AUTOMOBILE ENGINEERING
(5ME6.2A)

DEPARTMENT

OF

MECHANICAL ENGINEERING

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UNIT-3

WHEEL AND TYRES
STEERING AND SUSPENSION SYSTEM

INTRODUCTION

Wheels and Tyres:
Wheels must be strong enough to support the vehicle and withstand the forces caused by normal operation. At the same time, they must be as light as possible, to help keep un-sprung weight to a minimum.
The tyre provides a cushion between the vehicle and the road to reduce the transmission of road shocks. It also provides friction to allow the vehicle perform its normal operations. Modern tyres are manufactured from a range of materials. The rubber is mainly synthetic. This unit will cover the key components associated with the Wheels and Tyres and the relevant environment, health and safety.

Wheels
Wheels must be strong enough to support the vehicle and withstand the forces caused by normal operation. At the same time, they must be as light as possible, to help keep un-sprung weight to a minimum.

Wheels can be made from cast aluminium alloy or magnesium alloy. Alloy wheels are popular because of their appearance and because they are lighter than similar steel wheels. Aluminium is a better conductor of heat, so alloy wheels can dissipate heat from brakes and tyres more effectively than steel ones. Most wheels have ventilation holes in the flange, so air can circulate to the brakes. Most passenger car wheels are of well, or drop-centre design. This design allows for tyre removal and fitting. The removal and fitting of tyres should be carried out according to manufactures instructions.

Types of Wheels

Passenger cars normally use rims which are of well based, or dropcentre design. The drop enter is used for mounting and demounting the tyre onto the rim. Wheels must be strong enough to carry the mass of the vehicle and withstand the forces that are generated during use. The wheel centre must accurately locate the wheel rim centrally on the axle. It must also provide the required distance from the centreline of the wheel, to the face of the mounting flange.

This is called offset. Offset is important because it brings the tyre centreline into close alignment with the larger inner hub bearing and reduces load on the stub axle. This allows the inside of the wheel centre to be shaped to provide space for the brake assembly, usually located inside the wheel. Ventilation slots allow air to circulate around the brakes. The rim must be accurately shaped and dimensioned and strong enough to support the tyre under the load of the vehicle and the forces generated by the motion of the vehicle When inflated, the tyre is locked to the rim by tapering the bead seat towards the flange, or by safety ridges or humps, close to the flange.

In the event of sudden deflation, or blow-out, safety ridges prevent the tyre moving down into the well. This helps maintain control of the vehicle while the brakes are applied. Well-based rims can also be used on heavy commercial vehicles for tubeless tyres.

Rim Sizes & Designations

To ensure correct fit between a tyre and rim, all manufacturers ofwheels and tyres comply with standard dimensions, as recommended by automotive manufactures. The width of the rim is the distance across the rim flanges, at the bead seat. Its diameter is the distance across the centre of the rim from bead seat to bead seat

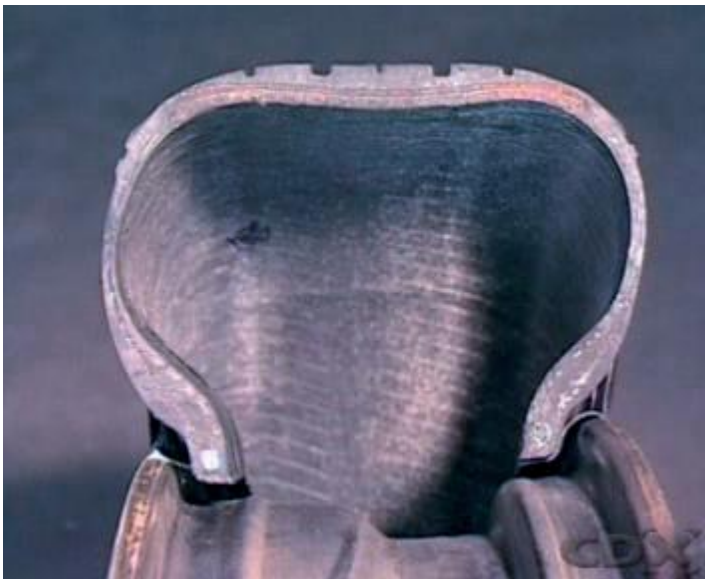
The tyre must be an exact fit on the rim, to fulfil a number of functions.
• It ensures that the narrow contact area between the beads of the tyre and the rim will seal the air in a tubeless tyre.
• It transfers all the forces between the tyre and the wheel, without slipping or chafing.
• It ensures the friction between the tyre and the rim prevents the tyre turning on the rim.

Tyre Types

The tyre provides a cushion between the vehicle and the road to reduce the transmission of road shocks. It also provides friction to allow the vehicle perform its normal operations. Modern tyres are manufactured from a range of materials. The rubber is mainly synthetic. Two types of tyre construction are common – cross-ply and radial. Most passenger cars now use radial tyres, as do most 4- wheel-drives and heavy vehicles. Tube tyres require an inner tube to seal the air inside the tyre.

Tubeless tyres eliminate the inner tube by making the complete wheel and tyre assembly air-tight. A special, air-tight valve assembly is needed. This can be a tight fit into the rim, or it can be held with a nut and sealing washers.
Tyres can be identified by markings on the sidewalls. This typically includes the maker's name, the rim size, the type of tyre construction, aspect ratio, maximum load and speed and, in some cases, intended use. Regulations cover the allowable dimensions for wheels and tyres on a particular vehicle. These dimensions are usually set out on the tyre spec attached to the vehicle. Incorrectly selected wheels and tyres can overload wheel bearings and change steering characteristics.
The tyre chart lists the wheel and tyre sizes approved by the manufacturer for the vehicle.
Using other wheels and tyres may be illegal. The repairing of punctures on tyres must be carried out in accordance with current
legalisation.

Tyre Construction
A tyre provides a cushion between the vehicle and the road, to reduce the transmission of road shocks. The air in the tyre supports the vehicle's mass and the tread provides frictional contact with the road surface, so the vehicle can manoeuvre for normal use. Radial ply tyres are usually manufactured in stages. The casing is initially formed by laying the rubber inner and the first layer of textile ply cords, around a flat drum mould. The rubber-covered bead wire and sidewalls are then locked into position.



The rubber sidewalls protect a finished tyre from kerb damage and weathering. At the second stage-building machine, the tyre is shaped.Belts of steel wire are guided into place. The tread is then positioned and the uncured tyre is consolidated by rollers, before it is placed in the mould. During the moulding and curing stage, the tyre is subjected to high temperature and pressure and it takes on its final fixed identity, with its own distinctive tread pattern. It is then trimmed and checked for balance and quality before it is inflated and run under load against a rotating drum. This is a final check for ride uniformity.

Tyre Tread Designs

Tyres generally fall into one of the following categories:

- Directional
- Non-directional
- Symmetric and Asymmetric.

Directional tread patterns are designed to provide a range of functions during particular driving conditions. The tyre can only be mounted to the wheel so that it revolves in a particular direction to correspond with the tread pattern. An arrow on the tyre sidewall indicates the designed

direction of forward travel. On-directional tread patterns are designed in such a way that the tyre can be mounted on the road wheel for any direction of rotation. Tyre treads can be directional, non-directional, symmetric and asymmetric.
In wet conditions, the coefficient of friction between a smooth tyre and the road surface falls to an extremely low value. Aquaplaning is prevented by Grooves in the tread pattern clearing water away from the contact patch area. This allows a relatively “dry area” to be formed and for road adhesion to be maintained.
Static friction occurs when two objects are not moving relative to each other e.g. the tyre against the road surface while the car is stopped. To overcome this, a force must be applied (car starting to move) which results in rolling friction. If rolling friction increases until it is greater than static sliding friction will result.

Cross-Ply Tyres
Two types of tyre construction are common cross-ply and radial ply. The cross-ply tyre is the older form. It is also called a bias-ply or conventional tyre. It is constructed of 2 or more plies or layers of textile casing cords, positioned diagonally from bead to bead.
The rubber-encased cords run at an angle of between 30 and 38 degrees to the centreline, with each cord wrapped around the beads.
A latticed criss-crossed structure is formed, with alternate layers crossing over each other and laid with the cord angles in opposite directions

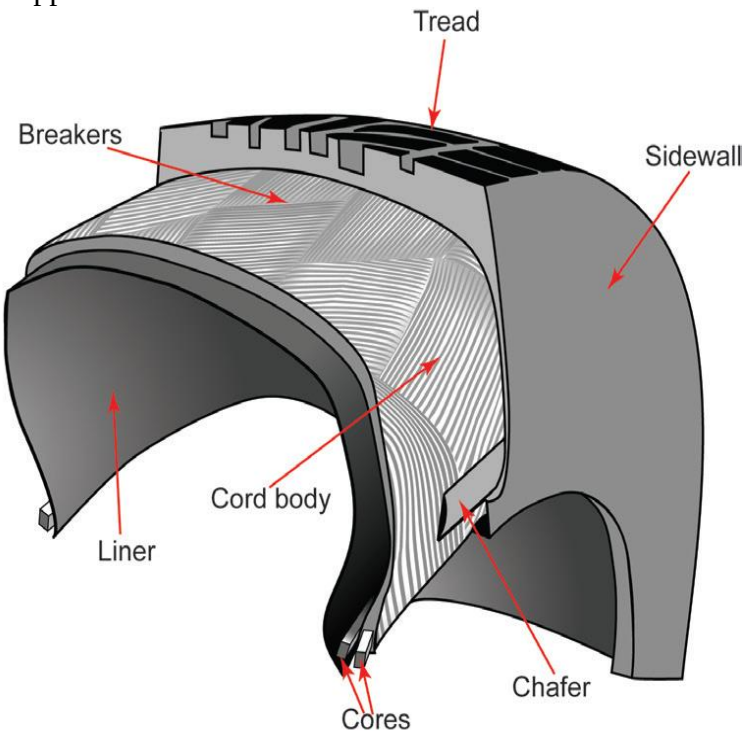
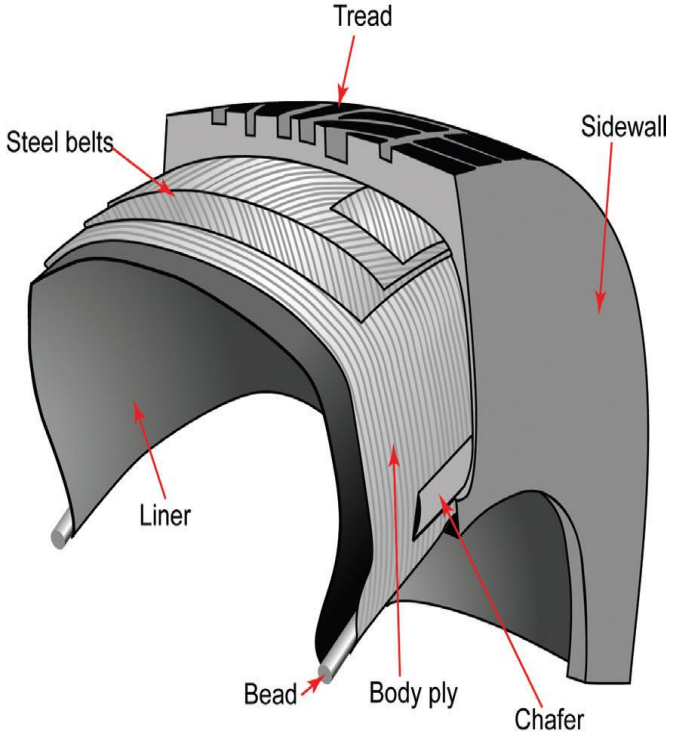


Fig.-Bias/Crossply Construction

This provides a strong, stable casing, with relatively stiff sidewalls.
However during cornering, stiff sidewalls can distort the tread and partially lifting it off the road surface. This reduces the friction between the road and the tyre. Stiff sidewalls can also make tyres run at a high temperature. This is because, as the tyre rotates, the cords in the plies flex over each other, causing friction and heat. A tyre that overheats can wear prematurely.

Radial Ply Tyres

Radial ply tyres have much more flexible sidewalls due to their construction. They use 2 or more layers of casing plies, with the cord loops running radially from bead to bead.



Radial Construction

The sidewalls are more flexible because the casing cords do not cross over each other. However, a belt of 2 or more bracing layers must be placed under the tread. The cords of the bracing layers may be of fabric, or of steel and are placed at 12, to 15 degrees to the circumference line. This forms triangles where the belt cords cross over the radial cords. The stiff bracing layer links the cord loops together to give fore and aft stability, when accelerating, or braking and it prevents any movement of the cords during cornering. The cord plies flex and deform only in the area above the road contact patch.

There are no heavy plies to distort and flexing of the thin casing generates little heat, which is easily dispersed. A radial ply tyre runs cooler than a comparable cross-ply tyre and this increase tread life. A radial tyre has less rolling resistance as it moves over the road surface.

Tyre Materials

Modern tyres are made from a range of materials. The rubber is mostly synthetic, with carbon black added to increase strength and toughness. When used in the tread, this combination gives a long life. Natural rubber is weaker than the synthetic version. It's used mainly in sidewalls. The plies are made from cords of fabric, coated with rubber. Manufacturers use a sophisticated selection process to create combinations that provide the required performance characteristics and 'hysteresis level' of the tyre. Hysterisis can best be described as the energy lost, usually in the form of a build up of heat, when a section of vulcanized rubber is deformed in a regular, constant manner. The more you subject a tyre to flexing and deformation the more heat will

build up within the tyre. Excessive heat is the enemy of a tyre so this builds up has to be kept under control.

TYRE WEAR DIAGNOSIS

1. *Check for foreign objects and pressure:* Inspect the tyres for embedded objects in treads and remove them and look for signs of wear on all wheels, including the spare. Check the pressure in the tyres.
2. *Check tread wear depth:* Most tyres have wear indicator bars incorporated into the tread pattern. Inspect the wear indicator bars. Tyres should have at least one sixteenth of an inch, or two millimetres of tread remaining. The wear indicator bars are normally set at this depth. If the tread is worn down to that level or below, they are unserviceable and must be eplaced.
3. *Check tread wear pattern:* Check the wear patterns with the vehicle's shop manual to indicate the types of wear that have occurred. Causes of uneven wear can include faulty shock absorbers, incorrect front alignment angles and wheels out of balance. Uneven tread and bald spots can indicate over- or under-inflated tyres and poor alignment.
4. *Check tyre for damage:* Inspect the sidewalls of the tyres for signs of cracking from impacts with blunt objects. Carefully examine the tread area for separation. This is usually identified as bubbles under the tread area. Spin the wheel and see if it is running true. If it is wobbling as it rotates, report it to your supervisor.

STEERING SYSTEM

Steering is the collection of components, linkages, etc. which allow a vessel (ship,boat) or vehicle (car, motorcycle, bicycle) to follow the desired course. An exception is the case of rail transport by which rail tracks combined together with railroad switches (and also known as 'points in British English) provide the steering function.

The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints (which may also be part of the collapsible steering column design), to allow it to deviate somewhat from a straight line. Other arrangements are sometimes found on different types of vehicles, for example, a tiller or rear–wheel steering. Tracked vehicles such as bulldozers andtanks usually employ differential steering— that is, the tracks are made to move at different speeds or even in opposite directions, using clutches and brakes, to bring about a change of course or direction.

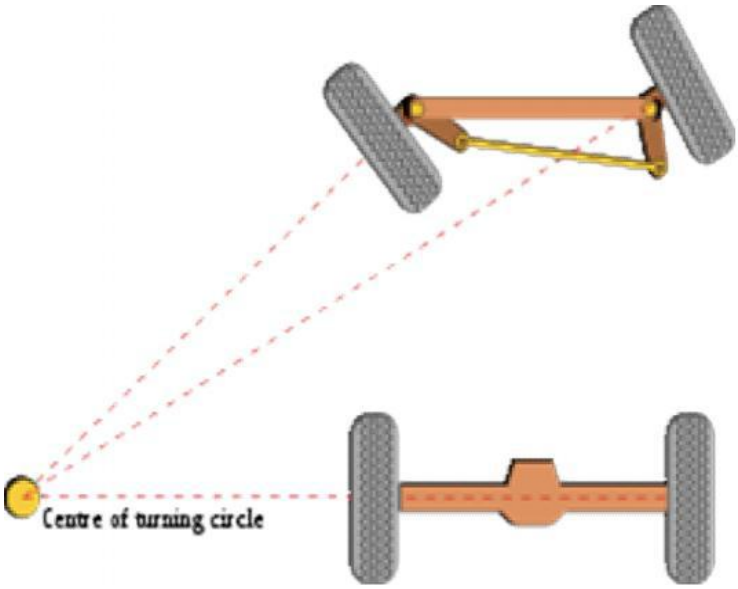
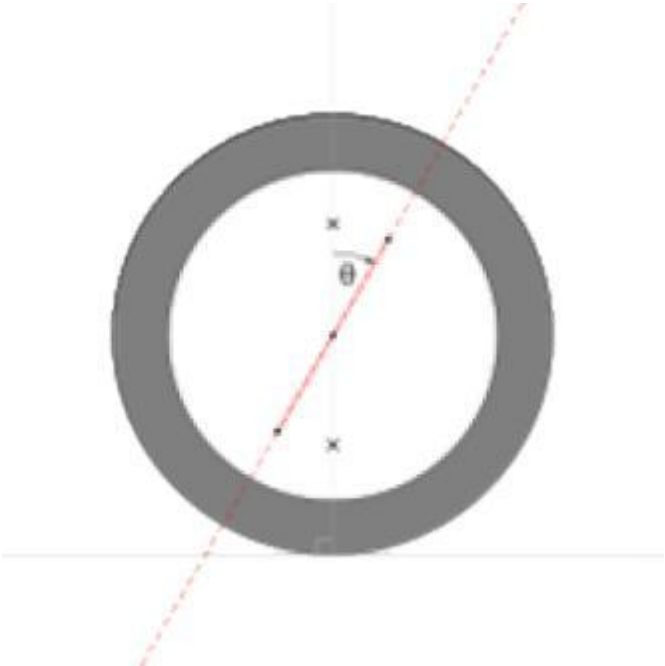


Fig.-Wheeled vehicle steering - Basic geometry

Ackermann steering geometry



Caster angle θ indicates kingpin pivot line and gray area indicates vehicle's tire with the wheel moving from right to left. A positive caster angle aids in directional stability, as the wheel tends to trail, but a large angle makes steering more difficult.

Curves described by the rear wheels of a conventional automobile. While the vehicle moves with a constant speed its inner and outer rear wheels do not.

The basic aim of steering is to ensure that the wheels are pointing in the desired directions.

This is typically achieved by a series of linkages, rods, pivots and gears. One of the fundamental concepts is that of caster angle – each wheel is steered with a pivot point ahead of the wheel; this makes the steering tend to be self-centering towards the direction of travel.
The steering linkages connecting the steering box and the wheels usually conforms to a variation of Ackermann steering geometry, to account for the fact that in a turn, the inner wheel is actually travelling a path of smaller radius than the outer wheel, so that the degree of toe suitable for driving in a straight path is not suitable for turns. The angle the wheels make with the vertical plane also influences steering dynamics (see camber angle) as do the tires.

Fig.- Rack and pinion, recirculating ball, worm and sector

Rack and pinion steering mechanism:
1. Steering wheel
2. Steering column
3. Rack and pinion
4. Tie rod
5. Kingpin

Rack and pinion unit mounted in the cockpit of an Ariel Atom sports car chassis. For most high volume production, this is usually mounted on the other side of this panel Steering box of a motor vehicle, the traditional (non-assisted), you may notice that the system allows you to adjust the braking and steering systems, you can also see the attachment system to the frame.

Many modern cars use rack and pinion steering mechanisms, where the steering wheel turns the pinion gear; the pinion moves the rack, which is a linear gear that meshes with the pinion, converting circular motion into linear motion along the transverse axis of the car (side to side motion). This motion applies steering torque to the swivel pin ball joints that replaced previously used kingpins of the stub axle of the steered wheels via tie rods and a short lever arm called the steering arm.

The rack and pinion design has the advantages of a large degree of feedback and direct steering "feel". A disadvantage is that it is not adjustable, so that when it does wear and develop lash, the only cure is replacement.

Older designs often use the recalculating ball mechanism, which is still found on trucks and utility vehicles. This is a variation on the older sector design; the steering column turns a large screw (the "worm gear") which meshes with a sector of a gear, causing it to rotate about its axis as the orm gear is turned; an arm attached to the axis of the sector moves the Pitman arm, which is connected to the steering linkage and thus steers the wheels. The recalculating ball version of this apparatus reduces the considerable friction by placing large ball bearings between the teeth of the worm and those of the screw; at either end of the apparatus the balls exit from between the two pieces into a channel internal to the box which connects them with the other end of the apparatus, thus they are "recalculated".

The recirculating ball mechanism has the advantage of a much greater mechanical advantage, so that it was found on larger, heavier vehicles while the rack and pinion was originally limited to smaller and lighter ones; due to the almost universal adoption of power steering, however, this is no longer an important advantage, leading to the increasing use of rack and pinion on newer cars. The recirculating ball design also has a perceptible lash, or "dead spot" on center, where a minute turn of the steering wheel in either direction does not move the steering apparatus; this is easily adjustable via a screw on the end of the steering box to account for wear, but it cannot be entirely eliminated because it will create excessive internal forces at other positions and the mechanism will wear very rapidly. This design is still in use in trucks and other large vehicles, where rapidity of steering and direct feel are less important than robustness, maintainability, and mechanical advantage.

The worm and sector was an older design, used for example in Willys and Chrysler vehicles, and the Ford Falcon (1960s). Other systems for steering exist, but are uncommon on road vehicles. Children's toys and gokarts often use a very direct linkage in the form of abellcrank (also commonly known as a Pitman arm) attached directly between the steering column and the steering arms, and the use of cable operated steering linkages (e.g. the Capstan and Bowstring mechanism) is also found on some home-built vehicles such as soapbox cars and recumbent tricycles.

Steering Gear Boxes;

The steering gears converts the rotary motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkages. Moreover it also provides necessary leverage so that the driver is able to steer the vehicle without fatigue.

There are various types of steering gear boxes are available in automobile.

- Worm and Wheel steering gear box
- Cam and double roller steering gear box
- Worm and nut steering gear box
- Recalculating ball type steering gear box
- -Rack and pinion steering gear box

Power steering

In automobiles, power steering (also known as power assisted steering (PAS) or steering assist system) helps drivers steer by augmenting steering effort of the steering wheel. Hydraulic or electric actuators add controlled energy to the steering mechanism, so the driver needs to provide only modest effort regardless of conditions. Power steering helps considerably when a vehicle is

stopped or moving slowly. Also, power steering provides some feedback of forces acting on the front wheels to give an ongoing sense of how the wheels are interacting with the road; this is typically called "road feel".

Representative power steering systems for cars augment steering effort via an actuator, a hydraulic cylinder, which is part of a servo system. These systems have a direct mechanical connection between the steering wheel and the linkage that steers the wheels. This means that power-steering system failure (to augment effort) still permits the vehicle to be steered using manual effort alone.

Other power steering systems (such as those in the largest off-road construction vehicles) have no direct mechanical connection to the steering linkage; they require power. Systems of this kind, with no mechanical connection, are sometimes called "drive by wire" or "steer by wire", by analogy with aviation's "fly-by-wire". In this context, "wire" refers to electrical cables that carry power and data, not thin-wire-rope mechanical control cables.

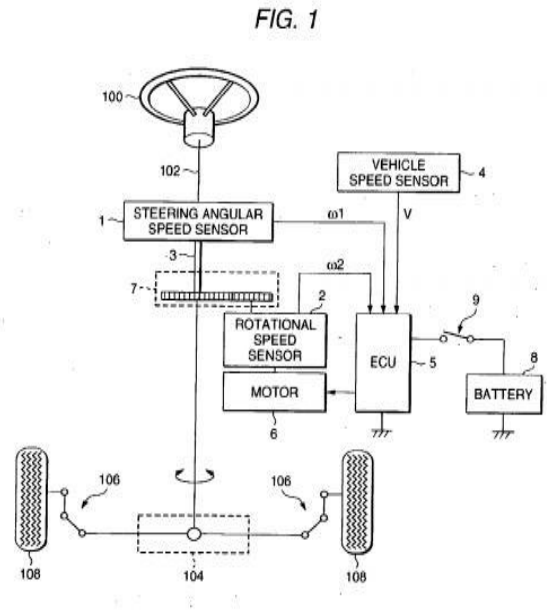
In other power steering systems, electric motors provide the assistance instead of hydraulic systems. As with hydraulic types, power to the actuator (motor, in this case) is controlled by the rest of the power-steering system.
Some construction vehicles have a two-part frame with a rugged hinge in the middle; this hinge allows the front and rear axles to become non-parallel to steer the vehicle. Opposing hydraulic cylinders move the halves of the frame relative to each other to steer.

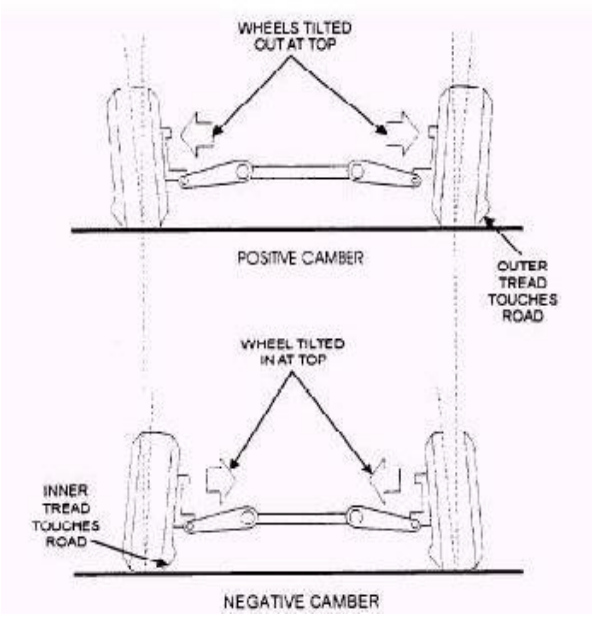
Power steering helps the driver of a vehicle to steer by directing some of the power to assist in swiveling the steered road wheels about their steering axes. As vehicles have become heavier and switched to front wheel drive, particularly using negative offset geometry, along with increases in tire width and diameter, the effort needed to turn the wheels about their steering axis has increased, often to the point where major physical exertion would be needed were it not for power assistance.
To alleviate this auto makers have developed power steering systems: or more correctly power-assisted steering—on road going vehicles there has to be a mechanical linkage as a failsafe.
There are two types of power steering systems;
1. hydraulic 2. electric/electronic.
A hydraulicelectric hybrid system is also possible.A hydraulic power steering (HPS) uses hydraulic pressure supplied by an engine-driven pump to assist the motion of turning the steering wheel. Electric power steering (EPS) is more efficient than the hydraulic power steering, since the electric power steering motor only needs to provide assistance when the steering wheel is turned, whereas the hydraulic pump must run constantly.

In EPS, the amount of assistance is easily tunable to the vehicle type, road speed, and even driver preference. An added benefit is the elimination of environmental hazard posed by leakage anddisposal of hydraulic power steering fluid. In addition, electrical assistance is not lost when the engine fails or stalls, whereas hydraulic assistance stops working if the engine stops, making the steering doubly heavy as the driver must now turn not only the very heavy steering—without any help—but also the power-assistance system itself.

Speed Sensitive Steering

An outgrowth of power steering is speed sensitive steering, where the steering is heavily assisted at low speed and lightly assisted at high speed. The auto makers perceive that motorists might need to make large steering inputs while manoeuvering for parking, but not while traveling at high speed. The first vehicle with this feature was the Citroën SM with itsDiravi layout[citation needed], although rather than altering the amount of assistance as in modern power steering systems, it altered the pressure on a centring cam which made the steering wheel try to "spring" back to the straight-ahead position. Modern speed-sensitive power steering systems reduce the mechanical or electrical assistance as the vehicle speed increases, giving a more direct feel. This feature is gradually becoming more common.





Suspension system:-

Suspension system is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels . It is basically cushion for passengers protects the luggage or any cargo and also itself from damage and wear.

Sir **William Brush** is the father of suspension system in automobiles.

The main role of suspension system are as follows:

-It supports the weight of vehicle .

- Provides smoother ride for the driver and passengers i.e. acts as cushion.
- Protects your vehicle from damage and wear .
- It also plays a critical role in maintaining self driving conditions.
- It also keeps the wheels pressed firmly to the ground for traction .
- It isolates the body from road shocks and vibrations which would otherwise be transferred to the passengers and load.

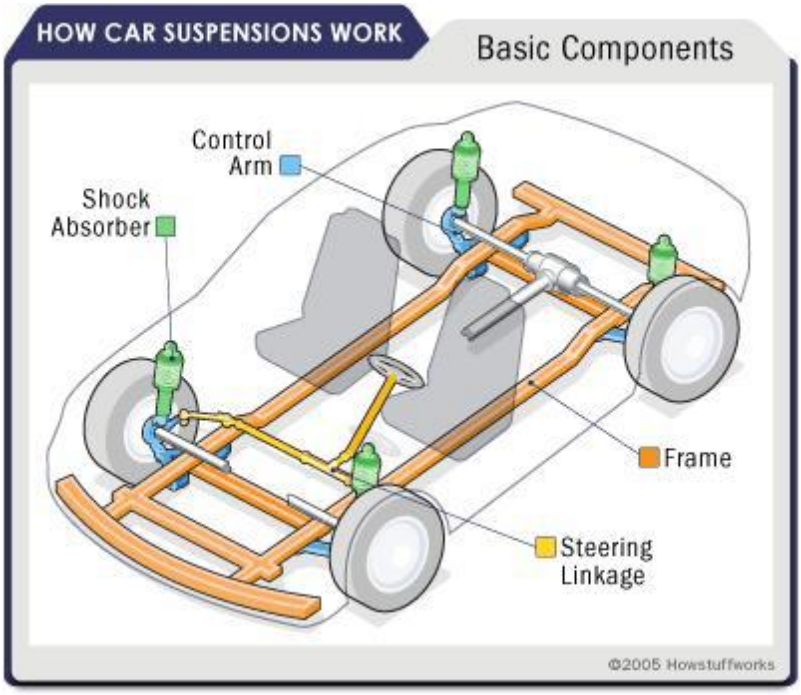
Principle :

When a tire hits an obstruction, there is a reaction force. The size of this reaction force depends on the unsprung mass at each wheel assembly.

In general, the larger the ratio of sprung weight to unsprung weight, the less the body and vehicle occupants are affected by bumps, dips, and other surface imperfections such as small bridges. A large sprung weight to unsprung weight ratio can also impact vehicle control. No road is perfectly flat i.e. without irregularities. Even a freshly paved highways have subtle imperfections that can be interact with vehicle's wheels. These are the imperfections that apply forces on wheels.

According to **Newton 's law of motion** all forces have both magnitude and direction. A bump in the road causes the wheel to move up and down perpendicular to the road surface. The magnitude of course ,depends on whether the wheel is striking a giant bump or a tiny speck. Thus, either the wheel experiences a vertical acceleration as it passes over an imperfection. The suspension of a car is actually part of the chassis, which comprises all of the important systems located beneath the car's body. These system include :

- Frame
- Suspension system
- Steering system
- Tires or Wheels

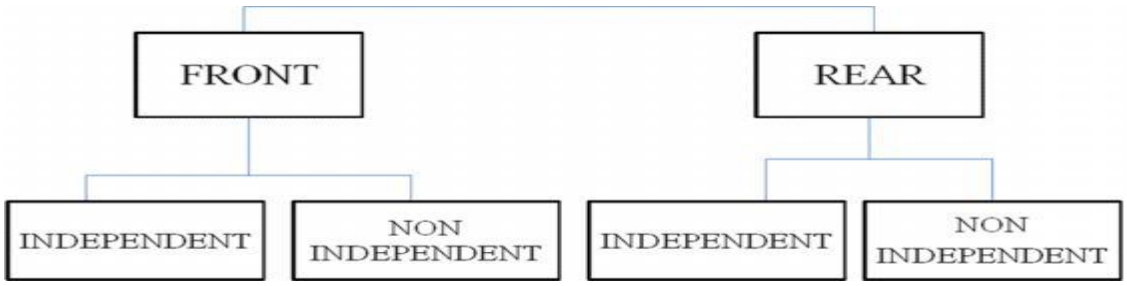


Components of Suspension system;

There are three fundamental components of any suspension system .

-Springs
-Coil spring
-Leaf springs
-Air springs
-Dampers
-Shock Absorbers
-Struts
-Anti-sway Bars

Types of Suspension system:



Advantages:

- Comfort to passengers
- Good handling
- Shields the vehicle from damage
- Increases life of vehicle
- Keeps the tires pressed firmly to ground.