Major Systems and Components of an Automobile

Introduction

In the previous Units, we learnt about the different types of automobile. In this Unit, we will discuss the major systems and components of an automobile. An automobile is made of several components, assemblies and systems. The growing automotive industry has given rise to a growing auto component industry also. India has emerged as a global outsourcing hub for manufacturing of various automobile components. All major companies like Toyota, Hyundai, Ford, Volvo, Renault and others are now sourcing their automotive components from Indian manufacturers.

The auto components industry is predominantly divided into five segments.

(i) Engine parts
(ii) Drive transmission and steering parts
(iii) Suspension and brake parts
(iv) Electrical parts
(v) Body and chassis

Global automobile manufacturers see India as a manufacturing hub for auto components due to the following reasons:

(i) Low-cost labour force and availability of raw material which makes India cost competitive
(ii) An established manufacturing base in India
(iii) Setting up of the operations of major international auto components including Delphi, Visteon, Bosch and Meritor in India
(iv) Setting up of International Purchasing Offices (IPOs) of automobile manufacturers and auto component manufacturers in India
(v) Fine-quality components manufactured in India
(vi) India being a global hub for research and development (R&D), General Motors, Diamler Chrysler, Bosch, Suzuki, Johnson Controls, etc., have their research centres in India

In this Unit, you will learn about the various components and systems that make a complete automobile — the engine and its parts, the body and chassis, drive transmission and steering parts, suspension and brake parts, electrical parts and other systems that make running an automobile possible.

Session 1: Chassis and Auto Body

Fig. 3.1: Chassis with suspension and exhaust system

Chassis

Chassis is a French term and was initially used to denote the frame or main structure of a vehicle. The chassis (Fig. 3.1) contains all the major units necessary to propel the vehicle, guide its motion, stop it and allow it to run smoothly over uneven surfaces. It is the main mounting for all the components including the body. It is also known as the carrying unit.

The chassis includes the following major components.

(i) A steel frame, which is a major part.
(ii) In case of a passenger car, the whole body is also an integral part of the chassis. However, in commercial vehicles like trucks and buses, the body is not a part of the chassis. Therefore, a chassis is almost a complete vehicle except the

body and other accessories, which are not involved in the movement of the vehicle.

(iii) Other major components include engine, transmission system, front and rear axle, steering system, suspension system, wheels, tyres and brakes.

Functions of the chassis

The functions of the chassis includes

(i) carrying the weight of the vehicle and its passengers,

(ii) withstanding the engine and transmission torque and thrust stresses, as well as accelerating and braking torque,

(iii) withstanding the centrifugal force while taking a turn and

(iv) withstanding the bending load and twisting due to the rise and fall of the front and rear axles.

Automobile Body or Superstructure

In case of integral or frameless construction, the body is an integral part of the chassis. But, in case of the conventional chassis, the body or superstructure is made after receiving the chassis from the manufacturer. The shape of the body depends upon the ultimate use for which the vehicle is meant.

The body of a car (Fig. 3.2) is made of a sheet of metal or fibre glass, so that passengers can sit in it. To make

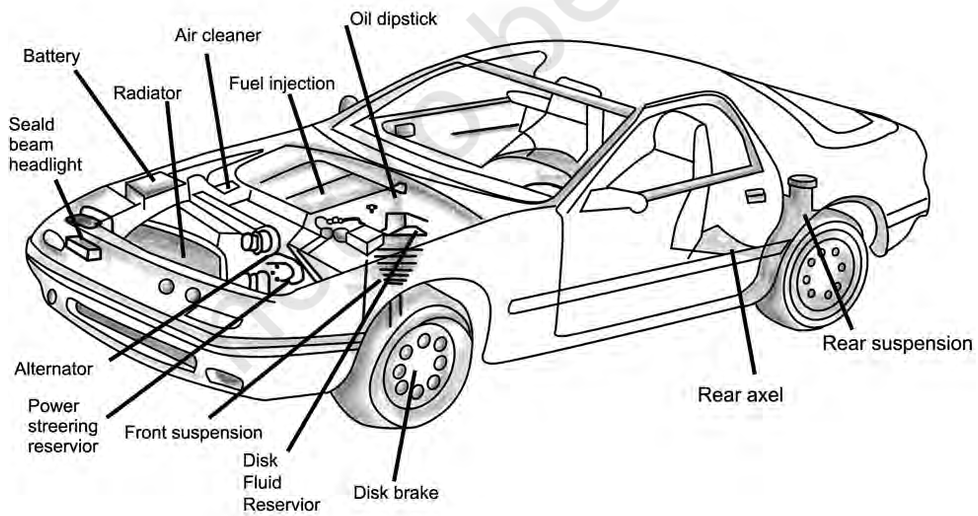


Fig. 3.2: Body of a car

the journey comfortable, cushioned seats are provided. The body is provided on all sides with glass panes fixed to protect the passengers from dust and rain.

The body of a bus is made of metal, like

(a) steel section pillars with steel sheet panelling,

(b) steel section pillars with aluminium panelling and

(c) all aluminium bodies, i.e., pillars, framework and panelling made of aluminium sections and sheets. This is because aluminium is very light in weight compared to steel.

The body of a truck has the driver's compartment covered and the rest is kept open. Such bodies are usually called load bodies. In most of the cases, it is an open body, whereas for liquid material like water, milk and fuel products, a tank is mounted on the chassis. The body is fixed to the chassis with the help of I- or U-bolts with rubber packing placed between the chassis and body cross members.

Requirements of automobile body

The body of a motor vehicle should fulfill certain requirements. It should

(i) be light weight.

(ii) have minimum number of components.

(iii) have long fatigue life.

(iv) have uniformly distributed load.

(v) have sufficient space for passengers and luggage.

(vi) have good access to the engine and suspension system.

(vii) have minimum vibrations when the vehicle is running.

(viii) have minimum resistance to air.

(ix) be cheap and easy in manufacturing.

(x) have clear all-round vision through glass areas.

(xi) have an attractive shape and colour.

Check Your Progress

A. Fill in the blanks

1. A chassis is almost a complete _____ mounting body.
2. The shape of the chassis depends _____ upon the ultimate use of the _____.

3. Major part of a chassis is the _____frame.
4. In commercial vehicles like trucks and buses the body is not a _____ of the chassis.
5. In most of the cases, it is an open body, whereas for liquid material like water, milk and fuel a _____ is mounted on the chassis.

B. Multiple choice questions

1. Chassis is a French term and was initially used to denote _____.
   (a) main structure of a vehicle
   (b) fixing the automobile body
   (c) transmission system, front and rear axle
   (d) carrying the bolt
2. What are the functions of the chassis frame?
   (a) To carry the weight of the vehicle and its passengers.
   (b) To withstand the engine and transmission torque.
   (c) To withstand the centrifugal force while cornering.
   (d) All of the above
3. Automobile body is made of _____.
   (a) sheet metal or fibre glass
   (b) iron
   (c) copper
   (d) gun metal
4. The body is fixed to the chassis with the help of _____ _____.
   (a) I or U bolts
   (b) rivet
   (c) welding
   (d) threaded bolt
5. Automobile body should fulfill which of the following requirements?
   (a) The body should be light.
   (b) It should have a long fatigue life.
   (c) Both (a) and (b)
   (d) None of the above

C. Short answer questions

1. Differentiate between chassis frame and automobile body.
2. Explain the use of the chassis frame.
3. How does auto body help in transport?

Session 2: Engine and Its Components

An engine (Fig. 3.3) is complex unit in which different components are assembled together, and fuel is burned to produce power or energy. The engine converts chemical energy (heat energy) into mechanical energy, which is then utilised for vehicular movement. There are different processes of fuel combustion. When the fuel is burned within the engine, it is called an Internal Combustion (IC) engine, and when it is burned externally and the produced steam is used for the mechanical movement, it is called an External Combustion (EC) engine. Nowadays, automobile engines are quite economical due to the developments taking place in the field of internal combustion engine.

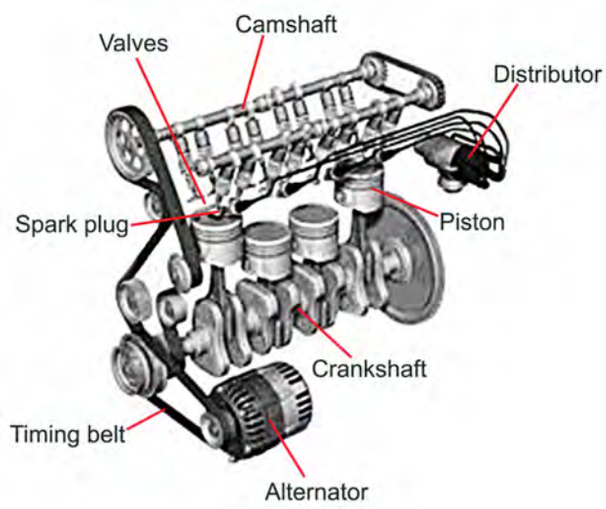


Fig. 3.3: Engine

On the basis of the process of ignition, the automobile engines are classified into spark ignition engine (petrol or gas) and compression ignition engine (diesel). In an IC engine, the reciprocating motion of the piston is converted into rotary motion of the crankshaft and the produced power is then transmitted to move the vehicle. In case of a rotary engine or Wankel engine, the rotor rotates and completes the process of combustion and produces the power, which helps the vehicular movement.

The spark ignition engine can be differentiated from the compression ignition engine as per the following factors.

(i) The type of fuel used.

(ii) The way the fuel enters in the combustion chamber.

(iii) The way in which fuel is ignited.

Spark Ignition Engine (Petrol or Gas Engine)

The spark ignition engine uses a highly volatile fuel, such as gasoline, which turns into vapour easily. The fuel is mixed with air before it enters in the combustion chamber, and forms a combustible air-fuel mixture. This mixture then enters the cylinder and gets

compressed with the help of a piston. An electric spark is produced by the ignition system which ignites the combustible air-fuel mixture. The combustible gases burn and expand, which forces the piston downwards for generating power.

Compression Ignition Engine (Diesel Engine)

In the compression ignition engine or diesel engine, only fresh air enters the cylinder, which is compressed to a very high pressure and temperature, which could go up to 1000°F (538°C). The diesel is then injected or sprayed into the engine combustion chamber. This spray contains very fine and tiny particles of diesel in an atomised form. The hot air or heat of compression ignites the fuel and generates the power stroke.

Components of an IC Engine

1. **Cylinder:** The cylinder or cylinder liner of an IC engine is fitted in the cylinder block, which is a single casted unit and is considered to be the main body of an engine. The block has cylinder liners. The piston reciprocates up and down from Top Dead Centre (TDC) to Bottom Dead Centre (BDC) to generate power.

   The cylinder liner and the cylinder block have to withstand very high pressure (about 70 bar) and temperature (about 700°C) during power stroke. The material used for the cylinder block must withstand such heat and also disperse it effectively. The cylinder block is well-designed with water passages to remove the excess heat and separate oil passages are provided for the circulation of lubricating oil. The top portion of the cylinder block is covered by the cylinder head. The crankcase is an integral part of the cylinder block which houses the crankshaft and the lower portion is dipped in an oil pan.

   Nowadays, cylinder liners are made of special alloy and internal portion is coated with material like titanium which provides mirror finish and can withstand the wear resistance. The upper end of

the cylinder liner has a flange which fits well in the cylinder block. The exterior portion of the cylinder liner is exposed to water jacket for easy dispersion of heat.

2. **Cylinder Head:** The cylinder head is also single-casted unit and bolted to the top portion of the cylinder block. The combustion chamber is a part of the cylinder head, where the combustion of gases takes place. The water passages are provided to remove the heat from the cylinder head. In latest engines, the cylinder head also houses the camshaft which has the inlet and exhaust valves with supportive valve mechanism.This provision is made to fix spark plug in SI engines and nozzle in CI engines. The lower portion of the cylinder head is well-machined to ensure there is no leakage of gases. Cylinder head gasket is usually cast as one piece and bolted to the top of the cylinder (engine block). Copper and asbestos gaskets are provided between the cylinder and cylinder-head to obtain a gas-tight joint. The charge enters the combustion chamber through the inlet valve connected to the inlet manifold, and the exhaust gases are removed through the exhaust valves connected to the exhaust manifold.
3. **Piston and Piston Rings:** Piston is a cylindrical unit, used to compress the charge during compression stroke and to transmit the gas force to the connecting rod and then to the crankshaft during power stroke. The pistons of IC engines are usually made of aluminium alloy, which has high thermal conductivity and is light in weight. The material of piston must have the ability for higher heat transfer. The piston moves up and down (from TDC to BDC) and assists in completing the engine cycle.

   The piston rings are placed in the ring groove and provide sealing between the piston and the cylinder liner, thereby preventing the leakage of high pressure gases. These are made of special grade cast iron, which retains its elastic property even at very high temperature. The upper piston rings are called the compression rings and the lower piston rings are called the oiling or oil control rings.

4. **Connecting Rod:** It is usually manufactured by using drop-forged steel. It is made in the shape of 'I' so as to reduce its weight and to withstand strength. Its small end is connected to the piston with the help of gudgeon pin and the big end is connected to the crankpin with shell bearings. It has a passage for the transfer of lubricating oil from the big end bearing to the small end bearing (gudgeon pin). The major function of the connecting rod is to convert the reciprocating motion of piston to the rotary motion of the crankshaft.
5. **Crank and Crankshaft:** The crankshaft (Fig. 3.4) is called the backbone of an engine because it converts the reciprocating motion of piston into the rotary motion of the crankshaft. The crankshaft is a single casted unit and is made of drop-forged steel main journals which are placed and supported in the crank case. The main journal and connecting journals are machined to a smooth finish to reduce

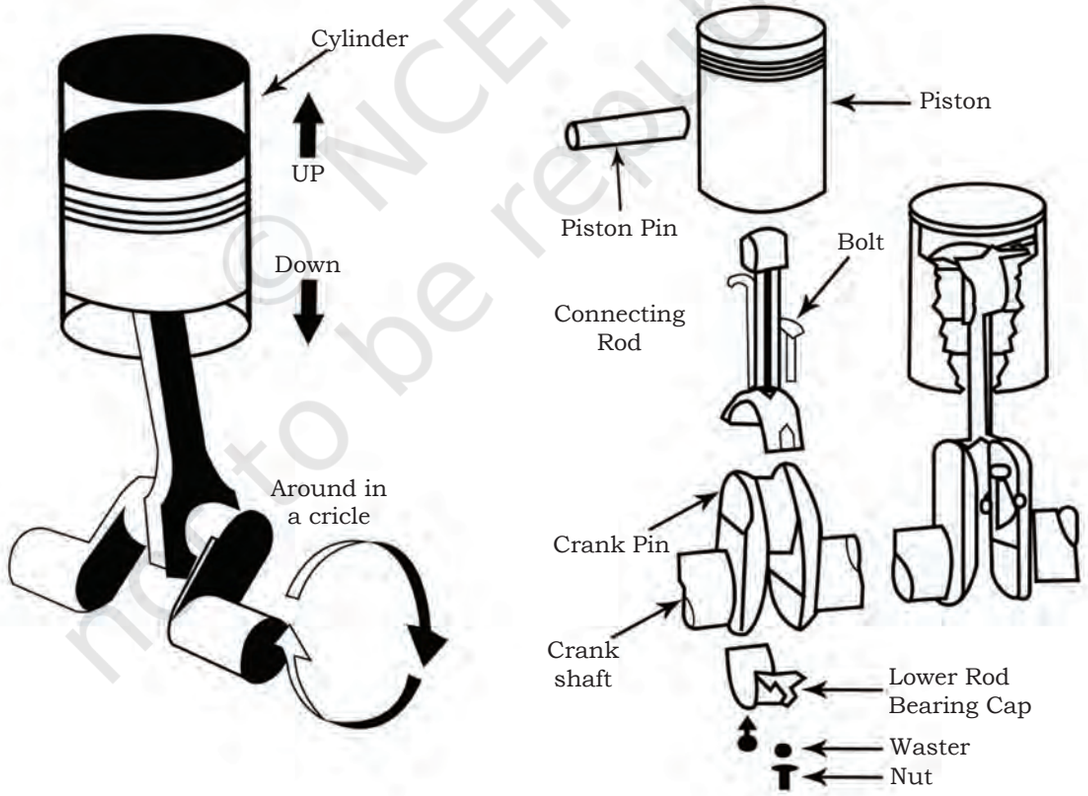


Fig. 3.4: Crankshaft of multicylinder engine

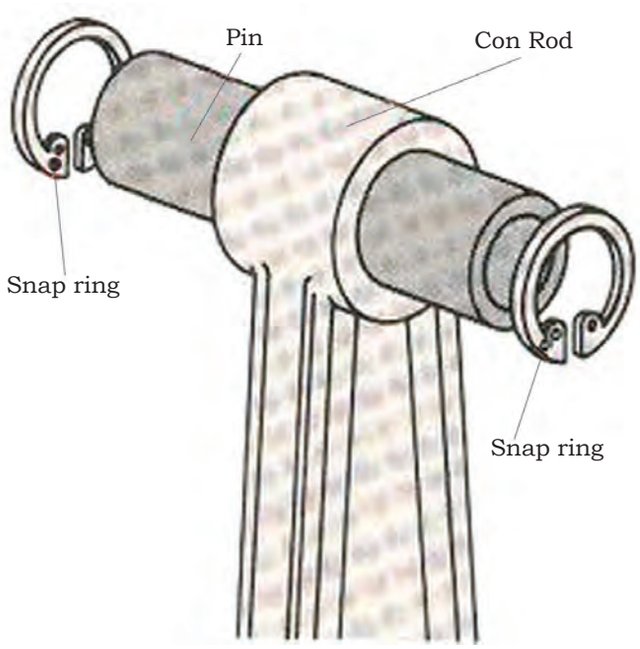


Fig. 3.5: Crank assembly of single cylinder engine

friction and shell bearings are used for smooth rotation of crankshaft. Front end of the crankshaft will transmit drive to the camshaft and also to the timing gear, whereas the flywheel is bolted to the flange at rear end of the crankshaft. Main journal of the crankshaft carries the oil passages to lubricate shell bearings.

In case of a single cylinder engine crank assembly (Fig. 3.5) is used, two crank webs are connected with the crank pin, and crank webs shafts are press fitted in both. At one side of the shaft magneto is fastened whereas clutch assembly is mounted to the other. The crank assembly is balanced dynamically as well as statically for the smooth transmission of power.

6. **Piston Pin or Gudgeon Pin.** This unit connects the piston and small end of the connecting rod and passes through the piston (Fig. 3.6). Circlips

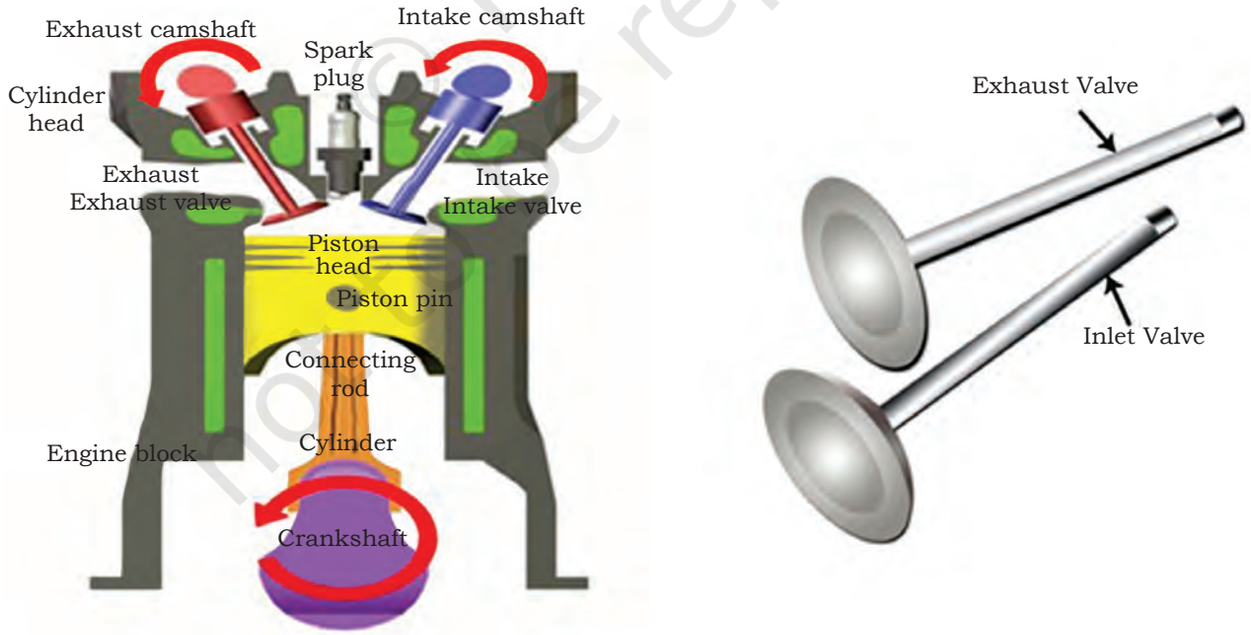


Fig. 3.6: Important components of piston

are fitted into recesses in the piston to prevent the gudgeon from touching the cylinder wall. The needle bearing or bronze bushing is press fitted into the connecting rod, due to this the gudgeon pin provides bearing for the oscillating small end of the connecting rod.

7. **Inlet Valve:** The major role of the inlet valve is to submit fresh charge in to the cylinder during the suction stroke. Opening and closing of the valve will control the admission of the charge into the petrol engine or air into diesel engine during suction stroke of an engine. The valve operations will be as per the valve timings. The inlet valve has a wider face or in latest engines two inlet valves are used to maintain volumetric efficiency of an engine.
8. **Exhaust Valve:** The exhaust valve removes out the burnt gases from the combustion chamber after power stroke. The exhaust valve has to bare more heat resistance.
9. **Valve Spring:** The valve spring (Fig. 3.7)plays an important role to close the valve and also provides air tight compartment to seal the combustible gases during power stroke and also maintain the self-centering movement of the valve. Both ends of the vale spring are machined for smooth function and up and down movements of the valves.

Fig 3.7: Valve Spring

10. **Inlet Manifold:** The fuel air mixture is carried from the carburettor to the cylinder through a separate pipe through inlet manifold in a carbureted engine. Whereas in compression ignition engines (diesel), the air is sucked through the induction manifold. In M.P.F.I the engine holds the throttle body on top of the manifold and the supply of air is monitored by the throttle body sensor.
11. **Exhaust Manifold:** It is a set of pipes and muffler, which is used to remove the exhaust gases from the exhaust ports. Engines oxygen sensors and catalic convertors are used to reduce sound and air pollution, respectively (see Fig. 3.8).

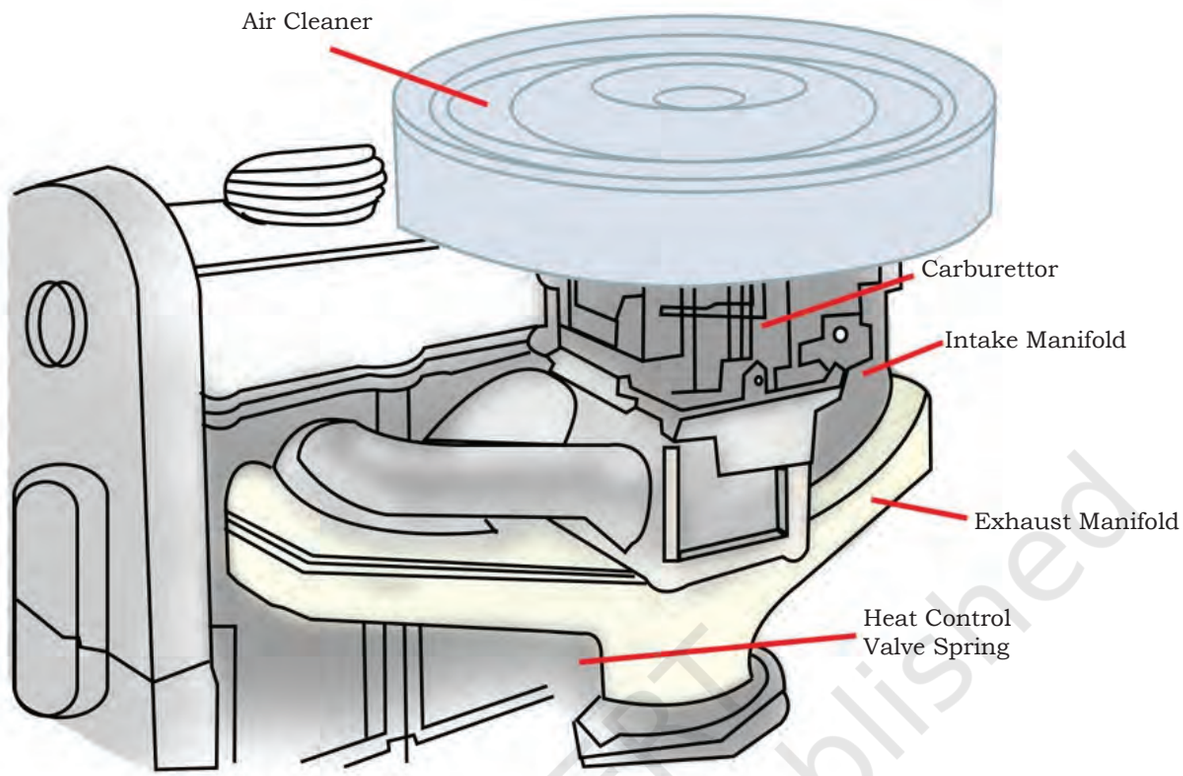


Fig. 3.8: Exhaust Manifold

12. **Camshaft:** The major function of the camshaft is to operate the intake and exhaust valves through the cam lobe, the gear drive transmits the power for the rotation of oil pump, therefore the oil pump sucks the oil from the oil sump and transits the same to the oil gallery. The camshaft (Fig. 3.9) is driven by crankshaft at half the speed of the crankshaft.
13. **Cam Lobe and Tappet:** The cam lobe (see Fig. 3.10) of the camshaft is placed directly above the bucket tappet, such that the lobe comes around it and pushes down the bucket tappet and the valve, thus opening the valve. In an overhead camshaft with rocker arm, the cam lobe comes under the valve lifter, and causes the rocker arm to rock or turn the lobe and pushes down the valve steam and it moves down to open. When the cam lobe passes the valve lifter the valve spring retains back to the original

Fig. 3.9: Camshaft

length. To close the valve the rocker arm turns back and the valve lifter is pushed down on the cam. In case of double overhead camshaft engine, the double row valves are usually operated by the separate overhead camshaft.

14. **Push Rod and Rocker Arm:** The motion of the cam lobe pushes the valve lifter upwards. This movement pushes the push rod (Fig. 3.11) and the rocker turns the upward motion of the push rod to the downward movement of the valve stem resulting in opening of the valve.

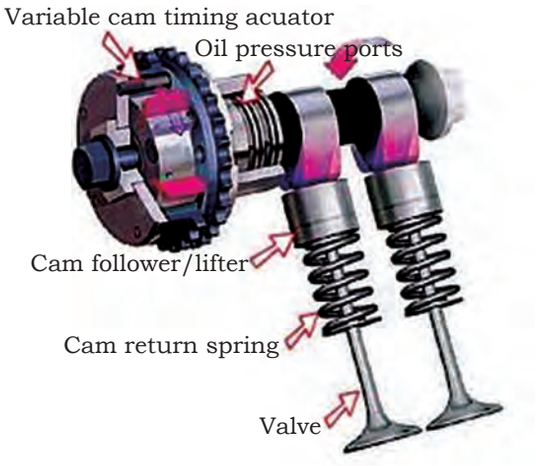


Fig. 3.10: Cam Lobe and Tappet

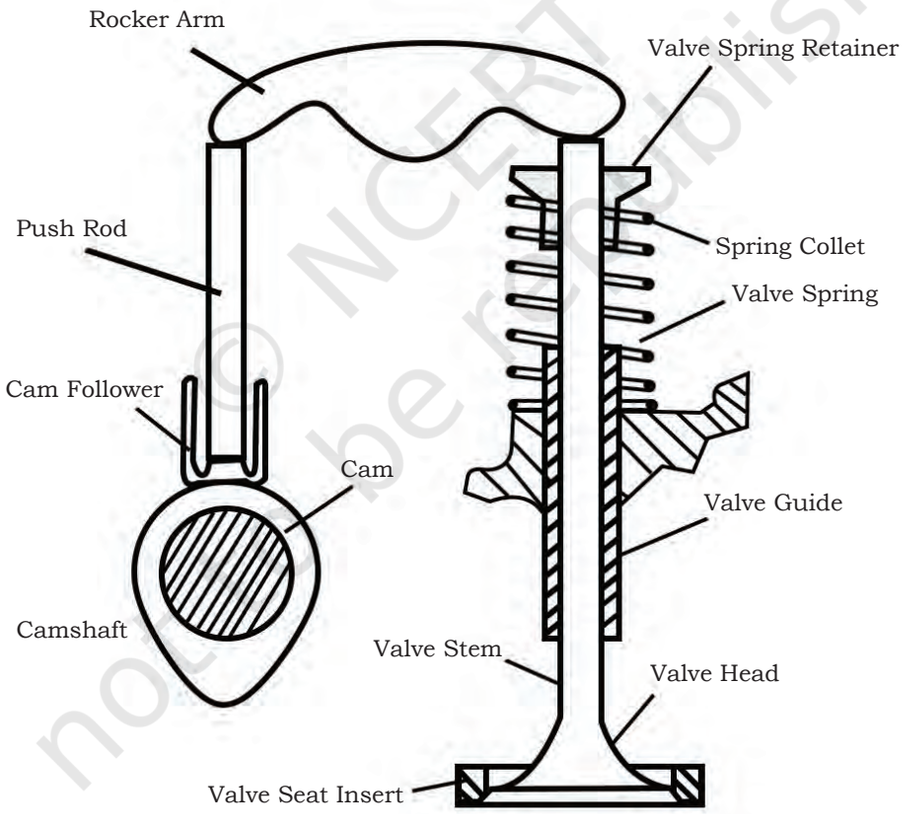


Fig. 3.11: Push Rod and Rocker Arm

Fig. 3.12: Crank Case

15. **Crank Case:** The crank case is an integrated part of the cylinder block. The casing is provided to hold the crankshaft. The crankshaft is allowed to rotate freely and transmit the power to the flywheel (Fig. 3.12).
16. **Water Pump and Water Jacket:** The function of water pump is to draw water from the radiator and supply it to the water passages provided in the cylinder block and cylinder head with certain pressure. The circulation of coolant removes the excessive heat from an engine. This helps in maintaining the engine temperature and also the life of an engine (Fig. 3.13).

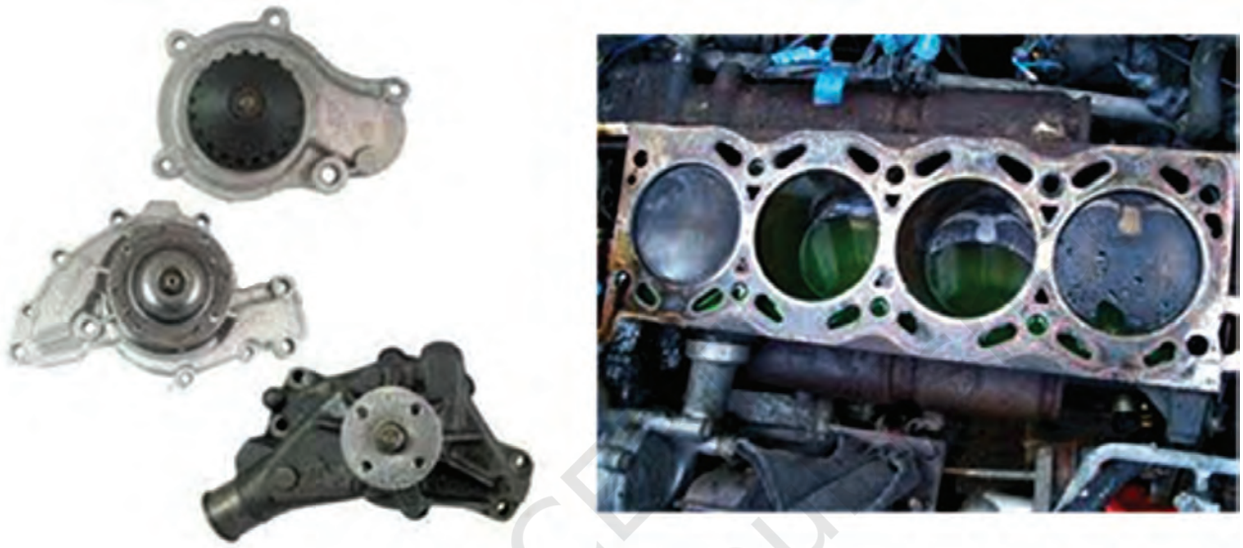


Fig. 3.13: Water Pump and Jacket

Fig 3.14: Radiator

17. **Radiator:** The major function of the radiator is to radiate the heat from the coolants. It has two tanks located at the top and bottom. The upper tank is connected to the lower tank with the core through the passages for easy radiation of the heat. The radiator also stores the coolant (Fig. 3.14).

18. Flywheel: It is a wheel mounted on the crankshaft which stores the energy during the power stroke and transmits the energy to the transmission system, the clutch and then to the gear box (Fig. 3.15).

Fig. 3.15: Fly wheel

19. Governor: It is run by drive from the crankshaft. The function of the governor (Fig. 3.16) is to regulate the charge in case of petrol engine and

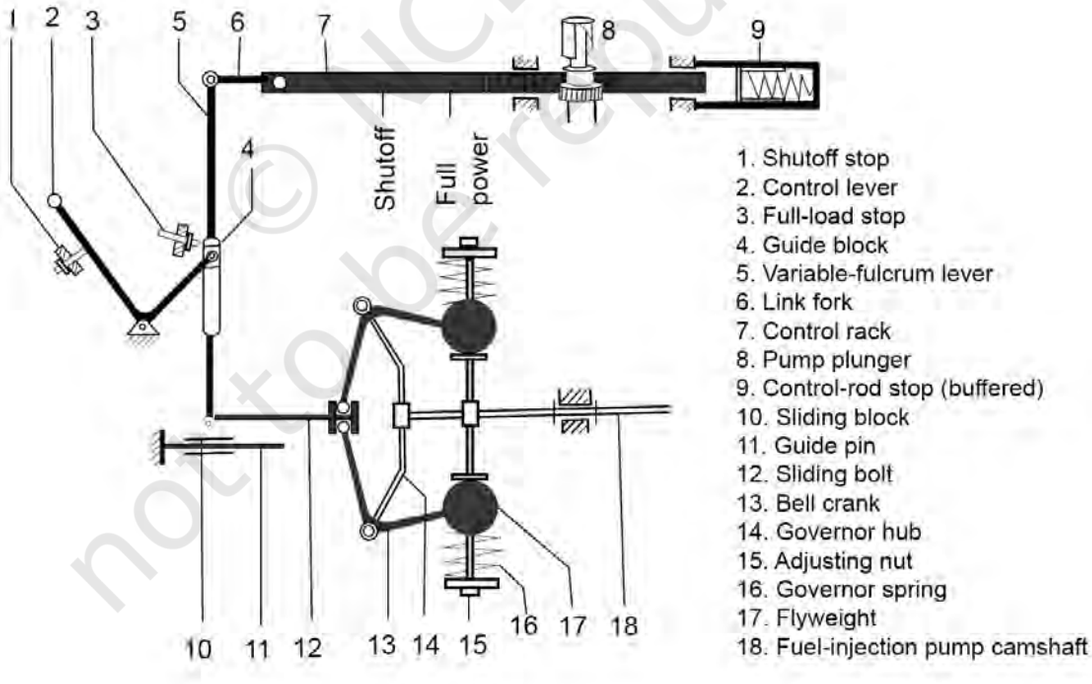


Fig. 3.16: Governor

amount of fuel in case of diesel engine to maintain the speed of the engine constant, when the load requirement varies.

The components described above are commonly used for all types of IC engine. Here we are describing only a few components which are used in particular types of engines.

20. Carburettor: The major function of the carburetor (Fig. 3.17) is to supply carburised fuel as per speed and the engine load. In petrol engines the carburettor is mounted on the induction pipe or on the induction manifold. The quantity of fuel air mixture in appropriate ratio is controlled by the throttle valve and the movements of the throttle valve are connected to the accelerator.

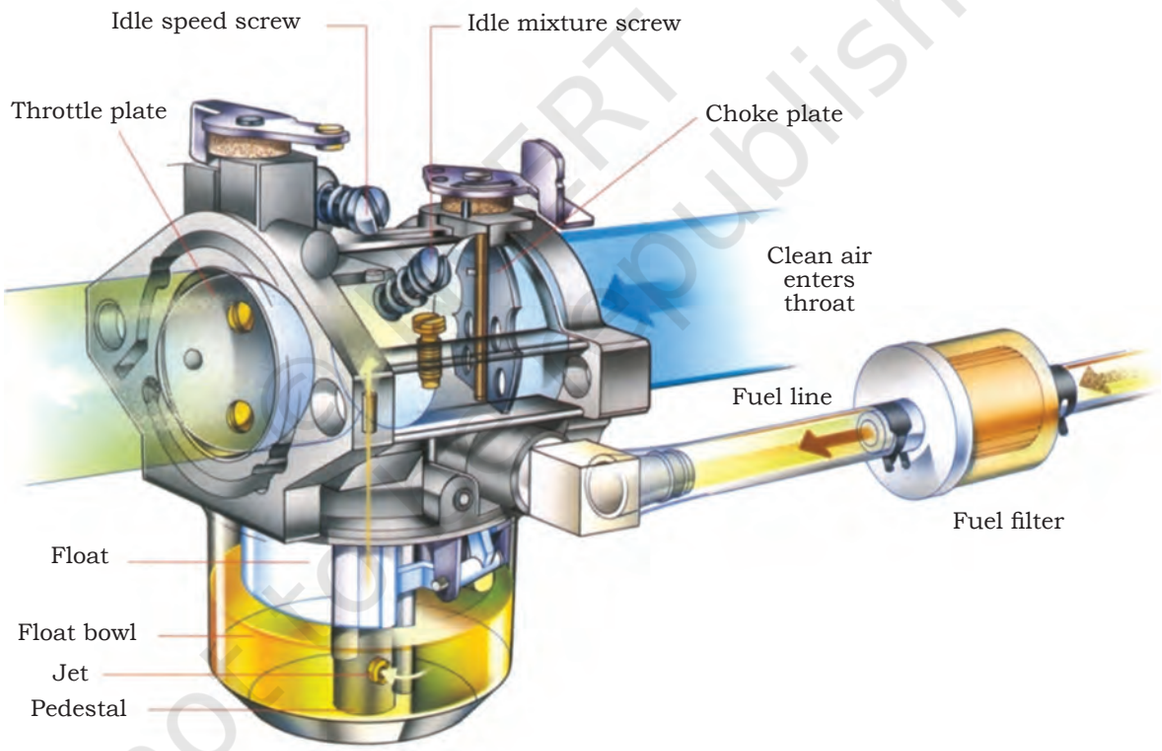


Fig 3.17: Carburettor

21. Spark Plug: The function of the spark plug is to ignite the fuel air mixture after completion of the compression stroke in an engine. It is generally

placed in the combustion chamber of the cylinder head. This is only used in petrol engine (Fig. 3.18).

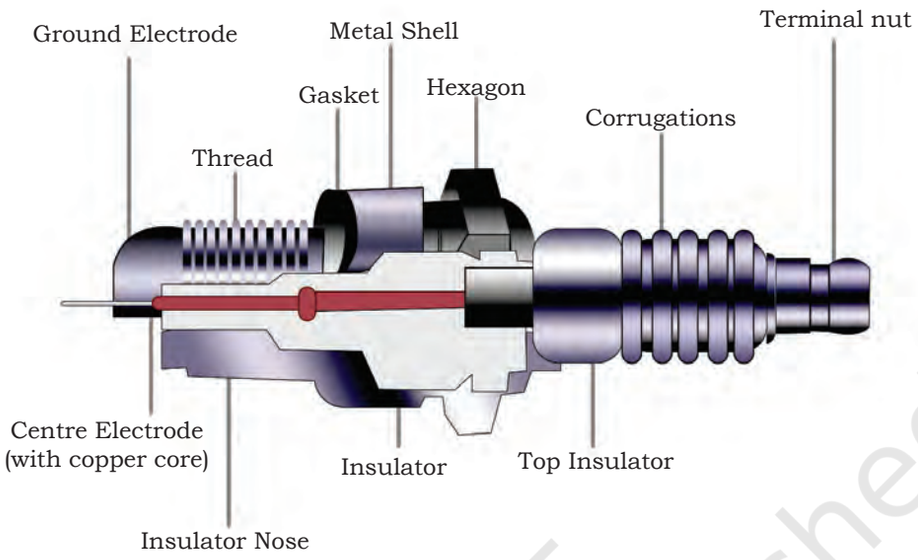


Fig. 3.18: Spark Plug

22. Fuel Injection Pump: In case of diesel engine the diesel oil from the fuel tank is sucked by the fuel feed pump. The pump first sends the diesel oil to the fuel filter and then to the transfer pump. The transfer pump increase the pressure of the fuel.

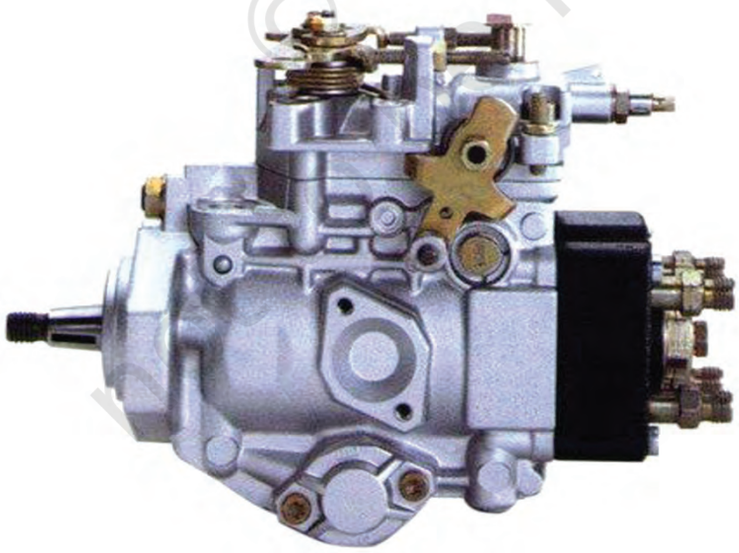


Fig. 3.19: Fuel Injection Pump

The high pressure of fuel is then sent to the distributor rotor through the metering valve and from rotor the fuel is sent to the injector (Fig. 3.19). In case of a multi point fuel injection system, the electric fuel pump is used and placed in the fuel tank. The pump generates the injection pressure and sends it to the fuel filter, and then to the common rail at a pressure of 3 to 4 bar. The common rail or fuel rail is connected to the fuel injector.

23. **Fuel Injector:** The function of fuel injector (Fig. 3.20) is to break the fuel into fine spray (atomised condition) as it enters the combustion chamber of diesel engine.In case of an MPFI engine petrol is injected at the end of compression stroke as the fine spray of the fuel burns more efficiently in the combustion chamber giving better fuel efficiency with less air pollution.

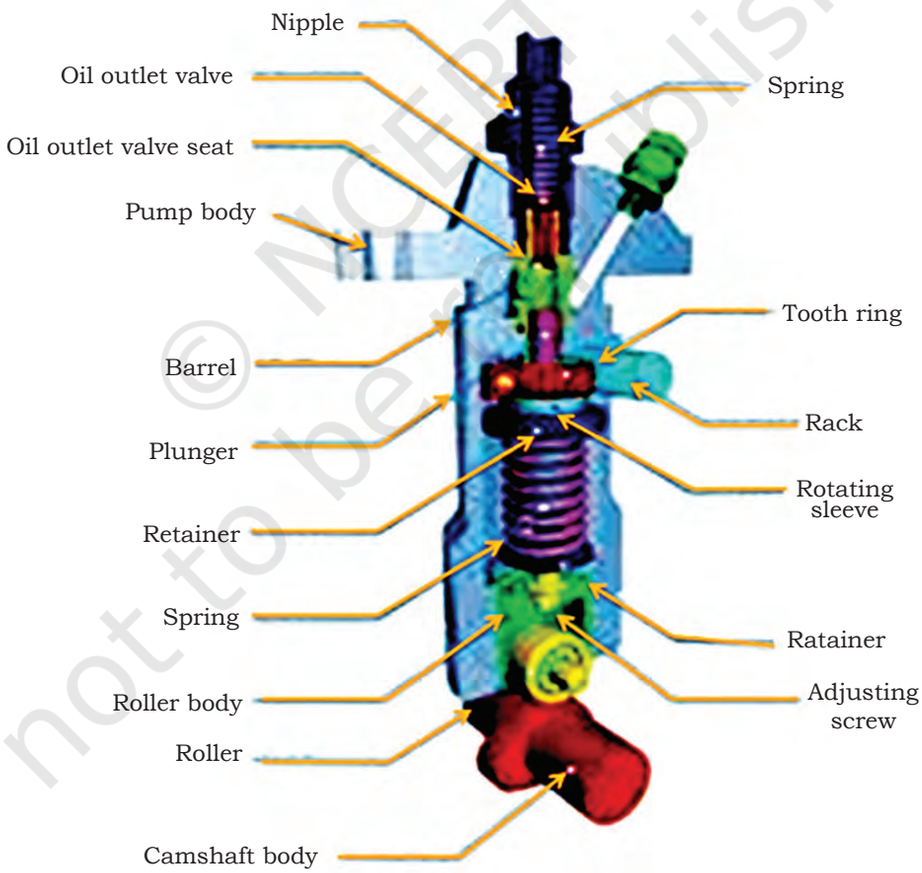


Fig. 3.20: Fuel Injector

Practical Exercises

Activity 1

Name any five components of an automobile system used in a vehicle.

S. No.	Name of the system
1.	
2.	
3.	
4.	
5.	
6.	
7.	

Check Your Progress

A. Fill in the blanks

1. Engine is the _____ of an automobile. Its role is very important.
2. Engine converts the Chemical Energy (heat energy) to _____ Energy.
3. Major parts of engine are _____, _____, _____ and _____.
4. The function of the carburettor is to supply uniform _____ to the cylinder of a _____ through the intake manifold.
5. Sparkplug is used to _____

B. Multiple choice questions

1. The compression-ignition engine air is compressed so that its temperature goes up to _____.
   (a) 538 °C (1000 °F) or higher
   (b) 348 °C
   (c) 2480 °C
   (d) None of the above

2. The cylinder of an IC engine is generally made of _____.
   (a) cast iron
   (b) copper
   (c) iron
   (d) fibre
3. The charge (fuel and air mixture for SI engine and only air for CI engine) enters through the _____.
   (a) inlet valve
   (b) spark plug
   (c) outlet valve
   (d) piston
4. The heart of the engine is the _____.
   (a) piston
   (b) cylinder head
   (c) connecting rod
   (d) All of the above

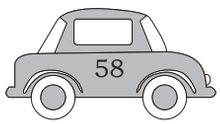
C. Short answer questions

1. Explain the role of engine and its components.
2. Explain the difference between compression ignition engine and spark ignition engine?

Session 3: Lubrication System

As you know, our body requires fluids like water and also oil in the form of fats like ghee, butter, cooking oil for maintenance of our system. Similarly, lubrication is required for maintenance of engine. Lubrication system is one of the most important parts of an engine. The engine cannot run smoothly for more than a few minutes without the lubricating oil.

Whenever two metallic surfaces move over each other under direct contact, dry or solid friction is produced. This is due to the irregularities on the two surfaces interlocking each other. The dry friction thus created produces a lot of heat and results in wear and tear of the metal surface.



Objectives of Lubrication

The main objectives of lubrication are

(i) to reduce friction between moving parts to its minimum value so that power loss is minimised, and

(ii) to reduce wear and tear of the moving parts as much as possible.

Apart from these objectives, lubrication also serves other important purposes, which may be called secondary. These are as follows.

(a) *To provide cooling effect:* The lubricating oil takes heat from the hot moving parts during its circulation and delivers it to the surrounding air through the crank case.

(b) *To provide cushioning effect:* The lubricating oil also serves as a good cushion against the shocks experienced by the engine. For example, instant combustion of the fuel in the combustion chamber produces a sudden rise of pressure in the cylinder and the shock goes to the bearings through the piston, gudgeon pin and the connecting rod. This shock is then absorbed by the layer of oil present in the main bearings.

(c) *To provide cleaning action:* The lubricating oil serves another useful purpose of providing a cleaning action. During its circulation, it carries away many impurities, such as carbon particles, etc.

(d) *To provide a sealing action:* The lubricating oil also helps the piston rings in maintaining an effective seal against the high pressure gases in the cylinder thus preventing leakage towards the crank case.

Practical Exercises

Activity 1

List a few important functions of lubrication.

S. No.	Functions of lubrication
1.	
2.	
3.	
4.	

Check Your Progress

A. Fill in the blanks

1. Dry or solid friction is produced in _____.
2. Dry friction creates lot of _____.
3. The objective of lubrication is to reduce _____.
4. Lubrication provides _____ and _____ effect.

B. Multiple choice questions

1. Viscosity is measured using a _____.
   (a) barometer
   (b) thermometer
   (c) viscometer
   (d) fathometer
2. Lubricating oil is used for _____.
   (a) minimising wear in moving parts
   (b) help in keeping parts cool
   (c) Both (a) and (b)
   (d) None of the above
3. Which type of lubrication system is used in a two-stroke engine?
   (a) petrol system
   (b) wet sump system
   (c) dry sump system
   (d) All of the above
4. Viscosity index is a measure for the change of viscosity with change in _____.
   (a) pressure
   (b) temperature
   (c) volume
   (d) mass

C. Short answer questions

1. Explain the importance of lubrication in engine.
2. List the properties of lubricant.

Session 4: Cooling System

Like our body requires air and water for cooling our system, similarly the engine of a vehicle also requires cooling.

The cooling system (Fig. 3.21(a-d)) has three primary functions, which are as follows.

(i) Remove excess heat from the engine

(ii) Maintain a constant engine operating temperature

(iii) Increase the temperature of a cold engine as quickly as possible by maintaining the thermostat valve

in a closed position which is fitted in the path of coolant circulation

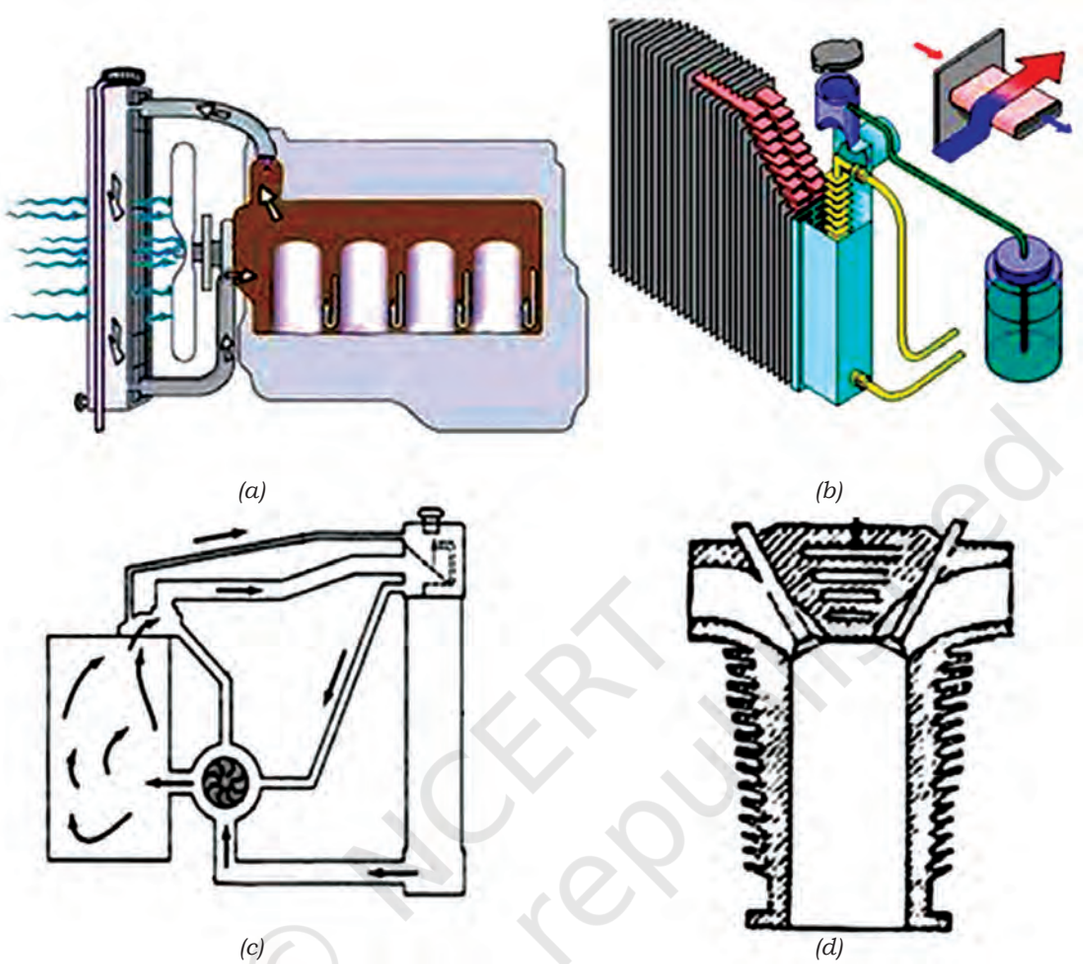


Fig. 3.21 (a–d): Cooling system of an engine

Necessity of Cooling

The cylinders of internal combustion engines require cooling because the engine cannot convert all the heat energy released by combustion into useful work. Liquid cooling is employed in most of the IC engines, whether they are used in automobiles or elsewhere. The water (coolant) is circulated around the cylinders to pick up heat and then dissipate it through a radiator. As the temperature increases from 71 to 82 degrees centigrade, the thermostat valve opens and sends water to the radiator to radiate the heat. When the temperature rises above 82 degrees, the thermostat switch operates the cooling fan to support the cooling process in radiator.

Practical Exercises

Activity 1

List a few important functions of the cooling system.

S. No.	Functions of cooling system
1.	
2.	
3.	
4.	
5.	

Check Your Progress

A. Fill in the blanks

1. The cooling system removes excess_____ from the engine.
2. Cooling_____a constant engine operating temperature.
3. The objective of cooling is to reduce_____.
4. Liquid cooling is employed in most_____engines.

B. Multiple choice question

1. Which of the following type of cooling system is used in a motorcycle?

   (a) Air cooling system
   (b) Water cooling system
   (c) Both (a) and (b)
   (d) None of the above

2. The cooling fan is _____.

   (a) driven by belt and pulleys
   (b) fitted between the engine and the radiator
   (c) driven from the camshaft
   (d) All of the above

3. In water cooling, the water in the jacket obtains heat from the cylinder due to _____.

   (a) conduction
   (b) convection
   (c) radiation
   (d) All of the above

C. Short answer questions

1. How does a cooling system work?
2. What is the role of coolants?

Session 5: Fuel Supply System

Fuel Supply System

In petrol engines, the fuel and air mixture is supplied to the combustion chamber of an engine. This mixture is atomised and then vapourised by the carburettor. Then the mixture is ignited by the spark plug. The fuels, such as petrol, benzoyl and alcohol are used in an SI engine (Fig. 3.22). Nowadays, fuel is injected in the flow of air at a certain temperature and pressure and the fuel vapourises faster and the combustion process is better, with low emission. It also shows better fuel efficiency.

In case of compression ignition engine (diesel) the fuel is sent through the fuel pump to the injector and the injector sprays the fuel at end of compression stroke (Fig. 3.23). The oil fuels which are used in CI engines do not vapourise easily. Therefore, a separate injection system is used consisting of fuel injection pump (FIP) and injectors. These injectors atomise the fuel and it is then sent for combustion. Nowadays, in case of compression

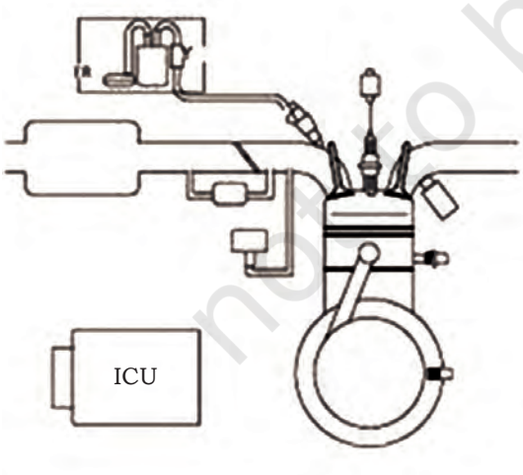


Fig. 3.22: Fuel Supply System

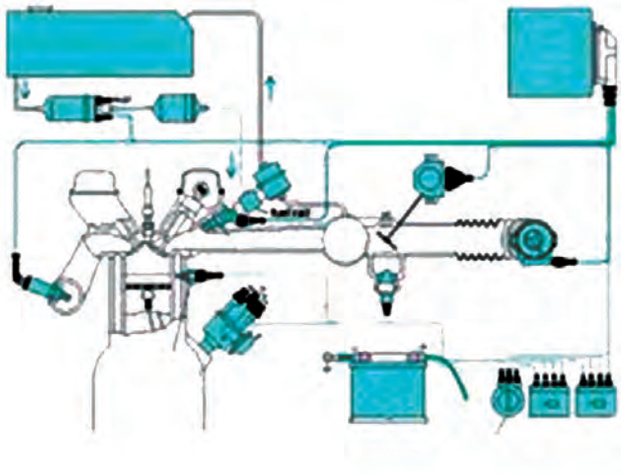


Fig 3.23: Fuel line

ignition engine the common rail direct injection system (CRDI) is used for better engine performance.

Fuel Supply Components

The fuel supply components include the following:

1. **Fuel Tank:** In most of the vehicles the fuel tank is located at the rear end of the vehicle. The fuel tank is made of a metal sheet or plastic. It is attached to the chassis. The filler opening is closed with a cap. The fuel line is attached to the fuel pump and also to the fuel gauge.
2. **Fuel Line:** The fuel line carries the fuel from the fuel tank to the carburettor or to the common rail system used in MPFI engines. The line has to withstand the pressure and provide resistance for the corrosion. The rigid line is placed safely in the chassis. It is connected to the units like carburettor, through a flexible pipe.
3. **Fuel Filter:** The major role of the fuel filter is to send clean fuel to the engine. This prevents blockages in the fuel system. The filter contains a cartridge of filtering the element through which the fuel passes the filter traps any particles and prevents them from entering the fuel system. The fuel filter is required to be replaced at regular intervals.
4. **Air Cleaner:** It is the main unit of the fuel system. It supplies clean air to the engine. The element of the air cleaner must be cleaned and replaced at regular intervals for maintaining a healthy life of the engine.
5. **Fuel Injection Pump:** In case of a diesel engine, the diesel oil from the fuel tank is sucked by the fuel feed pump. The pump first sends the diesel oil to the fuel filter. From there it is sent to the transfer pump. The transfer pump increases the pressure of the fuel. This high pressure of the fuel is then transferred to the distributor rotor through the metering valve. From the rotor the fuel is sent to the injector. In case of multi-point fuel injection system the electric fuel pump is used. The pump generates

the injection pressure and sends it to the fuel filter and then to the common rail at a pressure of 3 to 4 bar. The common rail or fuel rail is connected to the fuel injector

6. **Fuel Injector:** The solonide injector used in the M.P.F.I fuel system is operated electrically as per the variation in the supply of current with resistance. The solonide winding induces current within it and controls the movements of the needle valve to inject fuel as per the variations in speed and the load. The fuel system is controlled by the ECM.

7. **Pressure Regulator***:* It controls the amount of pressure that enters the injector. The extra fuel is sent back to the fuel tank.

Fuel Supply Components for SI Engine	**Fuel Supply Components for CI Engine**
• Fuel tank • Fuel lines • Fuel pump (A.C. mechanical type or electrical type) • Fuel filter • Carburettor • Inlet manifold • Air cleaner *Note*: In case of modern MPFI engines carburettor is replaced by injectors and sensors.	• Fuel tank • Fuel lines • Fuel feed pump (Mechanical type or electrical type) • Fuel filters • Fuel injection pump (FIP) • Fuel injectors

Practical Exercises

Activity 1

List the important functions of the fuel supply system.

S.No.	**Functions of the fuel supply system**
1.	
2.	
3.	
4.	
5.	

Check Your Progress

A. Fill in the blanks

1. Air and fuel are _____ outside the engine.
2. The fuels, such as petrol, benzol and alcohol are used in _____ engine.
3. Oil fuels which are used in CI engines do not _____ easily.
4. The fuel system is controlled by the _____.

B. Multiple choice questions

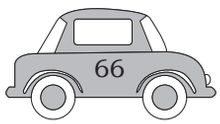
1. Which of these is used as a fuel in IC engine?
   (a) methanol
   (b) LPG
   (c) Benzoyl
   (d) All of the above
2. The carburettor is used to _____.
   (a) mix petrol and air in correct proportion
   (b) supply fuel air mixture to the engine
   (c) Both (a) and (b)
   (d) None of the above
3. In a multi-point fuel injection the injector is used for how many cylinder engines?
   (a) Five
   (b) Two
   (c) Four
   (d) Six
4. Which of the following is not an injector fault?
   (a) Blue nozzle body
   (b) Nozzle wetness blue nozzle body
   (c) Excessive leak off
   (d) Blow holes

C. Short answer questions

1. Write the importance of a fuel supply system.
2. Explain the correct method of injecting fuel in an automobile.

Session 6: Transmission System

Transmission system is used in motor vehicles to supply the output of the internal combustion engine to the drive wheels. The transmission reduces the higher engine speed to the slower wheel speed, increasing



torque in the process. Transmissions are also used in pedal bicycles, fixed machines and where rotational speed and torque need to be adapted.

Transmission System

The transmission system consists of the following components.

(i) Clutch assembly

(ii) Gear box assembly (Transmission case assembly)

(iii) Propeller shaft

Clutch assembly

Clutch (Fig. 3.24) is a mechanism which enables the rotary motion of one shaft to be transmitted, when desired. The axes of driving shaft and driven shaft are coincident.

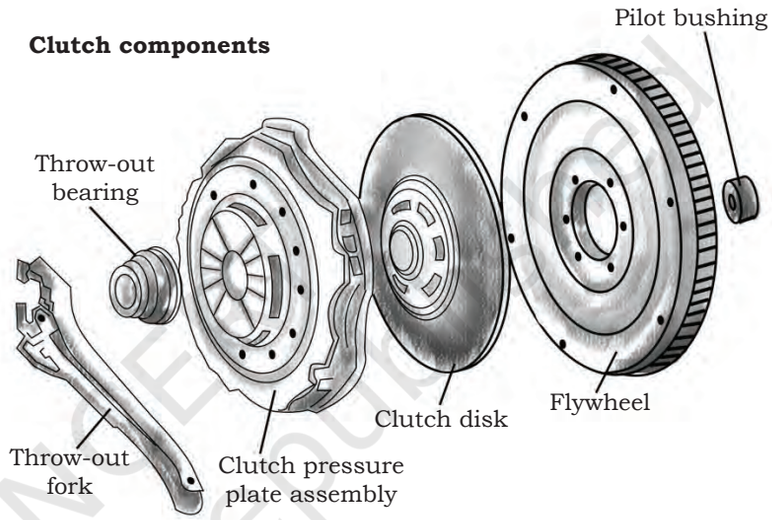


Fig. 3.24: Clutch assembly

Functions of clutch

(a) To disconnect the engine power from the gear box as required, under the following circumstances:

(i) to start the engine and warm it up;

(ii) to engage first and second gear to start the vehicle from rest;

(iii) to facilitate changing the gear as required; and

(iv) disconnect from the engine to stop the vehicle after application of brakes.

(b) To allow the engine to take up load gradually without shock or jerk.

Requirements of a Clutch

The clutch should meet the following requirements.

(a) Torque transmission or the ability to transmit maximum torque of the engine.

(b) Gradual engagement, i.e., to engage gradually and avoid sudden jerks.

(c) Heat dissipation, i.e., ability to dissipate large amount of heat generated during the clutch operation due to friction.

(d) Dynamic balancing, which means that the clutch should be dynamically balanced. This is particularly required in the case of high-speed engine clutches.

(e) Vibration damping, i.e., having a suitable mechanism to damp vibrations to eliminate noise produced during the power transmission.

(f) Size of the clutch should be as small as possible so that it occupies minimum space.

(g) Free pedal play, which helps the clutch to reduce effective load on the carbon thrust bearing and its wear.

(h) Easy in operation and requiring as little exertion as possible on the part of the driver.

(i) Light weight of the driven member of the clutch so that it does not continue to rotate for any length of time after the clutch has been disengaged.

Main Parts of a Clutch

The main parts of a clutch are divided into three groups.

(a) *Driving members:* The driving members consist of a flywheel mounted on the engine crankshaft. The flywheel is bolted to a cover which carries a pressure plate or driving disc, pressure springs and releasing levers. Thus, the entire assembly of the flywheel and the cover rotate all the time. The clutch housing and the cover provided with openings, dissipate the heat generated by friction during the clutch operation.

(b) *Driven members:* The driven members consist of a disc or plate, called the clutch plate. It is free to slide lengthwise on the splines of the clutch shaft (primary shaft). It carries friction material on both of its surfaces. When it is gripped between the flywheel and the pressure plate, it rotates the clutch shaft through the splines.

(c) *Operating members:* The operating members consist of a foot pedal, linkage, release bearing, release levers and the springs.

Gear Box (Transmission Case) Assembly

We need different gear ratios in the gear box or transmission system to enable the vehicle to move at different speeds. At the time of starting the vehicle, the maximum amount of torque is available on the flywheel, for which low gear ratio is selected for the movement of the vehicle. As the engine speed increases, the amount of torque is reduced on the flywheel and it is required to select higher gear ratio.

Functions of a gear box

(i) To provide a means to vary the leverage or torque ratio between the engine and the road wheels as required.

(ii) The transmission also provides a neutral position so that the engine and the road wheels are disconnected even with the clutch in the engaged position.

(iii) It provides a means to reverse the car by selecting the reverse gear.

Practical Exercises

Activity 1

Make a list of the parts of clutch assembly used in a vehicle.

S.No.	Parts of clutch assembly
1.	
2.	
3.	
4.	
5.	

Check Your Progress

A. Fill in the blanks

1. Transmission system consists of _____ components.
2. The main parts of a clutch are _____ and _____.
3. Different gear ratios in the _____ makes the vehicle move at different speeds.
4. The clutch assembly consist of flywheel, pressure plate and _____.

B. Multiple choice questions

1. Which of these systems is used in motor vehicles to supply the output of the internal combustion engine to drive wheels?
   (a) Transmission system
   (b) Power system
   (c) Torque system
   (d) None of the above
2. Which type of transmission system is used for a disengagement and engagement between the engine and the remainder of transmission system?
   (a) Clutch
   (b) Differential
   (c) Propeller shaft
   (d) None of the above
3. In a four-wheel drive there is _____.
   (a) one live axle
   (b) no live axle
   (c) two live axle
   (d) None of the above
4. _____ produces different gear ratios in automobiles.
   (a) Transmission system
   (b) Differential
   (c) Steering
   (d) Gear box

C. Short answer questions

1. Discuss the role of a transmission system.
2. Explain the function of a gear box.

Session 7: Front and Rear Axle

In this session, we shall discuss the axle and steering system, which transmits power to the wheel. It plays a crucial role in the movement of a vehicle.

Propeller Shaft

This is a shaft which transmits power from an engine to the wheels of a motor vehicle. It is a hollow tubular shaft and consists of mainly three parts.

(i) *Shaft:* It mainly bears torsional stress produced due to twisting. It is usually made of tubular cross section.

(ii) *Universal joints:* One or two universal joints are used, depending on the type of rear axle drive used. The universal joints help in the up and down movements of the rear axle when the vehicle is in running condition.

(iii) *Slip joint:* Depending on the type of drive, one slip joint may be there in the shaft. This serves to adjust the length of the propeller shaft when demanded by the rear axle movements.

Front and Rear Axle

Front axle

Front axle carries the weight of the front portion of the automobile as well as facilitates steering and controls the rolling of wheels. It also absorbs road shocks arising due to road surface variations.

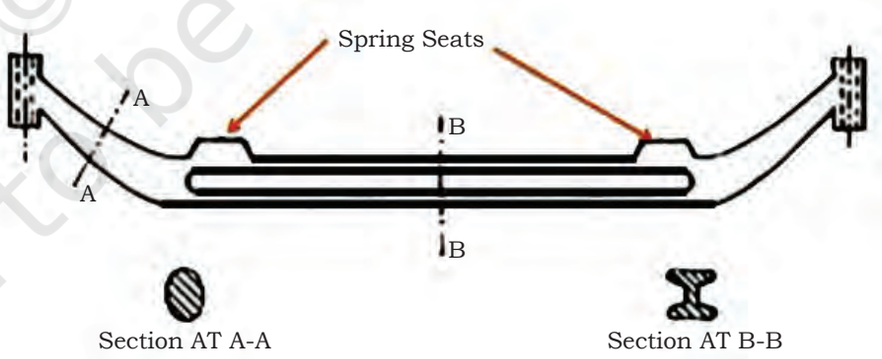


Fig. 3.25: Front axle

In case of a commercial vehicle the front axles (Fig. 3.25) are generally dead axles. The front axle is designed to transmit the weight of the automobile from the springs

to the front wheels, turning right or left as required. To prevent interference due to front engine location, and for providing greater stability and safety at high speeds by lowering the centre of gravity of the road vehicles, front axle includes the axle-beam, stub-axles with brake assemblies. It is made of drop forged alloy steel consisting of 0.4% carbon steel and 1.3% nickel steel.

The axle is made of I-section at centre and of circular or elliptical section in the ends since it has to bear the bending stress and torsional stress. In order to lower the chassis height a downward sweep is provided at the centre of the beam axle.

The main beam axle is connected to the stub axle with a king pin. The front road wheels are mounted on the stub axle.

For smooth steering effects and maintaining proper control, the front axle of a car is supported with an independent suspension system, such as Mac-pherson. The strut and coil spring allows the wheel to move up and down but does not allow to change the driving angle of axle shaft to transmit the drive smoothly. It also allows the wheel to rotate freely. This supports in steering the vehicle.

Fig. 3.26: Rear axle

Rear Axle

Like the front axle, the rear axle is also made of drop forged steel. The rear axle (Fig.3.26) bears the weight of the vehicle body and load with springs. It enables to transmit the driving and breaking torque to the chassis frame and body of the vehicle. It also bears the side thrust or pull due to any side load on the

wheel. It supports various parts like bevel pinion, bevel gear, cage of sun gear and star pinions, axle shafts, and different support bearings.

It is important to note that rear road wheels are mounted on the axle shaft and the differential mechanism enables the outer wheel to move faster than the inner wheel while taking a turn.

Practical Exercises

Activity 1

Make a list of parts of rear axle of a vehicle.

S. No.	List of parts of rear axle
1.	
2.	
3.	
4.	
5.	

Check Your Progress

A. Fill in the blanks

1. Axle and steering system transmit _____ to the wheel.
2. Front and rear axle system is used for _____.
3. Differential mechanism enables the _____ to move faster than the inner wheel while taking a turn
4. Rear axle _____ the weight of vehicle body.

B. Multiple choice questions

1. The central portion of the front axle is made of_____.

   (a) I section (b) T section
   (c) Q section (d) U section

2. The end of the front axle is mounted with _____.
   (a) stub axles (b) king pin
   (c) piston ring (d) axle shaft
3. What kind of load does the axle take due to the load of the vehicle?
   (a) Bending load (b) Frictional load
   (c) Torsional load (d) None of these

C. Short answer questions

1. What is the role of a front axle?
2. Why are rear axles required?

Session 8: Steering and Suspension System

Steering System

The steering mechanism permits the driver to control the car on a straight road and turn right or left as desired. The steering mechanism includes a steering wheel, which the driver controls, a steering gear, which converts rotary motion of steering wheel in to straight line motion and steering linkages. In modern cars, the manually operated steering system (Fig. 3.27) is assisted by power and is called power steering. The electric power drawn from the battery or hydraulic power is used.

Fig. 3.27: Steering System

Functions of a Steering System

1. It provides directional stability to the vehicle when moving in a straight (ahead) direction.

2. It provides perfect steering condition, i.e., perfect rolling motion of the wheels at all times.
3. It facilitates straight ahead recovery after completion of turn.
4. It controls the wear and tear of the tyre.
5. It is used to turn the vehicle as per the will of the driver.
6. It converts the rotary motion of the steering wheel into angular displacement of the front wheel.
7. It multiplies the effort of the driver to ease operation.
8. It absorbs road shocks and prevents them from reaching the driver.

Requirements of a Good Steering System

1. It should be very accurate.
2. It should be easy to handle.
3. The effort required should be minimal.
4. It should provide directional stability.
5. The front wheels should roll without lateral skid while negotiating curves.
6. There should be proper proportion between the angles turned by the front wheels.
7. The tyre must have good elasticity so that on turns, these may follow an arc of greater radius than the stiff tyre.
8. The wheels should automatically come to the straight ahead position after negotiating the bend. When going straight, the wheels must maintain the neutral position.
9. The angular oscillations of the wheels must be minimum.
10. The system must be irreversible to a certain degree so that minimum front wheel shocks are transmitted to the driver's hands.

Steering Mechanism

For perfect steering, it must always have an instantaneous centre about which all the wheels must rotate. To achieve this the inner wheel has to turn more than the outer wheel. Two types of

mechanism are available, viz., the Davis and the Ackermann steering mechanism. Out of these Ackermann type is more popularly used because of its simplicity. It also lessens wear of tyre and lowers friction.

Steering Linkages

A steering linkage is the part of an automotive steering system that connects to the front wheels. In a commercial vehicle a rigid axle type front suspension system is used.

Steering Wheel

It is made of polyurethane or hard plastic. It consists of a circular rim with a hub at the centre. The rim is slightly elliptical in cross section to maintain strength and provide hand grip. The steering shaft is mated in the undulations cut on the inside of the steering wheel hub.

Steering Column

It is tubular in nature. It provides switches for horn, light and wiper for easy and quick operation. The collapsible columns are used for safety, which collapse upon impact and reduce the chances of injury to the driver.

Steering Shaft

It is made from drop forged alloy steel. It connects the steering wheel to the steering gear box and transfers movements of the steering wheel to the steering gear, or to the pinion.

Drop Arm

It is also called as pitmen arm. It is made up of drop forged steel. It connects the cross shaft with the draglink.

Draglink

It connects the drop arm to the steering knuckle. It is also made up of drop forged steel.

The tie rod ends are different parts of the steering linkage will be connected to the ball joints which provide angular motion to the steering system.

Steering Gears

The steering gear converts the turning motion of the steering wheel into the to-and-fro motion of the link rod of the steering linkage. It also provides the necessary leverage so that the driver is able to steer the vehicle without fatigue.

Suspension System

Suspension is the term given to the system of springs, shock absorbers and linkages that connects a vehicle to its wheels. The suspension system serves a dual purpose, contributing to the vehicle's road holding or handling and braking for safety and driving comfort, and keeping the vehicle occupants comfortable and reasonably well isolated from road noise, bumps and vibrations, etc.

Functions of suspension system

The main functions of a suspension system are as follows:

(i) To safeguard the occupants against road shocks and provide riding comfort.

(ii) To minimise the effects of stresses due to road shocks on the mechanism of the motor vehicle and provide a cushioning effect.

(iii) To keep the body perfectly in level while travelling over rough uneven ground, i.e., the up and down movement of the wheels should be relative to the body.

(iv) To isolate the structure of the vehicle from shock loading and vibration due to irregularities of the road surface without impairing its stability.

(v) To provide the requisite height to the body structure as well as to bear the torque and braking reactions.

Various Components of Suspension System

The components of a suspension system can be categorised as follows.

Mechanical Suspension

(i) Leaf springs
(ii) Coil springs
(iii) Rubber springs
(iv) Torsion bars

Hydraulic Suspension

(i) Hydraulic shock absorber
(ii) Telescopic fork absorber

Air Suspension

Compressed air is used in an air suspension system.

Mechanical Suspension

1. **Leaf Spring:** A leaf spring (Fig. 3.28) is a component of a vehiclse' suspension system. Leaf springs are curved and the curvature helps the spring absorb impact.

Fig 3.28: Leaf spring

2. **Coil Spring:** Coil springs are commonly called compression springs, torsion springs or helical springs. They store energy and release it to absorb shock or maintain a force between two contacting surfaces. Mostly coil springs or helical springs are used in engine starter and hinges (Fig. 3.29).
3. **Rubber Spring:** A rubber string stores more energy per unit mass than any other type of spring

material. The rubber spring (Fig. 3.30) is installed between the frame and the top link of the suspension system. When the spring is connected to a point near the link pivot, deflection of the spring reduces to a minimum, without affecting the total wheel movement. The energy released from the rubber spring after deflection is considerably less than that imparted to it.

4. **Torsion Bars:** Torsion bars are of two types — helical or spiral. These bars are used in automobile vehicles for transmitting torque.

Fig. 3.29: Coil spring

Fig. 3.30: Rubber spring added

Hydraulic Suspension

Hydraulic suspension combines rubber springs with a damper system, linking the front and rear wheel on the same side of the car. As the front wheel rises over a bump, some of the fluid from its suspension unit (known as a displacer unit) flows to the rear-wheel unit and raises it, so tending to keep the car level. In each of the displacer units, the fluid passes through a two-way valve, which provides the damping effect. Once the rear wheel has passed over the bump, the fluid returns to the front displacer unit and the original level is restored.

1. **Hydraulic Shock Absorber:** It is a mechanical device designed to absorb shock impulses. This device is also used for checking or damping out the suspension spring to a comfort level.
2. **Telescopic Fork Absorber:** A telescopic fork is a form of motorcycle front suspension whose use is so common that it is virtually universal.

The telescopic fork uses fork tubes and sliders which contain springs and dampers.

Air Suspension

In this suspension, compressed air is used as a spring. This suspension system is operated with air and controlled by a microprocessor. It helps in maintaining self-driving conditions and supports the weight of the vehicle.

Practical Exercises

Activity 1

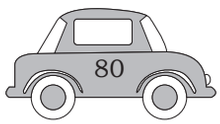
List the components of a suspension system.

S. No.	Name of the component
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

Check Your Progress

A. Fill in the blanks

1. Steering system is used for _____.
2. Main parts of steering system are _____and steering column.
3. A suspension system consists of springs, _____ and linkages that connect a vehicle to its wheels.
4. A suspension system keeps vehicle occupants _____.



B. Multiple choice questions

1. The tilting of the front wheels away from the vertical is called _____.
   (a) camber
   (b) caster
   (c) toe-in
   (d) toe- out
2. Which of the following types of mechanism is used in a steering system?
   (a) Rack and pinion steering
   (b) Rotary motion is turning
   (c) Reciprocating motion
   (d) Power steering system
3. Leaf spring absorbs shocks by _____.
   (a) tension
   (b) compression
   (c) twisting
   (d) bending
4. Compressed air is used for _____.
   (a) air suspension system
   (b) hydraulic suspension
   (c) mechanical suspension
   (d) None of the above

C. Short answer questions

1. How does a steering system work?
2. What is a power steering system?

Session 9: Wheel, Tyre and Brake

Wheel

The wheel is an important component of a vehicle. Wheel of a four-wheeler vehicle is mounted on a hub and consists of parts like rim, tyre and tube (Fig.3.31). The wheels not only support the weight of the vehicle, but also protect it from road shocks. All the four wheels must resist the braking stresses and withstand side thrust. A wheel should be light and easily removable.

Fig. 3.31: Wheel

Functions of the wheel

(i) To withstand the weight of the vehicle.
(ii) To absorb road shocks.
(iii) To grip the road surface.

(a)

(b)

Fig. 3.32(a–b): Rim

(iv) To balance dynamically (i.e., when the vehicle is in motion) and statically (i.e., when the vehicle is at rest).

Rim

The rim (Fig. 3.32 [a-b]) is the 'outer edge of a wheel, holding the tyre'. It makes up the outer circular design of the wheel on which the inside edge of the tyre is mounted on vehicles, such as automobiles. For example, on a bicycle wheel the rim is a large hoop attached to the outer ends of the spokes of the wheel that holds the tyre and the tube.

Different types of wheel rim

(i) Disc wheel rim

(ii) Wire spoke wheel rim (used in motorcycle, bicycle)

(iii) Split wheel rim (used in scooter)

(iv) Heavy vehicle wheel rim (available in three piece and four piece including locking ring)

1. Disc wheel Rim: A wheel is generally composed of rim and disc. Rim is an outer part of the wheel and holds the tyre. Disc is a part of wheel which connects the rim and the axle hub.

2. Wire Spoke Wheel Rim (used in motorcycle, bicycle): Wire spoke wheel rim is where the outside part of the wheel (rim) and axle installed part are connected by many numbers of wires called spokes.

3. Spilt Wheel Rim (used in scooter): Spilt wheel rim is used in a multi-piece wheel. This wheel rim holds the tyre with a locking ring. A split wheel rim cannot be used normally in all types of vehicle.

4. Heavy Vehicle Wheel Rim (available in three piece and four piece including locking ring): Heavy vehicle wheel rim have a three and four-piece locking ring. This type of wheel rim is used in heavy vehicles wheel like truck, buses container, etc., because it has a longer life.

Tyre

The tyre (Fig. 3.33) is mounted on the wheel rim. It carries the vehicle load and provides a cushioning effect. It must produce minimum noise, while the wheel turns on the road. It resists the tendency for the vehicle to oversteer. It should have good grip while accelerating and braking the vehicle on both dry and wet roads.

Fig. 3.33: Tyre

Desirable Properties of a Tyre

A tyre must have the following properties.

(i) *Non-skidding:* The tyre must have grip to avoid skidding or slipping on the road surface.

(ii) *Uniform wear:* The tyre must get worn uniformly over its outer circumference.

(iii) *Load carrying:* The tyre is required to carry the vehicle load.

(iv) *Cushioning:* The tyre needs to absorb the vibrations due to the different road surfaces and their impact, and thus, provide cushioning effect to the vehicle.

(v) *Power consumption:* While rolling on the road, the tyre should consume little power created by the engine.

(vi) *Noise:* The tyre should create minimum noise while running on the road.

(vii) *Balancing:* The tyre should be balanced dynamically as well as statically, i.e., maintain balance at both times — when the vehicle is in motion as well as at rest.

Functions of Tyre

(i) To carry the load of the vehicle.

(ii) To absorb minor road shocks.

(iii) To reduce vibration to some extent.

(iv) To transmit the power from the engine through gear box, propeller shaft and rear axle to the ground with which the vehicle moves.

(v) The treads made on the tyres grip the road for better traction.

Types of Tyre

(i) *Solid tyre:* It is used in children's cycle and is filled with solid material, like rubber, which makes it sturdy.

(ii) *Tube tyre:* It consists of a tube between the rim and the tyre, in which air is filled. It is used in most of the vehicles seen on road.

(iii) *Tubeless tyre:* Nowadays, with the advancements in technology, tubeless tyres are replacing the tube tyres. Tubeless tyres are mainly used in modern cars. The benefits of tubeless tyres include slow leakage of air during punctures, better balancing of wheels, low cost and ease of puncture repairing.

Brake

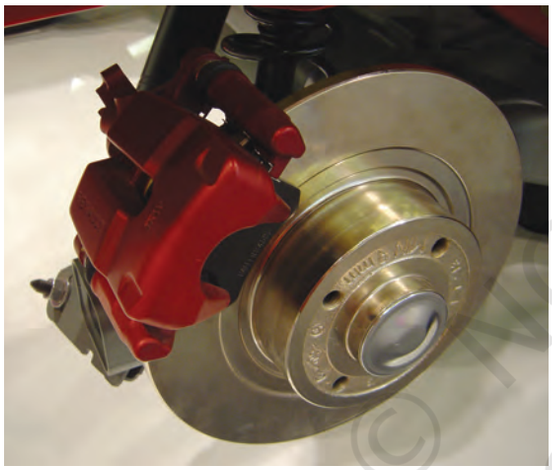


Fig. 3.34: Brake

Brakes (Fig. 3.34) are one of the most important control components of a vehicle. They are required to stop the vehicle within the smallest possible distance and this is done by converting the kinetic energy of the wheels into the heat energy which is dissipated into the atmosphere.

Requirements of A Good Braking System

(i) To stop the vehicle in the shortest possible distance and time.

(ii) To control the vehicle speed while moving on plain roads and hills.

(iii) To work equally well on fair and bad roads.

(iv) To ensure that the pedal effort applied by the driver is not much, thereby reducing the inconvenience for the driver.

(v) To work efficiently in all weathers.

(vi) It should have very few wearing parts.

(vii) It should require little maintenance.

(viii) Brake, when applied should not disturb the steering geometry.

(ix) There should be minimum sound when brake is applied.

Types of Brake

1. **Foot Brake:** Foot brake is one of the most common brake systems operated by the foot pedal. When pressure is applied to the foot pedal, the vehicle stops. Pedal force applied by the driver is further multiplied and sent to the braking drum or disc either by mechanical linkages or by hydraulic pressure which in turn causes braking. It is also known as a service brake.
2. **Hand Brake:** Hand brakes are usually used for stable parking of the vehicle either a on flat road or slope. They are also called parking brakes. Hand brakes are connected to the brake mechanism directly and the other end is operated by the driver. This type of brake is also known as emergency brake as it is independent of the main service brake.
3. **Drum Brakes or Internal Expanding Brakes:** Drum brakes (Fig. 3.35) are usually used as rear brakes in most automobiles, which utilises the friction between the drum and the brake shoes to stop the vehicle. This type of brake is fitted in automobile light vehicle, such as car and light trucks. These brakes have a two shoe, the left hand shoe is known as a primary shoe and the right-hand shoe is known as trailing shoe. Shoes are fitted in the drum. The friction between the shoes and the drum produces the braking torque and reduces the speed of the drum so that the vehicle stops.

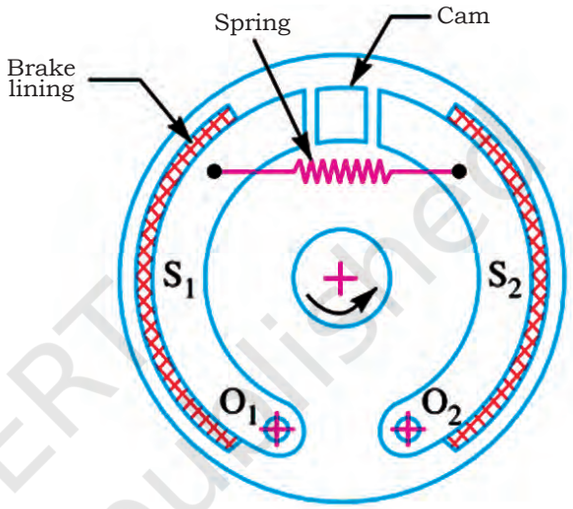
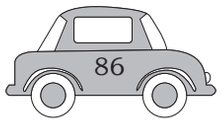


Fig. 3.35: Drum brake

Fig. 3.36: Disc Brake

4. **Disc Brake or External Contracting Brakes:** It is the type of braking system in which instead of a drum assembly a disc rotor is attached to the hub of the wheel in such a fashion that it rotates with the wheel (see Fig. 3.36). This disc rotor is clamped in between the caliper which is rigidly fixed with the knuckle or upright of the vehicle. When brakes are applied the actuation mechanism contracts the attached brake shoes which in turn make the frictional contact with the rotating disc rotor and cause the stopping of a vehicle. An external contracting brake is used for only parking purpose as well as used to operate in flour mills, various types of electrical components, etc.
5. **Mechanical Brake:** This brake system has an inbuilt mechanical device for absorbing energy from a moving system. Mechanical brake is a cable pull system, which consists of rim-like brakes just arranged in a different way.
6. **Power Brake:** Power brake system is a combination of the mechanical components to multiply the force applied to the brake pedal by the driver to stop the vehicle. In a power brake system we mainly use the vacuum booster and master cylinder, brake calipers, drum brake, etc. These braking systems are designed to reduce the effort required to depress the brake pedal when stopping a vehicle.
7. **Vacuum Brake:** It is the conventional type of braking system in which vacuum inside the brake lines causes brake pads to move, which in turn finally stop or deaccelerate the vehicle. This type of brake is mainly used in railways in place of air brakes. This brake can remove the kinetic energy and convert it into a form of heat. The conversion is usually done by applying a contact material to the rotating wheel attached to the axles. Vacuum brakes are cheaper than air brakes but are less safe than air brakes.



8. **Air Brake:** Air brake system is a very advanced braking system. It is generally used in very heavy vehicles like buses and trucks. It is the type of braking system in which the atmospheric air through compressors and valves is used to transmit brake pedal force from brake pedal to the final drum or disc rotor. Air brakes generate higher brake force than hydraulic brake which is the need of the heavy vehicle. High-end cars these days are using air brake systems due to its effectiveness and fail proof ability.
9. **Hydraulic Brakes:** A hydraulic braking system transmits brake-pedal force to the wheel brakes through pressurised fluid, converting the fluid pressure into useful work of braking at the wheels. The brake pedal relays the driver's foot effort to the master-cylinder piston, which compresses the brake fluid. This fluid pressure is equally transmitted throughout the fluid to the front disc-caliper pistons and to the rear wheel-cylinder pistons. The pressure on a liquid is called hydraulic pressure. The brakes which are operated by means of hydraulic pressure are called hydraulic brakes.
10. **Anti-lock Braking System:** Anti-lock Braking System prevents the wheels from locking or skidding. The anti-lock braking (ABS) system is a component that ensures passenger safety by stopping the vehicle in adverse conditions, like stopping very quickly or if the road is slippery. To simplify it, the ABS prevents the wheels of the vehicle from locking up and causing you to skid out of control.
11. **Electric Brake:** It is the type of braking used in electric vehicle. Electric brakes use electrical motors which are the main source of power in electric vehicles. Electric brakes or secondary shoe are similar to the drum brakes in an automobile. Electric brakes are actuated by an electromagnet.

Practical Exercises

Activity 1

List the different types of brake used in an automobile.

S. No.	Types of brake
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

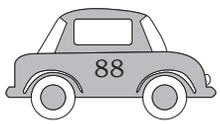
Check Your Progress

A. Fill in the blanks

1. Wheel is an important component of the _____.
2. Tyre is fitted on the _____.
3. Brake should work _____ on roads.
4. Hand brake is also known as _____ brake.

B. Multiple choice questions

1. The most important component of a vehicle is _____.
   (a) wheel
   (b) rim
   (c) disk
   (d) tyre
2. The tyre is mounted on the _____.
   (a) vehicle
   (b) disc



(c) wheel rim
(d) None of the above

3. The main component of the generating or charging system is (are) _____.

(a) generator/alternator
(b) ammeter
(c) the battery
(d) All of the above

C. Short answer questions

1. What are the components of a wheel?
2. How does the brake system function?

Session 10: Electrical or Electronic and Air Conditioning Systems

Electrical or Electronic System

Nowadays, all the automobiles run with the help of electrical and electronic system, and therefore, it plays an important part in the functioning of an automobile.

The electrical and electronic systems consist of the following.

(i) *Starting system:* The starting motor is driven by means of the current taken from the battery.

(ii) *Ignition system:* The function of the ignition system is to produce a spark in the engine combustion chamber at the end of the compression stroke.

(iii) *Generating or charging system:* The function of the charging system in an automobile is to generate, regulate and supply the electrical energy for charging the battery.

(iv) *Lighting system:* It consists of various types of lighting used during the vehicle running, such as head light, tail light, fog light, brake light, reversing light, left and right indicators, parking light, cabin light, panel board lights, etc.

(v) *Connections for other accessories.*

Main components of the electrical system

Starting system	Generating or Charging system	Ignition system	Lighting system	Accessories
• Battery • Starting • Motor • Motor • Control	• Generator/ Alternator • Ammeter • The cut-out • Switch • Battery • Voltage and current regulator	• Battery • Ignition switch • Ignition coil • Distributor • Spark plugs • Contact breaker • Automatic advance and retard unit • Vacuum control unit	• Headlight • Side light • Rear light • Fog Lamps • Number plate illumination lamp • Interior lights • Indicator flashers	• Horns • Wind screen wiper • Electric fuel pump • Fuel gauges • Temperature gauge • Radio sets • Cigar lighter/mobile phone charger • Heater • Wind screen defroster • Signalling devices

Note: In modern vehicles, various types of electronic sensors and actuators are fitted in different systems of the engines, which are also operated electrically.

Air Conditioning System

During summer, an automobile requires considerable amount of refrigerating capacity to maintain cool and comfortable conditions in the sitting space. Similarly, when moving in a cold day in winter, the same vehicle would require considerable heating capacity to keep it comfortably warm for passengers.

Modern-day automobiles have an air conditioning unit (Fig. 3.37) to maintain suitably controlled temperature and humidity conditions inside the vehicle. In automobiles, an air conditioner is a refrigeration machine which requires electrical energy drawn from the battery system. The battery is charged by energy of the engine.

Fig. 3.37: Air conditioner in a car

For heating purposes, the warm water from the engine cooling system is used. The heat required to warm the automobile is generally provided by circulating warm water through a heating coil.

Besides controlling the temperature levels, the air conditioner also cleans the air. During summer, the humidity of the air inside the vehicle is reduced with air conditioner in operation, which makes the sitting area comfortable. Car air conditioner comes inbuilt in air conditioned (AC) car models. However, these can also be fitted at a later stage in a non-AC model of the car.

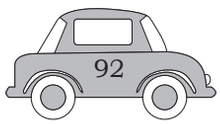
Different Components of Automobile Air Conditioning System

(i) Compressor
(ii) Magnetic clutch
(iii) Condenser
(iv) Receiver-drier (or dehydrator)
(v) Expansion valve
(vi) Evaporator
(vii) Throttling valve

1. **Compressor:** A compressor is unit driven by the engine. It has a low pressure side port which is connected to the evaporator and a high pressure side port which is connected to the condenser using rubber hoses. The compressor is the main mechanical part of the system. In hybrid engines the compressor is electrically powered. A small electric motor is fitted inside the compressor which pressurises the refrigerant. These compressors have a pair of large gauge wires which form the compressor controller. In latest cars, where the climetrons are used the electric power supply is controlled by ECU as per the temperature settings.
2. **Clutch:** The compressor is always fixed with a clutch. The major function of the clutch is to transmit the power smoothly to the compressor when the system is operated.
3. **Condenser:** The major function of this device will be to change the high-pressure refrigerant vapour to a liquid. The condenser is mounted in front of the engine's radiator, and it looks similar to

a radiator. The condenser is a cooling device in which the vapour is condensed to a liquid because of the high pressure that is driving it in, and this generates a great deal of heat. The heat is then in turn removed from the condenser by air flowing through the condenser on the outside.

4. **Receiver-drier:** The main function of this device is to filter refrigerant. The liquid refrigerant moves to the receiver-drier. This is a small reservoir vessel for the liquid refrigerant, which removes any moisture that may have leaked into the refrigerant and also stores excess quantity of refrigerant.
5. **Expansion Valve:** The pressurised refrigerant flows from the receiver-drier to the expansion valve. The expansion valve is a controlling device which controls the varying load when there are pressure changes in the evaporator, as it may increase or decrease. The valve maintains a constant pressure throughout the varying load on the evaporator controlling the quantity of refrigerant flowing into the evaporator.
6. **Evaporator:** It is the main component of a refrigeration system and is also called the cooling coil. It has tubes and fins or freezing coil. It is usually placed inside the passenger compartment above the footwell. As the cold low-pressure refrigerant is passed into the evaporator, it vapourises and absorbs heat from the air in the passenger compartment. The blower fan inside the passenger compartment pushes air over the outside of the evaporator, so cold air is circulated inside the car. On the 'air-side' of the evaporator, the moisture in the air is reduced, and the 'condensate' is collected.
7. **Throttling Device:** It is a part of refrigeration system and air conditioning system. When refrigerant comes out from the condenser at a medium temperature and high pressure, it enters the throttling valve. In the throttling valve, the pressure and temperature of the refrigerant are decreased suddenly and the cooling effect is provided to the evaporator.



Working of Air Conditioning System

In a car's air conditioning system, the refrigerant vapour from the evaporator is compressed to high pressure by the compressor. The compressor is driven by the engine through a belt drive. In a hybrid car, the compressor is driven by the motor and the power is used from the battery.

The compressor is connected by an electromagnetic clutch which serves, engages and disengages the compressor as required. A variable displacement A/C compressor is sometimes used to match a compressor capacity to varying cooling requirement. The refrigerant pressure and temperature increases in the compressor and converts it into the vapour form and then to the condensed form. In the condenser the refrigerant liberates heat and converts into the liquid form.

Sometimes the air is not sufficient and therefore, an extra engine or electric driven fan is used to cool the refrigerant. This cooled but high pressure refrigerant is passed through the dehydrator to extract any moisture. Dry refrigerant liquid is then made to pass through expansion valve mounted at the inlet side of the evaporator. The expansion valve allows the refrigerant liquid to expand to low pressure in the evaporator. The process of expansion to low pressure makes the refrigerant evaporate and thereby cool the evaporator.

A sensing device, called temperature tube signals the diaphragm in the expansion valve to change the size depending upon the refrigerant temperature at the evaporator outlet, thus achieving automatic temperature control (Fig. 3.38).

Fig 3.38: Air Conditioning System in a Car

Practical Exercises

A. Fill in the blanks

1. _____ is the main component of a refrigeration system.
2. Battery is used for _____ vehicle.
3. Starting system consist of battery and starting_____.
4. Warm temperature in the car is maintained by_____.

B. Multiple choice questions

1. The starting motor is driven by means of the current taken from the_____.
   (a) battery
   (b) stabiliser
   (c) ignition coil
   (d) None of the above
2. The function of the ignition system is _____.
   (a) to produce a spark in the engine combustion chamber
   (b) to generate, regulate and supply the electrical energy
   (c) to produce a current for charging
   (d) None of the above
3. List the electrical accessories used in vehicle.

S. No.	List of accessories
1.	
2.	
3.	

4. Air conditioner losses energy from the _____.
   (a) battery system
   (b) condenser
   (c) engine
   (d) None of the above

C. Short answer questions

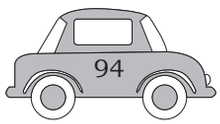
1. Discuss the importance of electrical and electronic system in automobiles.
2. What are the components of an air conditioning system?

Session 11: Active and Passive Safety

There are different safety and security systems for automobiles available in the market and some of which are fitted by the manufacturer. Some of the active and passive security systems are mentioned as follows.

Safety Glass

Safety glass is used in all windows and doors of automotives. The safety glass used in today's vehicles is of two types—laminated and tempered. These are considered as safety glass because of their varying strength.



Laminated plate glass is used to make windshields. It consists of two thin sheets of glass with a thin layer of clear plastic between them. Some glass manufacturers increase the thickness of the plastic material for better strength. When this type of glass breaks, the plastic material tends to hold the shattered glass in place and thus, prevents it from causing injury.

Tempered glass is used for side and rear window glass but rarely for windshields. It is a single piece of heat-treated glass and has more resistance to impact than the regular glass of the same thickness. Thus, it has greater strength compared to a laminated plate glass.

Seat belts

A seat belt is also called a safety belt. It is a harness designed to protect the occupant of a vehicle from harmful movement, during a collision or when the vehicle stops suddenly.

A seat belt (Fig. 3.39) reduces the likelihood and severity of injury in a traffic collision. It prevents the vehicle occupant from hitting hard against the interior elements of the vehicle or other passengers, and keeps the occupants positioned in place for maximum benefit from the airbag.

Fig. 3.39: Seat belt

The passenger must fasten the seat belt for crash protection. However, in case of a passive safety system, such as the inflation of air bags at the time of an accident, is automatic. No action is required of the occupant to make it functional. Nowadays, seat belts are also provided for rear seat occupants.

Airbags

An airbag (Fig. 3.40) is one of the passive safety systems for the occupants of a four-wheeler. The electrical system of airbags includes impact sensors and an electronic control module. In case of an accident, the sensor detects the impact and the airbag opens up to save the driver and other occupants.

Fig. 3.40: Air bags

Energy-absorber Safety Bumpers

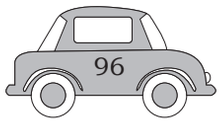
Modern bumpers are designed to absorb the energy of a low-speed impact, minimising the shock directed to the frame and to the occupants of the vehicle. Most energy absorbers are mounted between the bumper face bar or bumper reinforcement bar and the frame.

Security Devices

There are three basic types of security devices available — locking devices, disabling devices and alarm systems.

In automobile vehicle, an anti-theft system or device is installed to prevent theft of a vehicle. Many car security devices are available in the market. These are mechanical devices and ignition cut off devices, intelligent computerised anti-theft devices, satellite tracking system, engine control module, etc. Vehicle owners may select as per risk and install it in their vehicles. Prior to purchasing, the customers should check that these theft devices are duly approved from the Automobile Research Association of India (ARAI). Important features of these devices are explained below.

- **Alarm:** In the case of vehicle tampering, audible warning sounds emerge
- **Keyless Lock Device:** To use the vehicle, electronic coding device is required
- **Electronic Immobilisers:** These built-in transponders send signals to the ignition and fuel pump system. The vehicle remains in stationary or inoperable state if the ignition starters do not get correct signals.
- **Steering Wheel Lock:** This device is fitted in the steering of the vehicle and it locks it in one place so that no one can drive it without removing the lock.
- **Vehicle Tracking:** Even if a thief steals a vehicle, the tracking technologies can help trace it. Tracking devices offer real-time location of the stolen vehicle with the help of the global positioning system (GPS).



Practical Exercises

Activity 1

List the different active and passive safety devices.

S.No.	List of devices
1.	
2.	
3.	
4.	
5.	

Check Your Progress

A. Fill in the blanks

1. Air bags are used for _____.
2. Seat belt is also known as a _____ belt.
3. Passive safety system helps _____.
4. Active safety system is used for avoiding _____.

B. Multiple choice questions

1. Which types of anti-theft devices are available in a vehicle?
   (a) Locking devices
   (b) Disabling devices
   (c) Alarm systems
   (d) All of the above
2. Tempered glass is used for _____.
   (a) side and rear window glass
   (b) auto window and door
   (c) head light
   (d) All of the above
3. Which of these safety systems are operated automatically?
   (a) Passive safety system
   (b) Active safety system
   (c) Energy-absorber safety
   (d) None of the above
4. Impact sensors are used in _____.
   (a) electrical system
   (b) mechanical system
   (c) auto-mechanical system
   (d) None of the above

C. Short answer question

1. Discuss the components of the active and passive safety system.