AUTOMOTIVE SYSTEM & HEAVY EQUIPMENTS

NILASAILA INSTITUTE OF SCIENCE & TECHNOLOGY

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(Approved by AICTE, Govt. of Odisha and affiliated to SCTE&VT, Odisha)

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AUTOMOTIVE SYSTEM & HEAVY EQUIPMENTS

SEMESTER:- 6TH **BRANCH:-** AUTOMOBILE ENGG.

THEORY:- 2

CHAPTERS:

1. FRONT AXLE
2. STEERING & STEERING GEOMETRY
3. SUSPENSION SYSTEM
4. BRAKE SYSTEM
5. WHEEL & TYRES
6. CHASSIS & HEAVY EQUIPMENTS

STATE COUNCIL FOR TECHNICAL EDUCATION & VOCATIONAL TRAINING, ODISHA, BHUBANESWAR

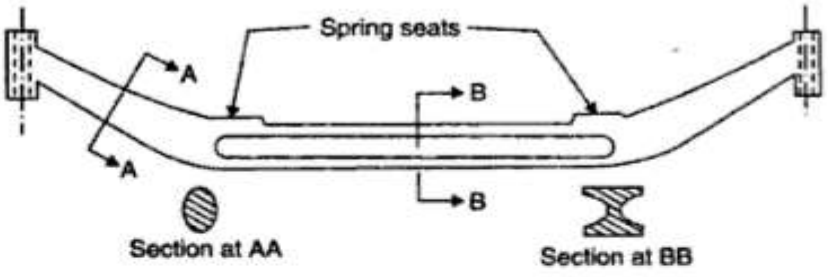
CHAPTER-1: FRONT AXLE

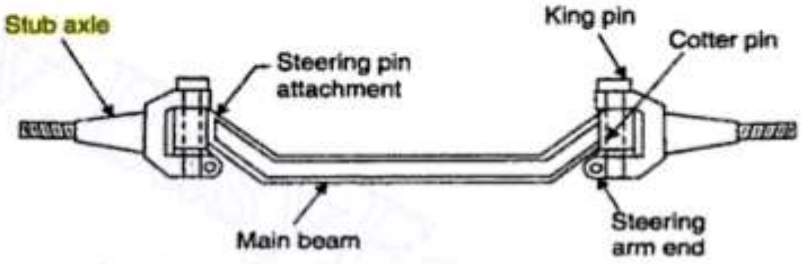
INTRODUCTION

- Front axle carries the weight of the front part of the automobile as well as facilitates steering and absorbs shocks due to road surface variations.
- The front axles are generally **dead axles**, but are **live axles** in small cars of compact designs and also in case of four-wheel drive.
- The front axle is designed to transmit the weight of the automobile from the springs to the front wheels, turning right or left as required.
- To prevent interference due to front engine location, and for providing greater stability and safety at high speeds by lowering the centre of gravity of the road vehicles, the entire centre portion of the axle is dropped.
- **A live front axle** contains the differential mechanism through which the engine power flows towards the front wheels.
- For steering the front wheels, constant velocity joints are contained in the axle half shafts.
- Without affecting the power flow through the half shafts, these joints help in turning the stub axles around the king-pin.

Front wheels of the vehicle are mounted on front axles.

- It supports the weight of front part of the vehicle.
- It facilitates steering.
- It absorbs shocks which are transmitted due to road surface irregularities.
- It absorbs torque applied on it due to braking of vehicle.





AXLE

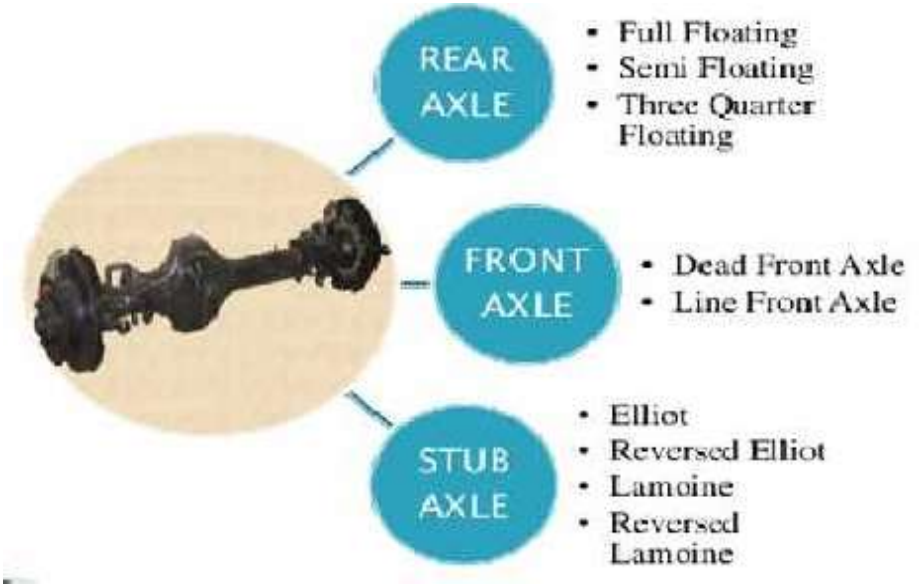
- Axles are also an essential component of an automobile. There are two types of axles: The one which transmits power to the wheel is known as live axle and the one which does not transfer any power and acts like a beam is known as a dead axle
- Axles are an important component of a car. All cars have two main axles in it: front axle and dead axle. Apart from this, there is a stub axle which is not found in every car. Axles are a kind of shaft which freely rotates on its desired axes, the axes connecting centers of opposite side of wheels. Axles are used to rotate the wheels of a car. Sometimes, other mechanical components are also mounted on axles.

DEAD AXLE

- Dead axles are those axles, which do not rotate
- These axles have sufficient rigidity and strength to take the weight.
- The ends of front axle are suitably designed to accommodate stub axles**.**

LIVE AXLE

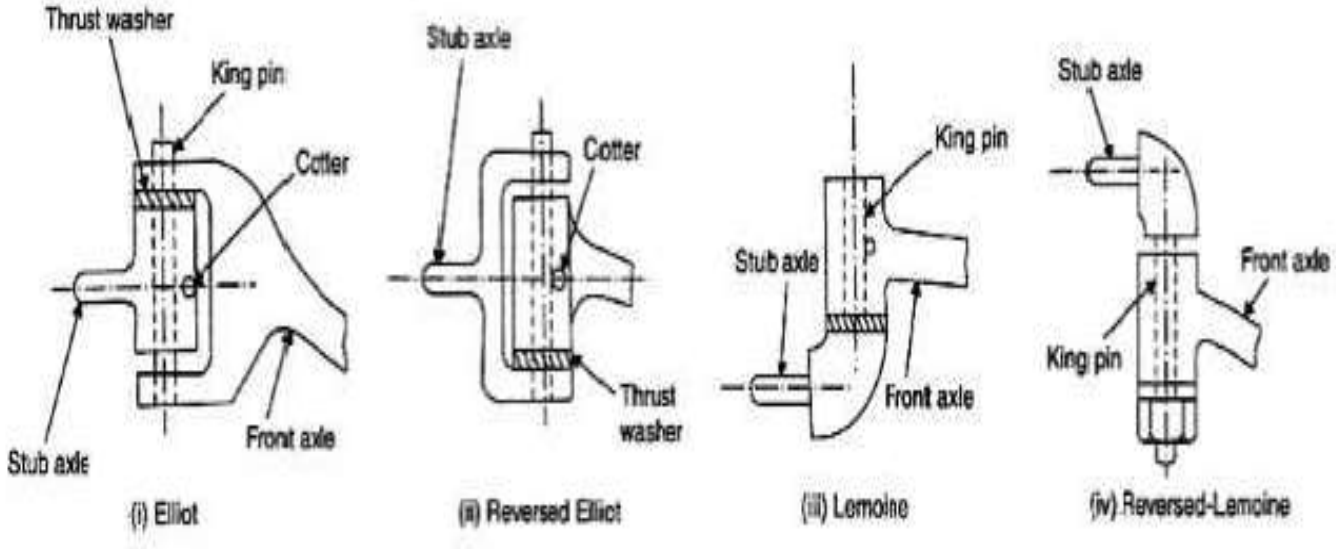
- Live axle transmits power to wheels coming from the differential. Or a mechanical engineer will call it a'prime mover'.
- The live axle is in a two half axles both of which are combined with a differential using the universal joint. Each half of a joint is connected to its corresponding wheels using constant velocity joint (CV). The role of CV joint is to facilitate vertical as well as pivot motions of a wheel assembly.



TYPES OF AXLE

TYPES OF STUB AXLES

- Elliot
- Reversed Elliot (Most commonly used)
- Lamoine
- Reversed lamonine



TYPES OF STUB AXLE

ELLIOT STUB AXLE

- In this type the axle is a single rigid 'I' shaped beam with a provision to fit the stub axle at its two ends. The end of the axle is Elliot shaped (U-shaped) with two eyes.
- The stub axle is mounted in between the two eyes with a thrust bearing at the top end of the stub axle

Reversed Elliot stub axle

- In reversed elliot type stub axle the arrangement is reversed. The axle beam is mounted in between the two eyes of the stub axle with a thrust washer at the bottom of the axle.
- It is commonly used in vehicle because of the following reasons.
  - It is easier to manufacture
  - Load exerted by the stub axle is equally distributed
  - Due to equally distributed load steering load steering is easy.

Lemoine type stub axle

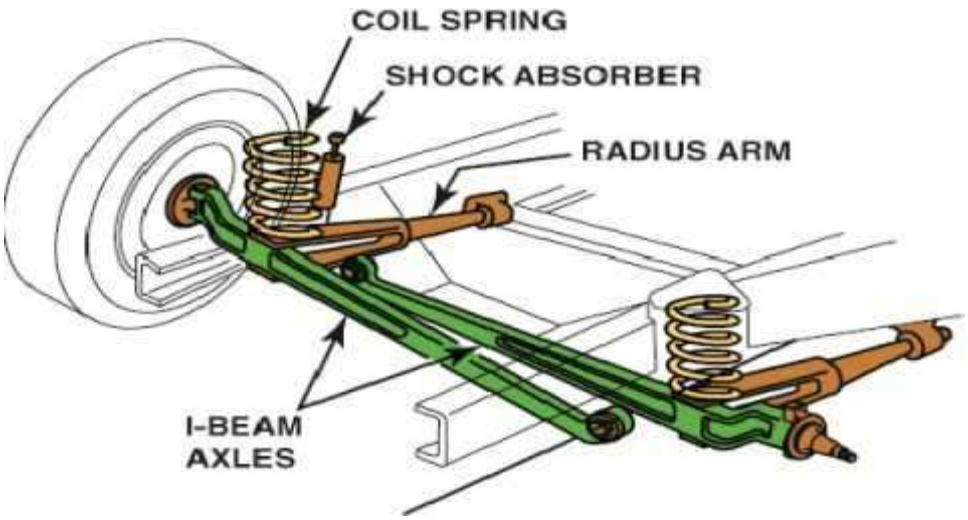
- In this type, instead of a yoke type hinge, an L-shaped. Spindle is attached to the end of the axle by means of a pivot.
- The stub axle is mounted on the bottom of the axle beam. It is used in tractors.

Reversed Lemoine type stub axle

- In this type of stub axle, the arrangement is reversed. Hence the stub axle is mounted on the top of the axle beam

Front Axle Construction

- The axle beam in use is of I or H-section and is manufactured from alloy forged steel for rigidity and strength.
- As compared to dead front axles, a totally different type of swiveling mechanism is used on the live front axle.
- To connect the wheel hub axles with driving axle shafts, constant velocity joints are used for the vehicles fitted with the front live axles.
- Tracta, Rzeppa (or Sheppa) on Bendix constant velocity or universal joints are normally used.



Loading

- Front axles are subjected to both bending and shear stresses.
- In the static condition, the axle may be considered as a beam supported vertically upward at the ends i.e. at the centre of the wheels and loaded vertically downward at the centres of the spring pads.
- The vertical bending moment thus caused is zero at the point of support and rises linearly to a maximum at the point of loading and then remains constant.
- Thus the maximum bending moment = Wl, Nm

  Where, W = The load on one wheel, N

  I = the distance between the centre of wheel and the spring pad, m

Front wheel assembly

• The wheel revolves over two ball bearings, which can be adjusted by means of an adjusting nut.

• Oil seals are provided to prevent the leakage of lubricant from the bearings.

• In modern cares, even the king pin has been replaced by ball joints at the ends of the stub axle.

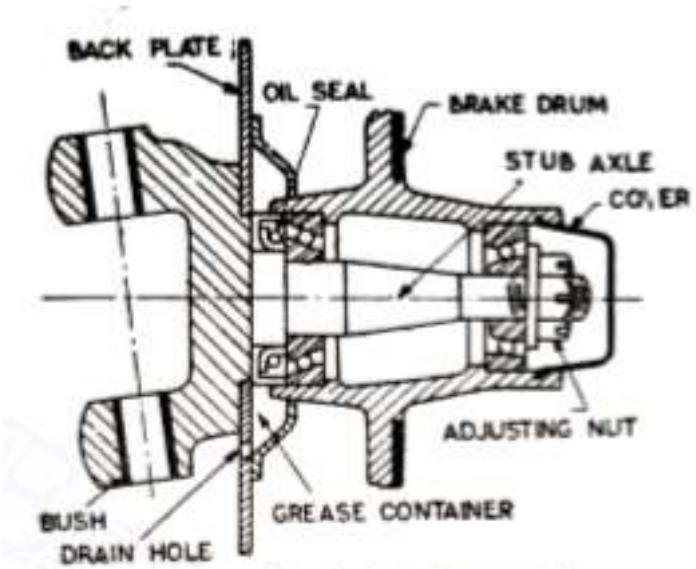
• The front wheel bearing have to withstand

a. The weight of the vehicle

b. Side thrust and tendency of the wheel to tilt when cornering

c. Shock loads due to uneven road surfaces.

• Generally, the ball bearings of semi-thrust type are use, but today most manufacturers prefer roller bearings.



Front wheel-stub axle assembly.

CHAPTER-2: STEERING & STEERING GEOMETRY

Primary Function: To achieve angular motion of the front wheels to negotiate turn.

Secondary Functions:

a) To provide directional stability of the vehicle when going straight ahead
b) To provide perfect steering condition (perfect rolling motion of the wheels at all times)
c) To facilitate straight ahead recovery after completing a turn.
d) To minimize tyre wear.

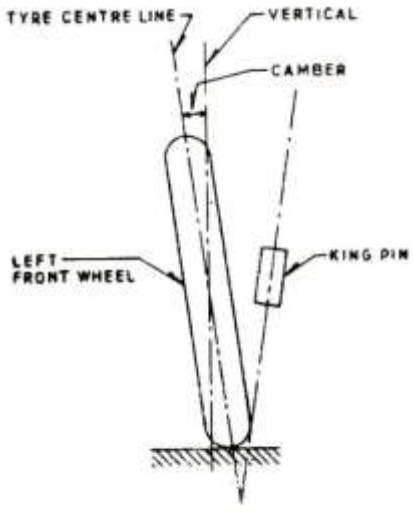
Requirements of Good Steering System:

1) The steering mechanism should be very accurate and easy to handle
2) The effort required to steer should be minimal and must not be tiresome to the driver
3) The steering mechanism should also provide directional stability.
4)

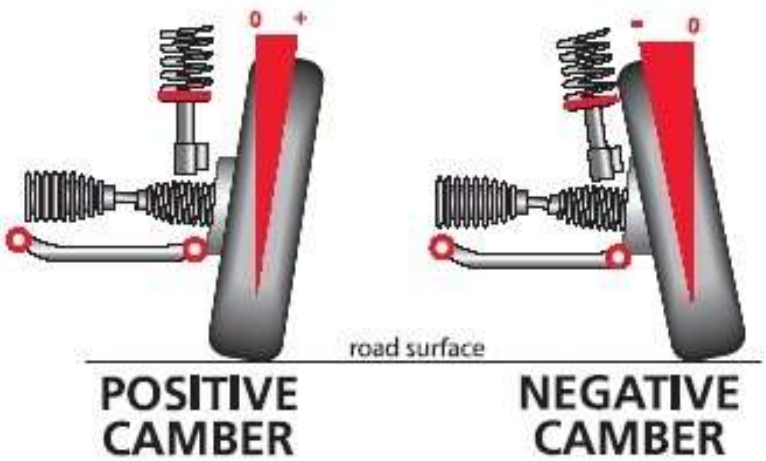
Steering Geometry:

Camber: Camber is the tilt of the car wheels from the vertical.

- Camber is positive if the tilt is outward at the top.
- Camber is also called 'Wheel rake"



Camber.

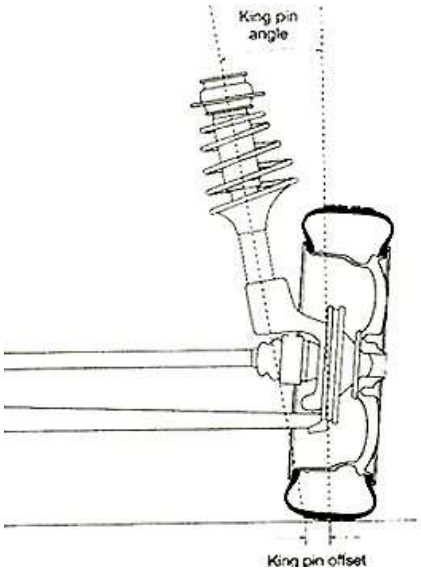


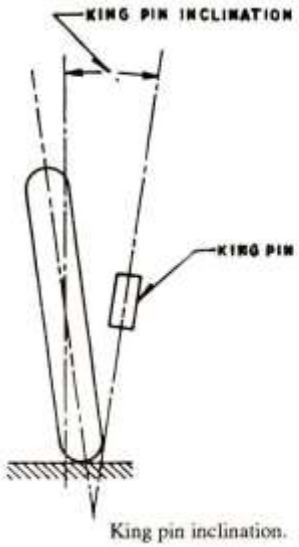
Effect of Camber:

- Bending stresses in the king-pin and stub axle are reduced
- Steering effort is greatly reduced
- Shock loads are not transmitted to the steering wheel at high vehicle speeds.
- Equal camber on both the wheels tend to reduce rattles in the steering linkage and imparts directional stability
- The cambered wheels have different rolling radii at different points on the tyre tread and so the wheels tend to roll like a truncated cone. The shoulders have to carry the vertical load and therefore scrub laterally on the road surface. This action causes wear of the tyre on one side only.
- Amount : Should not generally exceed 2^0

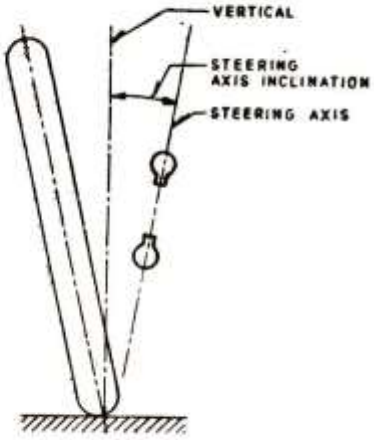
King pin Inclination (Steering Axis inclination) –

- Inclination of the king pin from vertical is called the king pin inclination or king pin rake.
- If ball joints are used, the inclination of the ball joint axis from the vertical is called as steering axis inclination.





King pin inclination.



Steering Axis inclination.

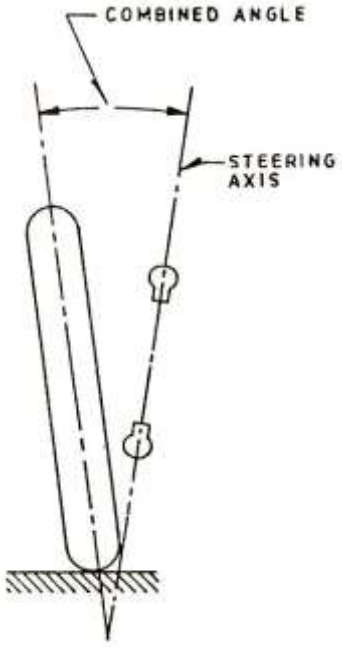
Effect of KPI: (about 7 to 8 degrees)

- KPI provide direction stability.
- During cornering this inclination raises the vehicle. Such an action exerts a force which tends the wheels to straighten up automatically after the turn has been negotiated.
- The tractive force acting along king pin axis and road resistance at the point of tyre contact with ground forms a couple if there is kingpin offset.

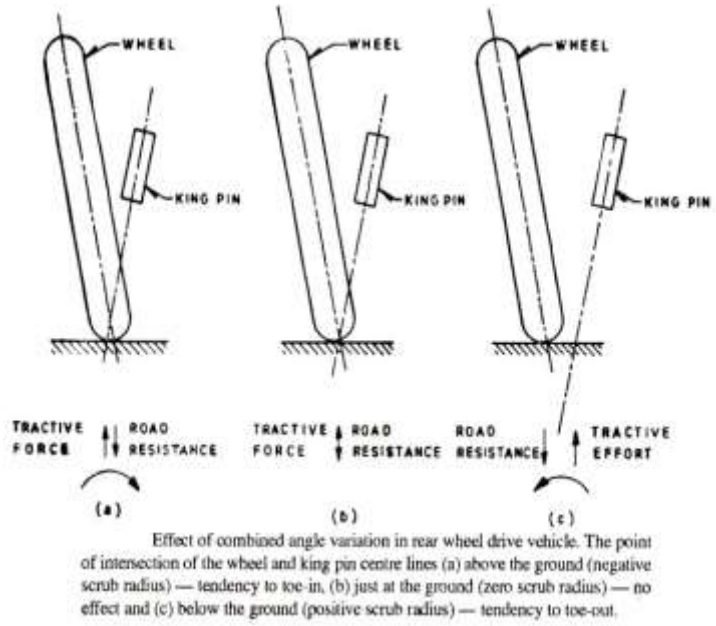
- If the point of intersection of kingpin axis and tyre axis is above the ground, the wheel tends to toe-out.
- If this point meets the road surface, the wheel retains straight position, i.e. the condition for centre point steering is reached.
- If the point of intersection is below the road surface, the wheel tends to toe-in
- During Centre point steering condition, the changes in length of springs causes the point of intersection to move alternatively above or below the road surface. This is called as wheel wander.

Combined Angle:

➢ It is the angle formed in the vertical plane between the wheel centre line and the king pin centre line or steering axis. (is equal to camber + king pin inclination or steering axis inclination).



Combined Angle.



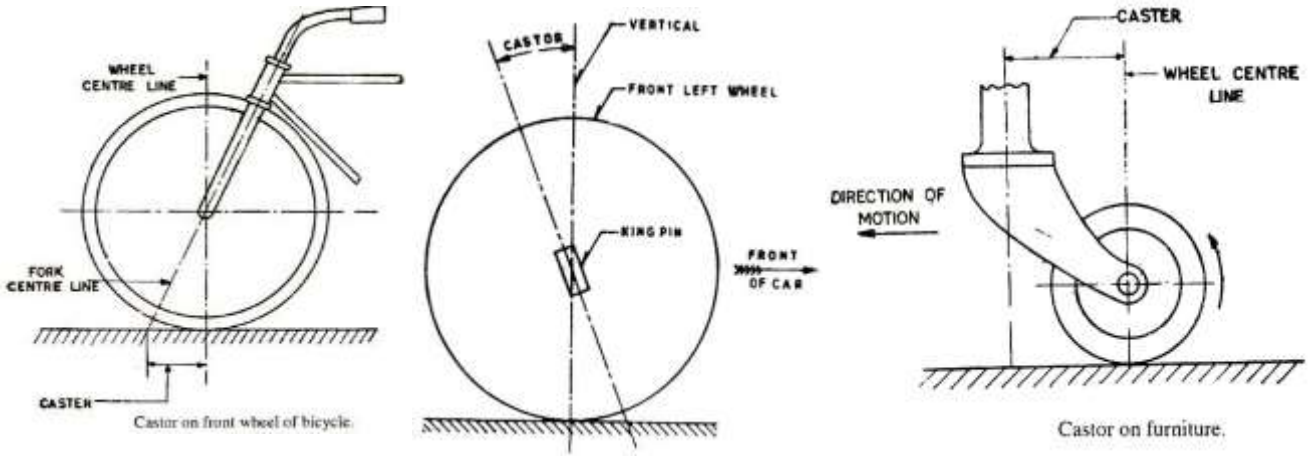
Effect of combined angle variation in rear wheel drive vehicle. The point of intersection of the wheel and king pin centre lines (a) above the ground (negative scrub radius) — tendency to toe-in, (b) just at the ground (zero scrub radius) — no effect and (c) below the ground (positive scrub radius) — tendency to toe-out.

Effect:

- If the point of intersection of kingpin axis and tyre axis is above the ground, the wheel tends to toe-out.
- If this point meets the road surface, the wheel retains straight position, i.e. the condition for centre point steering is reached.
- If the point of intersection is below the road surface, the wheel tends to toe-in
- During Centre point steering condition, the changes in length of springs causes the point of intersection to move alternatively above or below the road surface. This is called as wheel wander.
- **Amount:** 9 – 10 degrees. Scrub radius : up to 12 mm

Castor:

- The angle between the king pin centre line or steering axis and the vertical, in the plane of the wheel is called the castor angle.



- If the king pin centre line meets the ground at a point ahead of the vertical wheel centre line, it is called positive castor, while if it is behind the vertical wheel centre line, it is called negative castor.
- Positive castor provides directional stability and keeps the tyre self aligned after cornering.
- +ve castor aids the centrifugal force and causes rolling out of the vehicle, while – ve castor counteracts the effect of centrifugal force and causes rolling in of the vehicle.
- +ve castor tends the wheel to toe-in, while –ve castor caused the wheel to toe- out.
- If castor on one wheel is greater than other, the vehicle will pull to the side of the wheel having lesser castor angle. (so equal castor should be provided in the wheels)
- Too much +ve castor on wheels caused wheel 'shimmy' and hard steering. On braking the spring effect causes the +ve castor angle to reduce. Low value of castor angle causes wheel wander.
- Amount: About 3 degrees.

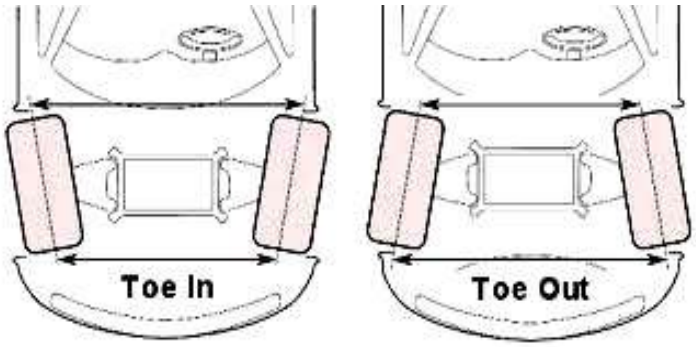
Toe-in & Toe-out

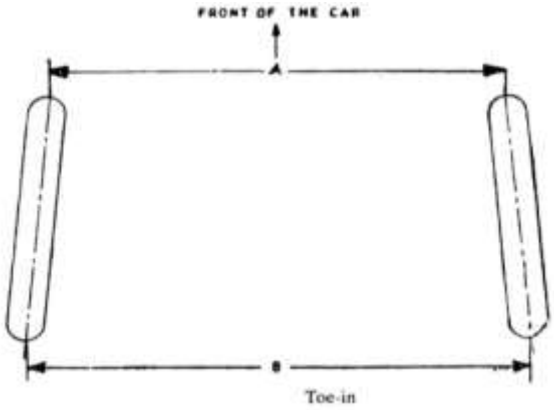
- Toe in is the amount by which the front wheels are set closer together at the front than at the rear when the vehicle is stationary
- Toe in = B – A.
- When the wheel may be set closer at the rear than at the front in which case the difference of the distances between the front wheels at the front and at the rear is called toe out.

Effects:

The purpose of toe in is to offset the camber and prevent excessive tyre wear.

- The purpose of toe out is to give correct turning alignment and to prevent excessive tyre wear.
- Toe in initially provided generally does not exceed 3mm.
- The steering angles are all adjustable at the manufacture's specification and the procedure should be followed closely when checking and setting up front end alignment.

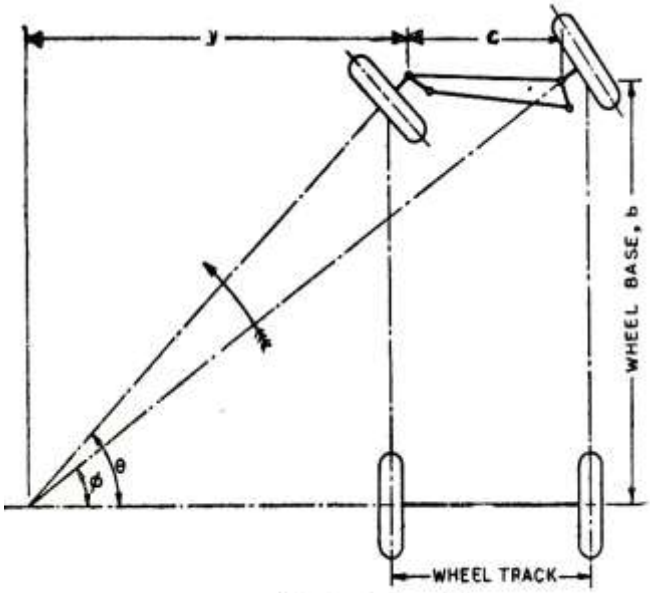




Toe-in

Correct Steering angle:

- The perfect steering is achieved when all the four wheels are rolling perfectly under all conditions of running.
- While taking turns, the condition of perfect rolling is satisfied if the axes of the front wheels when produced meet the rear wheel axis at one point.
- This point is the instantaneous centre of the vehicle.
- The inside wheel is require to turn through a greater angle than the outer wheel
- The larger the steering angle, the smaller is the turning circle.
- Steering angle of the inner wheel can have a maximum value of about 44o
- The extreme positions on either side are called lock positions.



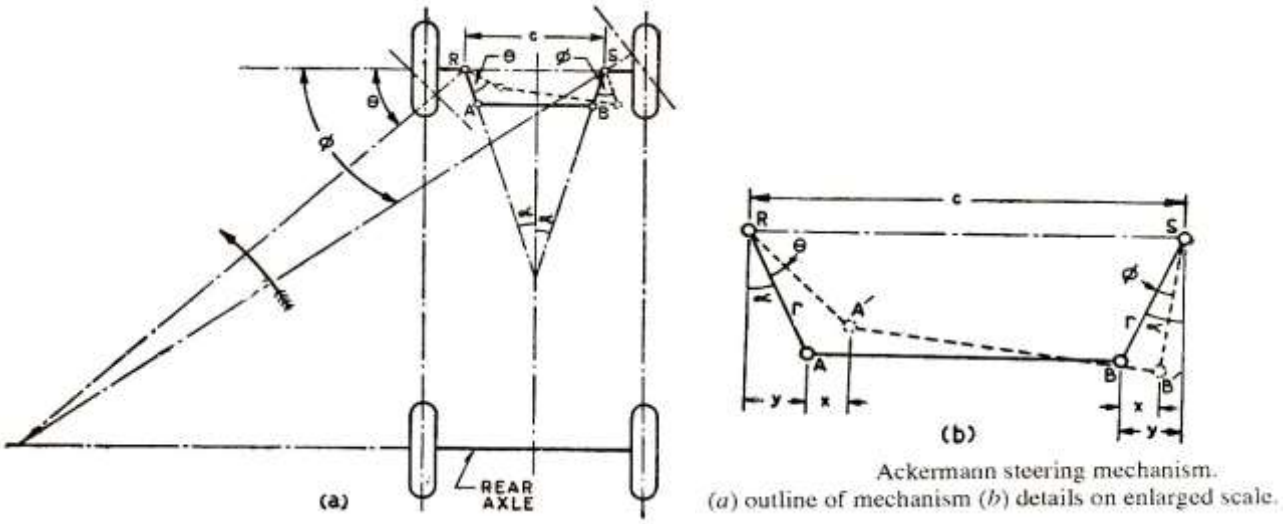
Correct steering angle.

- The diameter of the smallest circle which the outer front wheel of the car can traverse and obtained when the wheels are at their extreme positions is known as the turning circle.

Steering Mechanism

- For perfect steering, an instantaneous centre about which the wheels rotate should be present.
- To satisfy this, inner wheel has to turn more than the outer wheel.
- There are two mechanisms to achieve the above:
  1) Davis steering mechanism
  2) Ackermann Mechanism.
- Ackermann steering mechanism has universal acceptance owing to its simplicity, because it contains all turning pairs (double crank mechanism)
- Davis steering mechanism is almost obsolete because it contains turning and sliding pairs of which sliding pairs results in high friction causing wear and tear.

Ackermann Mechanism:



Ackermann steering mechanism.
(*a*) outline of mechanism (*b*) details on enlarged scale.

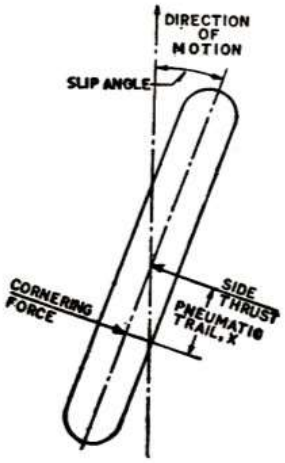
- It consists of a four bar chain having turning pairs only.
- Two Stub axles pivoted to the axle beam at R and S known as king pins.
- The stub axles are connected together by two short track arms and a track rod.
- The length between the kingpins is greater than the track rod length.
- This is to enable the inner wheels to displace through a greater angle than the outer.
- The Ackermann principle states that when a vehicle takes a bend, its wheels should make arcs round the same centre, i.e. the front wheels must move in relation to each other and the axes of front wheels should meet the axis of rear wheels at a point (Instantaneous Centre I).
- Such a condition imparts true rolling motion to all the wheels, avoids lateral slip and minimizes tyre wear.

- The fundamental condition for true steering is

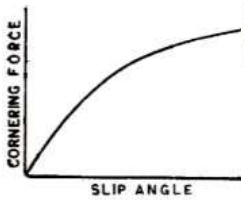
$$\cot \phi - \cot \Theta = \text{Wheel Track / Wheel base}$$

- Ackermann steering mechanism gives correct steering for a) straight ahead position when $\Theta = \phi = 0º$ and b) inside and outside 'Lock' angles.
- The advantages of such a mechanism are a) lesser wear of tyres b) Lower friction in pairs c) simplicity and durability of pin joints.

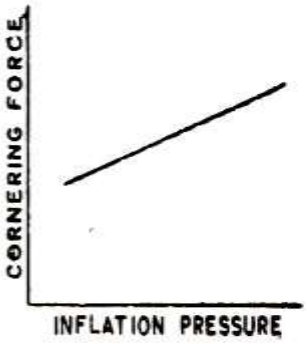
Cornering Force:



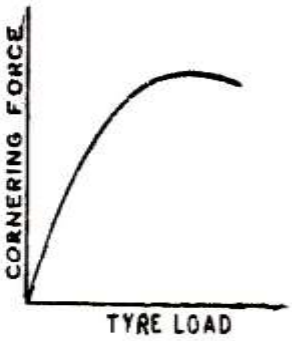
Cornering force and slip angle.



Effect of slip angle on cornering force.



Effect of inflation pressure on cornering force.



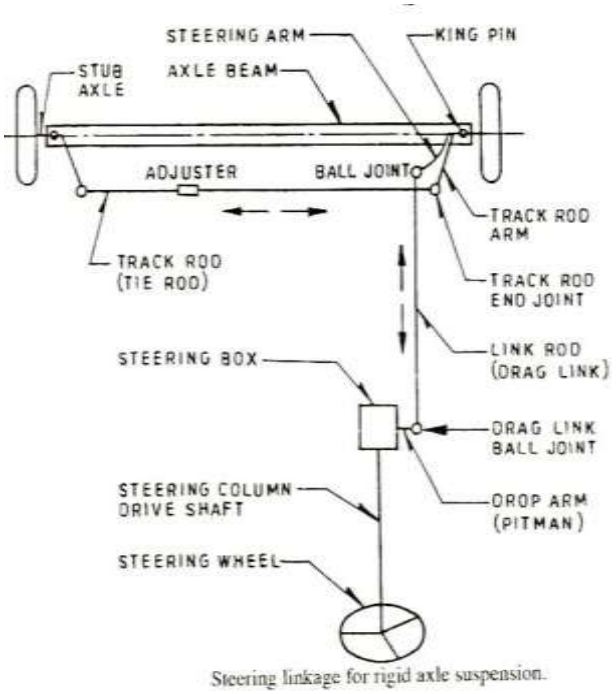
Effect of tyre load on cornering force.

- While taking a turn the centrifugal force acts on the vehicle which produces a side thrust.
- To sustain that force the plane of the wheel must make some angle with the direction of motion of the vehicle.
- The angle through which the wheel has to turn to sustain the side force is called the slip angle and the force produced due to this which counter the side thrust, is known as Cornering force.
- Slip angle value depends upon the amount of side force, the flexibility of tyre, load carried by the wheel and several other factors such as comber angle and road condition.
- For the same slip angel, +ve camber increases the CF while –ve camber decreases it. The alteration in the cornering force, due to camber is known as camber force.
- Slip angle magnitude is small at low speeds and less sharp curves, while it increases at high speed and on shap turns, till on excess of speed and sharpness of curve the wheel skids sideways.

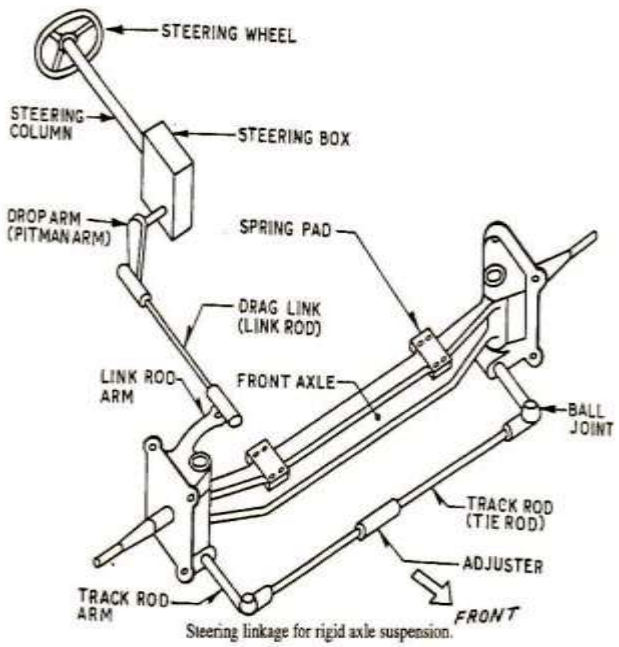
Under steer and Over steer:

- When the slip angles of the front wheels are greater than those for the rear wheels, (may be due to lower inflation pressure at the front than at the rear wheels), radius of the turn is increased.
- The vehicle will turn less sharply than it should for a given rotation of the steering wheel.
- The vehicle will try to move away from its normal direction of motion and therefore to keep it on the right path, driver to steer more than is theoretically needed.
- This condition is called as under steer.
- When the slip angle of the front wheels are less than those of the rear wheels, radius of the turn is decreased.
- The vehicle will turn more sharply than it should for a given rotation of the steering wheel.
- The vehicle will try to move away from its normal direction of motion and therefore to keep it on the right path, driver to steer a little less than is theoretically needed.
- This condition is called as over steer.
- Under steer is comparatively less undesirable because the driver reacts naturally and positively by steering in the desired direction.
- But over steer, he is always conscious of losing the control and therefore greater care is required.

Steering Linkages:



Steering linkage for rigid axle suspension.



Steering linkage for rigid axle suspension.

- Depends upon the type of the vehicle. Figure shows the conventional linkage system for steering Used in commercial vehicle .
- When the steering wheel is turned, motion is transmitted to the steering box by the steering shaft rotating in a hollow steering column.
- A drop or pitman arm is splined to the steering gear box rocker arm on one end and the other end is connected to the drag link by a ball joint.
- The drag link gives motion to the steering arm and to the steering knuckle.
- The other wheel is turned by a track rod.
- It is attached to the steering arms by the held of ball joints.

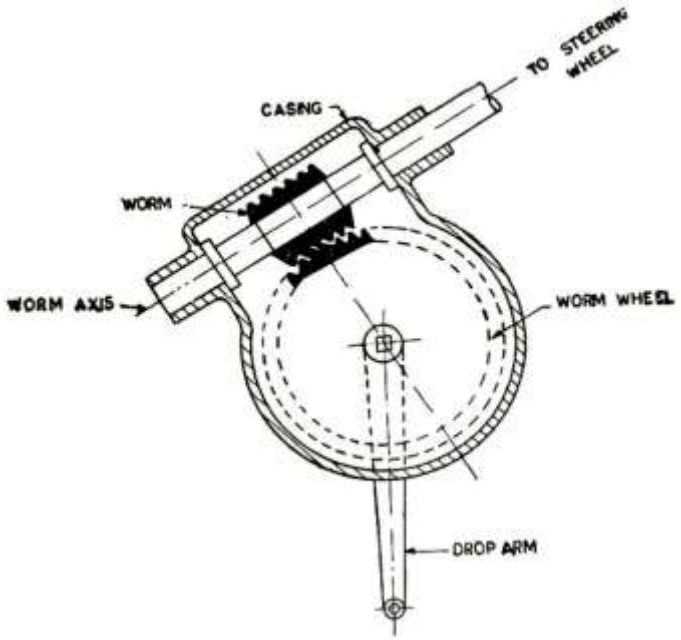
Steering Gears:

- The steering gear converts the turning motion of the steering wheel into the to and fro motion of the link rod of the steering linkage.
- It provides the necessary leverage so that the driver is able to steer the vehicle without fatigue.

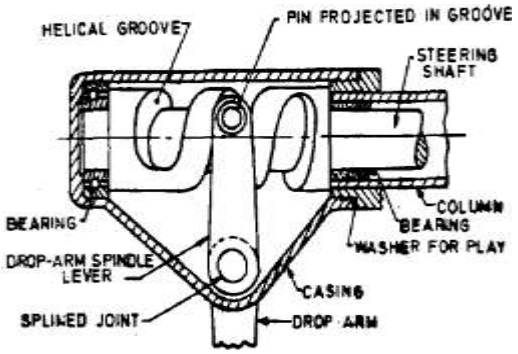
TYPES OF STEERING GEARS:

1.Worm and Wheel steering Gear:

- The movement of the steering wheel turns the worm, which in turn drives the worm wheel.
- Drop arm is rigidly attached to the wheel spindle.
- Therefore, a rotation of the steering wheel corresponds to a linear motion of the drop arm end, which is connected to the link rod.

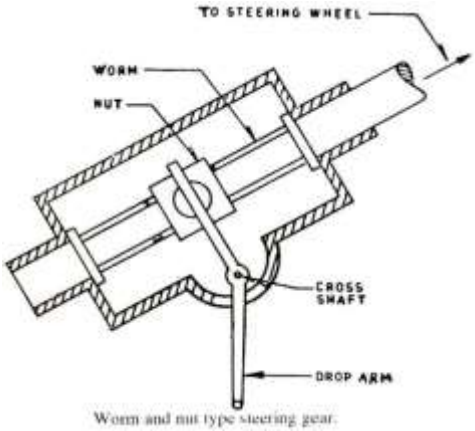


2.Cam and double roller steering gear:



- This type is employed in Ashok leyland vehicles
- Working is similar to the worm wheel type.
- The steering ratio is 24.7:1.

3. Worm and Nut steering Gear:

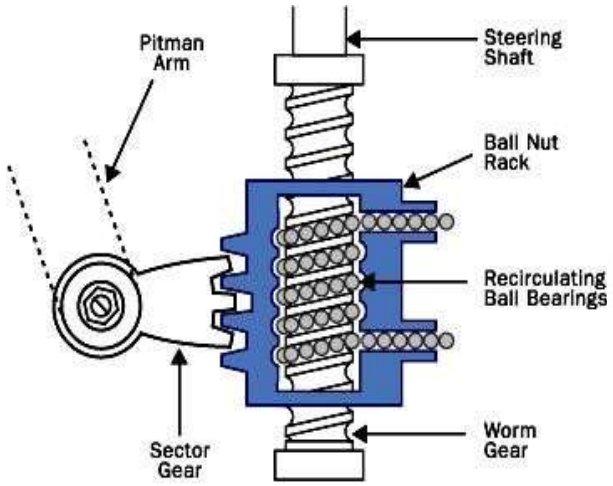


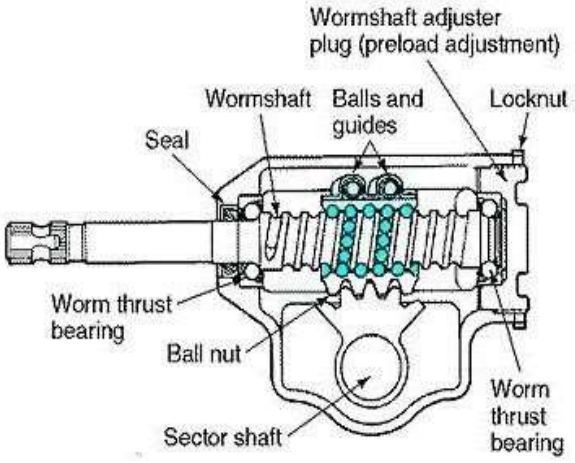
Worm and nut type steering gear.

- Steering wheel rotation rotates the worm which in turn moves the nut along its length.
- This causes the drop arm end to move linearly, further moving the link rod and thus steering the wheels.

4. Recirculating Ball Type steering Gear:

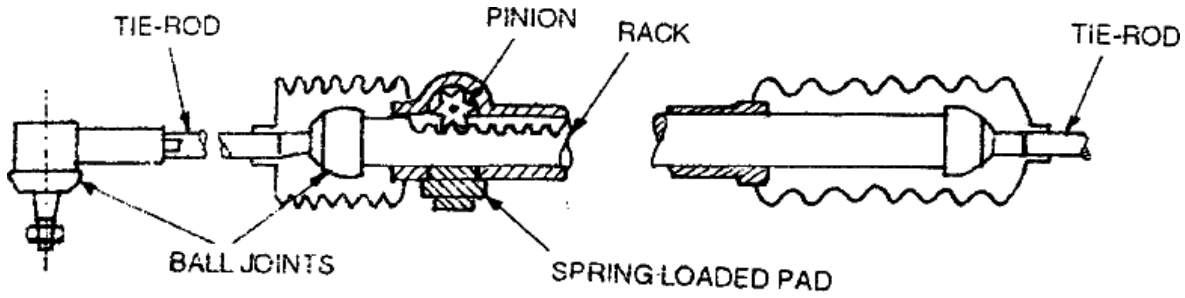
- Tata, Dodge/Fargo, Standard vehicles were used this type.
- Consists of a worm at the end of steering rod.
- A nut is mounted on the worm with two sets of balls in the grooves of the worm in between nut and the worm.
- The balls reduce the friction during the movement of the nut on the worm.
- The nut has a number of teeth on the outside.
- The nut mesh with the teeth on a worm wheel sector.
- On wheel is further mounted the drop arm, which steers the road wheels through the link rod and the steering arms.





5. Rack and Pinion steering Gear:

- Used in light vehicles like cars and in power steering.
- Simple, light and responsive.
- Occupies very small space and uses less number of linkage components
- The rotary motion of the steering wheel is transmitted to the pinion on the steering gear through universal joints.
- The pinion is in mesh with a rack.
- The circular motion of the pinion is transferred into the linear rack movement, which is further relayed through the ball joints and tie rods to the stub axles for the wheels to be steering.



6. Other Types of steering gears:

- Worm and roller steering Gear – Worm and a two toothed roller is fastened to the sector or roller shaft.
- Cam and peg steering gear – attached to the rocker arm is a taper peg which engages in the cam.

STEERING RATIO:

- It is the ratio of the angle turned by the steering wheel to the corresponding turning angles of the stub axle. Generally 12:1 for cars, 35:1 for heavy vehicles.

CHAPTER - 3 : SUSPENSION SYSTEM

- All the parts which perform the function of isolating the automobile from the road shocks are collectively called as A suspension system.
- System consists of a spring and a damper (restricting the oscillations to a reasonable level)

Objects of suspension:

- To prevent the road shocks from being transmitted to the vehicle components
- To safeguard the occupants from road shocks
- To preserve the stability of the vehicle in pitching or rolling, while in motion.

BASIC CONSIDERATIONS:

- **Vertical Loading**: due to bump or pit on the road
- **Rolling**: due to the centre of gravity of the vehicles is considerably above the ground, which causes the centrifugal force acts outwards on the C.G. of vehicle while taking the turns.
- **Brake Dip**: on braking, the vehicle has a tendency to be lowered or to dip, which based on the C.G., wheel base and other suspension characteristics.
- **Side Thrust**: Due to cornering, cross winds, cambering of the road etc.
- **Unsprung Weight**: The weight of vehicle components between the suspension and the road surfaces, which includes rear axle assembly, steering knuckle, front axle, wheels, tyres and brakes. (Sprung weight means the weight supported by the vehicle suspension system includes the frame, body, engine and the entire transmission system.
- **Miscellaneous:** Pitching, Yawing, etc.

Functions of Suspension Springs:

- Storing the energy by deflection
- Expending the energy by rebounding.

Types of Suspension springs:

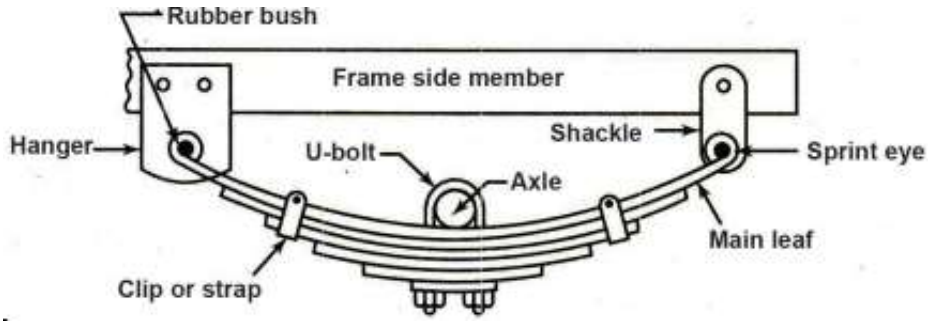
1. Steel Springs:
- Leaf spring
- Tapered Leaf Spring
- Coil Spring
- Torsion bar

2. Rubber Springs:
- Compression spring
- Compression shear spring
- Steel reinforced spring
- Progressive spring
- Face Shear spring
- Torsion shear spring

3. Plastic Spring
4. Air Spring
5. Hydraulic Spring

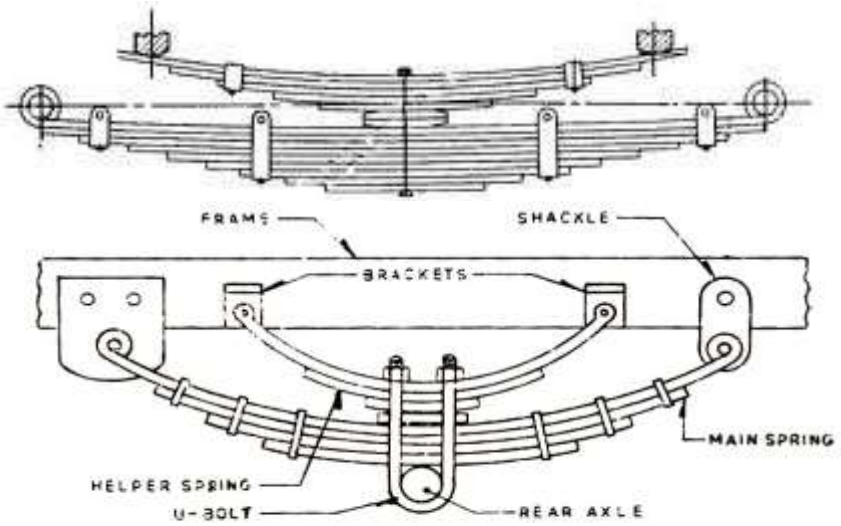
Types of Leaf Springs

- The quarter elliptic type was used earlier
- Most widely used type is semi-elliptic type
- The transverse spring is the cheapest one (vehicle body is attached to the springs at only two places, which imparts the vehicle a tendency to roll easily when it runs fast on sharp corners)



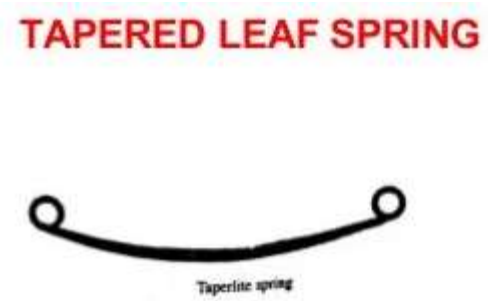
Helper Springs:

- On many commercial vehicles in addition to the main leaf springs
- Allows wide range of loading
- They come in to act only when the load is increased.
- Only provided in rear suspension only.



Helper spring.

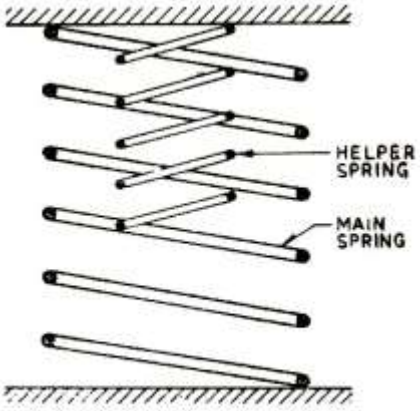
Tapered Leaf Springs:



- Another name is Taperlite springs
- Advantages over conventional Leaf springs:
  - Light weight (60%)
  - No interleaf friction as in conventional leaf spring
  - Absence of squeaking
  - Stresses are lower and more uniform
  - Occupy less space
  - No collection of moisture between the leaves and hence no fretting fatigue.

Coil Springs:

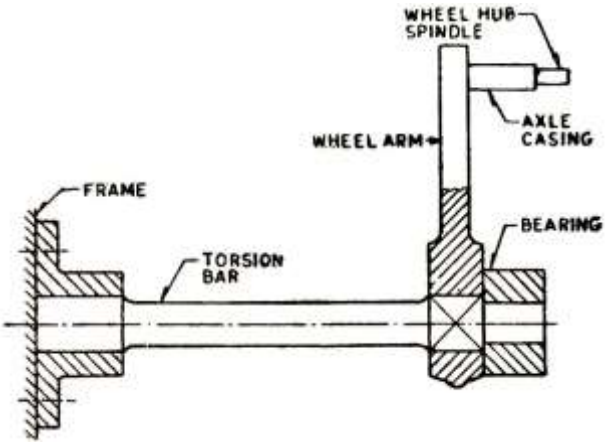
- Used in independent suspension
- The energy stored per unit volume is almost double in the case of coil springs than the leaf springs
- No noise problems, No static friction causing harshness
- Takes shear as well as bending stresses.
- Cannot take torque reaction and side thrust.
- A helper coil spring is also sometimes used to provide stiffness against increasing load.



Helper coil spring.

Torsion bar (Heat treated alloy spring steel):

- A rod acting in torsion and taking shear stresses only
- Used in independent suspension
- One end is fixed with frame, other at the end of the wheel arm and supported in bearing.
- The other end of the wheel arm is connected to the wheel hub
- When the wheel strikes a bump, it start vibrating up and down, thus exerting torque on the torsion bar, which acts as a spring.
- Occupies less space
- Some times torsion tubes are used instead of the bars, the former being stiffer than the latter ones



Disadvantages:

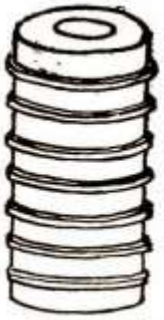
- Does not take the braking or driving thrust
- Absence of friction force, and hence of damping which is necessity to control the vibrations produced due to road shocks.

Rubber Springs:

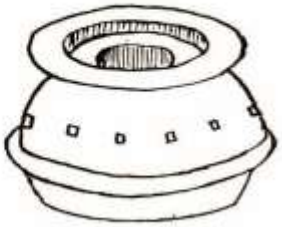
- **Advantages:**
  - Store Greater energy per unit weight
  - Excellent vibration damping properties
  - Absence of squeaking
  - Number of bearings is reduced considerably.
  - Rubber is more Reliable.

Types of Rubber Springs:

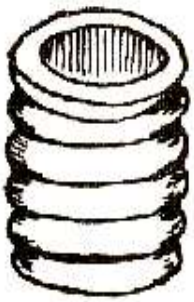
1. **Compression Spring**: It is reliable, simple construction, resist occasional overload of large magnitude and large measure of inherent damping.



Compression spring.



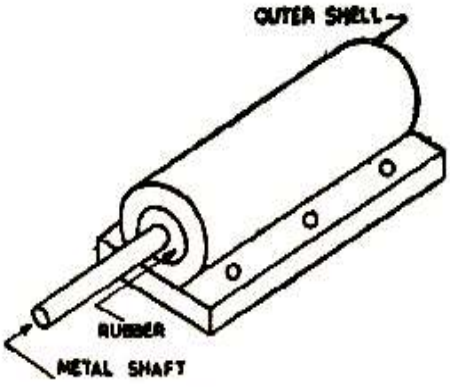
Compression shear spring.



Steel reinforced spring.

Progressive spring.

Face shear spring.



Torsional shear spring.

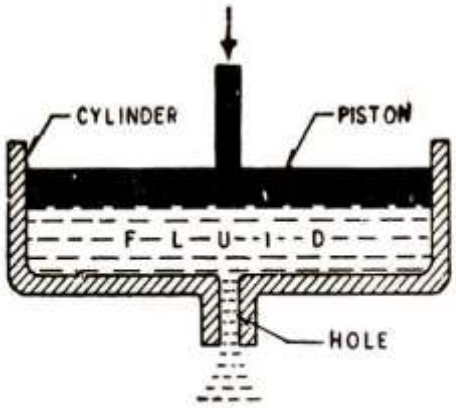
OUTER SHELL

2. **Compression Shear Spring**: The load is carried partly by shear and partly by compression components in the rubber and large strains may be allowed in the rubber body. Fatigue properties are excellent
3. **Steel Reinforced Spring**: 'Eligos' spring consists of a steel helical spring bonded in a rubber body. Steel spring carries about 20% of the load, balance carried by rubber material.
4. **Progressive spring**: It has initially an exceedingly small rate which rises rapidly as the central cavity closes.
5. **Face Shear Spring**: consists of a thick disc of rubber having metal plates bonded to its flat surfaces, and axially precompressed. It operates by relative rotation of the plates about its axis thus loading the rubber partly in shear.
6. **Torsional Shear Spring**: consists of an inner metal shaft, tubular or solid, and an outer trough-like shell between which rubber body is bonded, the later being put under pressure by closing the trough with a riveted or spot welded bas plate. The spring operates by the rotation of the shaft about its own axis relative to the shell.

SHOCK ABSORBERS:

- The shock absorbers are used to control the excessive spring vibrations (Control the amplitude and frequency of spring vibrations)
- Absorbs the energy of shock converted into vertical movement of the axle by providing damping and dissipating the same into heat.
- The shock absorbers are basically of two types: The friction type and hydraulic type.
- Friction type almost obsolete due to its non predictable damping characteristics.

Principle of Hydraulic shock absorber: When a piston forces the fluid in a cylinder to pass through some hole, a high resistance to the movement of piston is developed which provides the damping effect.



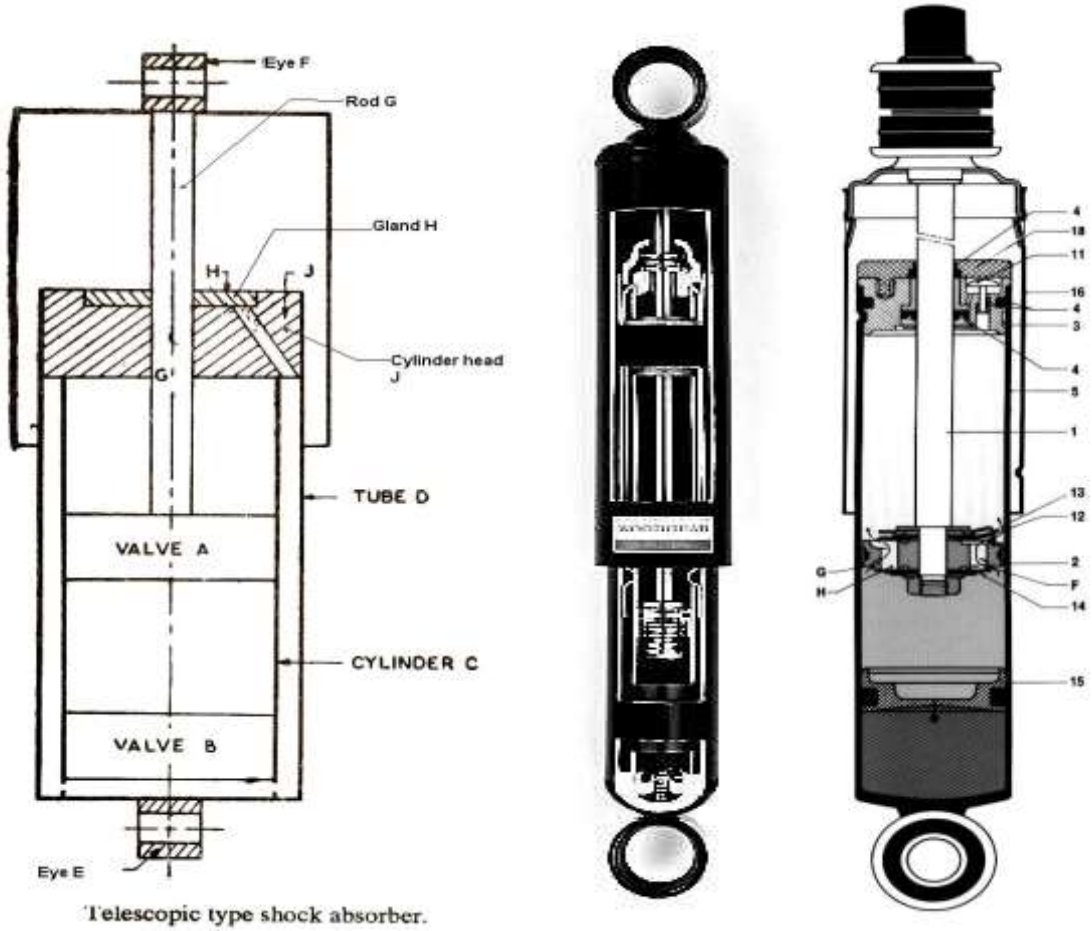
The principle of operation of hydraulic shock absorber.

- The dampening action of a hydraulic shock absorber comes from transferring oil, under pressure, through valves that restrict the oil flow. Resistance to motion is low when the piston moves slowly, and high when its velocity is high.
- In hydraulic type the damping effect is proportional to the square of the speed. Therefore, for small vibrations, the damping is small and for larger vibrations, the damping becomes automatically more.

Telescopic Type Shock absorber:

Construction of Shock absorber:

- Rod G is attached to the 2 way valve A, while another similar two way valve B is attached at the lower space between cylinder C and tube D, which is connected to the space below the valve assembly B
- H is the gland in the head J and any fluid scrapped off by rod G is brought down into the annular space through the inclined passage shown in the head.
- The eye E is connected the axle, while the eye F is attached to the chasis frame.
- The fluid used in SA is a mixture of 60% transformer oil and 40% turbine oil.



Telescopic type shock absorber.

Operation:

- Consider the car has come across a bump.
- Eye E would move up and thereby the fluid will pass from the lower side of valve assembly A to its upper side.
- Since the volume of the space above A is less by the volume of the rod G, the fluid will also exert its pressure on valve assembly B and go to the underside of valve B
- This passing of the fluid through valve openings provides the damping.
- Similarly for downward motion of the Eye E, the fluid will pass from the upper side of the valve assembly A to the lower side and also from the lower side of valve assembly B to its upper side.
- The construction of valve assembly A & B are shown in figure.
- When the pressure on the upper side become greater, the valve C opens against the force of the spring d and thereby allows the fluid to come down to the lower side.
- However when the pressure on the lower side becomes greater, the valve a is lifted against the force of star shaped spring b and the fluid passes up through the various openings.

Lever arm type shock absorber:

- Large deflections are possible in this type and its fade characteristics are better.
- This consists of two pistons operating in two adjacent chambers filled with oil and connected through holes which are covered or uncovered by means of a valve.
- The up and down movement of the lever arm due to road shocks causes one piston to move up and other down, thus causing the oil to flow through the oil holes which absorbs the energy of vibrations and causes their damping.

Independent Suspension:

- When rigid axle suspension is used in vehicle, which causes, the whole vehicle to tilt on one side, causing rough ride (wheel wobble) and road adhesion is also decreased.
- Tot avoid this the wheels are sprung independent of each other, so that tilting of one does not effect the other.

Advantages of Independent suspension:

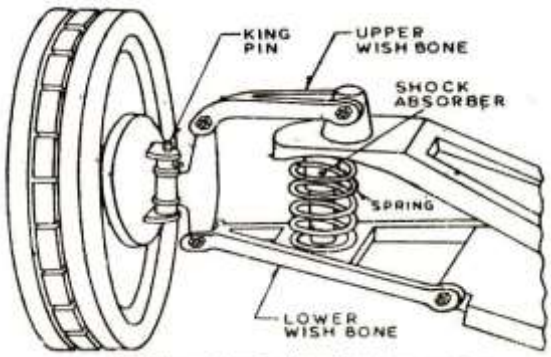
1. Lighter springs can be used (The elastic strain energy per unit spring weight store in a coil or torsion bar spring is greater than the leaf spring)
2. Unsprung weight is reduced, which reduces the tyre scrub and hence increases tyre life.
3. Softer springs can be used
4. Steering geometry is not altered with spring deflection as in case of conventional rigid axle suspension.
5. Engine and chasis frame can be placed relatively lower.

Types of Front wheel Independent suspension:

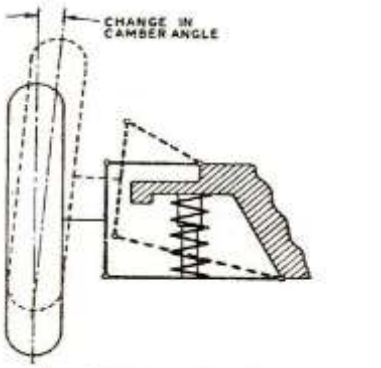
1. Wishbone type or parallel link type
2. Mac Pherson Strut Type
3. Vertical Guide Type
4. Trailing link Type
5. Swinging Half axle type.

1. Wishbone type suspension:

- Consists of upper and the lower wishbone arms (like chicken wishbone or letter V in shape) pivoted to the frame member.
- The spring is placed in between the lower wishbone and the underside of the cross member.
- The vehicle weight is transmitted from the body and cross member to the coil spring through which it goes to the lower wishbone member.



Wishbone type independent suspension.



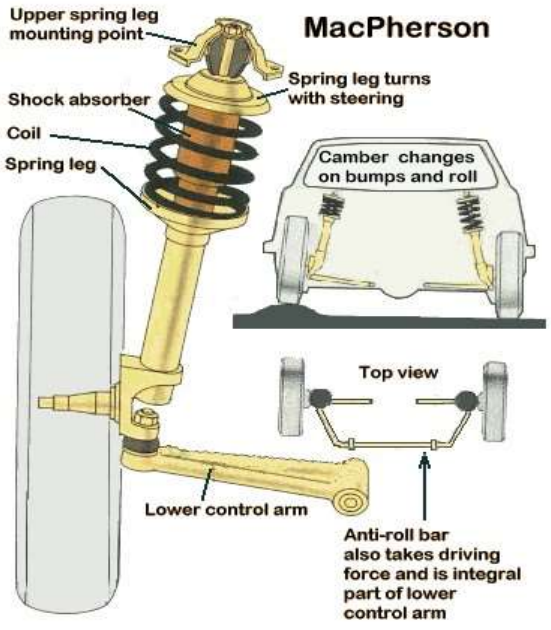
Changes in camber angle in wishbone suspension.

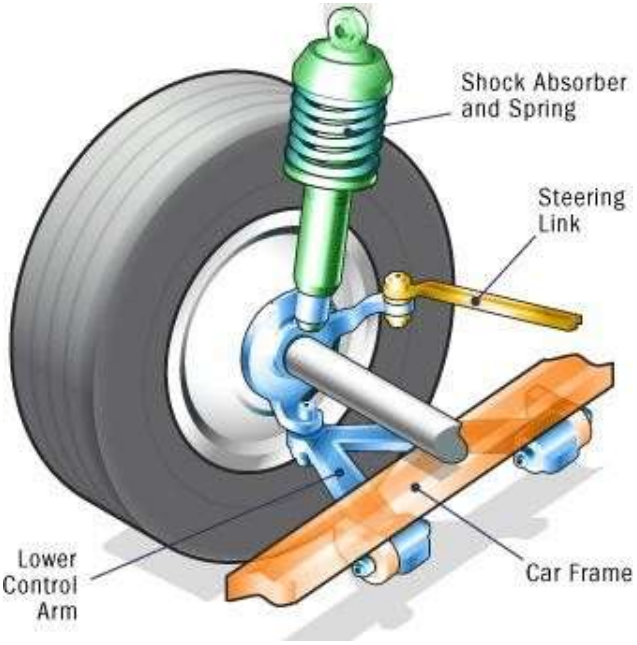
- The shock absorber is placed inside the coil spring and is attached to the cross member and to lower wishbone member.
- Due to the V shape, the wishbone is used to position the wheels and transmit the vehicle load to the springs and also resist acceleration, braking and cornering (side) forces.

- The upper arms are shorter in length than the lower ones, which helps to keep wheel track constant, thereby avoiding the tyre scrub thus minimizing tyre wear.
- However a small change in the camber angle does occur.
- Most popular independent suspension system.

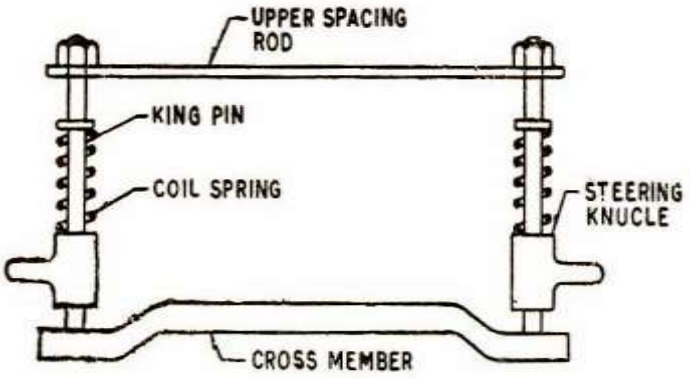
2. Mac Pherson Type of Suspension:

- Only lower wishbones are used.
- A strut containing shock absorber and the spring carries also the stub axle on which the wheel is mounted.
- The wishbone is hinged to the cross member and positions the wheel as well as resists accelerating, braking and side forces.
- Simpler than double wishbone type
- Lighter, keeping the unsprung weight lower.
- The camber also does not change when the wheel moves up and down.
- Gives the maximum room in the engine compartment.
- Commonly used on front wheel drive cars.
- When this system added with an anti-roll bar, which will give increased road safety, improved ride comfort and light and self stabilizing steering (car continues along its chosen line of travel when the brakes are applied even through the road surface may vary)





3. Vertical Guide Suspension:

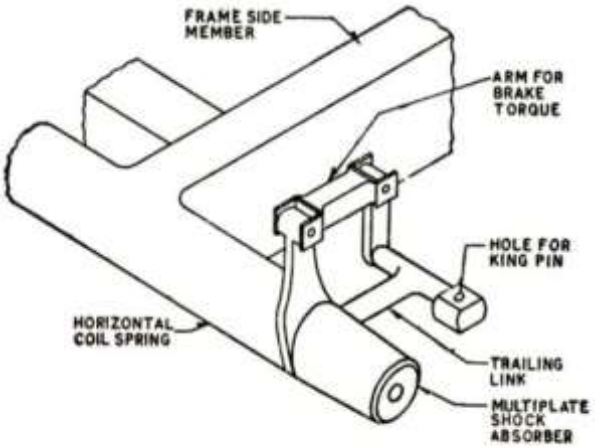


Vertical guide suspension.

- The king pin is attached directly to the cross member of the frame.
- It can slide up and down, corresponding to the up and down motion of the wheel, thus compressing or elongating the springs.
- The track, wheel base and wheel attitude remain unchanged.
- Main disadvantage: decreased stability.

4. Trailing link Suspension:

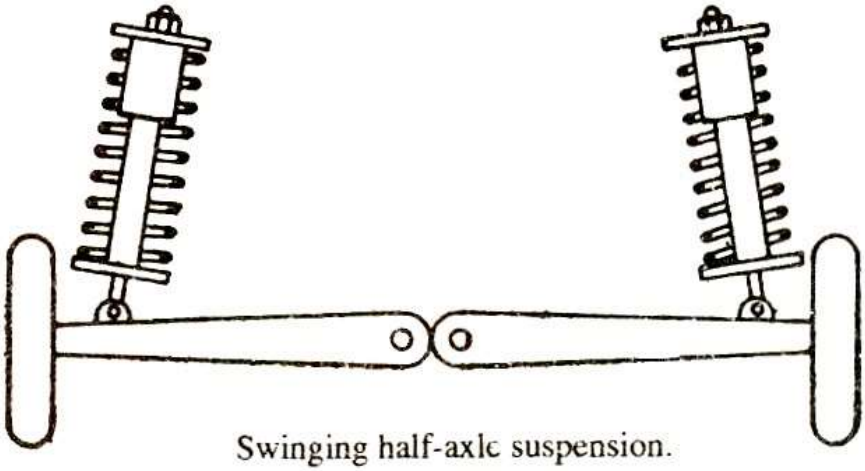
- A coil spring is attached to the trailing link which itself is attached to the shaft carrying the wheel hub.
- When the wheel moves up and down, it winds and unwinds the spring.
- A torsion bar has also been used in certain designs in place of the coil springs.
- This system maintains the camber and wheel track constant, but distance between the front and rear wheels does change.



Trailing link suspension.

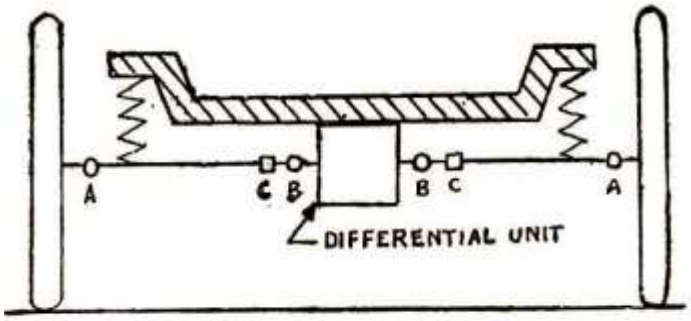
5. Swinging Half axle suspension:

- In this wheels are mounted rigidly on the half axles, which are pivoted on their ends to the chassis member at the middle of the car.
- The main disadvantage is that up and down movement of the wheel cause the camber angel to vary.

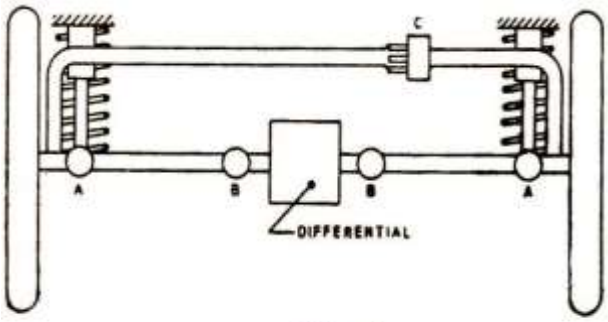

Swinging half-axle suspension.

Rear Wheel (Live Axle) Independent Suspension:

- There is a considerable difficulty in the rear wheel springing if the power has to be transmitted to the rear wheels.
- Figure shows one method of rear wheel independent suspension.
- Universal couplings A and B keep the wheel vertical, while the sliding coupling C is required to maintain the wheel track constant, thereby avoiding scrubbing of the tyres. Example: de Dion Axle



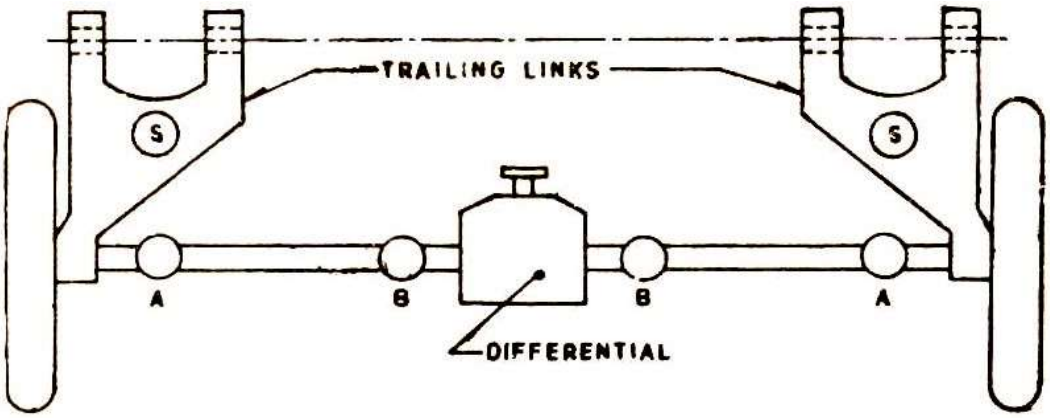
Rear wheel independent suspension.



de Dion axle.
A, B – Universal joints, C – Sliding joint.

Trailing Link Independent Rear Suspension:

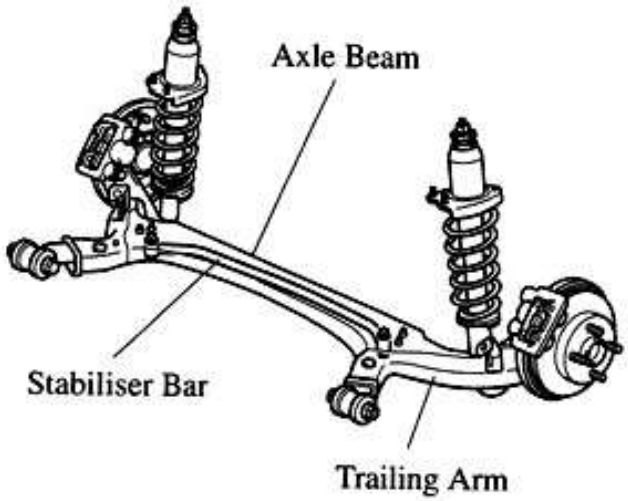
- In this type the trailing links are pivoted at right angles to the longitudinal axis of the car and carry the rear wheels at their ends.
- A and B are the universal joints to keep the wheel track and the camber constant with the up and down movement of the wheels.
- S are the coil springs with shock absorbers mounted concentrically within them.
- The trailing links hold the wheels firmly and also sustain accelerating and braking forces.



Trailing link independent rear suspension.

Linked trailing arm rear suspension:

- In this the combined metal-rubber mountings respond softly on straight roads, increasing ride comfort.
- When cornering, they resist lateral force with a reliable stabilizing effect, even when the car is fully loaded

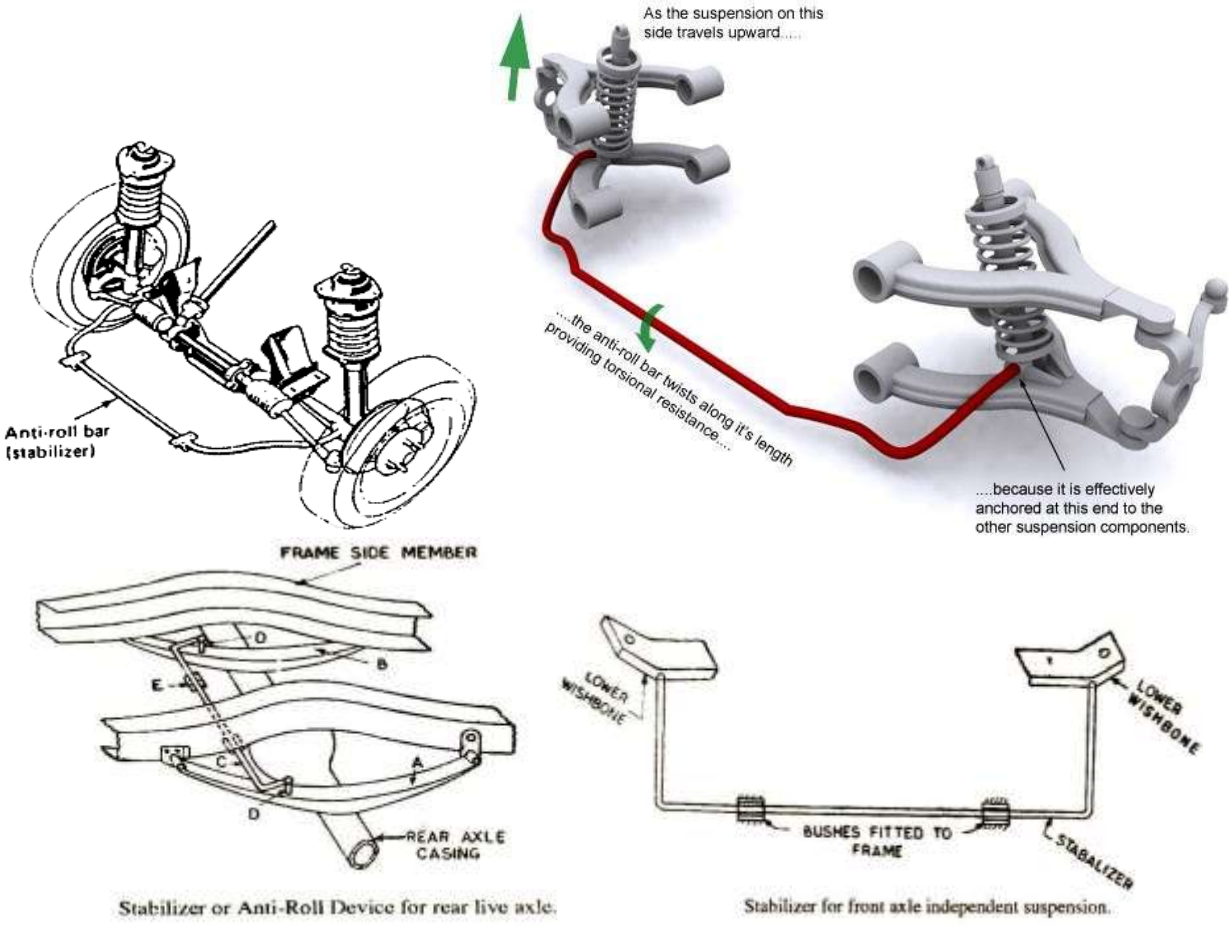


Disadvantages of Independent suspension system:

1. The initial cost is high.
2. Greater maintenance required because of larger number of bearings
3. Misalignment of steering geometry with the wear of components, thus requiring more frequent attention.
4. In the event of body roll, the wheels camber (tilt outwards in case of wishbone type and inwards in case of Mc Pherson Strut type), due to which cornering power is reduced.
5. More rigid sub-frame or chassis frame required.
6. Forces due to unbalanced wheels are more pronounced and transmitted easily to the steering wheel.

Stabilizer or Anti Roll device:

- When one road wheel is deflected more than the other, e.g., when it comes over a pump on the road, there is a tendency for the vehicle to roll
- To avoid this tendency, a stabilizer is used in the form of a torsion bar.
- The torsion bar C is fixed to springs A and B by means of two short rods D.
- The torsion bar is supported in two bearings E which are fixed to the frame.



Stabilizer or Anti-Roll Device for rear live axle.

Stabilizer for front axle independent suspension.

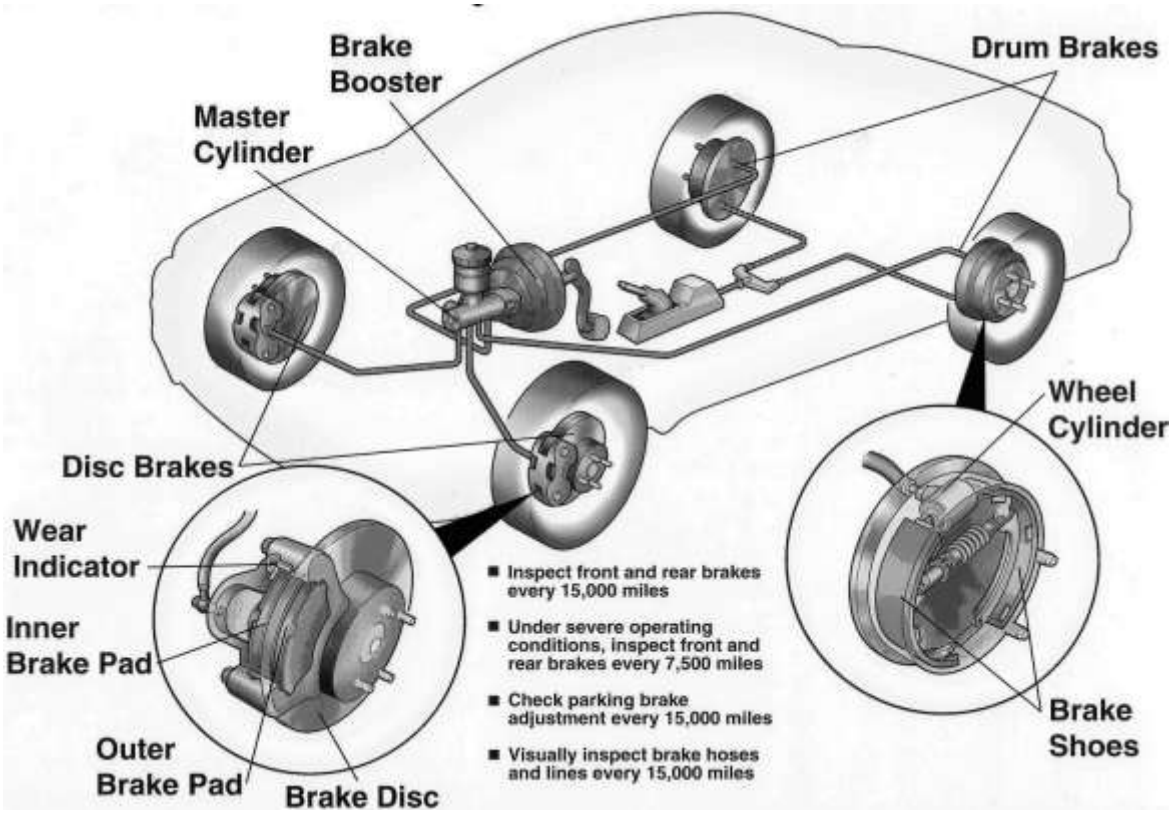
Working:

- When the car rolls out such that the nearer side in the figure moves up.
- That decrease load on spring A which caused the nearer rod D to move down.
- On the other hand the load on spring B is increased, thereby letting the farther rod D move up.
- Thus the bar C which is supported in bearings undergoes twisting.
- It is the resistance of the bar to twisting that counters the tendency of the car to roll out, thereby providing stability against lateral forces

CHAPTER - 4: BRAKE SYSTEM

INTRODUCTION:

- Brakes are applied on the running wheels to stop the vehicle.
- A moving vehicle possesses kinetic energy which is converted into heat energy on the application of brakes.
- The heat is transferred to the surrounding air.
- When the driver applies force on the brake pedal which gets amplified and pushes the stationary shoe to make contact with the rotating brake drum and stops its rotation due to frictional resistance.
- The heat generated due to braking action is proportional to the force which brings the shoe in contact with the drum.



Requirements of Brakes:

- To bring the vehicle to a relatively quick stop on any type of road.
- Components should require minimum maintenance.
- Minimum effort should be required for braking
- Allows minimum time between application of brake pedal and braking effect on the drum.
- Should not involve any noise; drift the vehicle away from its desired path.
- Provision for quick heat dissipation must be incorporated.
- A secondary braking system must be incorporated, should the primary braking system fail.

Functions of the Brakes:

- To stop or slow down the vehicle in the shortest possible distance in emergencies (Requires large braking torques to brake drums)
- To control the vehicle to be retained when descending a hill (Dissipate large quantities of heat without large temperature rise).

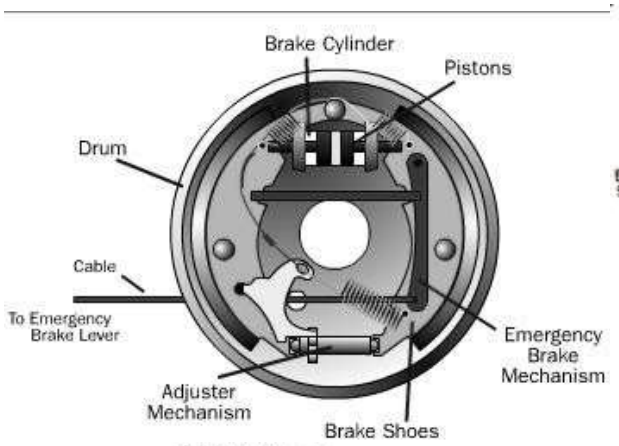
Classification of Brakes:

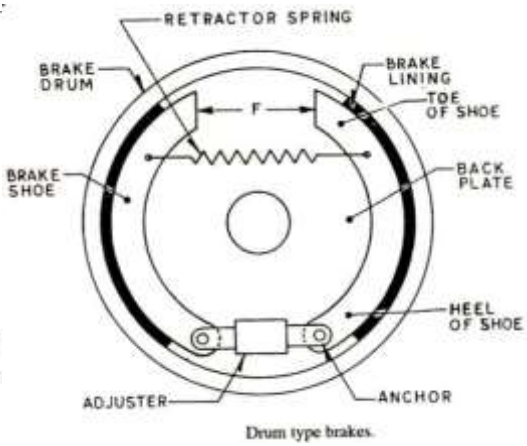
- With respect to application
  - Foot brake
  - Hand Brake
- With respect to the method of braking contact
  - Internal expanding brakes
  - External contracting brakes
- With respect to the brake gear:
  - Mechanical Brakes
  - Power Brakes
- With respect to the nature of power employed:
  - Vacuum brakes
  - Air brakes
  - Hydraulic brakes
  - Hydrostatic brakes
  - Electric brakes

Friction materials:

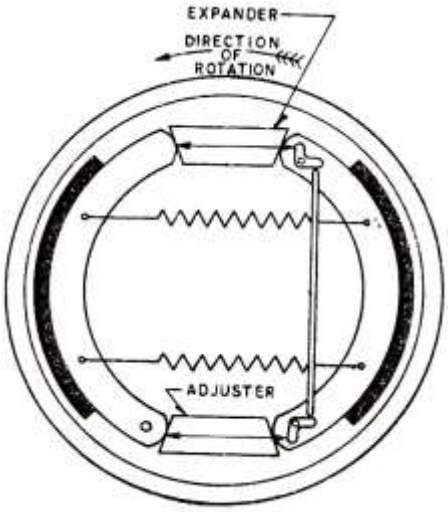
- Brake shoes and pads are constructed in a similar manner.
- The pad or shoe is composed of a metal backing plate and a friction lining. The lining is either bonded (glued) to the metal, or riveted.
- Generally, riveted linings provide superior performance, but good quality bonded linings are perfectly adequate.
- Friction materials will vary between manufacturers and type of pad and the material compound may be referred to as: asbestos, organic, semi-metallic, and metallic.
- The difference between these compounds lies in the types and percentages of friction materials used, material binders and performance modifiers.
- Organic and non-metallic asbestos compound brakes are quiet, easy on rotors and provide good feel. But this comes at the expense of high temperature operation, so they may not be the best choice for heavy duty use or mountain driving.
- In most cases, these linings will wear somewhat faster than metallic compound pads, so usually replace them more often. But, when using these pads, rotors tend to last longer
- Semi-metallic or metallic compound brake linings will vary in performance based on the metallic contents of the compound.
- The higher the metallic content, the better the friction material will resist heat. This makes them more appropriate for heavy duty applications, but at the expense of braking performance before the pad reaches operating temperature.
- The first few applications on a cold morning may not give strong braking. Also, metallic and semi-metallic are more likely to squeal.
- In most cases, metallic compounds last longer than non-metallic pads, but they tend to cause more wear on the rotors.
- Some more exotic materials are also used in brake linings, among which are Kevlar® and carbon compounds. These materials have the capability of extremely good performance for towing, mountain driving or racing.
- Wear characteristics can be similar to either the metallic or the non-metallic linings.
- Most race applications tend to wear like metallic linings, while many of the street applications are more like the non-metallic.

Drum brakes:

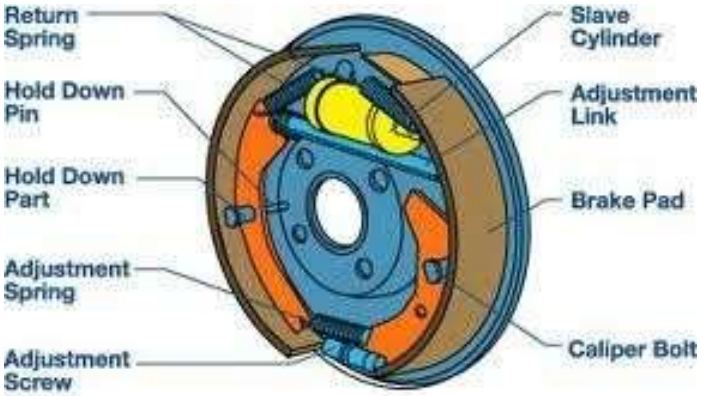




Drum type brakes.



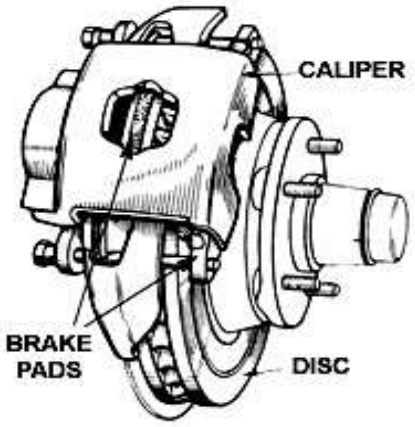
Two leading shoe brake (mechanical).

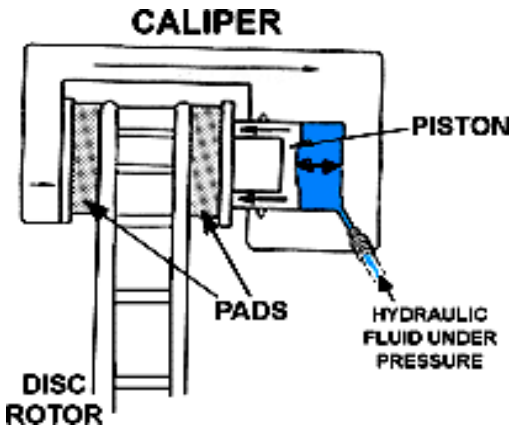


- Drum brakes use two brake shoes mounted on a stationary backing plate on each wheel.
- These shoes are positioned inside a circular cast iron drum that rotates with the wheel assembly.
- The shoes are held in place by springs; this allows them to slide toward the drums (when they are applied) while keeping the linings and drums in alignment.
- The shoes are actuated by a wheel cylinder that is usually mounted at the top of the backing plate.
- When the brakes are applied, hydraulic pressure forces the wheel cylinder's two actuating links outward.
- Since these links bear directly against the top of the brake shoes, the tops of the shoes are then forced outward against the inner side of the drum.
- This action forces the bottoms of the two shoes to contact the brake drum by rotating the entire assembly slightly (known as servo action).

- When pressure within the wheel cylinder is relieved, return springs pull the shoes away from the drum.
- Modern drum brakes are designed to self-adjust during application when the vehicle is moving in reverse.
- This motion causes both shoes to rotate very slightly with the drum, rocking an adjusting lever.
- The self-adjusters are only intended to compensate for normal wear.
- Driving the vehicle in reverse and applying the brakes usually activates the automatic adjusters.

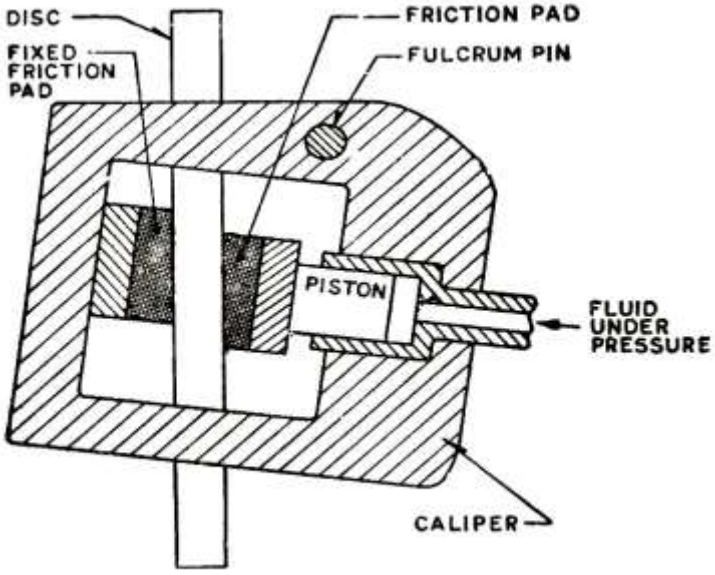
Disc brakes:



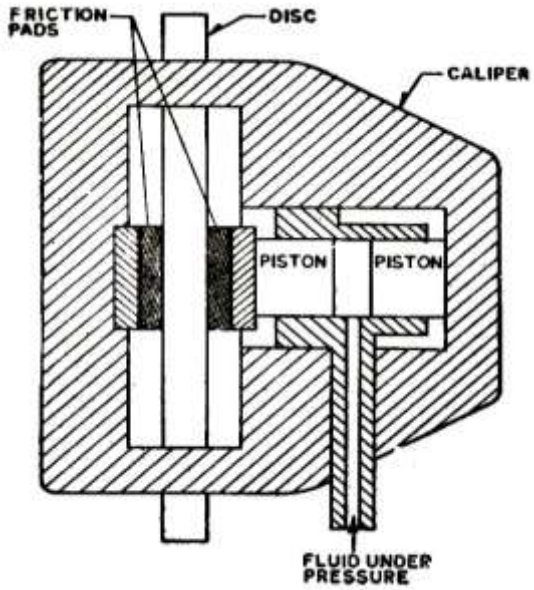


- Instead of the traditional expanding brakes that press outward against a circular drum, disc brake systems utilize a cast iron rotor (disc) with brake pads positioned on either side of it.
- The rotor (disc) is a one-piece casting with cooling fins between the two braking surfaces.
- This enables air to circulate between the braking surfaces making them less sensitive to heat buildup and more resistant to fade.
- Dirt and water do not affect braking action since contaminants are thrown off by the centrifugal action of the rotor (disc) or scraped off by the pads.
- In addition, the equal clamping action of the two brake pads tends to ensure uniform, straight-line stops.
- All disc brakes are inherently self-adjusting.

- There are three general types of disc brake:
  - A fixed caliper
  - A floating caliper
  - A sliding caliper



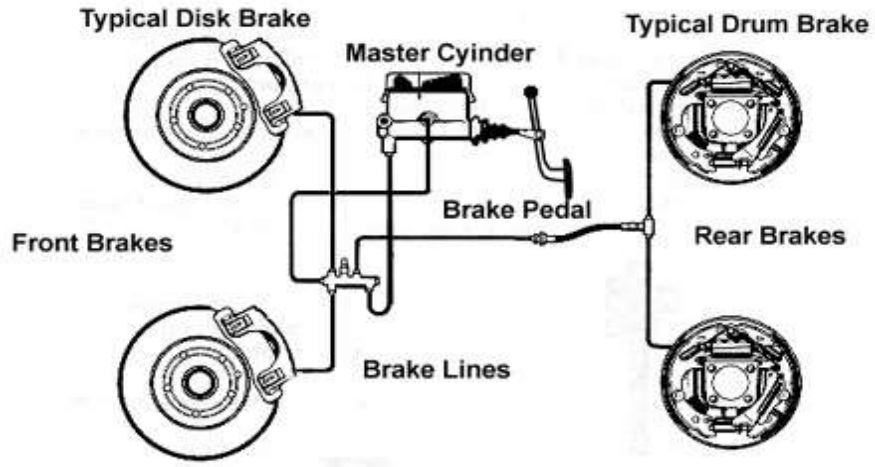
Swinging caliper type of disc brake.



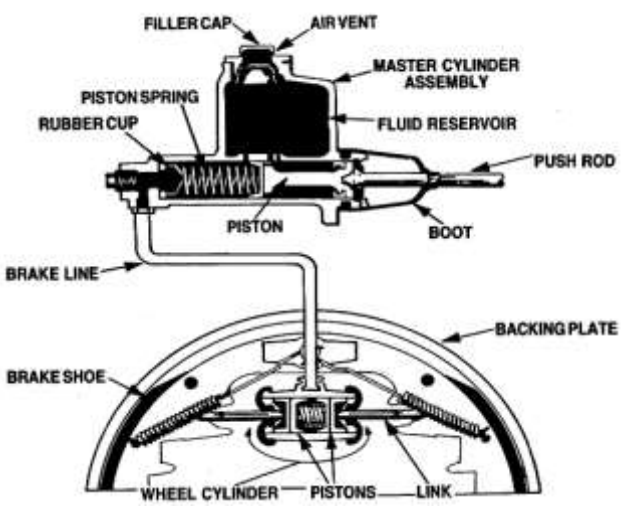
Sliding caliper type of disc brake.

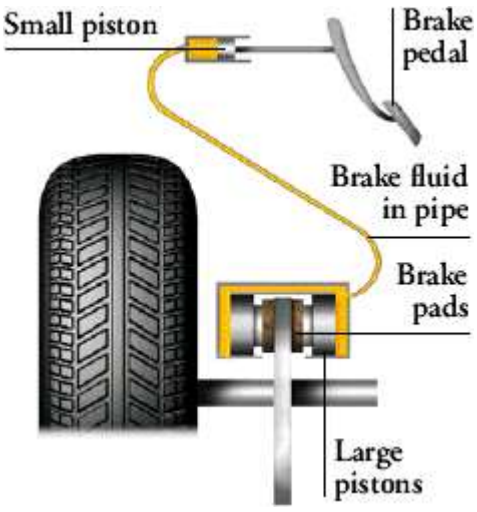
- The sliding and floating designs are quite similar. In both designs, the pad on the inside of the rotor is moved into contact with the rotor by hydraulic force.
- The caliper, which is not held in a fixed position, moves slightly, bringing the outside pad into contact with the rotor.
- Floating calipers use threaded guide pins and bushings, or sleeves to allow the caliper to slide and apply the brake pads.
- There are typically three methods of securing a sliding caliper to its mounting bracket: with a retaining pin, with a key and bolt, or with a wedge and pin.
- On calipers that use the retaining pin method, pins driven into the slot between the caliper and the caliper mount.
- On calipers which use the bolt and key method, a key is used between the caliper and the mounting bracket to allow the caliper to slide. The key is held in position by a lock bolt.
- On calipers which use the pin and wedge method, a wedge, retained by a pin, is used between the caliper and the mounting bracket.
- For pad removal purposes, fixed calipers are usually not removed, floating calipers are either removed or flipped (hinged up or down on one pin), and sliding calipers are removed.

Hydraulic Brakes:

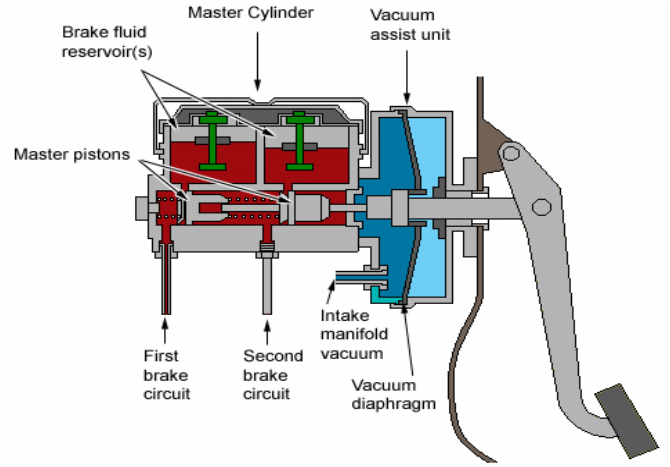


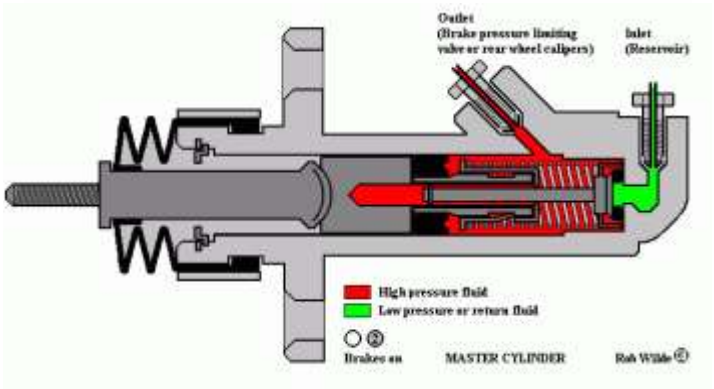
Typical Automotive Braking System

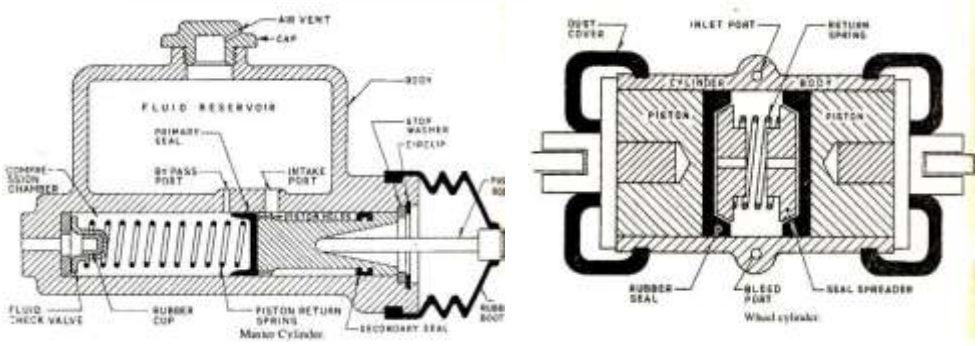




- When you step on the brake pedal, you expect the vehicle to stop.
- The brake pedal operates a hydraulic system that is used for two reasons.
- First, fluid under pressure can be carried to all parts of the vehicle by small hoses or metal lines without taking up a lot of room or causing routing problems.
- Second, the hydraulic fluid offers a great mechanical advantage-little foot pressure is required on the pedal, but a great deal of pressure is generated at the wheels.
- The brake pedal is linked to a piston in the brake master cylinder, which is filled with hydraulic brake fluid.
- The master cylinder consists of a cylinder containing a small piston and a fluid reservoir.
- Modern master cylinders are actually two separate cylinders. Such a system is called a dual circuit, because the front cylinder is connected to the front brakes and the rear cylinder to the rear brakes. (Some vehicles are connected diagonally.)







- The two cylinders are actually separated, allowing for emergency stopping power should one part of the system fail.
- The entire hydraulic system from the master cylinder to the wheels is full of hydraulic brake fluid.
- When the brake pedal is depressed, the pistons in the master cylinder are forced to move, exerting tremendous force on the fluid in the lines.
- The fluid has nowhere to go, and forces the wheel cylinder pistons (drum brakes) or caliper pistons (disc brakes) to exert pressure on the brake shoes or pads.
- The friction between the brake shoe and wheel drum or the brake pad and rotor (disc) slows the vehicle and eventually stops it.
- Also attached to the brake pedal is a switch that lights the brake lights as the pedal is depressed. The lights stay on until the brake pedal is released and returns to its normal position.

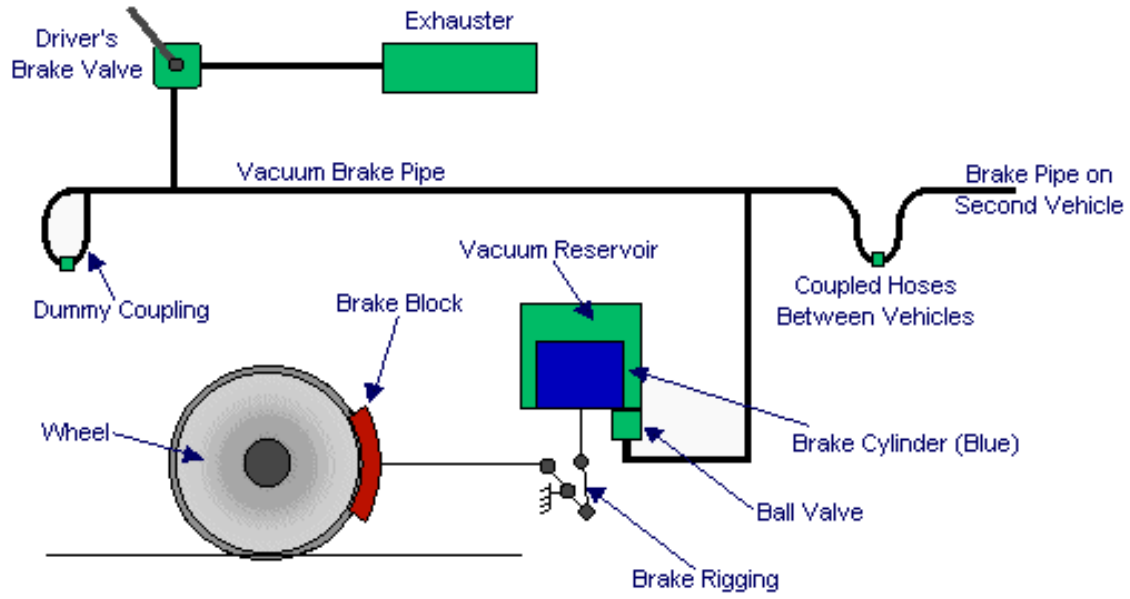
- Each wheel cylinder in a drum brake system contains two pistons, one at either end, which pushes outward in opposite directions.
- In disc brake systems, the wheel cylinders are part of the caliper (there can be as many as four or as few as one).
- Whether disc or drum type, all pistons use some type of rubber seal to prevent leakage around the piston, and a rubber dust boot seals the outer ends of the wheel cylinders against dirt and moisture.
- When the brake pedal is released, a spring pushes the master cylinder pistons back to their normal positions.
- Check valves in the master cylinder piston allow fluid to flow toward the wheel cylinders or calipers as the piston returns.
- Then as the brake shoe return springs pull the brake shoes back to the released position, excess fluid returns to the master cylinder through compensating ports, which have been uncovered as the pistons move back.
- Any fluid that has leaked from the system will also be replaced through the compensating ports.
- All dual circuit brake systems use a switch to activate a light, warning of brake failure.
- The switch is located in a valve mounted near the master cylinder.
- A piston in the valve receives pressure on each end from the front and rear brake circuits.
- When the pressures are balanced, the piston remains stationary, but when one circuit has a leak, greater pressure during the application of the brakes will force the piston to one side or the other, closing the switch and activating the warning light.
- The light can also be activated by the ignition switch during engine starting or by the parking brake.
- Front disc, rear drum brake systems also have a metering valve to prevent the front disc brakes from engaging before the rear brakes have contacted the drums. T
- his ensures that the front brakes will not normally be used alone to stop the vehicle.
- A proportioning valve is also used to limit pressure to the rear brakes to prevent rear wheel lock-up during hard braking.

Brake fluid:

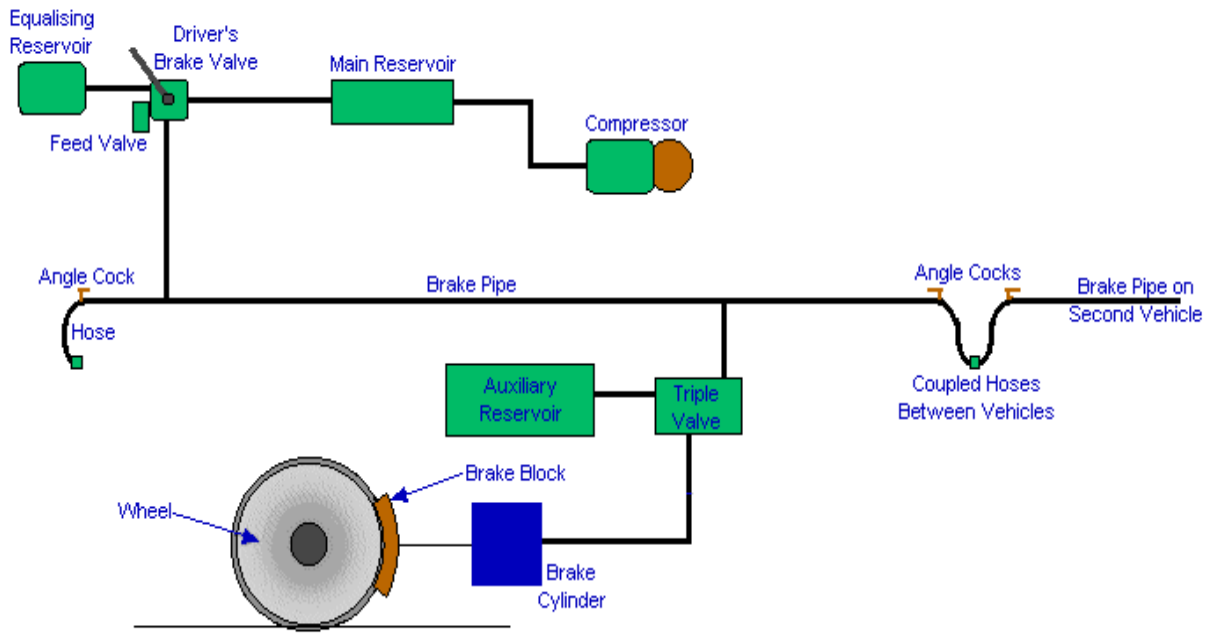
- Clean, high quality brake fluid is essential to the safe and proper operation of the brake system.
- If the brake fluid becomes contaminated, drain and flush the system, then refill the master cylinder with new fluid.
- Never reuse any brake fluid. Any brake fluid that is removed from the system should be discarded**.**
- Vehicle manufacturers recognized the need for a fluid that resisted high temperatures, had lubricating capabilities, had a low freezing point and resisted corrosion.
- Some vehicles have been built using a silicone-based brake fluid, but these are few and far between. petroleum-based liquids.
- Silicone fluids are, of course, not petroleum-based and are completely incompatible with other types and may cause damage to the rubber seals if added to systems that are not designed for silicone fluid.
- There are 2 chief advantages to silicone-based brake fluid.
- It has a superior ability to withstand heat.
- And it does not absorb moisture.
- However, petroleum based fluids are perfectly able to withstand the heat generated by just about all modern vehicles.
- Brake fluid is a specialized liquid and should never be mixed with any other type of fluid, such as mineral oil.
- Also, brake fluid has the ability to absorb moisture from the air, so, it can become contaminated simply by age.
- When removing the master cylinder cap or disconnecting brake lines, the system is open.
- The brake fluid will absorb small amounts of moisture, thereby reducing its effectiveness.
- Brake fluid contaminated with moisture will cause rust in the system as well as losing its ability to stand up to heat.
- Therefore, it is recommended by many vehicle manufacturers and most professionals that the brake fluid system be flushed and refilled every 2 years. This is especially true on vehicles with ABS systems.
- Brake fluid should be handled with care. Brake fluid is a nasty and poisonous substance. Keep it out of the eyes and off the skin.
- Also, it is an excellent paint remover.

Power brakes:

- Power brakes operate just as standard brake systems, except in the actuation of the master cylinder pistons.



Block Diagram of Basic Vacuum Brake Equipment

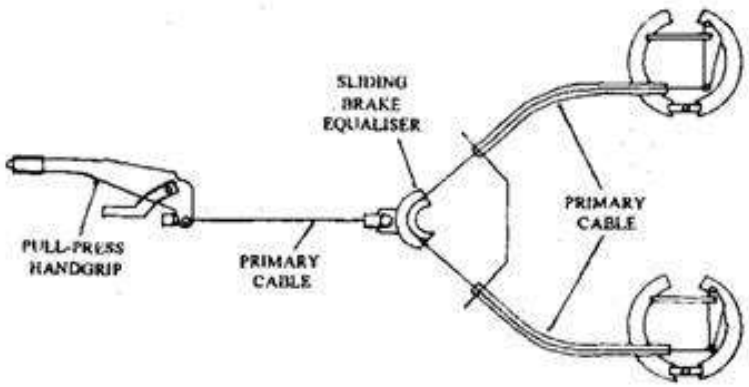


Block Diagram of Basic Air Brake Equipment

- A vacuum diaphragm is located behind the master cylinder and assists the driver in applying the brakes, reducing both the effort and travel he must put into moving the brake pedal.
- The vacuum diaphragm housing is connected to the intake manifold by a vacuum hose.
- A check valve at the point where the hose enters the diaphragm housing ensures that during periods of low manifold vacuum brake assist vacuum will not be lost.
- Depressing the brake pedal closes the vacuum source and allows atmospheric pressure to enter on one side of the diaphragm.
- This causes the master cylinder pistons to move and apply the brakes. When the brake pedal is released, vacuum is applied to both sides of the diaphragm, and return springs return the diaphragm and master cylinder pistons to the released position.
- If the vacuum fails, the brake pedal rod will butt against the end of the master cylinder-actuating rod and direct mechanical application will occur as the pedal is depressed.
- The hydraulic and mechanical problems that apply to conventional brake systems also apply to power brakes.

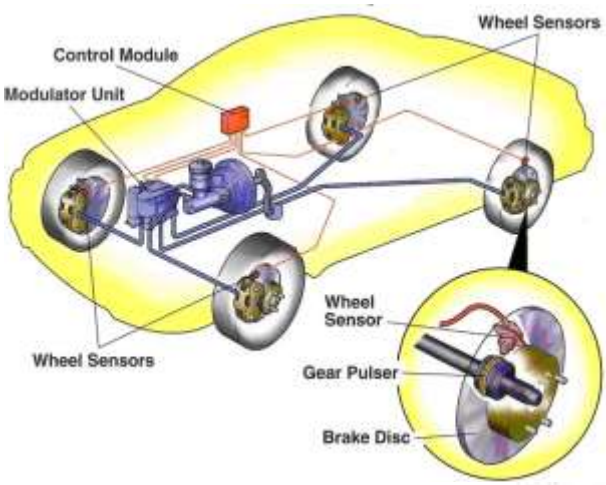
Parking brake:

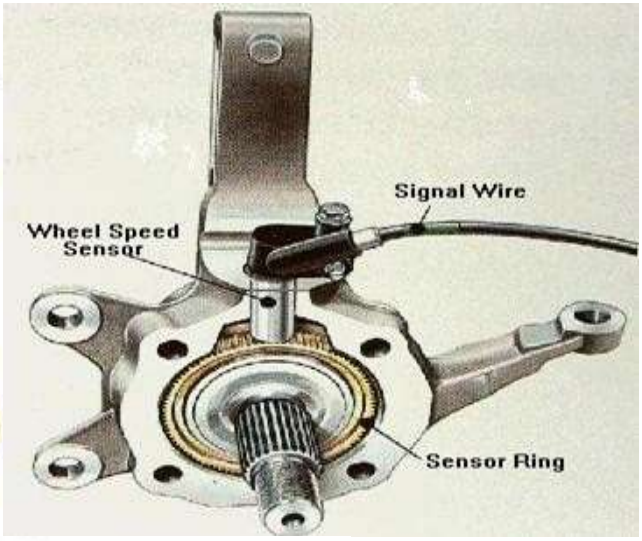
- The emergency or parking brake is used simply to hold the vehicle stationary while parked.
- It has no hydraulic connection and is simply a means of activating the rear (usually) or front (rarely) wheel brakes with a cable attached to a floor-mounted lever or dash-mounted pedal or lever

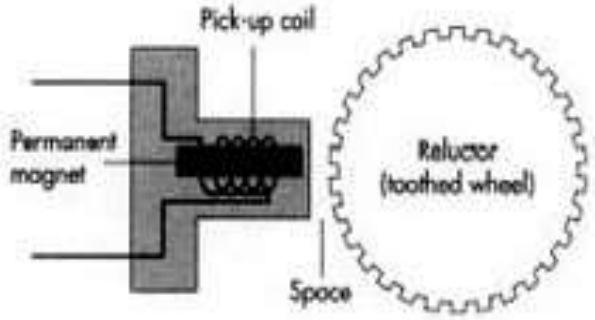


Anti-lock Braking Systems (ABS):

Anti-lock Braking Systems (ABS) are designed to prevent locked-wheel skidding during hard braking or during braking on slippery surfaces.



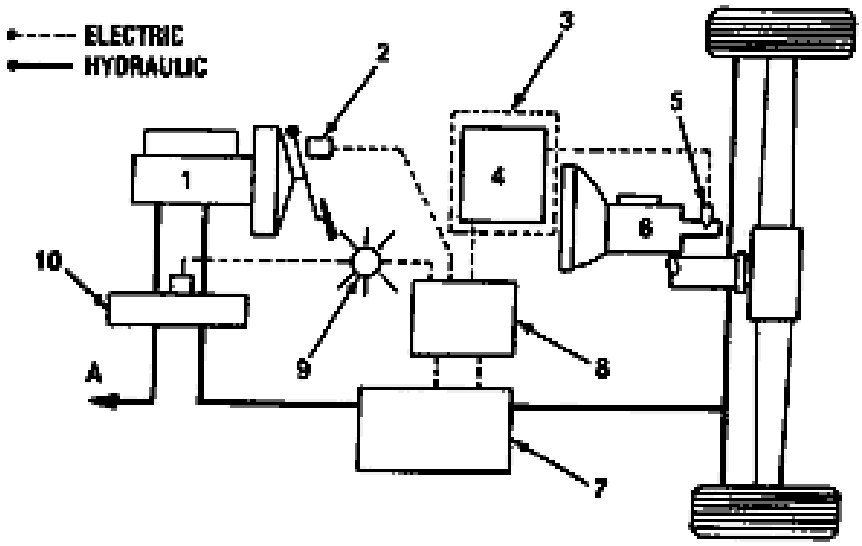




Speed Censor Circuit

- The front wheels of a vehicle cannot apply steering force if they are locked and sliding; the vehicle will continue in its previous direction of travel.
- The four wheel anti-lock brake systems found on many of today's vehicles hold the wheels just below the point of locking, thereby allowing some steering response and preventing the rear of the vehicle from sliding sideways while braking.
- The Rear Wheel Anti-Lock (RWAL) systems used primarily on trucks and vans is designed to prevent the rear wheels from locking up during severe braking.

- Especially since these vehicles are often designed to carry heavy loads, the rear brakes can be very touchy when the truck or van is unloaded.
- RWAL systems usually utilize a load sensing mechanism to adjust the sensitivity of the system to compensate for heavy or no load situations.
- There are conditions for which the ABS system provides no benefit.
- Debris, gravel, snow or sheets of ice render the ABS system ineffective since it relies on an underlying amount of road traction, which is not available when driving on gravel, excessive debris, snow or ice.
- Hydroplaning is possible when the tires ride on a film of water, losing contact with the paved surface.
- This renders the vehicle totally uncontrollable until road contact is regained.
- Extreme steering maneuvers at high speed or cornering beyond the limits of tire adhesion can result in skidding which is independent of vehicle braking.
- For this reason, the system is named anti-lock rather than anti-skid.
- Under normal braking conditions, the ABS system functions in the same manner as a standard brake system.
- The system is a combination of electrical and hydraulic components, working together to control the flow of brake fluid to the wheels when necessary.
- The anti-lock brake system's Electronic Control Unit (ECU) is the electronic brain of the system, receiving and interpreting speed signals from the speed sensors.
- The ECU will enter anti-lock mode when it senses impending wheel lock at any wheel and immediately control the brake line pressure(s) to the affected wheel(s).
- The hydraulic actuator assembly is separate from the master cylinder and booster.
- It contains the wheel circuit valves used to control the brake fluid pressure to each wheel circuit.
- If the ABS becomes inoperative for any reason, the fail-safe system insures that the normal braking system is operative. The dashboard warning lamp is activated to show that the ABS is disabled.



Typical rear wheel only (RWAL) ABS system components.

To front brakes:

1. Master cylinder
2. Brake light Switch
3. Instrument cluster
4. Digital radio adapter (part of instrument cluster)
5. Speed sensor
6. Transmission
7. Isolation/dump valve
8. RWAL control module
9. Brake warning light
10. Combination valve

Typical system operation:

- A typical 4-wheel anti-lock brake system uses a 4-sensor, 4-channel system.
- A speed signal for each wheel is generated by a speed sensor at the wheel.
- The hydraulic actuator contains 4 control solenoids, one for each wheel brake line.
- On RWAL systems, there is either one wheel speed sensor mounted at each rear wheel or one sensor mounted in the differential case, which reads the axle speed.
- The hydraulic actuator controls the brake line(s) feeding the rear wheel brakes.
- The system is capable of controlling brake line fluid pressure to any or all of the wheels as the situation demands.

- When the ECU receives signals showing one or more wheels about to lock, it sends an electrical signal to the solenoid valve(s) within the actuator to release the brake pressure the line.
- The solenoid moves to a position which holds the present line pressure without allowing it to increase.
- If wheel deceleration is still outside the pre-programmed values, the solenoid is momentarily moved to a position which releases pressure from the line.
- As the wheel unlocks or rolls faster, the ECU senses the increase and signals the solenoid to open, allowing the brake pedal to increase line pressure.
- This cycling occurs several times per second when ABS is engaged.
- In this fashion, the wheels are kept just below the point of lock-up and control is maintained.
- When the hard braking ends, the ECU resets the solenoids to its normal or build mode.
- Brake line fluid pressures are then increased or modulated directly by pressure on the brake pedal.
- Fluid released to the ABS reservoirs is returned to the master cylinder by the pump and motor within the actuator.
- On 4-wheel systems, the front and rear wheels are controlled individually, although the logic system in the ECU reacts only to the lowest rear wheel speed signal.
- This method is called Select Low and serves to prevent the rear wheels from getting greatly dissimilar signals which could upset directional stability.
- The operator may hear a popping or clicking sound as the pump and/or control valves cycle on and off during normal operation.
- The sounds are due to normal operation and are not indicative of a system problem.
- Under most conditions, the sounds are only faintly audible.
- If ABS is engaged, the operator may notice some pulsation in the body of the vehicle during a hard stop; this is generally due to suspension shudder as the brake pressures are altered rapidly and the forces transfer to the vehicle.
- There may also be a noticeable pulsation in the brake pedal as the hydraulic fluid is controlled by the ABS system; this is normal and should not be thought of as a defect in the system.
- Although the ABS system prevents wheel lock-up under hard braking, as brake pressure increases wheel slip is allowed to increase as well.
- This slip will result in some tire chirp during ABS operation.
- The sound should not be interpreted as lock-up, but rather as an indication of the system holding the wheel(s) just outside the point of lock-up.
- Additionally, the final few feet of an ABS-engaged stop may be completed with the wheels locked; the electronic controls do not operate below about 3 mph (5 km/h).

CHAPTER – 5 : WHEEL & TYRES

TYRES

INTRODUCTION

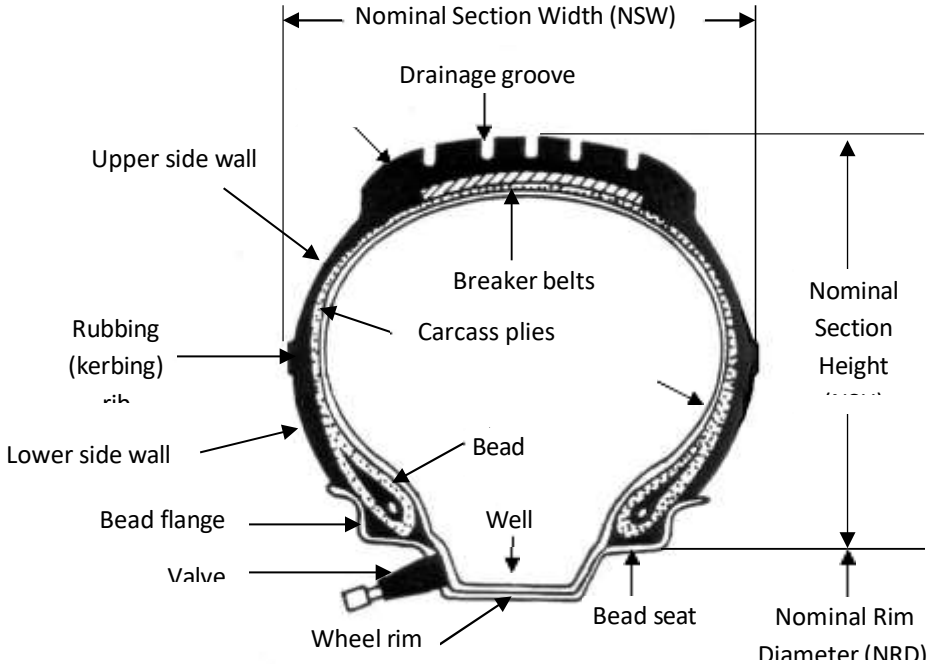
The transition from the early wooden and steel wheels first to solid rubber tires and then to pneumatic tires has probably had the most significant share in the level of sophistication reached by motor vehicles today. The development of the pneumatic tire has contributed significantly to the improved ride comfort, directional control, and stability, as well as to the safety and economy of the motor vehicle.

Tire Nomenclature

The load carried by the pneumatic tire cannot be related directly to the product of the inflation pressure and the contact area of the tire with the road surface. The common belief that it is the air inside the tire that carries the load, therefore, cannot be justified. It is evident that the outer rubber structure which forms the flesh of the tire cannot support the internal air pressure without a skeleton. This skeleton, which is called the carcass, is stressed by the air pressure and the other imposed loads on the tire and thus has a powerful influence on the determination of the final characteristics of the tire.

The pneumatic tire consists of three primary components. The carcass of a tire is composed of several layers of plies which are coated by a rubber compound on both sides. These layers maintain the internal air pressure of the tire in supporting the load. All plies are tied into bundles of steel wire which are called bead wires. The beads are the parts that fit the tire on the rim, preventing the tire from slipping out of the rim while the vehicle is in motion. Tread is the fleshy wearing surface of the tire and is molded to the carcass. It is manufactured from synthetic rubber compounds and provides resistance to abrasion and cutting, as well as a tread pattern to grip the road.

The standard nomenclature used for pneumatic tires of motor vehicles is shown in figure.



Types of Carcass Construction

There are two basic types of carcass construction:

i) Cross (bias or diagonal in the USA) ply,
ii) Radial ply.

These two basic constructions are illustrated in Fig. I-4.

A third type is produced by a combination of the two basic constructions and is named the belted bias tire. The belted bias carcass construction is illustrated in Fig. I-5.

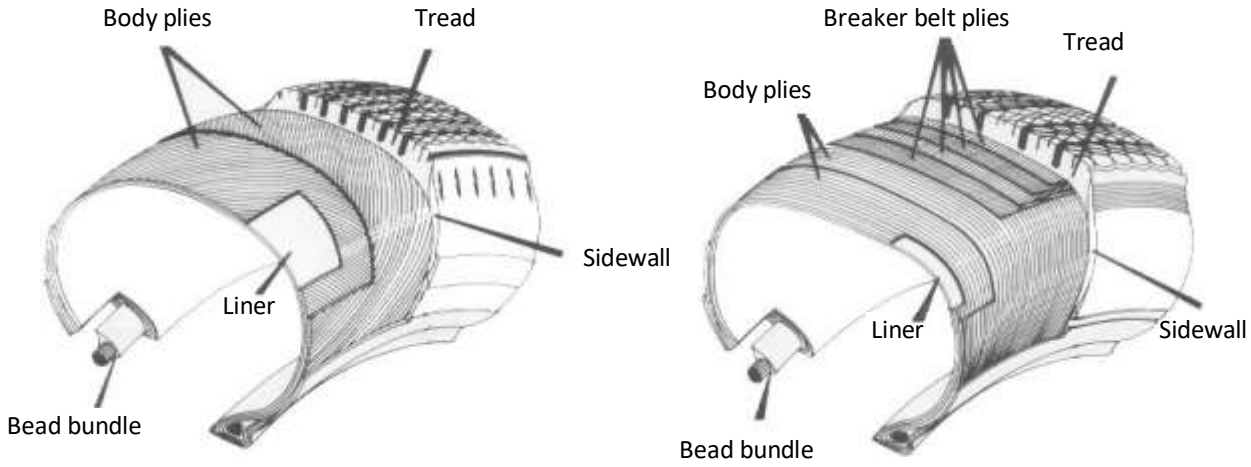


Figure I-4. Construction of cross and radial ply tires

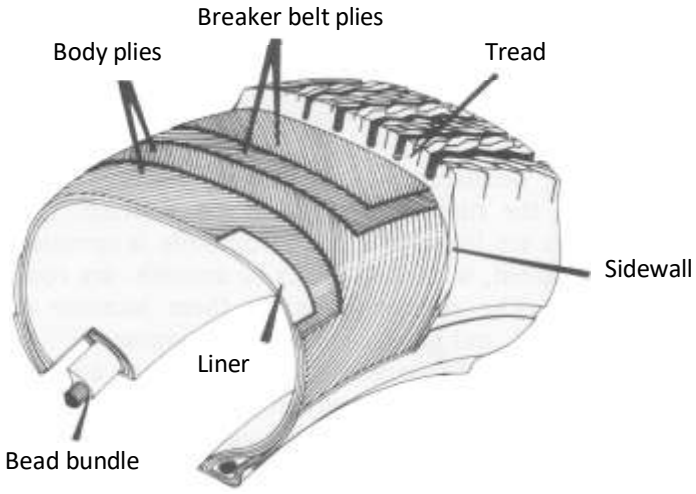
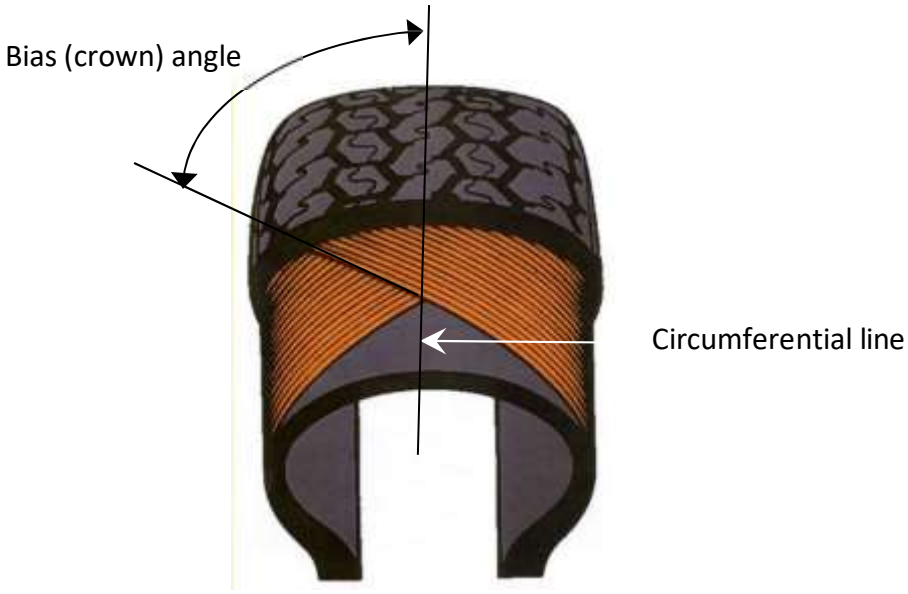


Figure I-5. Belted bias carcass construction

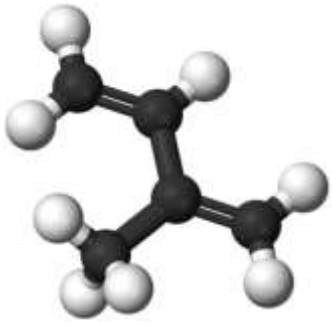


Bias (or crown) angle

As a result of these experiments, ***cross-ply tires*** were introduced in the early 1920s with a tenfold increased tire life. In this type of construction, the carcass is made up of two or more plies (layers) of fabric that have all its cords running in one direction only. To obtain the apparent compromise between the two extremes, layers are placed such that the cords make an angle (***bias or crown angle***) of 45 degrees with the circumferential line of the tire, Fig. I-8. The adjacent layers are placed at opposite bias. The bias angle was later reduced to about 40 degrees. In racing car tires, bias angles down to 25 degrees are encountered.

Tire Materials:

Natural rubber (NR), in its original state, is not a consistent engineering material. The means of imparting the desired properties of strength and elasticity to NR was accidentally discovered by C. **Goodyear** in 1839. This process involved heating NR mixed with sulfur and is called vulcanization. For many years after this discovery, tires were produced entirely of NR. It was shown in 1826 that the composition of NR could be expressed by the formula $(C_5H_8)n$, and in 1860 isoprene, C_5H_8, was isolated. Soon after, several synthetic rubber-like materials were produced from isoprene. Today, many synthetic rubber materials suitable for use in rubber compounds are available, and tires are manufactured almost entirely from various blends of synthetic rubbers.



Isoprene

Tread and Sidewall Materials

The rubber compound to be used in the tread must meet a number of requirements. It must provide a high frictional coefficient on the road surface. An adequate grip is expected on all kinds of road surfaces, cold, hot, wet, or covered with snow or ice. Tread rubber must have excellent abrasion resistance as well as resistance to tearing and cutting. It must provide acceptable behavior against cracking and oxygen and ozone attack. The ability to bond to carcass material effectively is still another requirement. Similar requirements are to be met by sidewall rubber, with the emphasis being on the cracking, abrasion, and bonding characteristics. It is evident that to meet such a diverse list of requirements, a compound of various synthetic rubbers together with other additives is necessary.

Styrene-butadiene rubber (SBR) is the most common synthetic material used in such compounds. It owes its popularity to the fact that it has excellent resistance to abrasion and a high degree of energy absorption (hysteresis), resulting in a less springy tire to provide a softer ride with good grip, particularly on wet road surfaces. Increasing the oil content of SBR results in oil extended SBR (OESBR), with even more improved wet grip. In addition, it is made from readily available materials and makes a firm bond with carcass materials.

Another very useful synthetic rubber is **polybutadiene** (BR or sometimes PB) which is very hard to wear and less sensitive to changes in temperature than other rubbers. Its resistance to cutting and tear propagation is also exceptionally high. However, too much of it will make tires scream on dry roads and slip on wet roads. It is usually added to SBR, to NR, or both in small quantities, causing a significant improvement in wear resistance with a slight decrease in wet grip because of its high resilience.

The synthetic, which is the nearest thing to natural rubber, is ***polyisoprene*** (PI). PI is mixed in small quantities with SBR or NR to provide better abrasion resistance due to its excellent wearing properties and extremely low sensitivity to heat. It is particularly suited for use in truck tires that run at relatively high temperatures.

Inner Lining Materials

The most crucial requirement in the case of inner tubes and the lining of tubeless tires is that of low permeability to gases. The synthetic rubber which meets this requirement best is the ***butyl rubber*** (IIR) which also has very high hysteresis and traction characteristics. It cannot be used as a tread material because it blends neither with NR and nor with SBR.

Carcass Materials

In carcass construction, the best material for impregnating and coating the fabrics is still natural rubber. In the early tires, cotton cords were used in the plies. The later use of plies made up of rayon, polyester, nylon, glass fiber, and more recently, aramids embedded in rubber has resulted in increased life as well as the load-carrying capacity of tires.

Breaker Cord Materials

The usual cord materials for the breaker belts of the radial-ply tires are rayon and fine steel wire. ***Steel belted radials*** (SBR) offer better cornering ability and directional control, lower rolling resistance improved fuel consumption and performance for the vehicle - and longer life at the expense of inferior ride comfort and quietness in addition to a 10 percent higher cost compared with ***textile belted radials*** (TBR). Recently nylon and glass fiber have been used for breaker cords. The former is stronger, more elastic, and more flexible than rayon and is preferred for applications involving high speeds and heavy loads. It tends, however, to lose its flexibility when cold. The latter is very strong and elastic but requires special techniques in production.

Additives

In addition to the main ingredients above, there are other additives used in rubber compounds. The most important of these are the following.

i/ **Vulcanizing agents** to impart strength and elasticity, basically sulfur.

ii/ **Activators** and accelerators to modify the chemical action before or during vulcanization.

iii/ **Fillers** to provide cheap bulk to save expensive rubber. Carbon black is the best filler that provides extra strength and resistance to wear and, as such, can be considered as a reinforcing agent as well. Carbon black gives the tires their characteristic black color. Recently, in the so-called “energy tires”, some of the carbon black in the compound is replaced by silica. This reduces the rolling resistance and improves traction on wet or snowy road surfaces, while life and ride are unaffected.

iv/ **Plastisizers** (**extenders**) and softeners to reduce time and temperatures involved in processing. Oils of petroleum origin are used as extenders, and they provide the additional benefit of the better road holding at the expense of rapid tire wear.

v/ **Antioxidants** and **antiozonants** to preserve the consistency of rubber in time.

Tread Pattern

The primary function of the tread pattern is to improve the tire grip, particularly on road surfaces covered with water, snow, slush, mud, or ice. In performing its function, the tread pattern must meet the requirements on tread wear, noise generated, and other characteristics peculiar to the particular conditions and applications.

A completely smooth tire would give the greatest possible area of contact between the tire tread and the road surface, and consequently, the best possible grip, provided that the road surface is clean and dry. It will also have the longest working life because of reduced loading on the unit area of rubber. Such a tire would have hardly any grip, however, in the presence of even a slight amount of water on the road surface. The water forms, in this case, a lubricating film between the tire and the road surface, causing a loss of steering control and braking ability. If the amount of water is appreciable, it builds up in front of and beneath the tire forming a wedge as illustrated in Fig. I-9. The tire will then be lifted off the road and slide on the water with no directional control. This phenomenon is called **aquaplaning** (or **hydroplaning**).

To help the tire to grip the road surface in the presence of water, a tread pattern consisting of longitudinal primary and secondary **drainage grooves** (channels), lateral drainage grooves, and micro slits like knife cuts, which are called **sipes**, must be provided. If there is only a thin film of water on the road, the tread pattern breaks through the film and grips the road surface. In the case of larger amounts of water on the road, the same function is performed in three stages.

i/ The tread pattern pushes the water aside and pumps it backward and sideways through the drainage grooves.

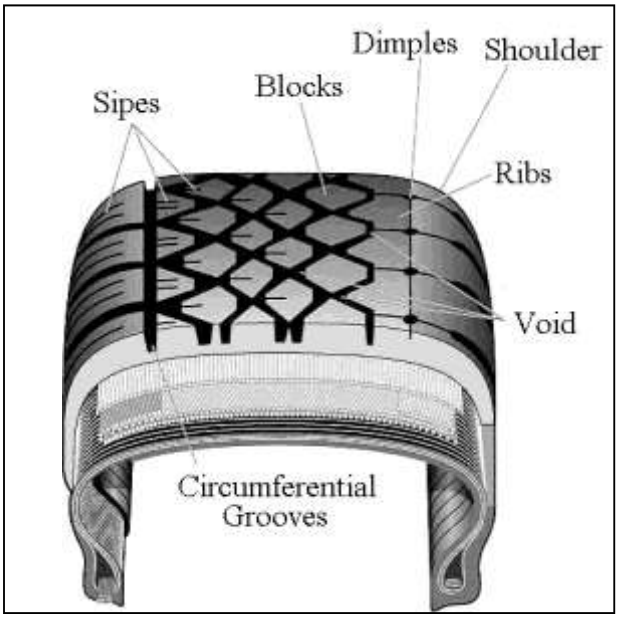
ii/ The remaining thin film of water is broken by the tread pattern, and the small amount of water left on the surface is absorbed by the sipes, which act like a sponge.

iii/ The tread pattern contacts the now dry road surface to develop the maximum possible grip.

It should be clear that as vehicle speed increases, there will be less time for the tread pattern to perform its function, and the grip provided will decrease. Aquaplaning is a possibility even with new tires of good tread design if there is plenty of water on the road and the vehicle speed is high enough.

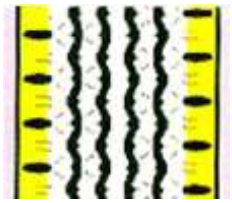
In improving the grip of the tire, the mere frictional transmission of loads involved in acceleration, braking, and cornering is not sufficient, and some kind of mechanical grip must be provided. This requirement is met by a tread pattern having well-defined and sharp edges. When these biting edges are parallel to the

circumference of the tire, good steering and cornering characteristics are obtained. Good traction and braking, on the other hand, are obtained with biting edges perpendicular to the circumference. Since traction, braking, and steering are all critical to most motor vehicles, the obvious compromise is to position these edges diagonally in a zig-zag pattern as illustrated in Fig

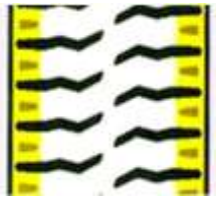


Tread pattern

Basic types of tread patterns and their properties and applications are summarized below.



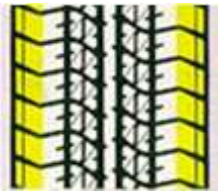
Rib Shape: This tread pattern is characterized by multiple circumferential grooves. Advantages include lower rolling resistance plus good directional stability, and steering control. Rib-type patterns are suitable for sustained high speeds because of their low levels of heat generation. They have, however, poor braking and acceleration grip on wet
roads, and their use is confined to paved road surfaces and steered axles of trucks and buses.



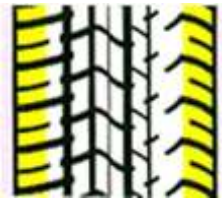
Lug shape: These patterns are identified by their groove arrangements perpendicular to the circumference of the tire. The main advantage of lug patterns is their excellent braking and traction characteristics.

Lug patterns are not suitable for high-speed driving due to their high rolling resistance and noise generation. They are mainly used for
dirt roads, rear wheels of buses and agricultural tractors, industrial vehicles, and dump trucks.

Rib-Lug shape: This is a combination of rib and lug designs. The main features are a rib in the center providing directional control and shoulder lugs giving good braking and traction characteristics. They find applications in tires for both paved and dirt roads and are usually used in both front and rear wheels of trucks and buses.



Block-shape: These consist of independent blocks created by intersecting circumferential and lateral grooves. Block patterns provide good steering control and stability on snow-covered and wet roads as well as good water dispersal properties in the wet. However, because the tread blocks are smaller, tire wear tends to be fast. They are suitable for winter or all-season passenger car tires.



Asymmetric pattern: In this pattern, the design is different on either side of the tire. Asymmetric tires have been designed to optimize the opposing requirements of dry grip and water dispersal. They are suitable for high-speed cornering due to the greater contact area (low void ratio), which helps reduce tread wear on the outside of the tire. On the inside, the void
ratio is higher to give a better wet grip. Asymmetric tires must be positioned the right way around as marked. They are implemented on high-performance vehicle tires.

Directional pattern: These are tread patterns characterized by lateral grooves on both sides of the tire which point in the same direction. The advantages of directional tread patterns are good driving force and braking performance. In particular directional patterns provide good water dispersal, meaning stability on wet roads. Directional tires must be mounted
in the direction of the tread pattern. They are used on passenger car tires for high-speed use.

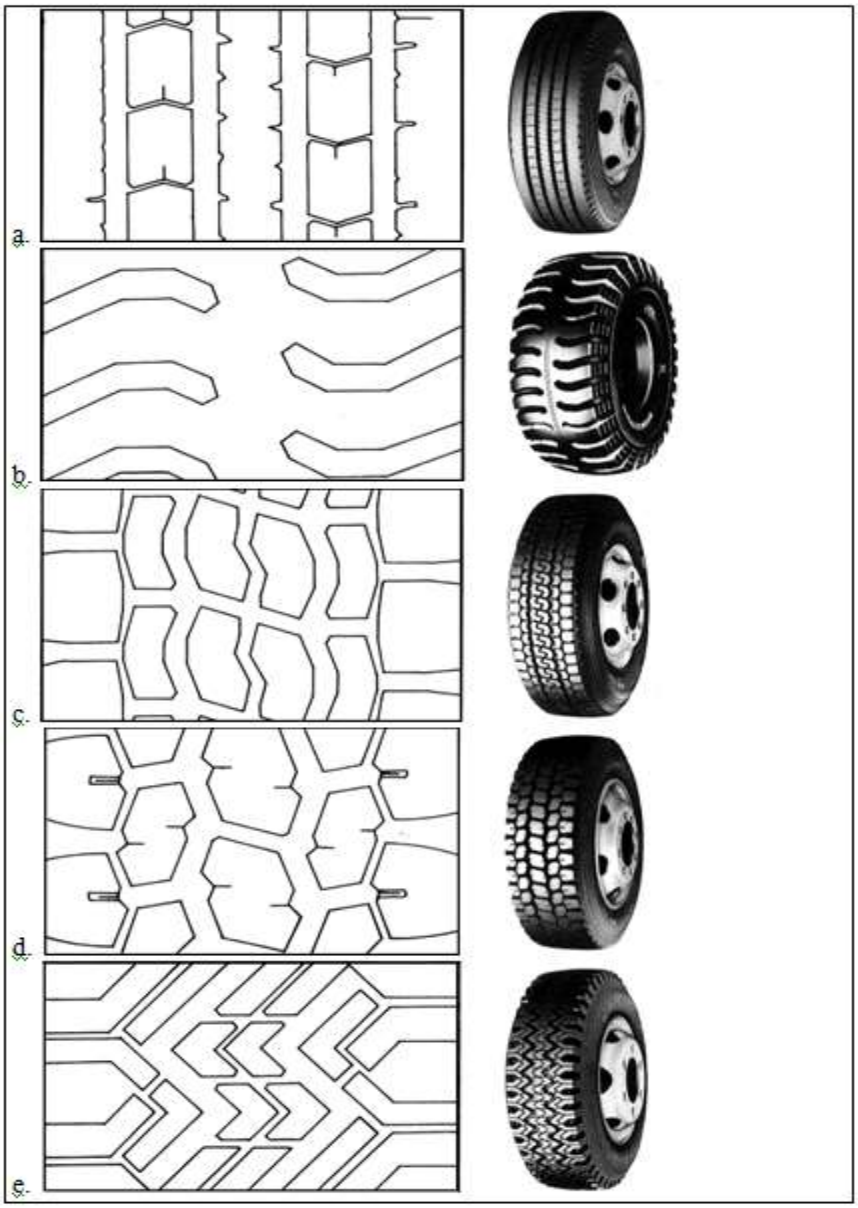


Figure I-11 Tires with various different tread pattern designs.

a. Rib type: Circumferential grooves for silent operation and better directional control,
b. Lug type: Tread for high traction performance, especially in off-road operation,
c. Block type: Circumferential grooves with teeth for handling and high traction performance,
d. Block type: For better traction and braking, especially on mud and snow,
e. Block type: Snow and mud tire.

Early Tire Designations

Tire markings on the sidewall indicate the tire size and, in some cases, the maximum speed rating as well as the load capacity. These apply to a fitted, properly inflated tire carrying its rated load. There have been various tire markings in the history of pneumatic tires, as explained below. The relevant dimensions are as illustrated in Fig

(i) International Tire Designation :

This designation is commonly used for cross-ply tires. A typical example is : 5.60 - 15

where 5.60 is the nominal section width in inches, and 15 is the nominal rim diameter in inches.

(ii) Millimeter-inch Designation:

This designation is now obsolete. A typical example is : 165 - 15

where 165 is the nominal section width in mm, and 15 is the nominal rim diameter in inches.

(iii) Early Radial Tire Designation

This designation is still used even though it has become outdated. A typical example is 165 SR 13

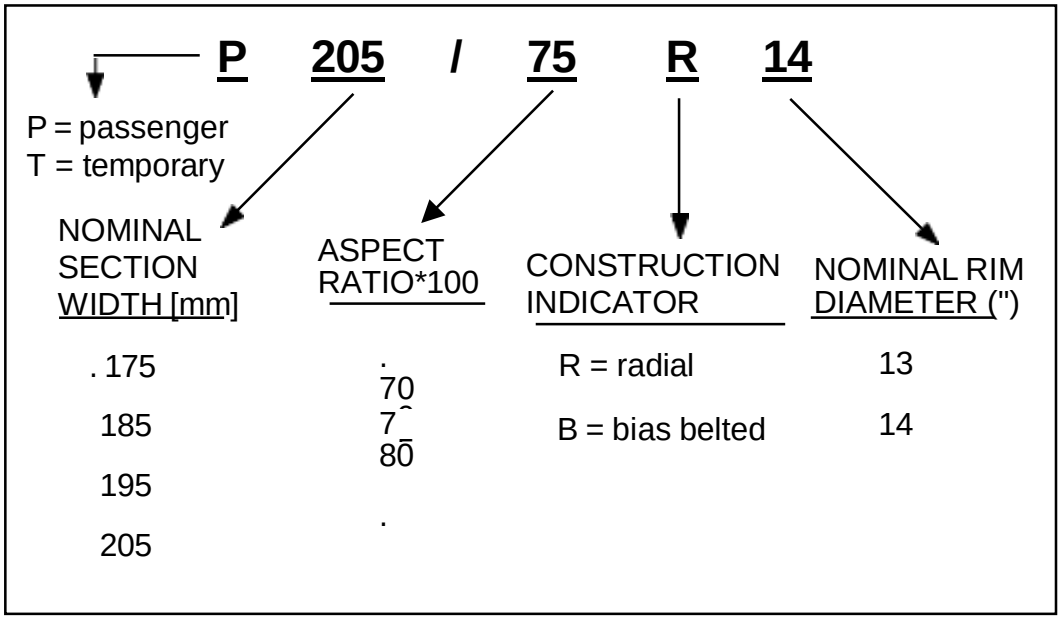
where 165 is the nominal section width in mm,

S is the speed rating that indicates that this particular tire can be used up to 180 [kph]. Other alternative letters are H and V, which indicate allowable speeds up to 210 and above 210 [kph], respectively,

R indicates that the tire is a radial-ply tire, and 13 is the nominal rim diameter in inches.

(iv) P-Metric Designation (ISO):

This is a passenger tire designation system originated by the International Standards Organization (ISO) and had been considered, until recently, to become the international passenger car tire standard. A typical example is given in Figure



P-metric size designation nomenclature

- P is for the passenger (T is for temporary) - optional,
- 205 is the nominal section width in mm. Nominal section widths are permitted in 10 mm increments with endings in "5", e.g. ....., 175, 185, 195, 205 ,
- 75 is the aspect ratio with endings in "0" or "5", e.g. ....., 70, 75, 80, ,
- R is the construction indicator: R-radial, B-bias belted, D-diagonal, and
- 14 is the nominal rim diameter in inches (for the time being, due to the current worldwide availability of rims. New rim designs that are incompatible with current rims will have nominal rim diameters designated in millimeters)

.

NEW TIRE DESIGNATIONS:

Designation for Automobile Tires :

Recently, a new designation that is based on the earlier P-metric designation has been introduced. In this designation, a two-digit number varying from 50 to 110 and a capital letter indicating the load capacity and the speed rating, respectively, are added, as illustrated in Fig. I-14.

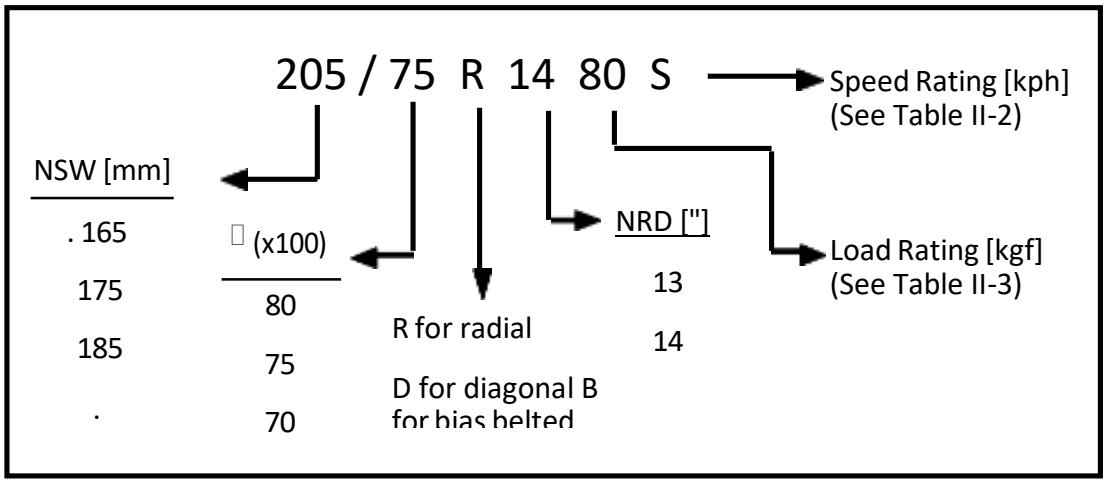


Figure I-14. New designation for automobile tires

The speed and load ratings indicated by the two-digit number and the capital letter added at the end of the designation are given in Table I-1 and I-2, respectively.

Table I-1. Speed ratings for automobile tires.

Letter	Speed rating [kph]
L	120
M	130
N	140
P	150
Q	160
R	170
S	180
T	190
U	200
H	210
V	240
W	270
Y	300
Z	>240

Table I-2. Load ratings for automobile tires.

Designation	Load Rating [kgf]	Designation	Load Rating [kgf]
50	190	80	450
51	195	81	462
52	200	82	475
.53	206	83	487
54	212	84	500
55	218	85	515
56	224	86	530
57	230	87	545
58	236	88	560
59	242	89	580
60	250	90	600
61	257	91	615
62	265	92	630
63	272	93	650
64	280	94	670
65	290	95	690
66	300	96	710
67	307	97	730
68.	315	98	750
69	325	99	775
70	335	100	800
71	345	101	825
72	355	102	850
73	365	103	875
74	375	104	900
75	387	105	925
76	400	106	950
77	412	107	975
78	425	108	1000
79	437	109	1030
		110	1060

Designation for Commercial Vehicle Tires :

Designation for commercial vehicle tires consists of the basic tire dimensions and construction indicator together with the load and speed ratings.

A typical example **11 R 22.5 145/142 L**

Where

11 is the nominal section width in inches,

R is the construction indicator - R for radial,
22.5 is the nominal rim diameter in inches,

145/142 is the load rating, the first number for a single wheel and the second number for a tandem wheel (the actual load capacities are given in Table I-4.),

L is the speed rating according to Table I-3.

Some new commercial vehicle tires may have a designation including the aspect ratio and/or nominal section width specified in [mm] just as in the case of automobile tires.

Table I-3. Speed ratings for commercial vehicle tires.

Letter	Speed rating [kph]
E	70
F	80
G	90
J	100
K	110
L	120
M	130
N	140

Table I-4. Load ratings for commercial vehicle tires.

Designation	Load Rating [kgf]	Designation	Load Rating [kgf]	Designation	Load Rating [kgf]
110	1060	142	2650	174	6700
111	1090	143	2725	175	6900
112	1120	144	2800	176	7100
113	1150	145	2900	177	7300
114	1180	146	3000	178	7500
115	1215	147	3075	179	7750
116	1250	148	3150	180	8000
117	1285	149	3250	181	8250
118	1320	150	3350	182	8500
119	1360	151	3450	183	8750
120	1400	152	3550	184	9000
121	1450	153	3660	185	9250
122	1500	154	3750	186	9500
123	1550	155	3875	187	9750
124	1600	156	4000	188	10000
125	1650	157	4125	189	10300
126	1700	158	4250	190	10600
127	1750	159	4375	191	10900
128	1800	160	4500	192	11200
129	1850	161	4625	193	11500
130	1900	162	4750	194	11800
131	1950	163	4875	195	12150
132	2000	164	5000	196	12500
133	2060	165	5150	197	12850
134	2120	166	5300	298	13200
135	2180	167	5450	299	13600
136	2240	168	5600	200	14000
137	2300	169	5800	201	14500
138	2360	170	6000	202	15000
139	2430	171	6150	203	15500
140	2500	172	6300	204	16000
141	2575	173	6500		

WHEELS

Introduction

A wheel is that rotating part of a suspension system that supports the tire. It consists of two main elements :

i / The rim is the supporting frame for the tire.
ii / The disc provides the connection between the rim and the wheel hub.

These two elements may be integral or are joined together either permanently by welding or by bolts and nuts (i.e., detachable). Wheels can be classified according to the type of service as follows :

i / Automobile wheels.
ii / Wheels for commercial vehicles. iii / Agricultural tractor wheels.
iv / Motorcycle, bicycle, and moto-scooter wheels. v / Industrial and fork-lift truck wheels.
vi / Wheels for earth-moving machinery.

Only the first two types, i.e., the automobile wheels and wheels for commercial vehicles, will be examined here.

Wheel Dimensions / Basic Designation

A wheel is designated by two major dimensions; width and diameter of its rim, both given in inches. A typical designation is, therefore, may be of the form

5.50 x 13

The cross sign, x, separating the two dimensions, indicates that the rim has a single-piece construction as in automobile and agricultural tractor wheels. Commercial vehicle wheels, on the other hand, may have rims consisting of two or more detachable pieces for ease of tire mounting and removal. These wheels are identified by using a dash "-" instead of the cross in the designation, i.e.

5.50 - 16

Automobile Wheels

The automobile wheel has a single-piece rim spot welded to the disc. The nomenclature for a typical automobile wheel is given in Fig. II-1. The central part of the rim has a large peripheral depression which is called a "well" or "drop center" to facilitate mounting and removal of the tire. The flats on both sides of the drop center provide the bead seats and the two flanges retain the tire on the rim under the action of lateral tire forces.

The cross-section of the rim is usually asymmetrical, with the drop center displaced towards the outside of the wheel to allow more space for the brake assembly inside the wheel. The distance between the rim centerline and the mounting face of the disc is called the "offset". There are some symmetrical rims as well, however, and they are distinguished from asymmetrical rims by the addition of a suffix S at the end of the designation, i.e. **5.50 x 13 - S**

Sizes and tolerances of rims have been standardized, and inch units are used internationally. Rim widths vary from 4 inches to 9 inches in half-inch increments, the most commonly used sizes being in the range of 4.0 to 5.5 inches. Rim diameters vary from 12 to 19 inches, the most commonly used sizes being 13 to 15 inches.

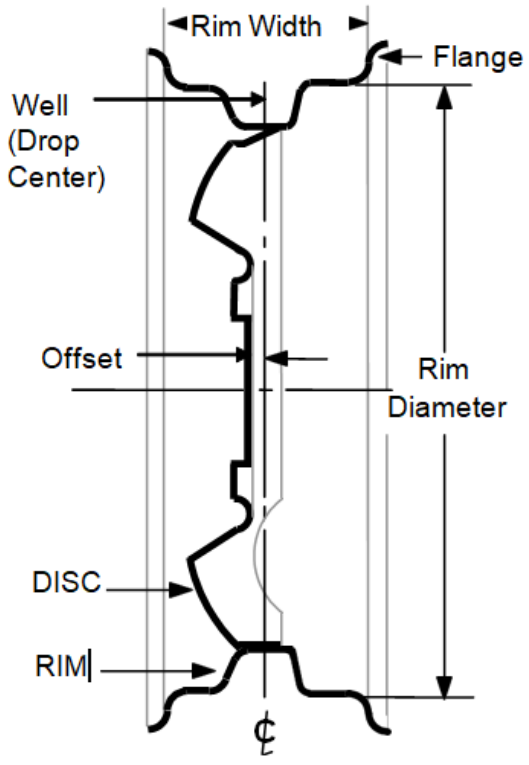


Figure II-1. A typical automobile wheel.

There are several rim flange shapes with different heights, widths, and curvatures. They have been standardized into six basic shapes, designated by letters B, J, JJ, JK, K, and L, as illustrated in Fig. II-2 below.

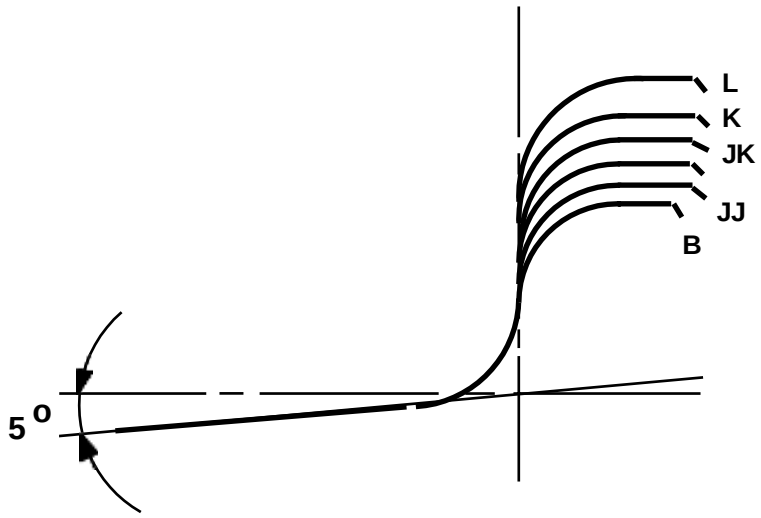


Figure II-2. Rim flange shapes.

The flange shape is indicated in the wheel designation by the shape symbol placed after the rim width.

5.50 JJ x 13

To improve the seating of the tire beads and ensure a tight fit, the surfaces on both sides of the well are slightly tapered. The standard slope towards the well is 5 degrees for automobile wheels. The seats may be flat or have a small obstruction called a "hump" at the well side. If the hump has a flat top, then it is called a "flat hump". These special bead seat contours keep the tire beads from being forced off the seats and fall into the well while cornering. Thus the accidental loss of air in tubeless tires is prevented. In addition, if the tire blows out, it won't leave the rim, improving safety and stability. If the seat is flat with no hump, then the bead seat is called "special ledge". The shapes of the hump, flat hump, and special ledge contours are given in Fig. II-3.

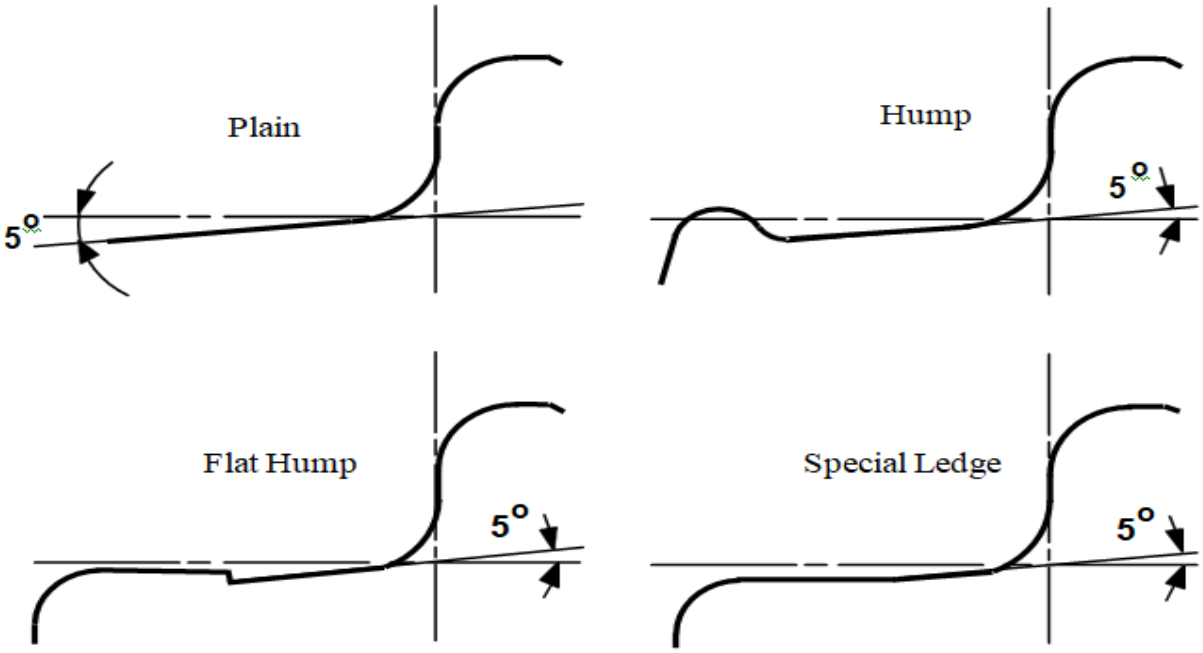


Figure II-3. Bead seat contours.

A rim may have any of these bead seat contours on any side of the well and is named according to the particular combination. Table II-2 gives a list of the combinations most commonly used and their corresponding symbols for use in wheel designations.

Table II-2. Bead seat contour combinations.

Designation	Bead Seat Contour		Symbol
	Outside	Inside	
Hump	Hump	Normal	H
Double hump	Hump	Hump	H2
Flat hump	Flat hump	Normal	FH
Double flat hump	Flat hump	Flat hump	FH2
Combination hump	Flat hump	Hump	CH
Special ledge	Special ledge	Normal	SL

Special bead seat contours are indicated by adding the appropriate symbol to the end of the basic rim designation, for example

5.50 JJ x 13 H2 - S

If there is no bead seat contour indication, then the bead seats are plain (5^{o} slope towards the well).

The disc shape has not been standardized to any extend and is determined according to:

i / the type (disc or drum) and the size of the brakes ii / the shape of the hub

iii / the number of wheel studs

iv / the method of mounting the hub cap

v / the geometry of the steering system, etc.

Therefore the shape of the disc varies widely from one vehicle to another. Construction-wise, the wheels are either made from rolled sheet steel strips welded to pressed steel plate discs or cast from a light magnesium-aluminum alloy and machined. Wire wheels have also been used for a long time.

CHAPTER – 6 : CHASSIS & HEAVY EQUIPMENTS

An automobile is made up of mainly two units, these are Chassis and Body.

- "Frame" + "Base components" = "Chassis"
- "Chassis" + "Body" = "Vehicle"

Chassis

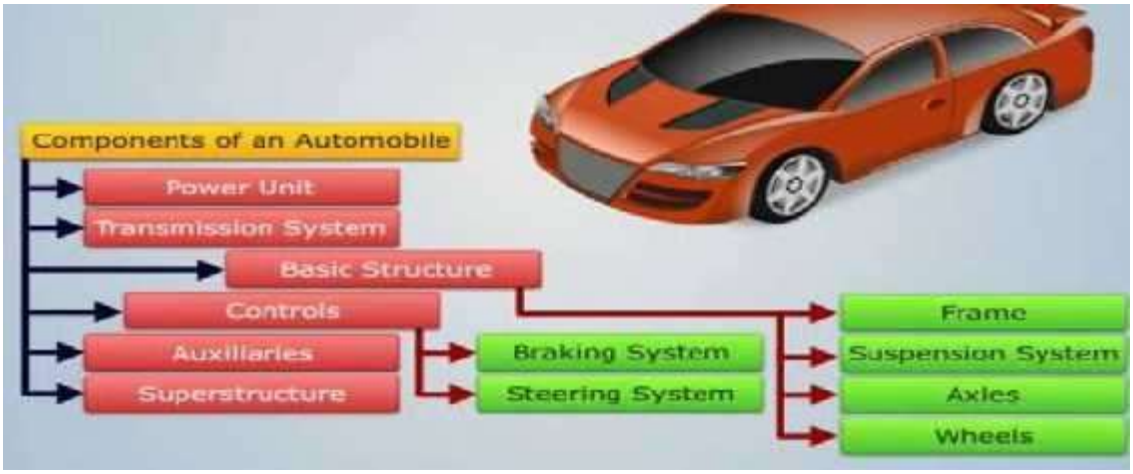
- A vehicle arrangement without body is called chassis.
- Various components and systems of the chassis are
  - The power system - Power units are clutch, gearbox transmission, differential, Rear axle shaft, universal joint &propeller shaft etc …
  - Running system - Running systems consists brakes, wheels, frame, suspension and steering system
  - Electrical system - Electrical system consists of starting circuit, charging circuit, ignition circuit lighting and horn circuit.

Body

- The purpose of the body is to provide accommodation to the driver and the passenger and to protect them against adverse conditions

COMPONENTS OF AN AUTOMOBILE

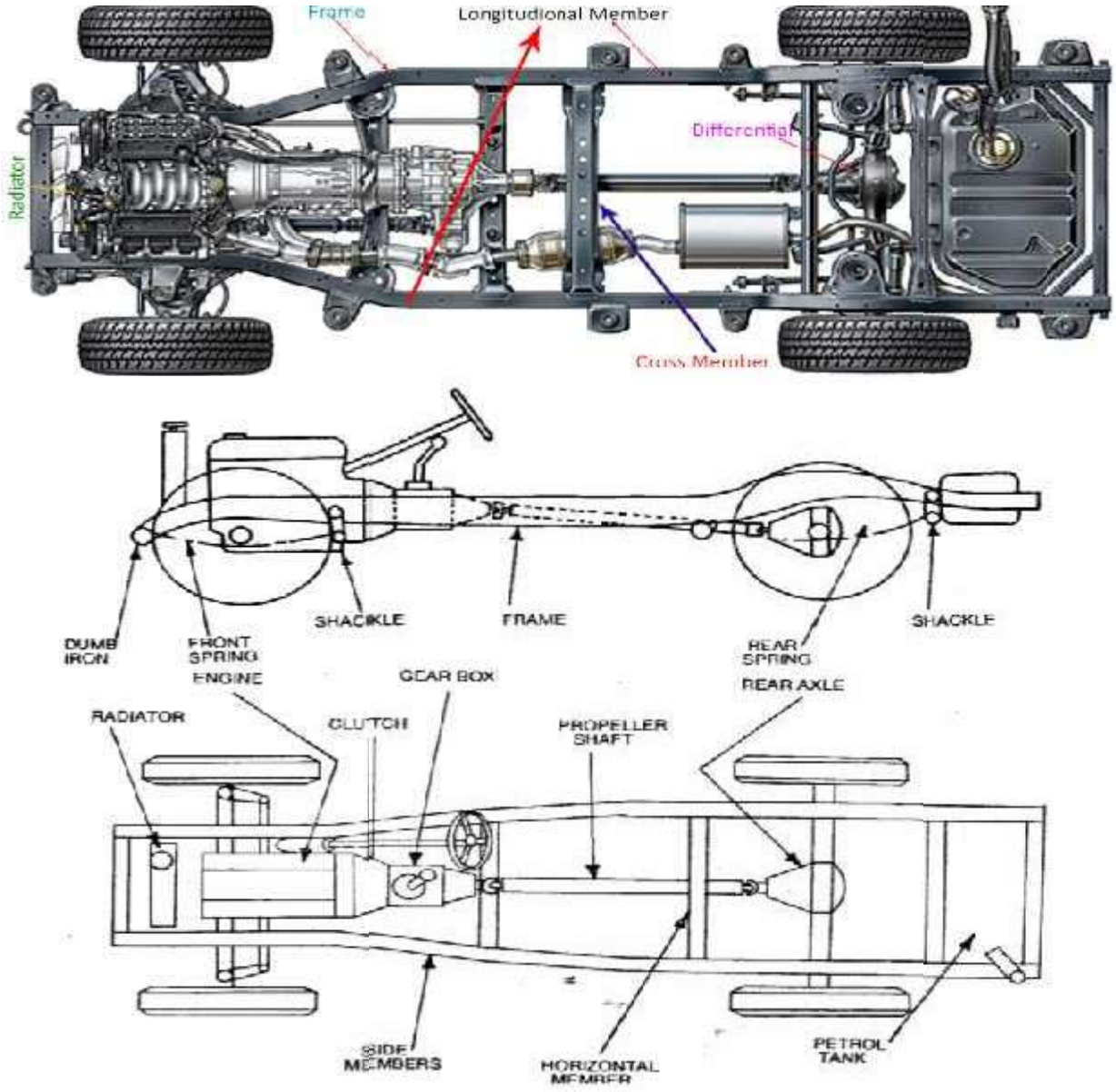
Automobile consists of the Basic structure, the Power plant, the transmission system, the auxiliaries, the controls and the superstructure.



BASIC STRUCTURE:

- This is the unit on which are to be built the remainder of the units required to turn it into a power operated vehicle. It consists of the frame, the suspension systems, axles, wheels and

tyres.



THE FOLLOWING MAIN COMPONENTS OF THE CHASSIS ARE

- **Frame**: it is made up of long two members called side members riveted together with the help of number of cross members.

- **Engine or Power plant**: It provides the source of power.

- **Clutch**: It connects and disconnects the power from the engine fly wheel to the transmission system.

- **Gear Box**- the energy transmitted will In effect change the speed, direction, or torque of the machine where it is installed.

- **Universal Joint**- The universal joint allows the drive shaft to move up and down, to allow for suspension travel. Some drive shafts also have slip joint the allows the drive shaft to make minor length changes as the vehicle suspension height changes

- **Propeller Shaft**- shaft makes any vehicle move by connecting the rear differential to the engine and transmission system. It is a mechanical component shaped like a tube which allows the transmission to the differential.

- **Differential**- It is a device that splits the engine torque two ways, allowing each output to spin at a different speed. The differential is found on all modern cars and trucks, and also in many all-wheel drives

Suspension System

Function of suspension system

- To stable the vehicle from shocks and vibration due to irregular road surface.
- To reduced or prevent the road shocks which are transmitted on the vehicle Frame.
- To regulate stability when vehicle is in motion.
- To maintain propersteering geometry.

Location of suspension system

- Location of suspension is in between axles and chassis.

Axle

There are two types of axles

- Live axle
- Dead axle

Function of live axle

- Live axle is the two half axle. In between them differential is attached, function of live shaft is to transmit the power from engine to wheel.
- It carries the weight of vehicle.

Function of dead axle

- It carries the load of engine.
- When brakes are provided at front wheels then it withstands bending or torsional stresses.
- It is support to the wheels.

Wheels and Tires

Function of wheels or tire

- To support the load of vehicle
- To provide cushion against the shock

- Good road grip when we accelerate or breaking the vehicle.

- To sustain the load of vehicle.
- To create contact with road surface.

Location

- It locate on front or rear axle (depends on drive used in vehicle)

Fuel System

- The fuel tank is fastened to the rear of the frame and is connected to the fuel pump through metal tubes. The exhaust pipe and muffler conducts the poisonous gases from the engine to the rear of the vehicle.

Cooling System

- A radiator is mounted on the chassis which is connected to the engine by rubber hoses to allow cooling water or coolant to circulate between radiator and engine. Fan, water pump and fan belt are other parts of the cooling system.

THANK YOU