KARPAGAM ACADEMY OF HIGHER EDUCATION
COIMBATORE – 21
FACULTY OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING

AUTOMOBILE ENGINEERING

15BEAEOE01 AUTOMOBILEENGINEERING 3 0 0 3100

OBJECTIVE

1. This course enables the students to know about all the main and auxillary systems of automobile with its base construction andworking

UNITI ENGINE AND FUELFEEDSYSTEMS 9

Classification of Engine , construction and working of four stroke petrol and diesel engine, firing order and its significance. Carburettor working principle, requirements of an automotive carburettor, Petrol injection Systems (MPFI, TBI), Diesel fuel injection systems (CRDI)

UNITII TRANSMISSIONSYSTEMS 9

Requirements of transmission system.Flywheel. Different types of clutches, principle, Construction, torque capacity and design aspects. Objective of the gearbox - Determination of gear ratios for vehicles. Performance characteristics at different speeds. Different types of gearboxes - operation. Function of Propellar Shaft Construction details of multi drive axle vehicles. Different types of final drive. Differential principles. Constructional details of differential unit. Non-slip differential. Differential lock

UNITIII SUSPENSIONSYSTEM 9

Need of suspension system - Types of suspension - Suspension springs - Constructional details and characteristics of leaf, coil and torsion bar springs - Independent suspension - Rubber suspension – Pneumatic suspension – Hydro Elastic suspension - Shock absorbers. Vibration and driving comfort.

UNITIV BRAKES 9

Necessity of brake, stopping distance and time, brake efficiency, weight transfer, shoe brake and disc brake theoryBrake actuating systems - Mechanical, Hydraulic and Pneumatic. Parking and engine exhaust brakes. Power and power assisted brakes. Antilock Braking System (ABS).

UNITV ELECTRICALSYSTEM 9

Principle and construction of lead acid battery.Lighting system: details of head light and side light, LED lighting system, head light dazzling and preventive methods – Horn, wiper system and trafficator.Starting System and charging system.

TOTAL 45PERIODS

TEXTBOOK

S. No.	Author(s) Name	Title of the book	Publisher	Year of Publication
1	Young U.P and Griffiths L	Automotive Electrical Equipment	ELBS & New Press	1999
2	Ganesan.V	Internal Combustion Engines	Tata McGraw-Hill Publishing Co., New Delhi	2003
3	Dr.Kirpal Singh	Automobile Engineering	Standard Publishes	2011

REFERENCES

S. No.	Author(s) Name	Title of the book	Publisher	Year of Publication

1	Heldt .P.M	The Automotive Chassis	Literary Licensing,LLC	2012
2	Crouse.W.H	Automobile Electrical Equipment	McGraw-Hill Book Co., Inc., New York.	1986
3	N.Newton, W. Steeds and T.K.Garrett	The Motor vehicle, 13th edition	SAE Inc	2001

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LECTURE PLAN

Subject Name : **Automobile Engineering**
Subject Code : **15BEAEOE01**
Name of the Faculty : **Mr. P. Arun Kumar**
Designation : **Assistant Professor**
Year/Semester/Section : **III / VI / A&B**
Branch : **B.E - Mechanical Engineering**

SL. NO.	LECTURE DURATION	TOPICS TO BE COVERED	SUPPORT MATERIALS
		UNIT-I ENGINE AND FUELFEEDSYSTEMS	
1.	1	Introduction about Automobile Engineering	**T[3]**
2.	1	Classification of Engine	**T[3]**
3.	1	construction and working of four stroke petrol and diesel engine,	**T[3]**
4.	1	Firing order and its significance.	**T[3]**
5.	1	Carburetor working principle,	**T[3]**
6.	1	Requirements of an automotive carburettor,	**T[3]**
7.	1	Petrol injection Systems (MPFI)	**T[3]**
8.	1	Petrol injection Systems (TBI),	**T[3]**
9.	1	Diesel fuel injection systems	**T[3]**
10.	1	Diesel fuel injection systems (CRDI)	**T[3]**
11.	1	Discussion about online injection pump	**T[3]**
Total no. of Hours planned for unit – I			**11**
SL. NO.	**LECTURE DURATION**	**TOPICS TO BE COVERED**	**SUPPORT MATERIALS**
		UNIT – II TRANSMISSIONSYSTEMS	
12.	1	Requirements of transmission system.Flywheel.	**T[3]**
13.	1	Different types of clutches, principle,	**T[3**
14.	1	Construction, torque capacity and design aspects.	**T[3]**
15.	1	Objective of the gearbox - Determination of gear ratios for vehicles.	**T[3]**
16.	1	Performance characteristics at different speeds.	**T[3]**
17.	1	Different types of gearboxes - operation.	**T[3]**
18.	1	Function of Propellar Shaft Construction details of multi drive axle vehicles.	**T[3]**

19.	1	Different types of final drive.	**T[3]**
20.	1	Differential principles. Constructional details of differential unit. Non-slip differential.	**T[3]**
21.	1	Differential lock.	**T[3]**
Total no. of Hours planned for unit – II			**10**
SL. NO.	**LECTURE DURATION (Hr)**	**TOPICS TO BE COVERED**	**SUPPORT MATERIALS**
UNIT-III SUSPENSIONSYSTEM			
22.	1	Need of suspension system	**T[3]**
23.	1	Types of suspension	**T[3]**
24.	1	Suspension springs	**T[3]**
25.	1	Constructional details and characteristics of leaf	**T[3]**
26.	1	Coil and torsion bar springs	**T[3]**
27.	1	Independent suspension	**T[3]**
28.	1	Rubber suspension	**T[3]**
29.	1	Pneumatic suspension	**T[3]**
30.	1	Hydro Elastic suspension	**T[3]**
31.	1	Shock absorbers. Vibration and driving comfort.	**T[3]**
Total no. of Hours planned for unit – III			**10**
SL. NO.	**LECTURE DURATION (Hr)**	**TOPICS TO BE COVERED**	**SUPPORT MATERIALS**
UNIT-IV BRAKES			
32.	1	Necessity of brake,	**T[3]**
33.	1	stopping distance and time,	**T[3]**
34.	1	brake efficiency, weight transfer,	**T[3]**
35.	1	shoe brake and disc brake theory	**T[3]**
36.	1	Brake actuating systems - Mechanical,	**T[3]**
37.	1	Hydraulic and Pneumatic.	**T[3]**
38.	1	Parking and engine exhaust brakes.	**T[3]**
39.	1	Power and power assisted brakes.	**T[3]**
40.	1	Antilock Braking System (ABS).	**T[3]**
41.	1	Antilock Braking System (ABS).	**T[3]**
Total no. of Hours planned for unit – IV			**10**
SL. NO.	**LECTURE DURATION (Hr)**	**TOPICS TO BE COVERED**	**SUPPORT MATERIALS**
UNIT-V ELECTRICAL SYSTEM			
42.	1	Principle and construction of lead acid battery.	**T[3]**
43.	1	Lighting system: details of head light and side light,	**T[3]**
44.	1	LED lighting system,	**T[3]**
45.	1	Head light dazzling and	**T[3]**
46.	1	Preventive methods – Horn	**T[3]**

47.	1	wiper system and	**T[3]**
48.	1	Trafficator	**T[3]**
49.	1	Starting System a	**T[3]**
50.	1	Charging system.	**T[3]**
51.	1	Charging system.	**T[3]**
52.	1	Discussion on previous year Questions	**T[3]**
Total no. of Hours planned for unit – V			**11**

TEXT BOOKS

S. No.	Author(s) Name	Title of the book	Publisher	Year of Publication
1	Young U.P and Griffiths L	Automotive Electrical Equipment	ELBS & New Press	1999
2	Ganesan.V	Internal Combustion Engines	Tata McGraw-Hill Publishing Co., New Delhi	2003
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UNIT	Total No. of Periods Planned	Lecture Periods
I	**11**	**11**
II	**10**	**10**
III	**10**	**10**
IV	**10**	**10**
V	**11**	**11**
TOTAL	**52**	**52**

I. CONTINUOUS INTERNAL ASSESSMENT : 40 Marks

(Internal Assessment Tests: 30, Attendance: 5, Seminar: 5)

II. END SEMESTER EXAMINATION : 60 Marks

TOTAL : 100 Marks

FACULTY **HOD / MECH** **DEAN / FOE**

UNIT- I
ENGINE AND FUELFEEDSYSTEMS

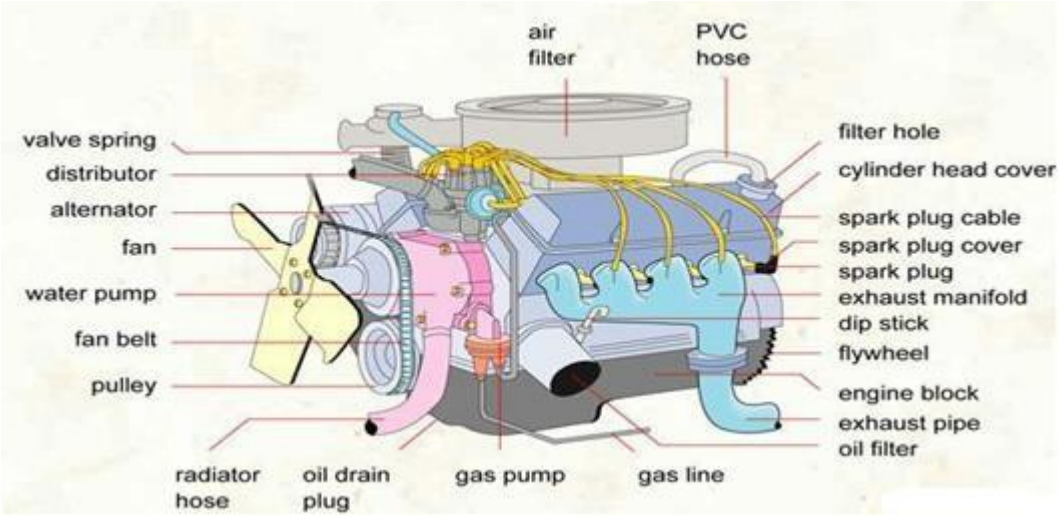
INTRODUCTION

Automobile is a vehicle driven by an internal combustion engine and it is used for transportation of passengers and goods on the ground. Automobile can also be defined as a vehicle which can move by itself.
Examples : Car, jeep, bus, truck, scooter, etc..,

AUTOMOTIVE COMPONENTS

- The Engine or Power Plant: It is source of power
- The Frame and Chassis: It supports the engine, wheels, body, braking system, steering, etc.
- The transmission which transmits power from the engine to the car wheels. It consists of clutch, transmission, shaft, axles and differential.
- The body
- Electrical components & Accessories: starting motor, lights, battery, alternator etc..,

ENGINE



The engine is the power plant of the vehicle. In general, internal combustion engine with petrol or diesel fuel is used to run a vehicle. An engine may be either a two-stroke engine or a four-stroke engine.

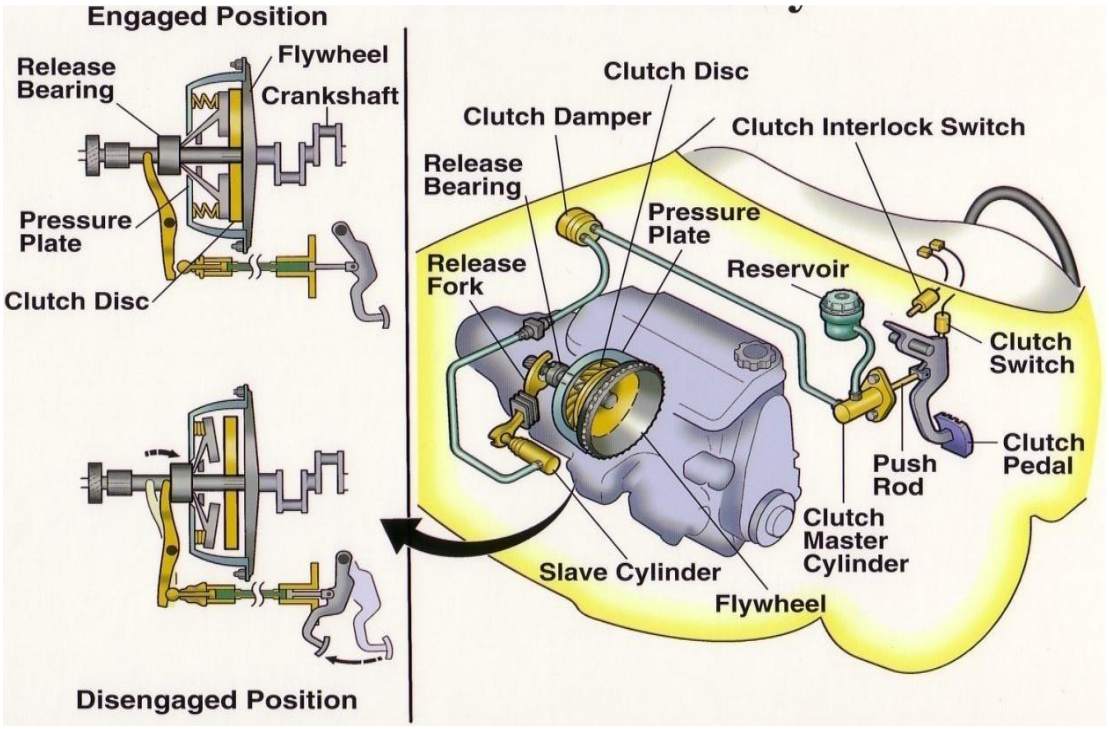
An engine consists of a cylinder, piston, valves, valve operating mechanism, carburetor (or MPFI in modern cars), fan, fuel feed pump and oil pump, etc. Besides this, an engine requires ignition system for burning fuel in the engine cylinder.

TRANSMISSION SYSTEM (CLUTCH AND GEAR BOX)

The power developed by the engine is transferred to the wheels by transmission system.

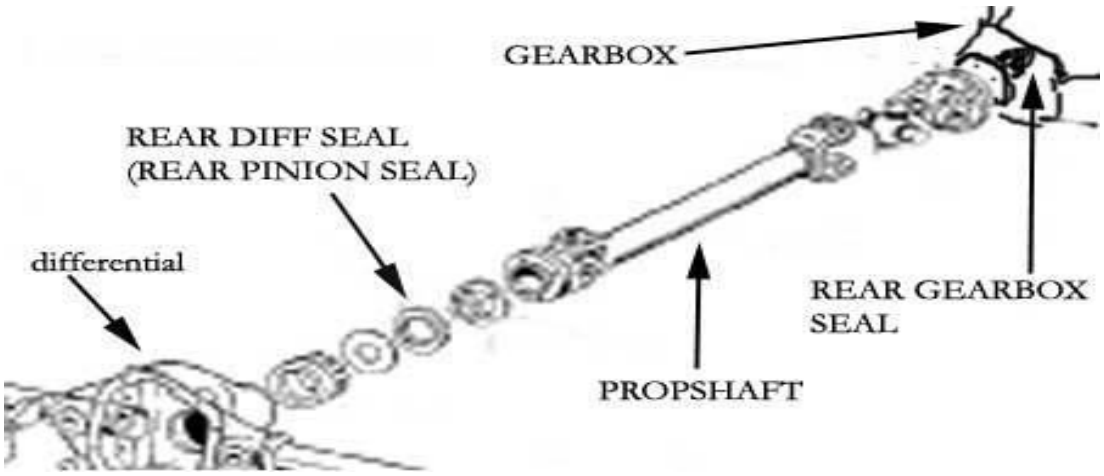
- It must provide varying gear ratios. Number of gear ratios is equal to number of gears in a vehicle.
- It must provide a reverse gear for moving vehicle in reverse direction.
- It must provide a neutral or disconnecting arrangement so that the engine can be uncoupled from the wheels of the vehicle. In a conventional transmission system, there is a clutch, a manually operated transmission (gear box), a propeller shaft and a differential or final drive.

CLUTCH



The purpose of the clutch is to allow the driver to couple or decouple the engine and transmission. When clutch is in engaged position, the engine power flows to the transmission through it (clutch). When gears are to be changed while vehicle is running, the clutch permits temporary decoupling of engine and wheels so that gears can be shifted. In a scooter, the clutch is operated by hand where as in a car the clutch is operated by foot. It is necessary to interrupt the flow of power before gears are changed. Without a clutch, it will by very difficult.

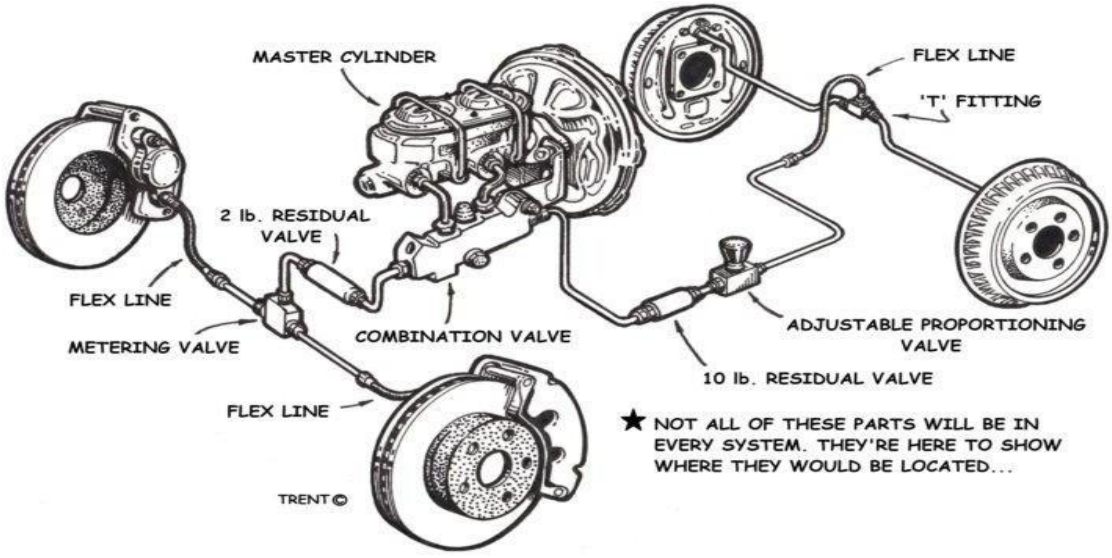
FINAL DRIVE



Final drive is the last stage in transferring power from engine to wheels. It reduces the speed of the propeller shaft (drive shaft) to that of wheels. It also turns the drive of the propeller shaft by an angle of 90o to drive the wheels.

The propeller shaft has a small bevel pinion which meshes with crown wheel. The crown wheel gives rotary motion to rear axles. The size of crown wheel in bigger than that of bevel pinion, therefore, the speed of rear axles (or crown wheel) in lower than the speed of pinion. Final drive is of two types, i.e. chain type and gear type.

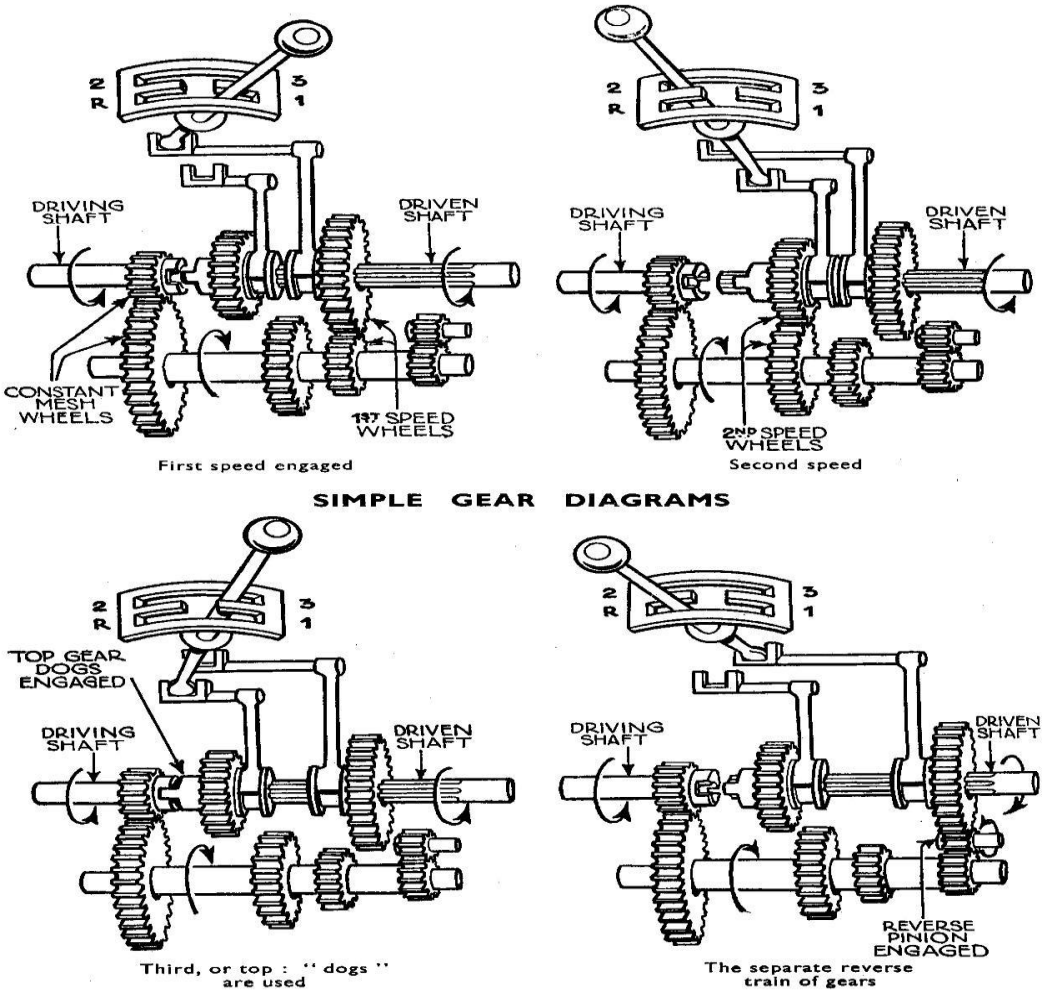
BRAKING SYSTEM



Brakes are used to slow down or stop the vehicle. Hydraulic brakes are generally used in automobiles, where brakes are applied by pressure on a fluid. Mechanical brakes are also used in

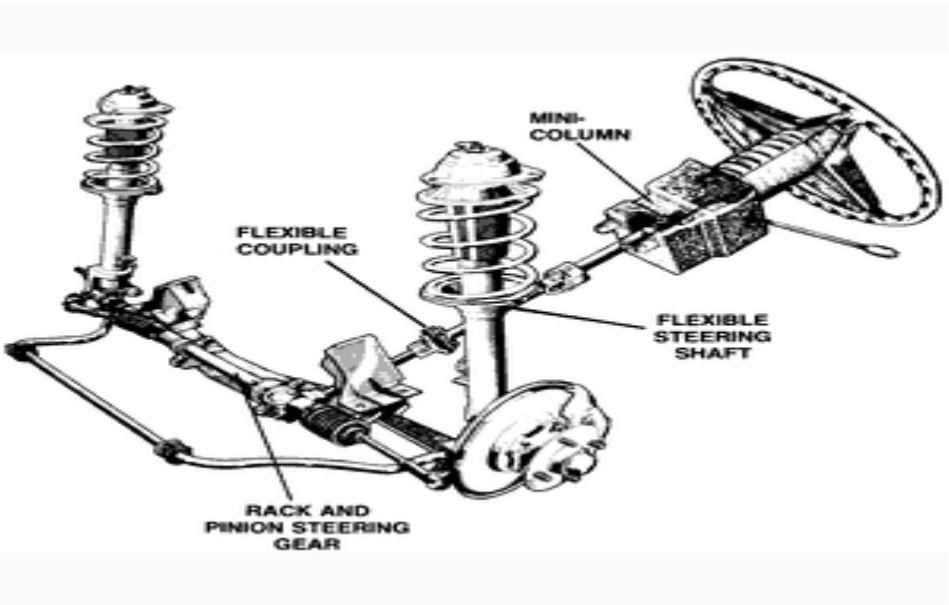
some vehicles. These brakes are operated by means of leavers, linkages, pedals, cams, etc. Hand brake or parking brake is usually a mechanical brake. These are used for parking the vehicles on sloppy surfaces and also in case of emergency.

GEAR BOX



Gear box contain gearing arrangement to get different speeds. Gears are used to get more than one speed ratios. When both mating gears have same number of teeth, both will rotate at same number speed. But when one gear has fewer teeth than other, the gear with less number of teeth will rotate faster than larger gear. In a typical car, there may be six gears including one reverse gear. First gear gives low speed but high torque. Higher gears give progressively increasing speeds. Gears are engaged and disengaged by a shift lever.

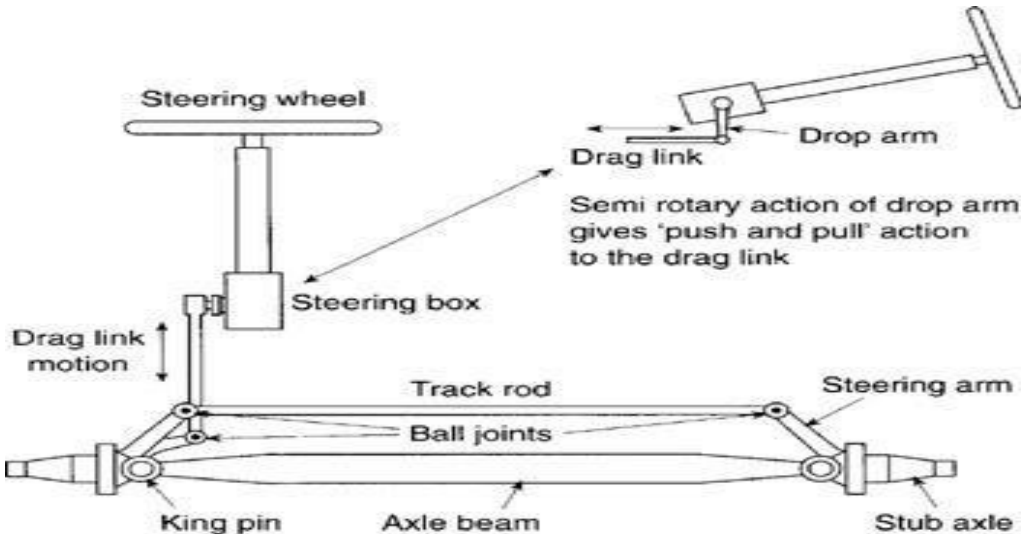
STEERING SYSTEM



In front wheels can be turned to left and right by steering system so that the vehicle can be steered. The steering wheel is placed in front of driver. It is mechanically linked to the wheels to provide the steering control. The primary function of the steering system is to provide angular motion to front wheels so that vehicle can negotiate a turn. It also provides directional stability to vehicle when the vehicle moves ahead in straight line.

Now-a-days, many vehicles are equipped with power steering which uses pressure of a fluid to reduce steering effort. When driver turns the steering wheel, a hydraulic mechanism comes into play to provide most of the effort needed to turn the wheel.

FRONT AXLE

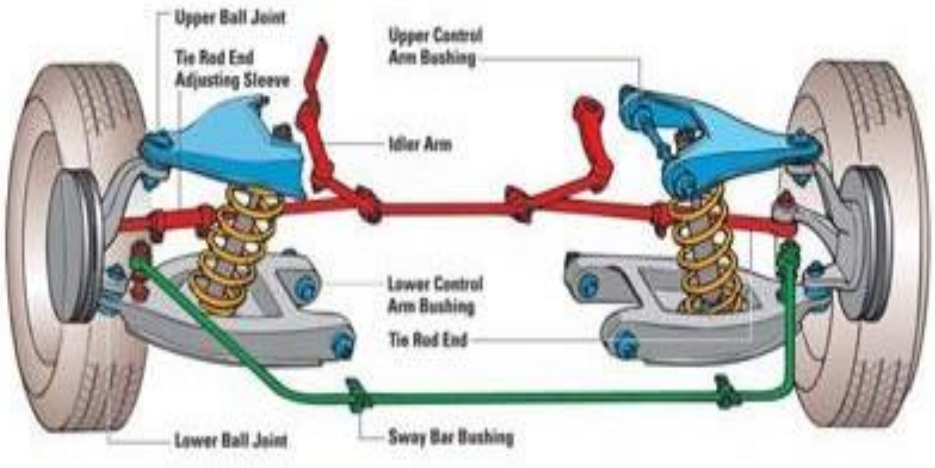


Front axles are mounted at the end of front axle. A part of the weight of vehicle is transmitted to the wheels through this axle. The front axle performs several functions.

It carries the weight of the front of the vehicle and also takes horizontal and vertical loads when vehicle moves on bumpy roads. When brakes are provided on front wheels, it endures

bending stresses and torsional stresses. It is generally made from steel drop forging. It is robust in construction.

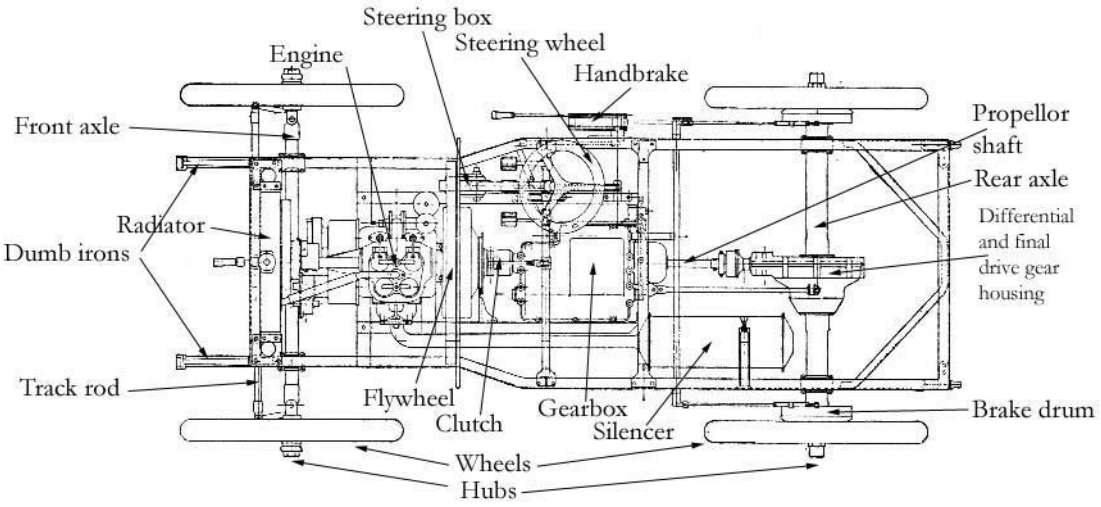
SUSPENSION SYSTEM



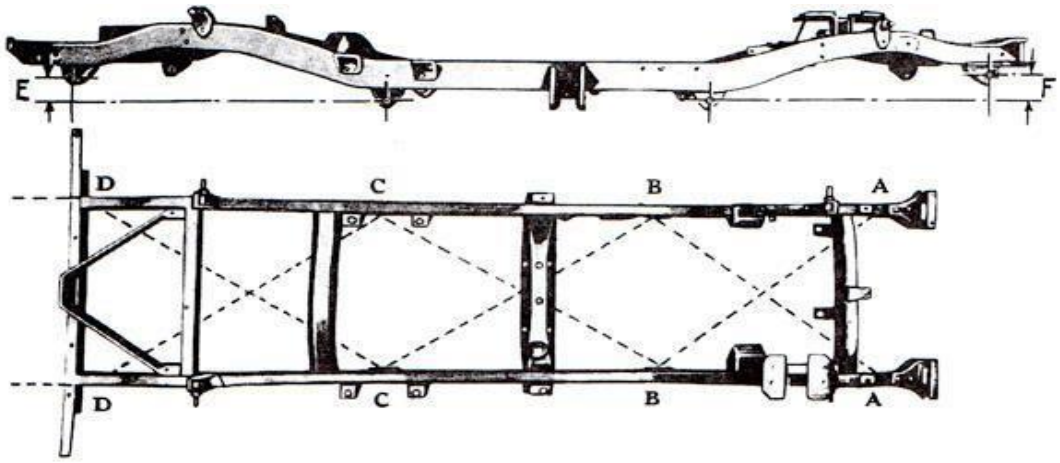
Suspension system of an automobile separates the wheel and axle assembly of the automobile from its body. Main function of the suspension system is to isolate the body of the vehicle from shocks and vibrations generated due to irregularities on the surface of roads. Shock absorbers are provided in the vehicles for this purpose. It is in the form of spring and damper. The suspension system is provided both on front end and rear end of the vehicle.
A suspension system also maintains the stability of the vehicle in pitching or rolling when vehicle is in motion.

CHASSIS

Chassis is a French term which is now denotes the whole vehicle except body in case of Heavy vehicles. In case of light vehicles of mono construction, it denotes the whole Vehicle except additional fittings in the body.
“Chassis consists of engine, power train, brakes, steering system and wheels mounted on A frame”.



FRAME



The frame is the main part of the chassis on which remaining parts of chassis are mounted. The frame should be extremely rigid and strong so that it can withstand shocks, twists, stresses and vibrations to which it is subjected while vehicle is moving on road. It is also called underbody.

The frame is supported on the wheels and tyre assemblies. The frame is narrow in the front for providing short turning radius to front wheels. It widens out at the rear side to provide larger space in the body.

TYPES OF FRAME

There are three types of frames:

- Conventional frame
- Semi-integral frame
- Integral frame

CONVENTIONAL FRAME

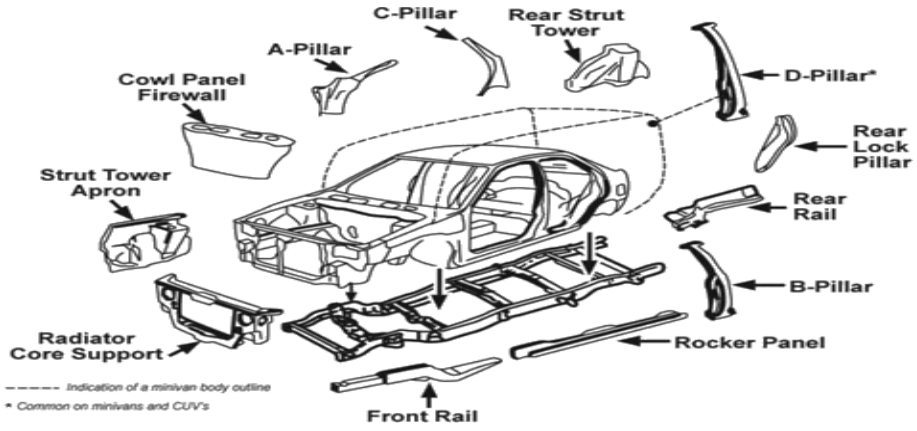
It is non-load carrying frame. The loads of the vehicle are transferred to the suspensions by the frame. This suspension in the main skeleton of the vehicle which is supported on the axles through springs. The body is made of flexible material like wood and isolated frame by inserting rubber mountings in between. The frame is made of channel section or tubular section of box section.

Example: This type of frame is used for trucks.

SEMI-INTEGRAL FRAME

In this case the rubber mountings used in conventional frame between frame and suspension are replaced by more stiff mountings. Because of this some of the vehicle load is shared by the frame also. This type of frame is heavier in construction.

Example: Popular in European and American car.



INTEGRAL FRAME OR FRAME-LESS CONSTRUCTION

In this type of construction, there is no frame. It is also called unitized frame-body construction. In this case, the body shell and underbody are welded into single unit. The underbody is made of floor plates and channel and box sections welded into single unit. This assembly replaces the frame. This decreases the overall weight compared to conventional separate frame and body construction.

TYPES OF SECTIONS USED IN FRAMES

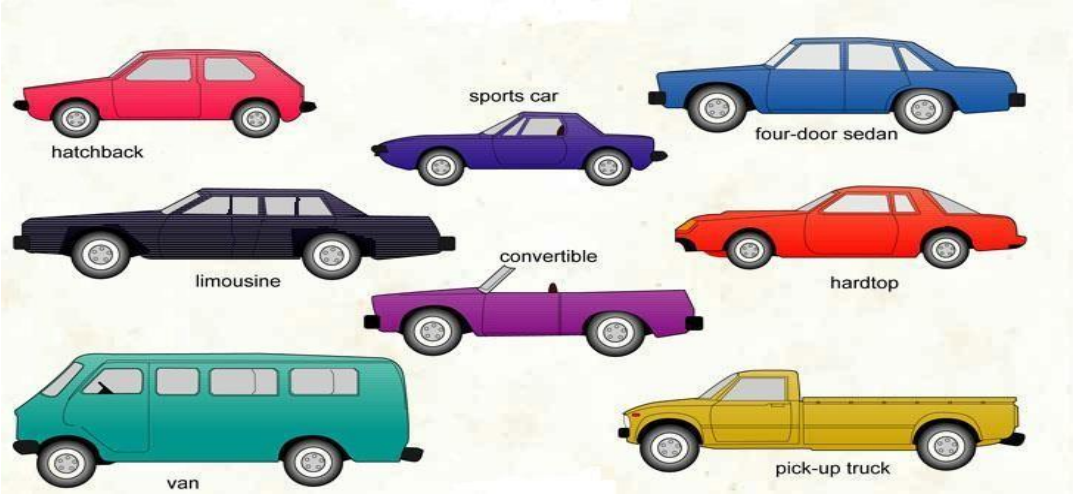
Three types of steel sections are most commonly used for making frames :

- Channel section
- Tubular section
- Box section

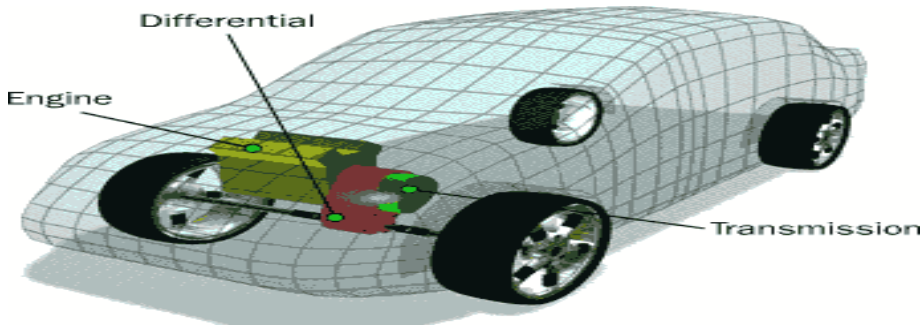
The channel section is best suited for bending loads. Box section is good for both bending and torsion and tubular section is good for torsion.

BODY

On the basis of body, the vehicles are classified as :
(a)Sedan with two doors
(b)Sedan with four doors
(c)Station wagon
(d)Convertible, e.g. jeep, etc.
(e)Van
(f) Special purpose vehicle, e.g. ambulance, milk van, etc.



FRONT-WHEEL DRIVE



Front-wheel drive (or FWD for short) is a common form of internal combustion engine / transmission layout used in modern passenger cars, where the engine drives the front wheels. Using the front wheels for delivery of power as well as steering allows the driving force to act in the same direction as the wheel is pointing.

OPERATION AND PERFORMANCE

Front-wheel-drive layouts are those in which the front wheels of the vehicle are driven. The most popular layout used in cars today is the front-engine, front-wheel drive, with the engine in front of the front axle, driving the front wheels. This layout is typically chosen for its compact packaging; since the engine and driven wheels are on the same side of the vehicle, there is no need for a central tunnel through the passenger compartment to accommodate a prop-shaft between the engine and the driven wheels.

ADVANTAGES

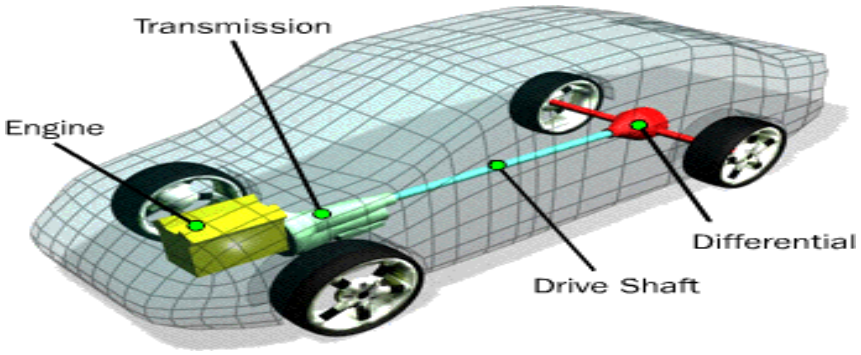
- Interior space: Since the powertrain is a single unit contained in the engine compartment of the vehicle, there is no need to devote interior space for a driveshaft tunnel or rear differential, increasing the volume available for passengers and cargo
- Weight: Fewer components usually means lower weight.

- Improved fuel efficiency due to less weight.
- Assembly efficiency: the powertrain can often be assembled and installed as a unit, which allows more efficient production.
- Placing the mass of the drivetrain over the driven wheels moves the centre of gravity farther forward than a comparable rear-wheel-drive layout, improving traction and directional stability on wet, snowy, or icy surfaces
- The wheelbase can be extended without building a longer driveshaft (as with rear-wheel-driven cars).
-

DISADVANTAGES

- Front-engine front-wheel-drive layouts are "nose heavy" with more weight distribution forward, which makes them prone to understeer, especially in high horsepower applications.
- In a vehicle, the weight shifts back during acceleration, giving more traction to the rear wheels.
- Traction can be reduced while attempting to climb a slope in slippery conditions such as snow- or ice-covered roadways.
- It makes heavier use of the front tyres (i.e., accelerating, braking, and turning), causing more wear in the front than in a rear-wheel-drive layout.
- Under extreme braking (like for instance in a panic stop), the already front heavy layout further reduces traction to the rear wheels.
- The steering 'feel' is more numbed than a RWD car.

REAR-WHEEL DRIVE



Rear-wheel drive (or RWD for short) was a common internal combustion engine / transmission layout used in automobiles throughout the 20th century. RWD typically places the engine in the front of the vehicle, but the mid engine and rear engine layouts are also used.

OPERATION AND PERFORMANCE

Rear-wheel drive (RWD) typically places the engine in the front of the vehicle and the driven wheels are located at the rear, a configuration known as front-engine, rear-wheel drive layout (FR layout). The front mid-engine, rear mid-engine and rear engine layouts are also used.

This was the traditional automobile layout for most vehicles up until the 1970s and 1980s. Nearly all motorcycles and bicycles use rear-wheel drive as well, either by driveshaft, chain, or belt, since the front wheel is turned for steering, and it would be very difficult and cumbersome to "bend" the drive mechanism around the turn of the front wheel

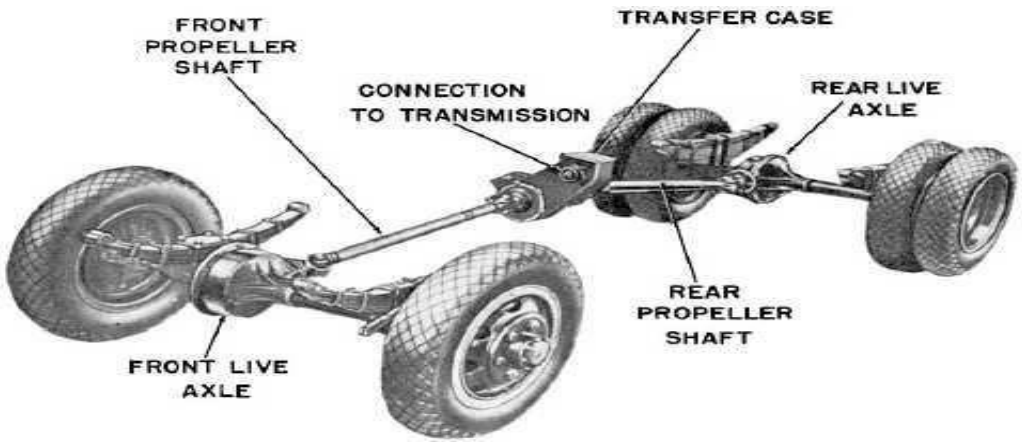
ADVANTAGES

- Even weight distribution — The layout of a rear-wheel-drive car is much closer to an even fore-and-aft weight distribution than a front-wheel-drive car, as more of the engine can lie between the front and rear wheels (in the case of a mid engine layout, the entire engine), and the transmission is moved much farther back.
- Weight transfer during acceleration — during heavy acceleration, weight is placed on the rear, or driving wheels, which improves traction.
- Steering radius — as no complicated drive shaft joints are required at the front wheels, it is possible to turn them further than would be possible using front-wheel drive, resulting in a smaller steering radius for a given wheelbase.
- Better braking — the more even weight distribution helps prevent lockup from the rear wheels becoming unloaded under heavy braking.
- Towing — Rear-wheel drive puts the wheels which are pulling the load closer to the point where a trailer articulates, helping steering, especially for large loads.
- Road grip feedback — front wheels are not affected by engine and gearbox, thus allowing for better feeling of tyre grip on road surface.
-

DISADVANTAGES

- Under heavy acceleration (as in racing), overseer and fishtailing may occur as the rear wheels break free and spin. The corrective action is to let off the throttle (this is what traction control automatically does for RWD vehicles).
- On snow, ice and sand, rear-wheel drive loses its traction advantage to front- or all-wheel-drive vehicles, which have greater weight on the driven wheels. This issue is particularly noticeable on pickup trucks, as the weight of the engine and cab will significantly shift the weight from the rear to the front wheels.
- Decreased interior space —Less front leg room as the transmission tunnel takes up a space between the driver and front passenger, less leg room for centre rear passengers (due to the tunnel needed for the drive shaft), and sometimes less boot space (since there is also more hardware that must be placed underneath the boot).
- Increased weight — the components of a rear-wheel-drive vehicle's power train are less complex, but they are larger. The driveshaft adds weight. There is extra sheet metal to form the transmission tunnel. There is a rear axle or rear half-shafts, which are typically longer than those in a front-wheel-drive car.
- A rear-wheel-drive car's centre of gravity is shifted rearward when heavily loaded with passengers or cargo, which may cause unpredictable handling behavior at the hands of an inexperienced driver.

FOUR-WHEEL DRIVE OR ALL-WHEEL DRIVE



Four-wheel drive, 4WD, 4x4 ("four-by-four"), all-wheel drive, and AWD are terms used to describe a four-wheeled vehicle with a drivetrain that allows all four roadwheels to receive torque from the internal combustion engine simultaneously. This system is common in off-road vehicles - powering all four wheels provides better control on loose and slippery surfaces. It is often used in rally racing on mostly-paved roads.

OPERATION AND PERFORMANCE

The term "four-wheel drive" usually refers only to drive trains which are primarily two-wheel drive with a part-time four-wheel-drive capability, as typically found in pickup trucks and other off-road vehicles, while the term "all-wheel drive" is used to refer to full time four-wheel-drive systems found in performance cars and smaller car-based SUVs.

ADVANTAGES

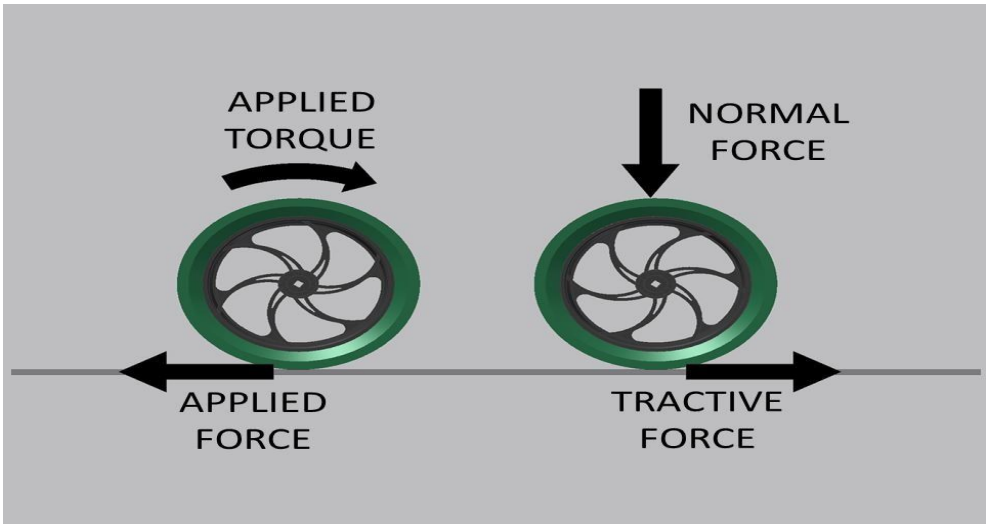
In terms of handling, traction and performance, 4WD systems generally have most of the advantages of both front-wheel drive *and* rear-wheel drive. Some unique benefits are:

- Traction is nearly doubled compared to a two-wheel-drive layout. Given sufficient power, these results in unparalleled acceleration and drivability on surfaces with less than ideal grip, and superior engine braking on loose surfaces. The development of 4WD systems for high performance cars was stimulated primarily by rallying.
- Handling characteristics in normal conditions can be configured to emulate FWD or RWD, or some mixture, even to switch between these behaviors according to circumstance. However, at the limit of grip, a well balanced 4WD configuration will not degenerate into either under steer or overseer, but instead break traction of all 4 wheels at the same time into a four-wheel drift. Combined with modern electronic driving aids, this flexibility allows production car engineers a wide range of freedom in selecting handling characteristics that will allow a 4WD car to be driven more safely at higher speeds by inexpert motorists than 2WD designs.

DISADVANTAGES

- 4WD systems require more machinery and complex transmission components, and so increase the manufacturing cost of the vehicle and complexity of maintenance procedures and repairs compared to 2WD designs
- 4WD systems increase power-train mass, rotational inertia and power transmission losses, resulting in a reduction in performance in ideal dry conditions and increased fuel consumption compared to 2WD designs
- The handbrake cannot be used to induce over-steer for maneuvering purposes, as the drivetrain couples the front and rear axles together. To overcome this limitation, some custom prepared stage rally cars have a special mechanism added to the transmission to disconnect the rear drive if the handbrake is applied while the car is moving.

TRACTION FORCE AND TRACTION RESISTANCE



As used in automobile engineering, the term tractive force can either refer to the total traction a vehicle exerts on a surface, or the amount of the total traction that is parallel to the direction of motion.

The term tractive effort is often qualified as starting tractive effort, continuous tractive effort and maximum tractive effort. These terms apply to different operating conditions, but are related by common mechanical factors: input torque to the driving wheels, the wheel diameter, coefficient of friction (μ) between the driving wheels and supporting surface, and the weight applied to the driving wheels (m). The product of μ and m is the factor of adhesion, which determines the maximum torque that can be applied before the onset of wheels pin or wheel slip.

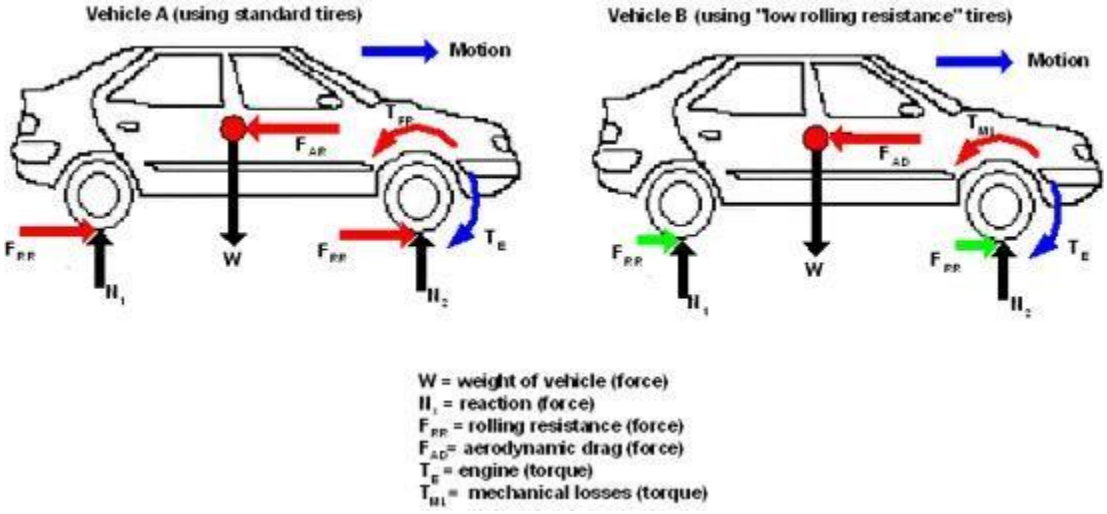
- **Starting tractive effort:** Starting tractive effort is the tractive force that can be generated at a standstill. This figure is important on railways because it limits the train weight that a locomotive can set into motion.

- **Maximum tractive effort:** Maximum tractive effort is defined as the highest tractive force that can be generated under any condition that is not injurious to the vehicle or machine. In most cases, maximum tractive effort is developed at low speed and may be the same as the starting tractive effort.

- **Continuous tractive effort:** Continuous tractive effort is the tractive force that can be maintained indefinitely, as distinct from the higher tractive effort that can be maintained for a limited period of time before the power transmission system overheats. Due to the relationship between power (P), velocity (v) and force (F), described as:
  $P = vF$ or $P/v = F$
  tractive effort inversely varies with speed at any given level of available power.

POWER REQUIRED FOR AUTOMOBILE:

ROLLING RESISTANCE



Rolling resistance, sometimes called rolling friction or rolling drag, is the force resisting the motion when a body rolls on a surface. It is mainly caused by non-elastic effects; that is, not all the energy needed for deformation of the wheel, roadbed, etc. ...
Rolling resistance is composed of the following components:

- Tire Rolling resistance: $F_{R,T}$
- Road rolling resistance: $F_{R,Tr}$
- Resistance due to tire slip angle: $F_{R,\alpha}$
- Resistance due to bearing friction and residual braking: $F_{R,fr}$

Hence the rolling resistance offered may be written as:

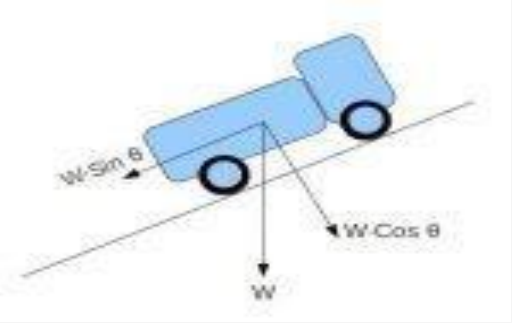
$$F_R = F_{R,T} + F_{R,Tr} + F_{R,\alpha} + F_{R,fr}$$

The tire rolling resistance $F_{R,T}$ is a result of the resistance due to flexure of the tire, air resistance on the tire and friction of tire with the road. These three can be summed up and written as:

$$F_{R,T} = F_{R.T.flex} + F_{R.T.A} + F_{R.T.fr}.$$

In a simplified manner the total rolling resistance can be related to the vertical load on the wheels and can be written as:
Co−efficient of rolling friction, $k_R = {}^{F_R}/_{FZ.w}$

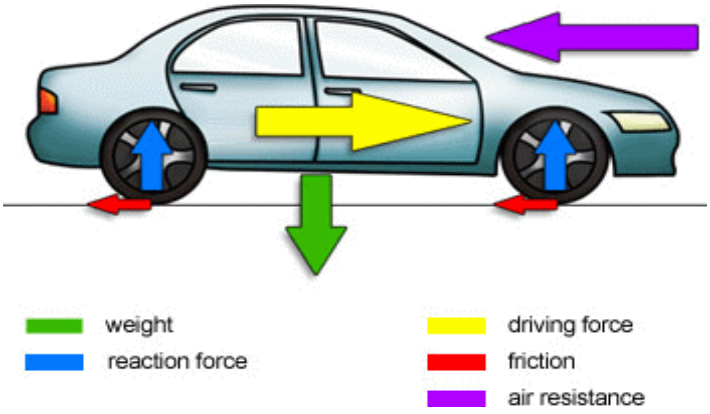
GRADIENT RESISTANCE



A truck moving uphill

When the vehicle travels uphill, a component of its weight works in a direction opposite to its motion. If some energy is not supplied to overcome this backward force, then the vehicle would slow down, stall and roll backwards. If the vehicle is trading uphill at a slope of θ, then the weight of the vehicle, W has two components: one perpendicular to the road surface (with a value W·Cos θ) and the other along the road surface (with a value W·Sin θ). The component along the road surface is the one that tries to restrict the motion.
The gradient resistance is given by: $F_G = W \cdot \sin \theta$

AIR RESISTANCE



Air resistance refers to a force that acts against relative motion of an object through a liquid or gas. It is also known as drag and acts in an opposite direction to the oncoming velocity. Mathematically it can be expressed as:

$$F_A = -\frac{1}{2} \times C_d \times P \times V^2$$

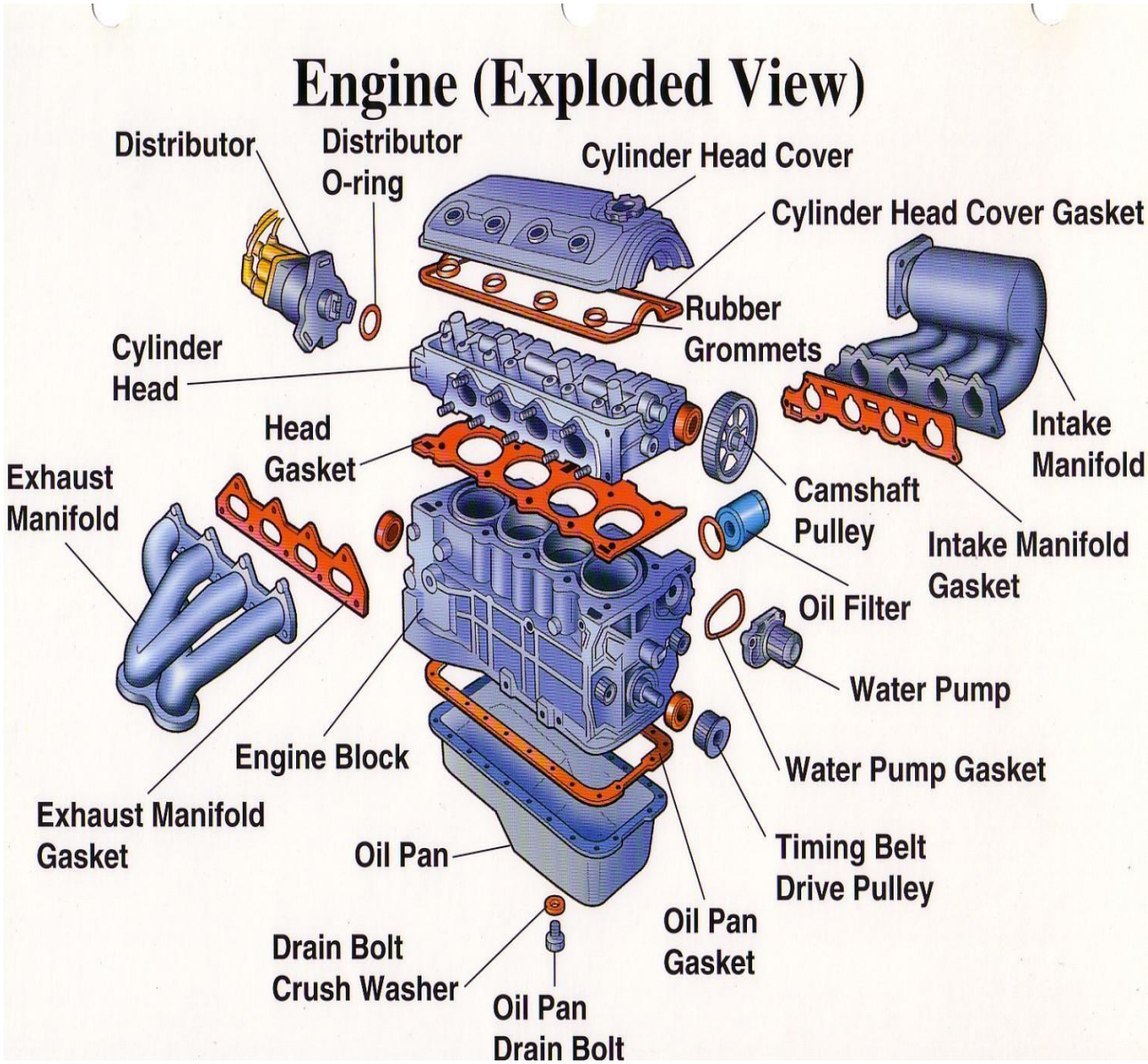
where
C_d = Co−efficient of discharge P = Pressure
V = Velocity of the vehicle

UNIT- II

UNIT – II TRANSMISSIONSYSTEMS

THE ENGINE

The engine is the power plant of the vehicle. An engine consists of a cylinder, piston, valves, valve operating mechanism, carburetor (or MPFI in modern cars), fan, fuel feed pump and oil pump, etc. Besides this, an engine requires ignition system for burning fuel in the engine cylinder.



TYPES OF ENGINE

Internal combustion engines can be classified in a number of different ways:

1. Types of ignition

(a) Spark Ignition (SI)

An SI engine starts the combustion process in each cycle by use of a spark plug. The spark plug gives a high voltage electrical discharge between two electrodes, which ignites the air fuel mixture in the combustion chamber surrounding the plug. In early engine development, before the inventor of electric spark plug, many forms of torch holes were used to initiate combustion from an external flame.

(b) Compression Ignition (CI)

The combustion process in a CI engine starts when the air-fuel mixture self-ignites due to high temperature in the combustion chamber caused by high compression.

2. Engine cycle

Four-stroke cycle: A four-stroke cycle has four piston movements over two engine revolutions for each cycle. **Two-stroke cycle**: A two-stroke cycle has two piston movements over one revolution for each cycle.

Note: Three stroke cycles and six stroke cycles were also tried in early engine development.

3. Valve location

a. Valves in head (Overhead valve), also called I Head engine.

b. Valves in block (flat head), also called L Head engine. Some historic engines with valves in block had the intake valve on one side of the cylinder and the exhaust valve on the other side. These were called T Head engines.

c. One valve in head (usually intake) and one in block, also called F Head Engine; this is much less common.

4. Basic Design

a. ***Reciprocating:*** Engine has one or more cylinders in which pistons reciprocate back and forth. The combustion chamber is located in the closed end of each cylinder. Power is delivered to a rotating output crankshaft by mechanical linkage with the pistons.

b. ***Rotary:*** Engine is made of a block (stator) built around a large non-concentric rotor and crankshaft. The combustion chambers are built into the non-rotating block. A

number of experimental engines have been tested using this concept, but the only design that has ever become common in an automobile is the Wankel engine in several Mazda models. Mazda builds rotary automobile engines with one, two, and three rotors.

5. Position and number of cylinders of reciprocating engines

a. ***Single Cylinder:*** Engine has one cylinder and piston connected to the crankshaft.

b. ***In-Line:*** Cylinders are positioned in a straight line, one behind the other along the length of the crankshaft. They can consist of 2 to 11 cylinders or possibly more. In-line four-cylinder engines are very common for automobile and other applications. In-line six and eight cylinders are historically common automobile engines In-line engines are sometimes called Straight (e.g., straight six or straight eight).

c. ***V Engine:*** Two banks of cylinders at an angle with each other along a single crankshaft, allowing for a shorter engine block. The angle between the banks of cylinders can be anywhere from 15° to 120° with 60°-90°. V engines usually have even numbers of cylinders from 2 to 20 or more. V6s and V8s re common automobile engines, with V12s and V16s (historic) found in some luxury and high performance vehicles. Large ship and stationery engines have anywhere from 8 to 20 cylinders. Volkswagen has a v5 on the market with two cylinders slightly out of line (15deg) with the other three so that the cylinders can be moved closer together to shorten the engine block. Honda makes a true V5 motorcycle engine.

d. ***Opposed Cylinder Engine:*** Two banks of cylinders opposite to each other on a single crankshaft (a V engine with 180 deg V). These are common on small aircraft and some automobiles with an even number of cylinders from two to eight or more. These engines are often called flat engines (e.g., flat four).

e. ***W engine:*** Engines of two different cylinder arrangements have been classified as W engines in the technical literature. One type is the same as a V engine except with three banks of cylinders on the same crankshaft. They are not common, but some race cars of 1930 s and some luxury cars of the 1990s had such engines either with 12 cylinders or 18 cylinders. Another type of W engine is the modern 16 cylinder engine made for the Bugatti automobile (W16). This engine is essentially two V8 engines connected together on a single crankshaft.

f. ***Opposed piston engine:*** Two pistons in each cylinder with the combustion chamber in the center between the pistons. A single combustion process causes two power strokes at the same time, with each piston being pushed away from the center and delivering power to a separate crankshaft at each end of the cylinder. Engine output is either on two rotating crankshafts or on one

crankshaft incorporating a complex mechanical linkage. These engines are generally of large displacement, used for power plants, ships, or submarines.

g. ***Radial engine:*** Engines with pistons positioned in a circular plane around a circular crankshaft. The connecting rods of the piston are connected to a master rod, which in turn, is connected to the crankshaft. A bank of cylinders on a radial engine almost always has an odd number of cylinders ranging from 3 to 13 or more. Operating on a four-stroke cycle every other cylinder fires and has a power stroke as the crankshaft rotates, giving a smooth operation. Many medium and large size propeller driven aircraft use radial engines. For large aircraft two or more banks of cylinders are mounted together, one behind the other on a single crankshaft, making one powerful smooth engine. Very large ship engines exist with up to 54 cylinders, engines six banks of 9 cylinders each. In the early part of 20^{th} century experimental radial aircraft here were a few experimental radial aircraft engines that had an even number of cylinders (4 to 12). These engines operated on a two-stroke cycle and never became standard.

6. Air Intake Process

(a) **Naturally Aspirated**: No intake air pressure boosts system.

(b) **Super charged**: Intake air pressure increased with the compressor driven off of the engine crankshaft.

(c) **Turbo charged**: Intake air pressure increased with the turbine compressor driven by the engine exhaust gases.

(d) **Crankcase compressed**: Two-stroke cycle engine which uses the crankcase as the intake air compressor. Limited development work has also been done on design and construction of four-stroke cycle engines with crank case compression.

7. Method of fuel input for spark ignition engines

(a) Carbureted: A device for mixing air and fuel to facilitate the combustion process

(b) Multipoint port fuel injection: One or more injectors at each cylinder intake.

(c) Throttle body fuel injection: Injectors upstream in intake manifold.

(d) Gasoline direct injection: Injectors mounted in combustion chambers with injection directly into cylinders.

8. Method of fuel input for compression ignition engines

(a) Direct injection: Fuel injected into main combustion chamber.

(b) Indirect injection: Fuel injected into secondary combustion chamber.

(c) Homogeneous charge compression ignition: Some fuel added during intake stroke.

9. Fuel used

(a) Petrol

(c) Diesel

(d) Gasoline

10. Application

Automobile, Locomotive, Stationery, Marine, Aircraft, Small, Portable, chain saw, model airplane.

11. Type of cooling

(a) Air cooled

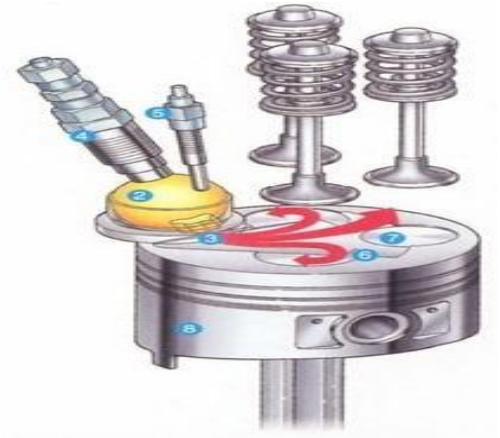
(b) Liquid cooled, Water-cooled.

Several or all of these classifications can be used at the same time to identify a given engine. Thus, a modern engine might be called a turbocharged, reciprocating, spark ignition, four-stroke cycle overhead valve, water-cooled, gasoline, multipoint fuel injected, v8 automobile engine.

MULTI VALVE ENGINE

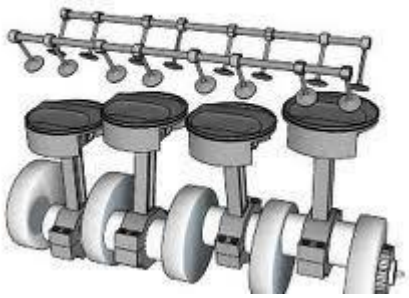
In automotive engineering a multi-valve or multivalve engine is one where each cylinder has more than two valves. A multi-valve engine has better breathing and can operate at higher revolutions per minute (RPM) than a two-valve engine, delivering more power.

3-VALVE ENGINES



The earliest mass production multi-valve engines were 3-valves because of its simple construction - it needs only a single Camshaft to drive both intake valves and the exhaust valve of each cylinder. Today, there are still a few car cars using this cheap but inefficient design, such as Fiat Palio and all Mercedes V6 and V8 engines. Mercedes uses that because of emission rather than cost reason.

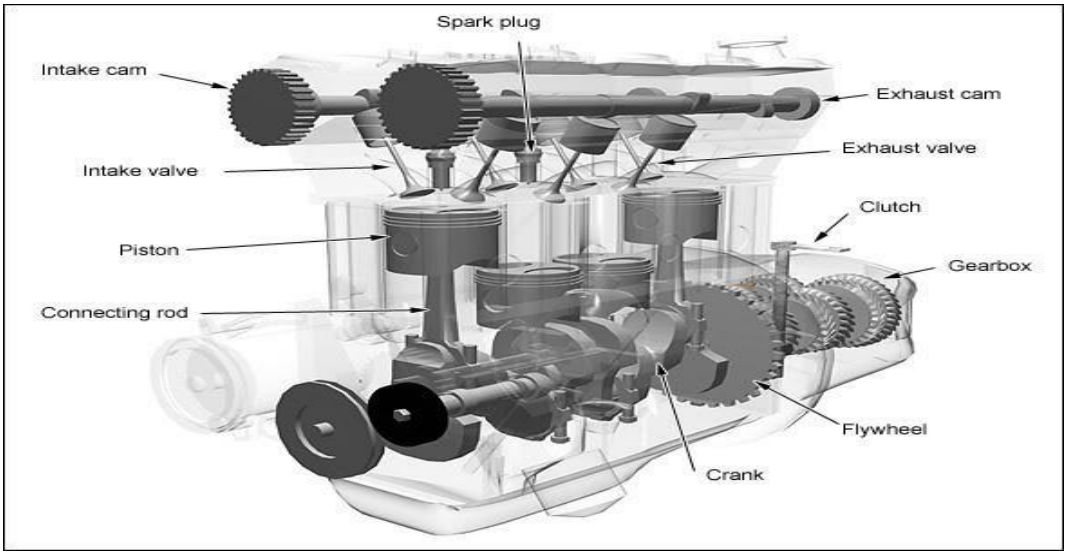
4-VALVE ENGINES



A typical 2-valve engine has just 1/3 combustion chamber head area covered by the valves, but a 4-valve head increases that to more than 50%, hence smoother and quicker breathing. 4-valve designs also benefit a clean and effective combustion, because the Spark Plug can be placed in the middle.

4 valves are better to be driven by twin-cam, one for intake valves and one for exhaust valves. Honda and Mitsubishi models prefer to use SOHC, driving the valves via rocker arms like the aforementioned Triumph. This could be a bit cheaper, but introduce more friction and hurt high speed power. Therefore the sportiest Honda and Mitsubishi still use DOHC.

IN-LINE ENGINE



The **inline-four engine** or **straight-four engine** is a type of internal combustion four cylinder engines with all four cylinders mounted in a straight line, or plane along the crankcase. The single bank of cylinders may be oriented in either a vertical or an inclined plane with all the pistons driving a common crankshaft

ADVANTAGES

Naturally balanced as in-line keeps drive-shaft in line forming a perfect match. They don't normally need balancing shafts, unlike the V's.

Naturally balanced means less vibrations therefore lesser load on bearing which can wear off faster even there is a smallest margin of error in balancing.

In-line engines are smothering and have higher top-end (red-line) as all pistons are firing in the same direction.

Preferred when there is a need for high torque to get of the line first. In-line generates higher torque due to long stroke and more rotational mass.

In-line/straight are cheaper, easier to maintain thanks to easy access under the hood.

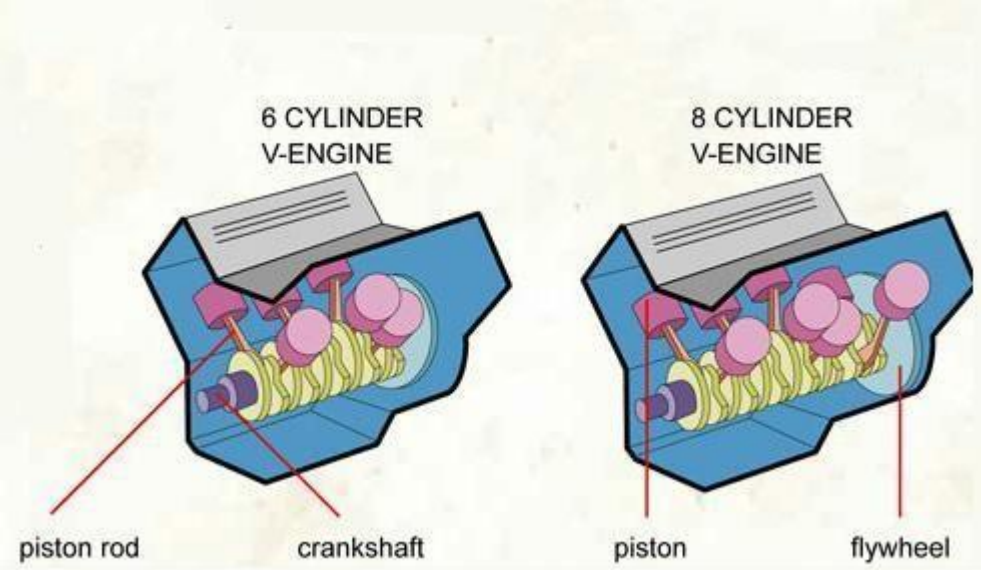
DISADVANTAGES

In-lines/straight are taller engines as the engine block needs to be fitted under the hood. This would cause aerodynamic and even HP losses.

In-lines are longer engines therefore need a much larger nose, which could cause problem in high bumper to bumper traffic.

In-line engines tend be heavier they need stiff blocks and lots of support. Earlier there used to be cooling issues with this format.

VEE-TYPE ENGINE



Vee engine is a common configuration for an internal combustion engine. The cylinders and pistons are aligned, in two separate planes or 'banks', so that they appear to be in a **"V"** when viewed along the axis of the crankshaft. The Vee configuration generally reduces the overall engine length, height and weight compared to an equivalent inline configuration.

ADVANTAGES

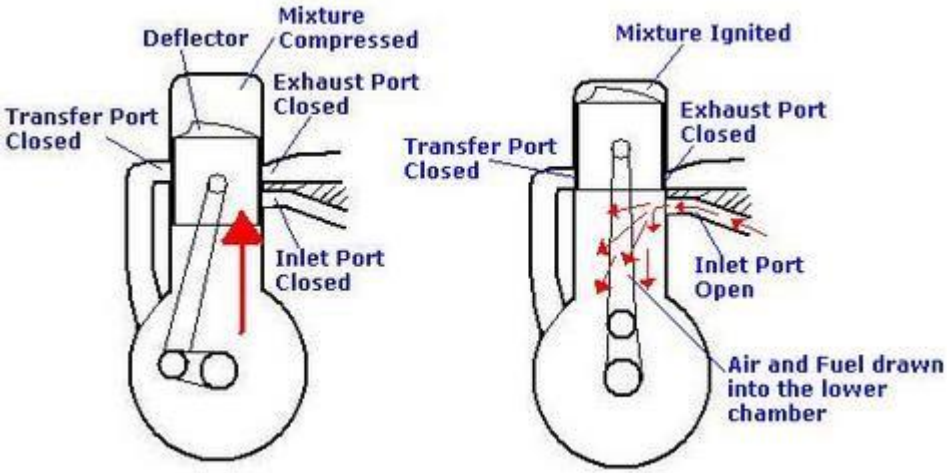
The appeal of the V engine design comes from its tendency to be lighter and shorter in height and length than an inline layout of the same cylinder number and displacement. The short length of the V design allows automotive producers to shorten the length of the hood and use that space for other purposes. The V engine tends to permit higher torsional stresses and rotational speeds as a result of its strong short crankshaft.

DISADVANTAGES

V engine has extra components, due to the doubling-up of cylinder heads, intake and exhaust manifolds, etc. This can make it more expensive and more difficult (i.e. expensive) to service and maintain.

PETROL ENGINE

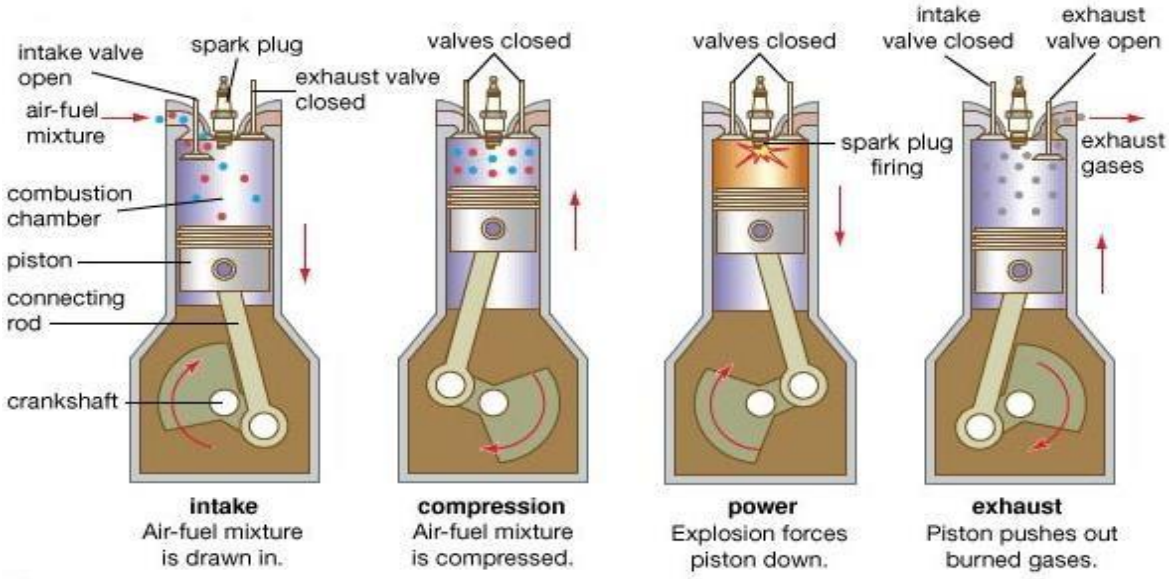
2-STROKE PETROL ENGINE



A **two-stroke**, **two-cycle**, or **two-cycle engine** is a type of internal combustion engine which completes a power cycle in only one crankshaft revolution and with two strokes, or up and down movements, of the piston in comparison to a "four-stroke engine", which uses four strokes to do so. This is accomplished by the end of the combustion stroke and the beginning of the compression stroke happening simultaneously and performing the intake and exhaust (or scavenging) functions at the same time.

Two-stroke engines often provide high power-to-weight ratio, usually in a narrow range of rotational speeds called the "power band", and, compared to 4-stroke engines, have a greatly reduced number of moving parts, are more compact and significantly lighter.

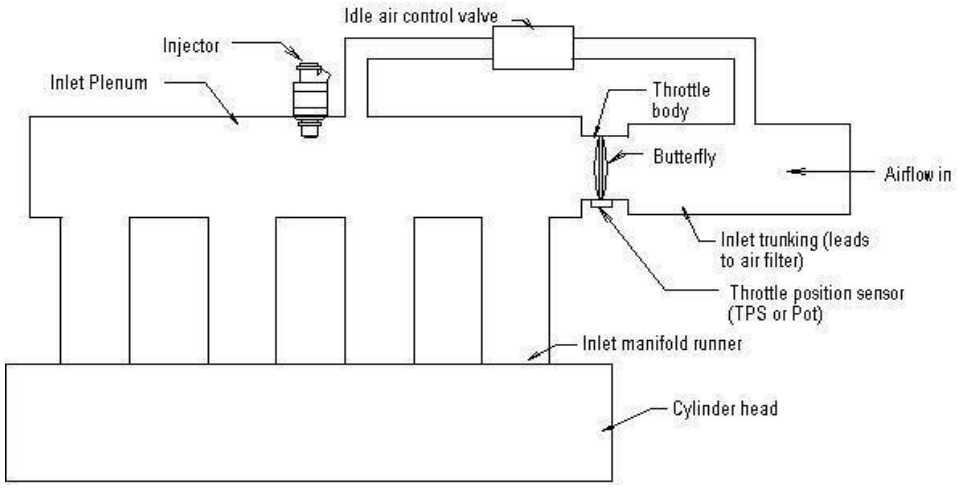
4-STROKE PETROL ENGINE



A **four-stroke engine** (also known as **four-cycle**) is an internal combustion engine in which the piston completes four separate strokes which comprise a single thermodynamic cycle. A stroke refers to the full travel of the piston along the cylinder, in either direction. While risqué slang among some automotive enthusiasts names these respectively the "suck," "squeeze," "bang" and "blow" strokes. They are more commonly termed

1. INTAKE: this stroke of the piston begins at top dead center. The piston descends from the top of the cylinder to the bottom of the cylinder, increasing the volume of the cylinder. A mixture of fuel and air is forced by atmospheric (or greater) pressure into the cylinder through the intake port.
2. COMPRESSION: with both intake and exhaust valves closed, the piston returns to the top of the cylinder compressing the air or fuel-air mixture into the cylinder head.
3. POWER: this is the start of the second revolution of the cycle. While the piston is close to Top Dead Centre, the compressed air–fuel mixture in a gasoline engine is ignited, by a spark plug in gasoline engines, or which ignites due to the heat generated by compression in a diesel engine. The resulting pressure from the combustion of the compressed fuel-air mixture forces the piston back down toward bottom dead centre.
4. EXHAUST: during the *exhaust* stroke, the piston once again returns to top dead centre while the exhaust valve is open. This action expels the spent fuel-air mixture through the exhaust valve(s).

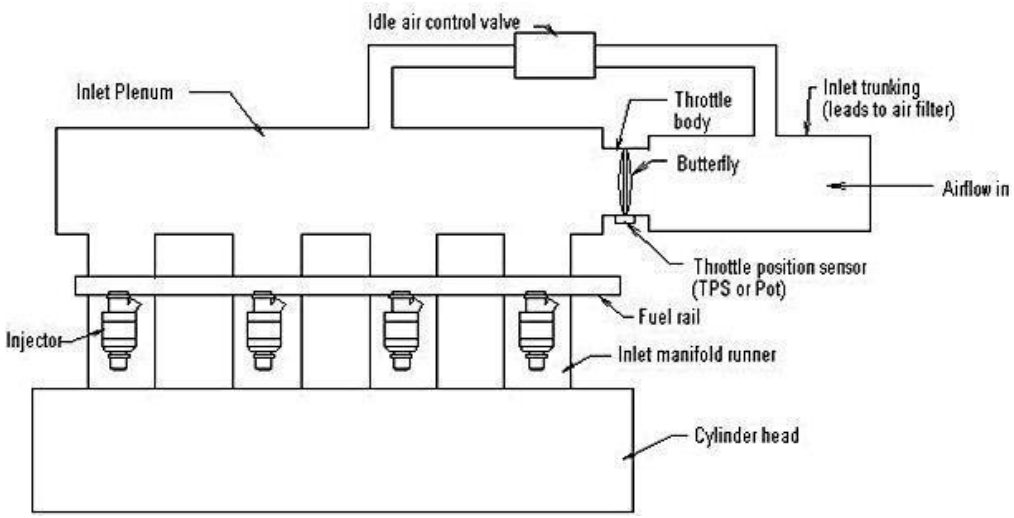
SINGLE POINT FUEL INJECTION



Single-point injection uses a single injector at the throttle body (the same location as was used by carburetors).
Since the fuel passes through the intake runners (like a carburetor system), it is called a "wet manifold system".

The justification for single-point injection was low cost. Many of the carburetor's supporting components- such as the air cleaner, intake manifold, and fuel line routing- could be reused. This postponed the redesign and tooling costs of these components. Single-point injection was used extensively on American-made passenger cars and light trucks during 1980-1995, and in some European cars in the early and mid-1990s.

MULTI POINT FUEL INJECTION



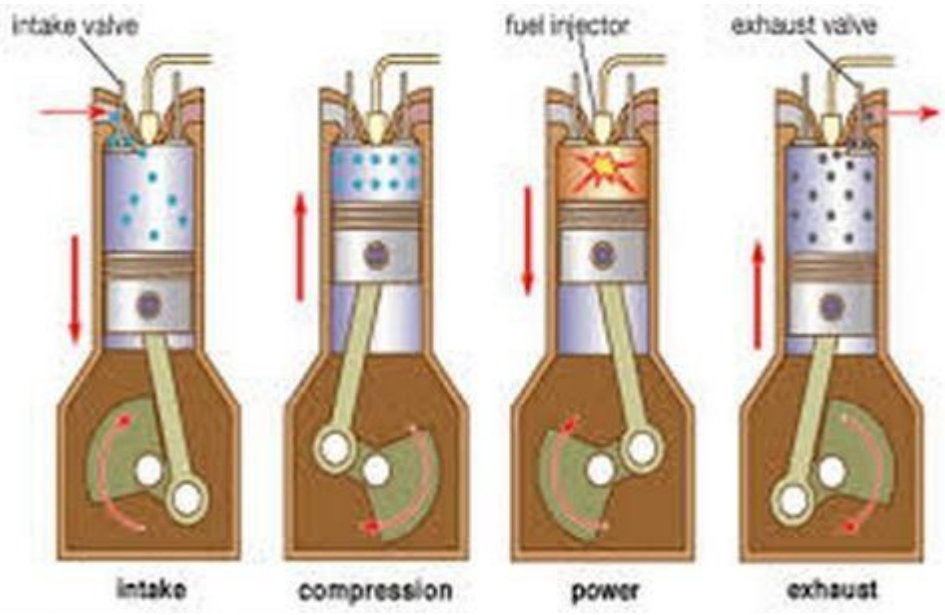
Multi point fuel injection or MPFI uses several injectors, normally respective to the number of engine cylinders and placed in the inlet port of each cylinder. It is to be noted that fuel spaying is taking place out side of the cylinder at the correct time according to the piston position inside the cylinder.

There will be electronic control unit or ECU which will be receiving feed back from several sensors like engine speed sensor, fly wheel position sensor, vehicle speed sensor, and atmospheric temp. Sensor, accelerator pedal position sensor intake airflow sensor.

This ECU will control the correct amount of fuel to be injected and the proper time at which the fuel will be injected at any speed and load condition. This will ensure maximum power output at minimum fuel.

DIESEL ENGINE

4-STROKE DIESEL ENGINE



The diesel engine has the highest thermal efficiency of any standard internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines (as used in ships and other applications where overall engine weight is relatively unimportant) can have a thermal efficiency that exceeds 50%.

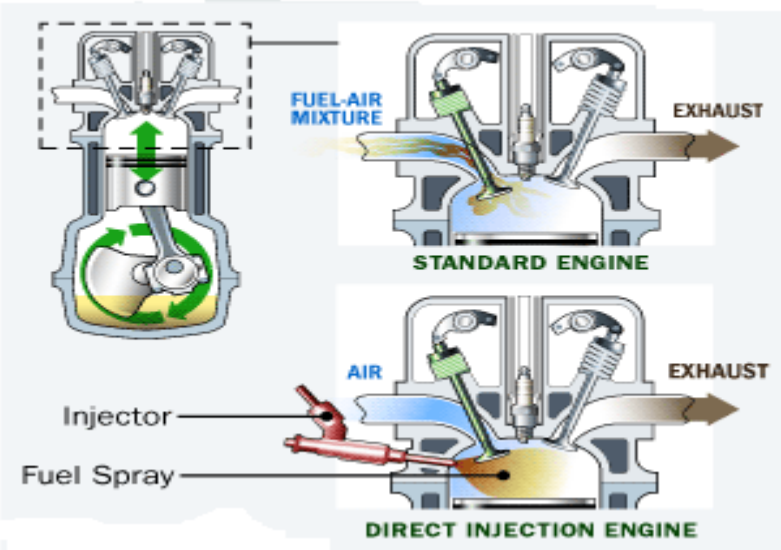
Diesel engines are manufactured in two-stroke and four-stroke versions. They were originally used as a more efficient replacement for stationary steam engines. Since the 1910s they have been used in submarines and ships. Use in locomotives, trucks, heavy equipment and electric generating plants followed later.

The diesel engine uses a four-stroke combustion cycle just like a gasoline engine. The four strokes are:

- **Intake stroke** -- The intake valve opens up, letting in air and moving the piston down.
- **Compression stroke** -- The piston moves back up and compresses the air.
- **Combustion stroke** -- As the piston reaches the top, fuel is injected at just the right moment and ignited, forcing the piston back down.
- **Exhaust stroke** -- The piston moves back to the top, pushing out the exhaust created from the combustion out of the exhaust valve.

Remember that the diesel engine has no spark plug, that it intakes air and compresses it, and that it then injects the fuel directly into the combustion chamber (direct injection). It is the heat of the compressed air that lights the fuel in a diesel engine. In the next section, we'll examine the diesel injection process.

DIRECT INJECTION



Direct fuel injection is a fuel-delivery technology that allows gasoline engines to burn fuel more efficiently, resulting in more power, cleaner emissions, and increased fuel economy.

Gasoline engines work by sucking a mixture of gasoline and air into a cylinder, compressing it with a piston, and igniting it with a spark; the resulting explosion drives the piston downwards, producing power. Traditional (indirect) fuel injection systems pre-mix the gasoline and air in a chamber just outside the cylinder called the intake manifold. In a direct-injection system, the air and gasoline are not pre-mixed; air comes in via the intake manifold, while the gasoline is injected directly into the cylinder.

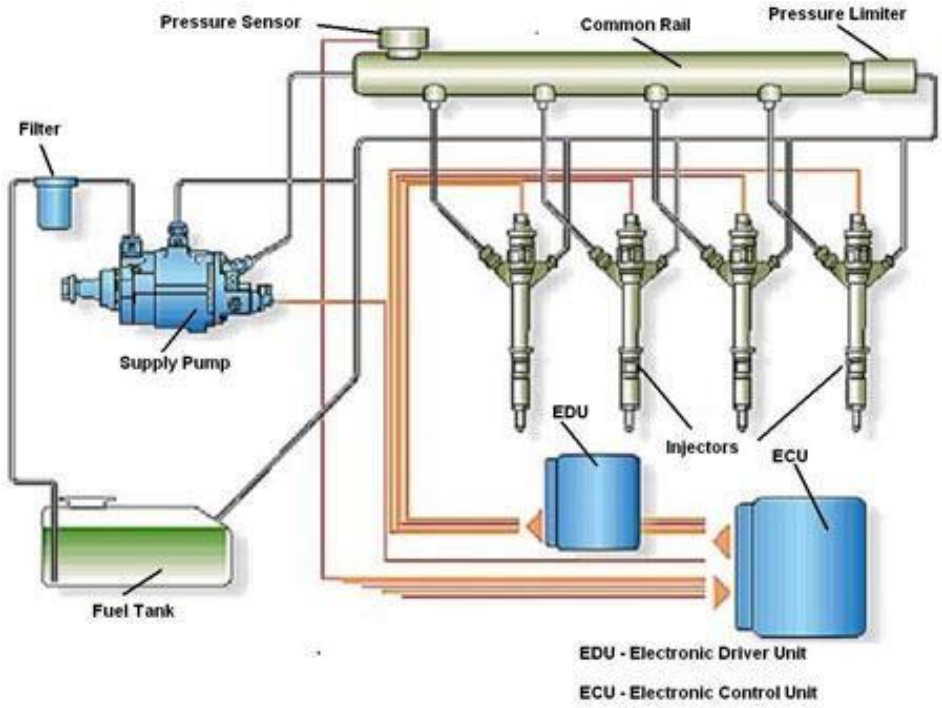
ADVANTAGES

Combined with ultra-precise computer management, direct injection allows more accurate control over fuel metering (the amount of fuel injected) and injection timing (exactly when the fuel is introduced into the cylinder). The location of the injector also allows for a more optimal spray pattern that breaks the gasoline up into smaller droplets. The result is more complete combustion -- in other words, more of the gasoline is burned, which translates to more power and less pollution from each drop of gasoline.

DISADVANTAGES

The primary disadvantages of direct injection engines are complexity and cost. Direct injection systems are more expensive to build because their components must be more rugged -- they handle fuel at significantly higher pressures than indirect injection systems and the injectors themselves must be able to withstand the heat and pressure of combustion inside the cylinder.

COMMON RAIL DIESEL INJECTION



CRDI helps to improve the power, performance and reduce harmful emissions from a diesel engine.

CRDI or common rail direct injection system is also sometimes referred to by many similar or different names. Some brands use name CRDe / DICOR / Turbojet / DDIS / TDI etc. All these systems work on same principles with slight variations and enhancements here and there.

CRDI system uses common rail which is like one single rail or fuel channel which contains diesel compresses at high pressure. This is a called a common rail because there is one single pump which compresses the diesel and one single rail which contains that compressed fuel. In conventional diesel engines, there will be as many pumps and fuel rails as there are cylinders.

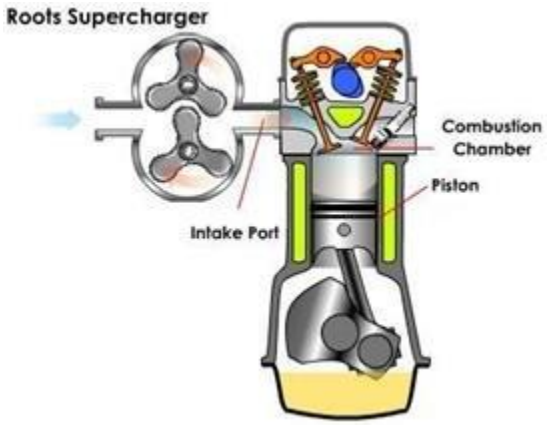
For a conventional 4 cylinder diesel engine there will be 4 fuel-pumps, 4 fuel rails each feeding to one cylinder. In CRDI, there will be one fuel rail for all 4 cylinders so that the fuel for all the cylinders is pressurized at same pressure.

The fuel is injected into each engine cylinder at a particular time interval based on the position of moving piston inside the cylinder. In a conventional non-CRDI system, this interval and the fuel quantity was determined by mechanical components, but in a CRDI system this time interval and timing etc are all controlled by a central computer or microprocessor based control system.

To run a CRDI system, the microprocessor works with input from multiple sensors. Based on the input from these sensors, the microprocessor can calculate the precise amount of

the diesel and the timing when the diesel should be injected inside the cylinder. Using these calculations, the CRDI control system delivers the right amount of diesel at the right time to allow best possible output with least emissions and least possible wastage of fuel.

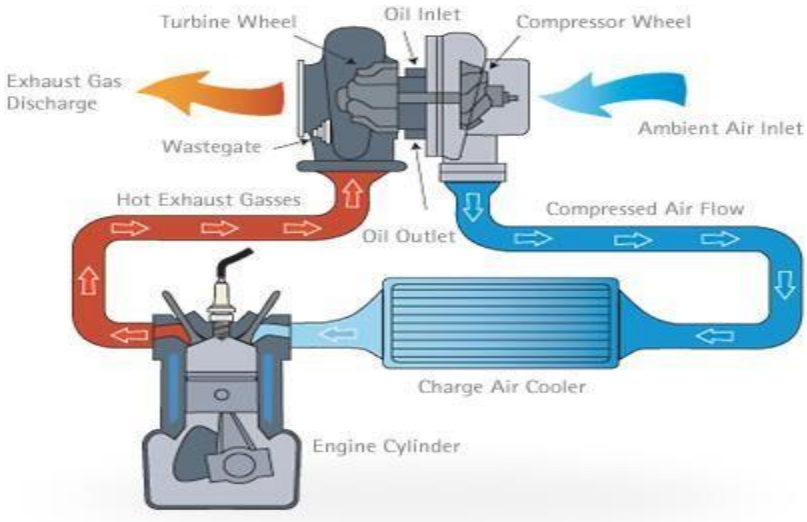
SUPERCHARGING



Both turbochargers and superchargers are called **forced induction systems**. They compress the air flowing into the engine .The advantage of compressing the air is that it lets the engine stuff more air into a cylinder. More air means that more fuel can be stuffed in, too, so you get more power from each explosion in each cylinder. A turbo/supercharged engine produces more power overall than the same engine without the charging.

The typical boost provided by either a turbocharger or a supercharger is 6 to 8 pounds per square inch (psi). Since normal atmospheric pressure is 14.7 psi at sea level, you can see that you are getting about 50-percent more air into the engine. Therefore, you would expect to get 50-percent more power. It's not perfectly efficient, though, so you might get a 30-percent to 40-percent improvement instead.

TURBO CHARGING



The key difference between a turbocharger and a supercharger is its **power supply**. Something has to supply the power to run the air compressor. In a supercharger, there is a **belt** that connects directly to the engine. It gets its power the same way that the water pump or alternator does. A turbocharger, on the other hand, gets its power from the **exhaust stream**. The exhaust runs through a turbine, which in turn spins the compressor.

ALTERNATE FUELS

Alternative fuels are non-petroleum based fuels that could ultimately help reduce the nation's dependence on foreign oil and improve air quality. Use of alternative fuels is one part of a comprehensive Federal fleet strategy to reduce petroleum consumption.
Alternative fuel vehicles (AFVs) are any dedicated vehicle or dual-fueled vehicle designed to run on at least one alternative fuel. AFVs are available in a variety of models ranging from sedans, SUVs, pickup trucks, and vans to heavy-duty buses and trucks.

ETHANOL

Ethanol is an alcohol-based fuel that is produced by fermenting and distilling starch or sugar crops (usually corn, barley, and wheat or sugar cane and fruit) to turn them into simple sugars. Most of the ethanol currently produced in the United States is derived from corn.
To oxygenate the fuel and reduce air pollution, nearly half of U.S. gasoline contains ethanol in a low-level blend such as E10 (gasoline containing up to 10 percent ethanol). Ethanol is also increasingly available in E85 (85 percent ethanol, 15 percent gasoline).

ETHANOL BLEND

Gasoline blended for use in an alternative fuel vehicle (AFV) may contain any percentage of agriculturally derived, denatured ethanol, up to and including 85% (E85). Ethanol and gasoline blended at the point of retail sale in an ethanol-blending fuel dispenser must be clearly labeled "FLEX-FUEL VEHICLES ONLY." If a retailer sells both ethanol blends for use in AFVs as well as ethanol blends for use in standard combustion engines, the ethanol blends for use in a standard combustion engine must be dispensed from dedicated hoses, nozzles, or other equipment, and clearly labeled for use in conventional vehicles.

COMPRESSED NATURAL GAS

CNG is made by compressing natural gas (which is mainly composed of methane, CH_4), to less than 1 percent of the volume it occupies at standard atmospheric pressure. It is stored and distributed in hard containers at a pressure of 200–248 bar (2,900–3,600 psi), usually in cylindrical or spherical shapes.

CNG is used in traditional gasoline/internal combustion engine automobiles that have been modified or in vehicles which were manufactured for CNG use, either alone ('dedicated'), with a segregated gasoline system to extend range (dual fuel) or in conjunction with another fuel such as diesel (bi-fuel)

ADVANTAGES

- CNG does not contain any lead, thereby eliminating fouling of spark plugs.
- CNG-powered vehicles have lower maintenance costs than other hydrocarbon-fuel-powered vehicles.
- CNG fuel systems are sealed, preventing fuel losses from spills or evaporation.
- Increased life of lubricating oils, as CNG does not contaminate and dilute the crankcase oil.
- Being a gaseous fuel, CNG mixes easily and evenly in air.

DISADVANTAGES

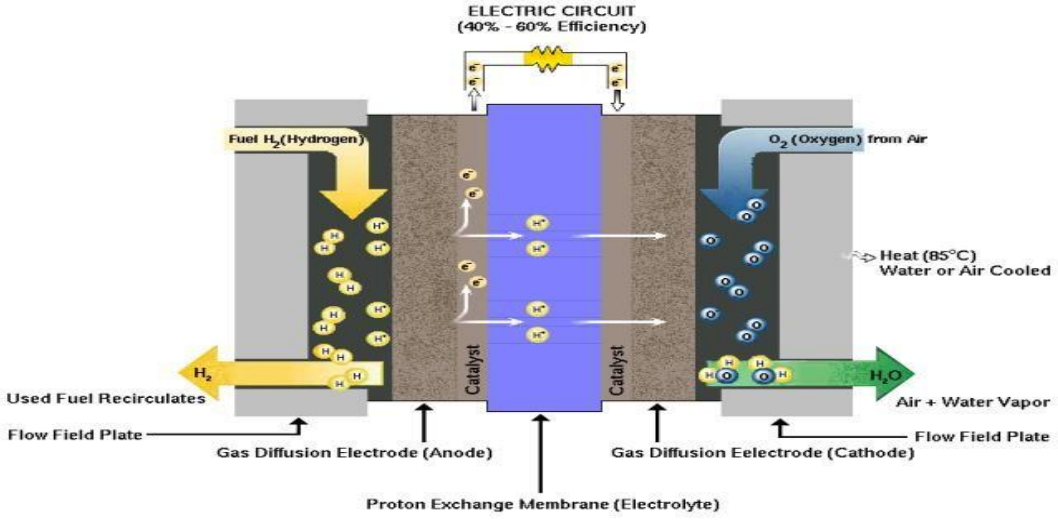
Compressed natural gas vehicles require a greater amount of space for fuel storage than conventional gasoline powered vehicles

FUEL CELLS

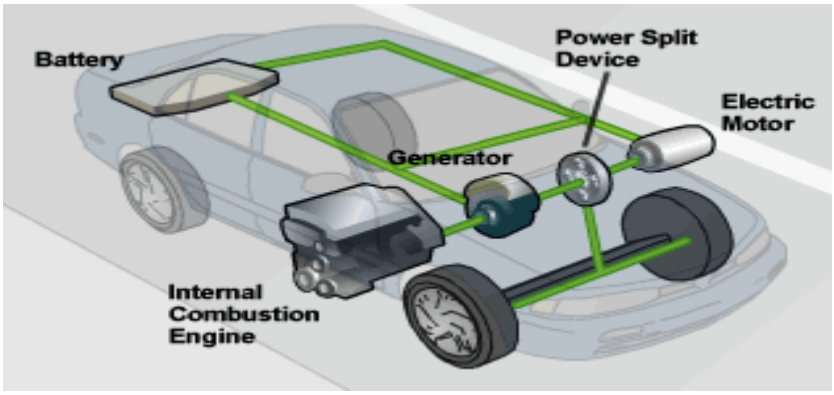
Fuel cells generate electricity from a catalyst-facilitated chemical reaction between hydrogen and oxygen ions in a cell. Several cells combined make up a fuel cell stack. Fuel cell systems have relatively few moving parts, and their only by products are water and heat when pure hydrogen is used as the fuel.

A fuel cell converts the chemical energy of a fuel directly into electricity without any intermediate thermal or mechanical processes. The electrical energy can be used to do useful work directly, while the heat is either wasted or used for other purposes.

A fuel cell "stack" requires fuel, oxidant and coolant in order to operate. The gases must be humidified, and the coolant temperature must be controlled. To achieve this, the fuel cell stack must be surrounded by a fuel system, fuel delivery system, air system, stack cooling system, and humidification system.



HYBRID VEHICLES

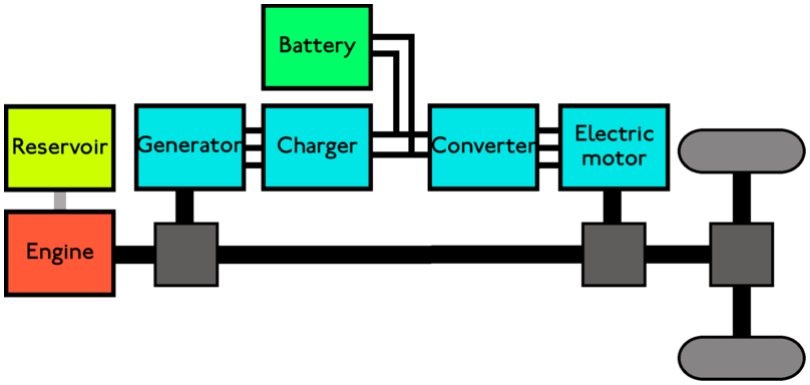


A hybrid vehicle is a vehicle that has two sources of power. A typical hybrid vehicle will have a fuel-driven combustion engine along with a rechargeable system for storing energy. A hybrid vehicle may also have other power sources such as a mechanism to utilize the power of the wind. Alternatively, the vehicle may use mechanical power like the pedaling motion of an individual. Based on the engine used, a hybrid vehicle may be classified into parallel and series type.

ADVANTAGE

- Fuel economy: The primary purpose of a hybrid vehicle is to achieve better fuel economy compared to conventional engines. At the same time, hybrid engines cut down gases emitted and are generally considered a 'cleaner' alternative to combustion engines.
- Recapture energy: Hybrid vehicles utilize the regenerative braking technique. This means that the energy used for braking is picked up by the battery system and used to charge the battery. This minimizes loss of energy.

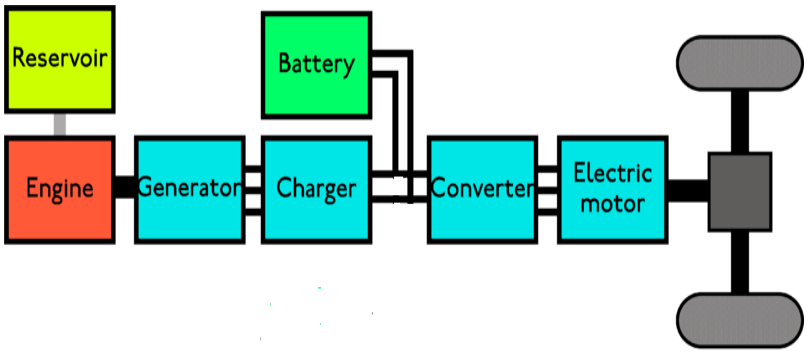
PARALLEL HYBRID VEHICLES



Parallel hybrid systems, which are most commonly produced at present, have both an internal combustion engine (ICE) and an electric motor coupled. If they are joined at an axis in parallel, the speeds at this axis must be identical and the supplied torques adds together. Most electric bicycles are of this type. When only one of the two sources is being used, the other must

also rotate in an idling manner, be connected by a one-way clutch, or freewheel. With cars, the two sources may be applied to the same shaft- for example with the electric motor lying between the engine and transmission. The speeds are thus equal and the torques adds up, with the electric motor adding or subtracting torque to the system as necessary. The Honda Insight uses this system.

SERIES HYBRID VEHICLES



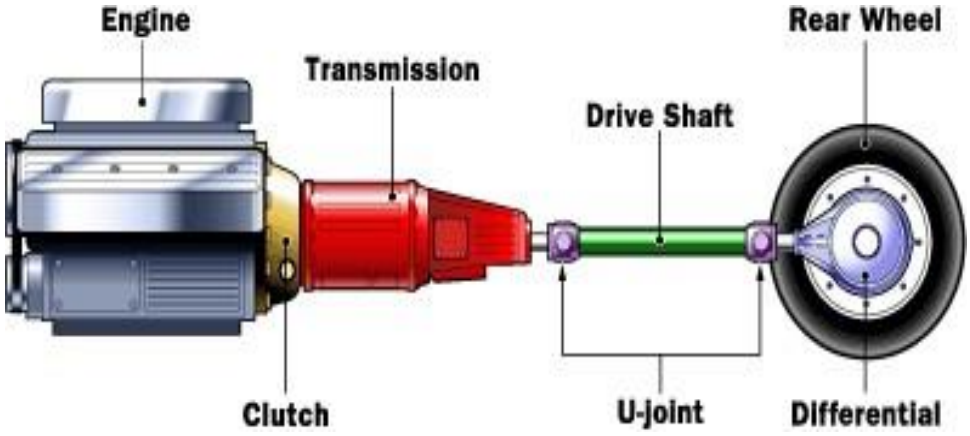
Series hybrids have also been referred to as extended-range electric vehicles (EREV) or range-extended electric vehicles (REEV) where they are designed to be run mostly by the battery, but have a petrol or diesel generator to recharge the battery when going on a long drive. However, range extension can be accomplished with either series or parallel hybrid layouts. Alternatively, it can be viewed as an electric transmission, with the battery storing reserve power until it is needed. In a series-hybrid system, the combustion engine drives an electric generator instead of directly driving the wheels. The generator provides power for the driving electric motors. In short, a series-hybrid is simple; the vehicle is driven only by electric motor traction with a generator set providing the electric power.

UNIT- III

SUSPENSIONSYSTEM

TRANSMISSION SYSTEM

The mechanism that transmits the power developed by the engine of automobile to the engine to the driving wheels is called the transmission system (or power train).Chief function of the device is to receive power at one torque and angular velocity and to deliver it at another torque and the corresponding angular velocity.

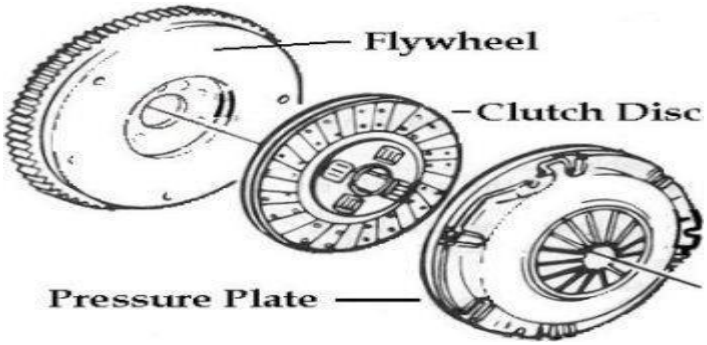


REQUIREMENTS OF TRANSMISSION SYSTEM

- To provide for disconnecting the engine from the driving wheels.
- When the engine is running, to enable the connection to the driving wheels to be made smoothly and without shock.
- To enable the leverage between the engine and driving wheels to be varied.
- It must reduce the drive-line speed from that of the engine to that of the driving wheels in a ratio of somewhere between about 3:1 and 10:1or more, according to the relative size of engine and weight of vehicle.
- Enable the driving wheels to rotate at different speeds.

CLUTCH

The clutch is housed between the engine and transmission where it provides a mechanical coupling between the engine's flywheel and the transmission input shaft. The clutch is operated by a linkage that extends from the passenger compartment to the clutch housing.

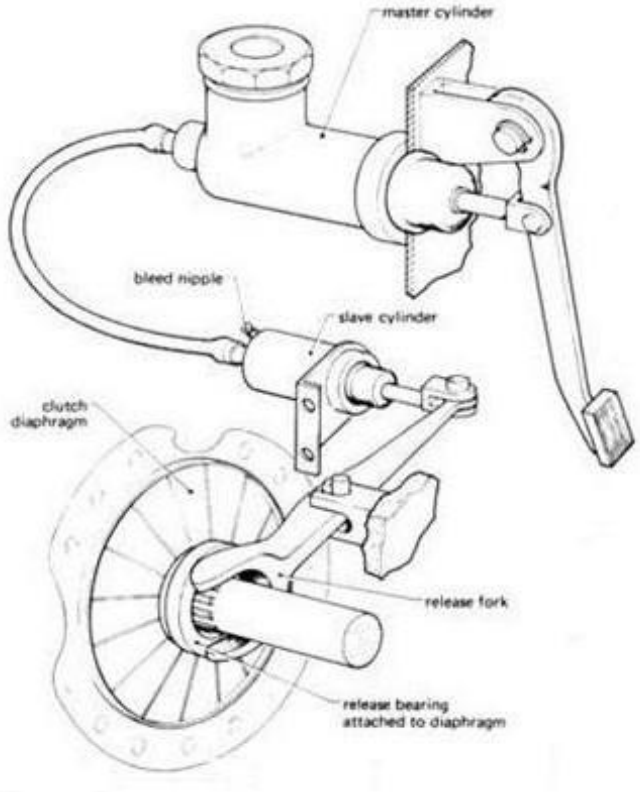


The purpose of the clutch is to disconnect the engine from the driven wheels when a vehicle is changing gears or being started from rest.

TYPES OF CLUTCH

- Coil spring type clutch
- Diaphragm type clutch
- Single plate clutch
- Multi plate clutch
- Centrifugal clutch

CLUTCH RELEASE MECHANISM



A hydraulic clutch release mechanism uses a simple hydraulic circuit to transfer clutch pedal action to the clutch fork. It has three basic parts—master cylinder, hydraulic lines, and a slave cylinder. Movement of the clutch pedal creates hydraulic pressure in the master cylinder, which actuates the slave cylinder. The slave cylinder then moves the clutch fork.

Clutch Fork

The clutch fork, also called a clutch arm or release arm, transfers motion from the release mechanism to the release bearing and pressure plate. The clutch fork sticks through a square hole in the bell housing and mounts on a pivot. When the clutch fork is moved by the release mechanism, it PRIES on the release bearing to disengage the clutch.
A rubber boot fits over the clutch fork. This boot is designed to keep road dirt, rocks, oil, water, and other debris from entering the clutch housing.

Clutch Housing

The clutch housing is also called the bell housing. It bolts to the rear of the engine, enclosing the clutch assembly, with the manual transmission bolted to the back of the housing. The lower front of the housing has a metal cover that can be removed for fly-wheel ring gear inspection or when the engine must be separated from the clutch assembly. A hole is provided in the side of the housing for the clutch fork. It can be made of aluminum, magnesium, or cast iron.

Release Bearing

The release bearing, also called the throw-out bearing, is a ball bearing and collar assembly. It reduces friction between the pressure plate levers and the release fork. The release bearing is a sealed unit pack with a lubricant. It slides on a hub sleeve extending out from the front of the manual transmission or transaxle.
The release bearing snaps over the end of the clutch fork. Small spring clips hold the bearing on the fork. Then fork movement in either direction slides the release bearing along the transmission hub sleeve.

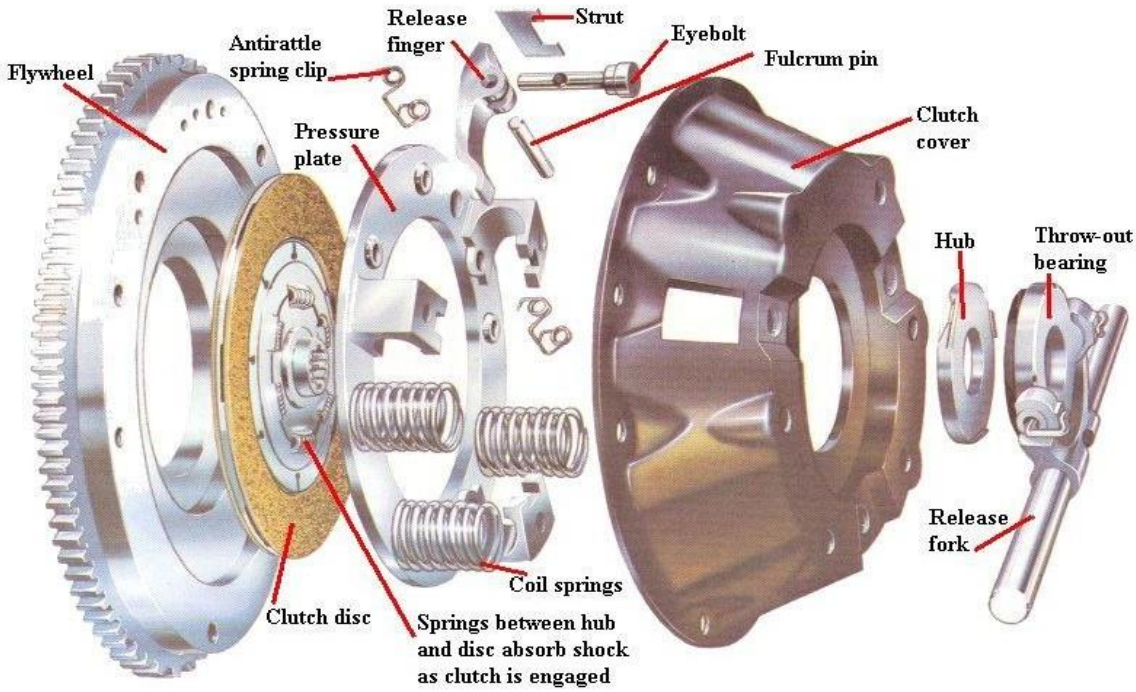
Pressure Plate

The pressure plate is a spring-loaded device that can either engage or disengage the clutch disc and the flywheel. It bolts to the flywheel. The clutch disc fits between the flywheel and the pressure plate. There are two types of pressure plates—the coil spring type and the diaphragm type.

COIL SPRING TYPE CLUTCH

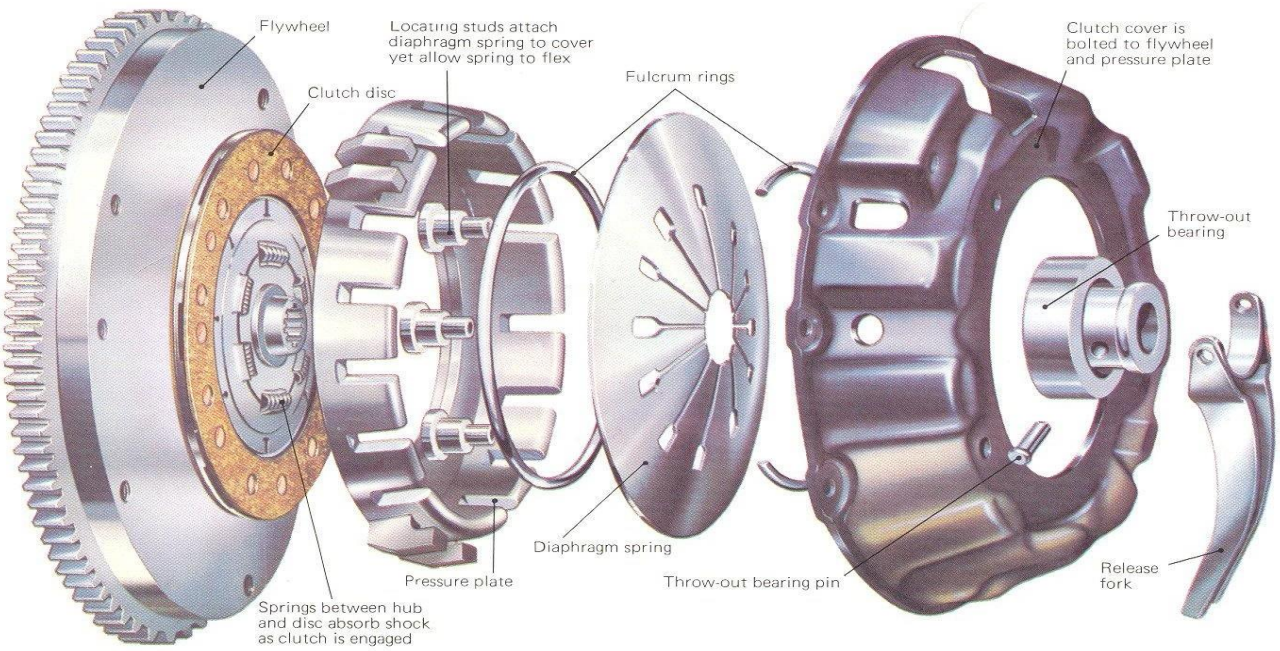
Coil spring pressure plate uses small coil springs similar to valve springs. The face of the pressure plate is a large, flat ring that contacts the clutch disc during clutch engagement. The backside of the pressure plate has pockets for the coil springs and brackets for hinging the release levers. During clutch action, the pressure plate moves back and forth inside

the clutch cover. The release levers are hinged inside the pressure plate to pry on and move the pressure plate face away from the clutch disc and flywheel. Small clip-type springs fit around the release levers to keep them rattling when fully released. The pressure plate cover fits over the springs, the release levers, and the pressure plate face. Its main purpose is to hold the assembly together. Holes around the outer edge of the cover are for bolting the pressure plate to the flywheel.



DIAPHRAGM TYPE CLUTCH

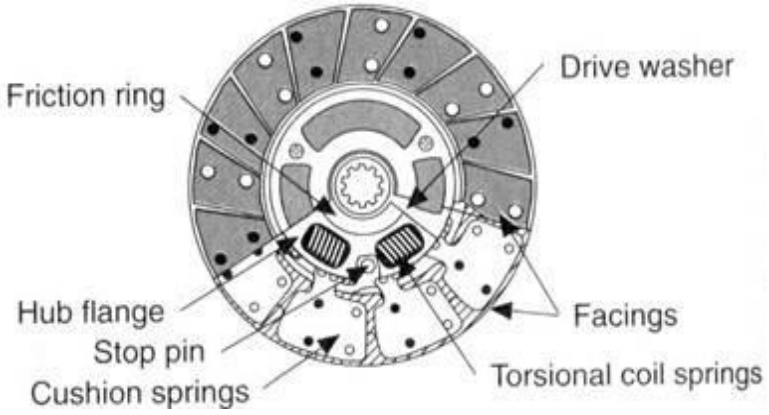
Diaphragm pressure plate uses a single diaphragm spring instead of coil springs. This type of pressure plate functions similar to that of the coil spring type. The diaphragm spring is a large, round disc of spring steel. The spring is bent or dished and has pie-shaped segments running from the outer edge to the center. The diaphragm spring is mounted in the pressure plate with the outer edge touching the back of the pressure plate face. The outer rim of the diaphragm is secured to the pressure plate and is pivoted on rings (pivot rings) approximately 1 inch from the outer edge. Application of pressure at the inner section of the diaphragm will cause the outer rim to move away from the flywheel and draw the pressure plate away from the clutch disc, disengaging the clutch.



Clutch Disc

The clutch disc, also called friction lining, consists of a splined hub and a round metal plate covered with friction material (lining). The splines in the center of the clutch disc mesh with the splines on the input shaft of the manual transmission. This makes the input shaft and disc turn together. However, the disc is free to slide back and forth on the shaft.

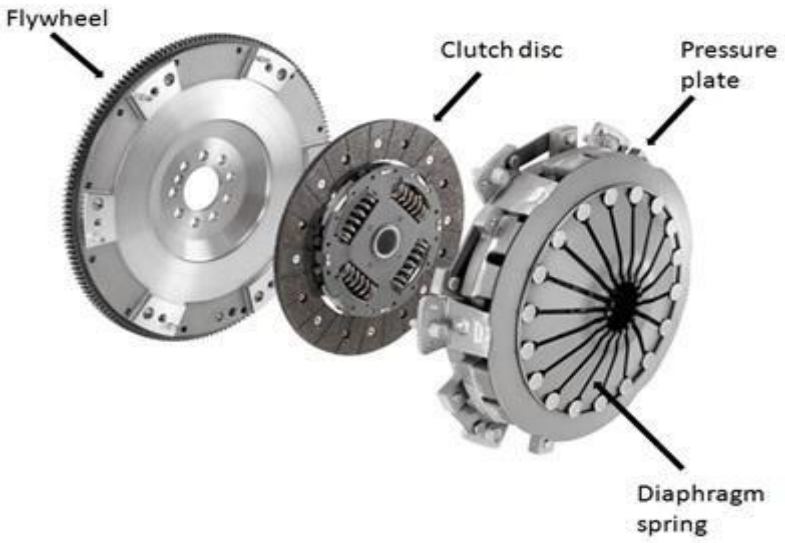
Clutch disc torsion springs, also termed damping springs, absorb some of the vibration and shock produced by clutch engagement. They are small coil springs located between the clutch disc splined hub and the friction disc assembly. When the clutch is engaged, the pressure plate jams the stationary disc against the spinning flywheel. The torsion springs compress and soften, as the disc first begins to turn with the flywheel.



Clutch disc facing springs, also called the cushioning springs, are flat metal springs located under the friction lining of the disc. These springs have a slight wave or curve, allowing the lining to flex inward slightly during initial engagement. This also allows for smooth engagement.

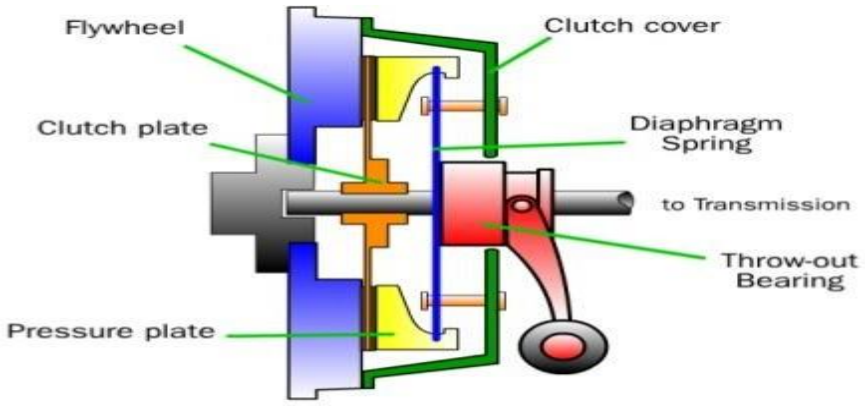
The clutch disc friction material, also called disc lining or facing, is made of heat-resistant asbestos, cotton fibers, and copper wires woven or molded together. Grooves are cut into the friction material to aid cooling and release of the clutch disc. Rivets are used to bond the friction material to both sides of the metal body of the disc.

Flywheel



The flywheel is the mounting surface for the clutch. The pressure plate bolts to the flywheel face. The clutch disc is clamped and held against the flywheel by the spring action of the pressure plate. The face of the flywheel is precision machined to a smooth surface. The face of the flywheel that touches the clutch disc is made of iron. Even if the flywheel were aluminum, the face is iron because it wears well and dissipates heat better.

SINGLE PLATE CLUTCH



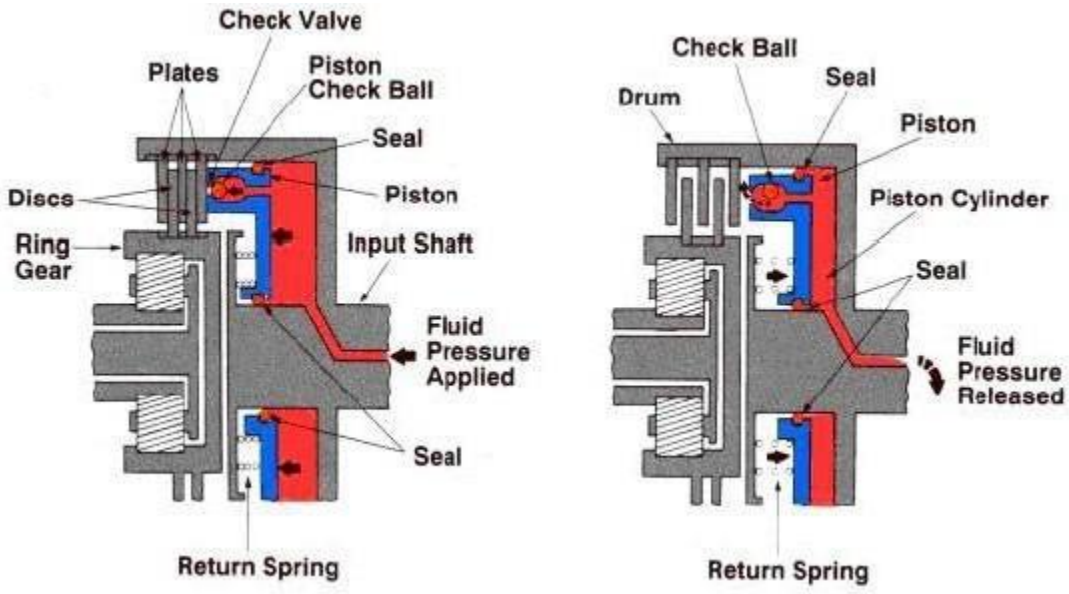
A single disc or plate clutch consists of a clutch plate whose both sides are faced with a frictional material. It is mounted on the hub which is free to move axially along the splines of the driven shaft. The pressure plate is mounted inside the clutch body which is bolted to the flywheel. Both the pressure plate and the flywheel rotate with the engine crank shaft or the driving shaft. The pressure plate pushes the clutch plate towards the flywheel by a set of strong springs which are arranged radially inside the body.

The three levers (also known as release levers or fingers) are carried on pivots suspended from the case of the body. These are arranged in such a manner so that the pressure plate moves away from the flywheel by the inward movement of a trust bearing. The bearing is mounted upon a forked shaft and moves forward when the clutch pedal is pressed when the clutch pedal is pressed down, its linkage forces the thrust release bearing to move in towards the flywheel and pressing the longer ends of the levers inward.

The axial pressure exerted by the spring provides a frictional force in the circumferential direction when the relative motion between the driving and driven members tends to take place. If the torque due to this frictional force exceeds the torque to be transmitted, then no slipping takes place and the power is transmitted from the driving shaft to the driven shaft.

MULTI PLATE CLUTCH

Multiplate clutch consists of a number of clutch plates, where as single plate clutch has only one clutch plate. As the number of clutch plates is increased, the friction surface also increases. The increased number of friction surfaces in clutch increases the capacity of the clutch to transmit torque in automobiles.



The plates are alternately fitted to the engine shaft and gear box shaft. They are firmly pressed by strong coil springs and assembled. Each of the alternate plate slides in grooves on the

flywheel and the other slides on splines on the pressure plate. Therefore, each alternate plate has inner and outer splines.

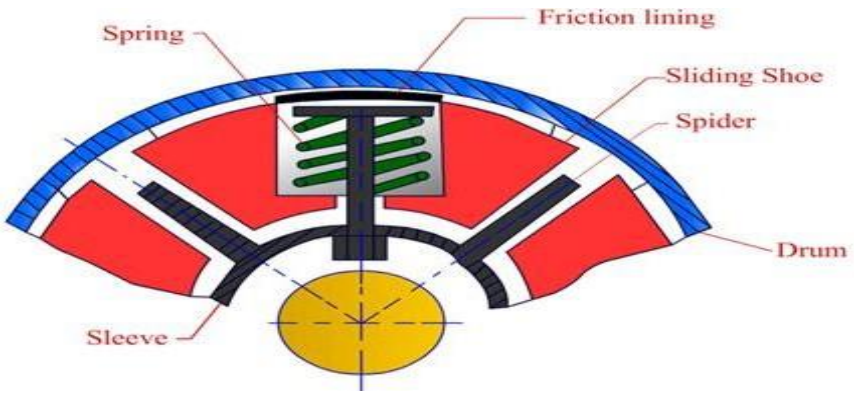
The multiplate clutches operating condition may be dry or wet. When the clutch is operated in an oil bath, it is called a wet clutch. When the clutch is operated dry, it is called dry clutch. The wet clutches are generally used in conjunction with the automatic transmission automotives.

Multiplate clutch works in the same way as the single plate clutch i.e. by operating the clutch pedal. The multiplate clutches are used in heavy commercial vehicles, automobiles, racing cars and motor cycles for transmitting high torque.

CENTRIFUGAL CLUTCH

A centrifugal clutch is a clutch that uses centrifugal force to connect two concentric shafts, with the driving shaft nested inside the driven shaft. It engages more at higher speeds.

The input of the clutch is connected to the engine crankshaft while the output may drive a shaft, chain, or belt. As engine revolutions per minute increase, weighted arms in the clutch swing outward and force the clutch to engage.



The most common types have friction pads or shoes radially mounted that engage the inside of the rim of housing. On the center shaft there are an assorted number of extension springs, which connect to a clutch shoe. When the central shaft spins fast enough, the springs extend causing the clutch shoes to engage the friction face. It can be compared to a drum brake in reverse.

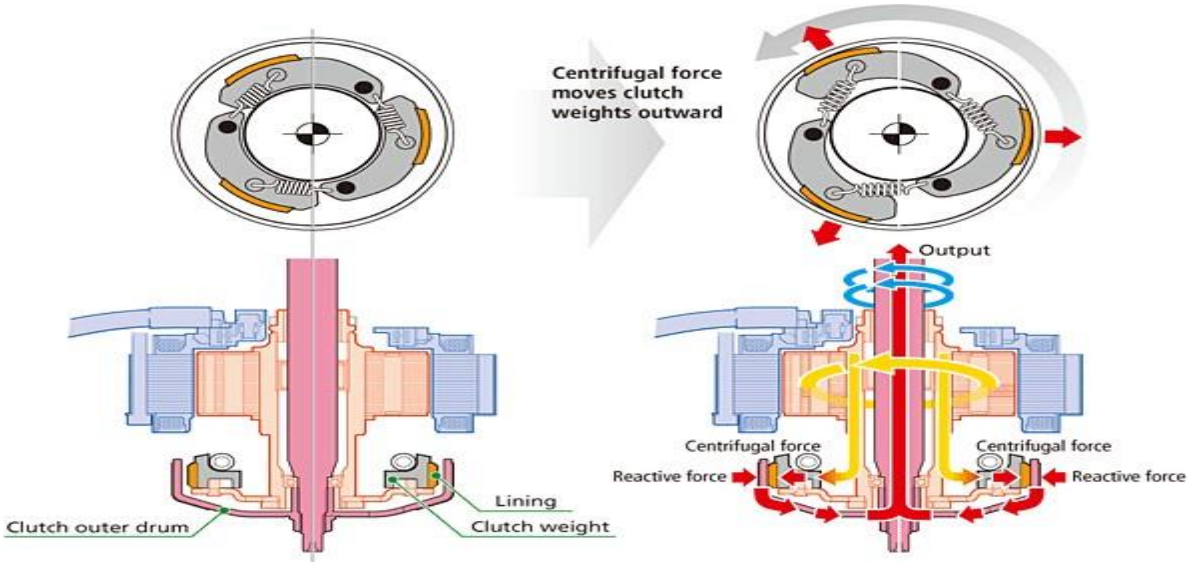
When the engine reaches a certain speed, the clutch activates, working somewhat like a continuously variable transmission. As the load increases, the speed drops, disengaging the clutch, letting the speed rise again and reengaging the clutch. If tuned properly, the clutch will tend to keep the speed at or near the torque peak of the engine. This results in a fair bit of waste heat, but over a broad range of speeds it is much more useful than a direct drive in many applications.

Advantages

- No kind of control mechanism is necessary
- It is cheaper than other clutches.
- Prevents the internal combustion engine from stalling when the output shaft is slowed or stopped abruptly therefore decreases the engine braking force.

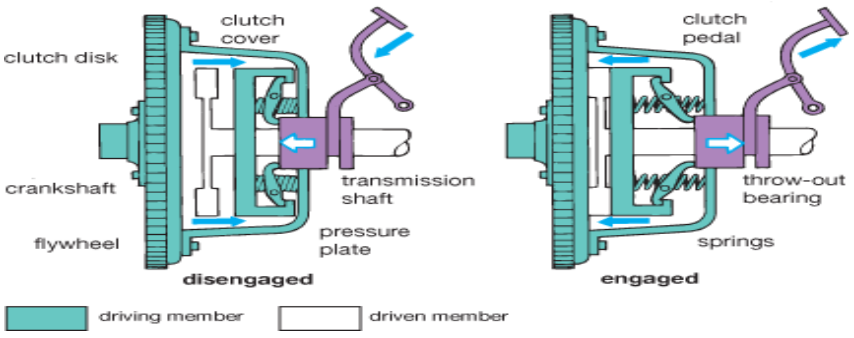
Disadvantages

- Since it involves friction and slipping between driving and driven parts there is loss of power.
- It involves slipping, therefore it is not desirable in high torque requirements or in cases where there is heavy load.



CLUTCH OPERATION

When the operator presses the clutch pedal, the clutch release mechanism pulls or pushes on the clutch release lever or fork . The fork moves the release bearing into the center of the pressure plate, causing the pressure plate to pull away from the clutch disc releasing the disc from the flywheel. The engine crankshaft can then turn without turning the clutch disc and transmission input shaft.



When the operator releases the clutch pedal, spring pressure inside the pressure plate pushes forward on the clutch disc. This action locks the flywheel, the clutch disc, the pressure plate, and the transmission input shaft together. The engine again rotates the transmission input shaft, the transmission gears, the drive train, and the wheels of the vehicle.

GEAR BOX

In motor vehicles, the transmission generally is connected to the engine crankshaft via a flywheel and/or clutch and/or fluid coupling, partly because internal combustion engines cannot run below a particular speed. The output of the transmission is transmitted via driveshaft to one or more differentials, which in turn, drive the wheels. While a differential may also provide gear reduction, its primary purpose is to permit the wheels at either end of an axle to rotate at different speeds (essential to avoid wheel slippage on turns) as it changes the direction of rotation.

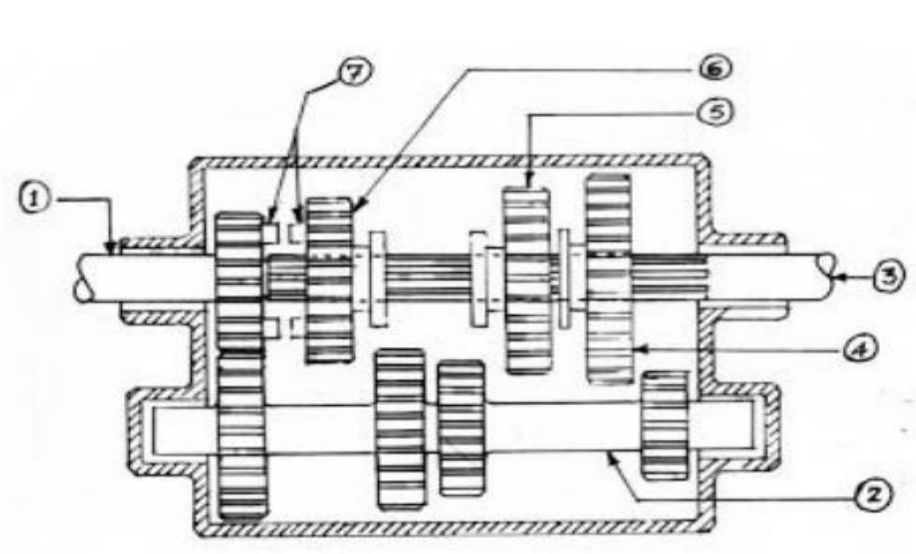
FUNCTION OF THE GEARBOX

- To provide a means to vary the torque ratio between engine and road wheels
- To provide a neutral position so that the engine can be disconnected of the road wheels
- A means to reverse the direction of rotation of the drive

TYPES OF GEAR BOX

- Sliding mesh gear box
- Constant mesh gear box
- Synchromesh gear box
- Automatic gear box

SLIDING MESH GEAR BOX



Primary shaft (main drive gear)

This shaft transmits the drive from the clutch to the gearbox. At the end, the shaft is supported by a spigot bearing positioned close to the splines on to which the clutch driven plate is connected. The main load on this shaft is taken by a bearing; normally a sealed radial ball type, positioned close to an input gear called a constant mesh pinion. The gear is so named because it is always in mesh with a larger gear, a c constant mesh wheel that I part of the lay shaft gear cluster. Note that a small driving gear is called a pinion and a large gear a wheel.

Lay shaft (counter shaft)

This shaft, which is normally fixed to the gearbox casing, supports the various-sized driving pinions of the lay shaft gear cluster.

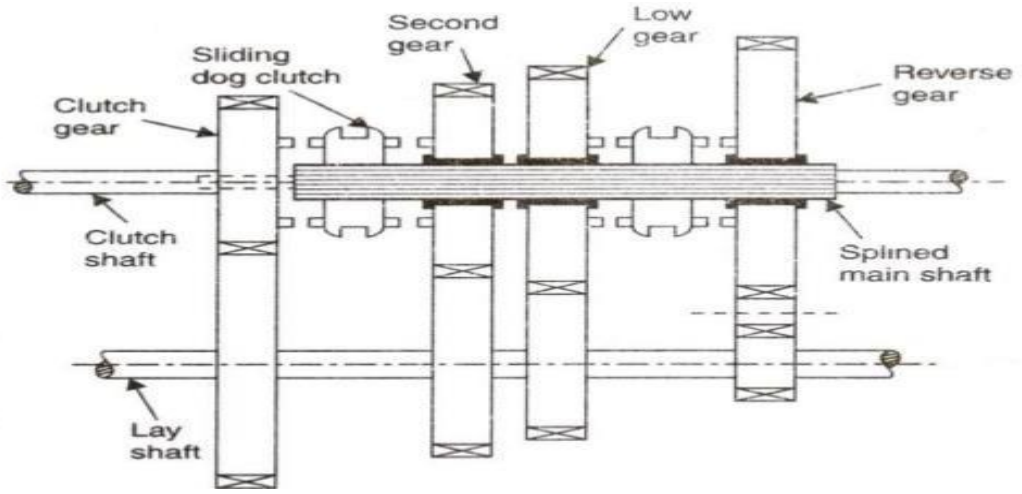
Main shaft

This splined output shaft carries spur gearwheels that slide along the shaft to engage with the appropriate lay shaft gears. At the 'front' end, the main shaft is supported by a spigot bearing situated in the centre of the constant mesh pinion. A heavy duty radial ball bearing is fitted at the other end to take the force of the gears as the attempt to move apart.

Disadvantages

- Gear noise due to the type of gear.
- The difficulty of obtaining a smooth, quit and quick change of gear without the great skill and judgment.

CONSTANT MESH GEAR BOX



The main feature is the use of the stronger helical of double helical gears which lead to quieter operation. In this design, the main shaft pinions revolves freely on bushes or needle-roller

bearings and are all in constant engagement with the corresponding lay shaft wheels. The gear operation is obtained by locking the respective gear to the main shaft by means of a dog clutch.

With this arrangement the quieter-running helical gears can be employed, and during gear changing the noise and wear are reduced by the simultaneous engagement of all the dogs instead of only a pair of gear teeth as on the sliding-mesh gearbox.

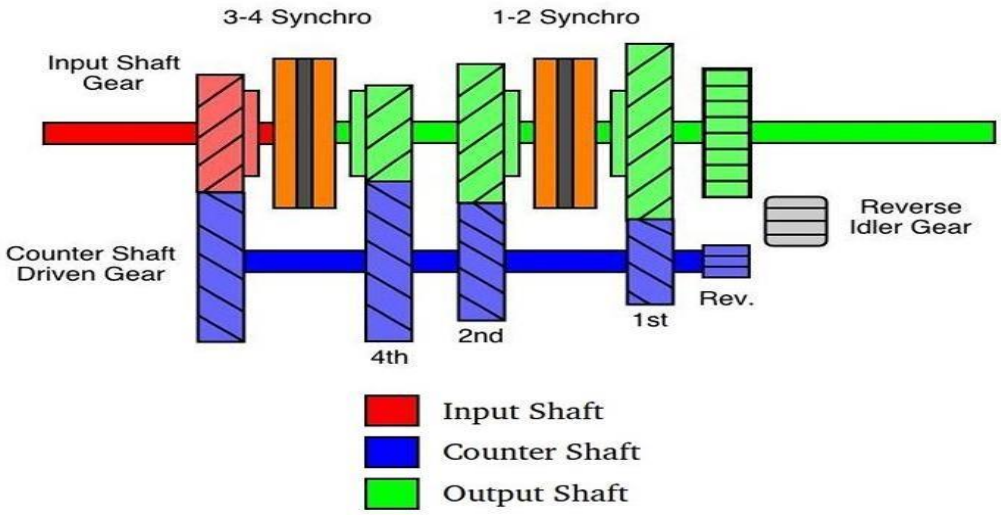
With single helical pinions (double helical is economically impractical), the driving loads on the teeth cause an axial thrust which must be resisted by thrust washers, or shoulders, on the main shaft.

SYNCHROMESH GEAR BOX

Synchromesh Gearbox is used to simplify the operation of changing gears without clashes and damages. The arrangement of Synchromesh gearbox is similar to that of constant mesh gearbox except it uses synchronizer unit instead of Dog Clutches. The synchronizer unit first engages two gears into frictional contact. Once their speed attains equal or synchronized, the gears are engaged smoothly. Hence it provides easy and noiseless gear changing operation.

Construction

- A Synchromesh unit has two sets of sleeves.
- Internal sleeve is splined to the output shaft and can slide easily on both sides. Outer sleeve engage the gears.
- The unit has gunmetal faced female cone which can be mounted on the male cones integrated with main gears.
- Shift mechanism is linked to the grooves on the outer sleeve and can be moved to mesh with each gear.

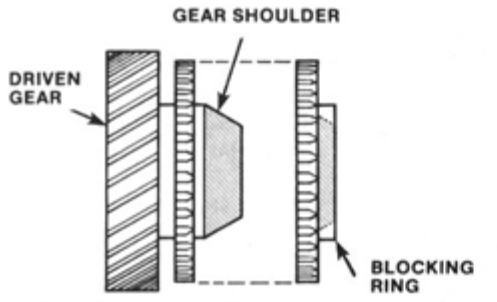


Working of Synchromesh Gearbox

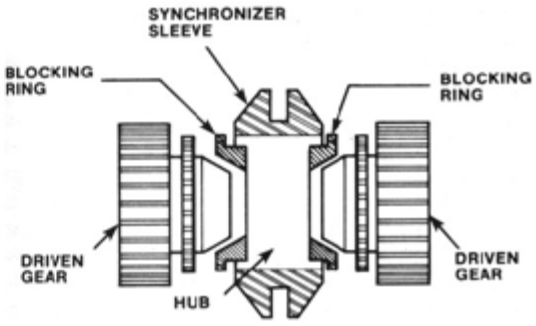
1. **Neutral Gear**
   Dog Clutch and Synchromesh units are not in mesh with any gears. Hence there is no transmission from input shaft to output shaft.

2. **First & Reverse Gears**
   First and Reverse gears are engaged only when the vehicle is stationary. Hence there is no need for synchromesh unit. They are engaged by dog clutch similar to Constant Mesh gearbox. Power is transmitted from input shaft to output shaft according to gear combinations.

3. **Second, Third and Top Gears**
   When the gear lever is operated to the select these gears, the synchromesh unit is moved towards that gear. The female cone in the inner sleeve is mounted over male cone in the main gear. They establish a frictional contact. This friction of cones helps to move the output shaft with main gear. When the speeds of both main gear and shaft are synchronized, further movement of gear lever engages outer sleeves with the gears similar to a dog clutch. Hence power is transmitted to output shaft.



Gear shoulder and blocker ring mating surfaces.



SYNCHRONIZER IN NEUTRAL POSITION BEFORE SHIFT

LAYOUT OF GEAR BOX

Direct gearbox layout

- Sliding mesh gear box layout
- Constant mesh gear box layout
- Synchromesh gear box layout
- Automatic gear box layout
- Overdrive layout

In direct gearbox layout

- Transaxle layout
- Two-speed transfer gearbox(transfer case)

- Four- and all-wheel drive

TRANSAXLE LAYOUT

The lay shaft two-stage gearbox is used in both longitudinal- and transverse-engine front-wheel-drive case

FOUR WHEEL DRIVE

4WD systems are those having a separate transfer case. They also give the driver the choice of operating in either 2WD or 4WD through the use of a shift lever or shift button.

ALL-WHEEL DRIVE

AWD systems do not have a separate transfer case. They use a front-wheel-drive transaxle equipped with a viscous clutch, center differential, or transfer clutch. All-Wheel-drive system does not give the driver the option of selecting 2WD or 4WD modes. The system operates in continuous 4WD. All-wheel-drive vehicle are usually passenger cars that are not designed for off-road operation. They are designed to increase vehicle performance in poor traction situations, such as icy snowy roads, and in emergencies.

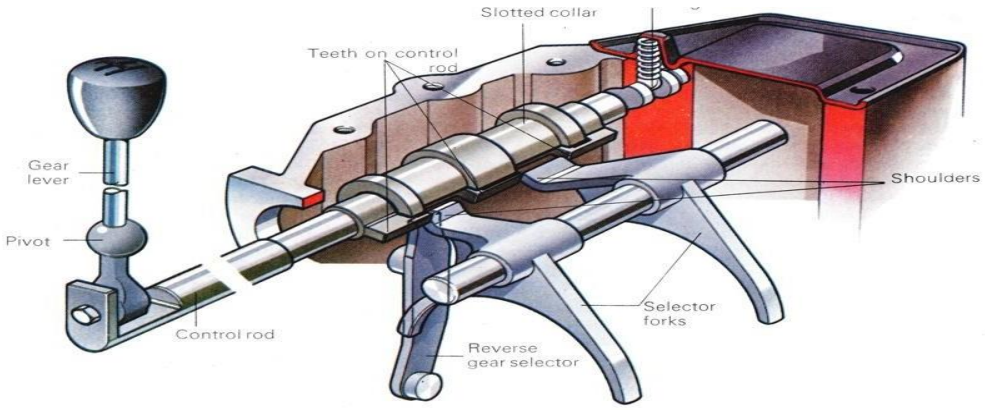
GEAR SELECTOR AND SHIFTING MECHANISM

The gear changing mechanism starts, quite obviously, with the gear lever. In early cars the lever ran straight down into the gearbox because the engine and gearbox were separated by a short shaft and this brought the gearbox into a convenient position for a directly-acting lever. The modern practice is to bolt these two major components together, in what became known as "unit construction".

This gave greater rigidity to the transmission, as well as cutting manufacturing costs. It did mean, though, that the gearbox was mounted further forward than it used to be and this, in turn, meant that a floor-mounted lever could not be directly coupled to the gearbox. If it was it would have been extremely awkward for the driver, being either too far forward or so long that efficient, accurate changes would be difficult to achieve.

The answer was to incorporate a remote control mechanism between the lever and the gearbox. Most floor-mounted, remote control mechanisms are based on a rod, though cables have been used, the rod running forward from the gear lever to the striker arm in the gearbox. This may sound simple enough but there are problems involved in this type of linkage.

- **The Sliding Selector Mechanism**
- **The Ball-Type Selector**
- **Steering Column Mounted Gear Levers**
- **Cable gear mechanisms**



OVERDRIVE

Overdrive is a device interposed between the transmission (gear box) and propeller shaft to permit the propeller shaft to turn faster than or-over drive the transmission main shaft. It is so called because it provides a speed ratio over that of the high speed ratio. The overdrive permits the engine to operate only about 70 percent of the propeller shaft speed, when the vehicle is operating in the high speed ranges. The overdrive is suited to high powered cars employing three-speed gear boxes, since in order to produce flexible top gear performance a low gear final drive;nay be necessary resulting in the engine running faster as high speeds than is desired. Generally an overdrive is fitted to the top gear only, but some sport cars have an over drive on2nd, 3rd and top gear giving seven forward speeds.

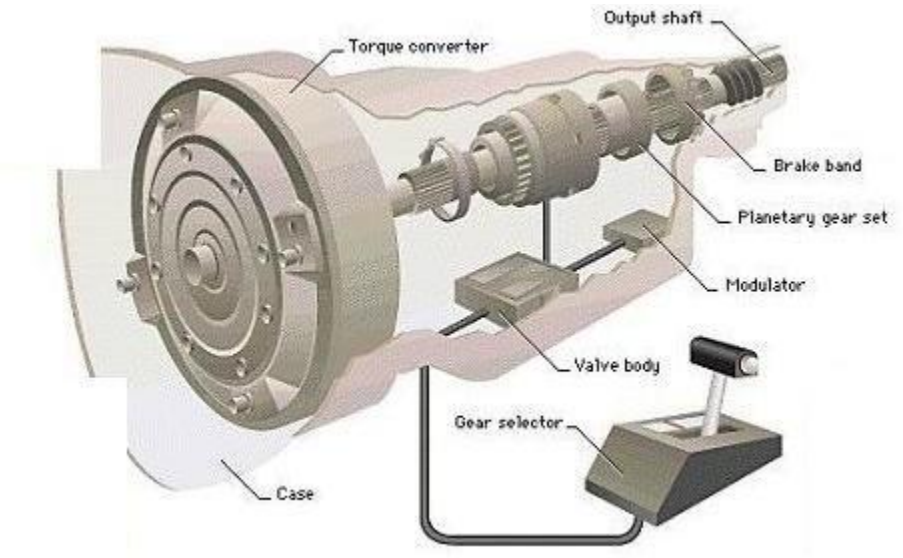
Overdrive is usually, employed to supplement conventional transmission. It is bolted to the rear of the transmission between the transmission and propeller shaft. A slightly higher rear-axle gear ratio is employed with an overdrive than without one.

Advantages

1. Prolonged engine life since the engine turns slower for any given speed.
2. Fuel economy.
3. Reduced vibration and noises.

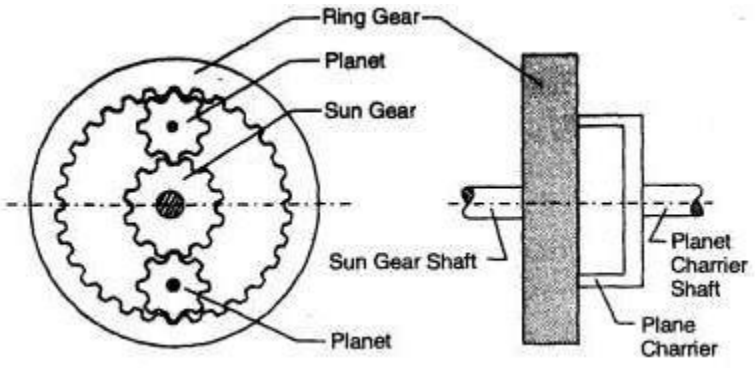
AUTOMATIC TRANSMISSION

Automatic transmission system is the most advanced system in which drives mechanical efforts are reduced very much and different speeds are obtained automatically. This system is generally also called hydramatic transmission. It contains epicyclic gear arrangement, fluid coupling and torque converter. In these planetary gears sets are placed in series to provide transmission. This type of transmission are used by Skoda, Toyota, Audi, etc



Epicyclic gearing (planetry gearing)

It is a gear system consisting of one or more outer gears, or planet gears, revolving about a central gear .By using epicyclic gear, different torque speed ratio can be obtained. It also compact the size of gear box.

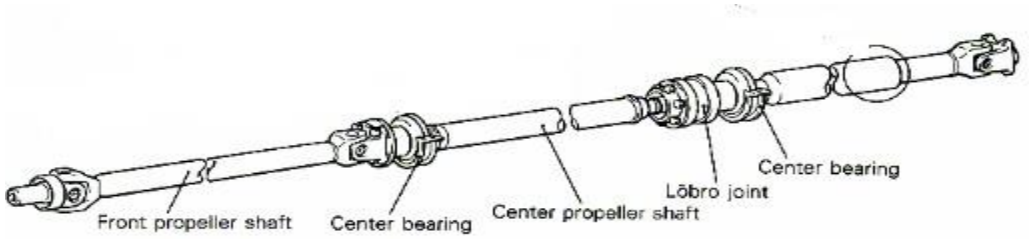


Stages of automatic transmission

- Park (P) - selecting the park mode will lock the transmission, thus restricting the vehicle from moving.
- Reverse(R) - selecting the reverse mode puts the car into reverse gear, allowing the vehicle to move backward.
- Neutral (N) - selecting neutral mode disconnects the transmission from the wheel.
- Low (L) - selecting the low mode will allow you to lower the speed to move on hilly and middy areas.
- Drive (D) - selecting drive mode allows the vehicle to move and accelerate through a range of gears.

PROPELLER SHAFT

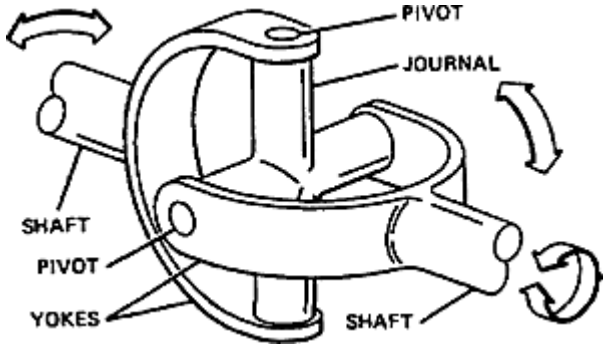
The propeller shaft is a shaft that transmits power from transmission (gear box) to the differential. On one end, propeller shaft in connected to main transmission shaft by universal joint. On the other hand, it is connected to differential pinion shaft by another universal joint. Propeller shaft transmits the rotary motion of main transmission shaft (coming from gear box) to the differential so that rear wheels can be rotated. A sliding (slip) joint, is also fitted between universal joint and propeller shaft on transmission side which takes care of axial motion of propeller shaft.



It is important to note that the differential pinion shaft and transmission main shaft are not in single horizontal level. The rear axle and differential is attached to automobile frame via springs. Therefore, distance between differential and gear box keeps on changing as vehicle moves along irregular road surface. Angle of propeller shaft also changes due to this fact. Universal joints provided at two ends take care of these two changes.

UNIVERSAL JOINT

Universal joint is used to connect two shafts at an angle for transmitting torque. In the transmission shaft of an automobile, two universal joints are used – one between main transmission shaft and propeller shaft and another between other end of propeller shaft and the differential. Therefore, the universal joints make the joints flexible so that power can be transmitted at an angle.



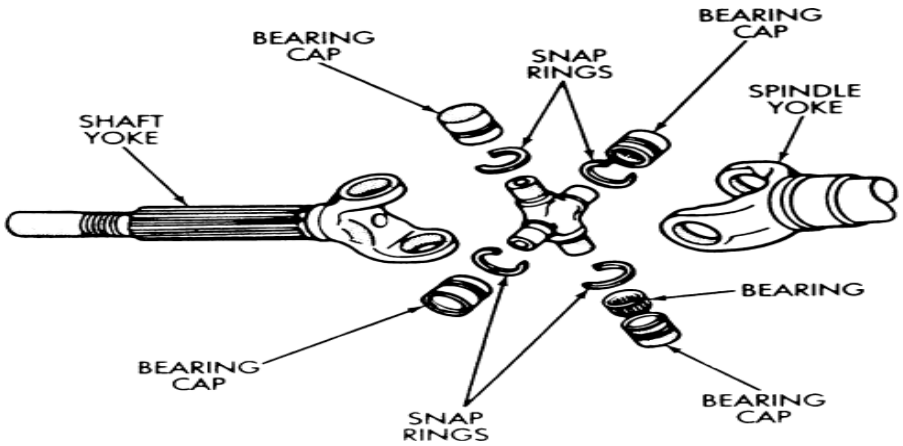
A universal joint takes care of rising and falling motion of the rear end of the propeller shaft which is connected to differential.

Types of universal joint

- Cross or spider joint (variable velocity joint).
- Ball and trunnion joint (variable velocity joint).
- Constant velocity joints.

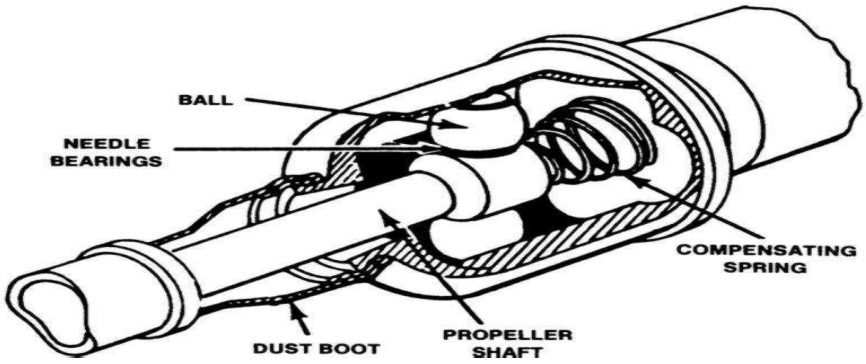
Cross or spider joint

It consists of two Y-shaped yokes and a cross piece (spider). One yoke is connected to driving shaft and other is connected to driven shaft. The cross-piece has four-arms which are known as trunnions and are attached to the ends of yokes. Four needle bearings are provided – one for each arm of cross-piece. These bearings allow the yoke to swing around the trunnion when driving and driven shaft remove together at an angle.



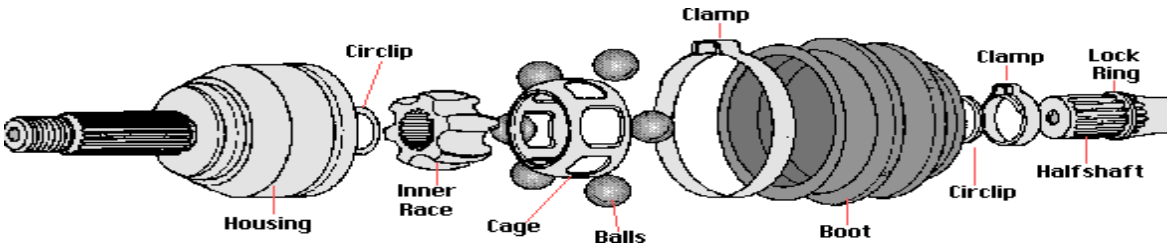
This is a variable velocity joint, i.e. the driving and driven shaft do not rotate at the same speed throughout a revolution. However, their rpm is same. This happens because both shafts are not in straight line. Ring and trunion type and cross ball type designs also come in this category of universal joints.

Ball and trunnion joint



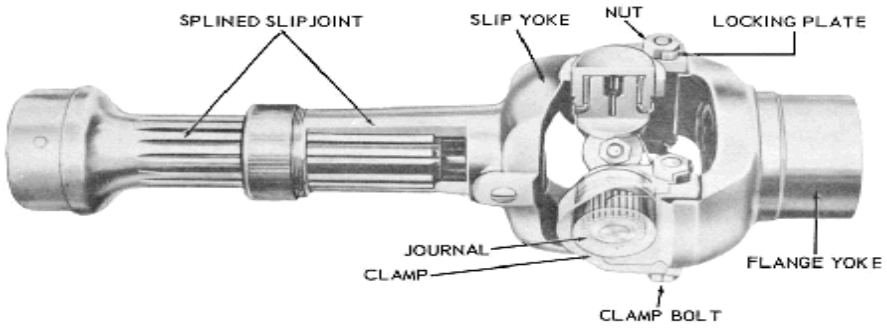
This type of joint consists of a ball type head which is fastened to one end of the propeller shaft. A pin is also pressed through this end of shaft. Two steel balls are fitted at the end of this pin. The joint facilitates rotary motion through ball and pin. The balls can also move axially.
Ball and trunnion joint is also a variable velocity joint.

Constant velocity joints



This type of joint permits movement of both driving and driven shafts at constant velocity. Because, two joints in this case operate at same angles. These joints are generally used when the automobile in a front wheel (axle) drive. Because speed variation between driving and driven shaft will introduce difficulty in steering and excessive tyre wear.

SLIP JOINT



A slip joint is provided between universal joint and propeller shaft to adjust for any change in length. Slip joint allows for the change in length of propeller shaft. When spring is compressed propeller shaft shortens and when spring is expanded, propeller shaft returns to original length.

FINAL DRIVE

Final drive is the last stage of power transfer from propeller shaft to rear (or front if – automobile is front wheel driven) axles and then to wheels. It turns the propeller shaft motion at right angle to drive the rear axle.
The final drive is composed of a bevel gear (or pinion) and crown wheel. The level pinion is connected to propeller shaft. The pinion is in mesh with the crown wheel. Crown wheel is part of differential. Final drive provides fixed speed reduction. Because the crown wheel has more number of teeth and it is connected to rear axles and level pinion has less number of teeth.

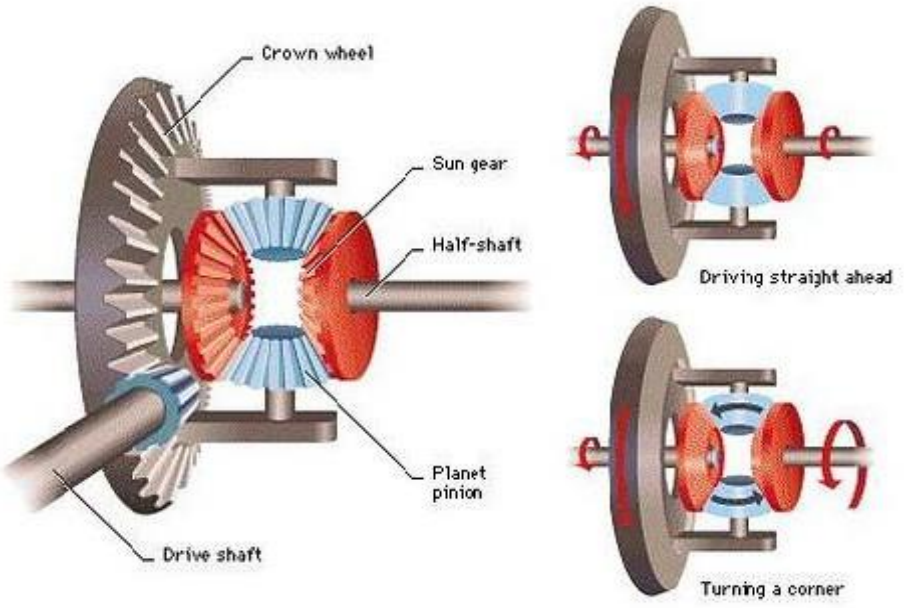
DIFFERENTIAL

When a four wheeler takes a turn, the outer wheel turns faster than inner wheel. Thus, there is relative movement between inner and outer wheel. The function of the differential is to permit the relative movement between inner and outer wheels when vehicle negotiates (takes) a turn. The torque transmitted to each rear wheel is equal in this case, although their speed is different.

The differential is made up of a system of gears which connect the propeller shaft and rear axles. It is a part of inner axle housing assembly. The assembly consists of differential, rear axles, wheels and bearings.

Construction and Working

It consists of sun gears, planet pinion, a cage, a crown wheel and a bevel pinion. A sun gear is attached to inner end of each rear axle (half shaft). A cage is attached on left axle. A crown gear is attached to the cage and the cage rotates with the crown gear.



The crown gear is rotated by the bevel pinion. Crown gear and cage remain free on the left rear axle. Two planet pinions are on a shaft which is supported by the cage. The planet pinions mesh with the sun gears. The rear wheels are attached to outer ends of two rear axles. When the cage rotates, sun gears rotate. Thus, the wheels also rotate. In case one inner wheel runs slower than other when the vehicle takes a turn, the planet gears spin on their shaft, transmit more rotary motion to outer wheel. When vehicle runs in straight line, the crown gear, cage, planet pinions and sun gears turn together as a unit. Thus there is no relative motion.

Types of differential

- Conventional type

- Non-slip or self locking type
- Double reduction type

Conventional type

Conventional type delivers same torque to each rear wheel. If any of the wheels slips due to any reason the wheel does not rotate and vehicle does not move.

Non-slip or self locking type

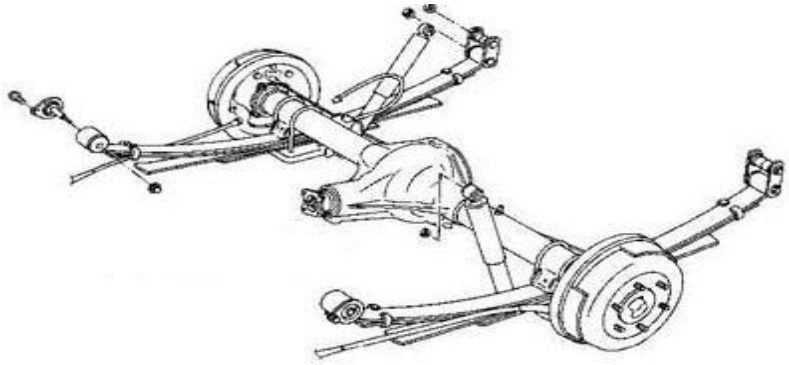
Non-slip or self locking type differential overcomes this drawback. It construction is similar to that of conventional type differential. But, two sets of clutch plates are provided additionally. Also, the ends of planet shafts are left loose in notches provided on the differential cage.

Double reduction type

Double reduction type differential provides further speed reduction by additional gear. This type of differential is used in heavy duty automobiles which require larger gear reduction between engine and wheels.

REAL AXLE ARRANGEMENT

Rear axle transmits power from differential to the wheels so that vehicle may move. Rear axle is not a single piece but it is in two parts which are connected by the differential.



Each part of rear axle is called the half shaft. Outer end of the rear axle carries the wheel while inner end is connected to sun gear of the differential. In vehicles which employ rear wheel drive, rear wheels are driving wheels. However, in front wheel drive vehicles, front wheels are driving wheels. Rear axles and differential are completely enclosed in a housing to protect them from dust, dirt, water and any possible damage.

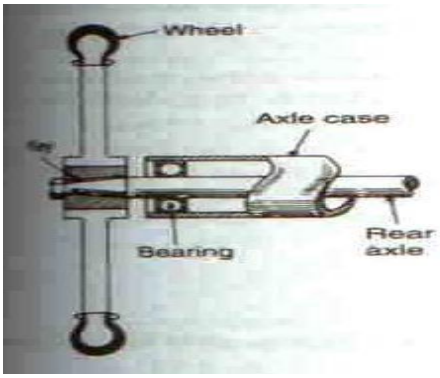
Functions of Rear Axle

- To transmit power from differential to the wheels. This is main function.
- To carry weight of automobile.

Rear axles differ on the basis of method of supporting them and mounting of rear wheels. On this basis, these axles can be classified into three types

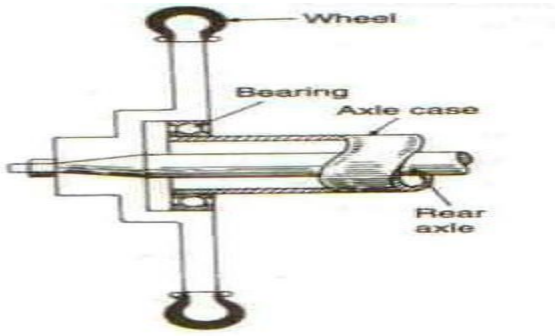
- Half floating axle
- Three-quarter floating axle
- Fully floating rear axle

Half floating axle



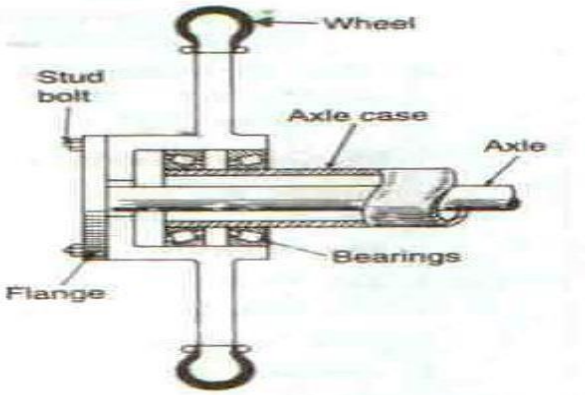
In a half floating rear axle, the axle is at the centre of the axle casing and the bearings are inside the axle casing. The weight of vehicle is transmitted first to suspension spring, then to axle casing, then to axle and finally to ground.

Three-quarter floating axle



In three-quarter floating rear axle, bearings are on the outer side of axle casing, i.e. between casing and wheel. In this case, major part of vehicle weight is taken by axle casing and not by axle. This is the main advantage of three-quarter floating type over half floating type. Thus, axle breakdown is less in this case compared to the previous type.

Fully floating rear axle



In fully floating rear axle, the bearings are provided between axle casing and the wheel. In this case, all the vehicle weight is transmitted to ground through axle case and wheel. The axle is not supported by bearings but it is supported at both ends. This type of axle is very strong and therefore, it is used for heavy duty vehicles. In the event of breakdown of axle, wheel cannot come out. This, it is safer but costly.

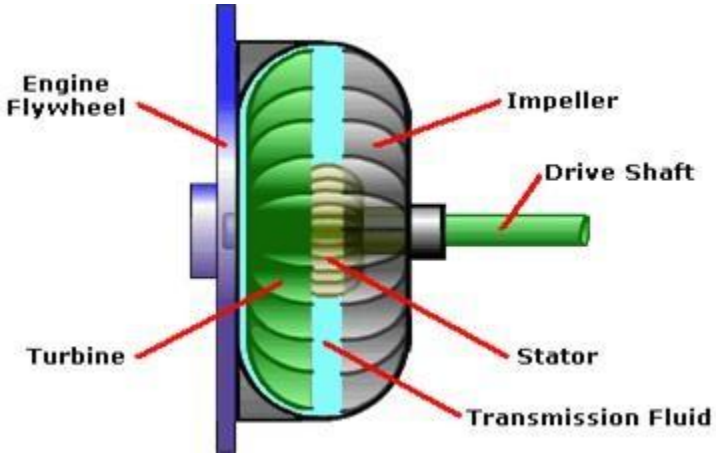
HYDRAULIC COUPLING

A fluid coupling or hydraulic coupling is a hydrodynamic device used to transmit rotating mechanical power. It has been used in automobile transmissions as an alternative to a mechanical clutch.

Fluid couplings work on the hydrodynamic principle. It consists of a pump-generally known as impeller and a turbine generally known as rotor, both enclosed suitably in a casing. The impeller and the rotor are bowl-shaped and have large number of radial vanes. They face each other with an air gap. The impeller is suitably connected to the prime mover while the rotor has a shaft bolted to it. This shaft is further connected to the driven machine through a suitable arrangement. Oil is filled in the fluid coupling from the filling plug provided on its body. A fusible plug is provided on the fluid coupling which blows off and drains out oil from the coupling in case of sustained overloading.

Operating Principle

There is no mechanical interconnection between the impeller and the rotor (i.e. the driving and driven units) and the power is transmitted by virtue of the fluid filled in the coupling. The impeller when rotated by the prime mover imparts velocity and energy to the fluid, which is converted into mechanical energy in the rotor thus rotating it.



The fluid follows a closed circuit of flow from impeller to rotor through the air gap at the outer periphery and from rotor to impeller again through the air gap at the inner periphery. To enable the fluid to flow from impeller to rotor it is essential that there is difference in the "head" between the two and thus it is essential that there is difference in R.P.M., known as slip between the two. Slip is an important and inherent characteristic of a fluid coupling resulting in several desired advantages. As the slip increases more and more fluid can be transferred from the impeller to the rotor and more torque is transmitted. However when the rotor is at standstill, maximum fluid is transmitted from the coupling. The maximum torque is limiting torque. The fluid coupling also acts as a torque limiter.

UNIT- IV

BRAKES

WHEEL

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

TYPES OF WHEEL

- Rim wheel
- Alloy wheel
- Spoke or wired wheel
- Split wheel

RIM WHEEL

The **rim** is the "outer edge of a wheel, holding the tyre".It makes up the outer circular design of the wheel on which the inside edge of the tyre is mounted on vehicles such as automobiles. Mostly made by steel.

ALLOY WHEEL

Alloy wheels are wheels that are made from an alloy of aluminium or magnesium. Alloys are mixtures of metal and other elements. They generally provide greater strength over pure metals, which are usually much softer and more ductile. Alloys of aluminium or magnesium are typically lighter for the same strength, provide better heat conduction, and often produce

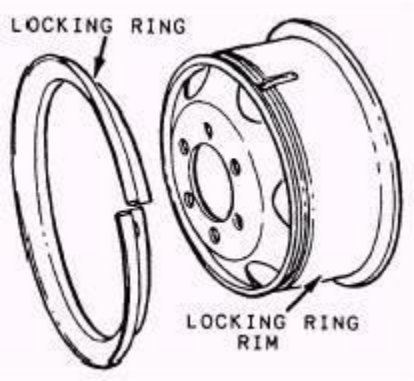
improved cosmetic appearance over steel wheels. Although steel is also an alloy, consisting of iron and carbon, it is the most common material used in wheel production. The term "alloy wheel" is usually reserved for wheels made from nonferrous alloys.

SPOKE WHEEL

A spoke is one of some number of rods radiating from the center of a wheel (the hub where the axle connects), connecting the hub with the round traction surface.

SPLIT WHEEL

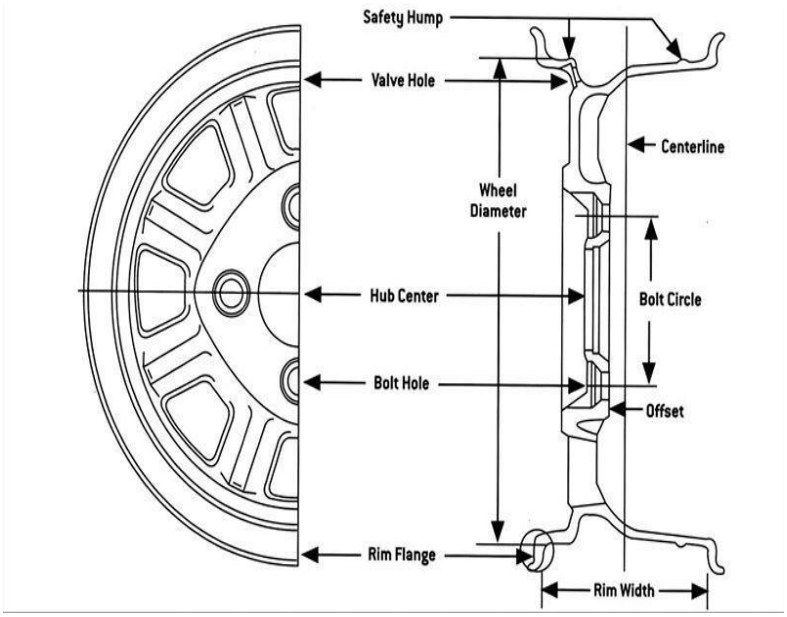
Truck tyres are split rims and rims with removable side rings.



SLIP ANGLE

In vehicle dynamics, slip angle or sideslip angle is the angle between a rolling wheel's actual direction of travel and the direction towards which it is pointing

WHEEL CONSTRUCTION



TYRES

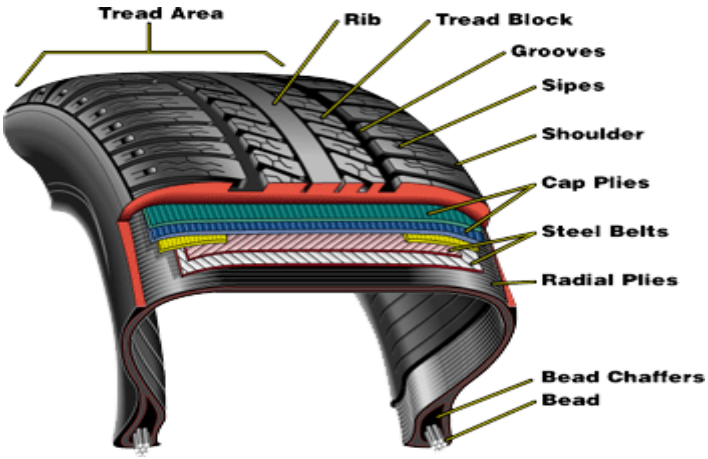
The tyre provides a cushion between the vehicle and the road to reduce the transmission of road shocks. It also provides friction to allow the vehicle perform its normal operations. Modern tyres are manufactured from a range of materials. The rubber is mainly synthetic.

Two types of tyre construction are common – cross-ply and radial. Most passenger cars now use radial tyres, as do most 4-wheel-drives and heavy vehicles. Tube tyres require an inner tube to seal the air inside the tyre.

Tubeless tyres eliminate the inner tube by making the complete wheel and tyre assembly air-tight. A special, air-tight valve assembly is needed. This can be a tight fit into the rim, or it can be held with a nut and sealing washers.

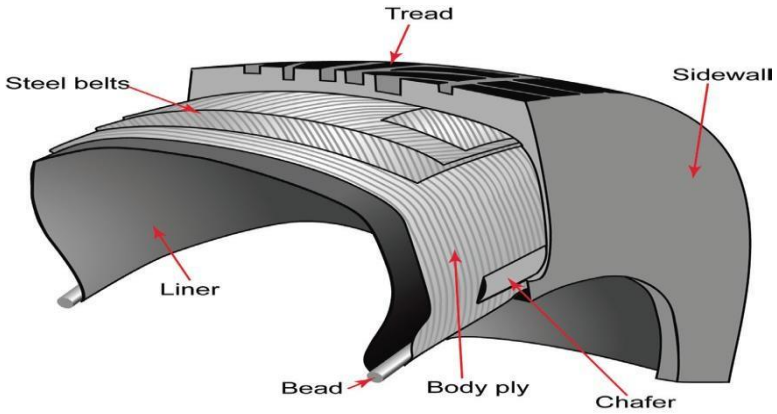
CONSTRUCTION

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



RADIAL PLY TYRES

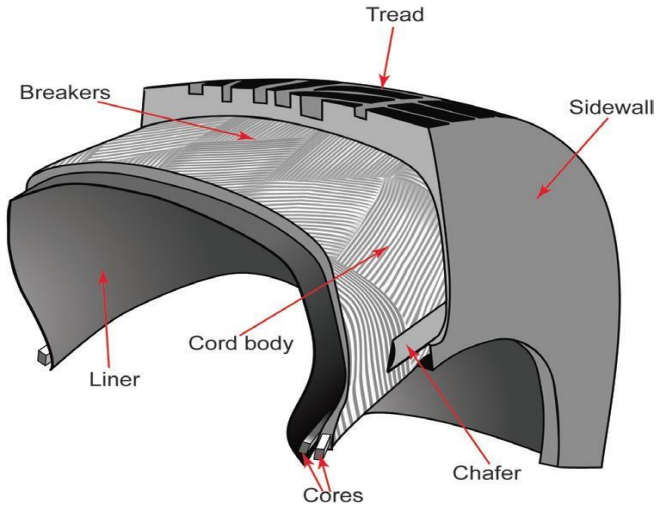
Radial ply tyres have much more flexible sidewalls due to their construction. They use 2 or more layers of casing plies, with the cord loops running radially from bead to bead.



The sidewalls are more flexible because the casing cords do not cross over each other. However, a belt of 2 or more bracing layers must be placed under the tread. The cords of the bracing layers maybe of fabric, or of steel and are placed at 12, to 15 degrees to the circumference line. This forms triangles where the belt cords crossover the radial cords. The stiff bracing layer links the cord loops together to give fore and stability, when accelerating, or braking and it prevents any movement of the cords during cornering. The cord plies flex and deform only in the area above the road contact patch. There are no heavy plies to distort and flexing of the thin casing generates little heat, which is easily dispersed. A radial ply tyre runs cooler than a comparable cross-ply tyre and this increase tread life. A radial tyre has less rolling resistance as it moves over the road surface.

CROSS-PLY TYRES

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



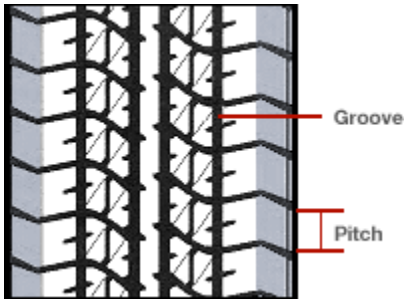
This provides a strong, stable casing, with relatively stiff side walls.However during cornering, stiff sidewalls can distort the tread and partially lifting it off the road surface. This reduces the friction between the road and the tyre. Stiff sidewalls can also make tyres run at a high temperature.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

TREAD PATTERNS

The tread of a tire or track refers to the rubber on its circumference that makes contact with the road or the ground. As tires are used, the tread is worn off, limiting its effectiveness in providing traction. A worn tire can often be retreaded

The word tread is often used casually to refer to the pattern of grooves molded into the rubber. Those grooves are correctly called the tread pattern, or simply the pattern. The grooves are not the tread. This distinction becomes significant in the case of racing slicks, which certainly have a tread but do not have a pattern.

TREAD DESIGN

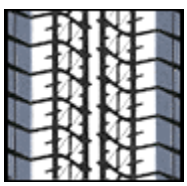


Groove:- The groove is the hollow part or the tread. The grooves are cut which makes the tyre pattern. Tyres come in different patterns and grooves, from the simple block pattern to the modern v tread designs. The hollow part (the groove) is designed to channel the water out and away. As a the tread wears the groove becomes less hollow and apparent. The design of the groove effects the performance and the quality of the tyre.

Pitch:- The pitch/cuff is the small tread at the edge of both sides of the tyre, as shown in the picture on the left. The pitch often wears out before the wrest of the tyre. The function of the pitch is to enhance the performance providing better steering and stability. The pitch is mostly visible on winter tyres, the pitch functions to byte the road and grip the ice.

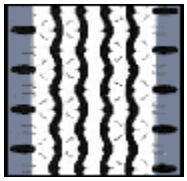
Rib shape:- As the name implies the design of this pattern is like a rib shape with the grooves running from the centre to the edges like a rib pattern. The pattern aids faster water drainage and hence gives good traction on wet roads. This pattern is commonly found on most tyres and in today's high speed driving is suitable for all car types. The disadvantage of this type of design is that it is rotational pattern meaning the direction has to be set when mounting the tyre. A tyre mounted on the left can not be mounted on the right, you have to actually demount the tyre from the rim and swap in the inside to face the outside to set the direction right.

Assymetric pattern:- Asymmetric tyres haven a different tread design on the inside to the outside. An asymmetric pattern looks like two different tyres joined in the middle. The sides differ in pattern to give different functionality, the inside offers better cornering traction while the outside is designed to channel water away. This type of design is commonly found on high-performance vehicles and more so on the wider tyres. Often people confuse a rotation tyre with an asymmetric pattern, unlike a rotation pattern, asymmetric tyres have an inside and outside marking. They also can be mounted on the car on the left or right.



Block shape:- This type of pattern as the name suggests has a block shape design. The grooves are very small the tread pattern is very tight and close. The

advances in tread design have seen this tyre less in use, it was very common on passenger cars up till the 90's. Today it is mostly seen on winter and all season type tyres.



ZigZag shape:- This is a classic tread design for a van. Even today most van tyres apart from a few are still using this zigzag design. The reason for the success of this design in commercial use is because of the grooves that are cut in a zigzag giving the tyre low rolling resistance, low heat generation ideal for the long journeys that commercial vehicles do. There are also many disadvantages of this type of pattern including poor cornering because of flex in the tyre, also lack of grip in wet and dry.

TYRE RETREADING

In the manufacture of a new tyre, approximately 75%-80% of the manufacturing cost is incurred in tyre body and remaining 20%-25% in the TREAD, the portion of the tyre which meets the road surface. Hence, by applying a new TREAD over the body of the worn tyre, a fresh lease of life is given to the tyre, at a cost which is less than 50% of the price of a new tyre. This process is termed as **tyre retreading'**.

However, the body of the used tyre must have some desirable level of characteristics to enable retreading. Retreading cannot also be done if the tyre has already been over used to the extent that the fabric is exposed/damaged. Retreading could be done more than once.

TYPES OF RETREADING

Retreading can be done by the following two processes:

1. Conventional Process (also known as 'mould cure' or 'hot cure' process) - In this process a un-vulcanized rubber strip is applied on the buffed casing of the tyre. This strip takes the pattern of the mould during the process of vulcanization;

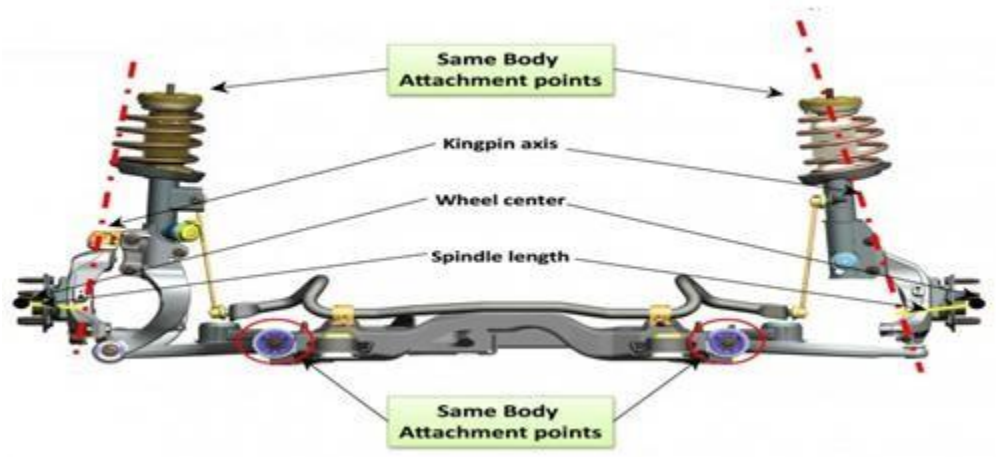
2. Precure Process (also known as 'cold cure')- in this process a tread strip, where the pattern is already pressed and precure is applied to the casing. It is bonded to the casing by means of a thin layer of specially compounded uncured rubber (known as cushion or bonding gum) which is vulcanized by the application of heat, pressure and time.
   The present all India pattern, by type of retreading, is as follows:
   Precured - 50%, Conventional 50%.

Retreading is primarly done in the Truck and Bus trye segment. On an average a Truck/Bus trye is retreaded 1.5 times.

FRONT SUSPENSION

There are two types of front suspension in general use: the independent system & the solid axle

system. Independent suspension usually operates through heavy-duty coil springs or torsion bars and direct, double acting shock absorbers. In solid axle construction, the axle beam and wheel assemblies are connected to the car by leaf springs and direct or in-direct shock absorber.

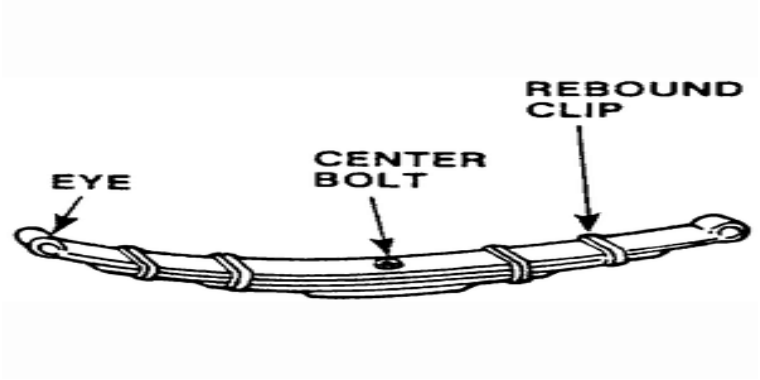


With the solid axle setup, the steering knuckle and wheel spindle assemblies are Connected to the axle beam by bronze-bushed kingpins, or spindle bolts, which provide pivot points for each front wheel. Modern independent front wheel suspension systems use ball joints, or spherical joints, accomplish the purpose. In operation, the swiveling action of the ball joints allows the wheel and spindle assemblies to be turned left and right and to move up & down with changed in roadservice.

LEAFSPRING

Front leaf, or late, springs are used in conjunction with solid axle beams in most truck applications. Rear leaf springs are used on trucks and some passenger cars. Single leaf or multi-leaf springs are usually mounted longitudinally over the front axle beam or under the rear axle housing.

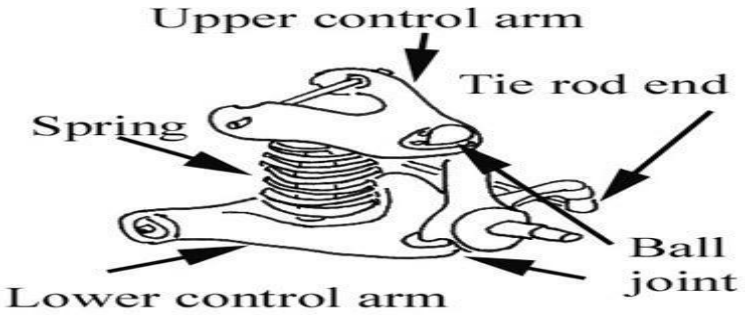
The spring center bolt fastens the leaves together, and its head locates the spring in the front axle beam or saddle on the rear axle housing. U-bolts clamp the spring firmly in place and keep it from shifting. Eyebolts, brackets and shackles attach it to the frame at each end.



COIL SPRINGS

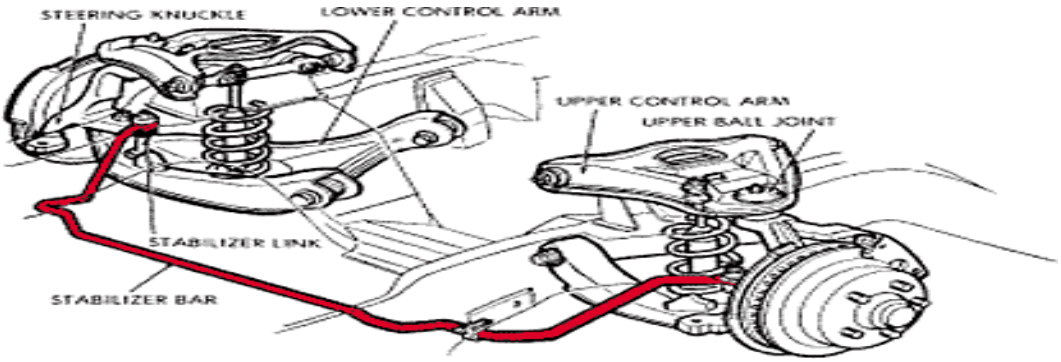
Many independent front suspension systems incorporate compression-type coil springs mounted between the lower control arms and spring housing in the frame. Others have the coil springs mounted above the upper control arms, compressed between a pivoting spring seat bolted to the control arm and a spring tower formed in the front-end sheet metal.

Generally, the upper control arm pivots on a bushing and shaft assembly, which is bolted to the frame. The lower arm pivots on a bushing and shaft assembly or on a bolt cross frame member. When the lower control arm is not the A-frame type, its supported by strut, which runs diagonally from the lower control arm to a bracket attached to the frame. On some models, this strut serves as a support; on others, it provides a means of adjusting caster.



STABILIZER BARS

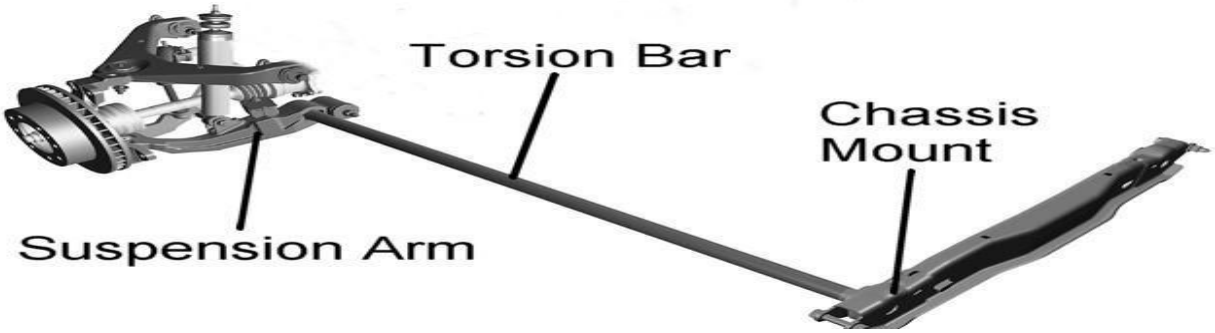
Stabilizers or sway bars are used in conjunction with front suspension on many cars to dampen rod shocks and minimize road sway. These bars are bracketed to the frame front cross member and extend from one lower control arm to the other.



TORSION BARS

Torsion bar suspension is a method of utilizing the flexibility of a steel bar or tube twisting lengthwise to provide spring action. Instead of the flexing action of a leaf spring, the torsion bar twists to exert resistance against up and down movement.

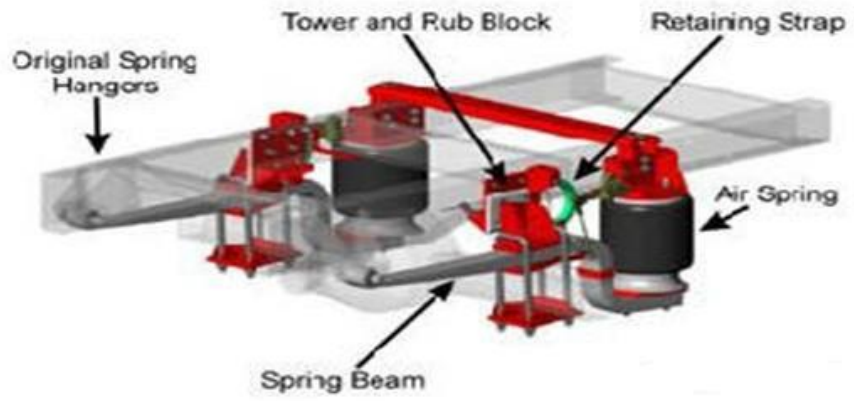
An independently suspended front system with torsion bars mounted lengthwise would have one end of the bars anchored to the car frame and the other end attached to the lower control arms. With each rise and fall of a front wheel, the control arm pivots up and down, twisting the torsion bar along its length to absorb road chock and cushion the ride.



Torsion bars can also be used laterally to provide spring action for front and/or rear wheel independent suspension system. Older Volkswagen cars offer a unique torsion bar arrangement with all four wheels independently suspended, but with two different torsion bar setup in use. At the front, two laminated square torsion bars hin separate axle tubes are anchored at the center to counteract twisting and lateral movement. Each has a lever or torsion arm attached to its outer end. Ball joints connect the torsion arms to the steering knuckle. The wheel spindle trails behind the axle and tends to swing in an arc when moved up and down by road irregularities.

AIR SUSPENSION

Air suspension system are designed to cushion the ride and keep the car, bus or truck level fore and aft and at a constant height regardless of load. Air suspension was introduced on many luxury cars in the late 1950s, but it was dropped after one or two model years. Recently, however, new leveling systems have been researched and developed for passenger car use, including air—adjustable rear shock absorber.



A typical air suspension system consists of an engine-driven air compressor, supply tank, filter or condenser, valves, piping, controls and air springs or bellows.in operation, the air compressor maintains a constant pressure in the supply tank. Air is piped to the control valves, which feed air to each spring as needed. Pressure is automatically increased on either side or at front or rear as required to keep the car level and to keep any desired height from the road (within limit of system).

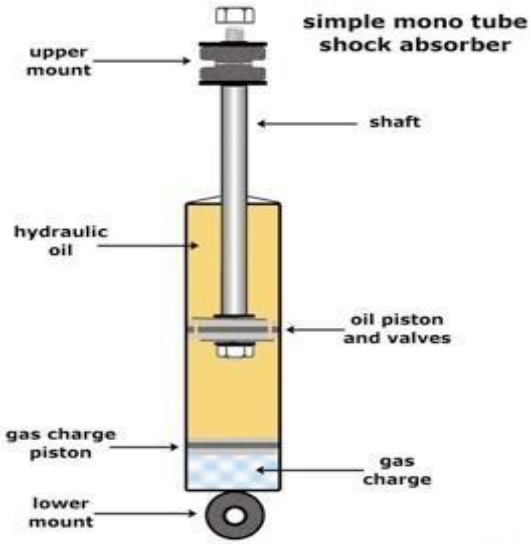
SHOCK ABSORBER

A wide variety of shock absorbing device have been used to control spring action. Today, however, direct double – acting, ‑telescoping‖ hydraulic shock absorbers have almost universal application.

At the rear, the lower end of the shock absorber usually is attached to a bracket welded to the axle housing. The upper end is fastened to the frame or to the coil spring upper seat, which is integral with the frame or body.

The operating principle of direct-acting hydraulic shock absorbers consists of forcing fluid through restricting orifices in the valves. The restricted flow serves to slow down and control the rapid movement of the car springs as they react to road irregularities. Generally fluid flow through the piston is controlled by spring loaded valves.

The hydraulic shock absorber automatically adapts itself to severity of the shock. If the axle moves slowly, resistance to the flow of the fluid will be light. If axle movement is rapid or forceful, the resistance is much stronger since more time is required to force the fluid through the orifices.

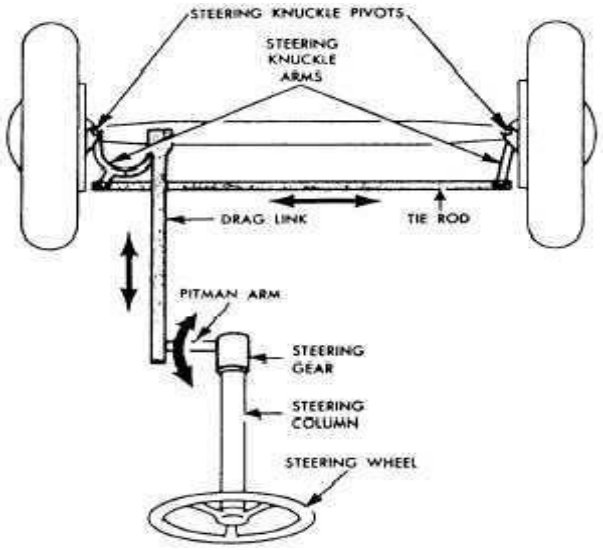


By these hydraulic actions and reactions, the shock absorbers permit a soft ride over small valves and provide firm control over spring action for cushioning large bumps. The double – acting units operate efficiently in both directions. Spring rebound can be almost as violent as the original action that compressed the shock absorber.

UNIT- V

ELECTRICAL SYSTEM

STEERING SYSTEM



This system provides the directional change in the movement of an Automobile and maintain in a position as per the driver's decision without much strain on him.

TYPES OF STEERING SYSTEMS

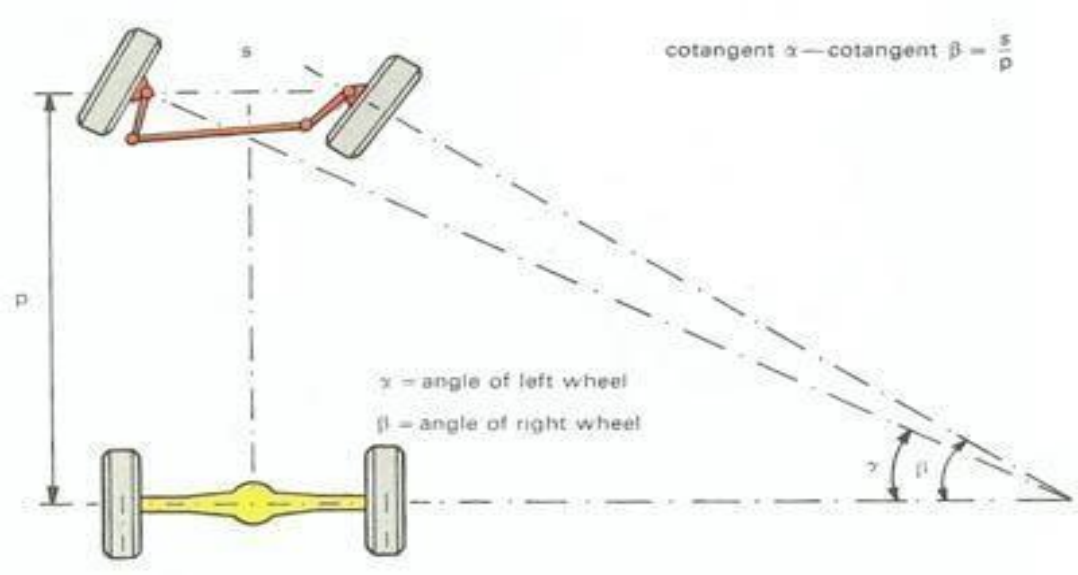
- Linkages steering system
- Rack and pinion steering system

FUNCTION OF STEERING SYSTEM

- It helps in swinging the wheels to the left or right.
- It helps in turning the vehicle at the will of the driver.
- It provides directional stability.
- It is used to minimize the tyre wear and tear.
- It helps in achieving self-centering efforts.
- It absorbs major part of the road shocks.

ACKERMANN PRINCIPLE

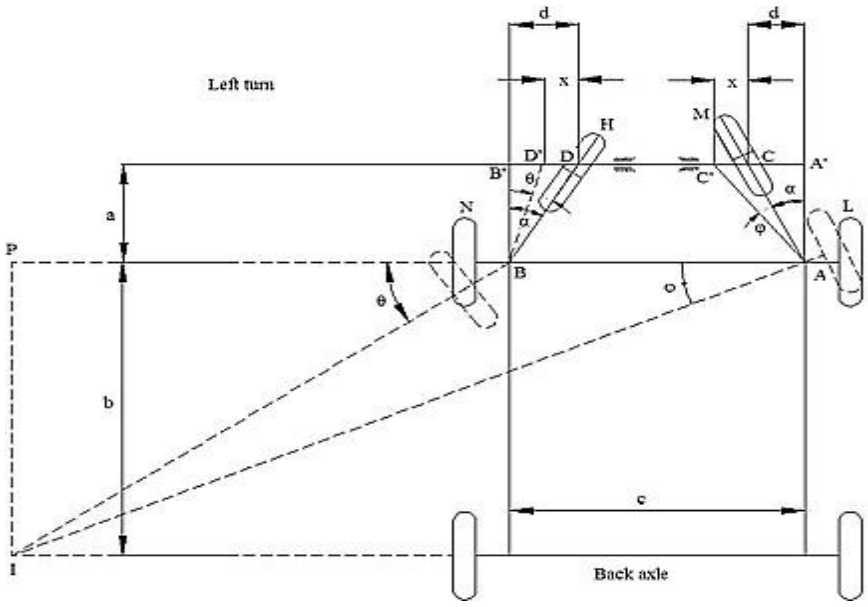
Ackermann steering geometry is a geometric arrangement of linkages in the steering of a car or other vehicle designed to solve the problem of wheels on the inside and outside of a turn needing to trace out circles of different radius.



The intention of Ackermann geometry is to avoid the need for tyres to slip sideways when following the path around a curve. The geometrical solution to this is for all wheels to have their axles arranged as radii of a circle with a common centre point. As the rear wheels are fixed, this centre point must be on a line extended from the rear axle. Intersecting the axes of the front wheels on this line as well requires that the inside front wheel is turned, when steering, through a greater angle than the outside wheel.

DAVIS STEERING GEAR

The Davis Steering gear has sliding pair; it has more friction than the turning pair, therefore the Davis Steering Gear wear out earlier and become inaccurate after certain time. This type is mathematically Accurate.



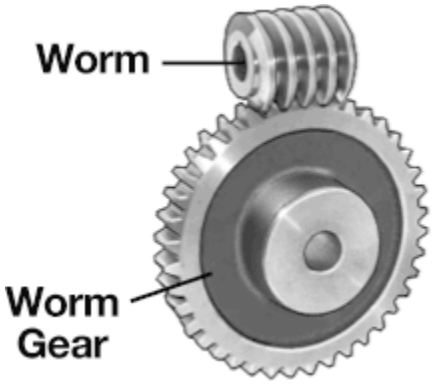
FUNCTIONS STEERING GEAR BOXES

- It converts the Rotary movement of the steering wheel in to the Angular turning of the front wheels.
- It also multiplies driver's efforts and gives MEHANICAL ADVANTAGE.

TYPES OF STEERING GEAR BOXES

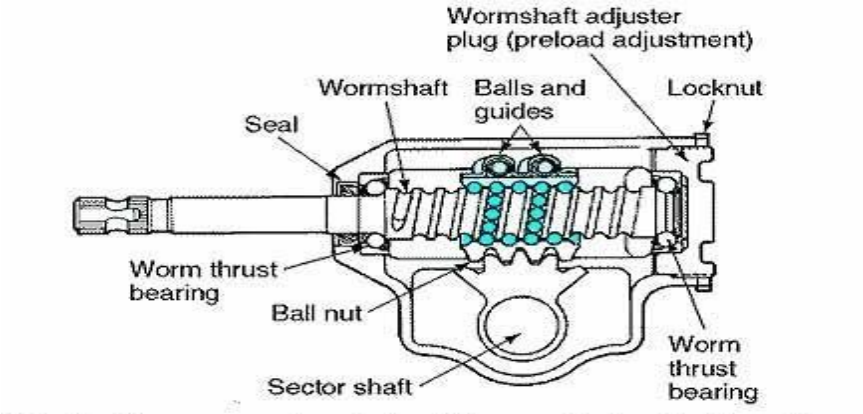
1. Worm and Wheel Steering Gear
2. Re-circulating Ball type Steering Gear
3. Rack and Pinion type Steering Gear
4. Cam and Roller Gear type Steering Gear
5. Worm and Sector Type Steering Gear

1. Worm and Wheel Steering Gear



This type of steering gear has a square cut screw threads at the end of the steering column; which forms a worm, at the end of it a worm wheel is fitted and works rigidly with it. Generally covered shaft is used for the worm wheel. The worm wheel can be turned to a new position the drop arm can be readjusted to the correct working position.

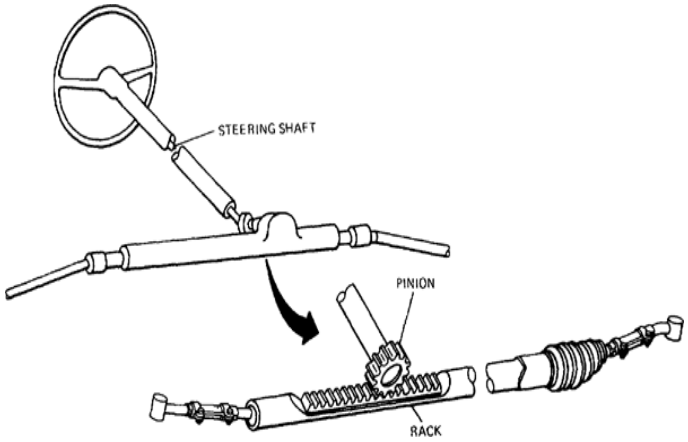
2. Re-circulating Ball type Steering Gear



The balls are recirculated through the ball guides.

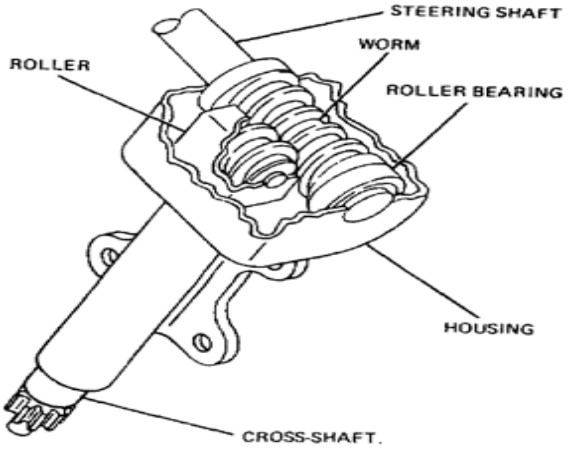
In this type of gear box the endless chain of balls are provided between the worm and nut members. The nut forms a ring of rack having an axial movement. So that the sector on the rocker shaft racks, the balls roll continuously between the worm and nut. Being provided with return chambers at the ends of the worm. This method reduces friction between worm and nut members. This type of steering gear is used for heavy vehicles.

3. Rack and Pinion type Steering Gear



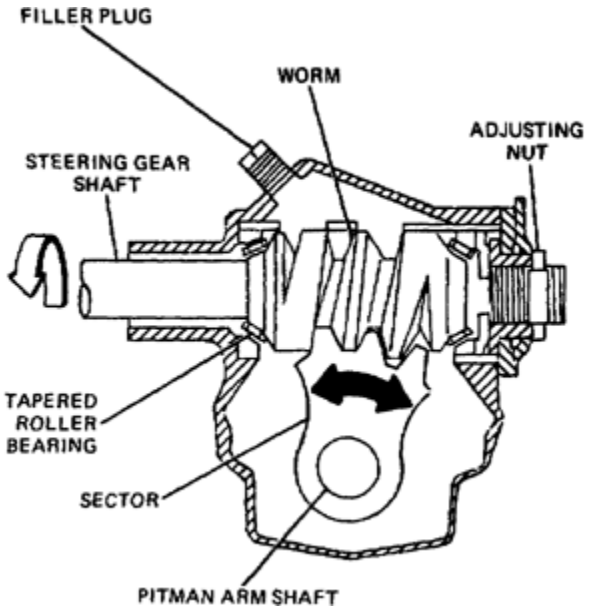
This is common manual type of steering gear box is used in most of the vehicles. In this type of steering a pinion is provided the bottom end of the steering column. The teeth of the pinion wheel in mesh with corresponding teeth provided on the rack, the end of which is connected to the stub axle through the rod. The rotating motion of the pinion operates the rack in FORE and AFT direction which in turn operates the stub axle.

4. Cam and Roller Gear type Steering Gear



The cam and lever steering uses one or two lever studs fitted in taper roller bearing. When the worm in the form of helical groove rotates the stub axle and it also rotates along with it. This imports a turning motion to the drop arm shaft.

5. Worm and Sector Type Steering Gear



In this type the worm on the end of the steering shaft meshes with a sector mounted on a sector shaft. When the worm is rotated by rotation of the steering wheel, the sector also turns rotating the sector shaft. Its motion is transmitted to the wheel through the linkage. The sector shaft is attached to the drop arm or pitmen arm.

STEERING LINKAGES

Steering Linkage is a connection of various links between the steering gear box and the front wheels. The motion of the pitman arm and steering gear box is transferred so the steering knuckles of the front wheels through the steering linkages. The swinging movement of the pitman arm from one side to the other side gives angular movement to the front wheel through the steering linkages.

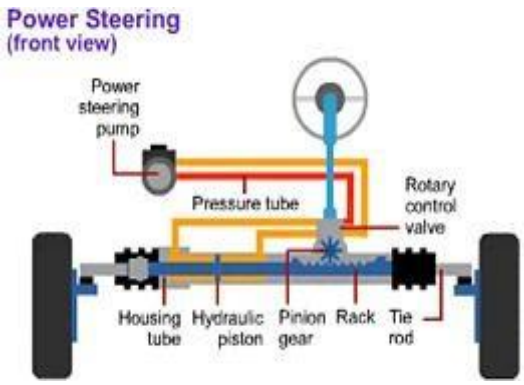
TYPES OF STEERING LINKAGES

1. Conventional steering Linkage
2. Direct cross type steering linkage
3. Three piece steering linkage
4. Center arm steering linkage
5. Relay type steering linkage

POWER STEERING

Power steering reduces much strain on the part of the driver while negotiating sharp curves. It makes easy to turn sharp corners. It is usually arranged to be operative when the effort of steering wheel exceeds a pre-determined value. It is fitted on heavy commercial vehicles and medium cars.

STEERING GEOMETRY

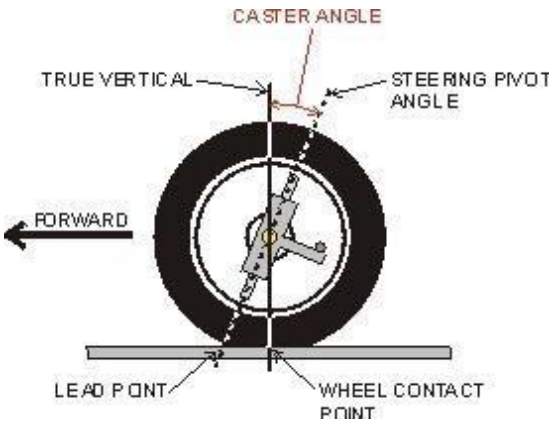


It refers to the angular relationship between the front wheels and parts attached to it and car frame.

THE STEERING GEOMETRY INCLUDES

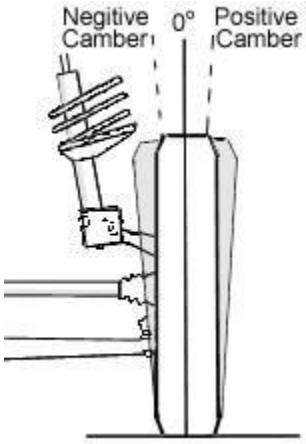
1. Caster angle
2. Camber angle
3. King-pin inclination
4. Toe-in
5. Toe-out

1. Caster angle



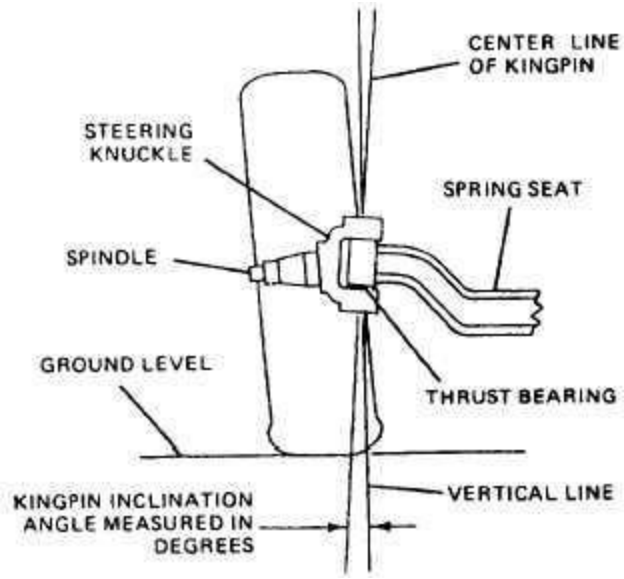
This is the angle between backward or forward tilting of the king pin from the vertical axis at the top. This is about 2º to 4º. The backward Tilt is called as positive caster. The forward tilt is called negative caster.

2. Camber angle



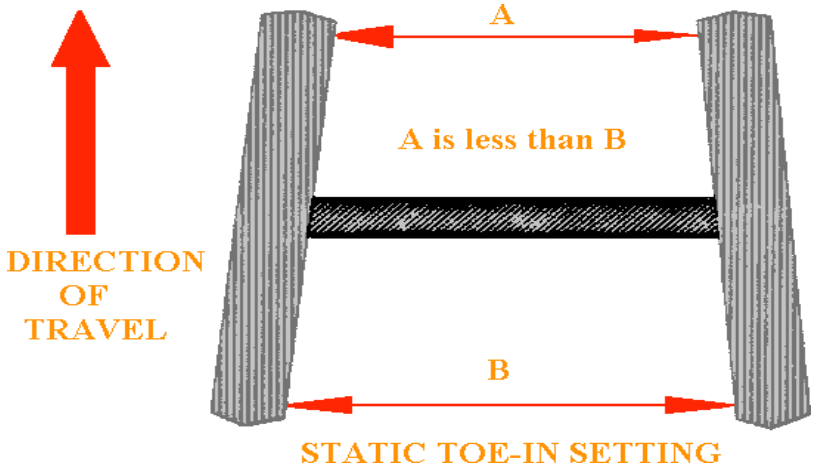
The angle between wheel axis to the vertical line at the top is called camber angle. It is approximately ½º to 2º.

3. King-pin inclination



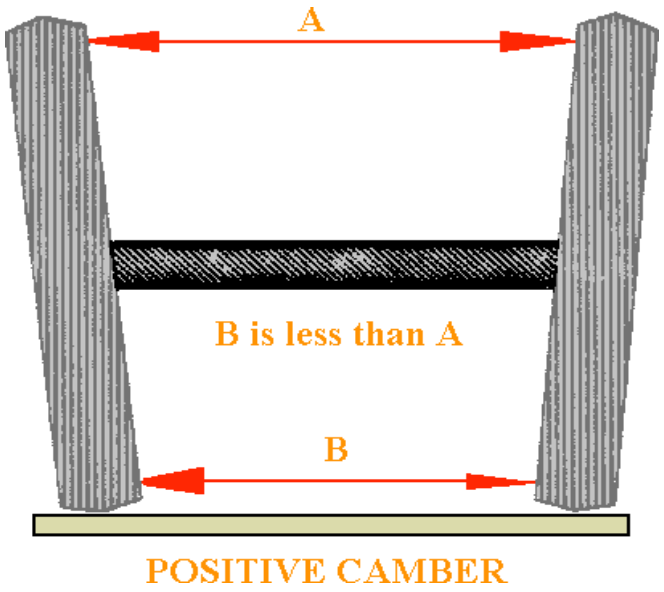
It is the angle between vertical line to the king pin axis. The inclination tends to keep wheels straight ahead and make the wheels to get return to the straight position after completion of a turn. The inclination is normally kept 7º to 8º

4. Toe-in



It is the amount in minimum at the front part of the wheel points inwards approximately 3 to5 mm. It prevents side slipping excessive tyre wear, proper rolling of front wheels and steering stability.

5. Toe-out



It is the difference in angles between two front wheels and vehicle frame during turning. It is used to prevent dragging of tyre during turn. Reversible steering: When the deflection of road wheels is transmitted through the steering wheel to road surface, the system is called Reversible.

If every imperfection of road surface causes the steering to rotate, it causes much strain on the part of the driver to control the vehicle. It causes much strain on the part of the driver to control the vehicle. Therefore such of the reversibility is not desired. But, some degree of reversibility desired, so that the wheel becomes straight after taking a curve.

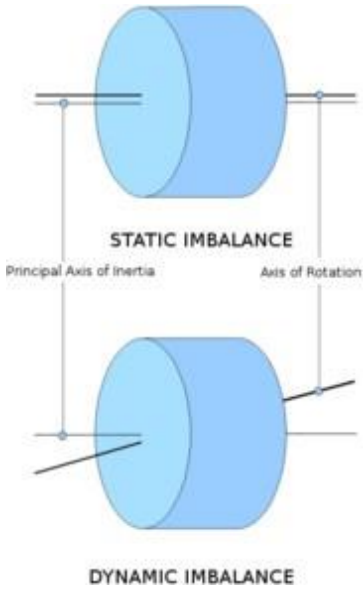
WHEEL ALIGNMENT

Wheel alignment, sometimes referred to as breaking or tracking, is part of standard automobile maintenance that consists of adjusting the angles of the wheels so that they are set to the car maker's specification. The purpose of these adjustments is to reduce tire wear, and to ensure that vehicle travel is straight and true (without "pulling" to one side). Alignment angles can also be altered beyond the maker's specifications to obtain a specific handling characteristic. Motorsport and off-road applications may call for angles to be adjusted well beyond "normal" for a variety of reasons.
All new vehicles leave the factory with their alignment checked and adjusted. Usually the technician paints the heads of the adjustment hardware to show it has been set, also to show if it has moved later on. It is advisable to do the alignment of the car after the first 5000 km, since all the suspension gets set. Failure to do this may result in the camber and toe specifications drifting outside the manufacturer's limit. This may lead to vehicle pulling and tire wear.

BALANCING

When the wheel rotates, asymmetries of mass may cause it to hop or wobble, which can cause ride disturbances, usually vertical and lateral vibrations. It can also result in a wobbling of the steering wheel or of the entire vehicle. The ride disturbance, due to unbalance, usually increases with speed. Vehicle suspensions can become excited by unbalance forces when the speed of the wheel reaches a point that its rotating frequency equals the suspension's resonant frequency.

Tires are balanced in factories and repair shops by two methods: static balancers and dynamic balancers. Tires with high unbalance forces are downgraded or rejected. When tires are fitted to wheels at the point of sale, they are measured again on a balancing machine, and correction weights are applied to counteract the combined effect of the tire and wheel unbalance. After sale, tires may be rebalanced if driver perceives excessive vibration.



STATIC BALANCE

Static balance can be measured by a static balancing machine where the tire is placed in its vertical axis on a non-rotating spindle tool. The spot on the tire with the greatest mass is acted upon by gravity to deflect the tooling downward. The amount of deflection indicates the magnitude of the unbalance. The angle of the deflection indicates the angular location of the unbalance. In tire manufacturing factories, static balancers operate by use of sensors mounted to the spindle assembly. In tire retail shops, static balancers are usually non-rotating bubble balancers, where the magnitude and angle of the unbalance is observed by looking at the center bubble in an oil-filled glass sighting gauge. While some very small shops which lack specialized machines still do this process, they have been largely replaced in larger shops with machines.

DYNAMIC BALANCE

Dynamic balance describes the forces generated by asymmetric mass distribution when the tire is rotated, usually at a high speed. In the tire factory, the tire and wheel are mounted on a balancing machine test wheel, the assembly is accelerated up to a speed of 100 RPM (10 to 15 mph with recent high sensitivity sensors) or higher, 300 RPM (55 to 60 mph with typical low sensitivity sensors), and forces of unbalance are measured by sensors as the tire rotates. These forces are resolved into static and couple values for the inner and outer planes of the wheel, and compared to the unbalance tolerance (the maximum allowable manufacturing limits). If the tire is not checked, it has the potential to wobble and perform poorly. In tyre retail shops, tire/wheel assemblies are checked on a spin-balancer, which determines the amount and angle of unbalance. Balance weights are then fitted to the outer and inner flanges of the wheel. Dynamic balance is better (it is more comprehensive) than static balance alone, because both couple and static forces are measured and corrected.

BRAKING SYSTEM

Brakes are generally applied to rotating axles or wheels, but may also take other forms such as the surface of a moving fluid (flaps deployed into water or air). Some vehicles use a combination of braking mechanisms, such as drag racing cars with both wheel brakes and a parachute, or airplanes with both wheel brakes and drag flaps raised into the air during landing.

FORCES ON VEHICLE

Motive force

- This means that the purpose of the engine is to provide a torque to the wheels, so they push backwards on the road.
- It is the road which then pushes the car forwards.

Braking force

- The car is moving – so the wheels are turning – usually at high speed.
- The braking force is provided by the brake pads gripping the wheel.

- The brakes provide a torque opposite to the torque driving the wheels round.
- This reduces the force of the wheels on the road, and hence the push of the road on the car.

Tyre grip

Tyre grip is an element of paramount importance for safety. It varies from 1 to 10 depending on the tyre. What comes into play is the state of repair of the road, the tread pattern and above all the weather conditions.

So there are several scenarios:

- Dry road
- Wet roads
- Snowy roads

LOAD TRANSFER

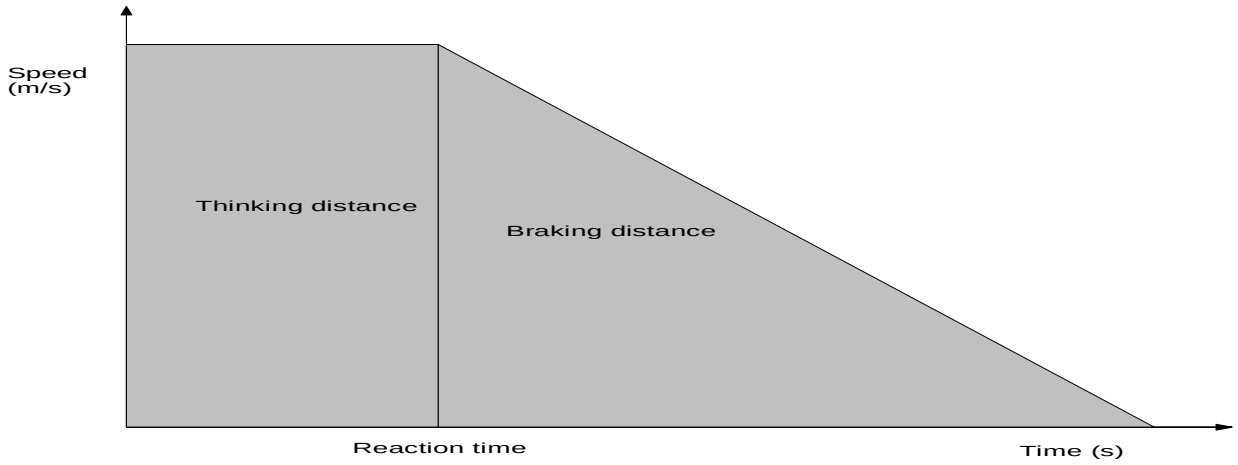
In wheeled vehicles, load transfer is the measurable change of load borne by different wheels during acceleration (both longitudinal and lateral). This includes braking, and deceleration (which is acceleration at a negative rate). No motion of the center of mass relative to the wheels is necessary, and so load transfer may be experienced by vehicles with no suspension at all. Load transfer is a crucial concept in understanding vehicle dynamics. The same is true in bikes, though only longitudinally.

BRAKING DISTRIBUTION BETWEEN AXLES

Electronic brake force distribution is an automobile brake technology that automatically varies the amount of force applied to each of a vehicle's brakes, based on road conditions, speed, loading, etc. Always coupled with anti-lock braking systems, EBD can apply more or less braking pressure to each wheel in order to maximize stopping power whilst maintaining vehicular control. Typically, the front end carries the most weight and EBD distributes less braking pressure to the rear brakes so the rear brakes do not lock up and cause a skid. In some systems, EBD distributes more braking pressure at the rear brakes during initial brake application before the effects of weight transfer become apparent.

STOPPING DISTANCE

- This is the distance moved by the vehicle between the driver seeing the obstacle and the vehicle stopping.
- The vehicle keeps moving at a steady speed whilst the driver reacts (thinking distance)
- The vehicle slows down whilst the brakes are applied (braking distance)
- Stopping = Thinking + Braking

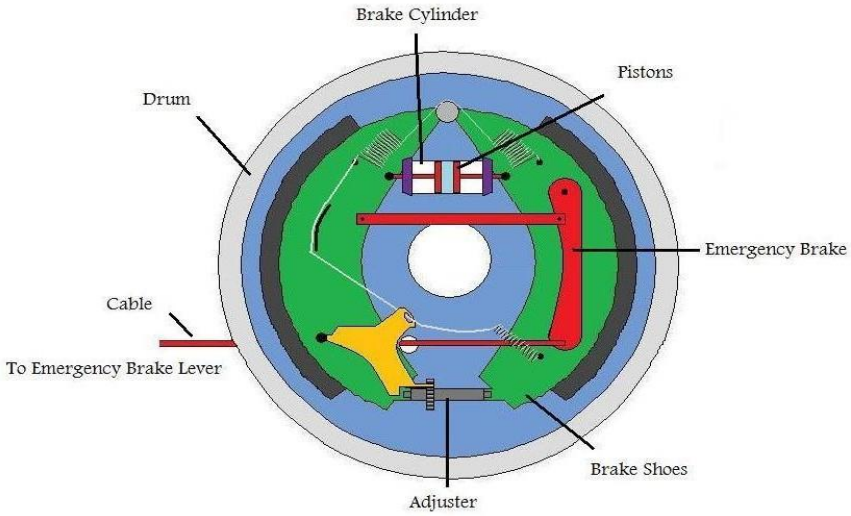


TYPES OF BRAKES

- Mechanical brake
- Hydraulic brake
- Air brakes
- Disc & Drum brakes

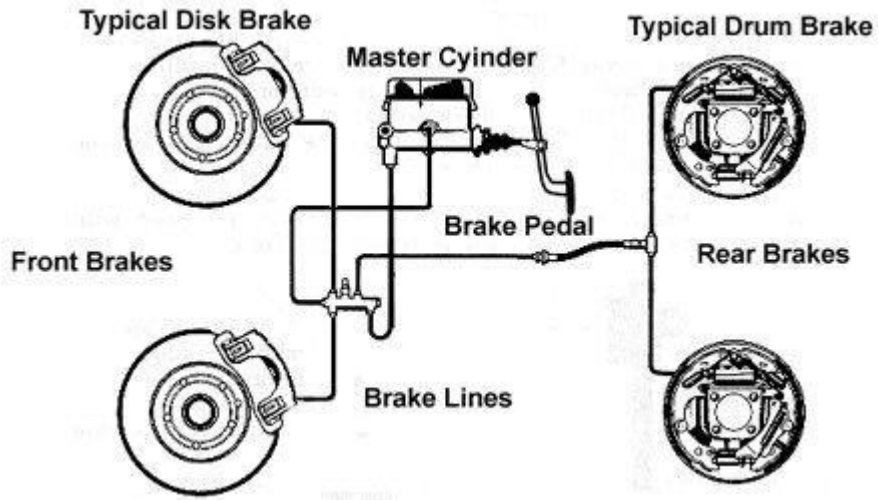
Mechanical brake

Internal expanding shoe brakes are most commonly used in automobiles. In an automobile, the wheel is fitted on a wheel drum. The brake shoes come in contact with inner surface of this drum to apply brakes.



Hydraulic brake

The brakes which are actuated by the hydraulic pressure (pressure of a fluid) are called hydraulic brakes. Hydraulic brakes are commonly used in the automobiles.



Advantages

- Equal braking action on all wheels.
- Increased braking force.
- Simple in construction.
- Low wear rate of brake linings.
- Flexibility of brake linings.
- Increased mechanical advantage.

Disadvantages

- Whole braking system fails due to leakage of fluid from brake linings.

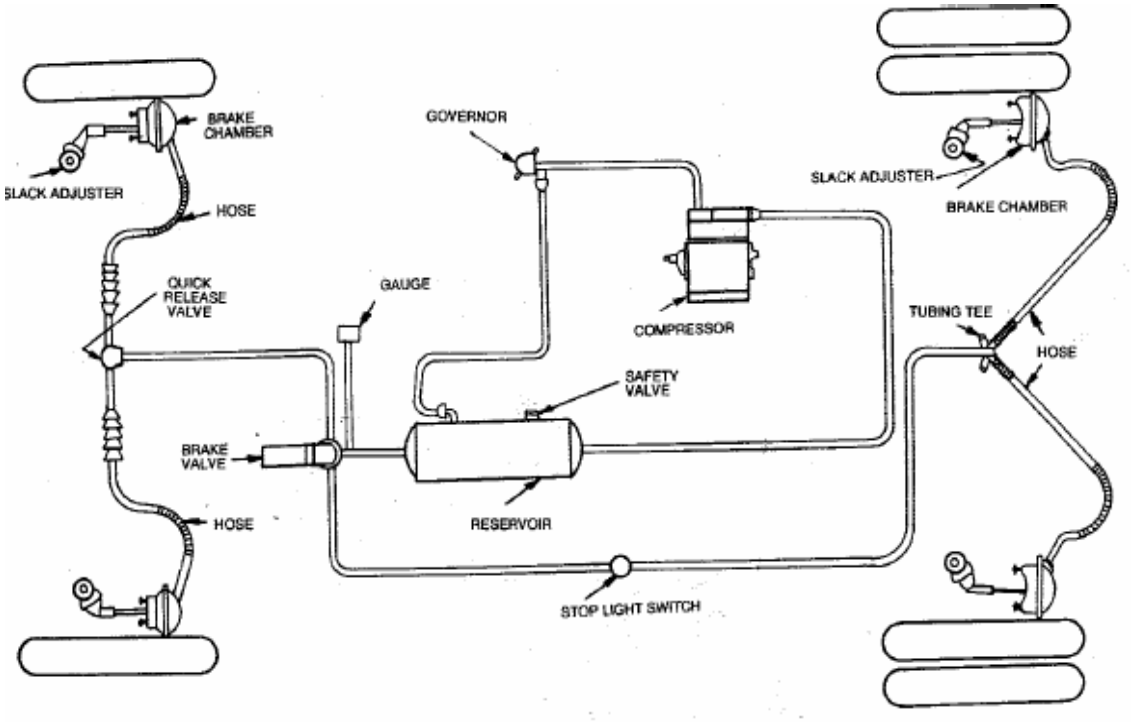
Air brakes

Air brakes are applied by the pressure of compressed air. Air pressure applies force on brakes shoes through suitable linkages to operate brakes. An air compressor is used to compress air. This compressor is run by engine power.

Air brakes are used as an alternative to hydraulic brakes which are used on lighter vehicles such as automobiles. Hydraulic brakes use a liquid (hydraulic fluid) to transfer pressure from the brake pedal to the brake shoe to stop the vehicle. Air brakes have several advantages for large multitrailer vehicles

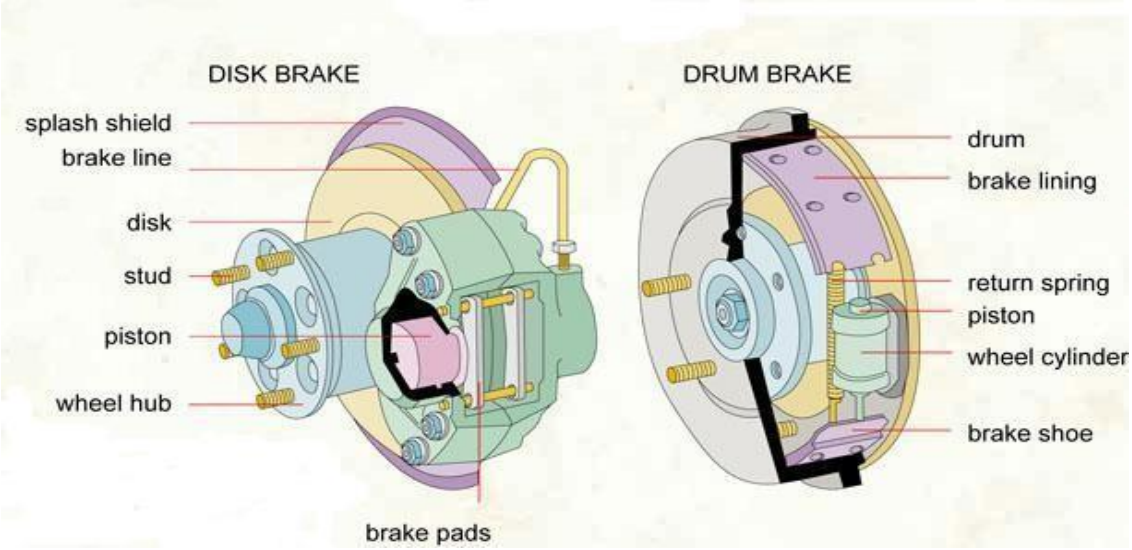
Advantages

- The supply of air is unlimited, so the brake system can never run out of its operating fluid, as hydraulic brakes can. Minor leaks do not result in brake failures.
- Air line couplings are easier to attach and detach than hydraulic lines; there is no danger of letting air into a pneumatic circuit. So air brake circuits of trailers can be attached and removed easily by operators with little training.
- Air brakes are effective even with considerable leakage, so an air brake system can be designed with sufficient "fail-safe" capacity to stop the vehicle safely even when leaking.



Disc brakes

Modern motor cars are fitted with disc brakes instead of conventional drum type brakes. In front wheels are provided with disc brakes whereas rear wheel are provided with drum brakes. A disc brake consists of a rotating disc and two friction pads which are actuated by hydraulic braking system as described earlier. The friction pads remain free on each side of disc when brakes are no applied. They rub against disc when brakes are applied to stop the vehicle. These brakes are applied in the same manner as that of hydraulic brakes. But mechanism of stopping vehicle is different than that of drum brakes.



Advantage

- Main advantage of disc brakes is their resistance to wear as the discs remain cool even after repeated brake applications.
- Brake pads are easily replaceable.
- The condition of brake pads can be checked without much dismantling of brake system.

Disadvantage

- More force is needed be applied as the brakes are not self emerging.
- Pad wear is more.
- Hand brakes are not effective if disc brakes are used in rear wheels also. (Hand brakes are better with mechanical brakes).

Drum brakes

A drum brake is a brake that uses friction caused by a set of shoes or pads that press against a rotating drum-shaped part called a brake drum.

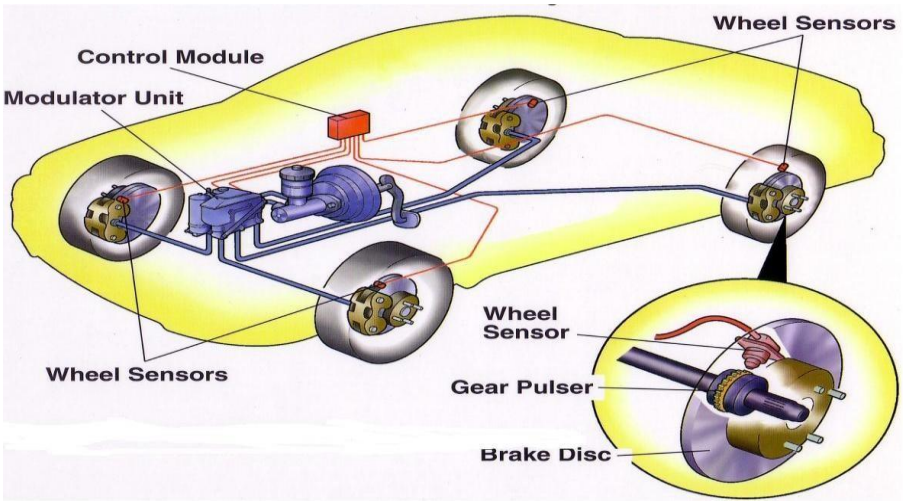
The term drum brake usually means a brake in which shoes press on the inner surface of the drum. When shoes press on the outside of the drum, it is usually called a clasp brake. Where the drum is pinched between two shoes, similar to a conventional disc brake, it is sometimes called a pinch drum brake, though such brakes are relatively rare. A related type called a band brake uses a flexible belt or "band" wrapping around the outside of a drum

Engine brakes

Engine braking occurs when the retarding forces within an engine are used to slow a vehicle down, as opposed to using additional external braking mechanisms such as friction brakes or magnetic brakes.

ANTI LOCK BRAKING SYSTEM

Anti-lock braking system (ABS) is an automobile safety system that allows the wheels on a motor vehicle to maintain tractive contact with the road surface according to driver inputs while braking, preventing the wheels from locking up and avoiding uncontrolled skidding. It is an automated system that uses the principles of threshold braking and cadence braking which were practiced by skillful drivers with previous generation braking systems. It does this at a much faster rate and with better control than a driver could manage.



ABS generally offers improved vehicle control and decreases stopping distances on dry and slippery surfaces; however, on loose gravel or snow-covered surfaces, ABS can significantly increase braking distance, although still improving vehicle control.

Advantages

- Shorter stopping distances: Anti-lock brakes reduce braking distances as the wheel does not waste distance skidding.
- Stopping on wet surface: ABS avoids wheel lock up and hence allows surefooted braking on wet sleety surfaces.
- Steer under braking: Anti lock brakes allow you to steer your car around objects if any as you still have grip on the wheels under intense braking.

Disadvantages

- The primary disadvantage of ABS brakes is the increased cost it adds to the overall cost of a vehicle. Also maintenance costs go up as the sensors on each wheel are expensive and get heavy on the pocket if they run out of calibration.
- The job of anti-lock brakes is to provide sure footed braking. But this also has a side effect that is the inconsistent stopping distances on various surfaces under variable conditions.
- Also a reason for concern is that these electronic systems are quiet delicate and adding more mechanics to your car increases the possibilities of system damages.