srivenkateshwaraa
College of Engineering & Technology
(Approved by AICTE, New Delhi & Affiliated to Pondicherry University, Puducherry)
13-A, Pondy - Villupuram Main Road, Ariyur, Puducherry - 605 102.
ASPIRE TO EXCEL

ISO 21001

DEPARTMENT OF MECHANICAL ENGINEERING

SUBJECT NOTES

SUB NAME: AUTOMOBILE ENGINEERING

SUBCODE : MEE61 **YEAR & SEM :** III/VI

PREPARED BY,

Mr. C.MANIKANDAN., B.E., M.E.,

ASSISTANT PROFESSOR

SVCET

ELECTIVE - II MEE61 AUTOMOBILE ENGINEERING (4 0 0 4)

OBJECTIVES

- ✓ *To explain the construction features of chassis systems.*
- ✓ *To analyze the various layouts by applying principles of mobility mechanics.*
- ✓ *To analyze the different configurations of IC engines by the principles of engine kinematics.*
- ✓ *To explain the transmission system of automobile*
- ✓ *To explain the Electrical system of automobile*

UNIT I

Classification of vehicles - drives - general layout. Engine - Diesel and Petrol engines for automobiles - two stroke and four stroke engines - comparison of performance - factors affecting choice - power requirements of an automobile - rolling, wind and gradient resultant-factors affecting resistance and power requirement.

(09 hours)

UNIT-II

Power transmission system - requirement of transmission system - clutches - plate clutches - semi automatic & automatic clutches - Gear box: manual shift four speed and positive speed gear boxes - synchromesh devices -fluid transmission - fluid flywheel and torque converter-automatic transmission - drive line - differential, conventional and non-slip types - drive axle. (09 hours)

UNIT - III

Suspension system - requirements - rigid axle and independent suspension - types of suspension - leaf spring - coil spring - torsion rod and air suspension - shock absorbers. Front axle: types - front wheel geometry - conditions for true rolling. Steering geometry - Ackerman and Davis steering - steering linkages - steering gear box-power and power assisted steering. Wheel alignment - Tyres: materials and type's static and rolling properties of pneumatic tyres. (09 hours)

UNIT-IV

Braking system - hydraulic braking systems - drum type and disc type brakes - power and power assisted brakes - factors affecting brake performance - tests on brakes - skid and skid prevention. Chassis - types of bodies - chassis frame - integral body - vehicle stability. (09 hours)

UNIT - V

Battery: types - Chemical reaction - charging - battery rating - battery life - battery testing. Starting motor: constructional features and operation - series wound motor - drive arrangements: types, Ignition: types - ignition coil - contact breaker - distributor –firing order – spark plug. Generator- constructional features of D.C generator and Alternator - Rectifier - Generator regulation - Automotive lighting - Electronics in automobile.
(09 hours)

Text Books:

1. W.H.Crouse, Automotive Mechanics, Tata McGraw Hill Publishing Co., 1995. 5. V.L.Maleev, Internal Combustion Engines, McGraw Hill, 1987.

AUTOMOBILE ENGINEERING

UNIT I

An automobile (or automotive) is a vehicle that is capable of propelling itself. Since seventeenth century, several attempts have been made to design and construct a practically operative automobile.

A self-propelled passenger vehicle that usually has four wheels and an internal combustion engine, used for land transport.

Today, automobiles play an unimaginable role in the social, economic and industrial growth of any country. After the introduction of internal combustion engines, the Automobile industry has seen a tremendous growth.

CLASSIFICATION OF AUTOMOBILE:

Automobiles can be classified into several types based on several criteria. A brief classification of automobiles is listed below:

Based on purpose:

1. *Passenger vehicles*: These automobiles carry passengers. (e.g.) Buses, Passenger trains, cars
2. *Goods vehicles*: These vehicles are used for transportation of goods from one place to another. (e.g.) Goods lorry, goods carrier

Based on capacity:

1. Heavy Motor Vehicle (HMV): Large and bulky motor vehicles. (e.g.) Large trucks, buses
2. Light Motor Vehicle (LMV): Small motor vehicles. (e.g.) Cars, Jeeps
3. Medium Vehicle: Relatively medium sized vehicles. (e.g.) Small trucks, mini buses

Based on fuel source:

1. *Petrol engine vehicles:* Automobiles powered by petrol engine. (e.g.) scooters, cars, mopeds, motorcycles
2. *Diesel engine vehicles:* Auto motives powered by diesel engine. (e.g.) Trucks, Buses
3. *Gas vehicles:* Vehicles that use gas turbine as power source. (e.g.) Turbine powered cars
4. *Solar vehicles:* Vehicles significantly powered by solar power. (e.g.) Solar powered cars
5. *Hydrogen vehicles:* Vehicles that have hydrogen as a power source. (e.g.) Honda FCX Clarity
6. *Electric vehicles:* Automobiles that use electricity as a power source. (e.g.) Electric cars, electric buses
7. *Steam Engine Vehicles:* Automotives powered by steam engine. (e.g.) Steamboat, steam locomotive, steam wagon.
8. *Hybrid Vehicles:* Vehicles that use two or more distinct power sources. (e.g.) Hybrid buses, hybrid cars like Toyota Prius, Honda Insight.

9. *Hybrid Electric Vehicle (HEV):* Automobile that uses both Internal Combustion Engine and electric Power Source to propel itself. (e.g.) Jaguar C-X75

Based on type of transmission:

1. Automatic transmission vehicles: Automobiles that are capable of changing gear ratios automatically as they move. (e.g.) Automatic Transmission Cars
2. Conventional transmission vehicles: Automotives whose gear ratios have to be changed manually
3. Semi-automatic transmission vehicles: Vehicles that facilitate manual gear changing with clutch pedal

Based on number of wheels:

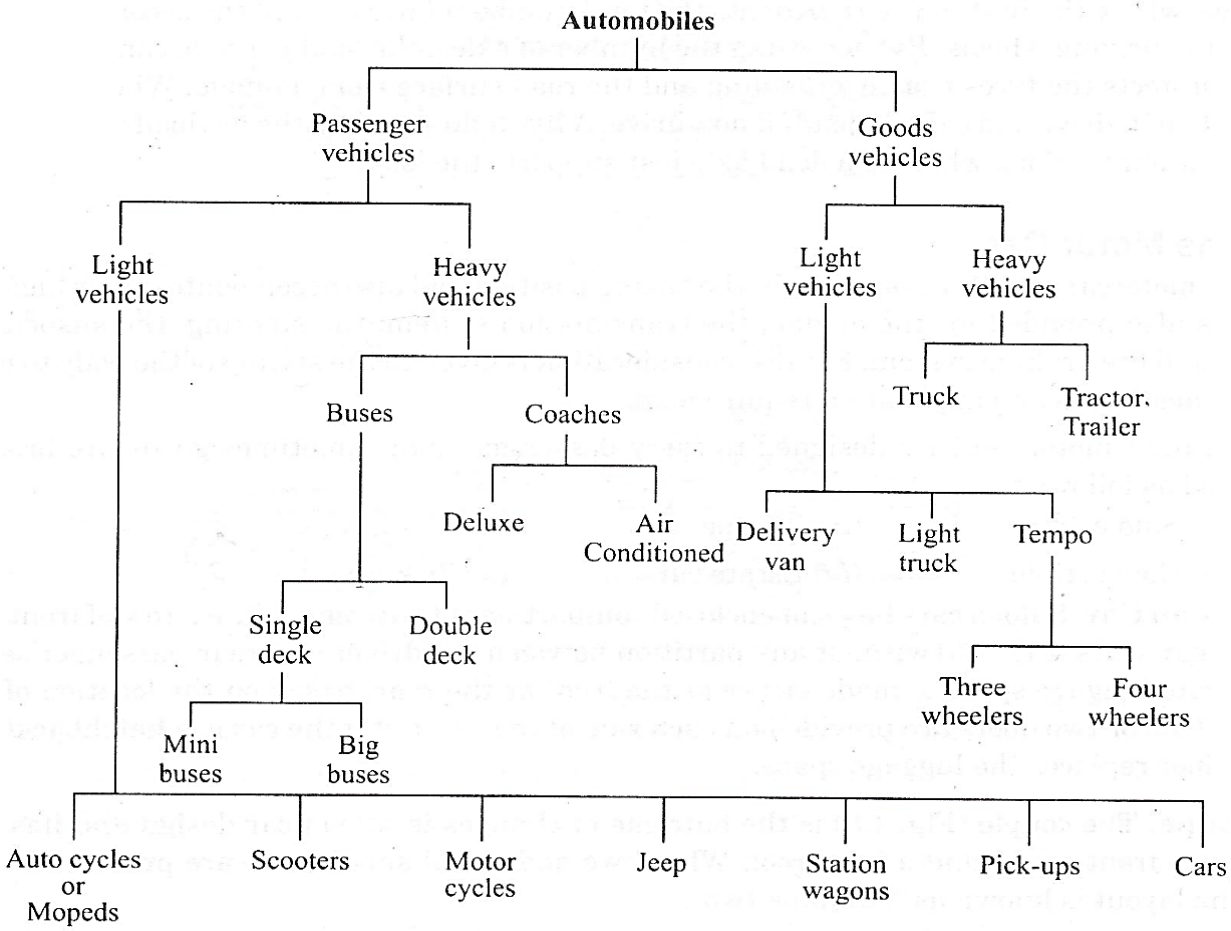
1. Two wheeler : Automobiles having two wheels. (e.g.) Scooters, motorcycles
2. Three wheeler : Automotive having three wheels. (e.g.) Tricycles, Auto rickshaws, Tempos
3. Four wheeler : Vehicle having four wheels. (e.g.) Car, Jeep
4. Six wheeler : Automobile having six wheels used for heavy transportation. (e.g.) Large trucks, large buses

Based on the side of drive:

1. *Left hand drive automobile:* Vehicle in which steering wheel is fitted on the left hand side. (e.g.) Automobiles found in USA, Russia
2. *Right hand drive automobile:* Vehicle in which steering wheel is fitted on the right hand side. (e.g.) Automobiles found in India, Australia

CLASSIFICATION OF VEHICALES

1. Motorcycles
2. Passenger Cars
3. Other Two Axle, 4 Tire Single Units
4. Buses
5. Two-Axle, 6 Tire Single Units
6. Three Axle Single Units
7. Four or More Axle Single Units
8. Four or Less Axle Single Trailers
9. Five Axle Single Trailers
10. Six or More Axle Single
11. Five or Less Axle Multi-Trailers
12. Six Axle Multi-Trailers
13. Seven or More Axle Multi-Trailers



AUTOMOTIVE DRIVES

- ✓ Crank Shaft Drives
- ✓ Cam Shaft Drives
- ✓ Flywheel

Crankshaft

The crankshaft transforms the linear motion of the pistons into a rotational motion that is transmitted to the load. Crankshafts are made of forged steel. The forged crankshaft is machined to produce the crankshaft bearing and connecting rod bearing surfaces. The rod bearings are eccentric, or offset, from the center of the crankshaft as illustrated in Fig.

This offset converts the reciprocating (up and down) motion of the piston into the rotary motion of the crankshaft. The amount of offset determines the stroke (distance the piston travels) of the engine (discussed later). The crankshaft does not ride directly on the cast iron block crankshaft supports, but rides on special bearing material as shown in Fig.

The connecting rods also have bearings inserted between the crankshaft and the connecting rods. The bearing material is a soft alloy of metals that provides a replaceable wear surface and prevents galling

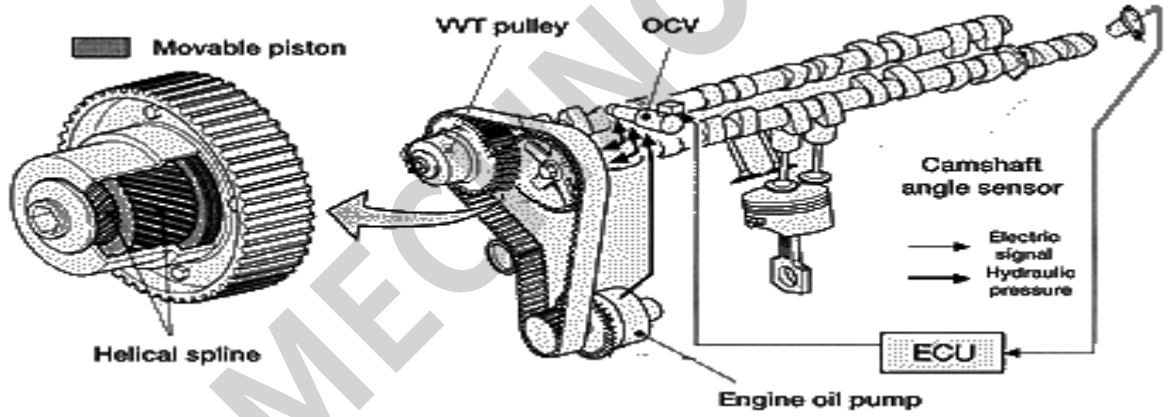
between two similar metals (i.e., crankshaft and connecting rod). Each bearing is split into halves to allow assembly of the engine.

The crankshaft is drilled with oil passages that allow the engine to feed oil to each of the crankshaft bearings and connection rod Bearings and up into the connecting rod itself. The crankshaft has large weights, called counter weights that balance the weight of the connecting rods. These weights ensure an even (balance) force during the rotation of the moving parts.

Cam Shaft

Cam shaft is used to operate the valves of the four stoke engine. It is connected to the crank shaft through timing gear or by timing chain it contains number of cams to actuate the valve in an engine. Additional cam is also providing to drive the mechanical fuel pump.

A gear is providing in the cam shaft to drive the ignition distributor. The cam shaft run at one half the revolutions of crank shaft. It is generally made with forged steel or cast steel



Flywheel

The flywheel is located on one end of the crankshaft and serves three purposes.

- ✓ *First:* Through its inertia, it reduces vibration by smoothing out the power stroke as each Cylinder fires.
- ✓ *Second:* It is the mounting surface used to bolt the engine up to its load.
- ✓ *Third:* On some diesels, the flywheel has gear teeth around its perimeter that allow the Starting motors to engage and crank the diesel.

ENGINE

Internal Combustion Engine

In internal combustion engine the combustion of fuel takes place inside the engine cylinder. Then the heat energy is transferred to where the work to the done. Eg: diesel engine, petrol engine, gas engines, gas turbine etc.

External Combustion Engine

In external combustion engines, the combustion of fuel takes place outside the engine cylinder. Then the heat energy is transferred to where the work to be done. Eg: steam turbines used in thermal power plant and steam engines used in railway engine.

Classification of I.C. Engines:

I.C. engines can be classified as follows:

1. According to the number of strokes required to complete a cycle:
- (i) 2 stroke engine
- (ii) 4 stroke engine

2. According to fuel used:
- (i) Petrol engine
- (ii) Diesel engine
- (iii) Gas Engine

3. According to thermodynamic cycle of operation:
- (i) Constant volume or Otto cycle
- (ii) Constant Pressure or Diesel cycle
- (iii) Mixed or Dual cycle

4. According to the ignition system used:
- (i) Spark Ignition engine
- (ii) Compression Ignition Engine

5. According to the number of cylinders:
- (i) Single cylinder engine
- (ii) Multi Cylinder engine

6. According to arrangement of cylinders:
- (i) Vertical engine
- (ii) Horizontal engine
- (iii) In line engines
- (iv) V engines
- (v) Radial engine

7. According to the cooling system:
- (i) Air cooled engine
- (ii) Water cooled engine

8. According to the speed of the engine:
- (i) Low Speed (below 400 rpm)
- (ii) Medium Speed (400 to 900 rpm)
- (iii) High Speed (above 900 rpm)

9. According to lubrication system:
- (i) Splash Lubrication
- (ii) Pressure Lubrication

10. According to field of application:
- (i) Stationary engine
- (ii) Mobile engine.

TWO-STROKE ENGINES

Introduction

As the name suggests, two-stroke engines perform only two-strokes to complete one working cycle. In a four-stroke cycle, the power is obtained only once in two revolutions of the crankshaft. Therefore, much attention was paid to obtain power once in every revolution of the crankshaft and this lead to the development of a two-stroke cycle. Two-stroke cycle engines will theoretically give twice the power obtained from a four-stroke cycle engine of similar size.

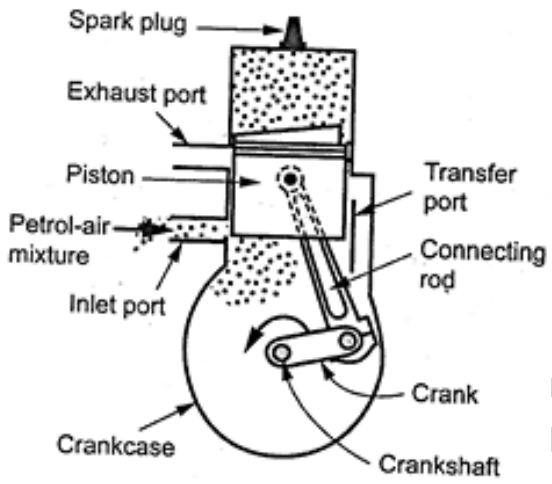
Construction

The two-stroke IC engine is similar in construction to the four-stroke IC engine except that the valves are replaced by ports, as shown in Fig.

The two-stroke engines are provided with ports or openings cut in the cylinder walls.

- ✓ The closing and opening of the ports are controlled by the movement of piston.

- ✓ **Inlet port** is provided to feed the fresh charge into the crankcase
- ✓ A **Transfer Port** is provided to take the compressed charge from the crankcase to the cylinder
- ✓ The burnt waste gases are discharged into the atmosphere through a **exhaust port**



The crown of the piston (i.e., top of the piston) is shaped in such a way to assist in deflecting the fresh charge upwards in the cylinder and help scavenging.

Scavenging: Scavenging is the process of forcing out the burnt exhaust gases from the cylinder by admitting the fresh charge into the cylinder. Now let us discuss the working of a two-stroke petrol and two-stroke diesel engines.

TWO STROKE - DIESEL ENGINE

The working principle of a two-stroke diesel engine is illustrated in ***fig.***

I. First Stroke (Upward Stroke of the Piston)

- ➢ **Compression and Inductance (Fig. a)**
  - ✓ During the upward movement of the piston from BDC to TDC, both the transfer and exhaust ports are covered by the piston.
  - ✓ The air which is already transferred into the engine cylinder is compressed by the moving piston. This increases the pressure and temperature of the air.
  - ✓ The compression process is continued until the piston reaches TDC.
  - ✓ At the same time, the inlet port is uncovered by the moving piston and the fresh air enters the crankcase through the inlet port.
- ➢ **Injection and Inductance (Fig. b)**
  - ✓ After the piston almost reaches the TDC, the fuel (diesel) is injected through the fuel injector in the cylinder.
  - ✓ The combustion of fresh fuel injected into the cylinder takes place due to the high temperature already developed in the cylinder during compression of the air.

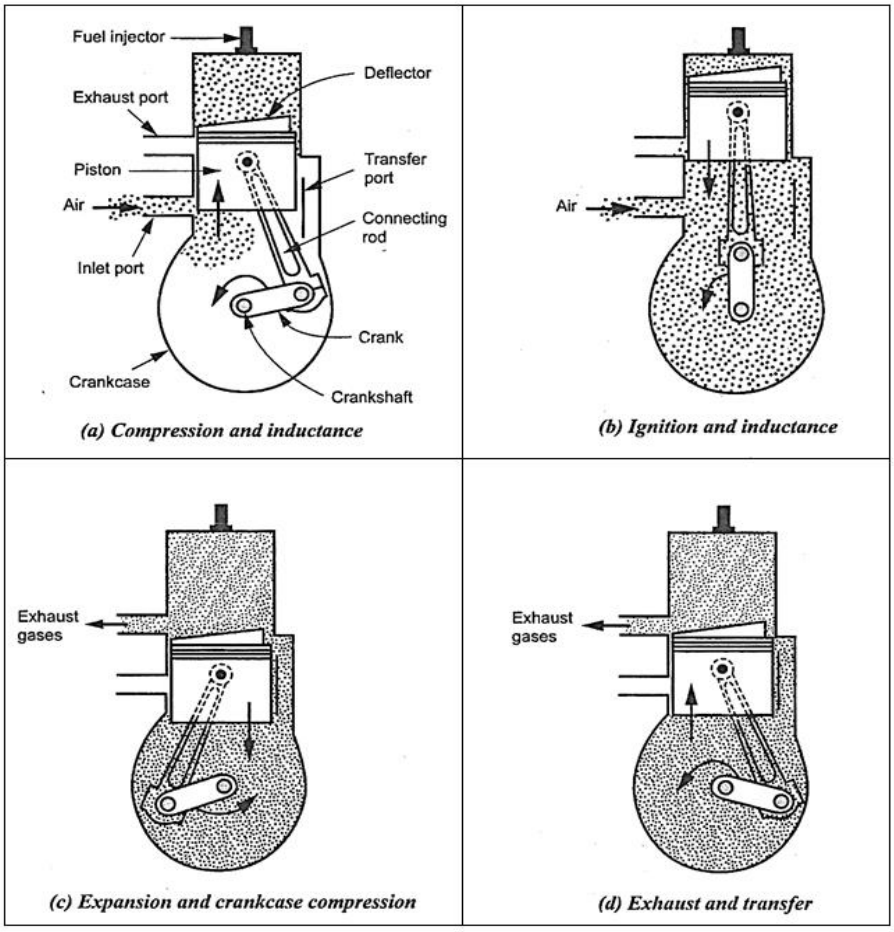
- ✓ The admission of fresh air into the crankcase continues till the piston reaches the TDC.

II. Second Stroke (Downward Stroke of the Piston)

- ➢ **Expansion and Crankcase Compression (Fig. c)**
  - ✓ The burnt gases expand and forces the piston to move down, thus useful work is obtained.
  - ✓ When the piston moves down, the air is partially compressed in the crankcase. This compression is known as crankcase compression.
- ➢ **Exhaust and Transfer (Fig. d)**
  - ✓ Nearly at the end of expansion, the exhaust port is uncovered and the combustion products escape to the atmosphere.
  - ✓ Immediately the transfer port is also uncovered and the partially compressed air from the crankcase enters the cylinder through the transfer port.
  - ✓ The cycle of operations are then repeated.

Summary

Thus in two-stroke engine, for every one complete revolution of the crankshaft, there is one power stroke.



Two Stroke - Diesel Engine

TWO STROKE - PETROL ENGINE

The working principle of a two-stroke petrol is illustrated in **Fig.**

I. First Stroke (Upward Stroke of the Piston)

- **Compression and Inductance (Fig. a)**
  - ✓ During the upward movement of the piston from bottom dead centre (BDC) to top dead centre (TDC), both the transfer and exhaust ports are covered by the piston.
  - ✓ The petrol-air mixture which is already transferred into the engine cylinder is compressed by the moving piston. Thus, the pressure and temperature of the charge increases at the end of compression.
  - ✓ The compression process is continued until the piston reaches TDC.
  - ✓ At the same time, the inlet port is uncovered by the moving piston and the fresh petrol-air mixture enters the crankcase through the inlet port.
- **Ignition and Inductance (Fig. b)**
  - ✓ After the piston almost reaches the TDC, the compressed petrol-air mixture is ignited by means of an electric spark produced by a spark plug.
  - ✓ The admission of fresh charge into the crankcase continues till the piston reaches the TDC.

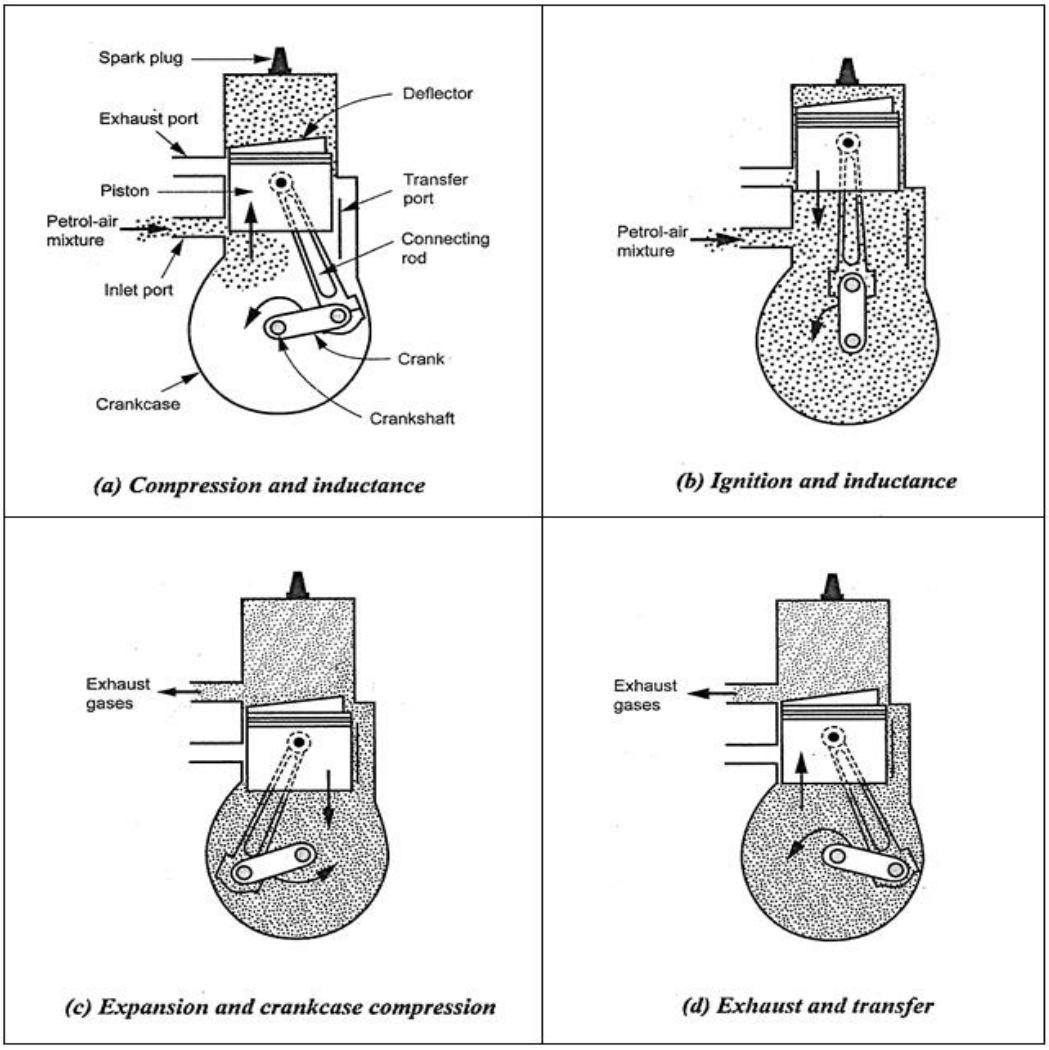
II. Second Stroke (Downward Stroke of the Piston)

- **Expansion and Crankcase Compression (Fig. c)**
  - ✓ The ignited gases expand and forces the piston to move down, thus useful work is obtained.
  - ✓ When the piston moves down, the petrol-air mixture is partially compressed in the crankcase. Thus compression is known as crankcase compression.
- **Exhaust and Transfer (Fig. d)**
  - ✓ Almost at the end of expansion, the exhaust port is uncovered and the combustion products escape to the atmosphere.
  - ✓ Immediately, the transfer port is also uncovered and the partially compressed air-fuel mixture from the crankcase enters the cylinder through transfer port.
  - ✓ The crown of the piston is made of a deflected shape, so the fresh air-petrol mixture entering the cylinder is deflected upward in the cylinder. Thus the escape of fresh charge along with exhaust gases is reduced.
  - ✓ The cycle of operations are then repeated.

Summary

- ✓ Thus in two-stroke engine, for every one complete revolution of the crankshaft, there is one power stroke.

- ✓ Since this engine requires only two-strokes to complete one cycle, it is called a two-stroke engine.
- ✓ The two-stroke petrol engines are popularly used in scooters and motor cycles because they run at higher speeds with moderate power outputs.



Two Stroke - Petrol Engine

FOUR STROKE - PETROL ENGINE

- ✓ Petrol engine is also known as Spark Ignition (SI) engine. The credit of inventing the SI engine goes to Nicolaus A. Otto (1876); that's why petrol engine is often referred to as Otto engine.
- ✓ Since ignition occurs due to a spark, petrol engines are called spark ignition (SI) engines.
- ✓ A four-stroke engine gives a power stroke in every set of four-strokes of the piston or two revolution of the crankshaft.

- ✓ The petrol engine operates on theoretical Otto cycle. It is also called as constant volume combustion cycle as the combustion takes place at constant volume with increase of pressure.

The cycle of operation of a four-stroke petrol engine consists of the following four-strokes:

- Suction or intake stroke.
- Compression stroke,
- Expansion or power stroke
- Exhaust stroke.

Working Principle

The working principle of four-stroke petrol engine is illustrated in Fig.

1. Suction Stroke (Fig. a)

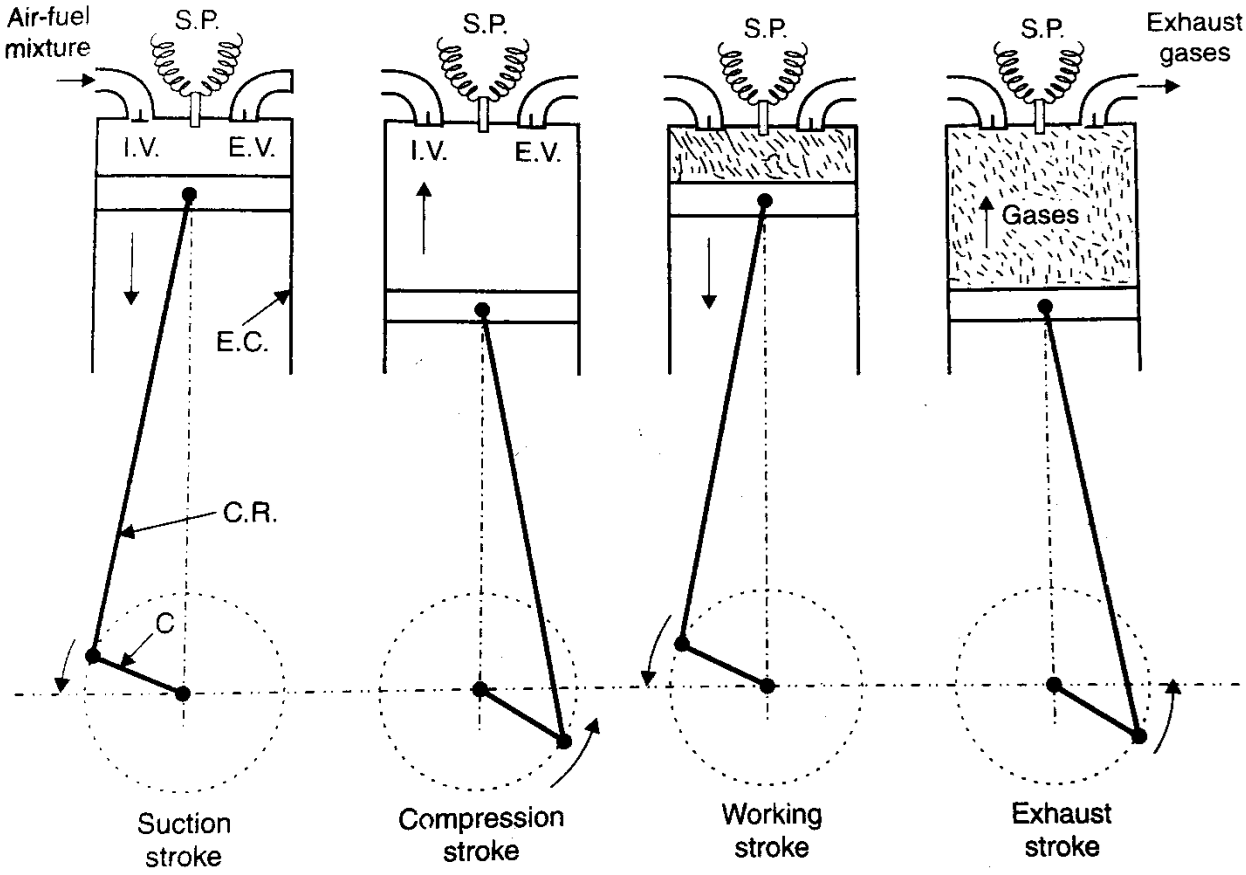
- ✓ During this stroke, the piston moves from Top Dead Centre (TDC) to Bottom Dead Centre (BDC) creating a vacuum inside the cylinder.
- ✓ During this stroke, the inlet valve is kept opened and the exhaust valve is kept closed.
- ✓ The vacuum created inside the cylinder draws the air-petrol mixture (which is also known as charge) into the cylinder through the inlet valve. It is performed till the piston reaches BDC.
- ✓ The above process is known as suction and this stroke is called the suction stroke.

2. Compression Stroke (Fig. b)

- ✓ *During this stroke, both the inlet and exhaust valves are closed.*
- ✓ The air-petrol mixture is compressed as the piston moves upwards from BDC to TDC. As a result of this compression, pressure and temperature of the air-fuel mixture or charge is increased.
- ✓ Just before the piston reaches the TDC, the air-petrol mixture (charge) is ignited by a spark plug; suddenly burning of the air fuel mixture takes place almost instantaneously.
- ✓ It increases the pressure and temperature inside the cylinder. Volume remains constant during combustion.
- ✓ These two-strokes (i.e., suction and compression stroke) complete one revolution of the crankshaft.

3. Expansion or Power Stroke (Fig. c)

- ✓ During this stroke, both the inlet and exhaust valves remain closed.
- ✓ The high pressure of the products of combustion (due to expansion of charge) pushes the piston from TDC to BDC. It is also called as working stroke as work is done by the expansion of hot gases.
- ✓ The force above the piston is transmitted to the crankshaft through the connecting rod and crank mechanism.
- ✓ Excess energy due to the combustion is stored in the flywheel which helps for the operation of three idle strokes.



I.V. = Inlet valve ; E.V. = Exhaust valve ; E.C. = Engine cylinder ; C.R. = Connecting rod ; C = Crank ; S.P. = Spark-plug.

4. Exhaust Stroke (Fig. d)

- ✓ At the end of the expansion stroke, the exhaust valve opens and the pressure inside falls suddenly. Thus during this stroke, the inlet valve is closed and the exhaust valve is kept opened.
- ✓ The upward movement of the piston from BDC to TDC, pushes out the products of combustion from the engine cylinder through the exhaust valve into the atmosphere. The cycle of operation is then repeated.
- ✓ These two-strokes (i.e., expansion and exhaust strokes) complete one revolution of the crankshaft.

Summary

- ✓ In four-stroke engines, four-strokes are completed in two revolutions of the crankshaft. Thus the power is developed in every alternate revolutions of the crankshaft.
- ✓ Since the four-stroke petrol engines have higher load carrying capacities than two-stroke petrol engines, they are generally used in passenger cars and also in some high power-high speed motor cycles.

FOUR STROKE - DIESEL ENGINE

Diesel engine is also known as compression ignition (CI) Engine.

- ✓ The credit for inventing the compression ignition engine goes to Rudolf Diesel (1892).
- ✓ The four-stroke diesel engine is similar to four-stroke petrol engine except that it operates at a higher compression ratio (M toJ22).
- ✓ In a diesel engine, only air is sucked from the atmosphere instead of air-fuel mixture during the suction stroke.
- ✓ In diesel engines, spark plug is not required for igniting the air-fuel mixture. Because the fuel is injected and forms an explosive mixture, which ignites spontaneously under pressure.
- ✓ The diesel engine works on the principle of theoretical diesel cycle. It is also called ***constant pressure combustion cycle*** as the combustion of fuel takes place at constant pressure with increase of temperature.
- ✓ Since ignition results due to high temperature of compressed air, these are called compression ignition (CI) engines.

Working Principle

The working principle of four-stroke diesel engine is illustrated in Fig.

1. Suction Stroke (Fig. a)

- ✓ During suction stroke, the inlet valve opens and the exhaust valve closes.
- ✓ The piston moves from TDC to BDC. This piston movement reduces the pressure inside the cylinder below the atmospheric pressure.
- ✓ S Due to the pressure difference, the fresh air is sucked into the cylinder through the inlet valve.

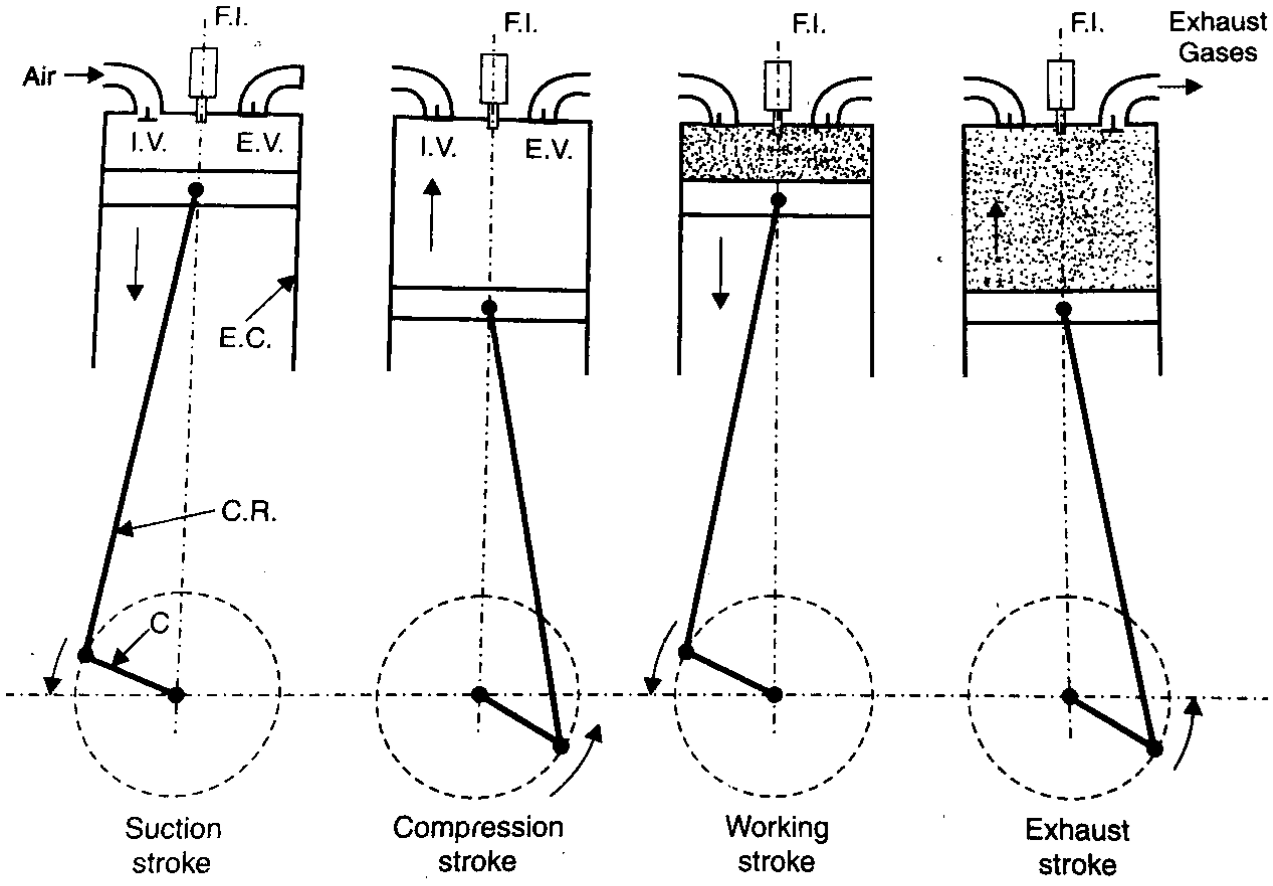
2. Compression Stroke (Fig. b)

- ✓ During this stroke, both the inlet and exhaust valves are closed.
- ✓ The air in the cylinder is compressed as the piston moves upwards from BDC to TDC. As a result of this compression, pressure and temperature of the air is increased.
- ✓ Just before the piston reaches the TDC, the diesel is injected into the cylinder in the form of a fine spray. The fuel gets vapourised and self-ignited due to the heat of compressed air. The fuel burns instantaneously at constant pressure.

3. Expansion or Power Stroke (Fig. c)

- ✓ During this stroke, both inlet and exhaust valves are closed.
- ✓ The combustion of fresh fuel injected into the cylinder is due to the high pressure and temperature developed during compression stroke. The fuel is continuously injected for 20% of the expansion stroke.

- ✓ The high pressure of the combustion products due to expansion of charge pushes the piston from TDC to BDC.
- ✓ It is also called as ***working stroke*** as work is done by the expansion of hot gases.



F.I. = Fuel injector ; I.V. = Inlet valve ; E.V. = Exhaust valve.

Four stroke Diesel cycle engine.

4. Exhaust Stroke (Fig. d)

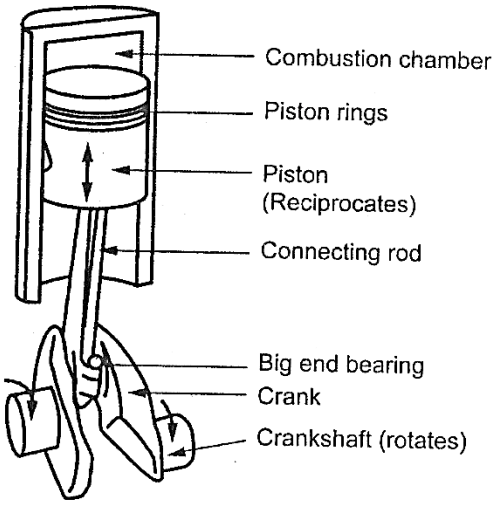
- ✓ *During this stroke, inlet valve is closed and the exhaust valve is opened.*
- ✓ The piston moves from BDC to TDC. The burnt waste gases are sent out through the exhaust valve and the cycle is repeated.

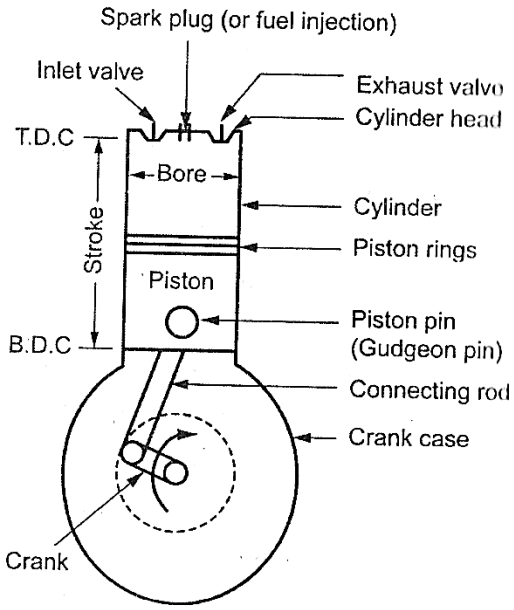
Summary

- Thus four-strokes are completed in two revolutions of the crankshaft. Hence for one complete cycle, there is only one power stroke and two revolutions of crankshaft.
- *Since four-stroke diesel engines produce higher power than the four-stroke petrol engines, they are generally used in tractors, tracks, etc.*

CONSTRUCTION AND COMPONENTS OF AN IC ENGINE

For complete understanding of the whole engine it is necessary to understand operation and purpose of the various parts present in the IC engine. A cross-section of a single-cylinder, four-stroke IC engine is shown in Fig. indicating the various components. The detail sketch of the same is shown in Fig





The main components of an IC engine and their functions are presented below

Cylinder Block

The heart of the engine is the cylinder block.It consists of three parts. They are:The cylinders in which the piston slides up and down, The ports or openings for valves, and The passages (water jackets) for the flow of cooling water.

Function: In the bore of the cylinder, the charge is compressed by piston, ignited and expanded to give power to piston.

Material: Aluminium alloy and grey cast iron.

Cylinder Head

The cylinder head is fitted on the top of the cylinder. It usually accommodates the inlet valve, exhaust valve and the spark plug or fuel injector.

Function: Through inlet valve fresh charge is admitted and through exhaust valve burnt gases are exhausted.

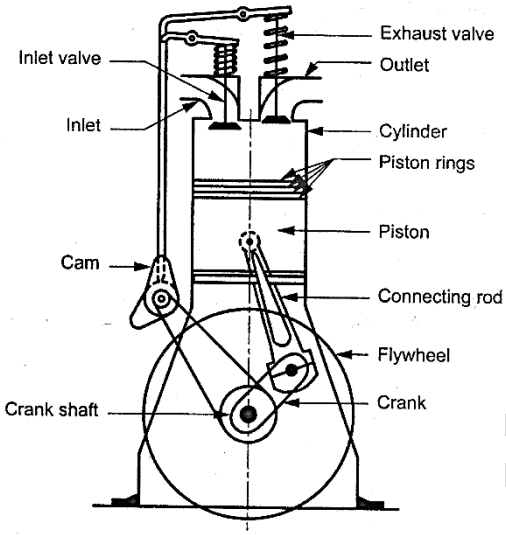
Material: Grey cast iron, aluminium alloy and cast steel.

Piston

It is the main active part of the engine. It is cylindrical in construction and slides up and down inside the cylinder. The piston is fitted with piston rings to provide good seal between the cylinder wall and the piston. There are three grooves to accommodate piston rings.

Function: To compress the fresh charge during the compression stroke. To transmit the force exerted due to combustion of the charge to the connecting rod finally to the crankshaft during the power stroke.

Material: Aluminium alloy, cast steel, cast iron and chrome nickel.



Parts of I.C engine

Combustion Chamber

The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber.

In other words, combustion chamber is the closed space in which combustion of fuel takes place.

Inlet and Exhaust Valves

Two valves are used for each cylinder of IC engines namely inlet valve and exhaust valve. The ***inlet valve*** is located at the junction of intake port and cylinder. The ***exhaust valve*** is located at the junction of exhaust port and cylinder.

Function: Inlet valve allows the fresh charge into the cylinder. Exhaust valve provides passages for the burnt gases to escape from the cylinder.

Material: Inlet valve is made of nickel chromium steel and exhaust valve is made of silchrome steel.

Inlet and Exhaust Manifolds

The pipe through which air or air-fuel mixture is drawn into the cylinder is called the inlet manifold. The pipe through which the flue gases *(**i.e.,*** exhaust gases) escape into the atmosphere is called the exhaust manifold.

Piston Rings

Piston rings are fitted into the grooves of the piston to maintain good seal between the piston and the cylinder walls.There are two types of pistons rings. Upper rings are called ***compression rings*** and the lower rings are called *oil rings.*

Function: Compression rings are used to provide gas tight sealing to prevent leakage of the lubricating oil into the engine cylinder.

The oil rings, also called as scrapper rings are used to scrap the used lubricating oil into the crank case.

Material: The material used for piston rings are alloy cast iron containing silicon, manganese, alloy steels, etc.

Connecting Rod

The connecting rod interconnects the piston to the crankshaft. The upper end of the connecting rod is fitted to the piston and lower end to the crankshaft.

Function: It transmits the power produced in the cylinder to the crankshaft. It converts the reciprocating motion of the piston into rotary motion of the crankshaft.

Material: Medium carbon steel and alloy steel.

Piston Pin

The piston pin is a pin that connects the small end of the connecting rod to the piston. It is also known as *gudgeon pin* or *wrist pin.*

Crank Pin

Crank pin connects the connecting rod big end to the crankshaft

Crank and Crankshaft

The crank is a lever that is connected to the end of the connecting rod by a pin joint with its other end connected rigidly to a shaft, called crankshaft. The crankshaft is the principle rotating part of the engine. The crankshaft is provided with suitable holes to help in the lubrication system.

Function: It converts the reciprocating motion of the piston into useful rotary motion of the output shaft.

Material: Forged steel.

Camshaft

A camshaft is a shaft on which cams are mounted. The camshaft is driven by crankshaft through timing gears. This shaft also provides the drive to the ignition system.

Function: It is used to operate the intake and exhaust valves through cam follower, push rod and rocker arm.

Material: Forged steel.

Cams

Cams are integral parts of the camshaft.

Function: Cams are designed in such a way to open the valves at the correct timing and to keep them open for the necessary duration.

Flywheel

The flywheel is a heavy wheel that is connected to the extreme end of the crankshaft. The size of the flywheel depends upon the number of cylinders and the general construction of the engine.

Function:

The flywheel stores the excess energy during the power stroke of the engine and supply the energy for the movement of the piston during the remaining stroke. Thus, its function is to maintain uniform rotation of the crankshaft.

Material: Cast iron.

Crankcase

It is a cast iron case, which holds the cylinder and the crankshaft. •S It also serves as sump for the lubricating oil.

Material: Cast iron and aluminium alloy.

COMPARISON BETWEEN TWO STROKE AND FOUR STROKE ENGINES

S.NO	TWO STROKE ENGINES	FOUR STROKE ENGINES
1	The power stroke is obtained in one revolution of the crank shaft	One power stroke is obtained in two revolutions of the crank shaft.
2	Simple in design and lighter in weight	Complicated design and heavier in weight
3	The torque obtained is uniform	The torque obtained is not uniform (high)
4	Starting is easy	Starting is not so easy
5	Mechanical efficiency is high	Mechanical efficiency is low
6	Air cooling is generally used	Water cooling is generally used
7	Fuel consumption is more	Fuel consumption is less
8	Consumption of lubricating oil is more	Consumption of lubricating oil is less
9	Some of the fuel may escape with exhaust gases	Fuel cannot escape with exhaust gases
10	Thermal efficiency is less	Thermal efficiency is more
11	Wear and tear of the moving parts is more	Wear and tear of the parts is less
12	It gives more noise	Noise is less
13	The initial cost and maintenance cost are less	The initial cost and maintenance cost are more
14	These engines are generally used in light vehicles such as motor cycles, scooters, mopeds, etc.	These engines are generally used in heavy vehicles such as buses, lorries, trucks, etc.
15	Engine size is more compact	Engine size is heavy and bully

COMPARISON BETWEEN PETROL ENGINE AND DIESEL ENGINE

S.NO	PETROL (S.I) ENGINES	DIESEL (C.I) ENGINES
1	It works on the basis of Otto cycle	It works on the basis of Diesel cycle
2	Air-fuel mixture is sucked into the cylinder during suction stroke	Air alone is sucked into the cylinder during suction stroke
3	Petrol engine operates with low pressure and temperature	Diesel engine operates with high pressure and temperature
4	Carburetor and spark plugs are provided	Fuel injection pump and injectors are provided
5	Ignition of air-fuel mixture takes place by an electric spark produced by the spark plug	Ignition of air-fuel mixture takes place due to the heat developed by the compression of air
6	They are quantity governed engines	They are quality governed engines
7	Operating speed is more	Operating speed is less
8	Weight per unit power is less	Weight per unit power is more
9	Starting is easy	Starting is not so easy
10	Initial cost and maintenance cost are less	Initial cost and maintenance cost are more
11	These engines produce less noise	These engines produce more noise
12	Thermal efficiency is less due to low Compression ratio	Thermal efficiency is more due to high Compression ratio
13	Compression ratio range is 6 to 10	Compression ratio range is 14 to 22
14	Fuel consumption per unit power is more	Fuel consumption per unit power is less
15	The cost of petrol is more	The cost of diesel is less than petrol
16	Engine life is less than 60,000 km	Engine life is more than 1,50,000 km
17	Petrol engines are widely used in light vehicles, automobiles, airplanes, etc.	Diesel engines are widely used in heavy vehicles such as buses, lorries, trucks, tractors, etc.

MERITS AND DEMERITS OF TWO STROKE AND FOUR STROKE ENGINE

TWO STROKE ENGINE	FOUR STROKE ENGINE
(Merits)	***(Demerits)***
One power stroke in every revolution of the crank shaft	One power stroke in two revolution of the crank shaft
For the same engine speed power developed theoretically twice that of a four stroke engine.	For the same engine speed power developed theoretically half that of a two stroke engine
As the engine produces uniform torque lighter flywheel can be used	As the engine produces fluctuating torque heav fly wheel can be used

COMPARISON BETWEEN PETROL ENGINE AND DIESEL ENGINE

Criteria	Petrol engine	Diesel engine
Working cycle	Otto cycle	Diesel cycle
Fuel used	Petrol	Diesel
Compression ratio	5.1-9.1	14.1-22.15
Fuel supply	Carburetor	Fuel injector
Ignition	Spark plug	Heat of compressed air
Pressure & temperature	Lesser due to lower compression ratio	Higher due to more compression ratio
Weight and size	Lighter and smaller	Heavier and larger
Initial cost	Less expensive	More expensive
Running cost	More	Less
Maintenance cost	Frequent but costs less	Rare but costlier
Thermal efficiency	Lesser about 25-35%	More about 40-50%
Starting effort	Less cranking effort	More effort reqd.
Chance of pre –ignition	More chances	No chances
Vibration and noise	Less	more
Field of application	Light duty work	Heavy duty work

Criteria	2 stroke cycle	4 stroke cycle
Power stroke	One stroke in each cylinder per one revolutions of crank shaft	One working stroke in each cylinder two revolutions of crank shaft
Weight and size	Lighter and compact for same power	Heavier and larger
Turning moment	Even and more uniform	Less uniform
Flywheel size	Smaller	Larger
Construction	Simple and easy to manufacture	More complicated due to va mechanisms
Moving parts	Few in number	More
Thermal efficiency	Lesser because a part of air-fuel Mixture goes as waste with exhaust g	More
Wear and tear	More due to smaller in size for same power	Less
Scavenging	Required	More efficient
Fuel consumption	More due to less moving parts	Less
Mechanical efficiency	More	Lesser

ADVANTAGES AND DISADVANTAGES OF TWO STROKE AND FOUR STROKE

Advantages	Disadvantages
Two stroke	
High power to weight ratio	Scavenging problem
Less number of stroke per circle	Fresh mixture is escaping with exhaust gases dur exhaust stroke
Less moving parts e.g. no valve mechanism	Non stable at idling speed
High speed engine due to less moving parts	
Low service and overhaul cost due to less number of parts	
Four stroke	
More torque even at idling speed	Low power to weight ratio
No scavenging problems	More moving parts. Not suitable for high speed
No fresh mixture escaping with exhaust gases	More number of stroke per circle
	High service and overhaul cost due to more parts

S.NO	AIR COOLING SYSTEM	WATER COOLING SYSTEM
1	Engine design is simple	Engine design is not much simple
2	Weight is less	Weight is more
3	No leakage problems	Leakage of water may occurs
4	No risk of freezing of water in cold climates	Freezing of water in cold climate may cause trouble
5	Less maintenance is sufficient	More maintenance is required
6	Requires less space	More space is required
7	No danger occurs due to the damage in cooling system	A small damage in the cooling system may cause danger
8	Cooling is not so efficient	Cooling is more efficient
9	Engine parts are not uniformly heated	Engine parts are uniformly heated
10	Higher compression ratio is not permitted	Higher compression ratio is permitted
11	It is used in light duty vehicles	It is used in heavy duty vehicles
12	The cost for cooling system is less	The cost for cooling system is more

GENERAL POWER REQUIREMENTS

Daytime functions

Table 4 presents the daytime power requirements for each function using both lighting systems. Each system's total is shown for two DRL implementations—no DRLs and dedicated DRLs.

When using dedicated DRLs, the traditional system requires about 20% more power than when using no DRLs at all, while the LED system requires about 45% more power when using dedicated DRLs, compared to using no DRLs at all.

A comparison between systems shows that the traditional system uses about three and a half times the power of the LED system when they both use dedicated DRLs, and about four times the power without DRLs.

Daytime power requirements of the traditional and LED-based exterior lighting systems.

Daytime functions	Number of lamps	Total power (W)		LED percent of traditional system
		Traditional system	LED system	
DRL, dedicated	2	45.8	22.8	49.8
Turn signal, front	2	53.6	13.8	25.7
Stop	2	53.0	11.2	21.1
CHMSL	1	17.7	3.0	16.9
Turn signal, rear	2	53.6	13.8	25.7
Backup/reverse	2	35.4	10.4	29.4
Total (no DRLs)		213.3	52.2	24.5
Total (with dedicated DRLs)		259.1	75.0	28.9

Night time functions

Table presents the nighttime power requirements for each function using both Lighting systems. The traditional system requires about two times the power of a Comparable LED system.

Nighttime power requirements of the traditional and LED-based exterior lighting systems.

Nighttime functions	Number of lamps	Total power requirement (W)		LED percent of traditional system
		Traditional system	LED system	
Low beam	2	112.4	108.0	96.1
High beam	2	127.8	68.8	53.8
Parking/position	2	14.8	3.3	22.6
Turn signal, front	2	53.6	13.8	25.7
Side marker, front	2	9.6	3.4	35.4
Stop	2	53.0	11.2	21.1
Tail	2	14.4	2.8	19.4
CHMSL	1	17.7	3.0	16.9
Turn signal, rear	2	53.6	13.8	25.7
Side marker, rear	2	9.6	3.4	35.4
Backup/reverse	2	35.4	10.4	29.4
License plate	2	9.6	1.0	10.4
Total		511.5	242.9	47.5

VARIOUS RESISTANCES TO MOTION

A gearbox is used to get different torques and speeds which are required to overcome the following resistances.

1. Air (or) wind resistance
2. Gradient resistance
3. Rolling resistance

1. Air (or) wind resistance

The moving vehicle has to face air resistance. To reduce this air resistance the front_bonnet and mudguard are given slope. So that air can be easily turned apart. The air resistance depends upon.

- Vehicle speed
- Shape and size of the body
- Direction of wind
- Velocity of the wind.

2. Gradient resistance

It is the resistance due to inclination of the road. It depends upon the angle of inclination and weight of the vehicle.

3. **Rolling resistance**

All the remaining resistances to the movement of vehicle are called rolling resistance. It includes internal frictional resistance due to deformation of road and tyre. The rolling resistance depends upon

- ✓ Nature of road surface
- ✓ Tyre cross-section
- ✓ Total weight of the vehicle
- ✓ Load on the vehicle
- ✓ Tyre inflation pressure

ROLLING RESISTANCE:

We assessed rolling resistance for 51 different currently available tire models in four sizes. These models represent only a fraction of the hundreds of models currently available today, but were chosen because previous tests or manufacturing claims indicated they might have lower than average rolling resistance or other distinctive performance features (best wet traction, high overall satisfaction, etc.).

The models we tested had rolling resistance coefficients ranging from 0.0062 to 0.0152. We recommend models with an RRC of 0.0105 or less, recognizing that low values are somewhat more difficult to achieve on larger, heavier tires than on smaller, lighter weight models.

Factor affecting resistance

- Air resistance
- Rolling resistance
- Inertial resistance
- Gradient resistance
- Transmission losses
- Losses from the use of auxiliaries
- Engine friction

Factors affecting rolling resistance

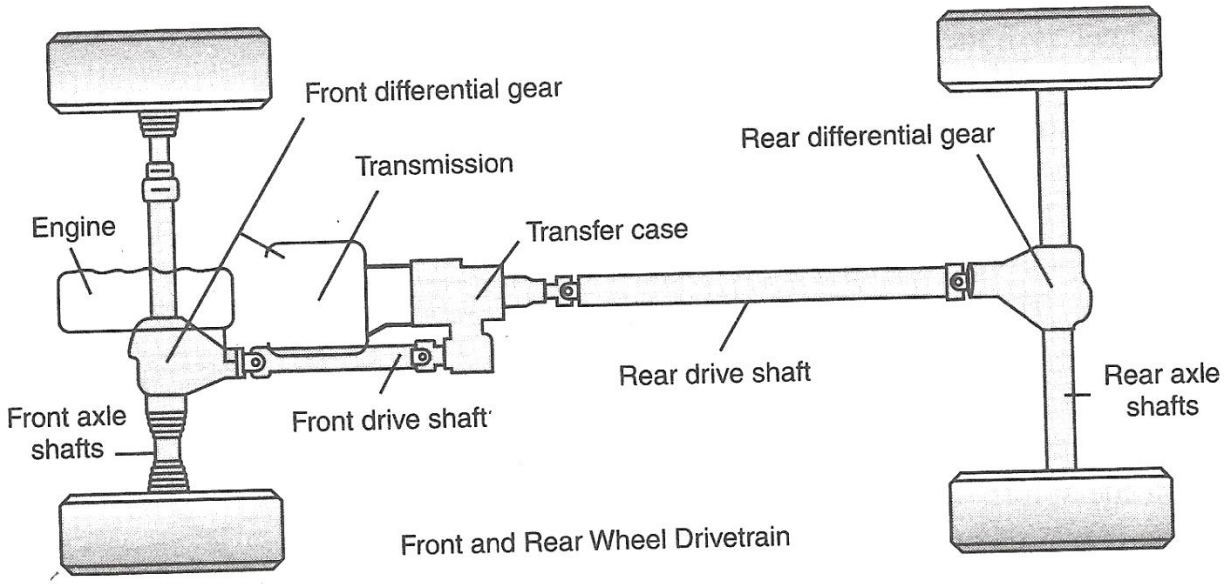
- Vehicle weight
- Tire inflation
- Vehicle speed
- Tire thread design ,composition and width
- Tire temperature
- Road structure and conditions

UNIT II

TRANSMISSION SYSTEM

The power developed by the engine is to be transmitted to the driving wheels. For this, some device capable of changing speed and power to meet the frequent changes in the requirements demanded on the engine is needed in order to propel the automotive vehicle. These devices are generally called transmissions.

These include all those components placed between the engine and the driving wheels, for transmission of engine power. These components are clutches, gear box, couplings, propeller shaft, axles and differential.



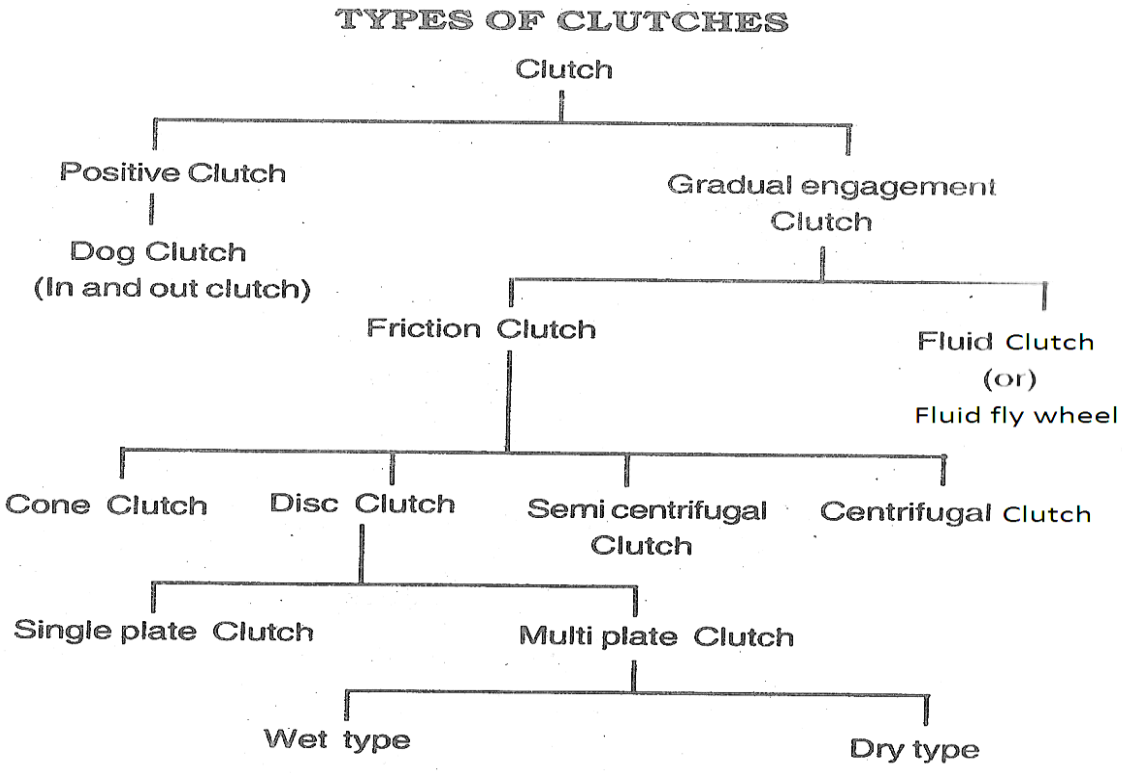
Transmission system

Requirements of Automotive Transmission

- ✓ To disconnect the engine from the drive wheels.
- ✓ To connect the engine smoothly and without shock to the driving wheels.
- ✓ To vary the leverage between the engine and the driving wheels.
- ✓ To reduce the speed of the engine in proper ratio according to the performance of the vehicle.
- ✓ To turn the drive round through 90°.
- ✓ To drive the wheels at different speeds, while taking a curve.
- ✓ To allow a relative movement between the engine and the driving wheels because of the flexibility and contour of the road.

CLUTCH

Clutch is a device, used in the transmission system of an Automobile to engage and disengage the engine to the gear box. Thus the clutch is fitted between the engine and the gear box. The disengagement and engagement of the drive from the engine to the gearbox should be smooth and progressive. When engaged position, the power is transmitted to the driving wheels through the transmission system. When disengaged position, the power is not transmitted to the driving wheels and the vehicle stop but the engine in running.



FUNCTION OF CLUTCH

- ✓ It is used for connecting (or) disconnecting the drive of the engine to the gearbox.
- ✓ To disconnect the engine power from the gear box as required under following situations.
    a) To start the engine and warm it up
    b) To facilitate to engage 1st (or) 2nd gear to move the vehicle from rest
    c) Disconnect power to gearbox for easy shifting of gears, so that the noise and damage to the gear is avoided
    d) Disconnecting drive from the engine to stop the vehicle after application of brakes
- ✓ To transmit the engine power to the rear wheels without shock.
- ✓ The clutch is engaged only when the vehicle is in motion.

QUALITIES OF GOOD CLUTCH

- ✓ Maximum torque transmission
- ✓ Gradual engagement.
- ✓ Heat dissipation
- ✓ Dynamic balancing

- ✓ Damp out vibration
- ✓ Free pedal play
- ✓ Easy to adjust, repair and overhaul
- ✓ Friction material must have high co-efficient friction
- ✓ Simple, cheap and long life.
- ✓ Occupy minimum amount of space.

COMPONENTS OF CLUTCH

The main components of a friction clutch are:

- ✓ Clutch plate
- ✓ Clutch lining
- ✓ Pressure plate
- ✓ Springs
- ✓ Bearing
- ✓ Clutch linkages

Clutch Plate

Clutch plate is the driving member of the clutch, which is held by the pressure plate with the flywheel. It is a steel disc which is connected to the splined hub through springs as shown in fig.

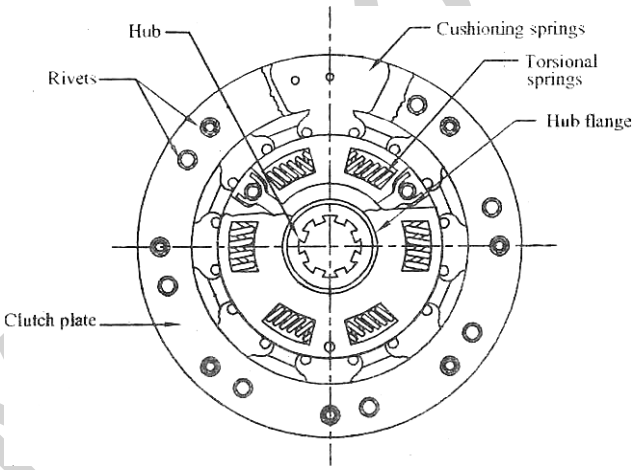


Fig. Clutch Plate

At its outer facings, the disc contains lining of heat resisting material having a high co-efficient of friction. The linings are rivetted to the clutch plate and can be replaced after they wear out.

Clutch Lining

The clutch linings are made of frictional material having higher co-efficient of friction. The linings are rivetted to the clutch plate and are replaced by new ones when the original linings wear out. The lining materials are made up of Leather, Cork, Fabric and Asbestos. Clutch linings are of the following two types.

(a) Woven type (b) Moulded type

(i) Laminated

(ii) Solid woven

Qualities of Good Linings

- ✓ High wear resistance
- ✓ High co-efficient of friction
- ✓ High resistance to heat
- ✓ Low cost
- ✓ Easy to manufacture

Pressure Plate

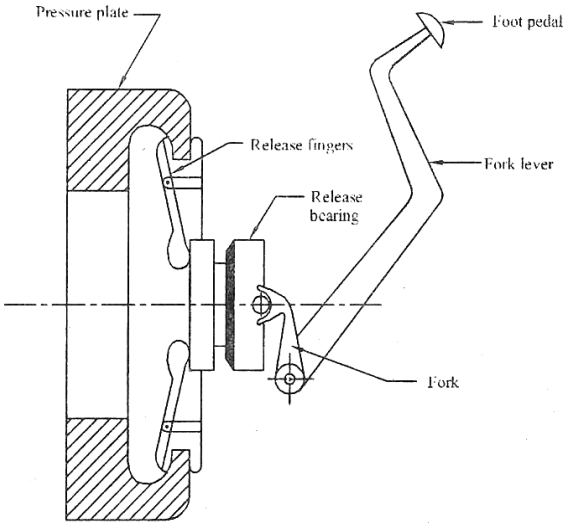
The pressure plate assembly is connected with the flywheel and holds the clutch plate with the flywheel due to its pressure. It consists of pressure disc, springs, operating fingers and holding down cover. The pressure plate is held with the cover through the bolts. The coil springs are held between the cover and the plate. The fingers act as lever and when pressed down the pressure plate will be withdrawn from the flywheel.

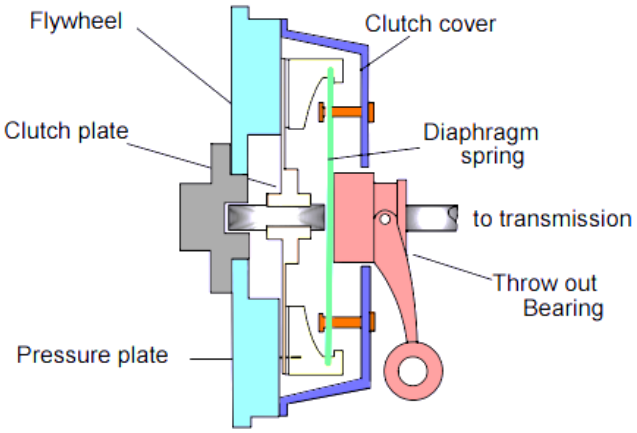
Springs

The cushioning and torsional springs are used to damp the vibrations produced during engagement and disengagement of the clutch. Inspect the springs on the clutch plate. In case they are found to be cracked (or) weak complete plate has to be replaced.

Bearing

It is used to transfer force at the foot pedal through the stationary linkage to the rotating clutch. This is a thrust ball bearing which is packed with grease for lubrication.





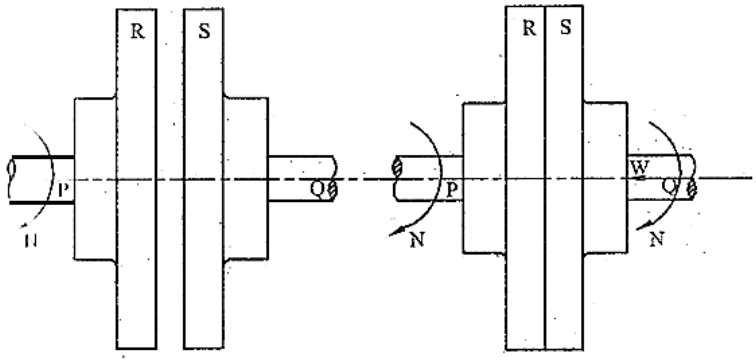
It consists of the foot pedal, Fork lever, Fork, thrust bearing and fingers as shown in fig. The release bearing is held in a fork and is free to move over the clutch shaft. The fork in turn is connected with the foot pedal through the fork lever. The thrust bearing operates the clutch release fingers provided in the pressure plate.

When pressure is applied at the foot pedal, it is transmitted to the release fingers through fork lever, fork and thrust bearing as a result, the pressure plate moves back thereby releasing pressure from the clutch plate.

Principle of Friction Clutches

The principle of a friction clutch may be explained the fig. Let shaft P and disc R be revolving at N rpm. Shaft Q and the disc S keyed to it are stationary, initially when the clutch is not engaged as shown Now apply some axial force W to disc S so that it comes in contact with disc R. When the contact is made, the force of friction produced between R and S consequently the disc S will also start revolving.

The speed of S depends upon friction force present and it is proportional to the force W applied. If W is increased gradually, the speed of S will be increased correspondingly till the stage comes when the speed of S becomes equal to the speed R. Then the clutch is said to be fully engaged .



Principle of Friction Clutches.

Then, T=μWR

Where,

W = Axial load applied

μ. = Co-efficient of friction

T = Torque transmitted

R = Effective mean radius of friction surface

The value of T depends on u, W and R that means increasing any (or) all of the above factors would increase the amount of torque transmitted by the clutch.

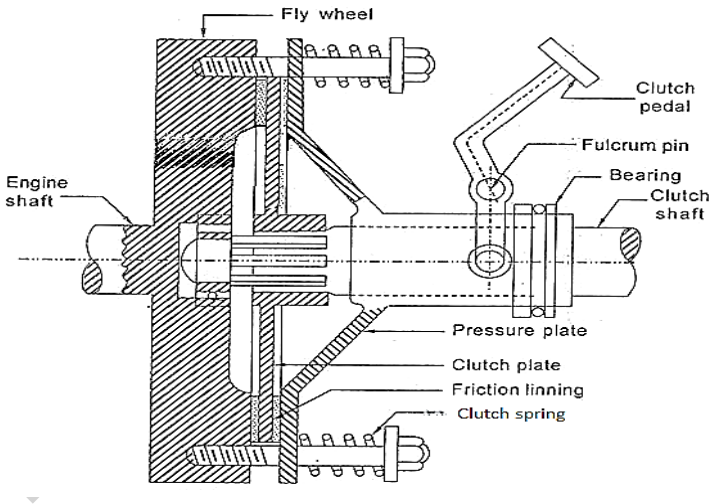
SINGLE PLATE CLUTCH

A simplified sketch of single plate clutch is shown it is the most common type of clutch used in motor vehicles for producing a quick disengagement.

Construction:

The clutch plate is splined to the clutch shaft. It is held between the flywheel and pressure plate. Friction lining is also provided on the both sides of the clutch plate. There are springs (the number may vary, depending upon design) arranged circumferentially, which provide axial force to keep the clutch in engaged position.

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. A pedal is provided to pull the pressure plate against the spring force whenever it is required to be disengaged. Ordinarily it remains in engaged position as shown.



Single plate clutch

Working:

When the clutch pedal is pressed, the pressure plate is moved to the right against the force of the springs. This is achieved by means of a suitable linkage and thrust bearing. With this movement of the pressure plate the clutch plate is released from the flywheel. Thus, the flywheel remains rotating as long as the engine is running and the clutch shaft speed reduces slowly and finally it stops rotating.

When the clutch pedal is released, the clutch plate is engaged with the flywheel due to the spring force and produces friction between the flywheel, clutch plate and pressure plate, the clutch plate revolves with the flywheel. As

the clutch plate revolves, the clutch shaft also revolves. Clutch shaft is connected to the Gearbox. Thus the engine power is transmitted to the gear box.

When the clutch pedal is pressed, the clutch is said to be disengaged, otherwise it remains engaged due to the spring forces. This can be used in contessa, premier, Maruti 800, Maruti 1000.

Advantages:

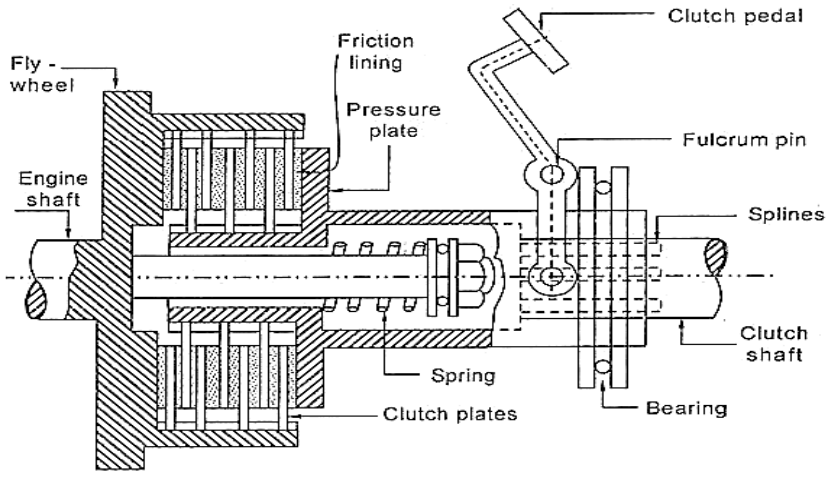
- ✓ Easy to change the gear
- ✓ Simple design
- ✓ More reliable
- ✓ Easy to adjust, repair and overhaul
- ✓ Noiseless operation

Disadvantages:

- ✓ Requires more pedal pressure
- ✓ Occupy more space

MULTIPLATE CLUTCH

Multi-plate clutch contains more than one clutch plates lined with a frictional material as in the case of single plate clutch. The increased number of plates provides the increased torque transmitting capacity of the clutch. They are alternately fitted to the engine shaft and the gearbox shaft. Each of the alternate plate slides in grooves on the flywheel and the other slides splined on the pressure plate as shown. Thus, each alternate plate has inner and outer splines. The plates are made of steel, bronze and brass etc.



Multi plate clutch

The multiplate clutch works in the same principle of single plate clutch. When the flywheel rotates the pressure plate and clutch plate are also rotated due to spring force. The clutch shaft is then rotated. When the driver presses the pedal, the friction plates are released. The flywheel is continued to rotate, but the clutch shaft stops to rotate.

These clutches are used in heavy commercial vehicles, racing cars and motor cycles for transmitting high torque. This clutch is either of wet type (or) dry type, depending on the fact whether it is operating in oil bath (or) not.

Advantages:

1. Transmitting high torque
2. Smooth engagement
3. Noiseless operations, more life

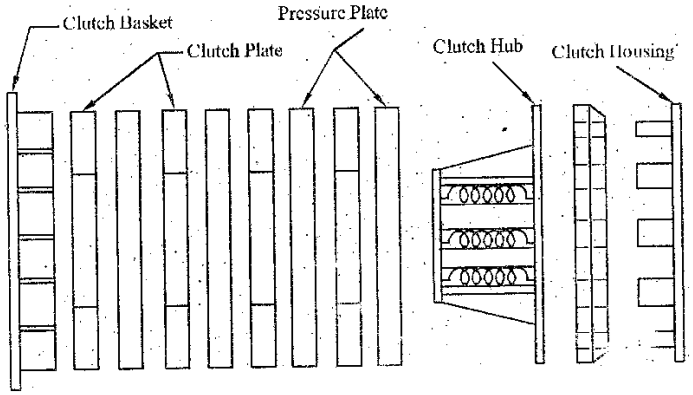
Disadvantages:

1. Initial cost is high
2. Maintenance cost.is high
3. Not used in light vehicles

MULTIPLATE WET TYPE CLUTCH

The single plate clutch is not able to use in the scooter and motor cycles because the size of single plate clutch unit is too large. So, the multiple wet type clutch is placed and this clutch occupies very lesser area.

The working of wet type multiplate clutch is similar to that of dry type clutch. But the whole assembly is immersed in oil for reducing the amount of heat which is produced by clutch unit, and also reduces the wear and tear.



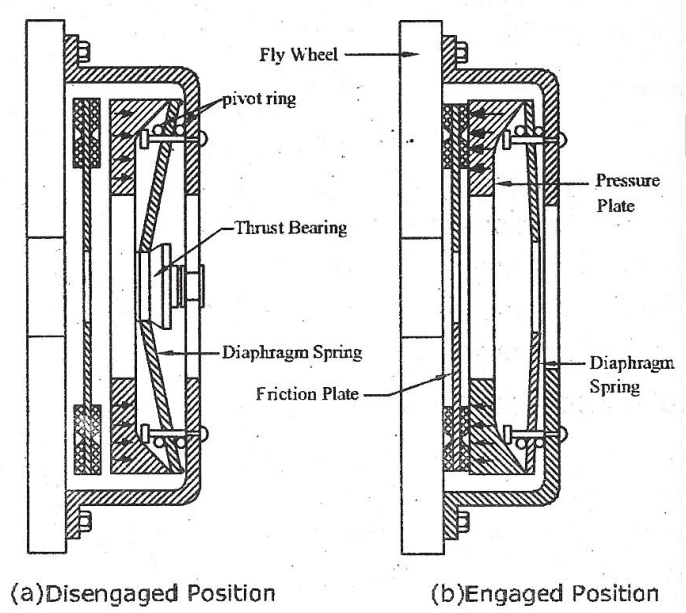
It consists of four clutch disks, four pressure plates, clutch hub and springs. When the control lever is operated the clutch gets disengaged. Then the plates will not press on the clutch disks. There is no power transmission taking place when the clutch lever is released, the springs press the pressure plates as well as clutch plates, and it transmits the power from engine.

DIAPHRAGM SPRING CLUTCH

In some modern vehicles, instead of using coil springs a conical dish-shaped steel plate diaphragm spring is used. It exerts force on the pressure plate to press the clutch plate firmly for engaging the clutch. It does not have release levers. The clutch cover is secured to the engine flywheel. The pivot rings are held in the clutch cover. The diaphragm spring pivots on the pivot rings. The outer rim of the diaphragm spring is in contact with the pressure plate.

In the natural conical position the diaphragm spring exerts sufficient pressure and keeps the pressure plate in firm contact with the clutch plate and the latter in firm contact with the flywheel. Now the clutch is in the engaged position. This is the case when the clutch releases bearing is held back as shown.

To disengage the clutch, the clutch pedal is pressed. This causes the throw out bearing moves towards the flywheel, pressing the centre portion of the spring, which causes the rim of the diaphragm spring to move backward. This happens because the diaphragm spring is pivoted on the pivot rings. This removes the pressure on the pressure plate and the clutch is disengaged as shown this type of clutch can be used in Tata sierro, Tata Estate, DCM Toyota, Swaraj Mazda etc...

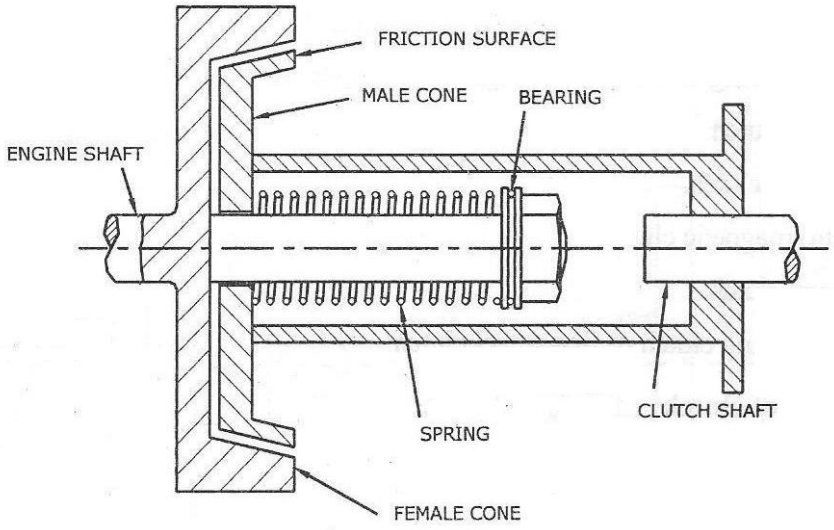


Advantages:

- ✓ Requires a lower operating effort.
- ✓ Accurate balancing at all times
- ✓ Vibrations eliminated
- ✓ Long life
- ✓ Compact design
- ✓ No need of release levers

CONE CLUTCH

Cone clutch is a friction type clutch, which consists of conical friction surfaces. The female cone is an integral part with engine shaft. The male cone is mounted on the clutch shaft over splines, so that it can slide over. In this clutch the frictional surfaces are only on the conical portion. The arrangement is shown in figure.



CONE CLUTCH

When the clutch is engaged, the male cone come in contact with the frictional surfaces of the female cone by means of the spring force. By pressing the clutch pedal, the male cone slide against the spring force and the clutch is disengaged. In fully engaged condition, the male cone remains fully within the female cone so that the friction surfaces remain in complete contact.

In the engaged position the power is transmitted from the engine shaft to the female cone, thence from the male cone to the gearbox through the splined shaft. When the clutch system is disengaged, the male cone is drawn or pulled out; thereby the contact surfaces are made free. But now-a days this type of clutch is obsolete

Advantages:

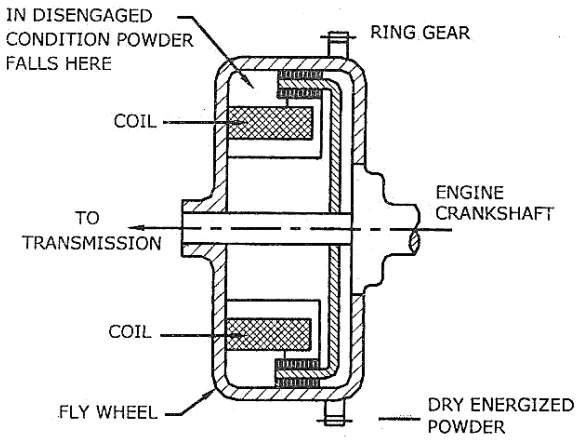
- ✓ The normal force acting on the friction surface is greater than the axial force as compared with that in the single plate clutch.

Disadvantages:

- ✓ If the angle is less than 20°, the male cones have a tendency to bind in the female cone. In this case it becomes very difficult for disengagements.
- ✓ Even a little amount of wear on the conical surfaces results in a considerable amount of movement of male cone in axial direction

MAGNETIC CLUTCH

In magnetic clutch the clutching medium is mixture of magnetisable metal and dry lubricant. A magnetic clutch shown in fig. As magnetization takes place, the dry powder particles are drawn together, so as to form a solid drive unit. Apart from the usual clutch components, magnetic clutch consist of a coil fully enclosed by a magnetic circuit.

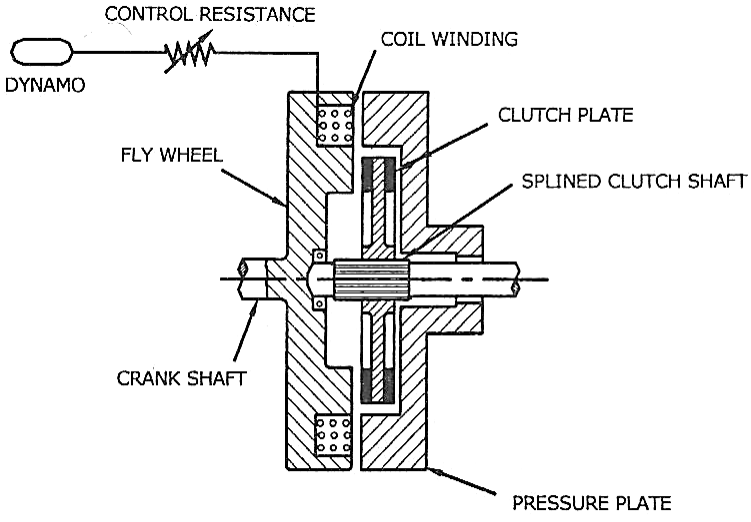


Magnetic clutch

The fine metal used in the mixture generally consists of steel, nickel and carbon. The fine metal and lubricant particles form a strong bond for low- transmission. The mixture frozen in engaged position and unfrozen in disengaged position. This freezing and unfreezing is in direct proportion to the amount of current applied on the coil. Therefore, the driver can make the extent of slippage or solid drive as per the need.

ELECTROMAGNETIC CLUTCH

The principle of electromagnetism is applied in the operation of electromagnetic clutch. There is no need of linkages for its engagement or disengagement. This is not suitable for remote operation. This has been employed in Renault Cars.



Electro-Magnetic Clutch

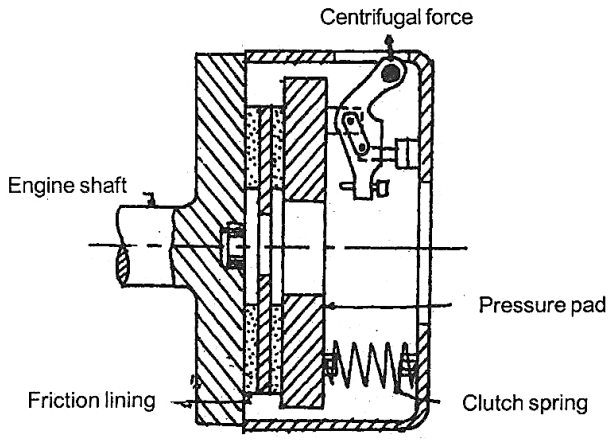
Like the conventional clutch, this also consists of flywheel, pressure plate, clutch plate, and splined shaft. This incorporates a coil winding which is housed in the flywheel. The dynamo supplies the electric power to the winding. The winding when energized, to engage the clutch and disengage when the supply is cut-off, attracts the pressure plate.

To regulate the electromagnetic force, a control resistance is mounted between the dynamo and the winding as shown in figure.

The operation of the accelerator pedal varies the resistance. During normal running, the clutch is disengaged by pressing the accelerator pedal thereby gradually cutting- off the electrical resistance. For momentary disengagement of the clutch, during change of gears, a clutch release switch mounted on gear lever is operated. During this change of cuts off the current to the winding. Care must be taken to see that the heating effect of the current may not cause breakdown of the coil insulation.

CENTRIFUGAL CLUTCH

In this arrangement, the centrifugal action of fly-weights is made use of for engaging and disengaging the pressure plate. A simple arrangement is shown in figure 8; in which the clutch pedal and the springs are eliminated. The functioning of the clutch is automatic and depends upon the engine speed. In this arrangement, there is no need for specific operation to disengage the clutch. The vehicle can also be stopped with the gear load, without stalling the engine. The vehicle is controlled by the accelerator pressure and gear transmission at the starting only. This arrangement makes the driving operation very easy and convenient.



Centrifugal clutch

As the speed increases, the fly-weights move outwards due to centrifugal force. This movement operates a bell crank lever and presses the floating plate. As shown in the figure, there are helical springs between the floating plate and pressure plate. The force is transmitted to the pressure plate through the springs.

The pressure plate containing the friction lining presses the clutch. There is one more set of springs on the back side of the pressure plate as shown in the figure to keep the clutch in disengaged position at low speed. A projection or a strip called stop is also provided to limit the movement of the fly-weights and the amount of the centrifugal force. Even if the speed is increased beyond this limit, the pressure on the plates will remain constant.

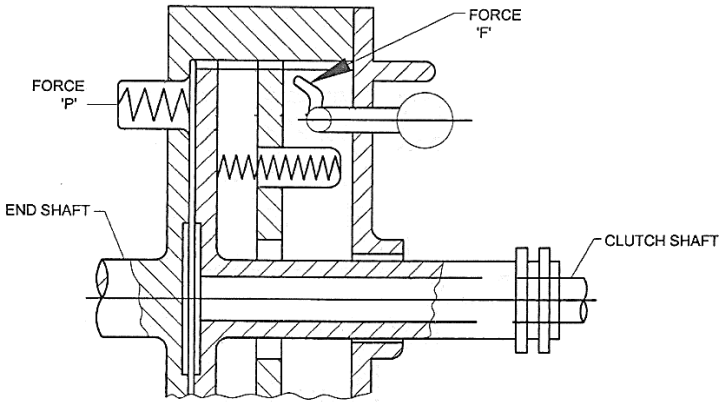
SEMI CENTRIFUGAL CLUTCH

For small torque transmission the clutch springs may be designed so that they have sufficient strength for applying the required amount of force and at the same time are not so stiff as to cause any strain to the driver while disengaging. However for high powered engines the clutch spring pressures required may be considerable and thus the action of disengaging the clutch becomes fatiguing to the driver.

To obviate this trouble, the help is taken of the centrifugal force. The clutch springs are designed to transmit the torque at normal speeds, while for higher speeds, centrifugal force assists in torque transmission. Such types of clutches are called semi centrifugal clutches.

Three hinged and weighted levers are arranged at equal intervals. One of these is shown in Fig. on enlarged scale. This lever is having fulcrum at A and is hinged to pressure plate at B. The upper end of the lever is weighted at C. 0 is the adjusting screw, by means of which the maximum centrifugal force on the pressure plate can be adjusted.

To reduce friction, the levers are mounted on needle roller bearings on the pressure plate. At moderate speeds the pressure of the springs is sufficient to transmit the required torque.



Semi centrifugal clutch

.

However at higher speeds, the weight C, due to the centrifugal force moves about A as fulcrum thereby pressing the pressure plate. The centrifugal force is proportional to the square of the speed so that adequate pressure level is attained. Fig. Shows the variation of force on the pressure plate at various speeds

FLUID COUPLING (or) FLUID FLYWHEEL

This is a liquid coupling used to transmit the engine turning force to a clutch. The assembly consists mainly of two members:

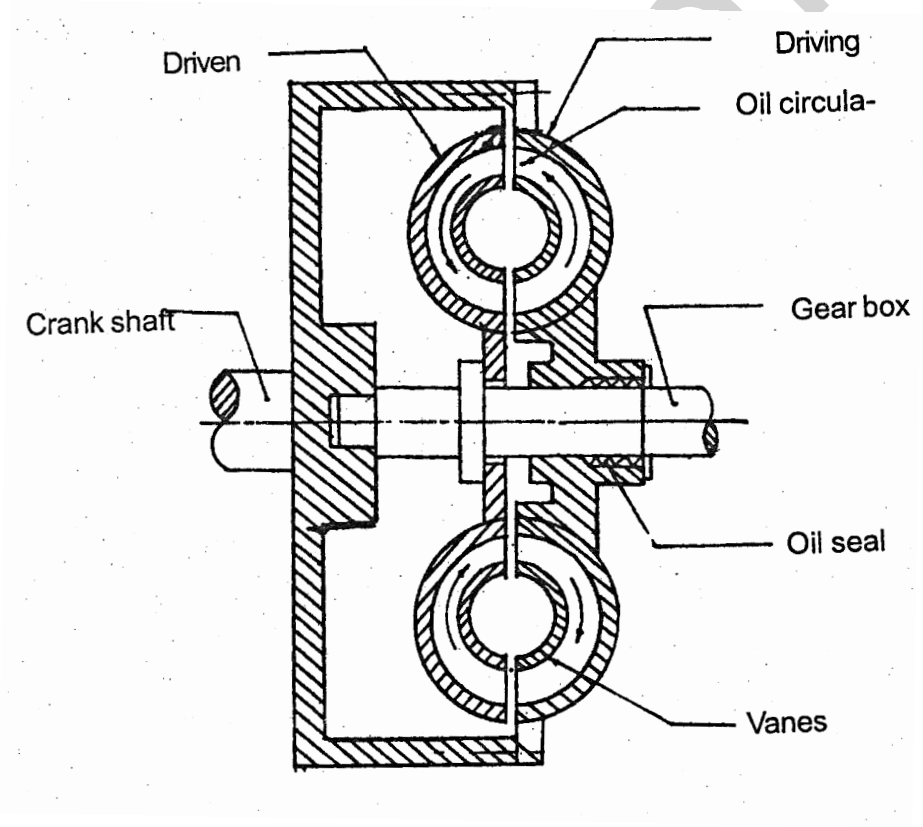
1) Driving member
2) Driven member

As shown in figure, the driving member or the pump impeller is connected to the fly wheel casing.

The driven member or the turbine runner is connected to the transmission shaft. In some other design the driving member may be placed at the left and the driven member at the right. But anyhow both members are positioned on the respective shafts with a small clearance between them.

These two members do not have any direct contact with each other. Splines are provided on the transmission shaft, over which the driven members is free to slide. These two members consist of two casings which are similar in shape and roughly circular. These casings are (Figure) provided with radial ribs which form a number of passages. These ribs are suitably grooved and a number of fins are formed in both casings and filled with oil.

When the engine is started, the oil from the driving member is forced outward radially because of the centrifugal force. The oil moves generally in two directions at the same time. A rotary flow at right angles to the shaft and also in a vortex flow, because of circulation between the impeller and the runner. The rotary flow initiates the movement of the runner. The vortex flow is at right angles to the rotary flow.



The oil is thrown out against the curved interior surface because of a centrifugal force. Then, it is directed across, to the runner and returned to the impeller. When the efficiency of the coupling is highest, under best operating conditions, runner speed is almost equal to the impeller. The lagging of the driven unit behind the driver unit is known as slip.

Advantages

- ✓ No wear on moving parts
- ✓ No jerk on transmission
- ✓ Gives vibration free drive
- ✓ Needs no separate pedal
- ✓ Noiseless operation
- ✓ No adjustment to be made
- ✓ Less Maintenance
- ✓ Requires less pedal pressure
- ✓ Simple design

Disadvantages

- ✓ Not suitable for conventional type of gear box.
- ✓ Slip of 2% is always occurs under all working
- ✓ Drag on the gear box.
- ✓ Gear changing is slightly difficult.

TORQUE CONVERTOR

This is a mechanism designed to get a mechanical advantage or gear ratio by hydraulic transmission. Torque converter in automotive transmission gives a maximum gear ratio during starting from rest. As the speed increases, this transmission gradually decreases the gear ratio.

The construction of the torque converter is almost similar to the construction of the fluid fly wheel. But an additional member called the reaction member is provided in between the turbine and the impeller.

As per the principle, the gear box transmits the torque variation only in some definite number of steps, but the torque converter varies continuously.

The principle of the single stage torque converter is shown in fig. This consists of (1) an impeller which is the driving member connected to the engine (2) the turbine which is the driven member connected to the propeller shaft. The stator is fixed to the frame.

To start with, the presence of a centrifugal force at the impeller, forces the fluid from the impeller into the turbine. It is to be noted that the impeller is driven by the engine shaft and the turbine attached to the output shaft is assumed to be initially stationary. Suppose, there was no stator, the fluid from the turbine would enter into the impeller directly.

This throwing of fluid will push the turbine blade in the opposite direction, causing a power loss. This dragging action on the turbine can be avoided if the fluid from the turbine is made to strike at a stator. In this operation the presence of the stator changes the direction of the fluid suitably to strike the impeller in the most favourable direction.

Later, the impeller pushes the fluid back into the turbine. This process is repeated continuously causing the torque on the turbine to increase. Of course, this favourable action of the stator in deflecting the fluid and subsequent increase of torque continues till the wheel speed remains lesser than the engine speed, like in any conventional gearbox. The principle of flow of fluid is shown in figure. As shown in figure, the stator deflects the fluid back to the impeller.

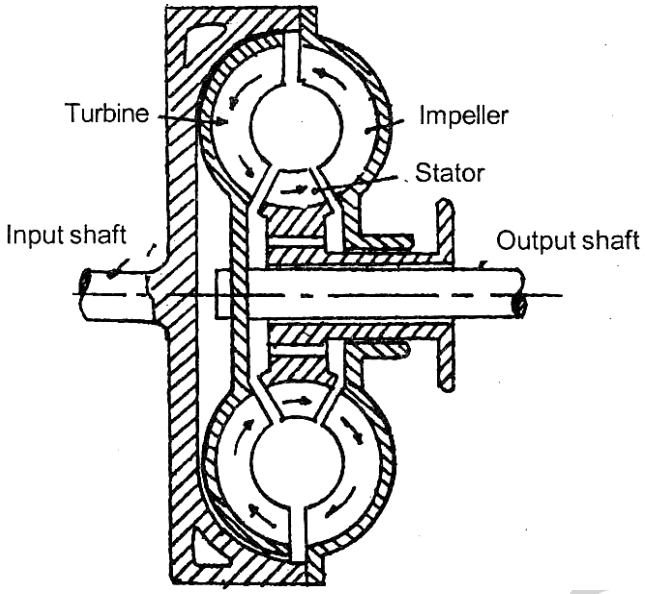


Fig. Torque converter

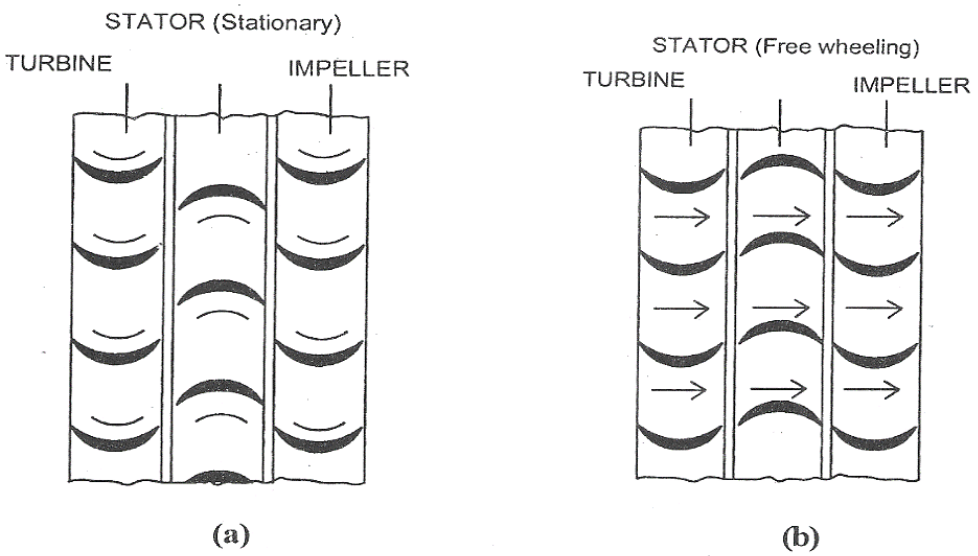


Figure : Principle of fluid flow

However, when the speed becomes nearly equal, the presence of the stator becomes a hindrance to the flow of liquid from turbine to the impeller. To eliminate this defect of power loss, the stator is mounted on a free wheel clutch, so that the position of the stator gets self-adjusted for a free flow of fluid. Refer to fig.(b). However, the stator is not allowed to move in the opposite direction.

Sl.no	Fluid coupling	Torque convertor
1	Contains only two members - impeller and turbine	Three members - impeller, turbine and a stator

2	Simply a torque transmission unit	Torque multiplication unit 3:1 to 4:1
3	Serves as an automatic clutch	Serves as an automatic clutch as well as a torque multiplier
4	Efficient at high speeds	Inefficient at high speeds but more efficient under load
5	Impeller and runner are locked up, and oil movement stops when centrifugal force is the same on both the member	No such locking and oil flows continuously

GEAR BOXES

Transmission refers to the transfer of engine torque to another system whenever required. A reduction unit used for this purpose is the "gear box". Gear box is a device placed in between the clutch and the rest of the transmission. It is a device that changes the speed and torque and transmits power from the engine to the driven wheel.

Functions of the gear box

a) To exchange engine power for greater torque and provide mechanical advantage to drive the vehicle under different operating conditions.
b) To provide reverse motion.
c) To provide neutral position and disallow power flow to the rest of the transmission.

When the vehicle is moving, there are a number of forces opposing the motion. The resistant forces opposing the movement of the vehicle are as follows:

1) Air or wind resistance.

2) Gradient resistance

3) Rolling resistance

I order to keep the vehicle moving, torque equal to the sum of the opposing forces must be made available. To overcome the variation of all the resistances at varied speed, a gear box is provided. So, the gear box provides high torque at the time of starting, for a move on gradient and acceleration. This is achieved by a set of gears arranged in order.

GEAR BOX

The set of gears arranged in a metal box is called Gear box. It is used for changing speed and torque and transmitting power from the engine to the diving wheels which is located between the clutch and the propeller shaft.

Purpose of the Gear box

- ✓ Gives different torque and speeds
- ✓ Provides a neutral position
- ✓ Reversing the direction of rotation

Various Resistances to Motion

A gearbox is used to get different torques and speeds which are required to overcome the following resistances.

a) Air (or) wind resistance
b) Gradient resistance
c) Rolling resistance

1. Air (or) wind resistance

The moving vehicle has to face air resistance. To reduce this air resistance the front bonnet and mudguard are given slope. So that air can be easily turned apart. The air resistance depends upon.

- ✓ Vehicle speed
- ✓ Shape and size of the body
- ✓ Direction of wind
- ✓ Velocity of the wind.

2. Gradient resistance

It is the resistance due to inclination of the road. It depends upon the angle of inclination and weight of the vehicle.

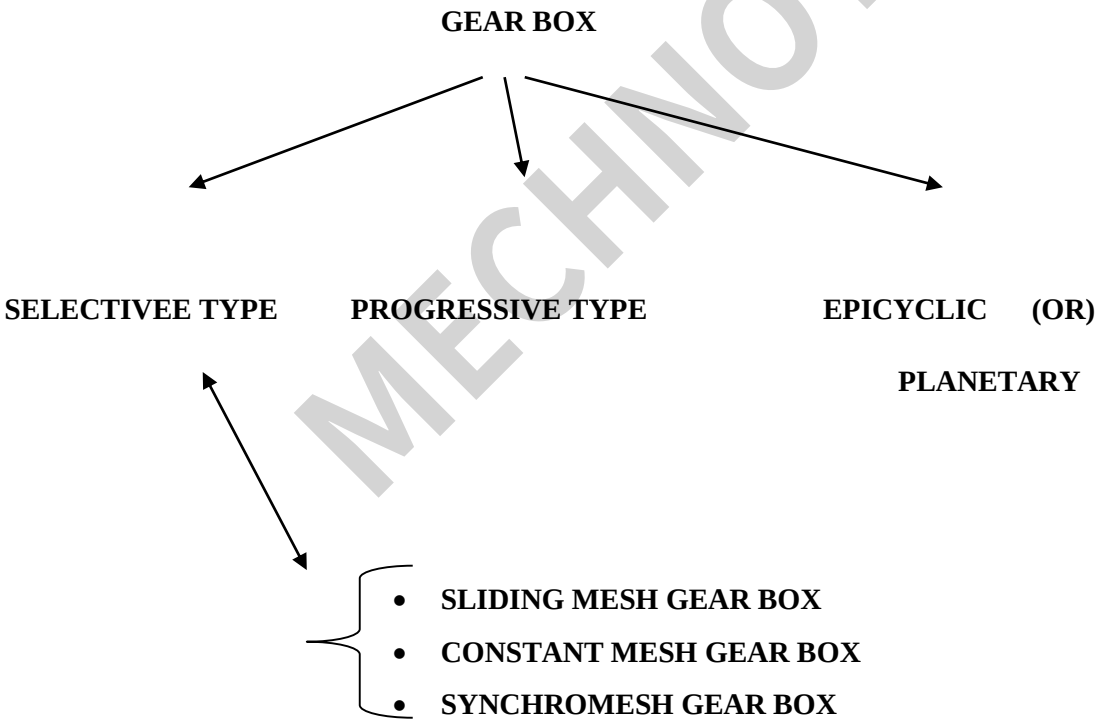
3. **Rolling resistance**

All the remaining resistances to the movement of vehicle are called rolling resistance. It includes internal frictional resistance due to deformation of road and tyre.

The rolling resistance depends upon

- ✓ Nature of road surface
- ✓ Tyre cross-section
- ✓ Total weight of the vehicle
- ✓ Load on the vehicle
- ✓ Tyre inflation pressure

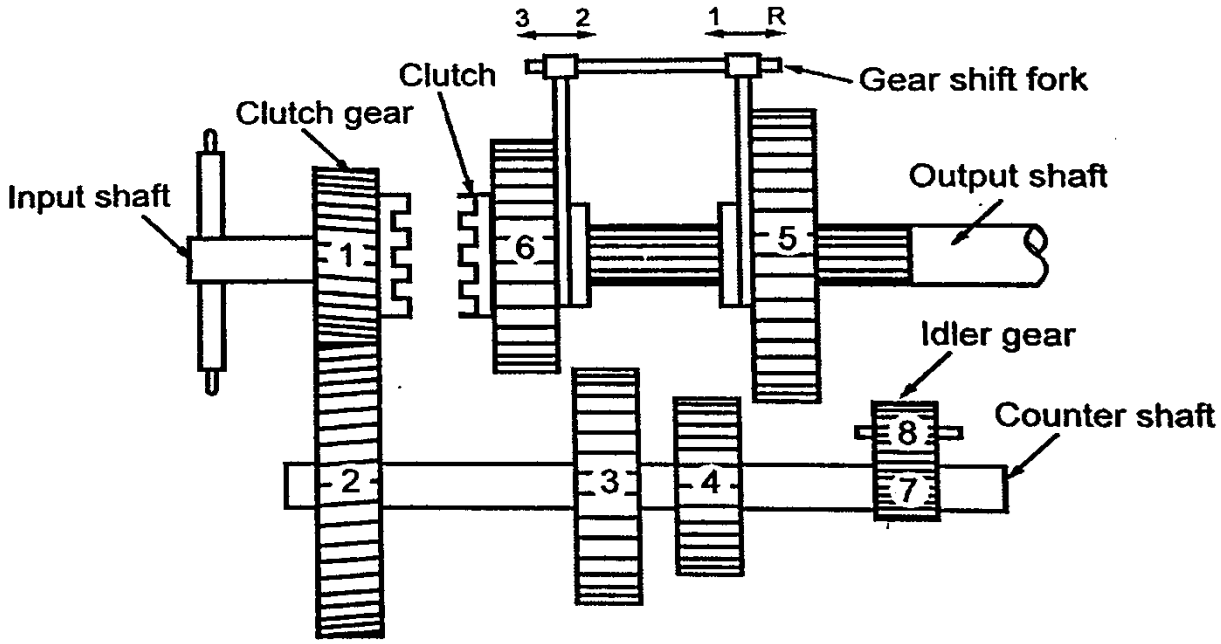
TYPES OF GEAR BOX:



1. SLIDING MESH GEAR BOX:

It is the oldest and simplest form of gearbox in which the gears on the splined main shaft are moved right (or) left for meshing them with appropriate gears on the layshaft for obtaining different speeds. The gears on the clutch shaft and layshaft are fixed. The idler gear is always in mesh with the layshaft gear.

To slide the gear on the shaft the shifter forks directly sit on the main shafts gear. The shifter forks are connected to the gear shift lever through the selector rods shown in fig. In this type of gearbox, spur gears are always used, because the gear is slided on the shaft to engage with the layshaft gear.



Sliding mesh gearbox

This is the simplest type of gear box. The figure gives a simplified view if the gear box. The power comes from the engine to the clutch shaft and hence to the clutch gear which is always in mesh with a gear on the lay shaft. All the gears on the lay shaft are fixed to it and as such they are all the time rotating when the engine is running and the clutch is engaged. Three direct and one reverse speeds are attained on suitably moving the gear on the main shaft by means of selector mechanism

First gear

When the gear shift lever is operated such that gear (6) meshes with gear (5). When the clutch shaft is rotating, the drive is transmitted from gear (1) to gear (2). Thus the counter shaft is also rotated. The direction of rotation of the counter shaft is opposite to that of the clutch shaft. When the counter shaft is rotating, gear (5) rotates gear (6). Therefore, gear (6) rotates the main shaft. The speed of the main shaft is very much reduced, approximately 3:1 is obtained. When climbing and moving off steep hills, this gear is usually used.

Second gear

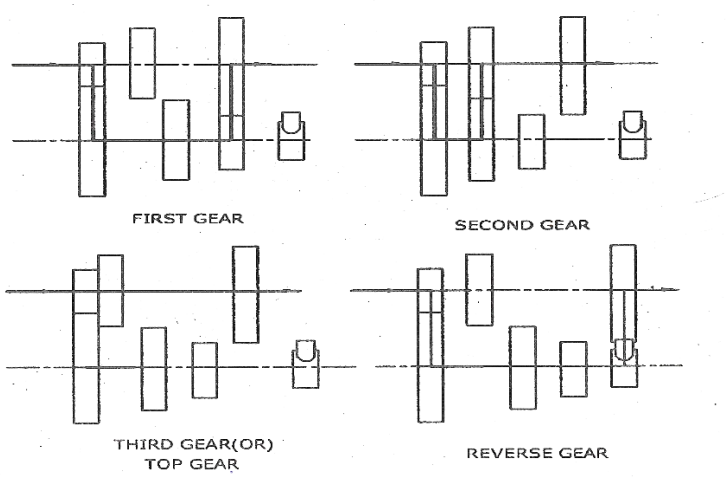
By operating the gear shift lever, the smaller gear (4) of the mainshaft is meshed with the second gear (3) of the layshaft. A gear reduction of approximately 2:1 is obtained. Now the wheel speed increases further.

Third gear

In this arrangement the dog of gear (4) is directly meshed with gear (1). The main shaft is in direct contact with the clutch shaft. Therefore, the main shaft rotates the same speed of clutch shaft.

Reverse gear

In this gear, the speed reduction is usually same as that in the first gear. But the direction of rotation of the mainshaft will be reversed by introducing an idler gear (7) between the counter shaft reverse gear (10) and main shaft bigger gear (6). So that the motor vehicle moves in reverse direction.



Sliding mesh gear box

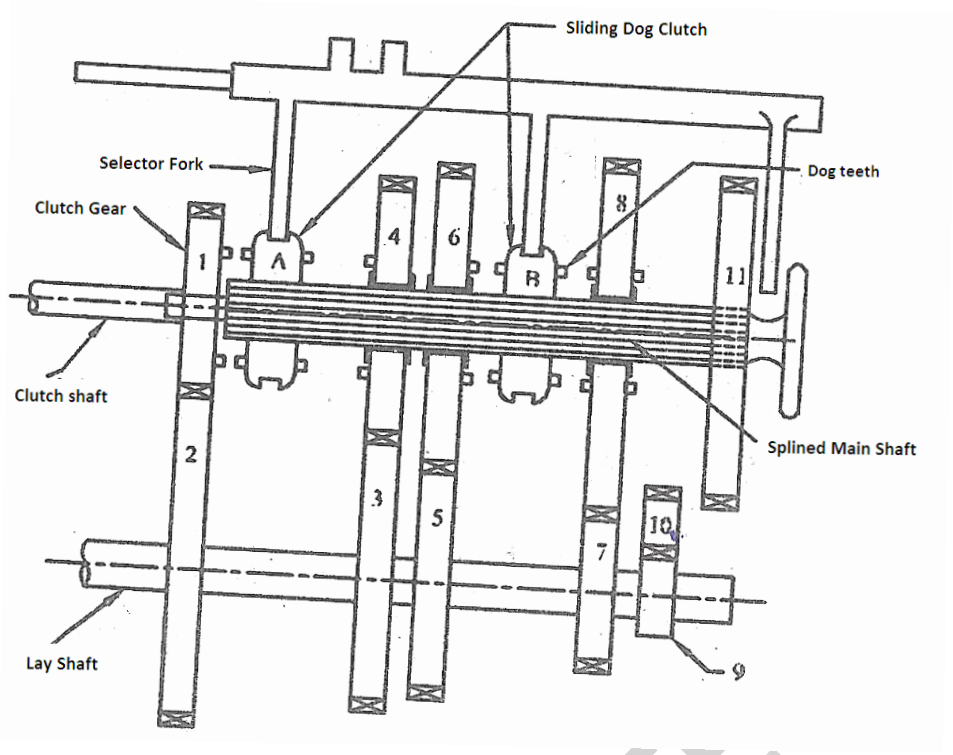
Neutral gear

When the gear shift lever is moved to the neutral positions, the flow of power from the clutch shaft to the counter shaft through the main drive gear (1 and 2). Other gears are free, and hence the transmission main shaft is not turning. The vehicle is stationary.

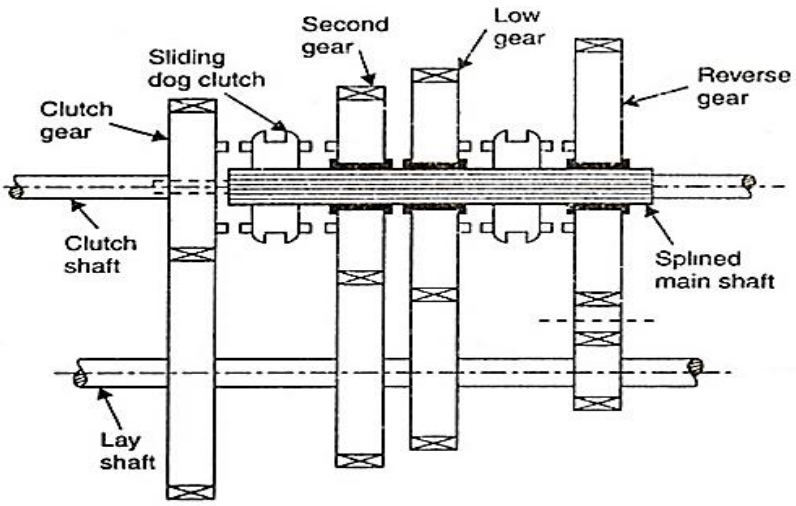
2. CONSTANT MESH GEAR BOX:

This type of gearbox is similar to the sliding mesh gear box, but this arrangement of all the gears on the main shaft is in constant mesh with the corresponding gears on the lay shaft. Two dog clutches are provided on the main shaft, one between the clutch gear and the Third gear (4), and other between the first gear (8) and second gear(6).

The main shaft is splined and all the gears are free on it. Dog clutch can slide on the shaft and rotate with it. All the gears on the countershaft are rigidly fixed with it. This type of gear box can be used in Tata 1210 vehicles.



Gear in Neutral



Constant Mesh Gear box

First gear

The dog clutch 'B' is slide to the right; it will couple the first gear (8) to the main shaft giving the first gear speed.

Second gear

The dog clutch 'B' is slide to the left; it will couple the second gear (6) to the main shaft giving the second gear speed.

Third gear

The dog clutch 'A' is slide to the right; it will couple the third gear (4) to the main shaft giving the third gear speed.

Fourth gear

The dog clutch 'A' is slide to the left it will couple the mainshaft directly to the pinion fixed to the clutch shaft. In this position the mainshaft is revolving at the same speed as the clutch shaft.

Reverse gear

In this position sliding dog A and B are not engaged Gear (11) can slide along main shaft, then it will couple the reverse gear (10) to the mainshaft. Power is transmitted from gear wheel (9) to gear wheel (11) through reverse gear (10). Due to this the main shaft rotates in the opposite direction. Thus, the vehicle moves in the reverse direction.

Neutral gear

When the gear shift lever is moved to the neutral position, the flow of power from the clutch shaft to the counter shaft through the main drive gears (1 and 2). The dog clutch units are idle, and hence the transmission main shaft is not turning. The vehicle is stationary as shown in fig.

3. SYNCHROMESH GEAR BOX

It is that gearbox in which sliding synchronizing units are provided in place of sliding dog clutches as in case of constant mesh gearbox. The other arrangements are similar to the constant mesh gearbox. The power flow for the various gears is described below. This type of gear box is mostly used in the entire vehicle.

Example: Swaraj Mazda, Mamti 800, standard 20 etc.

First gear

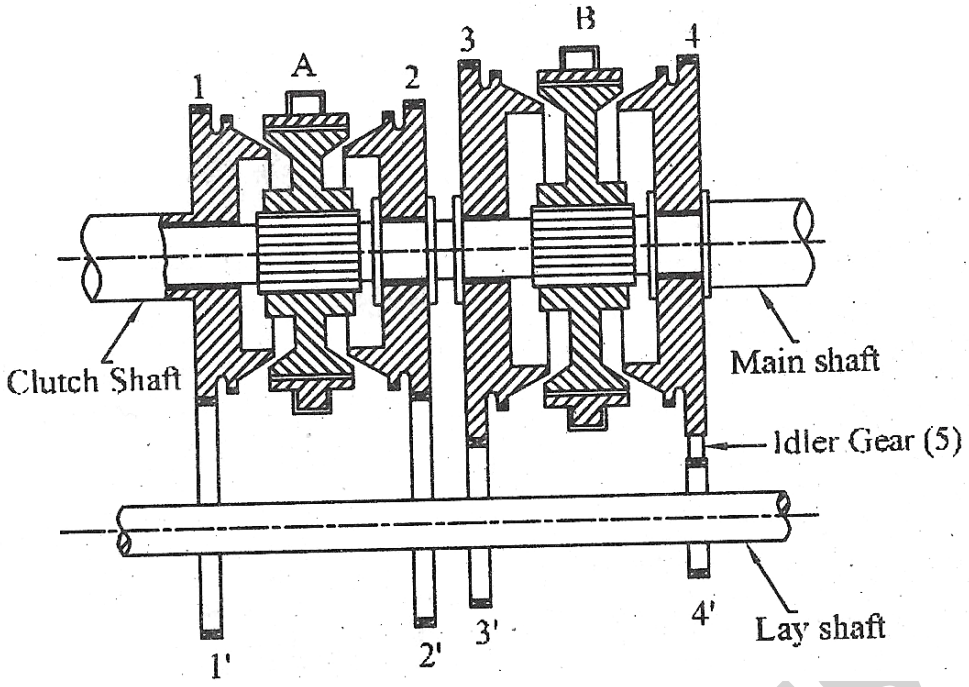
The synchronizing unit (B) is slide to the left. It will couple the first gear (3) to the main shaft giving the first gear speed

Second gear

The synchronizing unit (A) is slide to the right. It will couple the second gear (2) to the main shaft giving the second gear speed.

Third gear

The synchronizing unit (A) is slide to the left. It will couple the mainshaft directly to the pinion fixed to the clutch shaft. In this position the main shaft is revolving at the same speed as the clutch shaft.



Three speed Synchromesh Gear Box

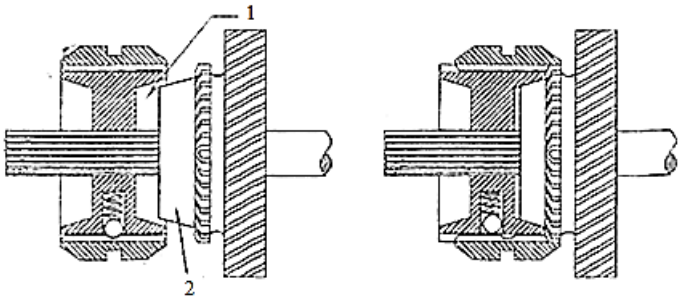
Reverse gear

In this position the synchronising unit (B) is slide to the right. It will couple the reverse gear (4) to the main shaft. Power is transmitted from gear wheel (4^1) to gear wheel (4) through idler gear (5). Due to this the main shaft rotates in the opposite direction. Thus the vehicle moves in the reverse direction.

Neutral Gear

When the gear shift lever is moved to the neutral position, the flow of power from the clutch shaft to the counter shaft through the main drive gear (1 & 1'). The synchronising units are idle, and hence the transmission main shaft is not turning. The vehicle is stationary as shown in fig.

SYNCHRONIZING UNIT



(a) Disengaged position (b) Engaged position

Synchronizing Unit Arrangement

A synchronizing unit works like a friction clutch Fig. Shows two conical surfaces. Cone (1) is part of the collar. Cone (2) is part of the gear wheel. Cone (1) and (2) are revolving at different speeds. While cone (2) is revolving cone (1) gradually slides on to it. Friction slows (or) speeds up the gear wheel. Finally both cones revolve at the same speed. Further movement of the collar makes toothed- outer ring slide into engagement.

Cone (2) is locked at different positions through balls and springs which are held in the inner cone (1). The shifting fork fits into the groove at the outer sleeve to slide it endwise for obtaining gear speeds.The synchronizing units make gear changing easy and minimized noise. In most of the cars, the synchronizing units are not fitted to all the gears. They are fitted only on the top gears. Reverse gear, and in some cases the first gear does not have synchronizing unit since they are intended to be engaged when the vehicle is stationary.

DIFFERENTIAL

When the Car is moving on a straight road both the rear wheels will be turning at the same speed. Suppose, the car takes a turn and both the wheels are rotating at same speed, it will be difficult for the return of the wheels to take place and the vehicle may get toppled if it is with solid rear axle. So, there will be a tendency for the wheels to skid.

To avoid this difficulty, the outer wheels must be made to turn at a large radius. In the case of a solid rear axle, the inner wheel will slip causing rapid type wear, steering difficulty and poor road holding.

So, in order to avoid the above difficulties, some mechanism is needed to reduce the speed of the inner wheel, and increase the speed of the outer wheel during turning and bring back the wheels to rotate at the same speed. Thus, there must be a relative movement between the rear wheel, while taking a turn, with the torque transmitted being equal. Such an arrangement which provides the above requirements is known as ‘Differential’.

Type of differentials

Normally the differential is of anyone of the type.

1) Conventional

2) Non slip

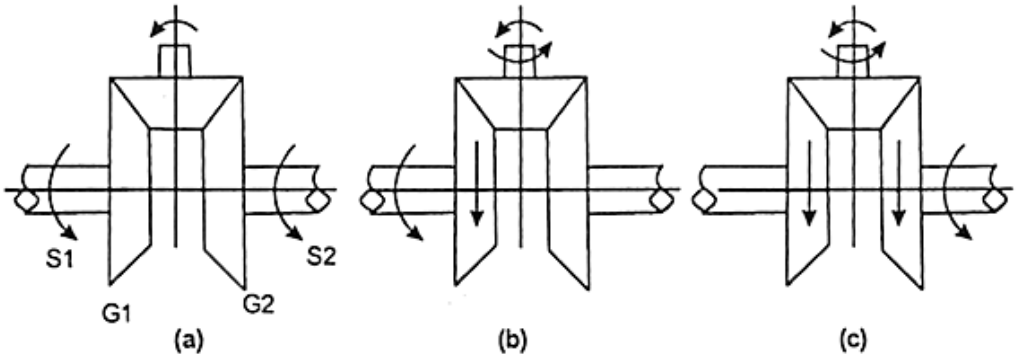
3) Double reduction type

Principle of differential

The Figure explains the functioning of differential. In figure (a) when the shaft is moved in a straight ahead position, the bevel gears along with the shaft shall revolve at the same speed in the same direction, irrespective of the speed of the shaft. If as shown in the figure-b, S-2, is held, stationary, then the right side bevel gear will not rotate. In this case, if the main shaft is assumed to move forward, the pinion rotates about its own axis and the left side bevel gear rotates faster, than in the previous case.

Because in this case the left side bevel gear receives two different motions due to

- ✓ Forward pulling of the shaft as before
- ✓ Rotation of the pinion about its own axis which is in constant mesh with the bevel gear



Principles of Differential

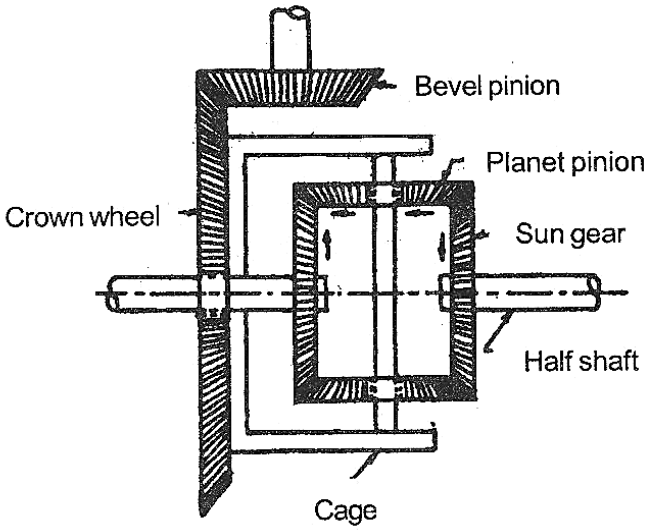
Suppose the right side bevel is allowed to slip on pinion wheel, then the left side bevel gear shall rotate at a lower speed than in the previous case.

CONVENTIONAL TYPE DIFFERENTIAL

Construction

A differential consist of a casing in which the differential gears are assembled, as shown figure. The crown wheel or ring gear is attached to the rear axle shaft on bearings. The drive pinion is attached to the propeller shaft; two gears are attached to the end of the rear axle. Star pinions mesh with the sun gears. Two or four star pinions are provided. The star pinions are carried on pins. The pinions are free to rotate above their axes.

The pin is held between the two parts of the cage. The sun gears and pinion are always in mesh and the sun gears are free to move inside the cage. The sun gears are positioned parallel to the ring gear, inside the differential cage. The assembly is supported on taper roller bearings. The entire arrangement may be made to rotate as a single unit, so that the axle shafts rotate at the same speed, when the vehicle is moving straight.



Working of the differential

When the vehicle is moving straight, there is no relative movement among the differential gears. The cage and the gears rotate as a single unit. If we assume the cage to be stationary during turn, one sun gear will cause the other to rotate in the opposite direction.

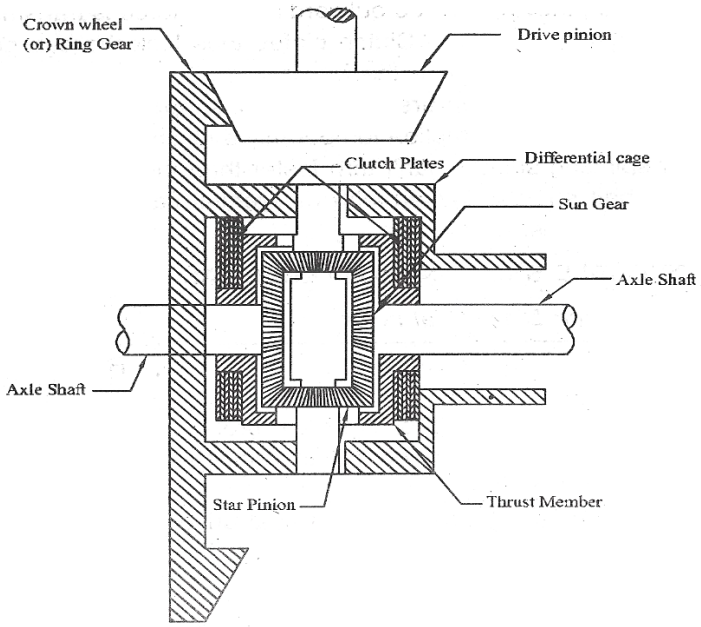
That is to say, when the vehicle takes a turn, a binding force acts on the inner wheel. In that particular side the sun gear is held to rotate slowly with respect to the movement of the cage. This results in the star pinion rotating the outer side sun gear with a loss in the inner wheel speed and gain on the outer wheel speed.

So the outer wheel moves faster. This rotation is super-imposed on the normal speed. Suppose, the vehicle is turning towards the right, at that time, there will be a resistance to motion on the right wheel.

Due to the result of differential action, if the right wheel rotates at 'N' rpm, the left wheel rotates in the opposite direction with 'n' rpm. This arrangement makes the resultant speed of the left wheel as (N + n) rpm and speed of the right wheel as (N - n) rpm. But, the torque transmitted is equal to both the rear wheels.

NON- SLIP DIFFERENTIAL OR LIMITED SLIP DIFFERENTIAL

The conventional differential delivers an equal amount of torque to both the wheels. Suppose the vehicle is moving on a muddy, or slippery road, or if only one wheel is on slippery surface, anyone or both the wheels may become stationary for a while. To avoid this trouble non slip differentials are provided. 'The non-slip differential is almost similar in construction to the conventional type.



But it is provided with two sets of multi plate clutch as shown in the figure. Moreover, the ends of the pinion shafts are made to float usually in notches in the differential cage. The clutches are positioned between the sun gears and the differential cage. If at all there exists any difference between the speeds of the sun gears and the cage, it is limited by the frictional resistance between the clutches and sun gears. The driving torque is increased by this increased frictional resistance.

In this condition because of the considerable side thrust and increase of the driving torque, the sun gears tend to slide up on the splines or notches in the half shaft outwards, thereby increasing the frictional resistance between the clutch and gears. At this stage the clutch plates lock the sun gears and the axle, along with the differential cage.

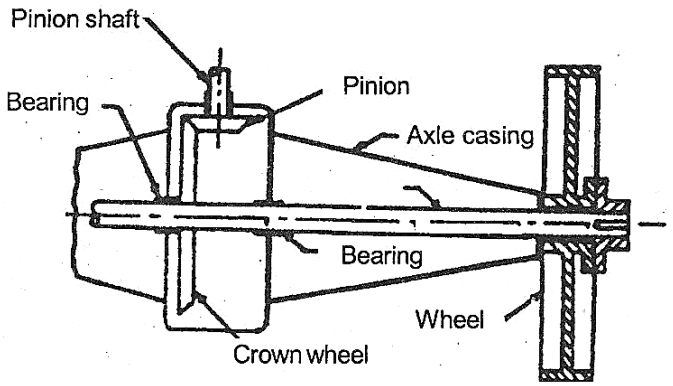
At this movement, the speed differences in between half shafts are reduced and wheel spinning or slipping is prevented. The differential mechanism gets locked up allowing both the rear wheels to develop maximum tractive force.

REAR AXLE

The figure shows the simple arrangement of the rear axle. The drive from the propeller shaft is transmitted through the pinion shaft. The pinion is supported on bearings provided in the axle casing. The pinion and crown wheel are in mesh.

The crown wheel is mounted at both ends of the shaft. The movement of the wheel in axial direction is restricted and mounted on the bearings. Mostly there are two half shafts instead of a single one. The entire rear axle casing is supported on the rotating wheels.

Like front axle, real axles also are of mainly two types - Live axle and Dead axle. Live axles apart from supporting the vehicle weight, also rotate to drive the road wheels, but dead axles, without any rotation, bear vehicle weight. In a four wheel, drive both the front and rear wheel axle will be of the live type in rear wheel drive the front axles remain as dead type. In case of front wheel drive, rear axles are of dead type.



Forces on rear axle

As per the transmission layout, the rear axle transmits the drive from the differential to the rear wheel hub. During this operation the rear axle is subjected to the following stresses.

1. Tensile and compressive stresses owing to the side thurst and cornering forces.

2. Bending stresses because of the vehicle weight.

3. Shear stresses because of the vehicle weight.

4. Torsional stresses because of the driving and braking torque.

Depending upon the supporting methods and according to the load, the axle has to take, three types of floating,

1. Semi floating

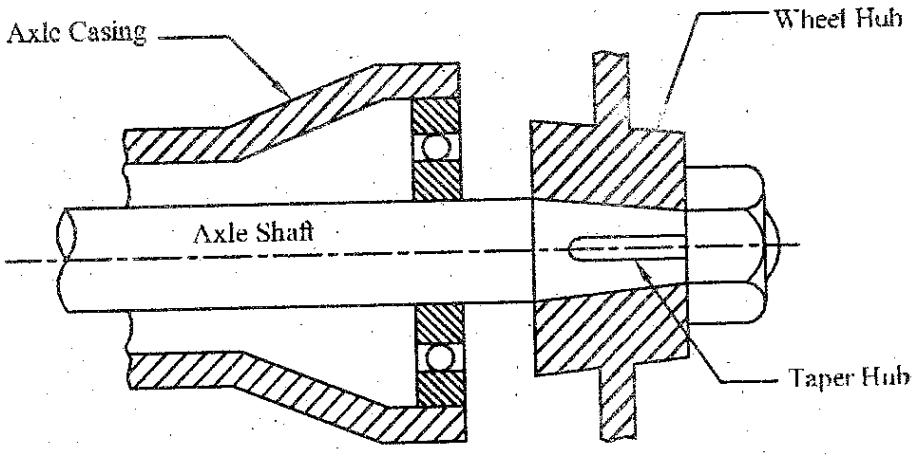
2. Full floating

3. Three quarter floating.

Semi floating axle

The arrangement is shown in the figure 44. In this case, all the load is taken up by the axle shaft. The support for the inner end of the shaft is given by the differential casing. This outer end of the axle has to support the weight of the vehicles and bear the end thrust.

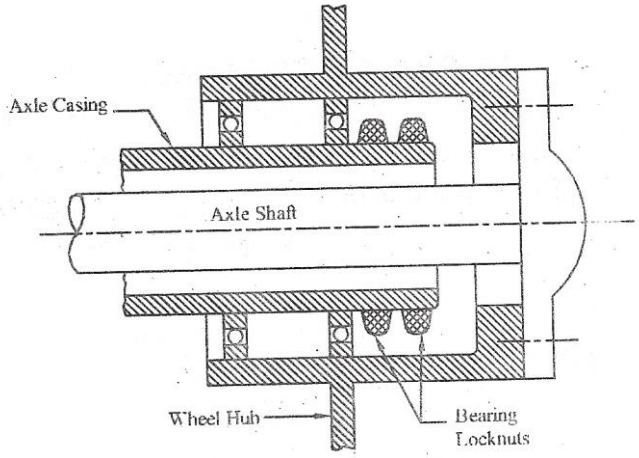
The wheel hub is keyed to the outer end of the shaft and the inner end is provided with splines with the differential side gear. The axle casing supports the wheel bearing, which is placed inside, at the outer end of the axle.



Full floating axle

This is used in heavy vehicles. In this case, the axle carries the driving torque only. The vehicle weight and end thrust are not carried by the axle. The wheels and the axle casing, completely take care of the vehicle weight.

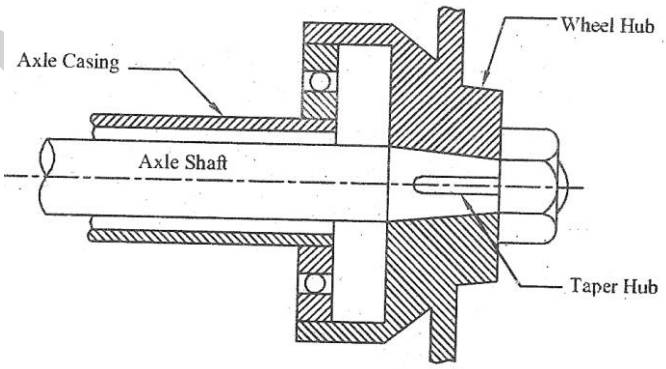
As shown in figure, the wheel hub is supported on two bearings placed upon the axle casing. The axle shaft is bolted to the wheel hub. Therefore, rotary motion of the hub is transmitted to the wheel.



The axle shaft is not supported by bearings but it is positioned at its ends. Hence, in this method, the axle is relieved of all strains due to the load of the vehicle or end thrust. Being free from all other strains, its duty is only to transmit a rotary motion to the wheel. Without disturbing the axle hub and the wheel, the axle shaft can be removed from the casing.

Three quarter floating

In this case, the load of the rear end of the wheel is borne by the axle hub. The wheel hub is supported by a single bearing, which is located between the axle casing and the hub as shown in figure. The axle shaft is free from shearing or bending action due to the weight of the vehicle. Yet the end loads and the driving torque are to be borne by the shaft.



So, heavier loads may be carried without danger of axle breakage. In this case the inner end of the axle shaft is in the differential. Thus 75 % of the vehicle's weight goes directly from the axle housing to the wheel. The axle is keyed rigidly to the hub.

Advantages of three - fourth floating axle

- ✓ Torque reaction and side thrust are balanced by the casing and driving torque is balanced by the axle shaft; this gives more stability. In the case of semi floating axle, all the forces are to be supported by the axle shaft only, leading to larger size. In case of full floating axle, only the driving torque is balanced
- ✓ Due to the divided supporting action, the size of the three fourth floating axle is reduced which is not possible in other cases
- ✓ Use of taper roller bearings is eliminated, thereby making the construction to be simple
- ✓ Conveniently used in medium size vehicles

HOTCH KISS DRIVE

This is the simplest one available for rear axle drive. The arrangement is shown in figure. Apart from taking the weight of the body, springs also bears the torque reaction, driving thrust and side thrust. There are two universal joints at the ends of the propeller shaft, which also carries a sliding joint as shown in the figure. The springs are rigidly supported in the rear axle. At the front end, the spring is fixed rigidly on the frame

UNIT III - SUSPENSION SYSTEM

INTRODUCTION:

The automobile frame and body are mounted on the front and rear axle not directly but through some form springs, mountings and shock absorber this provisions is called suspension.

While the vehicle moving on the road the wheels are thrown up and down due to the road. This results in strain on the components of the vehicle and the passengers. To prevent damage to the working parts and also to provide riding comfort, suspensions is used in the vehicle. The suspension system of a motor vehicle is divided into the *rear-end suspension and front-end suspension.*

Functions of suspension system:

1. It prevents road shocks reaching the frame and other units.
2. To safeguard the passengers from the road shocks and provide riding comfort.
3. To keep the body perfectly in level while travelling over rough uneven road.
4. To provide good road holding while driving, cornering and braking i.e., the system must always keep the tyres in contact with the road.
5. It gives cushioning effects.
6. To maintain proper steering geometry.

SPRINGS

The vehicle frame supports the weights of the engine, the power trains components and the passengers. The frame is supported by the springs. Springs are fitted between the wheels and the vehicle frame to cushion road shock, to know the vehicle body leveled up over uneven surfaces, to absorb driving and braking torque loads.

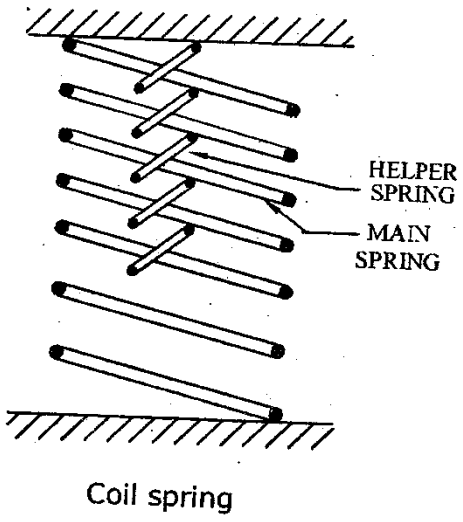
The springs cannot do the complete job by absorbing road shocks. The tyres absorb some of the irregularities in the road.

Types of springs:

- ✓ Coil spring
- ✓ Leaf spring
- ✓ Torsion bar
- ✓ Air bags
- ✓ Rubber springs.

COIL SPRINGS:

- ✓ The spring is made of a length of special spring steel, usually round in sections, which is wound in the shape of the coil. The ends of the coil spring are kept flat so that they could seat properly. Coil springs are mostly used in the independent suspension.
- ✓ The energy stored per unit volume is almost double in the case of coil springs than the leaf spring. Coil springs do not have noise problems. The spring takes the shear as well as bending stresses. The coil springs, however, cannot take torque reaction and side thrust, for which alternative arrangements have to be provided.
- ✓ A helper coil is also sometimes used to provide progressive stiffness against increasing load.



Coil spring

Advantages:

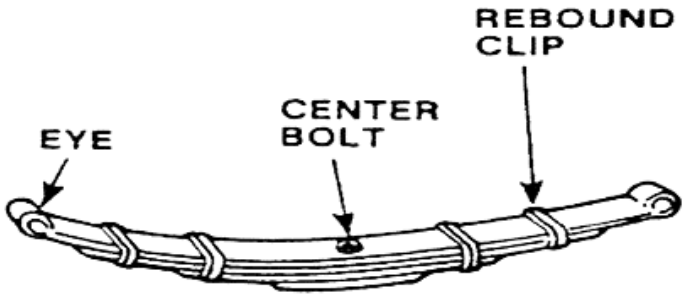
- ✓ Lighter in weight
- ✓ They require less space
- ✓ Compact design

Disadvantages:

- ✓ There is no friction damping effect.
- ✓ Powerful absorbers are required with coil springs.

LEAF SPRINGS:

- Leaf springs are the first type of spring used on vehicle suspensions and are still in use today, however, they are more commonly found on light duty trucks, SUVs, vans and on some passenger vehicles (on the rear only). Two basic types of leaf spring are mono-leaf and multi-leaf.
- Mono-leaf, or single-leaf, springs are thick in the center and taper off at each end, which provides a variable spring rate for good load carrying capability as well as a good ride. Mono-leaf springs are also less noisy while producing less static friction of multi-leaf springs.



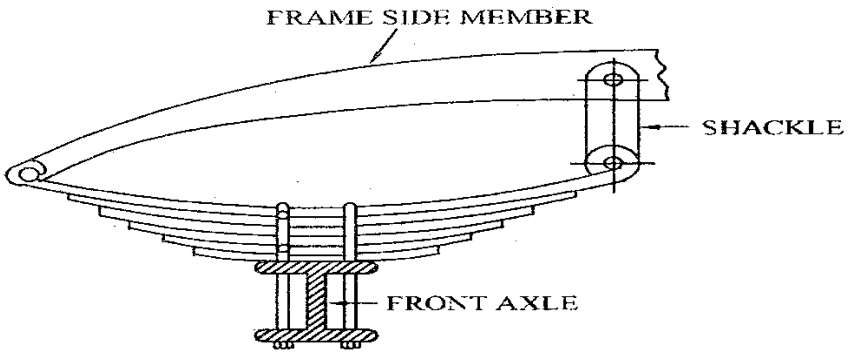
- Multi-leaf springs are made up of several flat steel leaves bound together and retained with a bolt or clips. The main leaf is the one leaf that is the full length of the spring from the front mounting bushing to the rear mounting shackle.
- Each leaf bound to the main leaf is gradually shorter which gives the spring a tapered profile. Each leaf added to the spring assembly contributes to its stiffening ability. Because of the curved construction of the leaf spring, it is also referred to as a semi-elliptical spring.
- Leaf eye at the rear of the spring leaf is secured to the vehicle frame using a shackle. The spring shackles allow some movement fore and aft in response to the physical forces on acceleration, deceleration and braking.

Types of leaf springs:

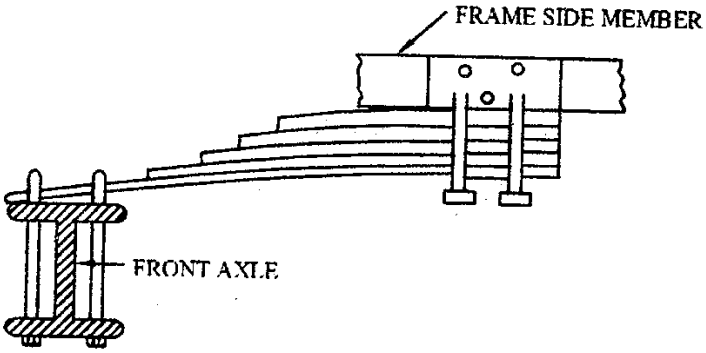
- ✓ Semi-elliptical springs
- ✓ Quarter elliptical springs
- ✓ Three quarters elliptical spring
- ✓ Transverse spring
- ✓ Full-elliptical spring

(i) Semi-elliptical springs

- Semi-elliptical springs are usually used in all the vehicles. Particularly in trucks, semi-elliptical springs are fitted in front and rear axle.
- But in cars employing independent suspensions system coil springs are used at front end and leaf springs are used at rear end. It is cheaper to repair and has long life.

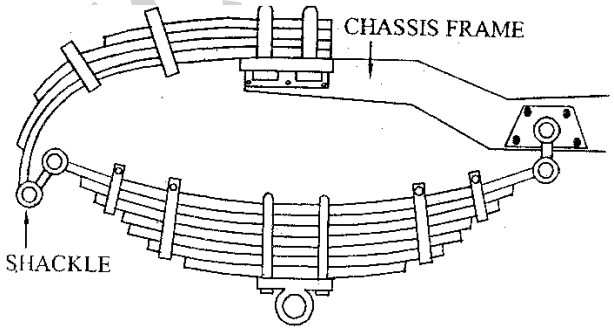


(ii) Quarter elliptical spring



- This system also called cantilever spring system was mainly used in cars in olden days both at front and rear end (crosley car). In this case half-elliptical spring is mounted in inverted position with its heavy end bolted to the chassis frame.

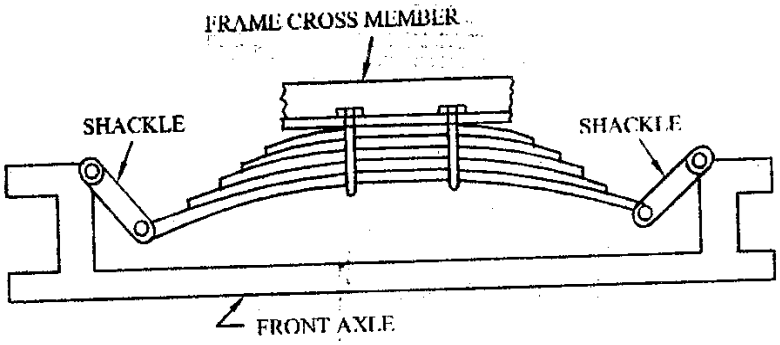
(iii)Three quarters elliptical spring



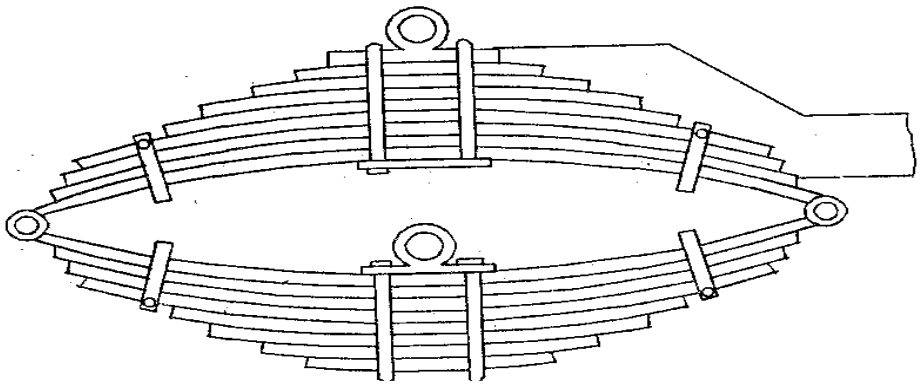
It is a combination of semi-elliptical and quarter elliptical spring. In the olden days it was popular but has been now replaced by semi-elliptical spring

(iv)Transverse spring

- It is just like the semi-elliptical spring but inverted in shape. Its centre is bolted to chasis frame and spring eyes pinned to axle by means of shackle.
- This type is the cheapest one and it is used in Ford perfect cars both in their front and rear suspension.



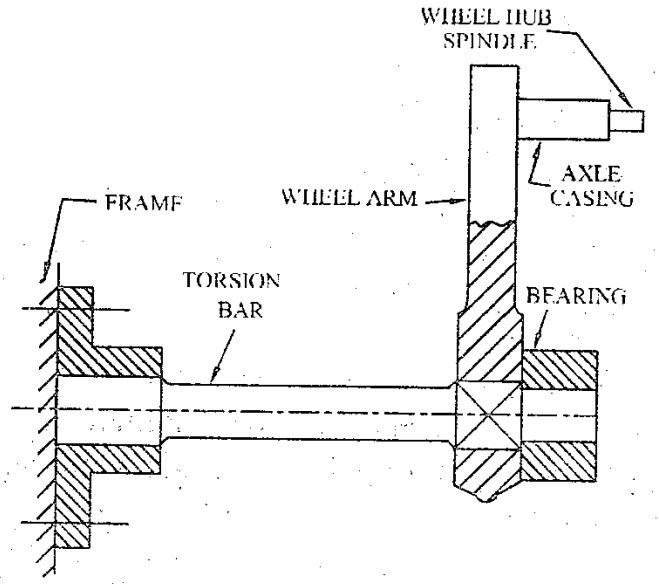
Full-elliptical spring



Full elliptical spring consist of two semi-elliptical springs joined together oppositely. This type of spring was used in old cars. They do not maintain correct axle alignment.

TORSION BARS:

- It is a steel bar which functions by twisting. The amount of energy stored per weight of material is nearly the same as for coil or leaf springs. One end of the torsion bar is fixed to the frame so that it may not turn. On the other end is fixed an arm over which is fitted road wheel.
- As the wheel moves up and down, the arm swings like a pump handle and torsion bar twists and untwists. An ambassador car is provided with torsion bars at the front independent suspension system.



Torsion bar

Advantages:

- ✓ Lighter in weight
- ✓ Occupies less space
- ✓ Less maintenance

Disadvantages:

- ✓ Does not take the braking or driving thrust so that additional linkages have to be provided for that purpose.
- ✓ There is no damping effect.

FRONT SUSPENSION SYSTEM

The front suspension allows the front wheels to move up and down and absorbs road shocks. The front end is more complicated than the rear end suspension, because the front wheels not axly move up and down with respect to the car frame, but also swings at various angles to the car frame for steering.

Types of front suspension system:

- Rigid axle front suspension system.
- Independent front suspension system.

RIGID AXLE FRONT SUSPENSION SYSTEM:

This type of suspensions was universally used before the introduction of independent front wheel suspension. In which the wheels are fitted on beam type axles which are attached to the chassis frame through road springs. In this type of suspensions, the effect on wheel is directly transmitted to the other side wheel through the axle.

INDEPENDENT FRONT SUSPENSION SYSTEM:

In the independent type of front suspension, each front wheel is independently supported by a coil, torsion bar and leaf springs, so that the up and down movement of one wheel does not affect the other wheel. Each wheel moves independently on pot holes and bumps in like in rigid suspensions.

Types of independent front suspension:

- Wishbone arm system
- Vertical guide suspension system
- Trailing link system
- Macpherson strut type
- Swing half axle type.

Macpherson strut type:

McPherson strut front suspension differs considerably from unequal length A-arm suspension. McPherson strut suspension is found most frequently on compact and subcompact cars, both domestic and imported. With this type of suspension, the shock absorber, strut and spindle are a combined unit, which is supported by the coil spring at the upper end and the lower control arm (sometimes called track control arm or transverse link) at the bottom.

Another type of front strut suspension is referred to as a modified McPherson strut suspension, which is the same as the regular McPherson strut unit except the coil spring is mounted separately from the strut, between the lower control arm and the frame.

There is only one ball joint in this design, and it is attached to the lower part of the spindle. Generally, this ball joint is not a load carrying ball joint, but a follower ball joint, which means it, is isolated from vehicle weight.

The shock absorber is built into the strut outer casing and, except for the modified McPherson strut; a coil spring sits on a seat welded to this casing. The upper mount of the shock absorber bolts to the vehicle body. On some models, the strut cartridge may be replaced, while on others the entire strut must be replaced. Due to the design of this type of suspension, the only front-end alignment procedure possible is toe-in adjustment, since caster and camber are fixed.

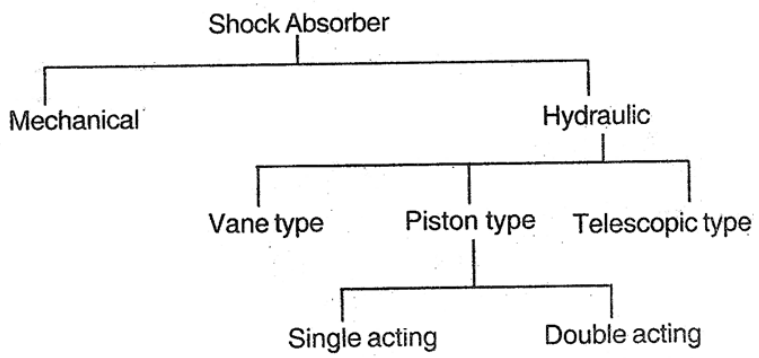
SHOCK ABSORBERS

It the suspension spring are rigid enough they will not absorb road shocks efficiently and it they are flexible enough, they will continue to vibrate for a longer time even after the bump has passed. Such spring actions on a car would produce a very bump and uncomfortable ride. It could also be dangerous, because a bouncing wheel makes the car difficult to control. Therefore a damping device is needed to control the spring oscillations. This device is the shock absorber.

Purpose

1. Absorb road shock
2. Prevent excessive tyre wear
3. Prevent damaging of chassis frame and other parts
4. Prevent the wheel from bouncing
5. Provide comfortable rides.
6. Enable the vehicle to settle down in a short time.

Types of Shock Absorbers



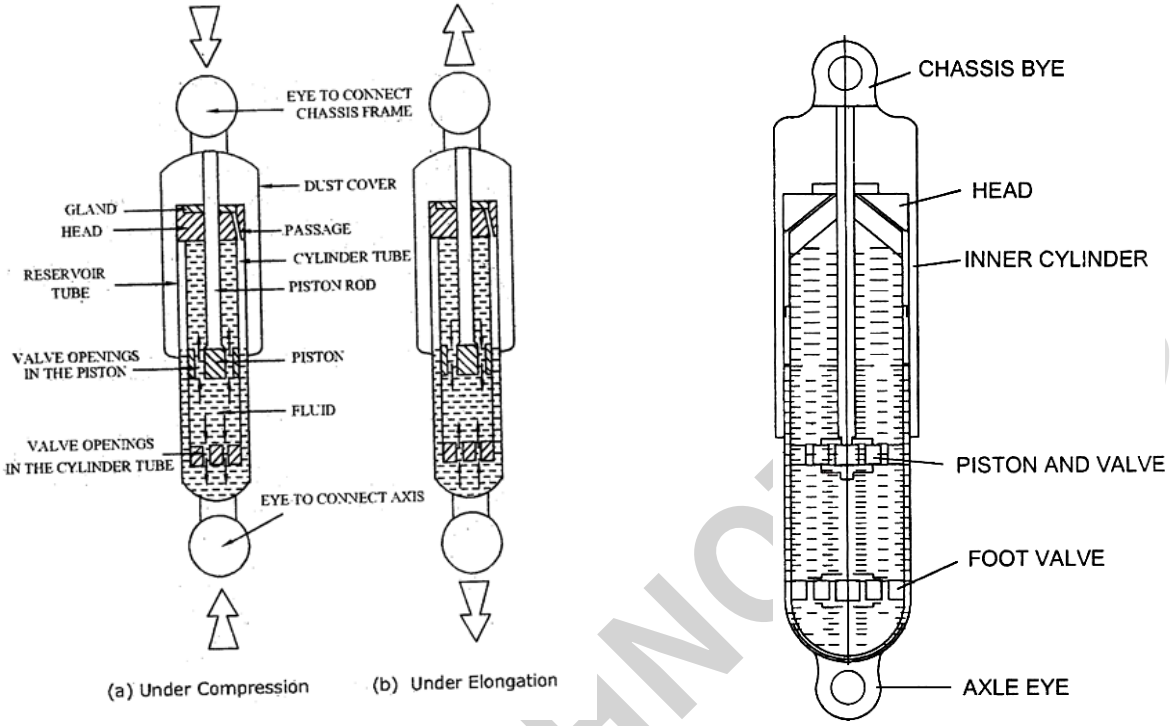
TELESCOPIC TYPE SHOCK ABSORBER

There is compact in design and can be easily mounted and do not require any linkages, Etc. suspensions control is done by movements of the piston in the fluid in the fluid filled chamber, it is most common type which is used now a days in most of the vehicles.

Construction:

- It is made of two thin steel tubes the inner forms the cylinder and outer forms the reservoir. It is called telescopic because the tubes are concentric. The outer tube is connected to the bottom eye, which is attached to the axle. A two way valve is attached to the lower end of cylinder.
- The cylinder contains a combined piston and valve which is connected to a rod. The combined piston and valve divide the cylinder into two chambers upper and lower. The upper chamber of the cylinder is called rebound chamber whereas the lower one compression chamber.

- At the upper end of the shock absorber a dual excluder is provided. The upper end of the piston rod is welded to an eye, which is attached to the frame. The head has a gland; any fluid scrapped off by the piston rod is brought down into the reservoir through the inclined passage.
- The inner cylinder is fully filled with hydraulic fluid and the reservoir is partly filled. The fluid generally used in shock absorber is a mixture of 60% transformer oil and 40% turbine oil.



Working:

- When the shock absorber is compressed combined piston and valve move into the lower chamber of the cylinder, compressing in this chamber. Since the fluid is incompressible, it opens the valve connected with the piston and enters into upper chamber of the cylinder.
- But since the volume of the space above the piston is less by the volume of the piston rod, the fluid will also exert its pressure on the cylinder valve assembly and fluid go to the underside of cylinder valve. This passing of the fluid through valve opening provides the damping.
- When the shock absorber is lengthening, the fluid from the top portions of the piston is forced downwards through the piston valves. At the same time the fluid from the reservoir tube enters through a valve at the bottom of the cylinder tube.
- So this way this type of shock absorber acts on both ways to work both compressions and lengthening of the shock absorber there by damping the shocks.

FRONT AXLE

- Front axle is the major component of a motor vehicle, it is used to carry the weight of the front part of the vehicle as well as to facilitate steering and absorb shocks due to road surface variation. It must be of very robust construction.
- It is made of I section in the central portion, while the ends are made either circular or elliptical. A downward sweep is given to the center portion to keep a low chassis height.
- The main axle beam is connected to the stub axles by means of a king pins. Hence to accommodate the stub axle and kingpins the ends of the beam are shaped either as a yoke or plain surface with drilled hole.
- They are made by drop forging from steel having 0.4% carbon or 1.3% nickel steel.

Function of the front axle:

- ✓ It carries stub axle, king pin, steering arm by which the vehicle can be steered.
- ✓ It facilitates steering
- ✓ It absorbs shocks which are transmitted due to road surface irregularities
- ✓ It supports the weight of front part of the vehicle.
- ✓ It absorbs torque applied on it due to braking of vehicle.
- ✓ It carries the brake systems
- ✓ It carries the hub and wheel.

Types of front axles:

- ✓ Live front axle
- ✓ Dead front axle

Line Front Axle:

It is the front axle containing the differential mechanism through which the engine power is transmitted to the front wheels. For steering the front wheels, constant velocity joints are contained in the axle half shafts. Without affecting the power flow through the half shafts, these joints help in turning the stub axle around the king pin. Maruti-800 has line front axle.

Dead Front Axle:

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

STUB AXLE

Stub axles are connected to the front axle by king pins. Front wheels are mounted on stub axle's arrangement for steering is connected to stub axles. Stub axle turns on kind pins. Kingpins is fitted in the front axle beam eye and is located and locked there by a taper cotter pin.

Stub axles are of four types:

- ✓ Elliot type
- ✓ Reversed Elliot type
- ✓ Lemoine
- ✓ Reversed lemoine

Elliot type:

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

Reversed Elliot type:

In reversed Elliot type stub axle the arrangement is reversed. The axle beam is mounted in between the two eyes of the stub axle with a thrust washer at the bottom of the axle. It is commonly used in vehicle because of the following reasons.

- ✓ It is easier to manufacture.
- ✓ Load exerted by the stub axle is equally distributed.
- ✓ Due to equally distributed load steering is easy.

Lemoine type:

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

Reversed lemoine:

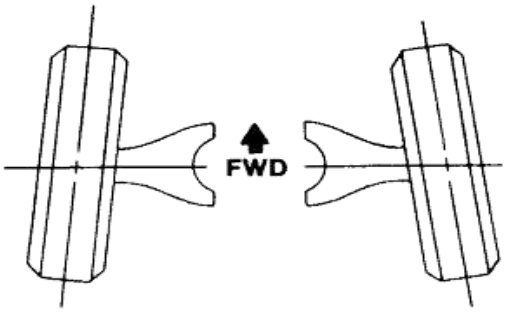
In this type of stub axle, the arrangement is reversed. Hence, the stub axle is mounted on the top of the axle beam.

FRONT WHEEL GEOMETRY:

- The steering and road holding of a car depend to some extent on the layout and orientation of the stub axles on which the front wheels are mounted.
- The suspension geometry is defined by the traditional terms camber angle, toe-in, and the swivel angles called castor and king pin inclination.
- These are shown in the following diagram, which also shows how they are inter-related.

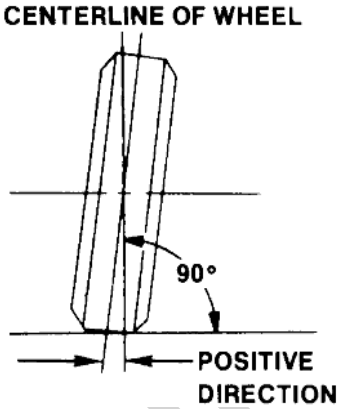
Toe-in:

It is the very small angle between the front wheel plane and the longitudinal axis of the car. It can be measured as the difference in the distance between the near side and offside wheel rims at the front and rear of the wheels. The object of toe-in is the keep the steering linkages under tension when driving straight ahead.



Camber angle:

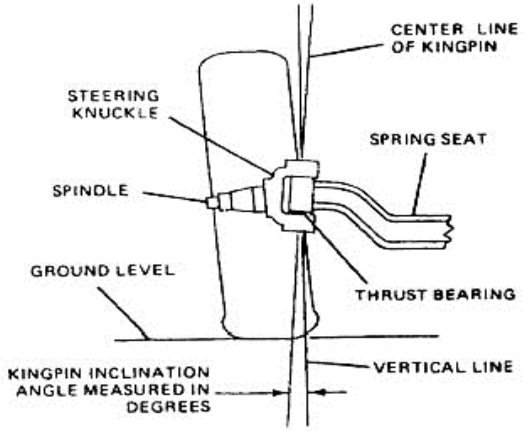
It is the angle, as viewed from the front of the car, between the plane of the front wheels and a vertical plane, and is called positive when the top of the wheels leans outward from the body of the car. A slight positive camber reduces the cornering power at the front and normally results in an under steering car.



King pin inclination:

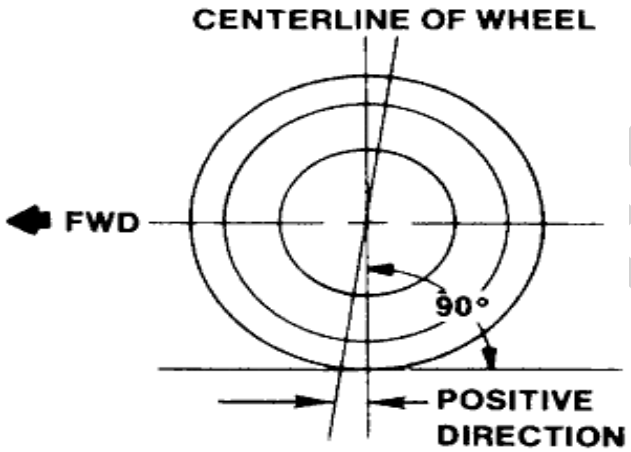
It is the transverse angle of the swivel axis of the front wheel and its stub axle. The Effect of the inclination is usually discussed in terms of the king pin offset which determines the self Centering torque when the steering is turned for cornering.

Although many cars have a positive value of offset which tends to return the wheel to the straight ahead position, some modern cars have a negative Offset to improve stability when the tire blows or the brake fails on one front wheel.



Caster angle:

- It introduces a self-centering torque when the car is traveling forward. This is achieved by the positive offset shown in the diagram where the contact of the tire on the road trails behind the king pin axis.
- With modern car design it has become more difficult to see and comprehend the interactions of front wheel steering geometry. Hence there are advantages in studying the set-up by using a one third scale model which is as close as possible to the real construction found in a large car.
- Nevertheless the needs of experimentation require some unusual variations like an adjustable stub axle.



STEERING SYSTEM

A good steering mechanism is must for a vehicle's stability at the time of turning. Steering of four wheeler is designed in a manner so that it will not permit lateral slip of front wheels during steering. There must be true rolling of wheels at the time of steering. The front wheels are mounted on front axles to allow their left and right swing for steering the vehicle. Steering is done by providing a suitable gearing and linkage between front wheels and steering wheel.

Qualities of steering system:

- ✓ It should be light
- ✓ Steering geometry should not get affected by bad road conditions
- ✓ It should be self-aligning and self-adjusting
- ✓ It should not transmit road shock to steering wheel
- ✓ It must be easily operatable

Functions of steering system:

1. It converts the rotary movement of the steering wheel into an angular turn of the front wheels.
2. To turn the vehicle whenever required.

3. To provide directional stability to the vehicle on road.
4. To provide true rolling motion of the wheels at all times.
5. To minimize wear and tear of tyres.
6. To prevent road shocks reaching the driver.
7. To provide self-centering action after taking a turn.
8. To multiply the drivers effort to turn the vehicle for easy operation.

Components of steering system:

- ✓ Steering wheel
- ✓ Steering column
- ✓ Steering shaft
- ✓ Steering gearbox
- ✓ Steering linkages

Steering wheel:

- It is a circular wheel mounted at the steering shaft and acts as a control to steer the vehicle. A horn push button is fitted at its hub. In modern cars, the push button has been replaced by a push ring which is placed inside the steering wheel.
- The steering hub sometimes contains trafficator switch, lighting switch (or) selector lever for controlling automatic transmission.
- In our country steering wheels have fixed positions, but in foreign countries, in some vehicle these wheels can be tilted and locked in any position to suit the driver.

Steering column:

- This is a hollow shaft in which the steering shaft is housed. Lower end of shaft is fixed on steering gear box, while the upper end is connected to the steering wheel.
- In modern cars, the gear change lever is provided at the steering column for the convenience of the driver.

Steering shaft:

- It is made out of good quality steel. One end is fixed in steering wheel with the help of splines (or) key and kept tight by nut. The other end with worm is connected to the steering gear box.
- The changes in length of the shaft are accommodated by universal joints, pot joints (or) flexible couplings. The steering shaft is inclined at 50° in the case of cars and 20° in the case of commercial vehicles.

Steering gear box:

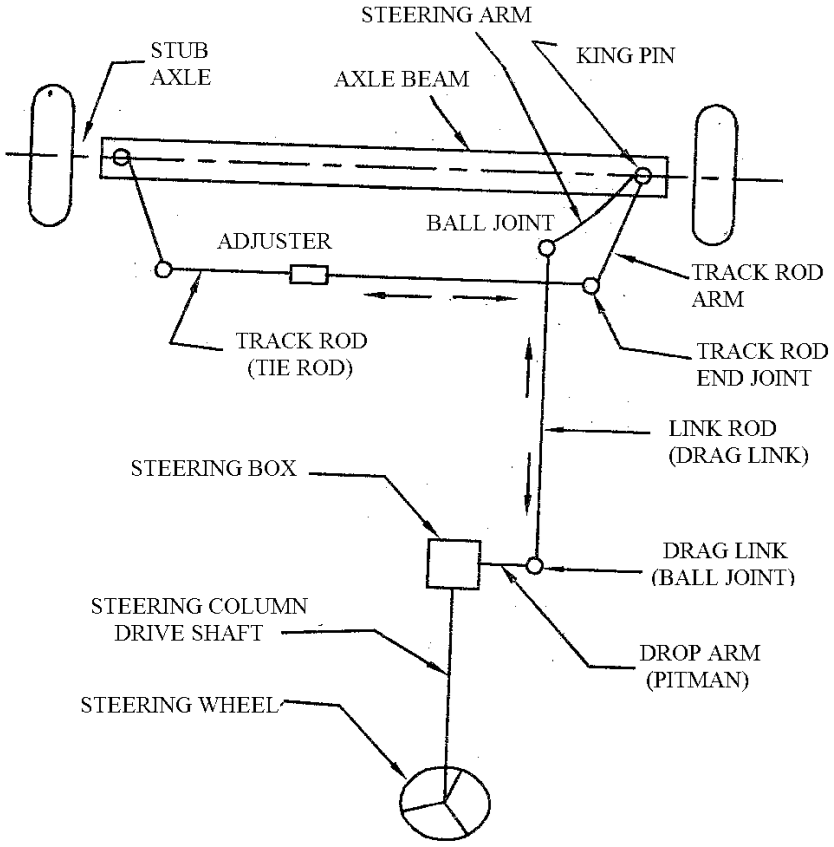
The steering gear serves the following purposes.

It provides mechanical advantages and enables the driver to steer the vehicle easily. It converts the turning motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkage.

Steering linkages

- Steering linkage depends upon the type of the vehicle. Fig shows a conventional steering linkage. It is commonly used in cars provided with rigid front axle.

- When the steering wheel is turned its motion is carried to the steering gear box through the steering shaft. In the steering gearbox this motion is converted into angular motion of the drop arm which is connected to the link rod.
- The other end of the link rod is connected to the steering arm by means of ball joint. The steering arm is connected to the stub axle spindle. At the lower end of the stub axle, the spindle steering arm is fitted. Both the steering arms are connected by a track rod.



When the steering wheel is rotated the drop arm moves towards or away from the front wheel depending upon the direction of turn right or left

TYPES OF STEERING MECHANISM:

- Ackerman steering mechanism
- Davis steering mechanism.

Only Ackerman steering mechanism is used in vehicles now a day because of its simplicity and less wear of the parts

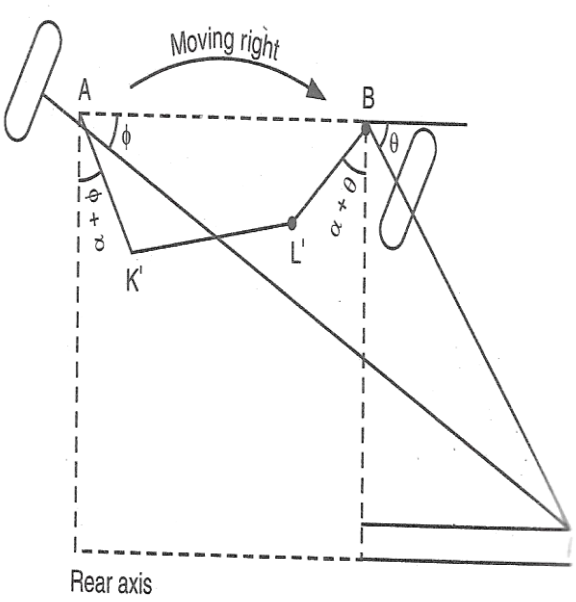
1. ACKERMAN STEERING MECHANISM:

The Ackermann steering gear mechanism consists of a cross link KL connected to the short axles AC and BD of the two front wheels through the short arms AK and BL, forming bell crank levers CAK and DBL respectively. When the vehicle is running straight, the cross link KL is parallel to AB, the short arm AK and BL both make angle 'a' to the horizontal axis of chassis. In order to satisfy the fundamental equation for correct steering, the links AK and KL are suitably proportioned and angle 'a' is suitably selected.

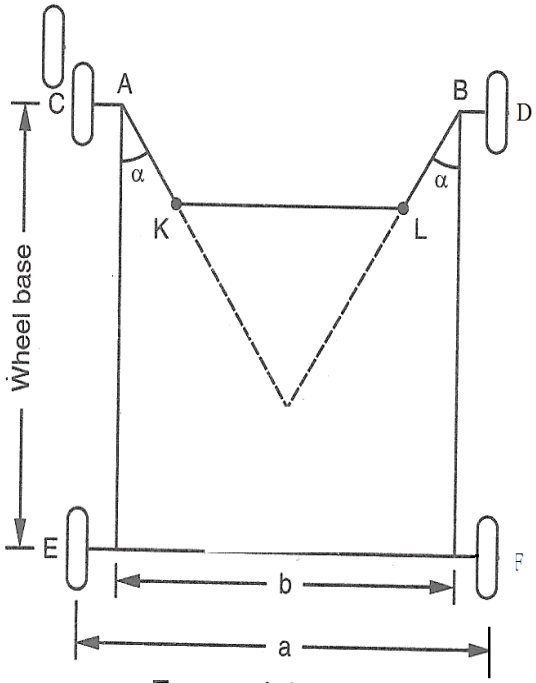
For correct steering

$$\textbf{Cot } (\phi) \textbf{ - Cos } \theta = b/l$$

The angles ϕ and θ are shown in the Fig. The value of (b/l) is between 0.4 and 0.5, generally *0.455*. The value of cot (ϕ) - cot θ corresponds to the positions when steering is correct. In fact there are three values of angle θ which give correct steering of the vehicle first while it is turning to right, second while it is turning to left and third while it is running straight.



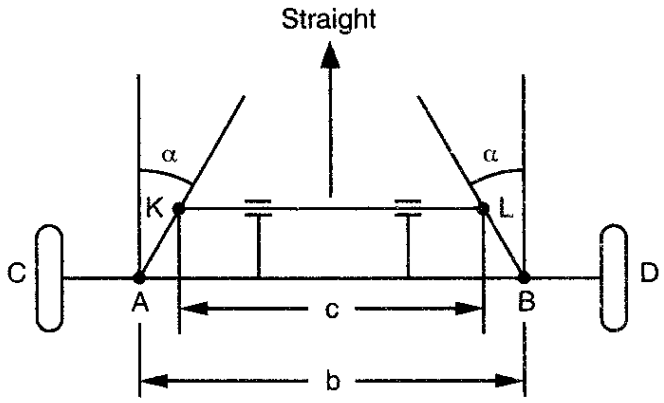
For Right Drive Ackermann steering gear mechanism.



For straight drive

2. DAVIS STEERING MECHANISM:

- The Davis gear mechanism consists of a cross link KL sliding parallel to another link AB and is connected to the stub axles of the two front wheels by means of two similar bell crank levers CAK and DBL pivoted at A and B respectively.
- The cross link KL slides in the bearing and carries pins at its end K and L. The slide blocks are pivoted on these pins and move with the turning of bell crank levers as the steering wheel is operated. When the vehicle is running straight, the gear is said to be in its mid- position.
- The short arms AK and BL are inclined at angle 90 + a to their stub axles AC and BC respectively.



Davis steering gear mechanism

The correct steering depends upon the suitable selection of cross- arm angle a, and is given by

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

where b = AB = distance between the pivots of front axles

l = wheel base

The range of — is 0.4 to 0.5

Hence angle a lies between 11.3 and 14.1°

STEERING GEAR BOX

Introduction:

Steering gear is enclosed in a casing known as steering gear box. it converts the rotary motion of the steering wheel into straight line motion of the linkage, these are two basic types of steering gears, the pitman arm type and the rack and pinion type. Either type can be used in a manual steering system (or) a power steering system.

The pitman-arm type has a gear box at the lower end of the steering shaft. The rack and pinion type has a pinion at lower end of the steering shaft. The action is the same in either system. When the steering wheel and shaft are turned by the driver, the rotary motion is changed into straight line motion. This causes the front wheels to swing from one side to the other to steer the vehicle.

TYPES OF STEERING GEAR BOX

1. Cam and double roller
2. Recirculating ball type
3. Rack and pinion
4. Worm and sector
5. Worm and nut
6. Cam and peg

1. Recirculating ball type:

It consists of a worm at the end of steering shaft. A nut is fixed on the worm with two sets of balls in the grooves of the worm, in between the nut and the worm. The balls reduce friction during the movement of the nut on the worm. The nut has a number of teeth on the outside, which mesh with the teeth on the worm sector, on which is further mounted the drop arm, which steers the road wheels through the link rod and the steering arm.

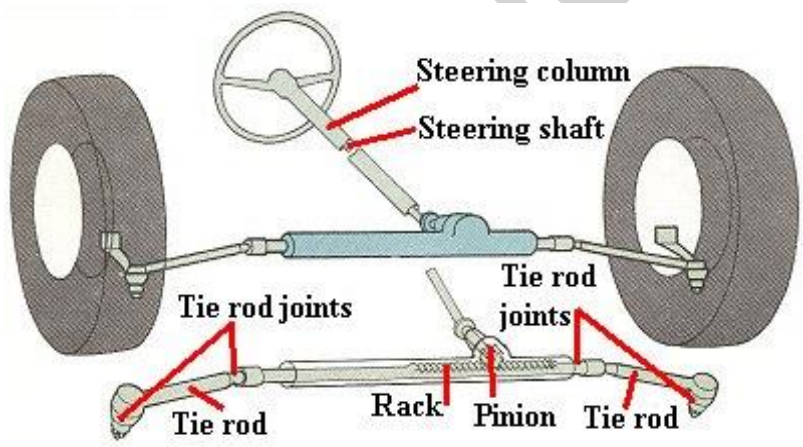
When the steering wheel is rotated the steering shaft also rotates and the nut moves downward (or) upward on the worm. This moves the sector, cross-shaft and drop arm to move in an arc. This movement is transmitted to the front wheels to turn the vehicles.

2. Rack and pinion type:

In this design, a pinion is employed at the steering shaft in place of worm (or) cam. The pinion always remains in mesh with the rack. A rack is operated by the pinion resulting in change in the rotary motion of steering shaft to straight line motion of the rack.

The rack has ball joints at each end to allow for the rise and fall of the wheels. The ball joints are further connected to the stub axles by rods.

In the modern design, the rack is connected in the centre by two halves of the tie rod'. It is simple and light. It occupies very small space and uses lesser number of linkage components compared to the other type of gear box. When the steering wheel is rotated the pinion also rotates and the rack moves left (or) right causing the wheels to turn. This types of steering gear provides sufficiently low gear reduction for cars and it is quite suitable even for heavier motor vehicles assisted with power. Rack and pinion type steering gear is used in Ambasador and maruthi 800 cars.



POWER STEERING

The purpose of power steering is to reduce the driver's effort at the steering wheel. Such a system is used in big cars and heavy commercial vehicles whose unladen weight is more than 1500 kgs. It is useful while driving on rough roads at low speeds and while reversing the vehicle for parking purposes. Power steering mechanism employs electrical devices, compressed air and hydraulic pressure. We shall explain the system, employing hydraulic pressure being widely used.

The two types of power steering used are

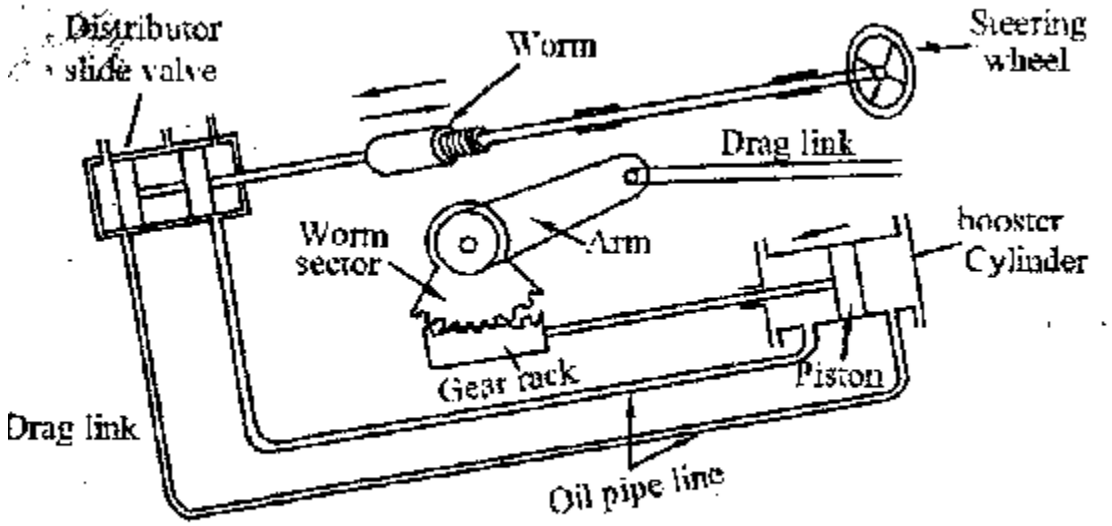
(i) Integral power steering

(ii) Linkage power steering

In the first type, the power steering system forms part of the steering gear whereas in the second type, it forms the part of the steering linkage.

- The principle of working of all the power steering systems is same. The slight movement of the steering wheel actuates a valve so that the fluid under pressure from the reservoir enters on the appropriate side of cylinder, thereby applying pressure on one side of a piston to operate the steering linkage, which steers the wheel in the appropriate direction.

- ***The oil assisted power steering as shown*** is fig. It consists of distributor slide valve which is driven by the steering wheel and it is connected to the booster cylinder through the pipe line.
- The piston in the booster cylinder is connected to the road wheels through the gear rack, the toothed worm sector, arm and drag link.
- When the steering wheel is turned, the worm turns the sector of the worm wheel and the arm. The arm turns the road wheel by means of the drag link.
- If the resistance altered to turn the wheels is too high and the effort applied by the driver to the steering wheel is too weak, then the worm, like a screw in a nut will be displaced axially together with the distributor slide valve.
- The axial movement of the distributor slide valve in the cylinder will adjust high pressure oil into the booster cylinder through the pipe line.
- The piston in the booster cylinder will turn the road wheels through the gear rack, the toothed worm sector, arm and drag link. This provides the driver with power assistance in turning the sector shaft.
- At the same time, the worm sector will act upon the worm and will shift it together with the distribution slide valve to its initial position and stop the piston travel in the booster cylinder.
- When the steering wheel is turned in the other directions, the wheels will be turned appropriately in the same sequence.
- The amount of pressure applied depends on how much resistance to turning the wheel the driver encounters. If the resistance is high, this allows more high pressure oil to the piston in the booster cylinder.
- Tyre is mounted on the wheel rim. They take all the load of the vehicle. They are flexible. They absorb most of the shocks when a car is moving on rough roads. The surface of the tyre has certain patterns. These enable the tyre to grip the road and provide good traction.



4.13. OIL ASSISTED POWER STEERING

TYRE

Functions of tyre

1. To support the vehicle load
2. Cushion the vehicle against road shock
3. To transmit driving and braking torque
4. To provide cornering power for smooth steering
5. Provide an effective grip on both wet and dry surfaces.
6. Transmit engine power to the road wheel in an efficient manner.

Types of tyres

The tyres may be of following types

1. Conventional tubed tyre
2. Tubeless tyre

Conventional tubed tyre

This is the type of tyre used widely. Inside the tyre, there is an endless tube fitted with a valve. Air is forced through the valve and is retained inside the tube under pressure. The air inside the tube acts as the cushioning medium. It consists of two main parts, viz the carcass and the tread. The carcass is the basic structure taking mainly the various loads and consists of a number of plies wound in a particular fashion from the cords of rayon (or) any other suitable material.

Each cord in each ply is covered with layer of rubber compounds and all the plies are insulated against each other. At the inner edges, beads are formed by reinforcing with steel wires. This provides the tyre with strong shoulders for bearing against the wheel rim. All plies are tied to the beads which prevent any change of shape. The tread is the outer part of the tyre which contacts the road surface when the wheel rolls. It is generally made of synthetic rubber and on the design of the tyre tread depends various tyre properties, viz. the grip, the noise and the wear. The tread provides road grip and to resist the abrasive action of the road surface. This can be retarded whenever required.

The tyres are specified to run on recommended inflation pressure by the manufacturers according to the size, quality of the tyre and load to be imposed upon it.

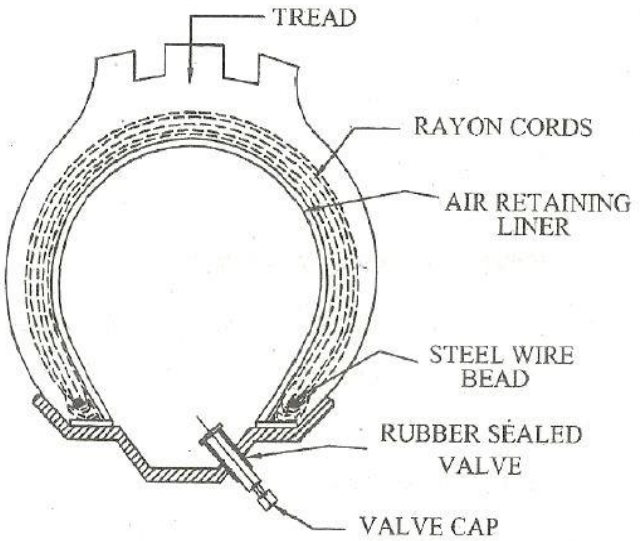
Tubeless tyre:

This type of tyre does not needs a separate tube. The air under pressure is filled in the tyre itself. The inner construction of this type of tyre is almost similar to that of conventional tubed tyre. A non return valve is fitted to the rim through which the air is forced inside the tyre.

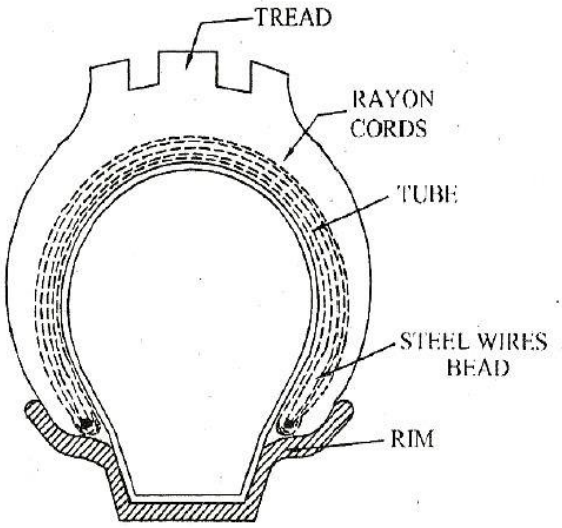
The tubeless tyres are lighter and run cooler than tubed tyre. The main advantages of-a tubeless tyre is that it retains air for a long period even after being punctured by nail, provided the nail remains in the tyre. But in case of tubed tyre releases the air almost immediately after being punctured. Also, any hole in the tubeless tyre can be repaired simply by rubber plugging. Ordinary punctures can be repaired without removing the tyre from the wheel. It can be retreated in the same manner as the tubed tyre.

Advantages of tubeless tyre

- ✓ Reducing wheel bounce
- ✓ Better cooling
- ✓ Slower leakage of air
- ✓ Simpler assembly
- ✓ Improved safety.



4.52. Tubeless tyre



4.51. Conventional tubed tyre

CONSTRUCTION OF TYRES

The tyre construction is divided into two classes

1. Cross-ply tyre construction
2. Radial-ply tyre construction.

1. Cross-ply tyre construction

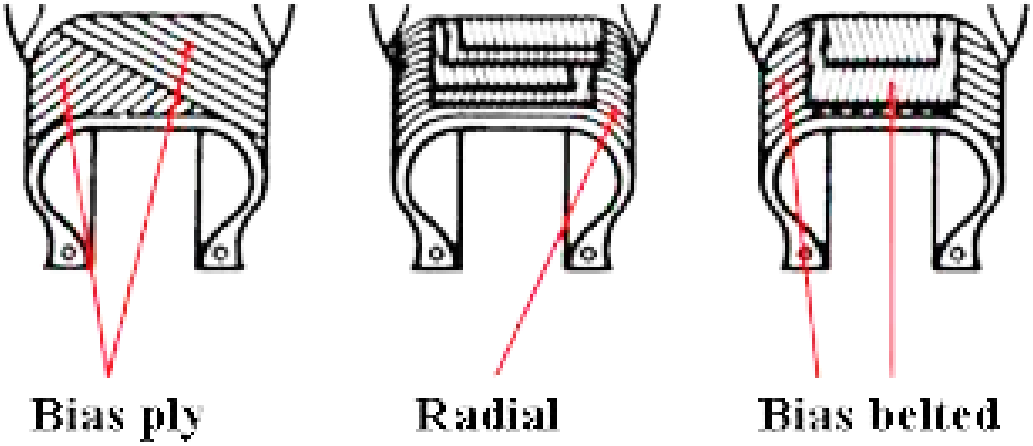
In this type, the ply cards are woven at an angle (30°-40°) to the tyre axis. There are two layers which run in opposite directions. These types of tyres have better wear and road holding characteristics. The cards in the layer cross one another to form a biased (or) lattice pattern, because that would lead to rubbing of the two layers and thus produce heat which would damage the tyre material.

Low cord angles in the carcass plies are generally better for high speed performance. They generate less heat and provide lateral stability. But they increase tread wear. Racing car tyres are made with an angle of 20°.

High card angles in the carcass plies will usually give a greater strength, increase its fatigue resistance and improve the contact path. At high speed the resulting friction increases the rolling resistance of the tyre increase the temperature of the tread and causes the outer ribs of the tread to wear faster than those in the centre.

2. Radial-ply tyre

In this the ply cords run in the direction of the tyre axis. Over this basic structure, run a number of breaker strips in the circumferential directions. The material for the breaker strips must be flexible but inextensible, so that no change of circumference takes place with change in the amount of inflation.



Cross and radial ply tyre

Without the breaker strips, radial plies would give very soft ride, but there will not be any lateral stability. The inextensible breaker strip behaves like a girder in its own plane and provides the directional stability.

Advantages of radial ply tyres

- ✓ Lower rolling resistance
- ✓ Better fuel economy
- ✓ Increase tread life
- ✓ Improved traction and high speed stability
- ✓ Better steering characteristics
- ✓ Puncture resistance
- ✓ More load carrying capacity
- ✓ Increase running speed
- ✓ Ride is more comfortable at high speeds
- ✓ Better braking grip properties of tyre

Disadvantages

- ✓ Ride is uncomfortable below 55kmph
- ✓ Improper steering characteristics at low speed
- ✓ Not stable while turning corner

Properties of tyre

- ✓ The tyre should not skid (or) slip
- ✓ The tyre must get wear uniformly
- ✓ It must be able to carry the vehicle load
- ✓ Providing cushioning effect
- ✓ It consume least power developed by the engine
- ✓ The tyre should create minimum noise
- ✓ The tyre should be balanced dynamically and statically.

Causes of tyre wear

There are a large number of causes of tyre wear. They are as follows

- ✓ Incorrect inflation, under inflation (or) over inflation
- ✓ Incorrect caster, camber (or) toe-in
- ✓ Excessive braking
- ✓ More acceleration
- ✓ Worn out steering mechanism

- ✓ Worn out king-pins
- ✓ Misalignment of wheels
- ✓ Defective brakes
- ✓ Over-loading
- ✓ Unequal size of tyre

UNIT IV

BRAKING SYSTEM

INTRODUCTION

Braking is the mechanism in the motor vehicle which is used to slowing down and stopping the vehicle to rest in the shortest possible distance.

Principle of Braking system:

While operating the braking system the kinetic energy of moving vehicle is converted in to heat energy.

Functions of Brakes:

- ✓ Brakes have the following functions.
- ✓ It is used to stop the vehicle.
- ✓ It is used to control the speed where and when required.
- ✓ It is used to control the vehicle while descending along the slope.
- ✓ To park the vehicle and held it in stationary position without the presence of Driver.

Requirements of Automobile Brakes:

1. It should work efficiently irrespective of road condition and quality
2. The retardation must be uniform throughout its application
3. The pedal effort must be within the convenient capacity of the driver.
4. It must be reliable and should not be effected by heat water and dust.
5. It should be in minimum weight
6. It should have long life
7. It should be easy to maintain and adjust
8. Noise and vibrations are to be minimum
9. There should be provision for secondary brake or parking brake

Stopping distance and Braking efficiency:

For practical measure for braking efficiency that of the minimum distance in which it can be brought in to rest after the brake is applied.

The stopping distance depends upon:

- ✓ Grip between the tyre and road surface
- ✓ Tyre tread condition
- ✓ Tyre inflation
- ✓ Nature of road surface

The stopping distance is calculated by

$$D=kv^2$$

Where d = stopping distance in kilometres

K = Constant depending upon the road and tyre inflation.

V = velocity of the vehicle per hour

The value of **k** is 1/25 for 4 wheel braking system,

1/12 for 2 wheel braking system

✓ The braking efficiency is calculated by the equation:

$$n = V^2/3D$$

where v = Velocity of the vehicle

d = Stopping distance

S.no	Condition of Brake	Braking efficiency in %
1	Perfect	90%
2	Excellent	77%
3	Good	70%
4	Fair	60%
5	Poor	50%
6	Bad	37%
7	Very bad	30%

- Below Fair is very danger.

CLASSIFICATION OF BRAKES

The following are the classifications of Brakes

1***. By method of power***

a) Mechanical brakes
b) Hydraulic brakes
c) Vacuum brakes
d) Air brakes
e) Electrical brakes
f) Magnetic brakes
g) Air assisted hydraulic brakes

2. By method of application

a) Service or foot brakes
b) Parking or hand brakes

3. By method of operation

a) Manual
b) Servo
c) Power operation

4. By method of Braking contact

a) Internal Expanding Brakes
b) External Contracting Brakes.

5. By Method of Applying Brake force

a) Single Acting Brakes.
b) Double Acting Brakes.

Types of Mechanical Brakes:

a) Drum Brakes (Internal Expanding or External Contracting)

b) Disc Brakes (Single or Two caliper)

DRUM BRAKES

Construction: The main components of drum brakes are

- ✓ Brake drum
- ✓ Back plate
- ✓ Brake shoes
- ✓ Brake Liners
- ✓ Retaining Springs
- ✓ Cam
- ✓ Brake Linkages

In this system the wheel is attached to drum. There are brake shoes used to contact the rotating drum for braking operation. The shoes provide lining on their outer surface. The cam is used to lift the brake shoes at one end, other end is connected by some method so as to make as the brake sleeve come into contact in the brake drum.

The retaining spring is provided for bringing the brake shoes back to its original position, after releasing the brake pedal. All these parts are fitted in the back plate and enclosed with brake drum.

Working: When the pedal is pressed the cam moves the shoes outwards through linkages, there by coming in frictional contact with the rotating drum. As soon as the brake pedal is released the retaining springs help the brake shoes to brought back and release the brakes.

Disc brakes: There are two types of disc brakes:

1. Spot Type
   - ✓ Swinging Caliper Type
   - ✓ Sliding caliper type
2. Clutch Type

Construction: The discs are made of gray cast Iron. The brake pressure in case of disc brakes have to be much lighter than the drum brakes.

It consists of rotating disc and two friction pads which are actuated by the four hydraulic wheel pistons contain in two halves of an assembly is called a caliper.

CLASSIFICATION OF BRAKES

Brakes may be classified as follows:

1. Mechanical brakes.
2. Hydraulic Brakes.
3. Air Brakes.

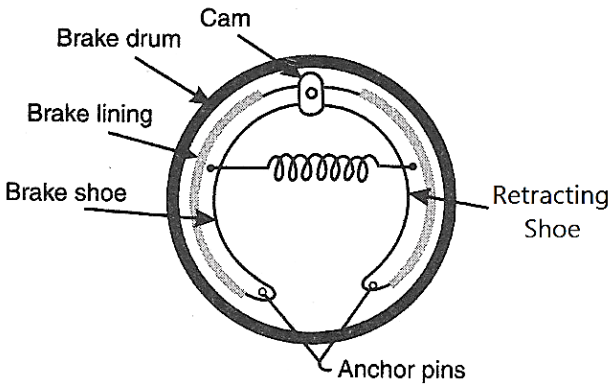
4. Electric Brakes.
5. Vacuum Brakes.

Mechanical Brakes

Figure shows how mechanical brake operates. In a mechanical system the pressure from the brake pedal is transmitted to the wheel brakes by means of cables, cams and linkage etc. The cam operates the brake shoe against the revolving brake drum to stop or slow down the motion of the car.

The cam itself is actuated through various mechanical linkages. Each brake shoe is pivoted on anchor pin and is made to contact a cam, so that when cam is turned, the shoes are forced towards the brake drum. On the outside surface of the shoes, brake linings are riveted to it.

Lining increases the coefficient of friction and also prevents, the wearing away of the metallic surface of the brake shoe. Also when the brake linings are worn out, they can be replaced.



Mechanical Brakes (Cam - Operated)

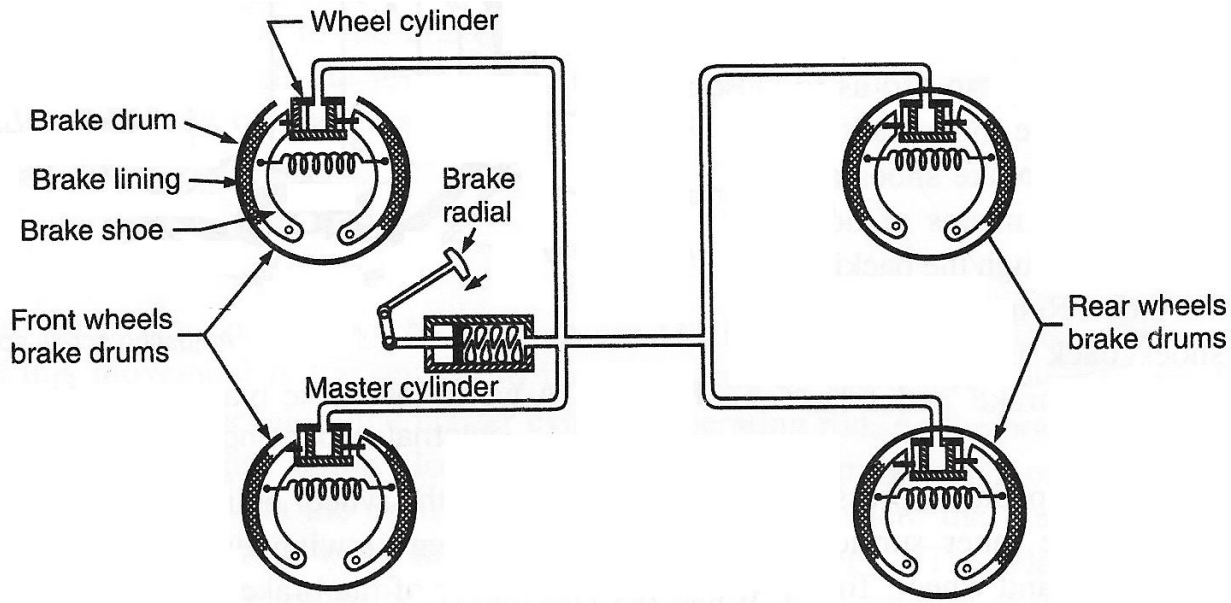
Operation

- ✓ When the brake peal is pressed down, its motion is transmitted to the cam through various mechanical linkages. The motion of the cam tends to expand out the brake shoes.
- ✓ This outward motion of the brake shoes will try to slow down the motion of the rotating brake drum. Because the wheel is fixed to the brake drum, so automatically it will be held to move further.
- ✓ When the brake pedal is released, the pedal will move up because of the tension of the return spring. A retracting spring draws the shoes away from the drum when the cam is moved to its initial position and hence the brake shoes are no longer in contact with the drum, which is now free to rotate.

HYDRAULIC BRAKES

- Mechanical brake system as described above has one major drawback, as in this system when the brakes are applied, it is very difficult to get simultaneous brake action on all the four wheel.
- Those brakes with the better linings or the closer adjustments would stop the wheel before the others when the brakes are applied. Also length of various rods and cables vary and this causes unequal braking action.

- In a hydraulic system, when the brakes are applied, the pressure is increased sufficiently in the system to produce equal and uniform braking action on all the four wheels.
- In Hydraulic brakes, the force exerted on the brake pedal is transmitted to the brake shoes with the help of a confined liquid commonly known as brake fluid.
- The force applied to the pedal is multiplied and transmitted to all the brake shoes by a system which operates on ***Pascal's Principle***.
- This principle states that *"A liquid unlike a gas, will not compress under pressure and that pressure applied to a part of an enclosed liquid is distributed throughout the liquid equally in all directions."*



Hydraulic brake system

- The hydraulic braking system consists for four wheel cylinders, one at each of the four wheels of the vehicle as shown in Fig. The system also consists of one master cylinder, which is connected to the wheel cylinders by steel tubing.
- Each wheel cylinder contains two pistons, which will move out when the pressure will be applied through brake fluid. When the brakes are not in operation, the system is filled with brake fluid. Each wheel brake consists of a cylindrical brake drum which is mounted on the inner side of the wheel and revolves with it.
- There are two brakes shoes mounted inside each of the brake drum but do not rotate with it. On the outer surfaces of the shoes are fitted a heat and wear resisting brake lining. When the brakes will be applied, the brake shoes together with the brake linings will be forced out against the inner surface of the revolving brake drum, to slow down or stop its motion.
- When the driver depresses the pedal, the force from the pedal operates the piston in the master cylinder. This will increase the pressure on the fluid in the cylinder and the centre hydraulic system will be under considerable pressure.

- This pressure is transmitted instantaneously to the wheel cylinder at each of the four wheel brake. The pressure of the fluid in the wheel cylinder forces their piston outward. Which in turn force the brake shoes outward against the brake drum, which will be slowed down or completely stopped.
- When the brake pedal is released, the pressure in the system drops to the original low value. This pressure drop allows the return spring in the master cylinder to return the piston and brake pedal to its initial position and allows retracting springs on the wheel brakes to pull the brake shoes out of contact with the brake drums into their original positions.
- The retracting springs on the brake shoes return the pistons in the wheel cylinders to their normal positions, forcing the hydraulic brake fluid back into the master cylinder.

Advantages

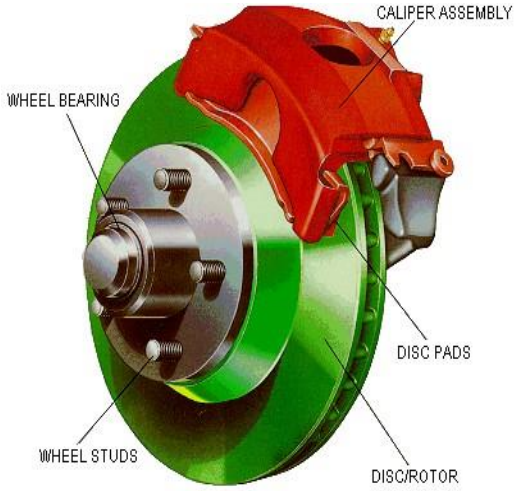
- ✓ Simple in construction
- ✓ Equal braking effort to all the four wheels
- ✓ Increased braking effort
- ✓ Self-lubrication
- ✓ Low wear rate
- ✓ High mechanical advantage
- ✓ Minimum moving parts and less complicated linkage
- ✓ Friction losses are low
- ✓ Application of brake is very smooth.

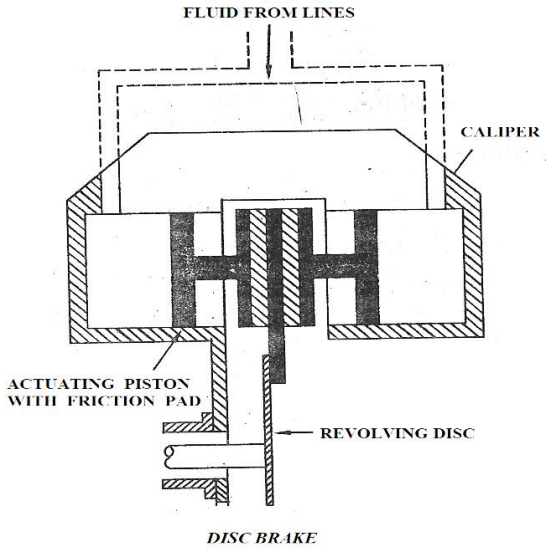
Disadvantage

- ✓ The braking system fails if there is any leakage in the brake lines.
- ✓ If the brake fluid leaks out on the brake shoes, they will be ruined.

DISC BRAKE

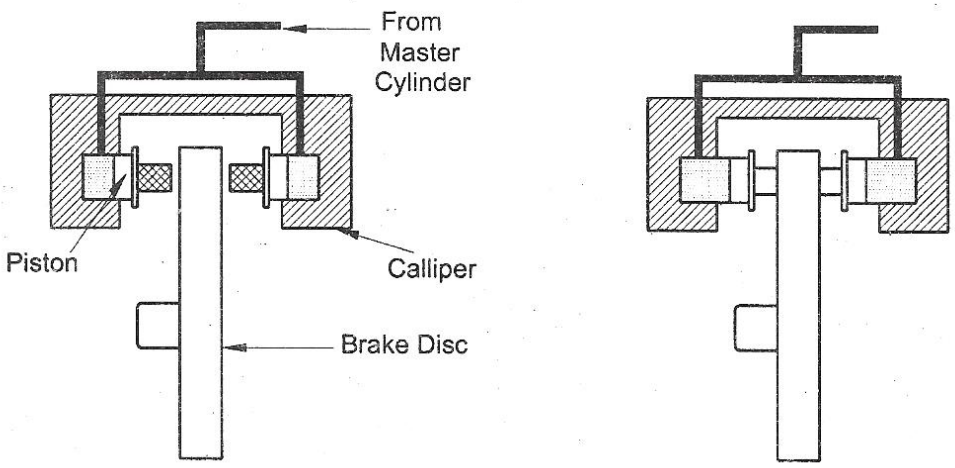
- The motor vehicles are being now fitted with disc brakes instead of the conventional type drum brakes. In this brake, a circular plate replaces the drum while flat pieces of friction material grip the disc instead of shoes.
- A disc brake usually consists of a rotating disc and two friction pads actuated by four hydraulic wheel pistons. A caliper which is an assembly of two halves contains the wheel pistons.
- The caliper assembly is secured to the steering knuckle in a front wheel brake and to the axle housing in a rear wheel brake.
- It is cast into two parts, each part containing a piston. In between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the caliper for the fluid to enter (or) leave each housing.





DISC BRAKE

- When the brake pedal is applied the fluid will be displaced from the master cylinder to the wheel cylinder pistons. This will exert equal and opposite pressure on the friction pads by forcing them against the rotating disc to grip it.



Disk brake

- More force is needed to apply the disc brakes for same brake requirement because they are not self-energizing. The pads will still maintain slight pressure on the disc although the pressure on the disc relieved when the pedal is released.
- In India disc brakes have been used for the first time in Maruti 800 cars at the front wheels. These have now been employed in many other cars also.

Advantages of Disc Brakes

- ✓ Better cooling
- ✓ Pad wear adjustment is automatic

- ✓ It is possible to check the condition of the pad wear without dismantling the brake system
- ✓ Renewal of the pad is quite quick and easy

Disadvantages

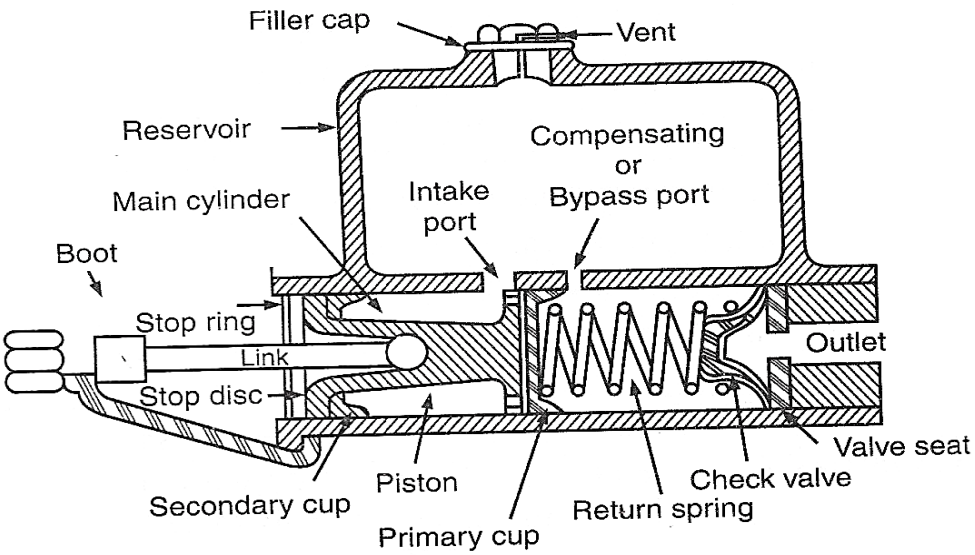
- ✓ It requires higher pedal pressure
- ✓ Greater friction pad wear
- ✓ Less effective.

MASTER CYLINDER

Construction:

The heart of the hydraulic system is the master cylinder. It comprises a reservoir and a compression chamber filled with hydraulic fluid. Piston is attached to the brake pedal. On one side of piston is the main seal (primary cup) and is held in position by a helical spring. Feed holes in the piston allow transfer of fluid into the compression chamber.

Fluid enters the rear of the piston through an inlet port. The leakage of this oil is prevented by a secondary rubber cup. The reservoir and compression chamber are connected by the inlet and by-pass port. A small by pass port which connects the reservoir directly with compression chamber when piston is in the release position. The larger inlet port is connected to the hollow portion of the piston. A check valve always maintain a low pressure in the system.



Master cylinder

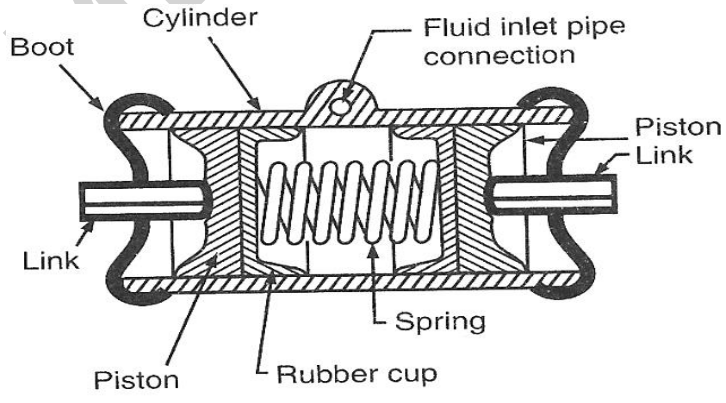
Working:

- When the brake pedal is pressed, the push rod moves the piston towards the right and in the process, covers the by-pass port. The oil in the compression chamber is pressurized, opening the check valve.
- Fluid under pressure flows to wheel cylinders through the brake lines. The wheel cylinder pistons move apart allowing the brake shoes to come in contact with the brake drums.

- When the brake pedal is released, the spring, suddenly pushes the master cylinder piston to the left. The delay of the fluid from the brake lines is due to inertia of fluid and check valve remains closed for some time.
- This delay creates vacuum in the compression chamber and may allow the leakage of air inside it and air, being compressible. It may be harmful the braking action. Now the fluid from reservoir to the rear of the piston and enters the compression chamber through feed holes deflecting the primary cup and destroying the vacuum.
- In the meanwhile, fluid from the brake lines enters the compression chamber which is at atmospheric pressure.When the pedal is in off position, the liquid may flow from the reservoir through the by-pass port in the master cylinder, supply lines, and wheel cylinders to make up for any fluid that may be lost or to compensate for shrinkage cooling of the liquid.
- In this way, a complete system of liquid is always maintained between the master cylinder and wheel cylinder.

WHEEL CYLINDER

- Wheel cylinder is the second important component of the hydraulic system. As shown in Fig., it consists of two pistons which are spring loaded and carry rubber cups, in order to seal the hydraulic fluid from leakage. It is rigidly mounted on the back plate.
- The tips of the brake shoes come into the slots of the wheel cylinder push rods. Dust covers are provided at each end to prevent dirt from entering in.
- The spring within the cylinder holds the cup seals in contact with the pistons. Two openings are provided to the wheel cylinder, one takes the brake line connection and the other, the bleeder screw.



Wheel cylinder

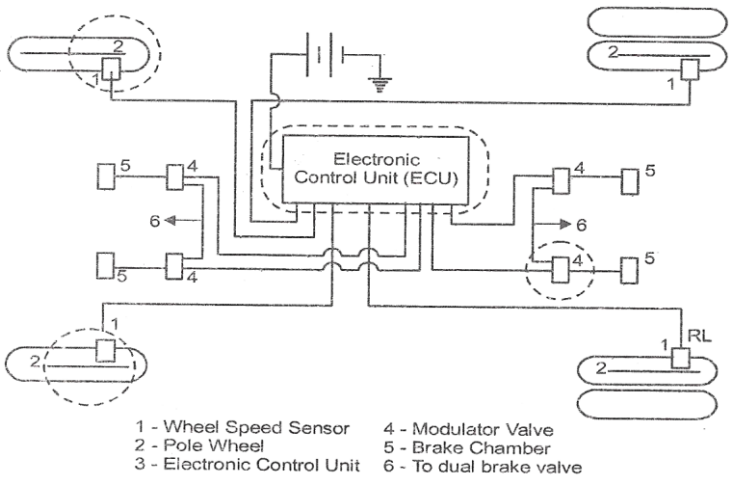
Working:

- When the brake pedal' is pressed the master cylinder forces fluid along the brake lines and into the wheel cylinder. Then fluid is entering between the two pistons. It causes them to force out the two pistons in opposite direction.

- This outward movement pushes the brake shoes to make contact with the brake drums. Once the pressure is released, the retracting spring brings both the pistons back to their initial positions.

ANTILOCK BRAKING SYSTEM

- Anti-lock Braking Systems (ABS) are designed to prevent locked-wheel skidding during hard braking or during braking on slippery surfaces. The front wheels of a vehicle cannot apply steering force if they are locked and sliding; the vehicle will continue in its previous direction of travel.
- The four wheel anti-lock brake systems found on many of today's vehicles hold the wheels just below the point of locking, thereby allowing some steering response and preventing the rear of the vehicle from sliding sideways while braking.
- The Rear Wheel Anti-Lock (RWAL) systems used primarily on trucks and vans is designed to prevent the rear wheels from locking up during severe braking. Especially since these vehicles are often designed to carry heavy loads, the rear brakes can be very touchy when the truck or van is unloaded.
- RWAL systems usually utilize a load sensing mechanism to adjust the sensitivity of the system to compensate for heavy or no load situations.
- There are conditions for which the ABS system provides no benefit. Debris, gravel, snow or sheets of ice render the ABS system ineffective since it relies on an underlying amount of road traction, which is not available when driving on gravel, excessive debris, snow or ice. Hydroplaning is possible when the tires ride on a film of water, losing contact with the paved surface.



Anti-lock braking system

- This renders the vehicle totally uncontrollable until road contact is regained. Extreme steering maneuvers at high speed or cornering beyond the limits of tire adhesion can result in skidding which is independent of vehicle braking. For this reason, the system is named anti-lock rather than anti-skid.

- Under normal braking conditions, the ABS system functions in the same manner as a standard brake system. The system is a combination of electrical and hydraulic components, working together to control the flow of brake fluid to the wheels when necessary.
- The anti-lock brake system's Electronic Control Unit (ECU) is the electronic brain of the system, receiving and interpreting speed signals from the speed sensors.
- The ECU will enter anti-lock mode when it senses impending wheel lock at any wheel and immediately control the brake line pressure(s) to the affected wheel(s). The hydraulic actuator assembly is separate from the master cylinder and booster.
- It contains the wheel circuit valves used to control the brake fluid pressure to each wheel circuit. If the ABS becomes inoperative for any reason, the fail-safe system insures that the normal braking system is operative. The dashboard warning lamp is activated to show that the ABS is disabled.

FACTORS INFLUENCING BRAKING EFFECT

The following are the factors mainly responsible for affecting the ability of the brakes.

1. ***Size of Brake Drum and the Wheel:*** A higher brake drum radius increases the retarding force produced at the ground, while a bigger wheel would decrease it.
2. ***Pressure on the Brake Shoe:*** The amount of Pressure applied at the brake lining increases the braking effect directly.
3. ***Area of the Brake Lining:*** The area of the brake lining also increases the braking effect directly.
4. ***Coefficient of Friction:*** The higher coefficients of friction between drum and lining as well as between tyre and ground are also useful in increasing the braking effect directly. The too high coefficients must be avoided which may cause locking of the wheel.
5. ***Leverage or Mechanical Advantage:*** For better braking requires a larger force on the expander. The effort applied on the brake pedal by the driver. This effort has to be multiplied through linkages of various kinds. A larger leverage is desired for less pedal effort and better braking.

COMPARISONS OF DISC AND DRUM TYPE OF BRAKES

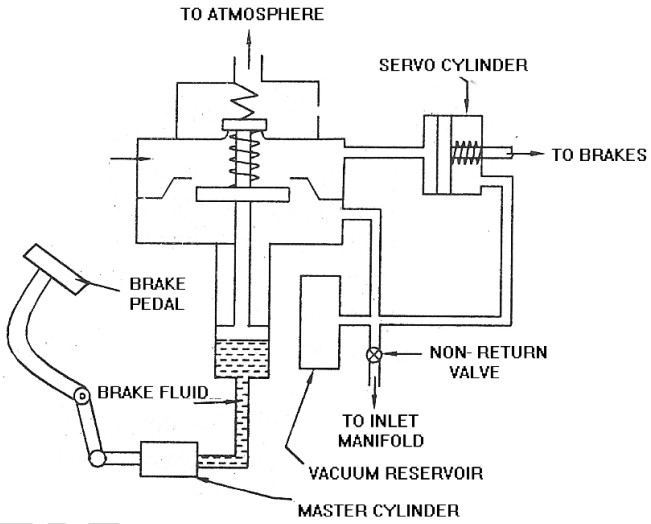
S.no	Disc brakes	Drum brakes
1	Friction surfaces are directly Exposed to the cooling air.	The friction occurs on the internal surface.
2	The friction pads are flat	Curved friction linings
3	Uniform wear of friction pads	Uniform wear of brake drum
4	Less weight	More weight
5	Automatic friction pad wear adjustment	Manual brake shoe adjustment

6	Better cooling effect	Poor cooling effect
7	Simple design	Complicated design
8	It is very easy to replace the friction pads when required	It is difficult to replace brake shoe when compared to disc brake.

SERVO BRAKE SYSTEM

Long journeys can be very tired for the driver. Then even the simple application of brakes can become a great strain. For this reason servo brakes are introduced which state that any mechanism which adds to the driver's effort in applying the brakes is called a servo mechanism this mechanism is used to reduce the drivers effort. Especially when the weight of the vehicle goes on increasing beyond the limit the assistance of the servo action is needed.

VACUUM SERVO BRAKES



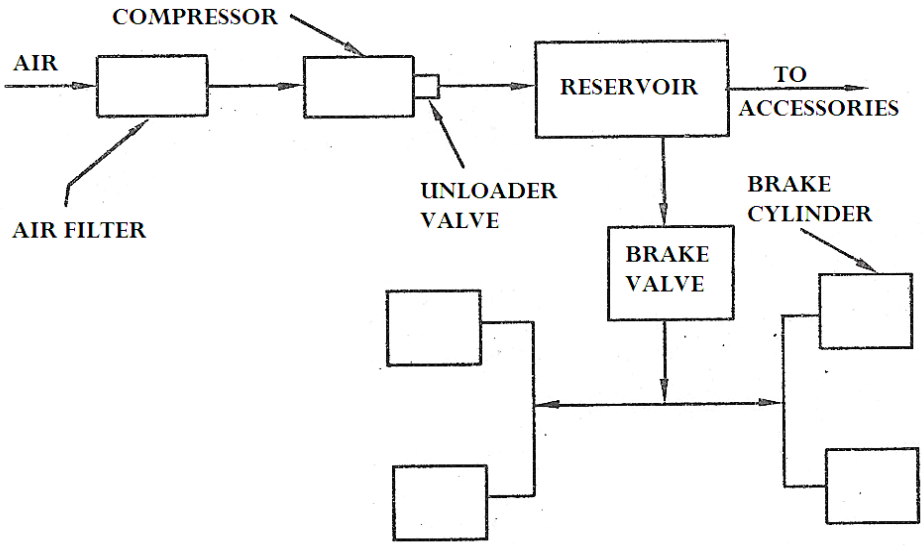
Vacuum servo brake

- These brakes are operated with the vacuum of engine manifold. It consists of servo cylinder, control unit, vacuum reservoir, master cylinder, non-return valve etc. Servo cylinder contains a piston which moves inside a cylinder is connected to the brake shoe operating cam through the links and levers.
- Vacuum reservoir is connected through a non-return valve to the inlet manifold between the carburetor and the engine. Vacuum reservoir is further connected to the servo cylinder on both sides of the piston, on left side the connection is through the control unit, while on the right side it is direct connection.
- Control unit also contains a piston to which two valves are attached. The upper valve controls the connection between the atmosphere and left side of the piston in the servo cylinder. The lower valve controls the connections between the vacuum reservoir and left side of the servo cylinder piston.
- The piston in the control unit itself is actuated by the brake pedal through the master cylinder as shown in the figure.

- In this principle, vacuum from the suction side is transmitted to maintain a pressure difference with the atmospheric pressure. When the brake pedal is free upper valve in the control unit is closed and the lower one is open. Thus both sides of the piston in the servo cylinder are exposed to the engine vacuum.
- However, when the brake pedal is pressed to apply the brakes, the pressure of the brake fluid pushes the piston in the control unit up thereby closing the lower valve there and opening the upper valve. Thus left side of the servo piston is exposed to atmospheric pressure, whereas vacuum acts on the right side.
- This causes the servo piston to move to the right. This movement is utilized to apply the brakes in the wheels through some linkage which may be mechanical or hydraulic. Thus the force to be exerted by the driver for applying the brake is considerably reduced and practically the whole of the braking effort is supplied by the engine vacuum.

AIR BRAKES

- In these brakes, the brake shoe operating cam is operated by means of air pressure which is developed by an air compressor driven by the engine.
- There are separate brake chambers are connected with the air reservoir by means of pipe line. A brake valve operated by the foot pedal, controls the pressure of air which affects the brake chambers.
- As the foot pedal is pressed down, air pressure acts on the diaphragm of brake chamber. The diaphragm is linked with the brake shoe operating cam shaft.
- The diaphragm is pushed outward in the brake chamber causing the movement of brake shoe operating cam. The brake shoes expand outwards and hold the moving brake drum as they come into its contact.
- When the pressure is released from the brake pedal, its comes back with the help of return spring. This results in the closing of brake valve and release of pressure inside the brake chamber. The brake shoe operating cam moves in the reverse direction as a result of pressure release on the brake chamber.
- The brake shoe contracts inward with the help of retracting spring, releasing the brake drum of the binding effect. The brakes are thus released.
- Air brakes are widely used in heavy vehicles like buses and trucks which require a heavier braking effort that can be applied by the driver's foot.



Air Brake System

COMPONENTS OF AIR BRAKE SYSTEM

1. Air compressor

It is a machine which builds up air pressure in reservoir. A piston type air compressor is commonly employed in the brake system. Air is drawn into the cylinder through in take valve when piston moves downwards. When the piston moves upward the intake valve is closed and outlet valve is opened by the air pressure and the air is forced out into the reservoir.

2. Governor or unloader valve

A governor is the form of safety valve which prevents the building up of excessive and dangerous pressures in the reservoir. The valve opens and relieves excessive pressure when it reaches the predetermined limit

3. Reservoir

The reservoir (or) air tank stores compressed air at the specified pressure for brake application. It is made of steel sheet. A safety valve is provided at the top of the reservoir to regulate the air pressure. A drain plug is also provided at the bottom for periodic draining of the reservoir.

4. Brake valve

It is the control valve which is operated by the brake pedal. It is located between the reservoir and air lines leadings to individual brake chambers.

5. Brake chamber

One brake chamber is installed on each wheel. Its function is to convert the pressure energy of compressed air into useful mechanical energy for the application of brakes.

It consists of a housing which encloses a movable diaphragm connected by a rod linked to the brake shoe operating cam-shaft. The chamber is divided into two parts by the diaphragm, the side opposite to rod being air tight. Air pressure acts in the air tight portion of the chamber which causes deflection of diaphragm and application of brakes.

6. Quick release valve

This valve is used in the front brake lines to accelerate the release of air from the brake chambers. It directly releases pressure to the atmosphere rather than through the brake valve.

7. Relay valve

It speeds up the application and release of air from the brake chambers, it supplies air to the brake chamber directly from the reservoir for quick application of the brakes it also exhausts compressed air from the rear brake chambers directly to the atmosphere rather than through the brake valve.

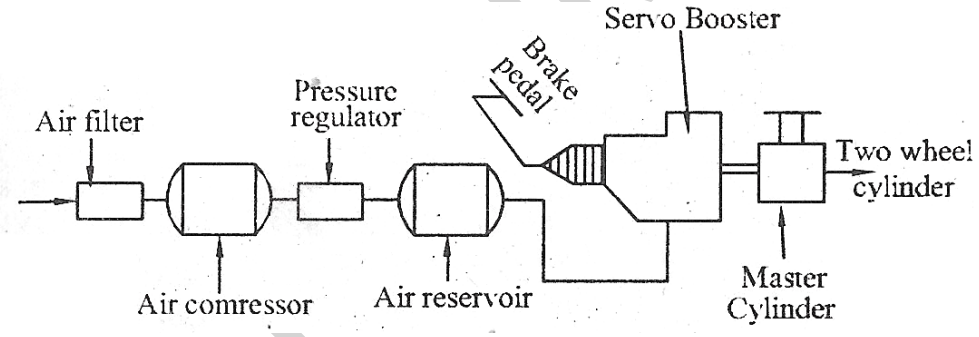
8. Warning signal

It is a warning light or buzzer which warms low pressure in the reservoir.

Advantages of Air Brakes

1. It is powerful brake than any other types
2. It is especially suitable for heavy vehicles
3. It is simplifies the chassis design.
4. Apart from braking, the compressed air from the reservoir can be used for tyre inflation, wind screen, wipers, horns and many other accessories

AIR ASSISTED HYDRAULIC BRAKES



In vacuum assisted brake, vacuum was taken for pushing the push rod of the master cylinder. In air assisted hydraulic brake system instead of vacuum, air is used for application of brakes. The brake pedal link and push rod of master cylinder are so designed and linked that in the event of failure of air pressure, brakes can be applied but once again more foot pressure will be required.

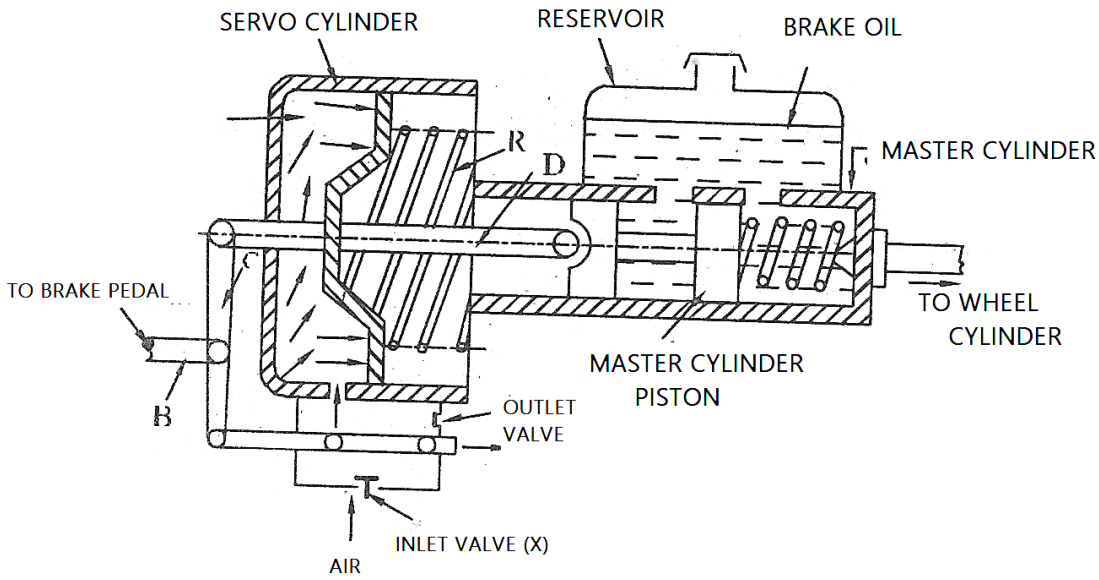
It is also designed that to stop the vehicle in air servo brake approximately half foot pressure is required in comparison to the vehicle with hydraulic brakes. A layout of air assisted hydraulic brake system is shown in fig.

The brake system consists of compressed air system and hydraulic system.

The compressed air system consists of air compressor, pressure regulator, air reservoir and servo Booster. Air compressor in Tata vehicle gets its drive from the engine cam shaft and the compressor takes

clean air through the pipe from air cleaner of the engine. Air gets into the compressor inlet valve and after being compressed sent to the air reservoir via outlet valve and pressure regulator.

The hydraulic system compresses master cylinder, wheel cylinder, brake drum, brake shoes, brake fluid lines and hoses. There is a check valve at the end of the master cylinders to control the flow of brake oil.



- The servo booste is mainly made up of 3 parts such as (i) Air control valve (ii) piston and cylinder and (iii) master cylinder. A line diagram of brake booster used in Tata vehicle is shown in fig. (a). In this figure the rod (B) is linked to the brake pedal. The other end of rod B is linked with lever (C).
- The upper portions of lever (C) are linked with piston rod (D) and lower part of lever (C) linked with pressure valve (X). The piston rod is fixed with piston which moves in cylinder. The piston rod (D) is connected to the master cylinder piston and the piston kept in off positions by spring R.
- When the brake pedal is pressed, the rod (B) moves forward. This movement of the brake pedal rod makes the valve rod to move which in turn makes the air control valve opens which allows the high pressure air to get into the cylinder behind the piston.
- Due to this high pressure, piston moves forward pushing the master cylinder rod. Due to this' the brake oil under pressure from the master cylinder goes to the wheel cylinders and brakes are applied. When the brake pedal is released, inlet valve is closed and outlet valve is opened.
- The entire pressure admitted into the servo cylinder is released to atmosphere and the spring moves the servo piston backward. The master cylinder piston return to its original position due to the return spring pressure.
- The fluid pressure in the entire system drops to its original low value and the return spring pull the brake shoes away from the brake drums. This causes the wheel cylinder piston also to come back to their original inward positions. Thus brake is released.

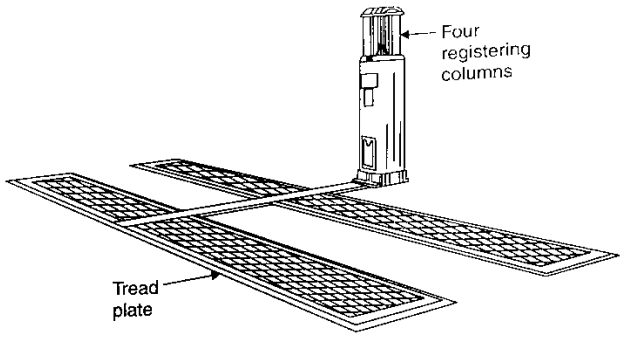
BRAKE TESTERS

The brake testers are of the following two types:

- ✓ Static brake tester.
- ✓ Dynamic brake tester.

1. Static brake tester:

One type of static tester has four tread plates and registering columns (Fig.). To make the test the car is driven onto the tread plates at a specified speed and the brakes are applied hard. The stopping force at each wheel is registered on the four columns. If the *readings are too low, or are unequal, brake service is needed.*

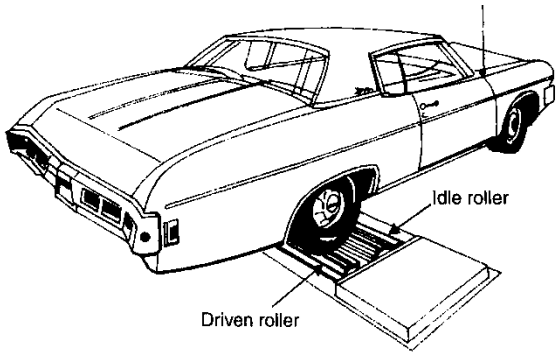


Static brake tester.

2. Dynamic brake tester:

The dynamic brake tester has rollers in the floor. The two wheels for which brakes are to be tested are placed on the rollers (Fig.). If these wheels are drive wheels, the wheels are spun at the specified speed by the vehicle engine.

For non-driving wheels, the rollers and wheels are spun by an electric motor. Then throttle is released or the electric motor is turned off and brakes are applied. The braking force at wheel registers on meters. This shows if the brake performs normally or if they need service.

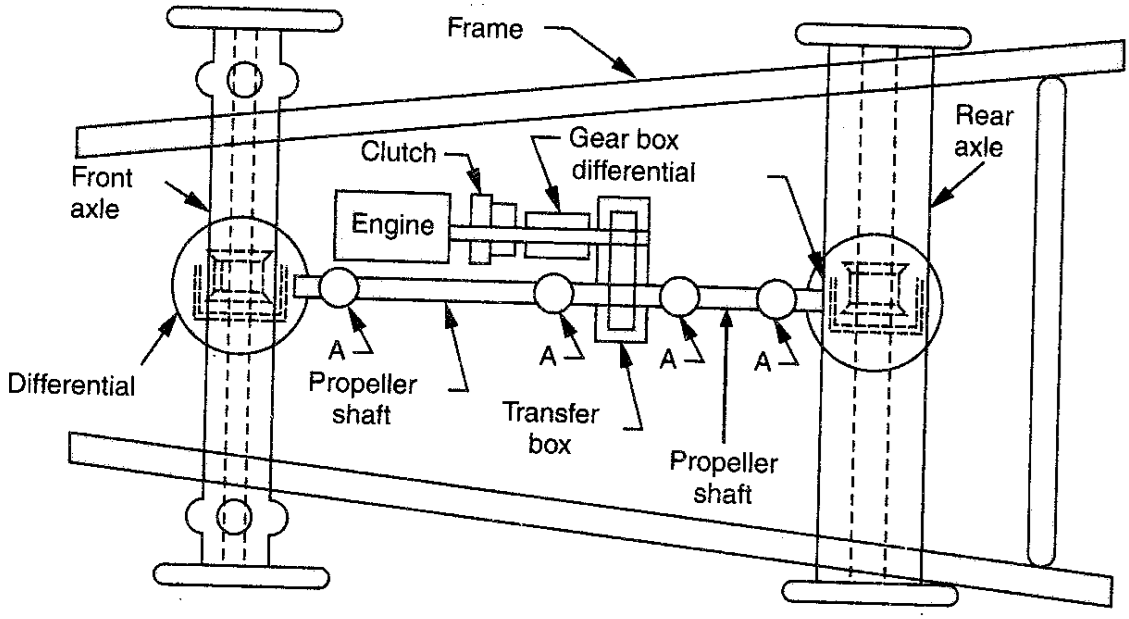


Dynamic brake tester.

CHASSIS

An Automobile is made up of mainly two units - The body and the Chassis. A vehicle arrangement without body is called chassis. The various components and systems of the chassis are the power unit, power train and the running system.

The power unit contains only the engine; transmission includes clutch, propeller shaft with universal joints, differential and the rear axle shafts; Running systems consist of brakes, wheels, tyres, frame, suspension and the steering system. The layout of a conventional chassis with various components mounted on it is shown in figure



- Cross bracings are provided in the chassis to withstand the shock, blows, twists and vibrations. As per the layout, the engine is mounted on the front part of the frame. Rubber cushioned mounts or pads are used to support the engine on the frame.
- The clutch is placed, next to the engine, connected to the flywheel, Transmission or the gear box is positioned or attached to the clutch shaft.
- Then a propeller shaft is laid to connect the gear box on one end and the final drive on the other end. These are enclosed in a housing, bolted to the rear axle spring, which is connected to the frame through springs.
- The entire arrangement mounted and bolted on the chassis frame is supported by the front and rear suspension systems. This is positioned over front and rear wheel and tyre assemblies, to avoid or minimize the transmission of shock to the frame.

The Chassis includes the following components

1. Frame
2. Front suspension
3. Steering mechanism
4. Radiator
5. Engine, Clutch, Gear box
6. Propeller Shaft
7. Rear springs
8. Road wheels

9. Differential, half shaft, Universal joints
10. Storage battery
11. Brakes and Braking system,
12. Silencer
13. Shock absorbers, fuel tank, Petrol and hydraulic pipe cables and some means of mounting these components.

FRAME

The word frame is used to denote the main skeleton of the vehicle. In automobile construction, chassis frame forms the basic requirement. It serves as the main foundation and base for alignment for the chassis.

The front end of the frame: anies the engine and the rear end carries rear axle housing, the wheels and tyres. The other components on the frame are steering system, fuel tank, battery, brake, shock absorber etc. The frame is provided with cross rods to increase the rigidity, withstand shocks and vibration.

The functions of the frame

- ✓ To carry the weight of the vehicle and passengers
- ✓ To withstand the engine and transmission torque
- ✓ To bear thrust, acceleration and braking torque
- ✓ To resist the centrifugal forces when cornering
- ✓ To withstand bending and twist
- ✓ To strengthen, to resist the severe twist and bending forces at high speed over rough road
- ✓ To provide correct spacing between the different components
- ✓ To serve as a bed for fuel tank, battery and other mounting units
- ✓ To bear the suspension system

Mostly the chassis frame is of 'X' constructions with some type of cross members made up of pressed steel, mild steels and nickel alloy sheets. Modern chassis frames are pressed steel members and are rigidly attached to each other by riveting or welding.

Types of frame

Generally there are three types of chassis frame

- ✓ Conventional frame
- ✓ Semi-integral frame
- ✓ Integral or unitised frame.

The frame consists of primarily two longtitudinal members made of mild steel with channel section. These members are connected cross-wise by cross members of tubular or box like cross section.

Construction

Mainly there are two distinct constructions

1. Conventional

- In this, pressed steel frame is used, with all the mechanical units attached. In the conventional construction, the loads on the vehicle are transferred to the suspension by a frame, which is supported on the wheel axis by the leaf springs.
- Normally used cross sections are channel section, Tubular or Box section. Channel section is good for bending; Tubular section resists torsion and Box section serves as good resistance to bending and torsion. The construction of chassis must maintain the working assemblies in their correct positions and also provide easy mounting of the body.
- The frame is closer at the front to provide adequate steering lock and unswept at the rear to provide clear space for the movement of the axle. Due to springing action it also makes the chassis height low.

2. Integral or frameless type

- The body structure is fabricated to carry out the functions of the body and frame. The units that are attached to the body are also rivetted directly to the frame.
- Frame-less construction has the advantage of reduced weight, less manufacturing cost, absorbing shock during accident.

BODY

Body is the superstructure of the vehicle. This is bolted to the chassis. A complete vehicle is referred to the combination of Chassis and Body. Body is merely a cover to the Chassis. The body may be shaped according to the needs and convenience.

The body of the motor vehicle must fulfill the following requirements.

- ✓ Sufficient space to accommodate passengers and luggage.
- ✓ Suitable shape to reduce air resistance
- ✓ It should be light and strong enough to resist bending, torsion and impact stresses.
- ✓ It should have continuous access to the engine and suspension system.
- ✓ The load should be distributed evenly.
- ✓ The mounting of the body should have minimum vibrations.
- ✓ It should be cheap and simple in manufacture.
- ✓ The design of the panels should be suitable for mass production and changes in style and design.
- ✓ It should be made of sheet metal of sufficient thickness for adequate safety during collision.
- ✓ It should provide clear vision and be of aesthetic in shape.

Types of bodies

- Car
- Truck - Punjab body straight truck
- Truck half body
- Truck - Platform type
- Tractor
- Tractor with articulated trailer
- Tanker
- Dumper truck

- Delivery van
- Station-wagon
- Pick-up
- Jeep

UNIT V

BATTERY

The Battery is the heart of the electrical systems in an automobile. It supplies the essential current. It is an electrical device used for storing energy in chemical form which can be released as electricity as and when required.

The Battery supplies the current fc: starting the motor and the ignition system when the engine is being cranked for starting Battery serves to supply the current for light, radio, heater and other accessories. Thus, the battery is the secondary source of electrical energy in addition to the generator.

The main functions of a battery

- ✓ To provide a source of current for starting and ignition.
- ✓ To supply current when the demand exceeds the generated output.
- ✓ To control the voltage of the electrical system.

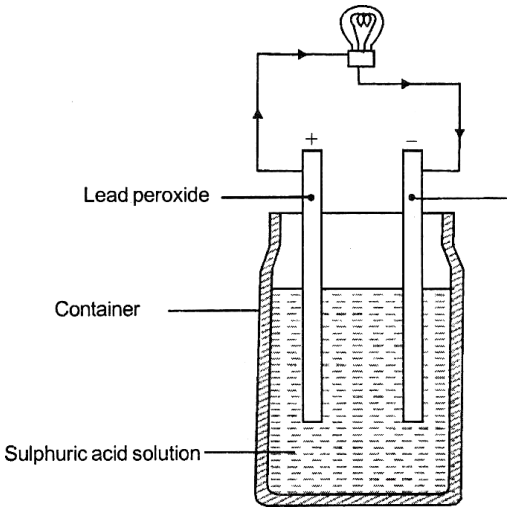
Types of batteries

- Wet
- Dry

A wet battery before put into service is to be charged by an external source after being filled with the electrolyte. In the case of a dry battery, it consists of fully charged positive or negative plates. Dry battery can be put to service immediately after filling electrolytes.

Other types are

1. Lead Acid batteries
2. Alkaline batteries
   - Nickel- iron battery
   - Nickel- cadmium type
3. Zinc - air battery.



Simple cell

The lead acid battery is mostly used in automobiles. The principle employed in this case is as follows:

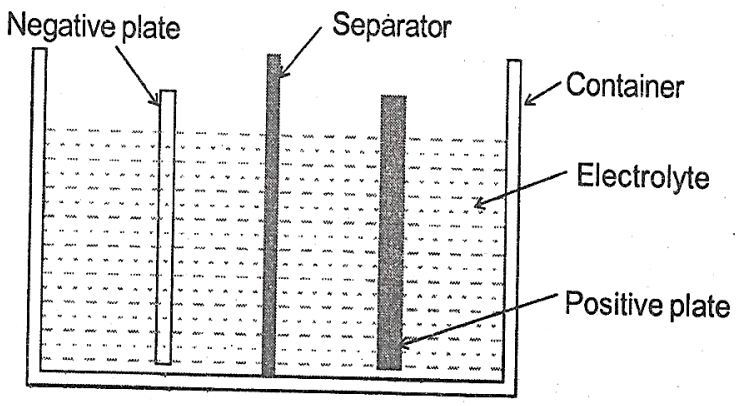
There are two rods; one is of pure lead and other rod is of pure lead peroxide which are in a solution of dilute sulphuric acid as shown in the fig. Then an electric voltage is generated between the rods, the lead peroxide forms the positive pole and pure lead forms the negative pole.

Depending upon the type of cells, the battery is classified into two types:

1) Alkaline battery 2) Acid battery.

The acid battery is widely used in automobiles because of its low internal resistance and low cost. This battery is also called as storage battery or accumulator or secondary battery. The cell in the secondary battery can be recharged by passing an electrical current through it. If it is primary, it cannot be recharged. Example: Dry cell battery.

The battery consists of cells. The cells are made of two plates; one of positive (+) plate and another of negative (-) plate. The plates are separated by a separator. The simplest storage battery is shown in the figure.



A storage battery cell

The plates carry an active material which is cast by a lead grid. The active material of the positive plate is lead peroxide ($Pb0_2$) and of the negative plate is spongy lead (Pb). These plates are immersed in a chemical solution. The chemical solution contains 25% of sulphuric acid in water. The separators are made of wood or porous rubber.

A number of positive plates and negative plates are arranged alternatively with a separate: in between them to form a cell. All positive plates are connected to a lug cast with £ grid. This forms the positive terminal, similarly the negative plates are connected to another lug.

Lead-Acid Battery Construction

The major components of the battery are:

Container:

Battery containers are single piece constructions. It is made of either hard rubber (moulded ebonite) (or) of a bituminous rubber. Modern car batteries are strong, transparent and light weight plastic.

Plates

There are two types of battery plates, the positive and the negative. The battery plates rest at the bottom of compartments containing bridges. For each plate there is supporting frame work or grid. It is made of an alloy of lead and antimony. The function of the grid is to hold the active materials and to carry current in the plates.

The active material in the positive plate grid is red lead ($Pb_3 04$) and the negative plate (Pbo) in the form of paste. After forming process, these are converted into lead peroxide for the positive plate and spongy lead for the negative plate. The negative plate group contains one plate more than positive plate group.

Separators

Thin sheets are called separators of some non-conducting material. To avoid direct contact and thus short circuiting of positive and negative plates, these sheets are inserted between them. The most widely used separator is P.V.C (polyvinyl chloride).

Cell covers

Cell covers provide a sealing for the cells. They are mounted from hard rubber. Each cell cover contains holes for the positive and negative posts, a vent and a filler opening. Filler openings are used to check specific gravity of electrolyte. Cell covers are sealed in the container by running pitch.

Electrolyte

The battery is filled with electrolytic solution of sulphuric acid. The ratio is one part of acid added to 3 parts of water.

Working principle

The positive plates contain lead peroxide $Pb0_2$ and negative plates have spongy lead Pb. The chemical reaction takes place; discharging and recharging processes are shown,

$$Pb0_2 + 2H_2S0_4 + Pb \underset{\text{Discharge}}{\overset{\text{Recharge}}{\Longleftrightarrow}} PbSo_4 + 2H_20 + PbS0_4$$

While discharging both $Pb0_2$ and Pb are converted to lead sulphate, $PbS0_4$. So the electrolyte is diluted due to water formation.

During recharging lead sulphate on positive plates is converted into lead peroxide, Pb02, while negative plates lead sulphate is converted to spongy lead. The water is splited into oxygen and hydrogen during charging. Then hydrogen combines with sulphate ions to form sulphuric acid.

Cell voltage

The open circuit voltage of a fully charged-battery cell is about 2.1. A six-volt battery would be made of 3 cells, and 12volt battery contains 6 cells connected in series. The cell voltage should not fall below 1.7volts during service.

BATTERY CAPACITY

It is defined as the amount of current delivered from a battery. It depends on the electrolyte, number and area of plates in the cell. The battery capacity decreases with decrease of temperature.

BATTERY RATING

- Twenty hour rate (Ampere-hour capacity)
- Twenty minute rate
- Cold rate (Zero test)

Twenty hour rate

It indicates the power loss of a battery on small load. The rate of current delivers for 20Hrs continuously by a battery. After which the cell voltage should not drop below, 1.75. During the test the temperature of the battery is 26°C.

Twenty minute rate

It is the rate of current delivering continuously for 20mts. The cell voltage should not drop below 1.5 at 26°C.

Cold rate

It represents the current in amperes which the battery can deliver continuously for 30 seconds without the cell voltage drop below 1.2V. The temperature of the battery is kept -18°C. It indicates the ability of battery during cold weather starting.

ALKALINE BATTERY

Alkaline batteries are of two types. The nickel-cadmium type is suitable for automobile service. Nickel-iron type is the other one. In nickel-cadmium type, the active material on positive plate is nickel hydroxide. On negative plate it is cadmium oxide. The electrolyte used is Potassium hydroxide solution. The positive and negative plates is in finely perforated steel tubes, which combine together to form a plate. Even under severe jolts, no active material is lost from the plates and no sediment is produced.

The electrolyte takes part in no chemical reactions on charging or discharging. The specific gravity is constant at about 1.20.

BATTERY CHARGING

Need for recharging

A generator is provided for charging the battery. If the battery is rundown, the charging rate will be higher. Under certain conditions, it happens. If the vehicle is in idle, frequent use of starter and the use of other

electrical accessories, the battery gets discharged to extent. So, the external recharging may become necessary apart from the generator charging.

Checking the state, of charge

It is seen that specific gravity is a very good indicator for the state of battery charge. This is done by gravity test. The general indications of

- **A fully charged battery cell**

(Below 32°C temperature the specific gravity is 1.290 and above 32°C temp the specific gravity is 1.230)

- **Half discharged battery cell.**

(Below 32°C temp) is 1.200 (above 32°C temp) is 1.140

- **Fully discharged battery cell**

(Below 32°C temp) is 1.110 (above 32°C temp) is 1.050

CHARGING

- ✓ Check electrolyte level, correct the level. Note the gravity and temperature readings.
- ✓ Use the battery charger. Connect the positive and negative terminals of the battery with the charger. The direct current is given. Adjust the value of current for charging. Generally it may be 8.5 amperes for 17 plate battery or for a 30 ampere hour battery the charging current may be adjusted to 3 amperes. Continue the charging till the gasing begins. Then decrease the charging current and continue till there is no further increase in the gravity and cell voltage readings for three hours.
- ✓ If the temperature exceeds 55°C, discontinue charging till the temperature of the battery cools down. Then restart the charging.
- ✓ The gravity and temperature readings should be taken hourly during charging.
- ✓ Overcharging damages the positive plates.

The several batteries to be charged are put under the series connection. The charging methods are constant current and the constant voltage types in practice. Generally recharging a battery takes from 12 to 20 hours, depending the conditions of the battery and the charging rate.

Slow and quick rate of charging

Slow rate of charging of battery is preferable. A battery takes about 12 to 20 hours for charging. It is a safe method.

Quick rate of charging of a battery which consumes a high charging current. After 80 percent charge is over, the current may be reduced. But the battery can be charged about one hour only. In this method, the good conditioned batteries only charged with rigorous observation.

Trickle charging

This charging is done during day time only. The self-discharged batteries, because of the batteries left in storage. Very low charging rate of about 5 percent of normal charging current is employed for keeping proper condition.

Dry charged batteries

Dry charged batteries are available which do not contain electrolyte. The plates are in it already charged. No moisture enters the battery, because the vent holes are closed. So, the battery is stored without damage for 2 to 3 years. When the battery is intended for service, open the vent holes and put the electrolyte to half, fill each cell. Allow it to stand for one or two hours. Then pour more electrolytes to bring it up to proper level. Now the battery is ready for use.

BATTERY LIFE

It is defined as the time for which it can serve without any damage. Overcharging caused by caused by overheating and the excessive gas bubbling reduces the battery life. The battery life greatly depends on materials, workmanship and maintenance.

BATTERY TESTING

Important tests conducted to a certain the conditions of the battery are

1. Specific gravity test
2. Open volt test
3. High discharge test
4. Cadmium test

Specific Gravity test

This is conducted with the help of a hydrometer containing a glass float. The float has a vertical density scale. To test the specific gravity, squeeze the rubber bulb of hydrometer to the battery cell. A sample of the electrolyte is to be drawn inside the glass body. Let the float inside rise. Read the scale at the surface level of the sample drawn in. The reading should not be taken while the battery is gassing and the pouring of distilled water for electrolyte level.

Open volt test

Voltmeter is used to find the open circuit voltage of the battery cell. This should be about 2.1 volts. Another way of expressing relation between the open circuit voltage of a battery cell and its specific gravity is **Voltage of cell = Sp. gravity + 0.840**.

If the battery is just charged, run the head lights for one minute. Then with the engine and all electrical accessories shut off, connect the voltmeter to battery terminals. In case of a 12-V battery, the voltmeter reads 12.6V it is fully charged. 12.2V is half-full charged 11.9V is fully discharged.

High discharged test

The cranking motor at the time of starting draws a heavy current. So, it causes the cell voltage to drop heavily, to test the condition of the cell, a cell voltage tester is used. The cell tester consists of a voltmeter. By pressing legs of the tester on the cell terminals causes heavy current to flow. The test **is made** for 5-10 seconds. The voltage should not fall below .5 volts. The difference of cells voltage should not exceed 0.2 volts; otherwise the battery may be taken to be defective.

Cadmium test

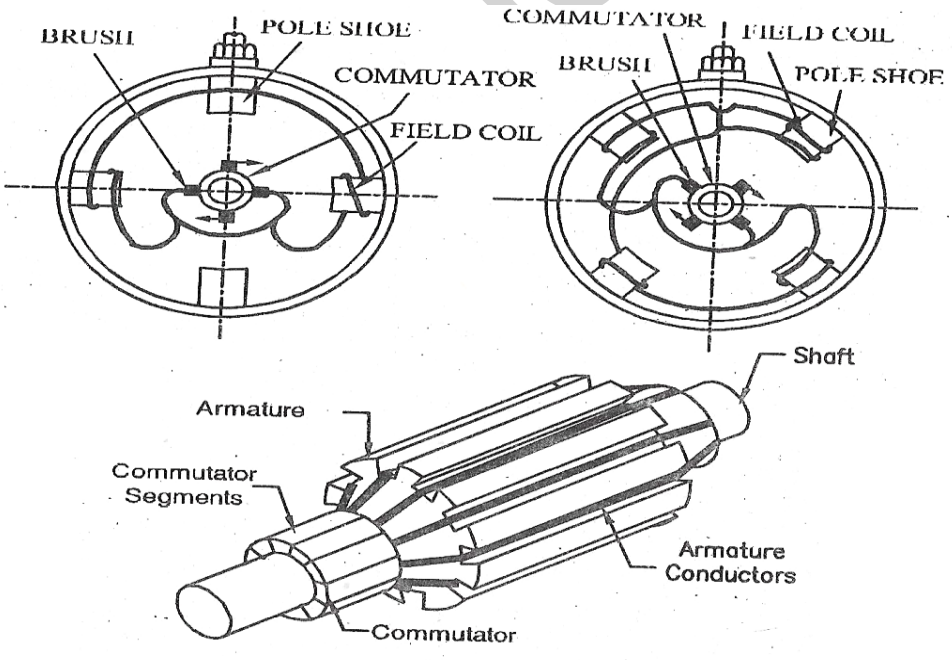
This test is conducted to know the chemical conditions of positive and negative plates and is performed only when the battery is on charge or discharge.

STARTER MOTOR

Construction

It consist of a cylindrical housing, field coils, pole shoes, armature and brushes etc as shown in fig. The steel pole shoes are securely attached to the inner surface of steel housing. The number of pole shoes varies from two to six but mostly there are four pole shoes. These pole shoes hold the field coils and become magnetized when the current flows through the coils.

The armature consists of a slotted iron core, shaft, commutator and armature windings. The windings are made of heavy flat copper strip for carrying heavy current. The windings consist of number of coils. These coils are connected to the commutator for flowing the current to all the coils at a time.



Starting motor construction

Working Principle

"Unlike magnetic fields attract each other and like magnetic fields repel each other".

When the starter motor switch is on, the current from the battery flows to the starting motor. One half of the current flows through one pair of field coils and other half flows through other pair of field coils to the other insulated brush.

It sets up a strong circular magnetic field around the armature coil. The reaction between the two magnetic fields exerts a force on the armature coils causing it to rotate. When the current flowing through the armature is more, the torque produced by the starting motor is also more.

Starting Motor Drives

For starting the engine it is sufficient to rotate it at about 100RPM, if the motor speed used is 1500RPM. Gear ratio between a pinion and flywheel teeth is of 15:1. So less torque is required to start the engine. But when the engine starts, the pinion should reach to its original position.

Otherwise the pinion will mesh with the flywheel. The flywheel will rotate, it at a high speed equal to 15 times the engine speed. The starting motor drive mechanism permits quick disengagement of drive gear from flywheel ring gear.

The drive mechanism is of the following two types

i) Over running clutch drive

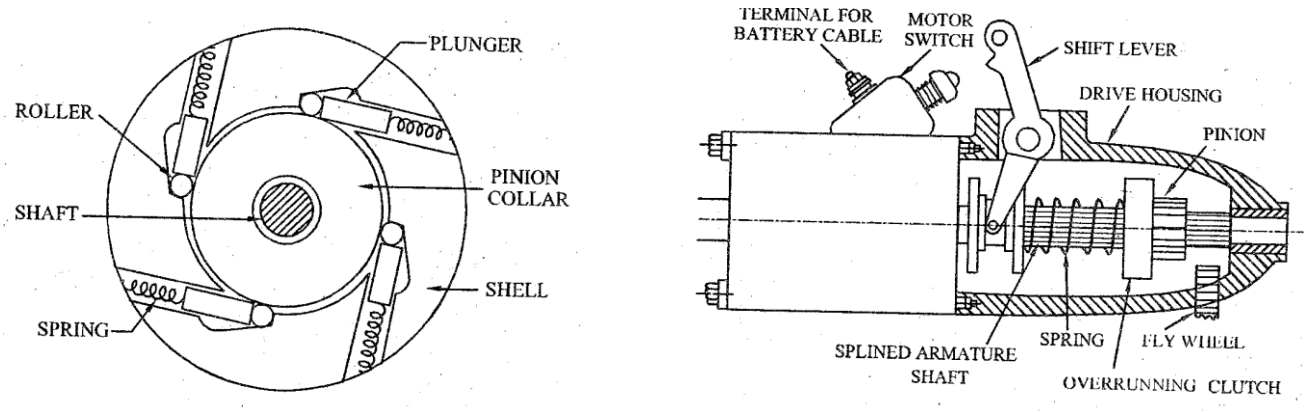
ii) Bendix drive

i) Over running clutch drive:

It consists of a shell and a pinion collar connected in such a way that when the shell is rotating at a speed greater than that of the pinion collar, the former will drive the later. Whenever the speed the collar becomes more than the speed of the shell, there is no connection between the two. Such a connection is provided by the spring loaded rollers, the shell is connected with the armature shaft through splines, whereas the collar is attached to the pinion.

A starting device employing the over running clutch is shown in fig. The shift lever is attached to the starting pedal in case of mechanical starters or may be operated by means of solenoid switches. When the starting pedal is pressed by the driver, the shift lever moves about its pivot, thereby pushing the switch of starting motor and moving the over running clutch and the pinion assembly through the spring simultaneously.

This causes the pinion to get engaged with the fly wheel teeth and also get the armature shaft and therefore the pinion to rotate, which starts the engine. As soon as the engine starts, the driver leaves the starting pedal which causes the shift lever to come back to its previous position.

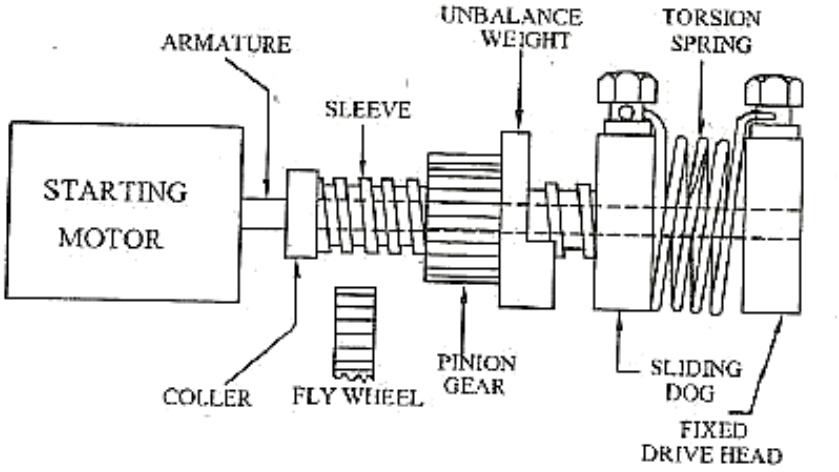


Over running clutch drive

ii) Bendix drive

Bendix drives are the- inertia drives. The starter motor pinion is made to engage or disengage with the toothed ring of flywheel. There are two types called, out board and inboard models. In the outboard type pinion moves away from the starter motor. In the inboard type the pinion moves towards the starting motor, there is a threaded sleeve on the armature shaft.

The sleeve can slide or {urn freely over the shaft. The shaft is keyed to the fixed drive head. The head is connected to the sleeve. A coil spring is attached to the sleeve. On the sleeve there is a pinion. An unbalanced weight is attached with the pinion. The purpose of weight is to prevent the rotation of the pinion on the sleeve threads.



When the motor starts, the armature shaft rotates. Due to the unbalance weight, the pinion cannot rotate and it moves axially towards the motor. The pinion is engaged with flywheel. There is collar attached on the sleeve. Now the pinion is engaged and rotates the flywheel of the engine and the engine starts. When the engine starts, the self-starter switch is off.

Now the flywheel rotates the pinion faster than the armature. Result of that the pinion is backed out of mesh with the flywheel. In compression spring type Bendix drive, the threaded sleeve is mounted directly on the splined armature shaft. When the motor is started, the sleeve starts rotating along with the armature shaft. This causes the pinion towards the motor and engaged with the flywheel ring gear.

Now the flywheel rotates and starts the engine. When the engine starts, the flywheel rotating at a faster speed causes the pinion to the backed out of meshing flywheel ring.

IGNITION SYSTEMS

The function of the ignition system is to produce spark in the engine cylinder. A spark should occur in each cylinder after two revolutions of the crank shaft for 4 stroke engine. In two stroke engine a spark must be given to each cylinder in each revolution.

Requirements of an ignition system

- ✓ Spark at the plug electrodes must be regular

- ✓ Spark should be strong enough to start ignition of the charge

Types of ignition system

A battery of 12Volts is generally employed. To produce such a high voltage (of 25000 Volts), a special ignition system has to be employed.

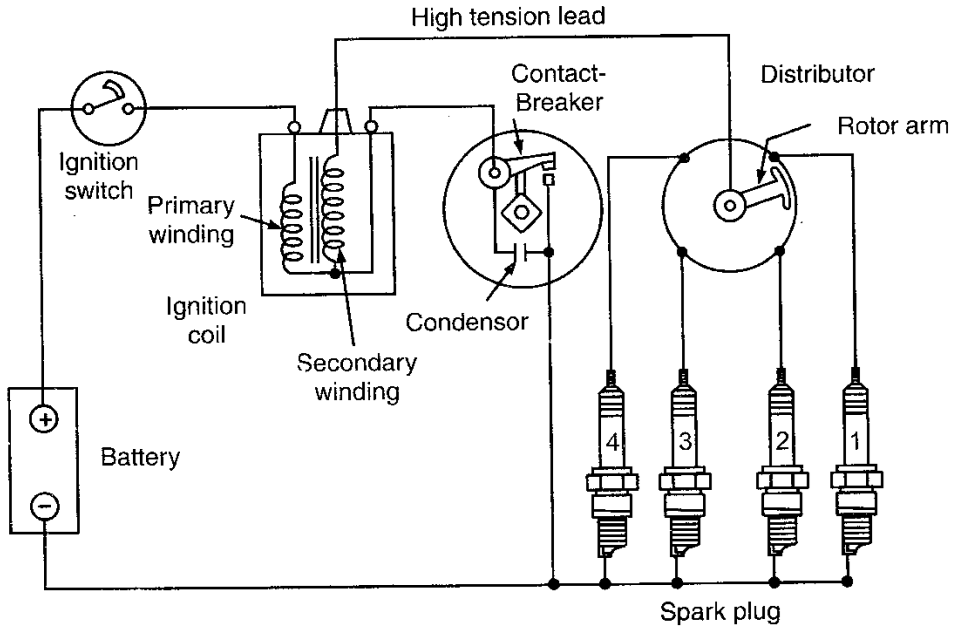
- ✓ Battery coil ignition system
- ✓ Magneto coil ignition system
- ✓ Electronic coil ignition system

1. BATTERY COIL IGNITION SYSTEM

A battery of 12Volts is employed. There are two basic circuits. Namely primary and the secondary circuits. The battery primary coil of the ignition coil, condenser and contact breaker form, the primary circuit. The secondary coil, the distributor and the spark plugs are arranged in secondary circuit.

When ignition switch is in the 'on' position the current flowing in the primary circuit. The buildup of current in the primary circuit is stored in the ignition coil. Due to the current flow in the primary circuit, the magnetic field formed and it collapses due to contact breaker. The energy stored during this period, a high sudden voltage produced in the secondary circuit.

Thus, the high voltage that makes the spark at the spark plug. Each spark plug is connected through H.T cables with distributor. The spark produced by sudden increase of voltage at each cylinder is distributed in the correct preset time.



Battery ignition system for four-cylinder engine

Components of Battery coil Ignition

The main components of a battery coil ignition system are:

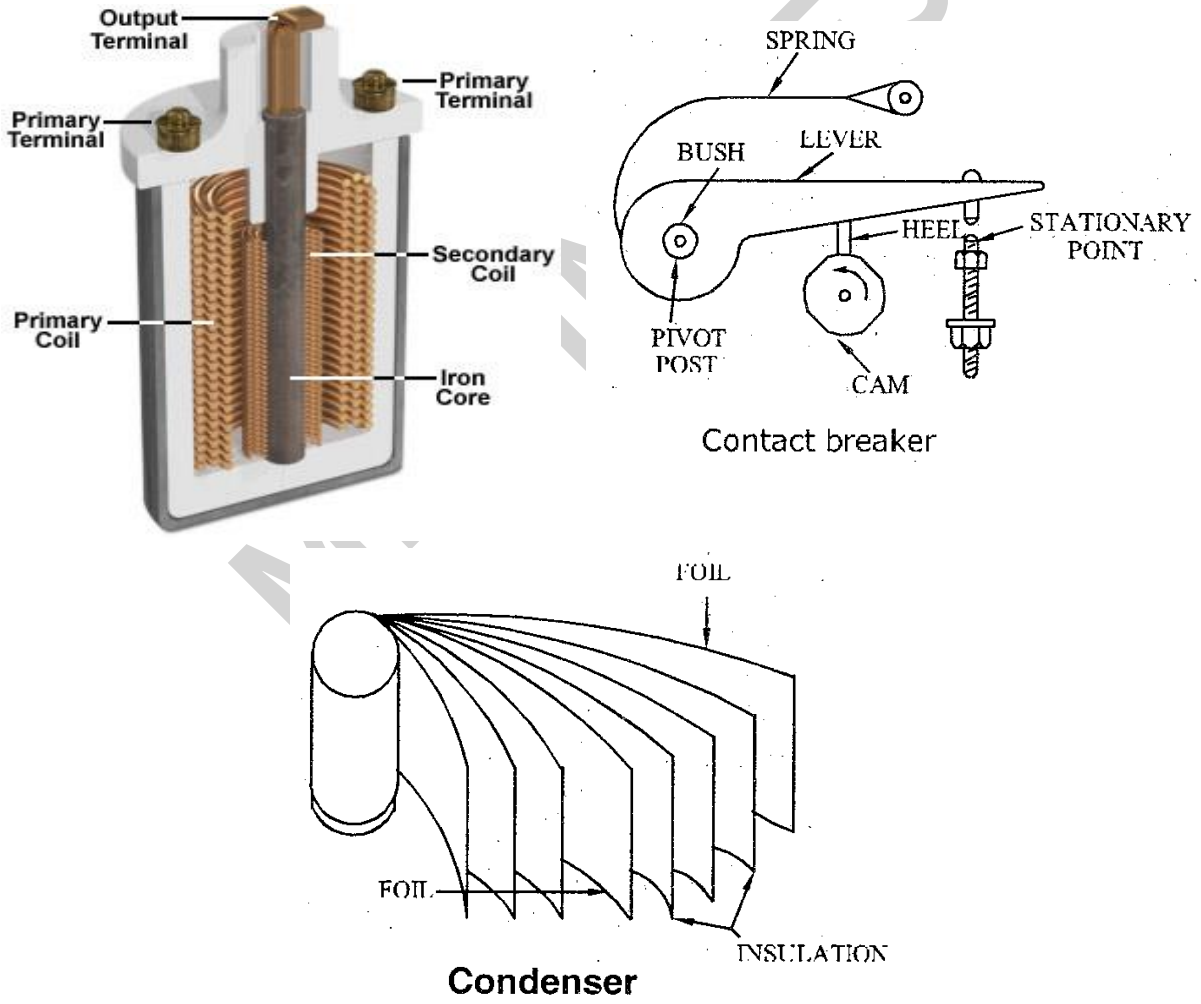
- Battery
- Condenser
- Ignition coil
- Distributor
- Contact Breaker
- Spark plug

1. Ignition coil

The ignition coil is a transformer. It serves to convert low battery voltage into high voltage. The primary winding consists of 200-300 turns of thick wire (20SW.G). The secondary winding is made up of large number turns of fine wire (40SWG - 15000 turns).

2. Contact breaker:

The function of a contact breaker is to make and break the primary ignition circuit. The contact breaker is placed in the distributor of housing itself. The cam is fitted to the distributor spindle.



3. Condenser:

Condenser is connected across the contact breaker. It may be considered as a kind of container in which the energy due to the inertia of the current flowing during the contact period is stored.

The functions of a condenser are

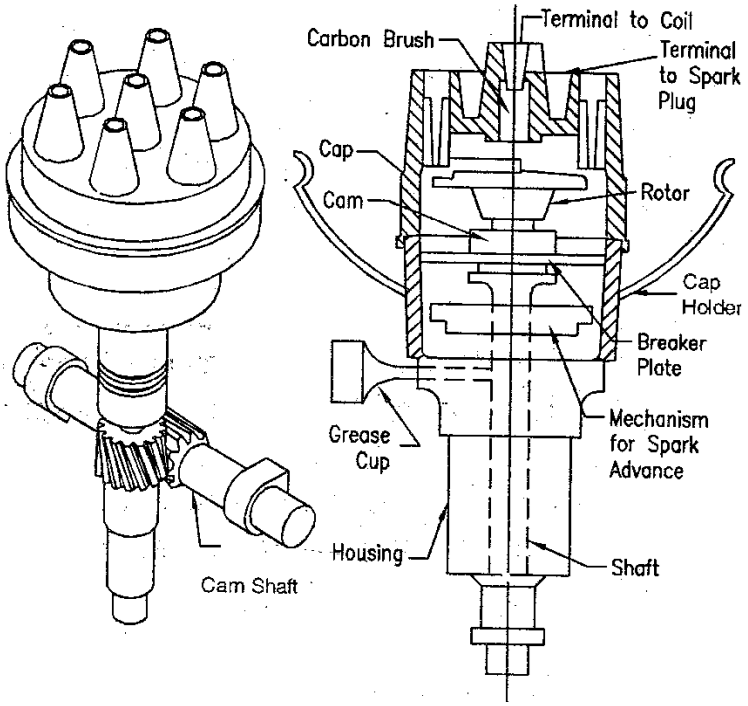
- ✓ To minimize arching at the breaker points
- ✓ To intensify the spark

Now aluminum foils are replaced by metallic paper has been used. Such a condenser is very small in size. The condenser is connected across the contact points. The current flow through the coil will now flow through the condenser.

3. Distributor:

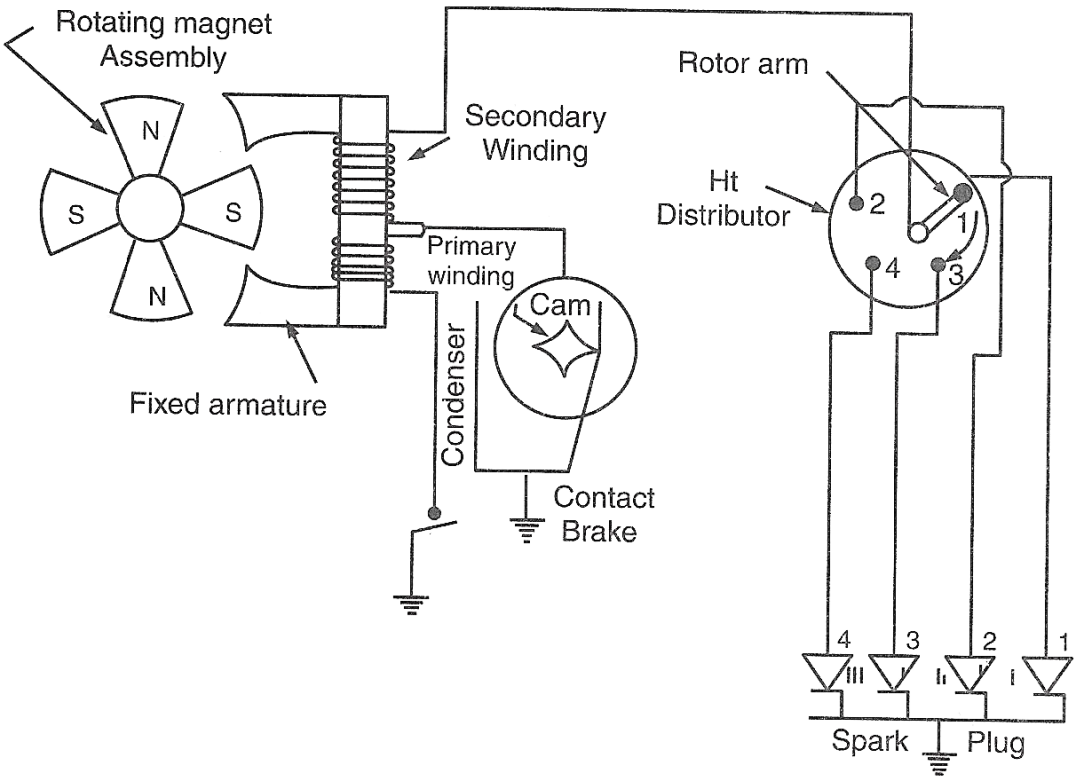
The distributor is situated in the same housing as the contact breaker. The distributor contains, the contact breaker, condenser, ignition advance mechanism and the distributor. The function of the distributor is to distribute the high voltage impulses in the circuit to the spark plugs at regular time intervals or according to the firing order of the engine.

It is made of Bakelite or fibre glass reinforced polyester resin plastic. The distributor cap contains the same number of contacts as the number of cylinders. Each of the metal inserts in the cap is connected to a separate terminal.



The H.T cables lead the high voltage to the spark plug. The central terminal is connected to the secondary of the ignition coil. As the distributor spindle has to rotate at half the crank shaft speed, the drive for it is taken from the cam shaft through spiral gears. As the distributor spindle rotates, the rotor point comes into contact with each terminal in the cap. Thus the high voltage passes to each cylinder in turn. Fig. shows the exploded view of distributor.

2. MAGNETO COIL IGNITION SYSTEM



Magneto ignition system for a four cylinder engine

It is shown in fig. This system generates the ignition current on its own. It does not depend on any battery or generator. Magneto system has rotating magnet and a fixed armature. There are contact breaker, condenser and a distributor.

Armature has one primary and one secondary windings connected to the magneto system as in the fig When the rotating magnet starts rotating, a current is produced. Then the current is passed through the contact breaker and to earth. Now a magnetic flux is formed in the coil.

Cam is running in the system, operating the breaker point and opened. So the magnetic flux formed is collapsed. Suddenly high voltage is induced in the secondary coil. Due to this a spark is produced in the spark plug. This system is mostly used in motor cycles and few vehicles such as tractors and fire engines.

Flywheel Magneto

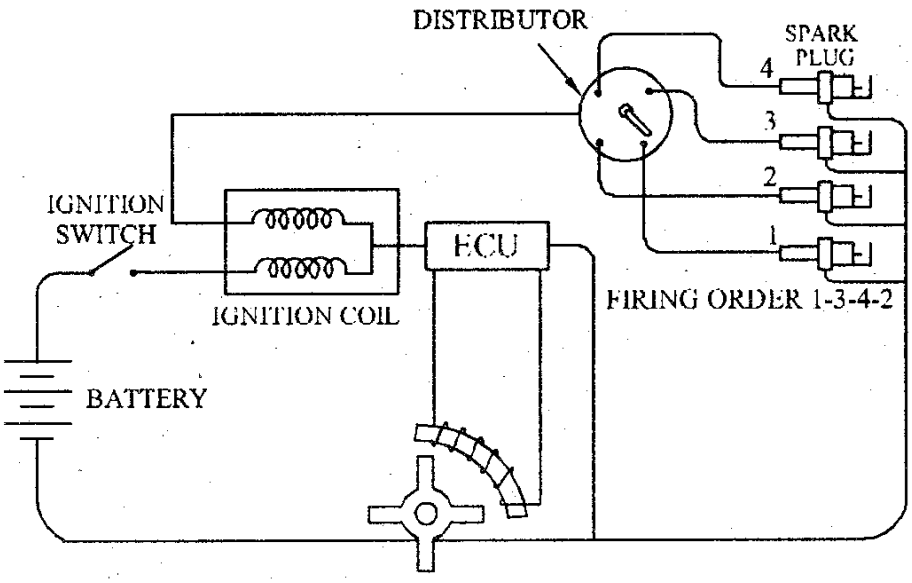
One H.T coil is placed in a fixed plate. Also the coil for lighting and horn is also provided in the plate. When the crank shaft starts rotating the magnetic wheel also is rotated. A condenser is fixed parallel to breaker point. It has a contact breaker and a cam for opening the point. It works as same as the above system.

Advantages

1. Good spark is produced at low speed.
2. Simple and less maintenance.
3. Spark is produced without failure even with the ignition advance or retard engine.

3. ELECTRONIC COIL IGNITION SYSTEM

In this system the contact breaker point is omitted. For that one magnetic pick up, electronic amplifying unit and a control unit are placed. One component is so called reluctor in the distributor. The reluctor is a rotor that contains tips of four numbers. A pick up coil and a permanent magnet are also in the distributor.



Electronic ignition system

The magnetic flux formed in the magnet flows through reluctor. The tips pass over the pick-up coil each time. So, the current made pulses after the flux is formed in the coil. The current runs the control unit.

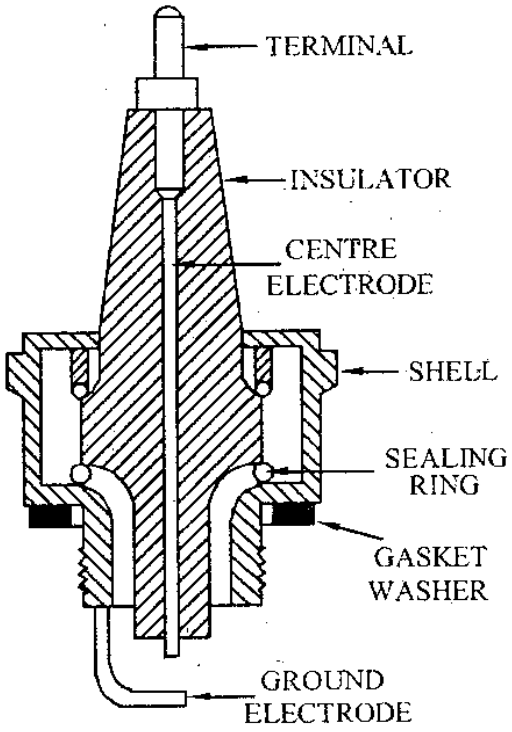
The unit consists of diode and transistors. The unit controls the current flow in ignition coil. When the. Pulses of current from pickup coil reaches the control unit, the current flow to ignition coil is stopped. So the- magnetic field is collapsed in the ignition coil. Due to this a high voltage is induced current in the secondary coil of ignition coil.

The high voltage jumped a current to the respective spark plug and made a spark in the engine cylinder. While pass over of the reluctor tip from pickup coil, the pulse of current in the coil is lost. Then the control unit connects the battery and the ignition coil circuit. Again the magnetic field is formed in the primary circuit of coil. The cycle is repeated, h is mostly used in high speed vehicles and racing cars.

SPARK PLUG

Spark plug is to ignite the fuel by producing spark at the engine cylinder. The parts are centre electrode, ground electrode and insulated casing. A gap is between centre electrode and ground electrode. A spark is produced or jumped in the gap at time of ignition.

The top of center electrode is connected to ignition system. Insulation is provided around the center electrode. The casing end is threaded form. The leak of fuel gas is prevented by the spark plug gasket which is provided between the insulator and casing.



Spark plug

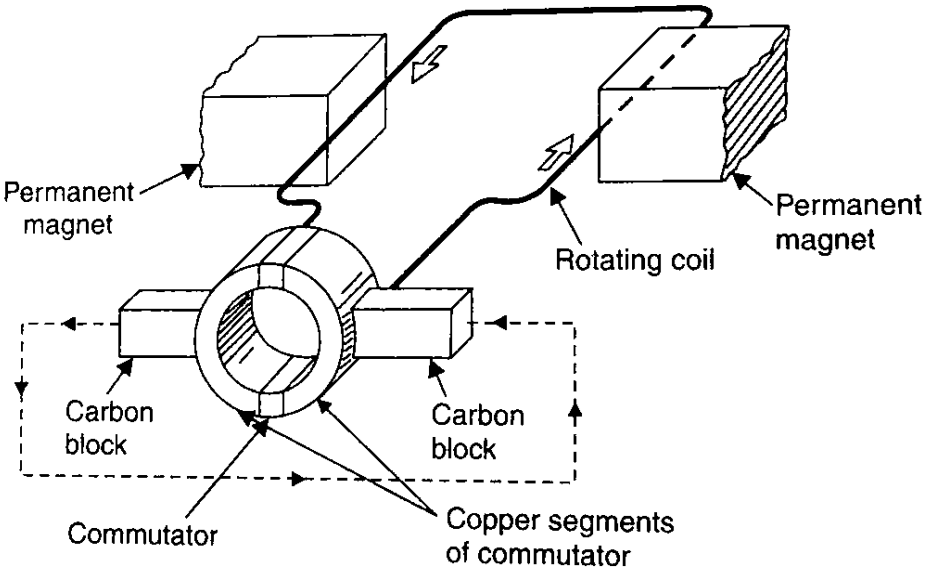
Heat range of spark plug

It denotes the spark plug heat during engine operation. The plug is getting more heat, if the distance of heat transfer is longer between the spark plug tip to cooling system. So, the spark plugs are divided as

- Hot plug
- Cold plug

DYNAMO (GENERATOR)

It is a device of supplying electrical energy charging the battery. The battery is a storage of direct current. It should always be kept in a charged condition. T in achieved by providing dynamo. The dynamo is run by engine crank shaft.



Principle and operation

The fig shows the principle. There are t permanent magnets N and S. There is also a rotating coil and a commutator. The two copper segments and are in touch with carbon blocks contact with the external circuit. When a conductor is rotated in a magnetic field, an electric current will flow through it. It is determined by Fleming's right hand rule. This simple principle is used in the dynamo.

When the coil is rotated the current will flow in the direction as shown in fig. The generated current is completed by flowing copper segments and magnets.If there are a large number of coils and segments of the commutator in the dynamo, the current passing through the brushes will have greater strength. This is required for the automobile dynamo.

A regulator is to control the amount of electrical energy produced by the generator. An ammeter is used to indicate the current flow in the system.

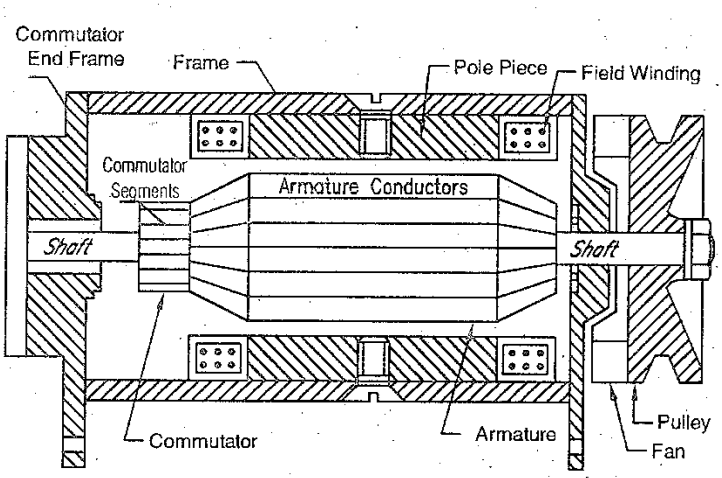
Constructional details of dynamo

The main components of a dynamo are:

1. Frame
2. Armature
3. Field coils

1. Frame:

Generator frame is made of steel and is of cylindrical. The pole shoes are accommodated inside the machined surface. The end covers support the bearings for the armature shaft. The end cover on the commutator side carries the brushes, and the generator output terminals Openings are provided for inspection and also for the removal from the generator.



D.C Generator

2. Armature:

The major parts are shaft, core, commutator and coil windings. The shaft is made of mild steel. The core is made from soft iron laminations. The core has longitudinal slots. The coil winding is made on the core slots. The windings are insecure position in the slots by wedges of mica insulation.

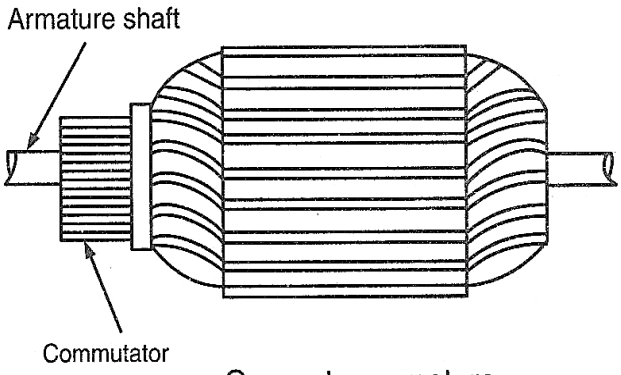
The windings are coated with insulating varnish and dried, commutator consists of a copper segments insulated from each other from the shaft by mica. Armature coils are wound in two methods, the lap winding and the wave winding.

Two spring loaded carbon brushes held in brush holders are employed to connect the armature coils to the outside circuit

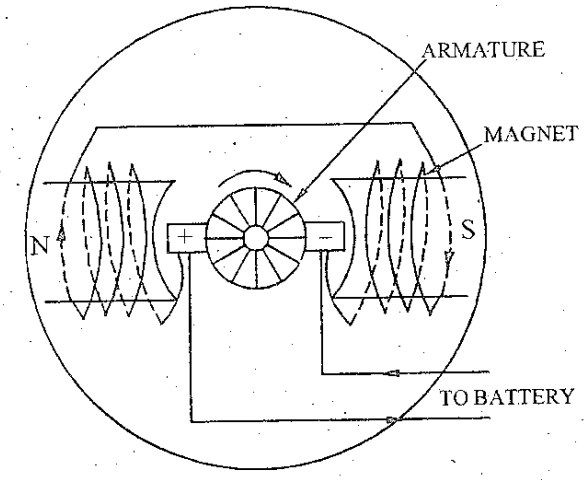
3. Field coils:

Field magnets used are not permanent. They are electromagnets. The generator field coils are shunt windings. It is best suited for the constant voltage with varying speed and current regulations. About one fifth of total output is consumed as the field current and the generator output is controlled by the field circuit regulation field coils are in the form of many turns of insulated fine wire.

The field magnets have a small residual magnetism. It provides the initial field to start the generator operation.



Generator armature

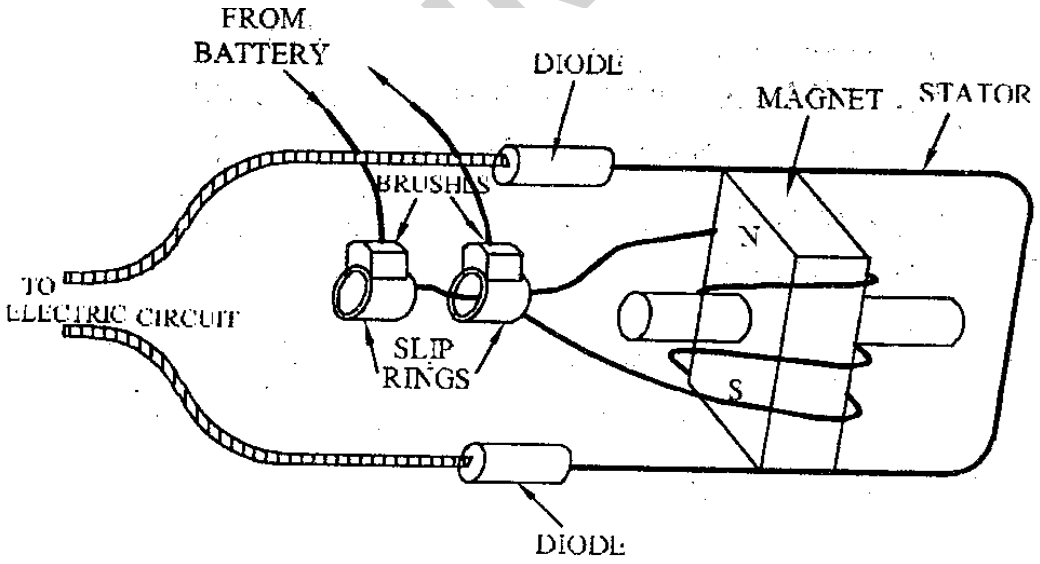


Field Coils

ALTERNATOR

The alternator or a.c generator is the generator which produces alternating current. However, as the automobile. Electrical system requires direct current. So, the alternating current produced in the a.c generator is to be converted full into the direct current with the help of diodes.

An electromagnet or rotor is mounted on a shaft. The battery supplies the current for rotor energisation. The slip rings and brushes are at the rotor shaft. The rotor is turned by a belt and pulley by the engine. Two diodes are connected to outside electric circuit with stator winding.



Principle of alternator

When the electromagnet is rotated the magnetic lines of force cut the stator loop to produce an induced current. Every 1/2 revolution, the magnet reverses its polarities thus the stator alternates the current produced in one revolution. To convert the alternating current into the direct current, diodes are employed. So, the diodes allow the current to pass in only one direction and are fed to the electrical circuit.

Construction details

a) ***Housing:*** This encloses the entire alternator assembly. It is made of aluminum alloy casting in two pieces. Aluminum is light weight, non-magnetic and higher thermal conductivity. The drive end has ball bearings and brush end housing contains a roller bearing.

b) ***Rotor:*** It consists of an iron core around the rotor shaft. Many turns of copper wire coated with varnish are wound over the core. On both sides of the rotor winding are thick metal plates bent over the winding with triangular fingers called poles.

c) ***Slip rings and brushes:*** The current to the rotor winding is carried through the copper slip rings and carbon brushes. These brushes carry the field current only. They have a much longer life.

d) ***Stator***: Between two halves of the alternator casing the stator is situated. The stator consists of three sets of winding wounded over a laminated iron core. When the rotor rotates, its moving magnetic field induces current in all the three stator windings.

VEHICLE LIGHTNING

Information regarding:

- Side Lights
- Dipped Headlights
- Main Beam Headlights
- Fog Lights
- Parking Lights
- Hazard Lights
- Brake Lights
- Indicators

Side Lights

Side Lights are not always on the side of the car. They are dim lights (with small bulbs) which help other road users to see your car, but may not help you to see other road users. They should be used for at least 1 hour after sunrise, and one hour before sunset. You may also use side lights when visibility is poor, due to light rain for example. When your side lights are on, your tail lights are also on.

Dipped Headlights

Dipped Headlights must be used at night, and when visibility is seriously reduced due to heavy rain, fog, or snow. The level of dip should be adjusted according to the weight in the rear of the car. Dipped

headlights should not cause other road users to be dazzled. Use your dipped headlights if you have the windscreen wipers on constantly.

Main Beam Headlights

These are also known as Full Beam, or High Beam. They should be used on unlit roads at night (for example, in the countryside.) They may also be used as a means of informing other road users of your presence (for example, when approaching a hump back bridge.) You must dip the headlights when there are other road users approaching you.

Fog lights

My car in only fitted with a rear fog light. Many cars also have front fog lights. They should not be used if visibility is better than 100m (25 car lengths). Using rear fog lights in good conditions creates dazzle for following drivers. On some models the fog lights can make the brake lights less conspicuous.

Parking lights

Parking Lights are fitted to most cars. They must be used when parking on a road where the speed limit exceeds 30mph (even if you are parking all night!). This rule may seem strange, as leaving lights on all night may drain the battery. However, it is quite unusual to park on a road where the speed limit exceeds 30mph anyway. Normally you would park off-road.

Hazard Lights

Hazard Lights should be used to alert other road users of a hazard in the road. For example, if you are following a truck, and a box falls from the back of the truck, then you should use your hazard lights as a warning to others. You may also use hazard lights when you have broken down, and need to warn other road users of your presence.

Brake Lights

Brake lights are activated by the footbrake, NOT by the handbrake. Many cars now have three lights at the back, so that it is more difficult to confuse them with tail-lights. Use the brake gently and early to warn following traffic of your intentions.

Indicators/Signals

Use directional indicators to give a **Clear** message to other road users of your intentions, and to eliminate confusion. If you think that another road user has not registered your signal, turn it off, and then on again. On many cars the signal is automatically cancelled after turns. However, it may automatically cancel too soon. You must repeat signals if they prematurely cancel.

SRI MANAKULA VINAYAGAR ENGINEERING COLLEGE

DEPARTMENT OF MECHANICAL ENGINEERING

MEE 61 - AUTOMOBILE ENGINEERING

TWO MARKS QUESTIONS

1. What are the functions of a frame?

- ✓ To support the chassis components and the body.
- ✓ To withstand static and dynamic loads without undue deflection or distortion.
- ✓ To carry the load of the passengers or goods carried in the body.

2. List out the various materials used in the construction of chassis frames.

- ✓ Low Carbon Steel - 0.18 or 0.20 % carbon content
- ✓ High Carbon Steel - 0.25 % carbon content
- ✓ Alloy Steel – With alloying elements like Ni & Cr

3. Write down any to two main sections of vehicle construction.

- ✓ Chassis construction
- ✓ Body construction

4. What are to two types of vehicle suspensions?

- ✓ Rigid axle suspension
- ✓ Independent suspension

5. What loads are coming to axle?

- ✓ Vertical bending load due to vehicle weight
- ✓ Driving torque
- ✓ Braking torque
- ✓ Side thrust

6. What are the functions of a gear box?

- ✓ It has to provide torque multiplication
- ✓ It has to provide neutral position
- ✓ It has to provide the means to reverse a vehicle

7. Why you need a gear box?

When a vehicle is moving on a road, it has to encounter different resistances depending upon the road surface, vehicle speed and road gradient. Hence, wheel torque required at road wheels is different for different operating conditions. To satisfy this requirement, a gearbox is necessary in a vehicle.

8. Name the different kind of resistances to vehicle motion.

- ✓ Air resistance
- ✓ Rolling resistance
- ✓ Gradient resistance

9. Why is the frame narrow at front?

The frame is narrowed at the front to provide a better steering lock. This also permits smaller turning circle radius

10. List out the various materials used in the construction of vehicle body

Wood, Metals, Plastics, Mixed construction of all these materials

11. Why are the side members of the frame upswept at two places?

The frame is upswept at the rear and front to accommodate the movement of the axles due to springing. It also keeps the chassis height low.

12. What is the function of a bumper?

A bumper is the front-most or rear-most part, which is designed tallow the vehicle to sustain an impact without damage to the vehicle's safety systems

13. What are the stresses to which the frame members are subjected to?

- ✓ Frame longitudinal members – bending stress
- ✓ Frame side members – twisting stress

14. Name few components of engine.

- Cylinder block
- Cylinder head
- Crankcase
- Cylinder
- Piston
- Connecting rod
- Crankshaft
- Camshaft
- Valves
- Spark plug (in the case of petrol engine)
- Fuel injector (in the case of diesel engine)

15. What are the types of frames?

- ✓ Ladder type frame
- ✓ Perimeter type frame
- ✓ X type frame
- ✓ Backbone type frame

16. What is meant by self-propelled vehicle?

A self-propelled vehicle is known as an "Automobile"

17. List the various manufacturers of automobile products in India.

- ✓ Maruti, Hyundai, Nissan, Ford – Passenger Vehicles
- ✓ Tata, Ashok Leyland – Heavy Commercial Vehicles
- ✓ Bajaj, Hero Honda, TVS Suzuki – Two Wheelers
- ✓ Bajaj, Mahindra – Three Wheelers

18. State the major types of automobiles according to the fuel used.

- ✓ Petrol Engines (SI engines)
- ✓ Diesel Engines (CI engines)
- ✓ Gas Engines (either SI or CI mode)

19. Classify automobiles with respect to the drive of the vehicle.

- ✓ Front wheel drive
- ✓ Rear wheel drive
- ✓ All four wheel drive
- ✓ Left hand drive
- ✓ Right hand drive

20. What is meant by the term Chassis?

A complete vehicle without a body structure is known as Chassis. It comprises of basic structure, power unit, transmission system, controls and auxiliaries.

21. How automobiles are classified into different types?

- ✓ Based on Make & Model
- ✓ Based on Fuel
- ✓ Based on Body Style
- ✓ Based on No. of Wheels
- ✓ Based on Drive
- ✓ Based on Transmission

22. What are the two types of cylinder liners?

- ✓ Dry liners
- ✓ Wet liners

23. What are the functions of piston rings?

To provide a gas tight seal between the piston and cylinder liner to prevent the escape of gases from top side of the piston to the underside.

24. What are the two types of piston rings?

- ✓ Compression rings
- ✓ Oil rings

25. What are the different methods of engine cooling?

- ✓ Air cooling
- ✓ Oil (or) Water cooling

26. What are the advantages of air-cooled engines?

- ✓ Less weight-power ratio
- ✓ Does not require radiator and water pump

- ✓ No antifreeze agents required
- ✓ No salt and mud deposits in the system
- ✓ Air cooled engines are cheaper

27. What are the components of water cooling method?

- ✓ Water pump, radiator tube, upper tank,
- ✓ Lower tank, thermostat valve etc.

28. State the difference between S.I and C.I engine.

- ✓ Parameter SI Engine CI Engine
- ✓ Type of fuel Petrol Diesel
- ✓ Compression Ratio Low (6 t10) High (12 t24)
- ✓ Operating cycle Otto cycle Diesel or Dual cycle
- ✓ Thermal efficiency Low High

29. What is clearance volume? And what are its effects?

The volume above the piston, when it reaches TDC is known as clearance volume. The clearance volume is inversely proportional to the compression ratio.

30. What are the functions of piston, connecting rod, crank shaft and cylinder head?

- ✓ Piston - The piston assembly transfers the force from the power stroke to the crankshaft
- ✓ Connecting rod - converts reciprocating motion of piston into rotary motion of crankshaft
- ✓ Cylinder head - it acts as a top cover to the cylinder block. The valves are placed in the
- ✓ Cylinder head - in an overhead valve engine.

31. What is the purpose of cooling system?

The purpose of cooling system is to cool the engine components in order to keep their temperature below certain limit and thereby avoiding excessive thermal stress in those components.

32. State the merits and demerits of air and water cooling system.

Air Cooling

Merits	**Demerits**
1. Less weight-power ratio	1. Cooling efficiency is lower
2. Does not require radiator and water pump	2. Non uniform cooling
3. No anti-freeze agents required	3. Engines are noisier.
4. No salt and mud deposits in the system	4. It needs impellor or blower to blow air over the fins
5. Air cooled engines are cheaper	

Water Cooling

Merits

1. Cooling efficiency is better
2. More uniform cooling
3. Engine operation is silent in nature
4. It does not need an impeller or blower

Demerits

1. More number of components like radiator, water pump
2. Antifreeze agents needed (Ethylene Glycol, Methanol)
3. More salt and mud deposition in the system
4. Engines are costlier

33. What is the purpose of lubricating system? State its types.

The purpose of lubrication system is to supply the lubricating oil between the moving parts of the engine in order to

- ✓ Reduce the friction
- ✓ Provide the cooling effect

- ✓ Carry away the deposits formed due to wear and tear

Types: -

- ✓ Mist lubrication
- ✓ Splash lubrication
- ✓ Pressure feed lubrication
- ✓ Combined splash & pressure feed lubrication

34. What is meant by turbo charging?

Increasing the density of inducted charge/air by using a compressor which gets its power from exhaust driven turbine is known as Turbo charging.

35. What are the various pollutants in I.C engine?

- ✓ HC, CO, NOx, Particulates, SO2, CO2

36. What is meant by P.C.V? And what are its effects?

- ✓ PCV – Positive Crankcase Ventilation
- ✓ It is used to reduce the blow-by and thereby unburned hydrocarbon emissions

37. What is a Catalyst?

Catalyst is a chemical substance which increases the rate of chemical reaction.

- ✓ Examples are Platinum,
- ✓ Palladium and Rhodium.

38. Write down the firing order a 4 cylinder and 6 cylinder engine

- ✓ 4 cylinder engine firing order: 1-4-3-2
- ✓ 6 cylinder engine firing order: 1-5-3-6-2-4

39. What is Gasoline Direct Injection?

The gasoline (petrol) is directly in to the cylinder at the end of compression stroke as such in diesel engines. This is called Gasoline Direct Injection (GDI)

40. What is conventional ignition system?

The conventional ignition system gets its electrical voltage either from battery or dynamo, which will be boosted ta very high voltage due to which spark is produced in the cylinder to combust the mixture.

41. Define common rail injection system.

A common rail which is maintaining high fuel pressure is connected to individual fuel injectors of a multi cylinder engine.

42. What is unit injection system?

It is an integrated direct fuel injection system for diesel engines, combining the injector nozzle and the injection pump in a single component

43. What is a rotary distributor?

The rotary distributor has a rotating element, which releases a high intensity spark to the individual spark plugs according to the engine firing order.

44. What is the function of a spark plug?

The spark plug is a device to produce electric spark to ignite the compressed air-fuel mixture inside the cylinder.

45. What is an Electronic ignition system?

The ignition system, in which the mechanical contact points are replaced by electronic triggering and switching devices, is known as electronic ignition system.

46. What are the functions of Turbo chargers?

- ✓ To produce more power from the same size engine
- ✓ T provide the altitude compensation
- ✓ To improve more complete combustion & hence less emissions

47. Why the engine emissions to be controlled?

Some of the engine emissions are carcinogenic. Moreover, the engine emissions led to greenhouse effect. For these reasons, the engine emissions need to be controlled.

48. What are the advantages of petrol injection?

- ✓ High power can be developed
- ✓ It has quick starting characteristics
- ✓ It has lowest specific fuel consumption
- ✓ Less engine emissions than carburetted engines

49. What is super charging?

The process of increasing the density of inducted charge/ air is known as supercharging.

It is performed for the following reasons.

- ✓ To produce more power from the same size engine
- ✓ To provide the altitude compensation
- ✓ To improve more complete combustion & hence less emissions

50. What is meant by carburetion in I.C engine?

The method of preparing the air-fuel mixture in an IC engine is known as carburetion. The device used for this purpose is known as carburettor.

51. What are the advantages of electronic fuel injection system over conventional injection?

- ✓ Cold starting is easier
- ✓ High fuel economy
- ✓ Less engine emissions
- ✓ Quick response to varying engine operating conditions

52. What are the functions of generator and starting motor?

The function of the generator is to produce electricity to charge the battery. The starting motor is used to crank the engine during the starting condition.

53. What is the function of an ignition system in I.C engine?

The function of an ignition system is to ignite the air-fuel mixture at the end of the compression stroke.

54. State the requirements of ignition system? And state its types

- ✓ It should consume minimum of power and produce high intensity spark across spark plug electrodes
- ✓ It should have a sufficient spark duration which is sufficient to establish burning of air-fuel mixture under all operating conditions
- ✓ It should provide sufficient ignition energy over the entire speed range of the engine
- ✓ Good performance at `high speed
- ✓ Longer life of contact breaker points and spark plug
- ✓ Adjustment of spark advance with speed and load

Types:

- ✓ Battery ignition
- ✓ Magnet ignition
- ✓ Electronic ignition

55. What is the ignition advance?

When the speed of the engine increases, the ignition timing also needs to be advanced for combustion. This process is known as ignition advance.

56. Mention three important functions of a piston?

A piston serves to:

- ✓ transmit forces of explosion to the crank shaft through a connecting rod,

- ✓ act as a guide for the upper end of the connecting rod, serves as a carrier for piston rings.

57. What is the sealed head lamp system?

A sealed headlamp system is a type of unitized lamp with a parabolic reflector, one or more filaments and a glass or polycarbonate lens all permanently attached together and sealed.

58. What is the function of carburettor?

The function of a carburettor is to prepare the pair-fuel mixture according to the engine operating conditions.

59. Which side of the piston is the major thrust side?

The side opposite to the crank throw is the thrust side as it is driven down on the power stroke.

60. List the different methods of battery charging.

- ✓ Constant current charging
- ✓ Constant voltage charging
- ✓ High rate charging
- ✓ Slow rate charging

61. State the principle of working of an A.C.Generator.

The basic principle of ac generator is electromagnetic induction when a coil of a conductor moves in a magnetic field the electrons in it starts moving because of attraction and repulsion of magnetic field. Thus an emf is induced in it.

62. In what respect does a Dynamo differ from an Alternator?

- ✓ Dynamo produces Direct Current (DC), while Alternator produced Alternating Current (AC) which can be converted to DC using rectifiers
- ✓ Alternator is lighter in construction than dynamo for the same output

63. What is the purpose of Stator in the Torque Converter?

The stator resides in the center of the torque converter. Its job is to redirect the fluid returning from the turbine before it hits the pump again. This dramatically increases the efficiency of the torque converter.

64. What are the components of lead acid battery?

- ✓ Lead terminals
- ✓ Electrolyte
- ✓ Internal plates (positive and negative plates)
- ✓ Resilient Plastic container

65. What are the different types of starter motor drives?

- ✓ Bendix drive
- ✓ Overrunning drive
- ✓ Outboard drive

66. What are the chemicals used in battery?

- ✓ PbO_2 – Positive plate
- ✓ Pb – Negative plate
- ✓ Electrolyte – Diluted Sulphuric acid

67. What is a dry charged battery?

The battery is built, charged, washed and dried, sealed, and shipped without electrolyte. It can be stored for up t18 months. When put into use, electrolyte and charging are required

68. What is the purpose of the grid?

The more "plates" in the grid, the more surface area exposed to the electrolyte, hence the more power produced.

69. How will you distinguish a positive plate from a negative plate in a lead acid battery?

The positive plates are coated with PbO_2 and chocolate brown in color. The negative plates are coated with spongy lead and grey in color.

70. What is the function a cut out in a charging system?

The cut out permits the current flow from dynamo/alternator to battery for charging while it does not permit the reverse flow of current.

71. What is the function of regulators in a charging system?

- ✓ Current regulator – regulates the alternator/dynamo current for charging the battery (constant current charging mode)
- ✓ Voltage regulator – regulates the alternator/dynamo voltage for charging the battery (constant voltage charging mode)

72. What is the function of clutch?

The function of the clutch is connect and disconnect the engine with road wheels. The clutch has the disengaged during gear shifting, idling etc.

73. What are the types of clutch?

- ✓ Friction clutches
- ✓ Single plate clutch
- ✓ Multi plate clutch
- ✓ Cone clutch
- ✓ Semi centrifugal clutch
- ✓ Centrifugal clutch
- ✓ Fluid clutches
- ✓ Fluid flywheel

74. State the requirements of an automotive clutch

a) Torque transmission should be maximum
b) Gradual engagement of clutch plates
c) Heat dissipation should be more
d) Dynamic balancing of clutch components
e) Vibration damping
f) Size should be small
g) Inertia should be low
h) Clutch free pedal play should be sufficient
i) Ease of operation

75. What is the function of gear box? State its types.

The functions of the gearbox are:

- ✓ To provide the leverage ratio
- ✓ To provide the neutral position
- ✓ To provide a means reverse the vehicle.

Types

- ✓ Sliding mesh gearbox
- ✓ Constant mesh gearbox
- ✓ Synchromesh gearbox
- ✓ Automatic gearbox – Torque converter

76. Why is gear box necessary in automobile?

- ✓ The variation of resistance vehicle motion at different speeds
- ✓ The variation of tractive effort of the vehicle required at various speeds
- ✓ For above said reasons, a gearbox is necessary in an automobile

77. What is tractive effort?

It is the force available at the road wheels for propelling the vehicle.

$$T = \mu W$$

Where, T- Tractive effort
μ- Coefficient of friction between tyre and road surface
W- Load of the vehicle

78. Why is sliding mesh gear box not preferred?

- ✓ More noise
- ✓ More wear and tear on the gears
- ✓ For smooth, quiet and quick change of gears, the driver requires great skill

- ✓ For the above-said drawbacks, the sliding mesh gearbox is generally not preferred

79. What is automatic transmission?

In the automatic transmission, for changing the gear ratios, manual effort is not at all needed. The change of gear is performed automatically according tthe vehicle speed.

80. What is an over drive?

When the speed of the output shaft is greater than the speed of the input shaft, then the drive is known as overdrive.

Example: 0.8:1 or 0.9: 1

81. What is a universal joint? What are its types?

Universal joint is a type of flexible joint between two shafts whose axes intersect and may assume different inclinations at different times. It is used transmit power even at inclined angles of the shaft.

Types

Yoke joint
Single cardan joint
Double cardan joint
Rag joint
Canfield joint

82. State the functions of a slip joint.

The function of a slip joint is to accommodate the propeller shaft length variations, when a vehicle is moving over a bump or bit.

83. What is the necessity of a propeller shaft?

The propeller shaft is used to transmit the power from the gearbox to the final drive. It is also used to cover the span between these two components.

84. What is Hotchkiss drive and Torque Tube drive?

In Hotchkiss drive, the loads such as vehicle weight, driving torque, braking torque and side thrust all are taken by leaf springs. Two universal joints and one slip joint are must needed.

In Torque tube drive, the driving torque and braking torque are taken by torque tube while the vehicle weight and side thrust are taken care of by leaf springs. One universal joint is just sufficient.

85. What is the function of differential unit?

The function of a differential unit is to permit the vehicle turns without wheel skidding. It permits higher speed for outer wheels and reduced speed for inner wheels during turning.

86. What is the function of pressure plate in a clutch?

The function of a pressure plate is to hold the friction (clutch) plate tightly against the engine flywheel.

87. What is meant by differential lock?

A Differential lock will transmit the same amount of power to both wheels on the axle - which is very useful in 4WD applications where a truck might be stuck and have problems getting out of deep mud or snow.

88. What is a fluid coupling?

Fluid coupling is device which transmits torque due the kinetic energy of the moving fluid. In a fluid coupling, two members namely impeller and turbine are present.

89. What is the use of torque convertor?

The torque converter is device which provides a varying torque rationing fluid energy. In a torque converter, three members namely impeller, turbine and stator are present.

90. State the forces act on the rear axle

- ✓ Shear force due to vehicle weight
- ✓ Bending moment due to vehicle weight
- ✓ Driving torque
- ✓ Shear force due to side thrust

- ✓ Bending moment due to side thrust

91. What are the different types of rear axles?

- ✓ Semi floating rear axle
- ✓ Full floating rear axle
- ✓ Three quarter floating rear axle

92. What is the purpose of Stator in the Torque Converter?

The stator changes fluid flow between the turbine and pump and thus permits the torque multiplication. Without a stator, a torque converter will simply act as a fluid coupling.

93. Why Synchronizer is required in the automotive transmission system?

Synchronizer is used to equalize the speed of two mating surfaces, before the contact is established. By doing so, wear & tear and noise can be avoided.

94. What is transfer box? Where it is used?

The transfer box is used to convert 2 wheel drive int4 wheel drive. This is mainly used in hilly regions.

95. Define wheel track and wheel base.

- ✓ The distance between the tyre centers, mounted on the same axle is known as wheel track.
- ✓ The wheelbase is the distance between the centers of the front and rear wheels

96. Give a brief note on damper.

It is used to dampen the vibrations of the suspension springs. It is mostly used in independent suspension.

97. Distinguish between disc brake with drum brake.

Drum Brakes	*Disc Brakes*
• Relatively cheaper	Costlier
• More weight	Lighter than drum brakes
• Non uniform pressure distribution	Uniform pressure distribution

98. What is meant by bleeding of brakes?

The process of removing air from the hydraulic brakes is known as bleeding of brakes.

99. Define steering gear.

The steering gear is used to convert the rotational movement of the steering wheel into linear movement of the steering linkage. Moreover it provides mechanical advantage.

100. What are the different types of wheels?

- ✓ Pressed steel disc wheels
- ✓ Wire spoke wheels
- ✓ Light alloy casted wheels

101. What is the purpose of Toe-in and Toe-out?

The purpose of providing a toe in and toe out is straight line stability of the vehicle, after negotiating a turn.

102. What are the different types of tyres used in automobile?

- ✓ Cross ply tyres
- ✓ Radial ply tyres
- ✓ Belted bias tyres

103. What are the different types of springs used in suspension system?

- ✓ Leaf springs (Rigid axle suspension)
- ✓ Coil springs (Independent suspension)
- ✓ Torsion bar (Independent suspension)

104. Define king pin inclination.

The tilt of the king pin from the vertical reference line is known as King Pin Inclination (KPI). It is also called as Steering Axis Inclination (SAI)

105. Give the function of tyre?

- ✓ Supporting Vehicle Weight
- ✓ Transferring Traction & Braking forces to the Road Surface
- ✓ Changing & Maintenance Direction of Travel
- ✓ Absorbing Road shocks

106. Define castor and camber.

- ✓ Castor: The tilt of the king pin from the vertical reference line when viewed from side is known as castor.
- ✓ Camber: The camber angle is the inward or outward tilt of the wheel relative to the vertical reference

107. What are the benefits of anti-lock brake system?

- ✓ Preventing the wheel from locking at the time of braking
- ✓ Keeping the wheel rotating
- ✓ Due to rotating wheel, it helps you to steer away the vehicle from the object, while applying brakes at the same time.
- ✓ It is even more effective in sand, snow, water, and mud where loss of traction is even higher, as on these surfaces, with normal braking system, it is even easier to lock wheels and loose traction but ABS works excellent in these conditions also and stops the vehicle in a much shorter distance.

108. What is steering ratio?

The steering ratios defined as the ratio of angle turned on the steering wheel to the angle turned by the stub axle.

109. What is toe in and toe out?

- ✓ The distance between the front ends of wheels is less than the rear end, the condition is said to be toe-in.
- ✓ The distance between the front ends of wheels is more than the rear end, the condition is said to be toe-out.

110. What are the types of steering gear box?

a) Worm & Worm wheel steering gear
b) Worm and Nut steering gear
c) Worm and Roller steering gear
d) Recirculating Ball steering gear
e) Rack and Pinion steering gear

111. What are main advantages of power steering?

- ✓ The manual effort required to turn the vehicle is getting reduced.
- ✓ This layout also gives road feel to the driver.

112. What is function of suspension system in automobile?

The function of the suspension system is to isolate the vehicle and its occupants from road shocks and vibrations generated by the road surface, while maintaining steering control and stability at all times.

113. What is the function of brake? State its type.

The function of brake is to stop the vehicle within a short distance.

Types:

1. Mechanical brakes
   - Drum brakes
   - Disc brakes
2. Hydraulic brakes
3. Power brakes

Air brakes	Vacuum brakes
Air-hydraulic brakes	Electric brakes

114. What are the functions of front axles?

- ✓ It carries the weight of the front of the vehicle
- ✓ It carries the horizontal and vertical loads on bumpy roads
- ✓ It works as a cushion through its spring for a comfortable side
- ✓ In a four wheel drive, it also transmits power to the road wheels
- ✓ When brakes are provided at the front wheels, it withstands bending stresses and torsional stresses

115. What I section at middle and oval section at end is preferred for front axle?

'I' section is suitable for bending loads and 'circular' or 'oval' section is suitable for torsional loads. Hence I section at middle and circular or oval section at ends is provided in the front axle.

116. What are the different types of stub axles? Which is the most preferred one?

- ✓ Elliot
- ✓ Reversed Elliot
- ✓ Lamoine
- ✓ Reversed Lamoine

Out of these four types, Reversed Elliot is the most preferred type.

117. What is meant by the term "tread"?

The tread of a tire refers to the patterns on its rubber circumference that makes contact with the road.

118. Define detonation and pre-ignition.

- ✓ The abnormal combustion occurring in IC engines is called as detonation. This results in sudden rate of pressure rise, abnormal heat release, heavy vibrations of the engine and loud noise operation.
- ✓ The ignition of the air-fuel mixture before the introduction of the spark in the combustion chamber is called as pre-ignition.

119. What is a self-energizing brake?

A brake is called self-energizing if it uses the rotational force of the wheel to help stop the automobile.

120. What is disc brake?

These brakes are different from drum brakes in that the drum is replaced by a circular plate and the brake shoes are replaced by a calliper which supports a pair of friction pads, one on each side of the disc. These pads are forced inward by the operating force and so retard the disc.

121. What is meant by electric brake?

In an electric brake, the current from the battery is utilized to energize an electromagnet within the brake drum. This actuates a cam to expand the brake shoes. When the current is not supplied, the cam and brake shoes are returned to the release position by retractor springs.

122. What is regenerative braking?

A regenerative brake is an energy recovery mechanism, which slows a vehicle by converting its kinetic energy into another form, which can be either used immediately or stored until needed. This contrasts with conventional braking systems, where the excess kinetic energy is converted to heat by friction in the brake linings and therefore wasted.

125. What is a fuel cell?

A fuel cell is an electrochemical device that converts a source fuel into an electrical current and water. It generates electricity inside a cell through reactions between a fuel and an oxidant, triggered in the presence of an electrolyte.

126. Write the composition of LPG and CNG.

- ✓ Composition of CNG
  CH4 = 70.9%, C2H6 = 5.10%, H2 = 3%, C+ CO2 = 22%
- ✓ Composition of LPG:
  Propane= 30 % and Butane = 70 %

127. Define detonation and pre-ignition.

- ✓ The abnormal combustion occurring in IC engines is called as detonation. This results in sudden rate of pressure rise, abnormal heat release, heavy vibrations of the engine and loud noise operation.
- ✓ The ignition of the air-fuel mixture before the introduction of the spark in the combustion chamber is called as pre-ignition.

B.Tech. DEGREE EXAMINATION, NOVEMBER 2011

Mechanical Engineering

Elective — AUTOMOBILE ENGINEERING

Time: Three hours **Maximum: 75 marks**

PART A

Answer ALL questions. **(10 x 2 = 20 marks)**

1. Mention any four engine components along with materials.
2. Differentiate diesel and petrol engine.
3. Explain the importance of cut outs.
4. List the types of clutches.
5. What are the functions of suspension system?
6. What is Ackermann steering principle?
7. What is the need of antilock braking system?
8. Distinguish between single and multi-plate clutch.
9. Write a note on battery rating.
10. List the types of ignition coil.

PART B

Answer ONE question from each Unit. **(5 x 11 = 55 mark)**

UNIT I

11. Explain with neat sketch the working principle of four stroke engine.

Or

12. Explain the working of pressure lubrication system.

UNIT II

13. Explain with suitable sketches the operational features of sliding mesh gear box.

Or

14. Discuss the following with simple sketches:
    (a) Torque tube drive. (5)
    (b) Differential working. (6)

UNIT III

15. Discuss the working of telescopic suspension System used in cars.

Or

16. What is meant by steering geometry and explain any one type of steering gear box.

UNIT IV

17. What is the working principle of antilock braking system explain with neat sketch.

Or

18. Explain any two types of chassis with neat sketch.

UNIT V

19. Explain the working features of a starter motor with a neat diagram.

Or

20. Sketch and explain electronic type ignition system.

B.Tech. DEGREE EXAMINATION APRIL/MAY 2014.

Mechanical Engineering

Elective — AUTOMOBILE ENGINEERING

Time: Three hours **Maximum: 75 marks**

PART A

Answer ALL questions. **(10 x 2 = 20 marks)**

1. Define compression ratio.
2. What do you mean by scavenging of two stroke engines?
3. What are the requirements of a good clutch?
4. Mention the purpose of a differential.
5. Mention the purpose of torsion rod?
6. Define the term "toe-in" related to wheel alignment?
7. Mention the advantages of hydraulic brakes.
8. What are the functions of chassis frame?
9. List out the various tests to be carried out to chock the condition of a battery.
10. What is the purpose of ignition coil used in battery ignition system?

PART B

Answer ONE question from each Unit. **(5 x 11 = 55 marks)**

UNIT I

11. (a) Classify automobile vehicles based on various aspects
    (b) Compare CI engines with SI engines.

Or

12. Explain the working of a 4 stroke compression ignition engine with neat sketches.

UNIT II

13. Explain the constructional details and working of' a single plate clutch with a suitable line sketch.

Or

14. Explain the constructional details and working of a torque converter with a suitable sketch.

UNIT III

I5. Briefly explain any three types of suspension system used in automobile vehicles. Also mention their relative merits and demerits.

Or

16. With a neat sketch explain the following:
    (a) Davis steering mechanism. (5)
    (b) Ackermann steering mechanism. (6)

UNIT IV

17. (a) What are the requirements of brake fluid? (3)
    (b) With a neat sketch explain the constructional details and working of a drum Wake (8)

Or

18. Sketch a typical chassis of an automobile and mention the cross-section used as well as functions of various members.

UNIT V

19. Explain the constructional details and functions of various parts of a lead acid battery with suitable sketch.

Or

20. Write the short note on the following:

(a) Starter motor
(b) Distributor used in ignition system
(c) Alternator
(d) Rectifier

B.Tech. DEGREE EXAMINATION, NOVEMBER 2014

Mechanical Engineering

AUTOMOBILE ENGINEERING

Time: Three hours **Maximum: 75 marks**

PART A

Answer all the questions. **(10 x 2 = 20 marks)**

1. State the basis on which automobiles are classified.
2. Write any one difference between diesel engine and petrol engine.
3. What is the function of the transmission system?
4. What is a "Differential"?
5. What is bouncing in the suspension system?
6. What is meant by wheel base?
7. What is the function of a braking system?
8. What do you mean by a chassis?
9. What is a cell and Battery?
10. How are the ignition systems classified?

PART B

All questions carry equal marks. **(5 x 11 = 55 marks)**

UNIT I

11. List out various parts of a typical petrol engine. Explain briefly the construction of an S.I. engine.

Or

12. Explain the difference between two stroke and four stroke engines.

UNIT II

13. Explain briefly the principle and working of a differential with neat sketch.

Or

14. List out the various types of clutches, describe the working of cone clutch with a neat sketch

UNIT III

15. Explain the construction and operation of a shock absorber with a neat sketch.

Or

16. Explain briefly about the double wishbone suspension system with a neat sketch.

UNIT IV

17. With a neat sketch, explain the construction and operation of a hydraulic braking system.

Or

18. With a neat sketch, explain the construction and operation of a drum type braking systems.

UNIT V

19. Sketch an ignition coil and mention the parts. Explain the operation of battery coil ignition system with a circuit diagram.

Or

20. Explain the construction and working principle of D.C generator with neat sketch.

B.Tech, DEGREE EXAMINATION, APRIL/MAY 2015.

Mechanical Engineering

AUTOMOBILE ENGINEERING (2009 - 2012 Batches)

Time: Three hours **Maximum: 75 marks**

PART A

Answer ALL questions **(10 x 2 = 20 marks)**

1. What is an automobile?
2. What are the functions of compression rings in the piston?
3. What is the purpose of installing coil springs in a clutch plate?
4. What are the functions of front axle?
5. What is rolling in the suspension system?
6. How is the aspect ratio of a tyre defined?
7. How does the hydraulic brake function?
8. What are the functions of a frame?
9. What is the function of a starting motor?
10. Give a list of main lights in a modern vehicle.

PART B

Answer ONE question from each Unit. **(5 x 11 = 55 marks)**

UNIT I

11. List out various parts of a diesel engine. Explain the construction of an diesel engine.

Or

12. List out the difference between the diesel engine and petrol engine.

UNIT II

13. Explain the construction and operation of a single plate clutch with a neat diagram.

Or

14. Explain the working principle of Sliding mesh type gear box.

UNIT III

15. Explain the air suspension system with a neat sketch.

Or

16. Write short notes on: (3+4+4)
    (a)Cross ply tyre
    (b)Tubeless tyre
    (c)Radial Tyre.

UNIT IV

17. Explain in detail, construction and working of a disk brake system.

Or

18. Explain the construction of various frames used in automobiles with a neat sketch.

UNIT V

19. Explain the construction, operation of lead acid & battery.

Or

20. Explain the operation of a magneto coil ignition systems with a neat sketch.

5416092

B.Tech, DEGREE EXAMINATION, APRIL 2016

Mechanical Engineering

AUTOMOBILE ENGINEERING (2013 -14 Batches)

Time: Three hours **Maximum: 75 marks**

PART A

Answer ALL questions **(10 x 2 = 20 marks)**

1. What is the purpose of slip joint in the drive lines?
2. Why is crank case ventilation used in an automobile engineering?
3. State the functions of clutch in automobile.
4. Why are helical gears preferred in transmission systems?
5. What is steering geometry?
6. What is the use of stub axle?
7. What is the function of braking system? 1
8. What is meant by Weight transfer?
9. What are all the components of battery?
10. What are the causes of engine back fire?

PART B

Answer ONE question from each Unit. **(5 x 11 = 55 marks)**

UNIT I

11. Explain briefly following two types of construction of propeller shafts..
    (a) Torque tube type,
    (b) Hotchkiss drive type.

Or

12. Explain briefly the following phenomenon
    (a) pre-ignition,
    (b) auto-ignition and
    (c) detonation.

UNIT II

13. How is transmission systems categorized? Explain briefly.

Or

14. What is a fluid flywheel? How does it work?

UNIT III

15. Describe briefly the following three basic suspension movements in-a car

(a) Bouncing,

(b) Rolling and

(c) Pitching.

Or

16. What is the steering gear mechanism? Explain in detail with neat sketch.

UNIT IV

17. What is master cylinder? Give the principle of operations with suitable diagrams.

Or

18. Explain briefly the following brake tester

(a) Static brake tester and

(b) Dynamic brake tester.

UNIT V

19. What are the various components of 12 volt lead-acid battery? Indicate the chemical reactions taking place during charging and discharging.

Or

20. Using suitable diagram explain the construction and working of the following accessories in an automobile:

(a) Wind screen wiper,

(b) Horn and

(c) Speedometer.

5416092

B.Tech, DEGREE EXAMINATION, NOVEMBER 2016

Mechanical Engineering

AUTOMOBILE ENGINEERING (2013 -14 Batches)

Time: Three hours **Maximum: 75 marks**

PART A

Answer ALL questions **(10 x 2 = 20 marks)**

1. Define the term drive.
2. List out the factors affecting the resistance of automobiles;
3. What are the requirements of a clutch?
4. What are the forces acting on the rear axle?
5. What are the different types of springs used in suspension system?
6. State the advantages of radial tyres.
7. What is meant by bleeding of brakes?
8. What is chassis?
9. What are the chemicals, used in battery?
10. What are the different types of starter motor drives used in the automobiles?

PART B

Answer ONE question from each Unit. **(5 x 11 = 55 marks)**

UNIT I

11. How to classify the vehicles? Explain briefly.

Or

12. Discuss the merits and demerits of two stroke, and four strokes petrol engines.

UNIT II

13. What is a gear box? Explain the working principle of synchromesh gear box with neat sketch.

Or

14. Write short notes on:

    (a) Fluid flywheel

    (b) Differential.

UNIT III

15. What are the requirements of good suspension system? Explain briefly about the various suspension systems

Or

16. List down the various components of a steering system. Explain any ofie type of steering gear box with neat sketch.

UNIT IV

17. What is brake? Explain the construction and operation hydraulic braking system with a neat sketch.

Or

18. Explain briefly about the various types of chassis and state their merits and demerits.

UNIT V

19. What are the functions of an ignition system in the automobile? Explain the function of the main components in the magneto oil ignition system.

Or

20. Write short notes on:

(a) Battery life

(b) Firing order

(c) Automotive lighting