

Unit IV

Vehicle System

Introduction of Chassis Layout :

Chassis is a metallic structure on which various other components / assemblies are mounted. The chassis contains all the major units necessary to propel the vehicle, guide its motion, stop it and allow it to run smoothly over uneven surfaces.

The chassis includes the following major components,

- I. A steel frame, which is a major part.
- II. In case of a passenger car, the whole body is also an integral part of the chassis. However, in commercial vehicles like trucks and buses, the body is not a part of the chassis. Therefore, a chassis is almost a complete vehicle except the body and other accessories, which are not involved in the movement of the vehicle.
- III. Other major components include engine, transmission system, front and rear axle, steering system, suspension system, wheels, tyres and brakes.

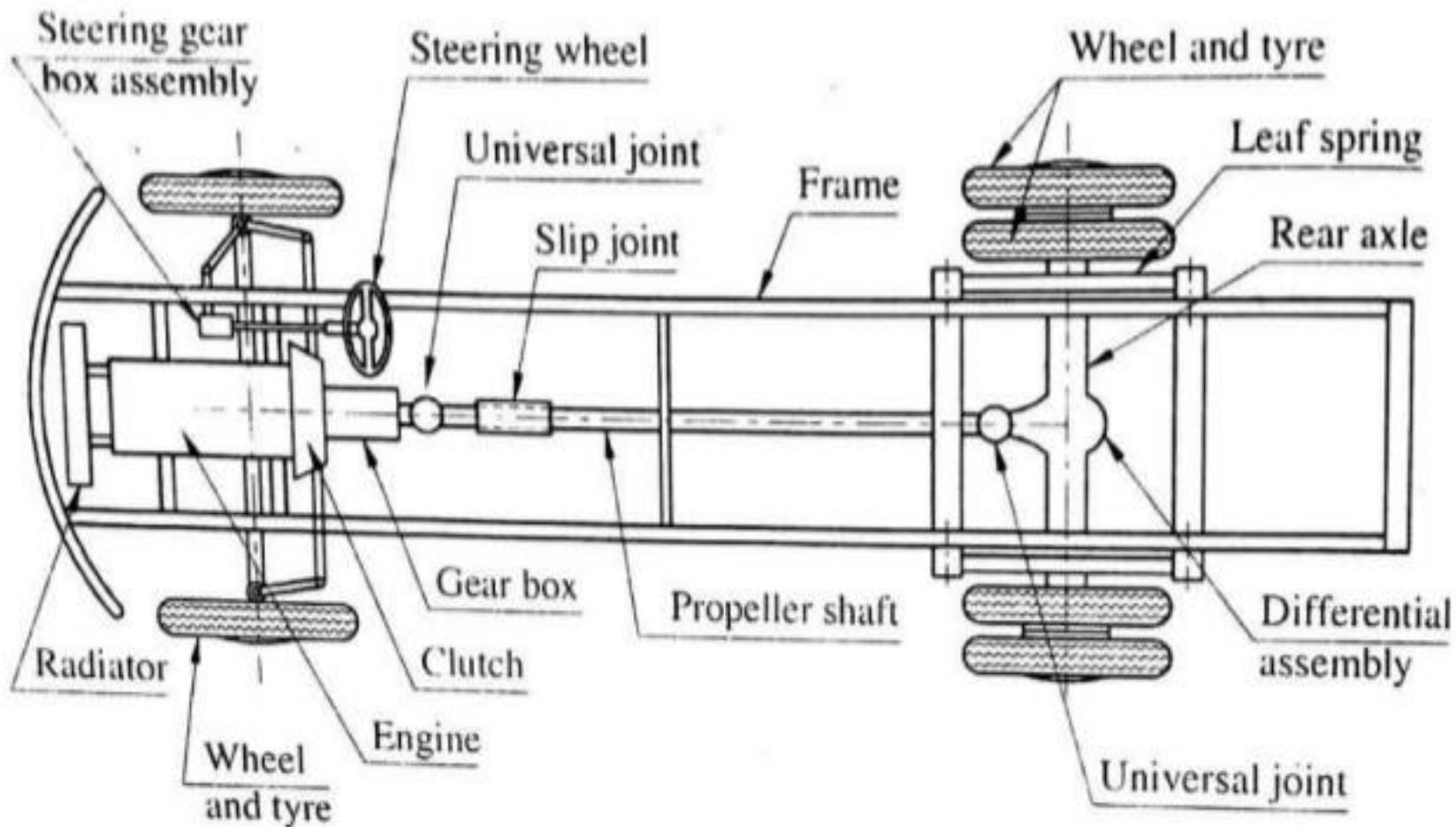
Functions of the chassis :

The functions of the chassis includes

- I. carrying the weight of the vehicle and its passengers,
- II. withstanding the engine and transmission torque and thrust stresses, as well as accelerating and braking torque,
- III. withstanding the centrifugal force while taking a turn and
- IV. withstanding the bending load and twisting due to the rise and fall of the front and rear axles.

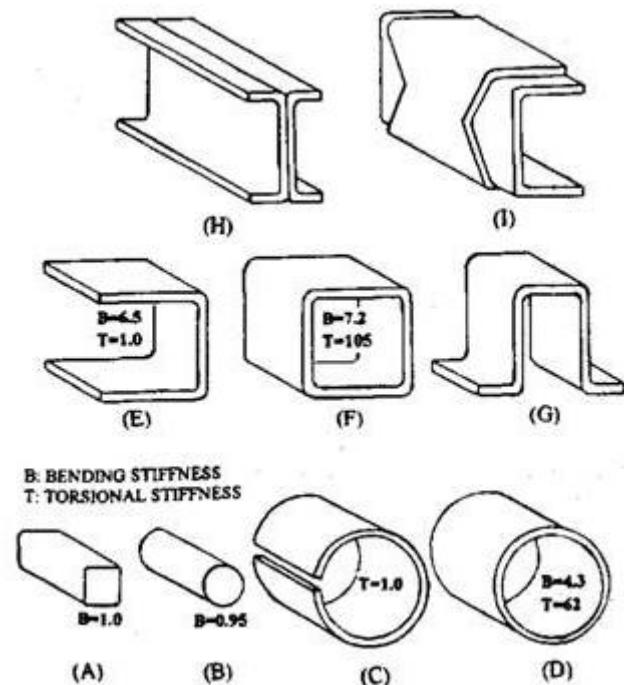
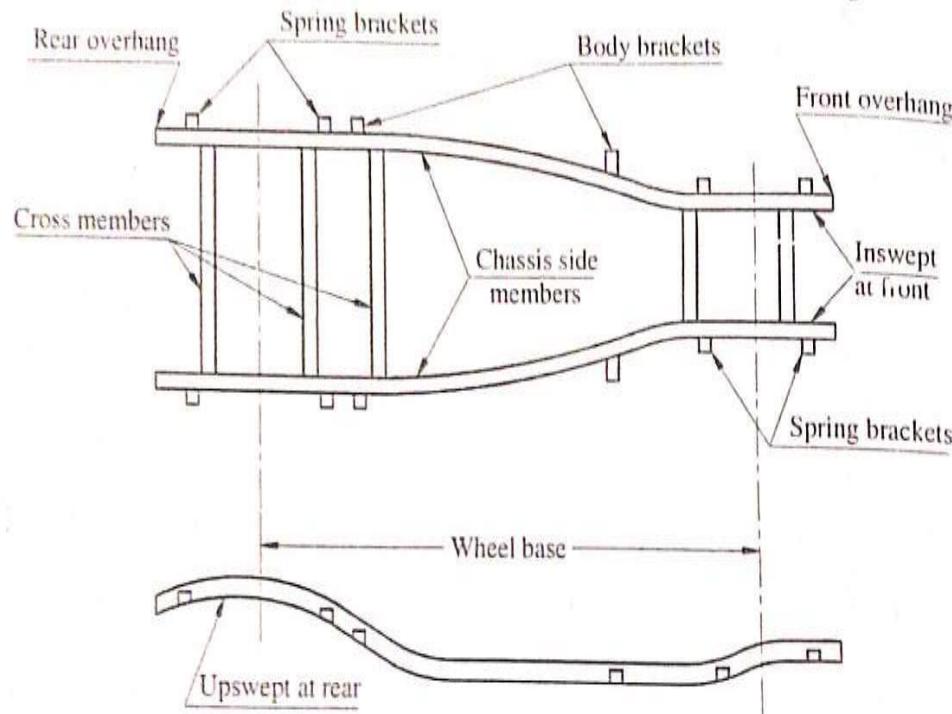


Layout of chassis for four wheeler :



Vehicle Frame :

- Function: to carry all main components or sub assemblies to make entire automobile systems.
- It is the supporting component of automobile vehicle.
- It is the foundation for carrying the engine, transmission system & steering system by means of spring , axle , rubber pads etc.
- The frame are made of box , tubular channels or U-shaped section , welded or riveted together.



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

“Frame” + “Base components” = “Chassis”

“Chassis” + “Body” = “Vehicle”

Types of Chassis:

- Backward control (conventional chassis)
- Forward control
- Semi – forward control

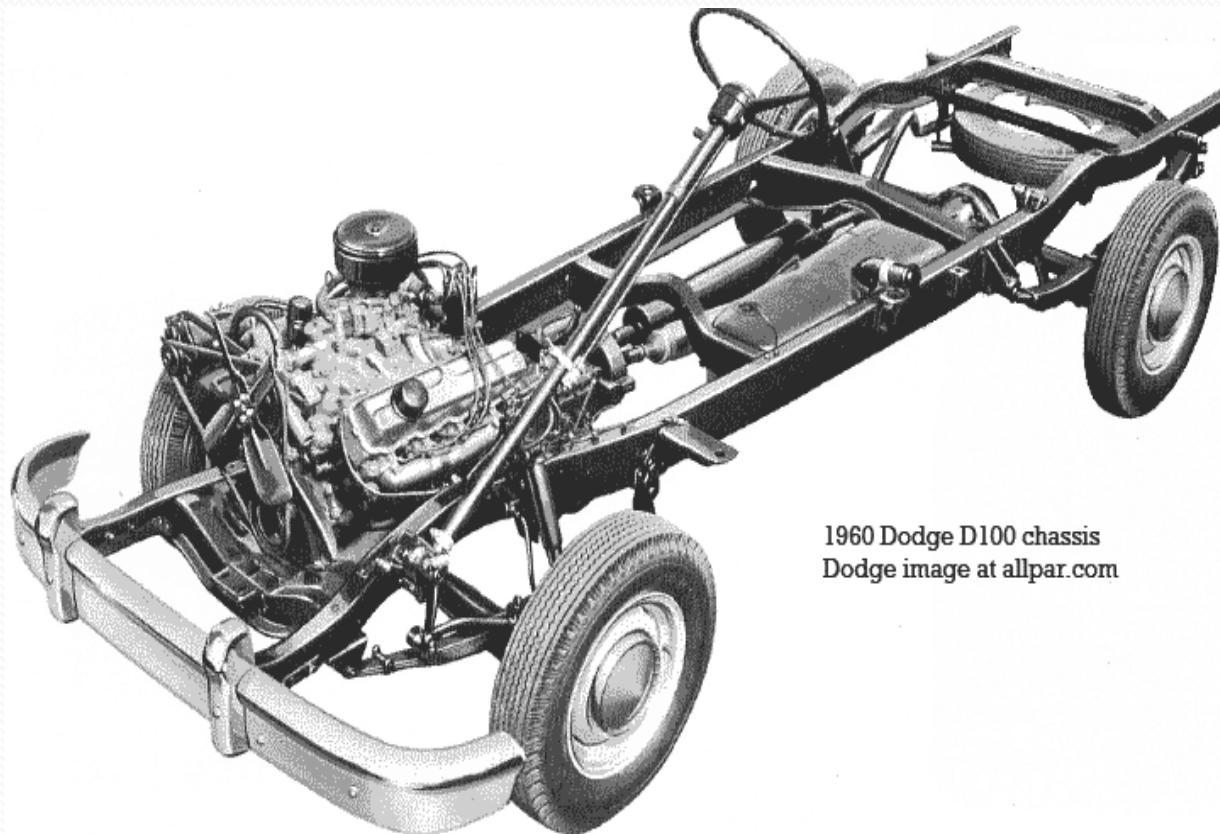
1. Conventional chassis:

- Engine is fitted in front of the driver cabin or driver seat such as in **cars**.
- Chassis portion can not be utilized for carrying passengers and goods.



2. Semi-forward chassis

- Half portion of the engine is in the driver cabin & and remaining half is outside the cabin such as in *Tata trucks*.
- In this arrangement a part of the chassis is utilized for carrying extra passengers



1960 Dodge D100 chassis
Dodge image at allpar.com

3. Full-forward chassis

- Complete engine is mounted inside the driver cabin
- Driver seat is just above the front wheel



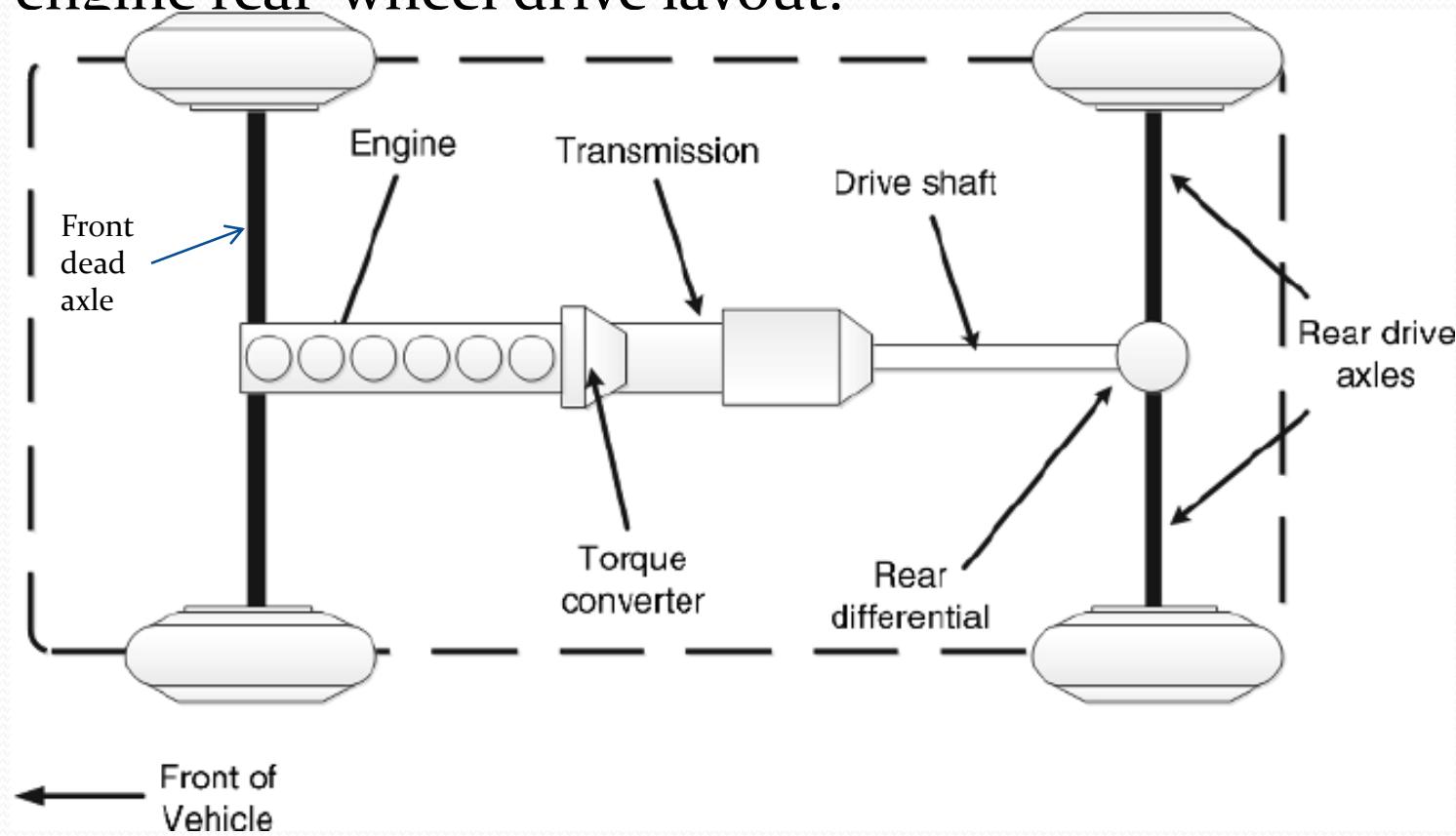
Types of Automobile Drive:

It is depends on engine mounting and its power transmission to wheels

1. Front engine rear wheel drive
2. Rear engine rear wheel drive
3. Front engine front wheel drive
4. Four wheel drive
5. Articulated vehicle layout

Layout of front engine rear wheel drive :

In this drive the engine in the front of the vehicle and the drive is transmitted to rear wheels. This configuration known as front-engine rear-wheel drive layout.



Advantages:

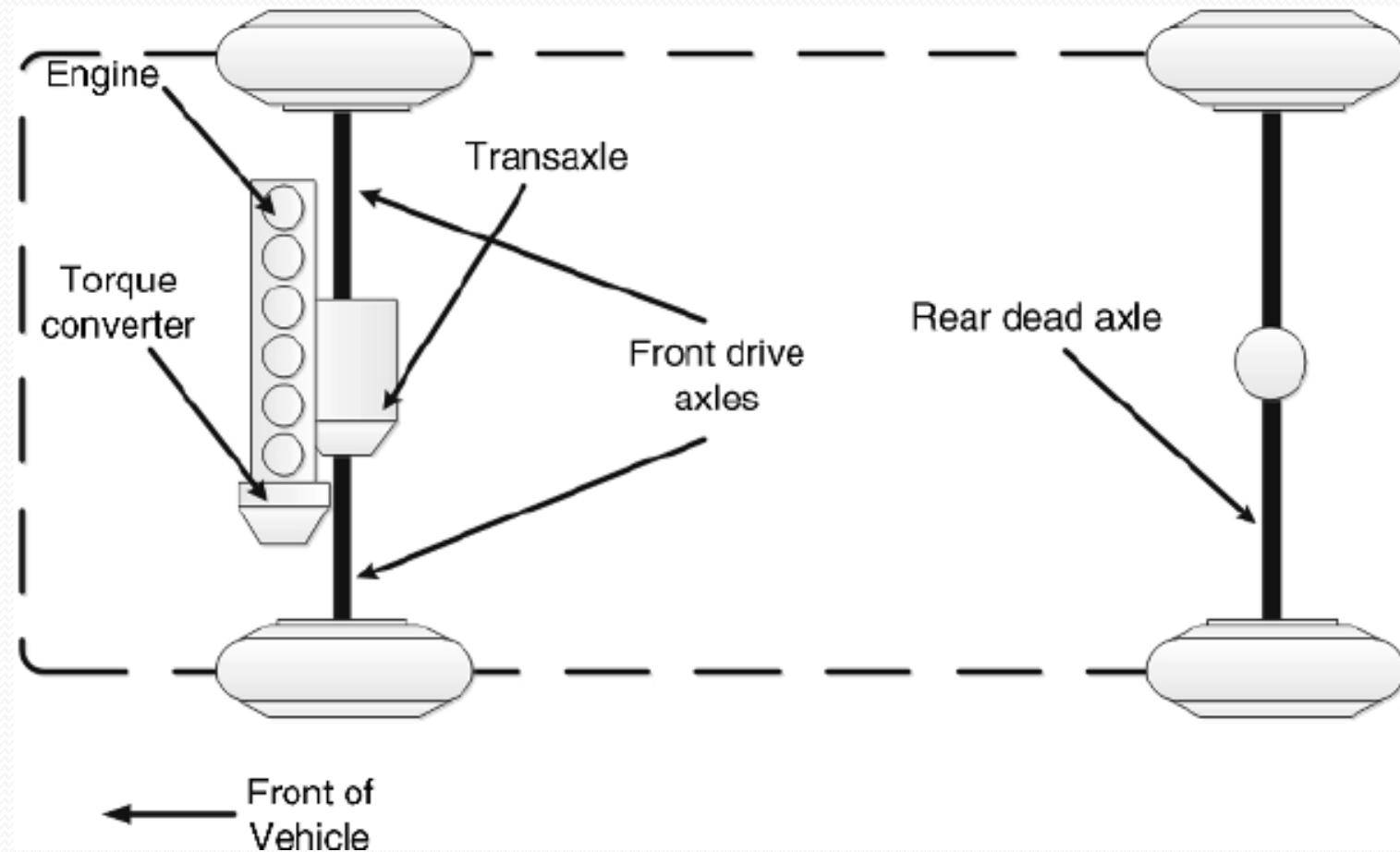
- Balanced weight distribution
- Luggage space available
- Control Linkages are short and simple
- Better engine cooling by taking full benefits of natural air stream flowing across the radiator
- Accessibility to various engine component is easier

Disadvantages

- It requires long propeller shaft to transmit the power to differential at rear
- Increased weight
- Decrease interior space
- Higher noise transmitted from front engine to driver cabin

Layout of front engine front wheel drive :

This layout is the most compact layout. It is being popularly used on most cars in India.



Advantages:

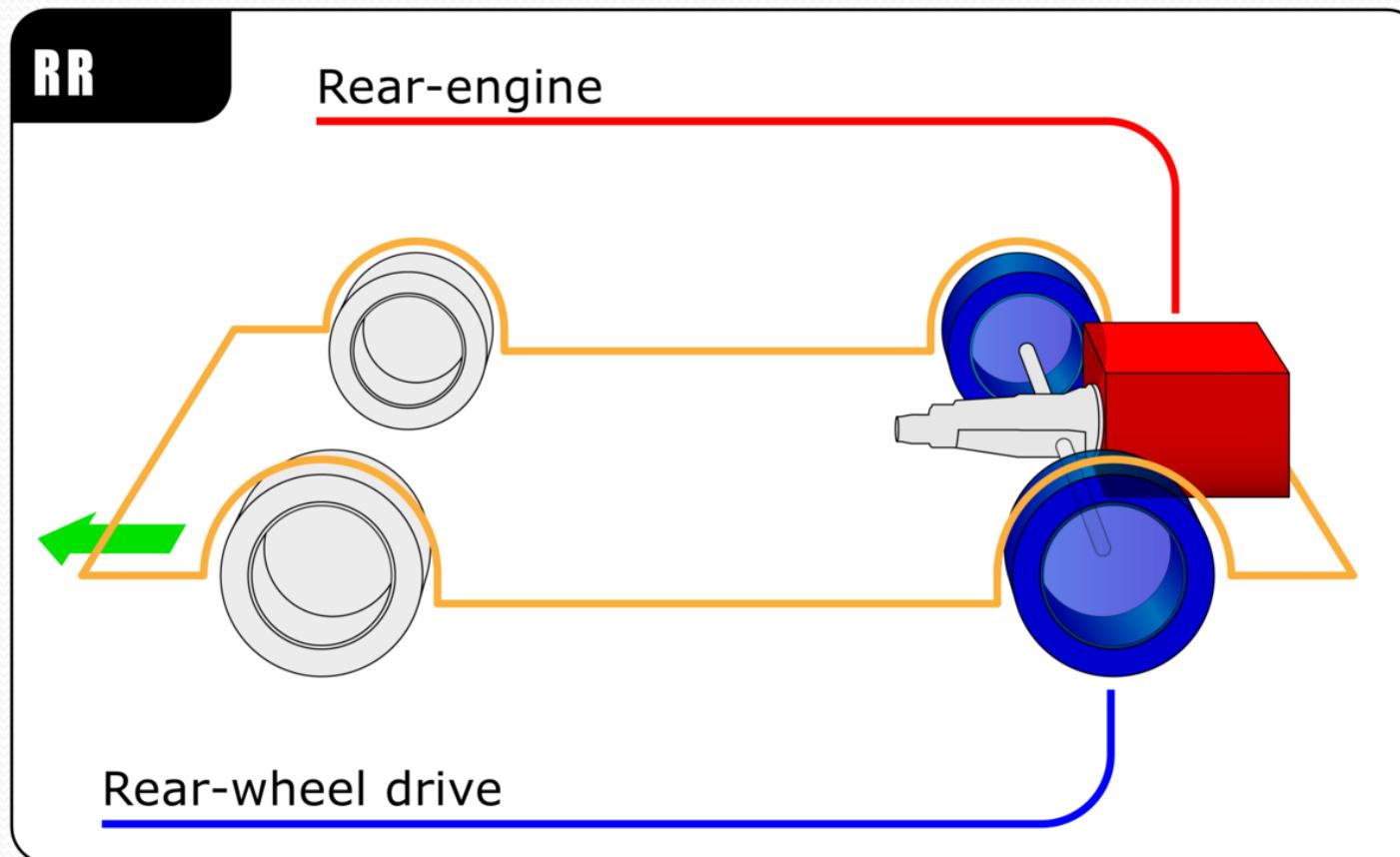
- Compact design of vehicles. Maximum passenger space
- Less weight
- No propeller shaft is required
- Due to higher Weight of the steering wheels , it provides stable steering during turns .
- Better engine cooling by taking full benefits of natural air stream flowing across the radiator

Disadvantages:

- More tractive effort required(Front wheel design is complicated)
- Complicated Design
- Less radius of turning
- High noise transmission from engine compartment to cabin
- Poor ability of the vehicle to climb a steep hill because of lower weight on rear wheel

Layout of rear engine rear wheel drive :

This layout consists of placing the engine, clutch and gearbox in the back. So taking the space of the boot. In these type of layout more than 50% of the weight is on the rear axle. The necessity of the propeller shaft is completely eliminated. The clutch, gear box and engine and final drive form a single unit.



Advantages :

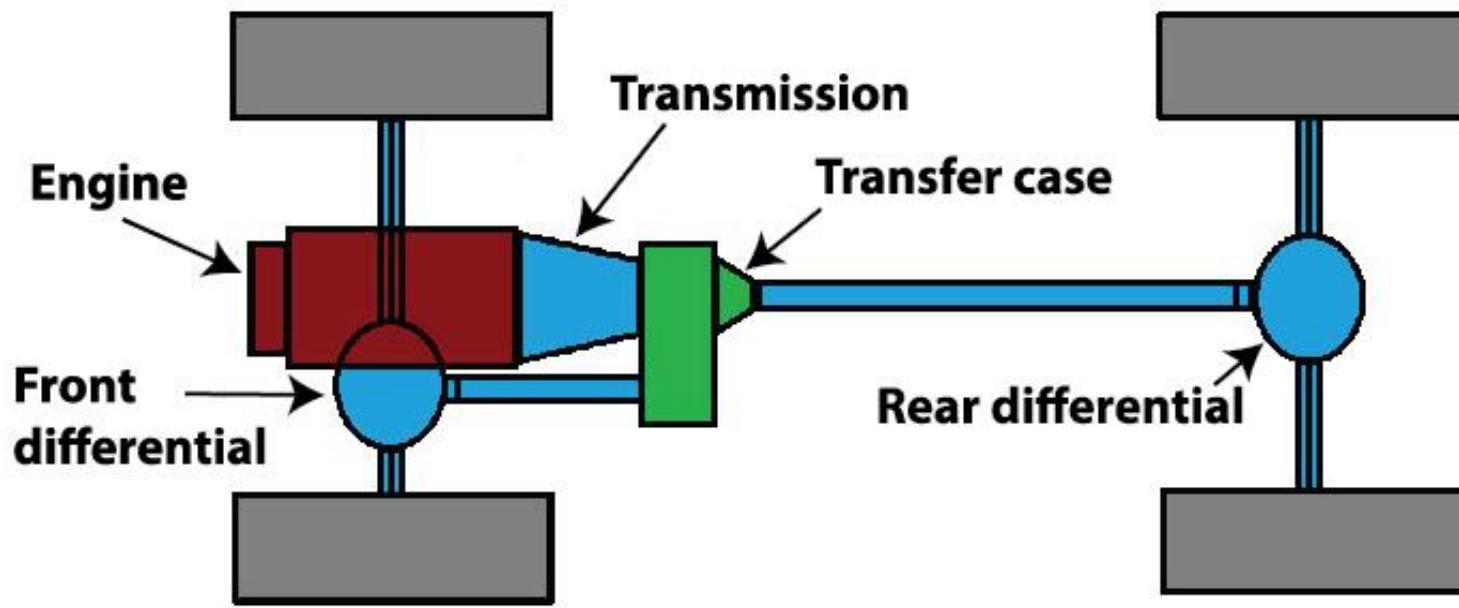
1. Excellent traction is available while climbing hills.
2. A larger passenger space is available for the given length of body.
3. Very compact and accessible power and transmission assembly is provided.
4. Passengers are comfortable from engine noise, heat and fumes.
5. Front of the vehicle provides good visibility and by designing the body to aerodynamic shape gives good streaming lining.

Disadvantages :

1. Long linkages are required
2. No natural air cooling requires powerful radiator fan
3. Uneven weight distribution
4. Becz. of higher wt distribution at rear the vehicle has tendency to oversteer

Layout of four wheel drive :

These four wheel drive vehicles are very useful on Hill station if one of the wheel slipping or skidding then the other axle wheel transmit the tractive force to the vehicle. The steering of the four wheel drive is hard to operate compared with other type of drive.



Advantages :

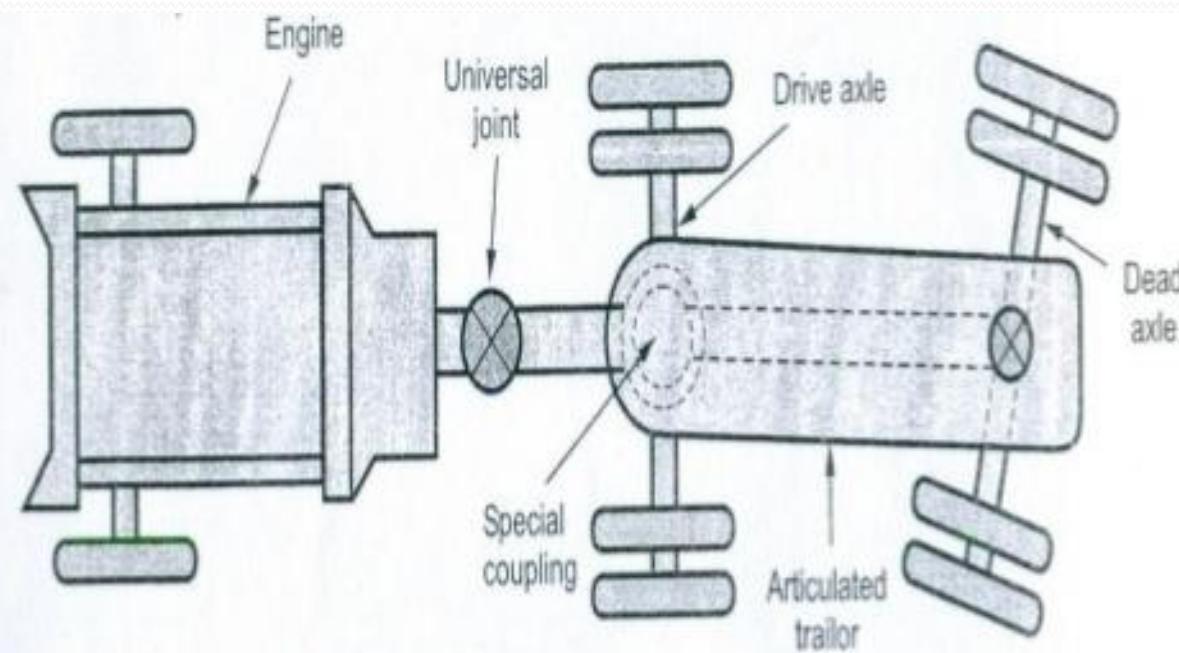
1. Traction is nearly doubled compared to a two-wheel drive layout.
2. Excellent road Handling characteristics
3. Gives sufficient power in unparalleled acceleration and drivability on surfaces with less than ideal and superior engine braking on loose surfaces.

Disadvantages :

1. The manufacturing cost of the vehicle is high.
2. More component and complicate transmission.
3. Increased power-train mass, rotational inertia and power transmission losses.
4. Increased fuel consumption compared to 2WD.

Articulated vehicle Layout :

This layout is used for very high load carrying vehicle like truck, tractor. It consist very powerful engine at front. The tractor part of vehicle can be a four wheel or six wheeled and consist of a drive axle.



Advantages :

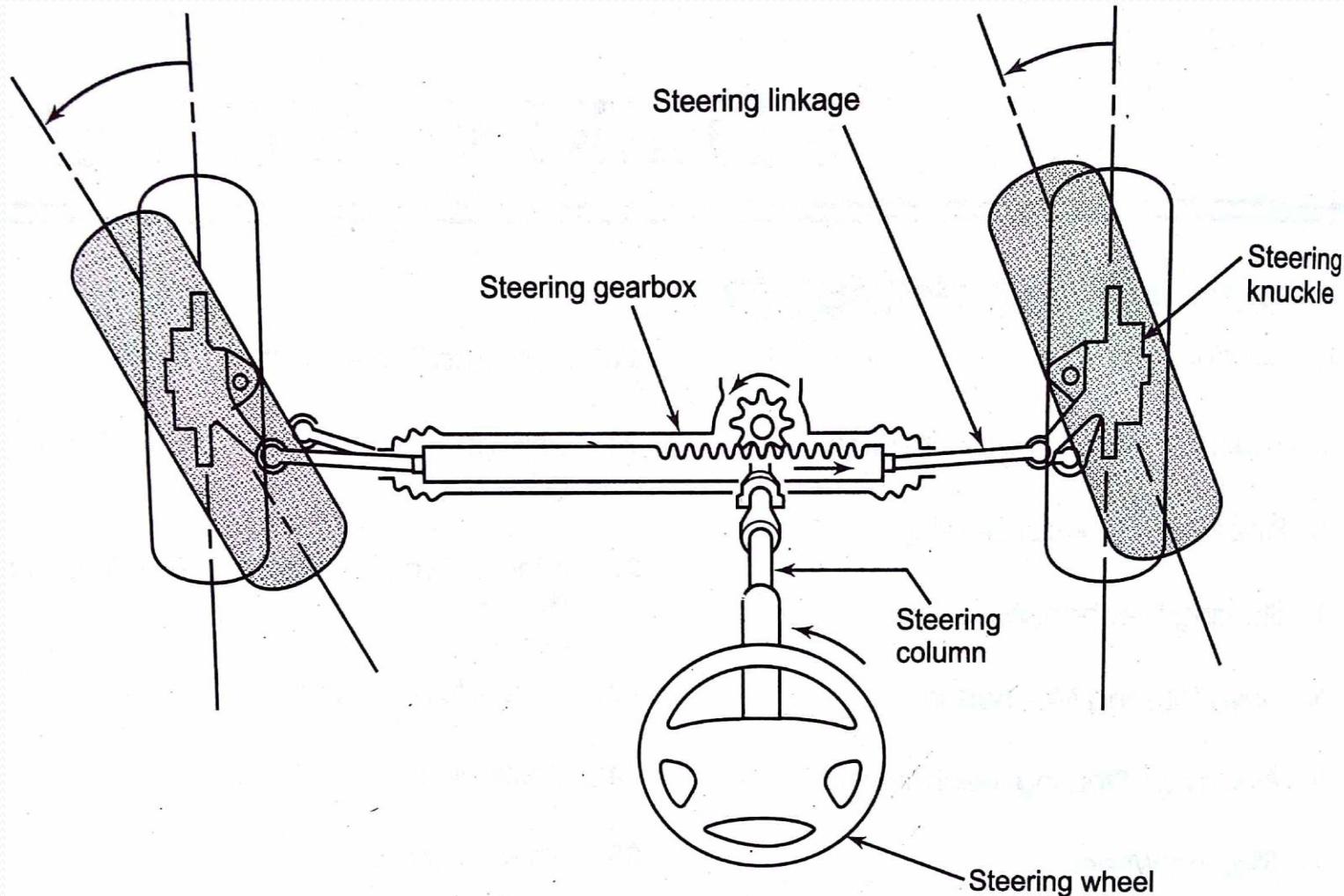
1. It provides large luggage / load carrying capacity.
2. Tractor compartment can be easily disengaged & connected to another preloaded trailer, hence reduced loading & unloading time

Disadvantages :

1. Difficult to drive on sharp turn.
2. Heavy vehicle weight is uneconomical for fuel efficiency
3. High cost

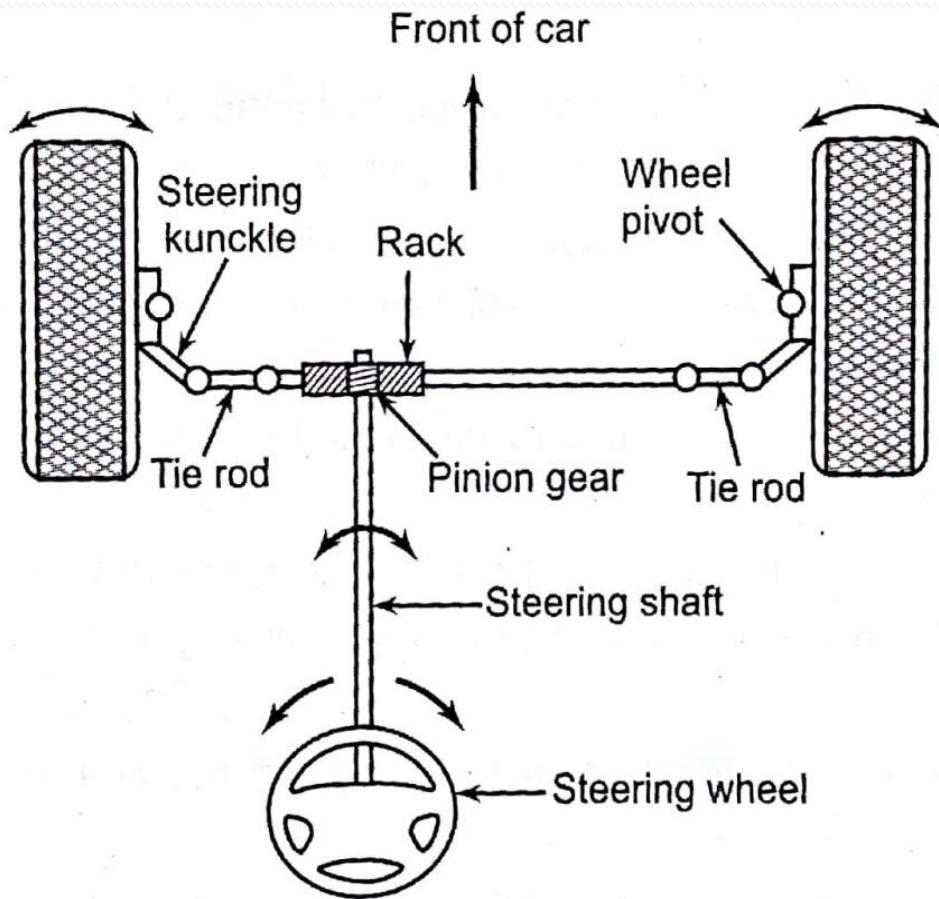
Steering System :

Steering mechanism is used in the automobile for changing the directions wheels with respect to chassis. So as to move vehicle in desired path.



Steering System :

The steering mechanism includes a steering wheel, which the driver controls, a steering gear, which converts rotary motion of steering wheel in to straight line motion and steering linkages. In modern cars, the manually operated steering system is assisted by



power and is called power steering.

The electric power drawn from the battery or hydraulic power is used.

Function Steering System :

To Achieve angular motion of front wheel to navigate turn

To provide directional stability while moving ahead

To minimize wear & tear of tyres

To provide perfect rolling motion of the road wheel all times

To facilitate straight ahead recovery after completing turn

Steering Mechanism :

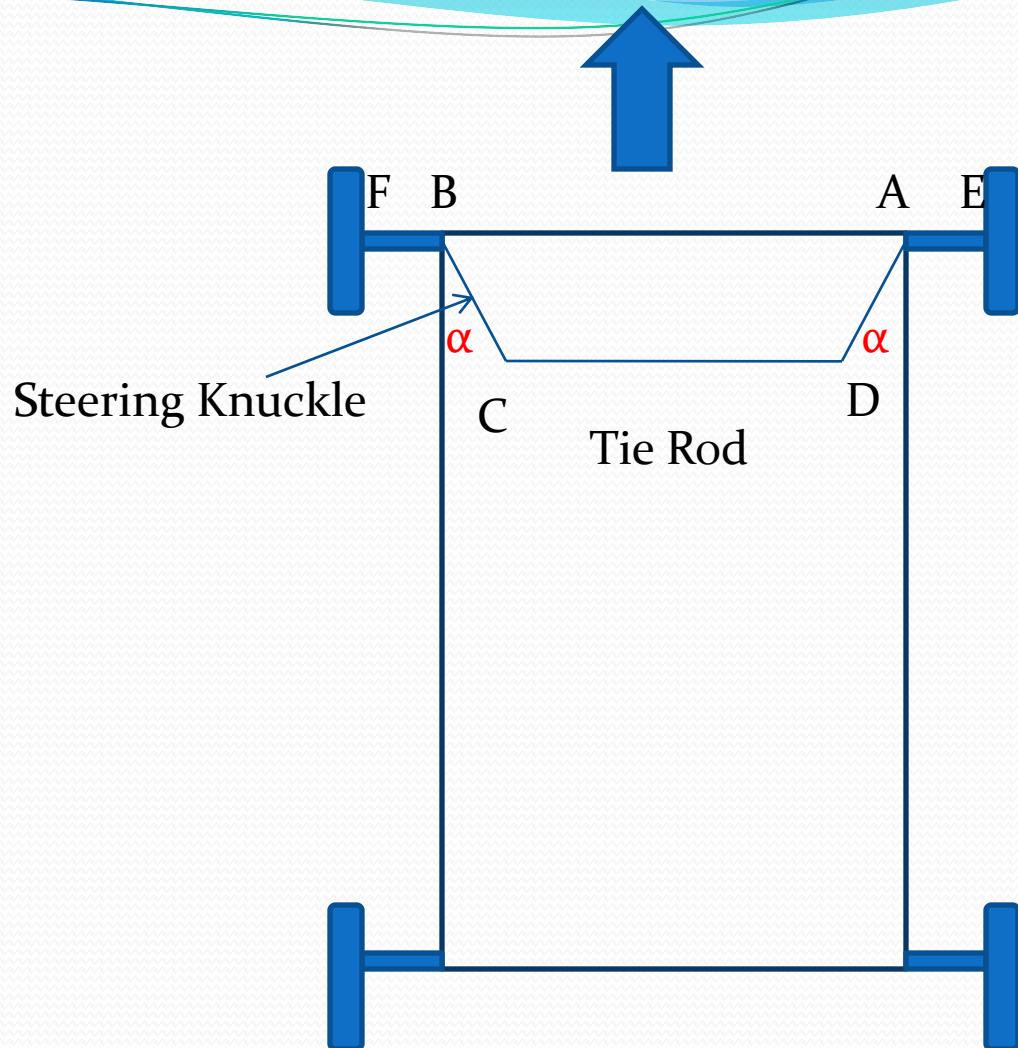
For perfect steering, it must always have an instantaneous center about which all the wheels must rotate. To achieve this the inner wheel has to turn more than the outer wheel.

Two types of mechanism are available,

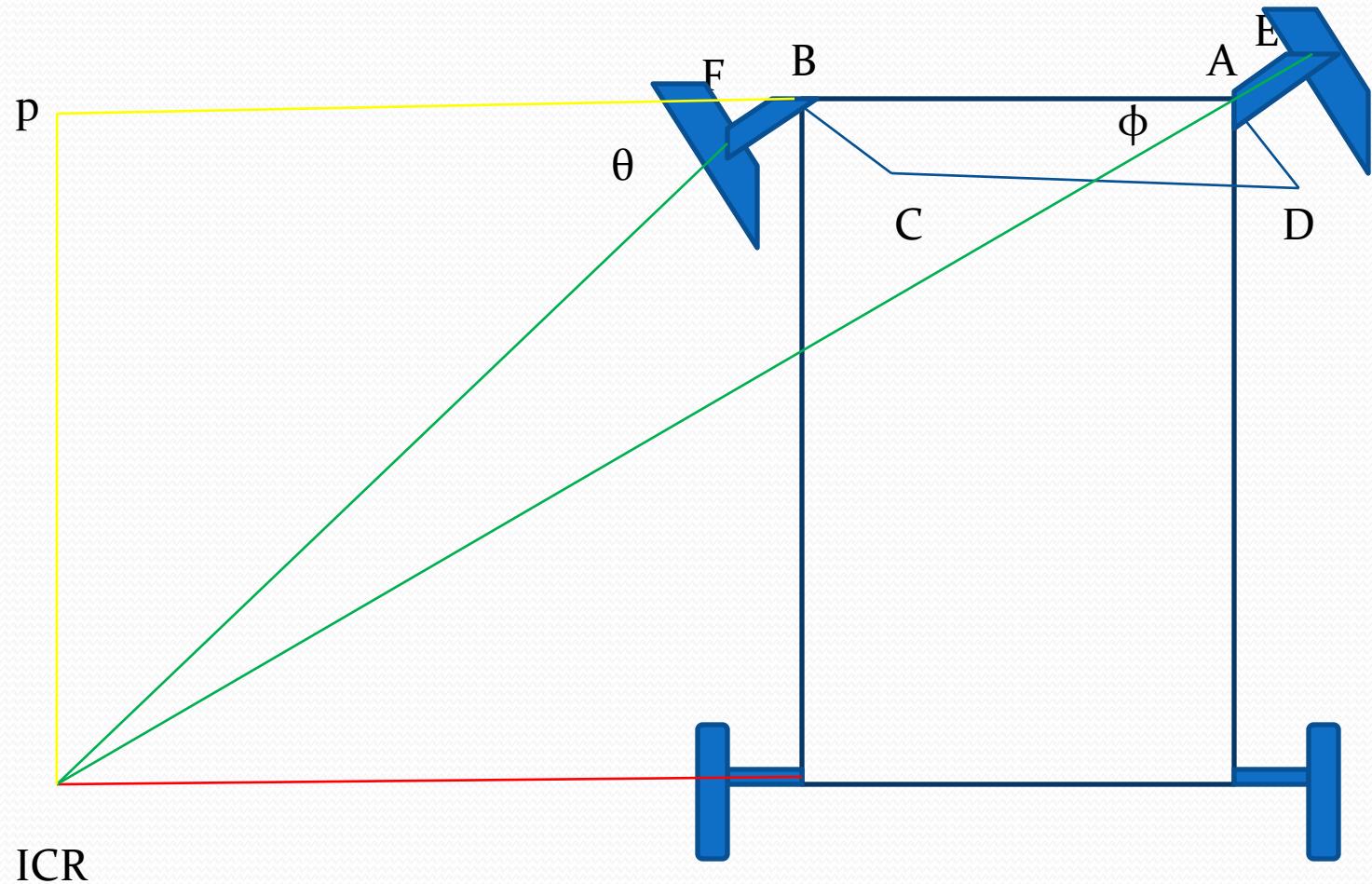
- Davis steering mechanism
- Ackerman steering mechanism

steering mechanism. Out of these Ackermann type is more popularly used because of its simplicity. It also lessens wear of tyre and lowers friction.

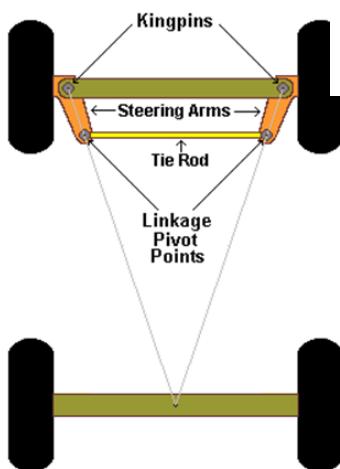
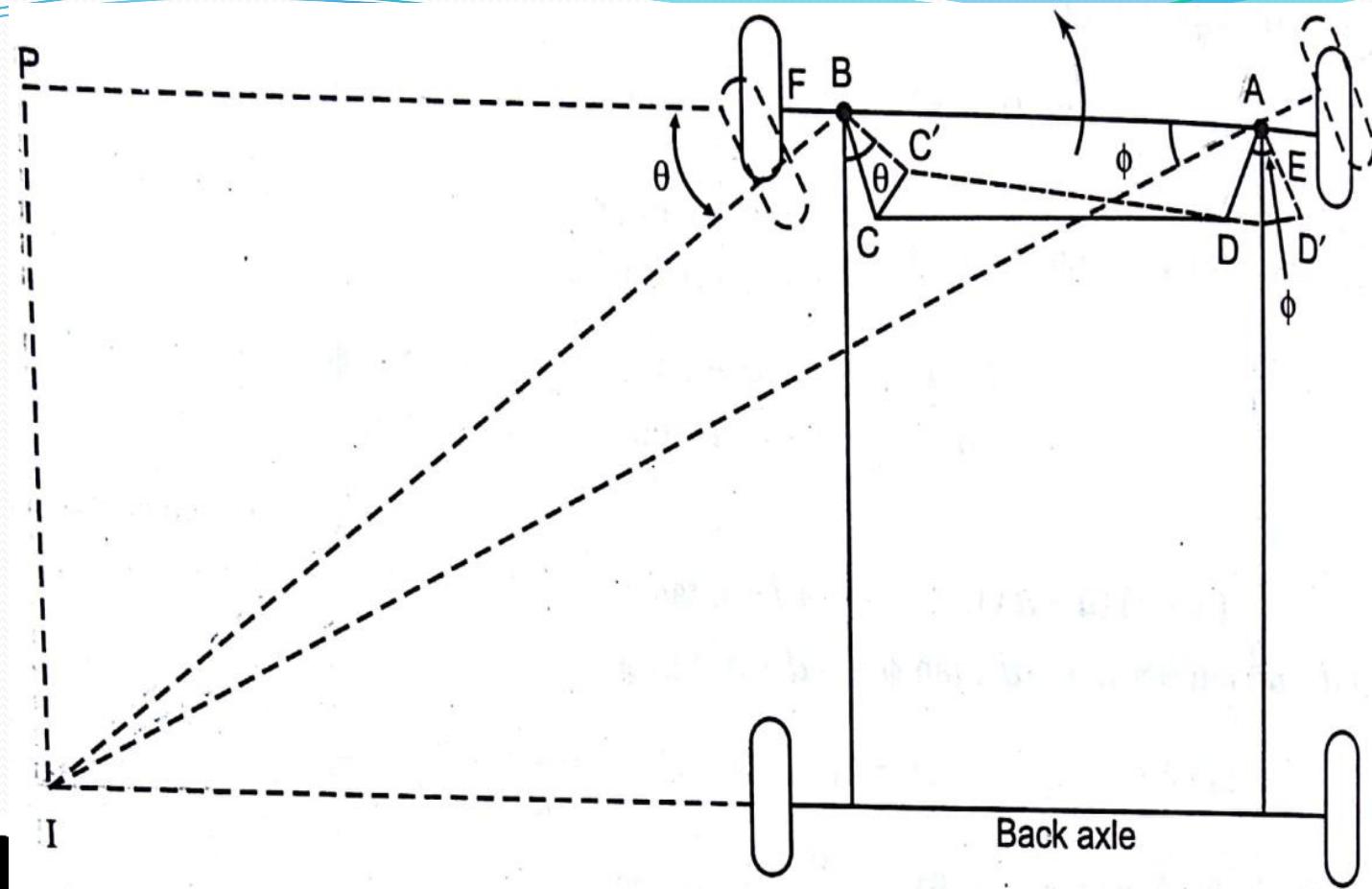
Ackerman Steering Mechanism :



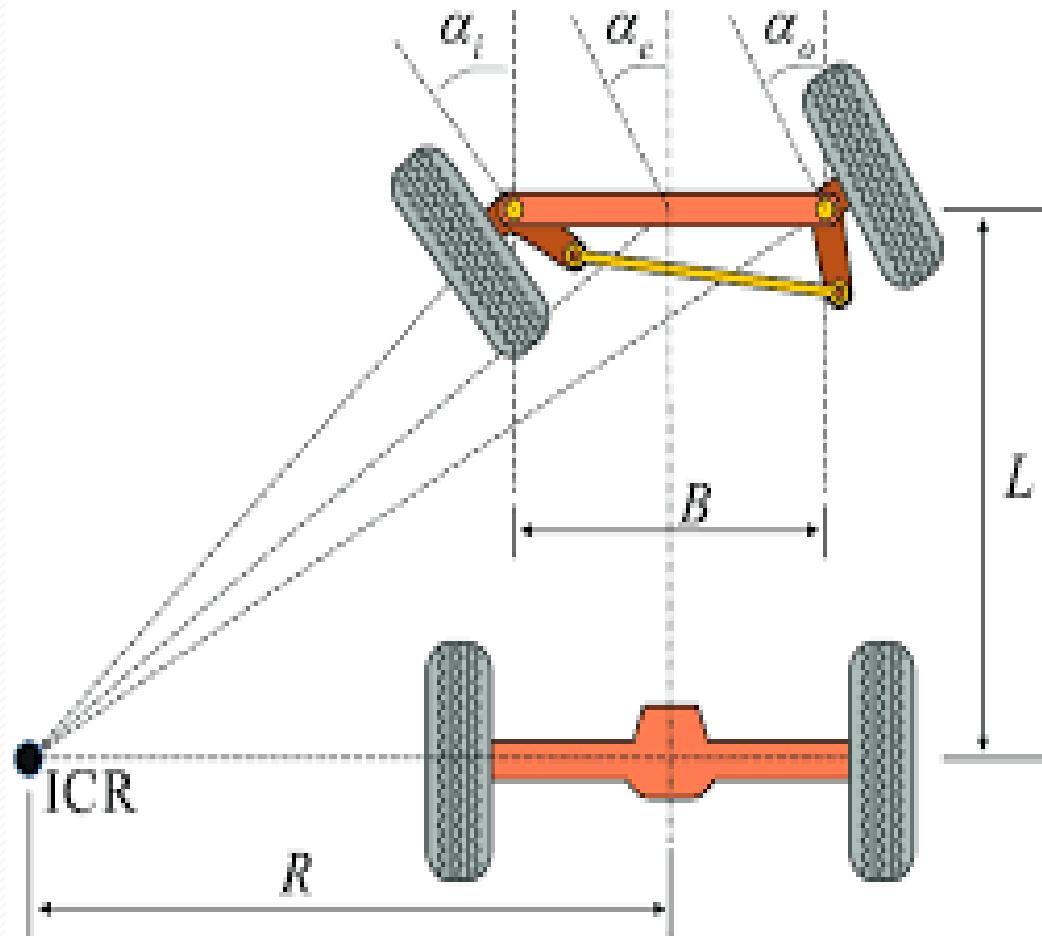
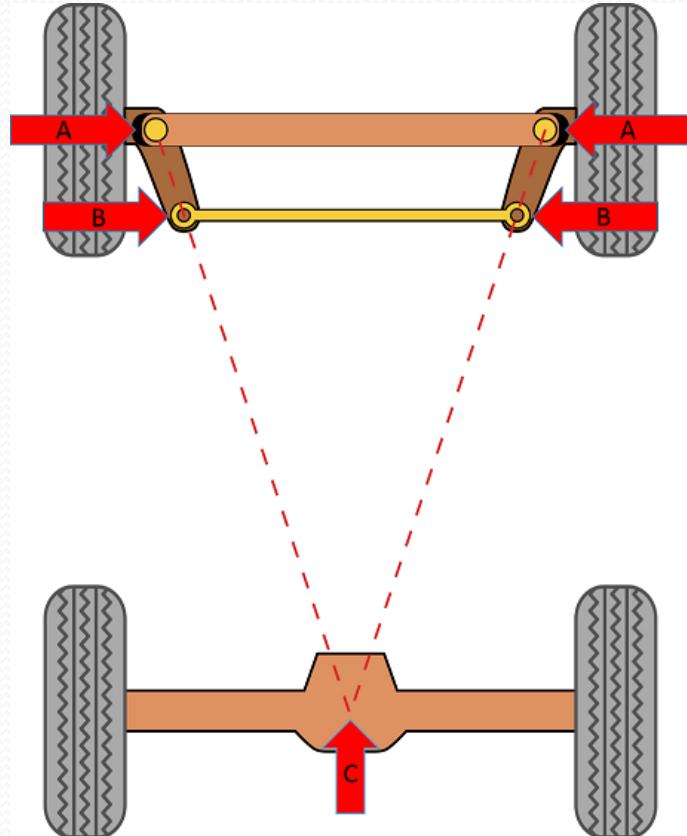
Ackerman Steering Mechanism :



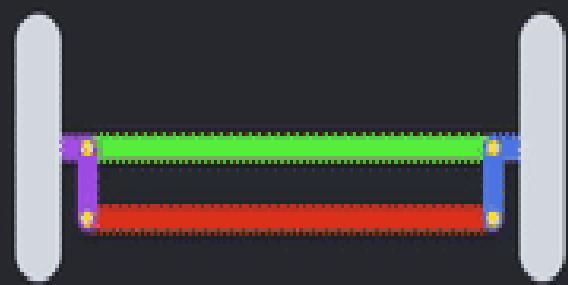
Ackerman Steering Mechanism :



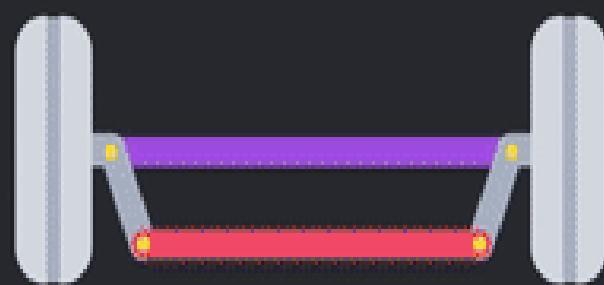
Ackerman Steering Mechanism :



ACKERMANN STEERING

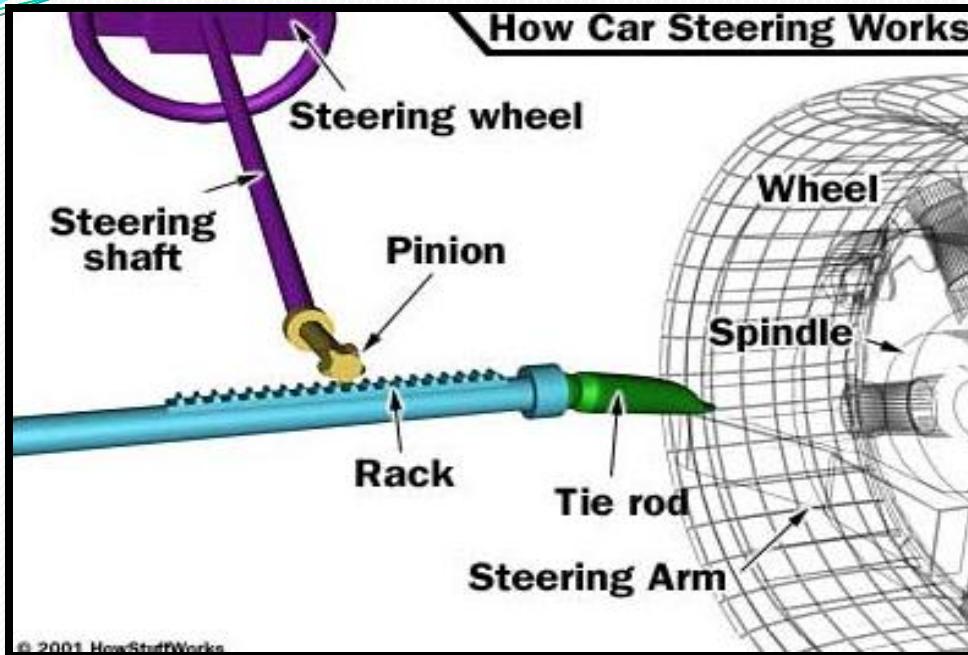


4-BAR STEERING

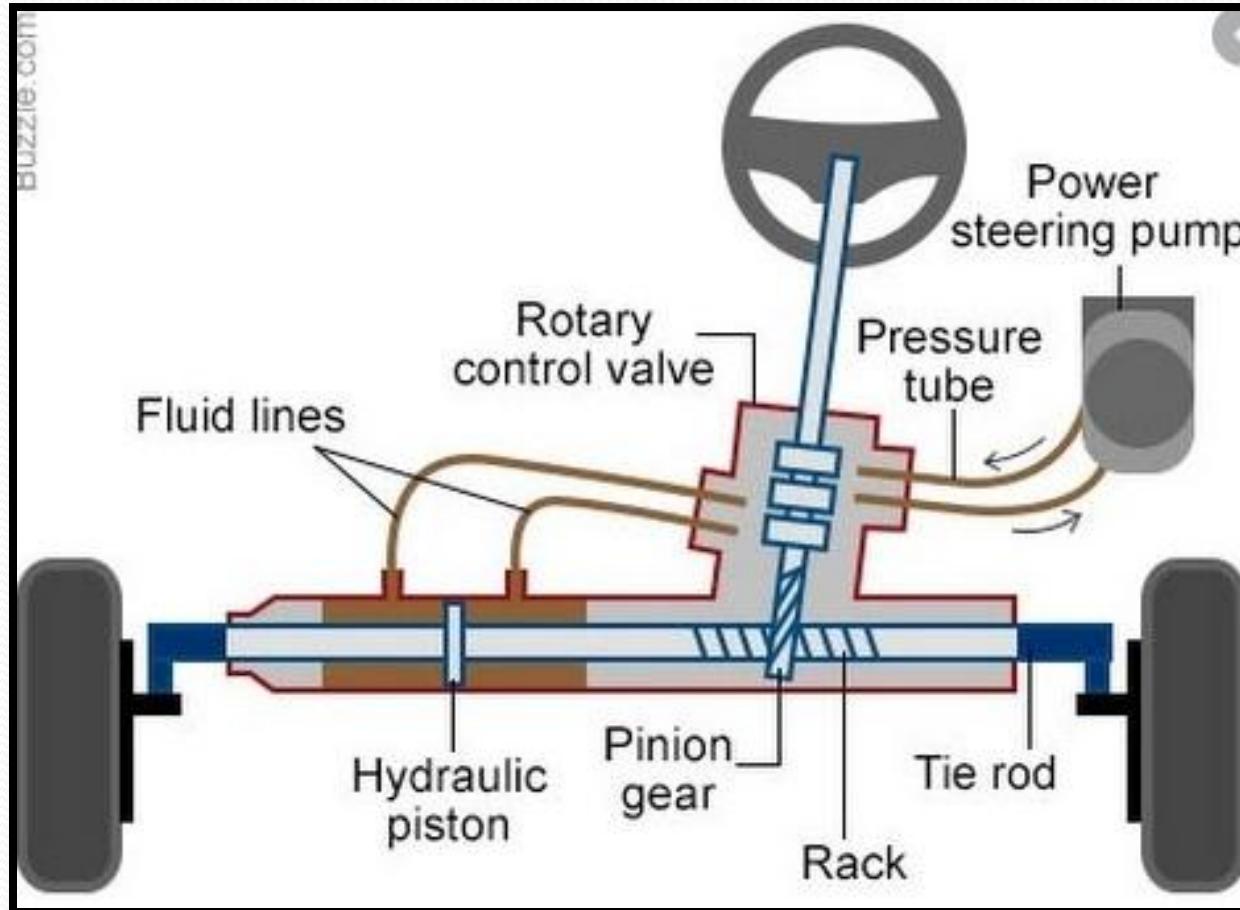


ACKERMANN STEERING

Rack and Pinion Steering Gear :



1. Power Assisted Steering :



Suspension System :

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. The suspension system serves a dual purpose, contributing to the vehicle's road holding or handling and braking for safety and driving comfort, and keeping the vehicle occupants comfortable and reasonably well isolated from road noise, bumps and vibrations, etc. A suspension system provides stability to the vehicles in dynamic conditions like high speed, sharp turns and braking.

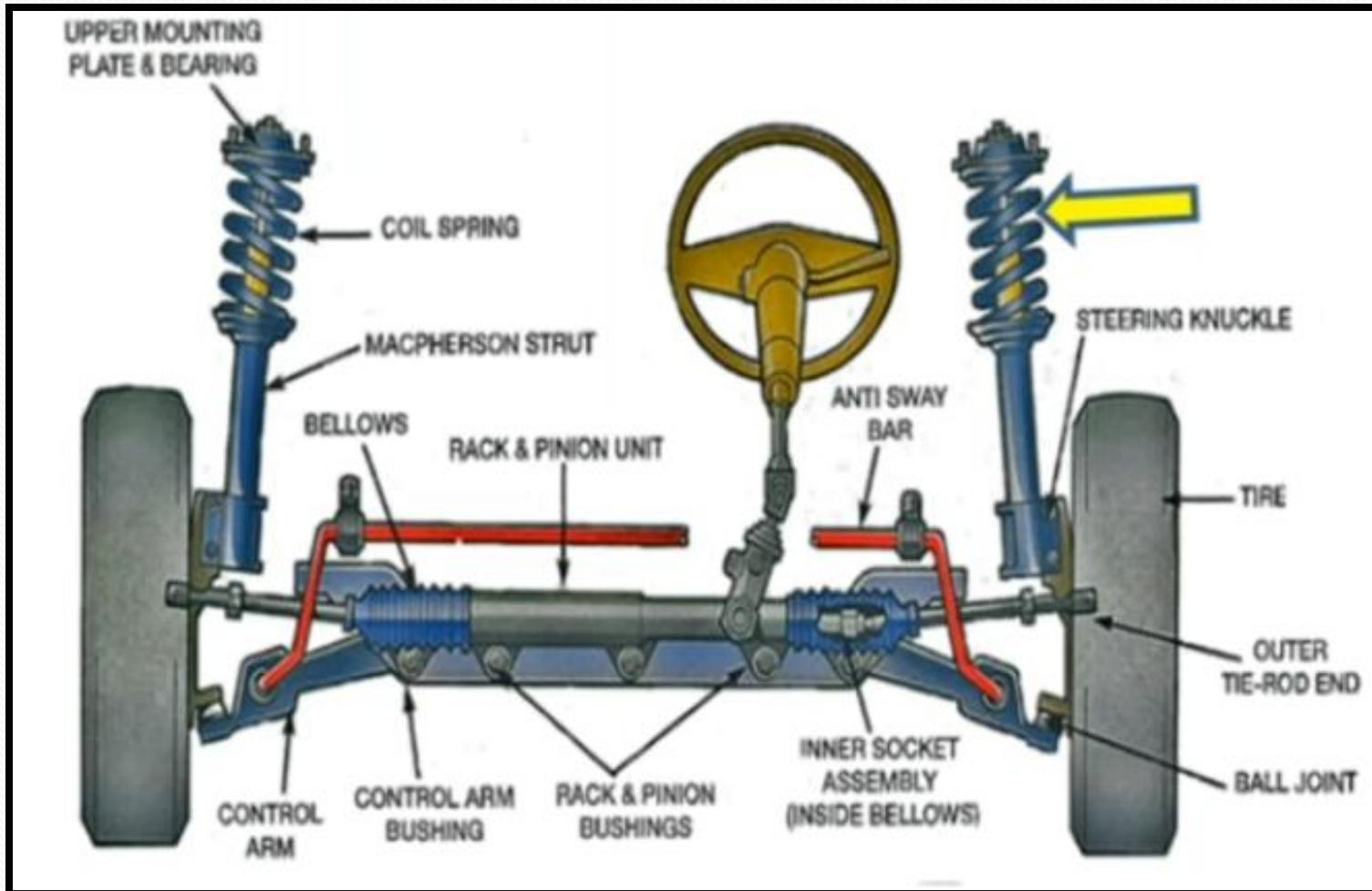


Functions of suspension system :

The main functions of a suspension system are as follows:

- To safeguard the occupants against road shocks and provide riding comfort.
- To minimize the effects of stresses due to road shocks on the mechanism of the motor vehicle and provide a cushioning effect.
- To keep the body perfectly in level while travelling over rough uneven ground, i.e., the up and down movement of the wheels should be relative to the body.
- To isolate the structure of the vehicle from shock loading and vibration due to irregularities of the road surface without impairing its stability.
- To provide the requisite height to the body structure as well as to bear the torque and braking reactions.

Basic Components of Suspension System :



1. Knuckle

A knuckle is provided with a king pin and caster angles that helps the front wheels of the vehicle to steer in right or left direction which in turns steers the vehicle.



2. Springs

Springs are the critical component in the suspension system that absorb the shocks and bumps while the car is in motion.



3. Shock absorber

These are generally fluid filled and work in tandem with the spring to minimize the shocks or vibrations.



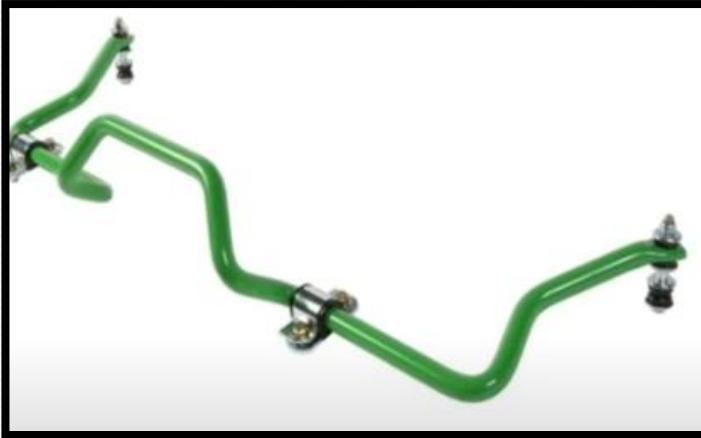
4. Strut

It joins the spring and shocks. It also provide dampening function as well as structural support for the vehicle suspension.



5. Anti Sway Bars

The anti sway bars are used for providing further stability to the moving vehicle.



6. Spindle

This part ties the wheel and tyre into the steering system



Various Components of Suspension System:

The components of a suspension system can be categorized as follows

1. Mechanical Suspension :

- Leaf springs
- Coil springs
- Rubber springs
- Torsion bars

2. Hydraulic Suspension :

- Hydraulic shock absorber
- Telescopic fork absorber

3. Air Suspension :

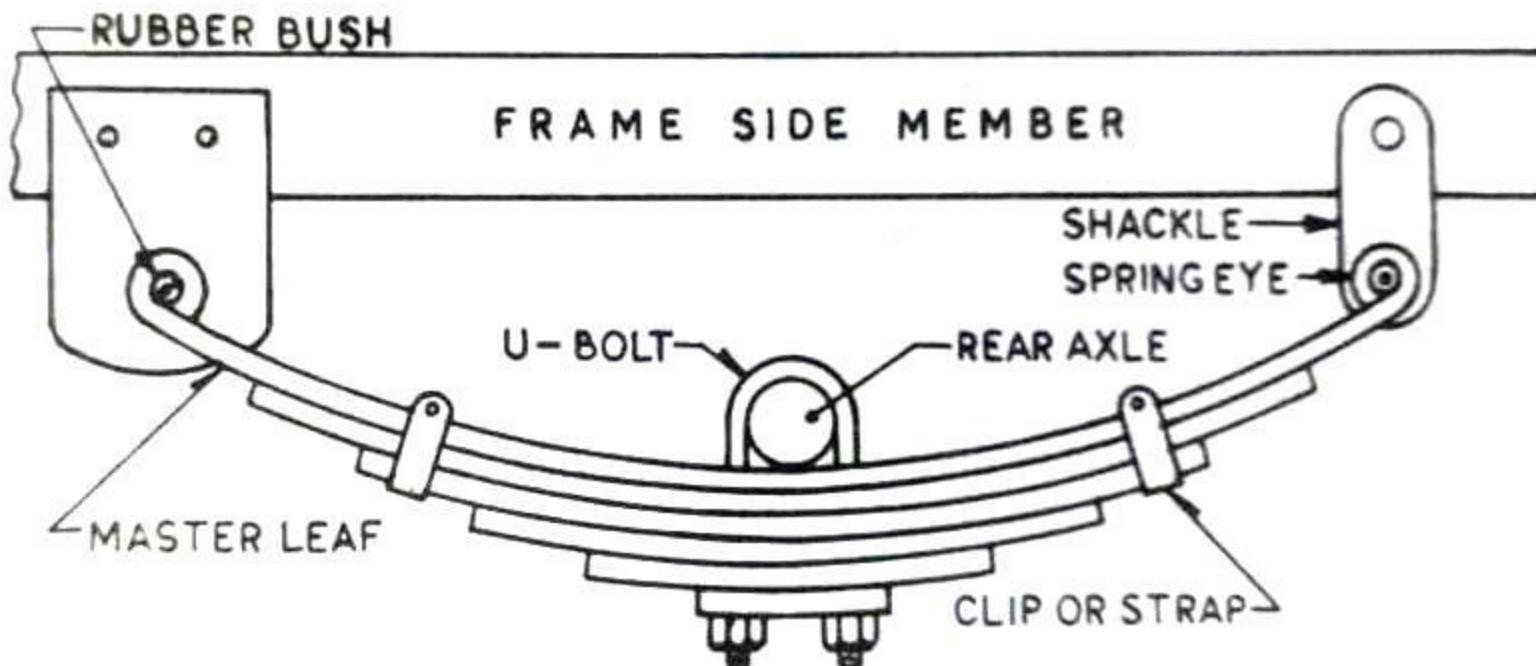
Compressed air is used in an air suspension system.

1. Mechanical Suspension :

Leaf Spring: A leaf spring is a component of a vehicles' suspension system.

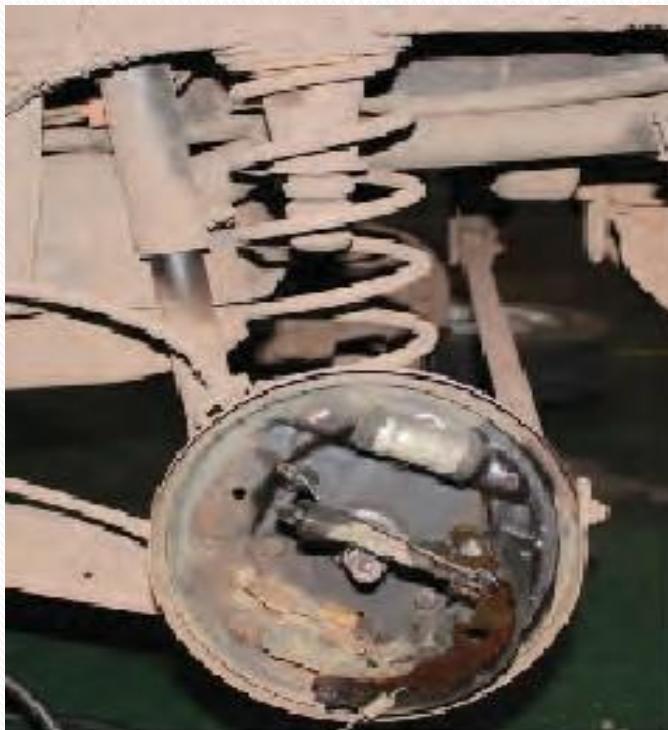
Leaf springs are curved and the curvature helps the spring absorb impact.

The springs are supported on the axle by means of U-Bolt. One end is bolted on the frame with simple pin with rubber or bronze bushes. Other end is connected to frame with shackle. This will give flexible connection as the length of the spring changes with road projections.



Coil Spring:

Coil springs are commonly called compression springs, torsion springs or helical springs. They store energy and release it to absorb shock or maintain a force between two contacting surfaces. Mostly coil springs or helical springs are used .



Telescopic Suspension System:

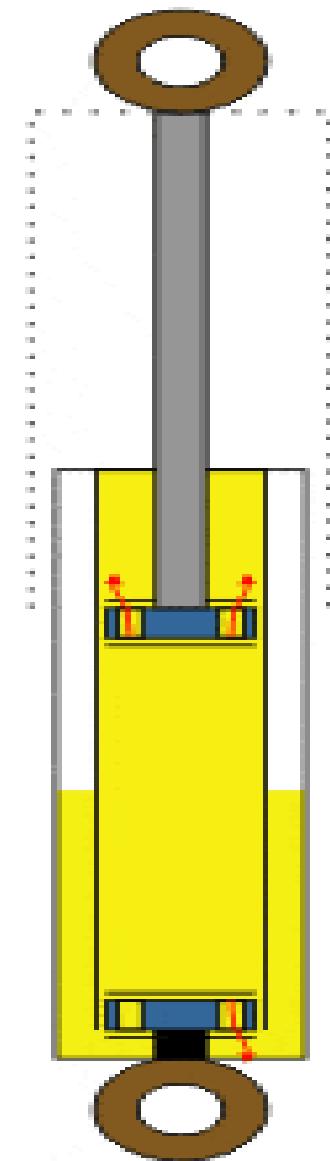
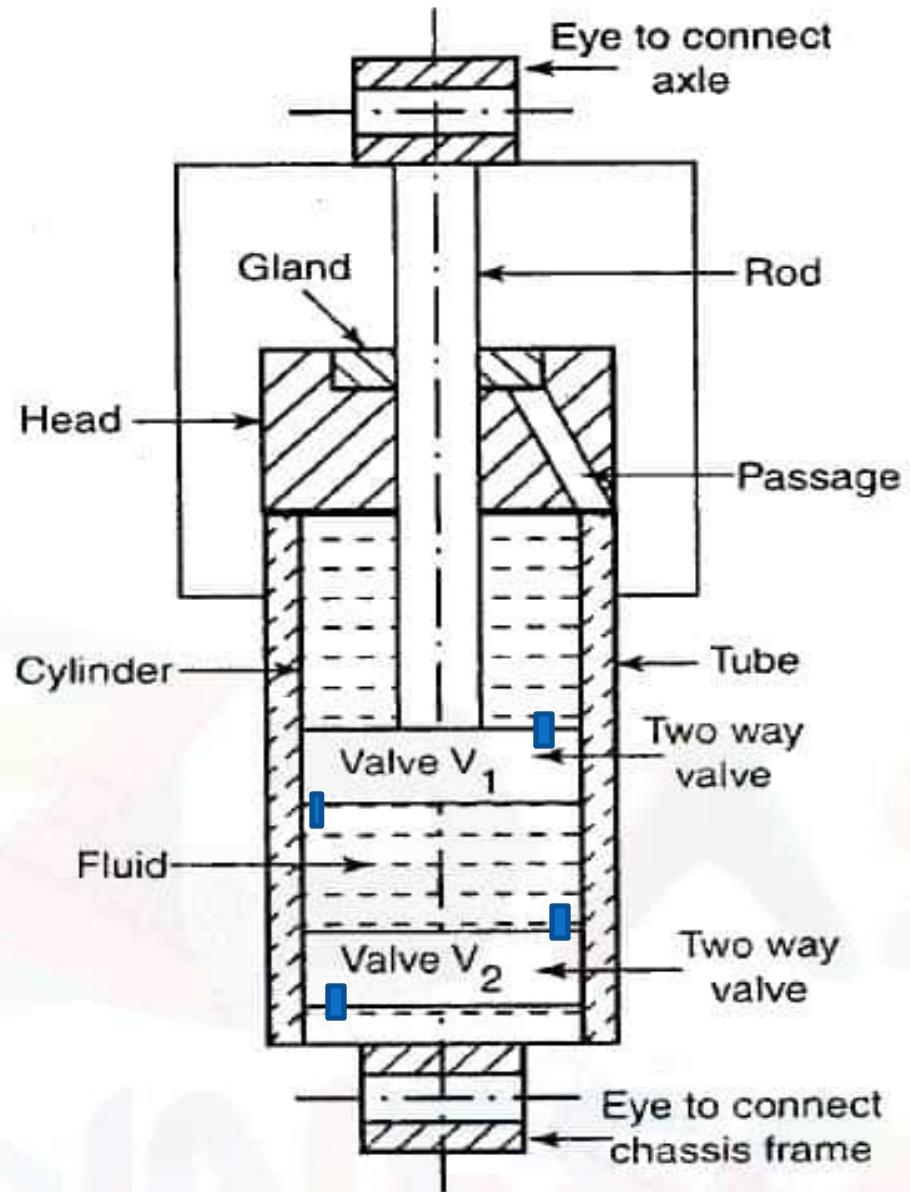


Figure 4.55 Telescopic shock absorber

Hydraulic Suspension:

1. Hydraulic Shock Absorber:

It is a mechanical device designed to absorb shock impulses. This device is also used for checking or damping out the suspension spring to a comfort level.

2. Telescopic Fork Absorber:

A telescopic fork is a form of motorcycle front suspension whose use is so common that it is virtually universal. The telescopic fork uses fork tubes and sliders which contain springs and dampers

Air Suspension:

In this suspension, compressed air is used as a spring. This suspension system is operated with air and controlled by a microprocessor. It helps in maintaining self-driving conditions and supports the weight of the vehicle

Breaking System :

- The brake is used to slow-down or stops the motion of the moving member whenever required. In other words brakes are one of the very important control components of vehicle.
- The main function of brake is to stop the vehicle within the smallest possible distance. This is done by converting the kinetic energy of the vehicle into heat energy & this heat dissipated in environment. In braking action, the kinetic energy is converted into heat by friction and the generated heat is ultimately dissipated to the atmosphere.

Types of Braking system in Automobile:

1. On the basis of mode of actuation:

- Foot brake
- Handbrake – it is also called parking brake operated by hand

2. On the basis of mode of operation

- Air brakes
- Electric brakes
- Hydraulic brakes
- Mechanical brakes
- Vacuum brakes

3. On the Basis of Action on Front or Rear Wheels

- Front-wheel brakes
- Rear-wheel brakes

4. On the Basis of Method of Application of Braking Contact

- Externally – contracting brakes
- Internally – expanding brakes

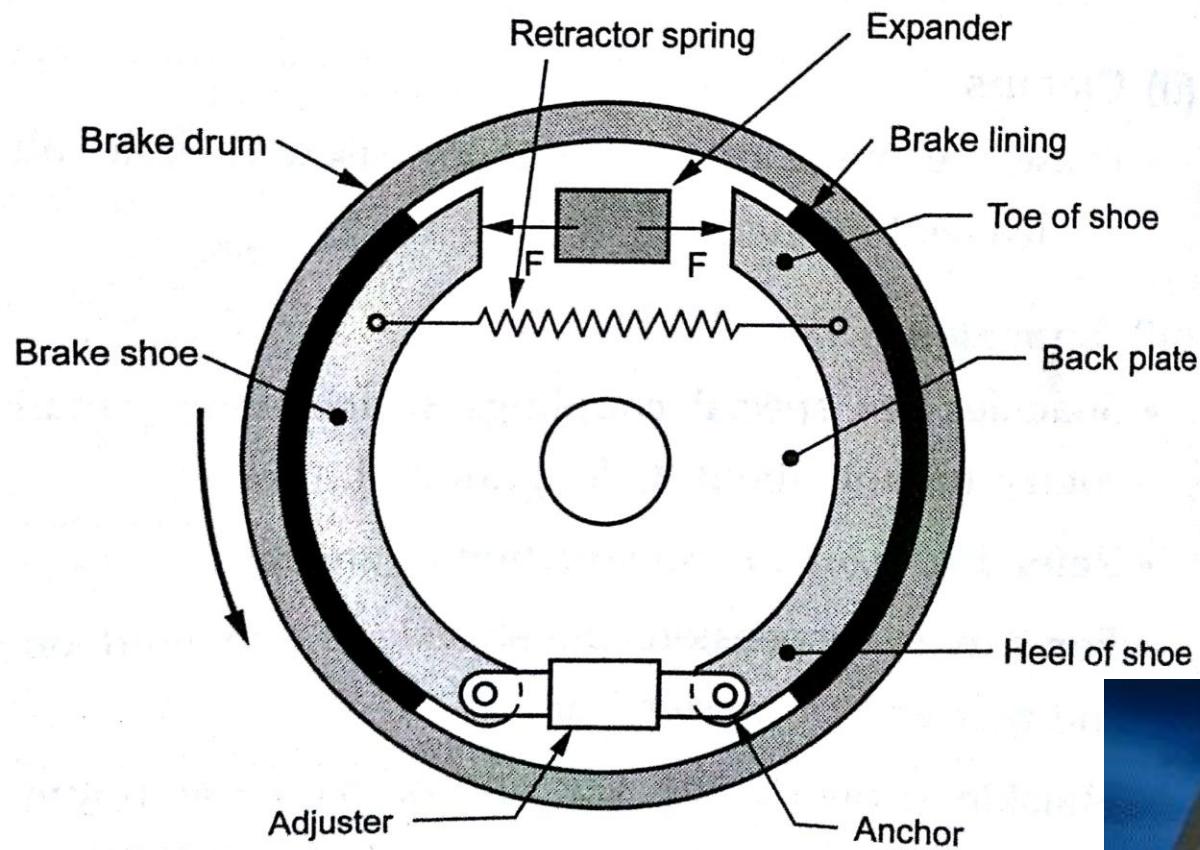
5. By construction –

- Drum type brake,
- Disc type brake

Drum Break :

Drum breaks are the cheapest and most widely used brakes. It consists of a rotating brake drum mounted on the wheel and two semi-circular brake shoes attached in a stationary back plate. The pressing of brake shoes on the rotating drum causes friction resulting in breaking

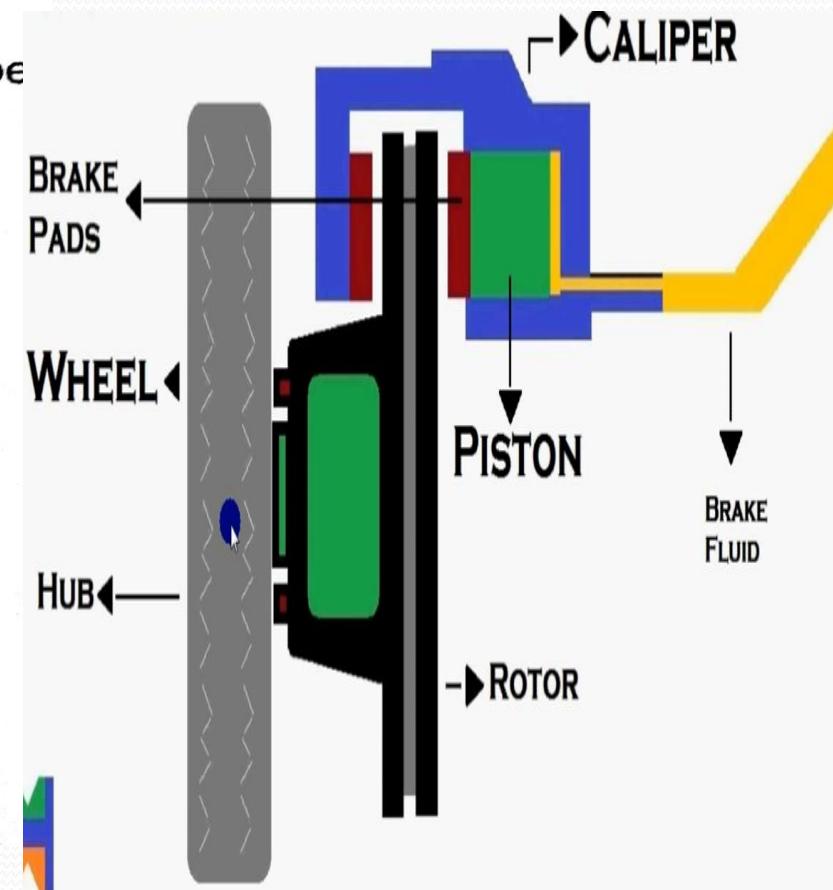
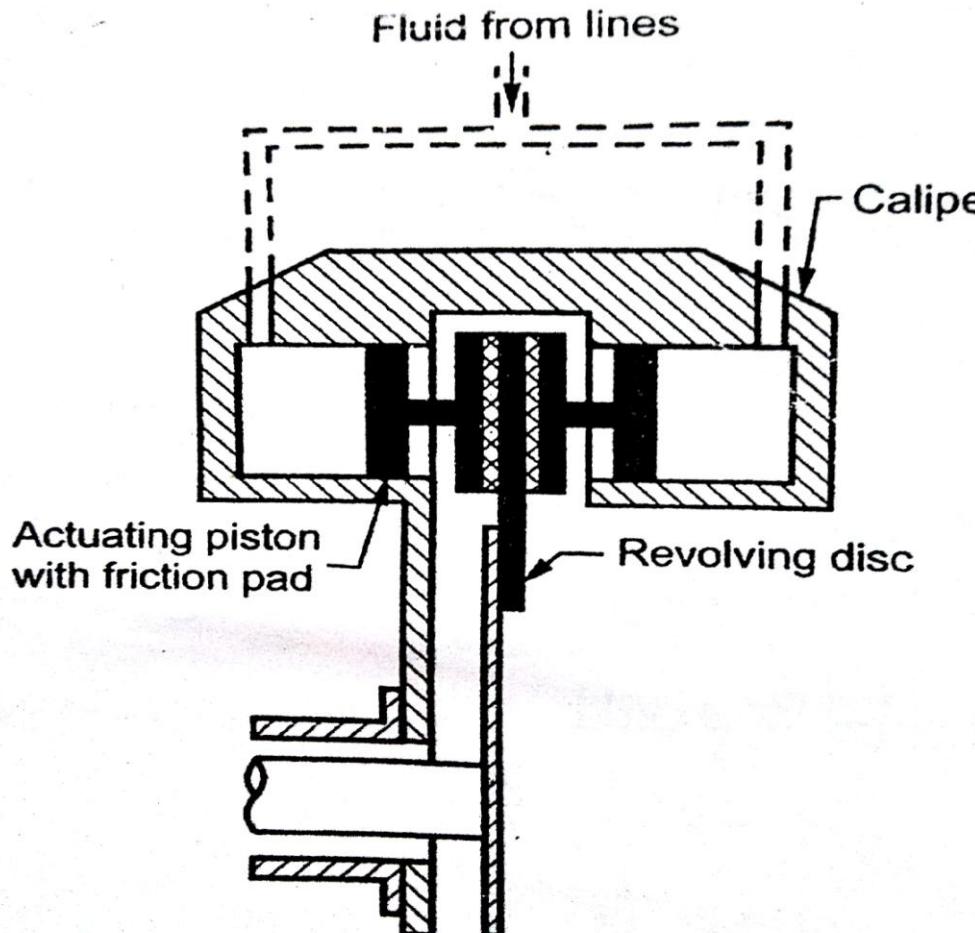
Drum Break :

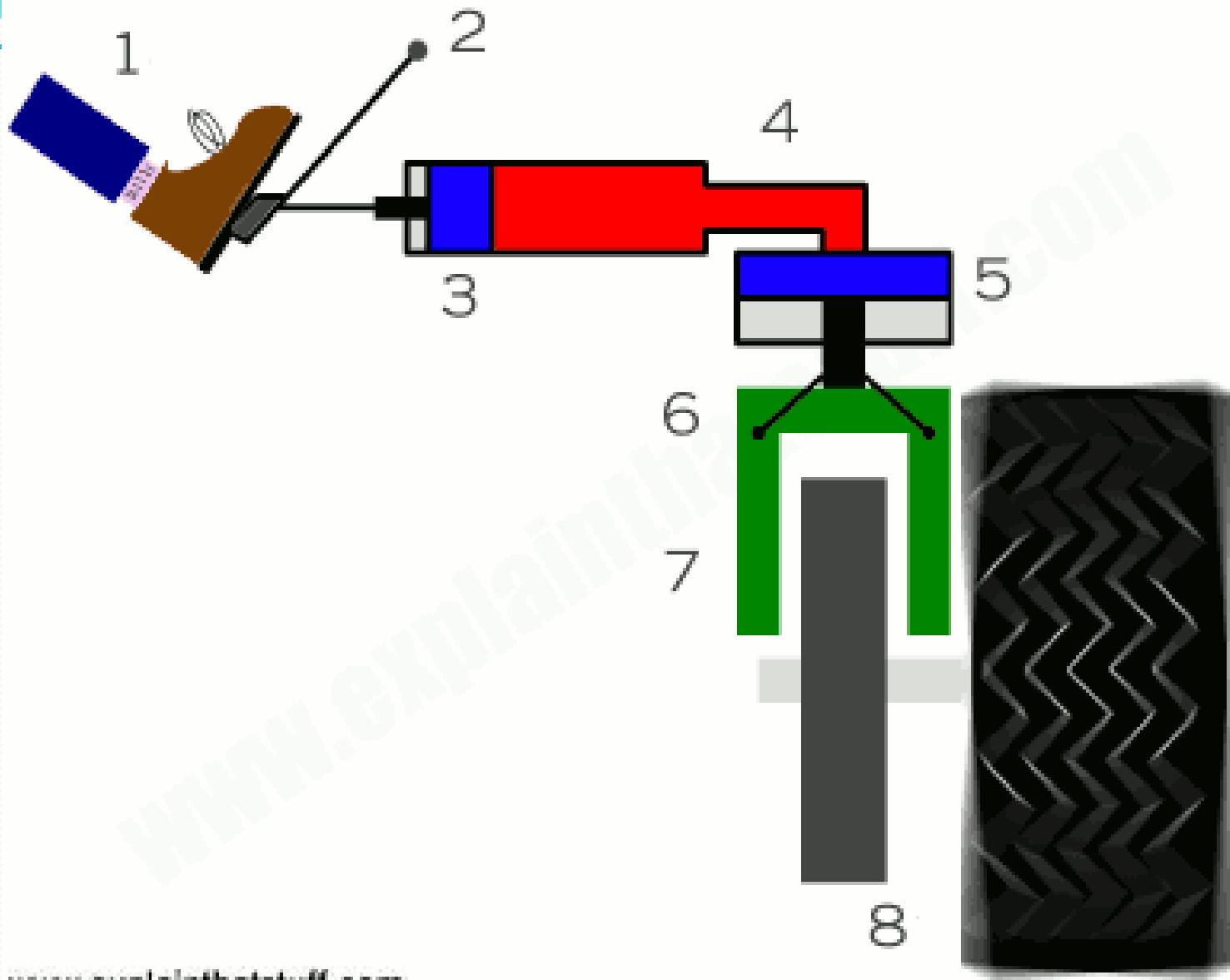


- **Drum brake advantages**
- Provide better braking
- Design & construction is simple
- Economical
- Drum brakes are cheaper to manufacture.
- Rear drum brakes generate lower heat.
- Drum brakes have a built-in self energizing effect that requires less input force
- Brake shoes can be remanufactured for future use.
- **Drum brake disadvantages**
- Wear & tear is not uniform
- Excessive heating can happen due to heavy braking, which then can cause the drum to distort, and thus cause vibration under braking.
- Under hard braking, the diameter of the drum increases slightly due to thermal expansion, the driver must press the brake pedal farther.
- Brake shoes can overheat to the point where they become glazed.
- Maintenance of drum brakes is more time-consuming, compared to disc brakes.

Disk Break : (Hydraulic braking system)

The disc brake is a device for slowing or stopping the rotation of a wheel while it is in motion.





- **Advantages:**
- Operation & assembly of disc brake is simpler
- As the friction pads are flat wear & tear is uniform
- Heat dissipation is faster
- Fewer moving parts. ...
- Longer life due to fewer moving parts and more effective heat dissipation.
- Friction pads are easily accessible for replacement or inspection.
- Easy access to caliper for cleaning and maintenance.
- Entire caliper can be removed for maintenance without removing rotor and hub.
- **Disadvantages:**
- Overall system cost is higher due to hydraulic caliper & fluid line
- If any air remains in disk brake system, it can be problematic as brakes may not work effectively.

Anti-lock braking system (ABS):

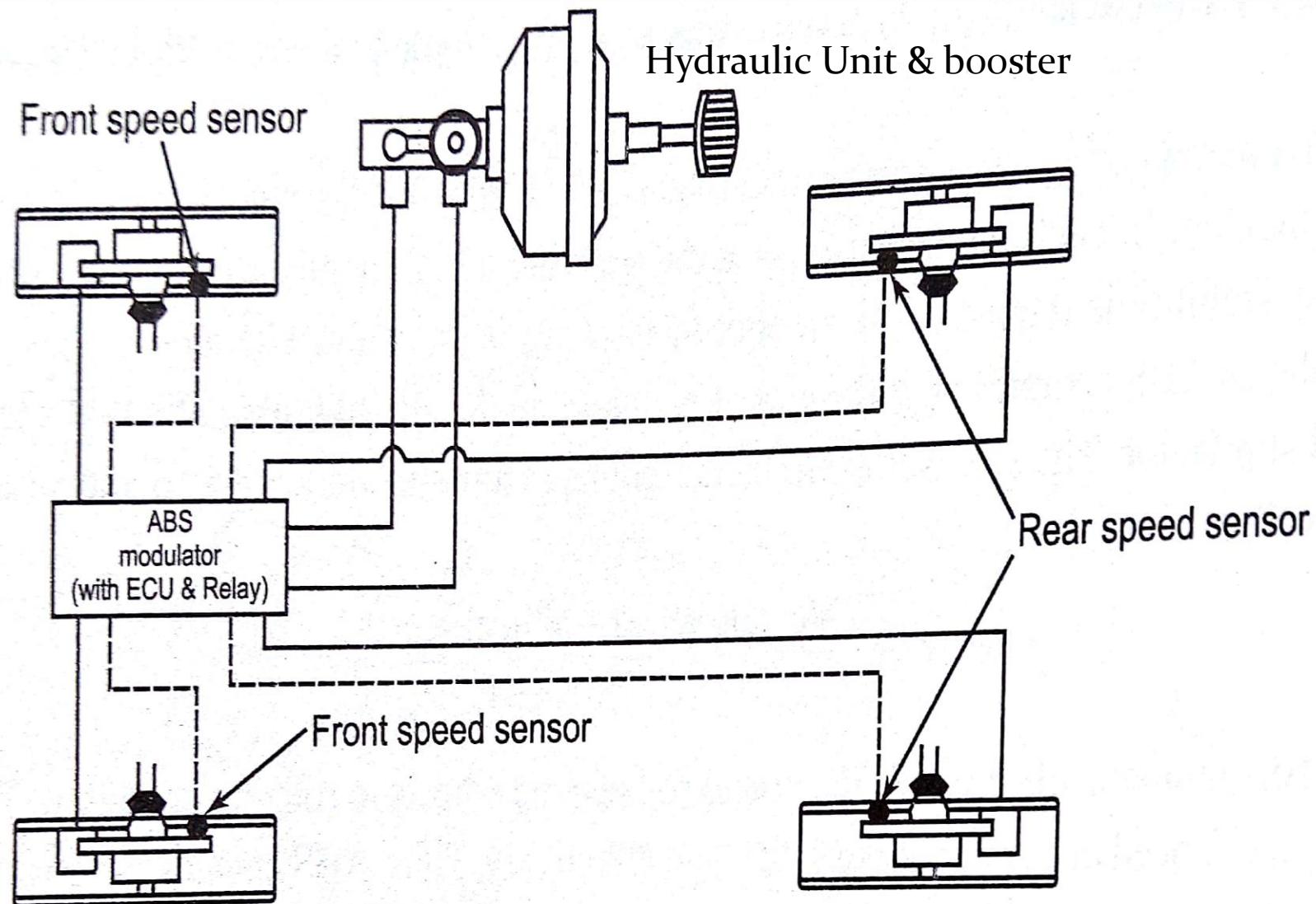
The antilock brake system (ABS) prevents the wheels of a vehicle from locking when the brakes are applied, thus maintaining the ability to steer a vehicle.

It is a type of electronic braking system which allows the driver various advantages which were not available with the conventional braking systems like drum brakes , air brakes etc.

Operation:

- 1 . Speed sensors:** It provides the information regarding the wheel Speed up to the dedicated electronic control unit (i.e. ABS ECU).
- 2. Modulator:** It controls the brake fluid pressure to each wheel.
- 3. Electronic control unit:** It controls the complete system operation. It receives the signals from the wheel sensors and controls the modulator.

Anti-lock braking system (ABS):



Engine Cooling System :

The cooling system has three primary functions, which are as follows.

- Remove excess heat from the engine
- Maintain a constant engine operating temperature
- Increase the temperature of a cold engine as quickly as possible by maintaining the thermostat valve in a closed position which is fitted in the path of coolant circulation
- To prevent the damage of vital engine components

Necessity of Cooling

The cylinders of internal combustion engines require cooling because the engine cannot convert all the heat energy released by combustion into useful work. Liquid cooling is employed in most of the IC engines,

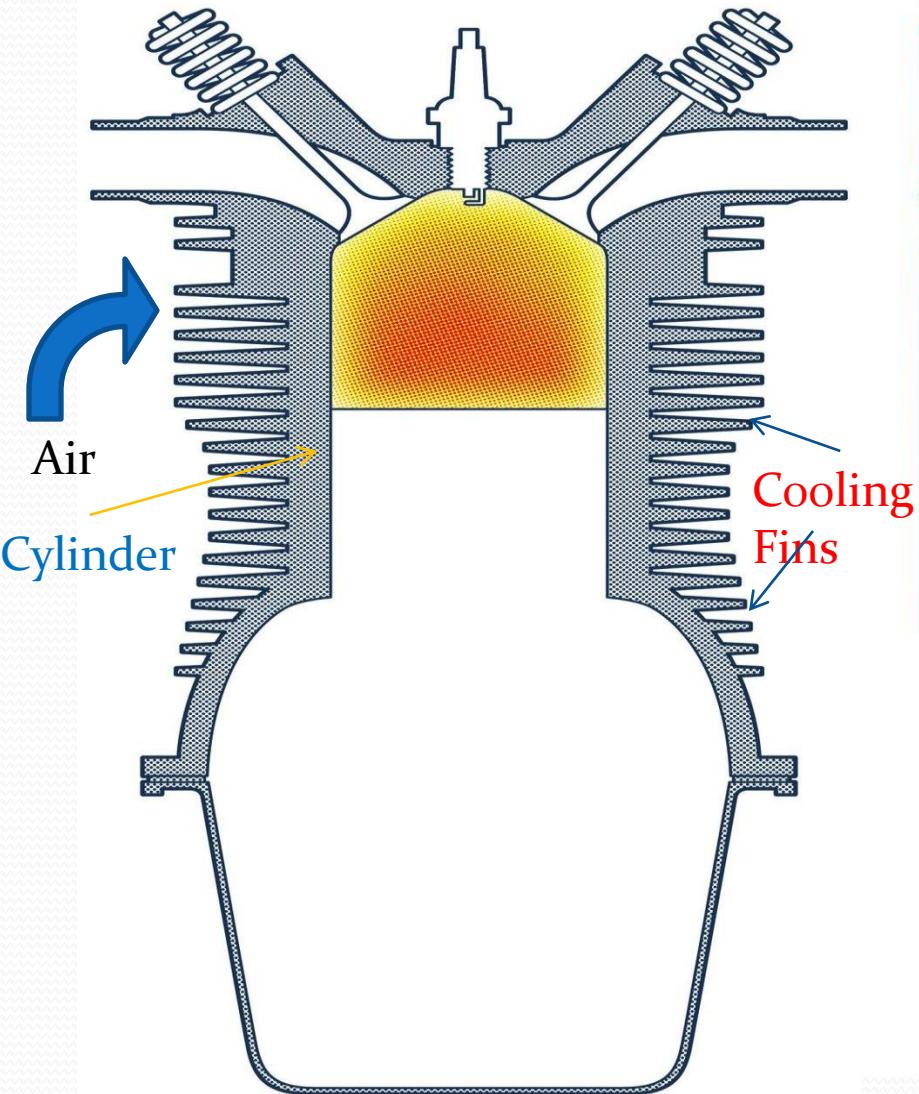
Types of cooling system:

The different Types of cooling system are

- Air cooling system (Direct Cooling)
- Liquid cooling system (Indirect Cooling)

Air cooling system:

Finned Engine Cylinder



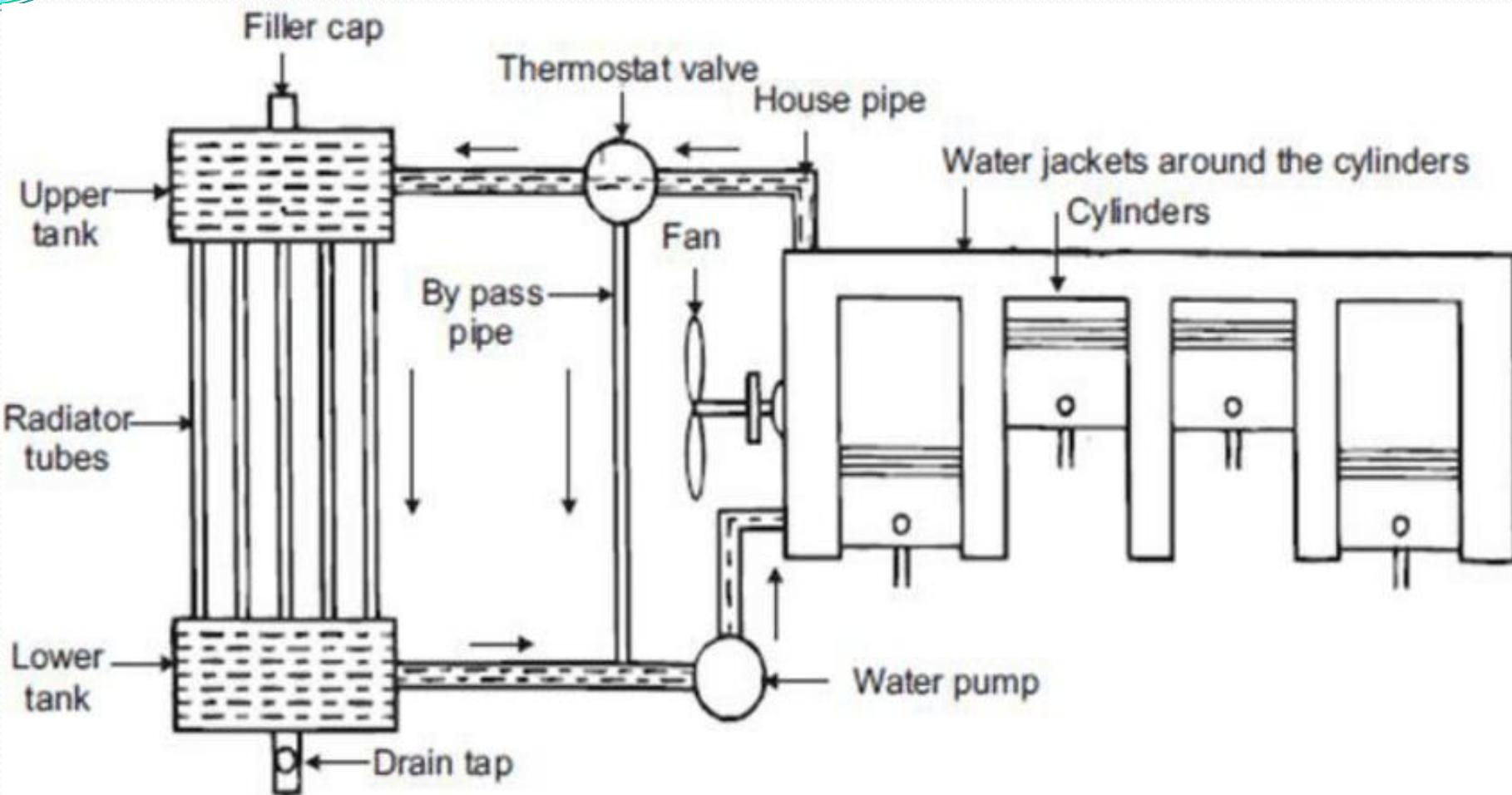
Air-Cooled System :

The simplest type of cooling is the air-cooled, or direct, method in which the heat is drawn off by moving air in direct contact with the engine. Several fundamental principles of cooling are embodied in this type of engine cooling. The rate of the cooling is dependent upon the following:

The amount of heat dissipated depends upon

- The cooling surface area in contact with passing air
- Rate of mass flow of air over cooling area
- Effective temperature difference between the cylinder and air
- Coefficient of heat transfer of metal in air

Water cooling system:



Fuel Supply system for SI engines :

Carburation :

Spark-ignition engines normally use volatile liquid fuels. Preparation of fuel-air mixture is done outside the engine cylinder and formation of a homogeneous mixture is normally not completed in the inlet manifold. The process of mixture preparation is extremely important for spark-ignition engines. The purpose of carburetion is to provide a combustible mixture of fuel and air in the required quantity and quality for efficient operation of the engine under all conditions.

Carburetor :

The process of formation of a combustible fuel-air mixture by mixing the proper amount of fuel with air before admission to engine cylinder is called carburetion and the device which does this job is called a carburetor.

Factors Affecting Carburetion

Of the various factors, the process of carburetion is influenced by

- The engine speed
- The vaporization characteristics of the fuel
- The temperature of the incoming air and
- The design of the carburetor

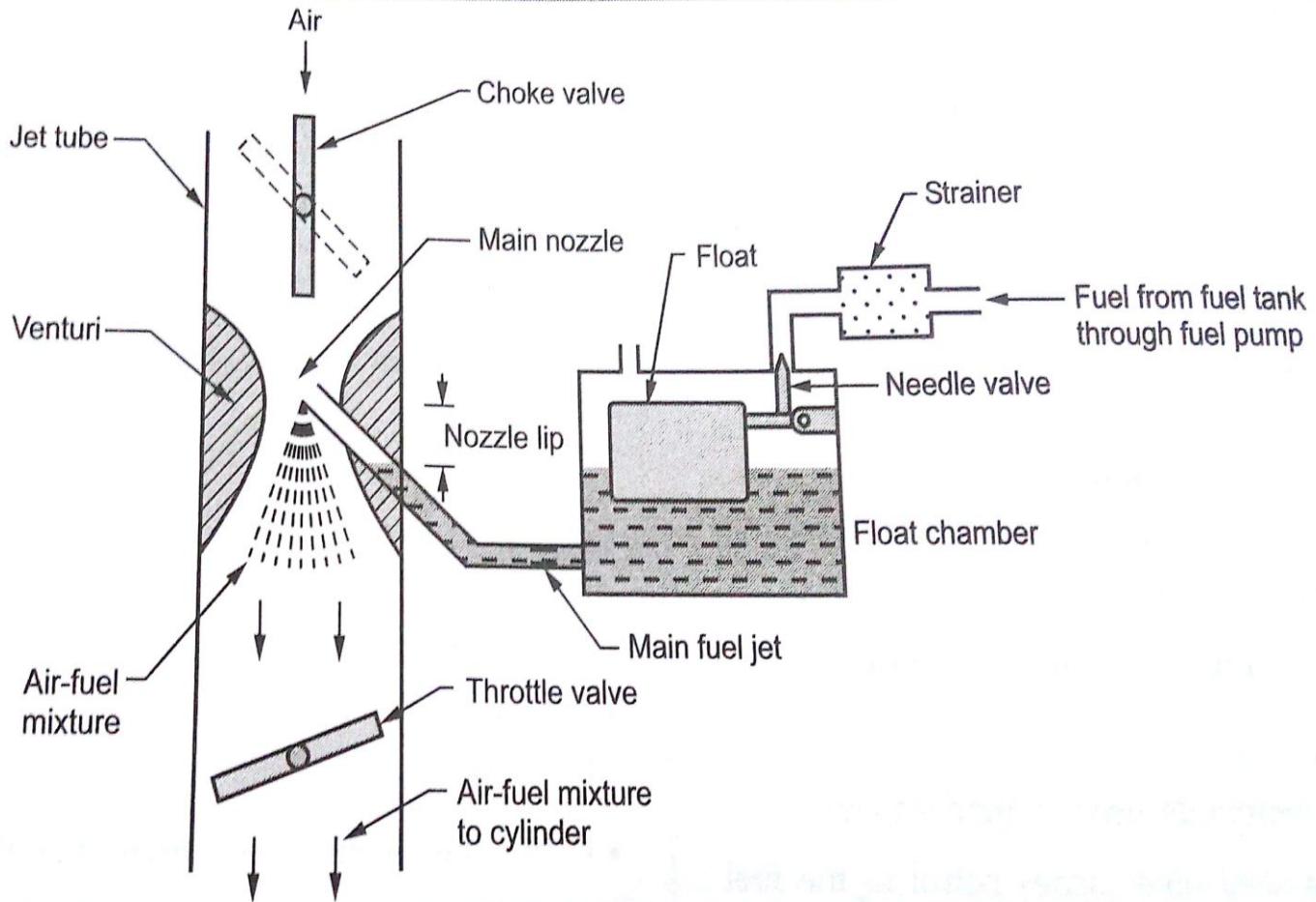
Carburetor :



Simple Carburetor :

Simple carburetor consist of following elements,

1. Float chamber
2. Fuel discharge nozzle
3. A metering orifice
4. A Venturi
5. Throttle valve
6. Choke



FUEL INJECTION SYSTEM:

The petrol injection system now comes to modern vehicles. the fuel is atomized by means of an air injector nozzle then delivered into an air stream. there may be separate fuel injectors are used for separate cylinder or one single **fuel injector** is used.

Advantages:

- This is the most accurate fuel supply system
- High power is developed
- It has quick starting and warms up
- Low specific fuel consumption rate

Disadvantages:

- Back-flow of petrol may take place
- High initial cost

THE COMPONENTS OF FUEL SUPPLY SYSTEM:

Fuel tank:

The fuel tank holds the fuel for the engine. It is made of steel or aluminum or synthetic rubber compounds and fiber reinforced plastics which are flame resistant

Fuel pump:

The fuel pump is used to deliver the fuel from the fuel tank to the carburetor.

Fuel lines:

These tubes are used for connects the fuel tank with the pump and pump to the carburetor. Generally, these tubes are made of Copper or Steel.

Air cleaner:

This is very necessary for an engine to get fresh air, otherwise, the polluted air causes several damages to the engine chamber.

Fuel filters:

A fuel filter is necessary for a vehicle to clean the fuel.

Fuel gauge unit:

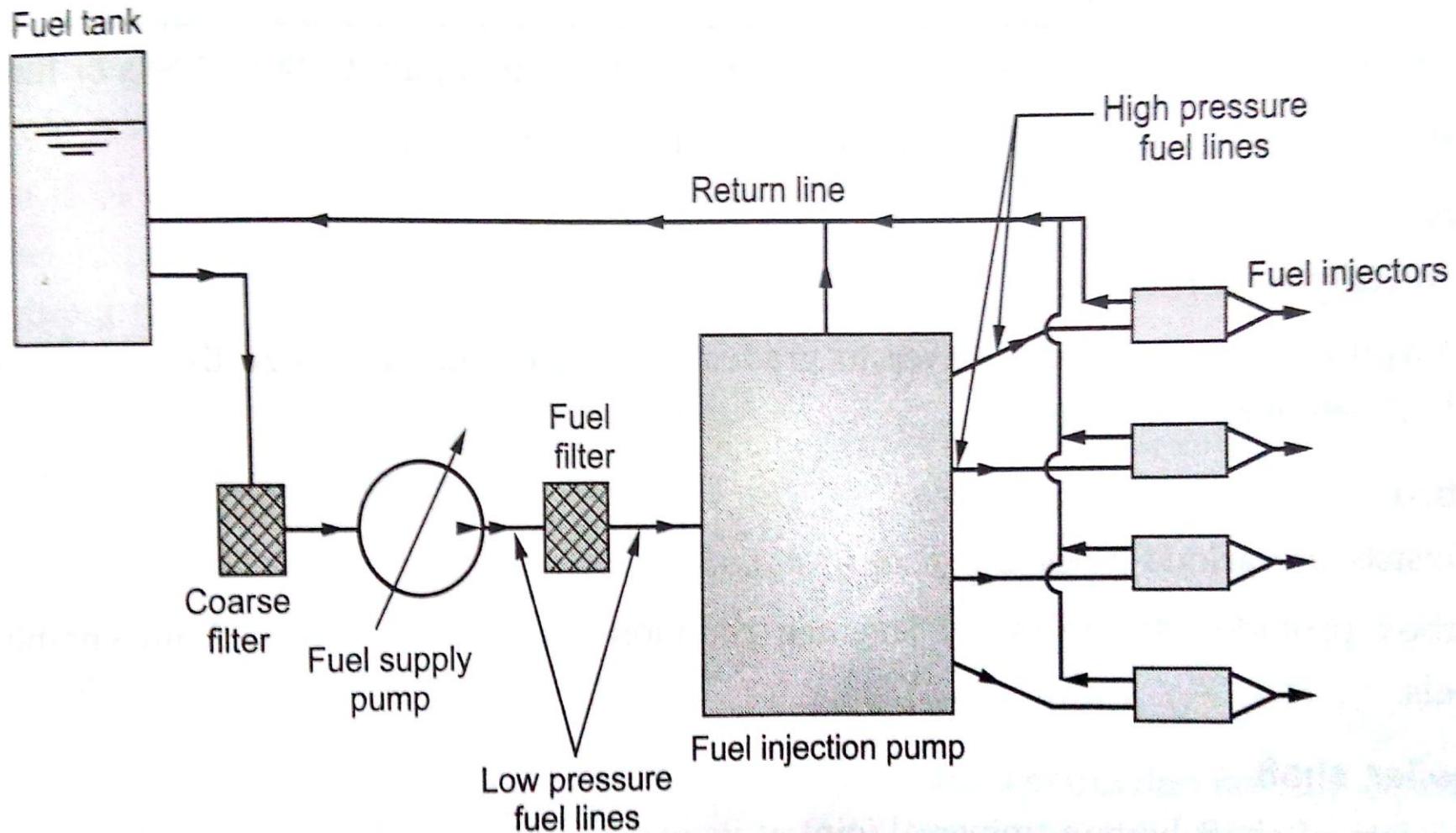
A fuel gauge is an instrument which is fitted to the dashboard of the vehicle so that driver can know the amount of fuel inside the fuel tank.

Carburetor:

A perfect air-fuel mixture is necessary for a petrol engine to run.

So, therefore, we use a carburetor. It is device which controlled the air-fuel mixture.

FUEL INJECTION SYSTEM:



Advantages Of Fuel Injection Over Carburetor :

- Fuel injection has no choke, but sprays atomized fuel directly into the engine.
- Electronic fuel injection also integrates more easily with computerized engine control systems.
- Multi port fuel injection delivers a more evenly distributed mixture of air and fuel to each of the engine's cylinders.
- Sequential fuel injection improves power and reduces emissions.

Single Point Injection system :

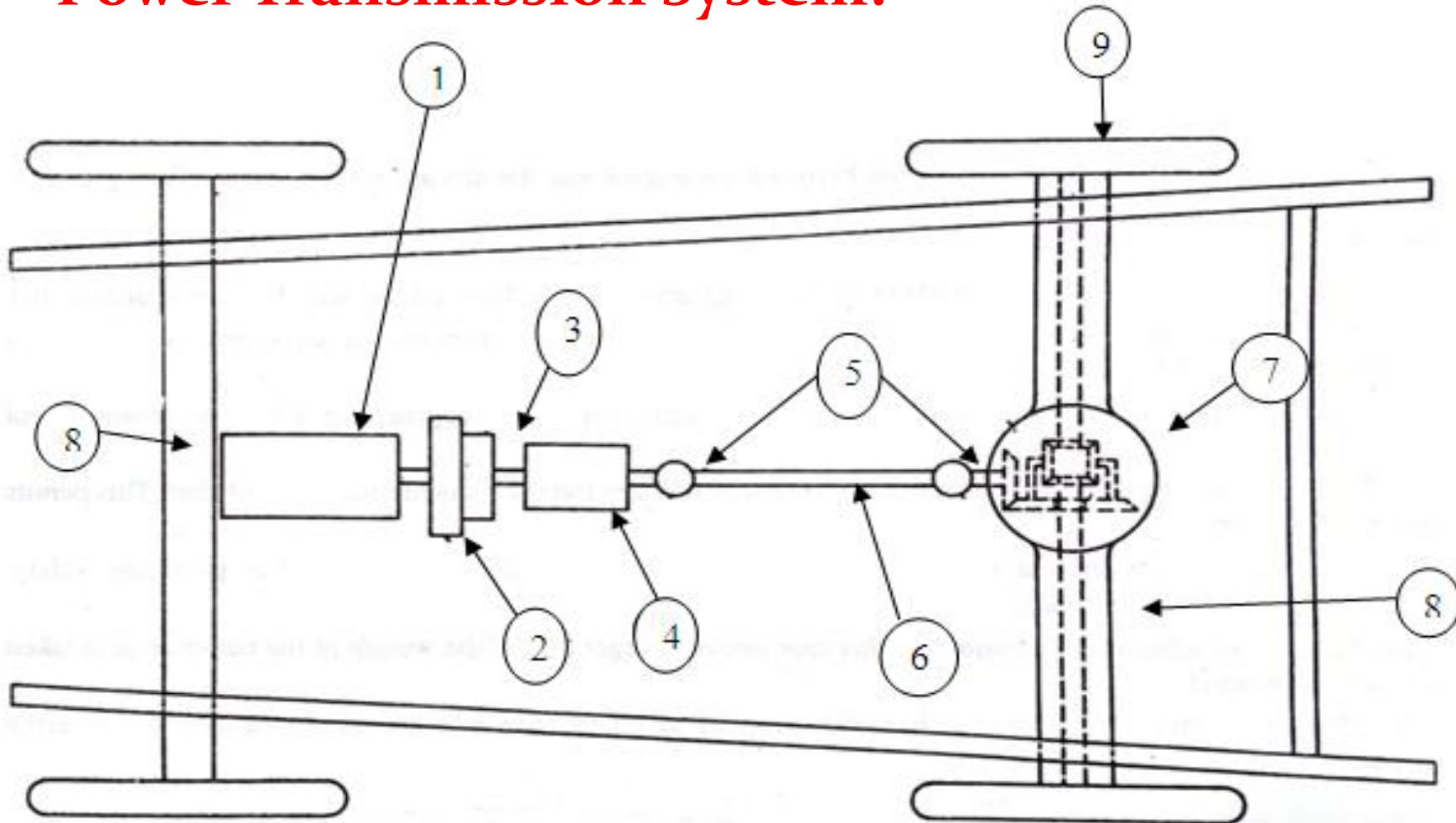
The earliest & simplest type of fuel injection, single point simply replaces the carburetor with one or two fuel injector nozzles in the throttle body, which is the throat of the engine's air intake manifold.

Single point injection system meters fuel better than a carburetor and is less expensive and easier to service.

Multi Point Fuel Injection System (MPFI) :

- MPFI system is widely used in petrol engine in place of carburetor.
- Purpose of MPFI is supply proper A/F ratio to each cylinder of engine.
- Fuel tank > Pump > High pressure petrol > Distributor > Fuel injector > Cylinder
- Now a days MPFI system control by Electric Control Module (ECM).
- ECM receives signal from different sensors.
- ECM receives signal and send to the solenoid operated fuel injector to meter and inject right amount of fuel at right time.

Power Transmission System:



- | | |
|---------------------|--------------------|
| 1. Engine | 6. Propeller Shaft |
| 2. Flywheel | 7. Differential |
| 3. Clutch | 8. Drive axle |
| 4. Gear Box | 9. Wheels |
| 5. Universal Joints | |

1. Clutch :

A clutch is a mechanical device which provides for the transmission of power (and therefore usually motion) from one shaft (the driving member) to another shaft (the driven member).

It is located between the transmission and the engine.

When the clutch is engaged, the power flows from the engine to the gear box drive transmission and the vehicle moves. When the clutch is disengaged, the power is not transmitted from the engine to the gear box and vehicle stops even if engine is running.

It works on the principle of friction.

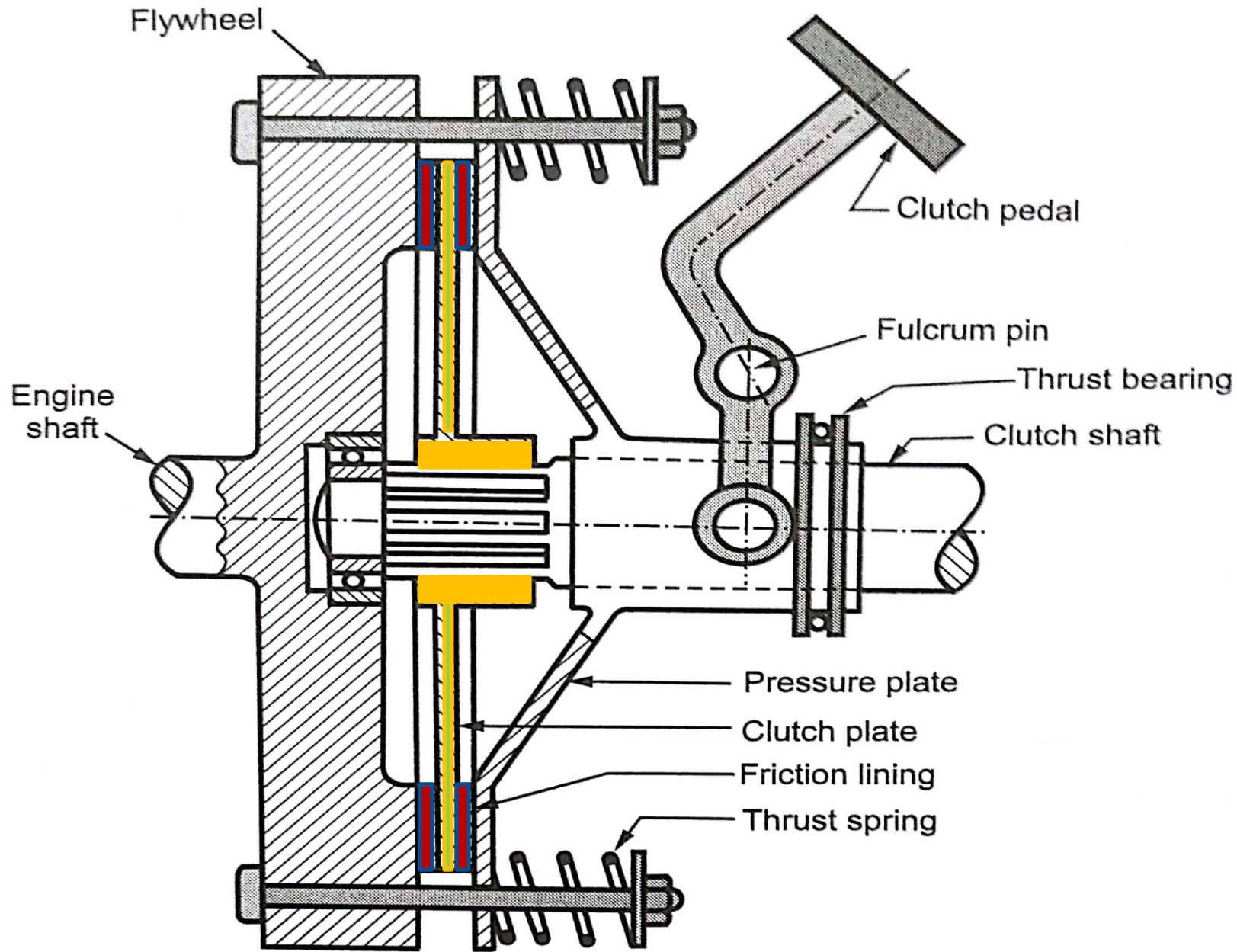
The friction depends upon the surface area contact. The friction surfaces are so designed that the driven member initially slips on driving member when initially pressure is applied. As pressure increases the driven member is brought gradually to speed the driving member

Types of Clutch :

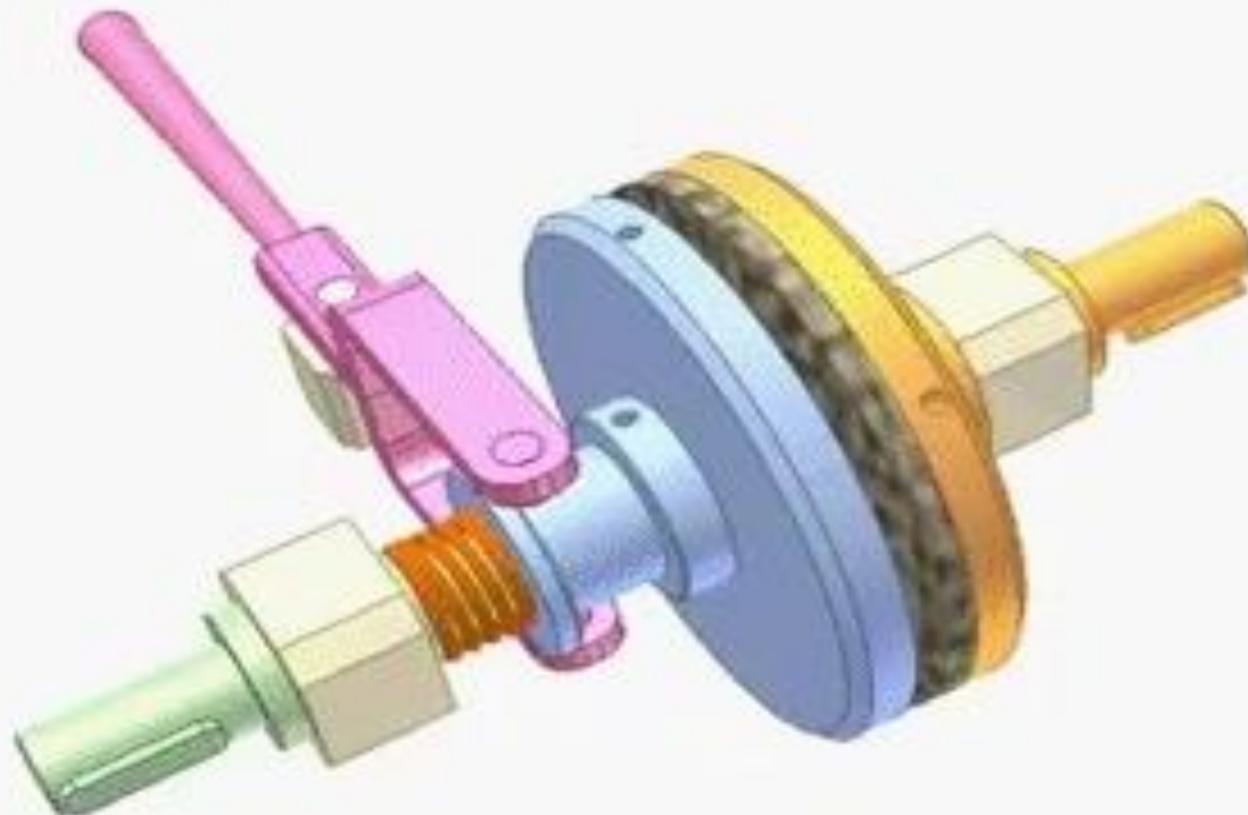
1. Single plate clutch
 2. Multi-plate clutch
 3. Semi-centrifugal clutch
 4. Centrifugal clutch
 5. Cone clutch
- ## 1. Single plate clutch :

It is the most common type of clutch plate used in motor vehicles. Basically it consists of only one clutch plate, mounted on the splines of the clutch plate. The flywheel is mounted on engine crankshaft and rotates with it. The pressure plate is bolted to the flywheel through clutch springs, and is free to slide on the clutch shaft when the clutch pedal is operated.

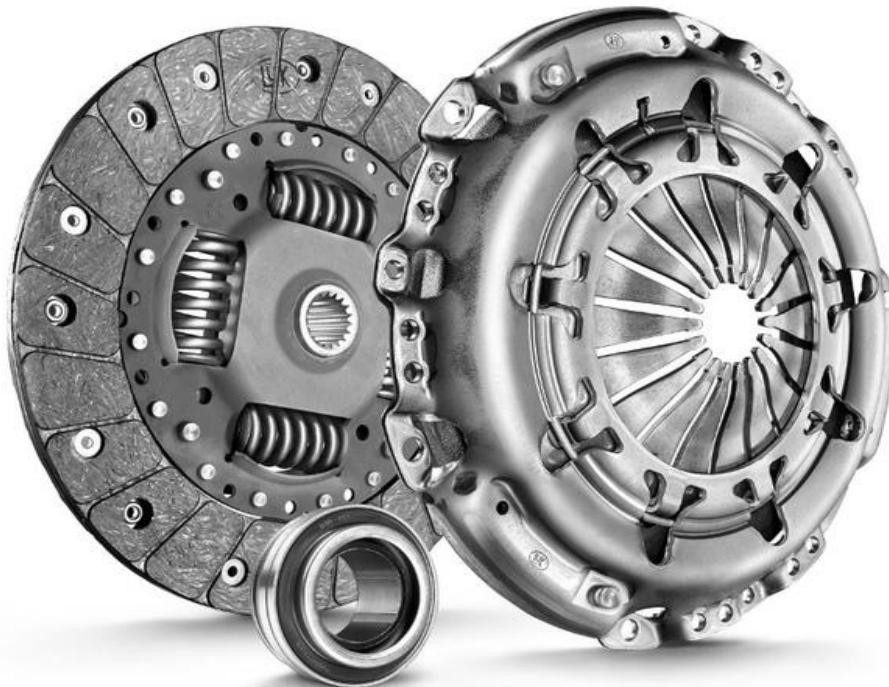
Single plate clutch



Single plate clutch



When the clutch is engaged the clutch plate is gripped between the flywheel and pressure plate. The friction linings are on both the sides of the clutch plate. Due to the friction between the flywheel, clutch plate and the pressure plate the clutch plate revolves the flywheel. As the clutch plate revolves the clutch shaft also revolves. Clutch shaft is connected to the transmission gear box. Thus the engine power is transmitted to the crankshaft and then to the clutch shaft.



When the clutch pedal is pressed, the pressure plate moves back against the force of the springs, and the clutch plate becomes free between the flywheel and the pressure plate. Thus the flywheel remains rotating as long as the engine is running and the clutch shaft speed reduces slowly and finally it stops rotating. As soon as the clutch pedal is pressed, the clutch is said to be disengaged, otherwise it remains engaged due to the spring forces.

Applications: These type of clutches are used in trucks, jeeps, cars and buses.



Advantages:

Simple design of construction & working

Better heat dissipation from single plate

Gear changing with single plate is easier

It has better tensional vibration absorbing capacity.

Disadvantages:

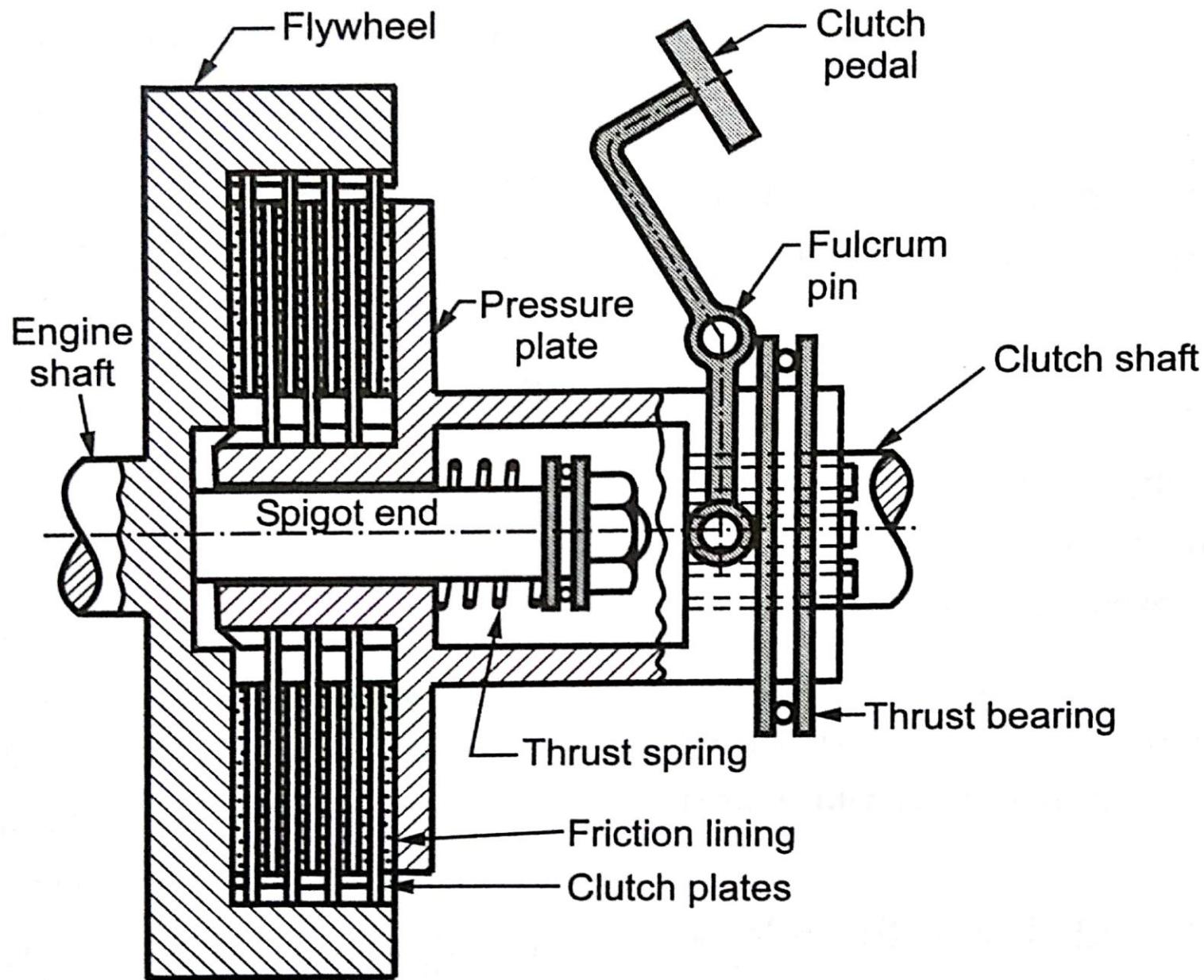
For higher transmission overall size of the plate increases

Pedal force required is higher

Multi Plate Clutch :

Multi-plate clutch consists of a number of clutch plates instead of only one clutch plate as in case of single plate clutch. As The number of clutch plates are increased, the friction surfaces also increases. The increased number of friction surfaces obviously increases the capacity of the clutch to transmit torque. The plates are alternately fitted to engine and gear box shaft. They are firmly pressed by strong coil springs and assembled in a drum. The multi-plate clutch works in the same way as a single plate clutch by operating the clutch pedal. The multi-plate clutches are used in heavy commercial vehicles, racing cars and motor cycles for transmitting high torque. The multi-plate clutch may be dry or wet. When the clutch is operated in an oil bath, it is called a wet clutch. When the clutch is operated dry it is called dry clutch

Multi Plate Clutch :

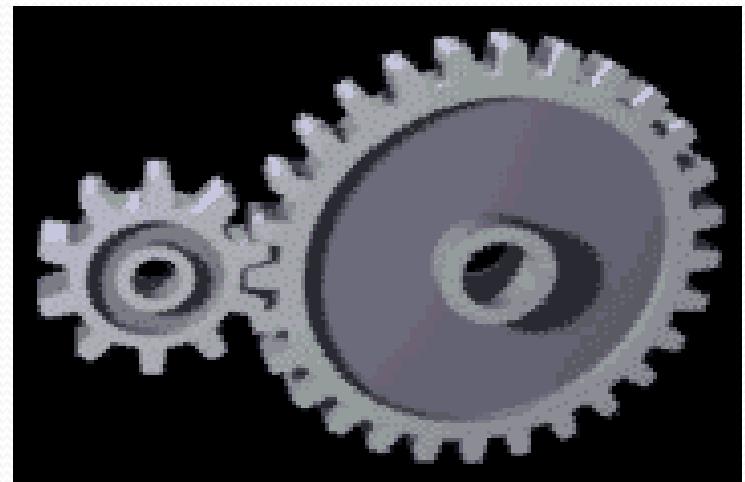
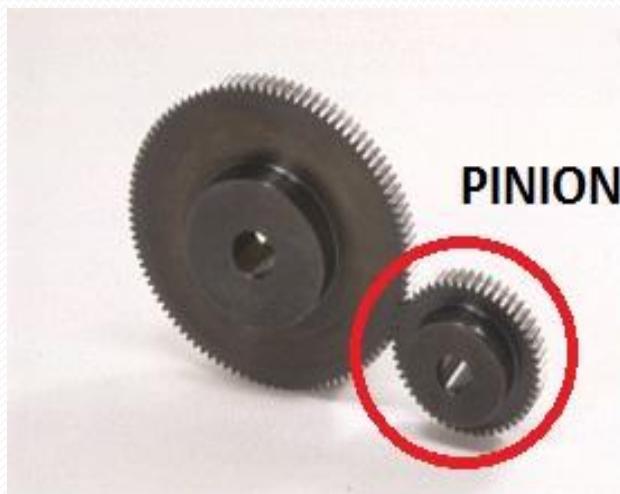


Gears

- Gears can be defined as the mechanical element used for transmitting power and rotary motion from one shaft to another by means of progressive engagement of projections called teeth.

Gears operates in pairs, the smaller of the pair is called pinion and the larger is called the gear

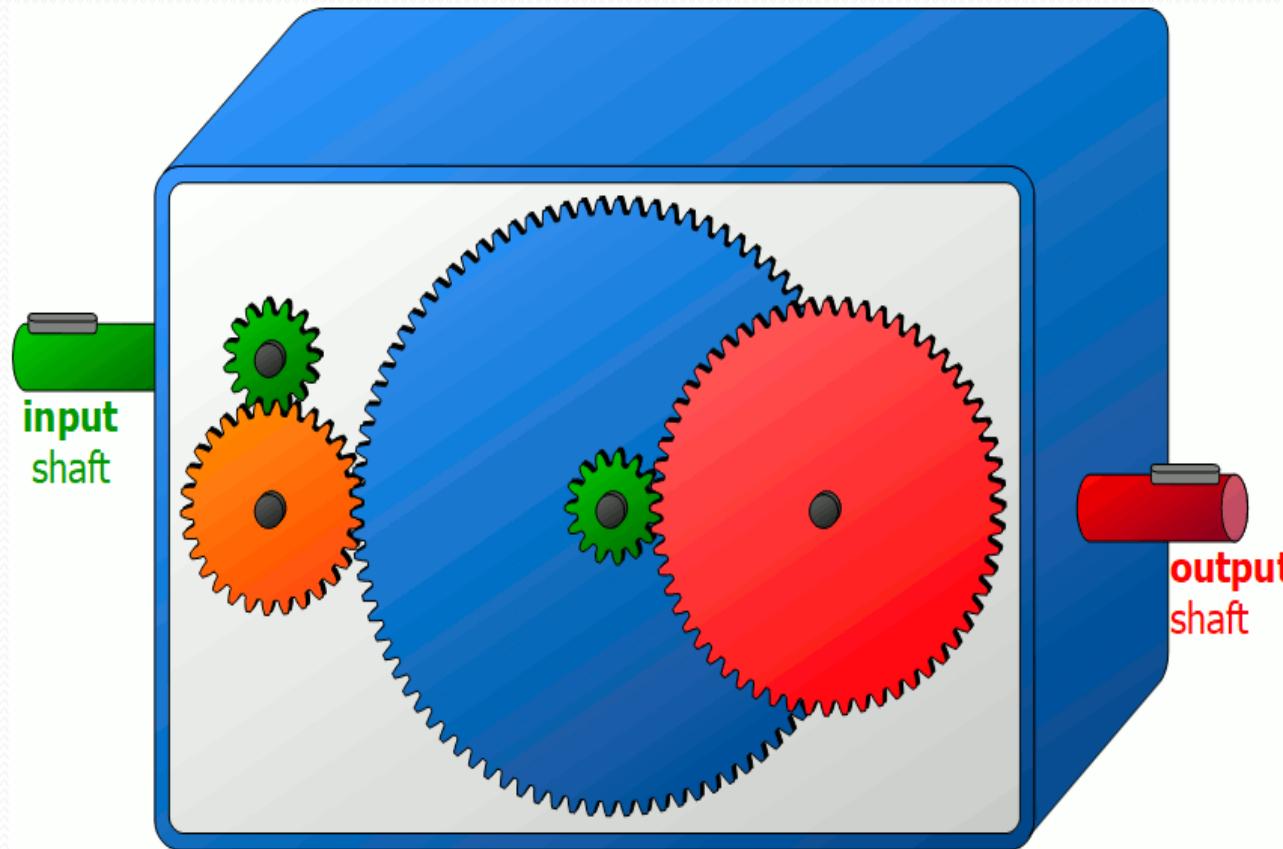
If pinion rotates in clockwise direction gear rotates in anticlockwise direction and vice versa



Gear Ration or Speed Ratio

- It is the ratio of the pinion speed to the gear speed.
- It can also be defined as ratio of no of teeth on the gear to the no of teeth on the pinion.

$$i = \frac{Z_g}{Z_p} = \frac{N_p}{N_g}$$

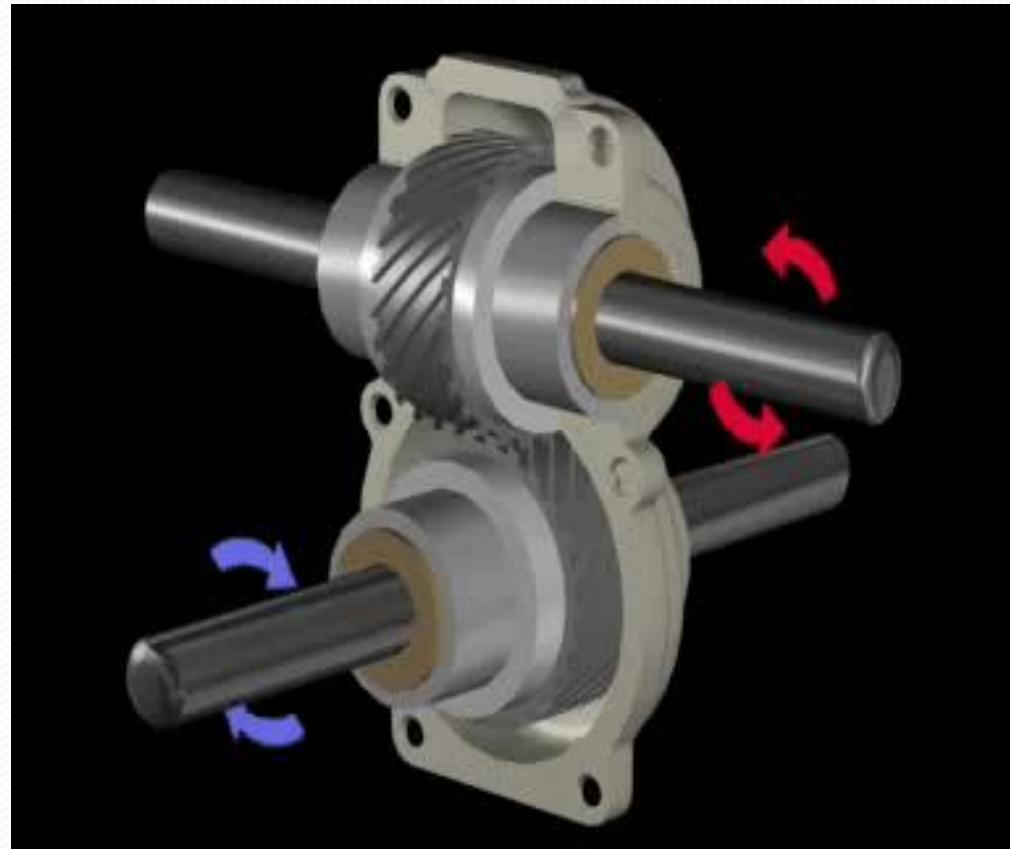


Functions:

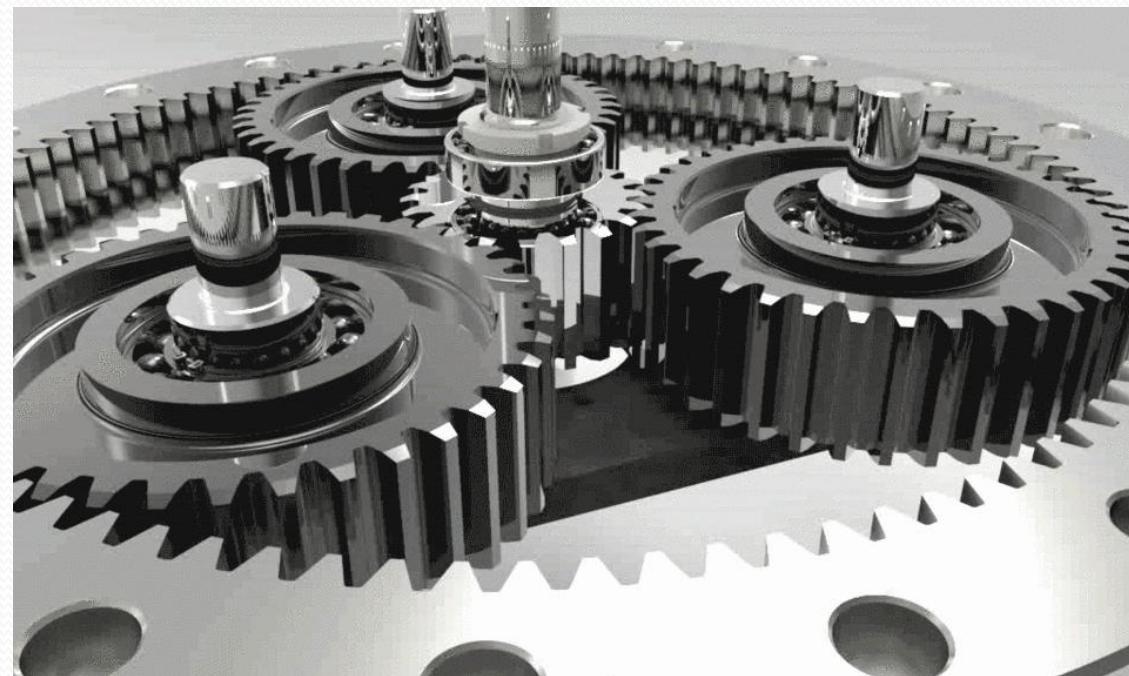
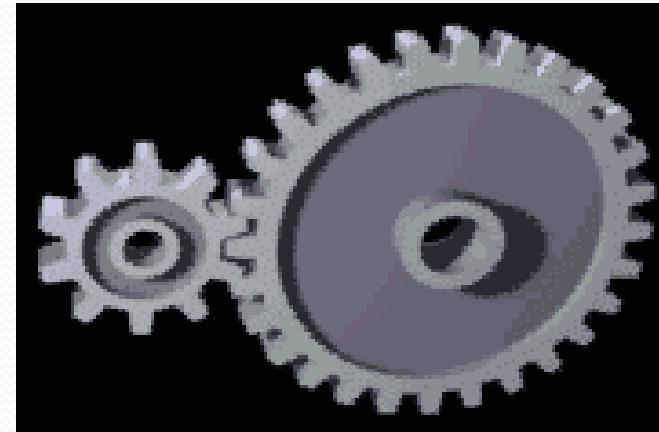
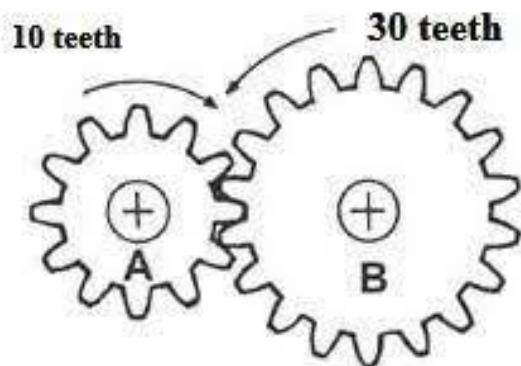
- To increase the torque and reduce the speed from the input shaft to output shaft.
- To increase the speed & reduce the torque from the input shaft to output shaft
- To transmit the power from one shaft to another shaft.
- To change the direction of rotation from one shaft to another shaft.

Torque is the measure of the force that can cause an object to rotate about an axis.

1. Parallel axes
2. Intersecting axes
3. Non intersecting & perpendicular axes
4. Non intersecting & non parallel gear



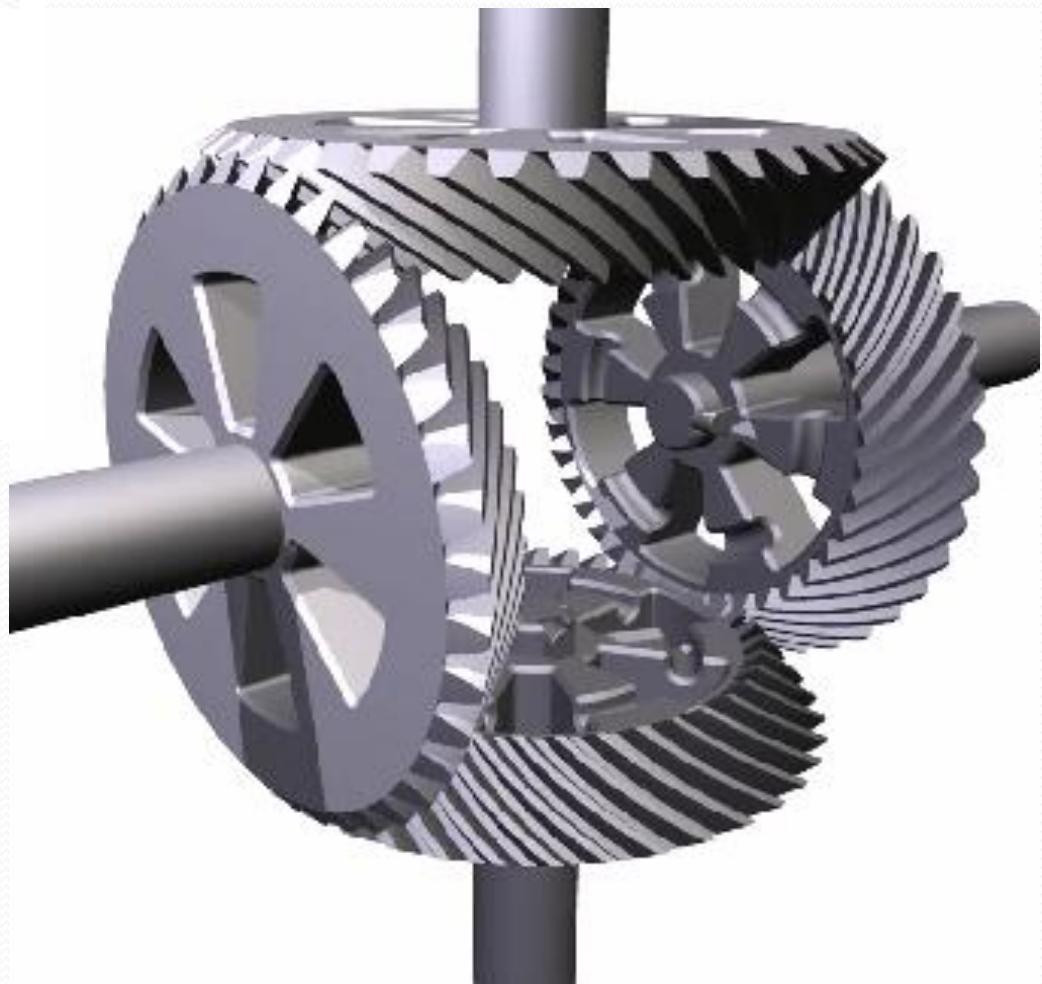
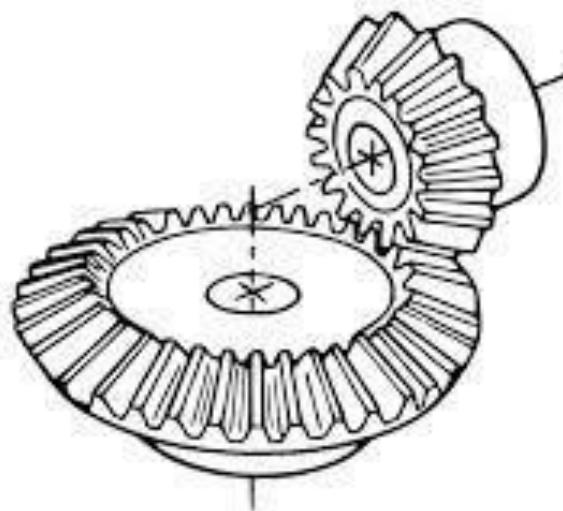
a. Parallel axes gear (Spur Gear)



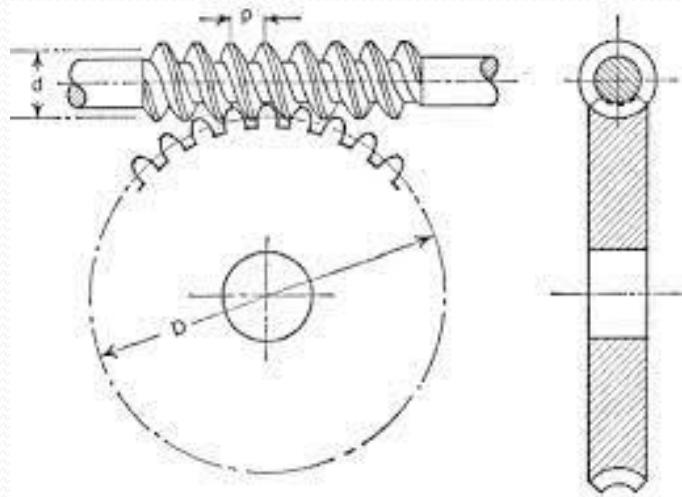
a. Parallel axes gear (Helical Gear)



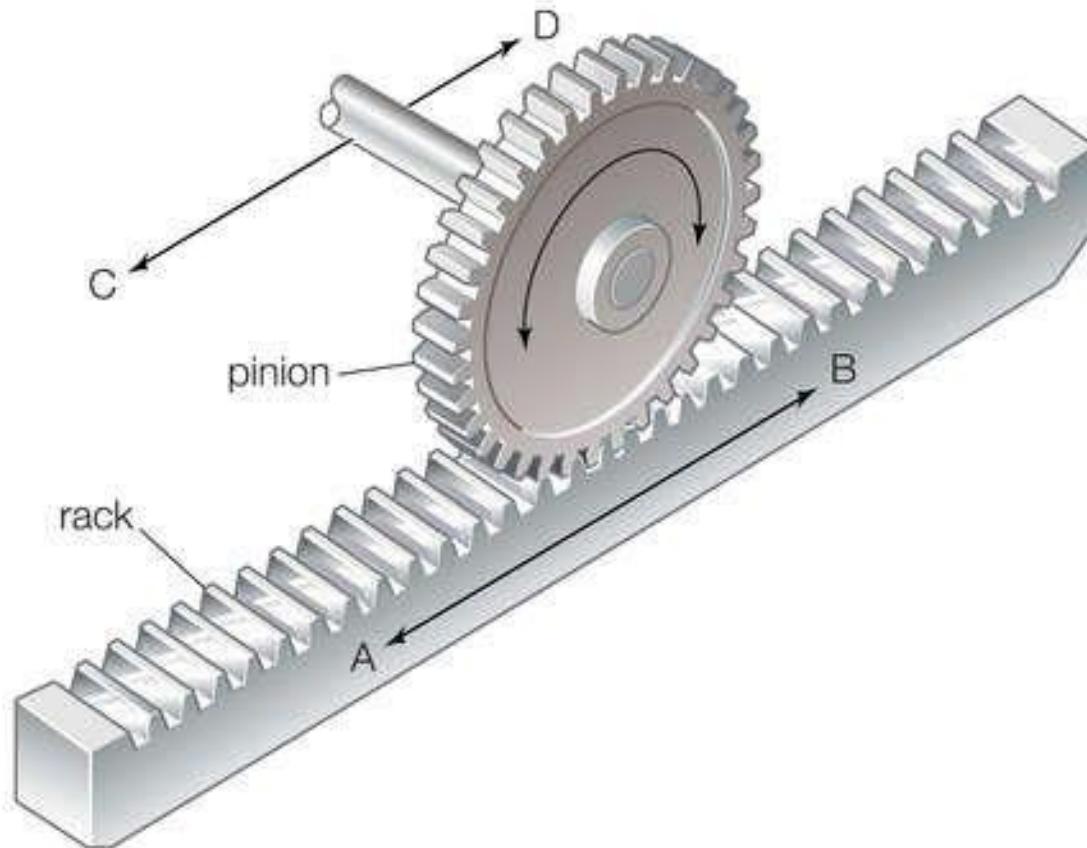
b. Intersecting axes gear (Bevel Gear)



c. Non intersecting & perpendicular axes gear (Warm & Warm wheel Gear)



c. Non intersecting & perpendicular axes gear (Rack & pinion Gear Gear)



A pinion with 120 mm pitch circle diameter meshes with a gear of 400 mm pitch circle diameter. The no of teeth on pinion is 18 and it rotates at 1440 rpm. Determine: i) Gear Ratio, ii) Number of teeth on gear, iii) Speed of the gear.

Given: $d_p = 120$ mm, $d_g = 400$ mm, $Z_p = 18$, $n_p = 1440$ rpm

Gear Ratio (i) = ?

Number of teeth on gear = ?

Speed of the gear = ?

Calculate the gear ratio:-

$$\text{Gear ratio} = I = \frac{d_g}{d_p} = \frac{400}{120} = 3.3333$$

Calculate Number of teeth on gear:-

$$I = \frac{Z_g}{Z_p}$$

$$\text{Therefore, } 3.3333 = \frac{Z_g}{18} \quad Z_g = 60$$

Calculate speed the gear:-

$$I = \frac{n_p}{n_g}$$

$$\text{Therefore, } 3.3333 = \frac{1440}{n_g} \quad n_g = 432 \text{ rpm.}$$

2. A pinion with pitch circle diameter 150 mm meshes with a gear having 80 teeth. Gear ratio is 4 and speed of the gear is 500 rpm. Determine: i) Diameter of gear, ii) Number of teeth on pinion, iii) Speed of pinion.

Calculate diameter of :-

Given: $d_p = 150 \text{ mm}$, $i = 4$, $Z_g = 80$, $n_g = 500 \text{ rpm}$

Diameter of gear $d_g = ?$

Number of teeth on pinion = ?

Speed of the pinion = ?

$$\text{Gear ratio} = I = \frac{d_g}{d_p} =$$

$$4 = \frac{d_g}{150} =$$

$$d_g = 600 \text{ mm}$$

Calculate speed of the pinion:-

$$I = \frac{n_p}{n_g}$$

$$\text{Therefore, } 4 = \frac{n_p}{500}$$

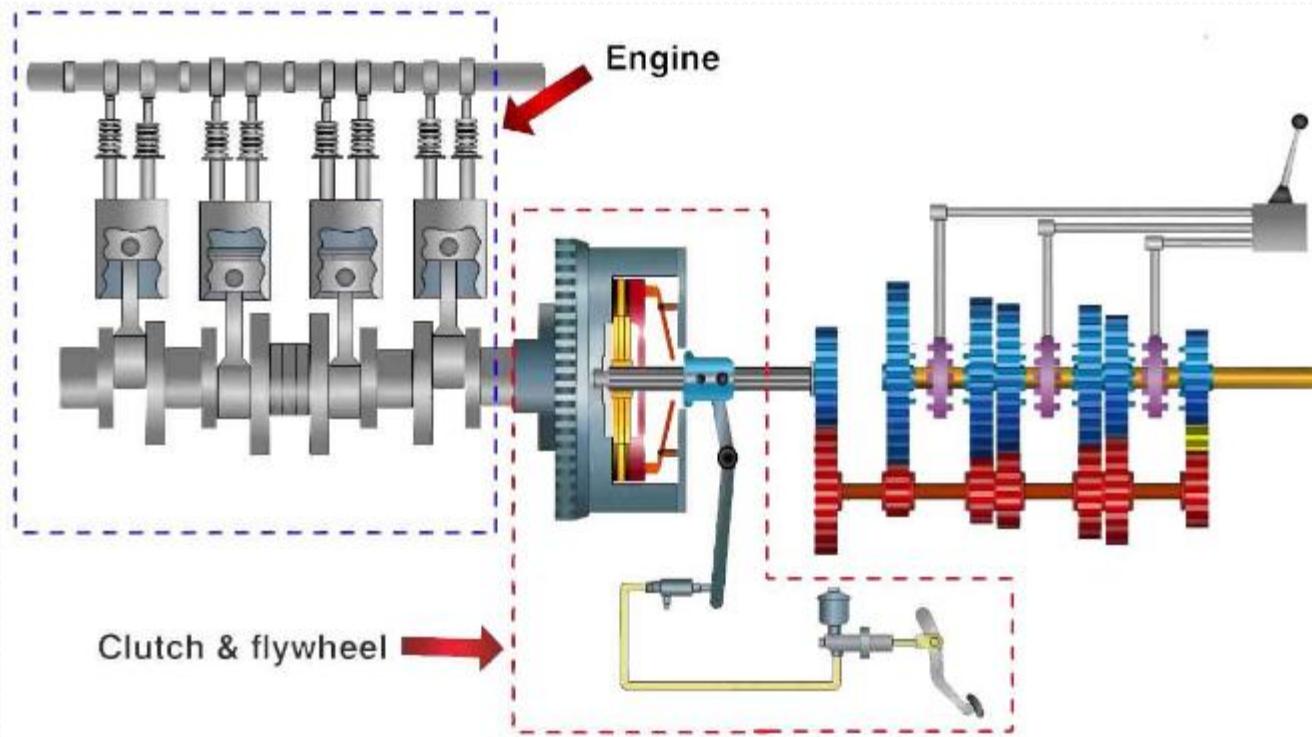
$$n_p = 200 \text{ rpm}$$

Calculate no of teeth on pinion:-

$$I = \frac{Z_g}{Z_p}$$

$$\text{Therefore, } 4 = \frac{80}{Z_p}$$

$$Z_p = 20.$$



2. Gear Box :

Functions of Gear Box:

- To increase the torque and reduce the speed from the input shaft to output shaft.
- To increase the speed & reduce the torque from the input shaft to output shaft
- Gear box provides a mean to move the automobile backward with a reverse gear.
- It also enables a neutral position for starting the engine and keep it running without transmitting drive to the road

Types of Gearbox :

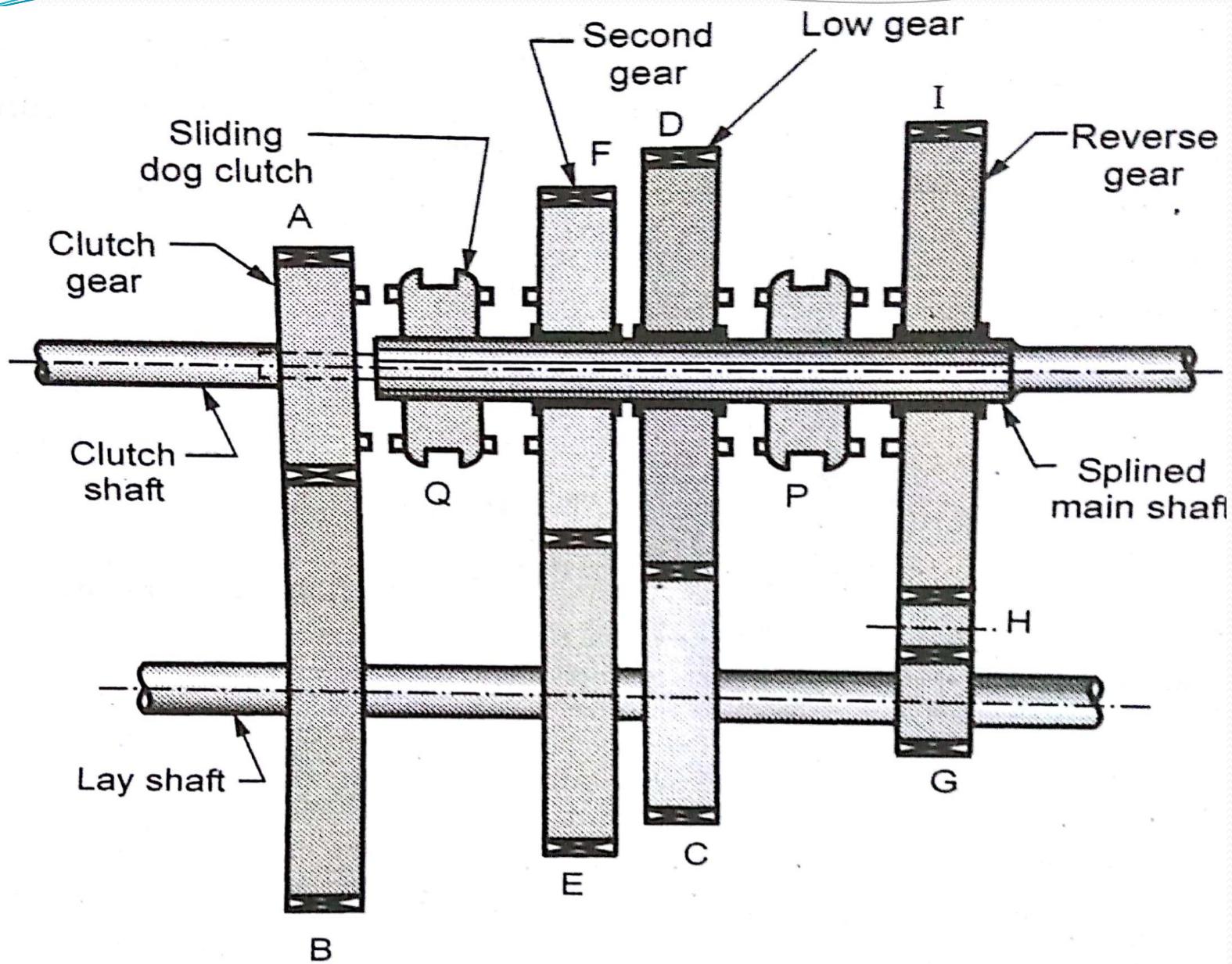
Following are the **types of gearbox** used in modern vehicles:

- Sliding mesh type gearbox
- Constant-mesh type gearbox
- Synchromesh gearbox
- Epicyclic gearbox

Constant-mesh type gearbox :

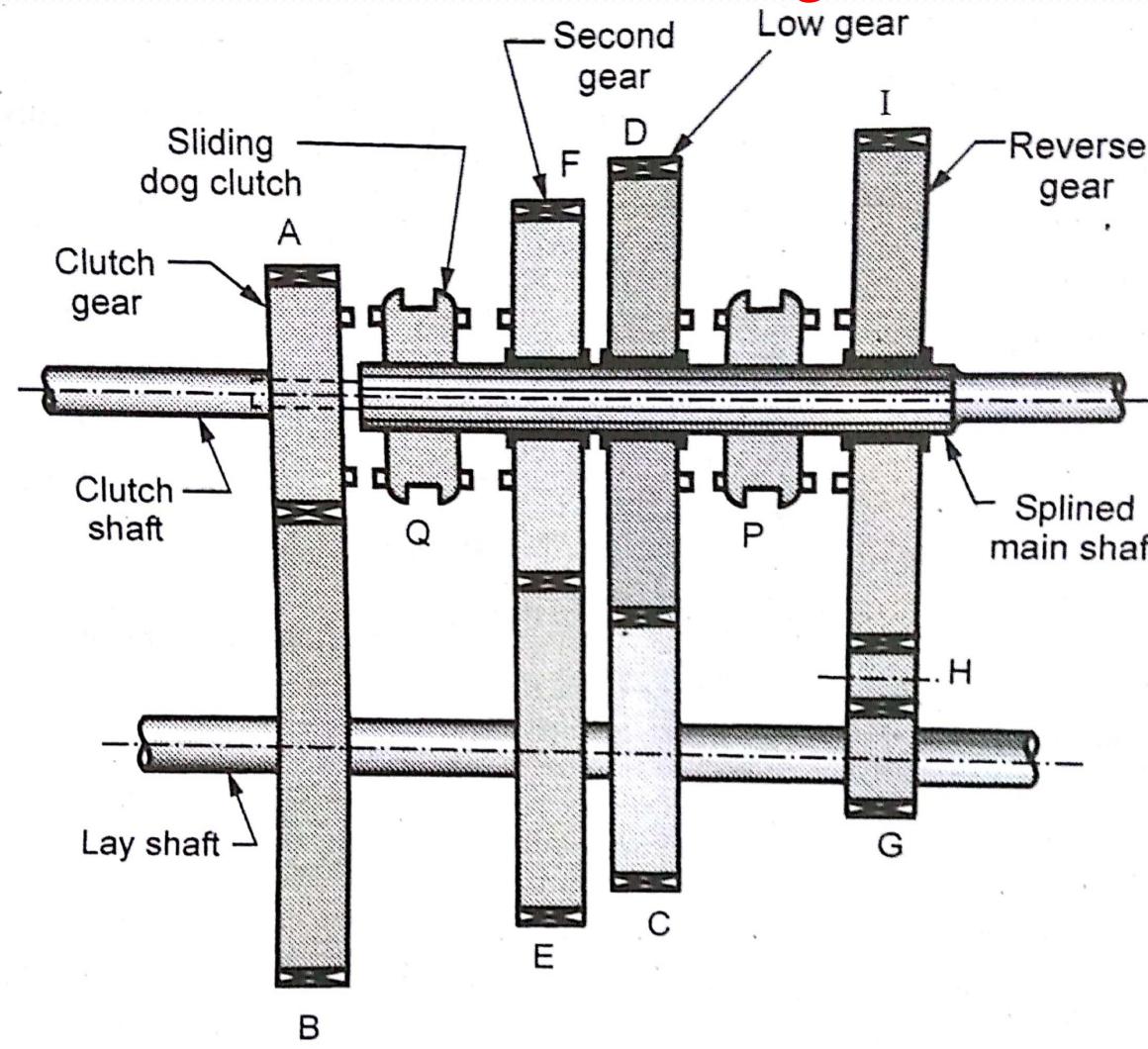
- As the name indicates in this type all the gears are in continuous constant mesh with each other. Selection of gears takes place by additional sliding dog clutches provided on the main shaft.

Working Principle of Constant Mesh Gearbox:



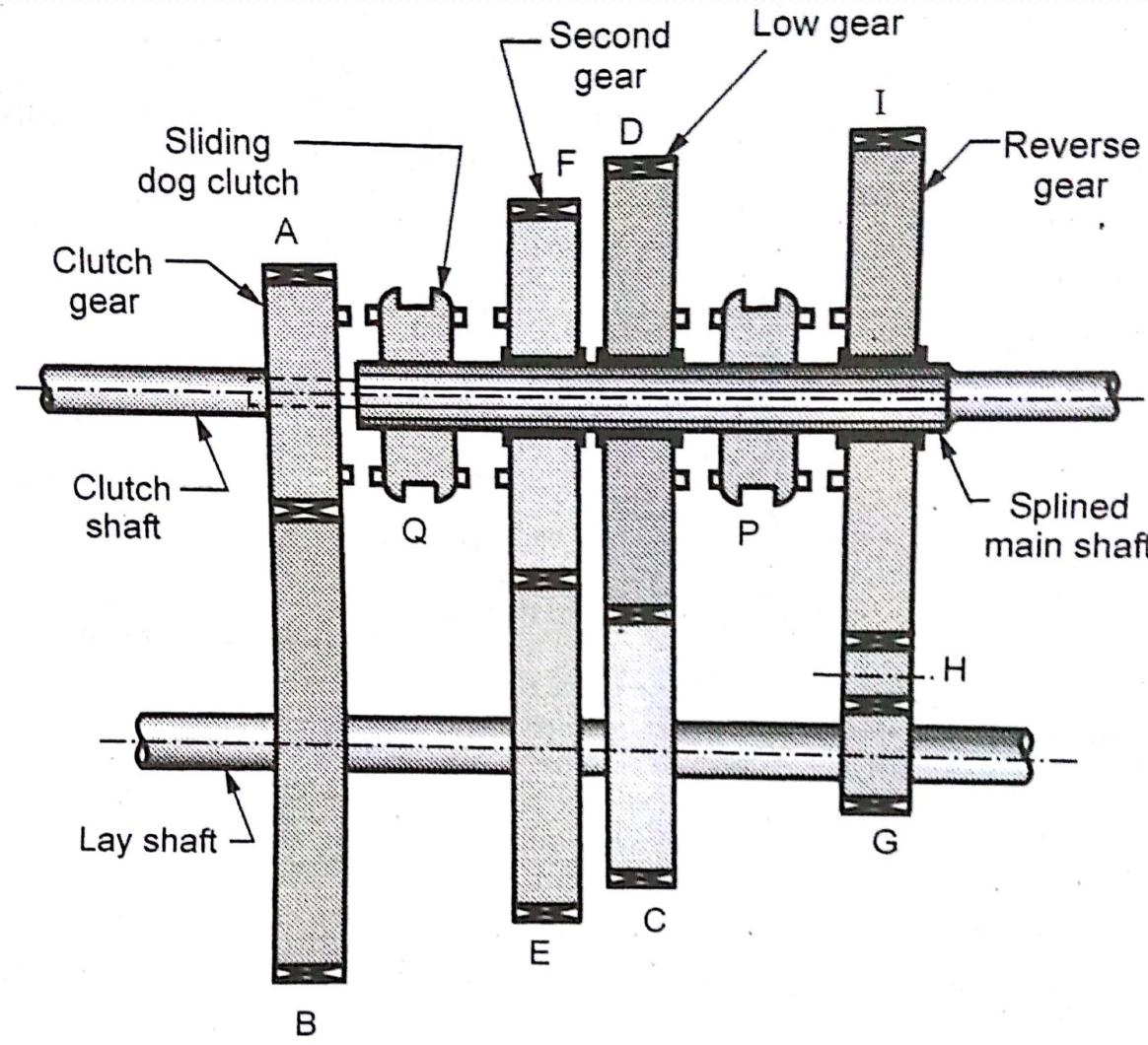
Working: First Gear:

- To engage first gear dog clutch P is shifted towards left side such that it engages with gear D.
- Power Flow:- Gear A – B – C – D to dog clutch P to Main Shaft



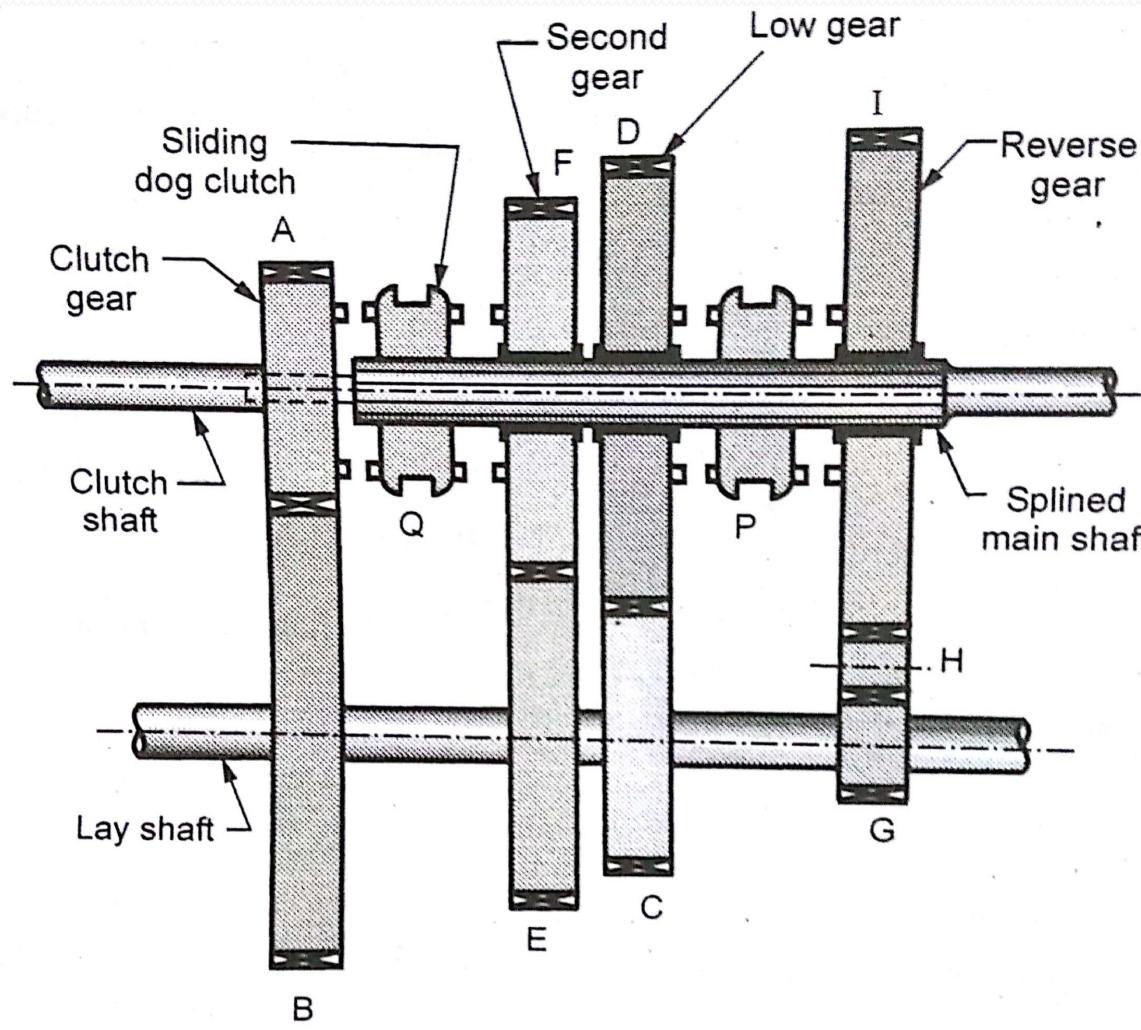
Working: Second Gear:

- To engage the second gear dog clutch P is disengaged.
- Then the dog clutch Q is shifted towards right such that it engages with gear F
- Power Flow:- Gear A – B – E – F then Dog clutch Q to Main shaft.



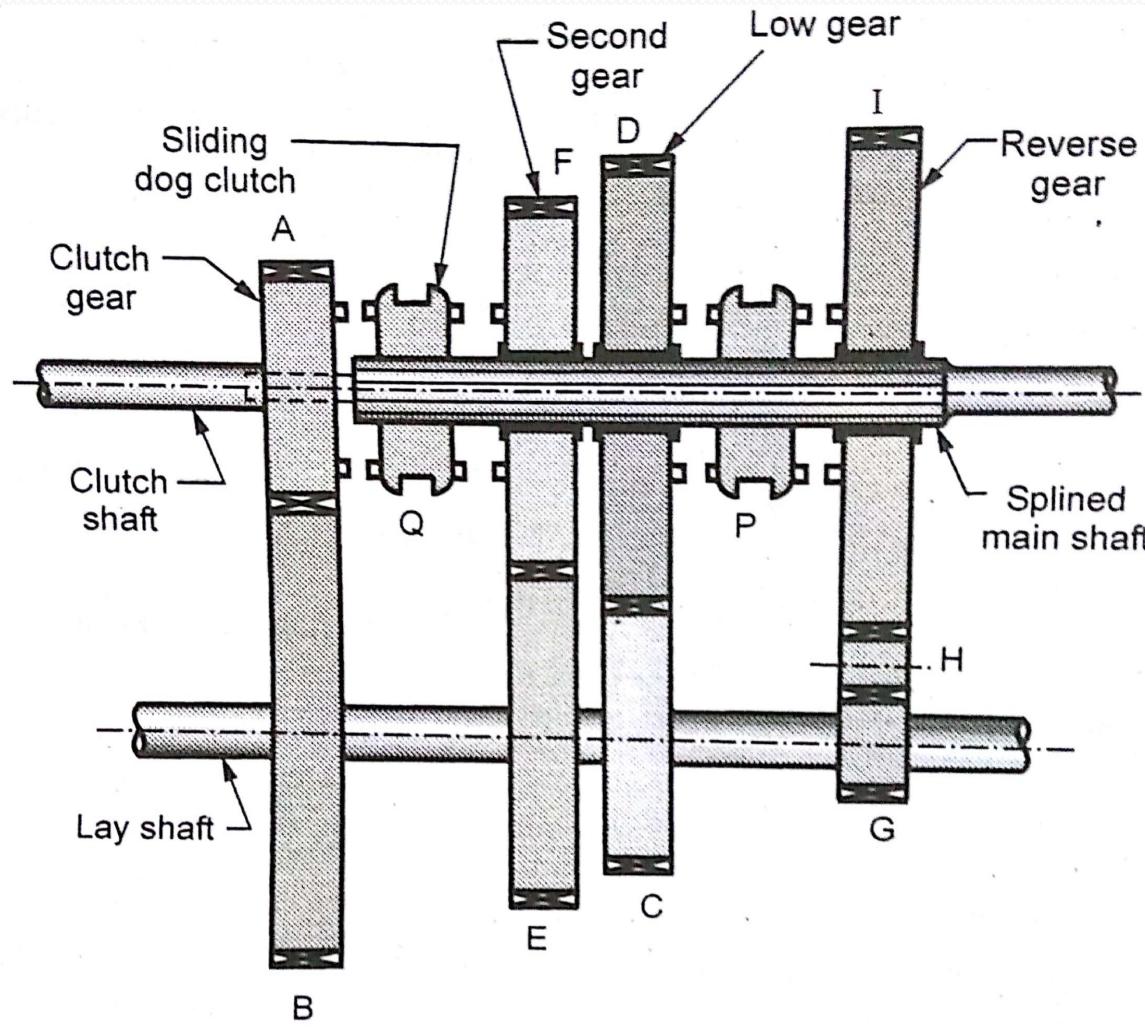
Working: Third Gear:

- To engage the third gear dog clutch Q is shifted toward left.
- It is made to engage directly with gear A.
- Power Flow:- Gear A to Dog clutch Q to Main shaft.



Working: Fourth Gear:

- To engage the reverse gear all other dog clutches are disengaged. Then dog clutch P is shifted toward right to engage with gear I rotate in opposite direction.
- Power Flow:- Gear A – B – G – H -- I then to Dog clutch P to Main shaft.



- **Advantages:**
- Since gears are in constant engagement, helical gears are used.
- With uses helical gears noise produced during operation is reduced.
- Wear and tear of dog teeth is reduced because all the teeth are in contact during power transmission.
- **Disadvantages:**
- Since all the gears are in continuous mesh some amount of power is wasted
- Gear box is costly due to sliding dog clutches.

Sliding mesh type gearbox :

It is simplest type of gear box out of the available gear boxes. In this type of gear box, gears are changed by sliding one gear on the other.

Components of Sliding Mesh Gearbox are as follows:

1. Shafts

- Clutch shaft
- Lay Shaft
- Main Shaft

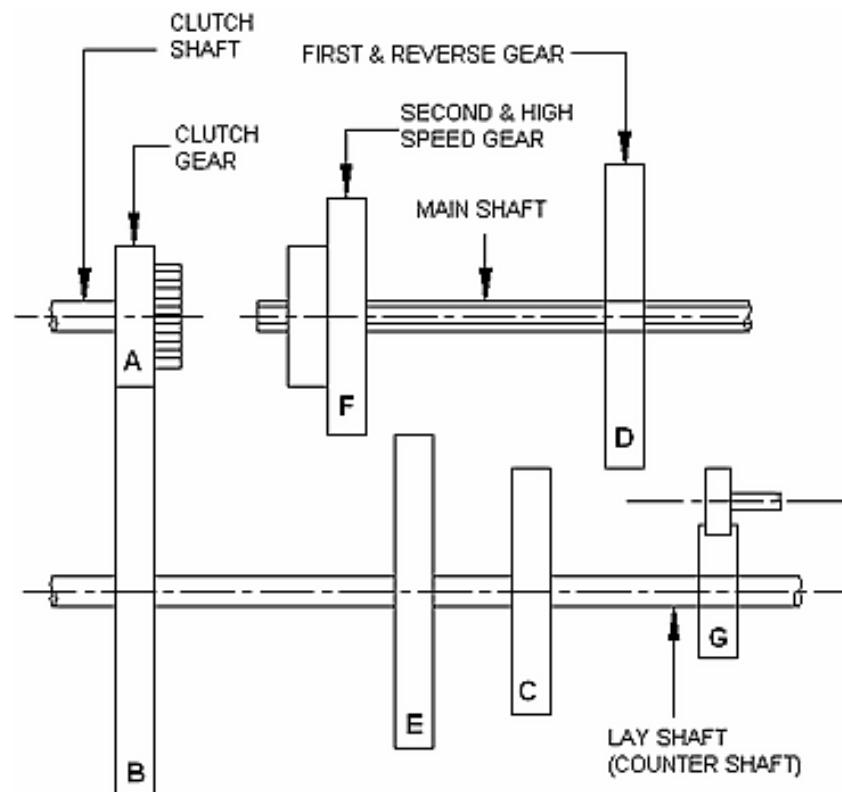
2. Gears

- Fixed Gears
- Movable Gears
- Idler Gear
- Clutch Gear

3. Gear Lever

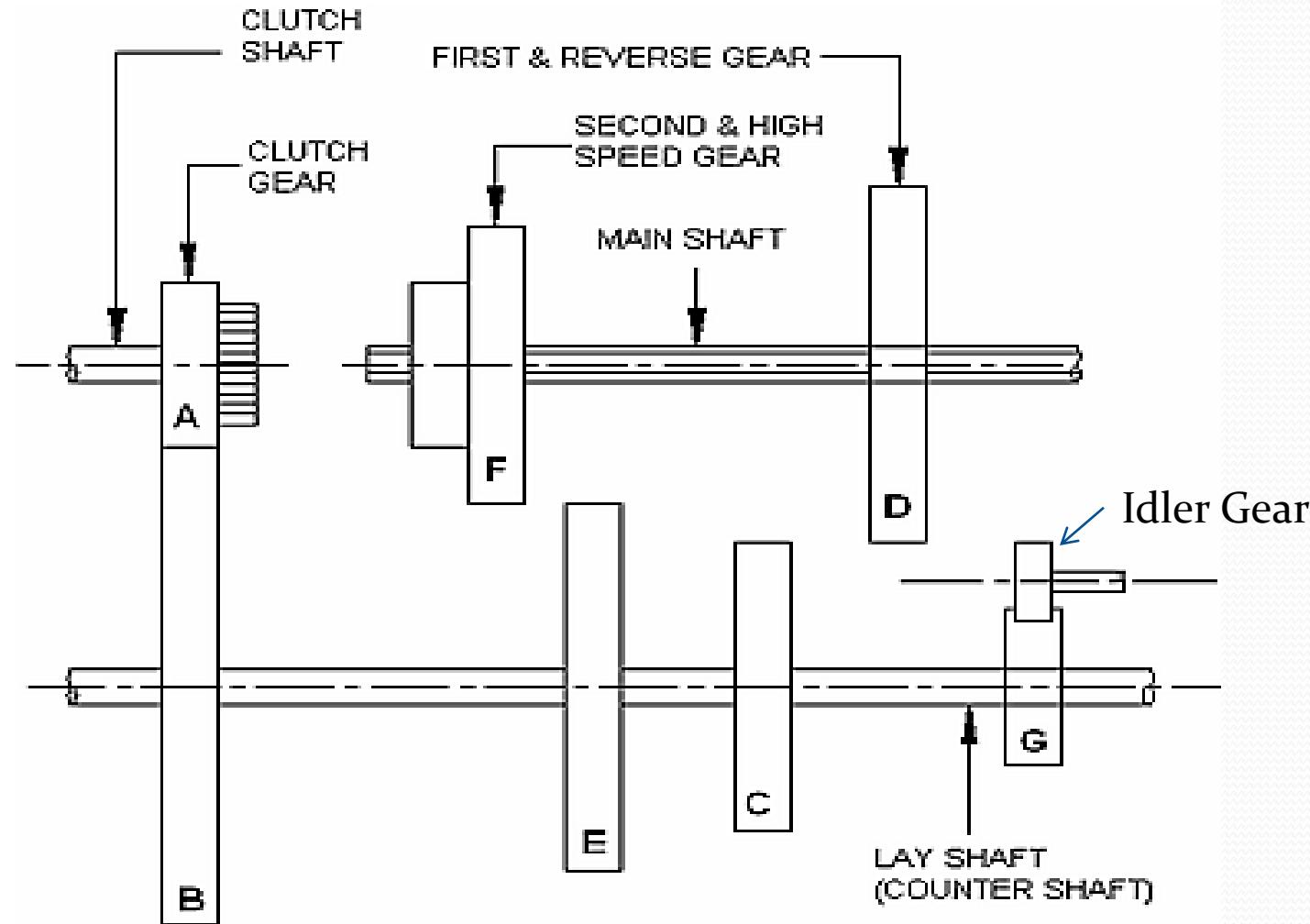
Working of Sliding Mesh Gearbox:

The Sliding Mesh Gear box uses Spur Gears for the transmission of power from the engine shaft to the main shaft. It generally consists of 3 shafts i.e. Clutch shaft, Lay shaft and Main Shaft. It is a transmission mechanism of Just 4 gears and out of these 4, one is the reverse gear. So here we have 1st gear, 2nd gear, Top gear and the Reverse gear. The power comes from the engine to the clutch shaft and thence to the clutch gear which is always attached at the end of clutch shaft. All the gears on the lay shaft are fixed and are in mesh with the clutch gear and main shaft gears.



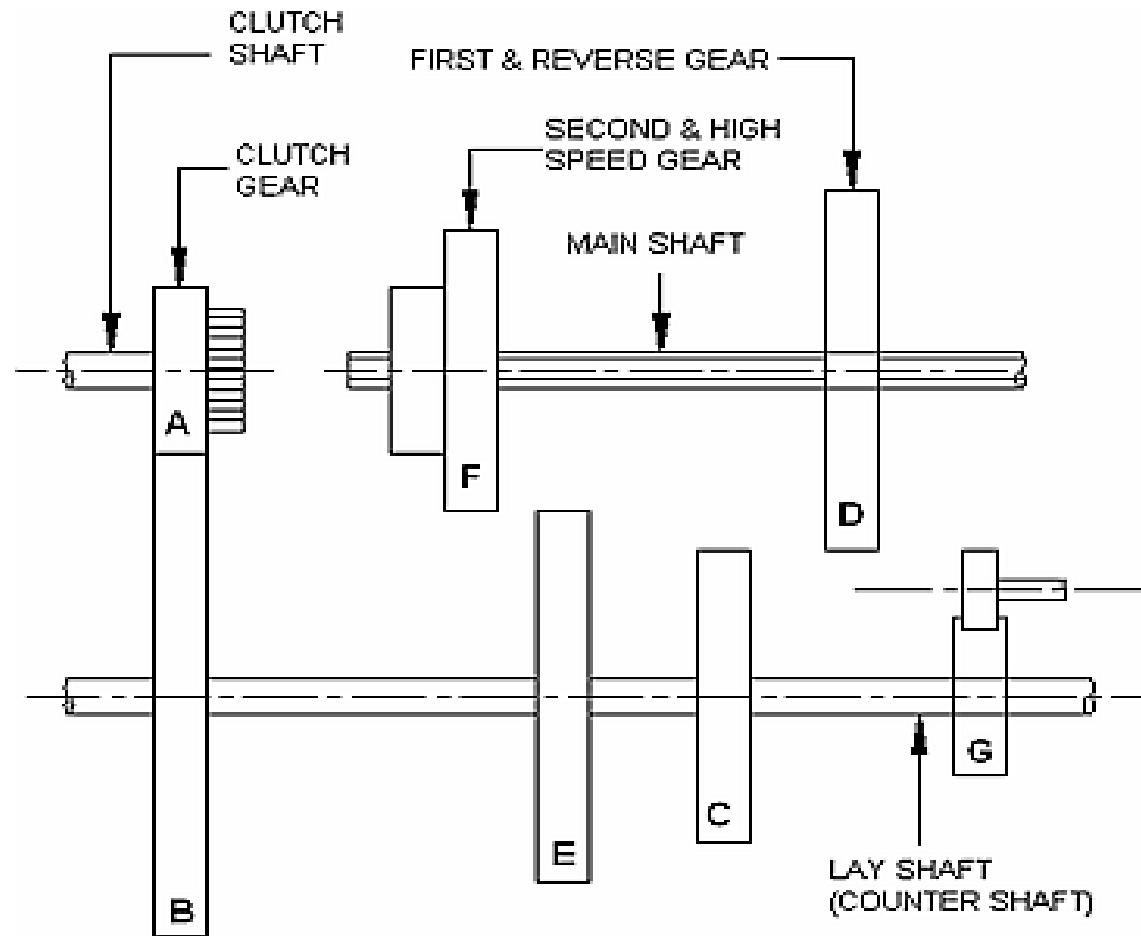
First Gear:

- To engage first gear, gear D is shifted towards left side such that it engages & meshes with gear C.



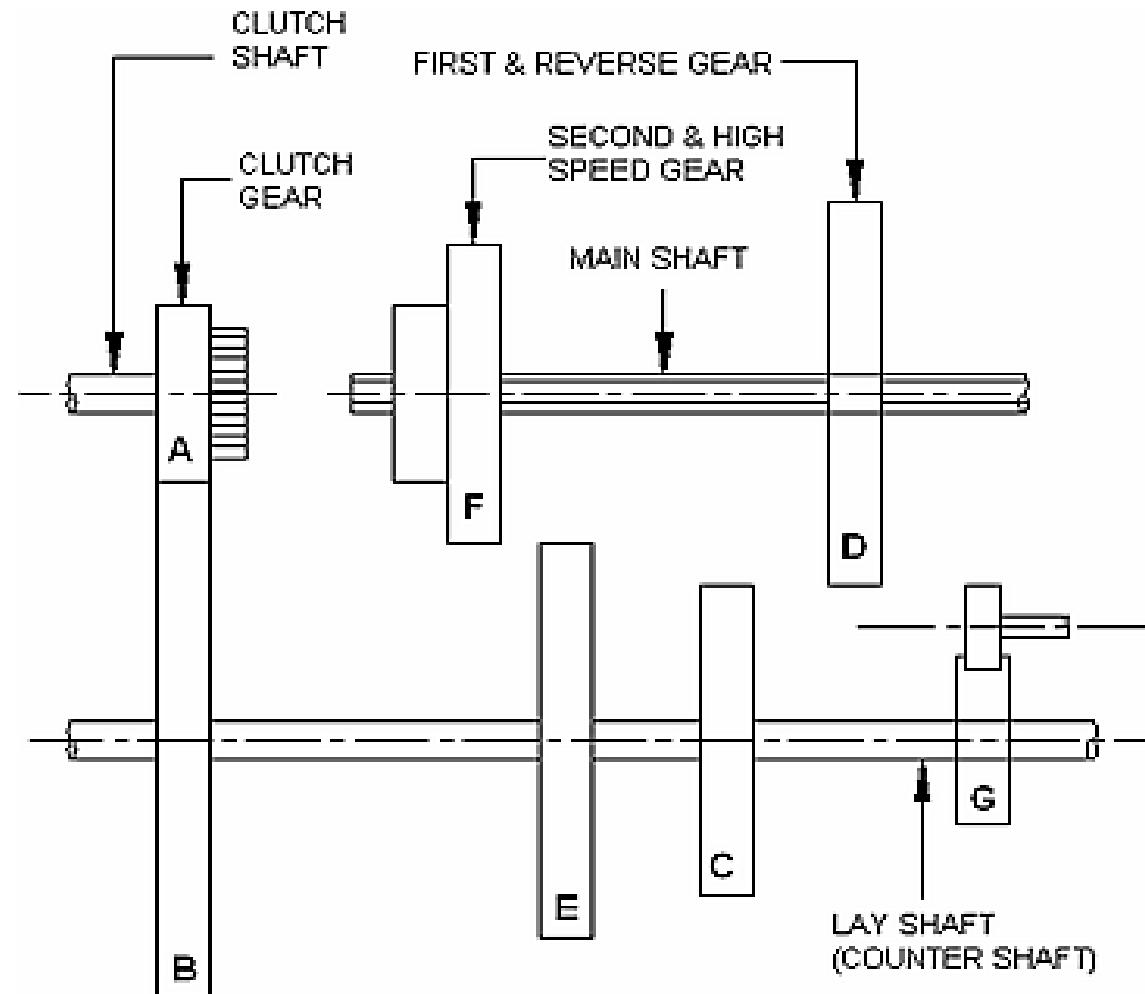
Second Gear:

- To engage the second gear, First gear is disengaged.
- Then the gear F is shifted towards right to mesh with gear E



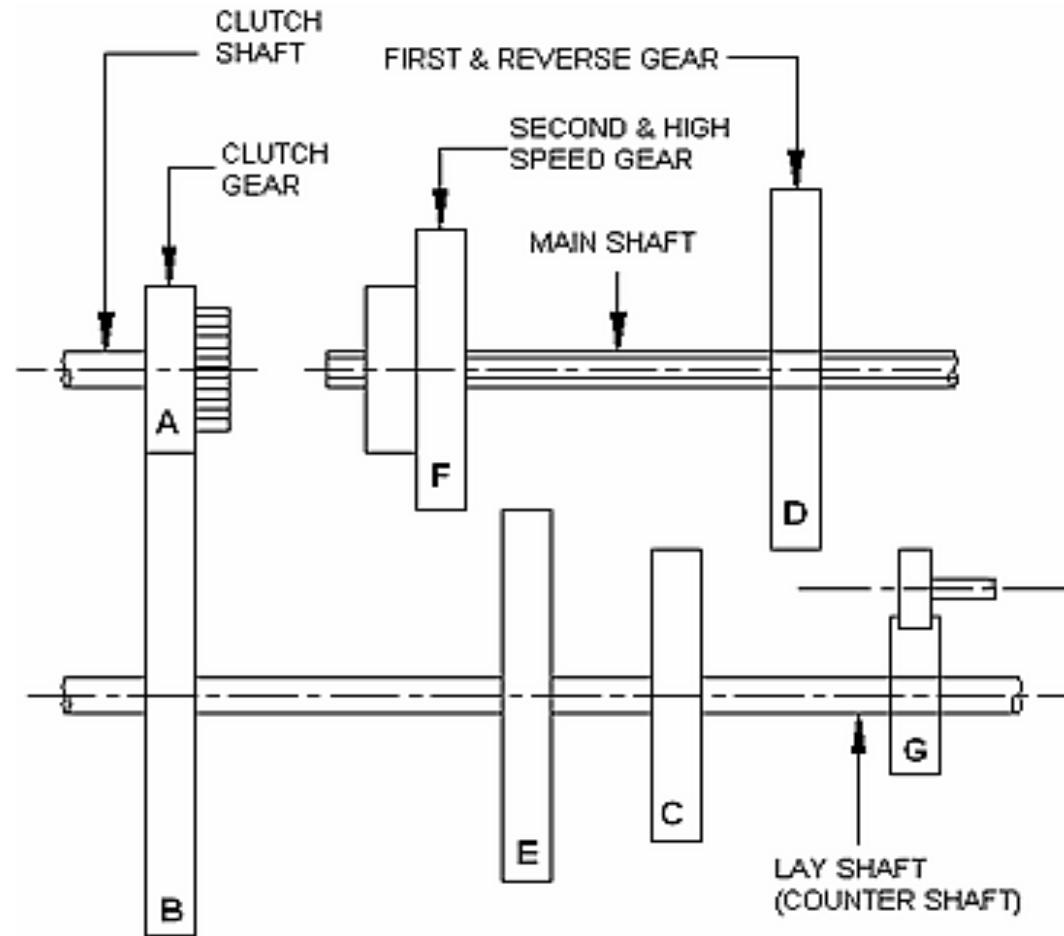
Third Gear:

- To engage the third gear the sliding gear F is shifted towards left such that its teeth meshes with teeth on gear A. This is also called as direct drive.



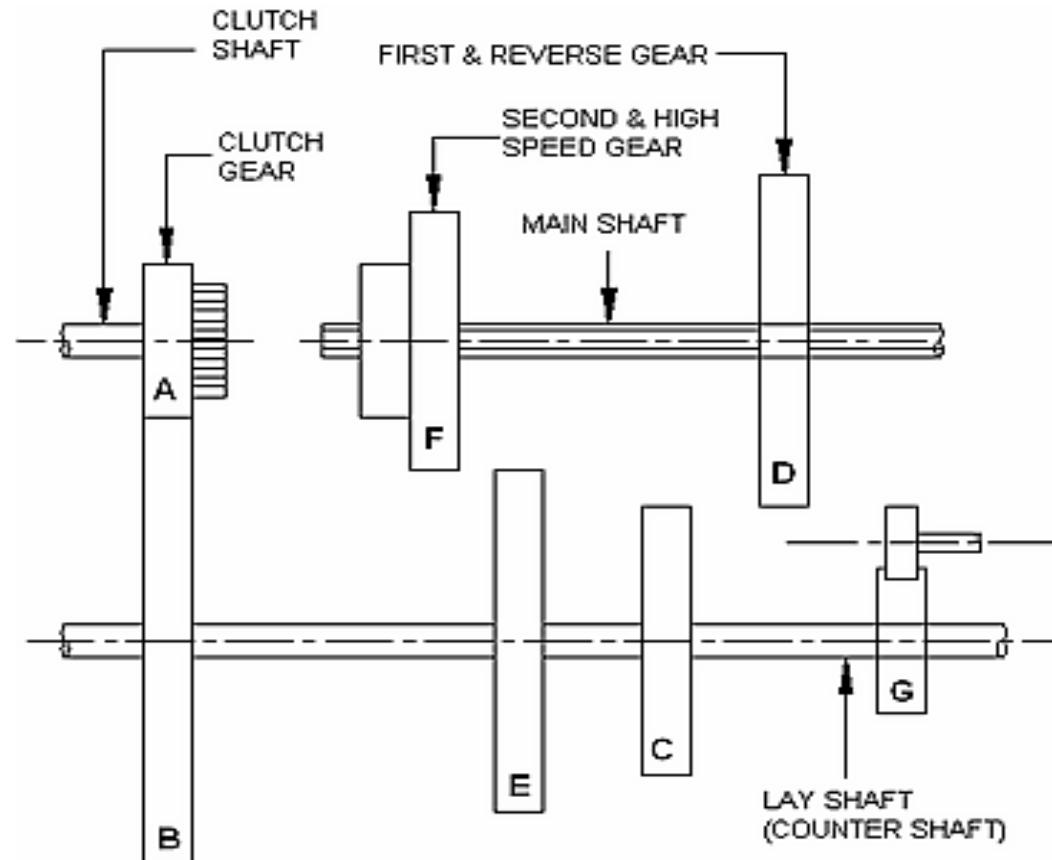
Reverse Gear:

- To engage the reverse gear all other gears are disengaged. Then the sliding gear D is shifted towards right such that it meshes with reverse idler gear H



Neutral Gear:

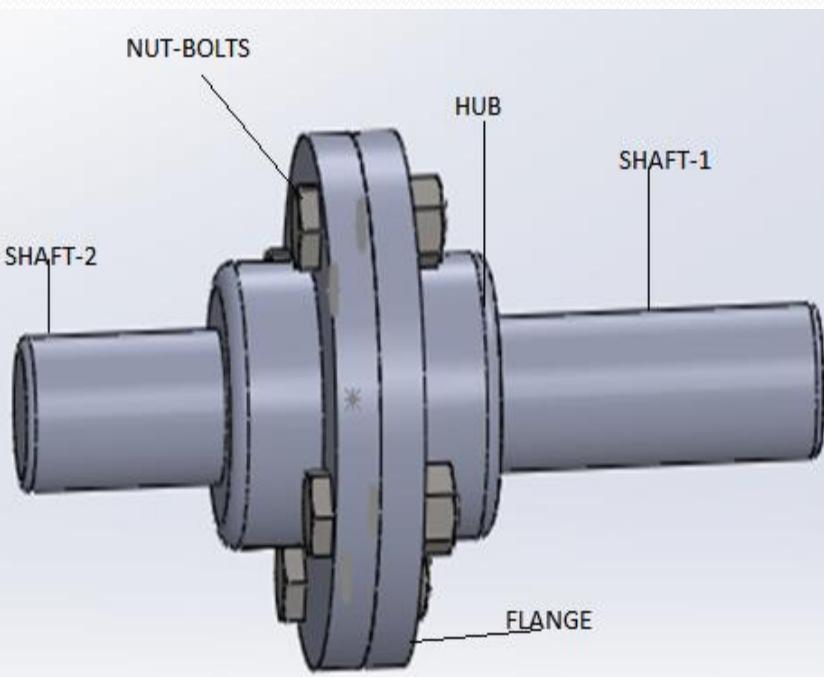
- When engine is running and the clutch is engaged, clutch shaft gear drives the drive gear of the lay shaft and thus lay shaft also rotates. But the main shaft remains stationary as no gears in main shaft are engaged with lay shaft gears.



- **Advantages:**
- It is most simplest in construction & working.
- Since it uses simple spur gear, It is cheaper than other types of gears
- **Disadvantages:**
- Spur gear are noisy in operation
- Teeth wear out is more
- Spur gear can not take any trust load

Coupling

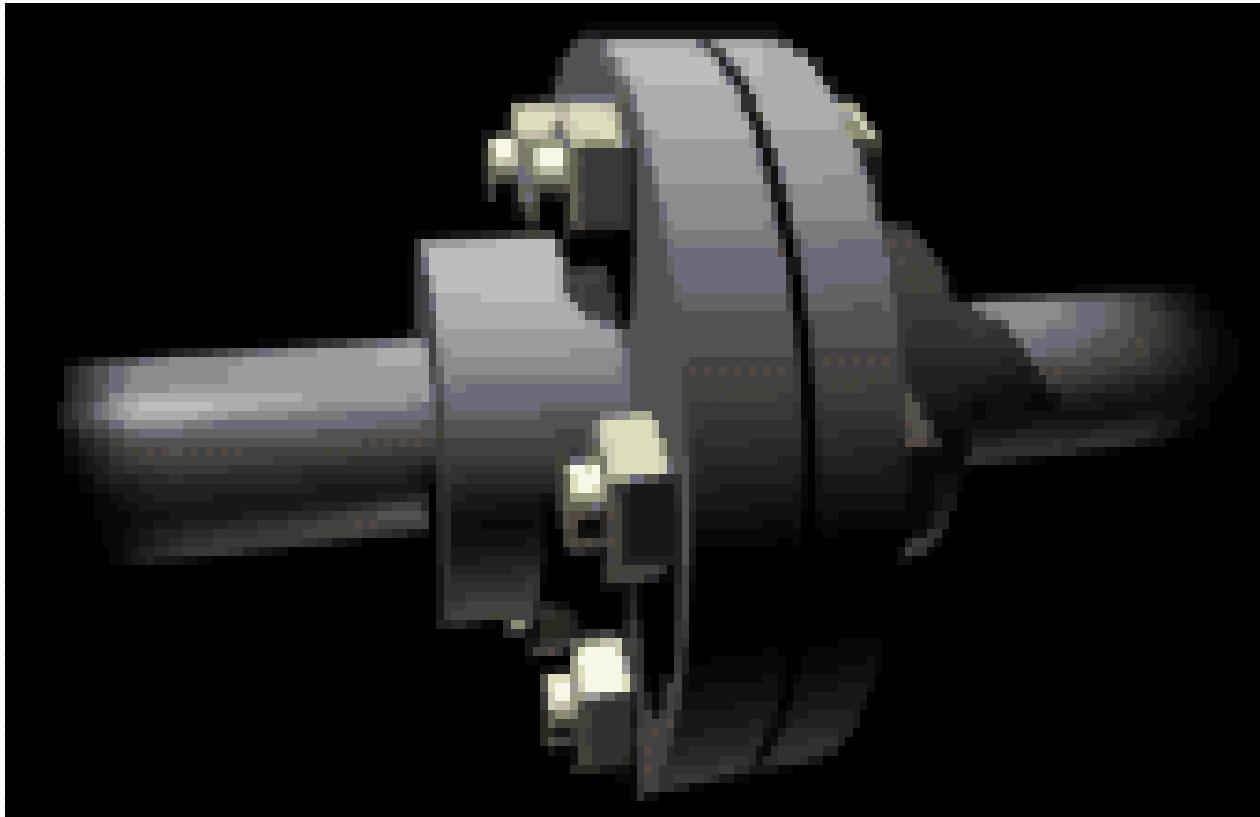
- Coupling is a mechanical element used to connect two shaft of a transmission system and transmit the torque from one shaft to another .



Functions:

- 1) It provides the connection of shafts of two different units such as electric motor and a machine.
- 2) It Makes the provision for disconnection of two units for repairs or alterations.
- 3) It reduces the transmission of vibrations and shocks between two connected units

Coupling



Coupling

Rigid Coupling

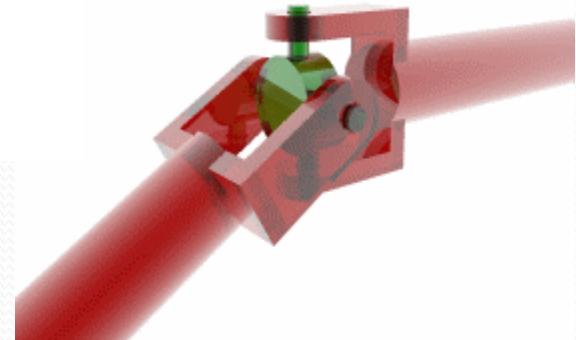
It is a device used to connect two shafts which are perfectly aligned



1. Muff or sleeve coupling
2. Split muff or clamp coupling
3. Rigid flange coupling

Flexible Coupling

It is used to connect two co-axial shafts

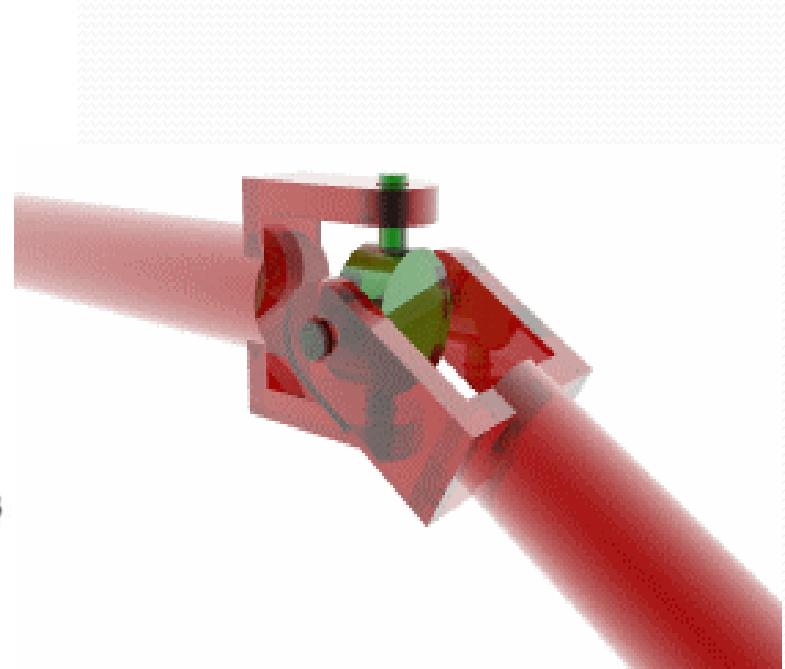
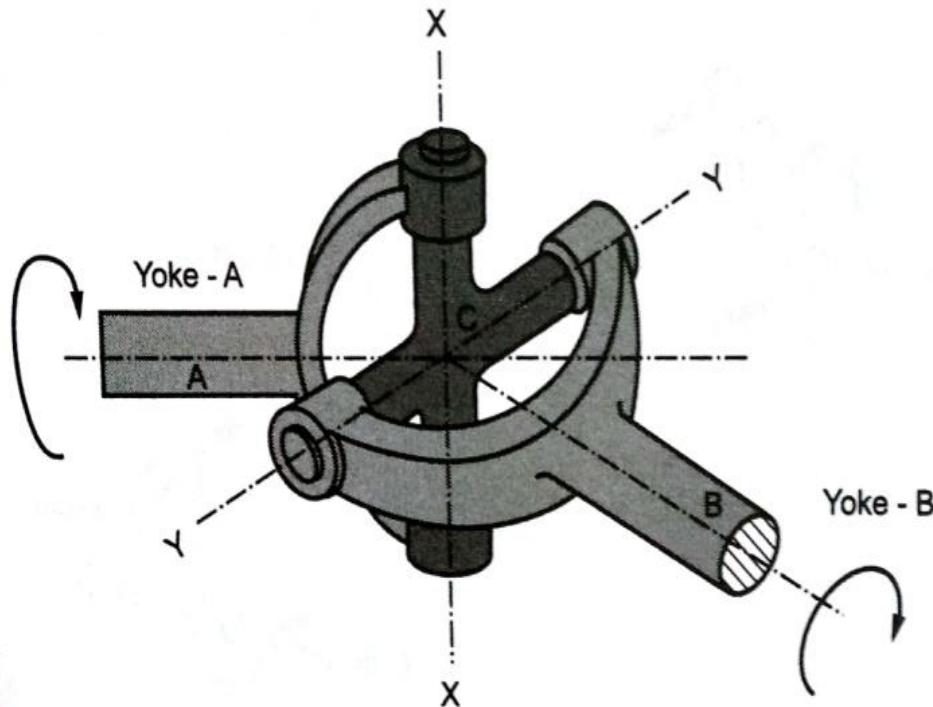


1. Bush pin type flexible coupling
2. Oldham's coupling
3. Universal coupling

Universal Joint:

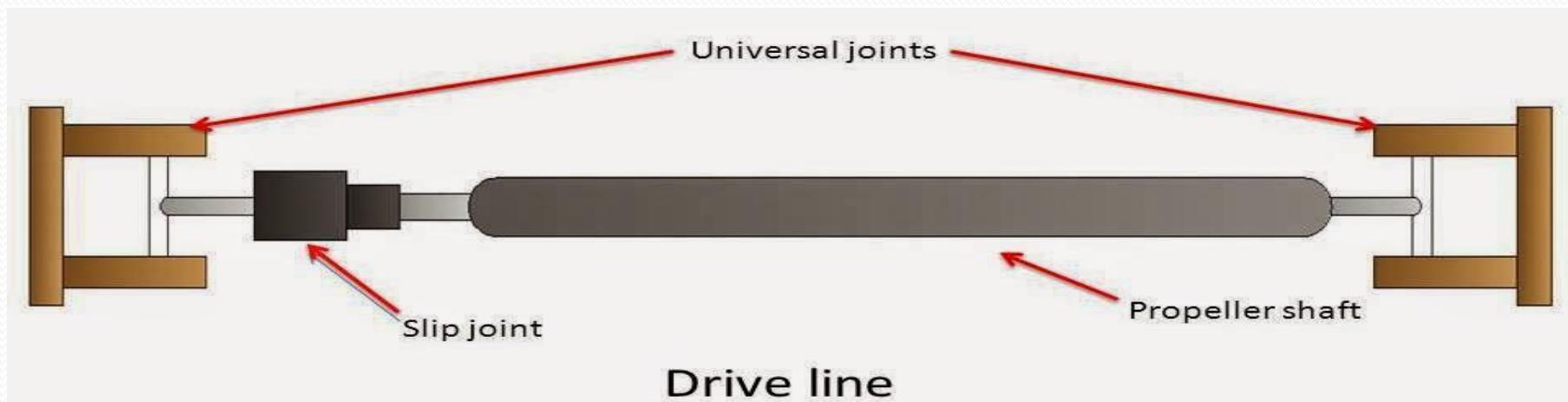
Universal joint is a special type of joint used to transmit power between two shafts that are inclined to each other.

Universal joint is used to transmit power from the gearbox output shaft to the differential input shaft.



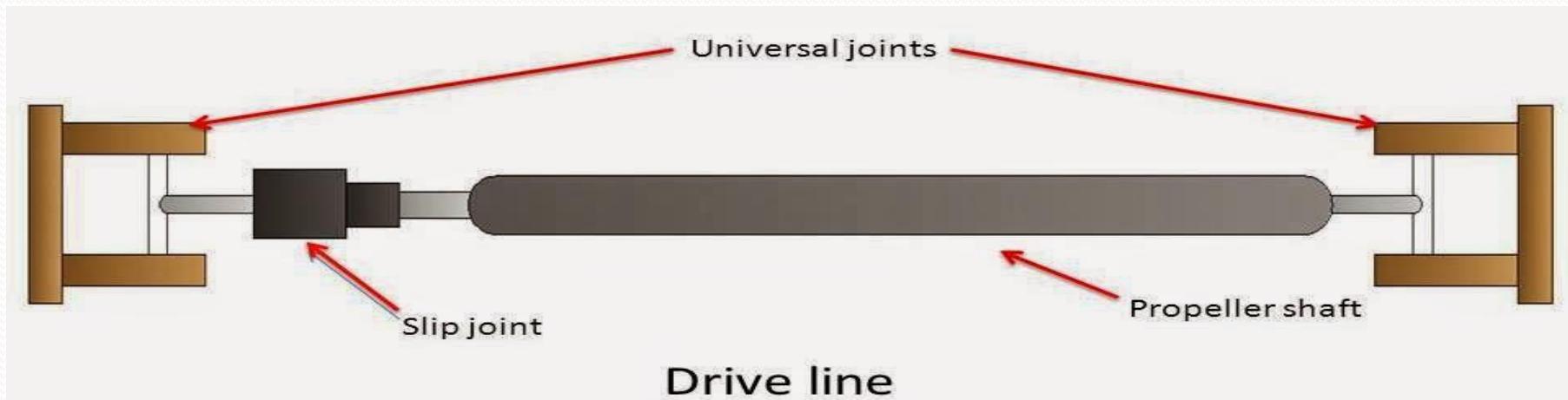
Propeller Shaft :

This is a shaft which transmits power from an engine to the Differential and then to the wheels of a motor vehicle. It is a hollow tubular shaft and consists of mainly three parts.



3. Propeller Shaft :

- *Shaft*: It mainly bears torsional stress produced due to twisting. It is usually made of tubular cross section.
- *Universal joints*: One or two universal joints are used, depending on the type of rear axle drive used. The universal joints help in the up and down movements of the rear axle when the vehicle is in running condition.
- *Slip joint*: Depending on the type of drive, one slip joint may be there in the shaft. This serves to adjust the length of the propeller shaft when demanded by the rear axle movements.



Axle

- An axle is a non rotating machine elements which is used to support rotating machine elements like- wheels, pulleys, etc



Functions:

- 1) To support the power transmitting elements like gears, pulleys, etc

Ex:- Front axle of car, wheel axle of motor cycle, etc

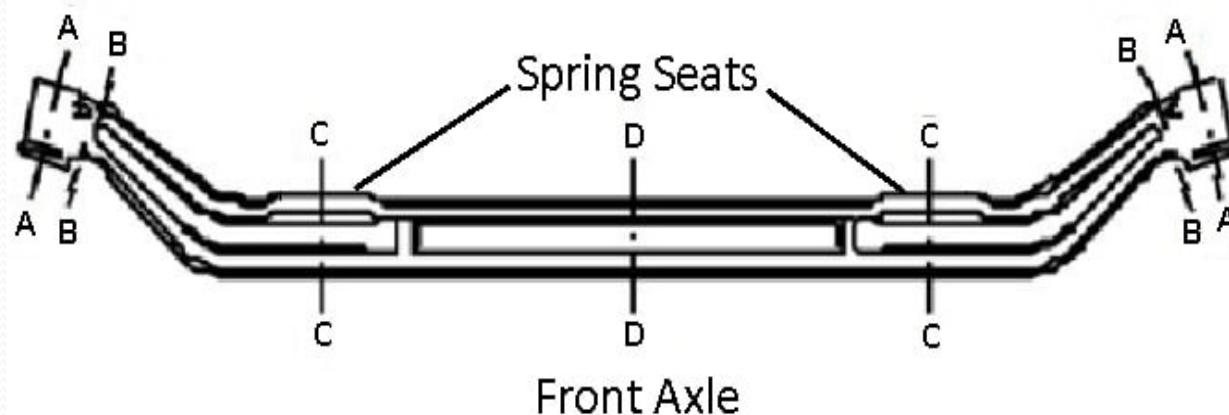
Front Axle:

Front axle is usually a forged member carrying the road wheels at its ends.

It carries the front weight of the vehicle.

It also carries the steering mechanism which is used to direct the vehicle in the desired direction.

Modern cars have live front axle while heavy vehicles use conventional dead front axle.



Rear Axle:

Rear axle drives are employed on front engine rear wheel drive vehicles.

The rear drive axle system consists of important sub- systems such as universal joint, slip joint, propeller shaft, suspension leaf spring, rear axle casing, final drive and differential.

The rear axle drive system subjected to following forces & torques.

Weight of the vehicle

Driving thrust

Torque reaction

Side thrust

Differential Gearbox:

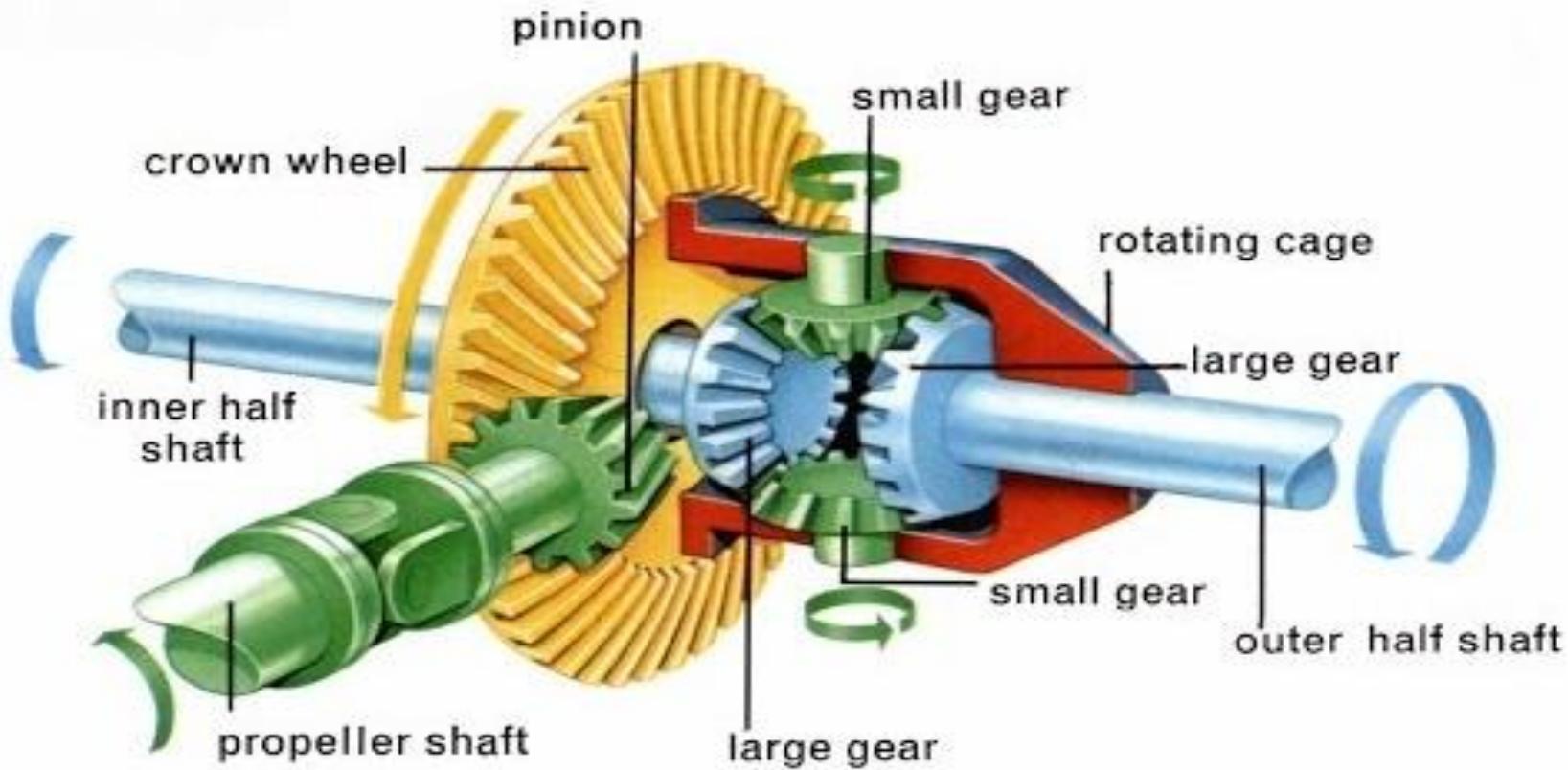
The differential gear is a part of the power transmission device. The driving force generated by an engine is transmitted to the tires through various types of bevel gears.

Consist bevel gears.

The differential gear assembly absorbs rotational differences due to the direction change of the rotational axis drive and/or the rotational differences between the right and left wheels that lead to smooth cornering.

During turn, the outer wheel must cover a greater distance than the inner wheel. However, since both wheels must travel around the turn at the same time, the outer wheel must rotate faster than the inner wheel.

The propeller shaft has a small bevel pinion which is in mesh with the crown wheel at right angle this crown wheel rotates the rear axles. The axles are two half shafts. The rotation of propeller shaft converted at right angles (90°) to the rear axles. The crown wheel size is larger than the size of the pinion bevel gear hence the speed of crown wheel is lower than bevel pinion



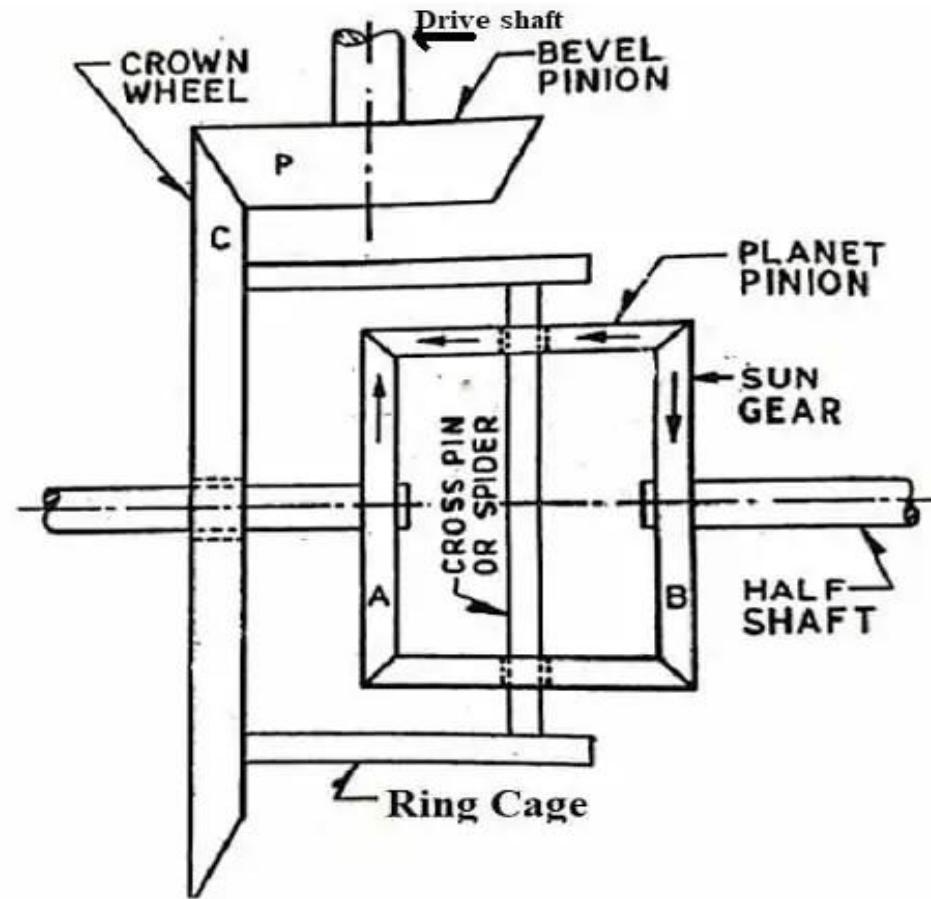
Components of Differential:

The components of Differential are as follows:

- Ring Gear or Crown Wheel
- Planet Pinion
- Drive Shaft
- Bevel Pinion
- Half Shafts
- Sun Gears – 2 No's
- Ring Cage
- Cross Pin

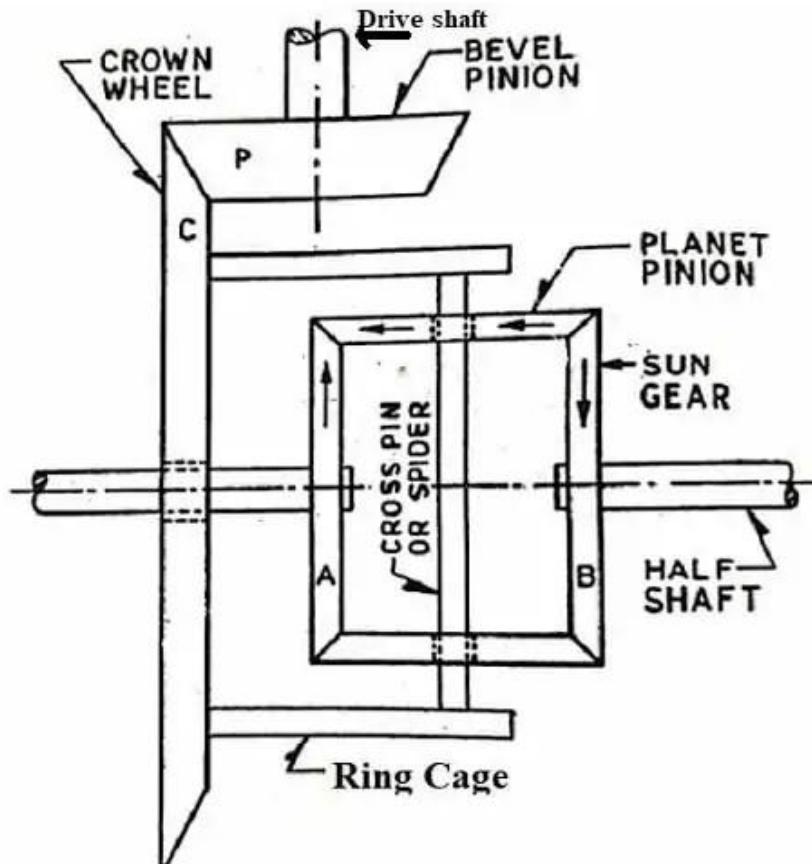
Ring Gear or Crown Wheel

Ring Gear will transmit the power to the Planet Pinions, Sun Gears and finally to the half shafts so that power will be used to drive the wheels.



The working Principle of Differential can be understood by the following 3 cases.

- **Case 1:** Vehicle is moving in STRAIGHT Direction.
- **Case 2:** Vehicle is Taking the TURN



Case 1: Vehicle is moving in Straight

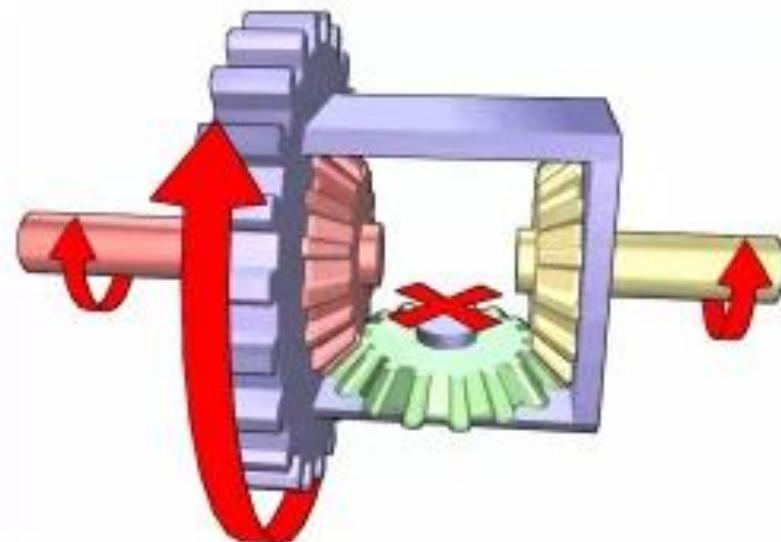
Direction :

Condition: $N_{\text{left}} = N_{\text{right}}$

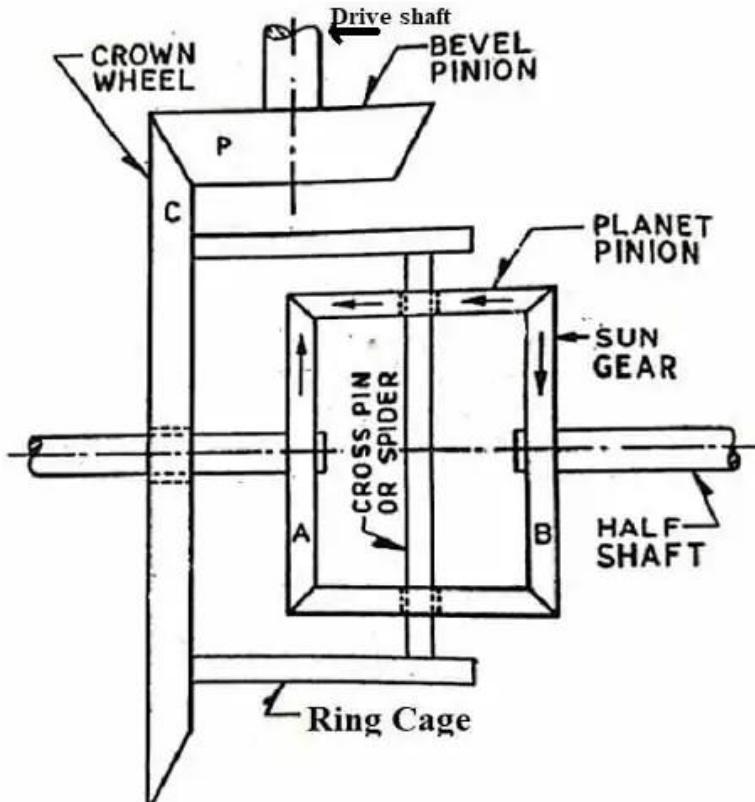
When the Vehicle is moving in Straight direction, then the speed of Rear wheels is same, in the sense both wheel rotate at the same speed. In this case, the Sun gears, Planet Pinions and the Ring Cage will act as a single unit and the two half shafts will revolve at the same speed.

In this situation, when all the parts of the differential act as a single unit, there is no relative motion among them and that's the reason all the rear wheels move with the same speed.

i.e. $N_{\text{left}} = N_{\text{right}}$



Case 2: Vehicle is Taking the Right Turn: Condition: $N_{\text{left}} > N_{\text{right}}$



Thus consider a vehicle moving in a straight direction with a speed 'N' rpm and when it takes a turn towards Right, at this time there will be a resistance offered to the motion of the right wheel and as a result of differential action, the right wheels rotate back at 'n' rpm and the left wheel rotate forward at 'n' rpm. This will give the Resultant speed of the Right wheels as $(N-n)$ and the Left wheels as $(N+n)$.

Advantages of Differential:

- Inspite of large amount of power delivered from the transmission system, the differential reduces the speed w.r.t. its movement in the right or left direction.
- It turns the flow of power by 90 degrees.

Disadvantages of Differential:

consider one side of the rear wheel is under the surface with a good traction and the other wheel is on a slippery track.

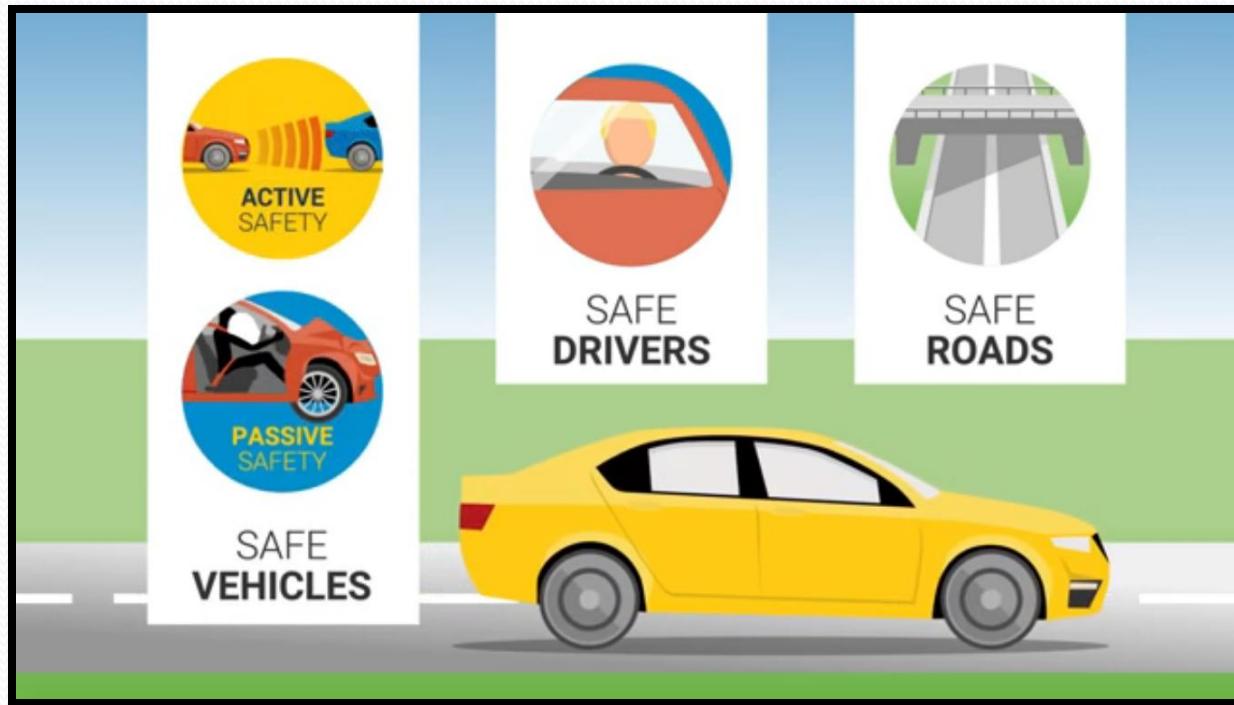
In this case, the standard differential sends the majority of the power to the slippery wheel and due to this, the vehicle won't be able to move from its position and in order to overcome this, limited slip differential are introduced.

Vehicle Safety :

Vehicle safety is the study and practice of design, construction, equipment and regulation to minimize the occurrence and consequences of traffic collisions.

The consideration for safety of an automobile is of two type;

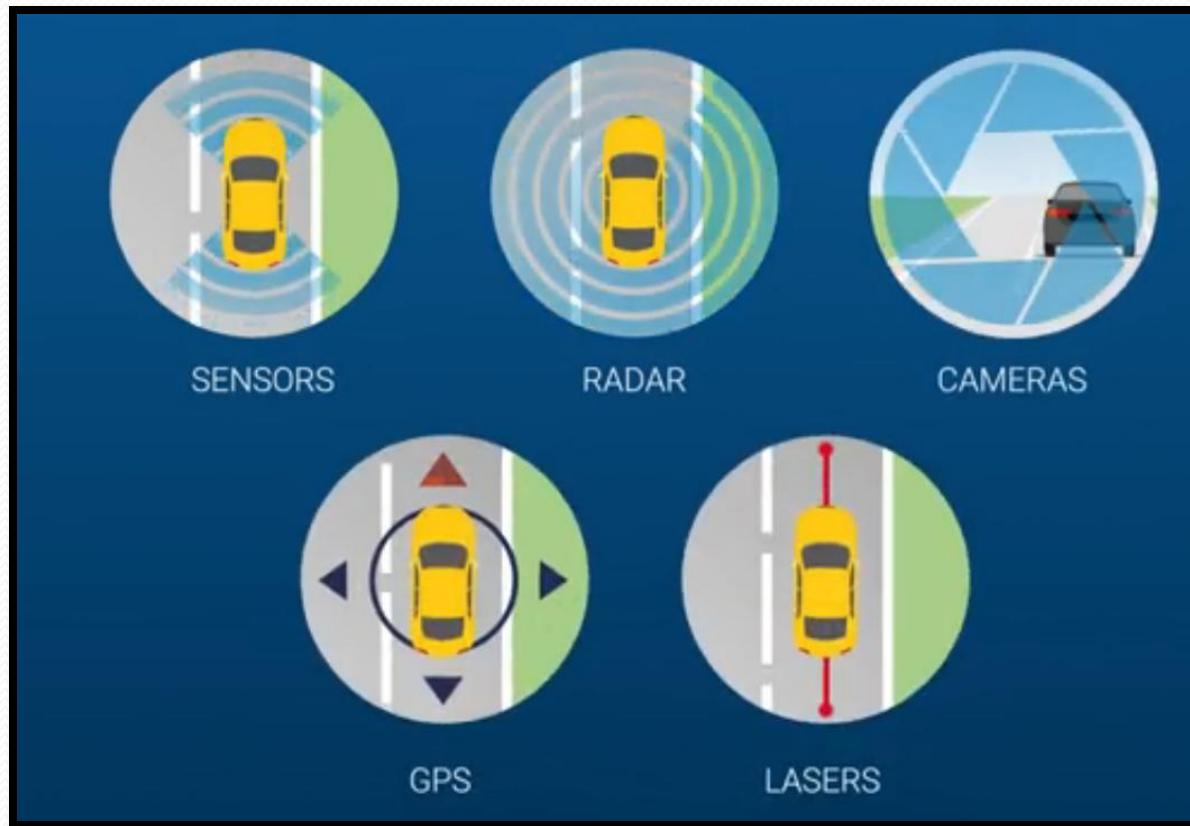
- 1.Active Safety
- 2.Passive Safety



1.Active Safety :

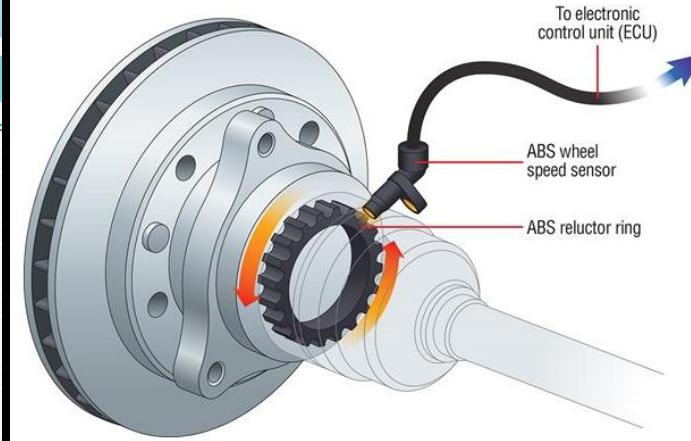
It plays the Preventive role in avoiding crashes and accidents by providing advance warning to the driver with additional assistance.

- Features works silently in background
- Some active safety indicators are as follows;



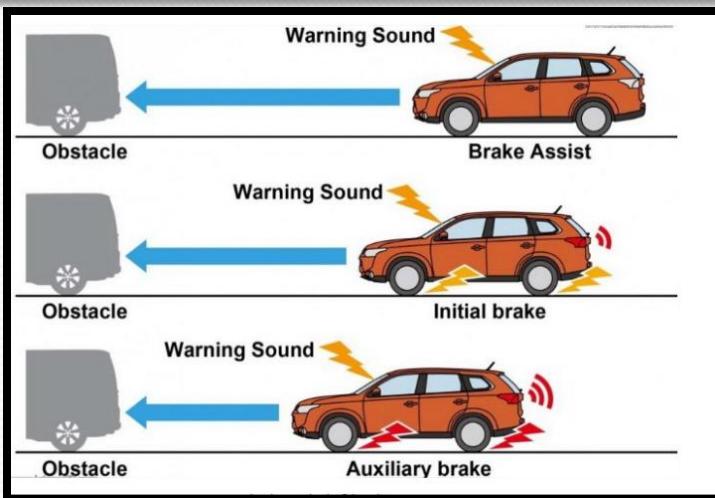
1. Antilock Braking System

ABS is an automobile safety system prevent the wheels of vehicle locking as brake pedal pressure is applied.



2. Collision Warning System

This sensors recognize the danger of collision. It's working based on speed of vehicle and distance to obstacle



3. Electronic Stability Control

A function is to prevent Vehicle Skidding.

It contains wheel speed sensors, accelerometer, yaw sensors, steering wheel sensors, brake force control, EBD



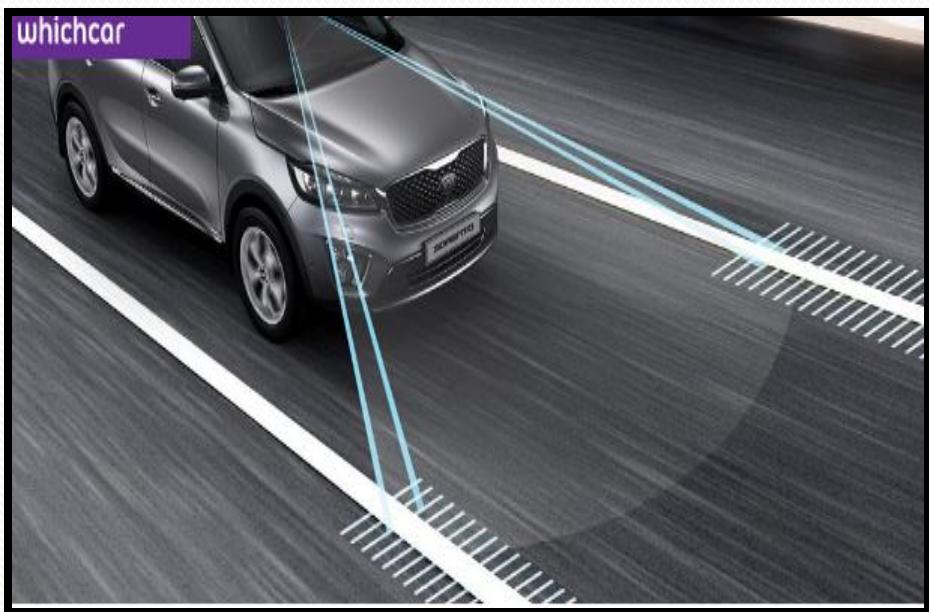
4. Blind Spot Detectors

Blind spot area is the area around the vehicle that can not be directly observed. It is shown by flashing warning or vibration in wheels. i.e. visibility and audibility warning.



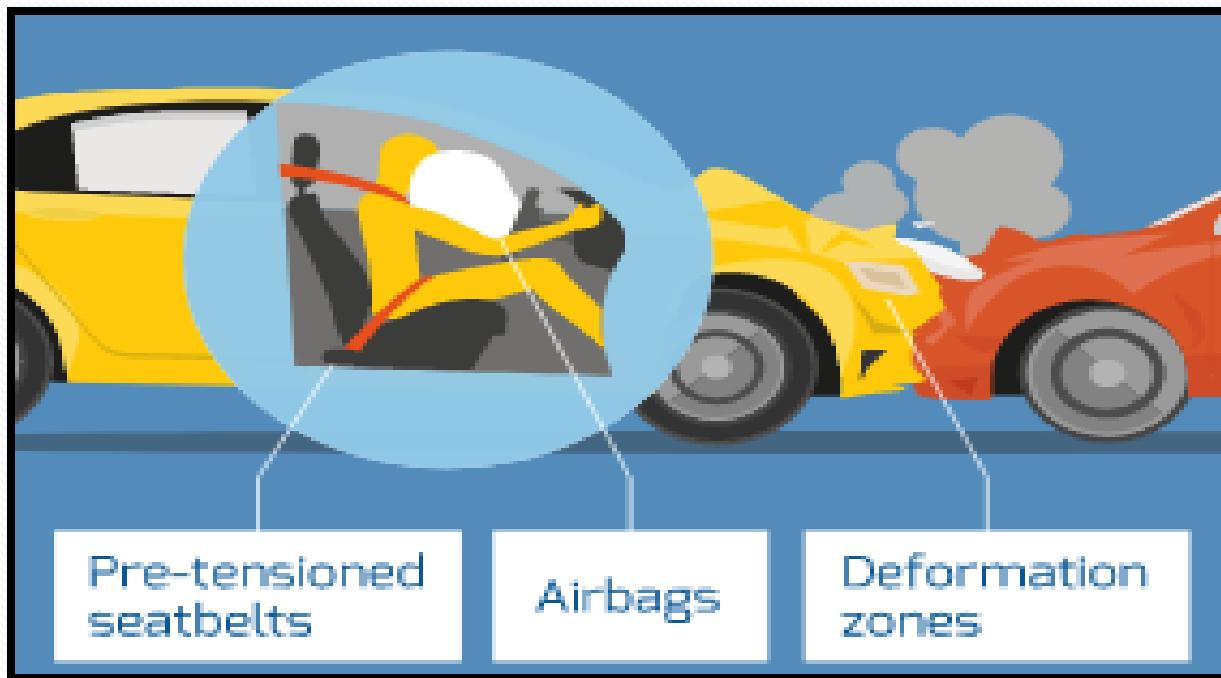
5. Lane Departure Warning System :

It can prevent a car from unintentionally running off the road, had lowered the rate of single-vehicle sideswipe and head-on crashes.



Passive Safety :

- Protect the occupants of the vehicle and other road users if a crash occurs.
- Reduce the impact of an accident or the level of injury.
- Some Passive Systems like; Seat belts, airbags, Head restraints, child safety system, Laminated glass etc



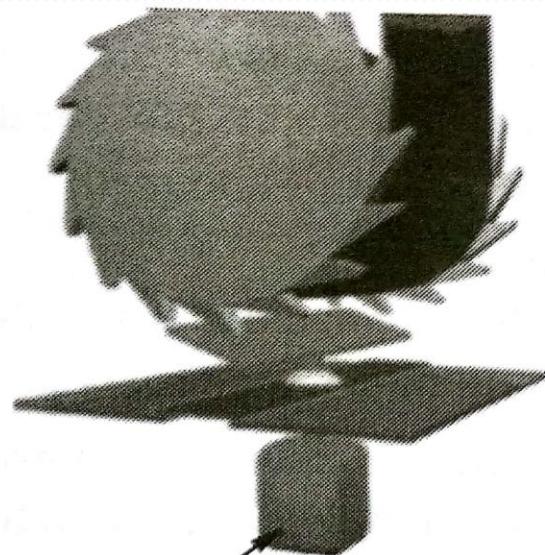
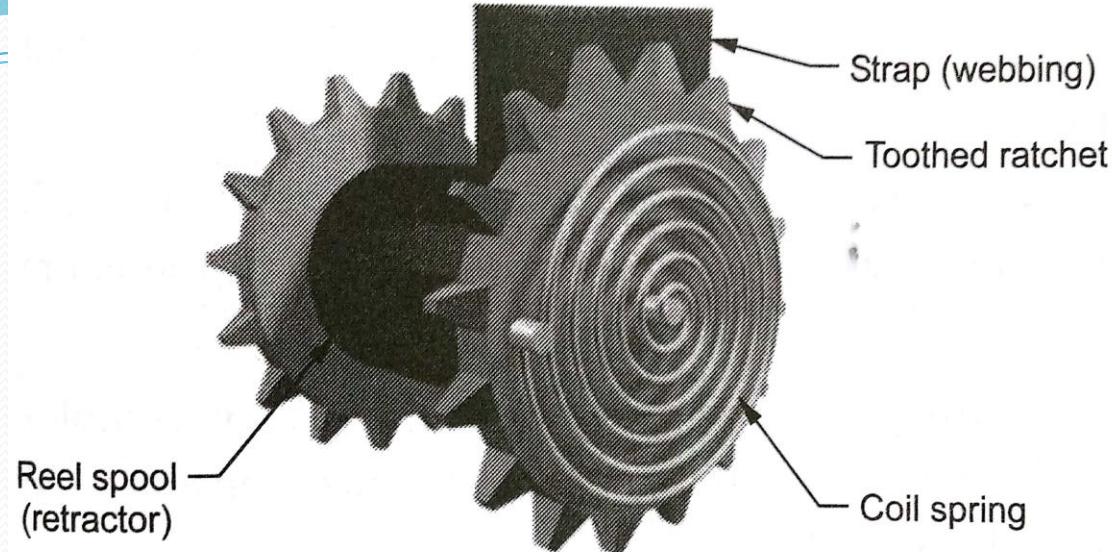
Seat belts :

A properly worn seat belt provides good protection but does not always prevent injuries. Three point lap/sash seat belts offer superior protection to two point seat belts and should be installed in all seating positions.

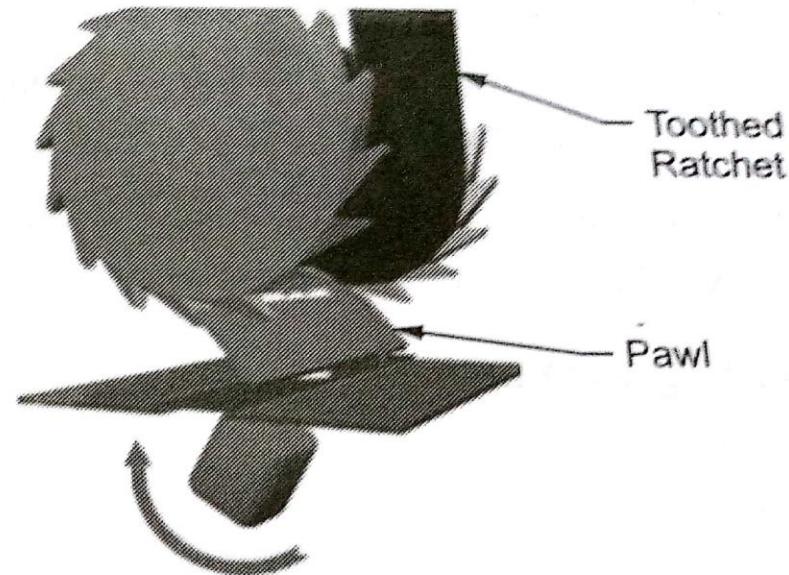
Recent improvements to seat belt effectiveness include:

- webbing clamps that stop more seat belt reeling out as it tightens on the spool
- pretensioners that pull the seat belt tight before the occupant starts to move
- load limiters that manage the forces applied to the body in a crash
- seat belt warning systems to remind you if seat belts have not been fastened.





(a) Under normal condition



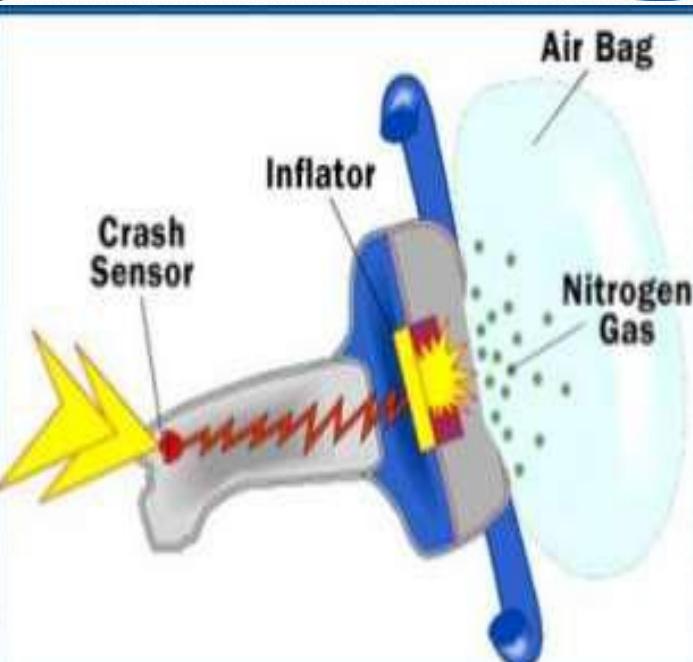
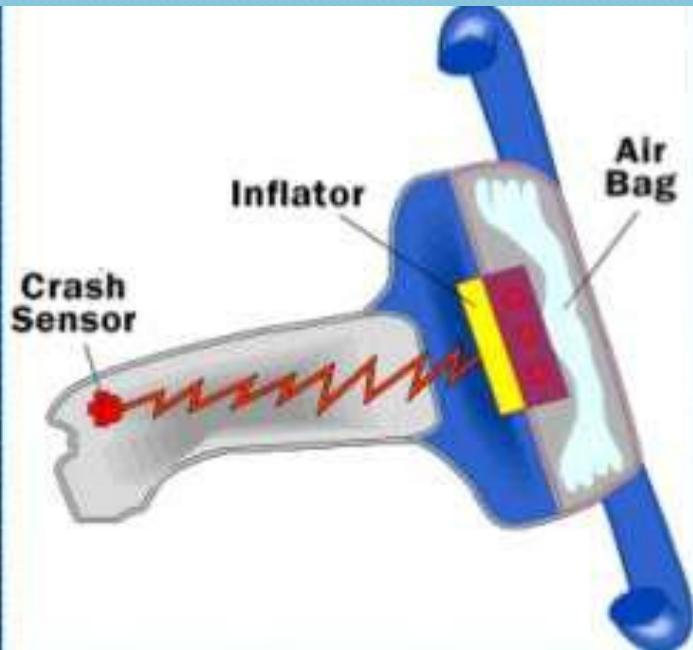
(b) Under rapid deceleration, reel gets locked by pendulum movement

Airbags :

Airbags are designed to supplement the protection provided by seat belts - they are not a substitute. The best protection in frontal crashes is achieved using a properly worn seat belt in combination with an airbag.

Drivers' airbags or frontal airbags typically deploy from the steering wheel to protect the driver from striking other parts of the car in a frontal crash.

Drivers' airbags are designed to be used in conjunction with seatbelts and do not offer protection in the event of a side impact crash.



Airbags help cushion the impact, reducing your momentum more slowly so that the force is less.

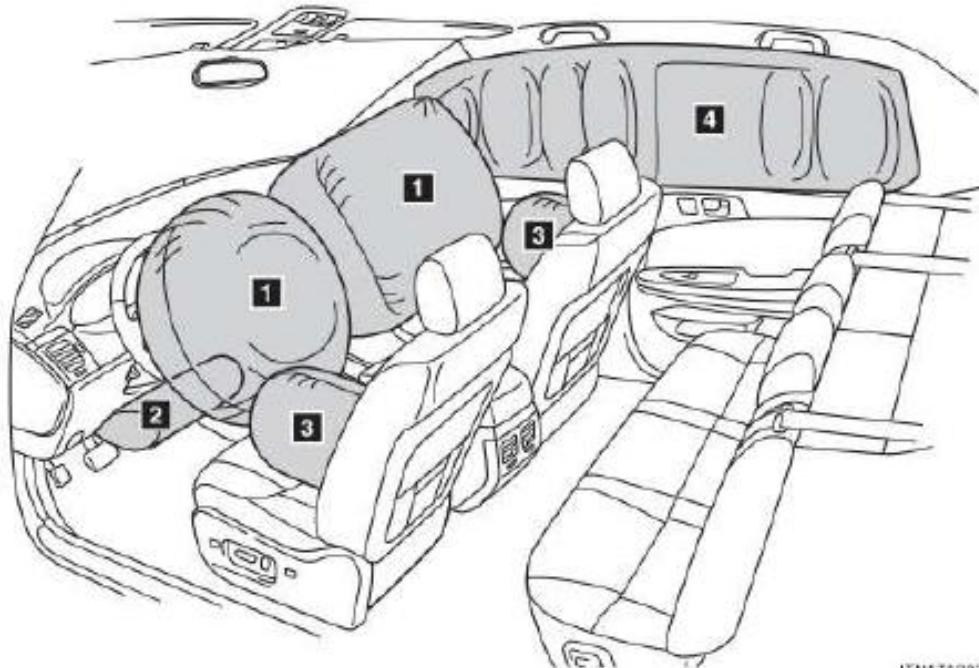
Airbags are intended to be used as a supplementary device to the seatbelt.

Airbags inflated



SRS & air bags

The SRS airbags inflate when the vehicle is subjected to certain types of severe impacts that may cause significant injury to the occupants. They work together with the seat belts to help reduce the risk of death or serious injury.



ITN17A002a

► Front airbags

1 Driver airbag/front passenger airbag

Can help protect the head and chest of the driver and front passenger from impact with interior components.

2 Knee airbag

Can help provide driver protection.

► Side and curtain shield airbags

3 Side airbag

Can help protect the torso of the front occupants.

4 Curtain shield airbag

Can help protect primarily the head of front occupants and rear outboard occupants.

Child-protection Rear Door Locks :

- This safety feature disable the rear doors' inside release handle via a small lever on the door-shut face.
- The rear doors can be opened only from outside and not accidentally by children from inside.
- The feature is activated manually by depressing the small lever down.

