Dt - 18-02-2025

Steering System

purpose of a steering system

- the steering system allows the driver to guide the car along the ~~turn~~ road and turn left or right as desired

the system includes the following:

i) the steering wheel ... which the driver control.

ii) the steering gear ... which change the rotary motion of the wheel into straight line motion. or

iii) the steering linkage ... which transmit the steering gear movement to the front wheels.

* the steering system configuration depends on vehicle design (the drive train and suspension system used, wheather it is a passenger car or a commercial vehicle etc) At present, the rack-and-pinion type and the recirculating ball types are in use.

* Most steering system were manual until a few year back. then power steering became popular. It is now installed on almost all costly cars.

Function of A Steering System

1- the primary function of the steering system is to achieve angular motion of the front wheels to negotiate a turn.

2- To provide directional stability of the vehicle ~~angular~~ when going straight ahead.

3- To facilitate straight ahead recovery after completing turn.

4- To minimise wear and tear of tyres.

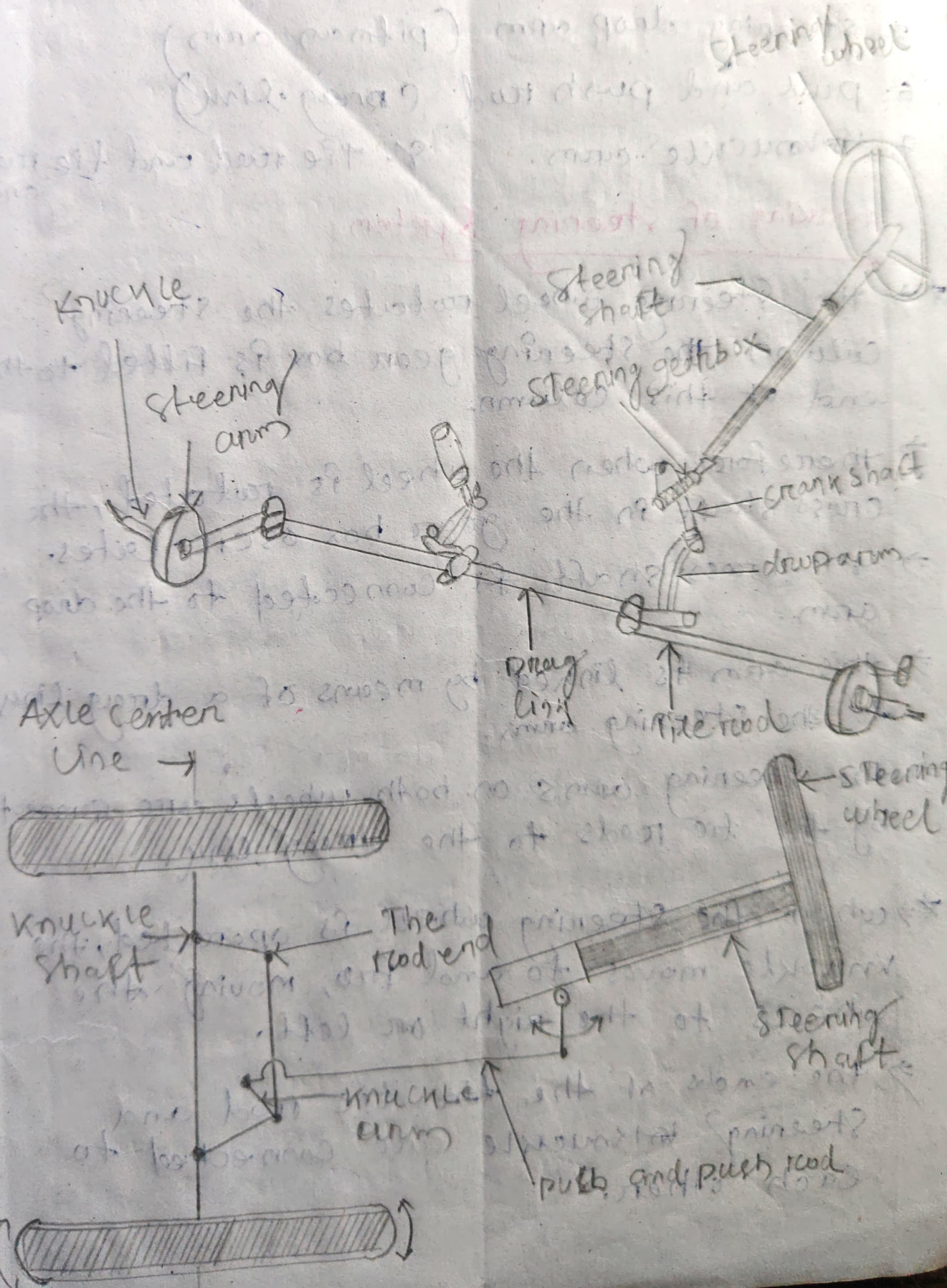
5- To absorb a major part of the road shock thereby preventing them to get transmitted to the hands of the driver.

6- To provide perfect rolling motion of the road wheels at all times

Requirements of a good steering System

1. very accurate
2. Easy to handle
3. provide directional stability.
4. Multiply the turning effort applied on the steering wheel by the driver.
5. Irreversible to a certain degree, so that the shocks of the road surface encountered by the wheels are not transmitted to driver's hands.

General Arrangement of a Steering System



The main parts of a steering system are:

1. steering wheel
2. steering column
3. steering shaft
4. steering gearbox
5. steering drop arm (pitman arm)
6. pull and push rod (drag link)
7. knuckle arm.
8. tie rod and tie rod end

working of steering System

* ⇒ the steering wheel rotates the steering column. the steering gear box is fitted to the end of this column.

⇒ therefore, when the wheel is rotated, the cross shaft in the gear box oscil-lates.

⇒ the cross shaft is connected to the drop arm.

⇒ this arm is linked by means of a drag link to the steering arms.

⇒ the steering arms on both wheels are connected by the tie rods to the drag link.

* ⇒ when the steering wheel is operated, the knuckle moves to and fro, moving the wheels to the right or left.

⇒ the ends of the tie rod and steering knuckle are connected to each other.

⇒ one end of the drag link is connected to the tie rod.

⇒ the other end is connected to the end of the drop arm.

⇒ A ball and a socket joint gives the required movement to the joints between the tie rod, drag link and drop arm.

⇒ when the vehicle is moving, the drop arm develop vibration.

⇒ So shock springs are used in ball and socket system to absorb this vibration.

Brief description of Steering parts

1. Steering wheel

⇒ It is made of steel ring welded together on a hub with the help of two, three or four spokes. After welding ring with the spokes is ebonite moulded on it.

⇒ In certain vehicles centre hub has plines cut on it while in other cases a key groove is given to secure the steering shaft firmly in it.

⇒ The steering wheels in over country, have a fixed position. However, in foreign countries these wheels in some vehicles can be ~~fitted~~ tilted and located in position to suit the driver.

- steering wheel is pulled out with the help of a puller.

2- steering outer tube or steering column:

⇒ this is hollow steel pipe in which steering shaft is housed.

⇒ one end of the pipe is fixed on steering box, the other end is usually held with the help of bracket under the instrument panel.

3. steering shaft

⇒ the steering shaft is made out of good quality steel.

⇒ one end is fixed in the steering wheel with the help of splines or key and kept tight by nut.

⇒ the other end with worm is secured firmly on the steering box with the help of bearing placed both on top and bottom.

⇒ Sometimes, instead of one shaft, two pieces of shaft are also used (in those cases where steering wheel and steering box are not in one line)

4. Steering gear box

⇒ It's function is to convert rotary motion of wheel into to-and-fro motion of drop arm so that the drag link tied up with drop arm can be pushed or pulled resulting into moving stub axle to right or left as desired by the driver.

5. Drop arm

⇒ It is forged out of good quality steel.

⇒ It one side is provided with splines which match the splines of sector shaft and held on sector shaft by nut.

⇒ the other end has taper hole in which ball end is held tight with the help of nut.

STEERING GEARS

- the steering gears perform the following two functions:-

i) change the rotary motion of the steering wheel into straight line motion that will move the steering linkage.

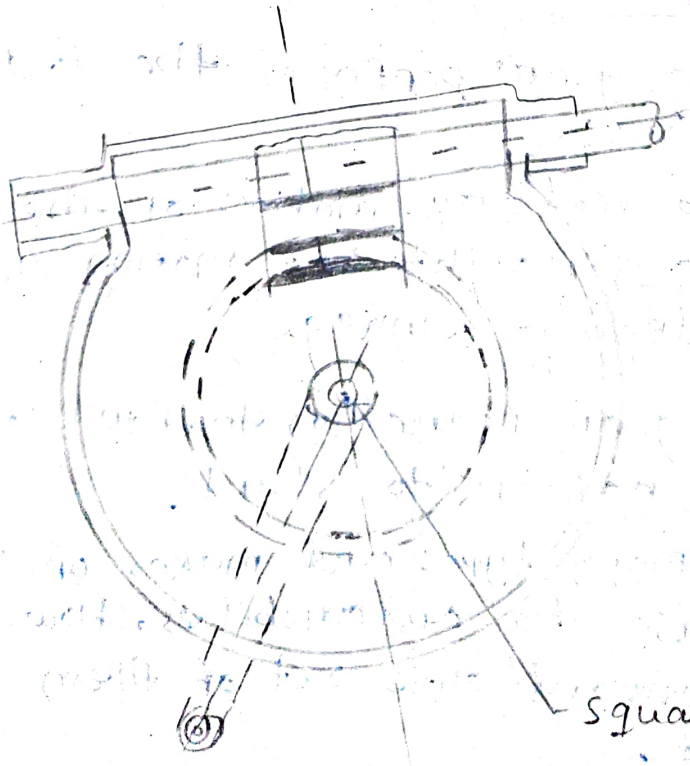
ii) provide a gear reduction that will make the automobile easier to start.

- there are many types and makes of steering gears in use for automobiles. However, only a few important ones out of them are enumerated.

1. worm and worm wheel steering gear.
2. worm and nut steering gear.
3. worm and roller steering gear.
4. Recirculating ball type steering gear.
5. Rack and pinion steering gear.

1. worm and worm wheel steering gear

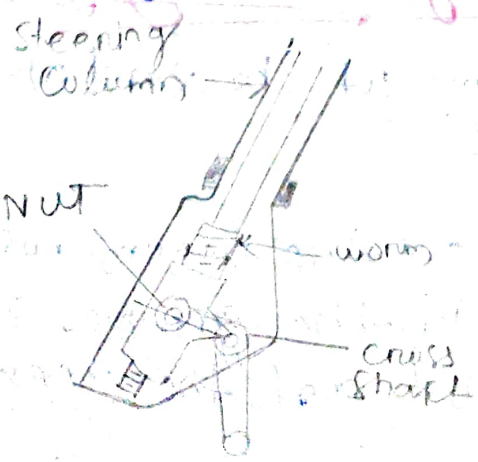
- In this steering system there are square threads or worms on the steering rod and which engages in a worm wheel.
- the drop arm (pitman arm) is keyed to the same shaft as the worm wheel and work rigidly with it.
- usually a square shaft is used for the worm wheel, so that as wearing of worm sector occurs, the worm wheel can be turned round to new position.

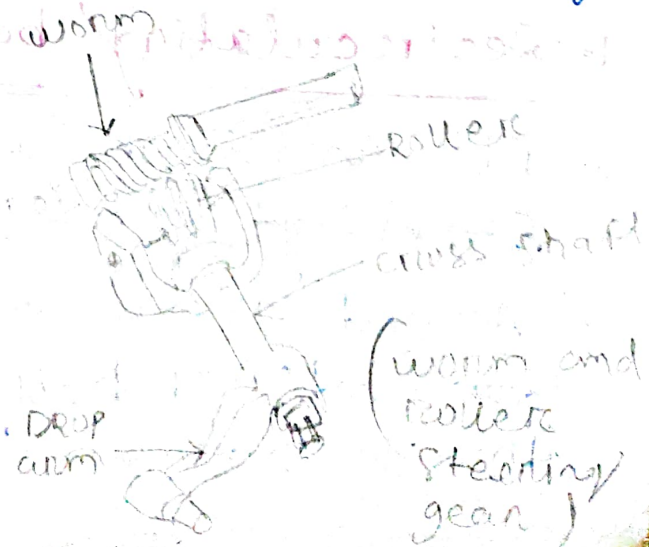


- the arc of movement of the drop arm is usually 60° to 90°.
- Many makers provide only a sector of a wheel for this purpose.
- this gives a smaller and lighter mechanism but has no provision for worm and wheel teeth wear.

2. worm and nut steering gear:

- In this system when the steering wheel is rotated the steering column rotates. the worm is an integral part of the steering column.
- therefore, when the steering column is rotated, the worm also rotates.
- Now the worm is in mesh with a nut arrangment
- thus when the worm rotates, the nut is able to move.
- this movement take place along the axis of the column either up or down.
- this enables the cross shaft to rotates in arc.
- this in turn helps drops arm to also move on an arm. this arm transmit the steering to all wheels.





3. Worm and roller steering gear:

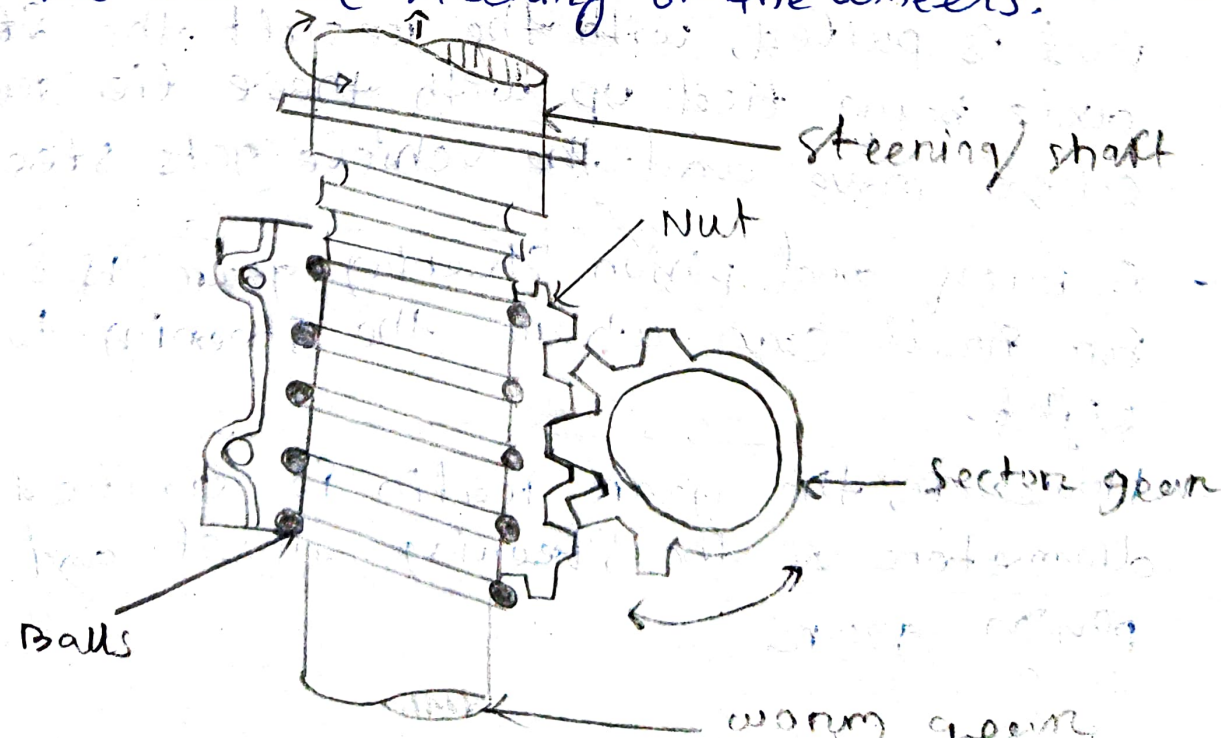
- In this system the worm is at the end of the steering column. the diameter of the worm is more at it's ends.
- it diameter is gradually reduced at the centre.
- A roller is in mesh with this worm.
- this roller has a cross shaft which is fitted to drop arm.
- when the steering wheel is ~~required~~ rotated, the column also rotates.
- Also, when the worm of the shaft is rotated, the roller rotates in an arc.
- At this time the cross shaft of the roller moves. this makes the drop arm move in an arc, which in turn rotates the wheels.

* This type of steering gear is fitted in Leyland vehicles and American passenger cars.

4. Recirculating ball type steering gear (good)

- It consists of a worm at the end of steering rod/shaft.
- A nut is mounted on the worm with two sets of balls in the grooves of the in between the nut and the worm.

- the ball reduce the friction during the movement of the nut on the worm.
- the nut has a number of teeth on the outside, which mesh with the teeth on a worm wheel sector, on which is further mounted the drop arm, which steers the road wheels through the link rod and the steering arms.
- when the steering wheel is turned, the ball in the worm roll in the grooves and cause the nut to travel along the length of the worm.
- the ball which are in two sets, are re-circulated through the guides.
- the ~~not~~ movement of the nut causes the sector gear to turn at an angle and actuate to link rod throug the drop arm, resulting in the desired steering of the wheels.

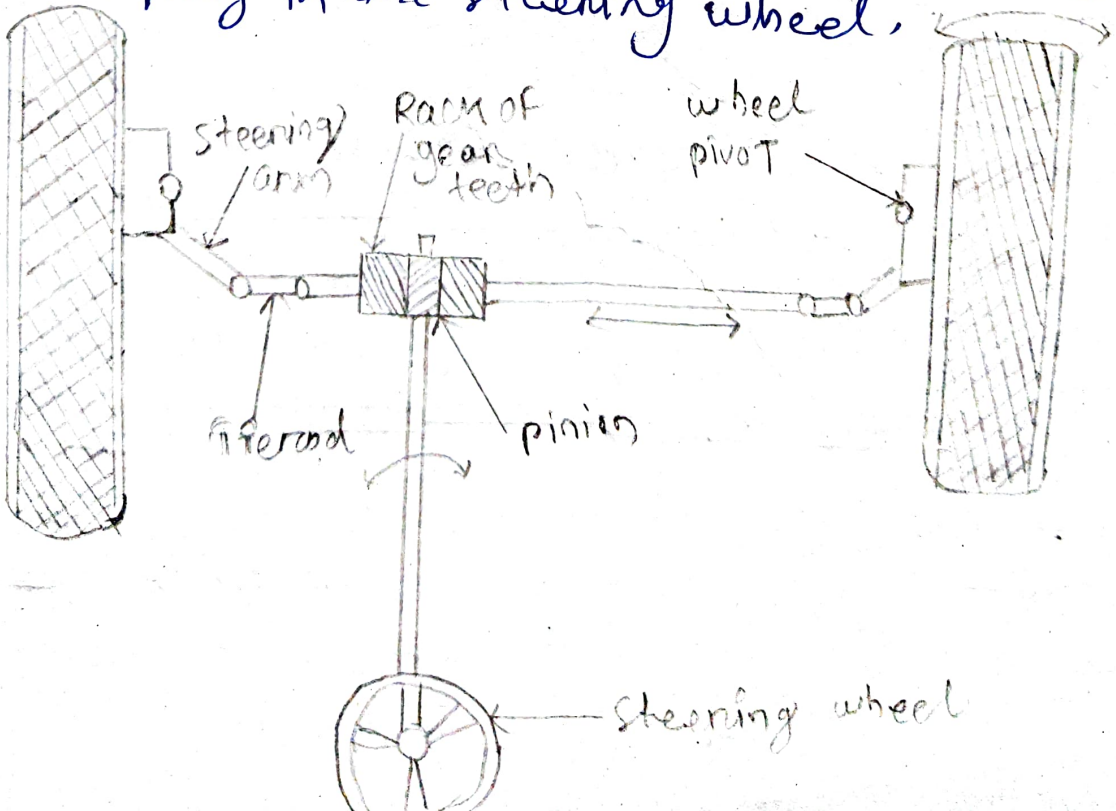


Recirculating ball steering gear

⑤ Rack and pinion steering gear:- most used

- the rack and-pinion steering gear has became increasingly popular for today's smaller cars.
- It is simpler, more direct acting, and may be straight mechanical or power assisted in operation.
- A pinion is mounted on the end of the steering shaft. It engages with a rack which has ball joints at each end to allow for the rise and fall of the wheels.
- On revolving the pinion shaft through steering wheel, the pinion revolves.
- As the pinion teeth mesh with rack teeth, rack moves to and fro.
- while moving to one side, it pushes the tie rod to that side while the other tie rod is pulled, with the result the stubs axle being tied up with these tie rods also move and the vehicle gets steered.
- A rack and pinion steering gear is suitable for small cars where the steering force are light.
- However, the gear ratio is limited by the diameters of the steering wheel and the pinion gear.

- on larger, heavier vehicles, this can be a disadvantage..
- therefore, other types of steering gears such as the recirculating ball are usually found on large cars and trucks.
- the greater mechanical advantage possible with other types reduces the effort required to steer a larger vehicles.
- In a small car, Rack-and-pinion is quick and easy.
- It provides the maximum amount of road feel as the tyres meet irregularities in the road.
- there is no damping out of road shock and vibration
- other types of steering systems usually provide some damping action.
- they can also be adjusted to eliminate almost all play in the steering wheel.



Dt- 20-02-25

CAMBER, CASTER, TOE IN, TOE OUT

what is CAMBER

⇒ CAmber is the angle of the wheel relative to the vertical of the vehicle, and depending on the tilt, it either considered positive camber or negative camber.

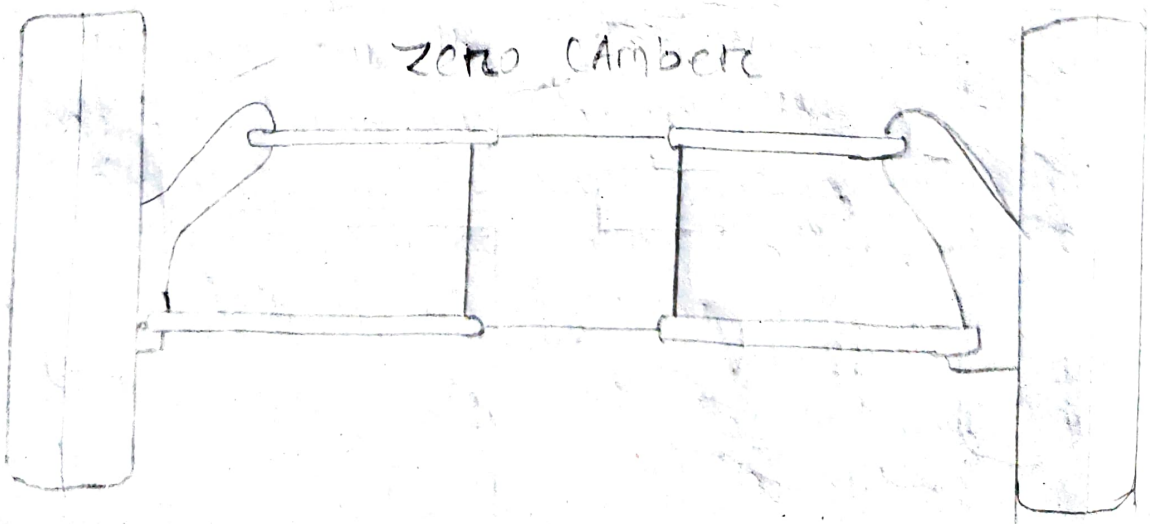
⇒ when the top of the tires tilt away from the center of the vehicle, you have positive camber, and when the top of the tires are tilted inward you have negative camber.

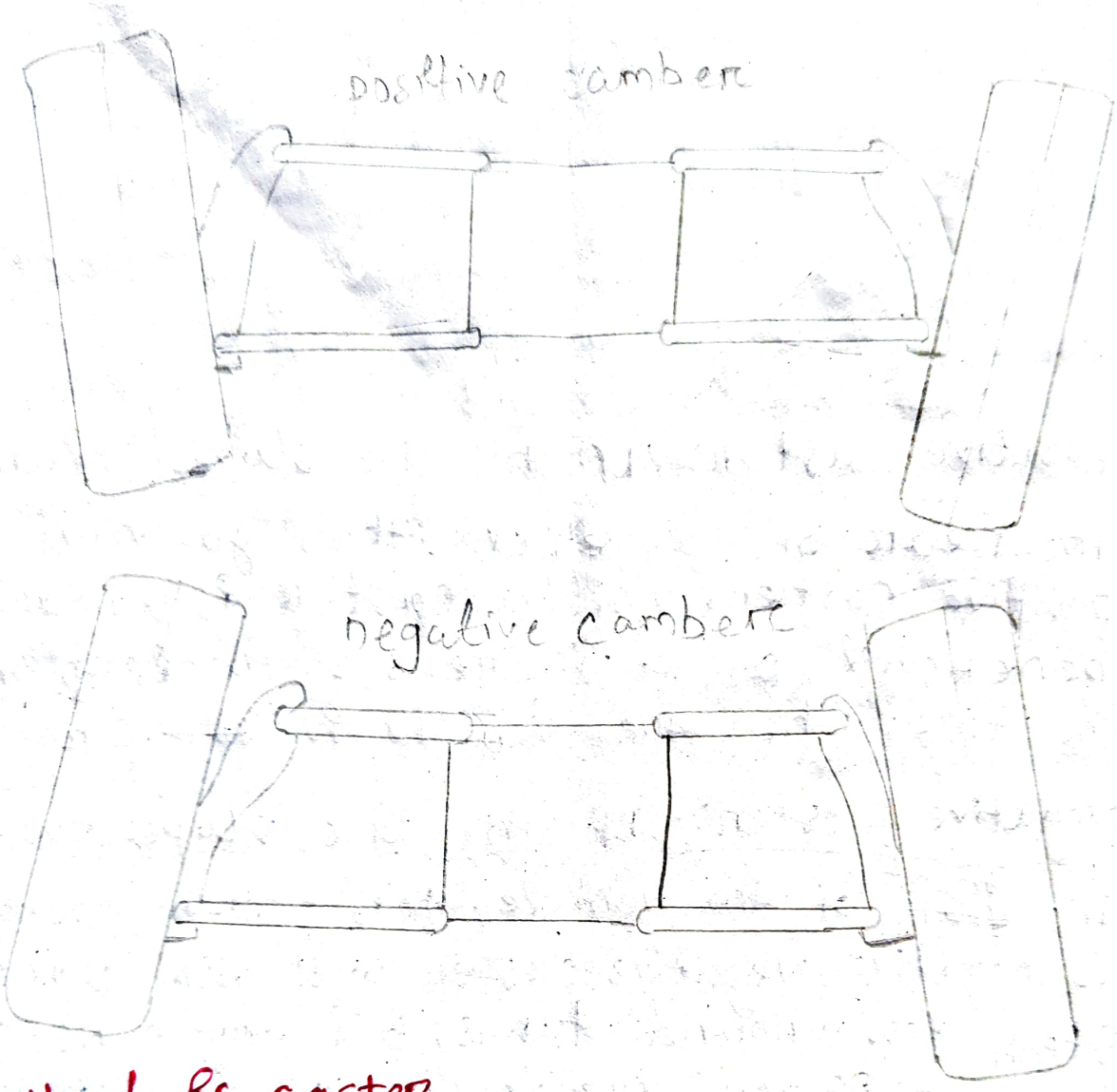
★ positive chamber:-

- when your wheels are tilted outward, the vehicle has improved stability.

★ Negative Camber:-

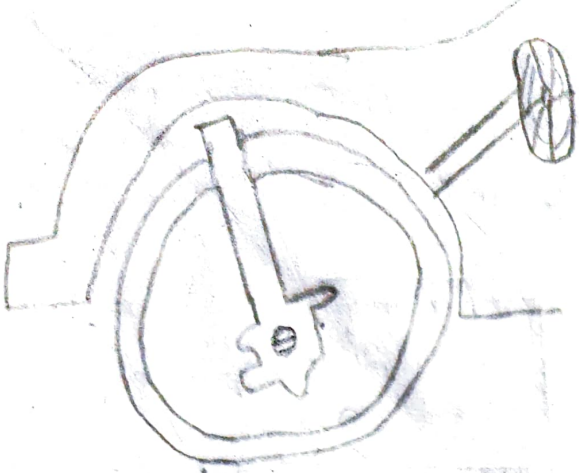
- High performance vehicles that required better cornering tend to use negative camber, because it gives the drivers more control in this regard.



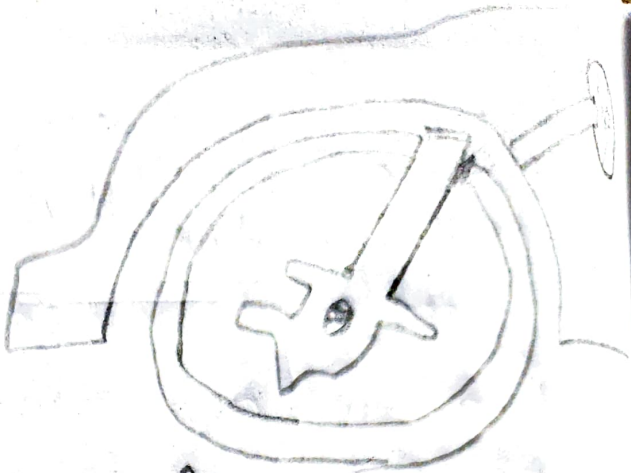


what is caster

- caster is the angle that identifies the forward or backward slope of a line that is drawn through the upper and lower steering pivot points.
- it does not affect tire wear, but caster does have an influence on the directional control of the steering.
- caster angle settings allow manufactures to balance steering effort, high speed, stability, and front end cornering effectiveness.



Negative caster



positive caster

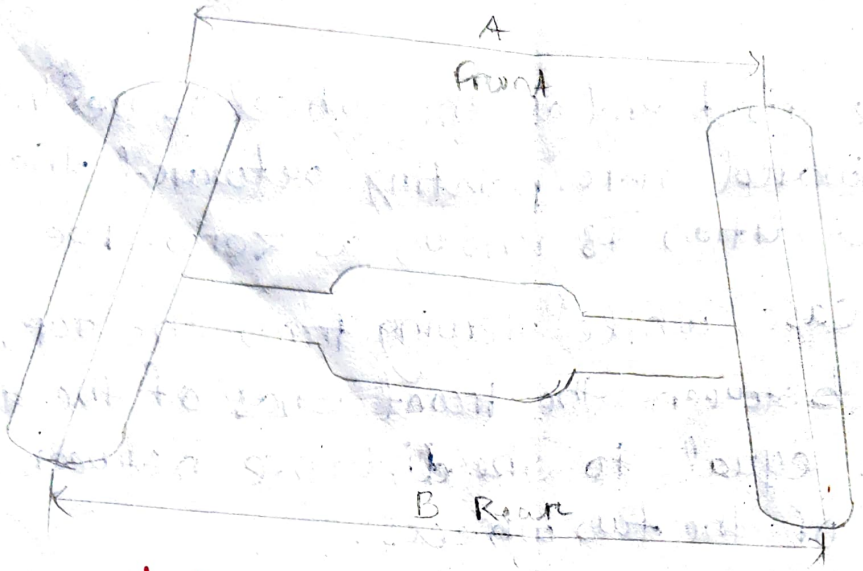
- **positive caster:-** If the line slopes towards the rear of the vehicle, then you have positive caster. positive caster is primarily beneficial as it increases the lean of the tire when the vehicle is ~~cor~~ cornering

- **Negative caster:-** If the line slopes toward the ~~rear~~ front of the vehicle, then ~~you~~ the caster is negative, Negative caster will allow you to steer less around turns, but may cause you to drift if you are driving straight forward.

Toe-in

⇒ the toe-in says that the front ends of the wheel are pointing toward the central axis of the vehicle. In a toe-in situation, the wheels are closed to each other, at the front end than at the rear end.

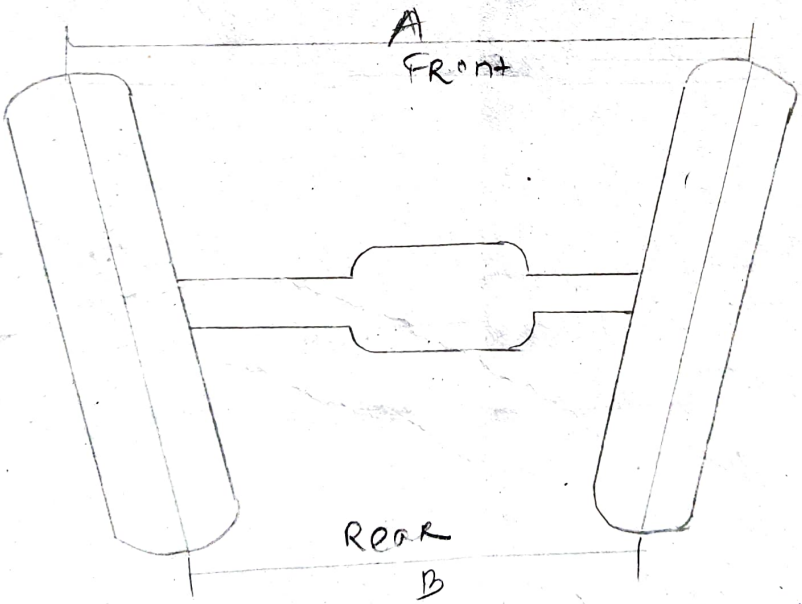
⇒ thus the toe-in indicates the distance by which the front ends of the wheel are closer than the rear ends.



Toe-in = B - A

Toe-out :

- The toe-out indicates that the front ends of the wheels are pointing away from the central axis of the vehicle. in a toe-out situation, the wheel are closer at the rear end.



Toeout = A - B

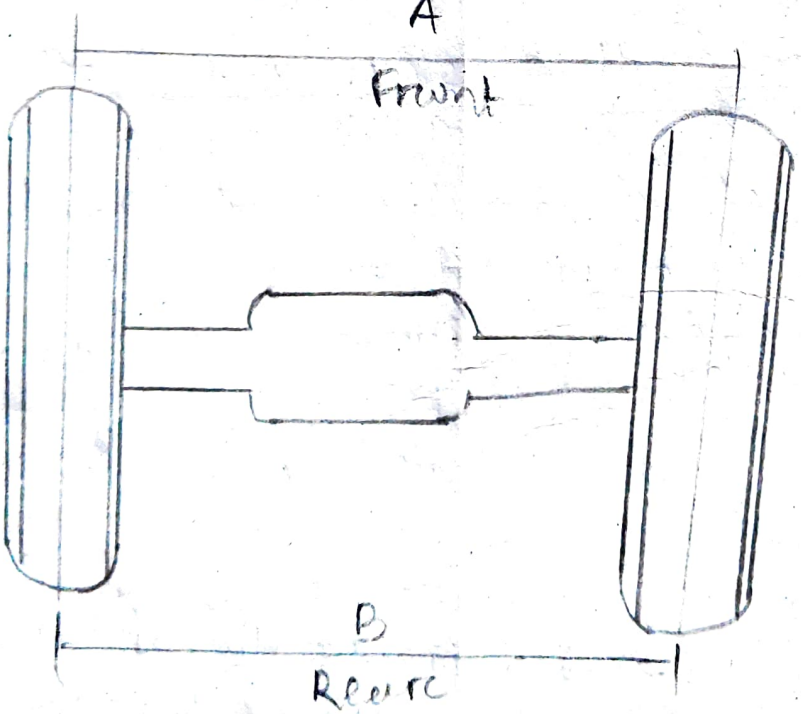
- thus the toe-out indicates the distance by which the front ends of the of the wheels are away from each other than the rear ends

Zero - toe:-

- when the front end of the wheel is neither pointing inward nor pointing outward then such a condition is known as zero-Toe
- In this case, while viewing from the top, the distance between the front ends of the two wheels is equal to the distance between the rear end of the two wheels.

$$A = B$$

- with the zero-toe adjustment, the car is more stable to move in a straight line at high speed.



Effects of toe-in

1. Toe-in causes increase in slip angle of tyre which helps to increase the grip between tyre and road.
2. The toe-in helps to minimize the cone rolling effects caused due to the camber.
3. In the case of engine driven wheels, the increase in toe-in angle help to accelerate the vehicle faster.
4. In the case of wheel that are not driven by the engine, the increased grip due to the toe-in angle offers resistance to the vehicle motion and reduces the acceleration of the vehicle.
5. The top speed of the vehicle also gets decreases with an increase in the toe-in angle
6. In this case, the driver has to put more steering effort to turn the vehicle.
7. The vehicle with a toe-in angle is more stable on high speed corners.
8. It helps to overcome the oversteer effects.
9. Due to increase slip angle, the stress on the tyre increases which decreases the life of the tyres.

10. the increase grip due to toe-in causes the tyres to heat up faster.

11. the incorrectly set toe-in angle increases the wear rate of the tyre.

Effects of Toe-out

1. the toe-out also increase the slip angle of the tyre which increases the grip between the tyre and the road.

2. In the case of engine-driven wheels, the increase in grip causes the vehicle to accelerate faster.

3. In the case of wheels that are not driven by the engine, the increased toe-out angle increase the resistance to the motion of the vehicle. Thus the driven wheels have to put more effort to push/pull these non-driven wheels. Therefore it lowers the acceleration of the vehicle.

4. the peak speed of the vehicle decrease with an increase in toe-out angle.

5. The toe-out angle increases the sensitivity of the steering, thus it becomes easy to turn the vehicle faster with minimum effort. thus the toe-out helps to overcome the understeer effects.

6. the vehicle with excessive toe-out are unstable on high speed corners.

7. the increase in the slip angle causes the tyres to heat up faster and also increases the rate of wear.

Difference Between Toe-in and Toe-out:

Toe - in	Toe - out
1. In this case, the wheels are closer at the front end than the rear end.	- In this case, the wheels are closer at the rear end than the front end.
2. It is also known as (+ve) toe.	- It is also known as (-ve) toe.
3. It helps to decrease oversteer.	- It helps to decrease understeer.
4. More efforts are required to turn vehicle	- the vehicle can turn faster with minimum effort
5. More stability on high speed curves	- Less stable on the high speed corners.
6. Excessive toe-in causes understeer	- Excessive toe-out causes oversteer.

Advantage Toe-in

1. A prupere toe-in helps to reduce the over steer effect.
2. It provides more stability to the vehicle while moving on high-speed corners.
3. It reduces the cone-rolling effects caused by camber.
4. It increases the grip between the tyre and the road which helps to accelerate the vehicle faster on the road.

Disadvantage of Toe-in

1. the excessive toe-in causes harder steering
2. the improper toe-in increase the vibration and the wheels wobble.
3. It lower the peak speed of the vehicle.
4. It lowers the tyre life.

Advantage of Toe-out

1. the proper toe-out adjustment helps to overcome the effects of under-steer.
2. the vehicle turns faster with minimum effort.
3. the toe-out increases the grip between road and tyre due to the increase in tyre slip angle.

Disadvantage of toe-out

1. the excessive toe-out causes the vehicle to oversteer.
2. the vehicle become unstable on high-speed corners.
3. It can cause the wheel to wander.
4. It reduce the peak speed of the vehicle
5. It increases the wear rate of the tyre and lowers its life.

Dt-4/3/25

FRONT AXLES

① - The front axle is used to carry the weight of the front part of the vehicle as well as to facilitate steering and absorbs shocks due to road surface variations.

② - It must be right and robust in construction.

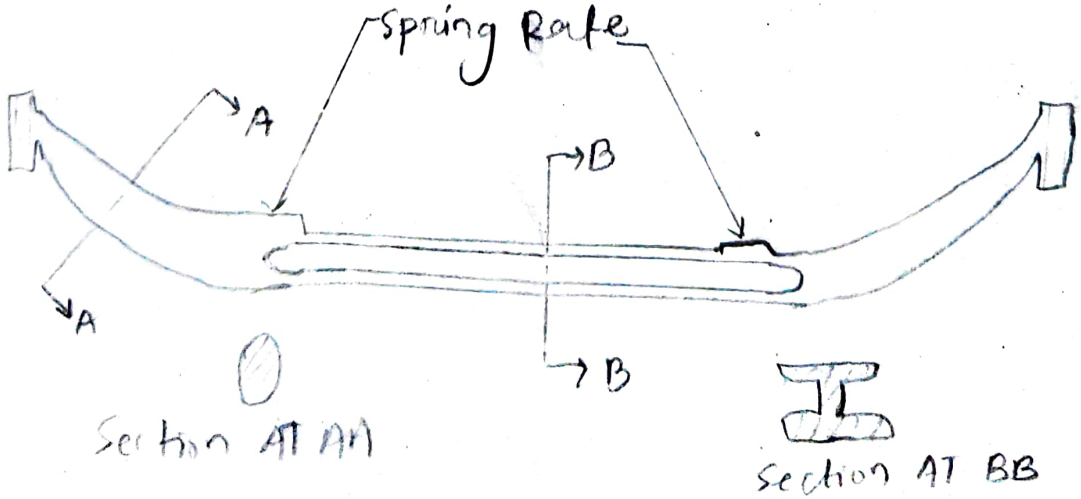
③ - It is usually a steel drop forging having 0.4% carbon steel or 1-3% nickel steel.

④ - It is made of I-section in the centre portion, while the ends are made either circular or elliptical.

⑤ - with this construction, it take bending loads due to the load of the vehicle and also torque due to braking of the wheel.

⑥ - To keep the low chassis weights it's centre portion is given a downward sweep.

⑦ - the different component of the front axle are the axle beam, stub axle, swivel pin and Track rod.



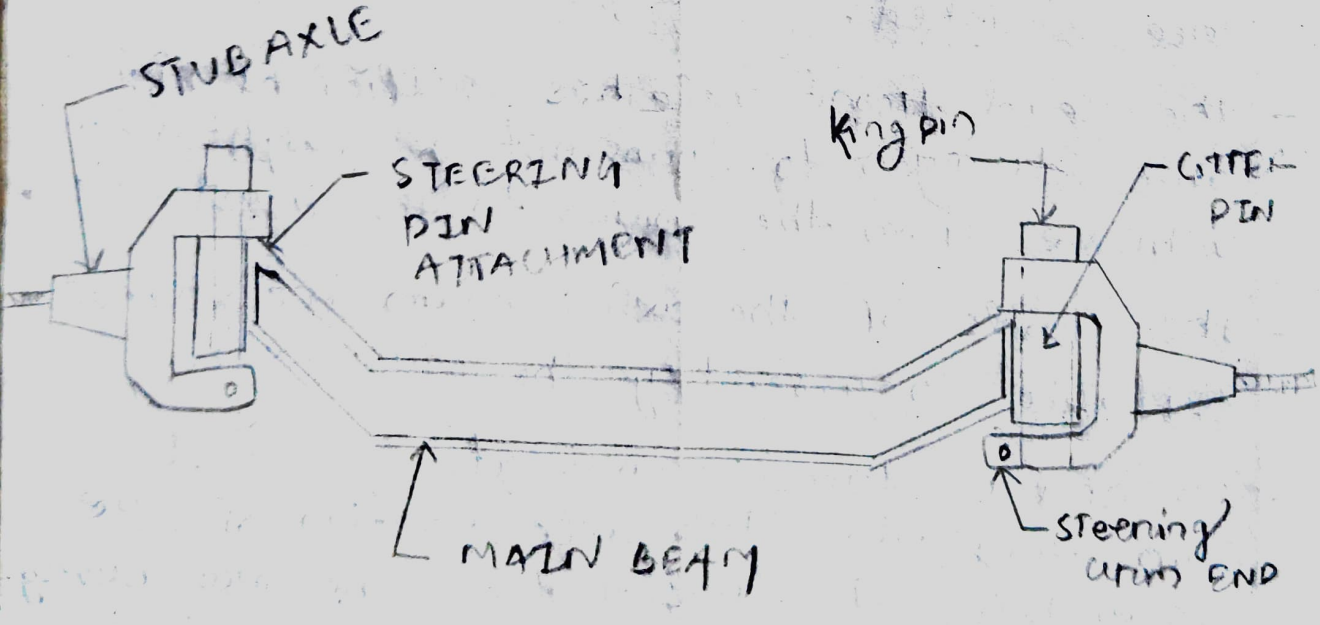
Types of front Axle

there are two main types

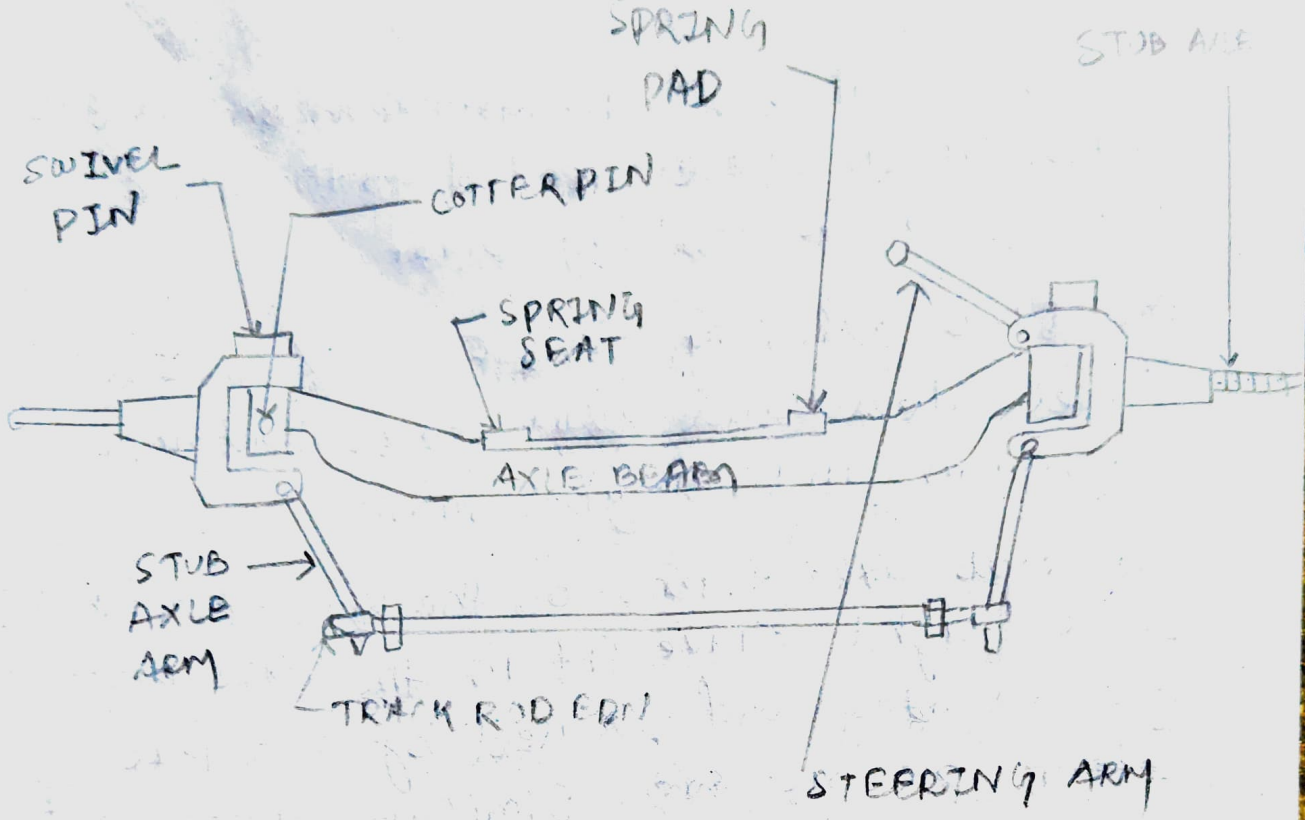
1) Live front Axle 2) Dead front Axle

- the front axle are usually dead axles because they do not rotate, In contast to the live axle that they are used in the rear axle to transmit power to the rear wheels.
- A live front axle, as compared to the dead axle has the additional function of transmitting the driving power Taken from a transfer gearbox to the front wheels having different swivelling mechanism.
- the live front axles although resembling the gear axle have some difference at the axle half shaft ends where the wheel are mounted.
- the dead front axle has sufficient rigidity and strength to transmit the weight of the vehicle from the spring to the front wheel.
- the ends of the axles beam are shaped suitable to assembly the stub axle.
- In order to accomodate a swivel pin connecting the stub axle portion of the assembly, the ends of the beam are usually shaped either as a yoke or plain surface with drilled hole.

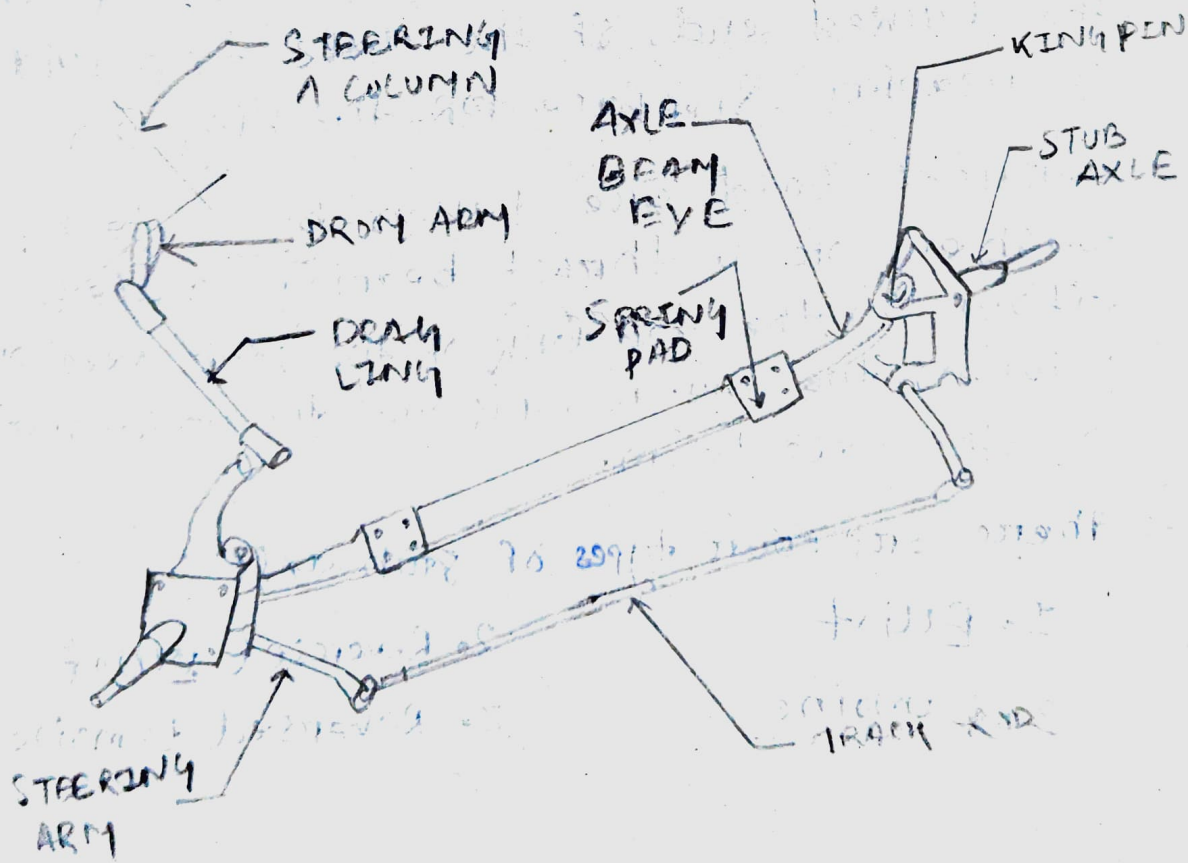
- ~~A typical front axle~~
- Another front axle assembly with Stub axle and track rod. front
- the wheels are mounted on stub axles which are often pivoted, from the stub axle the inclined steering arm are connected to the track rod ends; and ~~are~~ a third steering arm is attached to the drag link.
- Some vehicle have the drag link placed Transversely instead in the front and at position in order to allow a more compact vertical design.
- It is often used in independent wheel suspension systems.
- the drag link connects the steering linkage to the drop arm of the steering box.



FRONT AXLE



FRONT AXLE ASSEMBLY



FRONT AXLE COMPONENTS WITH STEERING LINKAGE

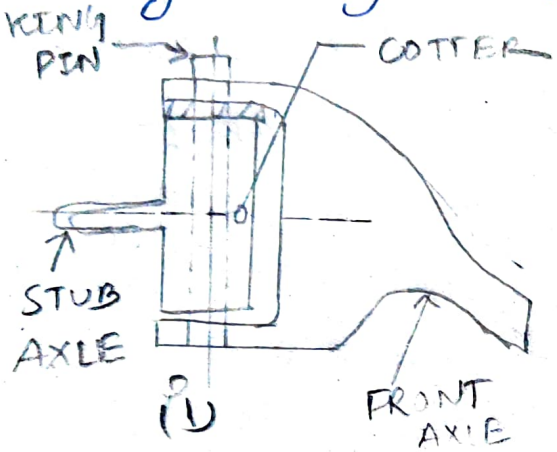
STUB AXLE

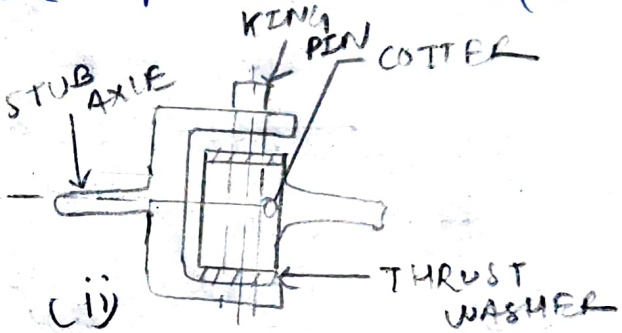
- the front wheels are mounted on the stub axles, which are connected to the front axle by means of king pins.
- the stub axles are the forging of 5% nickel steel and alloy steels containing chromium and molybdenum.
- the stub axle turns on the king pin which is a light drive fit in the axle beam eye located and locked by a taper cotter pin or some similar arrangement.
- phosphor bronze bushes are fitted into the forked ends of the axle to provide a bearing surface for the king pin.
- vertical load are taken by a steel washer or a thrust bearing located either on the top fork of the stub axle or between the lower fork and the underside of the axle beam.

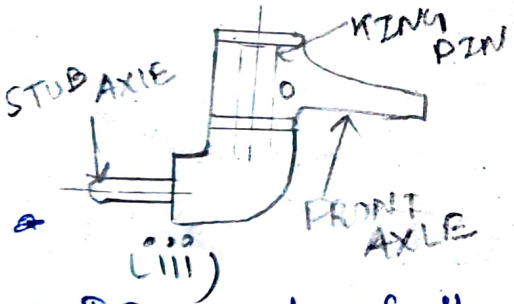
☆ there are four types of stub axles: NV1

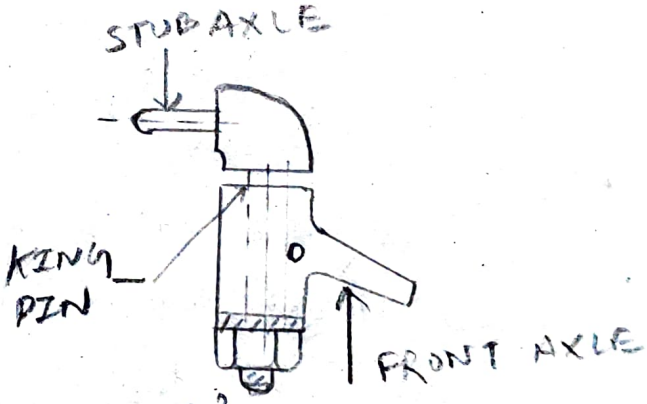
1. Elliot
2. Reversed Elliot
3. Lamoine
3. Reversed Lamoine

- the elliot stub axle is attached to the front axle by placing in the yoke end with a king pin and cotter to join the two together.
- In reversed elliot type stub axle, the arrangement is reversed.
- In lemoine type stub axle, instead of yoke type hinge, L-shaped spindle is used.



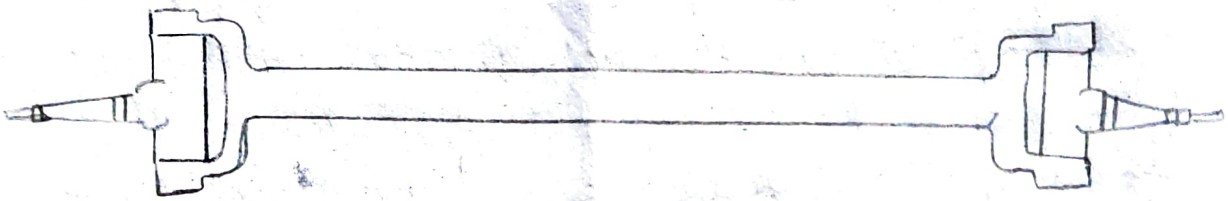




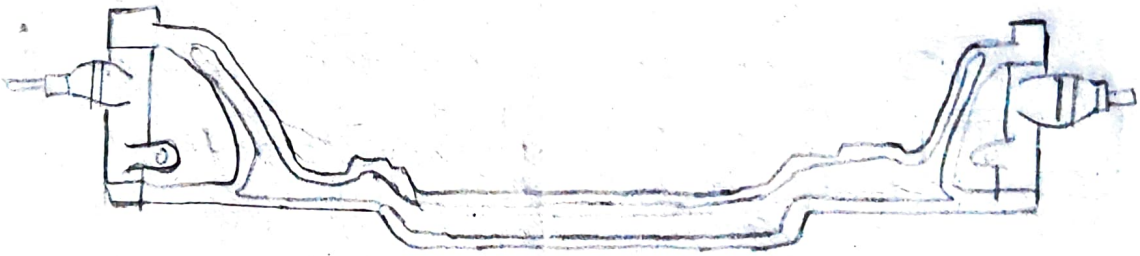


- In most of the earliest road vehicles, the front axles were straight.
- Later, when the engine was loaded infront, it neccessitated the 'dropping' of the axle at the centre in order to prevent interference.
- Furthere, when the centre of gravity of the road vehicle had to be lowered for the purpose of the greatest stability and safety at high speeds, the entire centre portion of the axle was dropped.

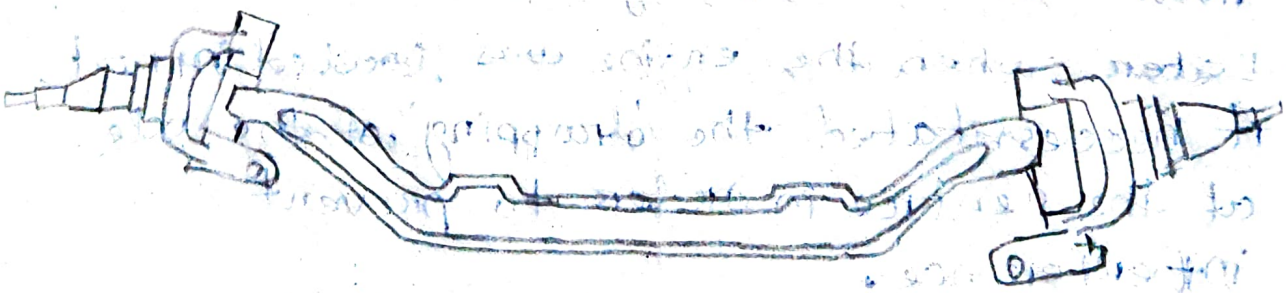
- the straight type axle is still being used in vehicle where high ground clearance is required as in the case of farm tractors.
- the axle is one which is generally used in the case of commercial vehicles of Today.



(a) STRAIGHT AXLE



(b) DOUBLE DROP AXLE



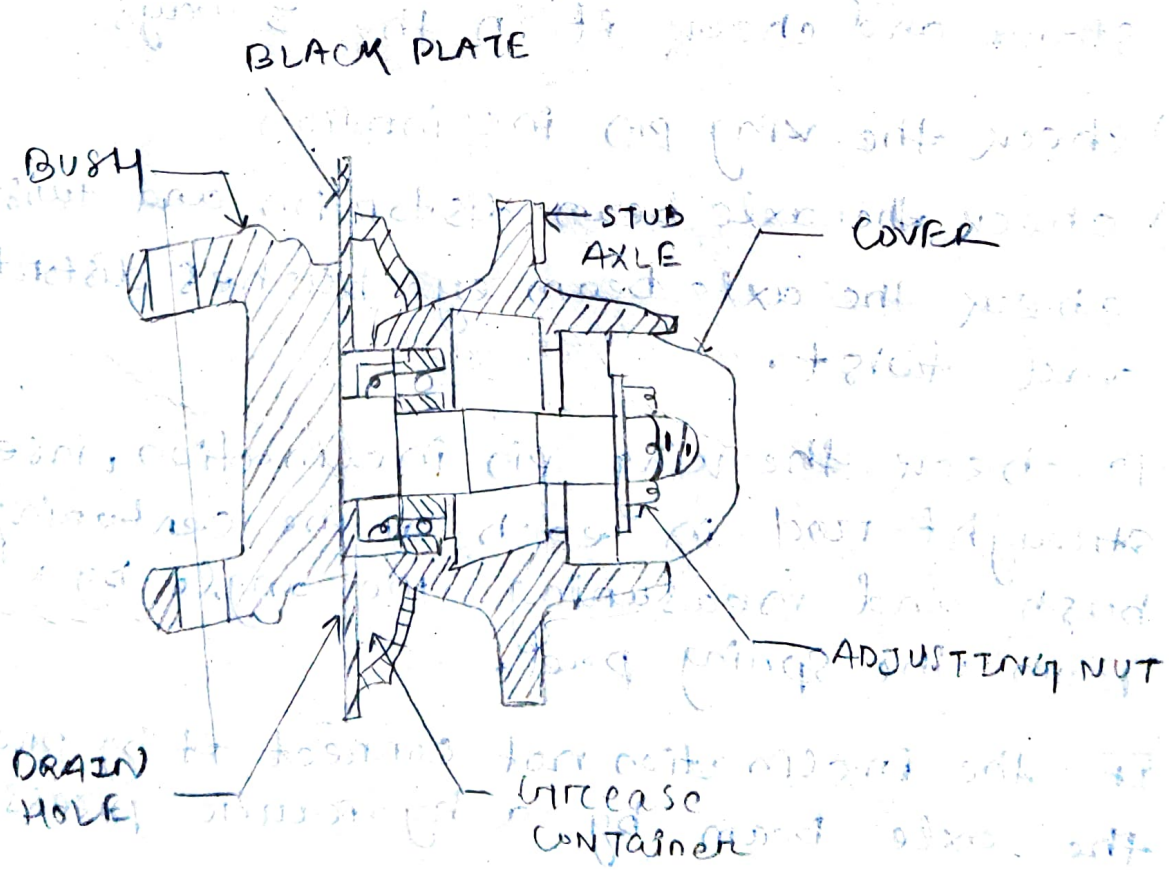
(c) FULL DROP AXLE

FRONT WHEEL ASSEMBLY

- the wheel revolves over two ball bearing which can be adjusted by means of an adjusting nut.
- the front wheel Bearing have to withstand.

1. the weight of the vehicle
2. Side thrust and tendacy of the wheel to Tilt when cornering.
3. Shock loads due to uneven road surfaces.

- Generally, Ball Bearing of semi-thrust type are used, but today most manufactures prefer Roller bearing.



CHECKING THE AXLE BEAM AND STUB AXLE AFTER ACCIDENT

- It is necessary to check the axle beam and stub axle after accident, otherwise the tyre will wear out more, steering will be hard and the vehicle will be pulling a side.
- To check the stub axle, clamp it at the lathe chuck and check it's bearing surface by a dial gauge.
- If the run out is 0.05 mm or less, the stub axle is o.k. otherwise Replace it.

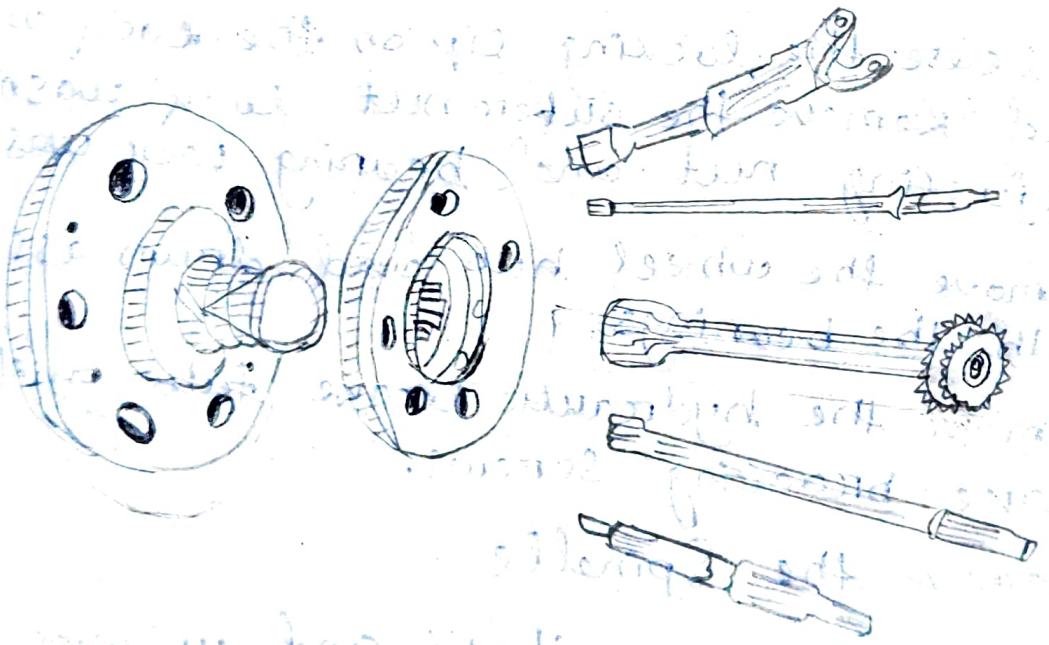
To check the axle beam, clamp it on the axle stand and check it in the 3 ways.

1) check the king pin inclination
2) check the axle beam distortion and twist.
3) check the axle beam eye bushes distortion and twist.

- To check the king pin inclination, insert a straight rod in each of the centering bush and measuring the angle by a gauge from the spring pad.
- If the inclination not correct it by pressing the axle beam by a hydraulic press.
- To check the axle for distortion and twist, place two strips, each one meter long, on the spring pad and see whether the ends of the strips

are in straight line.

- If not, the axle has distortion and twist; correct the axle by pressing it by a hydraulic press.
- To check the eye bushes beam for distortion and twist, insert a straight long rod in each eye bush and see whether they are in one vertical plane.
- If not, then correct the eye bushes by pressing the beam by a hydraulic press



AXLE PARTS

REMOVING THE FRONT AXLE

- To Remove the front axle and universal joint assembly of 4-wheel drive vehicle, adopt the following procedure.

1) Remove the wheel assembly
2) Remove the hub cap with a puller
3) Remove the axle shaft driving flange bolts.
4) Apply the foot brakes and Remove the axle shaft Flange with puller.
5) Release the locking lip on the lock washers and Remove the outer nut, lock washer adjusting nut and bearing lock washer
6) Remove the wheel hub and drum assembly with the bearings.
7) Remove the hydraulic brake tube and the brake bracking screws.
8) Remove the Spindle
9) Remove the axle shaft and universal joint assembly.

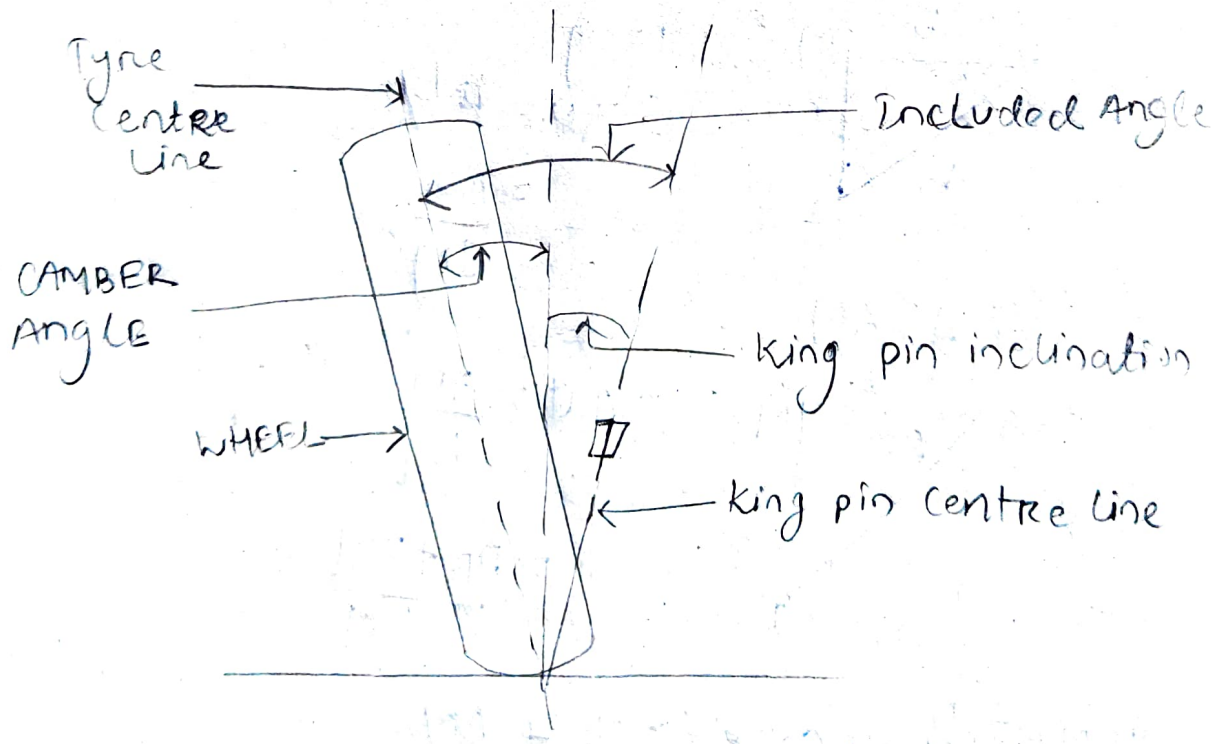
Dt - 7/03/2025

KING PIN INCLINATION

- the king pin inclination or steering axle inclination is the angle between the vertical line and the centre of kingpin on steering axle, when viewed from the front of the vehicle.

It is necessary because.

1. It helps the car to have steering stability.
2. It makes the steering operation easy.
3. It helps in reducing weare on tyre.

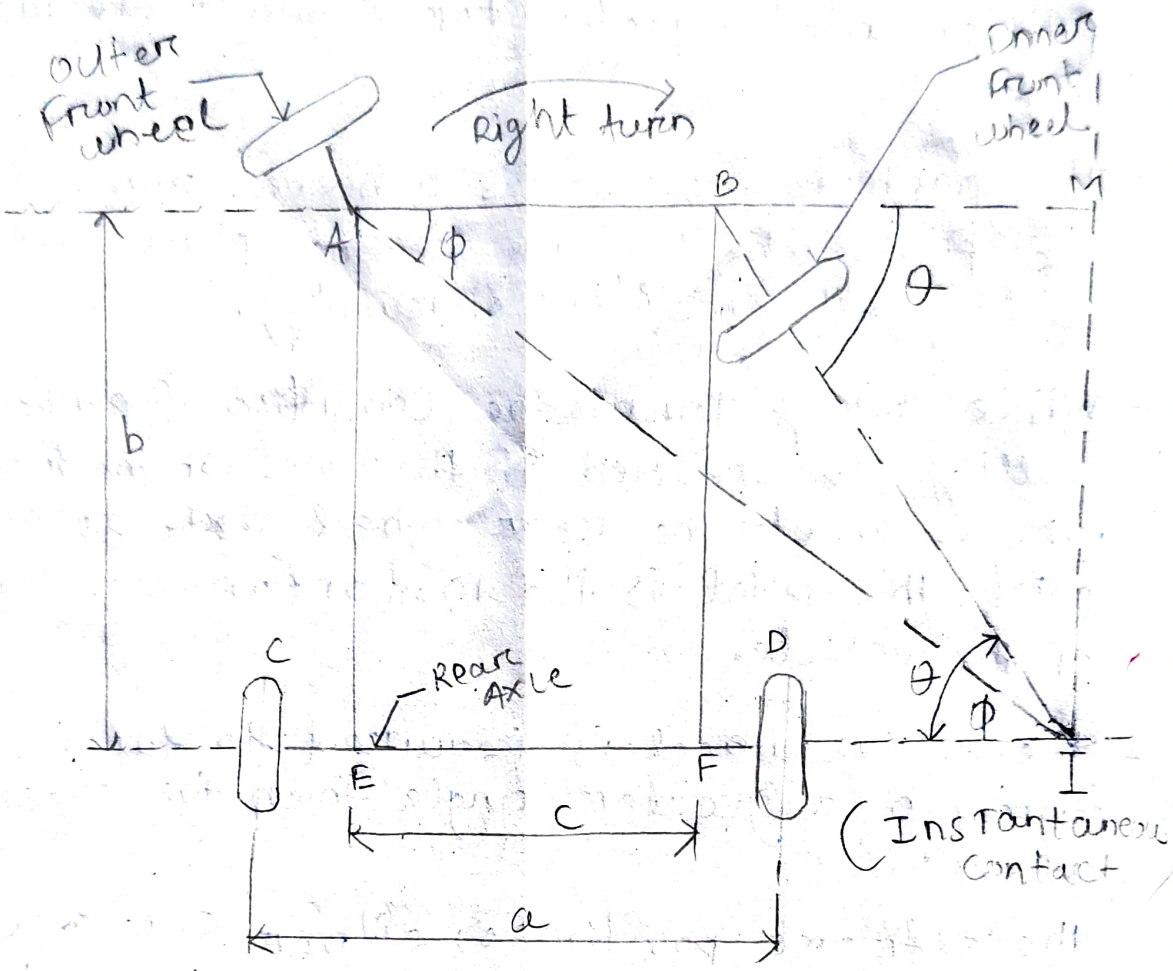


STEERING MECHANISM

Fundamental equation for correct steering Angles

- The perfect steering is achieved when all the four wheels are rolling perfectly under all condition of running.
- While taking turns the condition of perfect rolling is satisfied if the axles of the front wheel meet the rear wheel axis at one point this point is the instantaneous centre of the vehicle.
- the inside wheel is required to turn through a greater angle than the outer wheel.
- the extreme position on either side are called "lock" position. the dia of smallest circle which the outer front wheel can transverse & obtained when the wheels are at their extreme position is known as the "turning" circle.

CORRECT STEERING ANGLE:-



- the condition for correct steering is that all the four wheels must turn ~~about~~ about the same instantaneous centre.
- the axis of the inner wheel makes a larger turning angle θ than the angle 'ϕ' subtended by the axis of outer wheel.

let a = wheel track

b = Wheel base

c = Distance between the pivot A & B of the front axle.

in ΔIBM,

$$\cos\theta = \frac{BM}{IM}$$

ΔIAM, $\cot\phi = \frac{AM}{IM} = \frac{AB + BM}{IM} = \frac{AB}{IM} + \frac{BM}{IM}$

$$\Rightarrow \cot\phi = \frac{c}{b} + \cot\theta$$

$$\boxed{\Rightarrow \cot\phi - \cot\theta = \frac{c}{b}}$$

Further, the turning circle radius for different wheels. ~~can also be calculated from~~

$$R_{IF} = \frac{b}{\sin\theta}\left[\frac{a-c}{2}\right]$$

(ii) FOR the outer front wheel

$$R_{OF} = \frac{b}{\sin\phi} + \left(\frac{a-c}{2}\right)$$

(iii) FOR the inner rear wheel

$$R_{IR} = \frac{b}{\tan\theta} - \left[\frac{a-c}{2}\right]$$

(iv) For the outer rear wheel

$$R_{OR} = \frac{b}{\tan\phi} + \left(\frac{a-c}{2}\right)$$

Types of steering Gear mechanism

It is of two types.

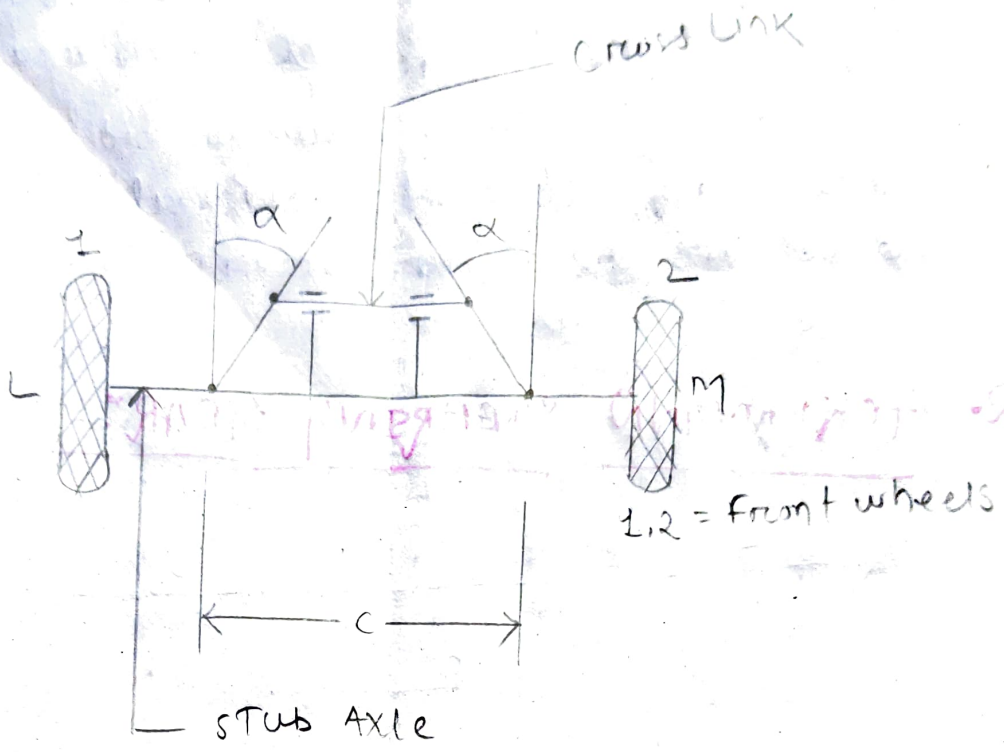
1. Davis Steering gear
2. Ackermann Steering gear.

* "Davis steering gear" has sliding ~~of points~~ pair. Since sliding pair has more friction than turning pair. therefore this type of gear will wear out earlier and become inaccurate after sometime.

* Ackermann Steering gear has turning pairs this type of gear is not Mathematically accurate w.r.t. Davis steering gear which however, the Ackermann Steering gear is preferred to the Davis steering gear.

* The whole mechanism of Ackermann Steering gear is on the back of the front wheels where as Davis Steering gear, it is on front of the wheels

1. Davis Steering Gear



(DAVIS steering gear mechanism)

The correct steering depends upon the suitable selection of cross-arm angle-α-

$$\tan\alpha = \frac{c}{2b}$$

Where c = Distance between the pivots of front axles

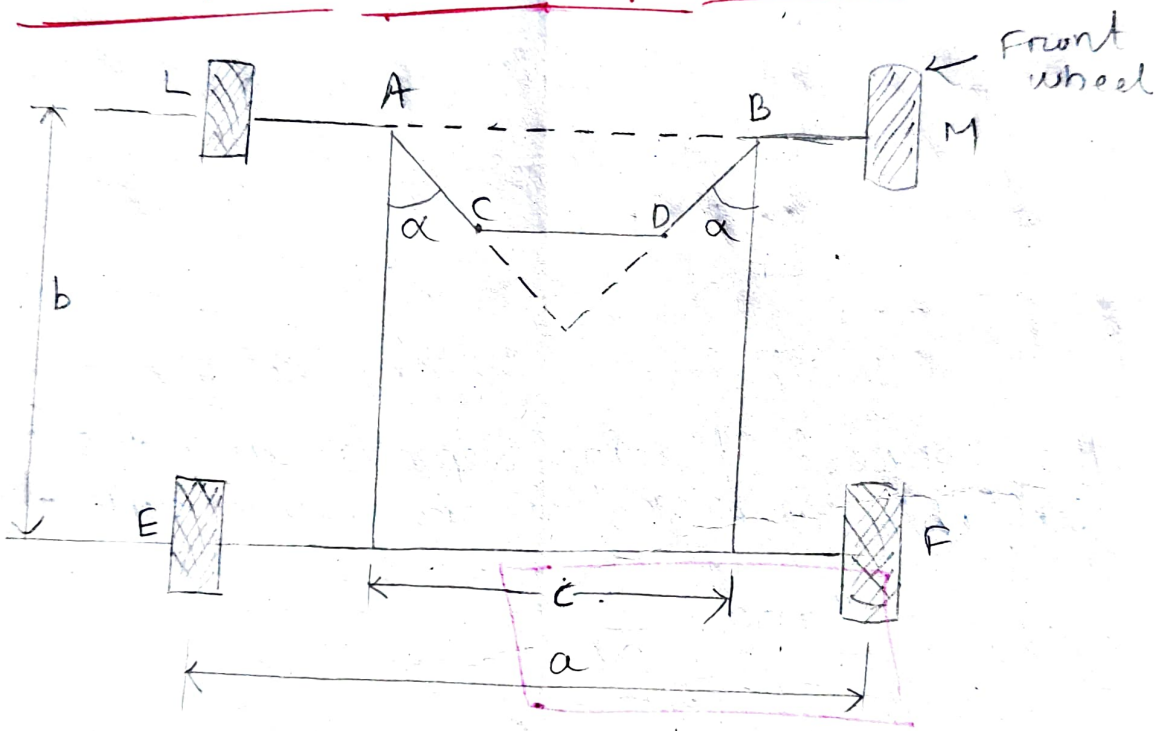
b = wheel base

the range of $\frac{c}{b}$ is 0.4 to 0.5

Hence α lies between 11.3° to 14.1°

* Davis steering gear is theoretically correct, but due to presence of more sliding members, the wear will be increased which produces slackness between sliding surfaces, thus eliminating the original accuracy, Hence this gear is not in common use.

2. ACKERMAN STEERING GEAR:-



For correct steering $\cot\phi - \cot\theta = \frac{c}{b}$

the value of $\frac{c}{b} = 0.4$ to 0.5

generally 0.455

the value of $\cot\phi - \cot\theta$ corresponding to the position when steering is correct.

Dt = 11/03/2025

NECESSITY OF A BRAKING SYSTEM

- In an automobile, if the pressure from accelerator pedal is Removed, the vehicle tends to slow up because of wind resistance, drag of engine and road friction.
- These forces, of course, would stop the vehicle but in the present day traffic, this would be quite unpracticable and dangerous.
- The braking system provides added friction to overcome motion and to slow up or to stop the vehicle. The momentum or kinetic energy developed by the vehicle when in motion is converted to heat energy by ~~the vehicle but in the present day traffic, this would be quite unpracticable~~ the friction of brake shoes and drums which is dissipated into the surrounding air.

FUNCTIONS OF BRAKES

Brake perform the following functions:

1. To stop the moving vehicle in the shortest possible time
2. To help in controlling the speed of the vehicle and to reduce the speed at turning and other crowded places.

3. To hold the vehicle in it's stationary position, without the presence of the operator, after it has been brought to a stop.

- In a moving vehicle, the friction between brake drum and brake shoes (having linning Riveted to it) slows down the rotation of wheel or stops the vehicle.

REQUIRMENTS OF A GOOD BRAKING SYSTEM

1. The brakes should stop the vehicle within a reasonable distance. the retardation shall be smooth and free from jerk or shudder.
2. the braking system should be very reliable to promote highest degree of safety on the road.
3. the braking system should not be affected by water, heat, road grit or dust etc.
4. pedal effort applied by the driver should not be more so as not to strain the driver.
5. Brake should work equally good in all weathers.
6. the wear and tear of the material of the brake linning should be minimum for it's longer life.
7. Due to rubbing action of brake shoes alongwith ~~System~~ linning ~~should~~ be against drum, large amount of heat is generated due to friction.

the brake design system should be capable of dissipating this heat very quickly.

8. All the components and levers of the braking system should be strong enough to take the mechanical stresses and strains which are encountered during brake actuation.

9. No braking system can work at its best through worn out or incorrectly inflated tyres. Good, tyres are therefore, a prime essential for efficient braking.

* the capacity of a brake depends upon the following factors:

(i) the unit pressure between the braking system
(ii) the co-efficient of friction between the braking surfaces.
(iii) the peripheral velocity of the brake drum.
(iv) the project area of the friction surfaces.
(v) the ability of the brake to dissipate heat equivalent to the energy being absorbed.

CLASSIFICATION OF BRAKES

1. Mechanical Brakes.
2. Hydraulic Brakes.
3. power Brakes
   (i) Air brakes (ii) Air-hydraulic brakes
   (iii) vacuum brakes (iv) Electric brakes.

1. MECHANICAL BRAKES

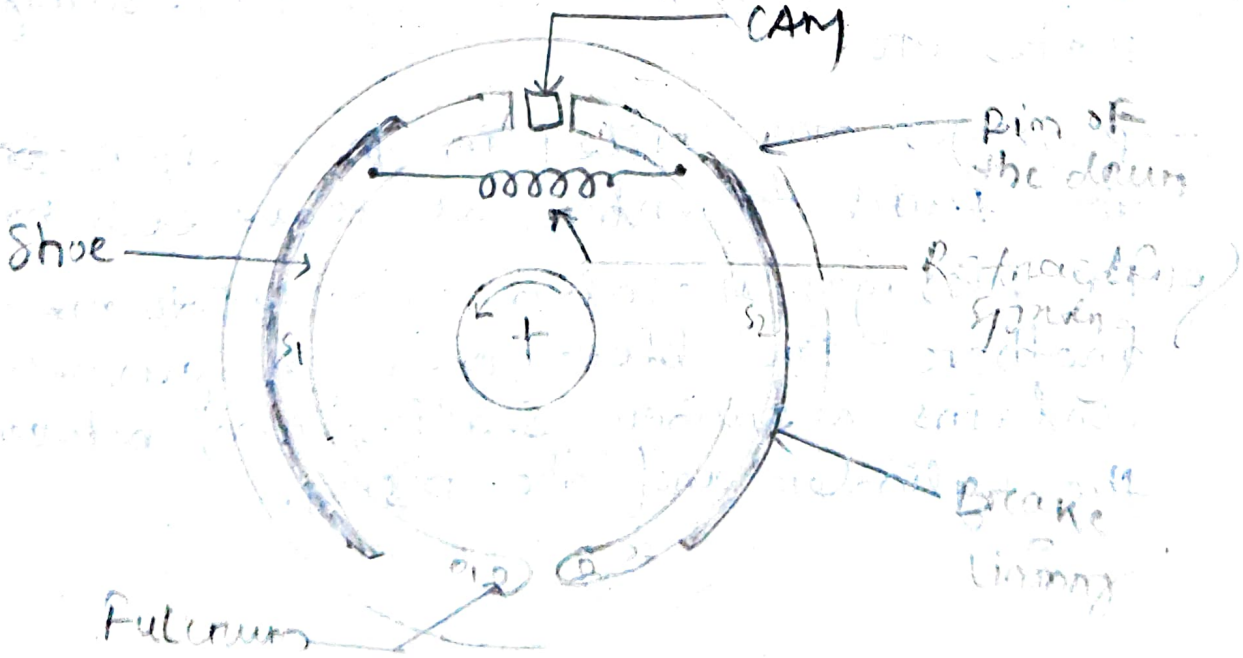
- the brakes which are operated mechanically by means of leveres, linkage, pedals, cams, bell crank etc. are knows as mechanical brakes.
- the external contracting brake which is usually hand brake in automobile is mechanical brake. Automobile contain service brakes operated mechanically.
- Mechanically brakes were employed in golden days but now hydraulic and other types of braking system have taken it's place

Internal Expanding Mechanical Brake.

- Construction:- It consists of two shoes S_1 & S_2. the outer surfaces of the shoes are lined with some friction material, to increase the frictional coefficients and to prevent wearing away of the metal.
- Each shoes is pivoted at one end about a fixed fulcrum (O_1 and O_2) and made to contact a cam at the other end.
- when the cam rotates, the shoes are pushed outward against the rim of the drum.
- the friction between the shoes and the drum produce the braking ~~tog~~ torque and consequently speed of the drum reduces.
- Brake shoe retracting spring which connects both the brake shoe at their loose end helps them in contracting after the brake are released

Operation

- when the brake pedal is pressed down, it's motion is transmitted to the cam through various mechanical linkages.
- the motion of the cam tends to expands out the brake shoes.
- this inward motion of the brake shoes will try to slow down the motion of the rotating brake drum.
- Because the wheel is fixed to the brake drum, so automatically it will be held to move further.
- when brake pedal is released, the pedal will move up because of the tension of the return spring.
- A Retracting Spring draws the shoes away from the drum when the cam is moved to it's initial position and hence the brake shoes are no longer in contact with the drum, which is now free to rotate.



DISC BRAKE

⇒ These brake are different from drum brakes in that the drum is replaced by a circular plate and the brake shoes are replaced by a caliper which supported a pair of friction pads, one on each side of the disc.

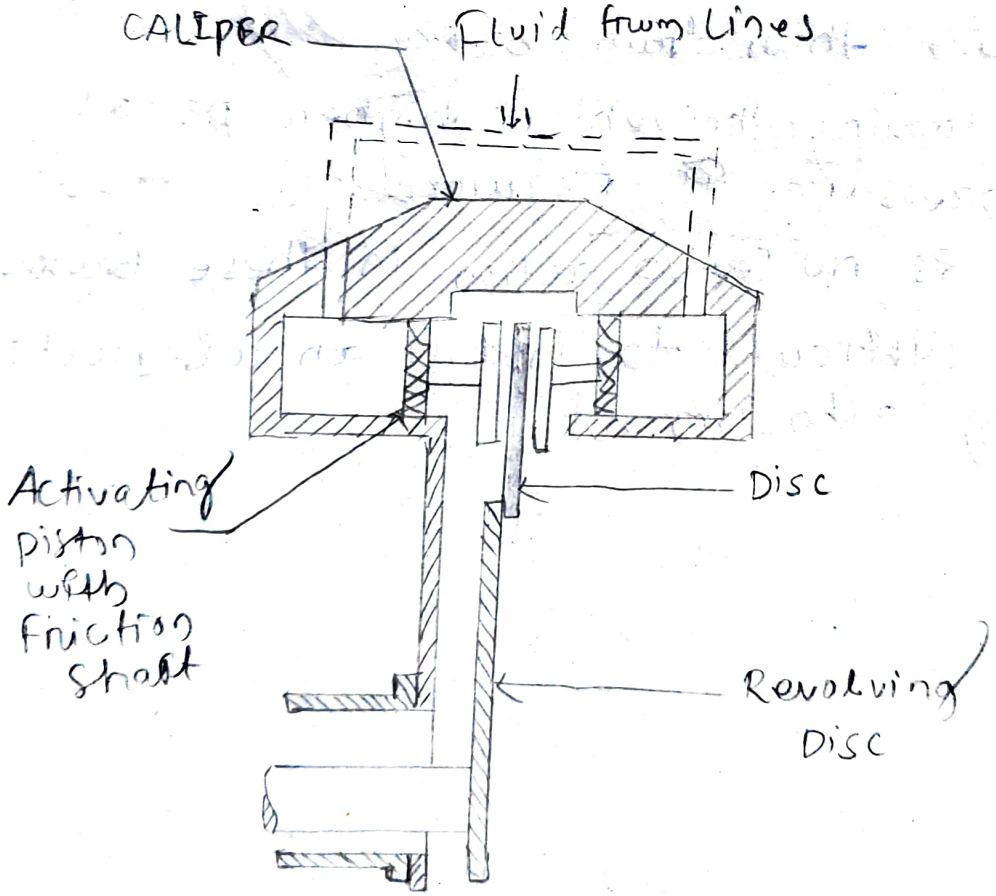
- these pads are forced inward by the operating force and so retard the disc

Construction :-

- A disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper.
- the caliper is connected to some stationary part of the vehicle (such as stub axle or axle casing) and is cast in two parts, each containing a piston.
- In between the each piston and the disc, there is a friction ~~plates etc~~, pads held in position by retaining pins, spring plates etc.
- passages are drilled in the caliper for the fluid to enter or leave each housing.
- the passages are also connected to one another for bleeding. Each cylinder contains a rubber sealing ring between the cylinder and the piston.

Working

- on the application of brakes, hydraulically actuated pistons moves the friction pads into contact with the disc, applying equal and opposite forces on the later.
- when the brakes are released, the rubber sealing rings act as return springs and retract the pistons and the friction pads away from the disc.
- Special types of disc brakes include the swinging caliper type and sliding caliper type.



DISC BRAKE

Advantages

(i) Lighter than drum brakes.
(ii) Better cooling (since the braking surface is exposed directly to air)
(iii) offer better Resistance to fade
(iv) uniform pressure distribution (since disc brakes have no self-servo effect.)
(v) Brake pads can be easily replaced.
(vi) these brake are self adjusting by design.

Disadvantages

(i) Costlier than drum brakes
(ii) for stopping the vehicle higher pedal ~~pedal~~ pressure is required.
(iii) there is no servo action in these brakes.
(iv) it is difficult to install an adequate parking attachment.

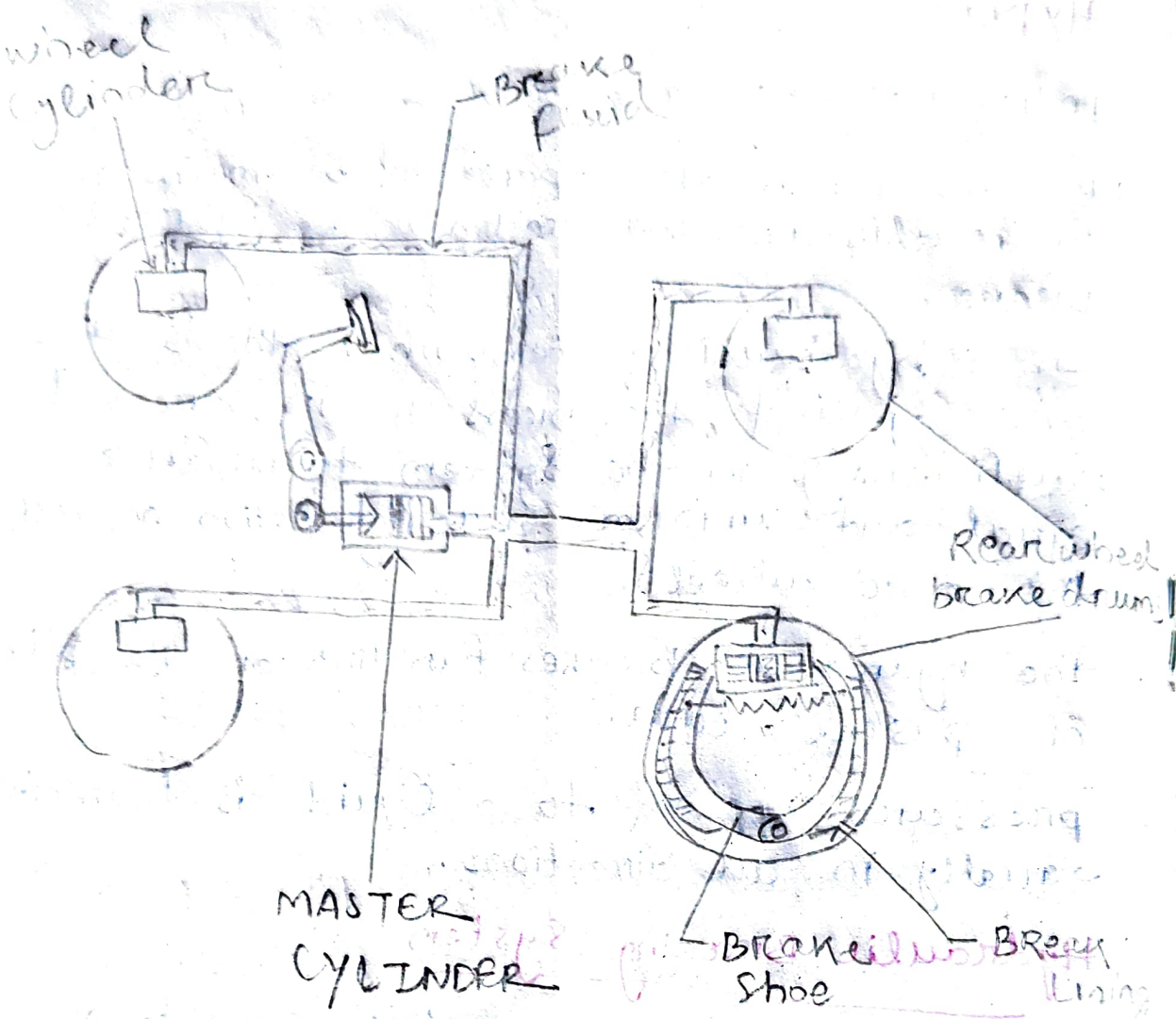
HYDRAULIC BRAKES

Introductions:

- Breakes which are opereated by means of hydraulic pressure are known as hydraulic Breakes.
- In a hydraulic system, when the breakes are applied, the pressure in increased sufficiently in the system to produce equal and uniform backing action on all the four wheels.
- the hydraulic breakes function on the principle of pascal's law.
- pressure applied to a liquid is transmitted equally in all directions.

Hydraulic Breaking System

- the hydraulic breaking system consists of four wheel cylinderes, one at each of the four wheels of the vehicle
- the system also consists of one mastere cylinder which is connected to the wheel cylinder by steel tubing.
- Each wheel cylinder contains two pistons, which will move out when the pressure will be applied through breake fluid.
- when the breakes are not in operation, the system is filled with breake fluid.



- Each wheel brake consists of a cylindrical brake drum which is mounted on the inner side of the wheel and revolves with it.
- there are two brake shoe mounted inside each of the brake drum but do not rotate with it.
- when the brakes are to be applied, the driver presses down the brake pedal, the piston is forced into the master cylinder, thus increasing the pressure of the fluid in the master cylinder and in the entire hydraulic system.

- This pressure is conduct instantaneously to the wheels cylinders on each four brakes, where it forces the wheel cylinders pistons outwards.
- these pistons, in turn, force the brake shoes out against the brake drums, thus the brake are applied.
- when the driver released the brake pedal, the master cylinder piston return to it's original position due to the return spring pressure; and ~~the~~ thus the fluid pressure entire system drops to it's original low value, which allows retracting spring on wheel brakes to pull the brake shoes out of contact with the brake drum into their original positions.
- this causes the wheel cylinder ~~po~~ pistons also to come back to their original inward position. thus the brakes are released.

the hydraulic brakes system contains two important components upon which the system is mostly dependent are,

1. Master cylinder
2. wheel cylinder

1. Master cylinder

- It is the main cylinder in the hydraulic brake system.

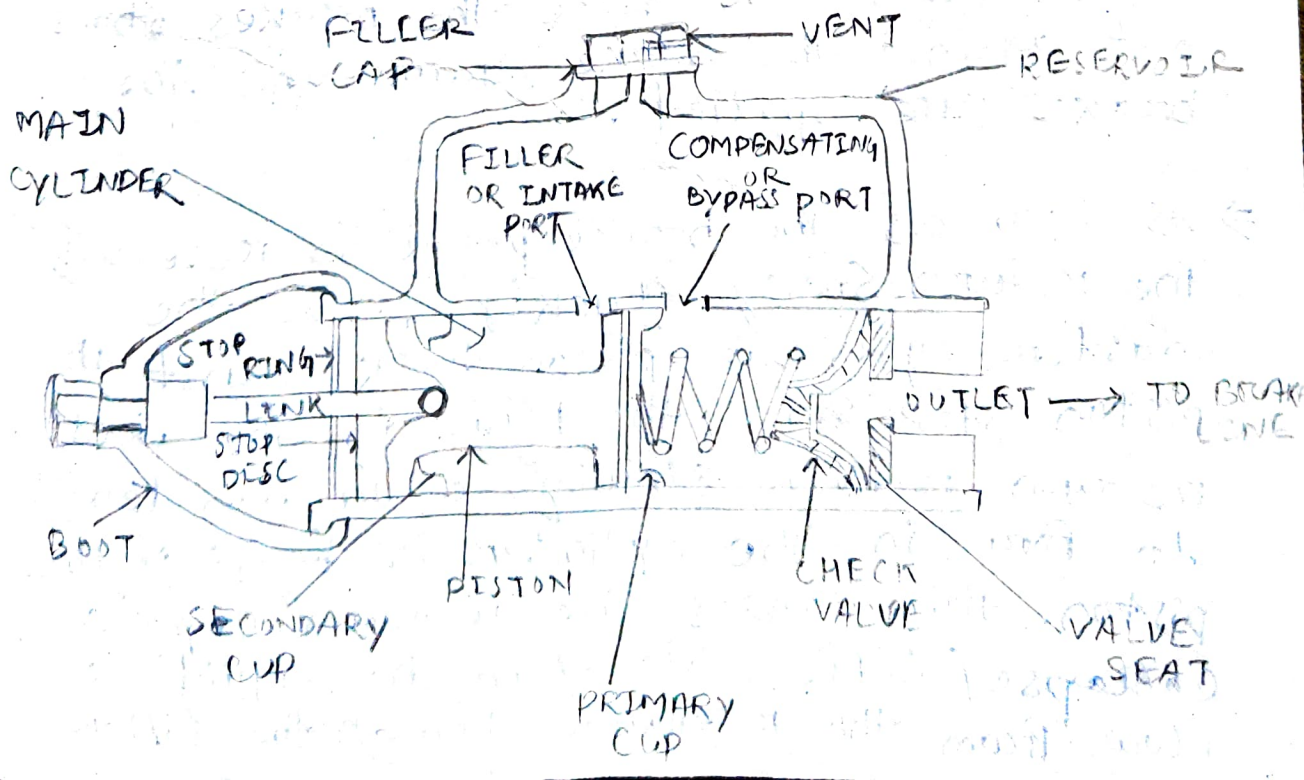
- It serves the following object in the system
(i) It builds up hydraulic pressure to operate the brakes.
(ii) It maintains a constant volume of fluid in the system owing to it's reservoir
(iii) It serves as a pump to bleed or force air out of the hydraulic system.
- there are two types of master cylinder:
(a) "Single master cylinder" for all the front and rear wheel cylinder
(b) "Tandem master cylinder" containing separate units for front and rear wheel cylinders.

(a) Single master cylinder:

Construction

- the masterc cylindere ~~m~~named as the heart of the hydraulic brake system, consists of two main chamberes
(i) the "fluid reservoir" (which contains the fluid supply to the brake system)
(ii) the "compression chamber" (in which piston operates).
- the reservoir supplies fluid to the brake system through two parts.

- the largere port is called the fillere or intake porct and is connected to the hollow portion of the piston (there are a numbere of holes in the piston on the primary or higher pressure seal side) between the primary and Secondary cups which act as piston seals.
- the Smaller porct is called the compensating bypass or relief porct which connects the reservoire directly with the cylindere and lines when the piston in the released position.
- the reservoire is vented to the atmosphere so that atmospheric pressure causes the flow through the filler porct.



- the vent is placed in the filler cap. the "boot" covers the push rod and the end of the cylinder to keep it free from foreign matter.
- towards the brake lines side of the compression chamber, there is a fluid "check valve" with a rubber cup inside.
- It serves to ~~earth~~ retain the residual pressure in the brake lines even when the brakes are released.

working

⇒ when the brake pedal is pressed piston of the master cylinder moves forward to force the liquid under pressure into the system. the relief port is sealed out of the system. the liquid pressure is conducted to the wheel cylinders, where it forces the wheel cylinder piston outward. the pistons force the brakes shoes out against the brake drums and the brakes are applied.

⇒ As soon as the brake pedal is released the return spring quickly forces the master cylinder piston back against the piston stop. Since the fluid in the lines return rather slowly, a vacuum tends to form in the cylinder in front of the piston. this causes the primary cup to collapse/deflect to allow the liquid to flow from the reservoir through the filler

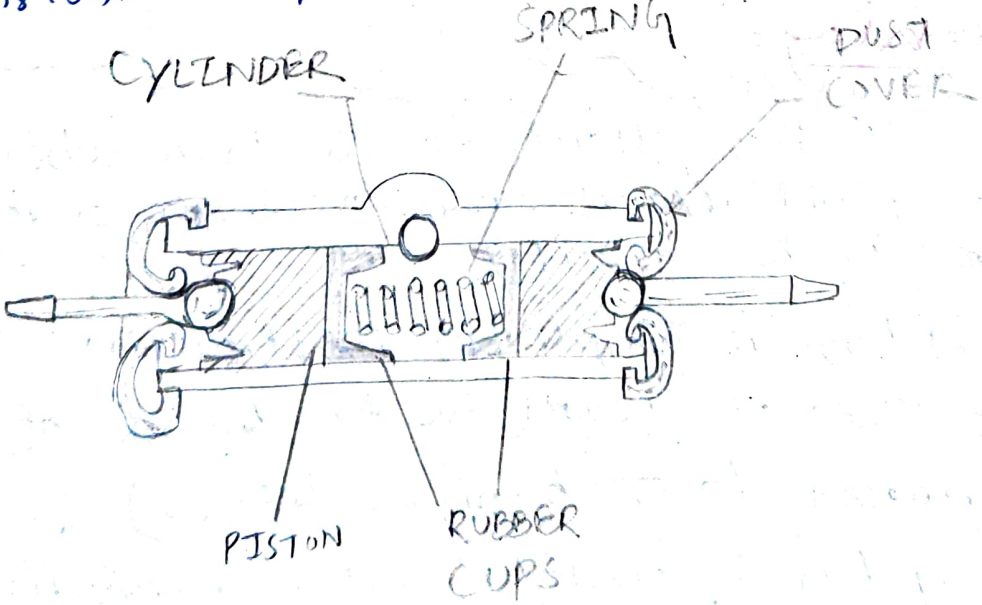
port past the piston to fill the vacuum.

⇒ when the pedal is in "off position" the liquid may flow from the reservoir through the relief port in the master cylinder, supply lines, and wheel cylinders to make up for any fluid that may be lost or to compensate for shrinkage cooling of the ~~fluid~~ liquid. In this way, a complete column of liquid is always maintained between the master cylinder piston and wheel cylinder pistons.

- In some makes of master cylinder a bleeders a screw is also provided to bleed air out of the master cylinder.

2. WHEEL CYLINDER (OR Slave cylinder)

- A wheel cylinder, two pistons, two rubber cups and a spring. the Fluid presses against pistons. the pistons move outward in the cylinder.



- when the pistons come closer, the liquid is forced into the master cylinder. the spring between the two pistons holds the rubber cups in the position.

⇒ The copper-coated, tin-plated annealed steel tubing and flexible hoses are used to connect the master cylinder to the wheel cylinders.

⇒ the hoses are use to connect the lines to the front wheel cylinders to permit the front wheel to be turned. rear wheel cylinder are generally connected directly to a line fastened to the rear axle housing. the brake lines are attached directly or by means of brackets to the frame or axle housings.

Advantage and disadvantage of Hydraulic Brakes.

Advantage

1. Equal braking effort to all four wheels (since fluid exerts equal pressure every where in the circuit)
2. The system is simple in construction
3. Less rate of wear (due to absence of joints compared to mechanical brakes)
4. the system is mostely self-lubricating

5. Increased braking effort.
6. High mechanical advantage.
7. Flexibility in brake line.
8. The hydraulic brake can also provide differential braking action between the front and rear brakes by using the wheel cylinder of different size for the front and rear wheels.

Disadvantage

1. Even slight leakage of air into the braking system makes it useless.
2. The brakes & shoes are reliable to get ruined if the brake fluid leaks out.
3. This system is suitable only for applying brake intermittently. For parking purpose separate mechanical has to be employed.

Hydraulic brake fluid

- The fluid used in the braking system is special kind of fluid which has to be satisfactory under all conditions. Most fluids are based on polyglycols and additives are added to achieve the required properties.
- A 50 percent solution in castor oil in alcohol to which a neutraliser is added, the meets the above mentioned requirments satisfactory the neutraliser is added to counter act the effects of any free acids which may be present in castor oil or alcohol.

The hydraulic brake fluid should posses following characteristics:-

1. Should be non-Compressible
2. Must remain fluid at low temprature.
3. Should not rust corrode or rust metalic parts in the brake system.
4. Mix satisfactory with other makes of hydraulic fluid.
5. Must be chemically stable
6. Should not soften the rubber parts used in the hydraulic fluids.
7. Must acts as lubricant to the moving parts inside the system.
8. Must retain all lists characteristics for a maximum ~~long~~ long period.

Dt-25/03/25 Suspension System

Functions of Suspension System

1. The Suspension System Connects the body of vehicle with the wheels and restricts the ~~direction~~ direct impact of wheels to the chassis and body.

2. During running, together with the tyres, it acts to absorb and dampen various vibrations, oscillation and shock recieved by the vehicle due to irregularities in the surface of the road.

3. It protect the passenger and cargo and improve ~~during~~ stability.

~~4. It protect the passengers~~

4. The driving and braking forces generated due to friction between the wheels and road surface are transmitted to the chassis and the body.

5. Proper geometrical relationship between the body and the wheel is maintained.

6. It support the body on the axles.

Components

1. Springs To neutralize the shocks from the road surface.
   (i) Leaf Spring
   (ii) Coil Spring
   (iii) Torsion Spring (iv) Air Spring

2. DAMPERS Improve comfort of the passenger by limiting the free oscillation of the spring
   (i) Telescopic hydraulic shock absorbers
   (ii) Pneumatic shock absorbers.

3. STABILIZER BARS prevent lateral swaying of the vehicle.
   (i) Sway bar
   (ii) Anti-roll bar

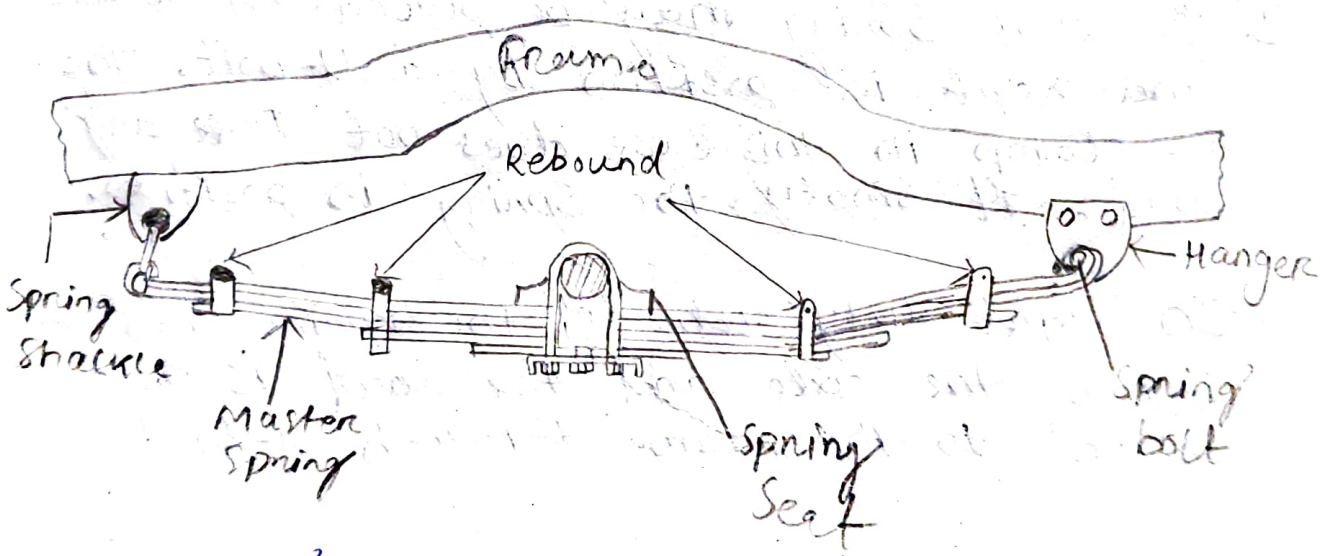
4. LINKAGE SYSTEM To hold the various component of the suspension system and control the longitudinal and lateral movement of the wheels.
   - The above components are combined to form the various types of suspension system for different vehicle designs.

1. SPRINGS
   Springs are the most important component of the system.

(i) Leaf Spring
   - Leaf springs are generally used for rigid axle suspension of the Truck and the other heavy duty vehicles.
   - Leaf Spring are used at the rear for some passenger cars. Truck often use leaf Spring at the front.

Construction

- Leaf Spring are made from flat strips of Spring steel. Each strip is called a leaf.
- Several strips are placed one over the other. these are joined together by clamp and a central bolt.
- the length of each leaf decreases so that Spring assembly acts as a flexible beam and is uniform in strength.
- the longest strips is called master leaf. the ends of the master leaf are formed into loops called Spring eye.



Working

- one end of the Spring assembly is attached to the frame through a Spring bolt passing through the Spring eye.
- the other end is secured through a shackle the shackle helps in accomodating the change in length of the Spring.

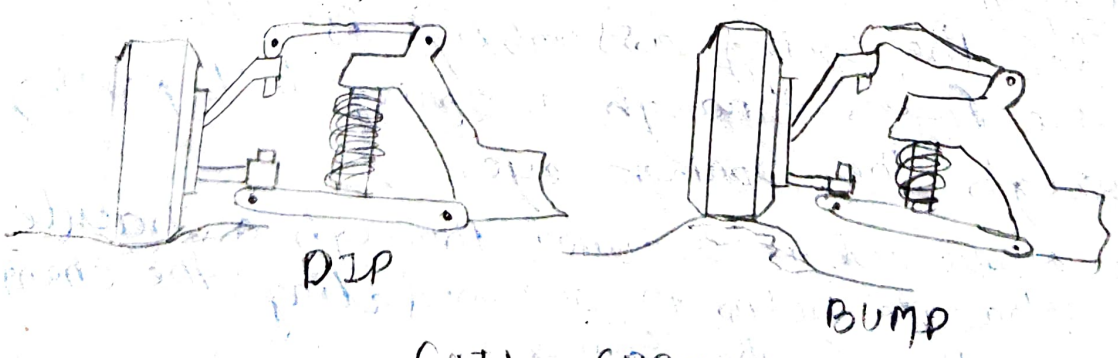
- when the wheel encounters a bump, the Spring expands and increase in length Take place which is done by the shackle.
- Similarly the reverse process of contraction is accomodated by the shackle.
- Bronze brushes are generally fitted in the Spring eye through which bolt passes. In some cases rubber is used in place of bushes. the rubber bushes are quiet in operation and require no lubrication.

Attachment of leaf Spring

- There are many methods of attachment of leaf Springs to the axle.

1. the leaf Spring may be placed on the axle and kept in position by a U-bolt. The U-clamp in this case does not Take any load. It Simply the Spring in position.

2. In light duty vehicle, the Spring is placed below the axle and the load is transmitted to the frame through u-bolt.



COIL SPRING

2. COIL SPRING

- Coil Spring are generally used in independent Suspension System in cars and the light duty vehicles. An Ideal Spring ~~load~~ should absorbs the road shock Rapidly and Return to it's normal position Slowely.
- this satisfactory rendering quality is achieved by using a fairly soft coil Spring with a shock absorber.

Construction

- A Coil Spring is made of special Spring steel wire. the Spring is circular in cross-section and of Suitable diameter to have desired Stiffness.
- The wire is wound in the shape of a coil. the Spring is formed at high temprature followed by coiling and Suitable heat treatment to impart Characteristics of elasticity.

Operation

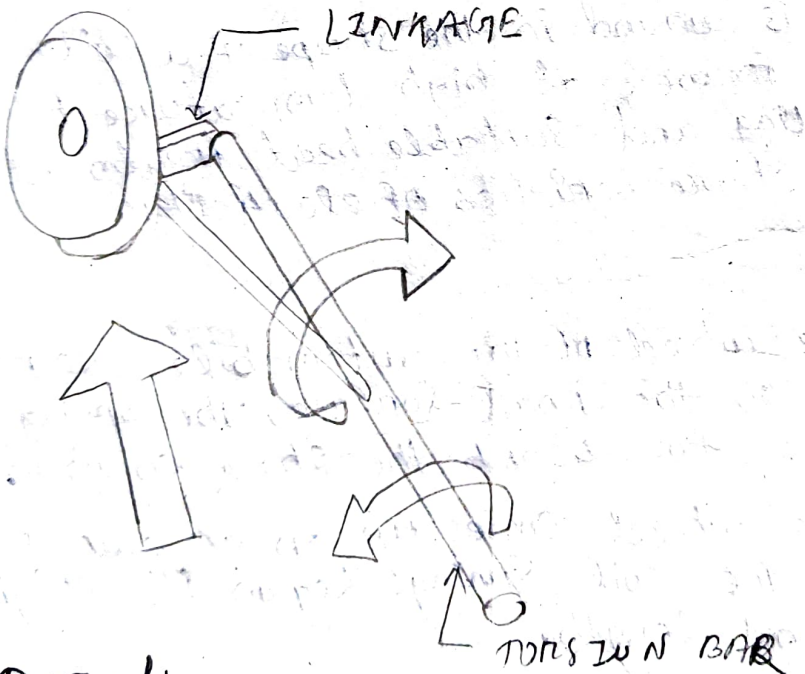
- when the wheel of the automobile experiences a bump on the road Surface, the Spring compresses to absorb the shock energy.
- when the wheel comes up on an even road Surface, the coil Springs Regain it's original Shape and length.
- the process of compression and elongation action continues ~~are~~ as per road Surface condition.

Attachment of Coil Spring

- One end of coil spring rests on the frame and the other end rests on an axle or suspension member.
- The coil springs are commonly used in front suspension system.

3. TORSION BAR

- The torsion bar is round steel rod which performs the spring action by resisting of twisting. The torsion bar twists and untwists to control wheel movement.
- Some front suspension system are use torsion bar in place of coil spring.



Operation

- The torsion bar is attached to the frame at one end and control arm at other end.
- As the wheel moves up and down, the torsion bar twist. when the torsion bar untwist the wheel Returns to its normal positin

Arrangment

- The end of torsion bar fixed to the frame cannot rotate. the opposite end of bar is free to twist which is attached to a support arm carrying the wheel.
- the car weight places an initial twist on the bar similar to initial compression of coil spring used in suspension system.

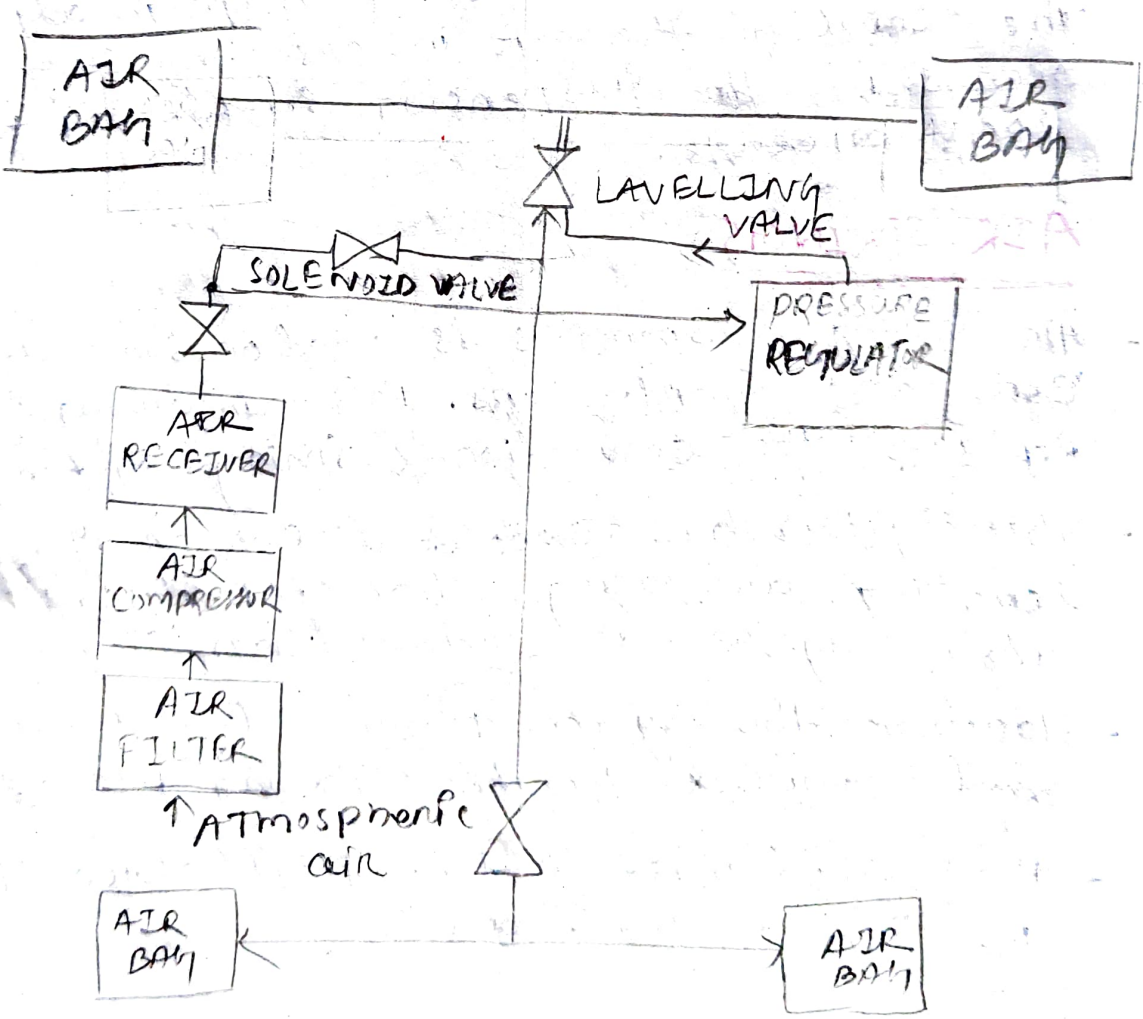
1. The bar is mounted Transversely in some vehicle and longitudinal along the frame in other design.
2. The torsion bar is also used in the car ~~leaving~~ leveling device. It helps in adjusting the level of the car in case any ~~sag~~ sag occurs in the suspension system after long mileage.

AIR SPRINGS

- Air ~~Spring~~ suspensions is used on some luxury cars and sports cars. this air spring system Replaces the conventional spring system.
- this system has excellent cornering, leveling and riding characteristics. It is also lighter in weight than conventional
- However, this system requires high repair costs and complex Trouble shooting procedures.
- the system must be turned off before lifting the car of the ground.

Construction

- The system uses four air bags filled with compressed air. A plastic piston is attached to the control arm carrying the wheels.
- As the wheel moves up and down, a valve on the top of the air bag opens to add or released compressed air.
- The compressed air provide the spring action. An air compressor connected to the valve keeps the air strip inflated.



System operation

1. An air compressor belt driven from engine supplies high pressure air (20 bar) to the system
2. the same pressure is maintained in the air receiver with the help of air relief valve.
3. the air pressure is reduced to 12 bar by pressure regulator and admitted to four air bags through leveling valves.
4. the leveling valve feed or release air from the bags to keep the car level proper.

DAMPERS

- Spring alone are not satisfactory for suspension system. the ideal spring for automotive suspension would be one that would absorb road shock rapidly and then return to its normal position slowly.
- This is quite impossible in case of spring. as they are by nature to oscillate.
- the spring must be a compromise between flexibility and stiffness. An extremely flexible spring or too soft a spring would allow too much movement of frame.
- A stiff or a hard spring on the other hand would give too rough a ride. Satisfactory riding qualities are attained by using a fairly soft spring in combination with a shock absorber which acts as a damper.

- The shock absorbers smooth out the oscillating effect of the springs.

There are 3 types of shock absorbers.

1. Friction shock absorbers.
2. Pneumatic " "
3. Hydraulic " "

* Hydraulic shocks absorbers are most commonly used in automobile suspension system.

Telescopic shock absorber

- A telescopic tube is partially filled with a fluid. An orifice plate is introduced to restrict the flow of fluid. The resistance to the flow of fluid imposes a drag on spring movement, quickly damping out spring oscillations.

- There are usually four shock absorbers on a car, one located near each wheel. they are called direct-acting as they make a direct connection between the frame and axle.
- they control motion in both directions of the suspension motion, upward movement is called rebound and downward movement of the frame is called compression.

Construction

⇒ the telescopic shock absorber consists of a cylinder in which a piston is moved up and down by a rod.

⇒ the piston rod is attached to the frame and the case of cylinder is connected to the axle. there is fluid reservoir around the cylinder.

⇒ the upper portion of unit is surrounded by a dust cover which also moves up and down loosely around the reservoir.

⇒ the upper shock mounting is attached to a piston rod and rebound valve assembly.

⇒ A rebound chamber is located above the compression ~~and~~ chamber below the piston.

⇒ The chamber are both filled with hydraulic fluid.

⇒ A compression intake valve is positioned in the bottom of the cylinder and hydraulically converted to a reserve chamber filled with hydraulic fluid.

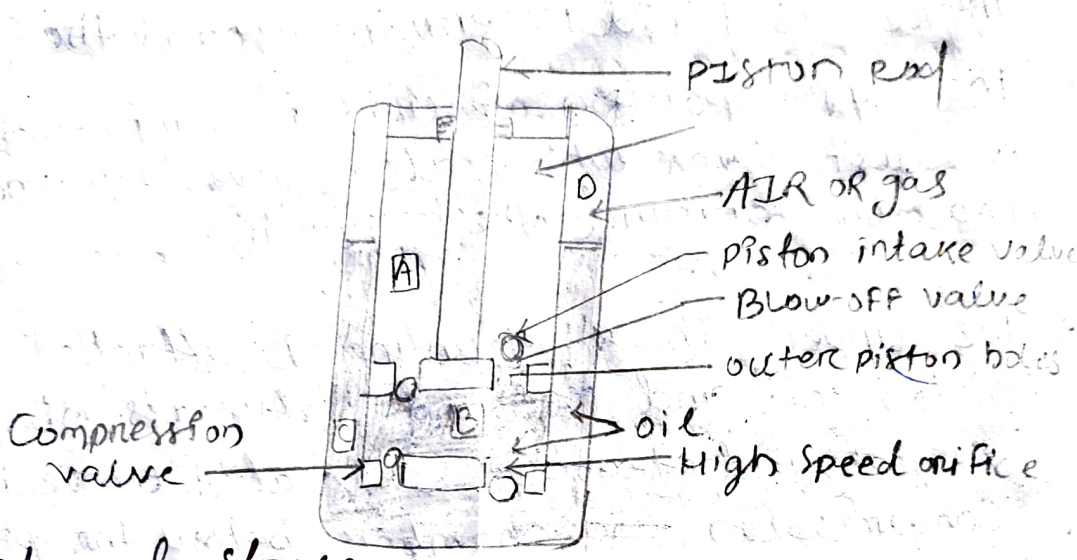
⇒ The lower mounting is attached to the cylinder tube in which the piston operates.

1. Compression Stroke

⇒ the compression movement of the shock absorber causes the piston to move downward in the cylinder tube. the fluid is Transferred from Compression chamber B To Rebound chamber A.

⇒ the fluid moves through outer piston hole and opening of piston intake valve.

⇒ The fluid volume equal to volume of piston rod is discharged into reserve chamber C through Compression valve. the air in reserve chamber D is compressed accordingly.

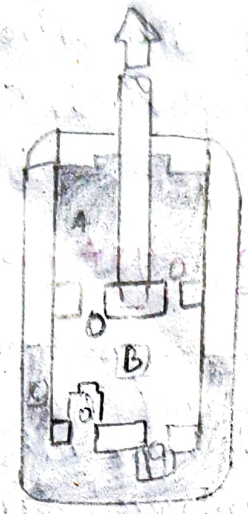


2. Rebound Stroke

⇒ During Rebound Stroke, the fluid pressure in compression character B will fall below the pressure in reserve chamber C.

⇒ The compression valve opens and fluid flows from rebound chamber A is transferred into compression chamber B through inner piston holes and Rebound valves.

⇒ the air in reserve chamber D expands equal to volume of Piston rod moved.



Rebound Stroke

STABILIZER BARS

1- During a bump, one side of the frame rises the opposite side of the frame also. this rising movement is counteracted by the stabilizer bars which twists creating a downward forces, keeping the frame level.

2. when a vehicle takes a turn, centrifugal force tends to decrease the weight on the inner suspension system and increase the ~~weight~~ weight on the outer suspension system. the vehicle level is ~~distrubed~~ distrubed. the vehicle leans out or the body ~~felts~~ rolls. the stabilizer bar is installed across the front of the frame which twist during turning and combats the tendency of the vehicle to learn out on turns the stabilizer bar is, therefore, also called sway bar or anti-roll bar.

Linkage System

- the Suspension System components are fastened together with the help of various fasteners - bushes, clamp, control arm etc.

Types of Suspension Systems

⇒ There are many types of suspension system used for rear axle and front axle depending upon front wheel or rear wheel drive, type of vehicle etc. However, Suspension can be roughly divided into two types.

1. Rigid axle Suspension
2. Independent Suspension.

1. Rigid-axle Suspension

= the rigid-axle suspension is used both for front axle and rear axle. the two front wheels or rear wheels are connected on a large axle that runs under the vehicle.

+ the two wheels bounce together through the axle resulting in a rough ride for the passengers.

the main characteristics are:-

1. the Suspension System has small number of parts.
2. the construction is simple
3. the maintenance is simple.
4. It is very durable for heavy-duty use

5. there is a little things of body when turning.
6. there is a little change in alignment due to up-and-down movement of the wheels on the rough road surface.
7. there is less tyre wear.
8. Riding comfort is poor as the unsprung weight is great.
9. the movement of the left and right wheels mutually influence one another, vibration and oscillation occur very easily..

- there are many types of rigid-axle suspension used for front suspension and rear suspension.

Independent Suspension

⇒ the independent suspension allows the two wheels to move up and down independently of one another.

⇒ the wheel can move up and down and yet not lift the frame. ~~the action of independent suspension~~

there are ~~very~~ various construction of independent suspension system.

1. the spring support the body only. the wheels are positioned ~~by~~ not by suspension system but by linkage
2. the unsprung weight is kept low and the road-holding characteristics of the wheels are good.
3. the riding comfort and handling stability are good

4. there is no axle connecting the left and right wheels.
5. the floor and engine mounting position can be lowered.
6. the vehicle centre of gravity is low
7. passenger compartment and luggage room can be made larger.
8. the construction is rather then complex.
9. thread and alignment change with the up and down motion of the wheels.

WHEELS AND TYRES

⇒ The wheel assembly is generally thought to consists of hub, disc or spokes, rim, tyre and tube. wheels are as important parts of a vehicle as the other parts.

⇒ All the parts beings perfectly in working order, the vehicle cannot move on the road without the wheels.

WHEELS

Introduction

⇒ The wheels are legs of the vehicle which carry it to far-off distances. They support the whole weight of the vehicle and convert Rotary motion into longitudinal one.

⇒ A wheel also resists side force, created by turning. Resistance is also necessary so that wheel will absorb hard shock and accidental damage.

Essential Requirment of wheels

1. Strong enough to take the weight of the vehicle torque etc.
2. Flexible to absorb the road shocks.
3. perfectly balanced statically as well as dynamically.
4. Lightest possible so that the unsprung weight is least.
5. Able to grip the road surface.
6. mounted or Removed easily.

7. Material of W's construction should not ~~deteriorate~~ deteriorate with weathering and age (To protect against corrosion, if required, suitable treatment must be given).
8. Not too expensive.

Types of automobile wheels

1. pressed steel disc wheels.
2. wire wheels.
3. Light alloy casting wheels.

1. Pressed steel disc wheels:

⇒ These wheels are most popular and most of the cars are fitted with this type of wheels.

advantages.

i) simple and robust in construction
ii) Easy to produce in large numbers at low cost.
iii) Require negligible maintenance
iv) Ease in cleaning.

⇒ It consists of a steel rim a pressed steel disc. this rim is rolled section, sometimes riveted but usually welded to the flange of the disc.

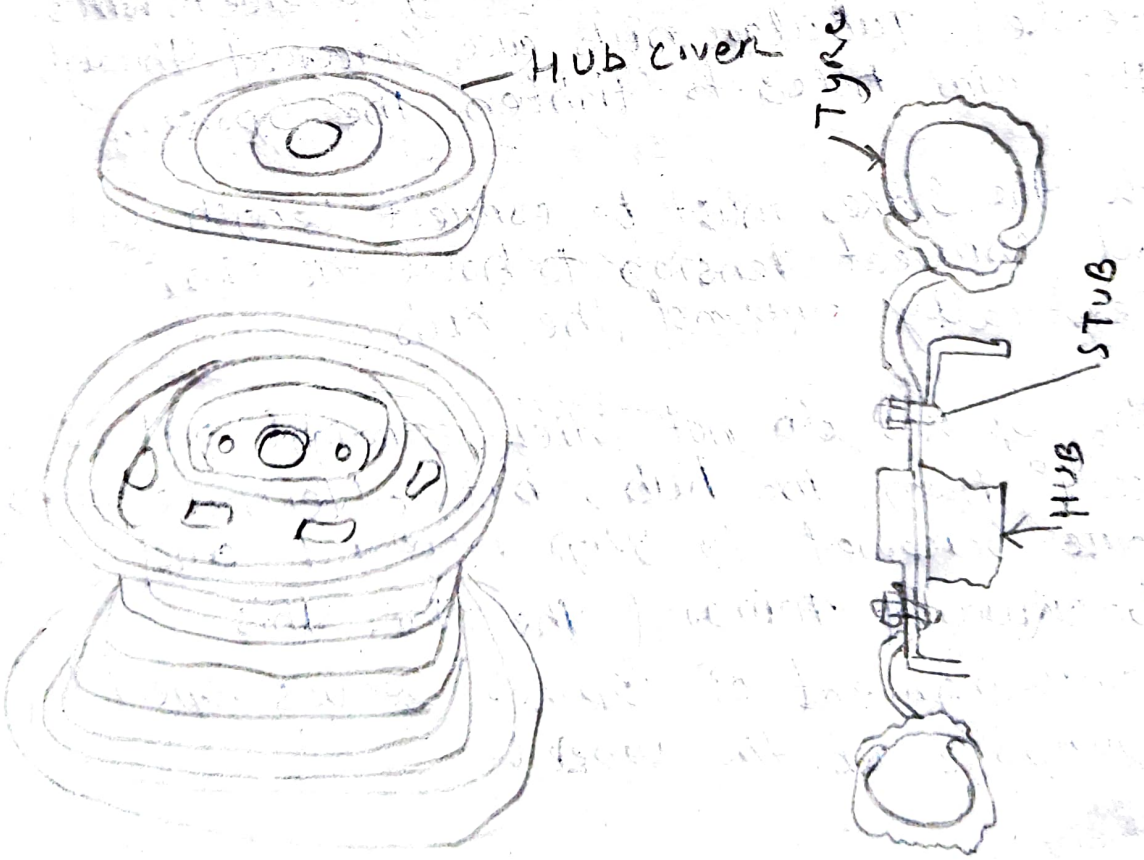
⇒ The ~~spring~~ disc performs the function of spokes.

⇒ The ~~wheel~~ a disc is frequently dished to bring the point of ground contact under the large wheel bearing.

⇒ the wheel assembly is bolted to the brake drum. the disc is often perforated with bluts near the rim, which act as a fan to blow air on the brakes.

⇒ A hole in the rim serves to accommodate Tube valve. A large chrome-plated or stainless steel hub cover can be sprung over the lungs in the disc.

⇒ It improve the general appearance of wheel and acts as a dust and water excluder as well. this cover can be readily detached by a screw driver.



2. Wire wheels

⇒ The wire wheel is the earliest type of wheel but presently it's use is limited to certain vintage sports and racing cars.

⇒ It is higher, heat dissipation is better and it can be fitted and removed very easily. However, Tubeless tyres cannot be fitted over wire wheels which are also difficult to clean.

⇒ A wire wheel consists of separate hub connected to the rim with a number of wires or spokes.

⇒ The headed inner ends of the spokes fit in the hub holes and the threaded outer ends fit in the rim holes, where mushroom headed Tubular nuts are screwed through the rim holes to tighten the spokes.

⇒ All the spokes must be correct length and at correct tension to hold the rim, centrally around the hub.

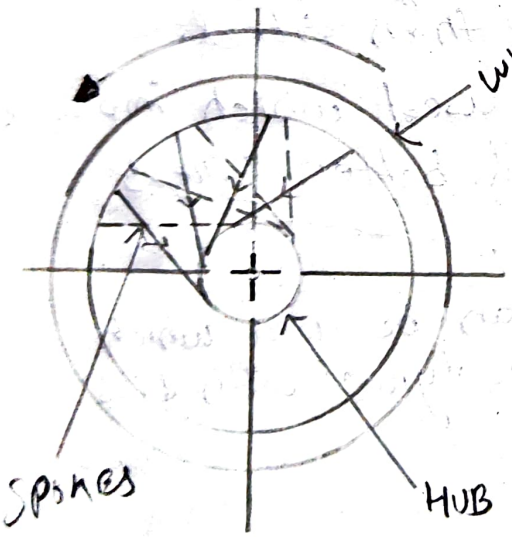
⇒ The spokes do not stick straight out as radii from the hub, but alternate spokes are screwed to slop forward and backward toward the rim. This arrangement of spokes serves special purpose of the wheel.

⇒ The forward-sloping spokes absorb braking torque and the rearward-sloping spokes convey driving torque.

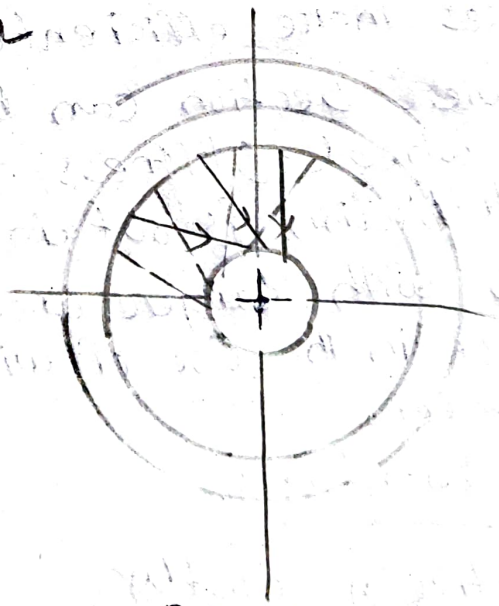
⇒ The holes in the hub are arranged in inner and outer rows so that one set of spokes slopes towards the rim from the outer row of the hub and the other set slopes outward to the rim from the inner row of the hub.

⇒ These sideways inclinations of the spokes hold the wheel upright against cornering loads and side thrust. A rubber chafing band is fitted in the well of the rim to keep tube touching the spoke nuts.

⇒ The wire wheels allow free circulation of air around the brake drum.



Driving torque



Braking torque

3. Light alloy casting wheels:

⇒ The light alloy cast or forged wheel is the most recent type, whose use in ever increasing in both road and sport cars.

⇒ the used of light alloys (aluminium and magnesium alloys) makes it possible to use wider rims, which allows low aspect Ratio (i.e wider tyres to be fitted), thus improving good adhesion, especially on corners.

Advantage

i- Light in weight.

ii- Light alloys being good heat conductor dissipate heat produced by tyres and brakes more efficiently than steel.

iii- Heavier section can be used which improve the wheel stiffness and better stress distribution is obtained.

iv- Rims with larger area can be used which Result in the use of wider tyres with less diameter.

Disadvantage

i) Relatively costly.

ii) More prone to corrosion.

★ Generally aluminium alloys are used for wheels of cars and commercial vehicles, whereas sports and racing cars usually have magnesium alloy wheel, probably the higher cost is the only Disadvantage

Tyres

Introduction

⇒ A tyre is a cushion provided with an automobile wheel. It consist of mainly the outer cover i.e, the tyre proper and the tube inside.

⇒ the tyre-tube assembly is mounted over the wheel rim. the air inside the tube carries the entire load and provides the cushion.

⇒ the tyres are final contact point between the road and the ~~wheel~~. vehicle. they take all the load of the vehicle.

~~⇒ the tyres are final contact point~~

⇒ they are flexible and absorb most of the shocks when a car in moving on rough roads.

⇒ the surface of the tyre has certain patterns which enable it to grip the road and provide good traction

Function of tyre

1. Supports the load of vehicle
2. provide cushion against shocks.
3. Transmits driving and breaking forces to the road.
4. provides cornering power for smooth steering.

Requirment of good tyre

1. To be strong enough to carry load and damage.
2. To provide a comfortable ride to the motorists.

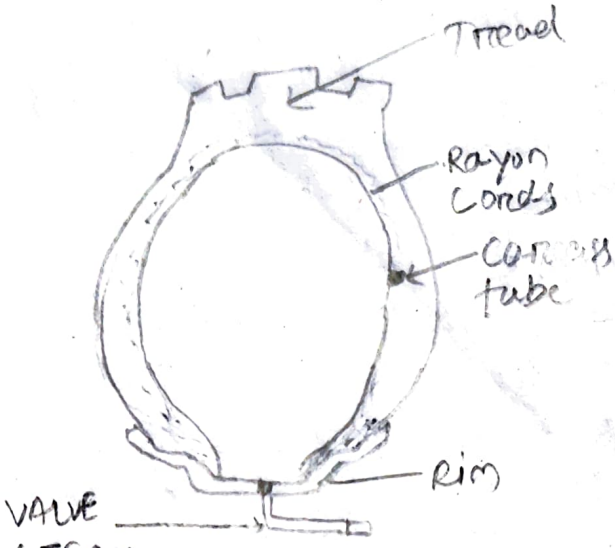
3. To provide good road grip for traction, cornering, ~~acel~~ accelerating and braking.
4. To provide quiet running.
5. To have a long life.
6. To respond accurately to steering without deflection by the ridge on the road.
7. To be flexible to cushion all shocks and impacts at least partly.
8. To be economical
9. To meet it's requirments in all weather and on all surfaces without overheating.

Types of tyres

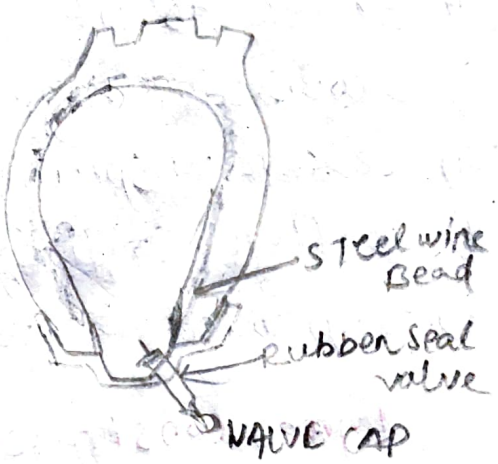
1. Conventional tubed tyre
2. Tubless tyre.

1. Conventional tubed tyre

- The outer portion of the tyre which rolls on the road is made of Synthetic rubber and is called "tread".
- The tyre enclose a tube in which air is forced to a high pressure as a cushioning medium. A valve stem is attached to the tube for inflating or deflating the same.
- In order to prevent the tyre from being thrown off the rim, the plies (formed from rayon cords) are attached to two rings of high tension hard steel wire. these rings are made to fit snugly against the wheel rim thereby anchoring the tyre to the rim these rims are called "Beads"



Convention tube tyre



Tubless tyre

2. Tubeless tyre

⇒ ~~A tubeless tyre~~ this type of tyre does not enclose a tube, instead the air under pressure is filled in the tyre itself for which purpose a non-return valve is fitted to the rim.

⇒ the inner construction of the type is almost same as that of the tubed tyre, expect that it is lined with a special air-retaining liner made up of halogenated butyl rubber e.g (chlorobutyl or bromobutyl) for better air permeability together with heat and weather resistance.

⇒ A tubeless tyre retain air for long period even after being punctured by nail, provided the nail remains in the tyre. Also; any hole in the tubeless tyre can be repaired simply by rubber plugging. ordinary punctures can be repaired without Removing the tyre from the wheel. It can be retreated in the same manner as the tube tyre.

Advantage

i) Easier to fit
ii) Slower leakege of air
iii) Lesser unsprung weight
iv) Better cooling.
v) Improved safety.

Tyre construction

- The lower portion on both sides has a set of steel wires called bead wires. these wires house tyre snugly in rim and also do not allow it comes ~~out~~ out even in the event of tyre burst.
- Bead wires are surrounded by bead core and plies of canvass. these days, instead of canvass, Rayon or nylon is used to give more strength to the tyre.
- on the tyre side walls as on plies rubber vulcanised which protects the plies from injury due to pebbles or any such object.
- The top portion is called Tread as it comes in contact with the road and is subject to wear. As such it is made thicker. Different designs are made in the tread for better grip and traction on different road condition.
- Breaker are rubber-covered cords similar to plies. the job of breaker is to distribute road shock and prevent separation of tread from tyre

- Cushion is soft heat resistance rubber, which absorbs & road shocks and also bind plies and break together.
- Cord plies give strength to resist internal pressure, to support load and road shocks

Tyre construction is divided into 3 classes.

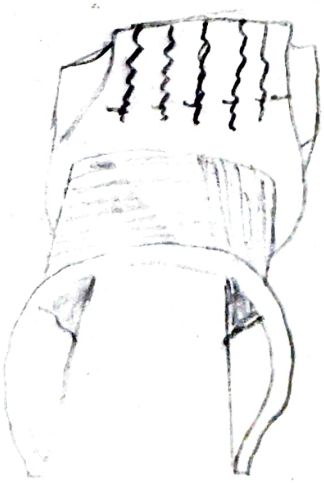
1. Cross play construction
2. Radial play construction
3. Belted bias construction.

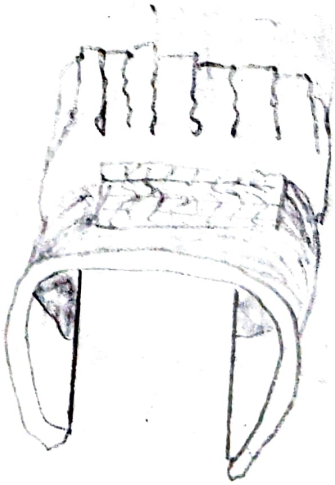
1. Cross ply construction

- In this type of tyre construction, the ply chords are woven at an angle (30° to 40°) to the tyre axis.
- there are two layers which run in opposite direction. However, the cords are not woven like wrap and weft of ordinary cloth, because that would lead to rubbing of the two layers and thus produced heat which would damage material of the Tyre.

⇒ This type of tyres have better wear and road holding charecteristics. But they must be fitted on the front wheels only. If radial tyres all around, or use cross ply on the front and radial ply tyres on the rear wheels otherwise covering charecterstics will be seriously impaired.

⇒ These tyre are economical. However they have a tendency to squirm as they go through the tyre foot print or contact patch.





2. Radial ply Construction

⇒ These tyre have plies running from bead to bead across the crown at right angles to the Rotation. on the side walls the direction of these piles is radial and hence the name.

⇒ However above the layers of these piles and ~~how~~ below the tyre tread, there are belt of cord or breakers which run around the circumference.

⇒ The angle between the cords varies from 18° to 22°. the numbers of layers depend upon the material used, the lateral stiffness needed and the load the tyre is required to carry.

⇒ Radial ply construction tyres are the most modern type and gradually replacing the other two.

Advantage

i) they can absorb more bounce of rough roads and thus the ride is more comfortable at high speeds.

ii) Improved acceleration and braking, operation (due to continuos flat contact-patch area with the road surface)

iii) lower rolling resistance and hysteresis loss, which ultimately means reduced fuel consumption.

iv) Longer tread life.

v) For similar tread design the water removal efficiency and hence the braking efficiency on wet-roads is better in case of Radial ply tyres.

vi) Better steering characteristics.

~~vii) For similar tread design the water removal efficiency and hence the braking efficiency~~

vii) Longer resistance to puncture, cuts and impacts in the tread area on account of the breaker belts.

viii) Less Tendency to distort and lift off the road from one side.

Disadvantage

i) Higher initial cost

ii) At low speed the ride is uncomfortable harsh.

iii) Heavier steering at low speeds.

3. Belted bias Construction

- This type of tyre construction is combination of the above two types. the basic construction is the bias-ply over which run a number of breaker belts.

- the belts improve the characteristics of the bias-ply tyre to a large extent. By keeping the Tread shape these tyres show advantage ~~over~~ cross ply over cross ply.

ii) Improved traction.
iii) Run Cooler.
iiii) Show greater road mileage.

- However since they do not flex as easily as cross ply, the ride is harder because all road shocks are transmitted to the body. Therefore for comfort, designed springs and suspension saystem have to be employed to reduce road shock Transfer to the passenger compartment.

Tyre material

⇒ Rubbed used in tyres is a blend of the natural and synthesis Rubbers to which various chemical (carbon, sulphur etc.) are added to obtain desired properties like wear resistance, less internal friction, Reduced hysteresis etc.

- Carbon black improves wear and abrasion Resistance.
- Sulphur acts as a vulcanising agent.
- Oil improves road holding at the expense of tyre wear.

* Bronze plated high tensile steel is used for beads. Around and between the separate stands a special Rubber insulation is squeezed. The wound bead is then covered with a strip of calendered fabric which provides additional strength and stability.

* The materials used for cords of the stabilizer belts are rayon, terylene, glass fibre, or steel.

- Glass fibre is very strong and extra classis but special techniques are required for spinning it into fibre cord and also achieving a satisfactory bond with rubber.
- Steel is very common in case of radial tyre belts but recently it has found use in the belted-bias tyre also.

Tyre shape

- A tyre is usually indicated by a series number such 100, 83, 78, 70 and so on. This designation is derived from the Aspect Ratio which is numerically equal to the ratio of the section height to width (i.e $\frac{H}{W}$).
- For quite some time the conventional tyre has 100 percent Aspect Ratio (i.e W=H) and was designated the 100 series. With the improvement in the design of car, increasing speeds, and need for better road grip led to wider car tyres with lower aspect ratio.
- Gradually the aspect ratio dropped from 90 to 85 percent to 70 percent.

- passenger cars now-a-days have an aspect Ratio of 70 percent in case of radial ply Tyres. However ratio below 60%. are difficult to accomodate in general automobiles and are used in ~~Mac~~ Racing cars (aspect Ratio may as low as 35 to 45%.)

★ The wider tyre claim advantages over the old symmetrical type:

i) vehicle handling is improved which gives a performance styling to the vehicle.
ii) Better load carrying capacity.
iii) Better Cornering.
iv) Better high speed performance
v) Longer life.

Tread pattern

* For different road condition there are different tread pattern.

⇒ A Tread pattern which is used on tyres that are employed on hard well surfaced roads.

⇒ Tread pattern which is only used ~~for~~ ful on soft ground. this type of pattern is not suitable for use on hard roads.

⇒ Tread pattern used on both good roads as well as on unmade surfaces.

Tread pattern

Tyre marking

E.g:- 8.25 × 20 - 10PR it means:

⇒ 8.25 (inches) is the width of tyre from shoulder to shoulder.

⇒ 20 (inches) is the diameter of the bead circle, which fit on the rim.

⇒ 10 PR is the ply rating i.e. in this tyre there are 10 plies.

- Scooters tyre consists of 1 to 4 plies, light truck tyre 10 to 22 plies. the number of plies makes the tyre hard to resists heavy loads, but the hard tyre does not absorb road shocks.
- "Metric designations" are based on internationally Recognize size / nomenclature.

Example: P 205/75 R14.

⇒ P means that tyre is for a passenger car. It's Section width is 205 mm, aspect Ratio 75-% It is of Radial Construction (R) and is meant for a rim of 14 inches diameter.

Tyre Selection

The tyre selection depends upon following factor

1. The load acting per tyre.
2. The surface on which the vehicle is going to move. the selection is made on the basis of above specification.

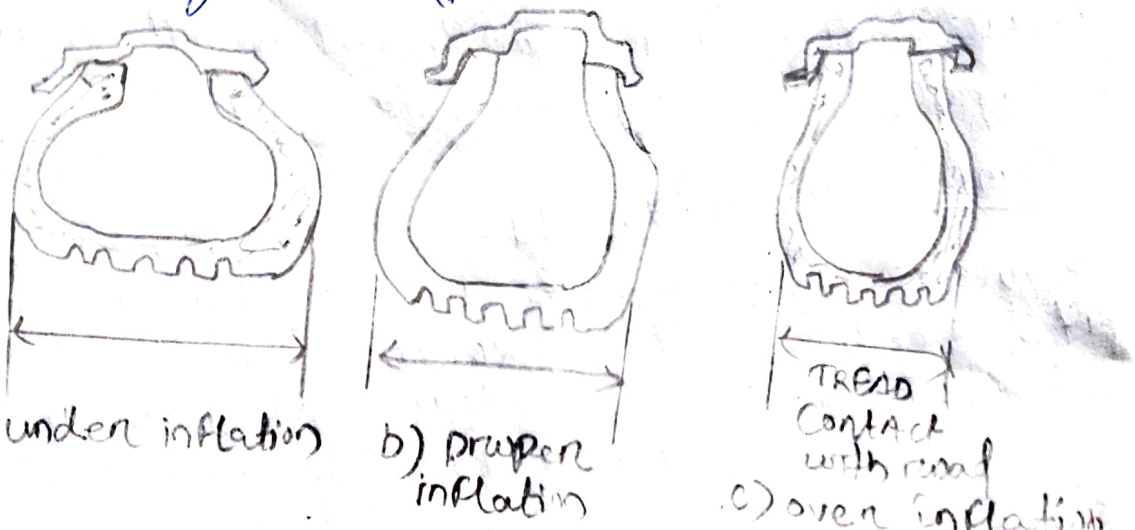
⇒ the selected tyre should be suitable for load capacity and road condition. It should also be prefer for the type of job for which the vehicle is intended.

Tyre inflation pressure

- FOR every type of tyre, inflation pressure are specified by manufacturers. these recomended pressure should be strictly adhered to since the help to meet the requirments of

(i) Good performance, (ii) Heat control (iii) Tread Kilometer (iv) comfort (v) Better vehicle CTRL

Incorrect pressure leads to
- overheating
- unsafe steering
- Rapid tyre wear.



a) under inflation b) proper inflation c) over inflation.

⇒ ~~Under inflation~~ ⇒

⇒ Under inflation causes severe flexing of the tyre plies, side walls and other components, excessive heat and premature failure. It causes the tyre to wear more on the edge than in the centre.

⇒ Over inflation over load the components of the tyre and causes abnormal wear in the centre of the tyre. Tyre tends to puncture when hitting a pointed object.

⇒ Both the above cases will cause dangerous steering and control.

⇒ High speed also causes the tyre wear and failure. When the vehicle is running at high speed, there will be high temperature produced by the distortion of tyre.

⇒ Such distortion can be reduced by increasing the air pressure slightly above the normally Recomended cold starting pressure.

Causes of tyre wear:

(i) Incorrect Inflation
(ii) unequal tyre
(iii) Bleeding of air in tyre.
(iv) Incorrect rotation of tyres.
(v) Missalignment
(vi) out of balance wheel.
(vii) worn Steering mechanism
(viii) Incorrect caster, camber, or toe in.
(ix) Excessive braking or violet acceleration
(x) wrong loading
(xi) Careless driving
(xii) Toe-out incorrect on turn.
(xiii) Defective brake
(xiv) overloading
(xv) worn kingpins.