UNIT-II

VEHICLE FRAMES AND STEERING SYSTEM

1.1. Introduction of Automobile or Vehicle:

An Automobile is a self propelled vehicle which contains the power source for its propulsion and is used for carrying passengers and goods on the ground, such as car, bus, trucks, etc.,,

1.2. Types of Automobile;

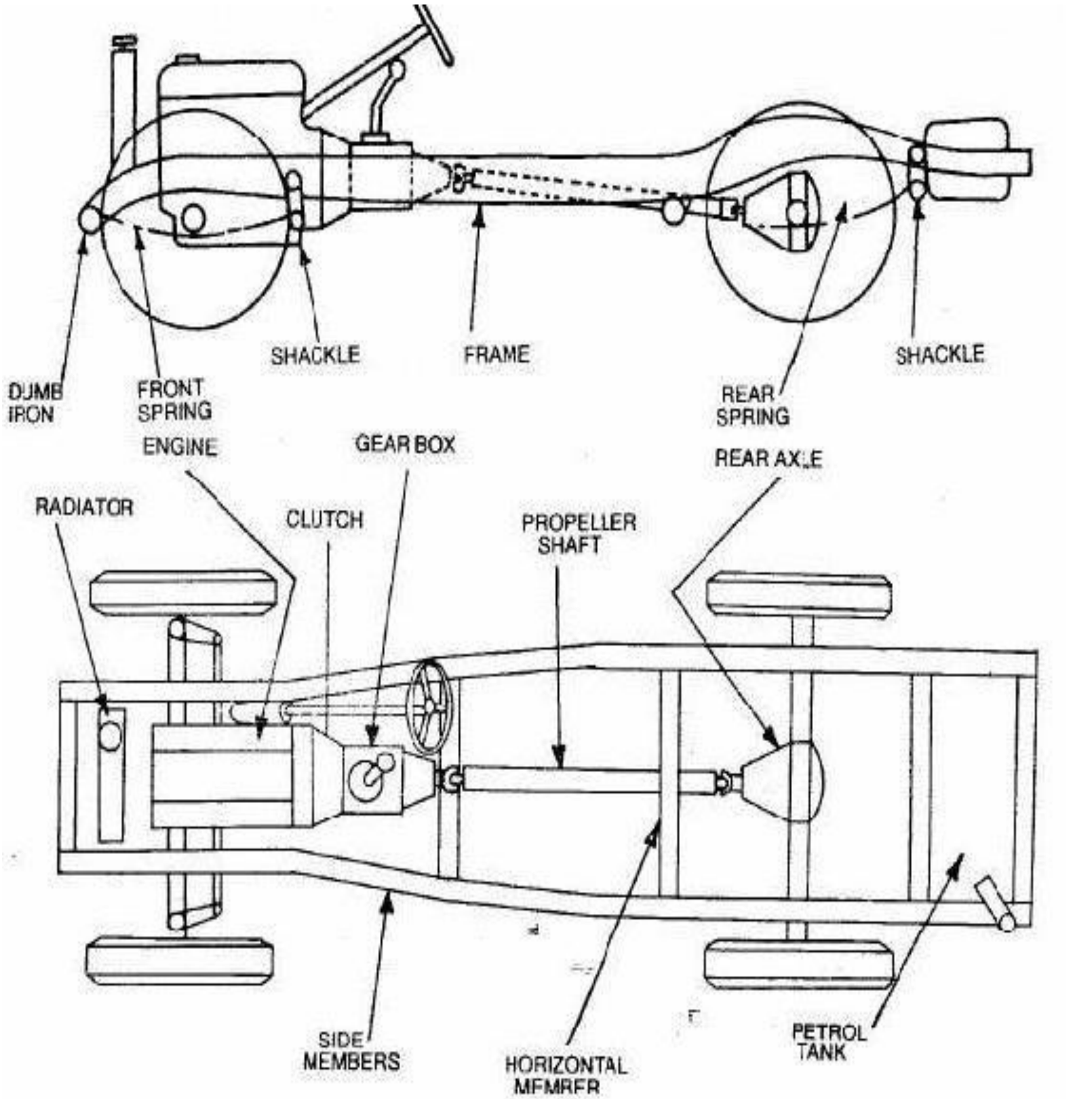
The automobiles are classified by the following ways,

1. **On the Basis of Load:**
   - Heavy transport vehicle (HTV) or heavy motor vehicle (HMV),
   - Light transport vehicle (LTV), Light motor vehicle (LMV),
2. **On the Basis of Wheels :**
   - Two wheeler vehicle, for example: Scooter, motorcycle, scooty, etc.
   - Three wheeler vehicle, for example : Auto rickshaw,
   - Three wheeler scooter for handicaps and tempo, etc.
   - Four wheeler vehicle, for example: Car, jeep, trucks, buses, etc.
   - Six wheeler vehicle, for example: Big trucks with two gear axles.
3. **On the basis of Fuel Used:**
   - Petrol vehicle, e.g. motorcycle, scooter, cars, etc.
   - Diesel vehicle, e.g. trucks, buses, etc.
   - Electric vehicle which use battery to drive.
   - Steam vehicle, e.g. an engine which uses steam engine.
   - Gas vehicle, e.g. LPG and CNG vehicles, where LPG is liquefied
4. **On the basis of body style:**
   - Sedan Hatchback car.
   - Coupe car Station wagon Convertible.
   - Van Special purpose vehicle, e.g. ambulance, milk van, etc.
5. **On the basis of Transmission:**
   - Conventional vehicles with manual transmission, e.g. car with 5 gears.
   - Semi-automatic
   - Automatic: In automatic transmission, gears are not required to be changed manually.
6. **On the basis of Drive:**
   - Left hand drive
   - Right hand drive
7. **On the basis of Driving Axle**
   - Front wheel drive
   - Rear wheel drive
   - All wheel drive
8. **Position of Engine:**
   - Engine in Front - Most of the vehicles have engine in the front. Example : most of the cars,
   - Engine in the Rear Side Very few vehicles have engine located in the rear. Example : Nano car.

1.3. Vehicle construction and Components;

The main components of an automobile refer to the following components;

- Frame,
- Chassis,
- Body,
- Power unit,
- Transmission system.



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

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

“Chassis” + “Body” = “Vehicle”

Frame :

The frame is the skeleton of the vehicle. It serves as a main foundation and base for alignment for the chassis.

Types;

- Conventional frame,
- Semi integral frame;
- Integral or untidiest frame.

Chassis;

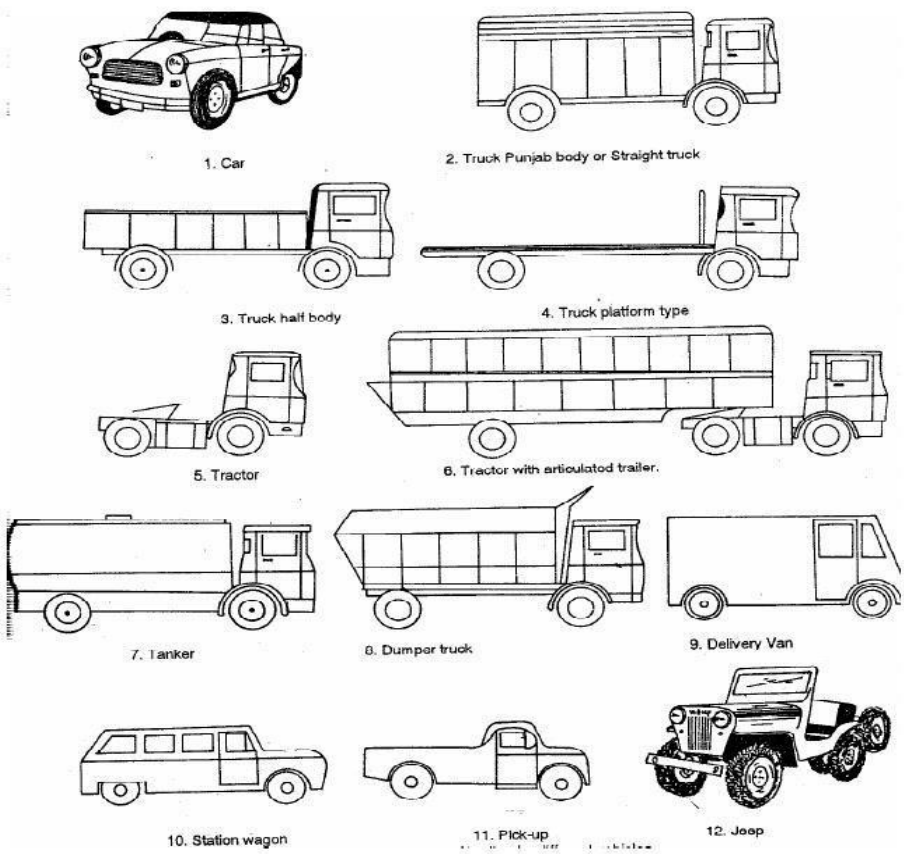
If the frame contains the base components its called as chassis. The components are like Engine, radiator, clutch, gearbox, silencer, road wheels, fuel tank, wirings, differential units, etc..,

Body:

Body is the superstructure of the vehicle and it is bolted to the chasis.

Types;

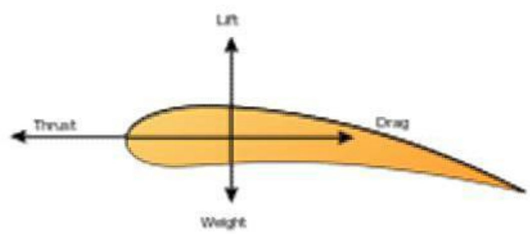
- Car,
- Truck,
- Tractor,
- Delivery van,
- Jeep,
- Bus, etc..,



1.4. Resistances to vehicle motion and need for a gearbox:

Aerodynamics

Aerodynamics, from Greek (dynamics), is a branch of dynamics concerned with studying the motion of air, particularly when it interacts with a solid object, such as an airplane wing. Aerodynamics is a sub-field of fluid dynamics and gas dynamics, and many aspects of aerodynamics theory are common to these fields. The term aerodynamics is often used synonymously with gas dynamics, with the difference being that "gas dynamics" applies to the study of the motion of all gases, not limited to air. Modern aerodynamics only dates back to the seventeenth century, but aerodynamic forces have been harnessed by humans for thousands of years in sailboats and windmills, and images and stories of flight appear throughout recorded history, such as the Ancient Greek legend of Icarus and Daedalus. Fundamental concepts of continuum, drag, and pressure gradients appear in the work of Aristotle and Archimedes.



Forces of flight on an airfoil

Fundamental Concept

Understanding the motion of air around an object (often called a flow field) enables the calculation of forces and moments acting on the object. In many aerodynamics problems, the forces of interest are the fundamental forces of flight: lift, drag, thrust, and weight. Of these, lift and drag are aerodynamic forces, i.e. forces due to air flow over a solid body.

Calculation of these quantities is often founded upon the assumption that the flow field behaves as a continuum. Continuum flow fields are characterized by properties such as velocity, pressure, density and temperature, which may be functions of spatial position and time.

These properties may be directly or indirectly measured in aerodynamics experiments, or calculated from equations for the conservation of mass, momentum, and energy in air flows. Density, velocity, and an additional property, viscosity, are used to classify flow fields.

1.5. Components of an Engine;

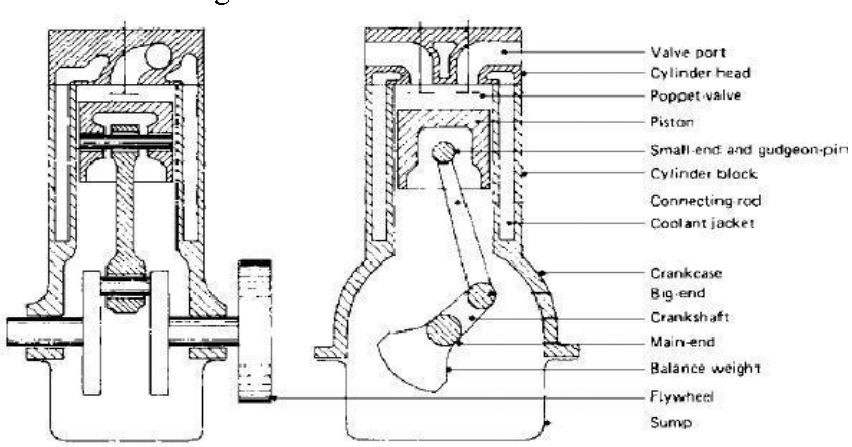
Even though reciprocating internal combustion engines look quite simple, they are highly complex machines. There are hundreds of components that have to perform their functions satisfactorily to produce output power. There are two types of engines, viz., spark ignition (S1) and compression-ignition (CI) engine. Let us now go through the important engine components and the nomenclature associated with an engine.

Terms connected with i.c. engines;

- **Bore:** The inside diameter of the cylinder is called bore
- **Stroke:** The linear distance along the cylinder axis between two limiting position s is called stroke.
- **Top Dead Center (T.D.C.)** : the top most position of the piston towards cover end side of the cylinder is called T.D.C.
- **Bottom dead Center (B.D.C.)** : The lowest position of the piston towards the crank end side of the cylinder is called B.D.C.
- **Clearance Volume** : The volume contained in the cylinder above the top of the piston , when the piston is at top dead center , is called the clearance volume.
- **Swept Volume:** The volume swept through by the piston in moving between T.D.C. and B.D.C, is called swept volume or piston displacement.
- **Compression Ratio:** It is the ratio of Total cylinder volume to clearance volume

<u>**Definition of 'Engine'**</u>

An engine is a device, which transforms one form of energy into another form. Normally, most of the engines convert thermal energy into mechanical work and therefore they are called 'heat engines'.



Engine Components

The major components of the engine and their functions are briefly described below.

Cylinder Block:

The cylinder block is the main supporting structure for the various components. The cylinder of a multicylinder engine is cast as a single unit, called cylinder block. The cylinder head is mounted on the cylinder block.

The cylinder head and cylinder block are provided with water jackets in the case of water-cooling with cooling fins in the case of air-cooling. Cylinder head gasket is incorporated between the cylinder block and cylinder head. The cylinder head is held tight to the cylinder block by number of bolts or studs. The bottom portion of the cylinder block is called crankcase. A cover called crankcase, which becomes a sump for lubricating oil is fastened to the bottom of the crankcase. The inner surface of the cylinder block, which is machined and finished accurately to cylindrical shape, is called bore or face.

Cylinder

As the name implies it is a cylindrical vessel or space in which the piston makes a reciprocating motion. The varying volume created in the cylinder during the operation of the engine is filled with the working fluid and subjected to different thermodynamic processes. The cylinder is supported in the cylinder block.

Piston

It is a cylindrical component fitted into the cylinder forming the moving boundary of the combustion system. It fits perfectly (snugly) into the cylinder providing a gas-tight space with the piston rings and the lubricant. It forms the first link in transmitting the gas forces to the output shaft.

Combustion Chamber

The space enclosed in the upper part of the cylinder, by the cylinder head and the piston top during the combustion process, is called the combustion chamber. The combustion of fuel and the consequent release of thermal energy results in the building up of pressure in this part of the cylinder.

Inlet Manifold

The pipe which connects the intake system to the inlet valve of the engine and through which air or air-fuel mixture is drawn into the cylinder is called the inlet manifold.

Gudgeon Pin

It forms the link between the small end of the connecting rod and the piston.

Exhaust Manifold

The pipe that connects the exhaust system to the exhaust valve of the engine and through which the products of combustion escape into the atmosphere is called the exhaust manifold.

Inlet and Exhaust Valves

Valves are commonly mushroom shaped poppet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder (inlet valve) and for discharging the products of combustion (exhaust valve) from the cylinder.

Connecting Rod

It interconnects the piston and the crankshaft and transmits the gas forces from the piston to the crankshaft. The two ends of the connecting rod are called as small end and the big end. Small end is connected to the piston by gudgeon pin and the big end is connected to the crankshaft by crankpin.

Crankshaft

It converts the reciprocating motion of the piston into useful rotary motion of the output shaft. In the crankshaft of a single cylinder engine there is pair of crank arms and balance weights. The balance weights are provided for static and dynamic balancing of the rotating system. The crankshaft is enclosed in a crankcase.

Piston Rings

Piston rings, fitted into the slots around the piston, provide a tight seal between the piston and the cylinder wall thus preventing leakage of combustion gases

Camshaft

The camshaft and its associated parts control the opening and closing of the two valves. The associated parts are push rods, rocker arms, valve springs and tappets. This shaft also provides the drive to the ignition system. The camshaft is driven by the crankshaft through timing gears.

Cams

These are made *as* integral parts of the camshaft and are designed in such a way to open the valves at the correct timing and to keep them open for the necessary duration.

Fly Wheel

The net torque imparted to the crankshaft during one complete cycle of operation of the engine fluctuates causing a change in the angular velocity of the shaft. In order to achieve a uniform torque an inertia *mass* in the form of a wheel is attached to the output shaft and this wheel is called the flywheel.

Basic Parts of the Gasoline Engine:

Basic Parts of the Gasoline Engine are listed below;

- Cylinder block
- Piston
- Piston rings
- Piston pin

- Connecting rod
- Crankshaft
- Cylinder head
- Intake valve
- Exhaust valve
- Camshaft
- Timing gears
- Spark plug

Cylinder Block:

Cylinder Block Basic frame of gasoline engine. Contains the cylinder.

Piston:

Piston A sliding plug that harnesses the force of the burning gases in the cylinder

Piston Rings:

Piston rings seal the compression gases above the piston keep the oil below the piston rings

Piston Pins:

Piston Pins Also known as the wrist pin, it connects the piston to the small end of the connecting rod. It transfers the force and allows the rod to swing back and forth.

Connecting Rod:

Connecting Rod Connects the piston and piston pin to the crankshaft.

Crankshaft:

Crankshaft Along the the piston pin and connecting rod it converts the up and down motion (reciprocating) of the engine to spinning (rotary) motion.

Flywheel:

Flywheel Carries the inertia when there is no power stroke.

Cylinder Head:

Cylinder Head Forms the top of the combustion chamber. Contains the valves, the passageways for the fuel mixture to move in and out of the engine.

Intake and Exhaust Valves:

Intake and Exhaust Valves Doorway that lets the gases in and out of the engine.

Camshaft:

Camshaft Through the use of an eccentric the cam lobes push the valves open. The valve springs close them.

Timing Gears:

Timing Gears These gears drive the camshaft from the crankshaft.

Why not diesel engines are not preferred in commercial ?:

1. Diesel engines, because they have much higher compression ratios (20:1 for a typical diesel vs. 8:1 for a typical gasoline engine), tend to be heavier than an equivalent gasoline engine.
2. Diesel engines also tend to be more expensive.

3. Diesel engines, because of the weight and compression ratio, tend to have lower maximum RPM ranges than gasoline engines .This makes diesel engines high torque rather than high horsepower, and that tends to make diesel cars slow in terms of acceleration.
4. Diesel engines must be fuel injected, and in the past fuel injection was expensive and less reliable
5. Diesel engines tend to produce more smoke.
6. Diesel engines are harder to start in cold weather, and if they contain glow plugs, diesel engines can require you to wait before starting the engine so the glow plugs can heat up.
7. Diesel engines are much noisier and tend to vibrate.
8. Diesel fuel is less readily available than gasoline

Advantages diesel engines:

The two things working in favor of diesel engines are better fuel economy and longer engine life. Both of these advantages mean that, over the life of the engine, you will tend to save money with a diesel.
However, you also have to take the initial high cost of the engine into account. You have to own and operate a diesel engine for a fairly long time before the fuel economy overcomes the increased purchase price of the engine.
The equation works great in a big diesel tractor-trailer rig that is running 400 miles every day, but it is not nearly so beneficial in a passenger car.

1.6. ENGINE SUPPORT SYSTEMS:

- Cooling system
- Lubrication system
- Fuel and ignition/injection system
- Intake system Exhaust system

1.6.1. Cooling system:

The cooling system removes excess heat to keep the inside of the engine at an efficient temperature.

- Air Cooling
- Liquid Cooling
- Water cooling

Coolant. Water Jackets:

Water Jackets Surrounds the cylinders with water passage. Absorbs heat from the cylinder wall. Pump move water to radiator where heat is exchanged to the air. 66

Coolant Flow:

Coolant flows through the water jackets where it absorbs heat. It then flows through the radiator where heat is transferred to the air passing through. The amount of flow is determined by the water pump. The flow direction is controlled by the thermostat.

Warm Engine:

The thermostat opens when the engine warms up. This allows coolant to circulate through the radiator and the water jackets.

Cold Engine:

When an engine is cold, the thermostat is cold. Coolant flow is through the bypass hose and the water jackets. This allows the engine to warm up evenly.

Coolant :

- Coolant Water (Boiling Point 100° C)

- Glycerin (Boiling Point 290 ° C)
- Ethylene glycol (Boiling Point 197 ° C)
- Antifreeze (methyl alcohol, ethyl alcohol)

Cooling System:

- Water pump is driven by the crankshaft through Timing Belt (Keeps Cam and Crank shafts in time)
- Drive/accessory Belt (Runs alternator, power-steering pump, AC, etc.) Serpentine Belt V-Belt
- Electric fan is mounted on the radiator and is operated by battery power. It is controlled by the thermostat switch.

Need for cooling system

The cooling system has four primary functions. These functions are as follows:

1. Remove excess heat from the engine.
2. Maintain a constant engine operating temperature.
3. Increase the temperature of a cold engine as quickly as possible.
4. Provide a means for heater operation (warming the passenger compartment).

Types of cooling system:

The different Types of cooling system are

1. Air cooling system
2. Liquid cooling system
3. Forced circulation system
4. Pressure cooling system

Air-Cooled System :

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

1. The area exposed to the cooling medium.
2. The heat conductivity of the metal used & the volume of the metal or its size in cross section .
3. The amount of air flowing over the heated surfaces.
4. The difference in temperature between the exposed metal surfaces and the cooling air.

Liquid-cooled system;

Nearly all multi cylinder engines used in automotive, construction, and material-handling equipment use a liquid-cooled system. Any liquid used in this type of system is called a COOLANT.

A simple liquid-cooled system consists of a radiator, coolant pump, piping, fan, thermostat, and a system of water jackets and passages in the cylinder head and block through which the coolant circulates. Some vehicles are equipped with a coolant distribution tube inside the cooling passages that directs additional coolant to the points where temperatures are highest.

Cooling of the engine parts is accomplished by keeping the coolant circulating and in contact with the metal surfaces to be cooled. The operation of a liquid- cooled system is as follows:

The pump draws the coolant from the bottom of the radiator, forcing the coolant through the water jackets and passages, and ejects it into the upper radiator tank. The coolant then passes through a set of tubes to the bottom of the radiator from which the cooling cycle begins.

The radiator is situated in front of a fan that is driven either by the water pump or an electric motor. The fan ensures airflow through the radiator at times when there is no vehicle motion. The downward flow of coolant through the radiator creates what is known as a thermosiphon action. This simply means that as the coolant is heated in the jackets of the engine, it expands. As it expands, it becomes less dense and therefore lighter. This causes it to flow out of the top outlet of the engine and into the top tank of the radiator. As the coolant is cooled in the radiator, it again becomes more dense and heavier. This causes the coolant to settle to the bottom tank of the radiator.

The heating in the engine and the cooling in the radiator therefore create a natural circulation that aids the water pump. The amount of engine heat that must be removed by the cooling system is much greater than is generally realized. To handle this heat load, it may be necessary for the cooling system in some engine to circulate 4,000 to 10,000 gallons of coolant per hour. The water passages, the size of the pump and radiator, and other details are so designed as to maintain the working parts of the engine at the most efficient temperature within the limitation imposed by the coolant.

Pressure cooling system

Radiator Pressure Cap

The radiator pressure cap is used on nearly all of the modern engines. The radiator cap locks onto the radiator tank filler neck Rubber or metal seals make the cap-to-neck joint airtight. The functions of the pressure cap are as follows:

1. Seals the top of the radiator tiller neck to prevent leakage.
2. Pressurizes system to raise boiling point of coolant.
3. Relieves excess pressure to protect against system damage.
4. In a closed system, it allows coolant flow into and from the coolant reservoir.

The radiator cap pressure valve consists of a spring- loaded disc that contacts the filler neck. The spring pushes the valve into the neck to form a seal. Under pressure, the boiling point of water increases. Normally water boils at 212°F.

However, for every pound of pressure increase, the boiling point goes up 3°F. Typical radiator cap pressure is 12 to 16 psi. This raises the boiling point of the engine coolant to about 250°F to 260°F. Many surfaces inside the water jackets can be above 212°F. If the engine overheats and the pressure exceeds the cap rating, the pressure valve opens. Excess pressure forces coolant out of the overflow tube and into the reservoir or onto the ground.

This prevents high pressure from rupturing the radiator, gaskets, seals, or hoses. The radiator cap vacuum valve opens to allow reverse flow back into the radiator when the coolant temperature drops after engine operation. It is a smaller valve located in the center, bottom of the cap.

The cooling and contraction of the coolant and air in the system could decrease coolant volume and pressure. Outside atmospheric pressure could then crush inward on the hoses and radiator. Without a cap vacuum or vent valve, the radiator hose and radiator could collapse

1.6.2. Lubrication System:

Parts require lubrications Crankshaft bearing Piston pin Timing gears Valve mechanism Piston ring and cylinder walls Camshaft and bearings.

Purpose of lubrication:

- Reduce friction & wear - by creating a thin film (Clearance) between moving parts
- Seal power - The oil helps form a gastight seal between piston rings and cylinder walls
- Cleaning - Cleans As it circulates through the engine, the oil picks up metal particles and carbon, and brings them back down to the pan.
- Absorb shock - When heavy loads are imposed on the bearings, the oil helps to cushion the load
- Cooling. - Cools Picks up heat when moving through the engine and then drops into the cooler oil pan, giving up some of this heat.

Types Lubrication System:

- Petroil system
- Splash system
- Pressure system
- Dry-sump system

Oil change:

- Every 5000Km for four wheeler , Every 2000 Km in two wheeler Ignoring regular oil change intervals will shorten engine life and performance.

All internal combustion engines are equipped with an internal lubricating system. Without lubrication, an engine quickly overheats and its working parts seize due to excessive friction. All moving parts must be adequately lubricated to assure maximum wear and long engine life.

Purpose of Lubrication;

The functions of an engine lubrication system are as follows: Reduces friction and wear between moving parts. Helps transfer heat and cool engine parts. Cleans the inside of the engine by removing contaminants (metal, dirt, plastic, rubber, and other particles).

Absorbs shocks between moving parts to quiet engine operation and increase engine life. The properties of engine oil and the design of modern engines allow the lubrication system to accomplish these functions.

Types of Lubrication Systems;

Now that you are familiar with the lubricating system components, you are ready to study the different systems that circulate oil through the engine. The systems used to circulate oil are known as splash, combination splash force feed, force feed, and full force-feed.

Splash Systems

The splash system is no longer used in automotive engines. It is widely used in small four-cycle engines for lawn mowers, outboard marine operation, and so on. In the splash lubricating system, oil is splashed up from the oil pan or oil trays in the lower part of the crankcase.

The oil is thrown upward as droplets or fine mist and provides adequate lubrication to valve mechanisms, piston pins, cylinder walls, and piston rings. In the engine, dippers on the connecting-rod bearing caps enter the oil pan with each crankshaft revolution to produce the oil splash.

A passage is drilled in each connecting rod from the dipper to the bearing to ensure lubrication. This system is too uncertain for automotive applications. One reason is that the level of oil in the crankcase will vary greatly the amount of lubrication received by the engine. A high level results in excess lubrication and oil consumption and a slightly low level results in inadequate lubrication and failure of the engine.

Combination Splash and Force Feed

In a combination splash and force feed, oil is delivered to some parts by means of splashing and other parts through oil passages under pressure from the oil pump. The oil from the pump enters the oil galleries. From the oil galleries, it flows to the main bearings and camshaft bearings.

The main bearings have oil-feed holes or grooves that feed oil into drilled passages in the crankshaft. The oil flows through these passages to the connecting rod bearings. From there, on some engines, it flows through holes drilled in the connecting rods to the piston-pin bearings. Cylinder walls are lubricated by splashing oil thrown off from the connecting-rod bearings.

Some engines use small troughs under each connecting rod that are kept full by small nozzles which deliver oil under pressure from the oil pump. These oil nozzles deliver an increasingly heavy stream as speed increases. At very high speeds these oil streams are powerful enough to strike the dippers directly. This causes a much heavier splash so that adequate lubrication of the pistons and the connecting-rod bearings is provided at higher speeds. If a combination system is used on an overhead valve engine, the upper valve train is lubricated by pressure from the pump.

Force Feed

A somewhat more complete pressurization of lubrication is achieved in the force-feed lubrication system. Oil is forced by the oil pump from the crankcase to the main bearings and the camshaft bearings. Unlike the combination system the connecting-rod bearings are also fed oil under pressure from the pump. Oil passages are drilled in the crankshaft to lead oil to the connecting-rod bearings.

The passages deliver oil from the main bearing journals to the rod bearing journals. In some engines, these opening are holes that line up once for every crankshaft revolution. In other engines, there are annular grooves in the main bearings through which oil can feed constantly into the hole in the crankshaft. The pressurized oil that lubricates the connecting- rod bearings goes on to lubricate the pistons and walls by squirting out through strategically drilled holes. This lubrication system is used in virtually all engines that are equipped with semi floating piston pins.

Full Force Feed

In a full force-feed lubrication system, the main bearings, rod bearings, camshaft bearings, and the complete valve mechanism are lubricated by oil under pressure. In addition, the full force-feed lubrication system provides lubrication under pressure to the pistons and the piston pins.

This is accomplished by holes drilled the length of the connecting rod, creating an oil passage from the connecting rod bearing to the piston pin bearing. This passage not only feeds the piston pin bearings but also provides lubrication for the pistons and cylinder walls. This system is used in virtually all engines that are equipped with full-floating piston pins.

Four-stroke Spark-ignition Engine

In a four-stroke engine, the cycle of operations is completed in four strokes of the piston or two revolutions of the crankshaft. During the four strokes, there are five events to be completed, viz, suction, compression, combustion, expansion and exhaust. Each stroke consists of 180° of crankshaft rotation and hence a four-stroke cycle is completed through 720° of crank rotation. The cycle of operation for an ideal four-stroke SI engine consists of the following four strokes:

i. Suction or intake stroke;

ii. Compression stroke;

iii. Expansion or power stroke and

iv. Exhaust stroke.

Working principle of a Four Stroke SI Engine

i. Suction or Intake Stroke: Suction stroke starts when the piston is at the top dead centre and about to move downwards. The inlet valve is open at this time and the exhaust valve is closed. Due to the suction created by the motion of the piston towards the bottom dead centre, the charge consisting of fuel-air mixture is drawn into the cylinder. When the piston reaches the bottom dead centre the suction stroke ends and the inlet valve closes.

ii. Compression Stroke: The charge taken into the cylinder during the suction stroke is compressed by the return stroke of the piston. During this stroke both inlet and exhaust valves are in closed position. The mixture that fills the entire cylinder volume is now compressed into the clearance volume. At the end of the compression stroke the mixture is ignited with the help of a spark plug located on the cylinder head. In ideal engines it is assumed that burning takes place instantaneously when the piston is at the top dead centre and hence the burning process can be approximated as heat addition at constant volume.

During the burning process the chemical energy of the fuel is converted into heat energy producing a temperature rise of about 2000 °C. The pressure at the end of the combustion process is considerably increased due to the heat release from the fuel.

iii. Exhaust Stroke: At the end of the expansion stroke the exhaust valve opens and the inlet valve remains closed. The pressure falls to atmospheric level a part of the burnt gases escape. The piston starts moving from the bottom dead centre to top dead centre and sweeps the burnt gases out from the cylinder almost at atmospheric pressure.

The exhaust valve closes when the piston reaches T.D.C. at the end of the exhaust stroke and some residual gases trapped in the clearance volume remain in the cylinder. Residual gases mix with the fresh charge coming in during the following cycle, forming its working fluid.

Each cylinder of a four stroke engine completes the above four operations in two engine revolutions, one revolution of the crankshaft occurs during the suction and compression strokes and the second revolution during the power and exhaust strokes. Thus for one complete cycle there's only one power stroke while the crankshaft
turns by two revolutions.

Consumption of lubricating oil is high in two-stroke engines due to higher temperature. A detailed comparison of two-stroke and four-stroke engines is given in the Table below

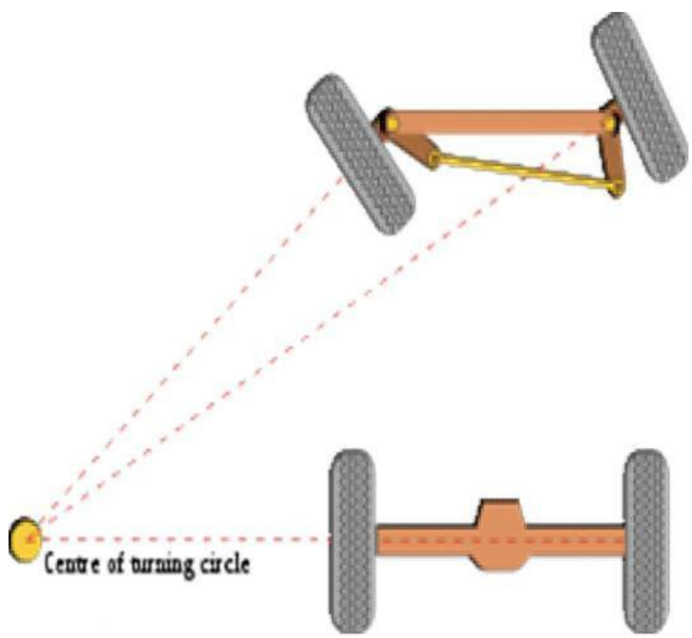
UNIT-IV

STEERING, BRAKES AND SUSPENSION SYSTEMS

4.1. Introduction of Steering system

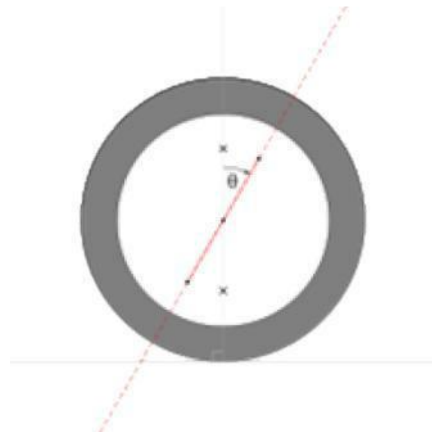
Steering is the collection of components, linkages, etc. which allow a vessel (ship,boat) or vehicle (car, motorcycle, bicycle) to follow the desired course. An exception is the case of rail transport by which rail tracks combined together with railroad switches (and also known as 'points' in British English) provide the steering function.

The most conventional steering arrangement is to turn the front wheels using a hand–operated steering wheel which is positioned in front of the driver, via the steering column, which may contain universal joints (which may also be part of the collapsible steering column design), to allow it to deviate somewhat from a straight line. Other arrangements are sometimes found on different types of vehicles, for example, a tiller or rear–wheel steering. Tracked vehicles such as bulldozers andtanks usually employ differential steering — that is, the tracks are made to move at different speeds or even in opposite directions, using clutches and brakes, to bring about a change of course or direction.



Wheeled vehicle steering - Basic geometry

4.2.Ackermann steering geometry

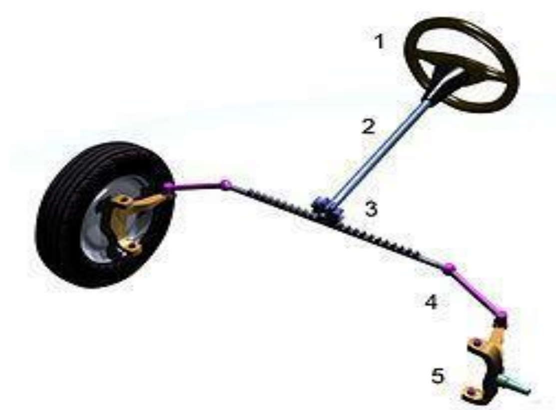


Caster angle θ indicates kingpinpivot line and gray area indicates vehicle's tire with the wheel moving from right to left. A positive caster angle aids in directional stability, as the wheel tends to trail, but a large angle makes steering more difficult.

Curves described by the rear wheels of a conventional automobile. While the vehicle moves with a constant speed its inner and outer rear wheels do not.

The basic aim of steering is to ensure that the wheels are pointing in the desired directions. This is typically achieved by a series of linkages, rods, pivots and gears. One of the fundamental concepts is that of caster angle – each wheel is steered with a pivot point ahead of the wheel; this makes the steering tend to be self-centering towards the direction of travel.

The steering linkages connecting the steering box and the wheels usually conforms to a variation of Ackermann steering geometry, to account for the fact that in a turn, the inner wheel is actually travelling a path of smaller radius than the outer wheel, so that the degree of toe suitable for driving in a straight path is not suitable for turns. The angle the wheels make with the vertical plane also influences steering dynamics (see camber angle) as do the tires.



Rack and pinion, recirculating ball, worm and sector

Rack and pinion steering mechanism:

1. Steering wheel;
2. Steering column;
3. Rack and pinion;
4. Tie rod;
5. Kingpin

Rack and pinion unit mounted in the cockpit of an Ariel Atom sports car chassis. For most high volume production, this is usually mounted on the other side of this panel

Steering box of a motor vehicle, the traditional (non-assisted), you may notice that the system allows you to adjust the braking and steering systems, you can also see the attachment system to the frame.

Many modern cars use rack and pinion steering mechanisms, where the steering wheel turns the pinion gear; the pinion moves the rack, which is a linear gear that meshes with the pinion, converting circular motion into linear motion along the transverse axis of the car (side to side motion). This motion applies steering torque to the swivel pin ball joints that replaced previously used kingpins of the stub axle of the steered wheels via tie rods and a short lever arm called the steering arm.

The rack and pinion design has the advantages of a large degree of feedback and direct steering "feel". A disadvantage is that it is not adjustable, so that when it does wear and develop lash, the only cure is replacement.

Older designs often use the recalculating ball mechanism, which is still found on trucks and utility vehicles. This is a variation on the older sector design; the steering column turns a large screw (the "worm gear") which meshes with a sector of a gear, causing it to rotate about its axis as the worm gear is turned; an arm attached to the axis of the sector moves the Pitman arm, which is connected to the steering linkage and thus steers the wheels. The recalculating ball version of this apparatus reduces the considerable friction by placing large ball bearings between the teeth of the worm and those of the screw; at either end of the apparatus the balls exit from between the two pieces into a channel internal to the box which connects them with the other end of the apparatus, thus they are "recalculated".

The recirculating ball mechanism has the advantage of a much greater mechanical advantage, so that it was found on larger, heavier vehicles while the rack and pinion was originally limited to smaller and lighter ones; due to the almost universal adoption of power steering, however, this is no longer an important advantage, leading to the increasing use of rack and pinion on newer cars.

The recirculating ball design also has a perceptible lash, or "dead spot" on center, where a minute turn of the steering wheel in either direction does not move the steering apparatus; this is easily adjustable via a screw on the end of the steering box to account for wear, but it cannot be entirely eliminated because it will create excessive internal forces at other positions and the mechanism will wear very rapidly. This design is still in use in trucks and other large vehicles, where rapidity of steering and direct feel are less important than robustness, maintainability, and mechanical advantage.

The worm and sector was an older design, used for example in Willys and Chrysler vehicles, and the Ford Falcon (1960s).

Other systems for steering exist, but are uncommon on road vehicles. Children's toys and go-karts often use a very direct linkage in the form of abellcrank (also commonly known as a Pitman arm) attached directly between the steering column and the steering arms, and the use of cable-operated steering linkages (e.g. the Capstan and Bowstring mechanism) is also found on some home-built vehicles such as soapbox cars and recumbent tricycles.

4.3.Steering Gear Boxes;

The steering gears converts the rotary motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkages. Moreover it also provides necessary leverage so that the driver is able to steer the vehicle without fatigue.

There are various types of steering gear boxes are available in automobile.

- Worm and Wheel steering gear box,
- Cam and double roller steering gear box,
- Worm and nut steering gear box,
- Recalculating ball type steering gear box,
- Rack and pinion steering gear box,

4.4. Power steering

In automobiles, power steering (also known as power assisted steering (PAS) or steering assist system) helps drivers steer by augmenting steering effort of the steering wheel.

Hydraulic or electric actuators add controlled energy to the steering mechanism, so the driver needs to provide only modest effort regardless of conditions. Power steering helps considerably when a vehicle is stopped or moving slowly. Also, power steering provides some feedback of forces acting on the front wheels to give an ongoing sense of how the wheels are interacting with the road; this is typically called "road feel".

Representative power steering systems for cars augment steering effort via an actuator, a hydraulic cylinder, which is part of a servo system. These systems have a direct mechanical connection between the steering wheel and the linkage that steers the wheels.

This means that power-steering system failure (to augment effort) still permits the vehicle to be steered using manual effort alone.

Other power steering systems (such as those in the largest off-road construction vehicles) have no direct mechanical connection to the steering linkage; they require power. Systems of this kind, with no mechanical connection, are sometimes called "drive by wire" or "steer by wire", by analogy with aviation's "fly-by-wire". In this context, "wire" refers to electrical cables that carry power and data, not thin-wire-rope mechanical control cables.

In other power steering systems, electric motors provide the assistance instead of hydraulic systems. As with hydraulic types, power to the actuator (motor, in this case) is controlled by the rest of the power-steering system.

Some construction vehicles have a two-part frame with a rugged hinge in the middle; this hinge allows the front and rear axles to become non-parallel to steer the vehicle. Opposing hydraulic cylinders move the halves of the frame relative to each other to steer.

Power steering helps the driver of a vehicle to steer by directing some of the power to assist in swiveling the steered road wheels about their steering axes. As vehicles have become heavier and switched to front wheel drive, particularly using negative offset geometry, along with increases in tire width and diameter, the effort needed to turn the wheels about their steering axis has increased, often to the point where major physical exertion would be needed were it not for power assistance.

To alleviate this auto makers have developed power steering systems: or more correctly power-assisted steering—on road going vehicles there has to be a mechanical linkage as a failsafe. There are two types of power steering systems; hydraulic and electric/electronic. A hydraulic-electric hybrid system is also possible.A hydraulic power steering (HPS) uses hydraulic pressure supplied by an engine-driven pump to assist the motion of turning the steering wheel. Electric power steering (EPS) is more efficient than the hydraulic power steering, since the electric power steering motor only needs to provide assistance when the steering wheel is turned, whereas the hydraulic pump must run constantly.

In EPS, the amount of assistance is easily tunable to the vehicle type, road speed, and even driver preference. An added benefit is the elimination of environmental hazard posed by leakage and disposal of hydraulic power steering fluid. In addition, electrical assistance is not lost when the engine fails or stalls, whereas hydraulic assistance stops working if the engine stops, making the steering doubly heavy as the driver must now turn not only the very heavy steering—without any help—but also the power-assistance system itself.

Speed Sensitive Steering

An outgrowth of power steering is speed sensitive steering, where the steering is heavily assisted at low speed and lightly assisted at high speed. The auto makers perceive that motorists might need to make large steering inputs while manoeuvering for parking, but not while traveling at high speed. The first vehicle with this feature was the Citroën SM with itsDiravi layout[citation needed], although rather than altering the amount of assistance as in modern power steering systems, it altered the pressure on a centring cam which made the steering wheel try to "spring" back to the straight-ahead position. Modern speed-sensitive power steering systems reduce the mechanical or electrical assistance as the vehicle speed increases, giving a more direct feel. This feature is gradually becoming more common.

FIG. 1