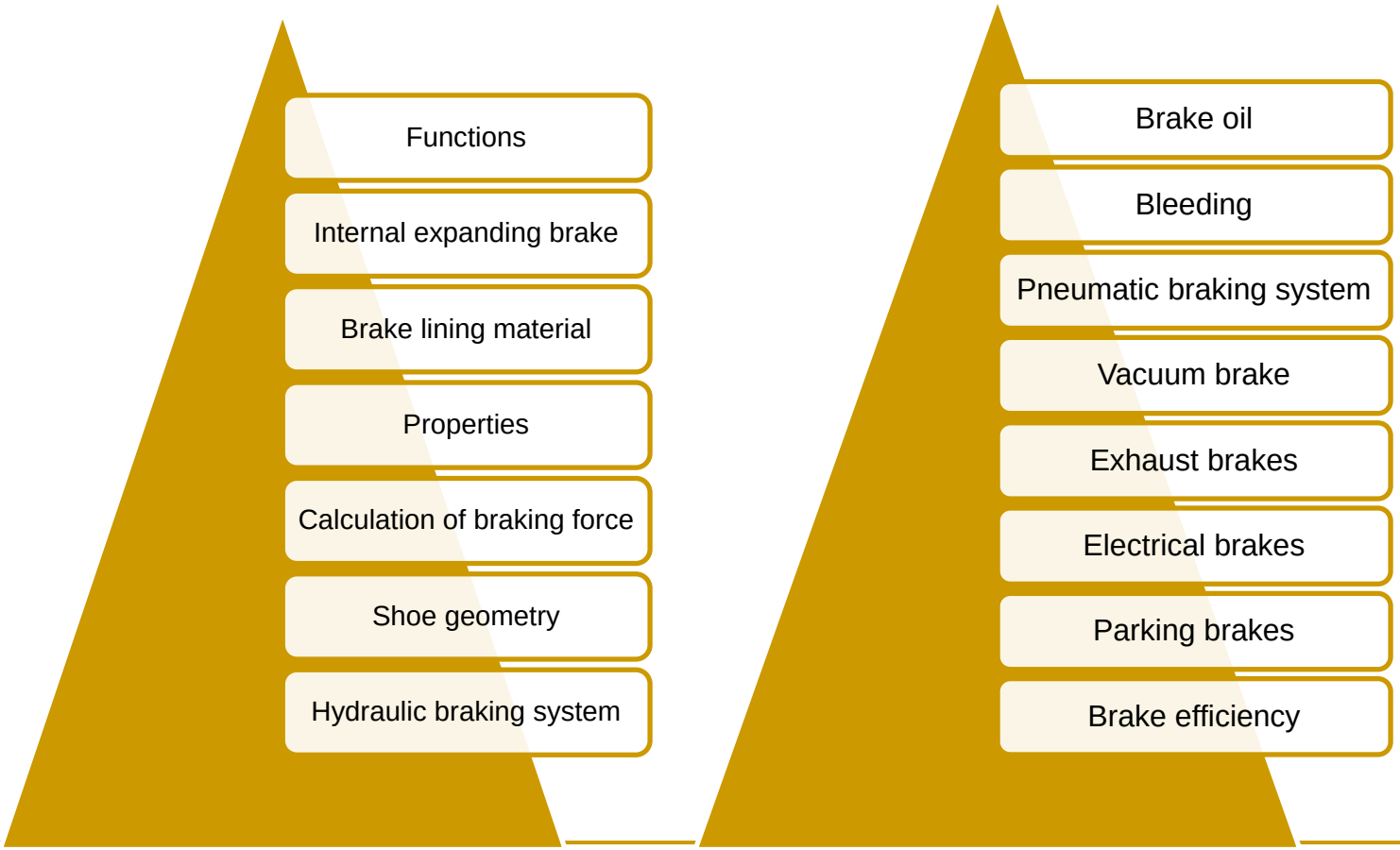
BRAKES

TOPICS

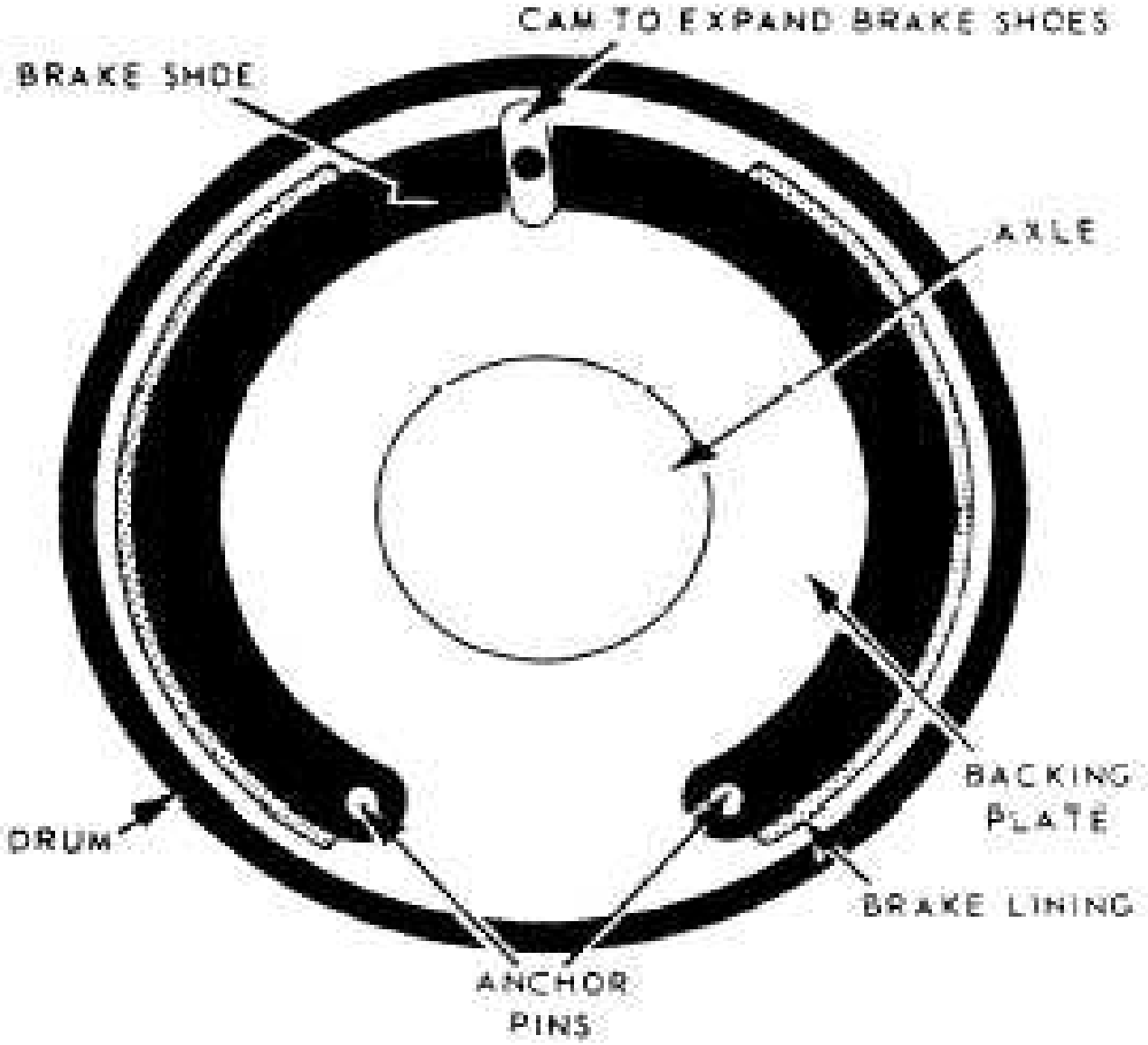

Functions
Internal expanding brake
Brake lining material
Properties
Calculation of braking force
Shoe geometry
Hydraulic braking system
Brake oil
Bleeding
Pneumatic braking system
Vacuum brake
Exhaust brakes
Electrical brakes
Parking brakes
Brake efficiency

Functions of Brake

- A brake is a device which inhibits motion
- Brakes are generally applied to rotating axles or wheels
- Friction brakes on automobiles store braking heat in the drum brakes or disc brake while braking then conduct it to the air gradually. When traveling downhill some vehicles can use their engines to brake

Internal Expanding Brake

- Internal expanding brakes are used exclusively as wheel brakes, but can be found on some cranes
- More compact and economical construction
- The brake shoe of an internal expanding brake is forced outward against the drum to produce the braking action

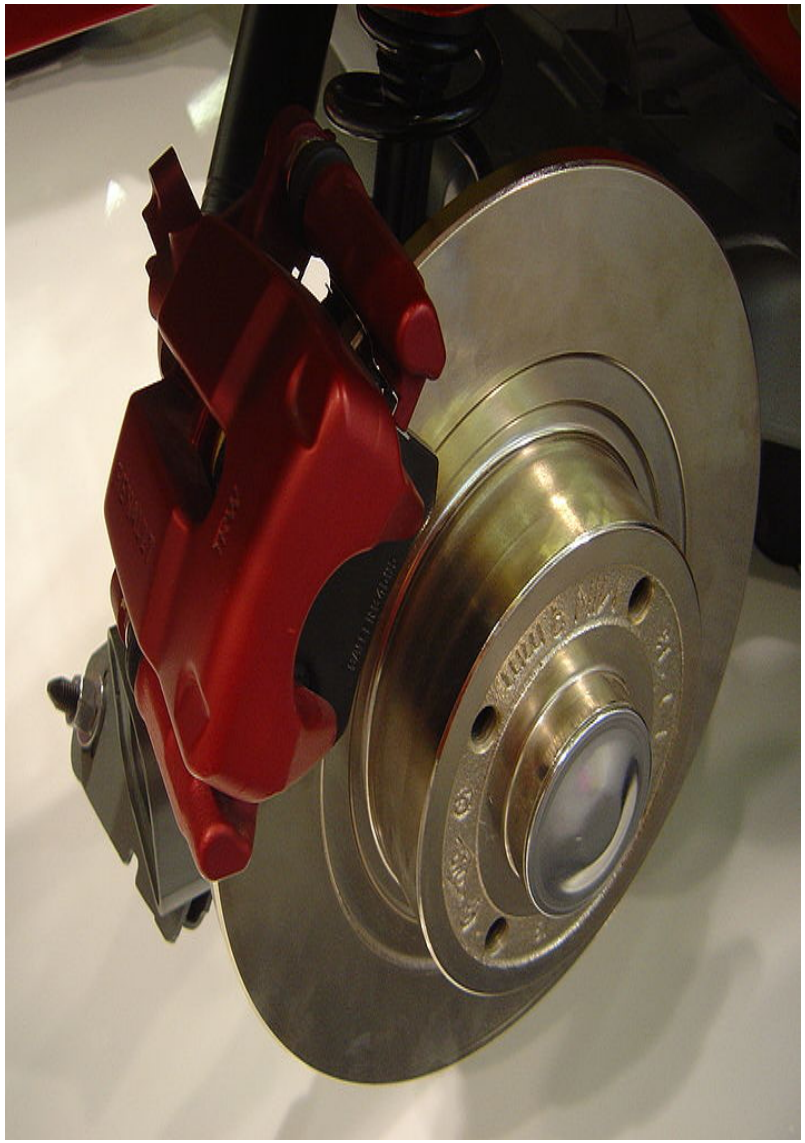

CAM TO EXPAND BRAKE SHOES
BRAKE SHOE
AXLE
BACKING PLATE
BRAKE LINING
DRUM
ANCHOR PINS

- When force from the operating mechanism is applied to the unattached end of the shoe, the shoe expands and brakes the wheel
- A retracting spring returns the shoe to the original position when braking action is no longer required

Brake Lining Material

- Are composed of a relatively soft but tough and heat-resistant material with a high coefficient of dynamic friction
- They are typically mounted to a solid metal backing using high-temperature adhesives or rivets
- The dynamic friction coefficient "μ" for most standard brake pads is usually in the range of 0.35 to 0.42

- Using a typical bicycle brake as an example, the backing would be the metal shell which provides mechanical support, and the lining would be the rubbery portion which contacts the rims when the brakes are applied
- In this view of an automobile disc brake, the brake pad is the black material held by the red metal component



Properties of Brake Lining

- Must be capable of enduring the high temperatures created by the friction forces of braking.
- Must have good energy absorption properties.

- For years, asbestos fibers were the most popular type of friction material.
- When these were banned, manufacturers started to discover better substances, of which ceramic materials are a great example.
- Because of the variety of organic and synthetic friction materials, with new developments always popping up, varying coefficients of friction are available.

Calculation of Braking Force

-BRAKING FORCE

- The total braking force required can simply be calculated using Newton's Second Law.

$B_F = Mag$

where:

B_F = total braking force (N)

M = total vehicle mass (kg)

a = deceleration (g units)

g = acceleration due to gravity (m/sec^2)

-WHEEL LOCK

- The braking force can only be generated if the wheel does not lock because the friction of a sliding wheel is much lower than a rotating one. The maximum braking force possible on any particular axle before wheel lock is given by:

$$F_A = M_{Wdyn} . g . \mu_r$$

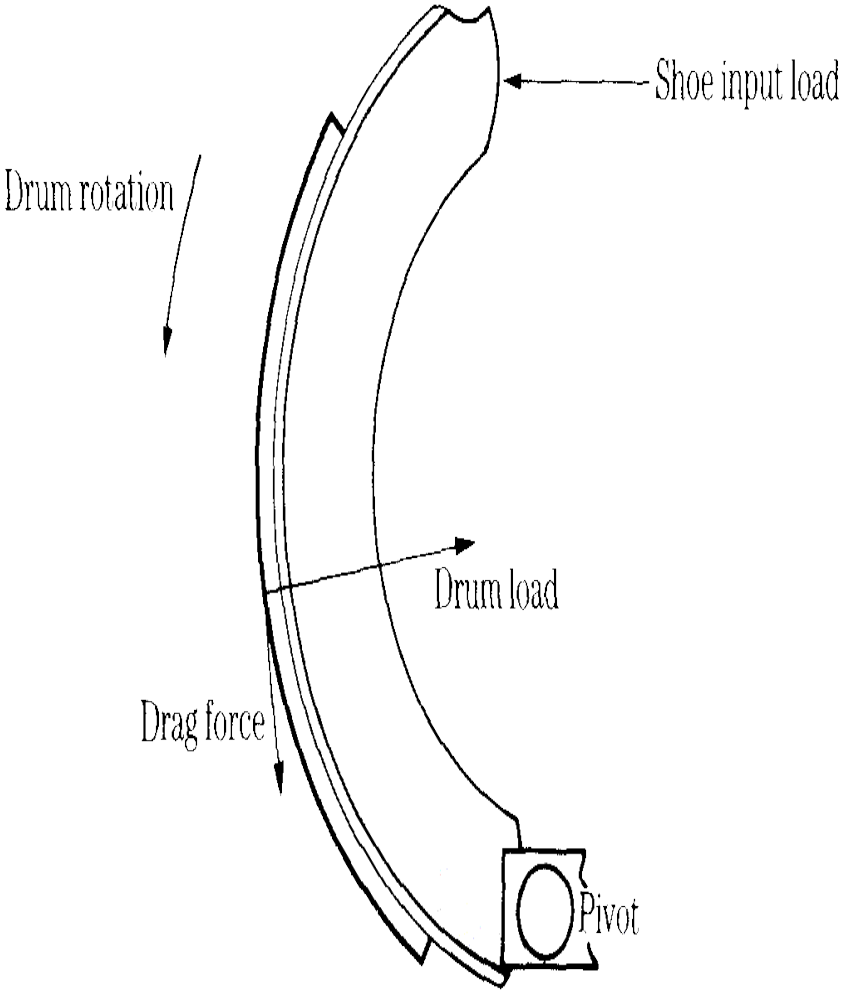
where:

F_A	=	total possible braking force on the axle (N)
M_{Adyn}	=	dynamic axle mass (kg)
g	=	acceleration due to gravity (m/sec^2)
μ_r	=	coefficient of friction between the road and tyre

Shoe Geometry

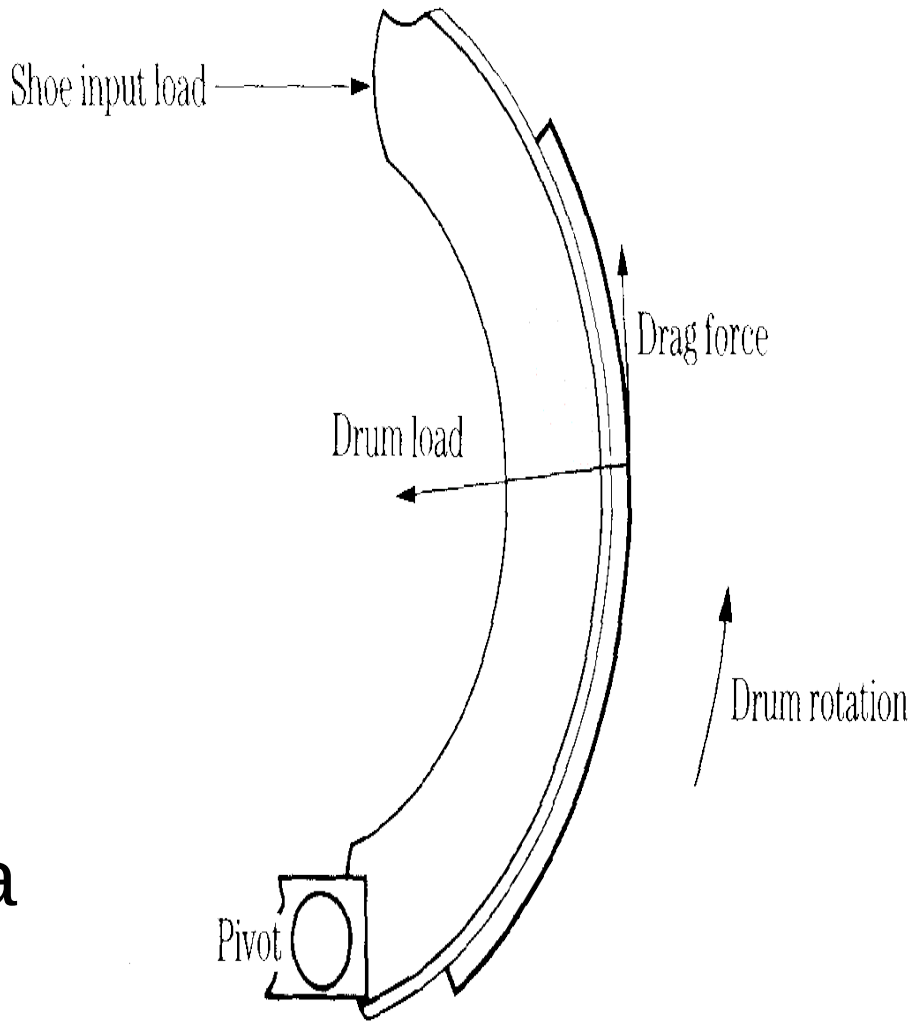
-LEADING SHOES

- From Figure you will see that, with the drum rotating in the direction shown, the upper shoe is ahead of its pivot point. It is said to be a leading shoe. Similarly the lower shoe trails behind its pivot point and is called a trailing shoe. There is an important difference in the way leading and trailing shoes act under braking.



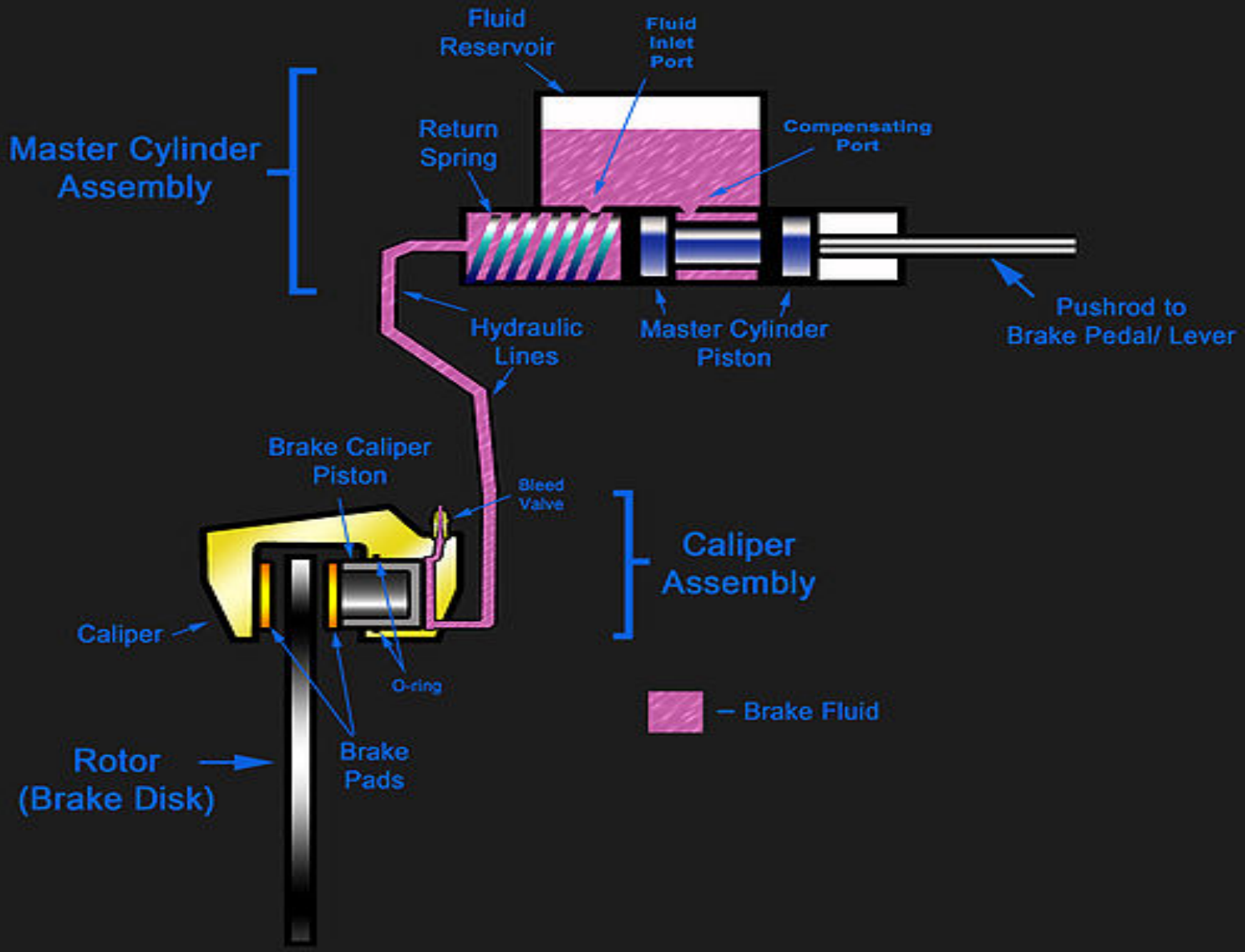
-TRAILING SHOE

- Figure shows the forces acting when a leading shoe is applied. Notice that the frictional drag force has a moment about the pivot point. This increases the input load and hence increases the drag. In other words, there is a self-servo action, which increases the braking effect.



Hydraulic Braking System

- The **hydraulic brake** is an arrangement of braking mechanism which uses brake fluid, typically containing ethylene glycol, to transfer pressure from the controlling unit, which is usually near the operator of the vehicle, to the actual brake mechanism, which is usually at or near the wheel of the vehicle.
- The system is usually filled with a glycol-ether based brake fluid.


Fluid Reservoir
Fluid Inlet Port
Master Cylinder Assembly
Return Spring
Compensating Port
Hydraulic Lines
Master Cylinder Piston
Pushrod to Brake Pedal/ Lever
Brake Caliper Piston
Bleed Valve
Caliper Assembly
Caliper
O-ring
Brake Fluid
Rotor (Brake Disk)
Brake Pads

-Operation of Hydraulic Brakes

- As the brake pedal is pressed/ brake lever is squeezed, a pushrod exerts force on the piston in the master cylinder causing fluid from the brake fluid reservoir to flow into a pressure chamber through a compensating port which results in an increase in the pressure of the entire hydraulic system
- This causes them to be pushed against the spinning rotor, and the friction between the pads and the rotor causes a braking torque to be generated, slowing the vehicle

Brake Oil

- Brake fluid is a type of hydraulic fluid used in hydraulic brake applications in automobiles, motorcycles, light trucks, and some advanced bicycles.
- It is used to transfer force under pressure from where it is created through hydraulic lines to the braking mechanism near the wheels.
- It works because liquids are not appreciably compressible.

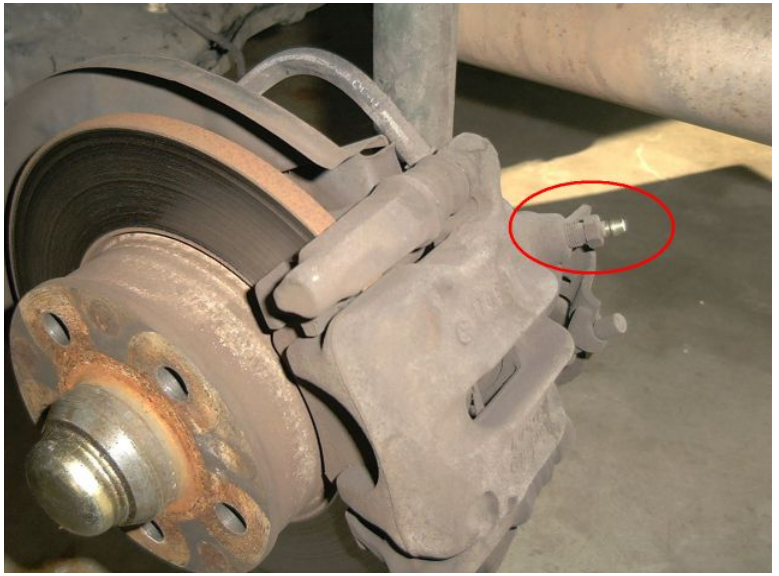
-CHARACTERISTICS

- **Boiling point**
- Brake fluid is subjected to very high temperatures, especially in the wheel cylinders of drum brakes and disk brake calipers. It must have a high boiling point to avoid vaporizing in the lines.
- **Viscosity**
- For reliable, consistent brake system operation, brake fluid must maintain a constant viscosity under a wide range of temperatures, including extreme cold.
- **Corrosion**
- Brakes fluids must not corrode the metals used inside components such as calipers, master cylinders, etc.
- **Compressibility**
- Brake fluids must maintain low level of compressibility that remains low, even with varying temperatures.

Bleeding in Brakes

- **Brake bleeding** is the procedure performed on hydraulic brake systems whereby the brake lines are purged of any air bubbles.
- This is necessary because, while the brake fluid is an incompressible liquid, air bubbles are compressible gas and their presence in the brake system greatly reduces the hydraulic pressure that can be developed within the system.
- The process is performed by forcing clean, bubble-free brake fluid through the entire system, usually from the master cylinder to the calipers of disc brakes, but in certain cases in the opposite direction.
- A brake bleed screw is normally mounted at the highest point on each cylinder or caliper.

-Pressure bleeding a brake system



-Close-up of a disk brake bleed screw

There are four main methods of bleeding:

-**Pump and Hold Method**: One person pumps the brake pedal to compress the air, then holds pressure on it. The other person opens the bleeder valve to let out fluid and air, then closes the valve after the pedal has landed.

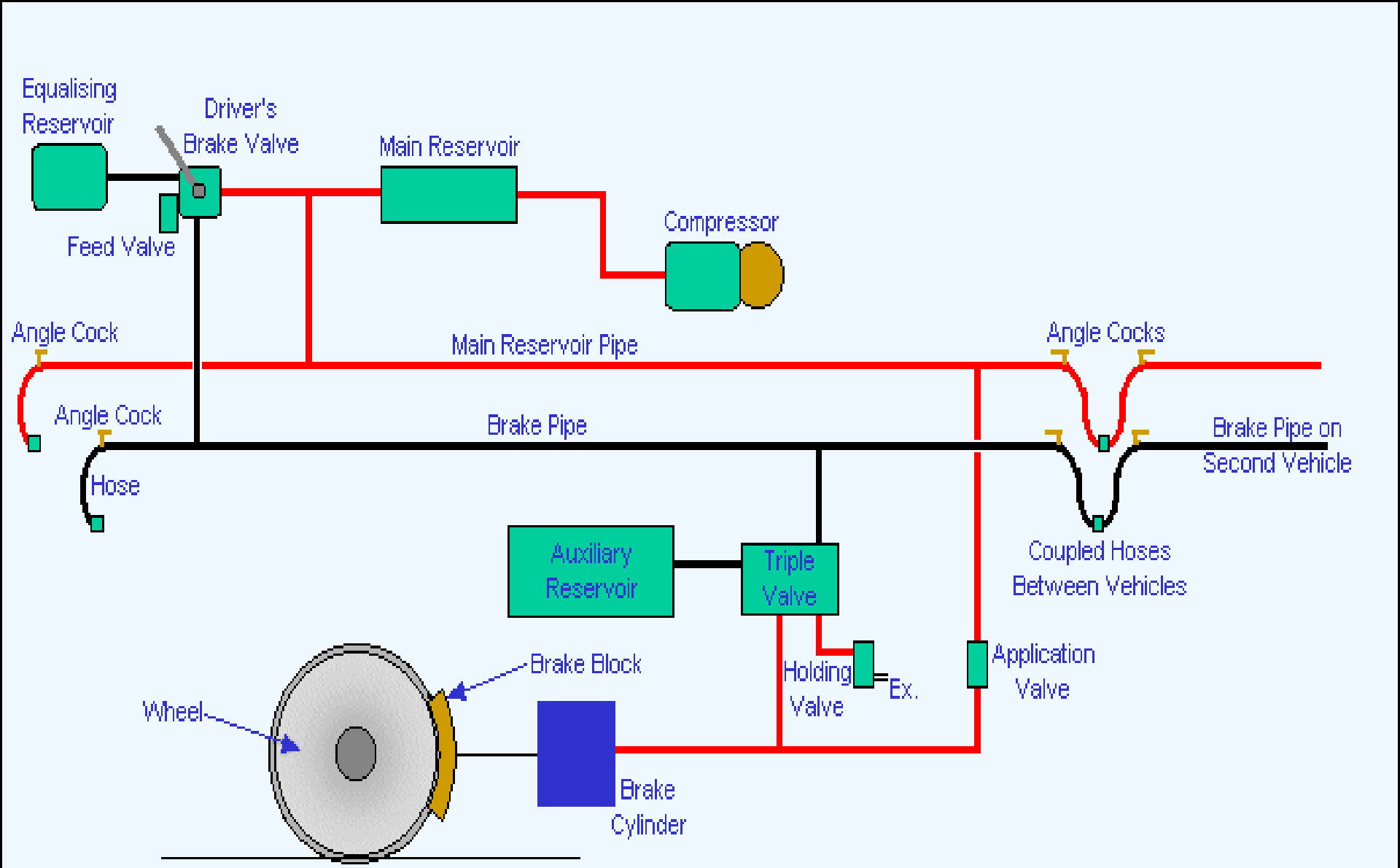
-**Vacuum Method**: The master cylinder is topped off and the cover left loose. A specialized vacuum pump is attached to the bleeder valve, which is opened and fluid extracted with the pump until it runs clear of bubbles.

-**Pressure Method**: A specialized pressure pump, is attached to the master cylinder and filled with fluid. The pump is used to pressurize the system to about 10psi, and the bleeder valves are opened one at a time until the fluid is clear of air. One advantage to this system is that the pump reservoir usually holds enough fluid that running dry is not likely.

-**Reverse Pressure Method**: In this method, a pump is used to force fluid through the bleeder valve to the master cylinder. This method may have advantages in some cases, however it is not in common usage.

Pneumatic Braking System

- Pneumatic brakes are equipment drive assemblies that use air-actuated components to slow or stop shafts.
- Prior to the introduction of air brakes, stopping a train was a difficult business. In the early days when trains consisted of one or two cars and speeds were low, the engine driver could stop the train by reversing the steam flow to the cylinders, causing the locomotive to act as a brake.
- The pressurized air comes from an air compressor in the locomotive and is sent from car to car by a *train line* made up of pipes beneath each car and hoses between cars.



Block Diagram of Electro-Pneumatic Brake System

There are several basic types of pneumatic brakes:-

-**Band brakes**, the simplest pneumatic brake configuration, feature a metal band lined with heat and wear resistant friction material.

-**Drum brakes**, which are commonly used on automobile rear wheels, actuate when shoes press against a spinning surface called a drum.

-**Disc brakes** consist of a caliper that squeezes brake pads against a rotor.

-**Cone brakes** include a cone that is lined with heat and wear resistant material that presses against a mating cup surface.

Vacuum Brakes

- The **vacuum brake** is a braking system employed on trains and introduced in the mid-1860s.
- A major advance was the adoption of a vacuum braking system in which flexible pipes were connected between all the vehicles of the train, and brakes on each vehicle could be controlled from the locomotive.

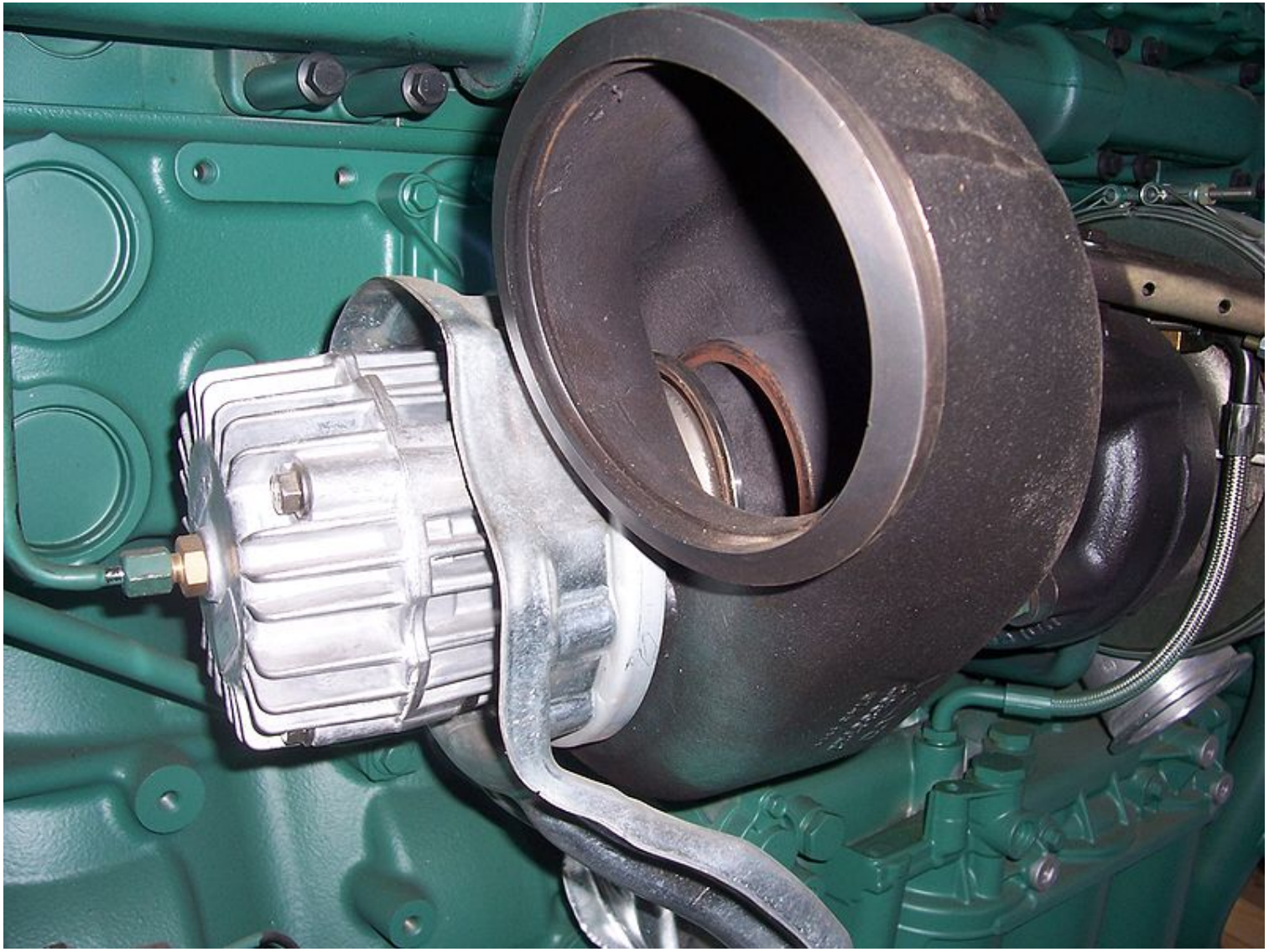
- The earliest pattern was a simple vacuum brake, in which vacuum was created by operation of a valve on the locomotive; the vacuum actuated brake pistons on each vehicle, and the degree of braking could be increased or decreased by the driver.
- Vacuum, rather than compressed air, was preferred because steam locomotives can be fitted with ejectors, which are simple venturi devices that create vacuum without the use of moving parts.

Limitations:-

- The practical limit on the degree of vacuum attainable means that a very large brake piston and cylinder are required to generate the force necessary on the brake blocks.
- The existence of vacuum in the train pipe can cause debris to be sucked in.
- The blockage should have been detected if a proper brake continuity test had been carried out before the train started its journey.

Exhaust Brakes

- An exhaust brake is a means of slowing a diesel engine by closing off the exhaust path from the engine, causing the exhaust gases to be compressed in the exhaust manifold, and in the cylinder.
- Since the exhaust is being compressed, and there is no fuel being applied, the engine works backwards, slowing down the vehicle.
- The amount of negative torque generated is usually directly proportional to the back pressure of the engine.

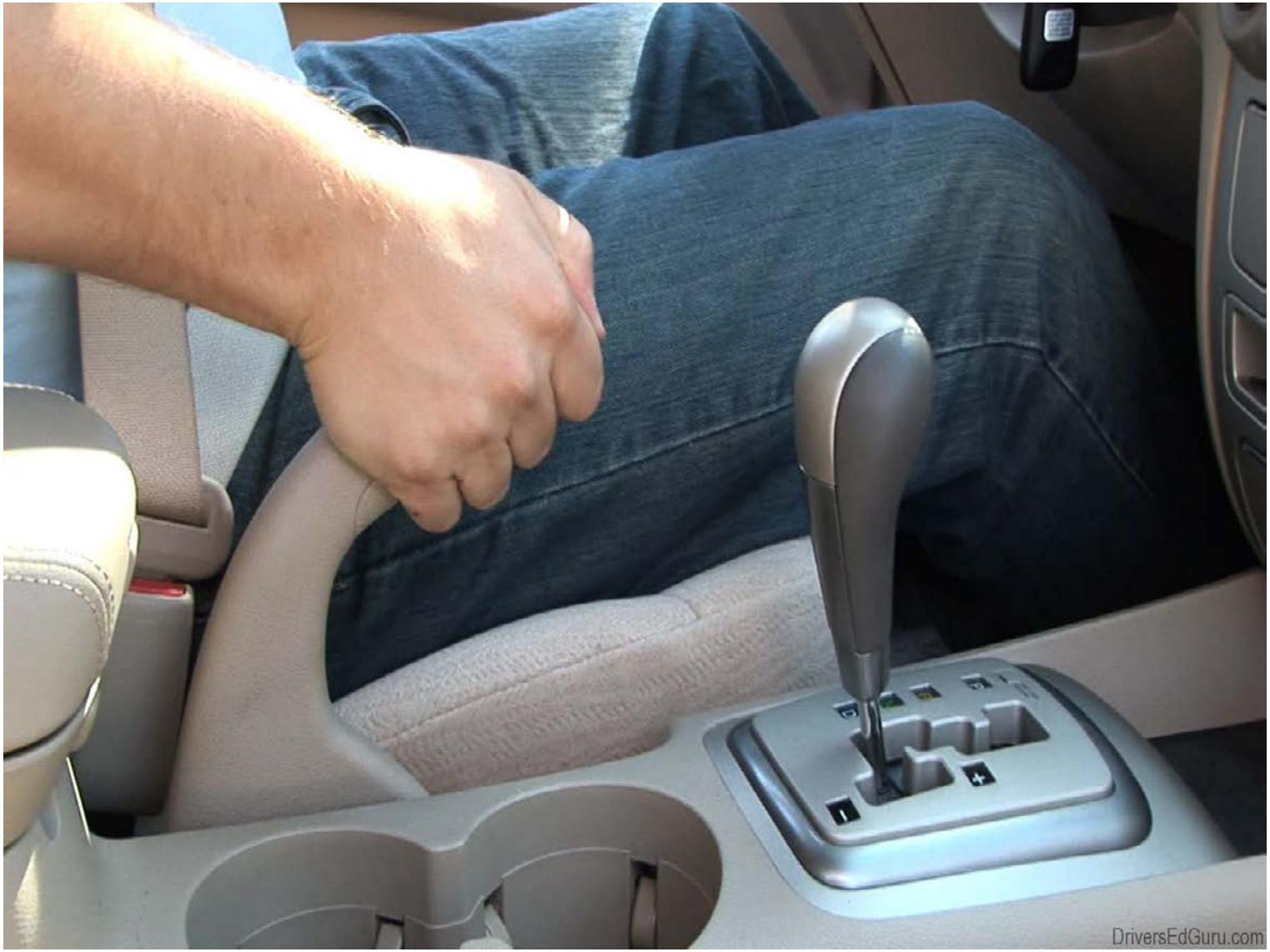


Electrical Brakes

- Electric brakes are equipment drive assemblies that use electrically actuated components to slow or stop shafts.
- There are several basic types of electric brakes.
- **Band brakes**, the simplest electric brake configuration, feature a metal band lined with heat and wear resistant friction material.
- **Drum brakes**, which are commonly used on automobile rear wheels, actuate when shoes press against a spinning surface called a drum.
- **Disc brakes** consist of a caliper that squeezes brake pads against a rotor.
- **Cone brakes** include a cone that is lined with heat and wear resistant material that presses against a mating cup surface.

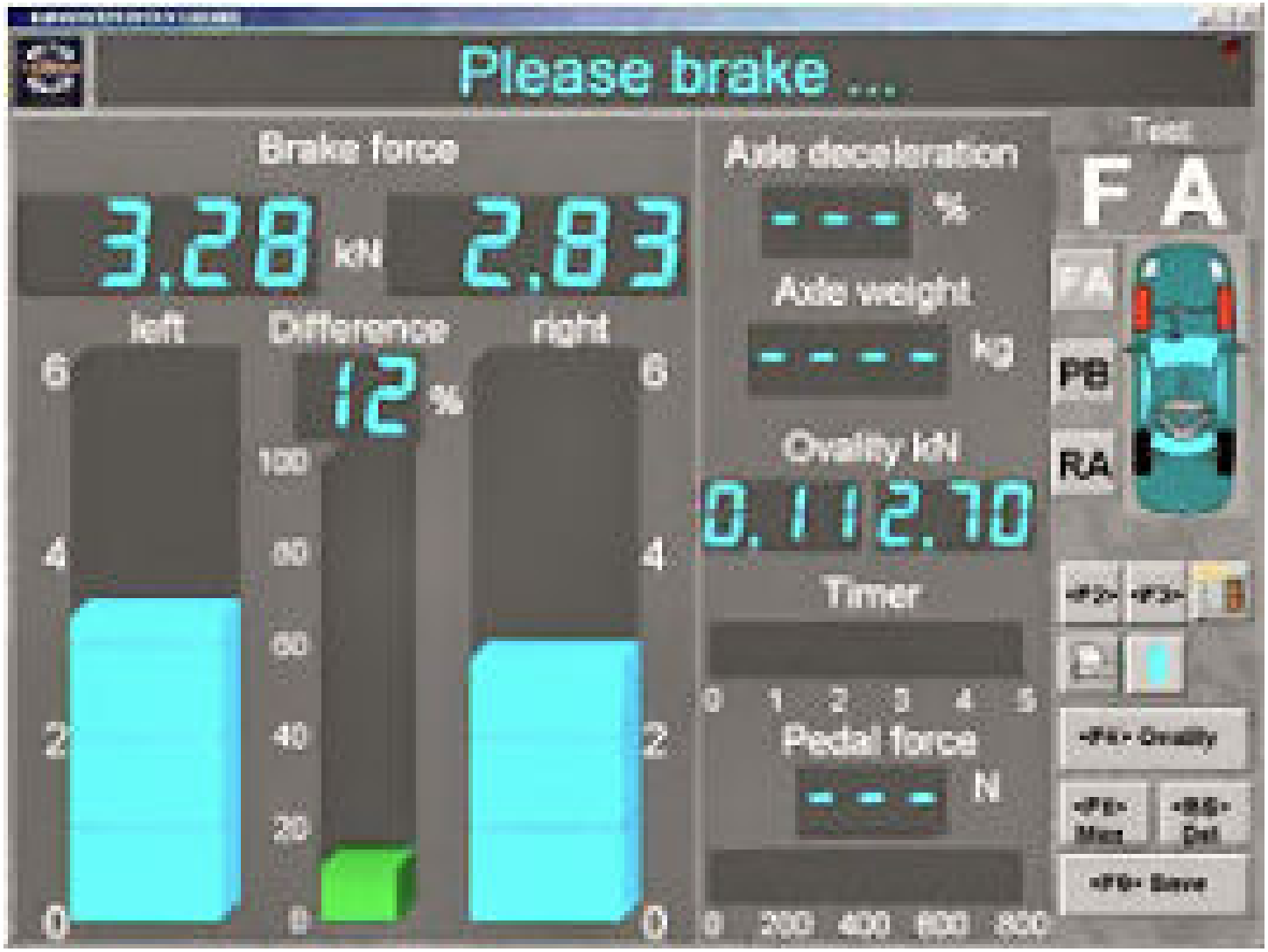
Parking Brakes

- In cars, the hand brake is a latching brake usually used to keep the car stationary.
- The most common use for an automobile emergency brake is to keep the vehicle motionless when it is parked, thus the alternative name, *parking brake*.
- It is important to know which wheels are providing the braking action when lifting the car with a jack.
- Typically the rear wheels are the ones that are stopped with parking brakes.


DriversEdGuru.com

Brake Efficiency

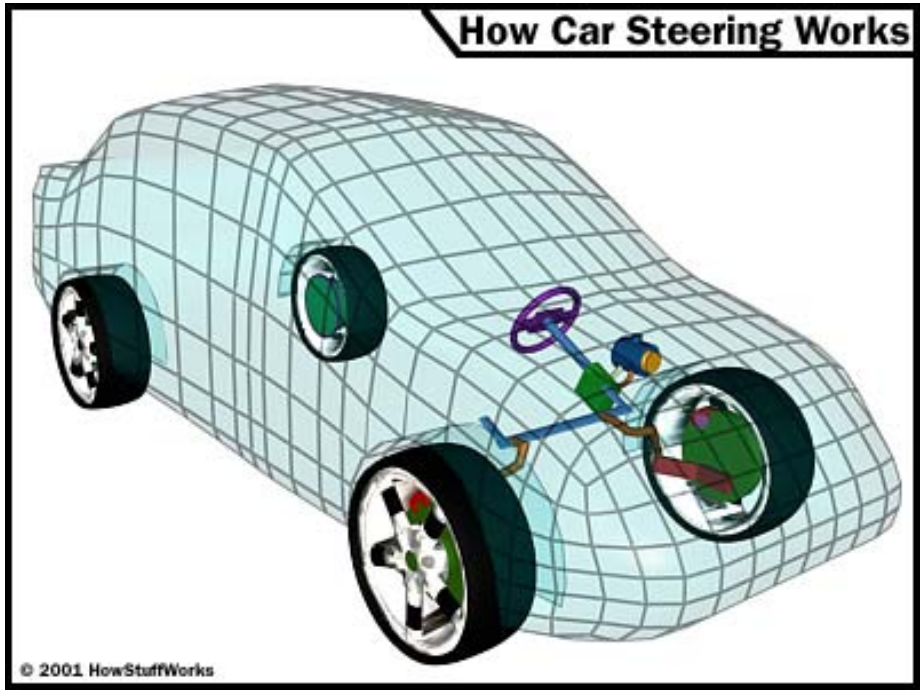
- The automotive industry commonly refers to braking performance in terms of “efficiency”, which is the ratio of A to the gravity acceleration (9,81 m/s^2), expressed in %.
- For example: Efficiency = 65% means that A = 0,65 * 9.81 = 6,38 m/s^2
-
- Braking efficiency check is mandatory in most countries; the minimum acceptable value is usually 50%, but depends on local legislation.
- HOWEVER the methods and instruments used in workshops to measure brake efficiency always check it at very low speeds (about 5 km/h), and often only one axle is measured a a time!


Please brake ...
Brake force
3,28 kN
2,83
left
Difference
right
12 %
Axle deceleration
%
Axle weight
kg
Ovality kN
0,112,70
Timer
Pedal force
N
Test
F A
FA
PB
RA
<F6> Ovality
<F9> Save

Steering System

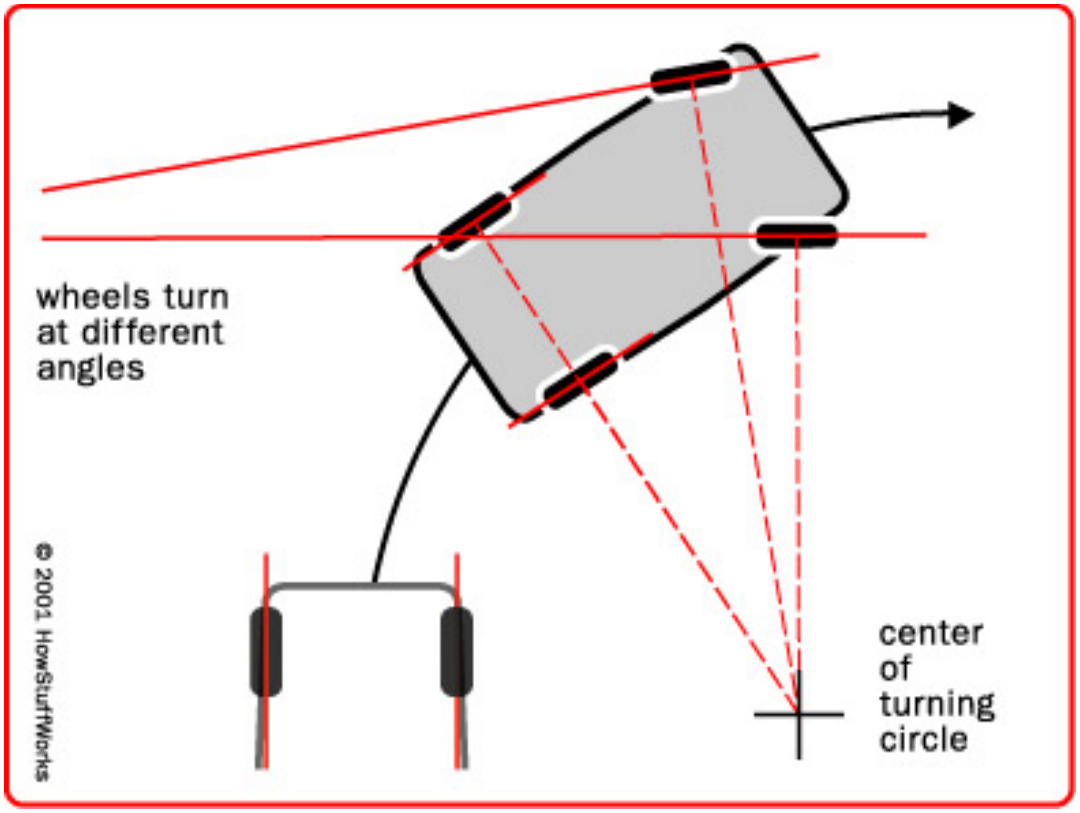
Function of Steering System

- Control of front wheel (sometimes rear wheel) direction.
- Transmit **road feel** (slight steering wheel pull caused by the road surface) to the drivers hand.
- Maintain correct amount of effort needed to turn the wheels.
- Absorb most of the shock going to the steering wheel as the tire hits holes and bumps in the road.
- Allow for suspension action.



Steering System

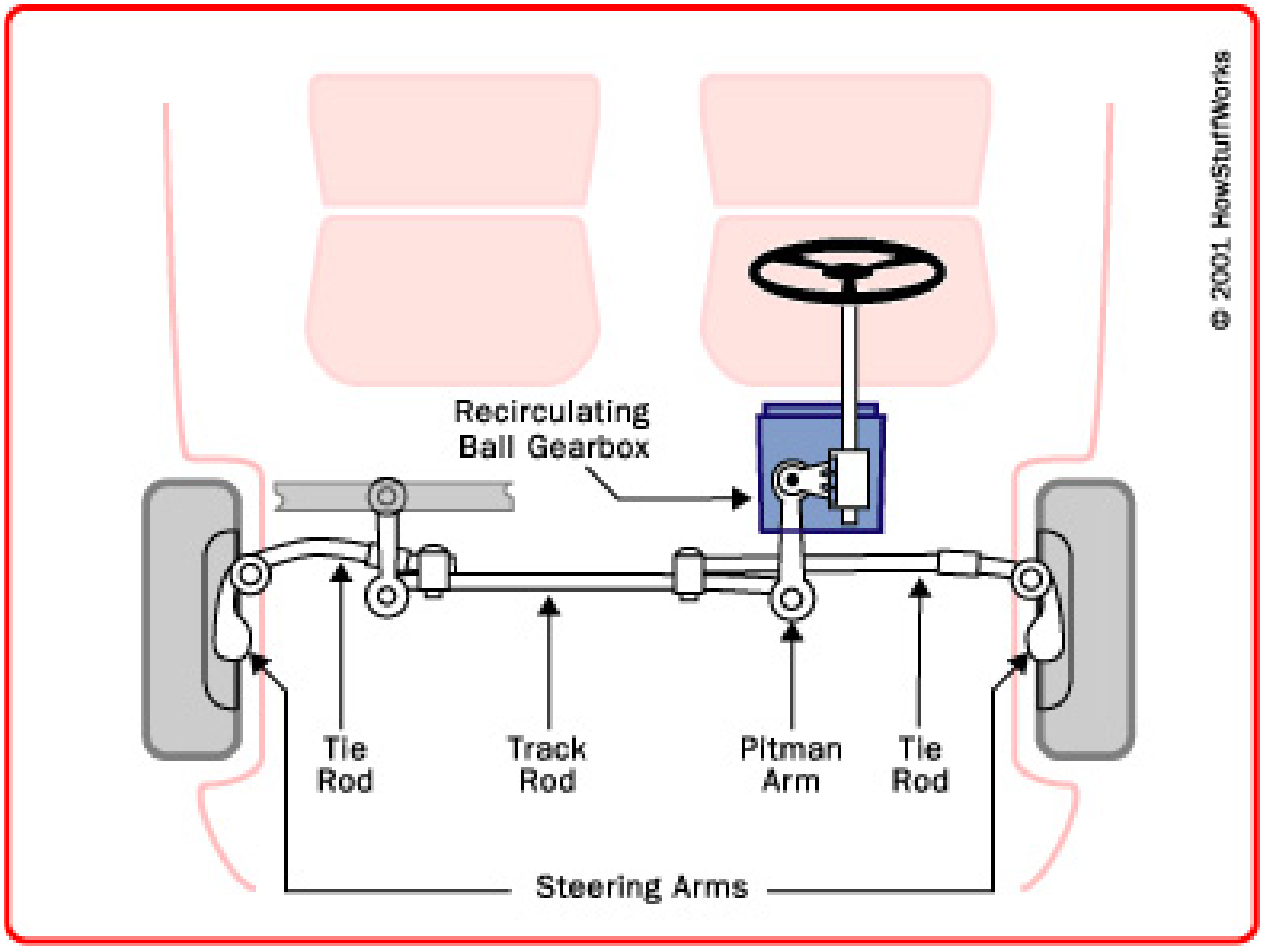
<u>Turning the Car</u> (when turning, front wheels don't point the same direction)



•Inside wheel turns at a smaller radius, hence the inside wheel turns at a steeper angle then the outside wheel.

Steering System

Linkage Steering System (Worm Gear)



Steering System

Linkage Steering System (Worm Gear) Parts

- **Steering Wheel** – used by the driver to rotate a steering shaft that passes through the steering column.

- **Steering Shaft –** transfers turning motion from the steering wheel to the steering gearbox.

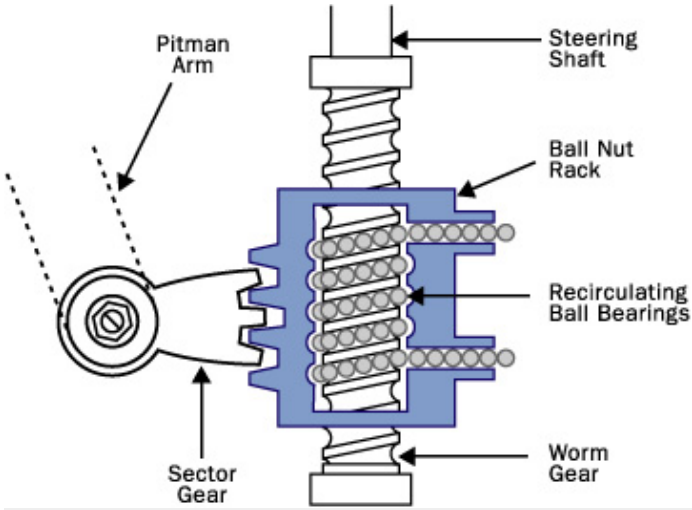
- **Steering Column –** supports the steering column and steering shaft.

Steering System

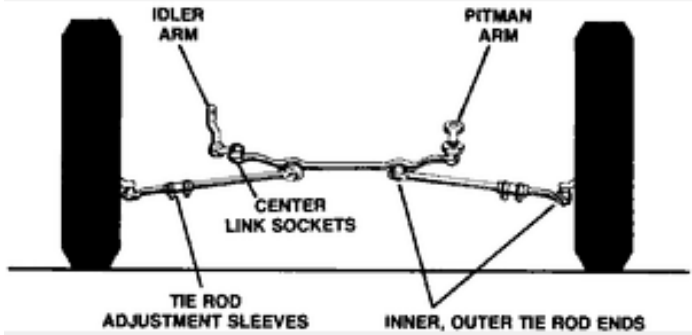
Linkage Steering System (Worm Gear) Parts

- **Steering Gearbox) –** changes turning motion into a straight-line motion to the left or right.

- Steering gear box ratios range from 15:1 to 24:1 (with 15:1, the worm gear turns 15 times to turn the selector shaft once).

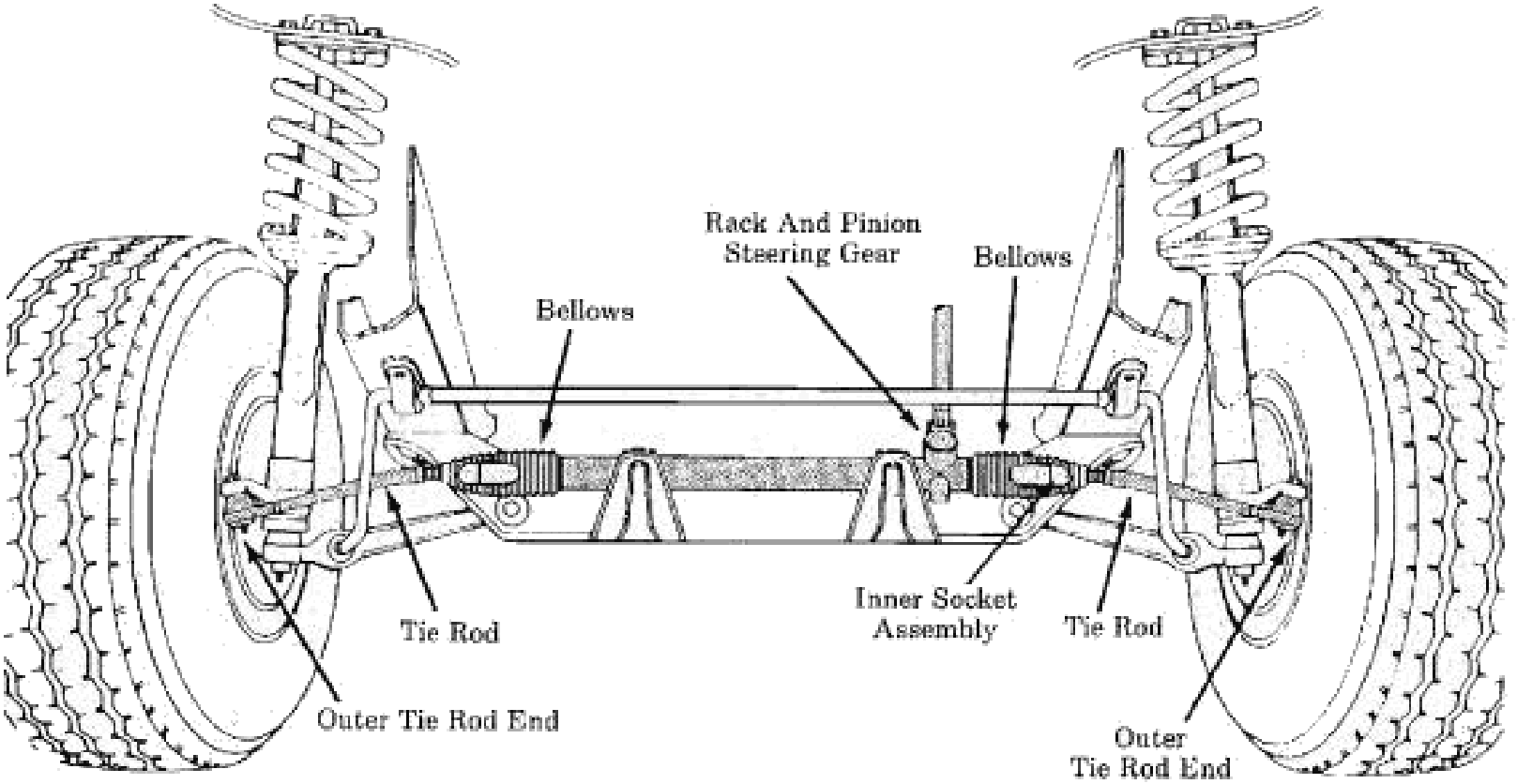


- **Steering linkage –** connects the steering gearbox to the steering knuckles and wheels.



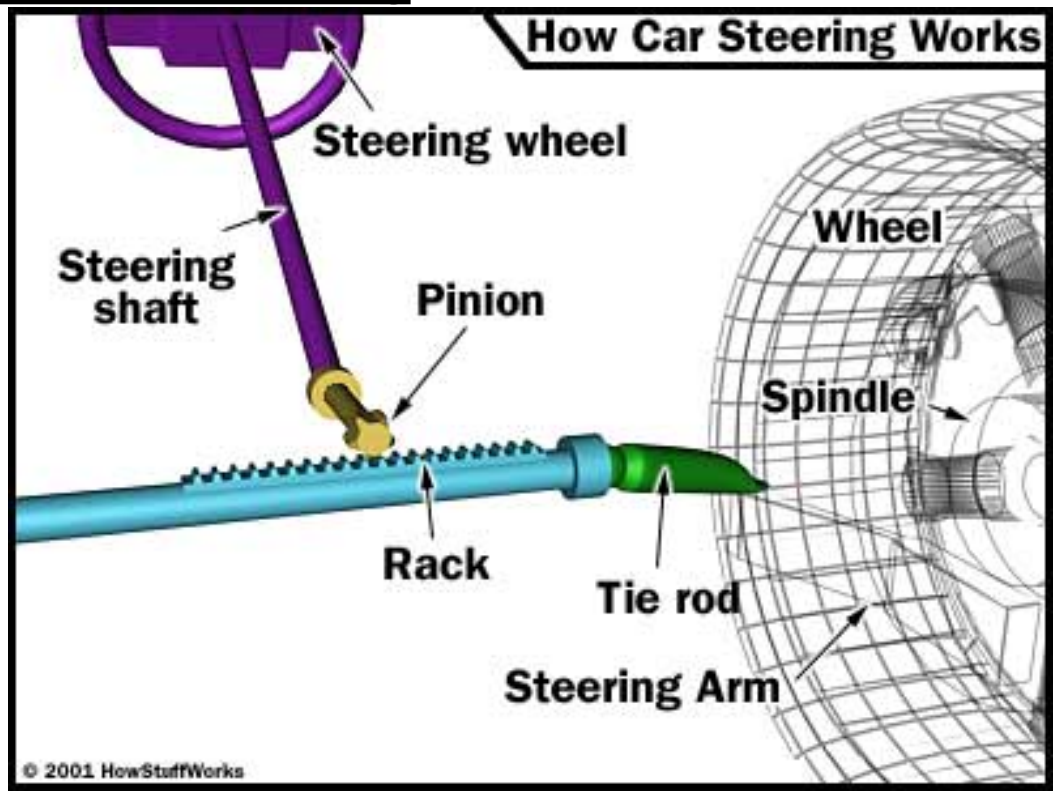
Steering System

Basic Rack-and-Pinion Steering



Steering System

Basic Rack-and-Pinion Steering



- **Pinion Gear-** rotated by the steering wheel and steering shaft; it's teeth mesh with the teeth on the rack.

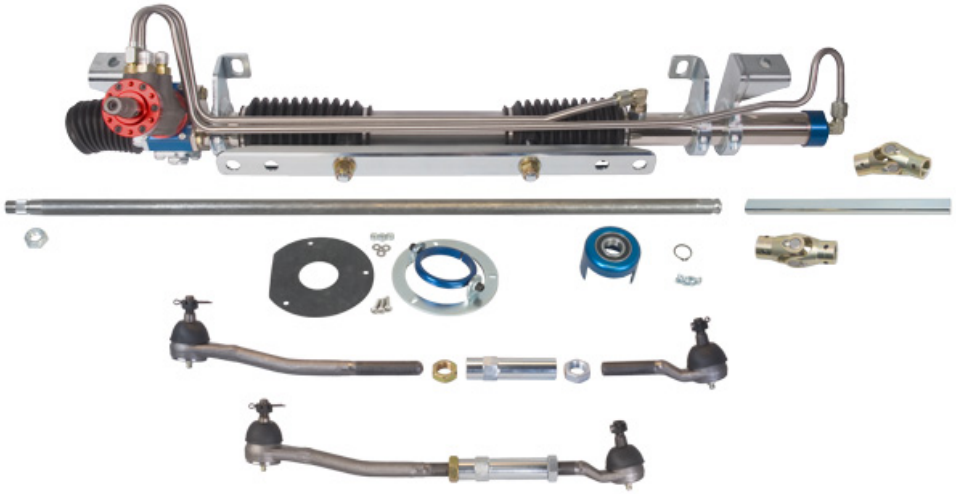
- **Rack-** long steel bar with teeth along one section; slides sideways as the pinion gear turns.

Steering System

Basic Rack-and-Pinion Steering

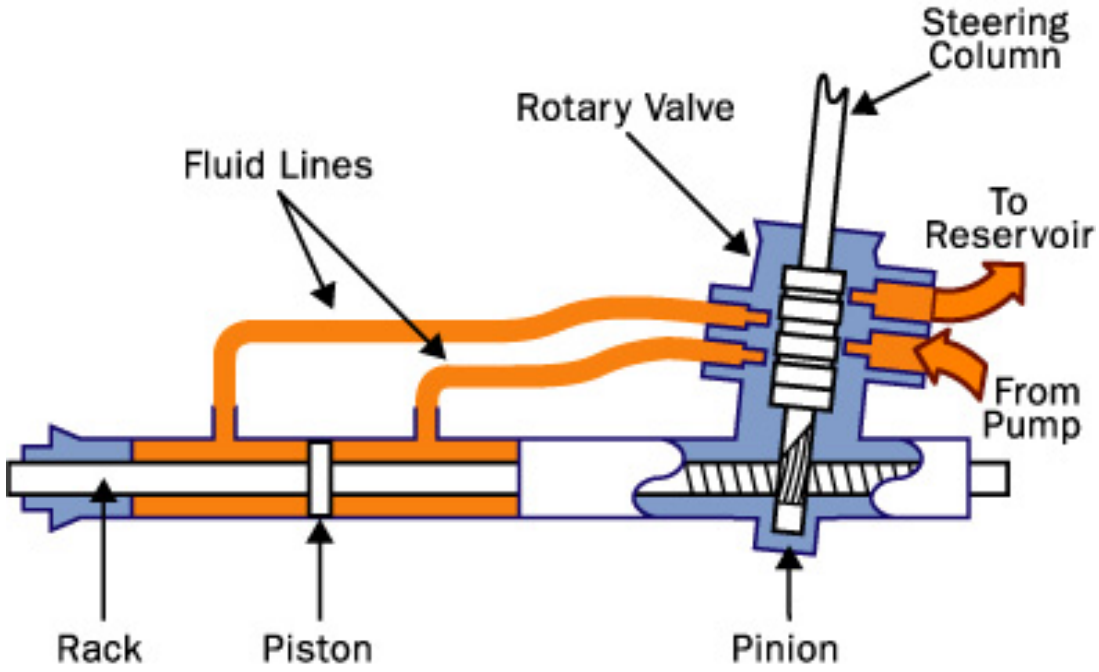
- **Gear Housing-** holds the pinion gear and rack.

- **Tie-rods-** connects the rack with steering knuckles.



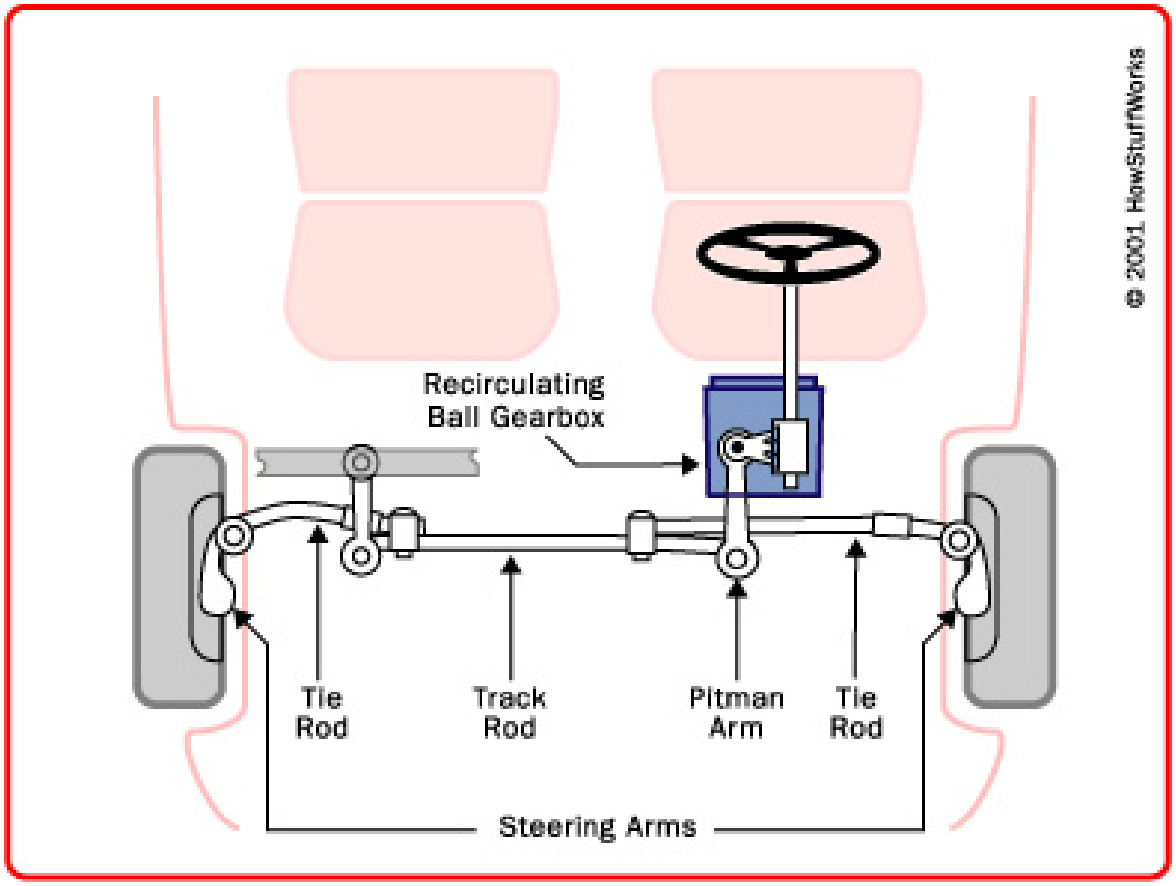
Steering System

Basic Rack-and-Pinion Steering



- Part of rack contains a piston
- Two fluid ports, one on each side.
- The side with high pressure pushes the piston to the opposite side (turning the wheel).

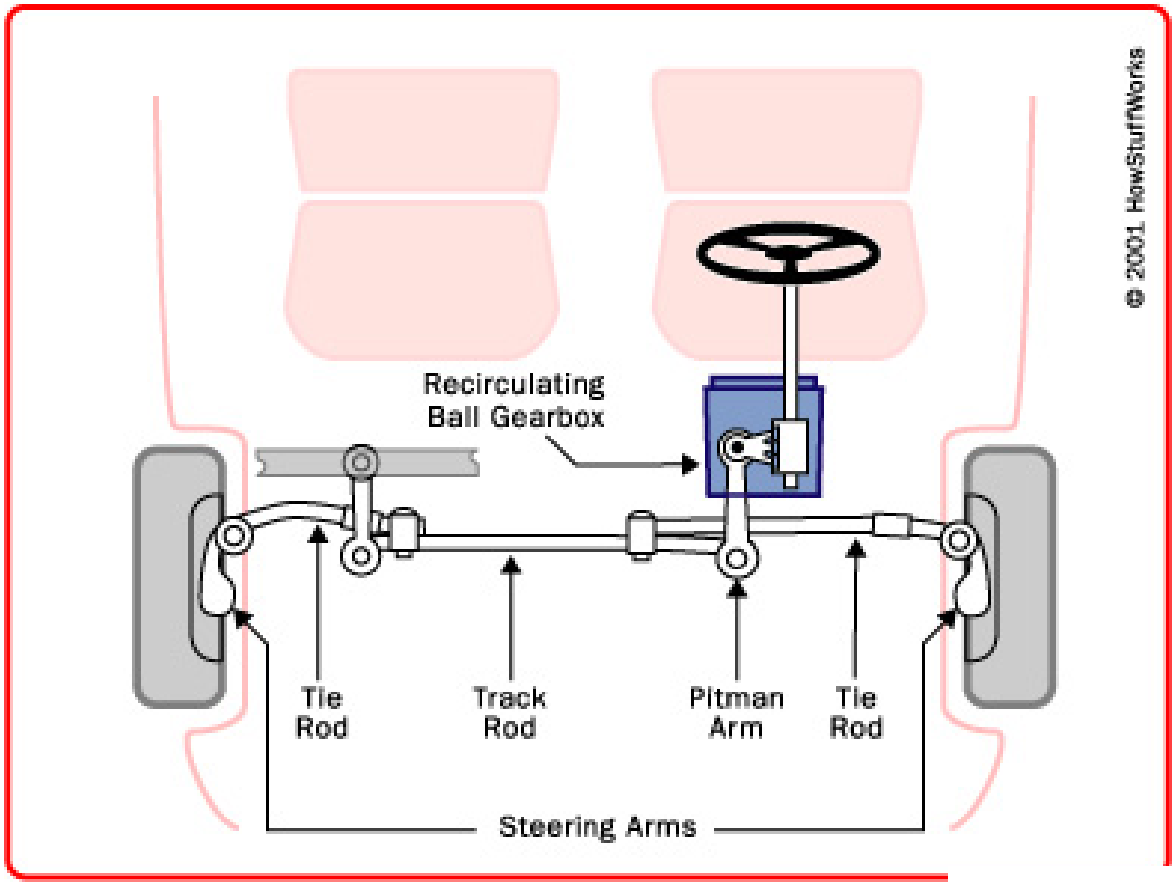
Steering Linkage



<u>Pitman Arm</u> transfers gearbox motion to the steering linkage.

•Pitman arm is splined to the gearbox.

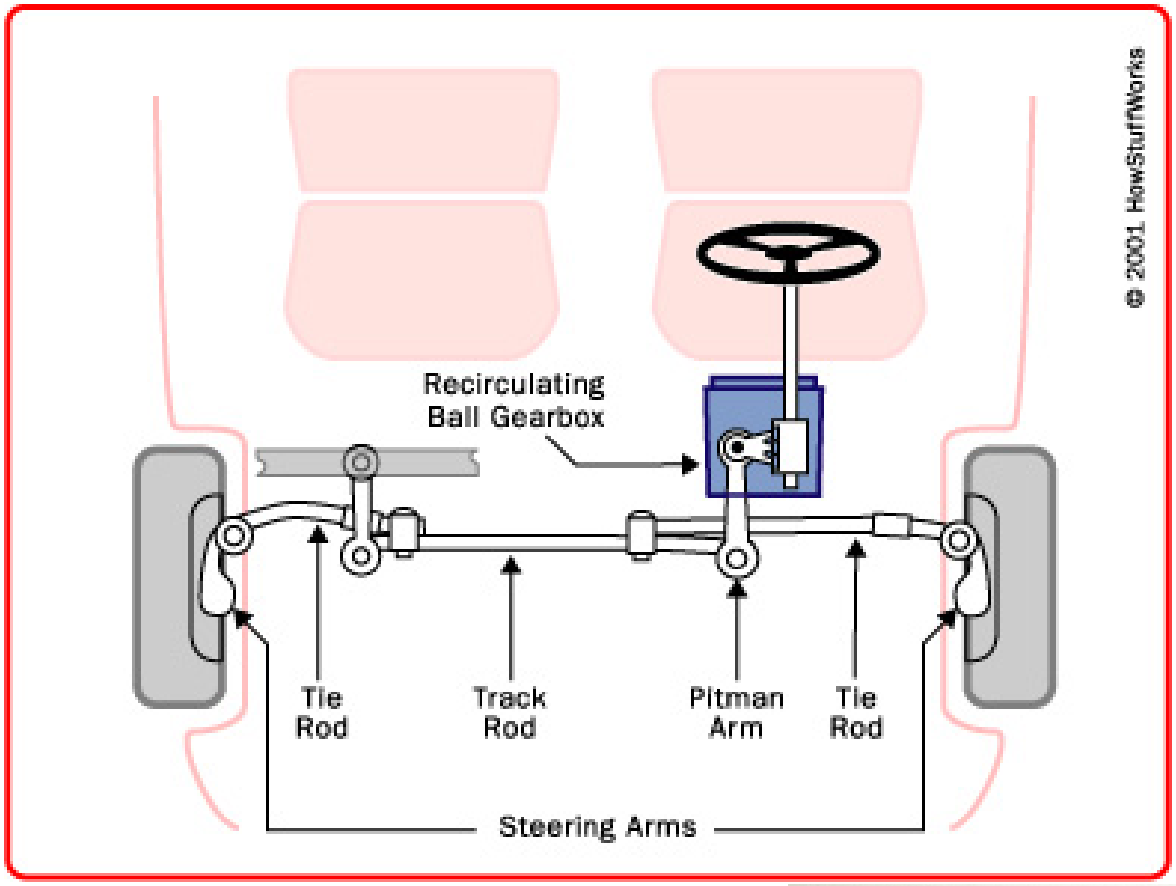
Steering Linkage



<u>Center Link (Relay Rod)</u> steel bar connects the right and left side of the steering linkage.

•Connects to Pitman arm, Tie rod ends, and Idler arm.

Steering Linkage

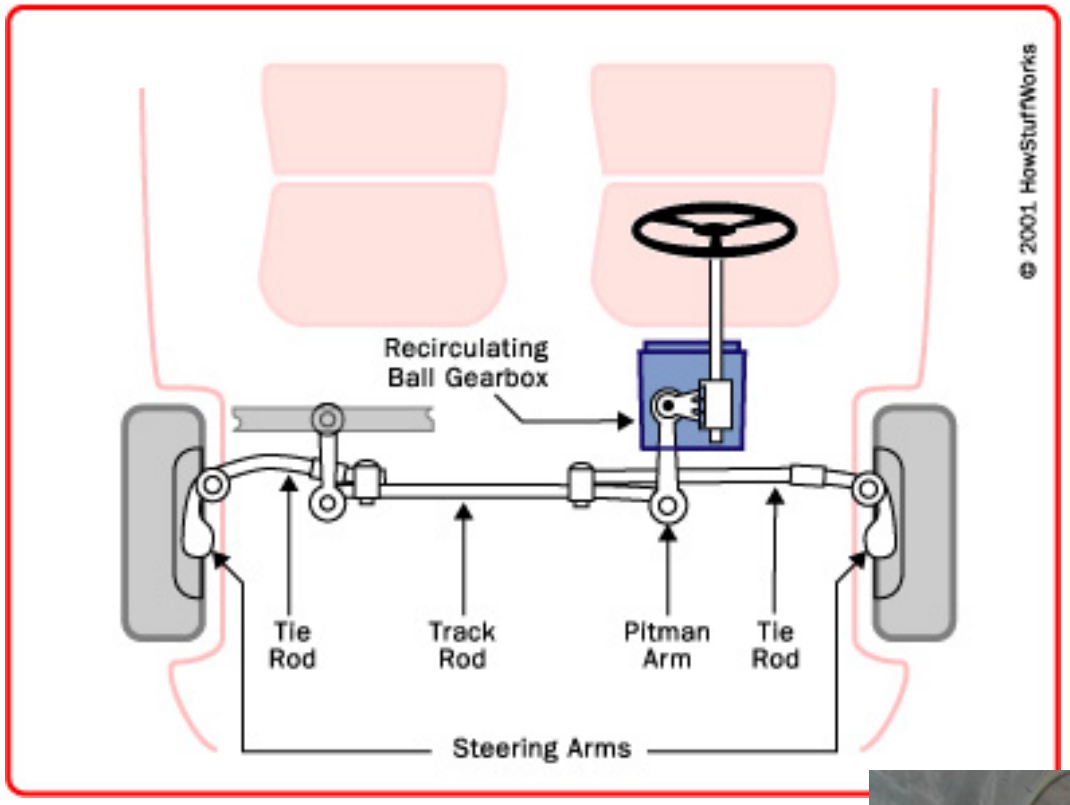


<u>Idler Arm</u> supports the end of the center link on the passenger side of the vehicle.

- Bolts to the vehicle's frame.

- If worn, will cause excessive steering play.

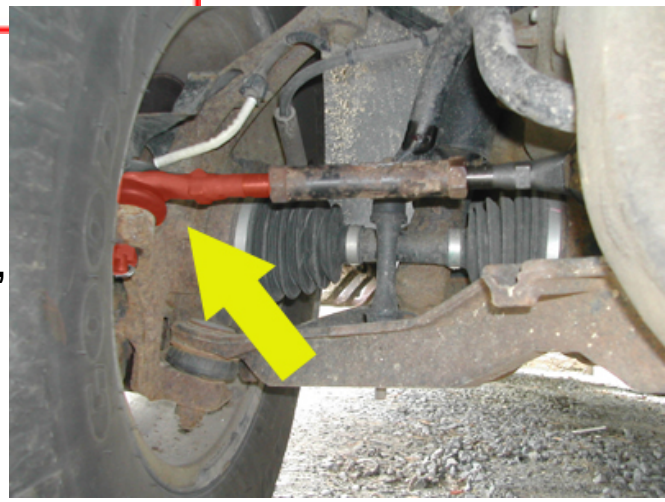
Steering Linkage



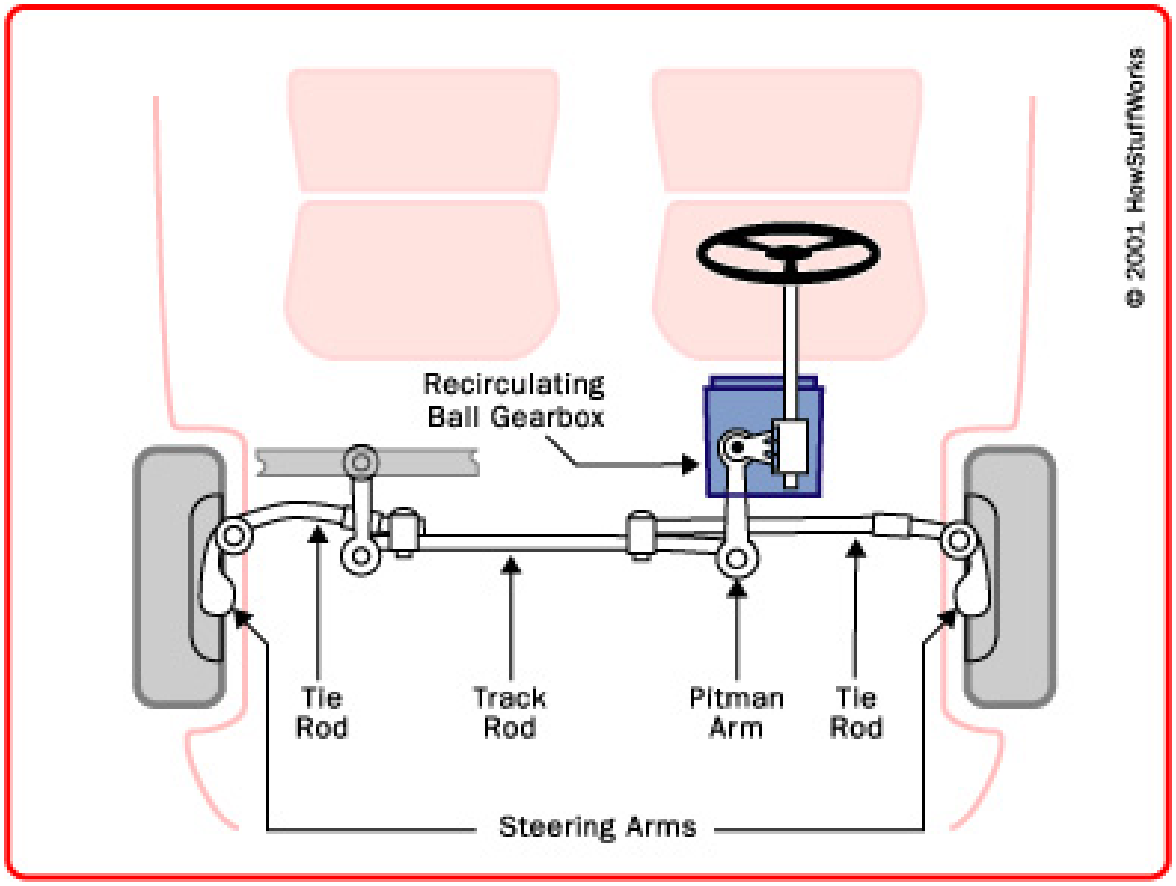
<u>Tie-Rod Assemblies</u>: Two tie-rod assemblies are used to fasten the center link to steering knuckles.

•Assembly is consist of inner tie-rod end, outer tie-rod end, and a toe adjustment sleeve.

•Be sure to check the toe setting after replacing the tie-rod ends.



Steering Linkage



Rack-and-pinion outer tie-rod end is similar to the regular tie-rod end, but the inner tie-rod end sits inside the rack assembly.

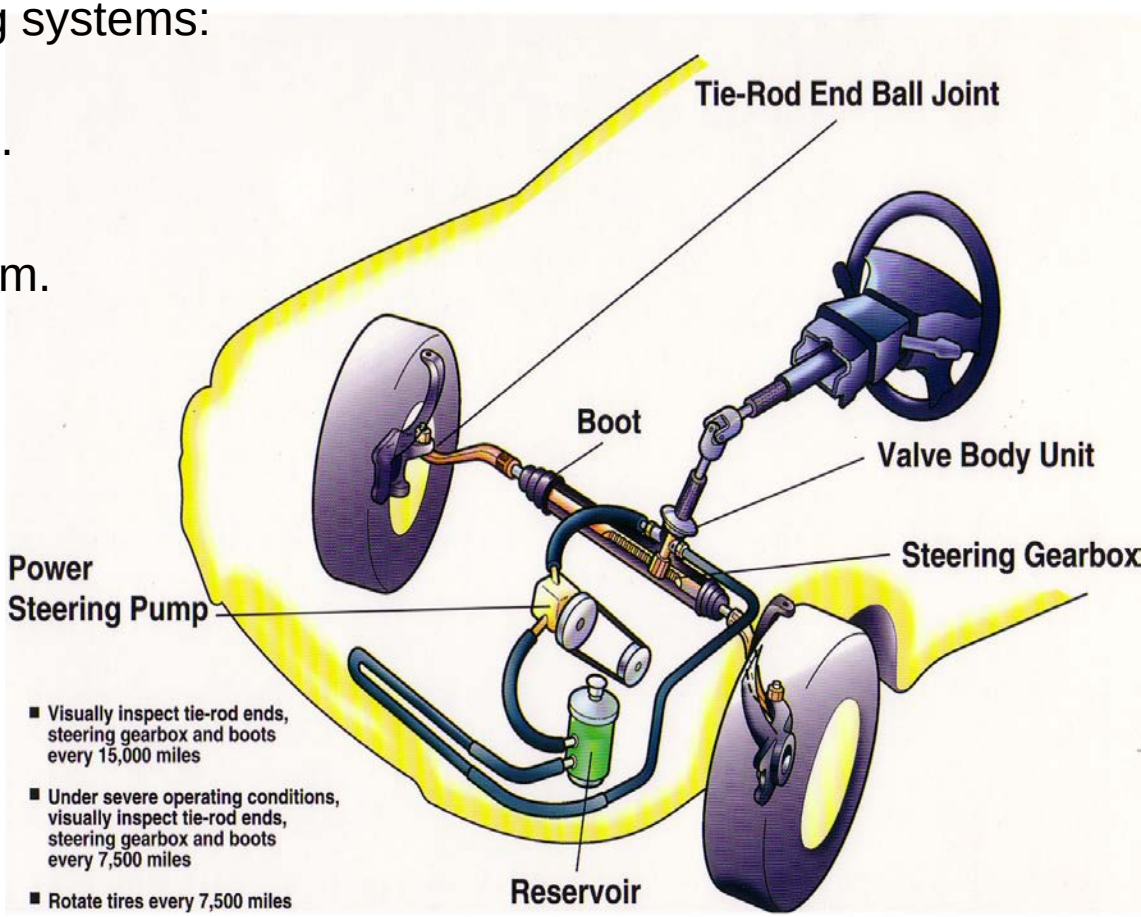
Steering System

Power Steering normally use an engine driven pump and a hydraulic system to assist steering action.

Three major types of power steering systems:

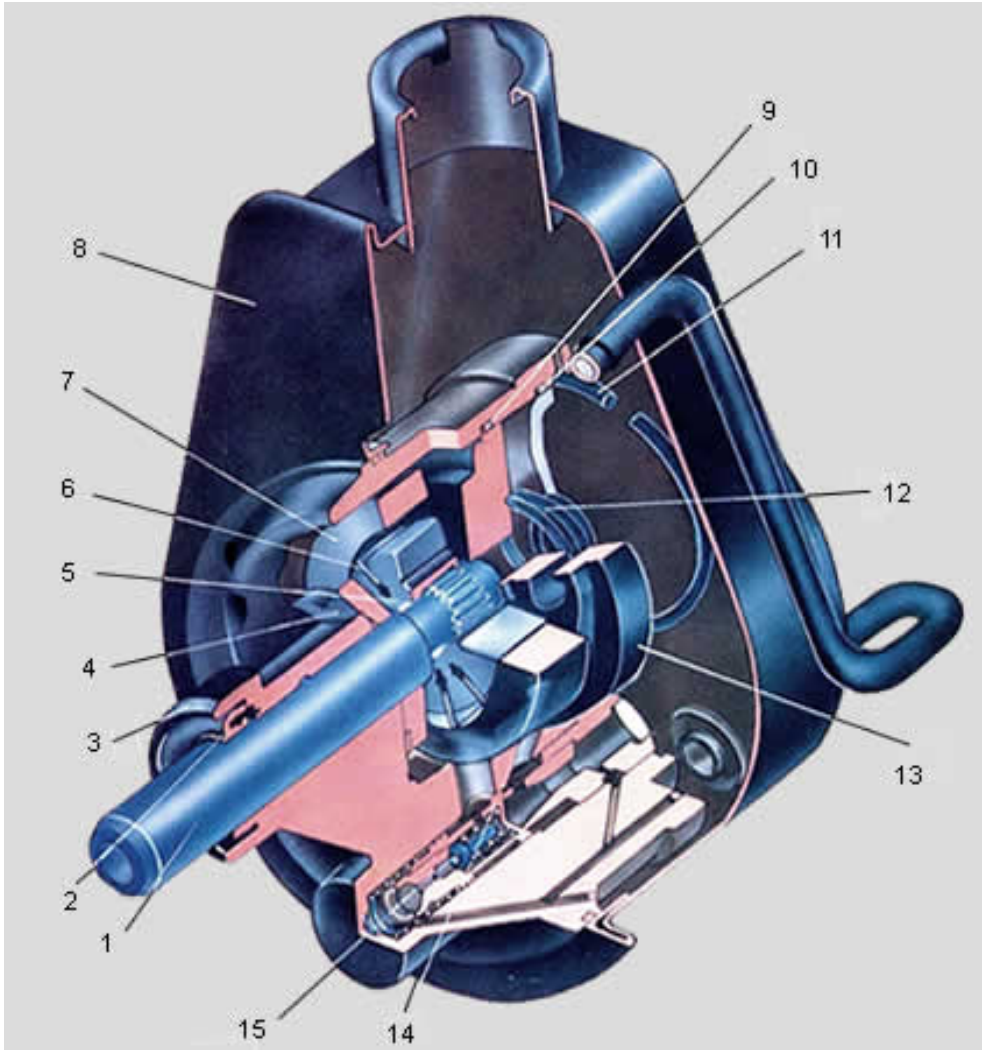
- Integral-piston linkage system.
- External power steering system.
- Rack-and-pinion system
  - Integral power piston.
  - External power piston.

Integral Rack-and-pinion system is the most common.



Steering System

Power steering pump is driven by the engine produces the hydraulic pressure for steering system operation.



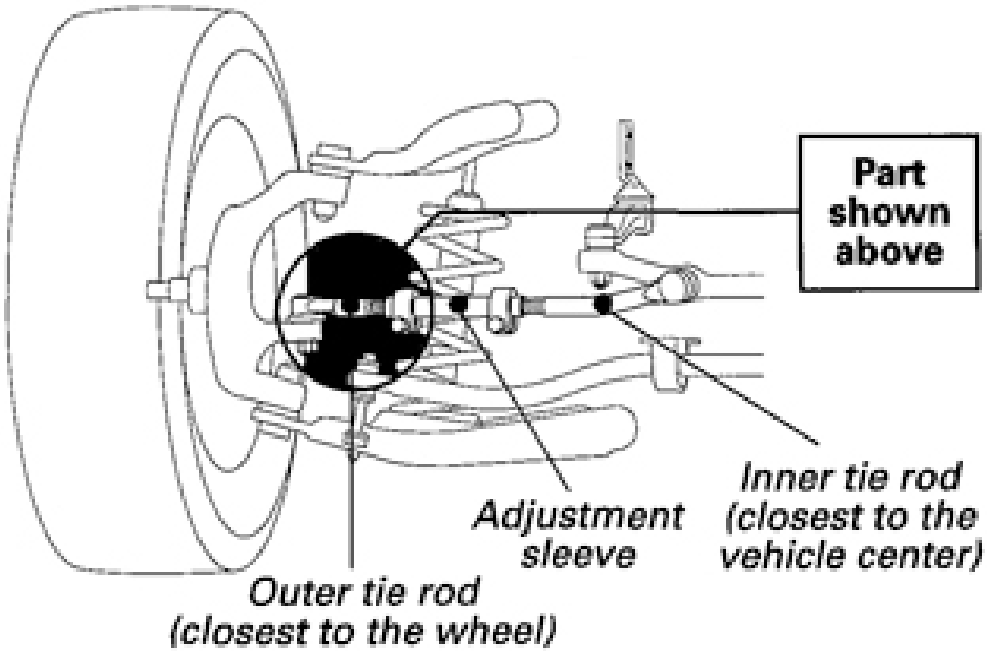
Four basic pumps:

- Roller pump.
- Vane pump.
- Slipper pump.
- Gear pump.

Steering System Diagnosis

<u>Steering Wheel Play</u> is the most common problem.

Should not be able to turn the steering wheel more than 1 ½" (33mm) without causing movement of the front wheels.



Move the wheel side-to-side, should have no play.

Steering System Diagnosis

Hard Steering (steering wheel requires excessive turning effort)

- Low power steering fluid.
- Pump belt broken or slipping.

Steering System Noise

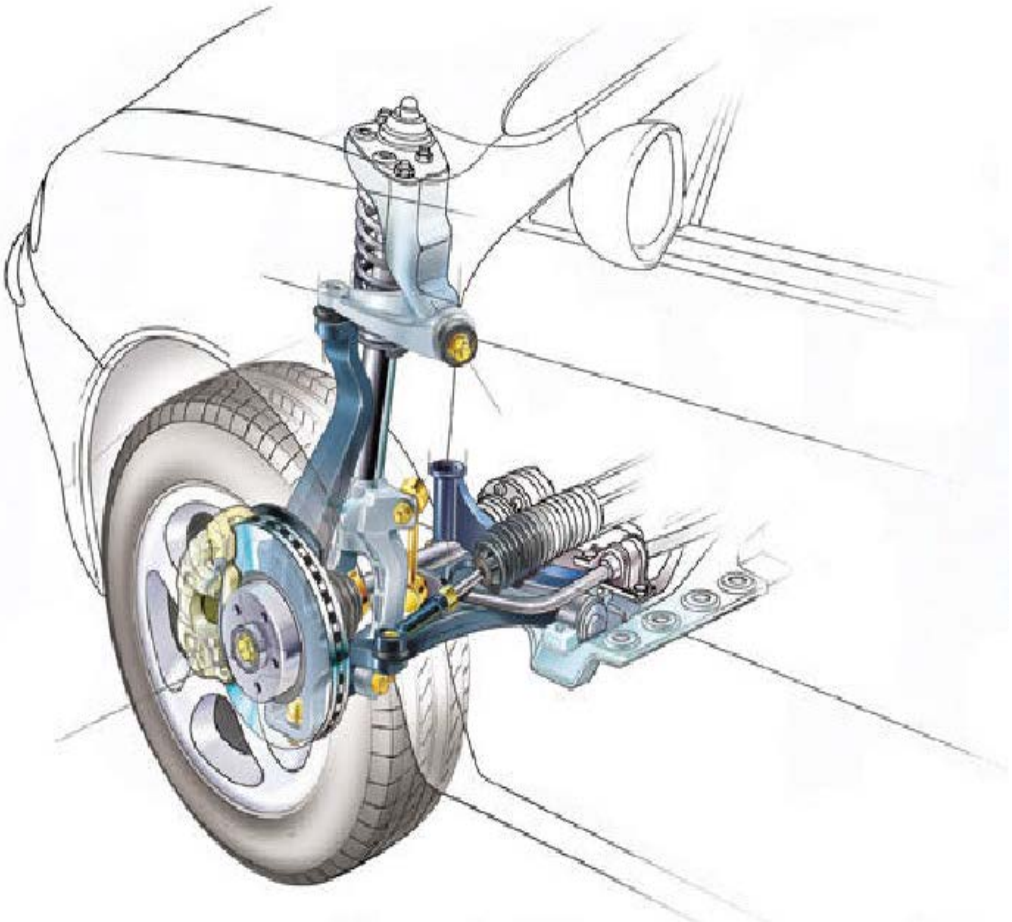
- *Belt squeal* is a loud screeching sound produced by a worn belt.
- *Power steering pump noise* is usually a loud whine that only occurs when the steering wheel is turned.
  - Low fluid level and air in the system.

Check fluid with engine turned off.

Steering System

Credits:
Google search engine

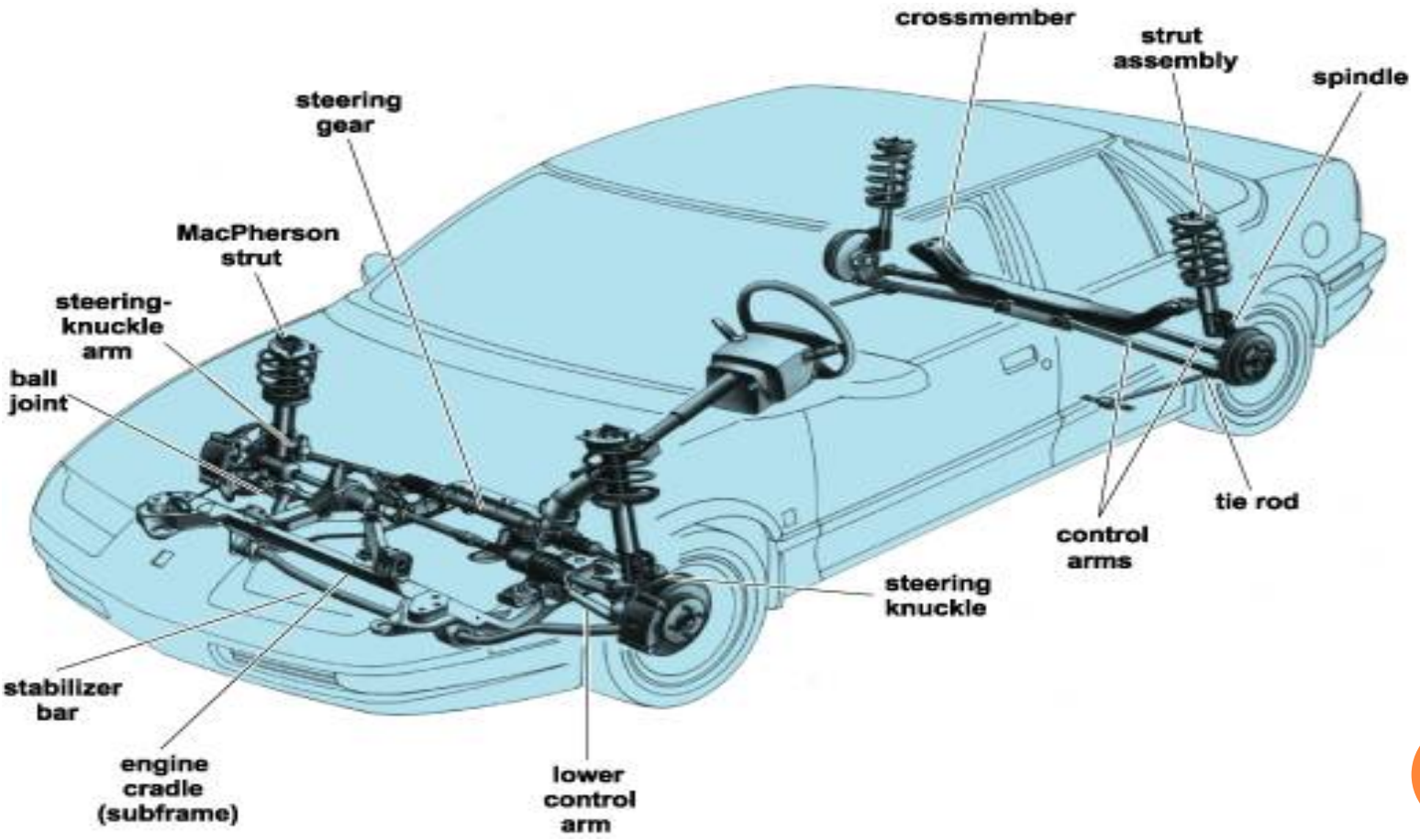
SUSPENSION SYSTEM IN AUTOMOBILES



What is suspension system

- **Suspension** is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels
- Serve a dual purpose – contributing to the car's handling and braking.
- Protects the vehicle itself and any cargo or luggage from damage and wear

SUSPENSION SYSTEM – LAY OUT



Different suspension systems

- Conventional suspension system
- Independent suspension system
- Air suspension system
- Hydro elastic suspension system

Conventional suspension system

- Two wheels are mounted on either side of the rigid axle
- When one wheel encounters the bump, both the wheel do not execute parallel up and down motion
- So it gives rise to gyroscopic effect and wheel wobble
- Rear driving wheels mounted on live axle suspended by laminated leaf springs and shock absorbers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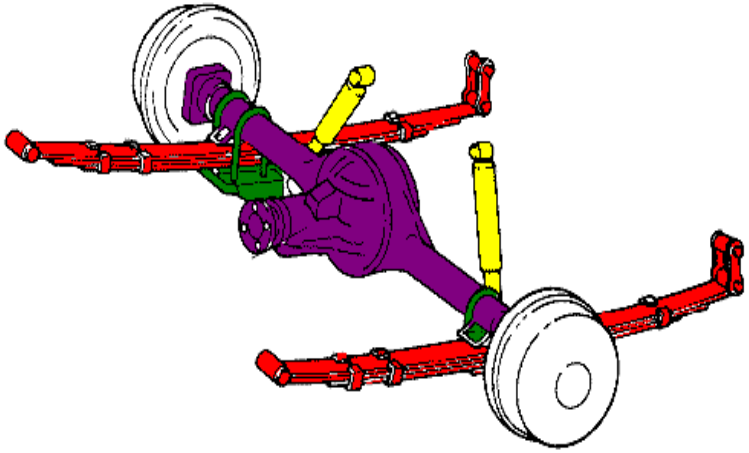
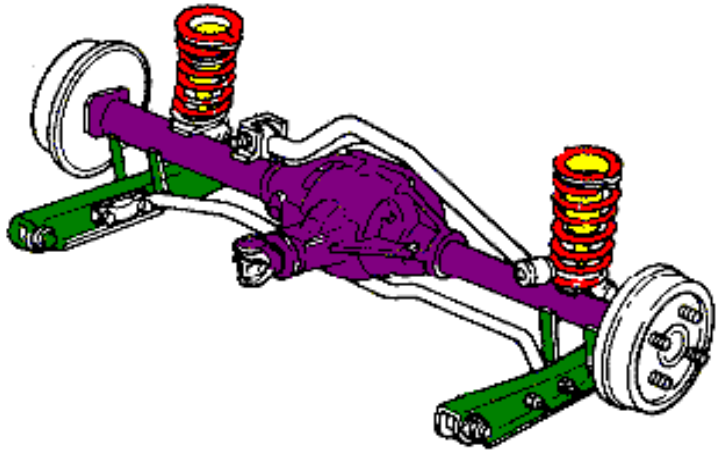




Independent suspension system

- Both the front and the rear wheel are utilized
- Design incorporated in the front wheels
- One wheel goes down ,the other wheel does not have much effect
- Basic classification of the design

1. **MacPherson Strut**
2. **Double Wishbone**
3. **Multi link**

MACPHERSON STRUT

- the most widely used front suspension system in cars
- comprises of a strut-type spring and shock absorber combo, which pivots on a ball joint on the single, lower arm.
- The steering gear is either connected directly to the lower shock absorber housing, or to an arm from the front or back of the spindle (in this case
- When you steer, it physically twists the strut and shock absorber housing (and consequently the spring) to turn the wheel

DOUBLE WISHBONE SUSPENSION

Type of *double-A* or *double wishbone* suspension

Wheel spindles are supported by an upper and lower 'A' shaped arm.

The lower arm carries most of the load.

If you look head-on at this type of system, parallelogram system that allows the spindles to travel vertically up and down.

This side-to-side motion is known as scrub

- Type of *double-A arm* suspension although the lower arm in these systems can sometimes be replaced with a single solid arm (as in my picture).
- The spring/shock combo is moved from between the arms to above the upper arm.
- This transfers the load-bearing capability of the suspension almost entirely to the upper arm and the spring mounts.
- The lower arm in this instance becomes a control arm.

Multi-link suspension

- It's currently being used in the Audi A8 and A4 amongst other cars.
- The basic principle of it is the same, but instead of solid upper and lower wishbones, each 'arm' of the wishbone is a separate item.
- These are joined at the top and bottom of the spindle thus forming the wishbone shape.
- The super-weird thing about this is that as the spindle turns for steering, it alters the geometry of the suspension by torquing all four suspension arms.
- Spring is separate from the schock absorber.

ADVANTAGES (INDEPENDENT FRONT)

- Bigger deflection of front wheels, no reaction on steering
- Greater distance for resisting rolling action
- Front axle (small-stub), improves road holding tendency of tyres.
- Minimum vibrations

DISADVANTAGES

- Better shock absorber required.
- Expensive
- Tyre wear increases due to transmission of torque.

ADVANTAGES (INDEPENDENT REAR SUSPENSION)

- Lesser unsprung weight – improves ride , reduces tyre wear.
- Increased passenger space
- Rear wheels remain stable ..

DISADVANTAGES

- Increased cost
- Complicated design
- Steering action is not proper

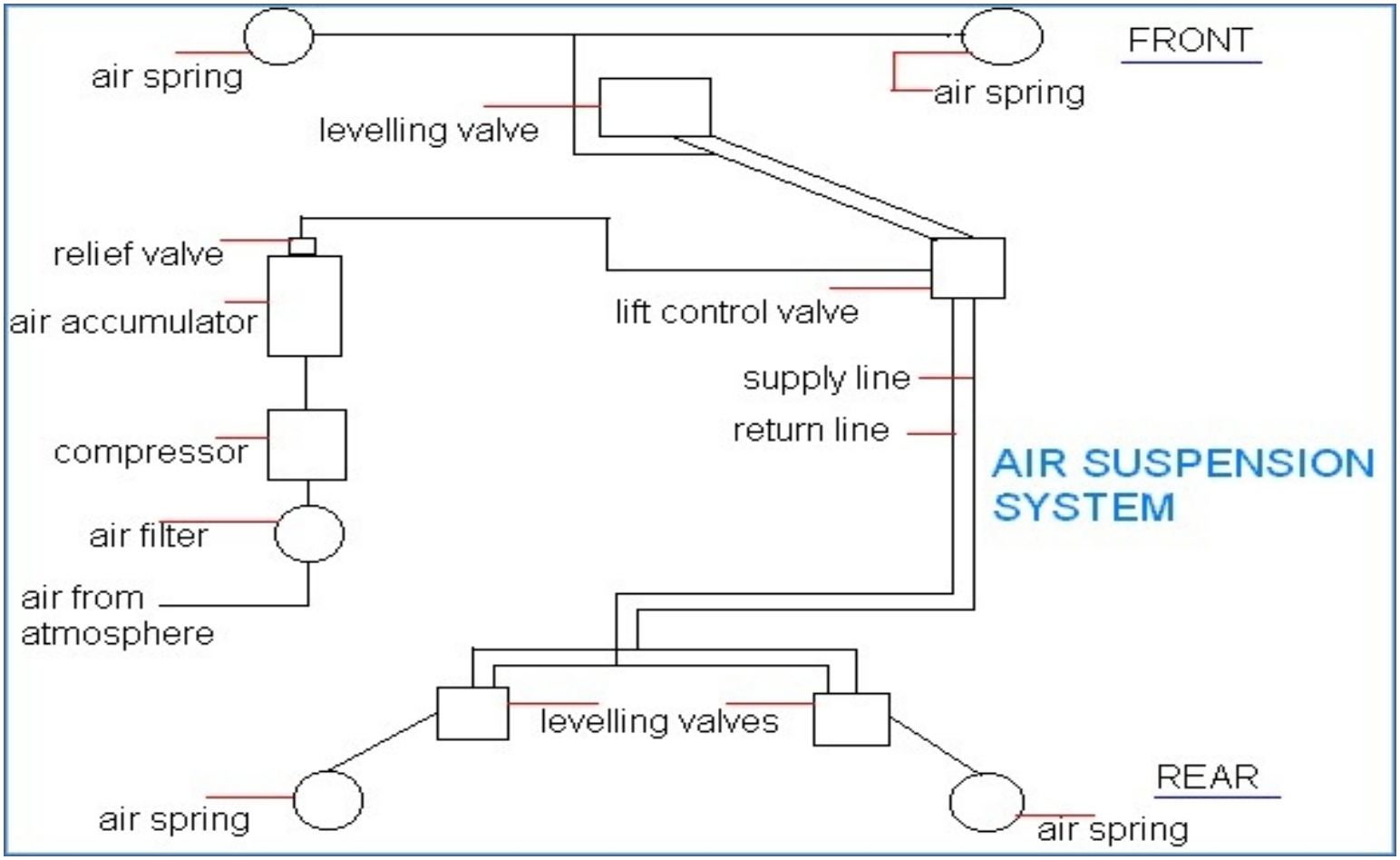
Traverse suspension system

- Normally find on the rear suspension
- Combines independent double wishbone suspension with a leaf spring.
- It involves one leaf spring mounted *across* the vehicle, connected at each end to the lower wishbone.
- The centre of the spring is connected to the front subframe in the middle of the car.
- There are still two shock absorbers, mounted one to each side on the lower wishbones.

Air suspension

- Comprises of compressor , suppling air to air tank
- Pressure maintained – 5.6 to 7 kg/sq.m
- Air bags – on each wheel
- As load applied , air bags compressed actuating the levelling valve .
- Air from the tank fills the compressrd air bag & hence raise the level of the frame.
- Air from air bag gets released as load on chassis decreases .

AIR SUSPENSION LAYOUT



Advantages of air suspension

- These maintain a constant frequency of vibration whether the vehicle is laden or unladen.
- Constant frame height is maintained.
- It helps to reduce the load while the vehicle in motion i.e. the dynamic loading as the spring rate variation between laden and unladen weight is much less.
- It gives smooth and comfort ride of the vehicle.
- The stiffness of the system increases with the increase of the deflection.

Common Air Suspension Problems

- **Air bag or air strut failure**

  - due to old age, or moisture within the air system that damages them from the inside.

- **Compressor failure**

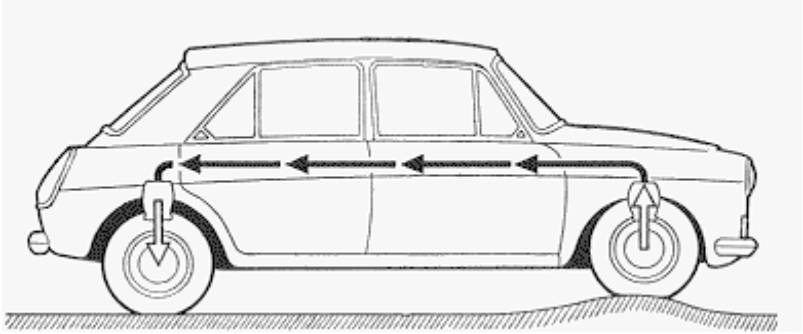
  - Primarily due to leaking air springs or air struts

  - Compressor burnout may also be caused by moisture from within the air system coming into contact with its electronic parts.

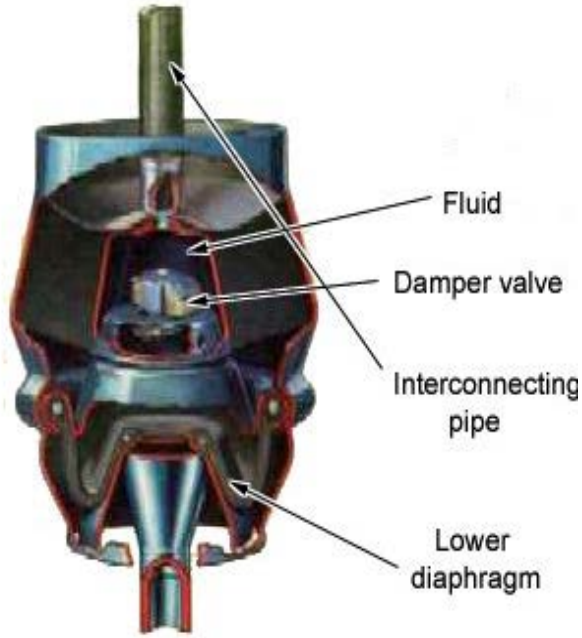
- **Dryer failure**

  - which functions to remove moisture from the air system eventually becomes saturated and unable to perform that function

Hydrolastic Suspension



- a system where the front and rear suspension systems were connected together in order to better level the car when driving.
- The front and rear suspension units have Hydrolastic displacers, one per side.
- These are interconnected by a small bore pipe. Each displacer incorporates a rubber spring
- Damping of the system is achieved by rubber valves.



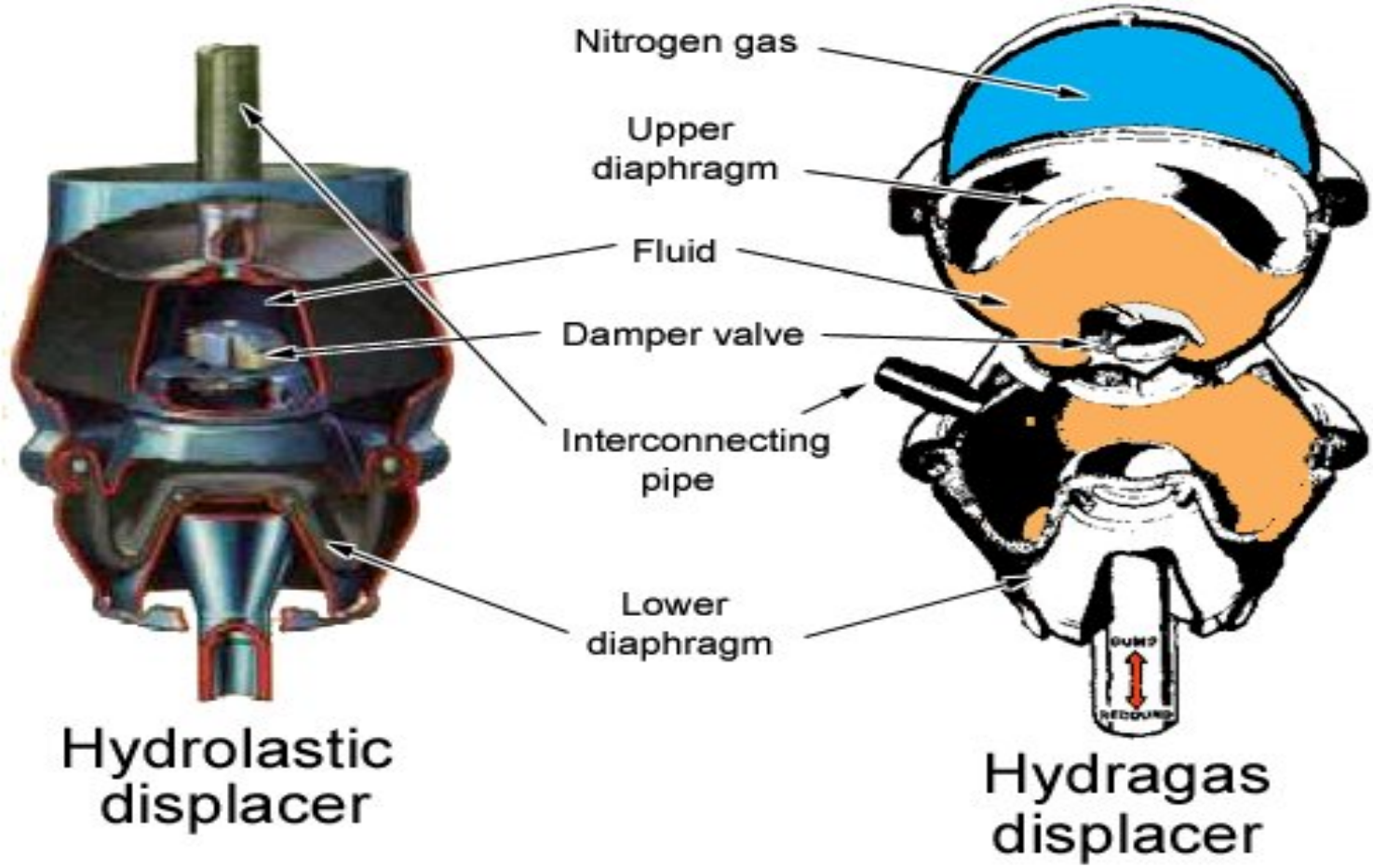
Hydrolastic displacer

- when the front wheel encounter bumps ,the piston moves upwards pressurising the fluid to enter into the rear unit.
- Hydroelastic was eventually refined into Hydragas suspension.....

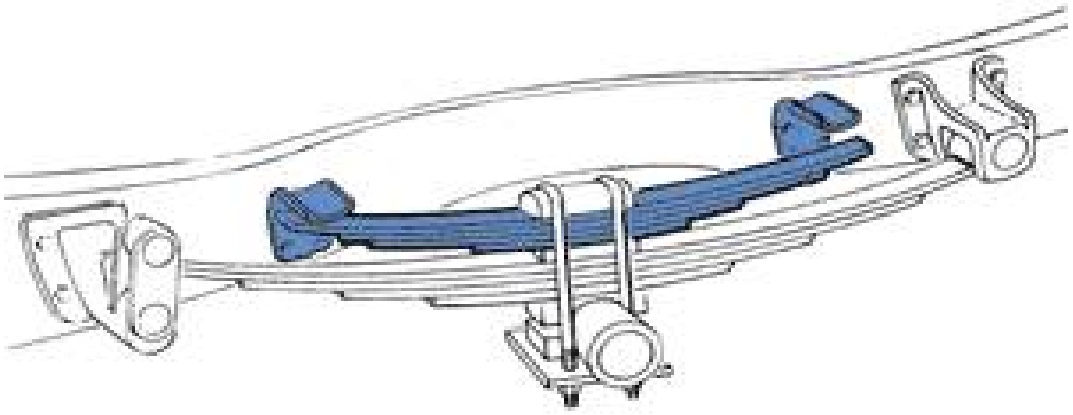
HYDROGAS SUSPENSION

- Known as hydro-pneumatic suspension.
- The difference is in the displacer unit itself.
- In the older systems, fluid was used in the displacer units with a rubber spring cushion built-in.
- With Hydragas, the rubber spring is removed completely.
- The fluid still exists but above the fluid there is now a separating membrane or diaphragm, and above that is a cylinder or sphere which is charged with nitrogen gas.
- The nitrogen section is what has become the spring and damping unit whilst the fluid is still free to run from the front to the rear units and back.

Difference …

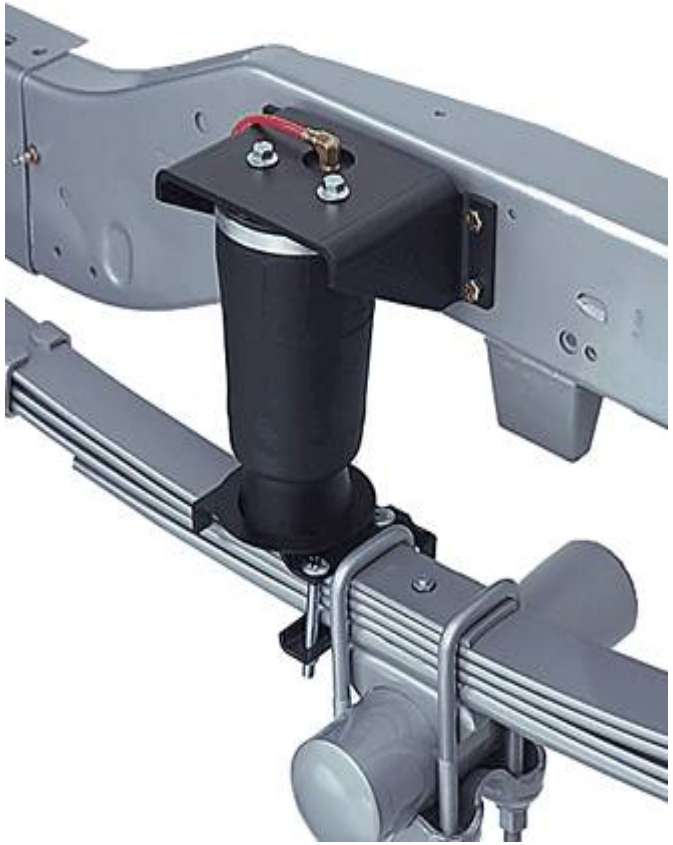

Nitrogen gas
Upper diaphragm
Fluid
Damper valve
Interconnecting pipe
Lower diaphragm
Hydrolastic displacer
Hydragas displacer

HELPER SPRING

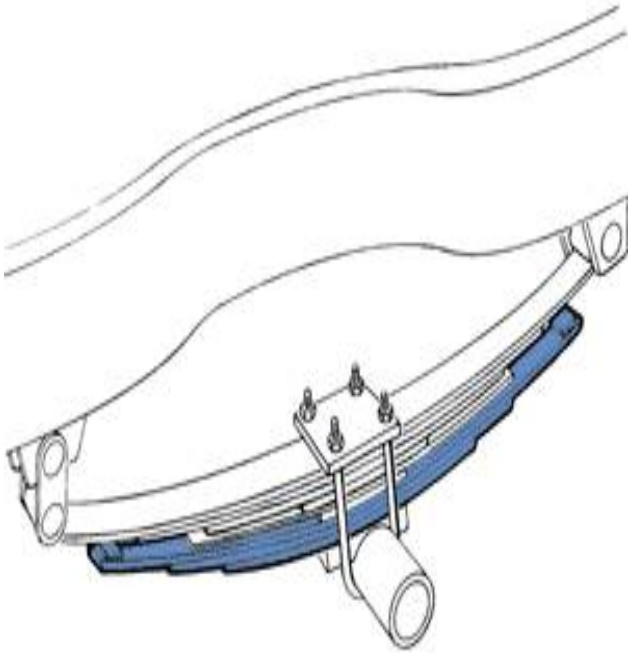


- DIRECTLY MOUNTED ON MAIN SPRINGS
- TAKE CARE OF LARGE VARIATION IN SPRING LOAD
- DURING LIGHT LOADS ,ONLY MAIN SPIRNG IS ACTIVE , AS LOAD INCREASE TO A PARTICULAR FIXED VALUE , BOTH THE SPRINGS ARE ACTIVE

AIR ASSISTED HELPER SPRING



LEAF HELPER SPRING



THANK YOU !!!