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Unit IV : Vehicle systems

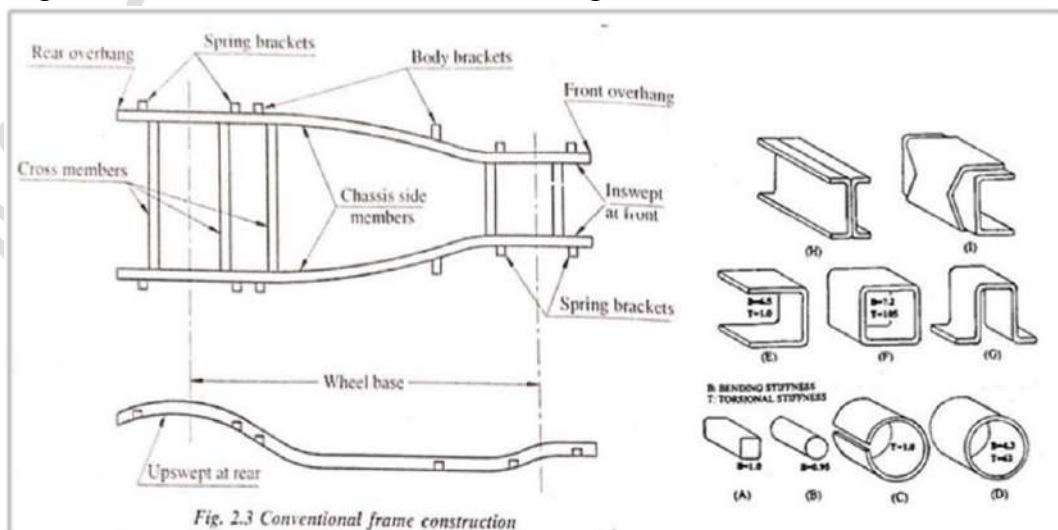
- Chassis layout,
- Suspension system,
- Steering system, Front axle, Ackermann steering mechanism
- Braking system,
- Cooling system,
- Fuel injection system & fuel supply system MPFI & Diesel

- a. State and explain any four systems of Two Wheeler. [6m]
- b. What is chassis? Draw the layout of Chassis of vehicle. [6m]
- c. What are the different layouts of vehicle. [9m]
- d. Explain with neat sketch "Front Engine Rear Wheel Drive" (FERWD). [6m]
- e. Explain with neat sketch "Articulated Vehicle Layout" [6m]
- f. What is Suspension system of automobile vehicle? State its functions. [6m]
- g. With neat sketch explain the Suspension system (leaf spring arrangement) [4m]
- h. Explain with neat sketch "Hydro-Gas Suspension System". [6m]
- i. Describe Steering System with sketch. [5m]
- j. State the functions of Braking system. [4m]
- k. Explain working of Mechanical Brake. [6m]
- l. What is the necessity of cooling System? What are the different methods of it? [6m]
- m. With neat diagram, explain cooling system used in four wheeler Engines. [6m]

1. Automobile Chassis :

chassis layouts : Concept of Chassis, Types of chassis layouts to be covered with arrangement of different components on it .

- Chassis is a basic structure of vehicle. Chassis carry all parts of vehicles. Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted



- Automobile chassis is usually made of light sheet metal. It provides strength needed for supporting vehicular components and payload placed upon it.
- Automobile chassis helps keep an automobile rigid, stiff and unbending. Auto chassis ensures low levels of noise, vibrations and harshness throughout the automobile.
- The frame is made of Box, Tubular channel or U-shaped sections ; which are welded or riveted together.

Types of Chassis (According to control)

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

Backward control (conventional chassis)

- Here engine is usually mounted in front of driver's seat. This offers advantage as safety of driver in case of head collision.
- Driver's front view is reduced as well as space utilization for pay load is also reduced.

Forward control chassis

- The engine is mounted completely inside driver's cabin.
- Full utilization of space.
- Driver's safety is reduced to large extent in case of head on collision with other vehicle.

Semi- forward control chassis

- Half engine fitted inside driver's cabin.
- This chassis layout gives advantage good drivers safety and more space utilization.

Typical Layouts in Automobile :

1. Front Engine Rear Wheel Drive (**FERWD**)
2. Rear Engine Rear Wheel Drive (**REPWD**)
3. Front Engine Front Wheel Drive (**FEFWD**)
4. All Wheel Drive (**AWD**)
5. Articulated Vehicle Layout (**AVL**)

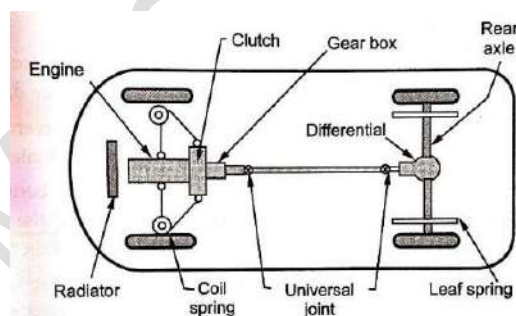


Fig. 6.4.1 Layout of front engine rear wheel drive

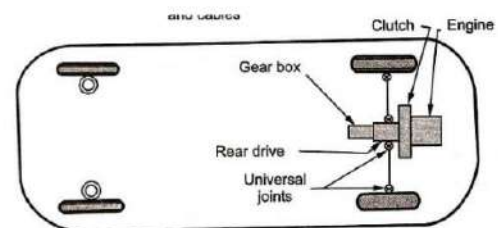


Fig. 6.4.2 Layout of rear engine rear wheel drive

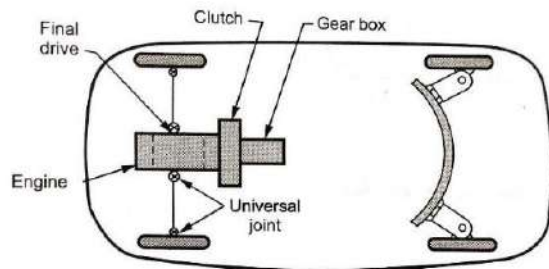
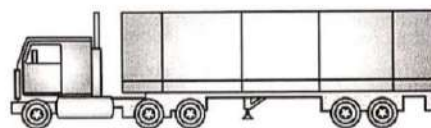
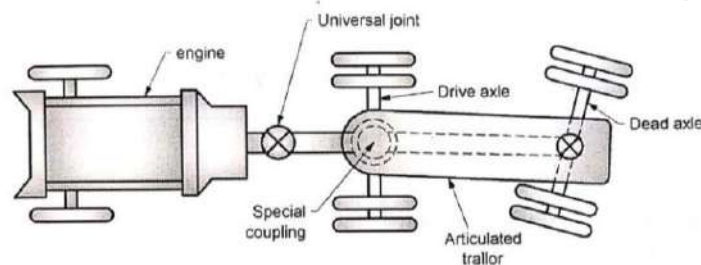
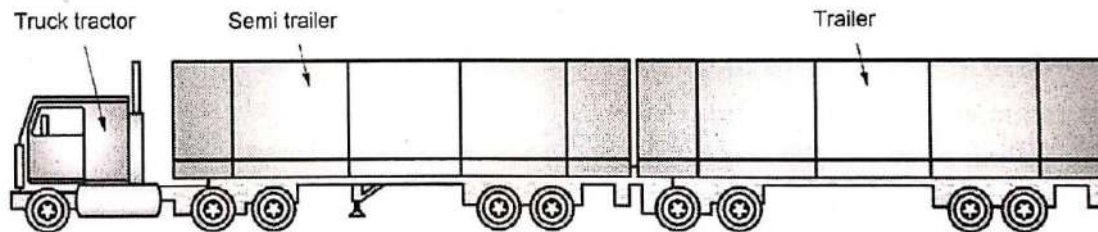
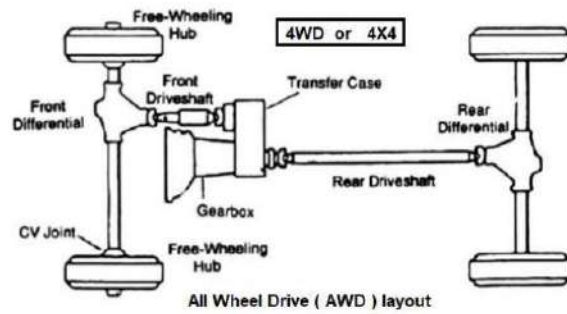


Fig. 6.4.3 Layout for front engine front wheel drive



Articulated vehicle the word articulated comes from the [Latin](#) *articulus* : small joint

An articulated vehicle is a vehicle which has a permanent or semi-permanent pivoting joint in its construction, allowing the vehicle to turn more sharply. There are many kinds of articulated vehicles, from heavy equipment to buses, trams and trains. In a broader sense, any vehicle towing a trailer could be described as articulated. Example: Busses, Trucks, Tractor, Locomotive, Heavy Equipments like [Front loaders](#), [graders](#), [dump trucks](#) and other vehicles have been made with articulated joints to greatly reduce their [turning radius](#). The most common models of [articulated haulers](#) are [Caterpillar](#), [Volvo](#) trucks ranging in tonnage from 25 to 40 ton.

Advantages of Articulated Vehicle :

Heavy loading capacity, better handling & turning – ease of steering & direction control on straight as well as curved path , ease of disengagement of tractor component thereby reducing loading and unloading time, Less cost of transport per unit Ton of material handled per km.

Limitations of Articulated Vehicle :

Articulated vehicles are not suitable on roads with sharp turns, Accidents or skidding leads to more damage due to huge size, Gross vehicle weight is higher leads to wasting more fuel in driving empty vehicle itself, Longer vehicles are not permitted in some countries or roads.

2. Steering system : Types of steering system & Focus on Ackerman's steering mechanism.

The purpose of steering system is to allow the driver to control the direction of vehicle by turning the front wheels. This is achieved by means of steering wheel and a steering column.

Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radii.

Ackermann Steering Mechanism is most widely used, has following main components- 1. Axle beam, 2. Stub axle, 3. King Pin (swivel pin), 4. Tie Rod (Track Rod), 5. Rack & Pinion, 6. Steering column, 7. Steering Wheel

- A steering column transmits the rotation of the steering wheel to the steering gears.
- The steering gears increase the rotational force of the steering wheel in order to transmit greater torque to steering linkage.
- The steering linkage transmits the steering gear movement to the front wheels of the vehicle

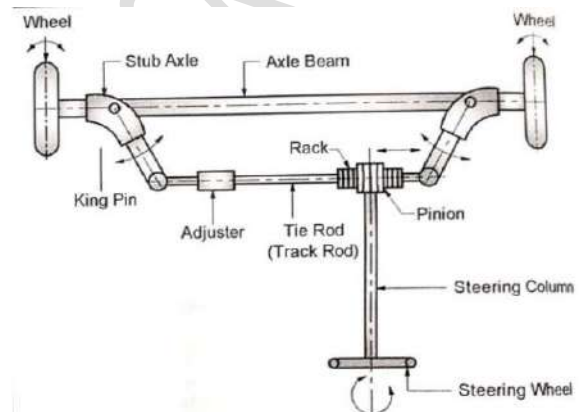
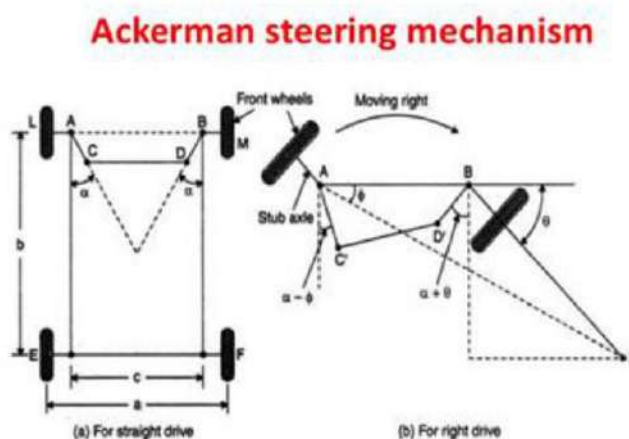


Fig. 4.4.1 : Steering System (Ackermann Steering Mechanism)

To reduce the efforts of driver, a hydraulic or electric power assistance to the turning efforts is applied to manual steering; called Power Steering.

Advantages

- Drive and Rotation functionality are separately.
- Typically, more stable.
- Less wear of joints

Disadvantages

- Mechanically complicated.
- Often complicated maneuvers (non-holonomic) means it does not have the ability to move in all direction and rotate independently.

3. Suspension system : Types of suspension system & Focus on Telescopic suspension system.

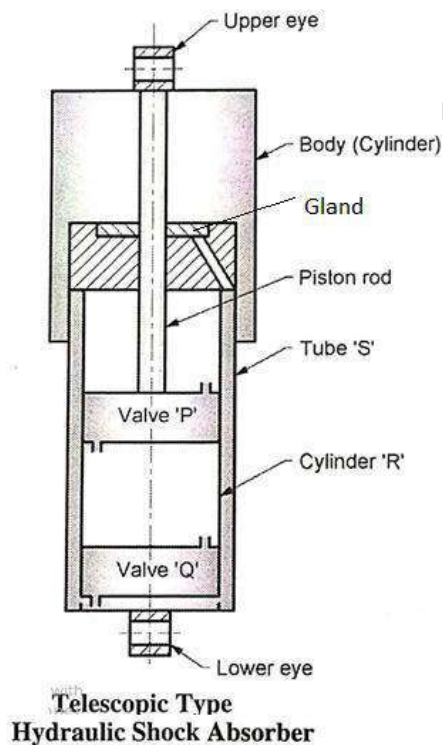
- The automobile chassis is mounted on the axles through some form of springs. This is done to isolate vehicle body from the road shocks which may be in the form of bounce, pitch, roll or sway. This will give rise to uncomfortable ride and also cause additional stress in the automobile frame and body.

Functions of Suspension System - All the parts which performs the function of isolating the vehicle from the road shocks are collectively called a suspension system.

- To prevent the road shocks from being transmitted to the vehicle components.
- To safeguard the occupants from road shocks.
- To preserve the stability of vehicle in pitching or rolling while in motion by maintaining contact between the Tyres and road
- To provide minimum required ground clearance to the vehicle
- Suspension system is provided in all vehicles so as to provide smooth and comfortable ride to passengers as well as to the driver

Two types of Suspension systems are used :

1. **Telescopic Suspension system (Helical coil & damper/ Shock absorber):**



Compression cycle is when vehicle goes over a bump, outer spring compresses, this damper slows down the compression. When road bump is cleared, the outer spring will expand but again this damper slows down the expansion, is extension cycle.

- All the **springs (Helical coil)** are flexible and stiff. So they will not absorb shocks efficiently and continue to vibrate/oscillate with the road irregularities.
- So **dampers** are provided with the springs which damp the vibrations. Dampers are piston -cylinder arrangement filled with oil. The oil in damper restricts the oscillation of helical compression spring.
- The shock absorbers absorb the energy of shock converted into vertical movement of axle by providing damping and dissipating the same into heat.

Telescopic Suspension system's load carrying capacity is less than the Leaf Spring. It is used in 2 Wheeler and Light Motor vehicles/ Cars.

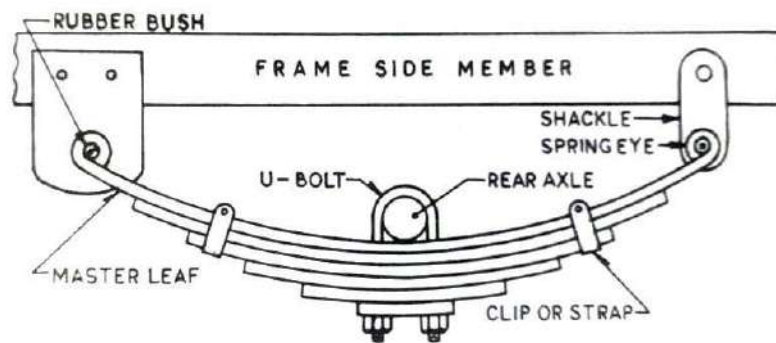
2. Leaf Springs

The spring consists of no. of semi- elliptic leaves called Blades.

The blades vary in length. The longest length has eye on its both ends, called as Master leaf. All blades are bound together by means of steel straps. 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.



When vehicle is subjected to shock, the wheel and axle move upward, deflecting the spring which absorbs the shock. Due to deflection of spring, its length increases. This increase is accommodated due to angular movement of shackle about the pivot.

Leaf Springs are used in heavy motor vehicle (buses, trucks, etc)

4. Braking system : Classification of braking system. Focus on working of disc and drum brake.

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 hybrid vehicles, the energy absorbed by the brakes is converted into electric energy & stored in battery ; called regenerative brake system.

Braking system has arrangement of various linkages and components to slow down or completely stop the moving vehicle, safely without skidding and within the shortest possible distance/time possible by applying artificial frictional resistance.

Different types of a brakes as follows

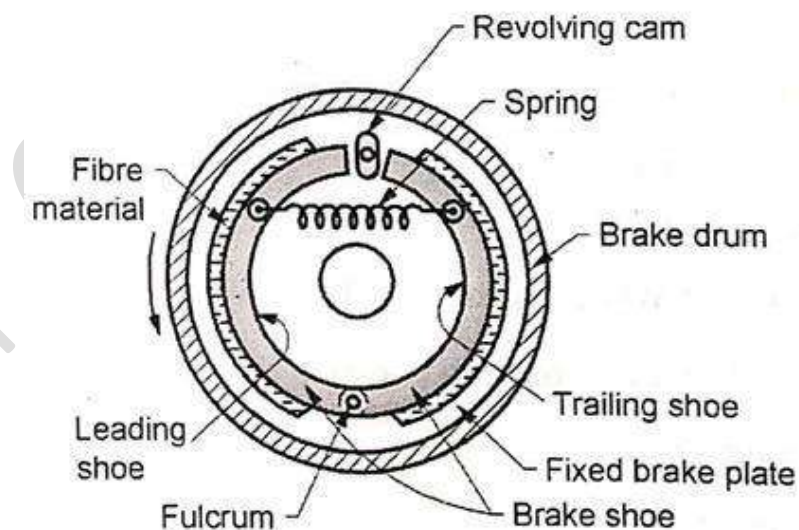
1. Drum Brake or Internal Expanding Shoe Brake or Mechanical Brake

IT consists of two brake shoes having outer surface lined with friction material. Each shoe is pivoted at one end about the hinge pin and subjected to an actuating force at other end.

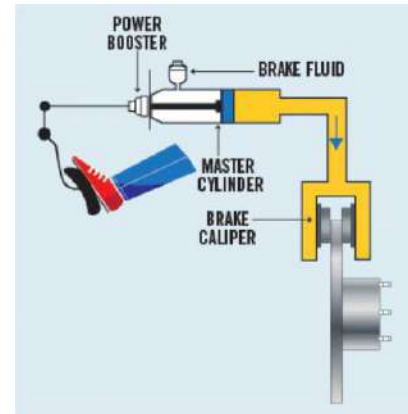
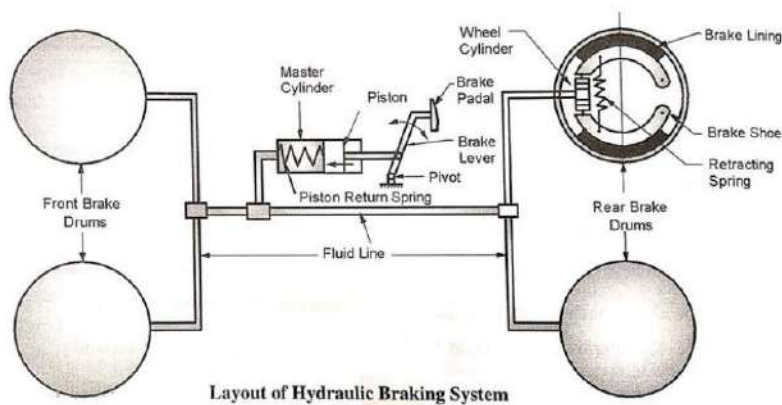
When driver presses Brake lever, piston moves in master cylinder; the braking force is converted into pressure energy in braking fluid. This pressure is transmitted to move brake shoes by a small hydraulic cylinder or by a cam mechanism. As shoes move outwards, they are pressed against the rotating wheel drum, causing them to retard or stop.

When actuating force is released, the retracting spring return the brake shoes to its normal position.

The drum brakes are used in automobile vehicles – trucks, buses, cars, motorcycles, etc.



Drum Type Mechanical Brake



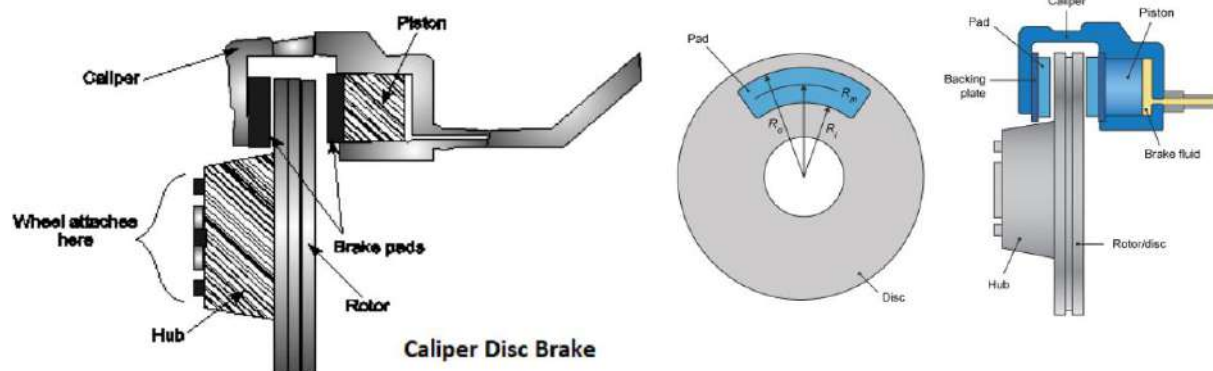
2. Disc Brake (Caliper Disk Brake)

Disc Brake : The disc brake is a wheel brake which slows rotation of the wheel by the friction. Most modern cars have disc brakes on the front wheels, and some have disc brakes on all four wheels. This is the part of the brake system that does the actual work of stopping the car. The main components of a disc brake are:

- The brake pads
- The caliper, which contains a piston
- The rotor, which is mounted to the hub

Types of Disc Brakes

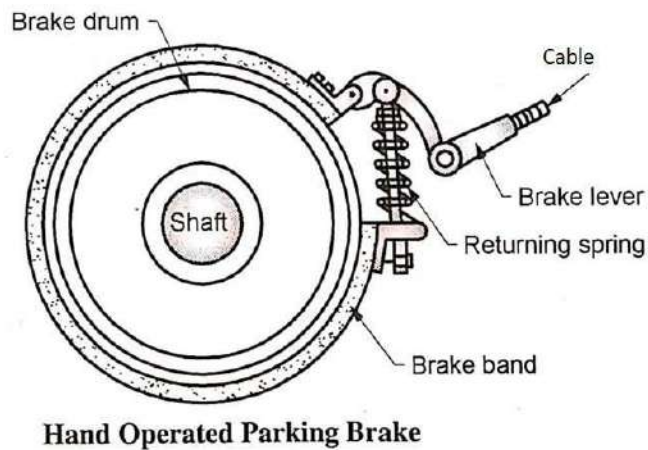
- Caliper type
- Sliding caliper type
- Swinging caliper type



The pressure transmitted from master cylinder through braking fluid **moves** the piston at the caliper disc brake. The fixed friction pads attached to the piston or calipers apply braking torque on the rotating disk so as to retard or completely stop its motion.

Caliper disc brakes have excellent control and are used in vehicles, racing cars. Also, it is used with ABS.

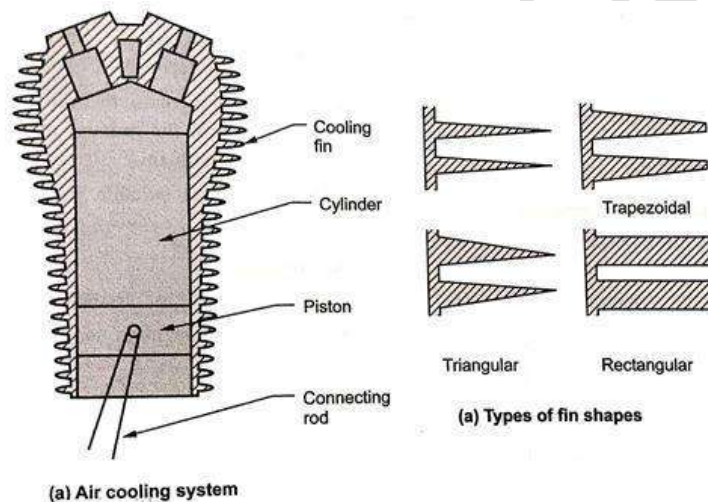
Hand Brake or Band Brake : These are used as a Parking Brake or Hand brake, applied when vehicle is standstill. Brake drum is mounted on the counter shaft of the gear box before universal joint. When lever is pulled, the brake band gets tightened on the drum and the motion is thus stopped. These are used in all passenger cars.



5. Cooling system : Classification of cooling system. Focus on working of water cooling system.

Cooling System of a Vehicle

- There are two methods used cooling of automobile engine.

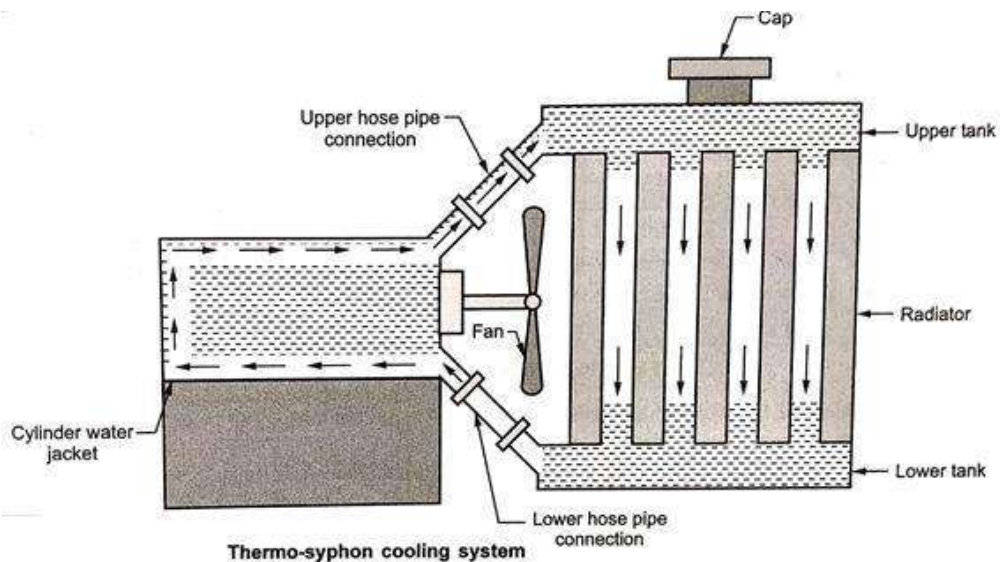


1. **Air Cooling :** Surface area of engine cylinder is increased by providing cooling fins or have increased air flow over its surface or both; allowing heat to be conveyed by convection process.

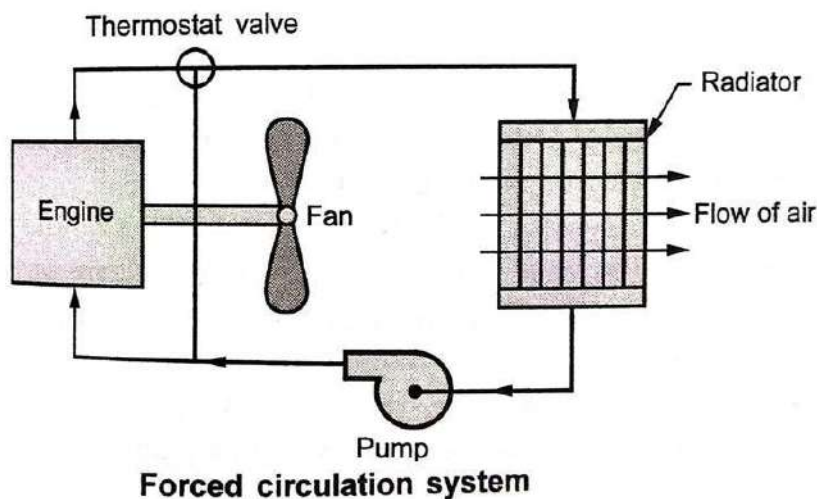
2. Water Cooling.

- Water cooling system having two types :

A) **Thermosyphon system** : In this system the water may circulate naturally (without any external power source) because of the density difference of hot water and cold water. The surface area of radiator is exposed to the air blast provided by the fan driven by crankshaft. This is used for low capacity engine and temperature of water should be watched not to exceed 80 deg C.



B) **Pump circulation system** : This is also called Pump assisted Thermosyphon cooling system. A water pump is included in circuit to have forced circulation of water, which ensures positive circulation under all conditions. But a thermostat is used to maintain constant temp of cooling water, else cold water may overcool the engine.



Q : Construction and working of Fuel injection system (for Petrol and for Diesel) and the components used in fuel supply system.

Ans : Fuel supply systems

1A. Fuel Supply system of S.I. Engine (Petrol Engine) with carburetor

It consists of Petrol Tank, Fuel lines, fuel pump, fuel filter, Air cleaner, Carburetor, Inlet manifold, Supply & return pipelines.

Following types of systems are used to supply Petrol from Tank to the engine cylinder ,
using a carburetor for mixing air-fuel in correct proportion –

- a. Gravity System – used for two wheelers as tank is placed on top
- b. Pressure System – Fuel tank is pressurized so it can be placed anywhere

c. Vacuum System – Engine suction brings fuel to a auxiliary tank then by gravity to carburetor

d. Pump system – a pump is used to bring petrol to carburetor , so placement of tank is not a problem.

Function of a Carburetor : The principle of carburetor is carburation, means atomization and vaporization. The main components are a float chamber, fuel jet, venturi, nozzle and throttle valve. A needle valve attached to float lever close or open the fuel inlet to float chamber. Venturi creates high velocity of intake air and low pressure which sucks petrol droplets to mix with air. The venturi

& nozzle are designed in such a way that air-fuel mixture is prepared in the required proportion. This is simple and cheaper system still used in motorcycles; but modern cars use MPFI system.

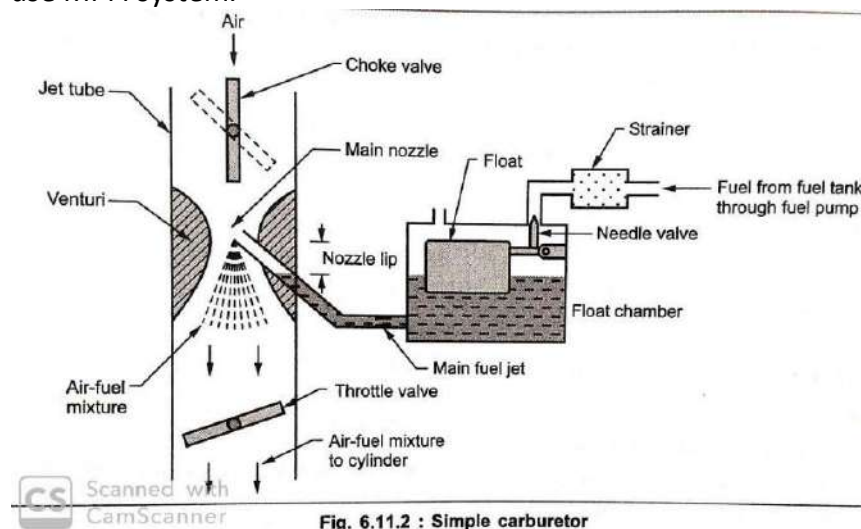


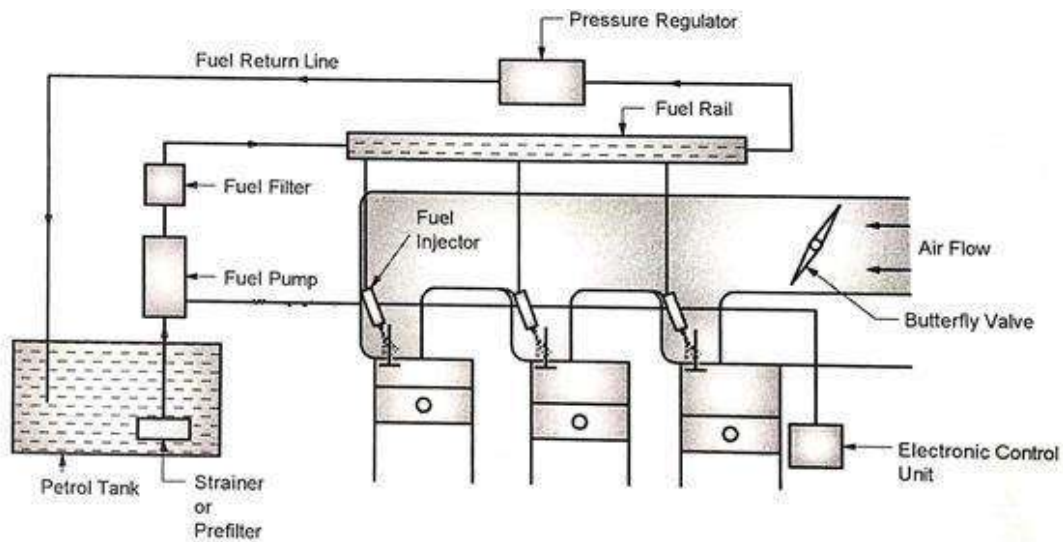
Fig. 6.11.2 : Simple carburetor

1B. Fuel Supply system of S.I. Engine (Petrol Engine) without carburetor

A 'Fuel Injection system' or 'Multi Point Fuel Injection (MPFI)' is used in modern vehicles without a carburetor; to directly inject atomized fuel into air stream by a fuel injector. Each cylinder has a separate injector which operates electrically. Proper Air-fuel mixture for different load & speed conditions is controlled electronically, which accurate & efficient.

Advantages of Multi Point Fuel Injection (MPFI) System :

- More uniform air-fuel mixture will be supplied to each cylinder, hence the difference in power developed in each cylinder is minimum.
- The vibrations produced in MPFI engines is very less, due to this life of the engine component is increased.
- No need to crank the engine twice or thrice in case of cold starting as happen in the carburetor system.
- Immediate response, in case of sudden acceleration and deceleration.



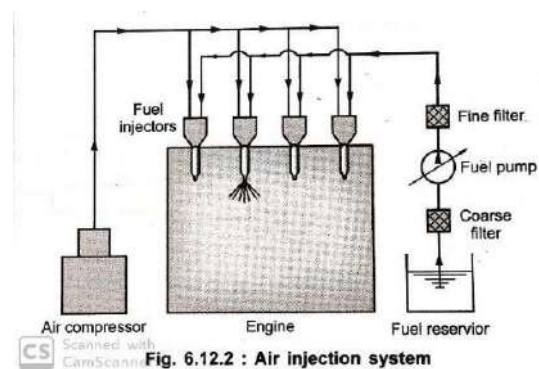
Fuel Supply and Fuel Injection System in Petrol Engine (MPFI)

- The mileage of the vehicle is improved.
- More accurate amount of air-fuel mixture will be supplied in these injection system. As a result complete combustion will take place. This leads to effective utilization of fuel supplied and hence low emission level.

2. Fuel Supply system of D.I. Engine (Diesel Engine) :

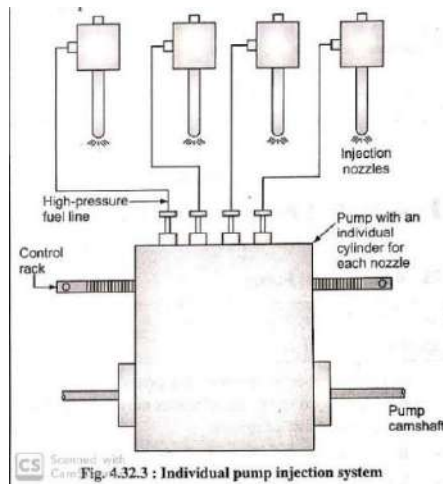
In diesel engine for direct injection of diesel in cylinder having compressed air; following two methods are available :

a) Air Injection (Diesel) : With a compressor high pressure air is used to inject fuel at about 70 bar into combustion chamber. It provides better atomization of fuel but its bulky & expensive; hence not used universally.



b) Solid or Airless Injection(Diesel) : Injection of fuel directly into combustion chamber without primary atomization is termed as solid injection or airless mechanical injection. It consists of a pressurizing unit (pump) and an atomizing unit (Injector). Main types of this system are :

i) Individual pump distribution system : Each cylinder will have a separate pump which meters the charge and also control injection timing.



ii) Distributor system (Diesel) : The fuel is metered at a central point by a single pump which pressurizes fuel , meters and also controls the injection timing through a rotating distributor.

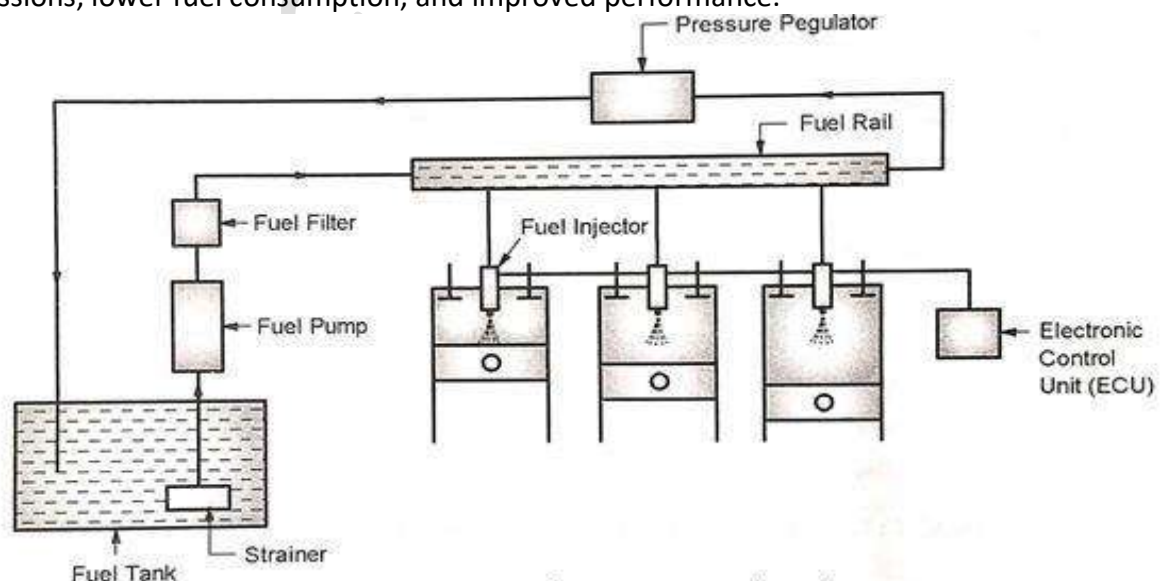
iii) Common Rail injection system (CRDI) for Diesel :

It consists of Diesel tank, Low pressure pump, Filter, Fuel injection pump, a header or manifold or common rail, High pressure relief valve, Fuel injectors and either mechanically or electrically / ECU operated injector spray nozzles.

Common Rail Direct Injection (CRDI) is a Diesel Engine technology used to deliver fuel to the cylinders at high pressure and in precise quantities. It stores the fuel in the common Rail and releases it to the cylinders based on the ECU configuration via the injectors.

The common rail connects all the injectors and contains fuel at a constant high pressure. In a CRDi engine, fuel quantity, engine pressure and timing of fuel injection are controlled electronically. The injectors have variable control heads which ensure that a highly precise amount of diesel goes into each cylinder.

It also offers superior pick up, lower levels of noise and vibration, higher mileage, lower emissions, lower fuel consumption, and improved performance.



Common Rail Direct Injection (CRDI)
Fuel Supply and Fuel Injection System of Diesel Engine

- **Study of Power Transmission Systems, Clutch, Gear Box (simple numerical), Propeller shaft, Universal joint, Differential Gear box, Axles**

- Describe basic components of Power Transmission system in Car with a block diagram. [5m]
- State the function of Clutch. Explain Single Plate Clutch with neat sketch. [5m]
- Write short note on Propeller Shaft. [5m]
- Write a short note on : a) Universal Joint, b) Differential Gear Box*
- What is an Axle? Explain Front & Rear Axle. *

Clutch

The clutch is the first power train component. The clutch is located between the engine and the transmission. When an operator shifts gears, it is used to temporarily disconnect the engine and the transmission. After shifting, it reconnects the engine and the transmission.

Single Disc (Plate) Clutch

The single disc clutch is a coupling between Engine's crankshaft and Gearbox. It is used to engage or disengage the engine from the gear box at the will of the driver. It is called as a dry clutch and it uses friction to operate.

The driving members of the single disc clutch consists of flywheel and the pressure plate. The pressure plate is spring loaded and bolted to the engine flywheel.

The driven member consists of a clutch disc, having friction material on both sides and splined to the clutch shaft.

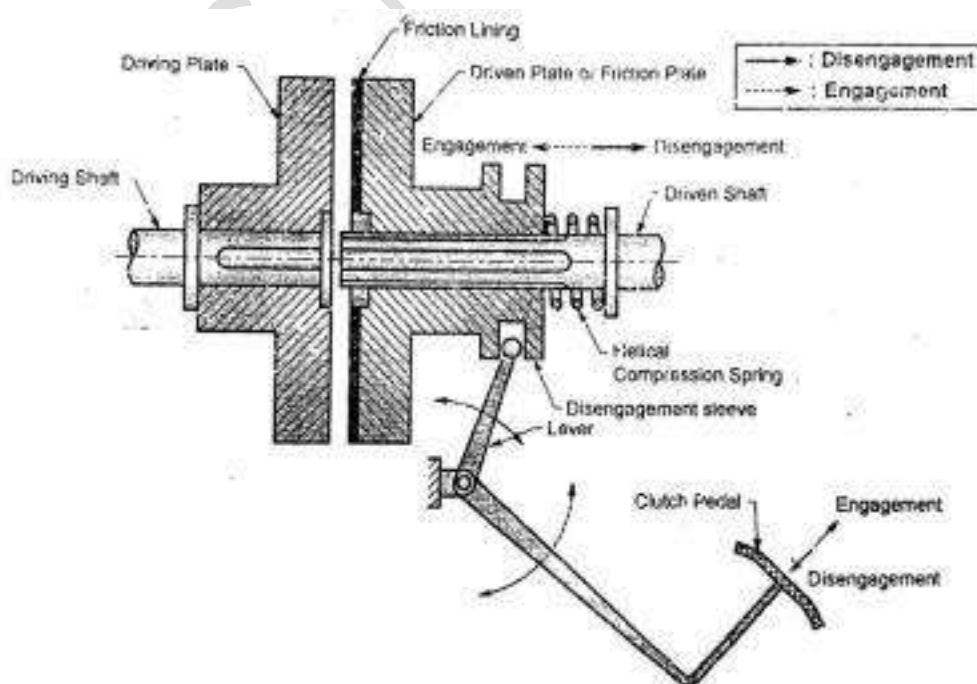


Fig. 1.11.2 : Friction Clutch

When the clutch is engaged, there is no pressure on the clutch pedal. The spring action of the pressure plate firmly clamps and holds the clutch disc against the flywheel. This results in a direct, non-slipping connection between the driving and driven clutch members.

The clutch disc rotates the clutch shaft which is attached to the Gear box input shaft. In this position, the clutch is fully engaged, the transmission transfers power flow to the wheel.

When there is pressure on the clutch pedal, the pressure plate pulls away from the clutch disc, releasing the disc from the flywheel. This results in a disconnection (gap) between the driving Pressure plate and driven clutch (Friction) plate. In this position, the clutch is disengaged and operator is able to shift gears.

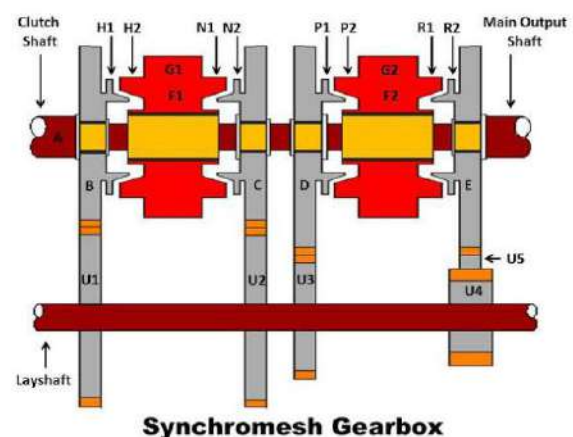
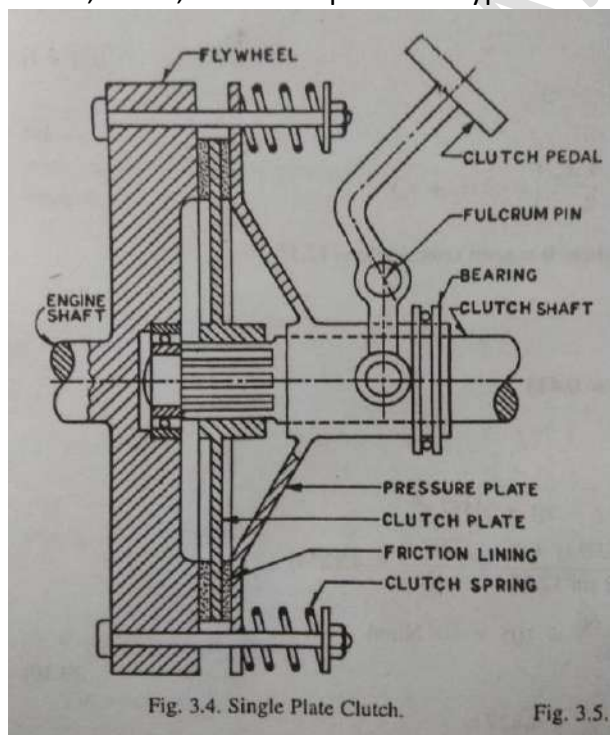
Advantages:

- Engagement and disengagement is very smooth in operation
- Less slip occurs in it; slip occurs only at the time of engagement
- Power losses are very less.
- Less heat generates because only single plate is used. Heat generation creates problem in power transmission and can damage the working parts.

Disadvantages:

- It has less torque transmitting capacity
- It has bigger in size even for transmitting less torque.
- It requires high maintenance because they are dry clutches and it is necessary to prevent them from moisture or any leakage of lubricant/oil in machinery.
- Single plate clutches have high wear and tear rate and have less smooth engagement.

Application : Single plate clutches are used where large radial space is available such as in trucks, buses, cars. Multiplate wet type Clutches are used in motorcycles in oil bath.



1. Transmission (Gear Box)

Gear box receives power from the engine through a clutch and transmits the power to the propeller shaft. Gear box produces different speed ranges for the vehicle. In gear box, torque is increased and speed is reduced. There is provision of reverse gear to move vehicle in reverse (backwards) direction. In neutral position, the gear box is disconnected from the Engine, even though clutch is in the engaged position.

There are three types of Gear Boxes:

1. **Sliding Mesh Gear Box:** not popular as meshing arrangement is not efficient
2. **Constant Mesh Gear Box:** Gears does not move/ slide, they are constantly in meshed or engaged position but rotates freely on the shaft; only a dog clutches slide and only a required pair is connected with the shaft. However, there is some jerk present.
3. **Synchromesh Gear Box :** This is improved version of Constant mesh gear box, where a synchromesh device matches the speed of gear before engagement. Hence, it gives very smooth engagement and quiet operation of gears.

1.1. Manual Transmissions

The manual transmission is often referred to as stick shift because the operator shifts gears using manual control lever, called a gear shift lever, and a clutch pedal.

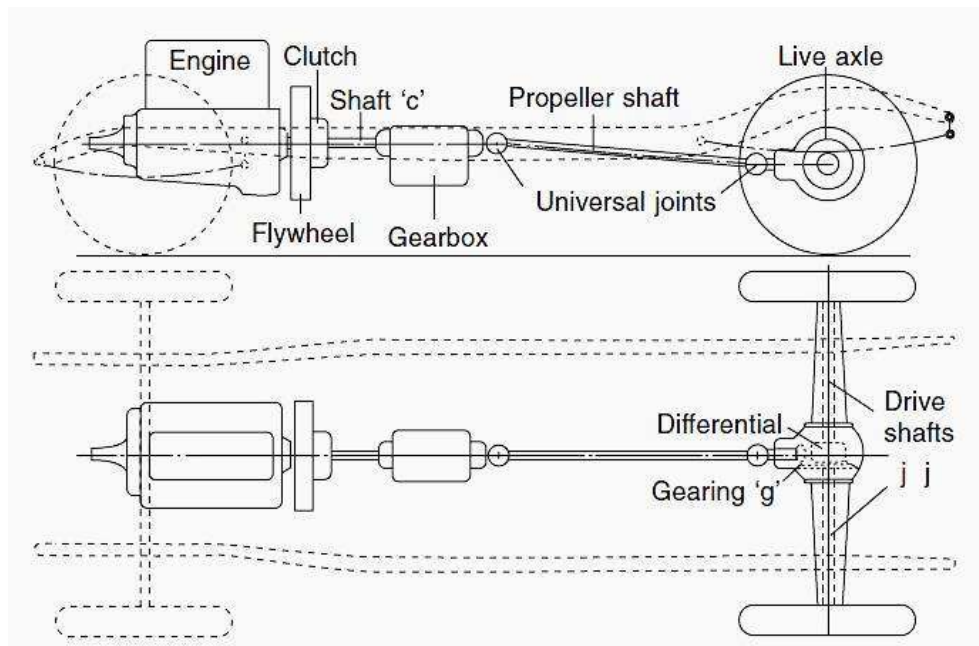
Another purpose of manual transmission is to provide the operator a selection of gear ratio between the engine and wheels, so that vehicle can operate under variety of operating conditions and loads. A manual transmission should do the following:

3. Increase torque going to the rear wheels for quick acceleration.
4. Supply different gear ratios to match different engine load conditions.
5. Provide a reverse gear ratio for moving the vehicle backwards.
6. Provide the operator an easy means of shifting transmission gears.
7. Operate quietly with minimum engine power loss.

Automatic Transmission

The automatic transmission does not have to shifted manually, it shifts automatically, depending upon the throttle position, vehicle speed, and position of selector lever.

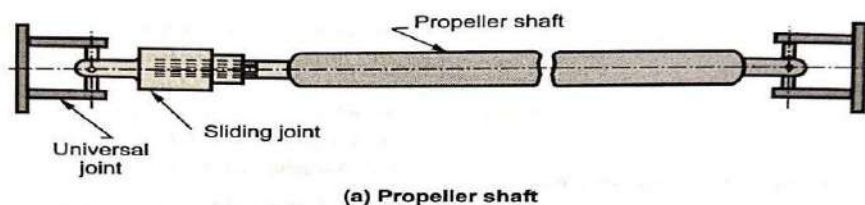
Automatic transmissions are used in vehicles that have two to five forward speeds and in some vehicles that are equipped with overdrive. Operator control is limited, the operator selects gear range by moving a transmission selector.



2. Propeller Shaft Assemblies

The propeller shaft assembly consists of a propeller shaft, commonly known as a drive shaft, a slip joint, and one or more universal joint. It provides flexible connection through which **power** is transmitted from the Gear box to Differential/rear axle assemblies.

A propeller shaft may be solid or tubular. A solid shaft is stronger than a hollow of the same diameter, but a hollow shaft is stronger than a solid shaft of **same weight**.



(b) Simplified representation of propeller shaft

A slip/sliding joint is formed by internal splines on the sleeve attached to universal joint at one end of the propeller shaft. As there is level difference between Gearbox output shaft and differential input pinion shaft/Rear axle; and due to suspension ; the angle as well as length of propeller shaft varies continuously. These fluctuations are accommodated by the sliding joint.

Functions of propeller shaft :

1. Transmits rotary motion from Gear box to differential
2. It transmits motion at an angle which varies frequently.
3. The propeller shaft continuously compensates the change in length between Gearbox and differential; due to telescopic arrangement with sliding joint at one end.

2.1 Universal Joint

A universal joint acts as a flexible coupling between two shafts. It permits one shaft to drive the other, even though they are at an angle from each other. The universal joint is flexible in the sense that it permits power to be transmitted, while the angle of the shaft continually changes.

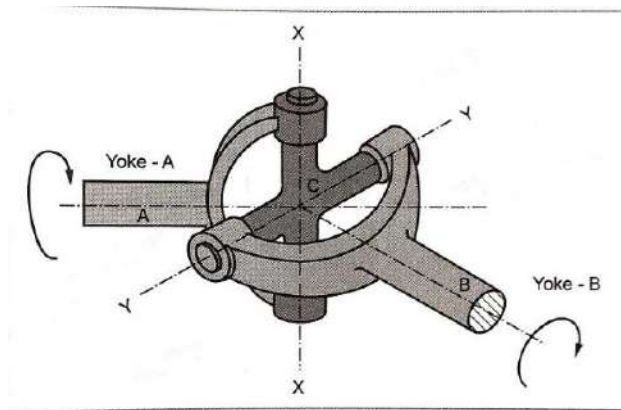


Fig. 6.20.1 Yoke type universal joint



Universal Joint

A simple universal joint is composed of **three** fundamental units: a journal and two yokes.

The two yokes are set at right angles to each other, and their open ends are connected by the journal. This construction permits each yoke to pivot on the axis of the journal and also permits the transmission of rotary motion from one yoke to the other.

As a result, two universal joints are used to connect propeller shaft to transmit power from Gear box to the differential/rear axle, even though there is level difference and irregular oscillations from the Suspension system due to road conditions.

3 Differential Gear Box

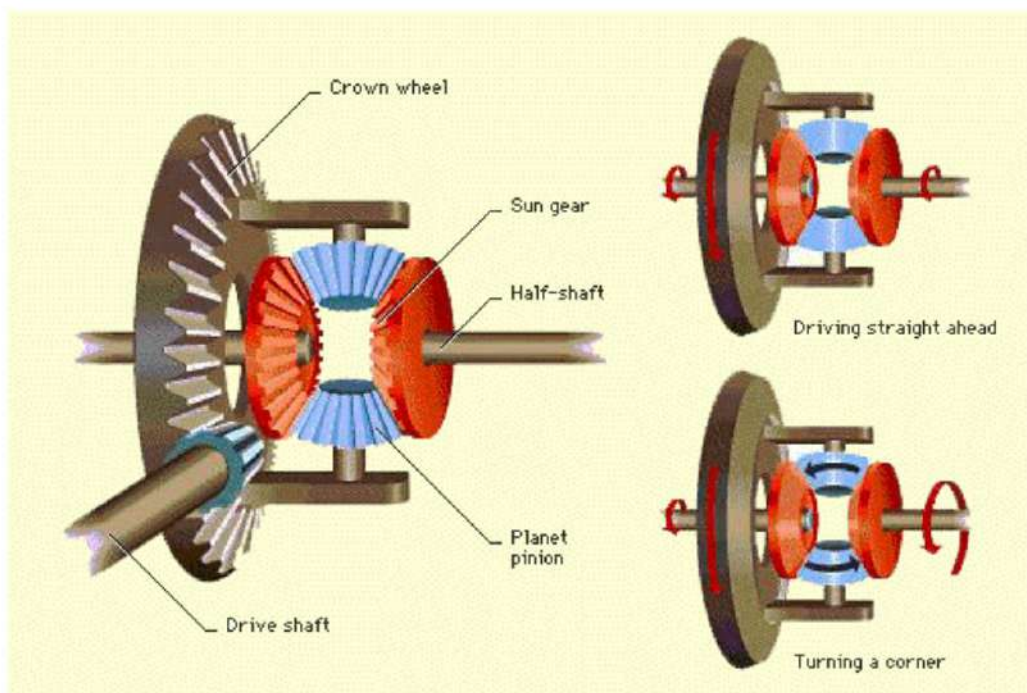
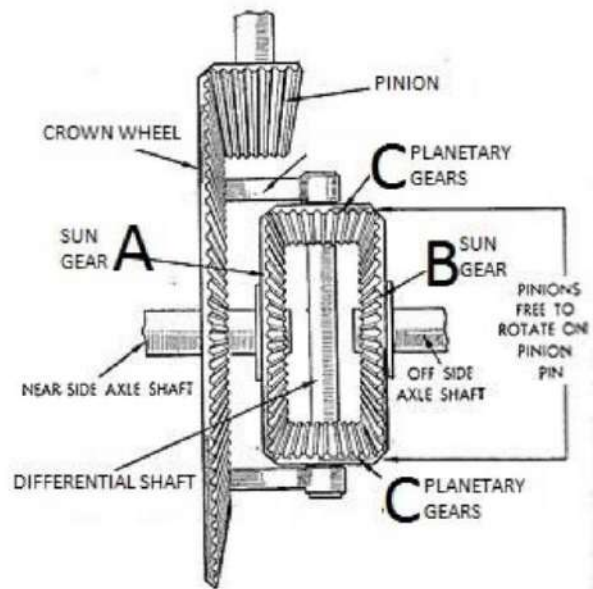
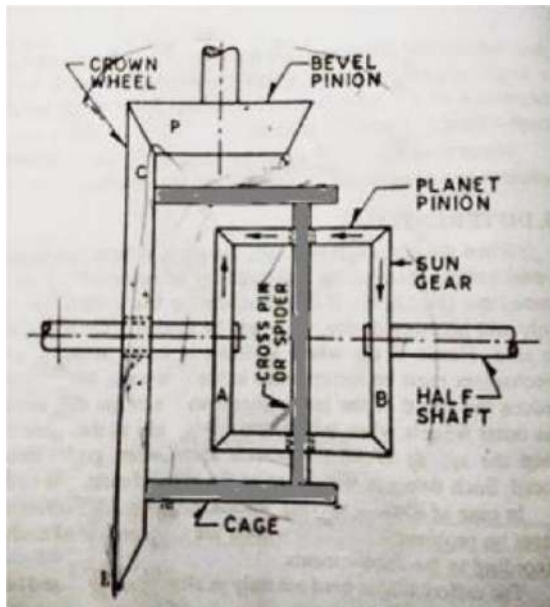
A final drive located in the rear axle housing, transmits the power from the propeller shaft to the driving wheels. It consists of two gears: the ring and pinion gear. They are bevel gears mounted on shafts that are 90 degrees apart. They may be worm, spiral bevel, spur bevel, or hypoid.

Function of the Differential Gear Box :

1. To change by 90 degree, the direction of the power transmitted through the propeller shaft to the driving axles.

2. The gear ratio of a final drive fixed, with bevel gears is found by dividing the number of teeth on the driven or ring gear by the number of teeth on the pinion. Torque is increased and speed is reduced.

3. The differential gear box allows two wheels to rotate at different speeds at the same time while transmitting power to both, when vehicle is taking a turn. It is very important as inner wheels rotate in small circle & outer wheels in a larger circle.



Operation of Differential (Note when driving straight Crown gear rotates Sun gears thru planet gears; but while turning planet gears rotate as Half shafts rotate at different speeds)

3.2 Driving Axle

Axles are classified as either live axle (called as Shaft) or dead axle. Live axles or Shafts transmit power. Dead axles only support part of the vehicle weight and provide a mounting for the wheel assembly.

There is a need for differential gear to allow two rear wheels to rotate at different speeds while vehicle is turning; however at same time power should be transmitted to these wheels. Hence, two half shafts coming out of differential, are used for driving two wheels. These two half transmission shafts are supported inside a hollow tube, called Rear Axle which is non rotating & fixed to chassis.

- **Vehicle Active and passive safety arrangements: Seat, Seat belts, airbags, antilock brake system**

- a. What is passive vehicle safety system? State examples of passive vehicle safety systems. [5m]
 - b. What is vehicle safety? Explain the types of vehicle safety systems. [6m]
 - c. Compare Active and Passive safety arrangements.*
 - d. Write short note on: Seat, Air Bag, ABS, Seat Belt. [9m]
-

Vehicle Safety

Vehicle safety is the study and practice of design, construction, equipment and regulation to minimise the occurrence and consequences of automobile accidents.

Active Safety (Care in design & manufacture to prevent/ avoid accident) **It is related preventive design and preventive maintenance of the vehicle.**

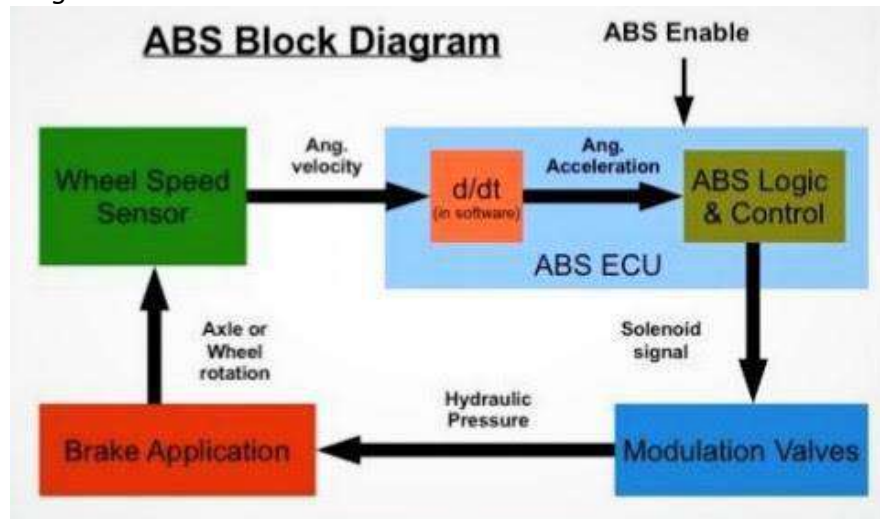
1. More visibility to driver and minimum blind spots to increase efficiency of driver in heavy traffic and during parking
2. Good mirrors
3. Headlights with adequate intensity
4. Instrument panel should be easy to read
5. All controls should be easily accessible to drive, including hearing of engine running noise.
6. Driver **Seat** should be comfortable and adjustable. Bucket type seat is used for front /driver in modern cars made of inexpensive durable material like polyester. Bucket seat have rounded back and variety of adjustment to fit different passengers. Rear seats can be fold down to gain cargo space. Special child seats are compulsory with safe restraint. Side air bags are provided to increase the safety of the passengers.
7. Vehicle noise should be minimum
8. Suspension system and steering system

9. Anti lock braking system (ABS) for better steering and control of vehicle

ABS Definition-An anti-lock braking system (ABS) is a safety anti-skid braking system used on vehicles, such as cars, motorcycles, trucks, and buses. ABS operates by preventing the wheels from locking up during braking, thereby maintaining rolling contact with the road surface.

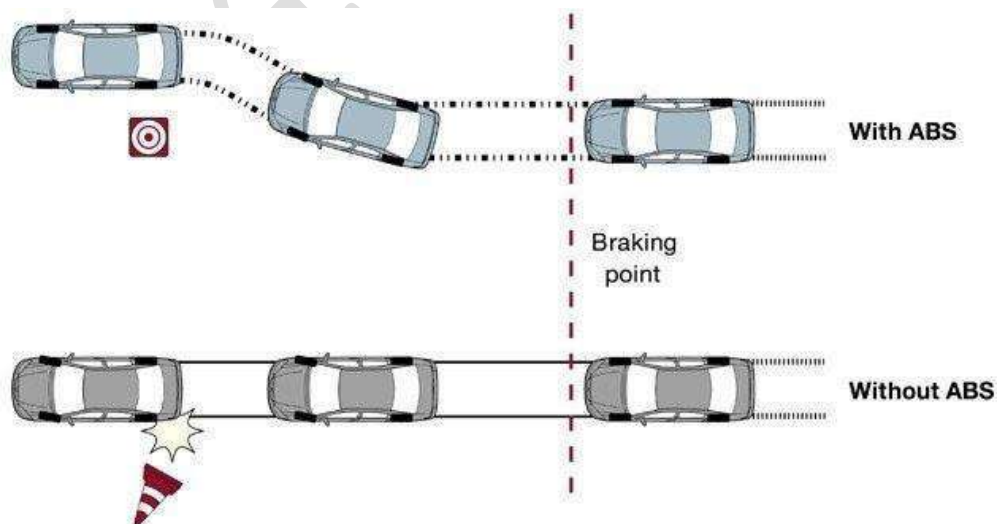
Construction-A Typical ABS System contains:

- *Electronic Control Unit*
- *Speed Sensors*
- *Hydraulic Control Unit*
- *ABS Control Valves*
- *Control Algorithm*



ABS Working principle

The basic theory behind anti-lock brakes is simple. It prevents the wheels from locking up, thus avoiding uncontrolled skidding. ABS generally offer improved vehicle control and decreases stopping distances on dry and slippery surfaces.



These brakes reduce the risk of skidding the tyres under heavy braking and allows the driver to maintain steering control of the car.

In case of emergency braking, ABS safety feature prevents abrupt locking of wheels which in turn lets the driver not lose control of vehicle. The car without skidding or being uncontrolled changes path and stops to a halt.

The sensor at each wheel provides the varying voltage signal to the ECU of the brake system. ECU computes the voltage signal and compares it with programmable information and determines whether a wheel is about to lock or skid. Based on this calculated slip rate it controls the brake fluid pressure to achieve the target slip rate.

An electrically driven hydraulic pump / booster and an accumulator charged with nitrogen maintains high fluid pressure in the pipelines.

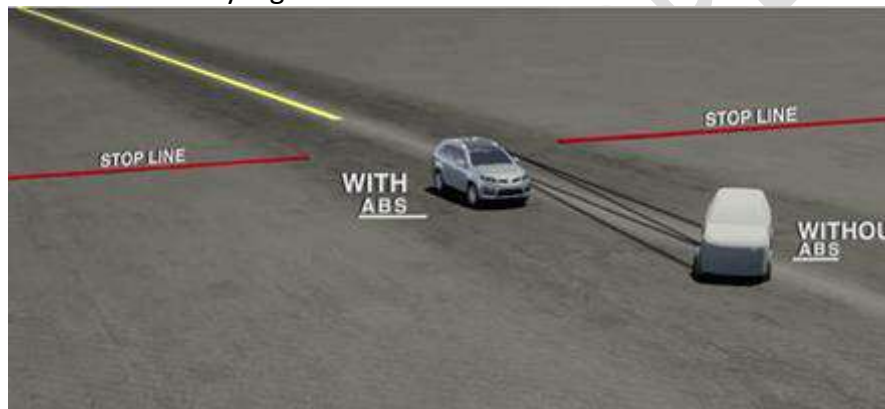
In some ABS, a lateral accelerator sensor is provided to monitor lateral (side) movement of the vehicle while taking a turn.

Advantages of ABS :

- It provides safety to the passengers
- It provides best traction during the operation of brakes
- It also controls the directional stability of vehicle at the time of turns.

Disadvantages of ABS :

- Under slipping/ slippery surface the stopping distance is high
- Vibrations are felt at the brake pedal during braking
- Its cost is very high



Passive Safety (Devices protects or minimize injury at the time of accident)

It is relating to the design of automobile vehicle for minimum injury at the time of accidents. Some of the passive safety features help to absorb crash forces during collision of vehicles, such as –

1. Rigid safety cells/ boxes for occupants
2. Doors/ body strengthened with side steel bars
3. Location of fuel tank as risk of fire after collision
4. Doors with safety lock as after collision passengers should not be thrown out
5. Knee bolsters and head rest needed to minimise leg and neck injury

6. **Seat belts** should be provided to stop the passenger from hitting hard against the interior

7. **Air Bags** get inflated quickly on getting signal from its sensor and protects passenger from an impact during collision. Air bags are designed to supplement the protection offered by the seat belts, so it is called Supplemental Restraint System (SRS) or air cushion restraint system (ACRS).

Many number of air bags are provided to increase the protection.

Air bag system consist of an air bag module (an inflator or gas generator and an air bag made up of thin nylon fabric) , crash sensors , detonator, a diagnostic condition monitor, indicator lamp on panel and connection with battery.

Crash sensor is a micro electro mechanical system (MEMS) accelerometer sensor. The sensors measure severity of impact and they are set to start inflation system when severe impact causing sudden negative acceleration of vehicle. The inflation system mixes Sodium amide (NaN_3) with potassium nitrate (KNO_3) to produce large volume of hot nitrogen gas at 322 kmph to inflate air bag within approx.. 60 -80 milliseconds.

