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Systems In Mechanical Engineering

Unit-04

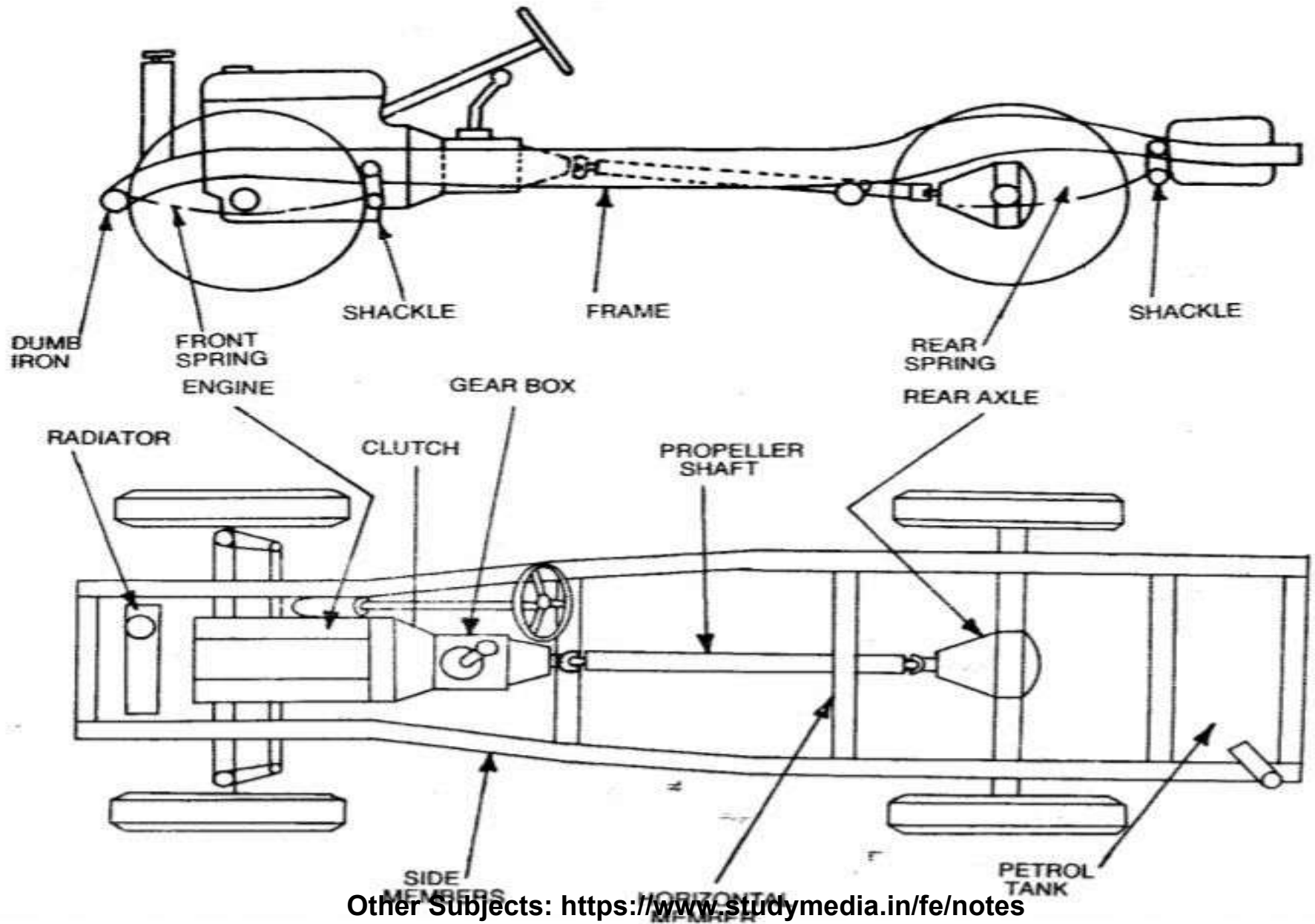
VEHICLE SYSTEMS

Mr. Girish G Khope

Introduction

- Chassis is a basic structure of vehicle. Chassis carry all parts of vehicles. Automotive chassis is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted
- **Types of Chassis-**
- Backward control (conventional chassis),
- Forward control,
- Semi – forward control

General Layout of vehicles



Chassis and its construction

- **Automobile chassis is usually made of light sheet metal.**
- **It provides strength needed for supporting vehicular components and payload placed upon it.**
- **Automobile chassis helps keep an automobile rigid, stiff and unbending.**
- **Auto chassis ensures low levels of noise, vibrations and harshness throughout the automobile.**
- **Chassis of an automobile generally consists of the following components suitably mounted on it**
 - **Engine and the Radiator**
 - **Transmission system(clutch, gear box, propeller shaft etc.)**
 - **Suspension system**
 - **Road Wheels**
 - **Steering System**
 - **Brakes**
 - **Fuel Tank**
- **Types of Chassis**
 - **Backward control (conventional chassis)**
 - **Forward control**
 - **Semi – forward control**

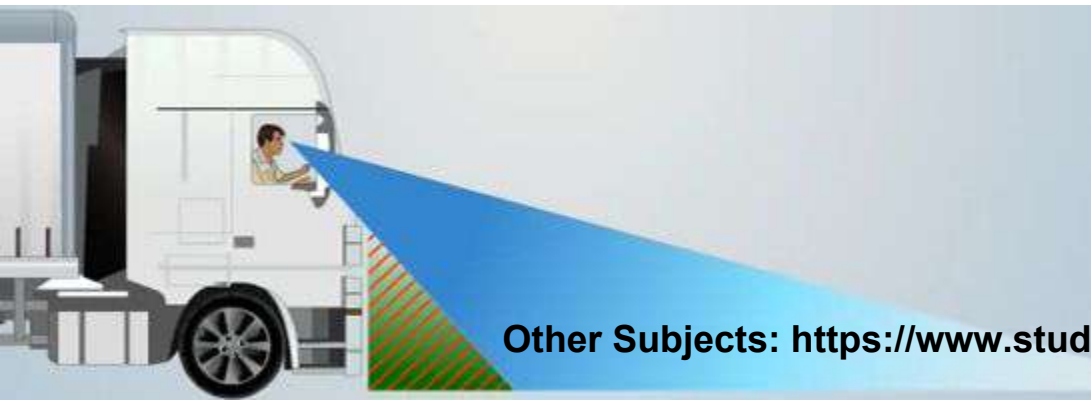
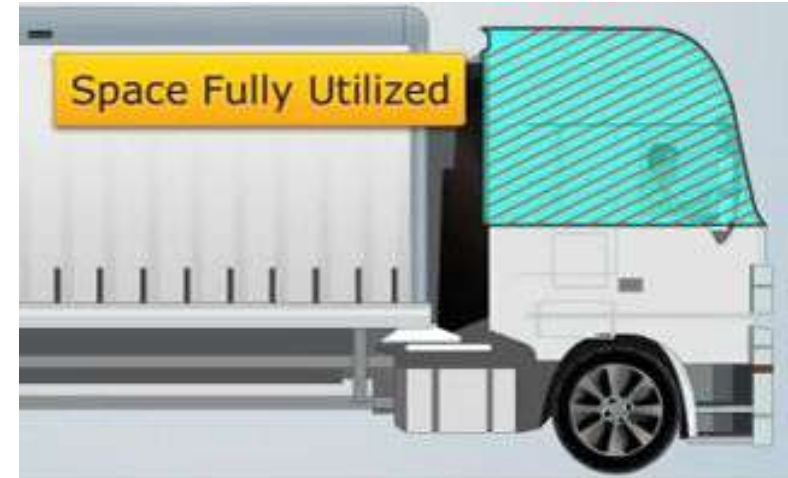
Backward control (conventional chassis)

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



Forward control chassis

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



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Machine

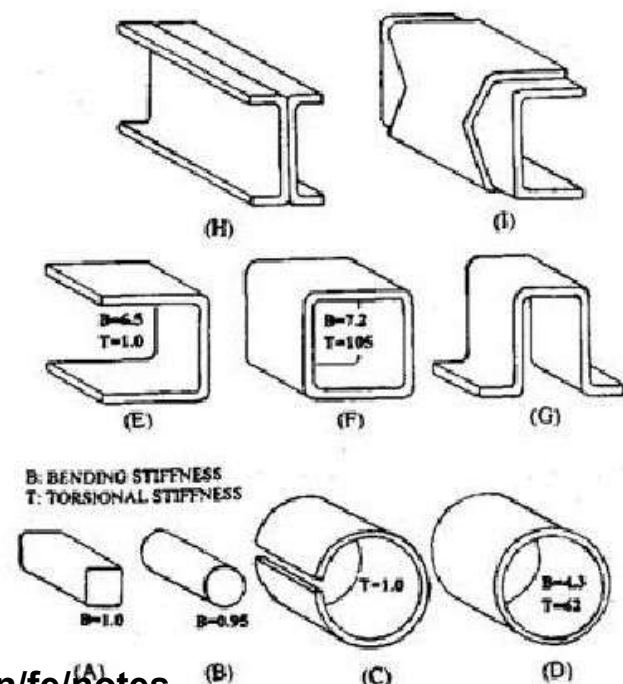
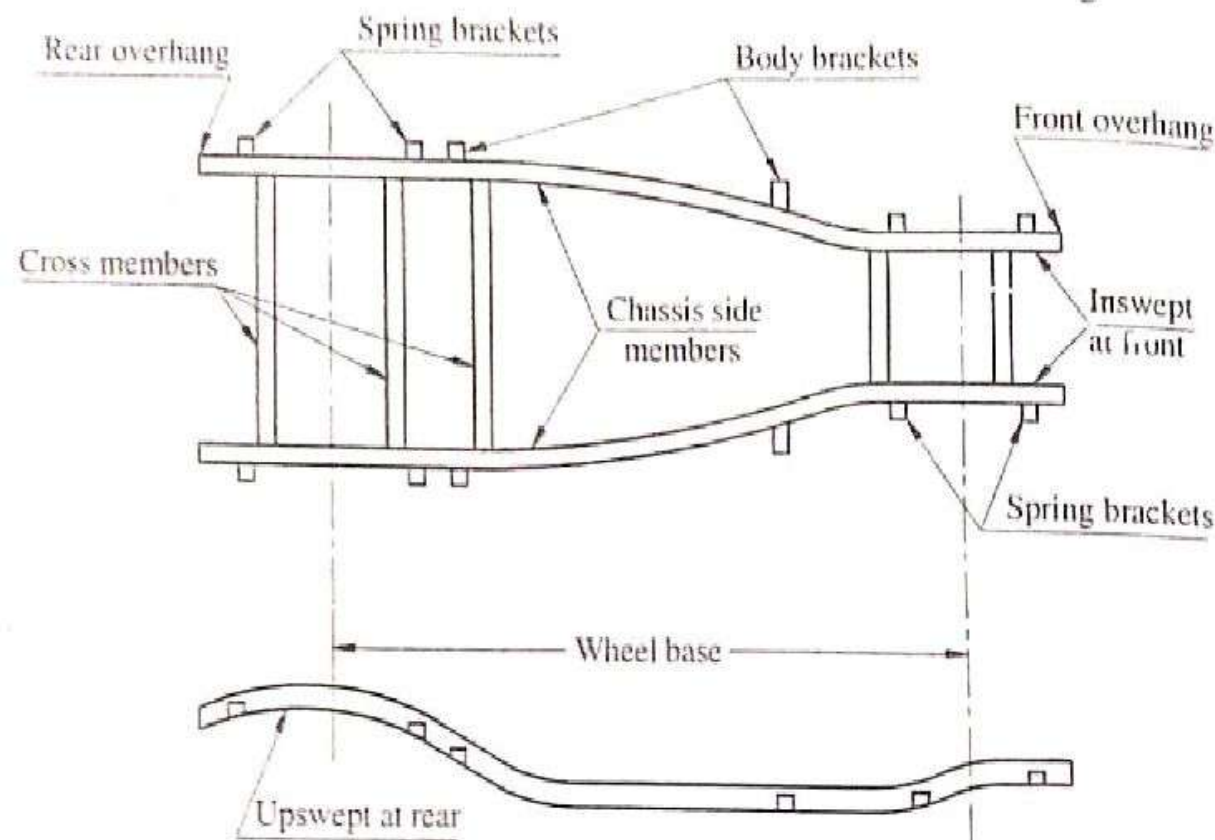
Semi-forward control chassis

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



Vehicle Frame

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



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 Fig. 2.3 Conventional frame construction

(i) CONVENTIONAL FRAME

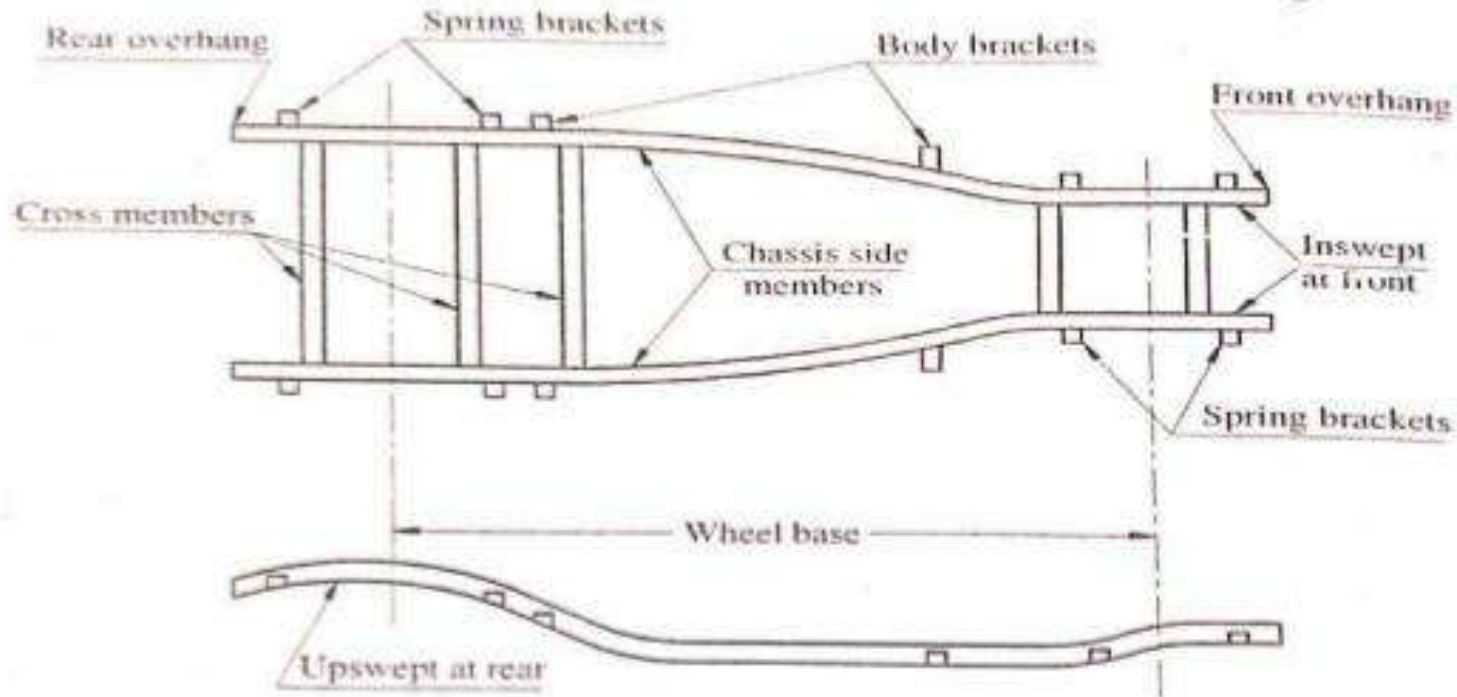


Fig. 2.3 Conventional frame construction

- It is used in most of the heavy vehicles.
- Construction of frame varies according to the type of vehicle.
- Generally made from the steel sections.
- This type of frame has “2 long side members” & “5 to 6 cross members” joined together with the help of rivets or bolts.
- Cross members are used to increase the strength of the frame.
- They are inswept (Narrow) at the front & are upswept (Broad) at the rear.

(II) INTEGRATED FRAME CHASSIS or FRAMELESS CHASSIS

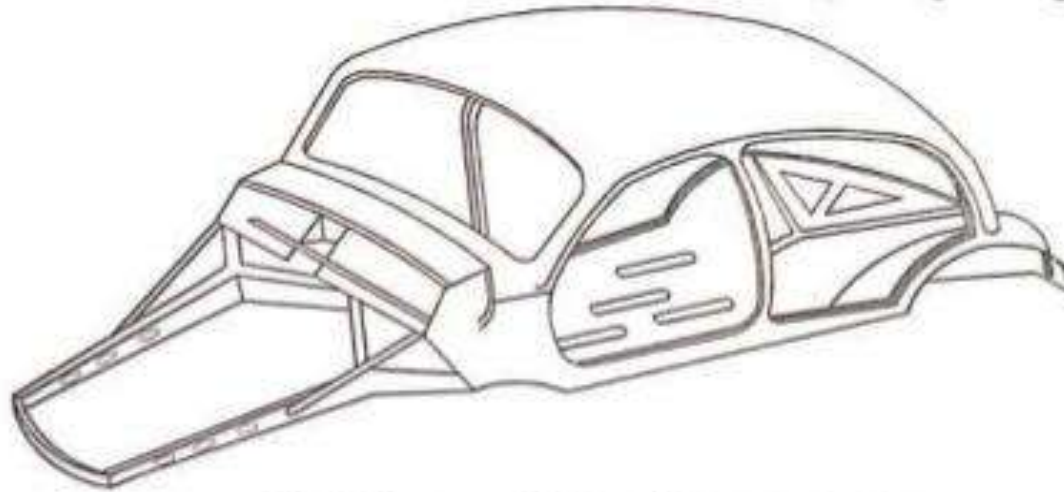


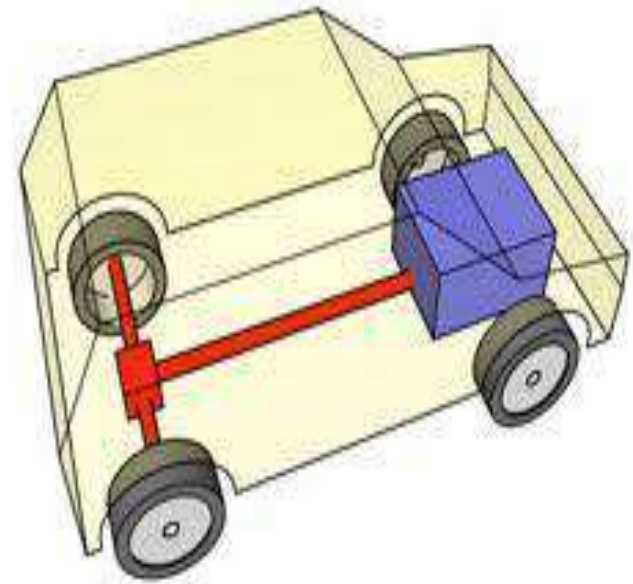
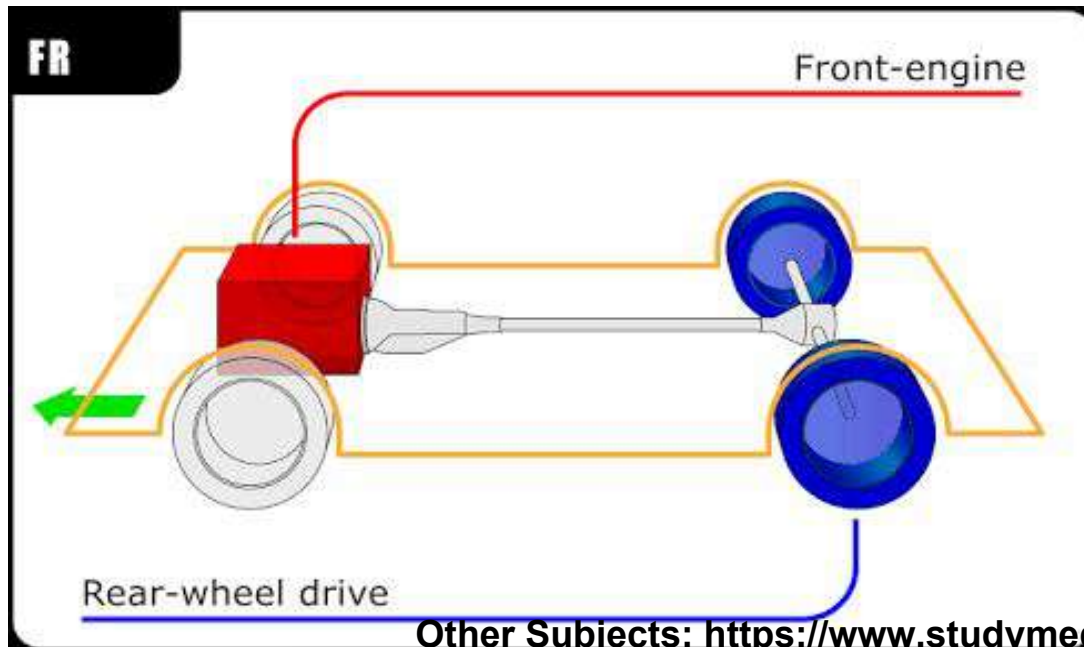
Fig. 2.5 Integrated body and frame construction

- This frame construction, now-a-days used in most of the motor cars called as a frameless or chassisless or mono or unit construction in which the floor assembly & frame form one integral unit.
- Need of the heavy side members are eliminated ,which is used in conventional frame & the floor is strengthened by cross members & body , all welded together.
- In some cases sub-frames are also used on which various chassis components are mounted. This sub-frames are supported by main frame.
- The main purpose of sub-frame are to provide isolation , flexibility & simplified production.
- So, in this type of construction all components like cross member , floor , body are welder or bolted together as one assembly.
- This type of construction gives more strength & rigidity.

Types of Automobile Drives or layout

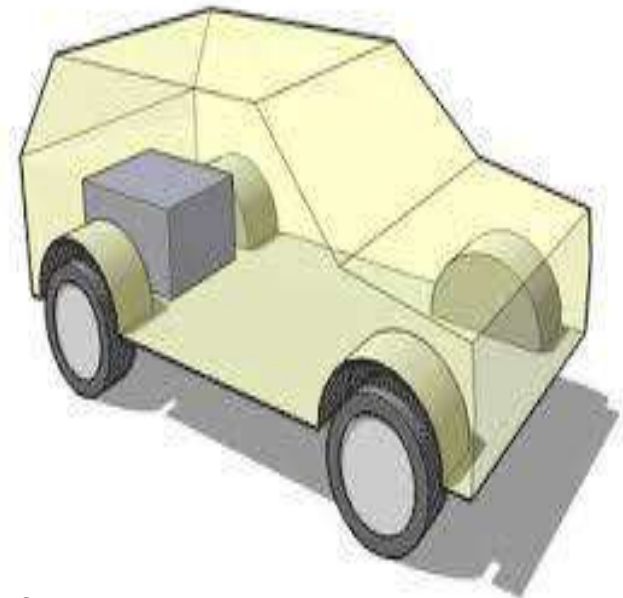
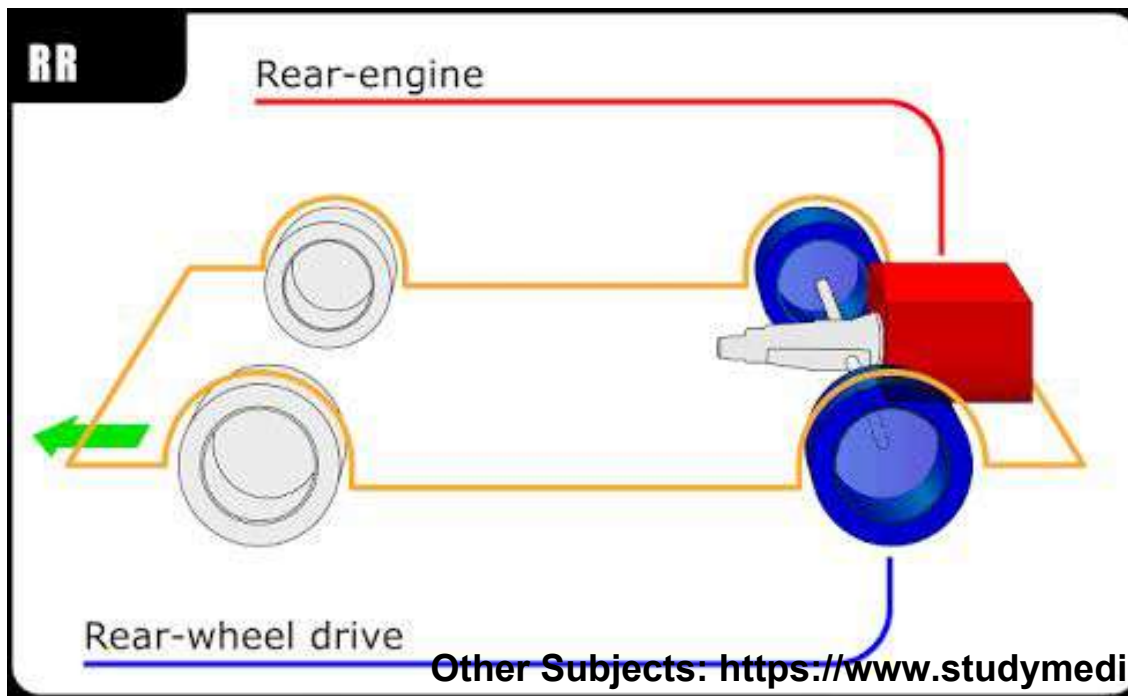
1. Front Engine Rear Wheel Drive :

- Rear wheel drive 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.



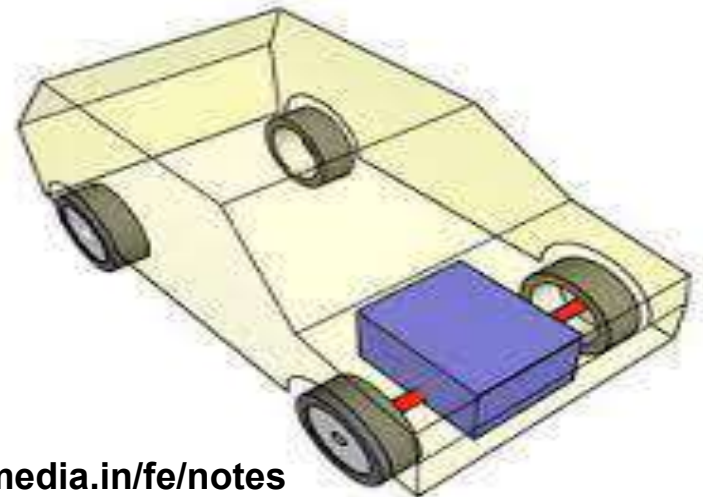
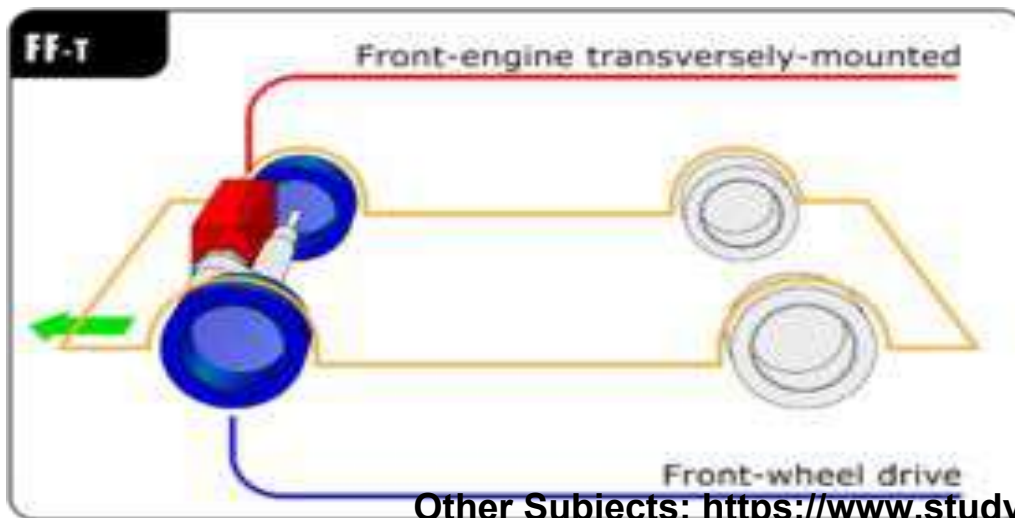
2. Rear Engine Rear Wheel Drive :

- This layout consists of placing the engine, clutch and gearbox in the back. So taking the space of the boot. In these type of layout more than 50% of the weight is on the rear axle.



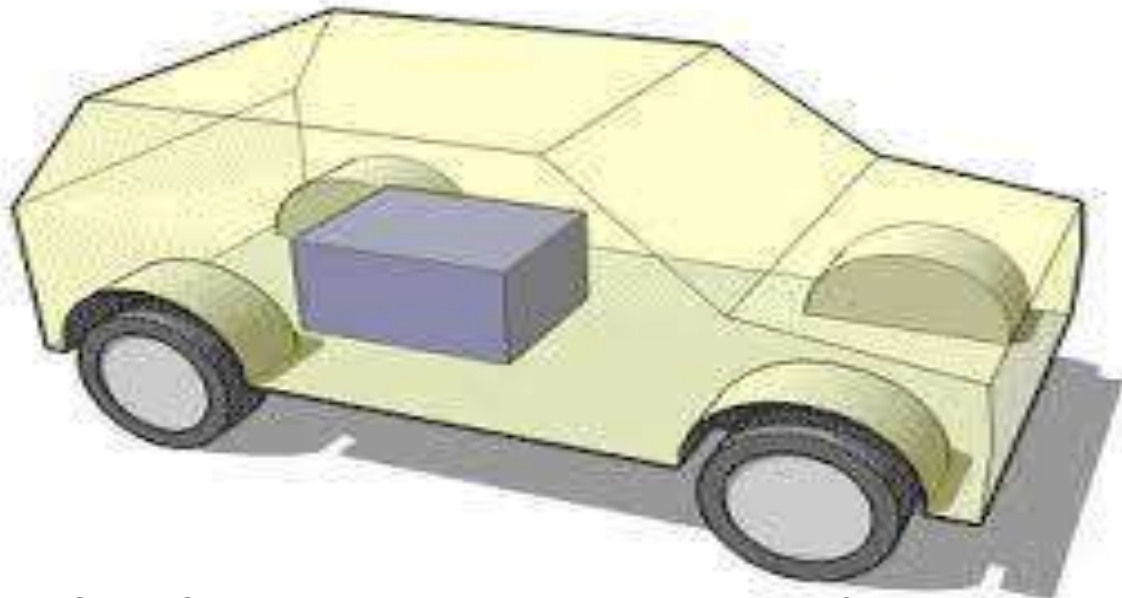
3. *Front Engine Front Wheel Drive :*

- This type Of arrangement provides optimum passenger space
- The propeller shaft length is reduced or neglects the propeller shaft.
- Good grip with road surface due to engine weight at front.



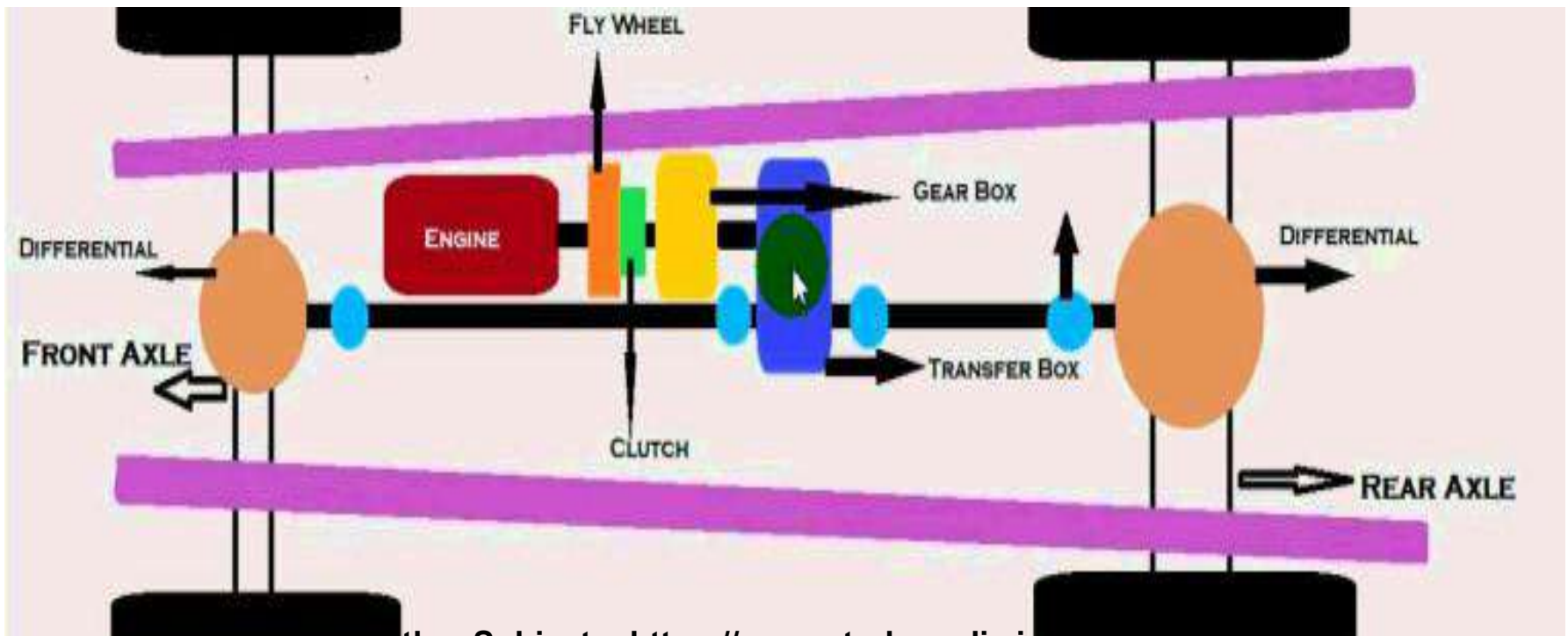
4. Mid-Engine, Rear Wheel Drive :

- This type of engine layout places the engine between the two axles and the rear wheels are driven. weight is equally distributed between front and rear wheel

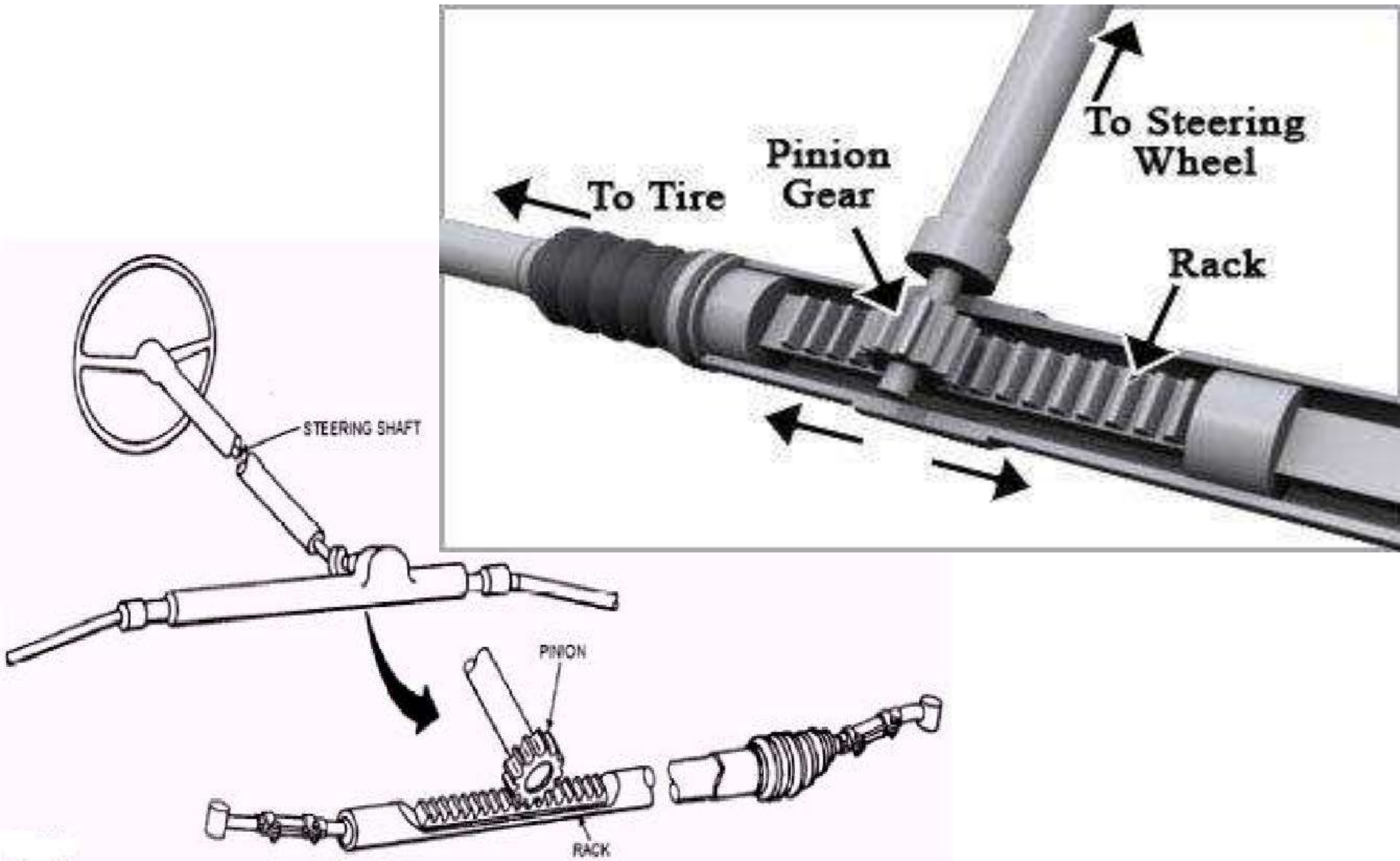


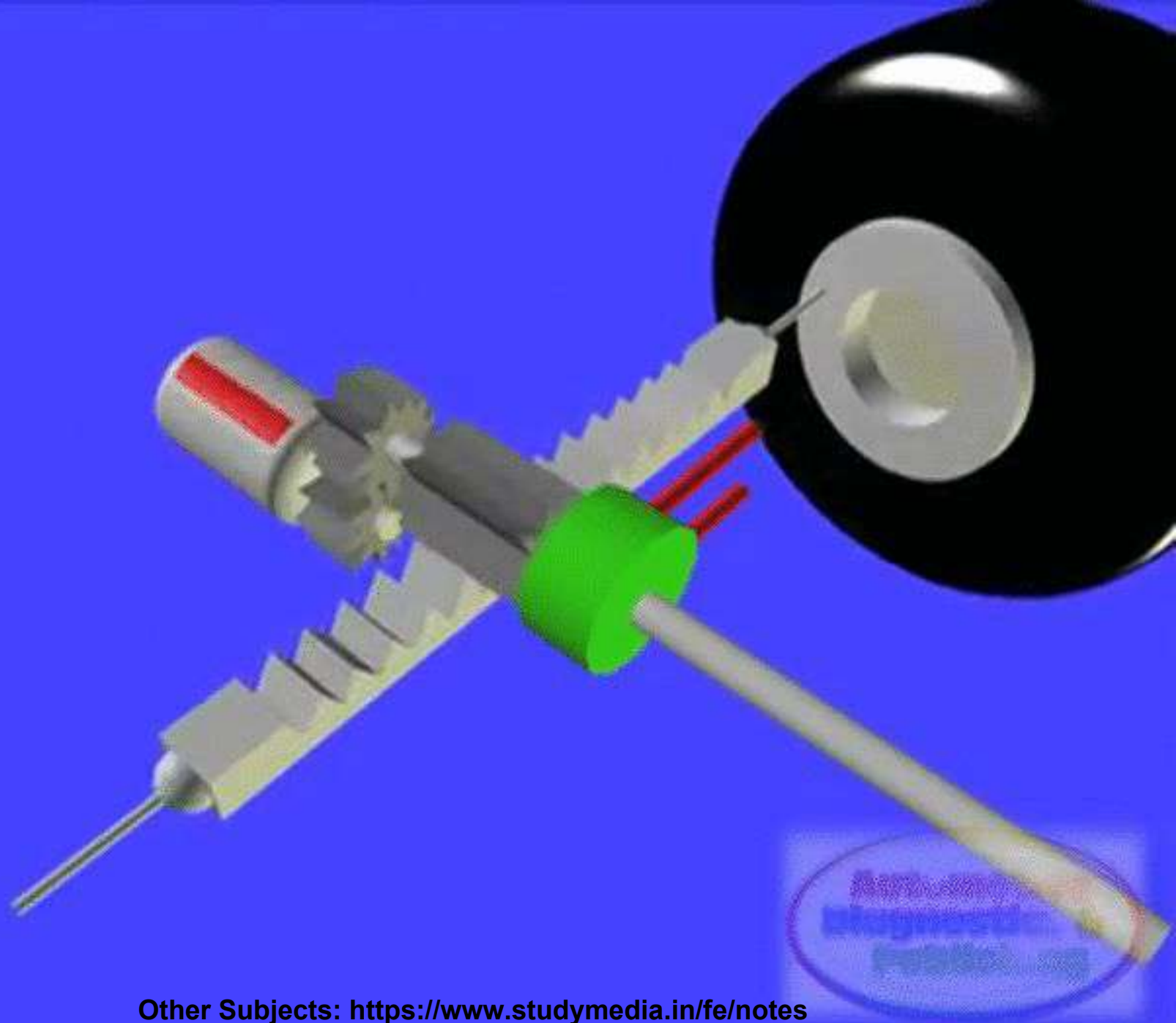
5. Four Wheel Drive :

- In this arrangement all the four wheels of the vehicle are driven by the engine thus making the entire vehicle weight available for traction.



Steering System



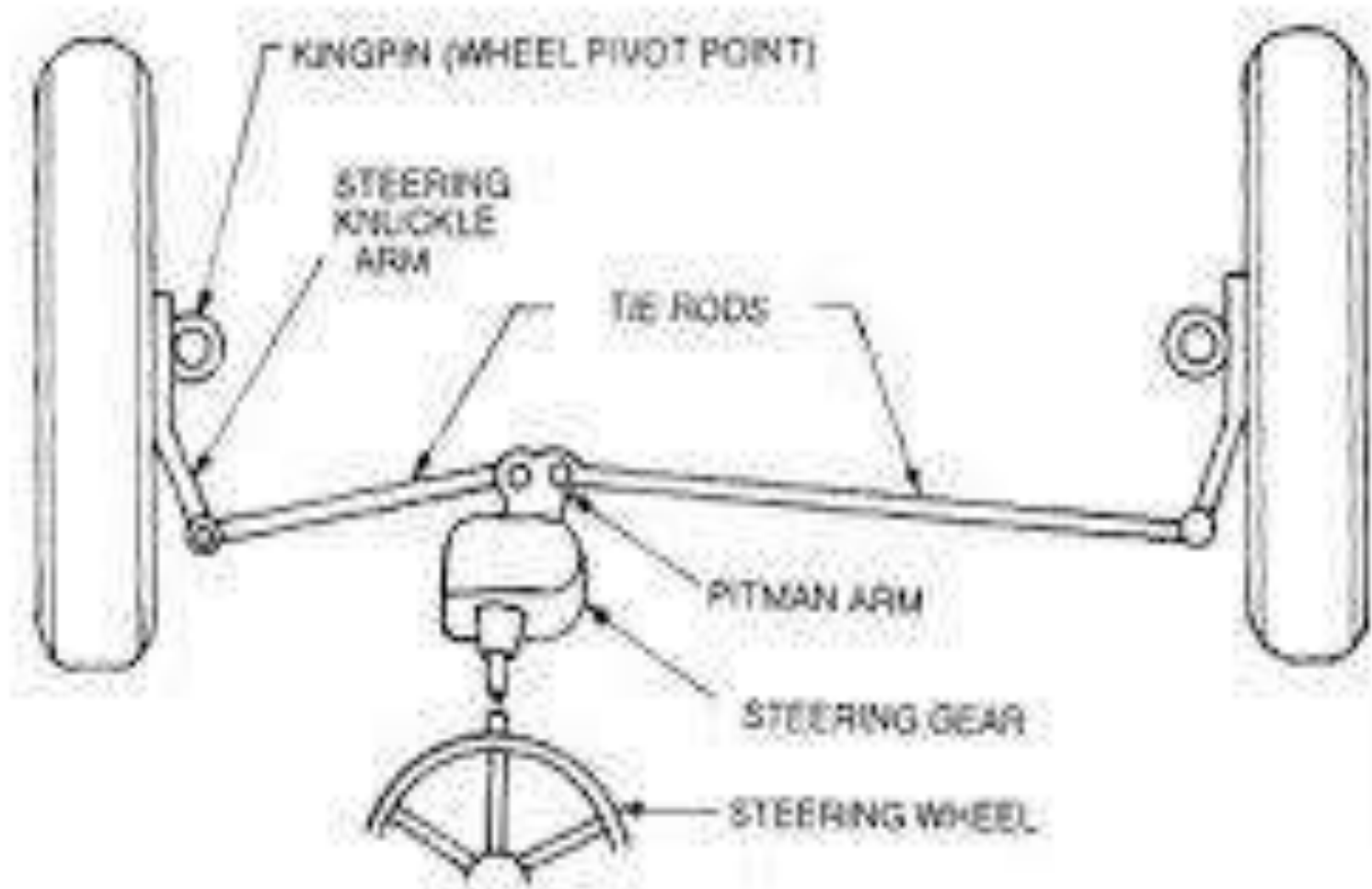


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STEERING SYSTEM

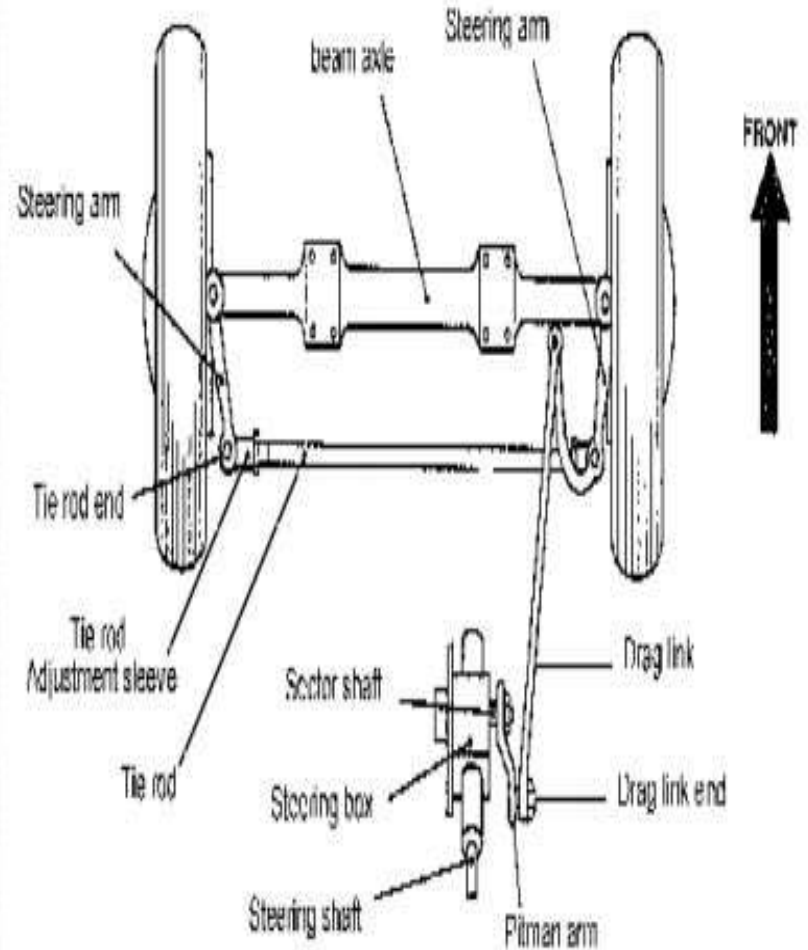
- The purpose of steering system is to allow the driver to control the direction of vehicle by turning the front wheels.
- This is achieved by means of steering wheel and a steering column.
- A steering column transmits the rotation of the steering wheel to the steering gears.
- The steering gears increase the rotational force of the steering wheel in order to transmit greater torque to steering linkage.
- The steering linkage transmits the steering gear movement to the front wheels of the vehicle.

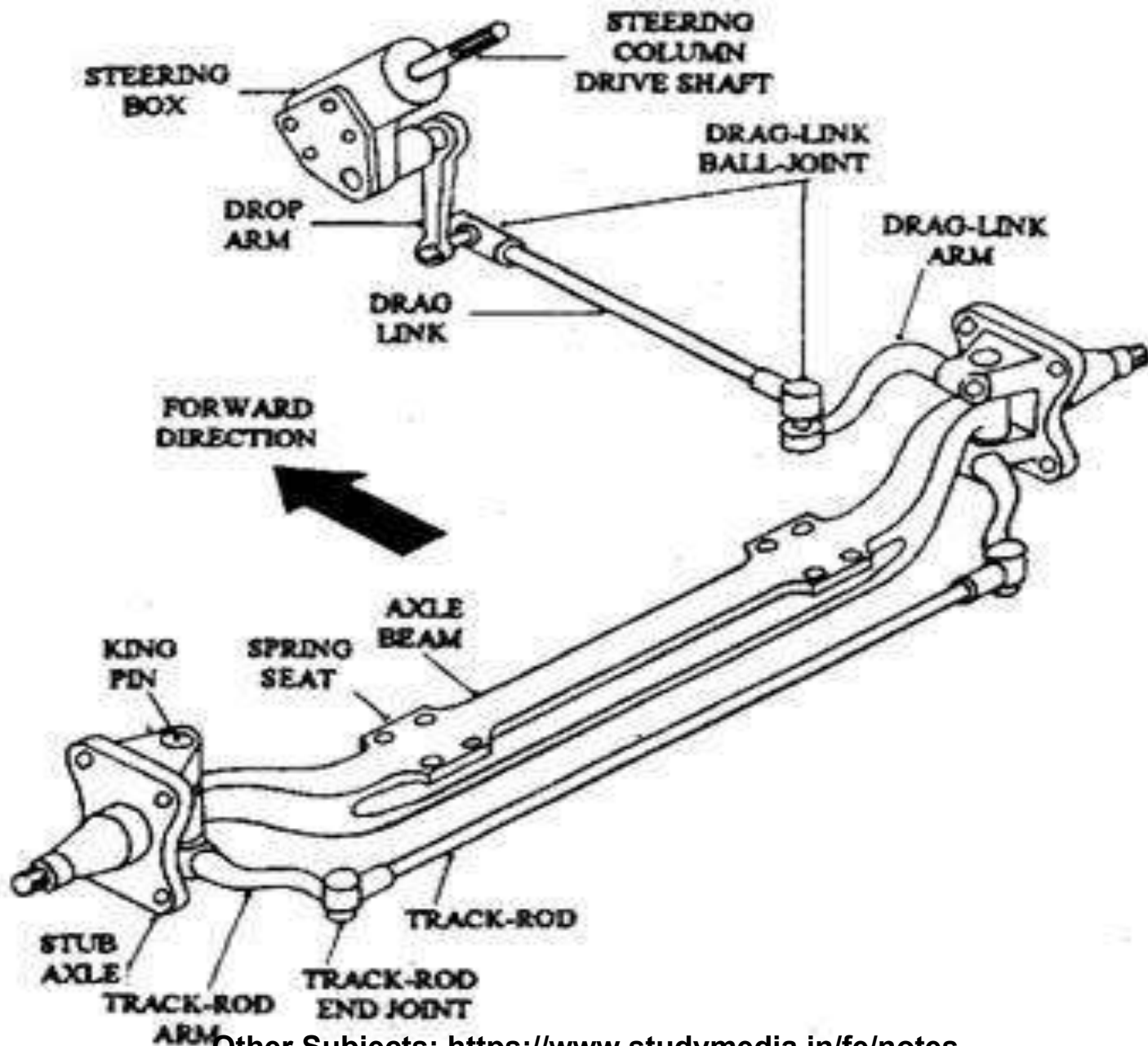
General arrangement of steering system

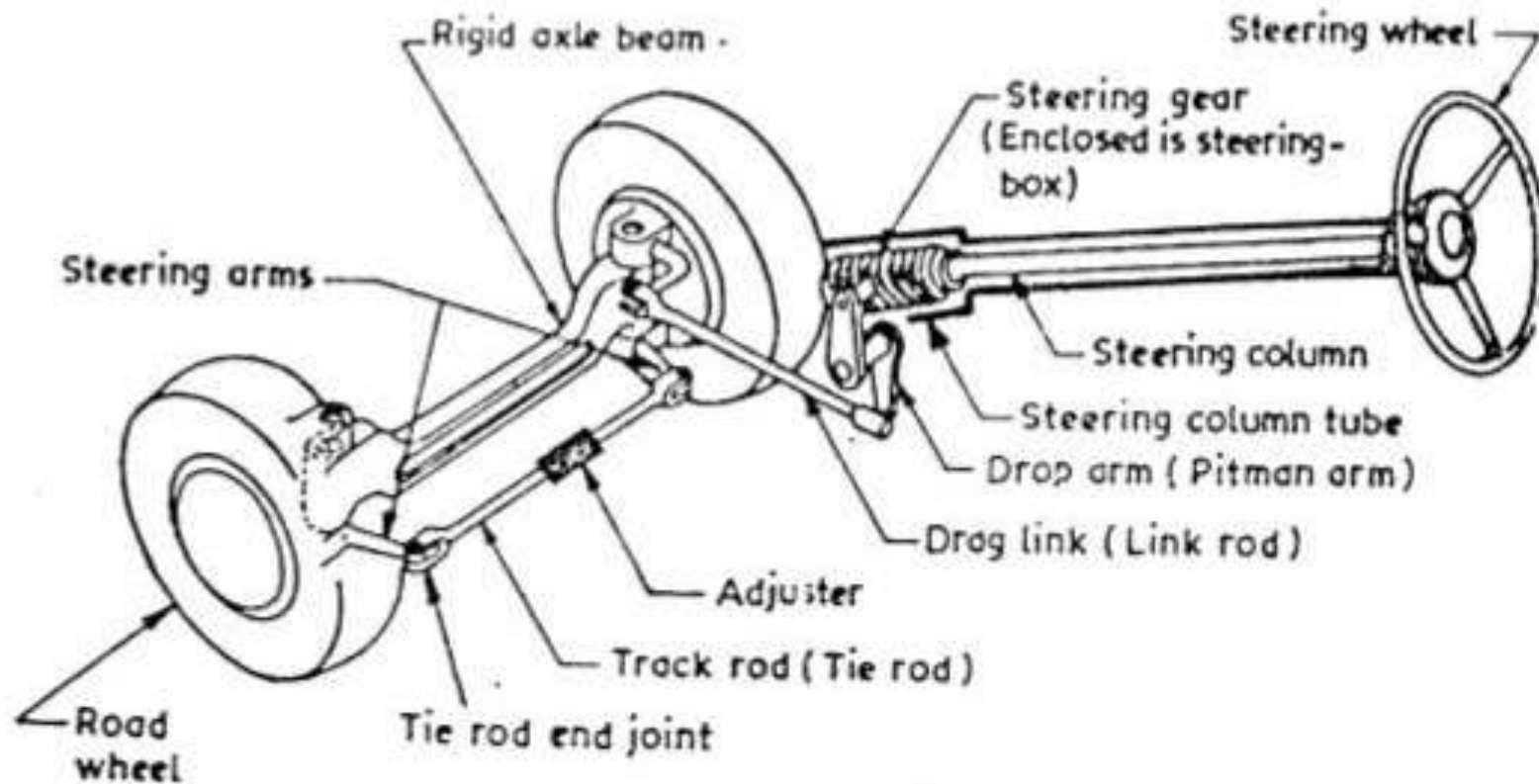


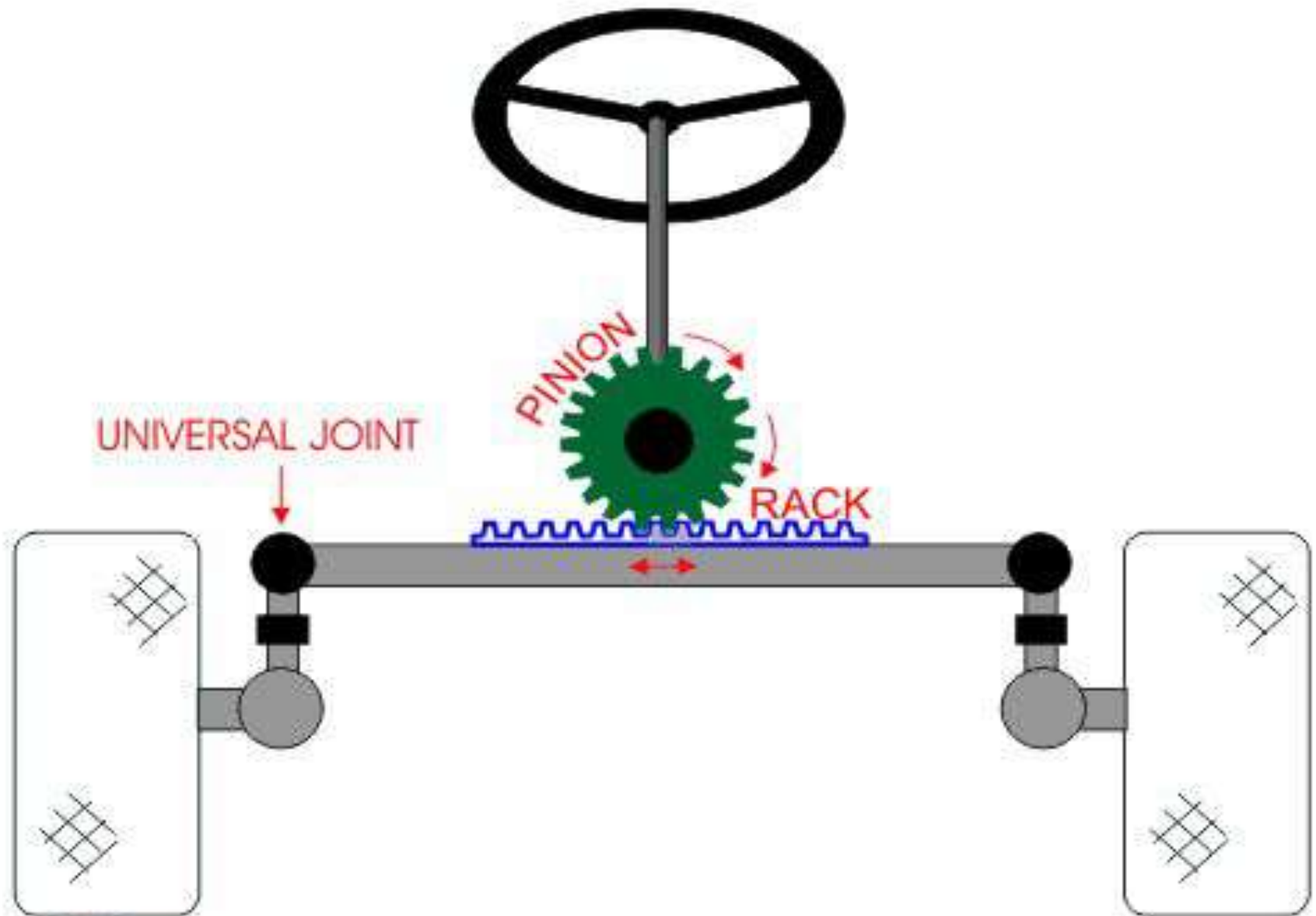
Steering Linkage with rigid axle front suspension

- The drop arm (also called Pitman arm) is rigidly connected to the cross-shaft of the steering gear at its upper end, while its lower end is connected to the link rod arm through a ball joint.
- Stub axle is rigidly attached to the other end of link rod arm.
- Each stub axle is has a forged track rod arm rigidly bolted to the wheel axis.
- The other end of track rod arms are connected to track rod by means of ball joints.









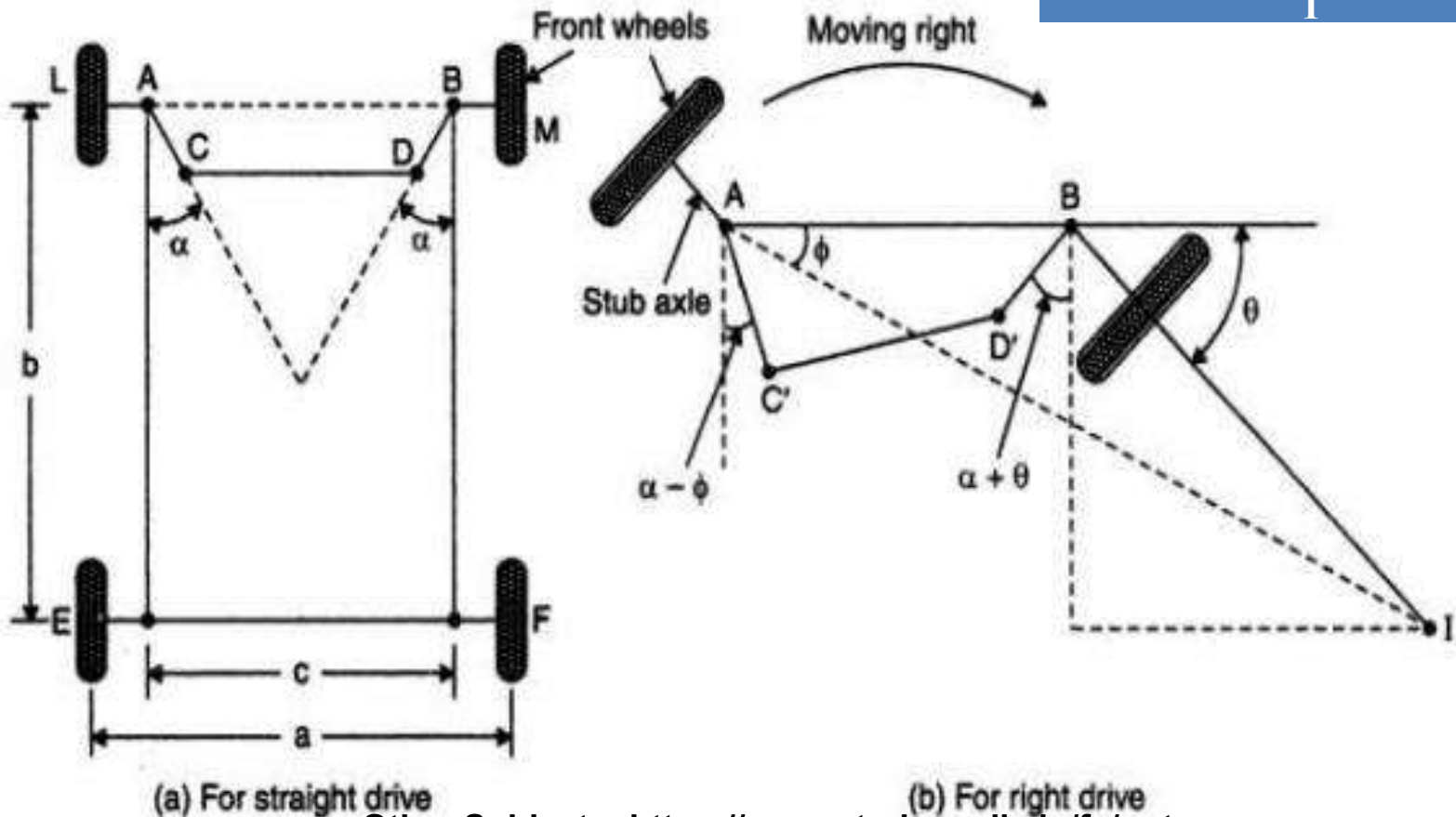
By V.Ryan



Steering system

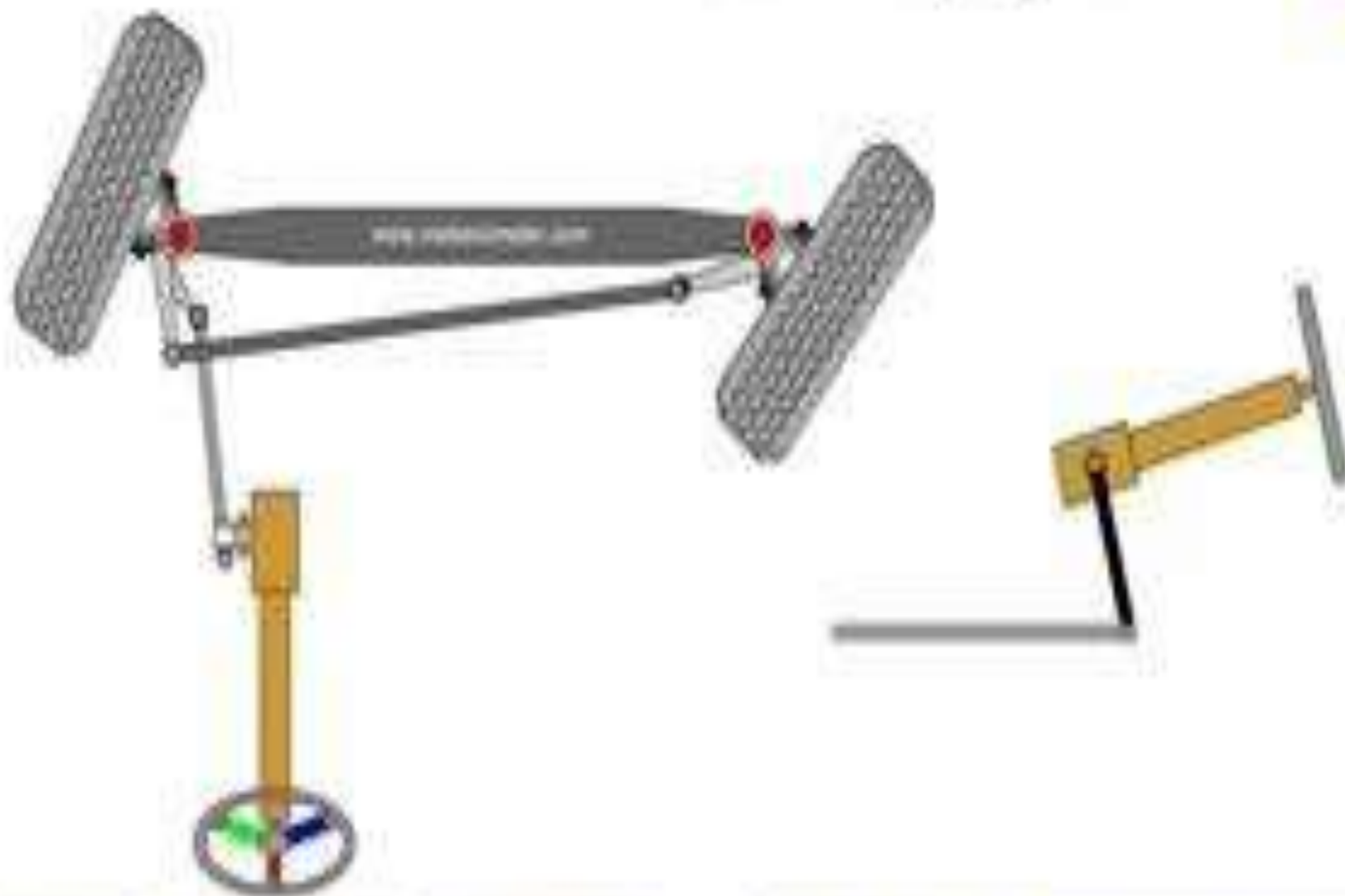
Ackerman steering mechanism

$$b/L = \cot \theta_1 - \cot \theta_2$$



Ackerman Steering Mechanism

- When a vehicle is turning, the inner front wheel needs to turn at a different angle to the outer because they are turning on different radii.
- The Ackermann steering mechanism is a geometric arrangement of linkages in the steering of a vehicle designed to turn the inner and outer wheels at the appropriate angles.



Power Steering

Power steering has two types of device for steering effort one type is a hydraulic device utilizing engine power. The other type utilizes an electric motor. For the former, the engine is used to drive a pump. For the latter, an independent electric motor in the front luggage compartment is used the pump. Both develop fluid pressure, and this pressure acts on a piston within the power cylinder so that the pinion assists the rack effort. The amount of this assistance depends on the extent of pressure acting on the piston. Therefore, if more steering force is required, the pressure must be raised. The variation in the fluid pressure is accomplished by a control valve which is linked to the steering main shaft.

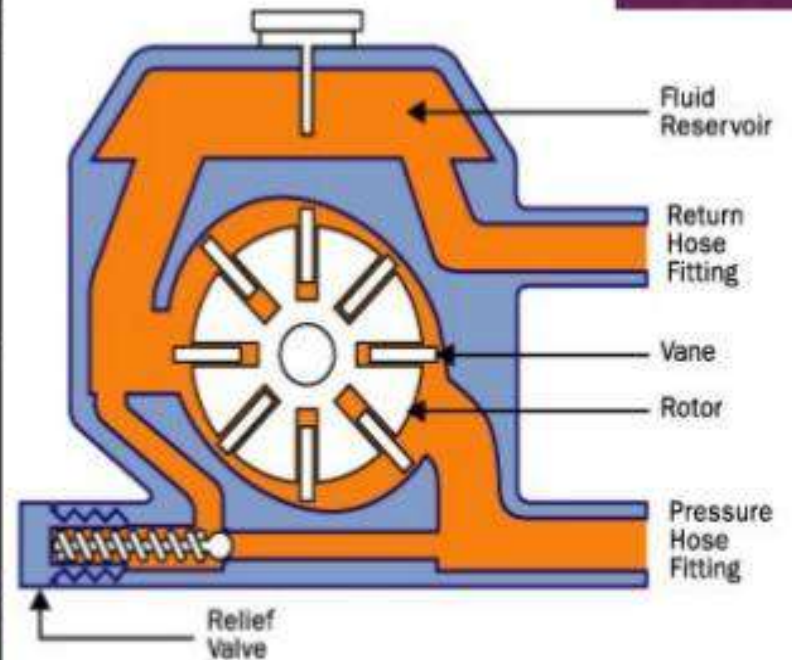
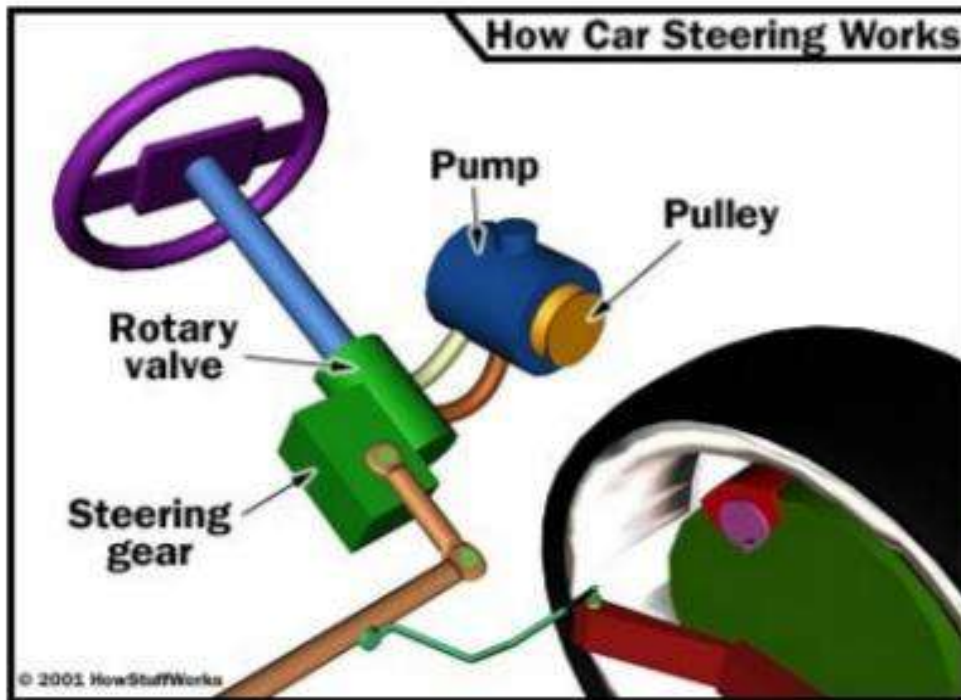
- ▣ **HYDRAULIC POWER STEERING (HPS)** is a hydraulic system for reducing the steering effort on vehicles by using hydraulic pressure to assist in turning the wheels. It is intended to provide for easier driving direction control of the car while preserving "feedback", stability and unambiguity of the trajectory specified. The steering booster is arranged so that should the booster fail, the steering will continue to work (although the wheel will feel heavier).

The steering booster consists of the following basic elements:

- ▣ Steer torque detector
- ▣ Controlled pressure distributor case
- ▣ Hydraulic booster pump
- ▣ Tank with a working liquid
- ▣ Connection hoses

The working liquid, also called "hydraulic fluid" or "oil", is the medium by which pressure is transmitted. Common working liquids are based on mineral oil. For pressure restriction in the pump there is a restrictive valve, which is adjusted on different cars in a range from 7 to 13 MPa.

HYDRAULIC POWER STEERING



SUSPENSION SYSTEM

What is suspension system?

- Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels
- Serve a dual purpose – contributing to the car's handling and braking.
- Protects the vehicle itself and any cargo or luggage from damage and wear

Suspension System

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

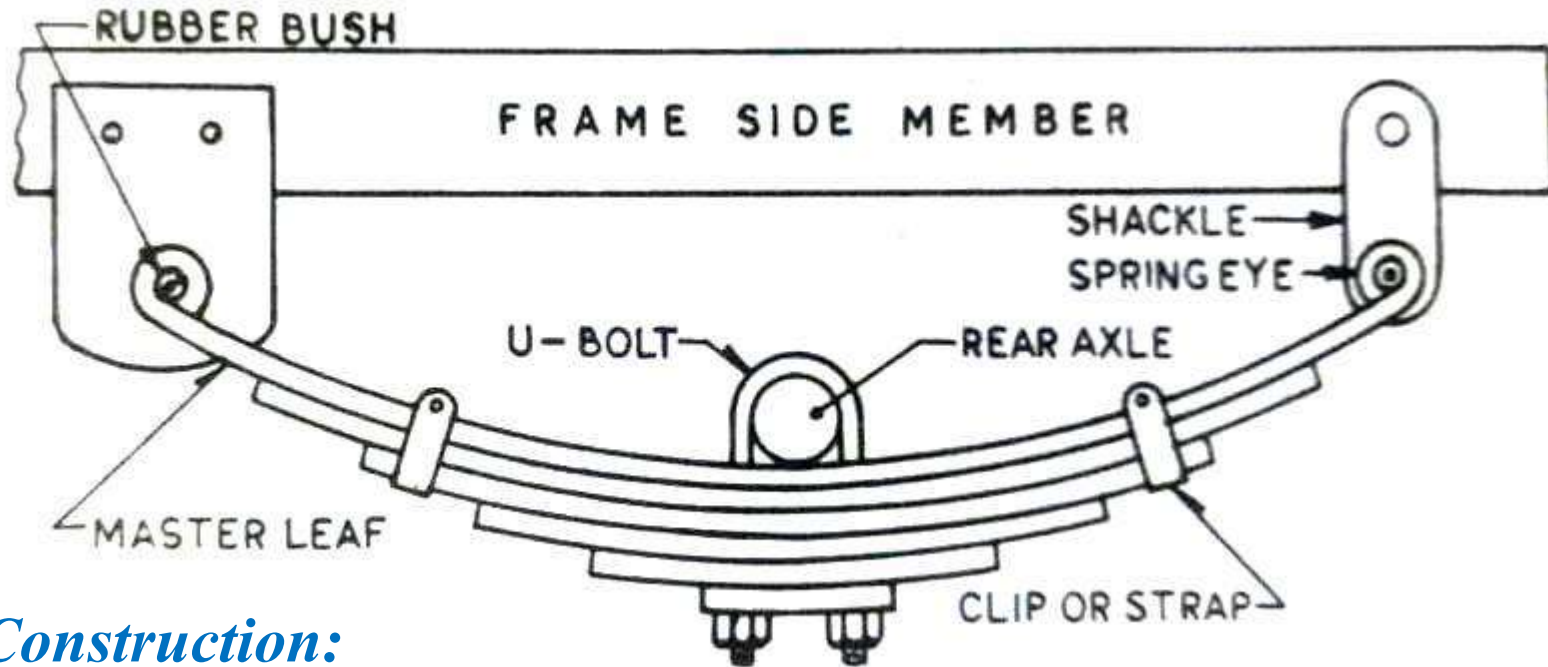
Objective:

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



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Leaf Springs



Construction:

The spring consist of no. of leaves called **Blades**.

The blades are **vary** in length.

The longest length has eye on its both ends, called as **Master leaf**.

All blades are bound together by means of **steel straps**.

The springs are supported on the axle by means of **U-Bolt**.

One end is bolted on the frame with **simple pin** with rubber or bronze bushes.

Other end is connected to frame with **shackle**. This will give flexible connection as the length of the spring changes with road projections.

COIL SPRING

- Little to no internal damping
- Low cost
- Compact Size
- Used in many Suspension types
- Coil spring is the most common type of spring found on modern vehicles

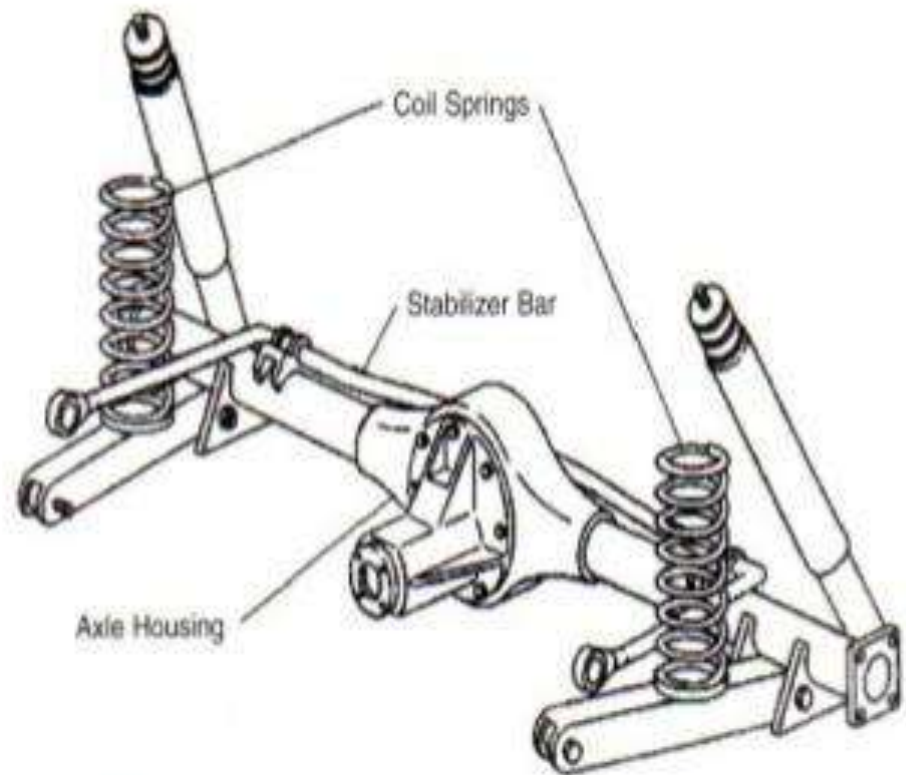
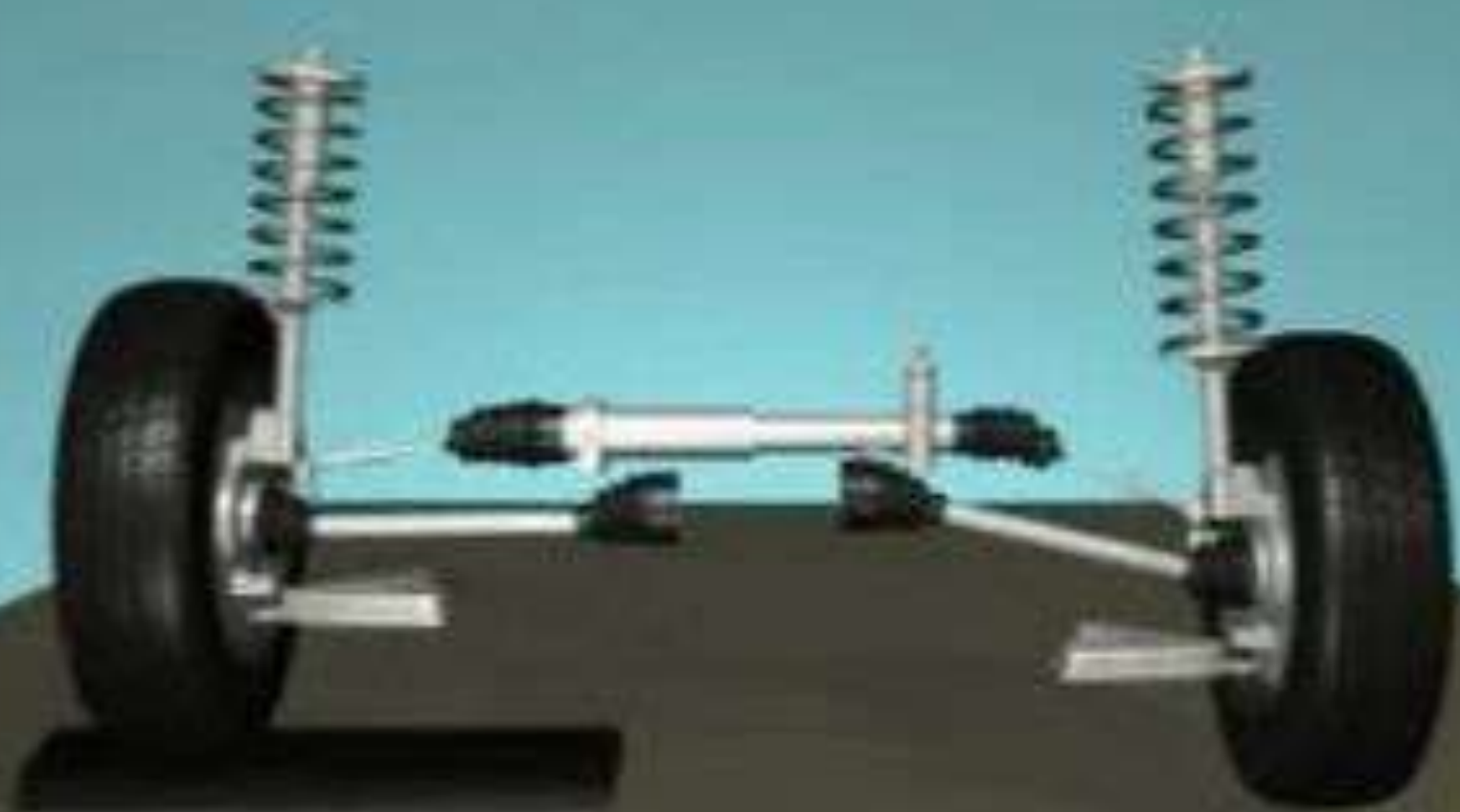


Figure 8.19. A coil spring suspension. Adapted from TM 9-8000 (1985).



Shock absorbers

- A shock absorber is a mechanical device designed to smooth out or damp shock impulse, and dissipate kinetic energy.
- Limits spring compression-extension movements to smooth the vehicle's ride.
- Without shock absorbers, the vehicle would continue to bounce up and down long after striking dip or hump in the road.



Shock Absorbers

- All the springs are flexible and stiff. So they will not absorb shocks efficiently and continue to vibrate with the road irregularities.
- So dampers are provided with the springs which damp the vibrations.
- The shock absorbers absorb the energy of shock converted into vertical movement of axle by providing damping and dissipating the same into heat.



Springs: Sprung and Unsprung Mass

- The **sprung mass** is the mass of the vehicle supported on the springs, while the **unsprung mass** is loosely defined as the mass between the road and the suspension springs.
- The stiffness of the springs affects how the sprung mass responds while the car is being driven.
- Loosely sprung cars, such as luxury cars can swallow bumps and provide a super-smooth ride; however, such a car is prone to dive and squat during braking and acceleration and tends to experience body sway or roll during cornering.
- Tightly sprung cars, such as sports cars, are less forgiving on bumpy roads, but they minimize body motion well, which means they can be driven aggressively, even around corners.

Brake

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

Different types of a brakes are as follows

1. Band Brake

2. Single Block Brake

3. Band and Block Brake

4. Internal Expanding Brake

5. Disc Brake

Classification of brakes

(A) Classification According to Purpose

- (i) Primary Brake (ii) Secondary Brake

(B) Classification According to Location

- (i) At the transmission
- (ii) At the wheel
- (a) Two Wheel Brake (b) Four Wheel Brake

(C) Classification According to Construction

- (a) Drum Brake (b) Disc Brake

(D) Classification According to Actuation

- (i) Mechanical Brake (ii) Hydraulic Brake
- (iii) Electrical Brake (iv) Vacuum Brake
- (v) Air or Pneumatic Brake

(E) According to Extra Braking Effort

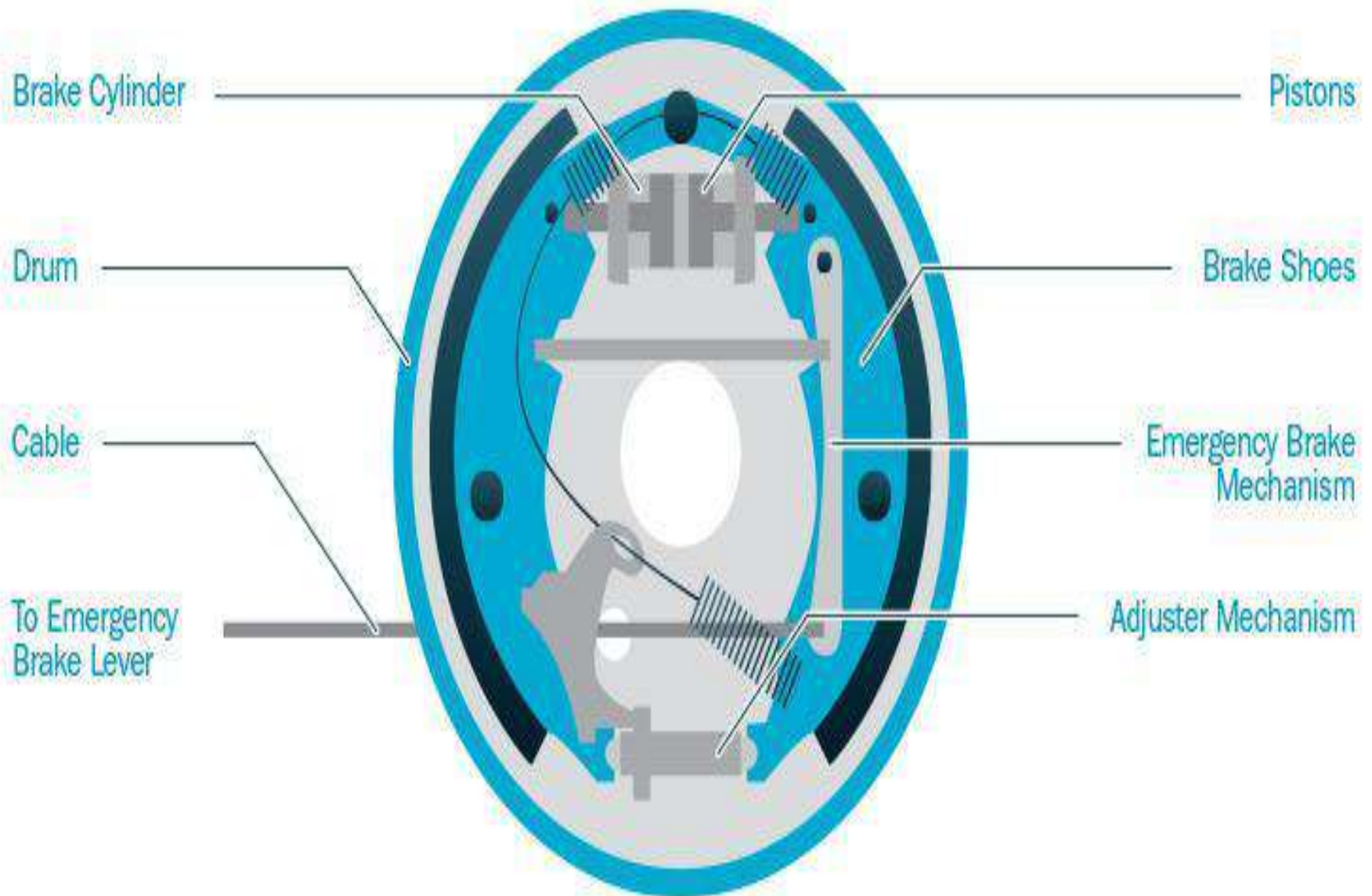
- (i) Servo Brake or power assisted brake.
- (ii) Power brakes or power operated brakes.

(F) According to Application

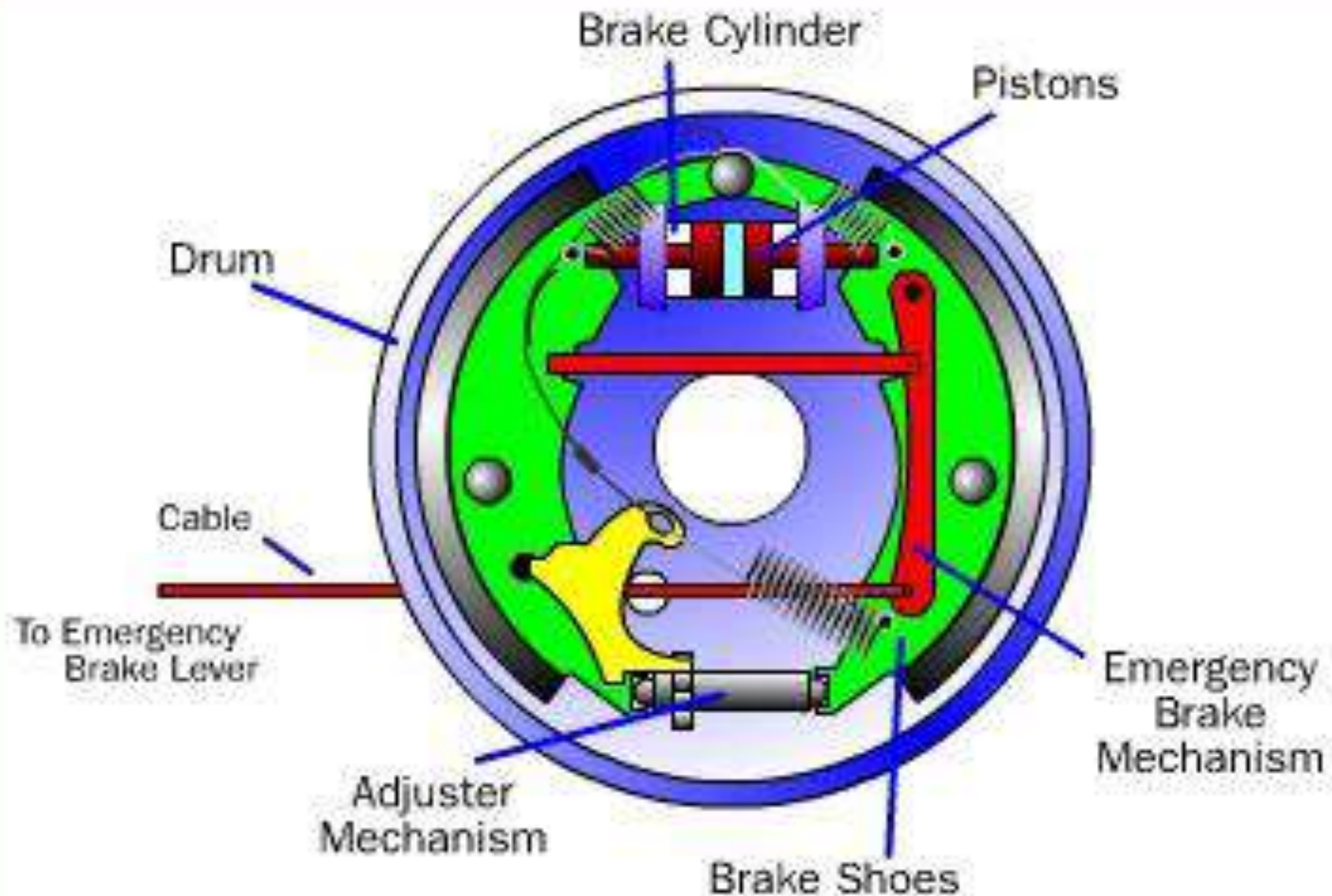
- (i) Foot Brake (ii) Hand Brake

Drum Brakes

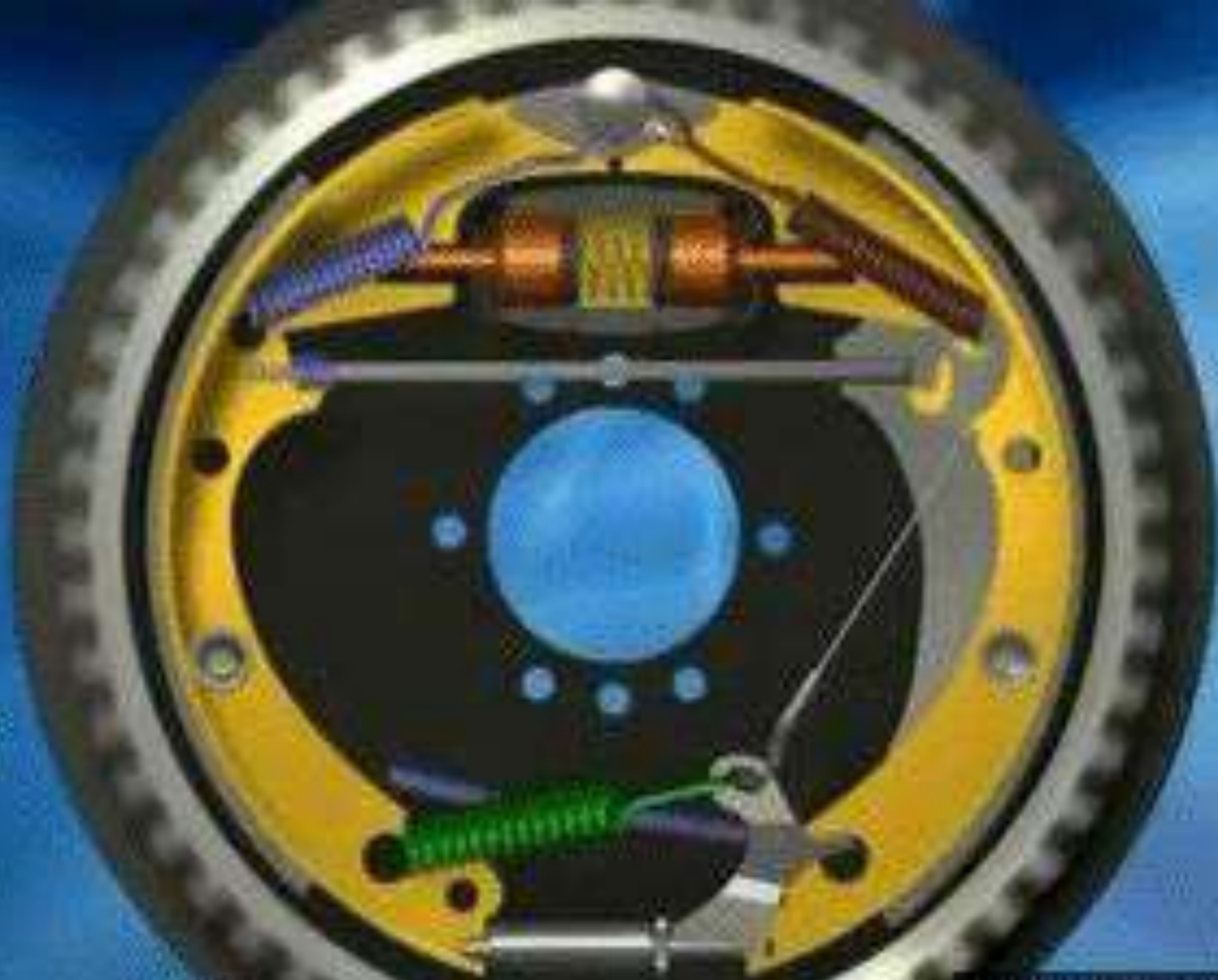
- Drum brakes consist of a backing plate, brake shoes, brake drum, wheel cylinder, return springs and an automatic or self-adjusting system.
- When you apply the brakes, brake fluid is forced under pressure into the wheel cylinder, which in turn pushes the brake shoes into contact with the machined surface on the inside of the drum. When the pressure is released, return springs pull the shoes back to their rest position.
- As the brake linings wear, the shoes must travel a greater distance to reach the drum.
- When the distance reaches a certain point, a self-adjusting mechanism automatically reacts by adjusting the rest position of the shoes so that they are closer to the drum.
- **Brake Shoes:** Like the disk pads, brake shoes consist of a steel shoe with the friction material or lining riveted or bonded to it.
- **Backing Plate:** The backing plate is that holds everything together. It attaches to the axle and forms a solid surface for the wheel cylinder, brake shoes and assorted hardware.



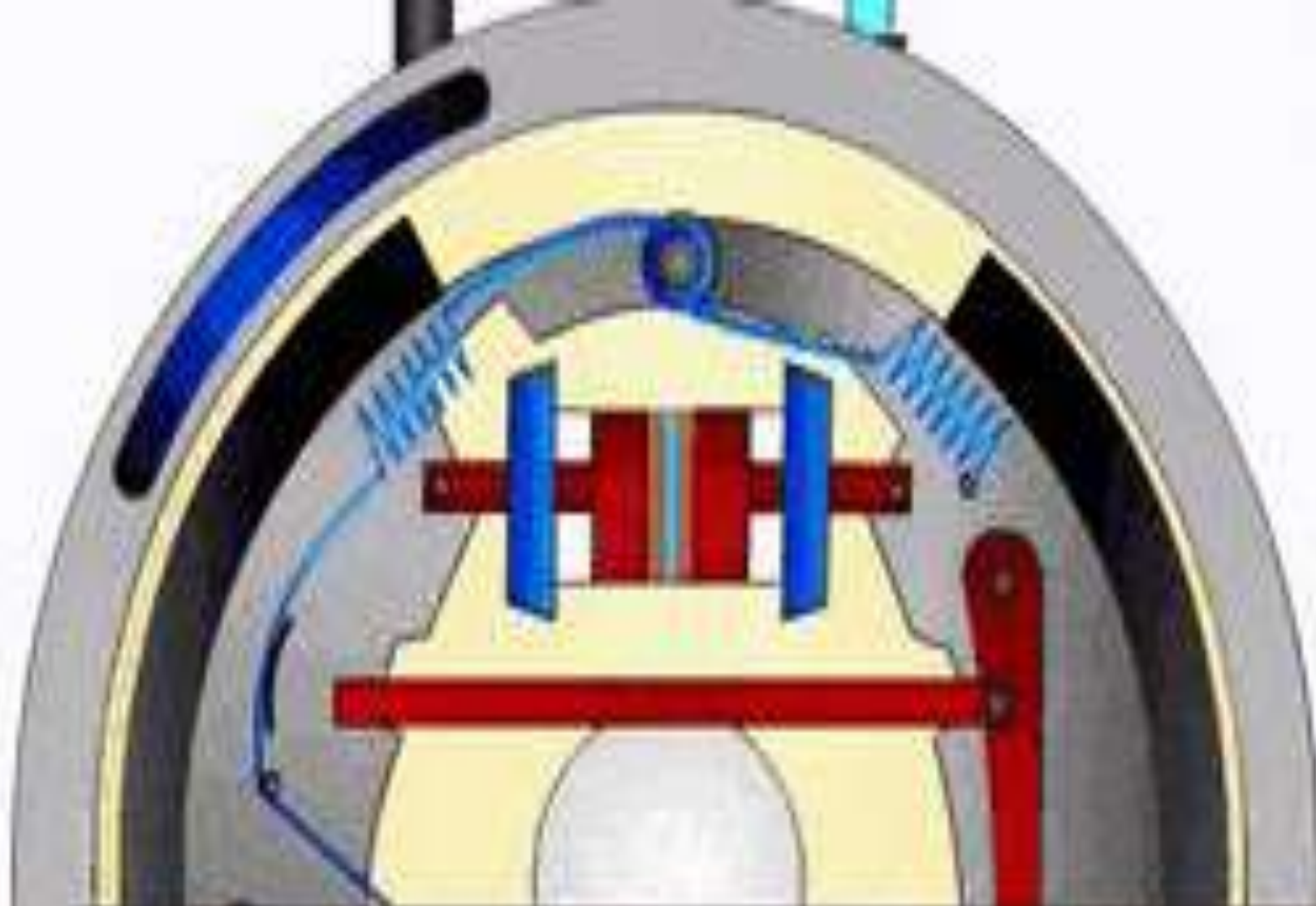
Drum Brake



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- **Brake Drum:** Brake drums are made of iron and have a machined surface on the inside where the shoes make contact. Just as with disk rotors, brake drums will show signs of wear as the brake linings seat themselves against the machined surface of the drum.
- **Wheel Cylinder:** The wheel cylinder consists of a cylinder that has two pistons, one on each side. Each piston has a rubber seal and a shaft that connects the piston with a brake shoe. When brake pressure is applied, the pistons are forced outpushing the shoes into contact with the drum. Wheel cylinders must be rebuilt or replaced if they show signs of leaking.
- **Return Springs:** Return springs pull the brake shoes back to their rest position after the pressure is released from the wheel cylinder. If the springs are weak and do not return the shoes all the way, it will cause premature lining wear because the linings will remain in contact with the drum.
- **Self Adjusting System:** The parts of a self adjusting system should be clean and move freely to ensure that the brakes maintain their adjustment over the life of the linings. If the self adjusters stop working, you will notice that you will have to step down further and further on the brake pedal before you feel the brakes begin to engage. Disk brakes are self adjusting by nature and do not require any type of mechanism.



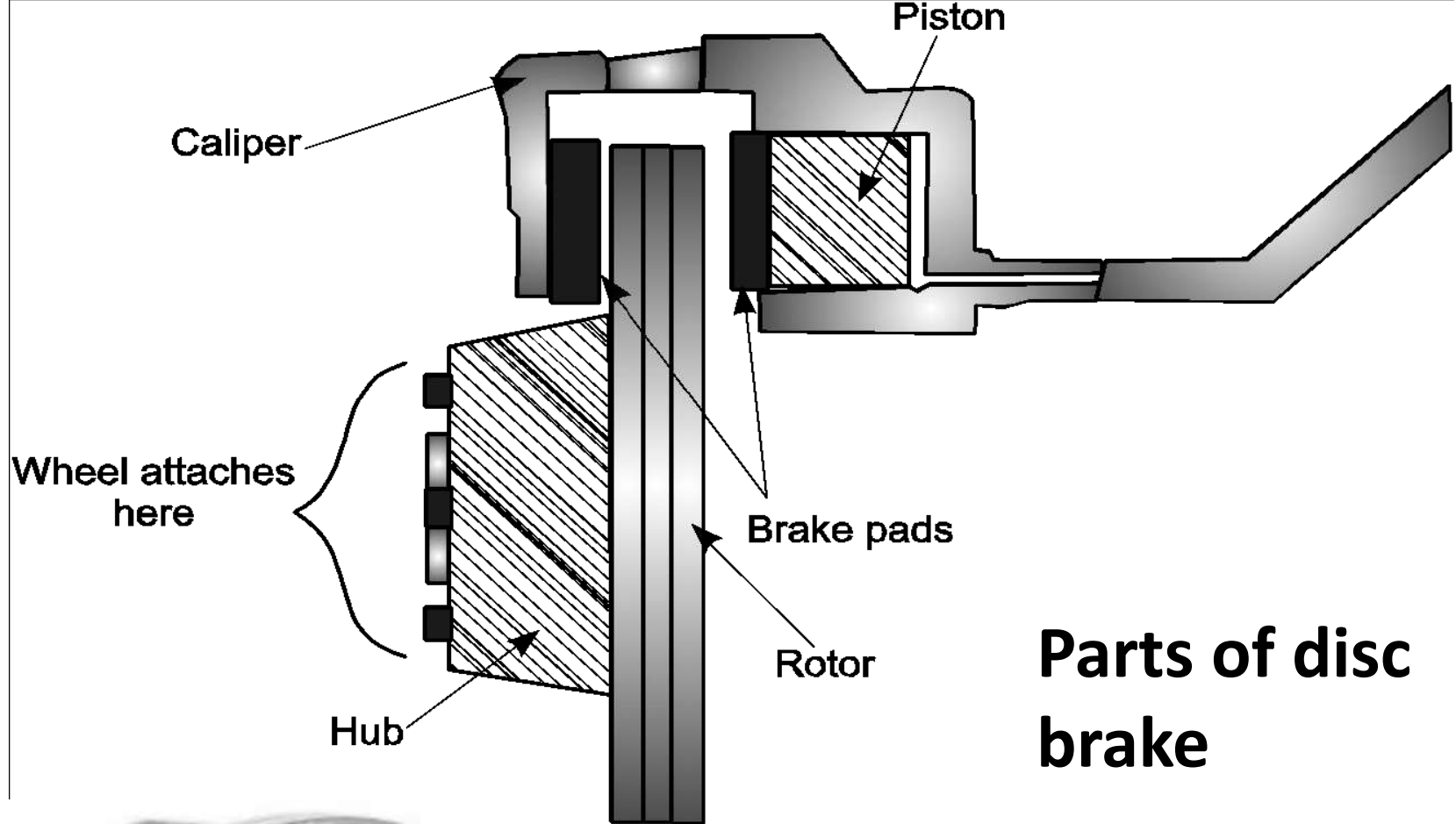
The pressurized fluid causes the piston inside the wheel cylinder to move outwards.

Disc Brake

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

The main components of a disc brake are:

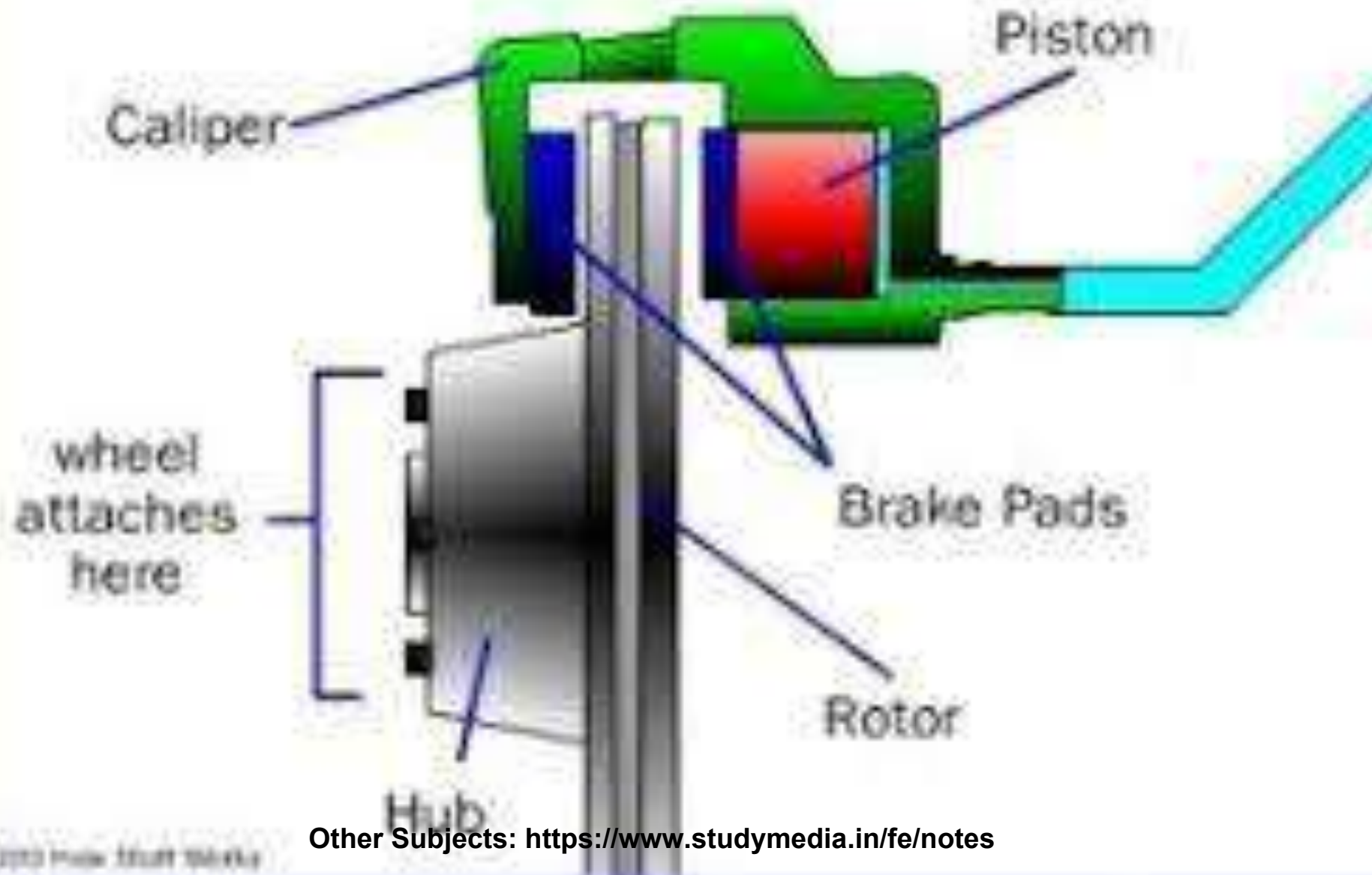
- The brake pads
- The caliper, which contains a piston
- The rotor, which is mounted to the hub



Parts of disc brake



How a Disc Brake Works



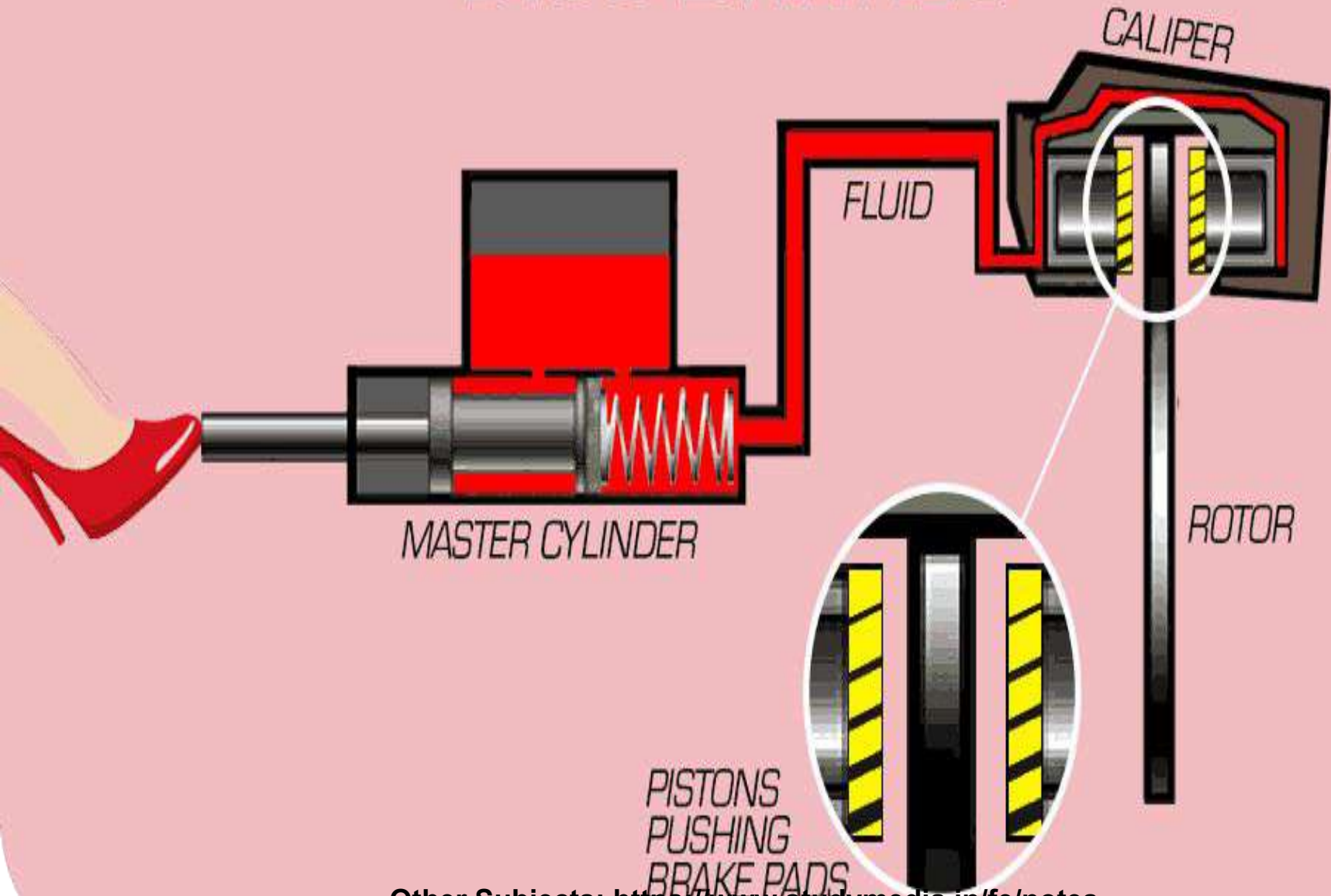
Disc Brakes

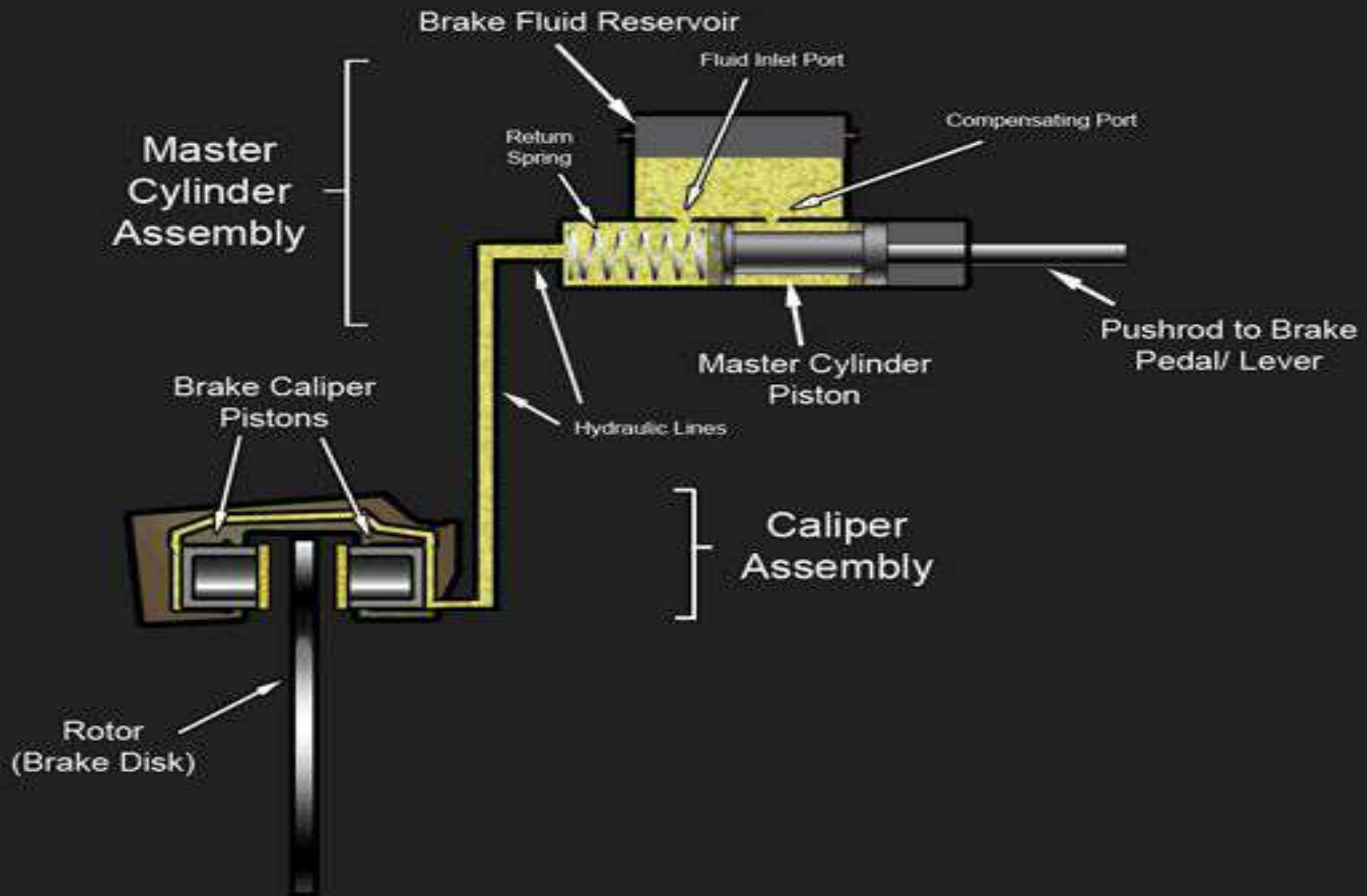
- Disk brakes wear longer, are less affected by water, are self adjusting, self cleaning, less prone to grabbing or pulling and stop better than any other system around.
- The main components of a disk brake are the Brake Pads, Rotor, Caliper and Caliper Support.
- **Brake Pads:** There are two brake pads on each caliper. They are constructed of a metal "shoe" with the lining riveted or bonded to it. The pads are mounted in the caliper, one on each side of the rotor. Brake linings used to be made primarily of asbestos because of its heat absorbing properties and quiet operation; however, due to health risks, asbestos has been outlawed, so new materials are now being used.
- **Rotor:** The disk rotor is made of iron with highly machined surfaces where the brake pads contact it. Just as the brake pads wear out over time, the rotor also undergoes some wear, usually in the form of ridges and groves where the brake pad rubs against it.

Disc Brakes

- **Caliper & Support:**
- There are two main types of calipers: Floating calipers and fixed calipers.
- A floating caliper "floats" or moves in a track in its support so that it can center itself over the rotor. As you apply brake pressure, the hydraulic fluid pushes in two directions. It forces the piston against the inner pad, which in turn pushes against the rotor. It also pushes the caliper in the opposite direction against the outer pad, pressing it against the other side of the rotor.
- Four Piston Fixed Calipers are mounted rigidly to the support and are not allowed to move. Instead, there are two pistons on each side that press the pads against the rotor.

DISC BRAKES





Antilock Brake System (ABS)

These types of a brakes are called as Anti-skid Brake system because of these brake reduces the risk of tyres skidding under heavy load condition and allows driver to maintain steering control of the vehicle.

Antilock brake system operates under heavy load braking or on slipping surface conditions.

- ABS calculates the required slip rate of the wheels accurately based on the vehicle speed and then controls the brake fluid pressure to achieve the target slip rate.
- Although Antilock brake system prevents complete locking of the wheels in practice it allows some wheel slip in order to attain the best possible braking.
- Modern ABS consists of an Electronic Control Unit (ECU). An individual sensor is connected to each wheel of car.

ECU controls and monitors the antilock function and when required.

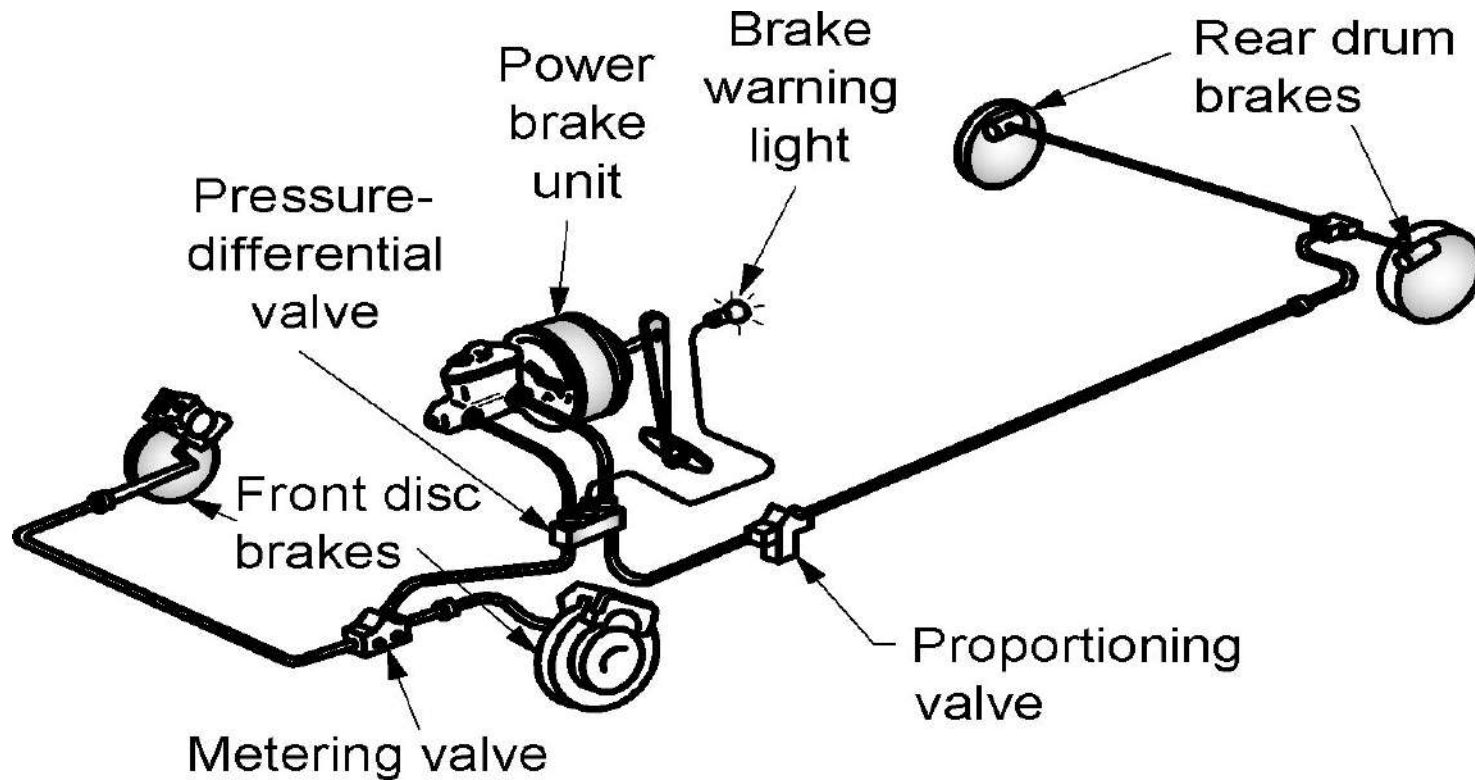
In some ABS, a lateral accelerator sensor is also provided to monitor the lateral (side) movement of the vehicle while taking a turn. This also ensures proper braking out the time of turning.

Electrically driven hydraulic pump is called as Hydraulic Booster. It has four outlet brake lines connecting to each wheel.

Working of ABS

- The sensor of each wheel provides the varying voltage signal to the E.C.U. of brake system .
- E.C.U. Computes the voltage signal and compares it with programmable information and determines whether a wheel is about to lock or skid.
- When the wheel is about to lock , the ECU signals the hydraulic unit to reduce hydraulic pressure at wheels brake calliper.
- Thus the wheel starts to spin again and avoids locking state.
- ECU then instructs hydraulic booster to reapply full pressure & again measures rotation of wheel.

ABS

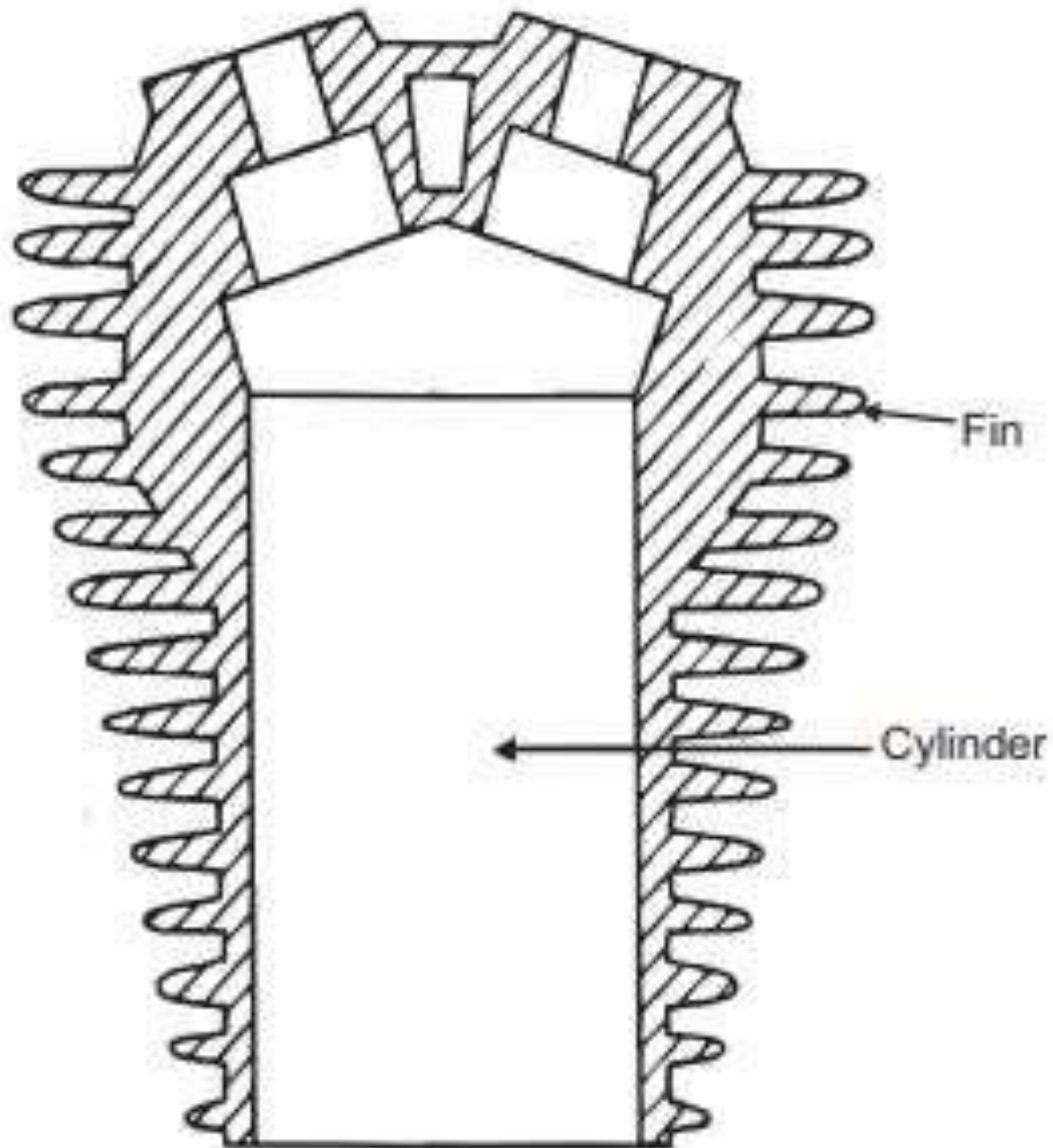


Cooling System of a Vehicle

- There are two methods used for cooling of automobile engine.
 1. Air Cooling.
 2. Water Cooling.
- Water cooling system having two types
 - A) Thermosyphon system.
 - B) Pump circulation system.

Air Cooling System

- Air cooled system is generally used in small engines say up to 15-20 kW and in aero plane engines.
- In this system fins or extended surfaces are provided on the cylinder walls, cylinder head, etc.
- Heat generated due to combustion in the engine cylinder will be conducted to the fins and when the air flows over the fins, heat will be dissipated to air.
- The amount of heat dissipated to air depends upon : (a) Amount of air flowing through the fins. (b) Fin surface area. (c) Thermal conductivity of metal used for fins.



Advantages of Air Cooled System

- (a) Radiator/pump is absent hence the system is light.
- (b) In case of water cooling system there are leakages, but in this case there are no leakages.
- (c) Coolant and antifreeze solutions are not required.
- (d) This system can be used in cold climates, where if water is used it may freeze.

Disadvantages of Air Cooled System

- (a) Comparatively it is less efficient.
- (b) It is used in aero planes and motorcycle engines where the engines are exposed to air directly

Direction of
air flow



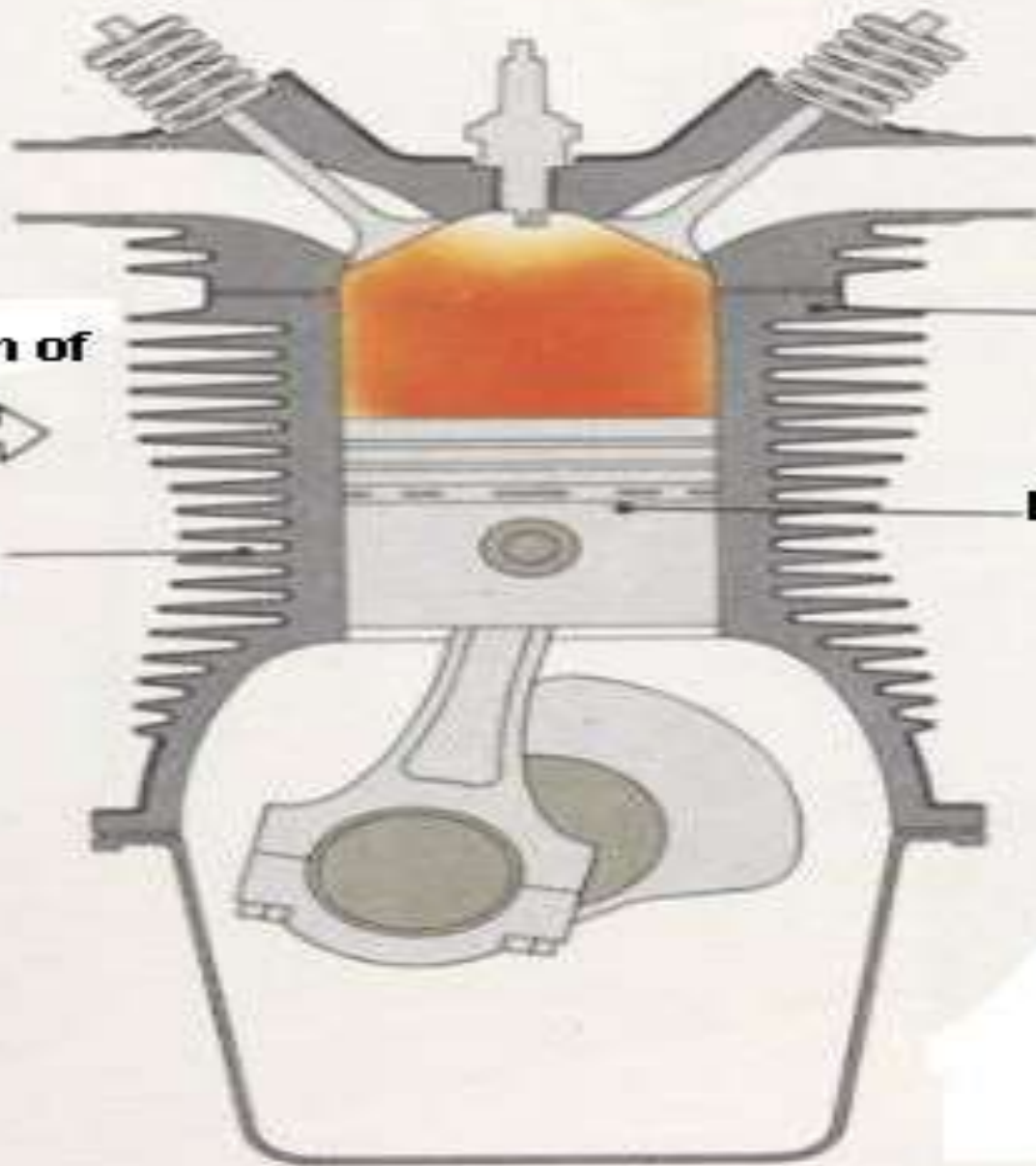
Fins

Longer fins
Where greater
heat develops
improves cooling

Piston

Cooling fins are used to increase the surface area
exposed to the air stream

Other Subjects: <https://www.studymedia.in/fe/notes>

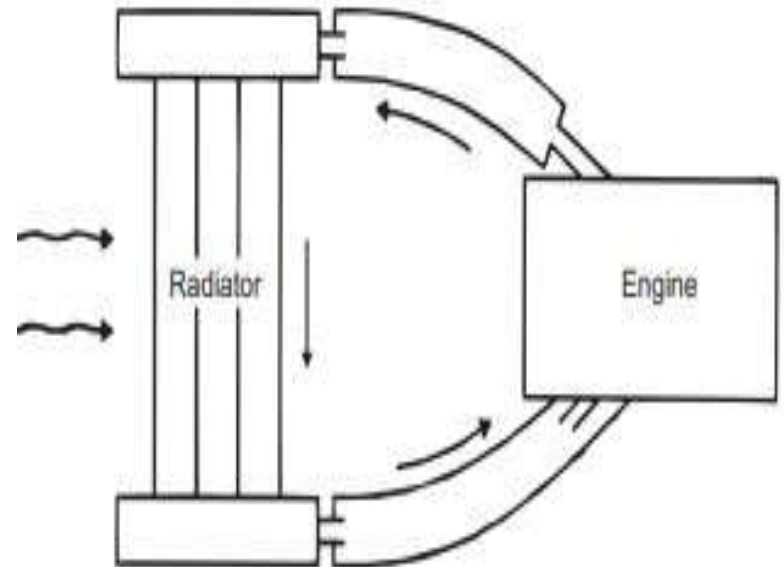


Water Cooling System

- The water cooling system is used in the engines of **cars, buses, trucks**, etc.
- In this system, the water is circulated through water jackets around each of the combustion chambers, cylinder, valve seats and valve stems.

1. *Thermo Siphon System*

- In this system the circulation of water is due to difference in temperature (i.e. difference in densities) of water. So in this system pump is not required but water is circulated because of density difference only.
- This system works on the principle that hot water being lighter rises up and the cold water being heavier goes down.
- In this system the radiator is placed at a higher level than the engine for the easy flow of water towards the engine.
- Heat is conducted to the water jackets from where it is taken away due to convection by the circulating water. As the water jacket becomes hot, it rises to the top of the radiator.
- Cold water from the radiator takes the place of the rising hot water and in this way a circulation of water is set up in the system. This helps in keeping the engine at working temperature.



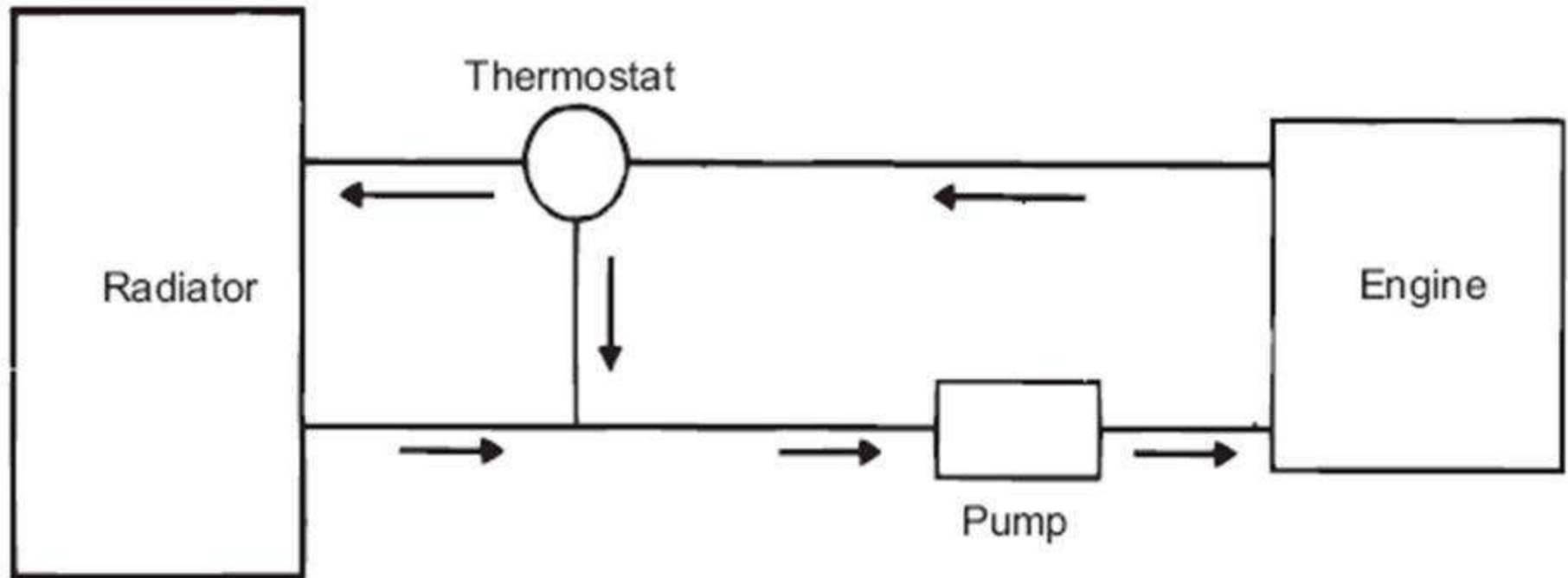
2. Non-Return Water Cooling System

- This is suitable for large installations and where plenty of water is available.
- The water from a storage tank is directly supplied to the engine cylinder.
- The hot water is not cooled for reuse but simply discharges.
- The low H.P. engine, coupled with the irrigation pump is an example

3. Force Circulation Water Cooling System

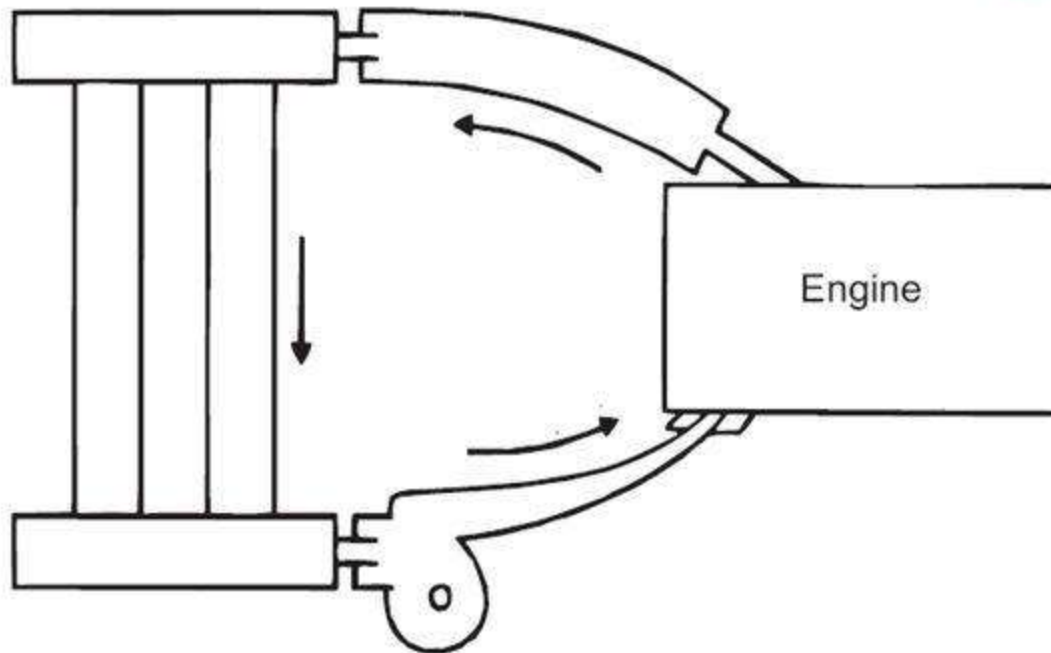
- This system is similar in construction to the thermo-syphon system except that it makes use of a centrifugal pump to circulate the water throughout the water jackets and radiator.
- The water flows from the lower portion of the radiator to the water jacket of the engine through the centrifugal pump.
- After the circulation water comes back to the radiator, it loses its heat by the process of radiation.
- This system is employed in cars, trucks, tractors, etc.

Forced Circulation System - Components



(a) Radiator, (b) Thermostat valve, (c) Water pump, (d) Fan, (e) Water Jackets, and (f) Antifreeze mixtures.

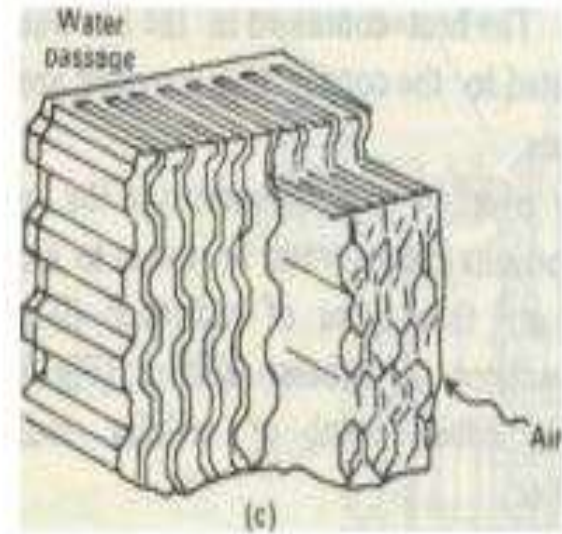
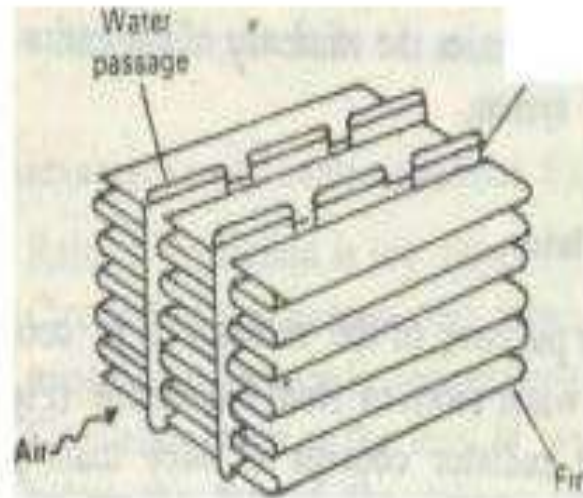
Pump or Forced Circulation Cooling System



- ◉ In this system circulation of water is obtained by a pump.
- ◉ This pump is driven by means of engine output shaft through V-belts.

Radiator

- The purpose of the radiator is to cool down the water received from the engine.
- The radiator consists of three main parts: (i) upper tank, (ii) lower tank and (iii) tubes.
- Hot water from the upper tank, which comes from the engine, flows downwards through the tubes.
- The heat contained in the hot water is conducted to the copper fins provided around the tubes.
- An overflow pipe, connected to the upper tank, permits excess water or steam to escape.
- There are three types of radiators: (i) gilled tube radiator, (ii) tubular radiator (Fig. b) and (iii) honey comb or cellular radiator (Fig. c)



Type of radiators

Gilled tube radiator:

- This is perhaps the oldest type of radiator, although it is still in use. In this, water flows inside the tubes.
- Each tube has a large number of annular rings or fins pressed firmly over its outside surface.

Tubular radiator:

- The only difference between a gilled tubes radiator and a tubular one is that in this case there are no separate fins for individual tubes.
- The radiator vertical tubes pass through thin fine copper sheets which run horizontally.

Honey comb or cellular radiator:

- The cellular radiator consists of a large number of individual air cells which are surrounded by water.
- In this, the clogging of any passage affects only a small parts of the cooling surface. However, in the tubular radiator, if one tube becomes clogged, the cooling effect of the entire tube is lost.

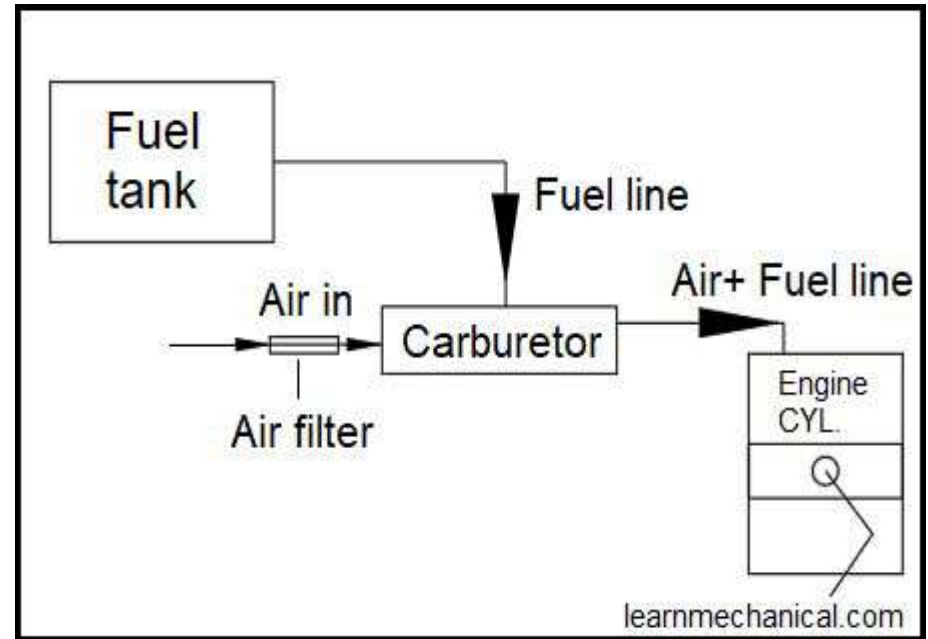
Fuel Supply System

For the supply of fuel from fuel tank to engine cylinder in **petrol Engine** following fuel feed systems are used:

- Gravity system
- Air pressure system
- Vacuum system (suction and gravity system)
- Pump feed system
- Fuel injection system

1. GRAVITY FUEL FEED SYSTEM:

- In this system, the fuel tank is mounted at the highest point of the [SI engine](#).
- This system is quite simple and cheap as the fuel drops into the float Chamber of the [carburetor](#) under Gravity.
- It is used in a small engine having low fuel consumption as sufficient head is not developed for large engine.
- **Advantages:**
The system is quite simple and cheap as of other fuel feed system
- **Disadvantages:**
The rigidity of placing the fuel tank necessarily over carburetor is its disadvantage



2. AIR PRESSURE FEED SYSTEM:

- In this system, an airtight fuel tank is used and is placed under the seat or near the engine.
- the hand operated a pump or mechanically operated pump supplies the high-pressure air to the fuel tank for supplying the fuel to the carburetor.
- **Advantages:**
The fuel tank can be placed at any suitable location
- **Disadvantages:**
There are chances of pressure leak within the chamber

3. VACUUM FEED SYSTEM (Suction and Gravity system)

- In this system, fuel from the fuel tank which is placed near the engine is sucked by means of suction from the induction manifold. by means of gravity, the fuel is supplied to the float of the [carburetor](#).
- **Advantages:**
The cost of the total system is less

4. PUMP FEED SYSTEM:

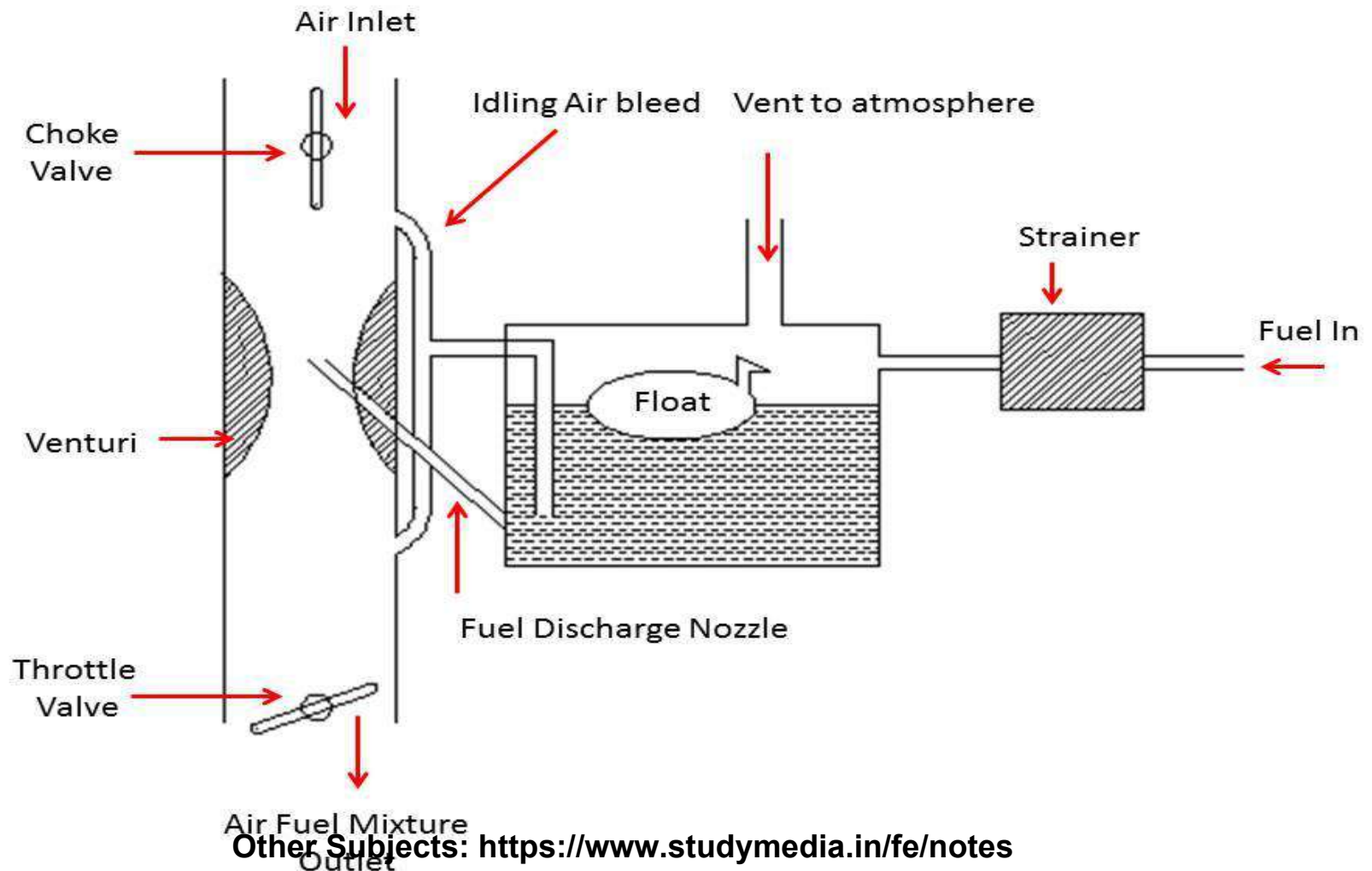
- In this system, a steel pipe carries petrol to the [fuel pump](#) which Pumps it into the float Chamber of the carburetor through the pipe.
- A mechanical or electrical or a diaphragm pump supplies the fuel from the fuel tank is placed at any suitable location and is vented to the atmosphere.
- This system is used in most vehicles in the present days.

5.FUEL INJECTION SYSTEM

- The petrol injection system now comes to modern vehicles. the fuel is atomized by means of an air injector nozzle then delivered into an air stream.
- there may be separate fuel injectors are used for separate cylinder or one single [fuel injector](#) is used.
- **Advantages:**
 - This is the most accurate fuel supply system
 - High power is developed
 - It has quick starting and warms up
 - Low specific fuel consumption rate
- **Disadvantages:**
 - Back-flow of petrol may take place
 - High initial cost

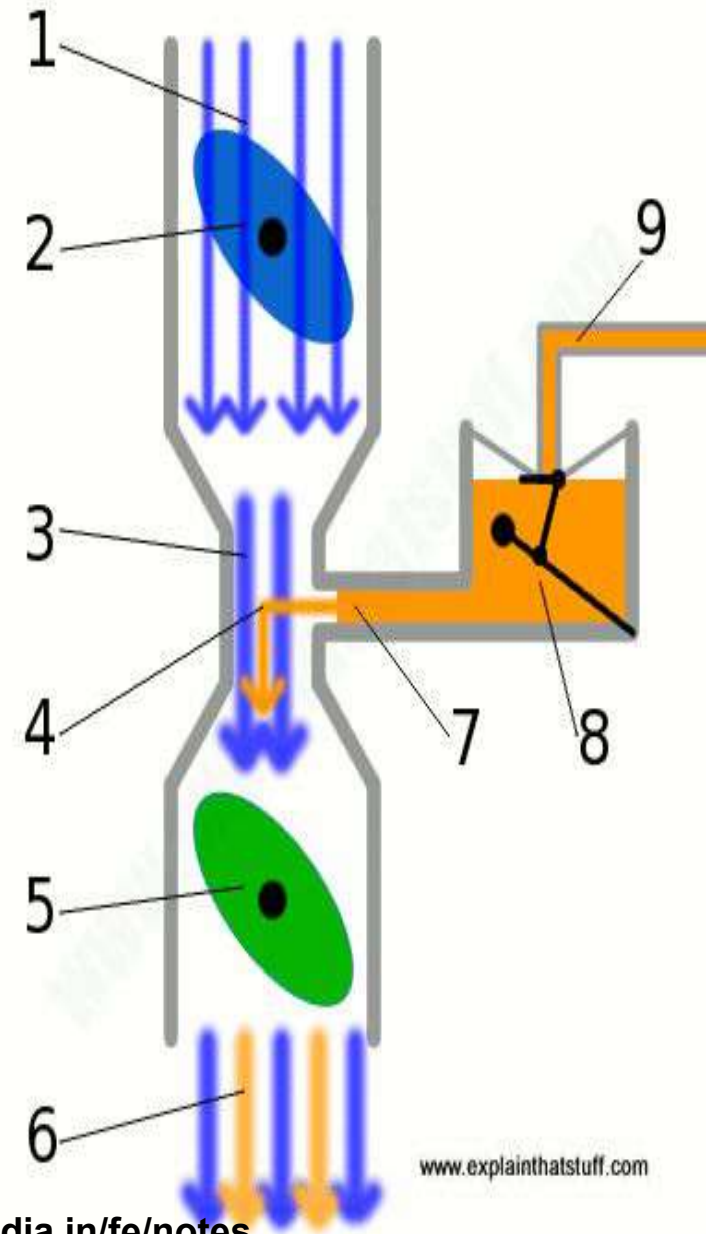
Carburetor

- Getting the fuel-air mixture just right is the job of a clever mechanical gadget called a **carburetor**: a tube that allows air and fuel into the engine through [valves](#), mixing them together in different amounts to suit a wide range of different driving conditions.

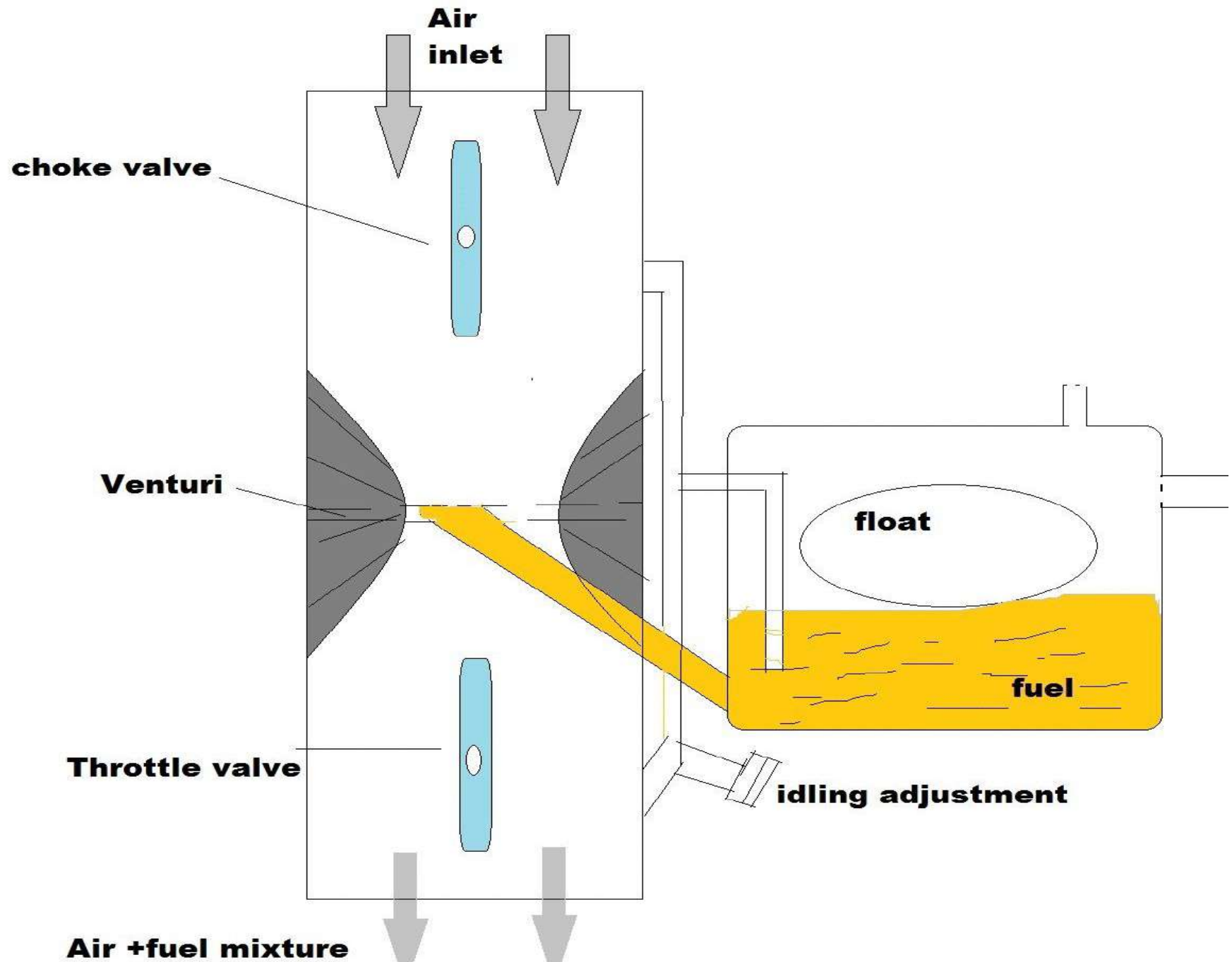


Working of Carburetor

1. Air flows into the top of the carburetor from the car's air intake, passing through a filter that cleans it of debris.
2. When the engine is first started, the choke (blue) can be set so it almost blocks the top of the pipe to reduce the amount of air coming in (increasing the fuel content of the mixture entering the cylinders).
3. In the center of the tube, the air is forced through a narrow kink called a venturi. This makes it speed up and causes its pressure to drop.
4. The drop in air pressure creates suction on the fuel pipe (right), drawing in fuel (orange).
5. The throttle (green) is a valve that swivels to open or close the pipe. When the throttle is open, more air and fuel flows to the cylinders so the engine produces more power and the car goes faster.
6. The mixture of air and fuel flows down into the cylinders.
7. Fuel (orange) is supplied from a mini-fuel tank called the float-feed chamber.
8. As the fuel level falls, a float in the chamber falls and opens a valve at the top.
9. When the valve opens, more fuel flows in to replenish the chamber from the main gas tank. This makes the float rise and close the valve again.



Other Subjects: <https://www.studymedia.in/fe/notes>



Fuel Injection System for Diesel Engine

- Fuel supply system is a separate system used to deliver diesel at correct time in correct quantity, to a diesel engine (or C.I engine), for smooth and efficient operation.
- The operation of a diesel engine is different from that of a petrol engine.
- In a **petrol engine**, air-fuel mixture is supplied by a **carburetor** to the engine, at the beginning of the suction stroke. But in a **diesel engine**, fuel (without air) is supplied at the end of the compression stroke, by means of a **fuel supply system**.
- Fuel supply system in diesel engine is made of the following components:

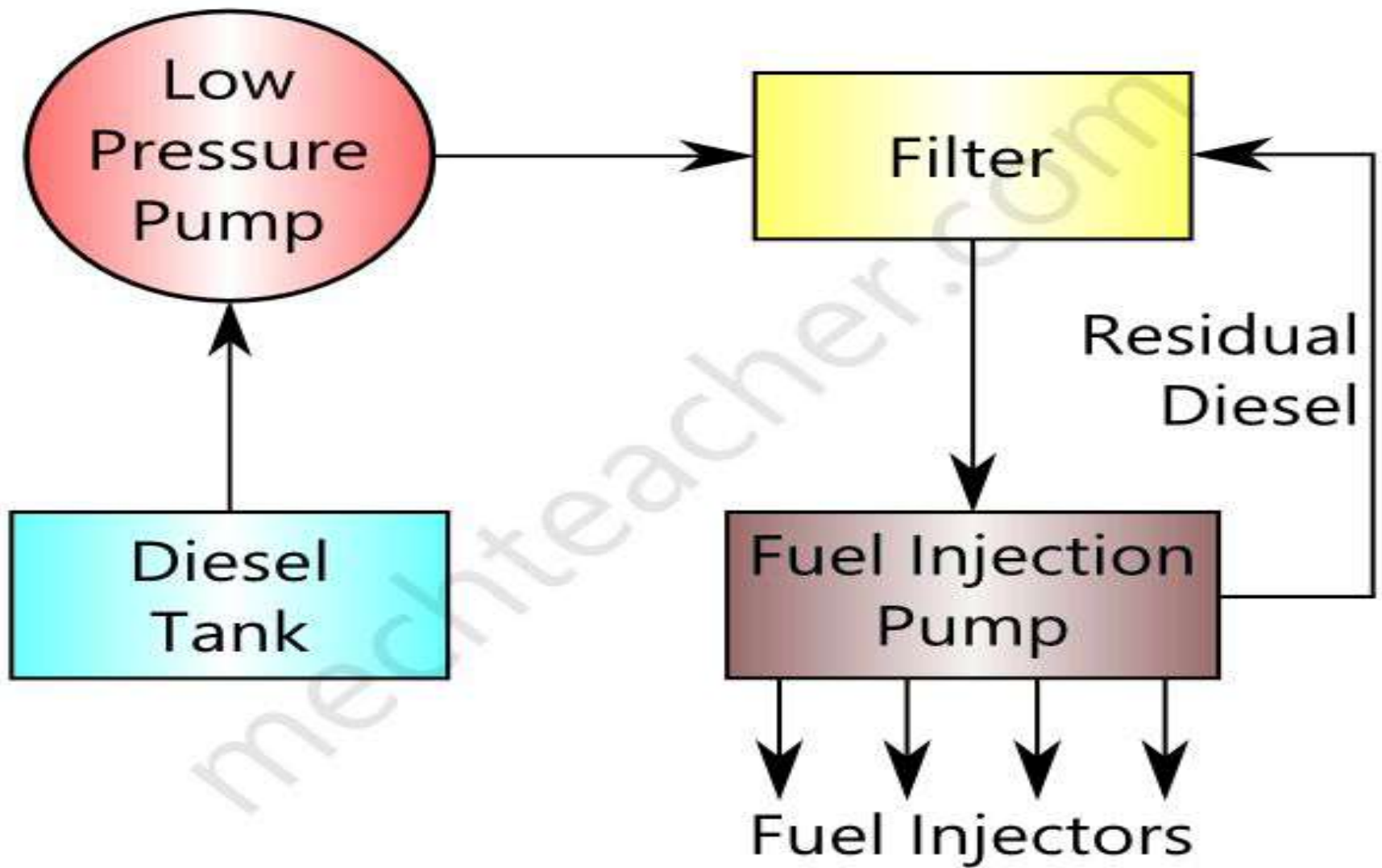
Diesel tank or reservoir

Low pressure pump

Filter

Fuel injection pump

Fuel injectors



1. Diesel tank or reservoir:

- Whenever you supply fuel to a diesel engine vehicle, it is stored in the diesel tank. Diesel tank temporarily stores diesel that is to be supplied to the engine.

2. Low pressure pump:

- It pumps the diesel at a low pressure to the fuel injection pump through a filter.

3. Filter:

- Before diesel is supplied to an engine, it must be filtered to remove any unwanted impurities. Filter is used for this purpose.

4. Fuel injection pump:

- This is the most important component of the fuel injection system.
- Fuel injection pump pressurizes the fuel to the required level and injects it correctly at the end of the compression stroke, during each cycle of operation of the engine.

5. Fuel injectors:

- Injectors are devices used to inject the fuel to the cylinder. In diesel engine, when fuel is injected, it is automatically atomized.

Working:

- Diesel is pumped from the diesel tank by a low pressure pump. It is passed through a filter. The filter removes any unwanted impurities in the diesel.
- Filtered diesel is supplied to the inlet port of the fuel injection pump. The fuel injection pump automatically pressurizes the diesel to the required level and supplies it to the fuel injector.
- The fuel injector forces the fuel into the cylinder at the end of the compression stroke, during each cycle of operation of the engine.
- Fuel injection pump is operated by means of a cam shaft. CAV fuel injection is the most common fuel injection pump used in diesel engines.
- Any leak-off diesel from the fuel injection pump is supplied back into the filter as shown in the figure.

Power transmission system-

- In Automobile, Power transmission is nothing but to transmit the power from crank shaft to the rear wheels. It covers different mechanisms & different system from engine to wheels.
- It includes **clutch, Gear box, Propeller shaft & differential.**

- **Function of transmission:-**

1. Vehicle at a low speeds, the torque produced by an I.C engine is very small, which increases with increase of speed, peaks at some optimum speed & starts decreasing beyond that.
2. The transmission provides a neutral position so that the engine & road wheels are disconnected so engine in running condition but power is not transmitted to wheels.
3. In reversing condition to transmit power from engine to wheels.

Clutch

- A clutch is a mechanical device used to connect or disconnect a driving shaft(**Engine**) from driven shaft (**Gear box**) at the will of the operator.
- Thus, clutch can permit the engine to run without driving a vehicle, if it is disengaged.
- Normally clutch remains in engaged position i.e. it transmits power from driving shaft to driven shaft.
- When it is disengaged, it stops transmitting power from driving shaft to driven shaft.

Clutch

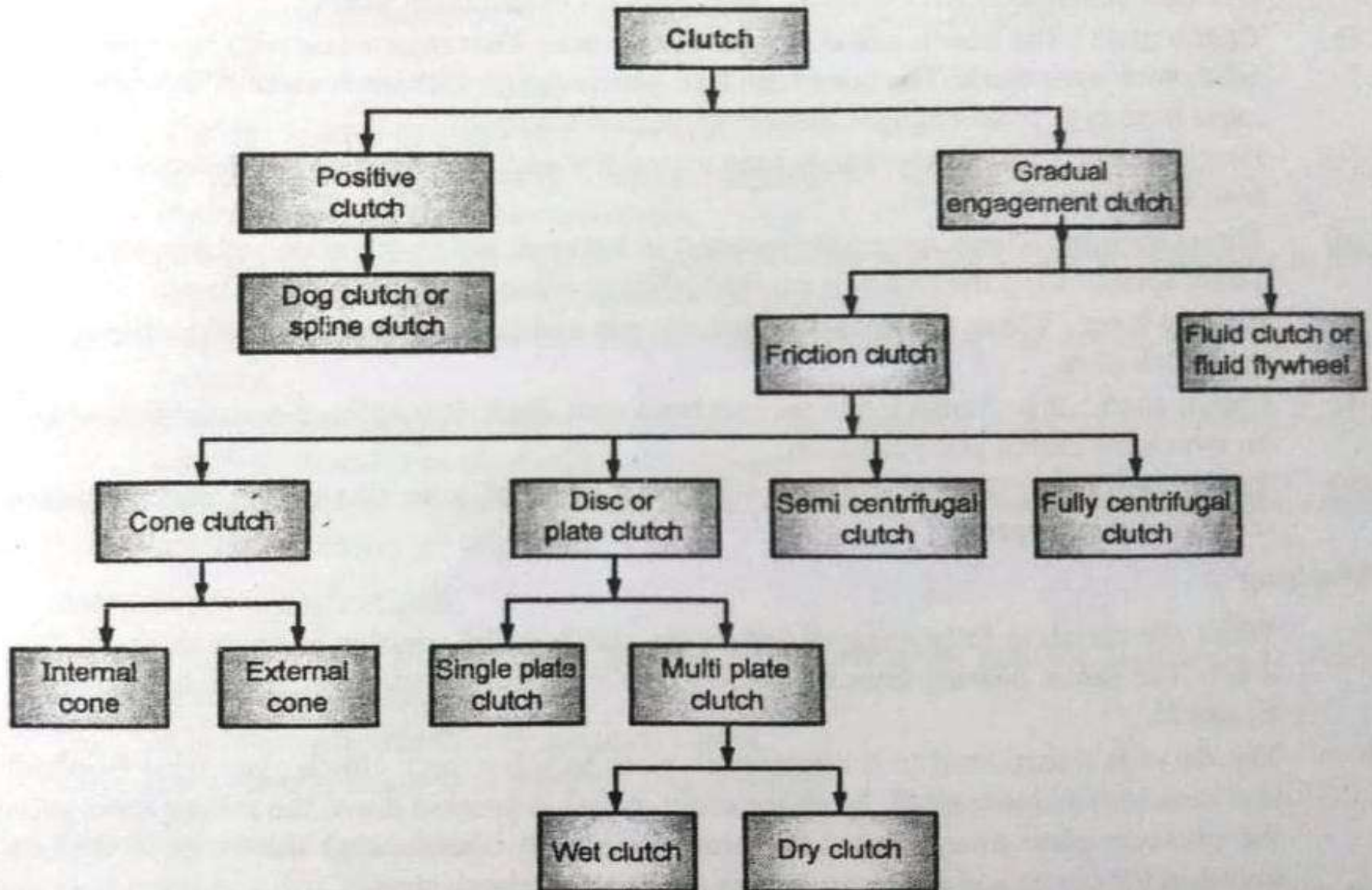
Clutches

- Clutch is defined as the mechanism to transmit rotary motion from driving shaft to driven shaft as and when required, without stopping the drive shaft.
- Clutch is a device used to engage and disengage two co-axial shafts while at rest or in relative motion gradually. The gradual engagement of driven shaft limits torque demanded from the driving shaft.

Need:

- To transmit power smoothly.
- Once the clutch is engaged , must transmit power without slipping.
- To overcome self inertia of vehicle.
- For gradual engagement of rotary motion from engine to the gear box shaft.
- These are also used to disengage drive from engine to gear box for changing of different gears.
- At the time of stopping of vehicle the clutch is utilized to disengage engine from drive wheels and enable smooth stopping of the vehicle.
- Clutch also takes the care of speed and torque fluctuations for engine crank shaft to gear box input shaft science clutch is made from friction

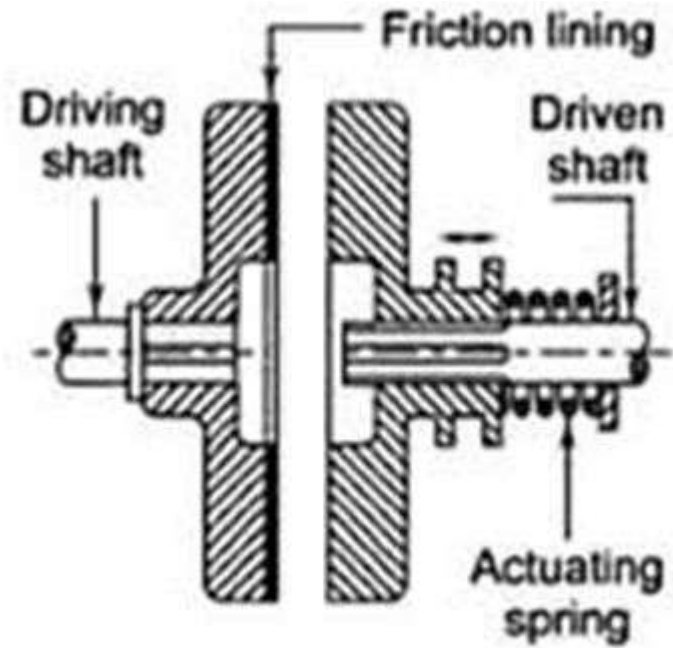
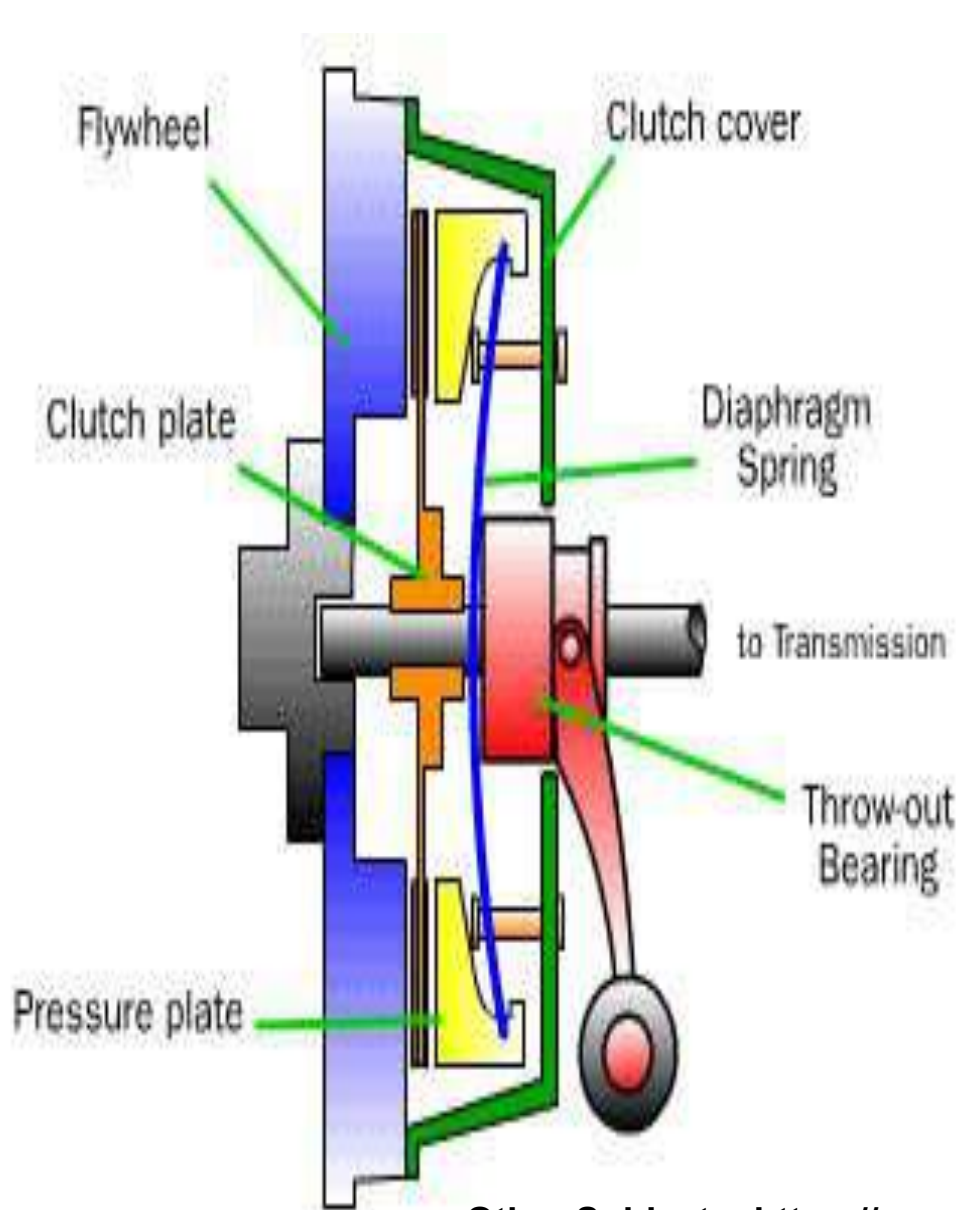
Classification of Clutches



Clutch Plate



Single plate clutch



Single Plate Clutch



Disc or Single Plate clutch

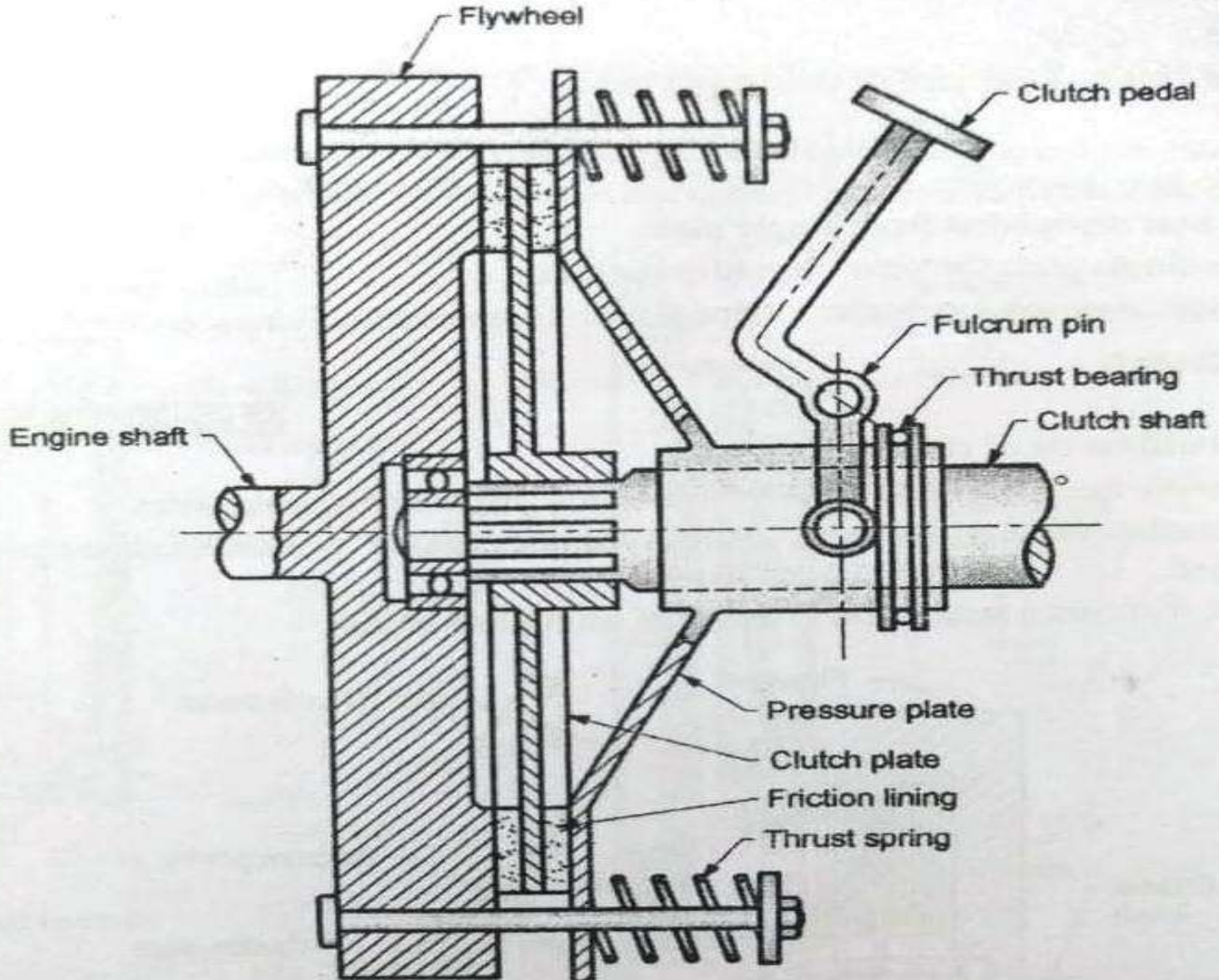


Fig. 2.1.2 : Single Plate Clutch

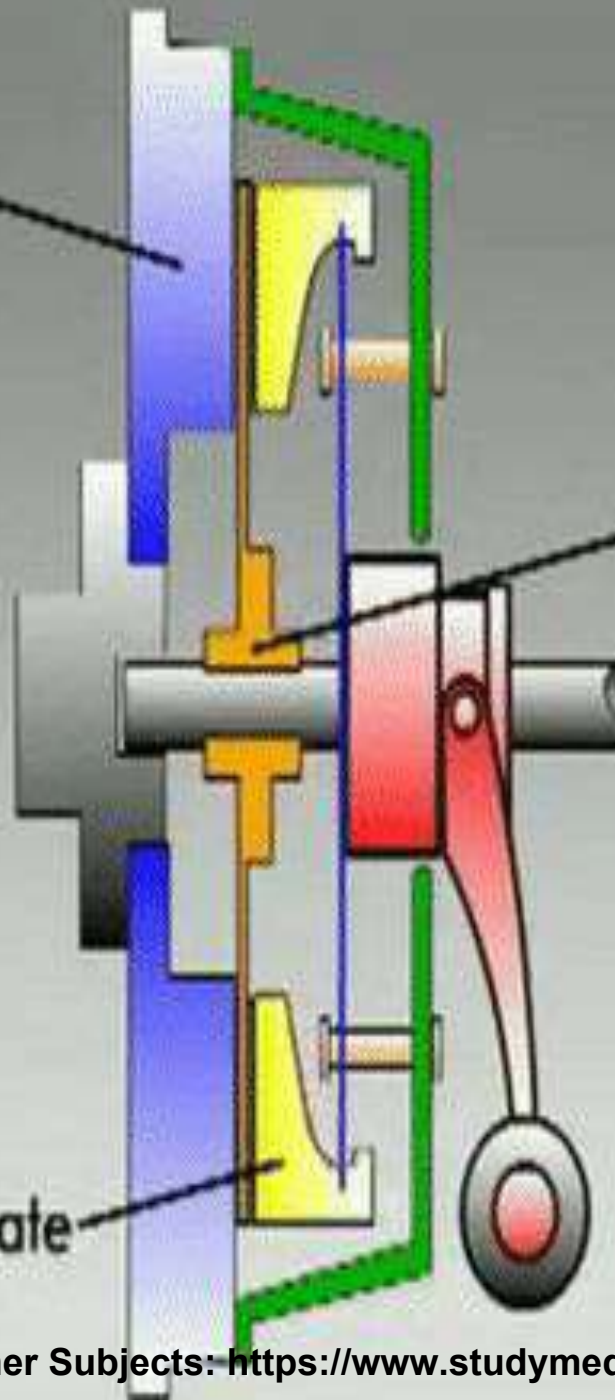
Single Plate Clutch

- Clutch in normal working remains engaged. i.e. it transmits power from driving to driven shaft.
- In this, the actuating force is provided by a spring, which forces the driven flange to move towards the driving flange.
- Torque is transmitted by means of frictional force between the driving and driven flanges.
- When the driven shaft is to be disengaged, axial force is applied, so that driven shaft flange moves along the axis, away from the other flange.
- It is a dry clutch, hence lubrication is required.
- **Application :** It is used in automobiles.

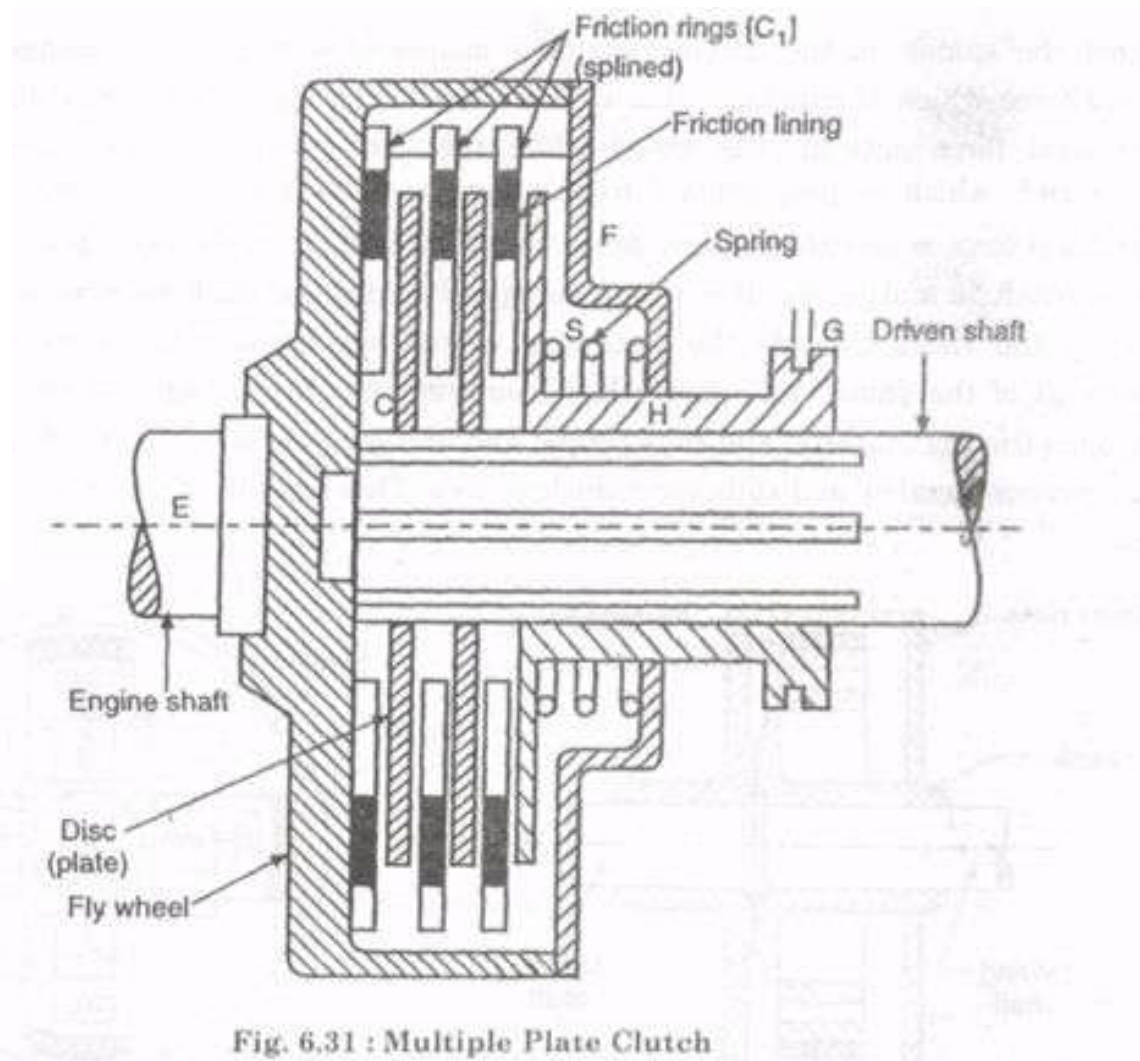
Flywheel

Clutch disk

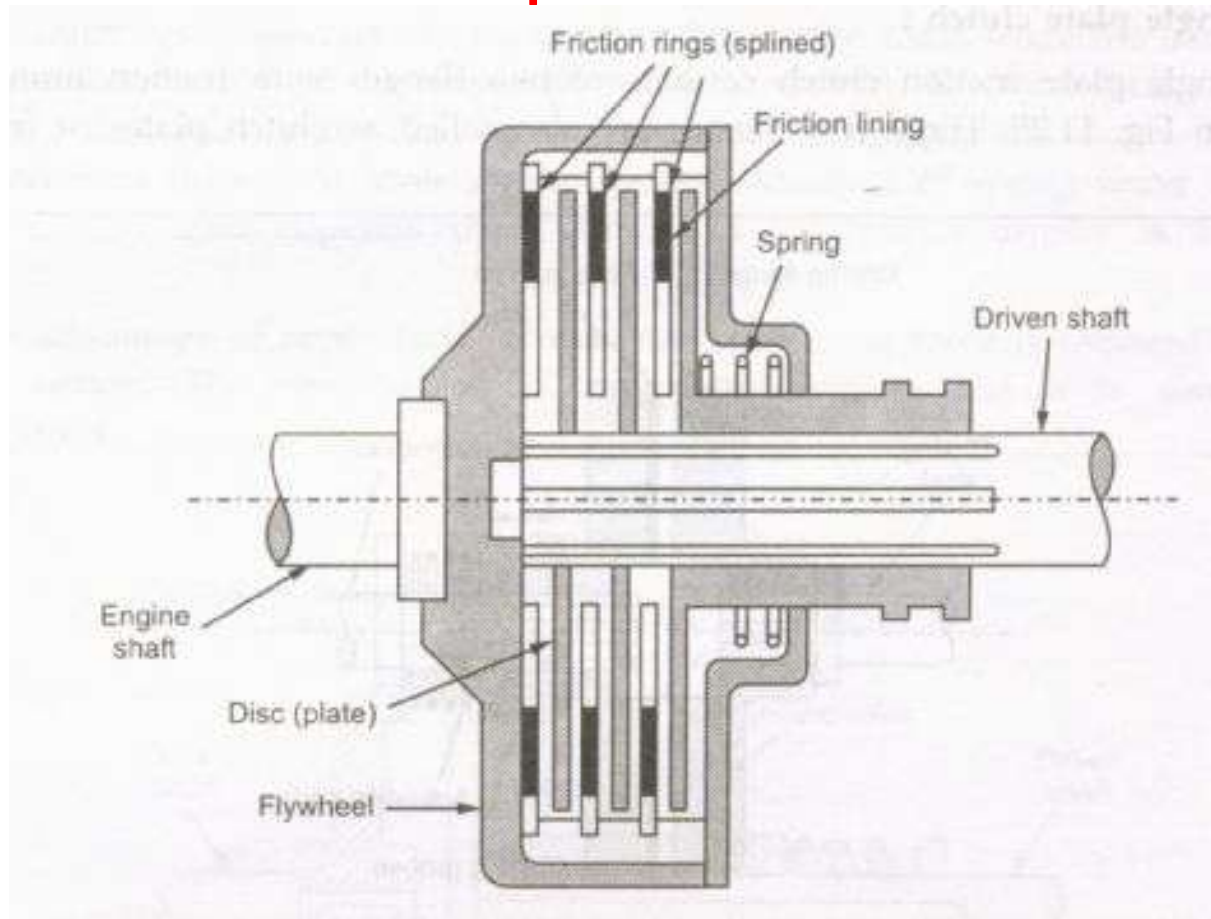
Pressure plate



Multi-plate clutch



Multiplate Clutch



- If the number of friction plates in friction linings are more than two, it is called as multiplate clutch.
- The plates are perpendicular to the axis of driving shaft. Multiplate clutch is shown in Fig.

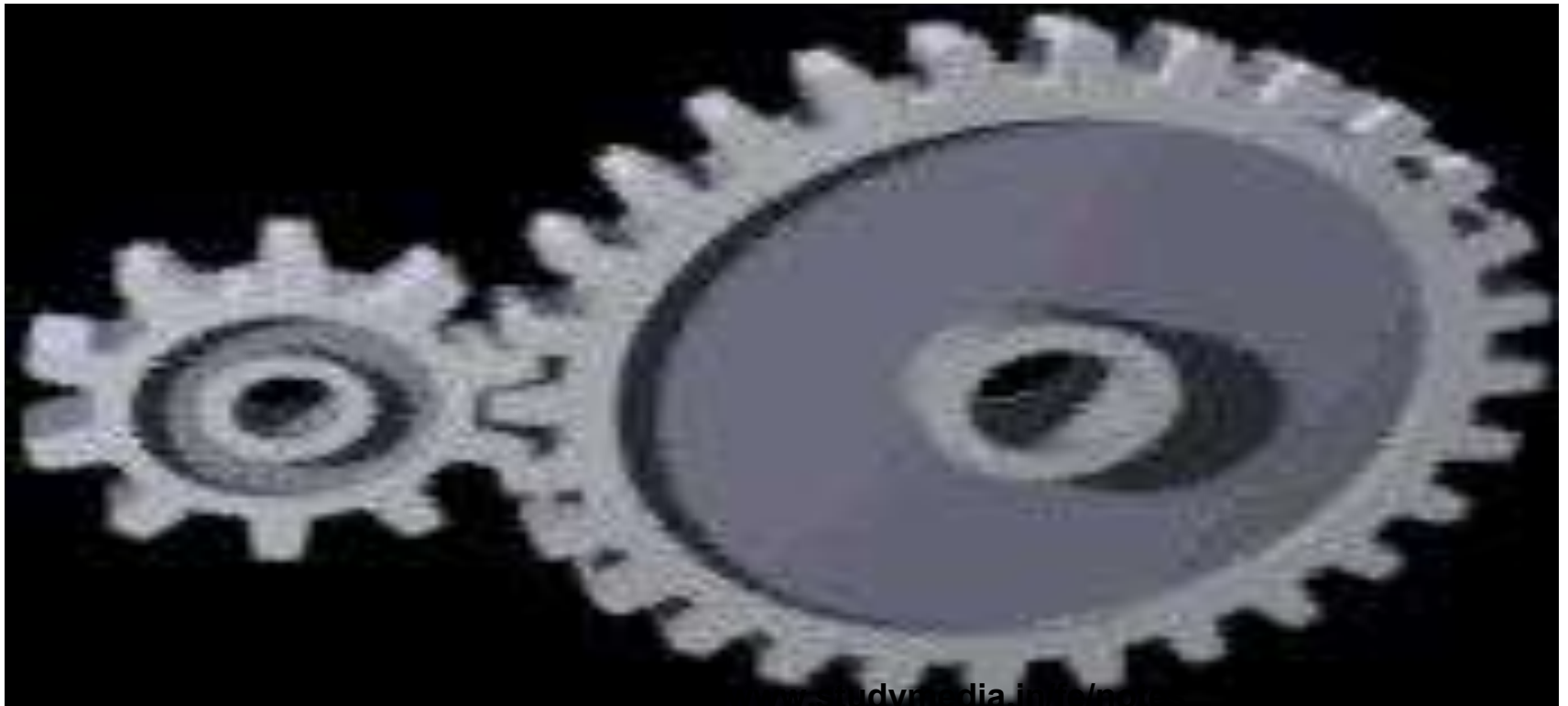
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Multiplate Clutch

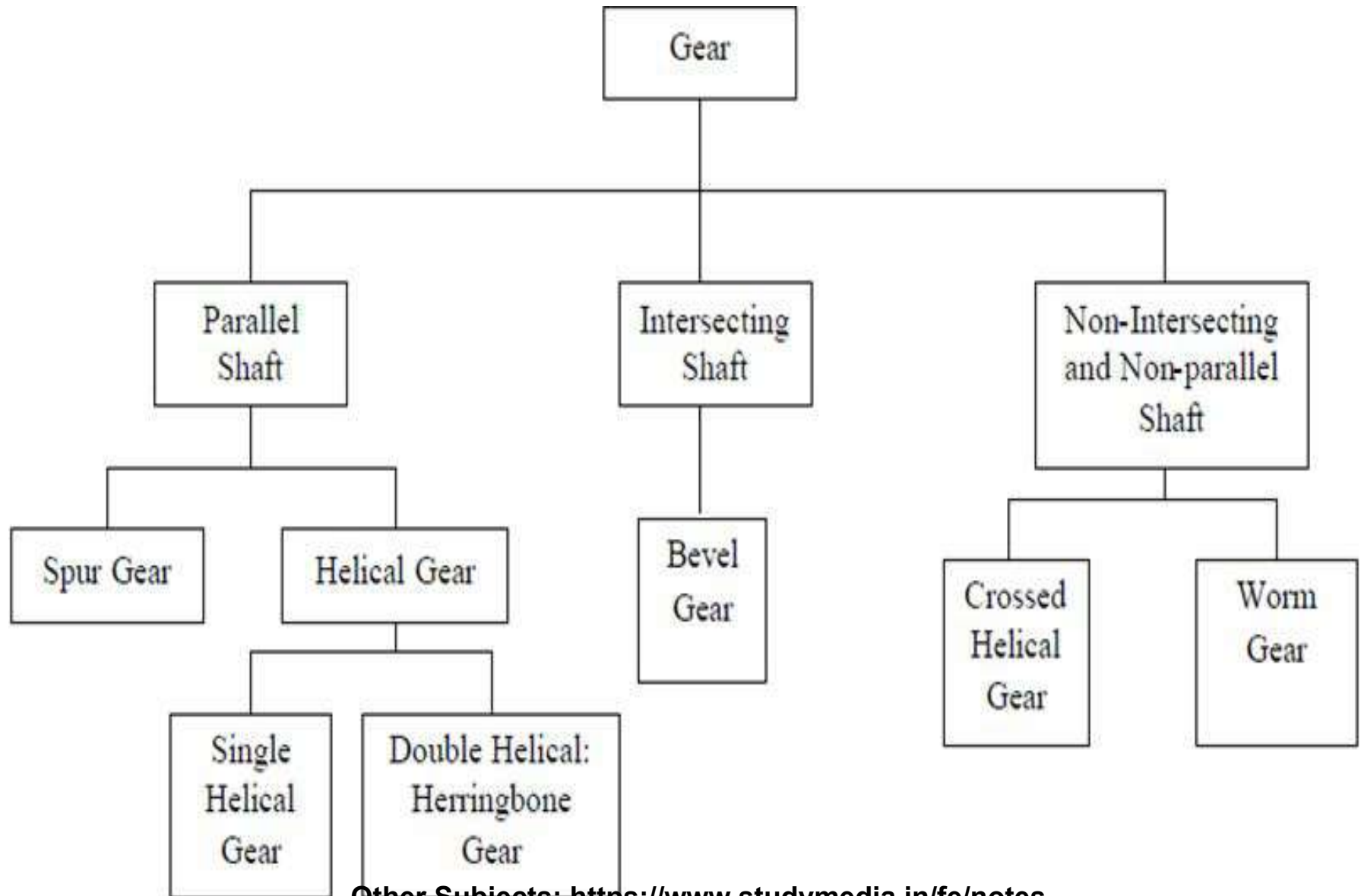
- Power transmitting capacity is more than single plate clutch for the same size. i.e. in multiplate clutch, larger frictional area is available which can be installed in a small space.
- It also have more effective heat dissipation surfaces. It is a wet clutch i.e. it requires lubrication so that heat generated is carried away quickly.
- It acts as a flywheel in motorcycles.
- **Application :** It is used in two wheelers such as scooter, motor cycle.

Gear: Definition

- A gear is a wheel with teeth along its rim.
- It is used to transmit power from one shaft to another.



Classification of gears



Gear Drive

Introduction

- Gears are defined as toothed wheels which transmit power and motion from one shaft to another by means of successive engagement of teeth.

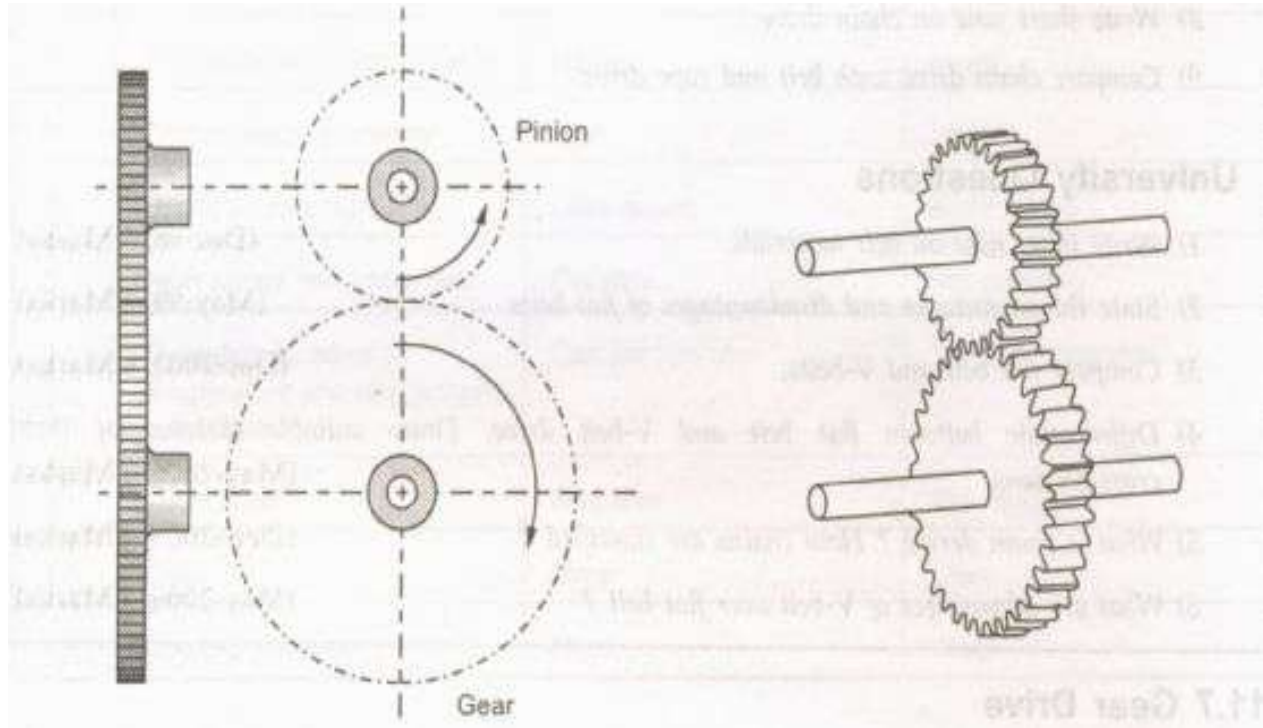
Classification of Gears

- The gears are classified according to the position of the axes of the shafts The shafts may be
 - a) Parallel shafts
 - b) Intersecting shafts
 - c) Non-intersecting and non-parallel shafts

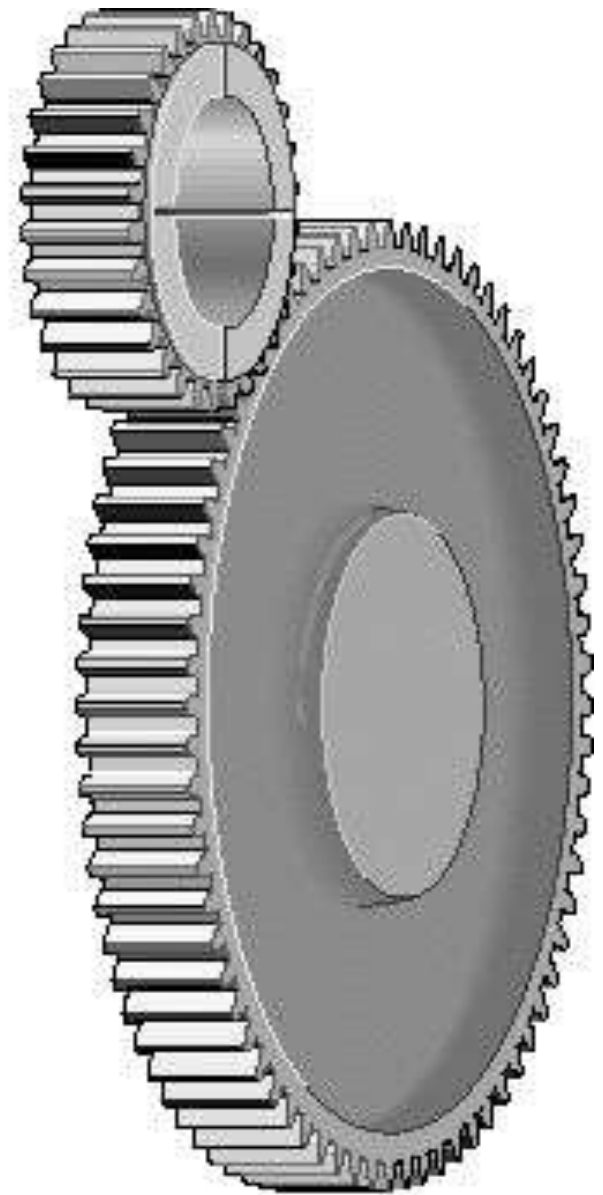
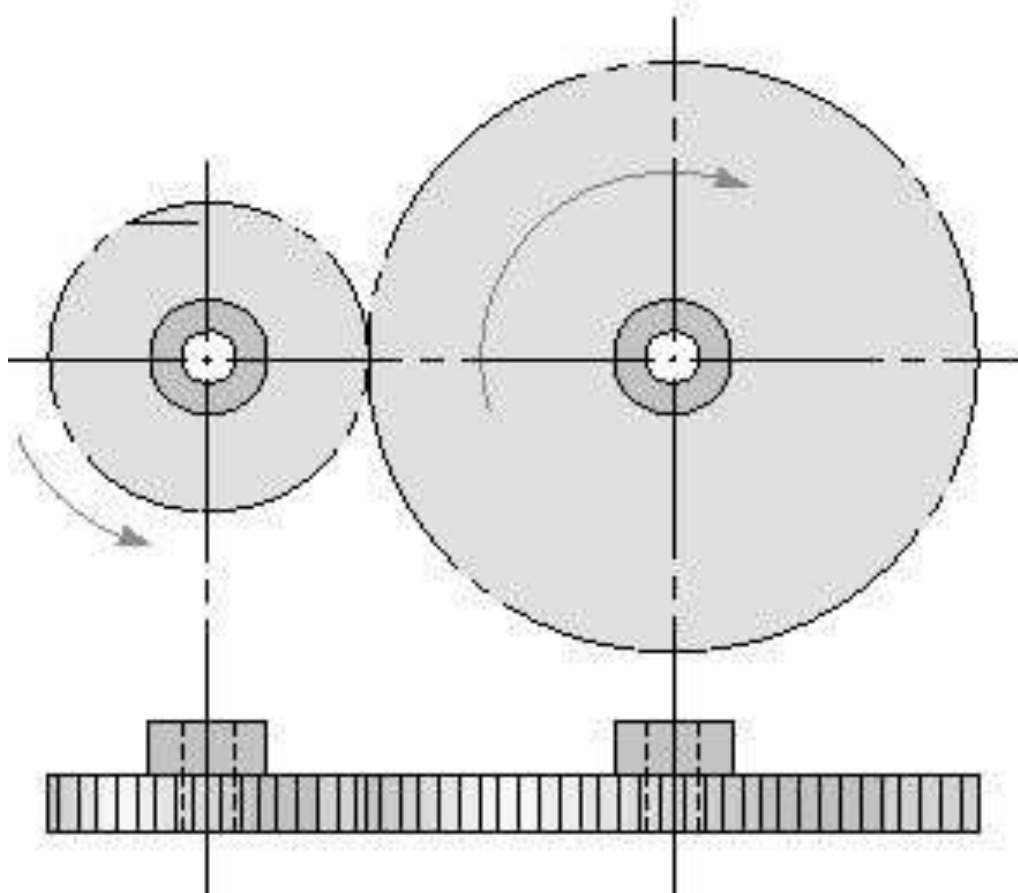
Parallel shafts

- When shafts are parallel to each other, two types of gears are mounted on the shaft to transmit the power. They are
 - 1) Spur gear
 - 2) Helical gear

Spur gear



- Spur gears are cylindrical and have teeth parallel to the axis of rotation.
- It is used to transmit the rotary motion between two shafts which are parallel and co-planer as shown in Fig.



Advantages of spur gears

- 1) Spur gears are simple and cheaper.
- 2) Manufacturing of spur gears is easy.
- 3) Spur gears impose only radial loads and no thrust load on the shaft.

Disadvantages

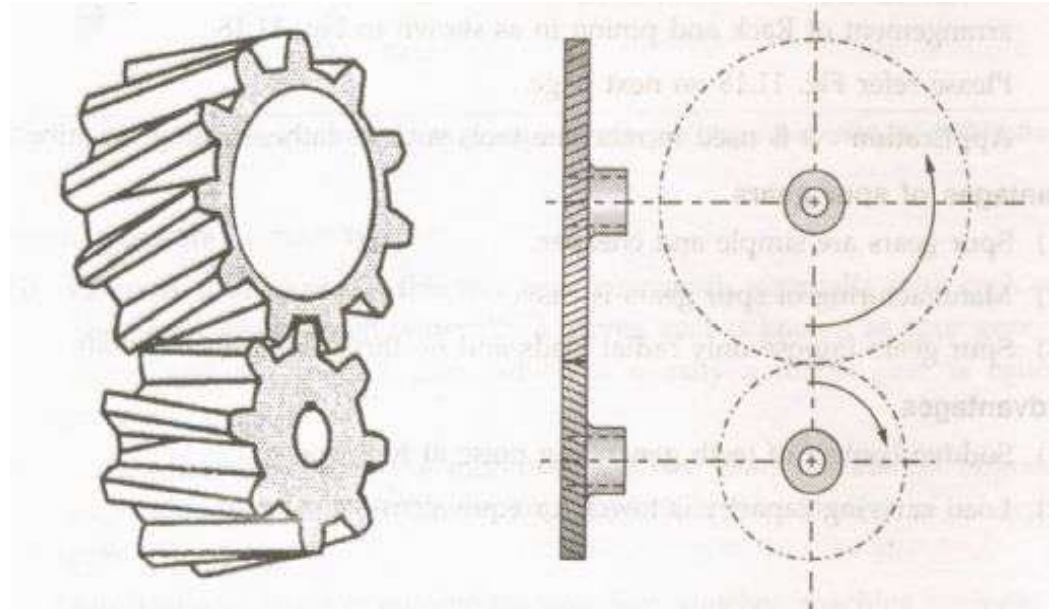
- 1) Sudden contact of teeth generating noise at high speed.
- 2) Load carrying capacity is lower

Applications

Automobile gear boxes, machine tool gear boxes, etc

Helical gears

- Helical gears are cylinder and have teeth at an angle with the axis of rotation.
- The angle of teeth with the axis of rotation is called as **helix angle**.
- The magnitude of helix angle of pinion and gear is same, however the hands of helix are opposite (one left handed helix and second right handed helix). It is as shown in the Fig.



b) Helical Gear

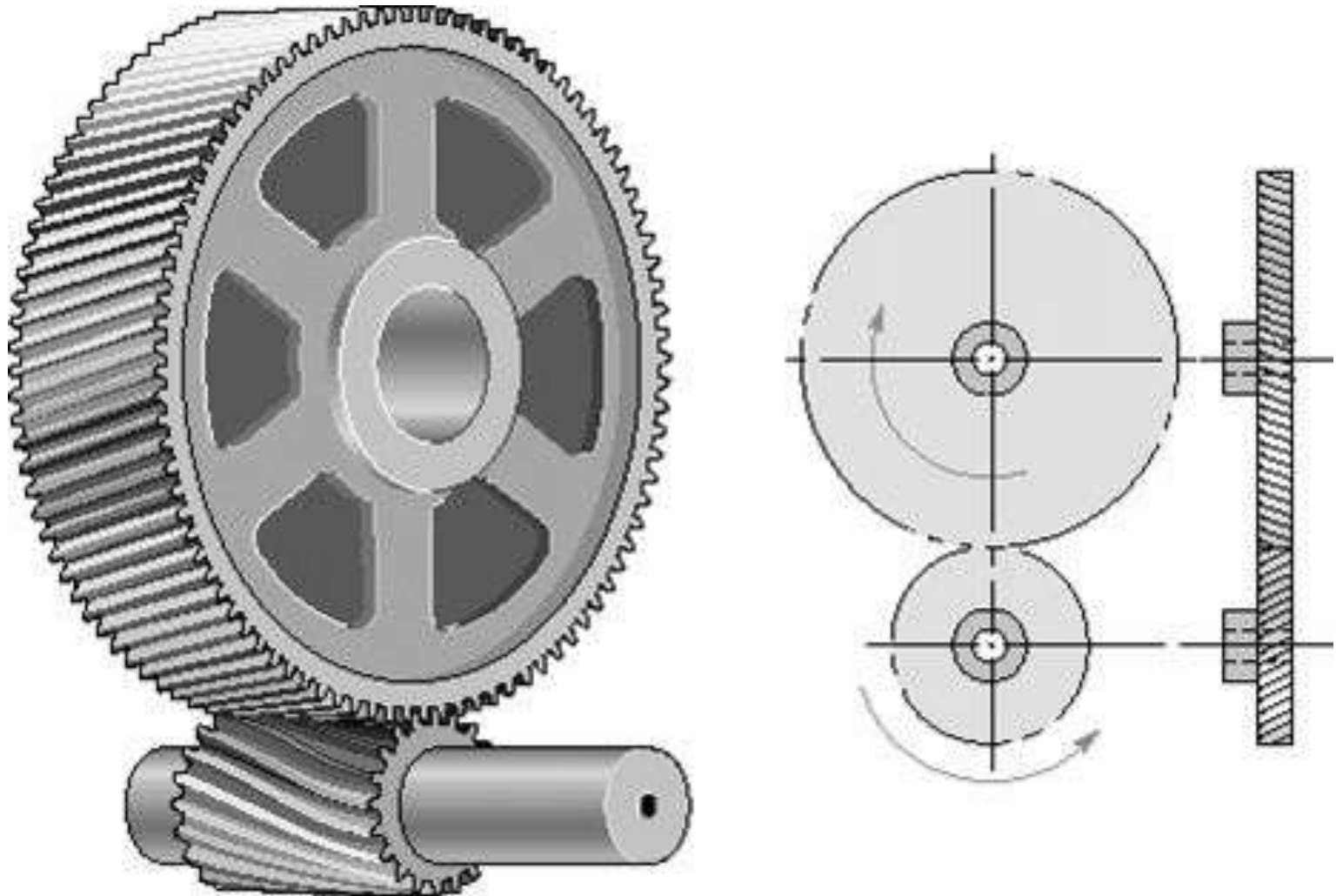


Fig: Single Helical Gears
Other Subjects: <https://www.studymedia.in/fe/notes>

Advantages of Helical Gear

- Engagement is gradual, hence operation is smooth and silent.
- Suitable for high speed applications.
- Power transmitting capacity of helical gears pair is higher.

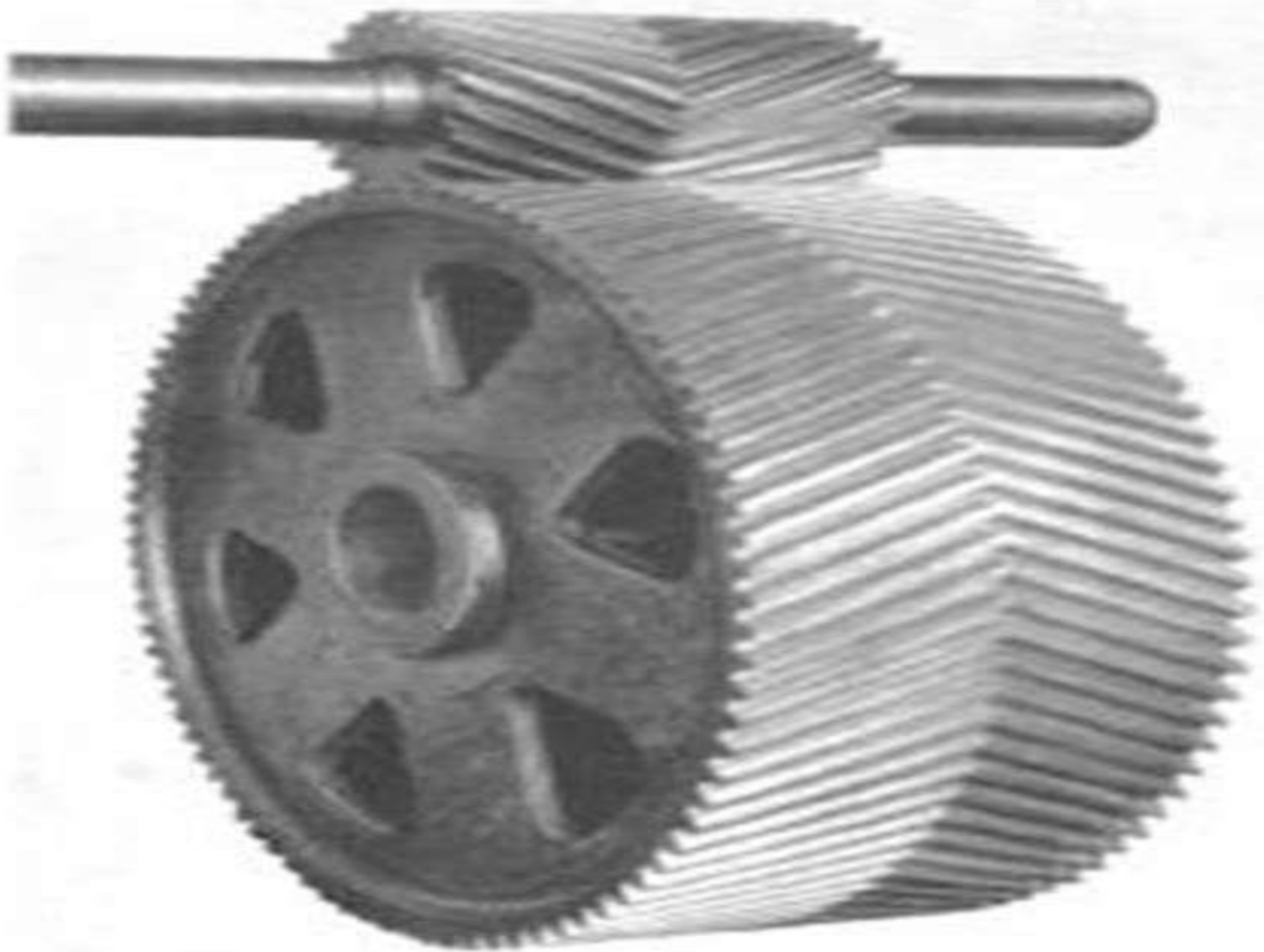
Disadvantages of Helical Gears

- Have end thrust on the shaft along the gear axis.
- Costlier than Spur gears.
- Difficult to manufacture as compared to Spur gear.

Applications of Helical Gears

- High speed stages of automobiles gear boxes, machine tool gear boxes, industrial gear box, etc.
- Used in high speed applications like Steam and Gas Turbines.

Double helical gears, or *herringbone gears*



Rack and Pinion

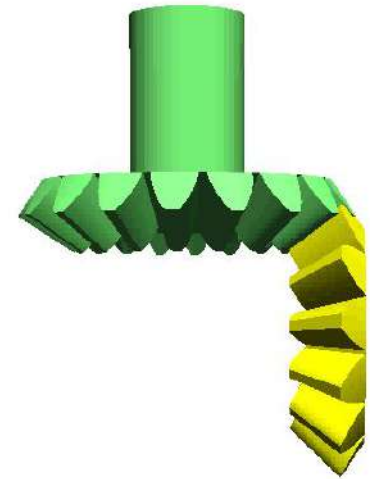
- In this type, the rotary motion is converted into linear one or vice versa.
- A straight line gear is known as '**Rack**'. Rack is also sometimes called as **wheel of infinite radius**.
- The circular gear is known as **pinion**.
- The arrangement of Rack and pinion is as shown in fig.
- **Application :**
It is used in machine tools such as lathe, drilling machine.



Bevel Gears



- Bevel gears are used for shafts, which are at right angles to each other. However angle may be less than 90.
- The teeth of the bevel gears can be cut straight or curved .
- Straight teeth bevel gears are used for low speed application while curved teeth are used for high speed application.



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Advantages

- 1) Can transmit the power at right angles or less.

Disadvantages

- 1) Difficult for manufacturing.
- 2) Cost is more.

Application :

Differential gear box in automobiles steering gear mechanism etc.



c) Non Intersecting and Non Parallel Shafts (Skew Shaft)

When the shafts are non intersecting and non parallel and non coplaner then for power transmission following gears are used.

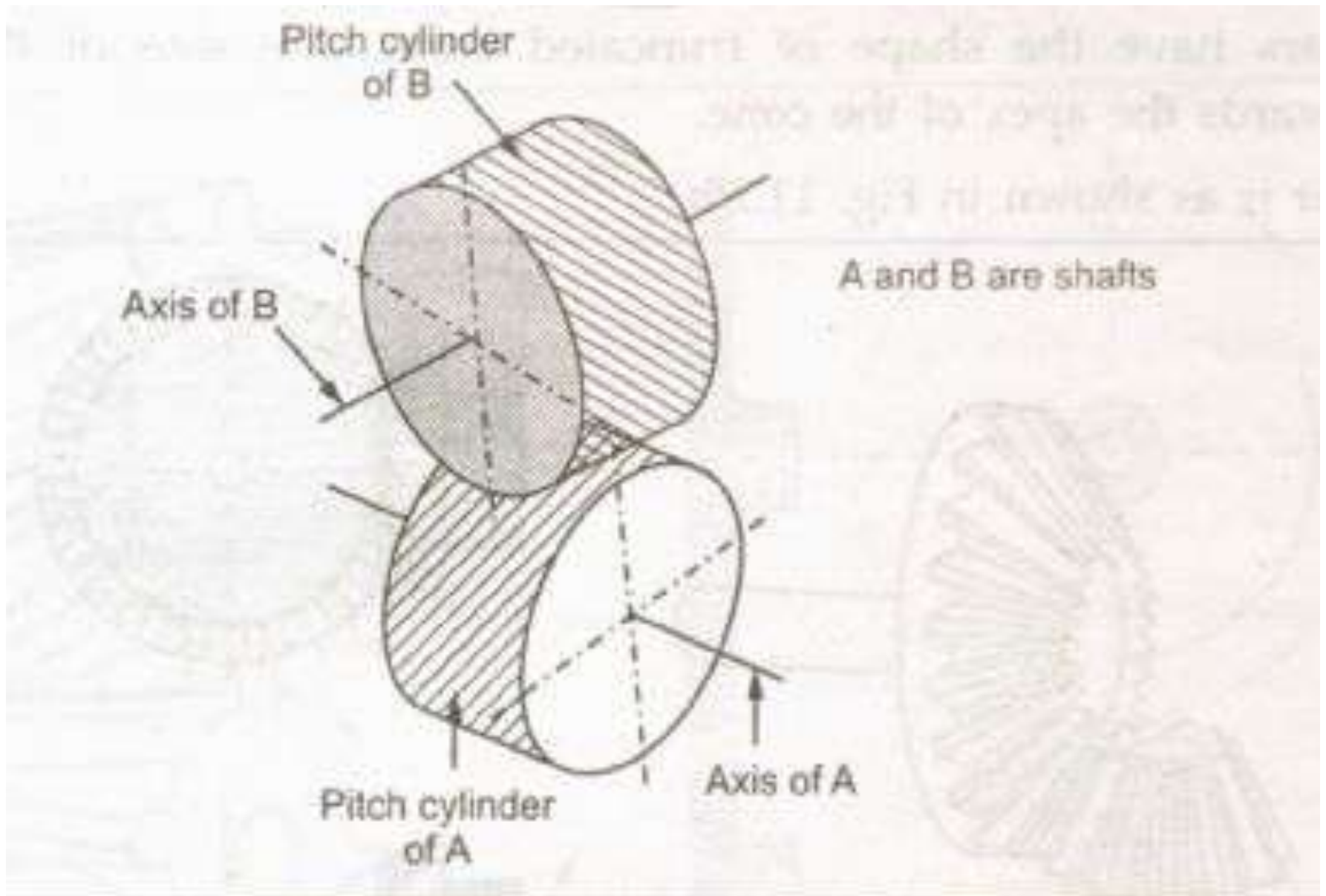
- 1) Spiral gear
- 2) Worm and worm wheel.

Spiral Gears

- Spiral gears are used to connect non-parallel and non-intersecting shafts.
- They are having point contact with each other and hence are suitable only for transmitting small powers.
- In this type of gearing, a left hand helical gear can mesh with right-hand helical gear or with left hand helical gear and helix angles of both the meshing gears may be having different values.
- The spiral gears are also known as **skew helical gears or crossed helical gears**. Helical gears is a special case of spiral gear, wherein two shafts are parallel with each other and helix

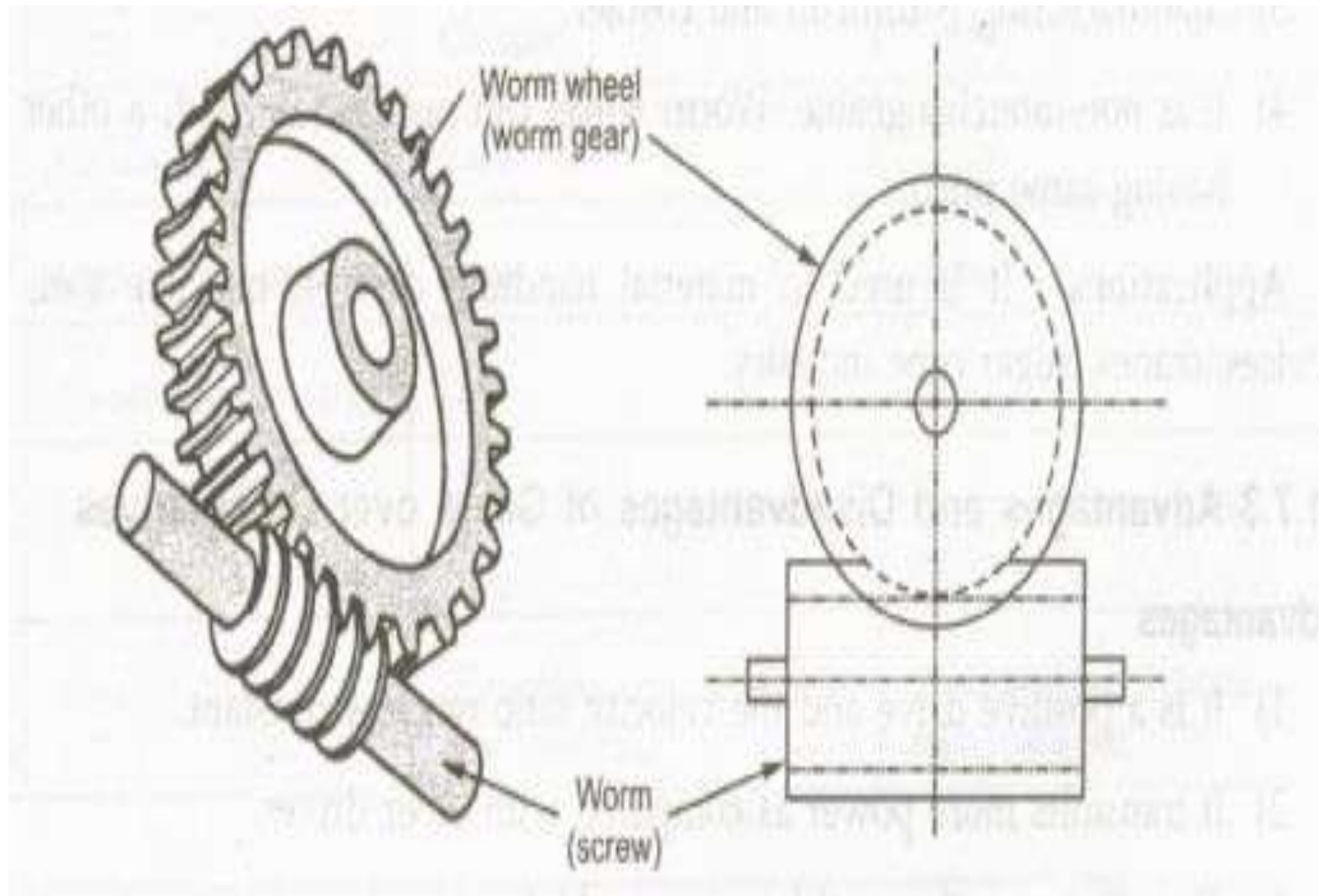
Applications

- Used to take light loads, because of point contact of meshing gears.
- Used to drive feed mechanisms on machine tools, camshafts and oil pumps on small I.C. engines.
- Both the gears are made of same material (steel or cast iron).
- angles are opposite and of same magnitude.



Worm & Worm Wheel

- **Worm gears is a special case of spiral gears, in which the axes of two gears do not intersect, but are right angles to each other in two different planes (non-planer).**
- It differs from spiral gears in one very important aspect namely the teeth have line contact instead of point contact and hence the load carrying capacity is much higher.
- **The smaller gear i.e. a driver gear is called as worm, which is basically a threaded screw. The threads of the worm may be left handed or right handed. A larger gear i.e. a driven gear is called as worm gear or worm wheel, which is similar to helical gear.**
- Manufacturing of worm gears is costly.
- Worm is made of steel or cast iron and worm wheel is of phosphor bronze.
- The specialty of worm gears is that it is used for high speed reduction ratio, as high as 100 : 1 in single stage. When worm completes one full rotation, the worm wheel will rotate by only one tooth.
- **e.g. If speed reduction ratio is 50 : 1, then worm wheel will be having 50 number of teeth. When worm will complete 50 number of rotations, then worm wheel completes one full rotation, during the same period of time.**



Worm & Worm Wheel

Advantages

- 1) High speed reduction ratio is possible. 100 : 1 in the small space.
- 2) Tooth engagement occurs without shock hence operation in quieter.
- 3) The provision of self locking can also be made.

Disadvantages

- 1) Transmission efficiency is very low as compared with other gears.
- 2) It generates considerable amount of heat, hence special cooling arrangement has to be made in gear boxes.
- 3) Manufacturing is difficult and costlier.
- 4) It is non-interchangeable. Worm wheel can not operate with a other worm having same pitch.

Applications

It is used in material handling devices, machine tool, lifting devices, cranes, sugar cane industry.

Gear Box

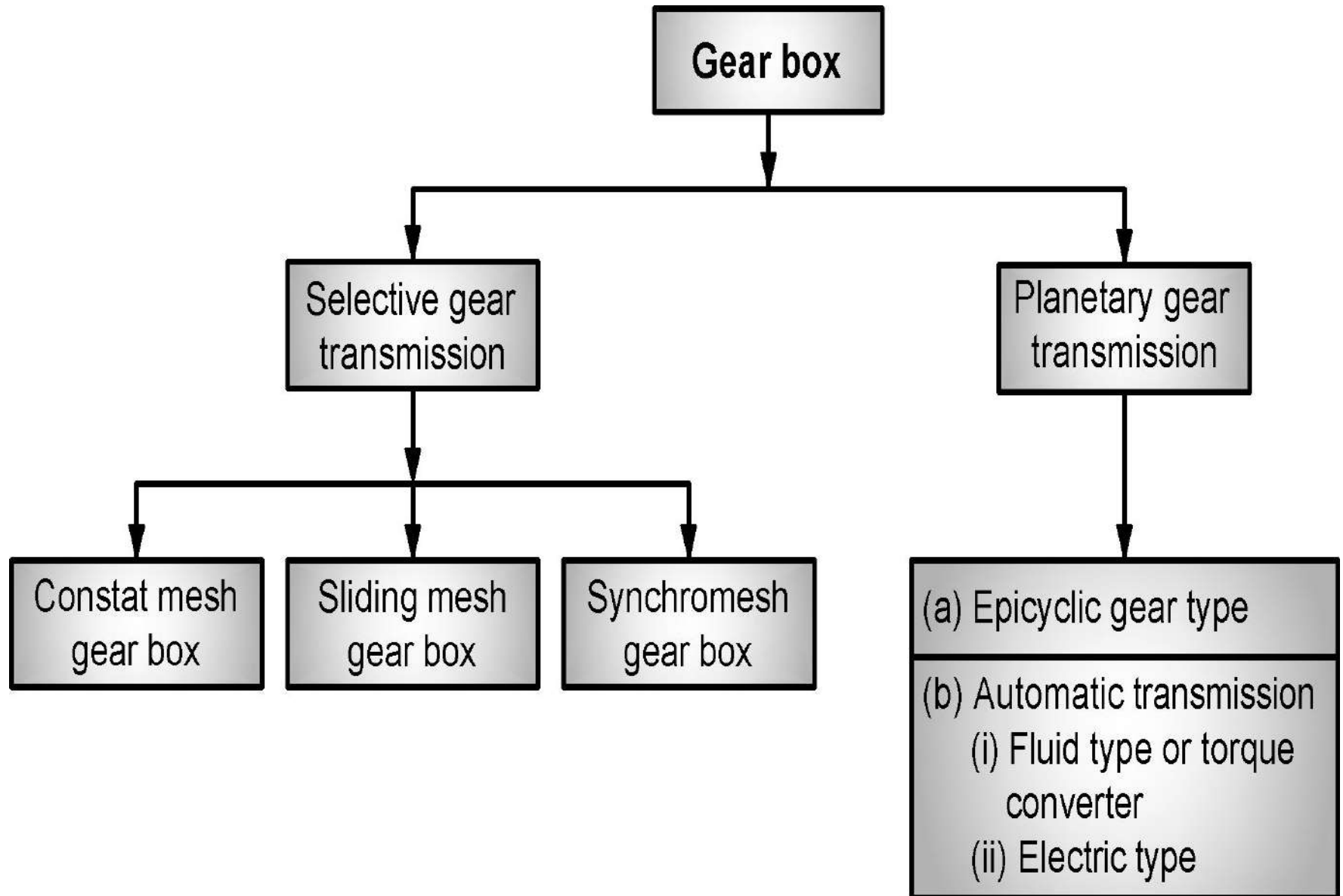
- *Need of gearbox for following reasons:*

1. Provide the torque needed to move the vehicle under a variety of road and load conditions. It does this by changing the gear ratio between the engine crankshaft and vehicle drive wheels.
2. Be shifted into reverse so the vehicle can move backward.
3. Be shifted into neutral for starting the engine When engine is coupled to gear box speed is given to the vehicle.
4. The gear box is provided with series of gears and shaft to obtain different speeds.
5. The gear box provides more torque on hill climbing and low torque at low speeds of engine.
6. The gear box is also necessary to provide a neutral gear so that the engine power does not transmit to the rest of transmission line upto the wheels even when the clutch is engaged.

Classification :

- Selective Gear Transmission
 - Sliding mesh Gear Box
 - Constant Mesh Gear box
 - Synchromesh Gear box
- Planetary Gear transmission
 - Epicyclic gear type
 - Automatic transmission
- Fluid type or torque converter
- Electric type

• Classification of Gear Box



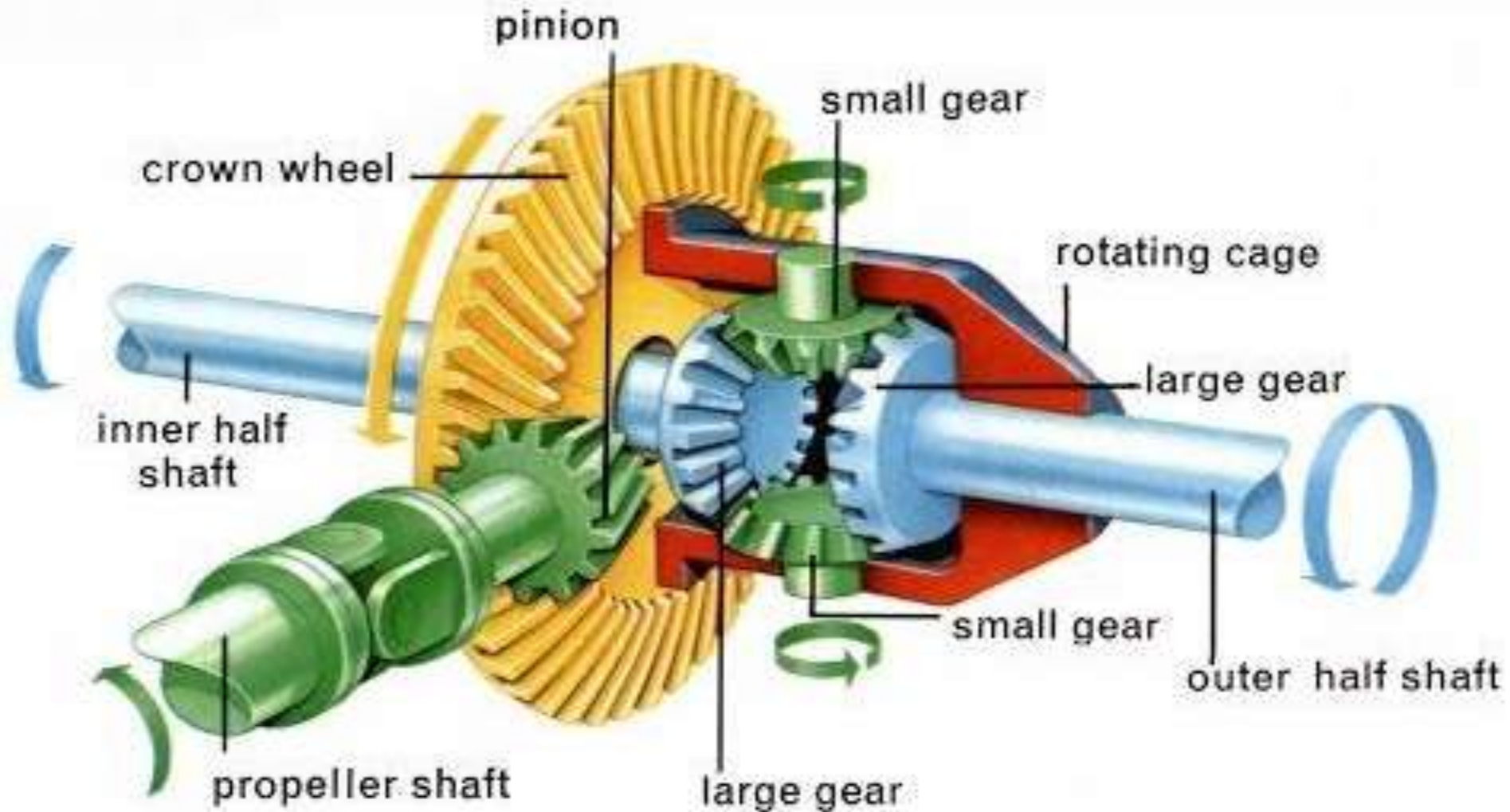
Differential Gear Box

- When the car is taking a turn, the outer wheels will have to travel greater distance as compared to inner wheels in this case differential works.
- The less rotation of a inner wheel and more rotation to outer wheel it is possible by only using different gears in differential. Or inner wheel steady and outer wheel in running condition. Due to this every vehicle required differential.

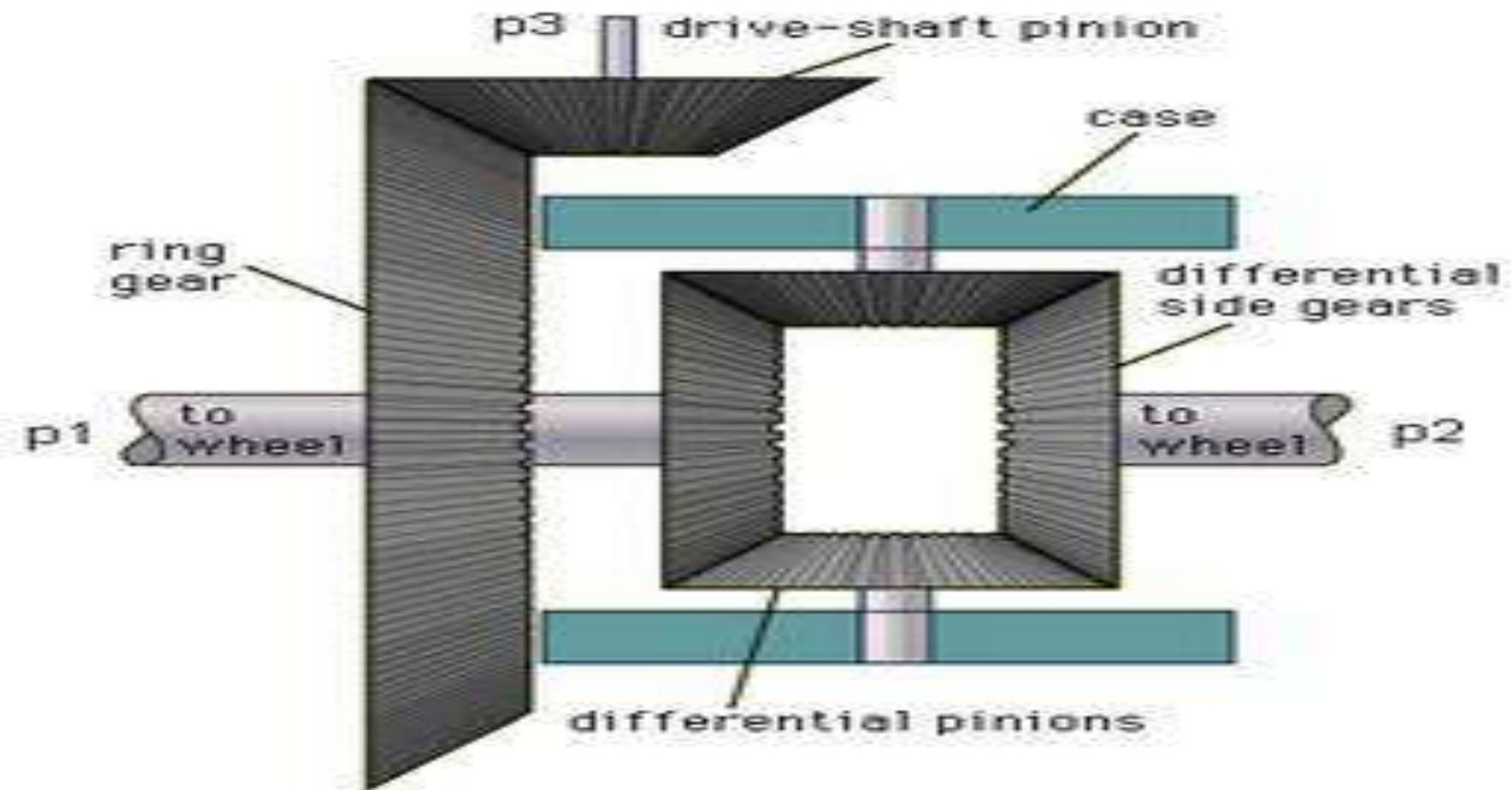
Function

- Reduce speed and increase torque
- Change the direction of torque as gearbox output shaft is longitudinal
i.e. it turns the drive of propeller shaft to that of the wheels.

Fig. Differential

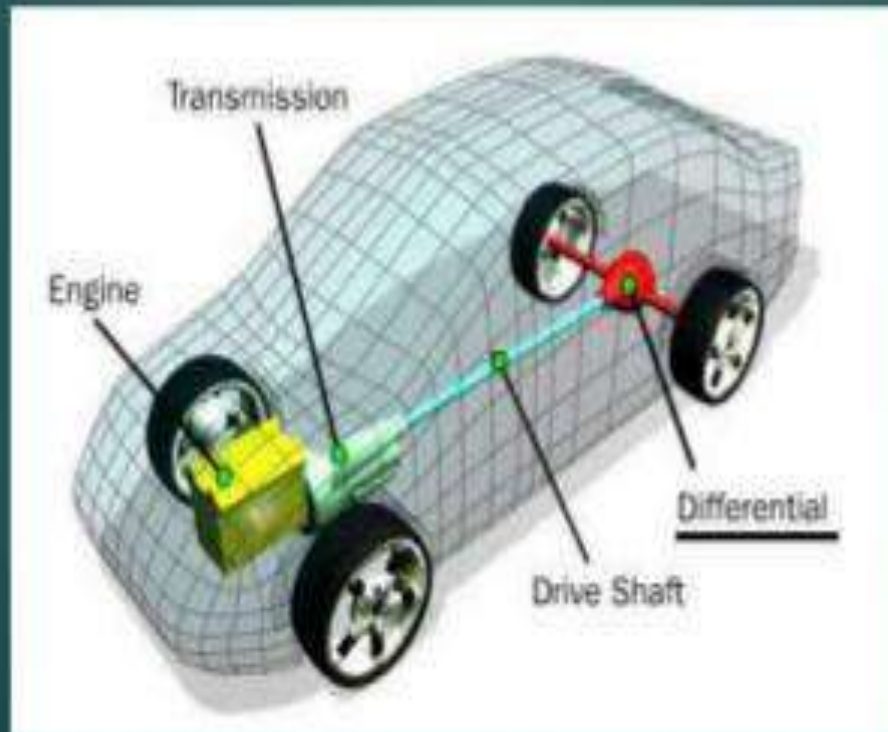


Schematic dia. Of Differential



INTRODUCTION

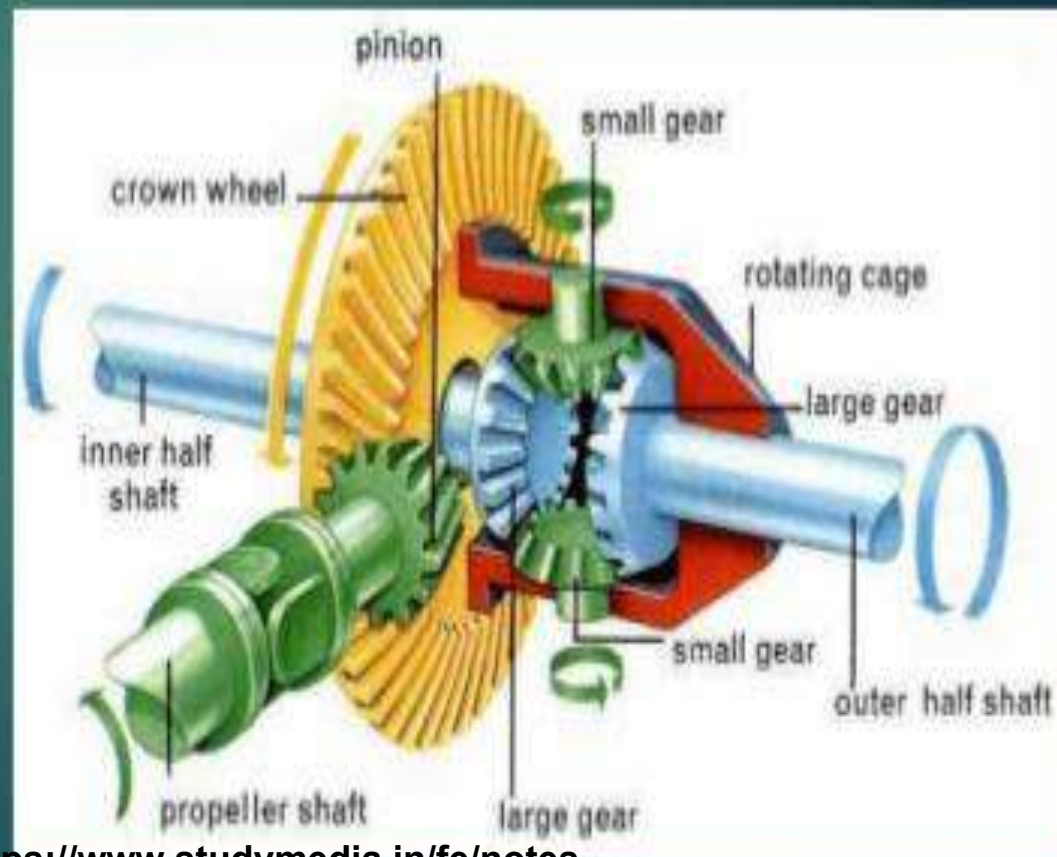
- ▶ Differential is an essential part of any four wheeled vehicle.
- ▶ A differential allows wheels of a vehicle to rotate at different speeds.
- ▶ This is necessary when the vehicle turns.



PARTS OF DIFFERENTIAL SYSTEM

- ▶ **Pinion drive gear** :- Transfer power from the drive shaft to the ring gear.
- ▶ **Ring gear** :- Will transfer power to differential case assembly.
- ▶ **Spider gear** :- Gear lies at the heart of differential and special mention should be made about its rotation.
- ▶ **Differential case assembly**:- Hold the gear and drive the axel.

- ▶ **Rear drive axel**:- Transfer torque from differential assembly to drive wheels.



WORKING OF DIFFERENTIAL

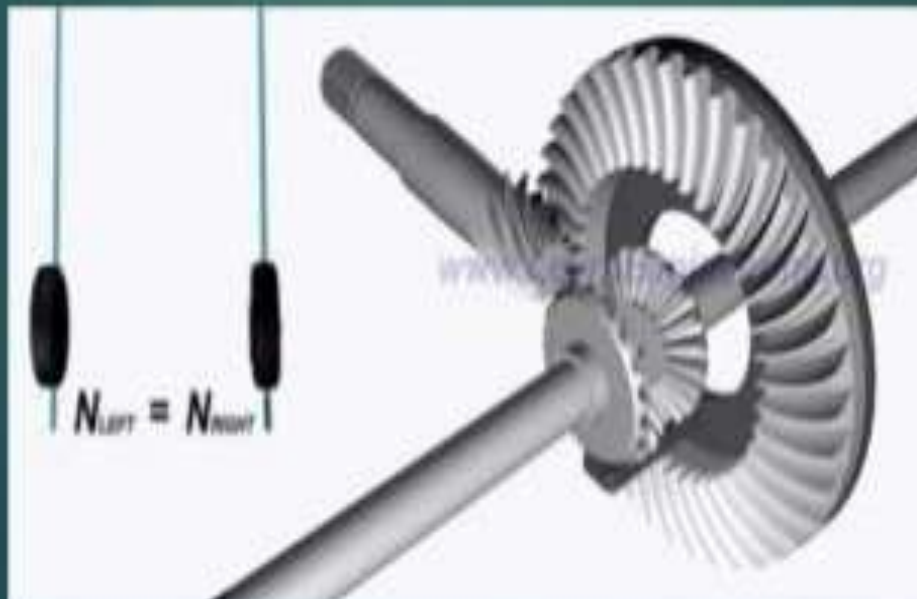
- ▶ While taking turn, the inner and outer wheels have different turning radius.
- ▶ The inner wheel travel less distance.
- ▶ From the drive shaft power is transferred to pinion gear first, since pinion and ring gear are meshed, power flow to the ring gear.
- ▶ As the spider gear is connected with the ring gear, power flows to it.
- ▶ At last power from spider gear gets transferred to both side gears.



DIFFERENT CASES

THE VEHICLE MOVES STRAIGHT

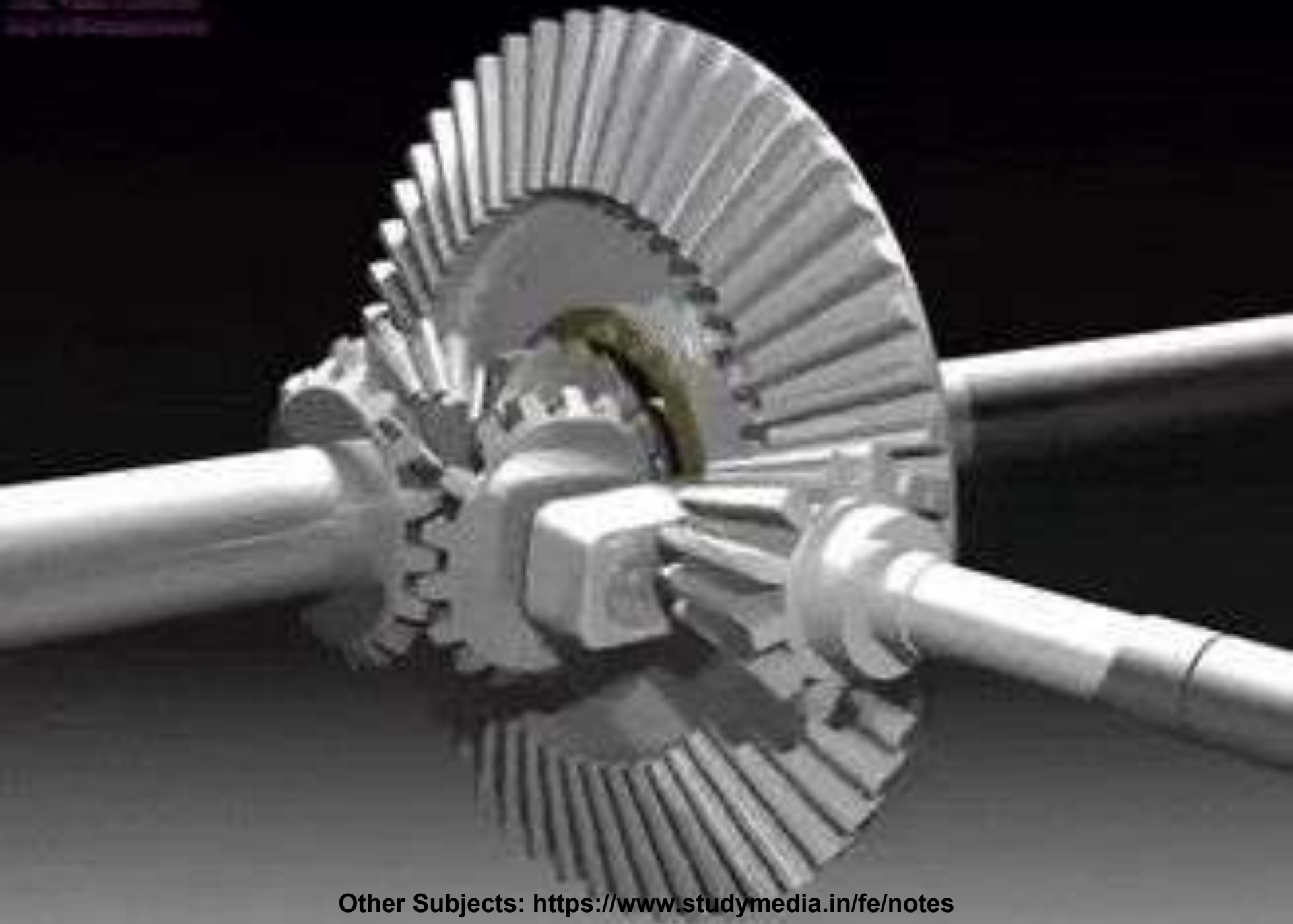
- In the case the spider gear rotates along with the ring gear but does not rotate on its own axis.
- So the spider gear will push and make the side gears turn and both will turn at the same speed.



VEHICLE TAKES A TURN RIGHT

- ▶ In this along with the rotation of the ring gear its rotates on its own axis.
- ▶ So the spider gear having a combined rotation.
- ▶ When the spider gear is spinning as well as rotating peripheral velocity at the left side of spider gear is the sum of the spinning and the rotational velocity
- ▶ But the right side it is the difference of the two since the spin velocity is in the opposite direction at this side.

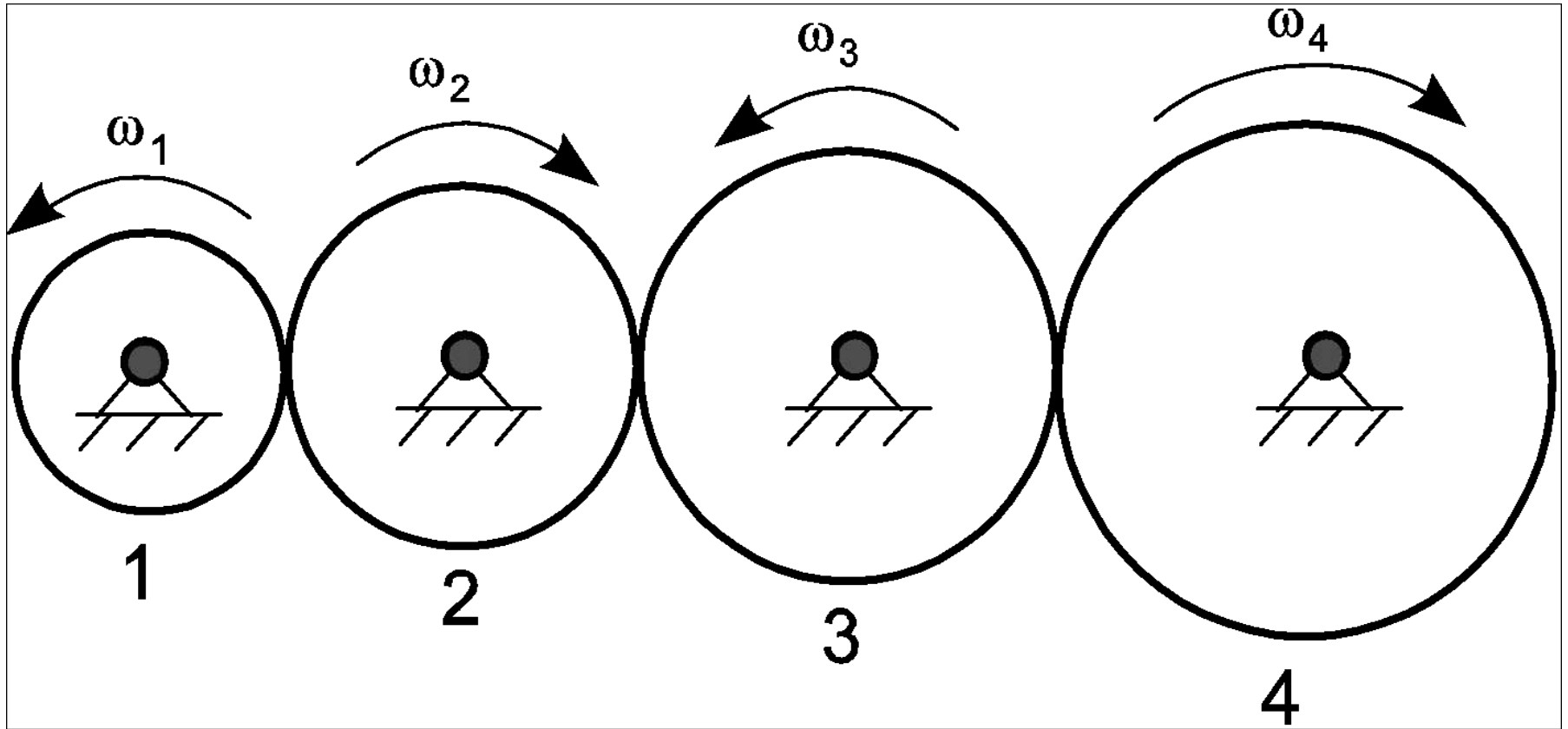






Simple Gear Trains

- A gear train is a set or system of gears arranged to transfer rotational torque from one part of a mechanical system to another.
- Gear trains consist of driving gears, intermediate or "idler" gears and transfer gears. The driving gear is where energy is input into the system of gears.
- The intermediate gears transfer that torque and may reduce or increase it according to the gear ratios involved.
- The transfer gear passes the modified torque onto the next component in the machine, whether it is a wheel, a winch, a counter or anything that needs power.
- Velocity ratio of a pair of gears is the inverse proportion of the diameters of their pitch circle, and the diameter of the pitch circle equals to the number of teeth divided by the diametral pitch.



Gear Ratio (Speed Ratio)

- It is defined as ratio of pinion speed to the gear speed.

$$G = n_p / n_g$$

- It is also defined as ratio of number of teeth on gear to number of teeth on pinion.

$$G = Z_g / Z_p$$

- It is also defined as ratio of diameter of gear to diameter of pinion.

$$G = D_g / D_p$$

NUMERICALS

Q.1 A pinion with 120 mm pitch circle diameter meshes with gear of 400 mm pitch circle diameter. Number of teeth on pinion is 18 & it rotates at 1440 rpm. Determine Gear Ratio, Number of teeth on Gear & speed of gear.

Q.2 The pitch circle diameter of pinion is 200 mm .Gear Ratio is 3.The pinion is attached to motor having 1440 rpm & 20 kw power. The number of teeth on pinion is 20.Determine torque required to transmit power at pinion & number of teeth on gear.

Propeller Shaft

It is the shaft which connects the transmission output shaft to the differential mechanism at the rear wheels.

In other words the shaft which transmits **the engine power** from slip joint (sliding joint) to wheels through differential, this power used for to move the vehicle from one place to another.

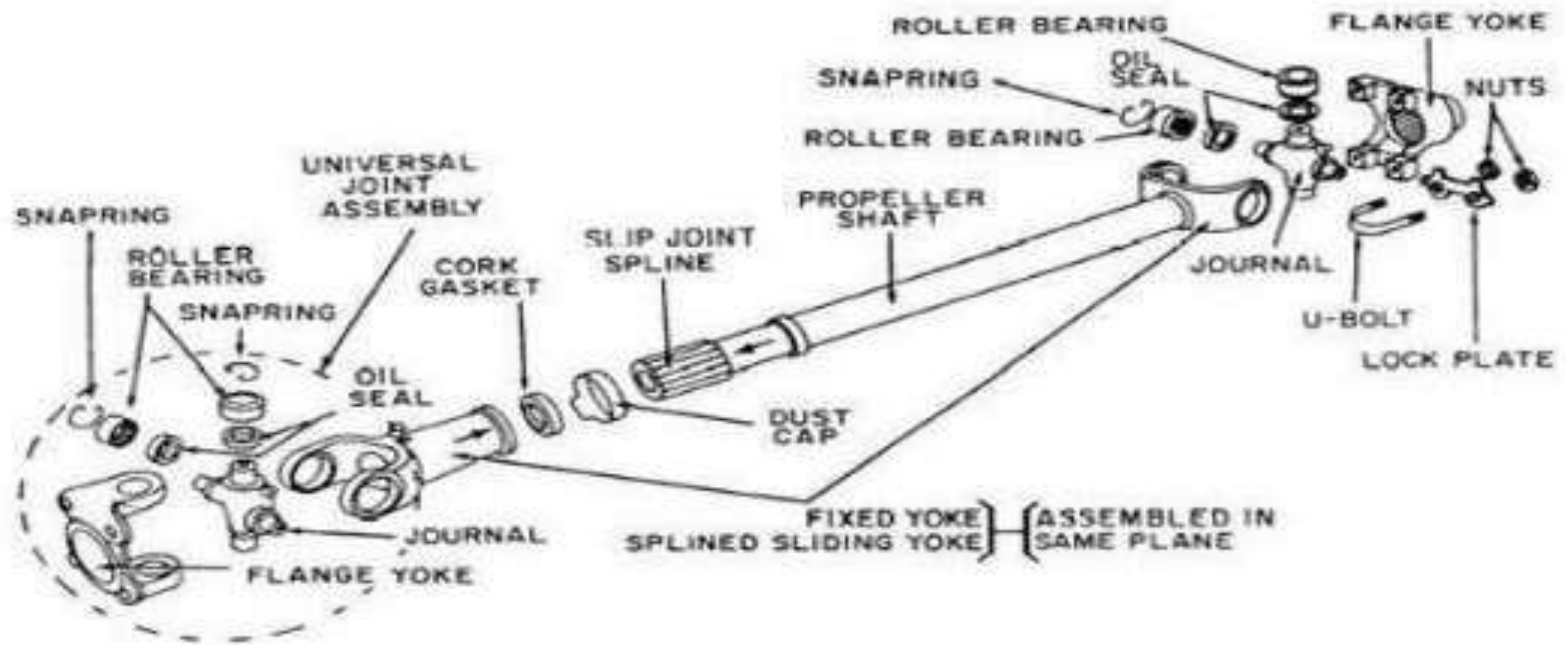
Functions:

- It transmits rotary motion of the gearbox output shaft to the differential.
- It transmits motion at some angle which varies frequently.

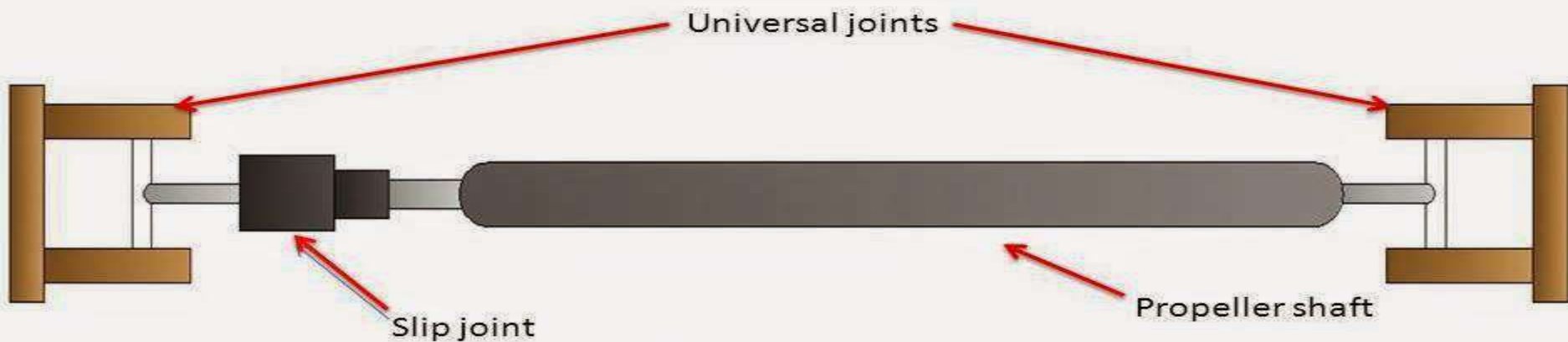
Construction:

- It is made up of a steel hollow tube, which are connected with slip joint and two universal joints.
- Having diameter 50 to 70mm and thickness from 1.5 to 7.5 mm.
- The slip joint are made on the propeller shaft with external splines on shaft and internal splines on the slide.

Propeller Shaft



COMPONENTS OF PROPELLER SHAFT



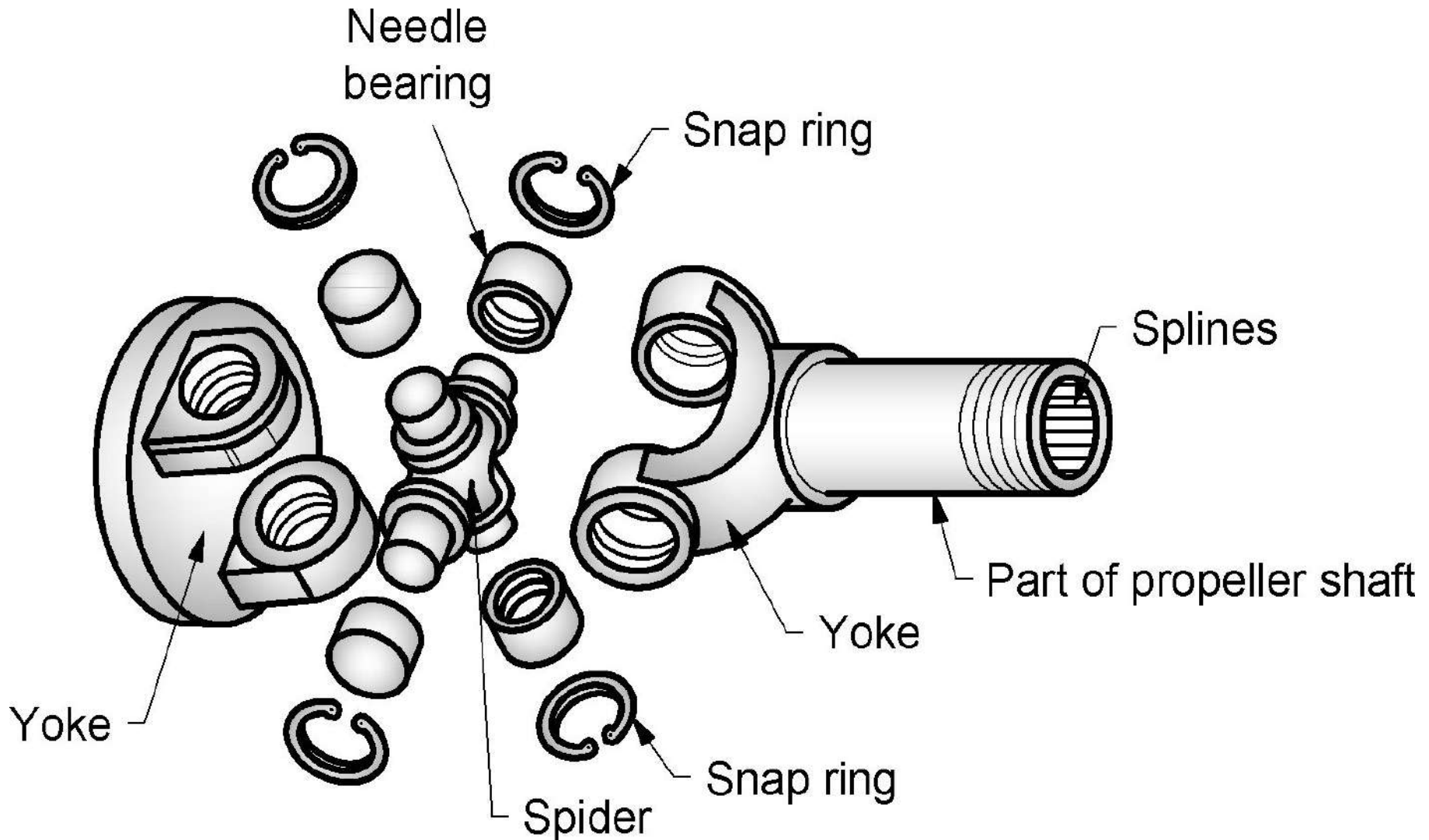
Drive line

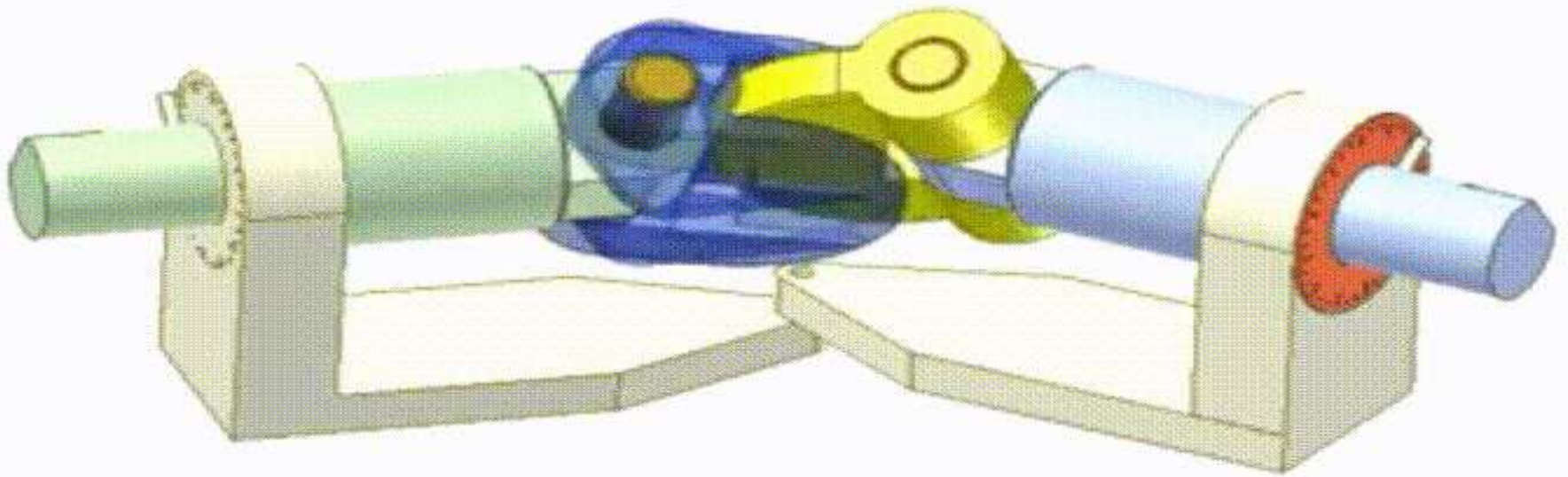
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Universal Joint

- A joint is a particular type of connection between two shafts, whose axes are inclined to each other.
- The Hooke's joint is simple type of universal joint which is widely used in vehicles.
- This type of joint is efficient for small angles of propeller shaft movement up & down, upto the 18°
- The angular movements between the two shafts are possible due to universal joint (Hook's Joint).
- The Hooke's joint uses needle roller bearing to support the cross in the yokes. This results in increase of joint efficiency.

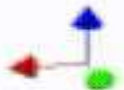
Universal Joint





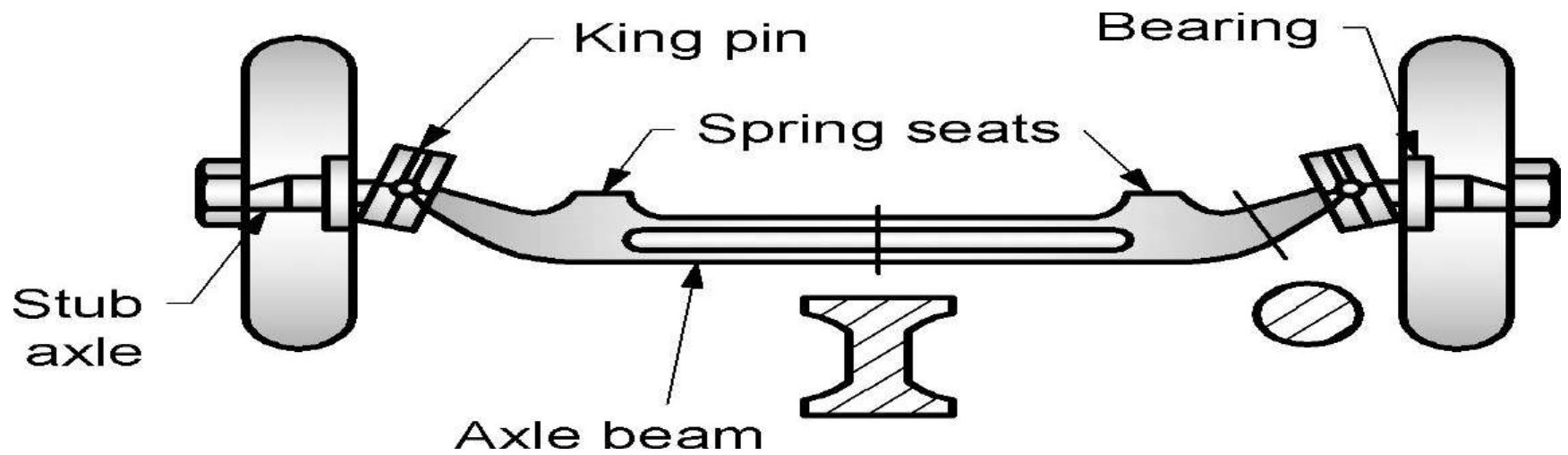
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Axles

- An axle is a straight shaft that is fixed in location and is used to mount rotating wheels or gears.
- The wheel or gear can be attached to it with a built-in bearing or bushing.
- A bearing or bushing fits inside the center of the wheel and allows it to rotate without affecting the axle itself.
- The purpose of an axle is to secure the wheels or gears to specific locations relative to other wheels or gears.
- On wheeled vehicles, the axle may be fixed to the wheels, rotating with them. e.g. bicycles, or fixed to its surroundings, with the wheels rotating around the axle as a spindle.
- In a vehicle, the axle absorbs braking and acceleration forces, as well as the actual weight of the vehicle.
- It forms a central part of the structural strength of the vehicle, and it must be able to absorb the weight and transfer the forces away from the wheels in order to reduce pressure on the joints of the vehicle.



FRONT AXLES

Front wheels of the vehicle are mounted on front axles .

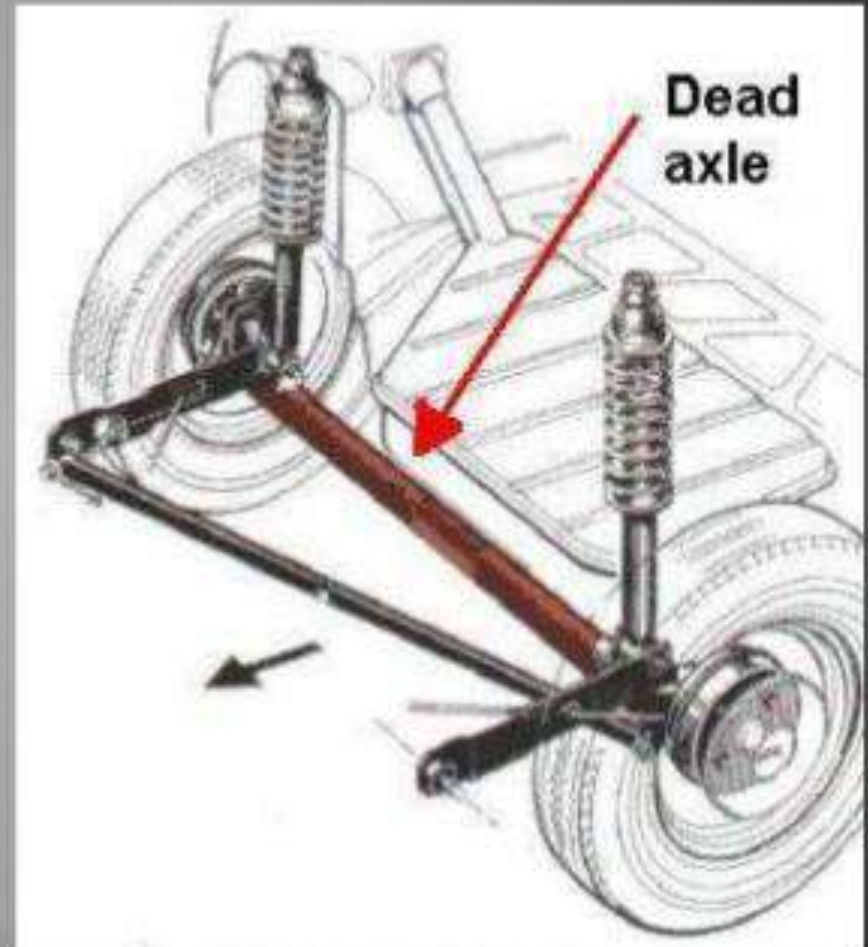
- It supports the weight of front part of the vehicle.
- It facilitates steering.
- It absorbs shocks which are transmitted due to road surface irregularities.
- It absorbs torque applied on it due to braking of vehicle.

REAR AXLE

- In between the differential and the driving wheels is the rear axle to transmit power from the differential to the driving wheels.
- It is clear from the construction of the differential, that the rear axle is not a single piece, but it is in two halves connected by the differential, one part is known as the half shaft.
- The inner end of the half shaft is connected to the sun gear of the differential. and the outer end of the driving wheel.
- Almost all rear axles on modern passenger cars are live axles, that is, they revolve with the wheels.

DEAD AXLE

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



VEHICLE SAFETY

- It is the study & practice of design, construction, equipment & regulation to minimise the occurrence & consequences of automobile accidents.
- **Following factor under Active Safety:-**
 - There should be more glass area with minimum blind spots. This will increase the efficiency of driver for parking and driving in heavy traffic.
 - Good mirrors will enable the driver to see potential hazards when reversing parking or changing lines. Mirrors are to be adjusted from inside of car. Heated mirrors should preferred to avoid fogging in bad weather.
 - Headlights should be designed in such a way that there is adequate intensity of lights. They should give a good view of road ahead to the driver. In some cars wipers or water jets employed to help cleaning the headlights.
 - The suspension system and steering system should be properly designed to get better holding of roads and improved characteristics while cornering.
 - Now a day's ABS (Antilock braking system) is applied for better steering and controlling of vehicle.

Passive Safety

- It comes under design automobile vehicle for minimum injury at the time of accidents.
 - Passive safety features are the features by which there is minimum, injury and crashing for occupants at the time of accidents.
 - Some of passive safety features help to absorb crash forces collision of vehicle.
 - **The following points come under passive safety features.**
- ☐ To reduce the risk of spilled fuel and consequent fire in case of near end collision fuel tank should be located at suitable positions.
 - ☐ In case of accident it is very important to consider the doors closing after car comes to rest otherwise there are chances of person to be thrown out and being killed are increased so the doors should be fitted with safety lock.
 - ☐ Various switches controls etc. should be so shaped that they are not protruding excessively so as to cause injury to the occupants at the front at the time of front side collision.
 - ☐ To minimize the leg injuries to occupants of front seats, a knee bolster must be provided knee bolster is an energy absorbing crushable barrier under the dashboard that stops occupant knees from striking hard components and surfaces below and behind the dash.
 - ☐ Seat belts should be worn both by passengers as well as drivers.

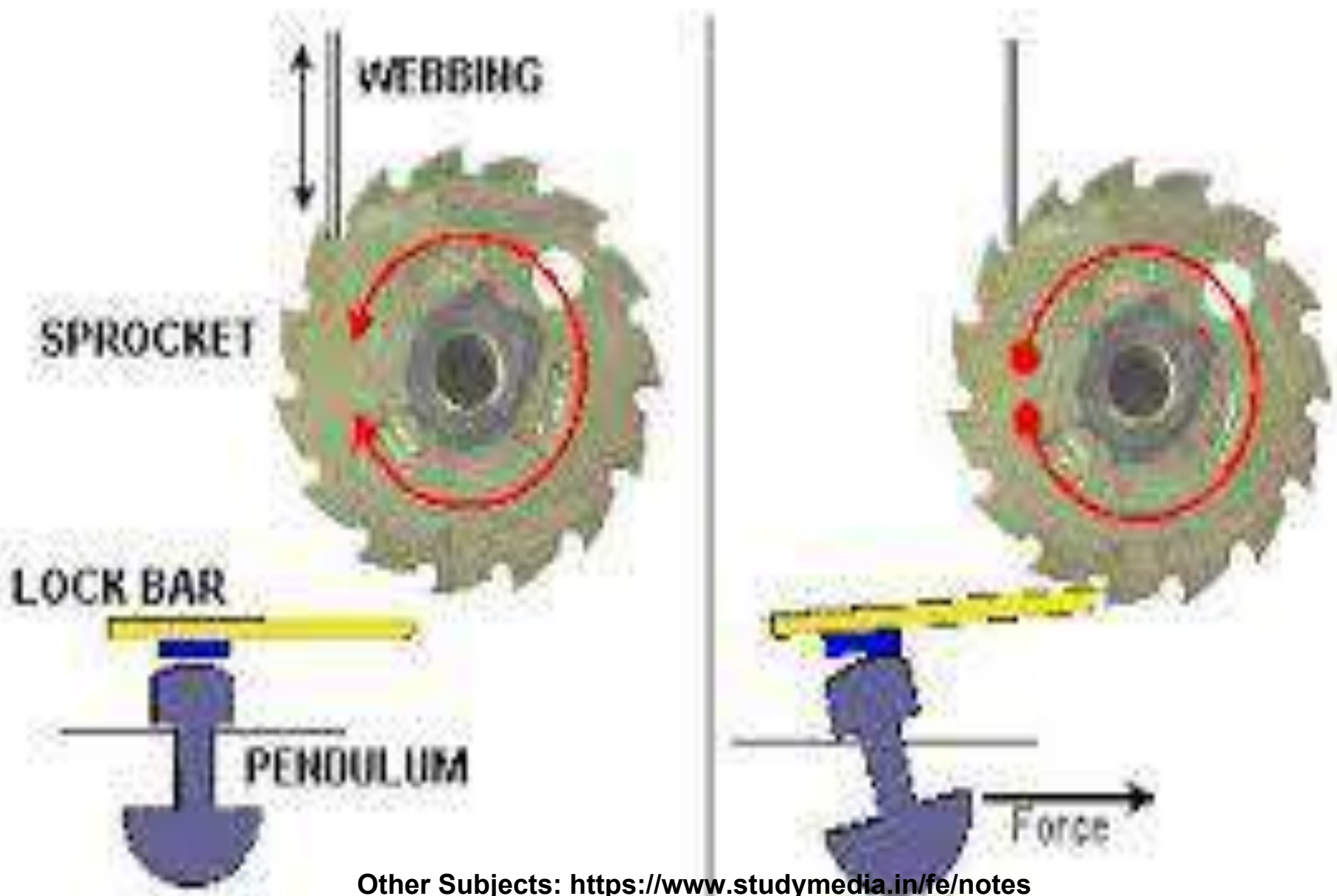
SEAT BELT

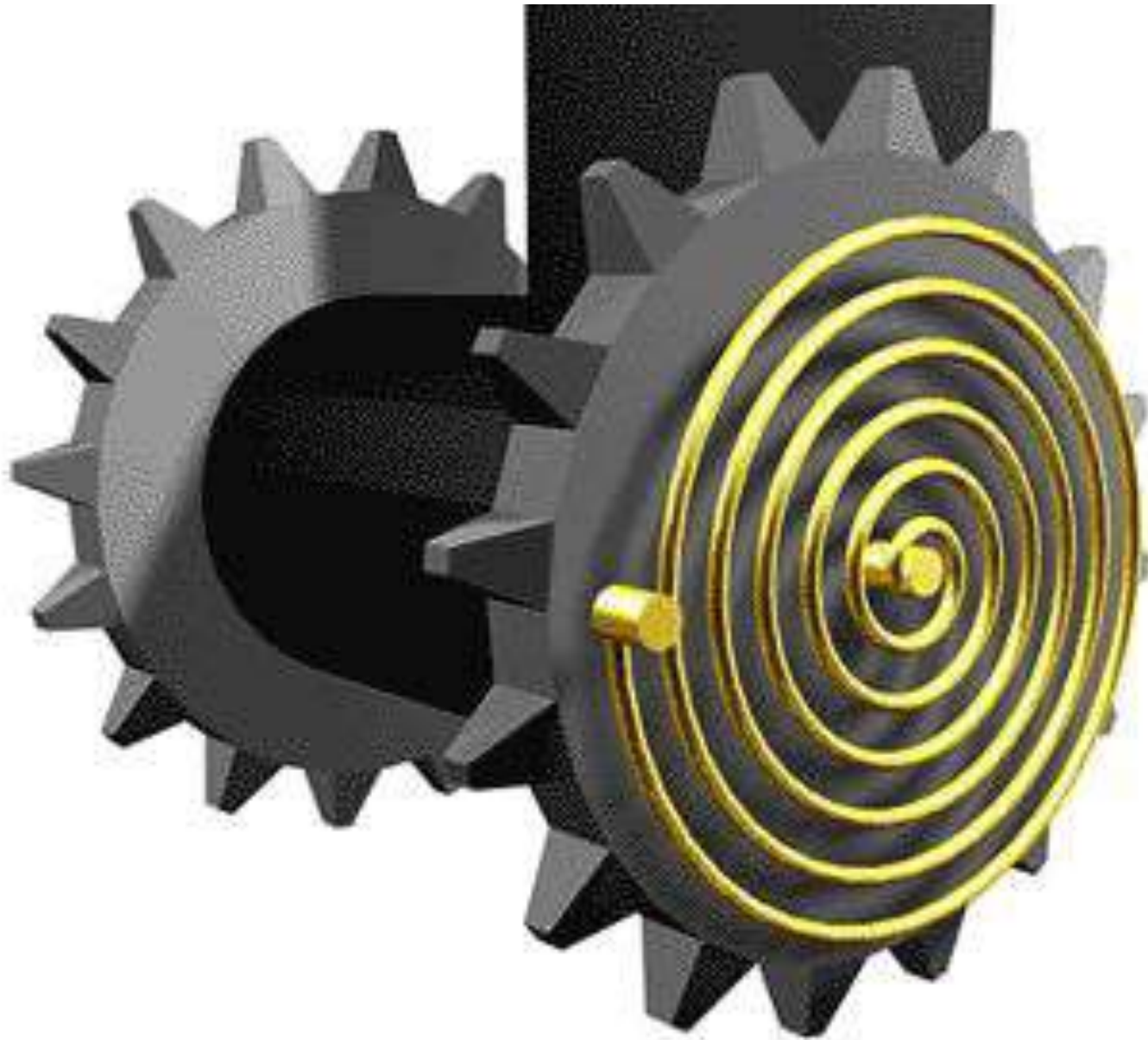
- The main purpose of a seat belt is to keep vehicle occupants safe in the event of a crash.
- The seat belt functions by keeping the occupant in a more static motion despite a sudden stop or change in momentum.
- A car moves with inertia, which is an object's tendency to move until something works against the motion of that object.
- When the vehicle hits something, or is hit by something, that inertia changes.
- Without the seat belt, occupants can be thrown into various parts of the interior of the car, or thrown completely out of the car. The seat belt usually stops this from happening.

SEAT BELT

- In a typical seatbelt system, the belt webbing is connected to a **retractor mechanism**.
- The central element in the retractor is a spool, which is attached to one end of the webbing.
- Inside the retractor, a spring applies a rotation force, or **torque**, to the spool. This works to rotate the spool so it winds up any loose webbing.
- When you pull the webbing out, the spool rotates counter-clockwise, which turns the attached spring in the same direction.
- Effectively, the rotating spool works to **untwist** the spring.
- The spring wants to return to its original shape, so it resists this twisting motion.
- If you release the webbing, the spring will tighten up, rotating the spool clockwise until there is no more slack in the belt.

HOW A SEAT BELT RETRACTOR WORKS



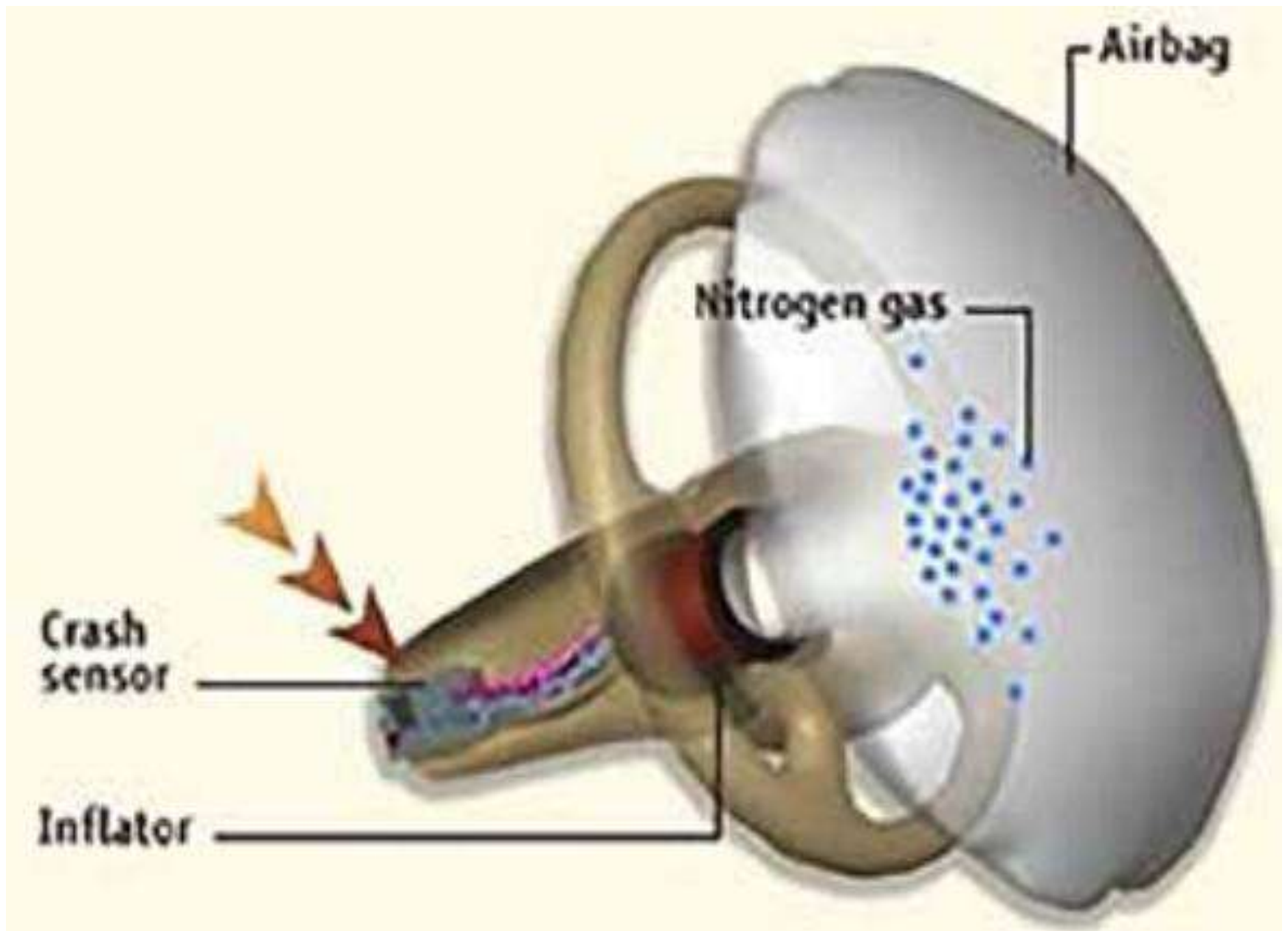


AIR BAGS

- Airbags are passive safety features designed to mitigate or prevent injuries among drivers and passengers in the event of a crash.
- Airbags provide added protection to seatbelts.
- For example, in higher-speed crashes, a seatbelt alone may not prevent a driver's head from hitting the steering column.
- The deployment of a airbag protects the head and upper body of the driver, and reduces some of the force exerted on the driver by the seatbelt.
- Airbags are strong fabric bags that are folded and concealed behind various parts inside of the vehicle.

AIR BAGS

- Airbag systems are composed of three basic parts: the bag itself, the inflator unit, and the crash sensor.
- The bag and inflator are contained together in the airbag module.
- Most often, the sensor is located in the passenger compartment of a vehicle and towards the front, so if a crash occurs it is quickly detected.
- When the crash sensor detects rapid deceleration, it triggers the inflator to produce nitrogen gas that quickly inflates the bag, causing the bag to escape from its module.
- A commonly used type of sensor is the electromechanical ball-and-tube design. This type of sensor is made up of a tube with a mechanical switch at one end and a steel ball on the other held in place by a magnet.
- When a sufficiently forceful deceleration occurs, the ball is knocked loose from its place, rolls down the tube and hits the switch. Hitting the switch causes the electrical circuit that inflates the airbag to close. With the circuit closed, the inflator engages to deploy the airbag.







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