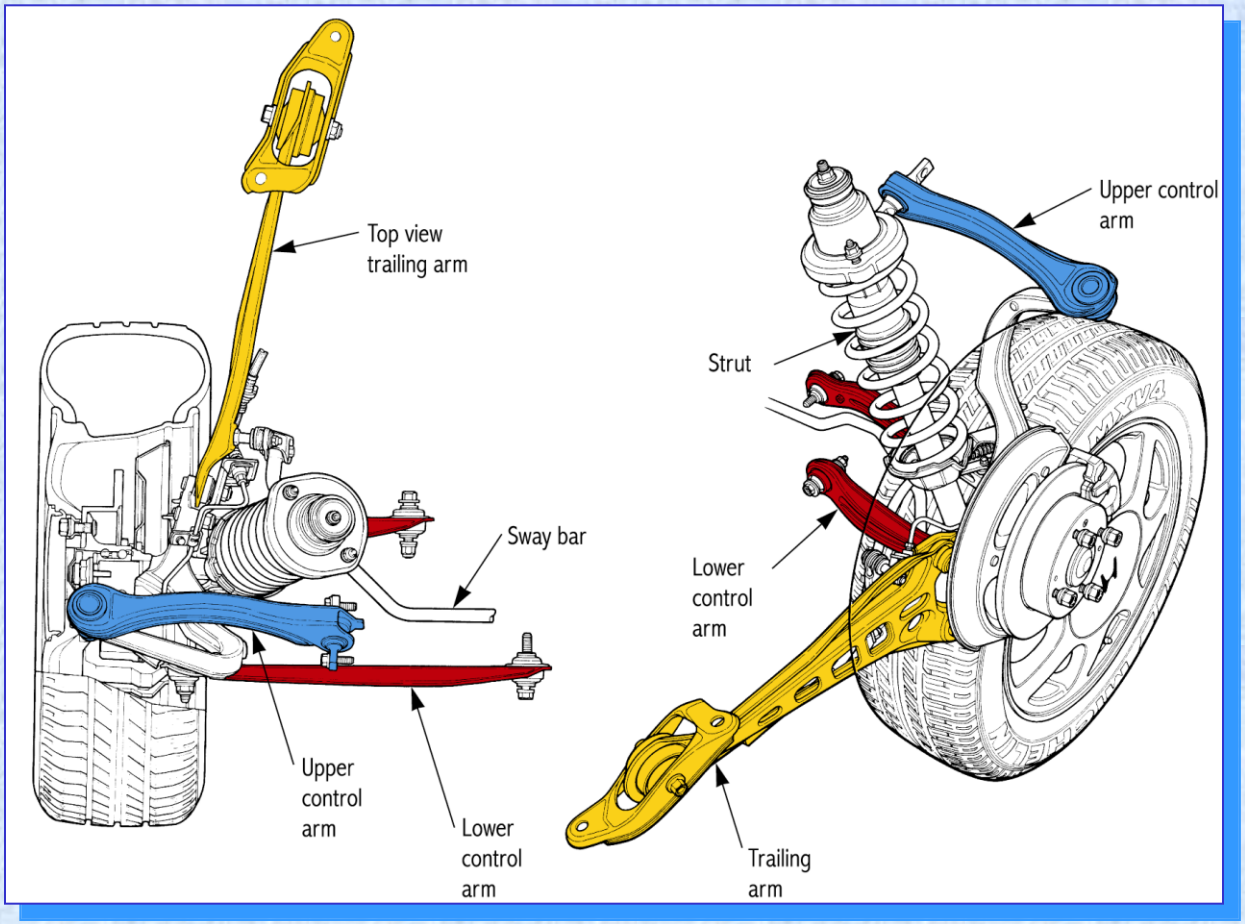
Trailing-arm design

Independent Rear Suspension



This differential is mounted to the frame

Independent Rear Suspension



Double wishbone suspension system

Suspension Leveling Systems

- Used to maintain the same vehicle attitude (body height) with changes in the amount of weight in the car
- Common classifications:
  - manual system
  - automatic system

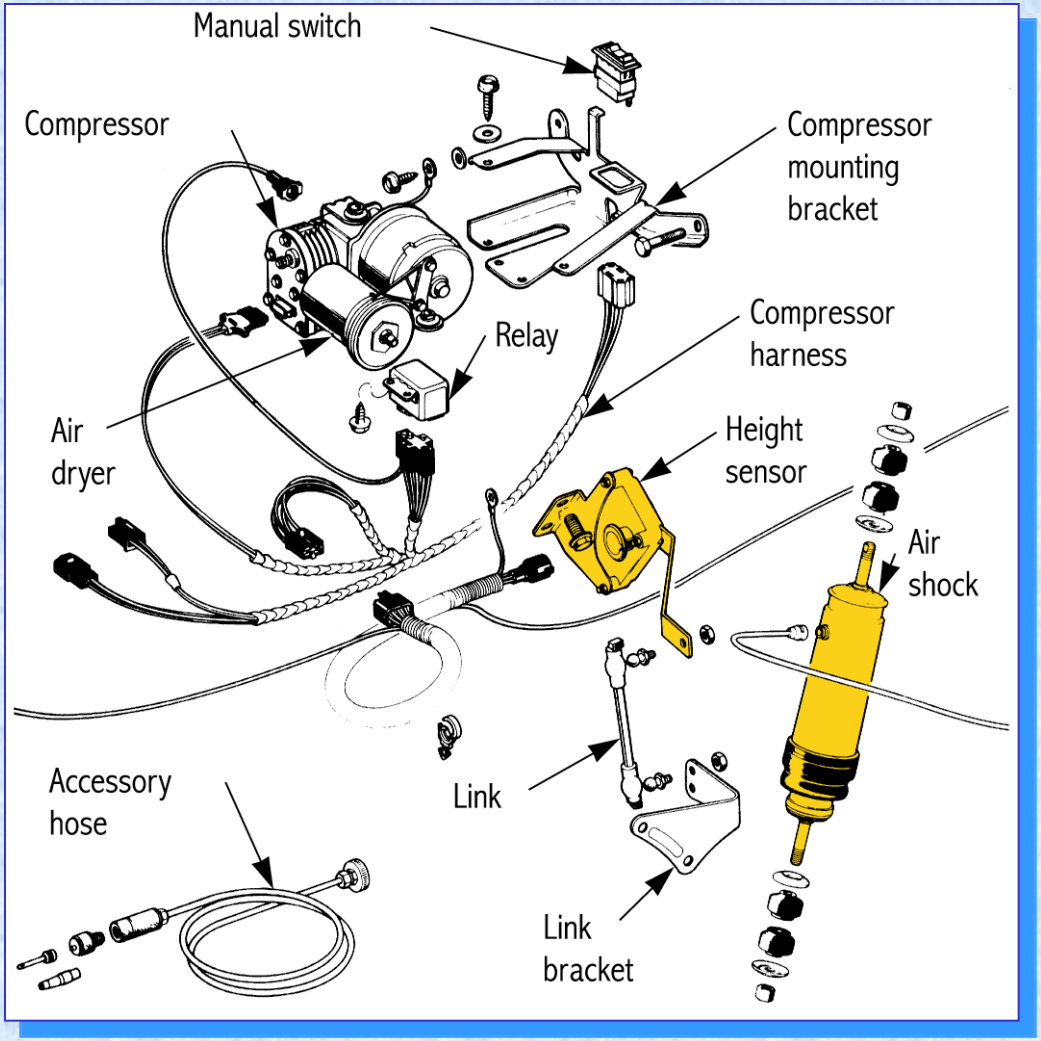
Manual System

- Uses air shocks and an electric compressor to counteract changes in passenger and luggage weight
- A manual switch is used to activate the compressor to alter air shock pressure and body height

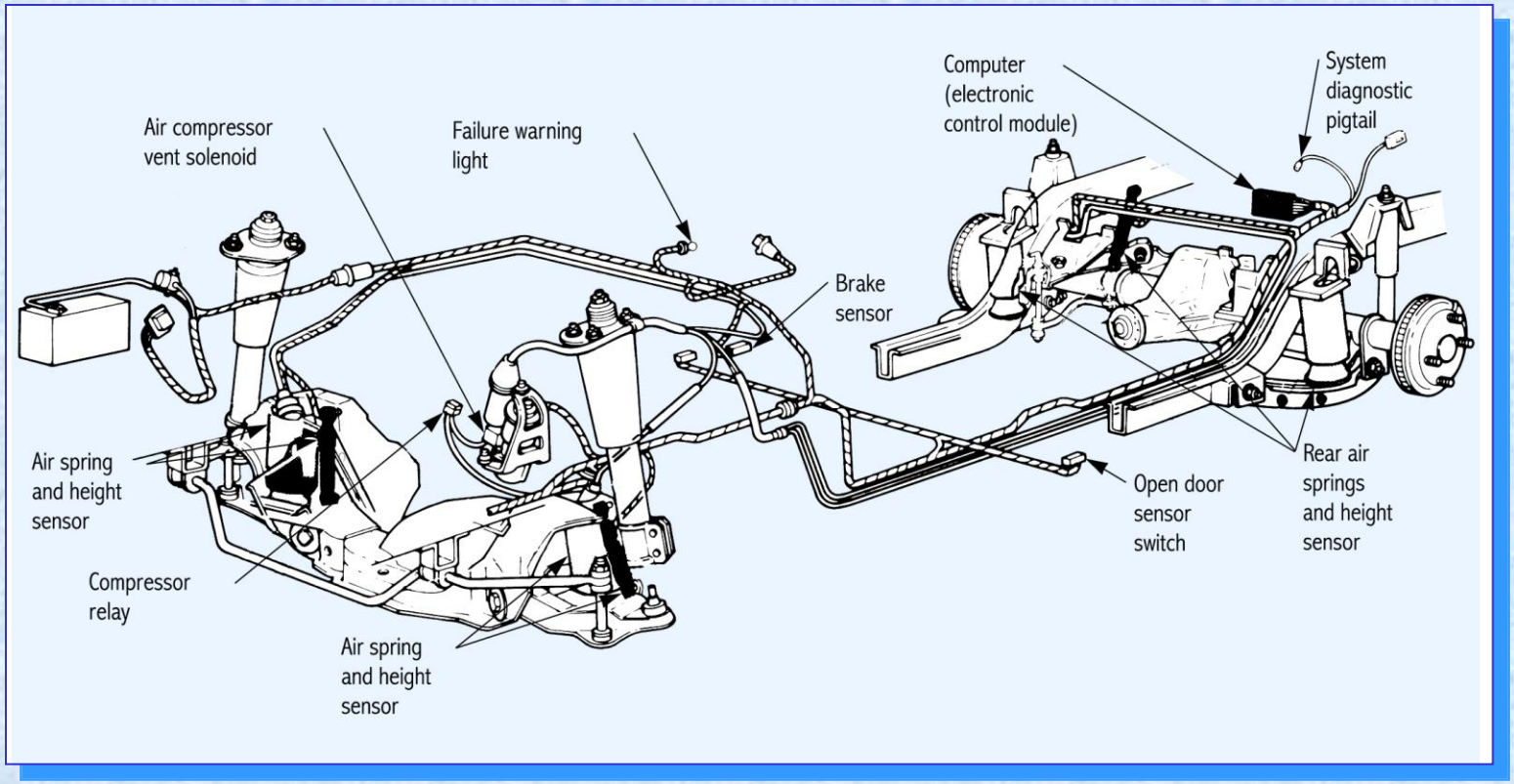
Automatic System

- Uses air shocks or air springs, height sensors, and a compressor to maintain curb height
- A height sensor is connected to the frame and to the axle housing
- If the load changes, the sensor can turn the compressor on to increase pressure to the shocks or turn a solenoid on to vent pressure from the system

Automatic System



Automatic System



This system uses air springs and height sensors on all four wheels

Electronic Height Control

- Uses height sensors and an electronic control module to control the operation of a small electric air compressor, which maintains the correct ride height
- Used on the rear of the car to compensate for heavy loads

Electronic Height Control

- Components:
  - height sensor
  - compressor assembly
  - pressure lines
  - air shocks
  - sensor link
  - solenoid valve
  - suspension control module

Operation

- If the trunk is heavily loaded, the weight will compress the rear air shocks
- When the car is started, the height sensor will be activated by the action of the sensor link, and the sensor switch will close, energizing the compressor
  - rear shock air pressure increases
  - car body rises

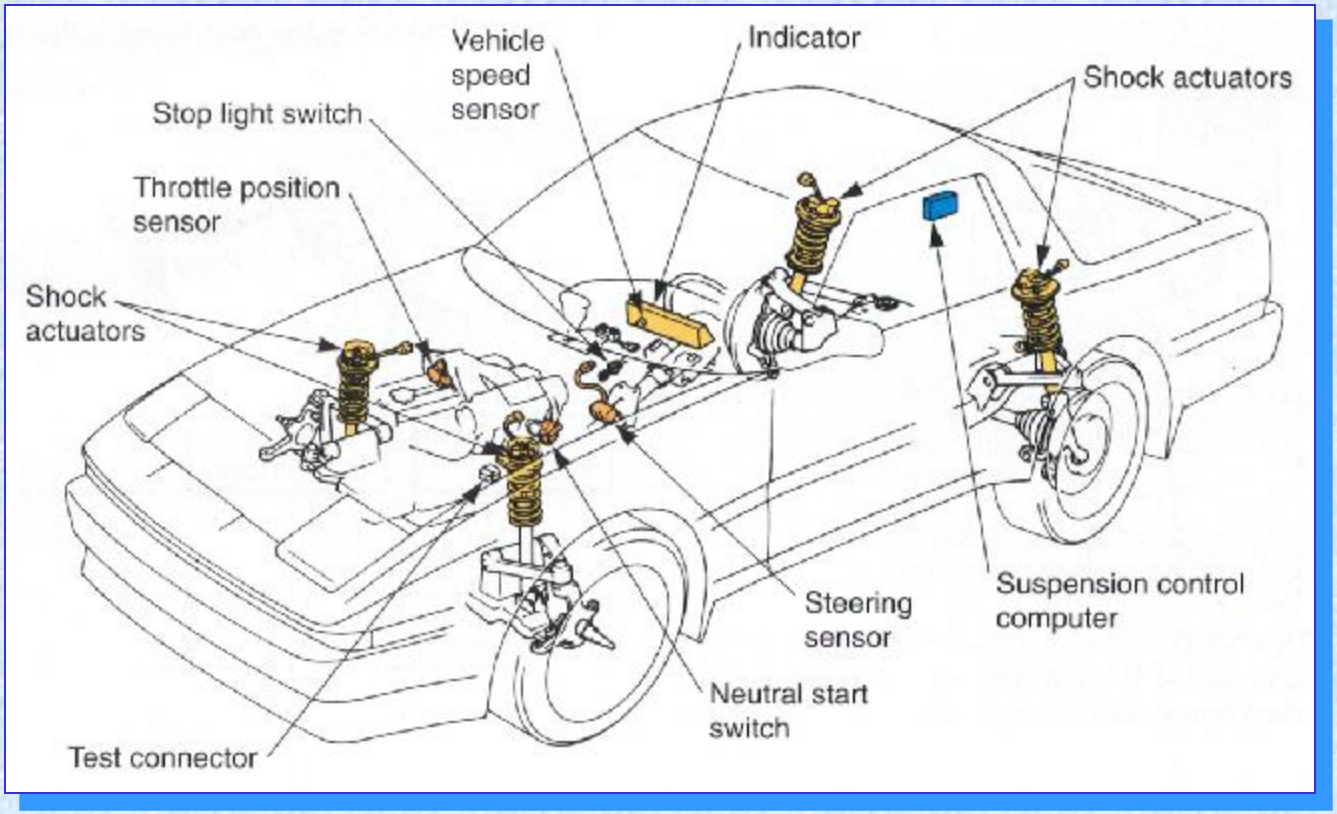
Operation

- When the weight is removed, the car body will rise
- The height sensor will then be moved in the other direction by the link, closing another set of internal contacts, energizing the pressure release solenoid valve
  - air pressure is vented from the rear shocks
  - body drops down to the correct ride height

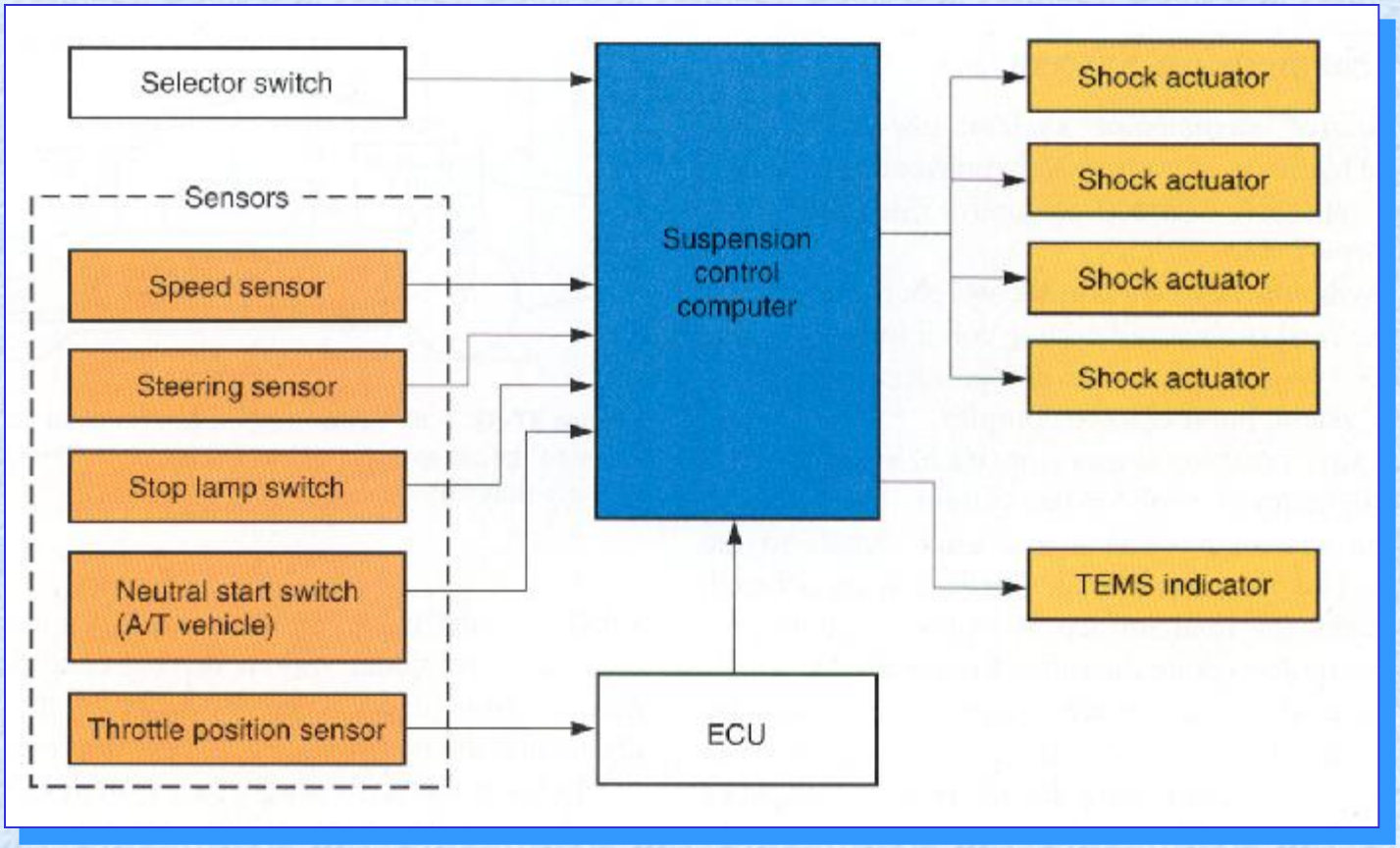
Electronic Suspension System

- Uses various sensors, a computer, and shock absorber actuators to control ride stiffness
- Increases comfort and safety by matching suspension system action to driving conditions

Electronic Suspension System Components



Electronic Suspension System Control



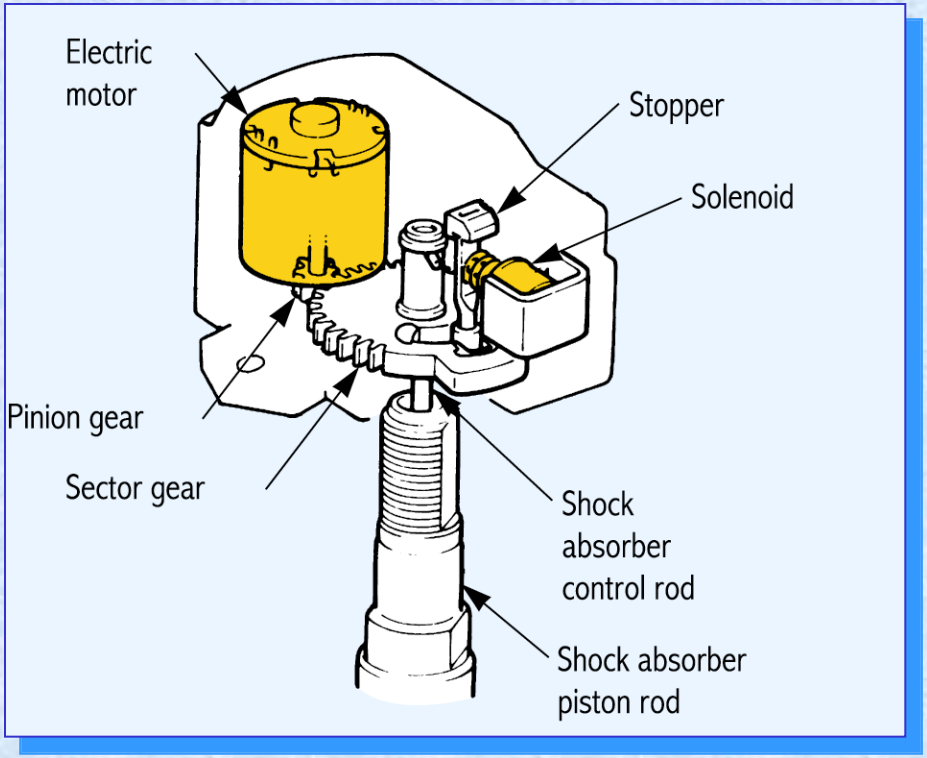
Operation

- The system can produce a soft, smooth ride when traveling down a straight highway
- Based on the selector switch setting and other inputs, the electronic control module would energize the shock actuators to open the valves more
  - reduces internal fluid restriction
  - softens the ride

Operation

- The system can stiffen the ride when cornering, accelerating, or braking
- Based on the selector switch setting and other inputs, the electronic control module would energize the shock actuators to close the valves more
  - increases internal fluid restriction
  - increases dampening action
  - prevents body roll and dive

Shock Actuator



Uses a solenoid and a small dc motor to move the control rod

Active Suspension System

- Uses computer-controlled hydraulic rams instead of conventional springs and shock absorber actuators to control ride characteristics
- Hydraulic rams support the weight of the car and react to the road surface

Operation

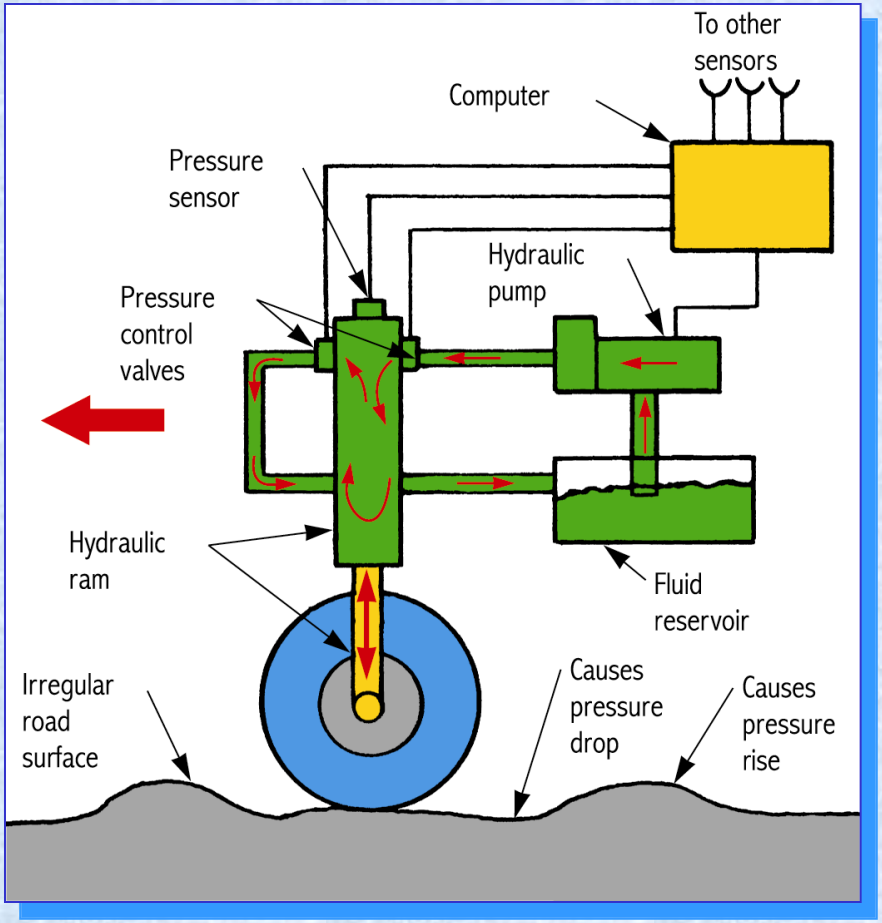
- Pressure sensors on each ram provide the main control for the system
- The sensors react to suspension system movement and send signals to the computer
- The computer extends or retracts each ram to match the road surface

Operation

- Pressure control valves are located on each ram
- By opening and closing these valves, the computer can adjust the pressure of the rams and the resulting height of each corner of the vehicle
- The computer can theoretically eliminate most body movement as the car travels over small dips and bumps

Active Suspension System

A hydraulic pump provides pressure to operate the rams



Active Suspension Advantages

- In turns, body roll is controlled, even banking into a turn is possible
- For highway driving, the car can be lowered to improve aerodynamics
- During city driving, the car can be raised for added ground clearance