EXCITING WORLD OF AUTOMOBILES

STUDENT WORKBOOK

Curriculum :AUTO-SRV *L2-NQ*^{2012}

Unit :AUTO-SRV *L2U1*

Automobile and their Components

Vocational Learning Material for Schools

PSS Central Institute of Vocational Education
Bhopal

PREFACE

Improving the parity of esteem between the general academic education and vocational education, is the policy priority of the Government of India. The National Vocational Education Qualification Framework (NVEQF) developed by the Ministry of Human Resource Development (MHRD), Government of India, is a descriptive framework that provides a common reference for linking various qualifications. It will be used for setting common principles and guidelines for a nationally recognized qualification system covering Schools, Vocational Education and Training Institutions, Technical Education Institutions, Colleges and Universities. The NVEQF will act as a translation device to make qualifications more understandable to employers, students and institutions. It will promote transparency of qualifications and facilitate learner's mobility between different qualifications, thus encouraging lifelong learning. PSSCIVE has taken lead in development of learning material for the Automobile Sector for all level in collaboration with the Automobile Skill Development Corporation (ASDC).

The present material contains activity related to Level L-2 for the Automobile service sector. This will fulfill the needs of the students willing to learn activities relating to the Automobile Service Sector. Any student/ entrepreneur willing to start an Automobile Service Sector can acquire the desired competencies with the help of this book.

The book has been written by experts but reviewed by all the members of the group. I am grateful to the authors for the development of this book and to the members of the Working Group for their candid suggestions, during the development and review. Their names are given elsewhere.

I appreciate efforts put in the by Dr. Saurabh Prakash, as the Project Coordinator of the Working Group in planning and organizing Meetings which led to the final form of this title.

I shall be grateful to receive suggestions and observations from readers, which would help in bringing out a revised and improved version of this book.

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June, 2012

This student workbook was developed, with active involvement of Automobile Skill Development Council (ASDC) keeping in view the National Occupation Standard (NOS) for Service Technician L4 developed by ASDC.

This project for development of the student workbook was coordinated by the PSS Central Institute of Vocational Education, a constituent unit of National Council of Educational Research and Training, which is under Ministry of Human Resource Development, Government of India.

Student Details

Student Name: _____

Student Roll Number:_____

Batch Start Date: _____

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About this Workbook

This workbook is to assist students with completing the Auto Sector **L2U1-NQ2012** unit of competency: **Automobile and their components**. Students should study the workbook in class or in their own time.

This workbook contains sessions for imparting knowledge & skills on various aspects of the unit of competency. The workbook also includes information, exercises, and assessment activities to complete. The assessment plan has been included in the workbook to assist you in scheduling your time for completing the assignments. Each assessment activity is followed by a checklist for meeting the assessment criteria. The criteria will help you to ensure that you have fulfilled all of the assessment requirements to receive a 'competency' grading/Certification by ASDC.

Unit Information

Unit name: Automobile and their components

Unit code: Auto L2U1-NQ2012

Unit descriptor:

This unit provides the knowledge & skills covering major components and systems of an automobile. This covers Chassis Frame, Auto Body, Engine, Lubrication System Cooling System, Fuel Supply System, Transmission system, Front Axle, Steering, Rear axle, Suspension system, Wheel and Tyre Brakes, Electrical and Electronics System.

Resource implications:

- Notebooks, Pen, Pencil, Eraser, Computer, LCD projector. Sketches, drawing, pictures and poster of various components of an automobile. Animation and videos of various components of vehicle. Sample and cut outs of various components and assembly system of an automobile.

Nominal hours: 96 hours

Elements and Performance Criteria

- Elements define the critical learning outcomes of a unit of competency.
- Performance criteria specify the level of performance required to demonstrate the achievement of the Competency Element.

Element	Performance Criteria
Role of each of the 13 components and system of an automobile as follows – Chassis – Body – Engine – Lubrication System – Cooling System – Fuel Supply System – Transmission System – Front Axle – Steering System, – Rear axle – Suspension System – Wheels and Tyres – Brakes – Electrical and Electronic System	1 Able to identify…….. 2 Able to describe (14 components and system of an automobile as follows) – Chassis – Body – Engine – Lubrication System – Cooling System – Fuel Supply System – Transmission System – Front Axle – Steering System – Rear axle – Suspension System – Wheels and Tyres – Brakes – Electrical and Electronic System

Relevant Knowledge and Skills

1. Relevant Knowledge

Introduction to various parts & systems like Chassis Frame, Body, Engine, Lubrication System, Cooling System, Fuel supply s, Transmission system Front and Rear Axle Steering System, Suspension System, Wheels and Tyre, Brakes, Electrical & Electronic Systems.

2. Skills

Ability to Identify & describe various parts & components like Chassis Frame, Body, Engine, Lubrication System, Cooling System, Front and Rear Axle, Steering System, Suspension System, Wheels and Tyres, Brakes, Electrical & Electronic Systems.

Assessment Plan

Session No.	Assessment method	Due Date	Completion Date
1.	Fill in the Blanks		
2.	Fill in the Blanks		
3.	Fill in the Blanks		

Introduction

As you know that the growth in the automobile sector is progressing in our country. New developments are taking place day by day. In level-1, you have gone through the basic concepts of anautomobile and its component. You learnt the role of each component in an automobile. In this unit we will be discussing the details of each component. It will help us in achieving a better understanding. These important components will be Chassis Frame, Body, Engine, Lubrication System, Cooling System, Fuel supply system, Transmission system Front and Rear Axle Steering System, Suspension System, Wheels and Tyre, Brakes, Electrical & Electronic Systems. As we know that theseall are very important component of automobile. A vehicle can not be complete without them.

In this Unit, you will develop an understanding of the components of Chassis Frame, Body, Engine, Lubrication System, Cooling System, Fuel supply system, Transmission system Front and Rear Axle Steering System, Suspension System, Wheels and Tyre, Brakes, Electrical & Electronic Systems of an automobile vehicle.

Session 1: Chassis

Relevant Knowledge

You have studied the definition of chassis, various major components mounted on a chassis frame and the functions of the chassis frame in the previous level. We can say that chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted) with the wheels and machinery. In this chapter you are going to learn more details about the chassis.

Figure of Chasis

THE CHASSIS

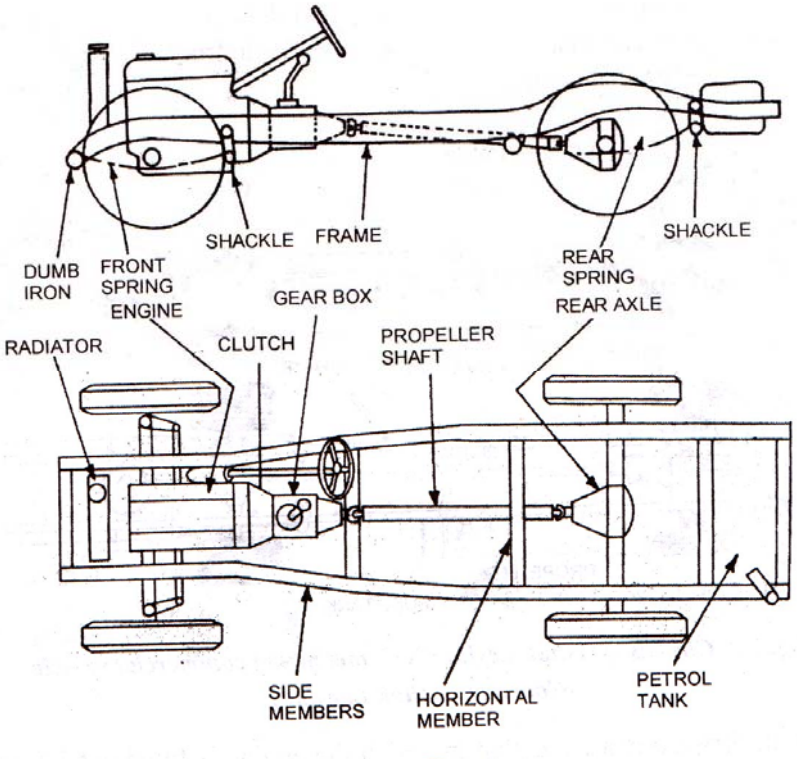


Fig : Chassis

Classification of Chassis

According to the fitting of engine the classification of Chassis is as follows:

1. Full forward
2. Semi-forward.
3. Bus chassis.
4. Engine in front.
5. Engine at centre.

Full forward chassis is one in which the engine is fitted outside the driver cabin or seat like in cars and old Tata-trucks. In this type of arrangement, the driver seat is far from the front wheels and he is not able to see just in front of the vehicle.

In Semi-forward chassis, half portion of the engine is in the driver's cabin and the remaining half is outside the cabin like in standard, Bedford pick. It provides better visibility of road to the driver.

In bus chassis, the whole engine is fitted in the driver cabin. It provides an increased floor space in the vehicle. The driver seat is just above the front wheel and he can see the full front road right from the front wheels.

In most of the vehicles, the engine is fitted in front portion of the chassis. The drive is given to the front wheels only in matador vehicles.

The engine may also be fitted at the back portion of the chassis, like in Tata and Ashok Leyland buses. This arrangement does not require long propeller shaft. Gearbox and differential are combined in one unit.

The engine may also be fitted at the centre of the chassis. This arrangement provides full space of chassis floor for use.

According to the number of wheels fitted in the vehicles and the number of driving wheels, the vehicle chassis's are of the following types:

(a) **4 X 2 drive chassis vehicle** – consists of 4 wheels out of which 2 wheels are the driving wheels,

(b) **4 X 4 drive chassis vehicle** – consists of 4 wheels and all of them are the driving wheels.

(c) **6 X 2 drive chassis vehicle** – consists of 6 wheels out of which 2 wheels are the driving wheels.

(d) **6 X 4 drive chassis vehicle** – consists of 6 wheels out of which 4 wheels are the driving wheels.

Classification of Chassis Frame

You have already studied that there are two types of chassis frames

1. Conventional Chassis frame.
2. Integral Chassis frame.

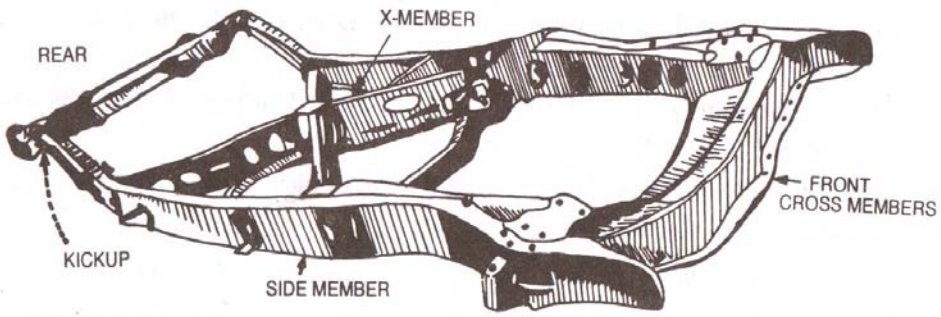


Fig : X-member type Jeep Chassis Frame

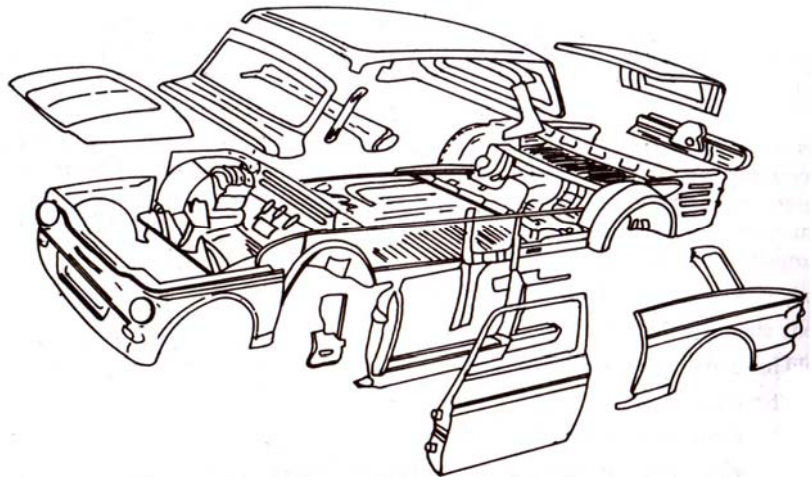


Fig : Integral or unit Frame and Body Construction

Advantages and disadvantages of Frameless or Integral Frame Chassis over conventional type Chassis frame

Advantages:

- Cost is less, as the body floor works as long and cross members.
- Deadweight of vehicle is less, as body floor works as a chassis and extra cross members are eliminated.
- Due to elimination of frame, the centre of gravity of the vehicle is lowered, which gives more stability, specially for fast moving vehicles. As stated above, the main floor works as a chassis. As such floor is pressed to form small sections and channels are welded to give it extra strength. A standard Car manufactured in India is equipped with this type of frameless construction

Disadvantages:

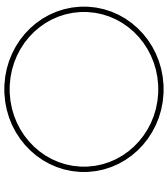
- The only disadvantage of having an integral frame chassis is, that, in case of an accident, it becomes difficult to repair, set it right and properly align the same.

The frames are made of following steel sections

- Channel Section

- Box Section

- Tubular Section



Channel Section is used in long member and box section in short members. **Tubular section** is used now-a-days in three –wheelers, scooters and matadors, pick-ups frames.

Loads on the Chassis frame

The frames should be strong enough to bear load, sudden brakes and accidents. Following loads act on the chassis frame.

- Weight of the vehicle and the passengers.
- Vertical loads when the vehicle comes across a bump or hollow.
- Engine torque.
- Inertia loads due to brake application.
- Sudden impact loads during a collision.
- Loads for longer periods e.g., cornering force while taking a turn.

Session 1: Chassis

Exercise: Assignment

1. List the types of chassis

S.No.	Types of chassis

2. Prepare a poster showing chassis used in a vehicle.

Session 1: Chassis

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Chassis is used for_____.
2. Channel section is used _____.
3. Tubular section is used in _____, _____ model.
4. In bus chassis, the whole engine is fitted in the _____ cabin.
5. Chassis is the _____ part of a _____ vehicle, consisting of the frame with the _____ and machinery.

B. Tick the correct answer

1. Channel section is made of :
   A. Iron
   B. Wood
   C. Steel
   D. Aluminum

2. A chassis is used for
   A. carrying the bolt
   B. opening the load
   C. fixing the auto body
   D. folding the nut

3. Chassis is made of
   A. wood
   B. oil
   C. metal
   D. plastic

Session 1: Chassis

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for chassis frame and automobile body.

Part A

- Share characteristics of chassis frame

- **Part B**

Discussed in class the following:

- What is meaning of chassis?
- What are the different types of chassis frames used in automobiles?
- Classification of chassis.
- Section used in the chassis.
- Advantage of integral frame chassis over conventional chassis frame.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of Chassis		
Able to identify general section used in chassis frame		

Session 2: Body or Superstructure
Relevant Knowledge

In the previous level you studied little about the type of body and their fixing methods with the chassis frame and the requirements of automobile body. Here you are going to learn about different the parts of the body or superstructure.

Different parts of Automobile Body

1. **Body shell** – The body structural assemblies are joined into an integral shell by electric spot welding.
2. **Floor Assemble** – Generally, the floor of the body is assembled first and after that the pillars, rails and panels are welded in order to form the complete body.
3. **Doors** – Each door is provided with a check arm consisting of an articulated plate secured on a pillar and sliding into a slot in door. A rubber pad on check arm tip prevents the arm from sliding out of its slot, thus checking opening of the door. Door windows are held by fasteners.
4. **Windshield and Back window** – To improve visibility the windshield and back window are curved. They are also provided with weather strips and bright metal reveals.
5. **Body inner trimming** – The car body is lined with special paints, sound reducing and water proofing compounds as well as stuffing and covering materials. It is done for following two main purposes.
    - To reduce mechanical components vibrations
    - To improve car appearance and comfort.
6. **Seats** – The bench type front seat consists of a metal framing on which the stuffed, cloth and imitation leather upholstered seat back is fixed. A lever projecting laterally to the cushion disengages the slide catch for

seat position adjustment. The cushion is just press fitted in the framing. The rear seat is in two separate parts.

- The back, fitted between the rear wheel boxes and resting against the luggage compartment partition.
- The cushion, resting directly on floor and positioned by two rubber studs.

7. **Hood** – The hood is made in a single piece, hinged at the rear to cover the engine compartment. Around the edges of the engine compartment on which the hood rests when closed are fitted rubber bumper pins. The hood is kept closed by a locking catch.

8. **Deck lid** – The deck lid is opened and closed, with the help of a handle. To keep the lid closed, a catch is engaged in a striker. The luggage compartment opening edge is lined with rubber weather strips. In a well at bottom of luggage compartment, is the spare wheel.

9. **Bumpers** – The rear and front bumpers consist of a single bar provided with two ornaments. The rear bumper is secured by screws of the ornaments and by two side screws covered with chromium plated bosses. The front bumper is secured through the ornament stud screws and nut, in two brackets welded on body.

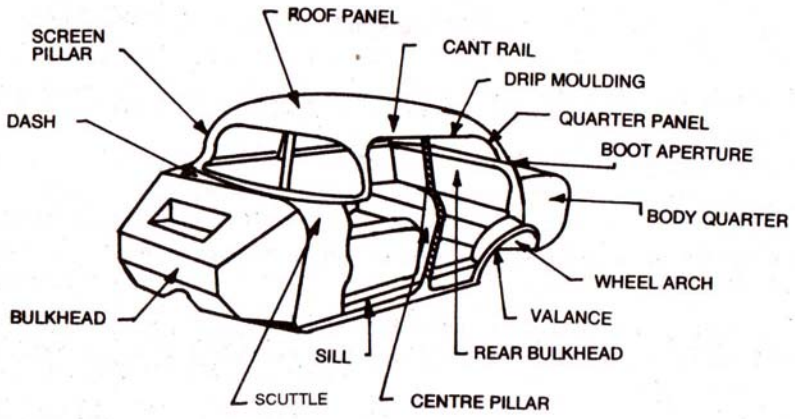


Fig : Various Parts of a Car Body

Session 2: Body or Superstructure
Exercise: Assignment

1. List the different part of the vehicle body

S.No.	Different parts of the vehicle body

2. Prepare a poster showing different parts of a body of a vehicle.

Session 2: Body or Superstructure
Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Body is used for_____.
2. Door windows are held by _____.
3. The hood is made in a _____ piece.
4. The rear and front bumpers consist of a _____ provided with two ornaments.

Session 2: Body or Superstructure

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for pollution control.

Part A

- Share importance of the body of a vehicle.

Part B

Discussed in class the following:

- What is meaning of body in a vehicle?
- What are the different components of the vehicle body
- Differentiate between hood and bumper.
- Name two important components used in a vehicle body.
- Write about the importance of windshield.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of body		
Able to identify general components of a body		

Session 3: Engine

Relevant Knowledge

In the previous level you studied about the definition of an IC engine, types of engine (SI Engine & CI Engine) and various components of an IC engine and their purposes.

We can say again that the engine or motor is a machine designed to convert energy into useful mechanical motion. Heat engines, including internal combustion engines and external combustion engines (such as steam engines) burn a fuel to create heat, which, is then used to create motion.

In this level you are going to learn about various classifications of automobile engines, different technical terms used in IC engine, etc.

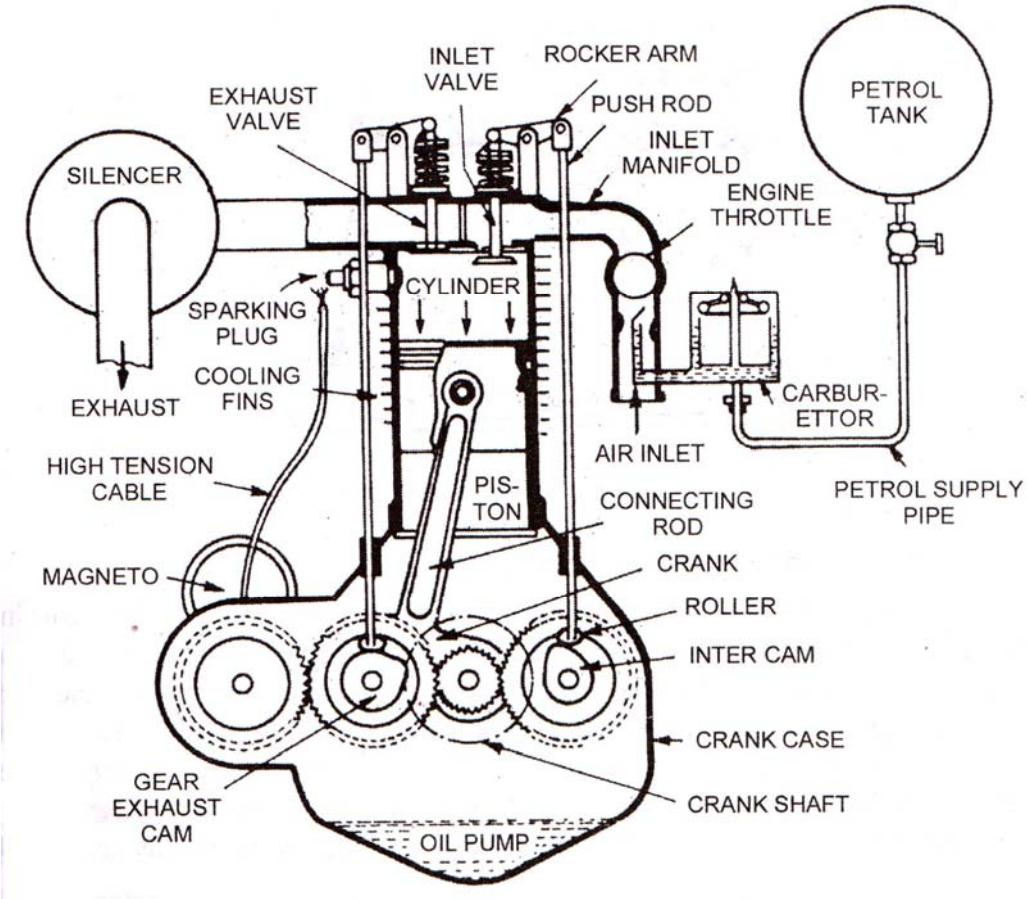


Fig : 4 – Stroke Petrol Engine

Classification of Automobile Engines

The engines for the automotive use may be classified according to the following considerations:

1. **Cycle of Operation**
   - Otto Cycle Engine
   - Diesel Cycle Engine
2. **No. of Strokes Per Cycle**
   - Two Stroke Engine
   - Four Stroke Engine
3. **Fuel Used**
   - Petrol Engine (or Gasoline Engine)
   - Diesel Engine
   - Gas Engine
4. **Types of Ignition**
   - Spark Ignition (SI) Engine
   - Compression Ignition (CI) Engine
5. **No. of Cylinders**
   - Single-cylinder Engine
   - Two-cylinder Engine
   - Three-cylinder Engine
   - Four-cylinder Engine
   - Six-cylinder Engine
   - Eight-cylinder Engine
   - Twelve-cylinder Engine
   - Sixteen-cylinder Engine
6. **Arrangement of Cylinders**
   - Inline Vertical Engine
   - Horizontal Engine
   - V-type Engine
   - Opposed cylinder Engine
   - Radial Engine

7. **Valve Arrangement Engine**
   - L-head Engine
   - I-head Engine
   - F-head Engine
   - T-head Engine
8. **Type of Cooling**
   - Air-cooled Engine
   - Water-cooled Engine

In addition to the above classifications, the internal combustion engines are classified on the following bases also:

9. **Speed**
   - Low Speed Engine
   - High Speed Engine
   - Medium Speed Engine
10. **Method of Fuel Injection**
   - Carburettor Engine
   - Air Injection Engine
   - Airless or Solid Injection Engine
11. **Method of Governing**
   - Hit and miss governed Engine
   - Qualitatively governed Engine
   - Quantitatively governed Engine
12. **Application**
   - Stationary Engine
   - Automotive Engine
   - Locomotive Engine
   - Marine Engine
   - Aircraft Engine
13. **Special Type Engine**
   - Wankel Engine
   - Automotive Gas Turbine

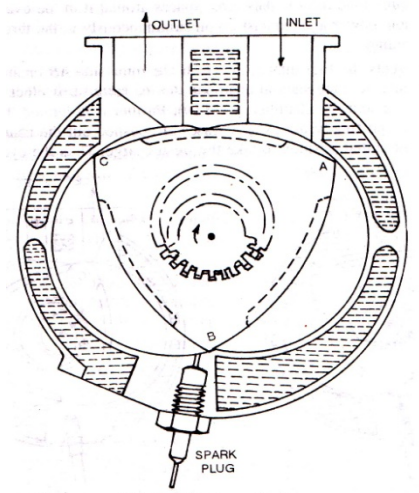


Fig : Wankel Rotary Engine

Technical Terms Used In Engine:

A number of basic terms are used to describe and compare engines. A few commonly used terms are described here.

- **Top Dead Centre (T.D.C):** This refers to the position of the crankshaft when the piston is in its topmost position i.e. the position closest to the cylinder head.
- **Bottom Dead Centre (B.D.C):** This refers to the position of the crankshaft when the piston is in its lowest position i.e. the position farthest from the cylinder head.
- **Bore:** Diameter of the engine cylinder is referred to as the bore.
- **Stroke:** Distance travelled by the piston in moving from T.D.C. to the B.D.C is called 'stroke'.
- **Clearance Volume:** The volume of cylinder (including the combustion chamber) above the piston when it is in the T.D.C. position is referred to as 'clearance volume' (Vc).
- **Piston Displacement:** This is the volume swept by the piston in moving from T.D.C. to B.D.C. This is also called 'swept volume'. If 'd' is the cylinder bore and 'S' the stroke, the piston displacement, Vs is given by.

$$Vs = \frac{\pi}{4} d^2 . s$$

- **Engine Capacity:** This is the total piston displacement or **the Swept volume** of all the cylinders. If 'n' is the number of cylinders and V*s* is the piston displacement, then 'engine displacement' or engine capacity V*d*, is given by,

$$V_d = V_s.n$$

- **Compression Ratio:** This indicates the extent to which the charge in the engine is compressed. This is calculated as the ratio of the volume above the piston at B.D.C. to the volume above the piston at T.D.C. If '*y*' is the compression ratio, then

$$Y = \frac{Vs + Vc}{Vc}$$

  For petrol engines, compression ratios are about 8 to 9.5 : 1, whereas for diesel engines, these vary from 16 to 22.
- **Power:** It is the work done in a given period of time. Doing the same amount of work in a lesser time would require more power.
- **Horse Power (H.P.):** This is the amount of energy required to do 4500kgm. of work in one minute.
- **Indicated Horse Power (I.H.P):** The power developed within the engine cylinders is called indicated horse power. This is calculated from the area of the engine indicator diagram.
- **Brake Horse Power (B.H.P):** This is the actual power delivered at the crankshaft. It is obtained by deducting various power losses in the engine from the indicated horse power.
- **Friction Horse Power (F.H.P.)**: This is the power lost due to friction present between different matching components.

$$F.H.P = I.H.P – B.H.P$$

- **Engine Torque**: It is the force of rotation acting about the crankshaft axis at any given instant of time. It is expressed in newton-metre (N*m*).

Engine torque goes through the vehicle transmission system, to the road wheels and is responsible for rotation of the latter and hence for pulling of the vehicle.

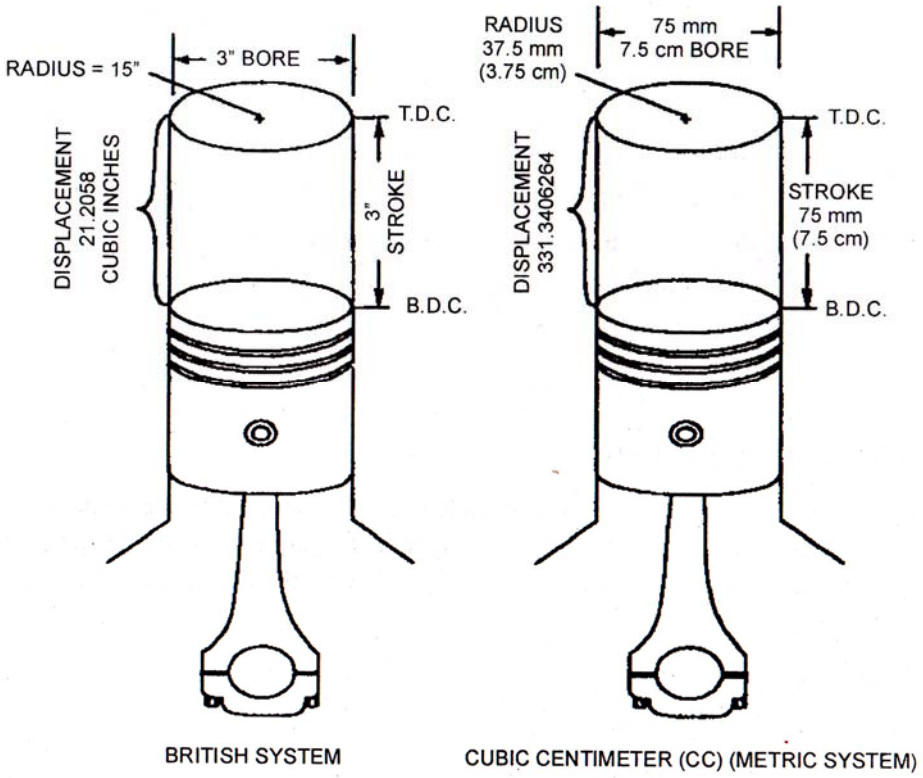


Fig : Engine Displacement

Session 3: Engine

Exercise: Assignment

1. List the components of an engine

S. No.	Name of component

2. Prepare a poster showing engine used in automobiles.

Session 3: Engine

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Full form of TDC is _____.
2. BDC full form _____.
3. Internal combustion engines_____ a fuel to create _____ which is then used to create motion.
4. Engine torque goes _____ the vehicle transmission system.

Session 3 : Engine

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for understanding of the engine.

Part A

- Share classification of engine used in a vehicle.

Part B

Discussed in class the following:

- Classification of engine
- Classification based on cylinder
- Capacity of an engine
- Name popular type of engine used in motor cycles.
- Importance of an engine.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of engines		
Able to classify the engine.		

Session 4: Lubrication System

Relevant Knowledge

In the previous level you studied about the object of lubrication in an automobile. In this level you are going to learn more about the lubrication system of an engine. We can say that the Lubrication system delivers oil to the moving parts of the engine to reduce friction and to assist in keeping the parts cool. The figure below shows the movement of oil to the different parts of an engine.

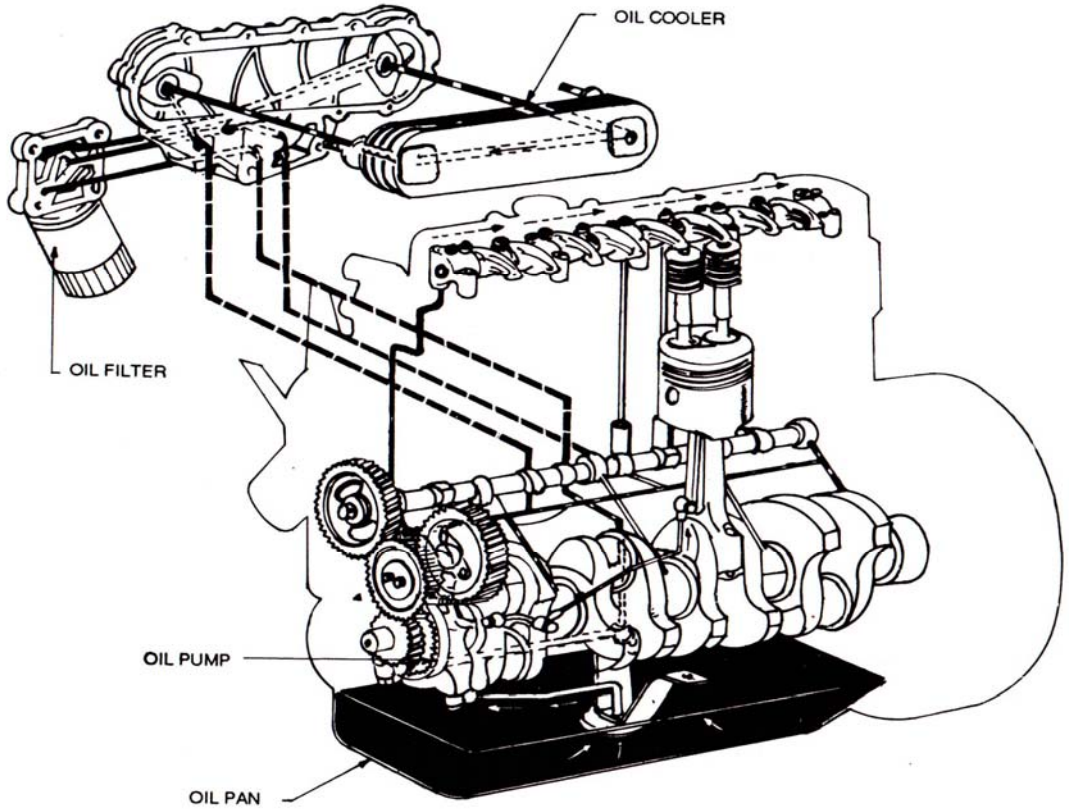


Fig : Lubrication System

Automobile Engine Lubrication

The main parts of an automotive engine which require lubrication are:

- Main crankshaft bearings
- Big end bearings
- Gudgeon pin bearings

- Piston rings and cylinder walls
- Timing Gears
- Camshaft and camshaft bearings

Properties of a good lubricant

As we understand that the lubricant is a very important component of an engine. We must know some of the properties. These properties are given here

1. **Viscosity:** In simple language, Viscosity may be considered as the resistance of the lubricating oil to flow. It is this property alone, due to which, the bearing surfaces are kept apart, i.e. hydrodynamic lubrication is maintained.

   The viscosity of the lubricating oil should be just sufficient to ensure hydrodynamic lubrication. A higher value than this would be of no use since it will involve higher power losses due to the increased oil resistance.

   The viscosity of the lubricating oil, at the time of starting the engine, should be low; otherwise the engine may not start. On the other hand with the engine running, the oil viscosity decreases due to increase of temperature, which is contrary to what is desirable, since at all operating temperatures, the viscosity should not fall below the minimum value required to maintain hydrodynamic lubrication. Therefore, the viscosity should ideally remain the same at all temperatures. Relative change of viscosity with temperature is called **viscosity index.** However, the viscosity of all the oils does vary with temperature and, therefore, the oil with minimum variation is preferred.

   Viscosity is the most important property of lubricants and they are mostly selected on the basis of their viscosity and temperature coefficient of viscosity (viscosity index).

2. **Physical Stability:** The lubricating oil must be stable physically at the lowest and the highest temperatures encountered in practice. There

should not be any separation of solids at the lower temperatures and at higher temperatures it should not vapourise beyond a certain limit.

3. **Chemical Stability:** At higher temperature the oil should remain chemically stable. There should not be any tendency for oxide formation; many of the oxidation products being sticky substances clog the lines and cause faulty piston rings and valve action.

   The oil should also not decompose at high temperatures to form carbon. Carbon thus formed, lowers rings efficiency, thus reducing engine compression. The spark plugs and the valves also do not function efficiently due to sticking of carbon particles.

4. **Resistance against Corrosion:** The oil should not have any tendency to corrode the pipe lines, crank case and other engine parts with which it comes into contact.

5. **Pour Point:** The minimum temperature at which the oil will pour is called its *pour point*. Obviously, since the oil will not be able to flow below the pour point, it cannot be used below this temperature for lubrication. Thus, the pour point of the oil should be less than the lowest temperature encountered in the engine.

   The pour point is the temperature at which a lubricant just ceases to flow when cooled under standard conditions. The lower the pour point, the better is the lubricant.

6. **Flash Point:** The flash point of the oil should be sufficiently high so as to avoid flashing of oil vapours at the temperatures occurring in common use. A flash point higher than the minimum desired value will not serve any useful purpose.

   Flash point of a lubricating oil is the minimum temperature at which it gives off sufficient vapour so as to form an explosive mixture with air. If the oil is heated further a stage will reach when it will begin to burn continuously on applying a flame to it. This temperature is called the fire point.

7. **Cleanliness:** The oil should be sufficiently clean and stable itself so that the crank case and oil lines are kept clean. Further it must contain agents, called detergents, which remove the impurities from the engine parts during oil circulation. These impurities may either be filtered out or removed with the change of oil at periodic intervals.

Types of Lubricants

Depending on widely varying requirements of different parts, the automotive lubricants may be classified as below.

1. **On the basis of their state**
   - Solid lubricant such as graphite, soapstone, talc, mica, molybdenum disulphide.
   - Semi-solid lubricants such as greases e.g., aluminium paste.
   - Liquid lubricants such as mineral oil, vegetable oils, animal oils.
   - Emulsions such as oil in water.
2. **On the basis of their origin**
   - Natural lubricants such as mineral oils, vegetable oils, animals oils, graphite.
   - Synthetic lubricants such as refined petroleum oils, commercial grade oils, grease.
3. **On the Basis of Variation in Viscosity**
   - Mono-grade oils such as SAE 20, SAE 30, SAE 50 etc.
   - Multi-grade oils such as SAE 20W 40, SAE 15W 40 etc.
4. **On the basis of special preparation**
   - Blended lubricants such as blended by castor oil, palmitic acid, oleic acid.
   - Compounded lubricants such as compounded with polyglycols, fluorocarbons, silicones.

Session 4: Lubrication System

Exercise: Assignment

1. List the parts which require lubrication

S.No.	Name of parts

2. Prepare a poster showing lubrication system.

Session 4: Lubrication System

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Lubrication system delivers oil to the moving parts of the engine to reduce friction
2. Viscosity of the lubricating ___ should be just sufficient to ensure _____ lubrication.
3. At higher _____-the oil should remain _____ stable.
4. Flash point of a _____oil is the minimum _____at which it gives off sufficient _____ so as to form an explosive mixture with air.

B. Tick the odd answer

1. Natural lubricants is made of.
   A. Mineral oil
   B. Vegetable oil

C. Animal oil
D. Aluminum

2. A synthetic lubricant is made from
A. refined petroleum oils
B. commercial grade oil
C. grease
D. water

3. Lubrication is used for reducing
A. friction
B. cooling part
C. decrease in temperature
D. spare parts

Session 4: Lubrication System

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for understanding the lubrication system.

Part A

- Share importance of the lubrication used in a vehicle.

Part B

Discussed in class the following:

- What is the meaning of lubricants?
- What are the different types of lubricant used in automobiles?
- Differentiate between different types of lubricants.
- Flash point and Pour point – explain.
- Importance of properties of lubricants.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of lubrication		
Able to identify general lubricants		

Session 5: Cooling System
Relevant Knowledge

In the previous level you learnt about only the function of the cooling system and its necessity. In this level you will learn more about the cooling system.

All the heat produced by the combustion of fuel in the engine cylinders is not converted into useful power at the crankshaft. A typical distribution for the fuel energy is given below:

Useful work at the crank shaft	= 20 percent
Loss to the cylinders walls	= 35 percent
Loss in exhaust gases	= 35 percent
Loss in friction	= 10 percent

It is seen that the quantity of heat given to the cylinder walls is considerable and if this heat is not removed from the cylinders it would result in the pre-ignition of the charge. In addition, the lubricant would also burn away, thereby, causing the seizing of piston. Excess heating will also damage the cylinder material.

Keeping the above factors in view, it is observed that suitable means must be provided to dissipate the excess heat from the cylinder walls, so as to maintain the temperature below certain limits. The engine gives best performance at temperature from 70 to 85 degree Celsius, which is called the optimum temperature limit. In optimum temperature limit the engine overhaul efficiency is highest.

Methods of Cooling

Various methods used for cooling of automobiles engine are:

- **Air Cooling:** The basic principle involved in this method is to have the current of air flowing continuously over the heated metal surface from where the heat is to be removed. The heat dissipatione depends upon following factors:
  1. Surface area of metal in contact with air.
  2. Mass flow rate of air.

3. Temperature difference between the heated surface and air.
4. Conductivity of metal used for engine.

   Use of copper, aluminum and steel alloys has been made to improve heat transfer because of their better thermal conductivity.

- **Water Cooling:** In water cooling, the engine cylinders are surrounded by water jackets through which the cooling water flows. Heat flows from the cylinder walls into water which goes to the radiator where it loses its heat to the air.
  Water cooling systems are of two types:
  (a) Thermo-siphon System
  (b) Pump Circulation System

In the modern automobiles, pump circulation system is employed because in this system the required size of the radiator is much smaller than the thermo-siphon system and the cooling is also faster.

Other Methods of Cylinder Cooling

Apart from the two widely used methods, i.e. air cooling and water cooling as discussed above, various other methods have been used to increase the cooling efficiency according to the need of the circumstances. The methods are:

- **Liquid cooling:** Sometimes instead of water, other liquids having higher boiling points are used for engine cooling. The examples are glycerin (boiling point 290^0C) and ethylene glycol (b.p. 195^0C). Higher boiling point increases the capacity of the liquid to carry heat and consequently weight of the coolant and hence that of the radiator is decreased.

- **Pressure sealed cooling:** The boiling point of water is raised at higher pressures, with consequent reduction in coolant and the radiator weights and greater thermal efficiency of the engine due to higher operating temperatures. For approximately 10 kN/m^2 increase in pressure, the boiling point is raised by 2.5^0C. To achieve this special

pressure, a sealed radiator cap is used. The pressure blow off valve opens when the pressure in the system exceeds a certain predetermined value, say 50 kN/m^2. A vacuum valve is provided to safeguard against the radiator collapse due to vacuum if the steam inside suddenly condenses to form a vacuum.

In some engines, instead of an overflow pipe, an expansion reservoir is provided. This is so connected with the radiator that it receives the excess cooling water as the engine temperature and hence the cooling water temperature increases. When the cooling water cools down, its volume decreases and the cooling water in the reservoir returns to the radiator. The reservoir is usually made of translucent plastic so that it can indicate the level of the coolant anytime.

Advantages of Pressure sealed cooling system

- There is no loss of coolant.
- Cooling efficiency of the system is not decreased at high altitudes, where due to low temperature pressure; the boiling point is otherwise low.

Components of Cooling System

The cooling system is made up of the passages inside the engine block and heads, a water pump to circulate the coolant, a thermostat to control the temperature of the coolant, a radiator to cool the coolant, a radiator cap to control the pressure in the system, and some plumbing, consisting of interconnecting hoses to transfer the coolant from the engine to radiator.

- The Radiator
- Radiator Cooling Fans
- Pressure Cap & Reserve Tank
- Water Pump
- Thermostat
- Bypass System
- Freeze Plugs
- Head Gaskets & Intake Manifold Gaskets

- Hoses

How Does a Cooling System Work?

A cooling system works by sending a liquid coolant through passages in the engine block and heads. As the coolant flows through these passages, it picks up heat from the engine. The heated fluid then makes its way through a rubber hose to the radiator in front of the car. As it flows through the thin tubes in the radiator, the hot liquid is cooled by the air stream entering the engine compartment from the grill in front of the car. Once the fluid is cooled, it returns to the engine to absorb more heat. The water pump has the job of keeping the fluid moving through this system of plumbing and hidden passages.

A thermostat is placed between the engine and the radiator to make sure that the coolant stays above a certain preset temperature. If the coolant temperature falls below this temperature, the thermostat blocks the coolant flow to the radiator, forcing the fluid instead through a bypass directly back to the engine. The coolant will continue to circulate like this until it reaches the design temperature, at which point, the thermostat will open a valve and allow the coolant back through the radiator.

Session 5: Cooling System

Exercise: Assignment

1. List the components of cooling system

S.No.	Name of component

2. Prepare a poster showing tools used in automobiles.

Session 5: Cooling System

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Quantity of ____given to the cylinder walls is _____ and if this heat is not removed from the cylinders it would result in the _____ of the charge
2. in Air Cooling, current of air flowing _____ over the heated metal surface from where the _____ is to be removed.
3. A thermostat is placed _____ the engine and the _____.
4. As the coolant _____ through these passages, it picks up _____ from the engine.

B. Tick the correct answer

1. Coolant is made of.
   A. Oil
   B. Water
   C. Chemical
   D. Liquid

2. Coolant is used for
   A. Heating the engine
   B. Cooling the engine
   C. Firing the engine
   D. Freezing the engine

3. It is not the part of cooling system
   A. The Radiator

B. Radiator Cooling Fans
C. Pressure Cap & Reserve Tank
D. Bonnet
E. Thermostat

Session 5: Cooling System

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for pollution control.

Part A

- Share importance of cooling system in a vehicle.

Part B

Discussed in class the following:

- What is the meaning of cooling system?
- What are the different components of cooling system used in an automobile?
- Differentiate between air and water cooling.
- Liquid cooling and Pressure sealed cooling.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of cooling system		
Able to identify general component of cooling system		

Session 6: Fuel Supply System
Relevant Knowledge

In the previous level, you studied the names of different components of fuel supply system for SI engine and CI engine. In this level you are going to learn more about the same.

It was already discussed that the basic fuel supply system in an automobile with a petrol engine, consists of a fuel tank, fuel lines, fuel pump, fuel filter, air cleaner, carburetor and inlet manifold. Now, let us discusses about different types of fuel supply system.

Types of Fuel supply system

- **Gravity System**: In this system, the fuel tank is mounted at the highest position from where the fuel drops into the carburetor float chamber by gravity. The system is very simple and cheap, but the rigidity of placing the fuel tank necessarily over the carburetor is a disadvantage.

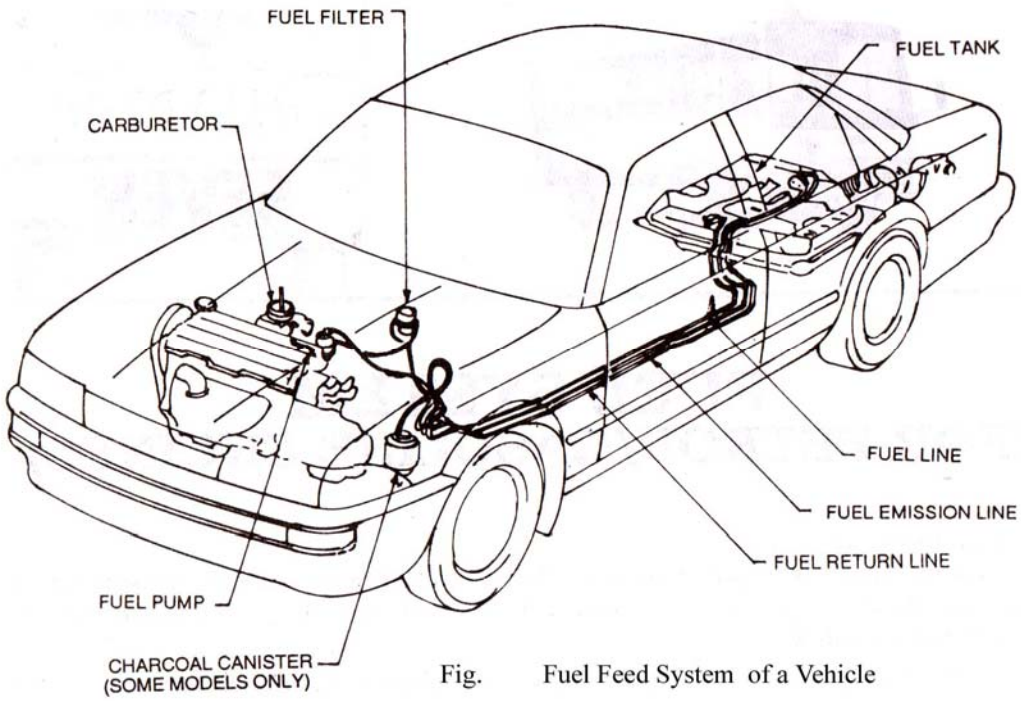


Fig. Fuel Feed System of a Vehicle

Pressure System: In the pressure system, a hermitically sealed fuel tank is used. Pressure is created in the tank by means of engine exhaust or a separate air pump. For starting, the pump is primed by hand. It is under the pressure thus produced, that, the fuel flows to the float chamber of the carburetor. There are chances of pressure leak, but, the advantage lies in the fact the fuel tank can be placed at any suitable location.

- **Vacuum System**: This system is based upon the simple fact that the engine suction can be used for sucking fuel from the main tank to the auxiliary fuel tank from where it flows by gravity to the carburetor float chamber.

- **Pump System:** In this system, a steel pipe carries petrol to the fuel pump which pumps it into the float chamber of the carburetor through a flexible pipe. If the fuel pump is mechanical, it has to be driven from the engine camshaft and hence placed on the engine itself. However, electrically operated fuel pump can be placed anywhere, the rear location (away from the hot engine) reducing the tendency of forming vapour lock.

- **Fuel Injection System:** The petrol injection system has been used successfully on some modern vehicles (MPFI engines). In this system, the carburetor is dispensed with altogether. The fuel is atomized by means of a nozzle and then delivered into an air stream. Separate fuel injection system is used for each cylinder which controls the mixture under different load and speed conditions.

Session 6: Fuel Supply System

Exercise: Assignment

1. List the components of the fuel supply system

S.No.	Name of components

2. Prepare a poster showing the fuel feed system of a vehicle.

Session 6: Fuel Supply System

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Fuel supply system in an _____ with petrol engine consists of a fuel tank, fuel lines, fuel pump, fuel filter, air cleaner, carburetor and inlet manifold.
2. In the Gravity System, the fuel tank is mounted at the _____ position.
3. In the pressure system, a hermitically sealed _____ is used.
4. Petrol injection system has been used _____ on MPFI engines.

Session 6: Fuel Supply System

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for Fuel Supply System

Part A

- Share importance of the Fuel supply system of a vehicle

Part B

Discussed in class the following:

- Different types of fuel supply system used in a vehicle.
- Difference between gravity and pressure system.
- Write the importance of pressure system.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of fuel supply system		
Able to identify fuel supply system of a vehicle		

Session 7: Transmission System

Relevant Knowledge

In the previous level, you studied very little about the Transmission System. In this level, you are going to learn more about those systems, i.e. Clutch Assembly, Gear Box Assembly and Propeller Shaft.

Clutch Assembly

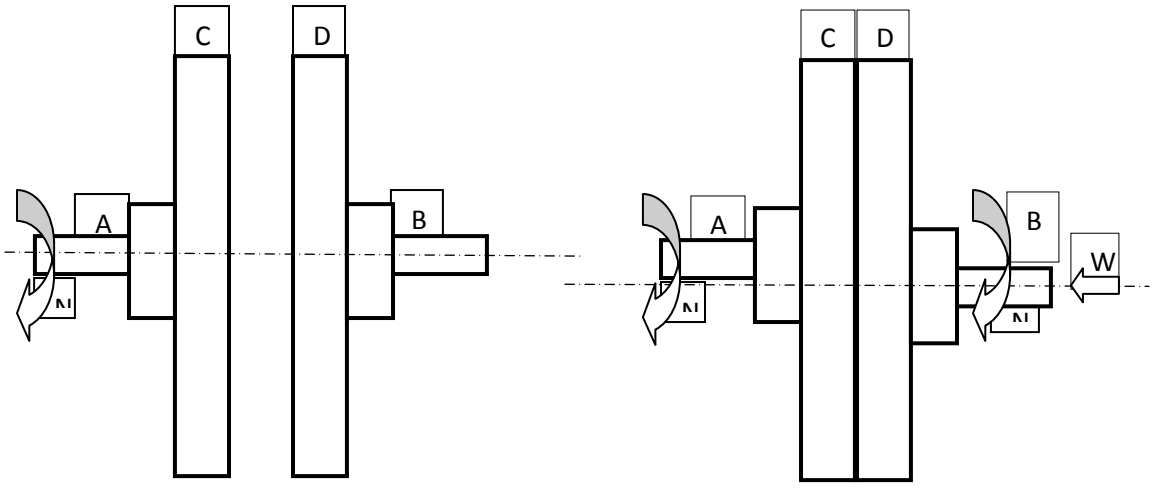
You have already studied functions of clutch, requirements of clutch and its main components. Now let us learn more about the Clutch Assembly.

Types of clutch

Different types of clutches are as follows:

1. Friction Clutch
   - Single plate clutch
   - Multiplate clutch
     - ❖ Wet
     - ❖ Dry
   - Cone clutch
     - ❖ External
     - ❖ Internal
2. Centrifugal Clutch.
3. Semi-centrifugal Clutch.
4. Conical Spring Clutch or Diaphragm Clutch
   - Tapered finger type
   - Crown spring type.
5. Positive Clutch – Dog and spline Clutch
6. Hydraulic Clutch
7. Electro-magnetic Clutch.
8. Vacuum Clutch
9. Over running Clutch or free-wheel unit.

Principle of Friction Clutches



The Principle of a friction clutch may be explained by means of above figure.

Let shaft A and disc C be revolving at some speed, say N r.p.m. Shaft B and the disc D keyed to it are stationary, initially when the clutch is not engaged. Now apply some axial force W to the disc D, so that, it comes in contact with disc C. As soon as the contact is made the force of friction between C and D will come into play and consequently the disc D will also start revolving. The Speed of D depends upon friction force present, which in turn, is proportional to the force W applied. If W is increased gradually, the speed of D will be increased correspondingly, till the stage comes when, the speed of D becomes equal to the speed of C. Then, the clutch is said to be fully engaged.

Let W = axial load applied

T = torque transmitted

R = effective mean radius of friction surface.

Then $T = \mu WR$

Thus, we see that the torque transmitted by a friction clutch depends upon 3 factors i.e., μ W and R. This means that increasing any or all of the above

factors would increase the amount of torque which a clutch can transmit. However, there are upper limits in each of these cases.

GEAR BOX (TRANSMISSION) ASSEMBLY

The functions of Gear Box have been discussed in the previous level. In this level, you are going to learn more about the transmission.

Need of a Gear Box

An auto-vehicle has to run on roads of various qualities and types, and at varying speeds. It also encounters with vivid nature of tyre-road adhesion, on level and sloped roads. Having different body profiles, various driving needs such as idling and quick acceleration etc., and widely varying driving habits of drivers, the vehicles have to overcome several resistances also. Moreover, they also meet the variations in tractive effort at various speeds. Various resistances encountered by the auto-vehicle during its operation are

1. **Rolling resistance** which mainly depends upon
    - material of the road surface : cemented, asphalted etc.
    - quality of the road surface : smooth or rough, dry or wet etc.
    - material and design of tyres tread
    - inflation (pressure) in the tyre : over-inflated, under-inflated, or correctly inflated
2. **Gradient resistance** which mainly depends upon
    - slope of the road : level, sleepy, down-a-hill, up-the-hill etc.
    - mass of the vehicle : light, medium or heavy
3. **Air resistance** which mainly depends upon
    - speed of the vehicle : slow, medium or fast
    - speed and direction of the wind : in-favour, against the vehicle's motion or cross-winds
    - body profile of the vehicle : streamlined, bluff body or otherwise
4. **Resistance due to driving requirements** which mainly depends upon
    - need of idling, or constant speed
    - acceleration and its rate
    - driving habits

- frictional resistance

Sum of all these resistances is known as Total Resistance

Types of Transmission (Gearbox)

Several kinds of transmissions are employed on auto-vehicles. These can be classified as follows.

1. **Manual Transmission**

The manual transmission i.e., the selective type gearboxes are the conventional means. They are widely used in cars, bases and trucks. It is also known as standard or conventional type Gear box.

- Sliding mesh gear box
- Constant mesh gearbox
- Synchromesh gearbox without overdrive
- Synchromesh gearbox with overdrive

2. **Semi-automatic transmission**

Semi-automatic transmission incorporates an intermediate arrangement which is combination of manual and automatic systems.

- Electric controlled with a fluid drive
- Electric controlled with overdrive
- Fluid-torque drive

3. **Automatic Transmission**

Automatic transmission is used mainly on luxury cars, or heavy vehicles which require frequent change of gears in the city and crowded highway driving. In automatic transmission, the different ratios between the engine crankshaft and the wheels are achieved by automatic means. The driver does not need to shift gears, such transmission make use of a fluid coupling or torque converter, as well as mechanical, hydraulic or electrical controls.

- Hydromatic drive
- Torque-converter drive

Principle of Gearing

A simple Gearing principle is shown below where two gear are engaged each other. Gear A is called driving gear or driver and gear B is called driven gear.

Suppose,

N_A = speed of gear A T_A = number of teeth on gear A

N_B = speed of gear B T_B = number of teeth on gear B

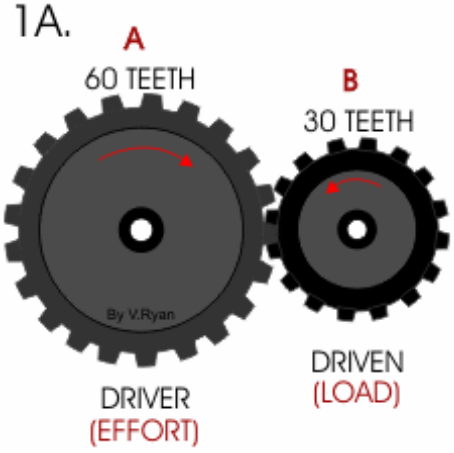
Therefore, the speed ratio of gear A and gear B is

$$\frac{N_B}{N_A} = \frac{T_A}{T_B}$$

With the following example, the principle of gearing will be very clear to you.

In the example below, the DRIVER has 60 teeth and because it is the largest we say that it revolves once. The DRIVEN gear has 30 teeth. Simply divide 60 teeth by 30 teeth to work out the number of revolutions of the driven gear.

1A.



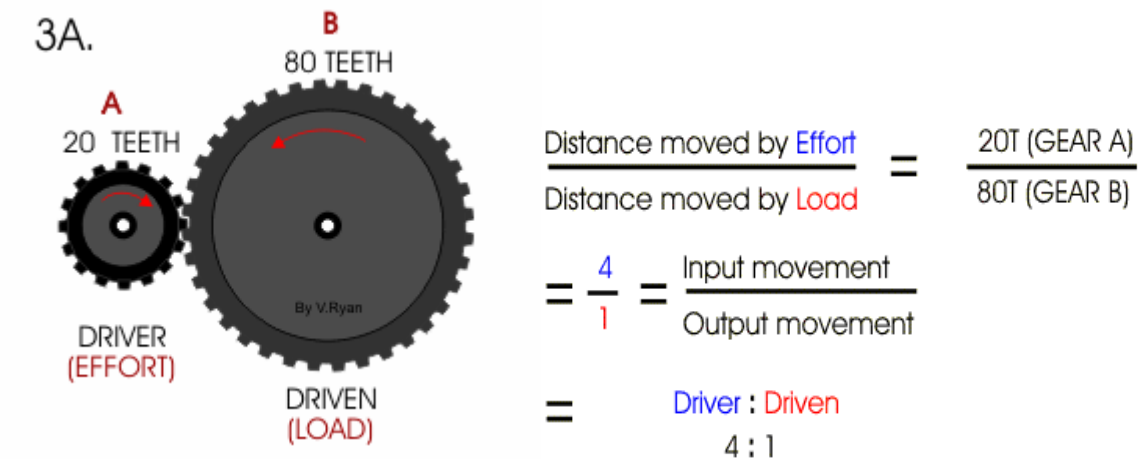
Work out the Velocity Ratio (Gear Ratio);

$$\frac{\text{Distance moved by Effort}}{\text{Distance moved by Load}} = \frac{25\text{T (GEAR A)}}{75\text{T (GEAR B)}}$$

$$= \frac{3}{1} = \frac{\text{Input movement}}{\text{Output movement}}$$

$$= \text{Driver : Driven}$$

$$3 : 1$$



Propeller Shaft and Universal Joint

The rotary motion of the transmission main shaft is carried out through the propeller shaft to the differential casing, the rear wheels to rotate. The propeller shaft has to withstand the torsional stresses of the transmitting torque and yet, it must be light and well balanced so that vibrations and whip will not occur at high speeds. For these reasons, it is made of a strong steel tube. Solid propeller shafts are also used. Some applications include bearings at or near the propeller shaft center to support the shaft. On some applications, the propeller shaft is in two sections, supported by a center bearing and coupled together by universal joint.

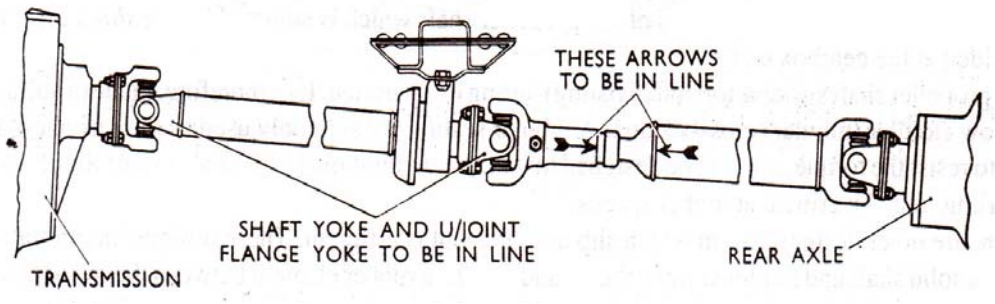


Fig : Arrangement of a Two-Piece Propeller Shaft

It is to be noted that the transmission main shaft and the differential pinion shaft are not in one horizontal level. The rear axle housing with differential is attached to the frame by springs, therefore, the distance

between the gear box and the differential, changes due to road irregularities. This also changes the angle of driver. In order that the propeller shaft must take curve of these two changes it is provided with one or more universal joints to permit variations in the angle of drive. Also, it must be provided with a sliding joint that permits the effective length of the propeller shaft to change.

Requirements of a Propeller Shaft

For efficient discharge of its functions, the following requirements are expected in a propeller shaft.

- High torsional strength (therefore, they are made circular in cross-section, preferably hollow circular).
- Toughened and hardened (they are generally induction hardened).
- Efficiently welded (they are generally welded by submerged arc CO_2 process).
- Dynamically balanced (they are tested on electronic balancing machine).
- Least stress concentration (the fillet radius is ground on centreless grinding machine).
- Reduced thrust loads under high torque.
- Higher fatigue life (to achieve it, they are made of superior quality steel).

Note : The size selection of propeller shaft depends on the following basic parameters

- Continuous operating torque
- Continuous true running angles
- Desired service life
- Power source

Universal Joints

An universal joint is used where two shafts are connected at an angle to transmit torque. In the transmission system of a motor vehicle, the transmission main shaft, the propeller shaft and the differential pinion shaft

are not in one line, and hence the connections between them are made by universal joint which is used to connect the transmission main shaft and the propeller shaft. The other universal joint which is used to connect the other end of the propeller shaft and the differential pinion shaft. Thus, connections between the three shafts are flexible and at an angle with each other. The universal joint permits the torque transmission not only at an angle, but also while this angle is changing constantly.

A simple universal joint consists of two Y-shaped yokes, one on the driving shaft and other on the driven shaft, and a cross-piece called the spider. The four arms of spider, known as trunions, are assembled into bearings in the ends of the two shaft yokes. The driving shaft and the driven shaft are at an angle to each other, the bearings in the yokes permits the yokes to swing around on the trunnions with each revolution.

A simple universal joint does not transmit the motion uniformly when the shafts are operating at an angle, except in constant velocity type universal joint. Because, the pivot pins do not revolve in the same plane, the driven shaft will increase to a maximum and decrease to a minimum, twice in each revolution. Although the degree of variation is small, it may be minimized by the use of two universal joints. The two joints are arranged so that the non-uniform rotation of each joint tends to neutralize that of the other.

Types of Universal Joints

In automobiles, the following types of universal joints are used.

- Cross
- Constant velocity
- Rubber coupling
- Pot type joints
- Lay rub type joints

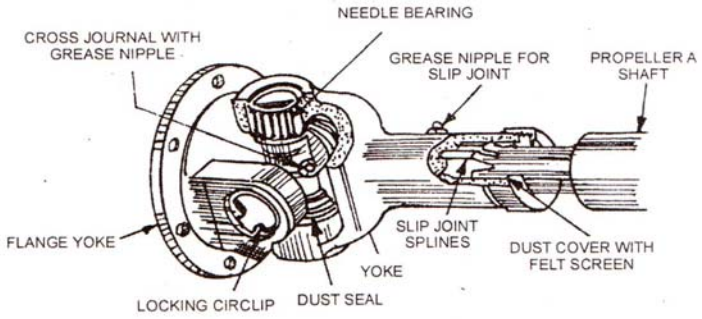


Fig. Universal joint assembly.

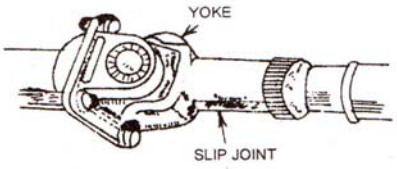


Fig. Universal joint as fitted to Propeller shaft.

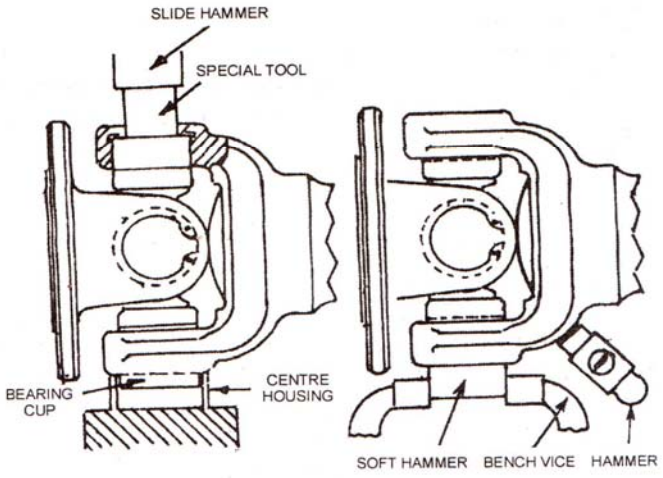


Fig. Removing cups from half shaft yoke.

Session 7: Transmission System

Exercise: Assignment

1. List the types of clutch

S.No.	Types of clutch

2. Prepare a poster showing principle of friction clutches

Session 7: Transmission System

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. An universal joint is used where two shafts are connected at an angle to _____torque
2. A simple universal joint consists of two _____ yokes, one on the driving shaft and other on the _____ shaft, and a cross-piece called the _____.
3. Automatic transmission is _____mainly on luxury cars, or heavy vehicles which require _____change of gears in the city and crowded highway driving.
4. The rotary motion of the_____ main shaft is carried out through the _____ shaft to the differential casing, the rear wheels to rotate.

B. Tick the correct answer

1. In automobiles, the following types of universal joints are used.
   A. Cross type
   B. Constant velocity type
   C. Non Rubber coupling
   D. Pot type joints
   E. Lay rub type joints

2. Size selection of propeller shaft depends on
   A. Continuous operating torque
   B. Continuous true running angles
   C. Desired service life
   D. Non power source

3. Air resistance depends upon
   A. speed of the vehicle
   B. speed and direction of the wind
   C. body profile of the vehicle
   D. fuel used in the vehicle

Session 7: Transmission System

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for pollution control.

Part A

- Share the importance of a transmission system used in workshop.

Part B

Discussed in class the following:

- Various resistances encountered by auto vehicle during its operation.
- Different types of transmissions used in automobiles
- Differentiate between propeller shaft and universal joint.
- Requirements of propeller shaft
- Function of front axle.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of transmission system		
Able to identify general components of transmission system		

Session 8: Front Axle

Related Information

Axle is a central shaft for a rotating wheel or gear. Axles are an integral component of a wheeled vehicle.

Function of the Front Axle

- It carries the weight of the front of the vehicle.
- It carries stub axle king pin steering arm by which the vehicle can be steered.
- It works as cushion through its spring for a comfortable ride.
- It controls the ride through shock absorber fitted on it.
- It carries the brake system with which the moving vehicle can be stopped.
- In case of a four wheel drive, it also transmits power to road wheels. It carries hubs and wheels.

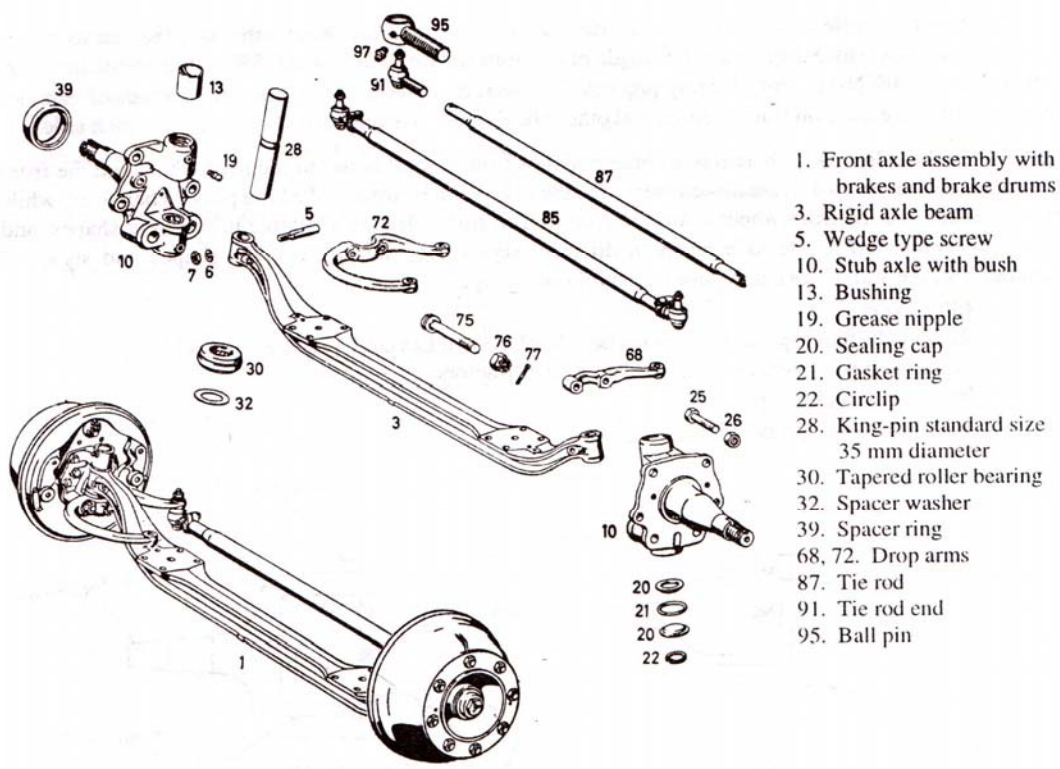


Fig : Exploded view of a heavy duty front axle used on a Tata truck

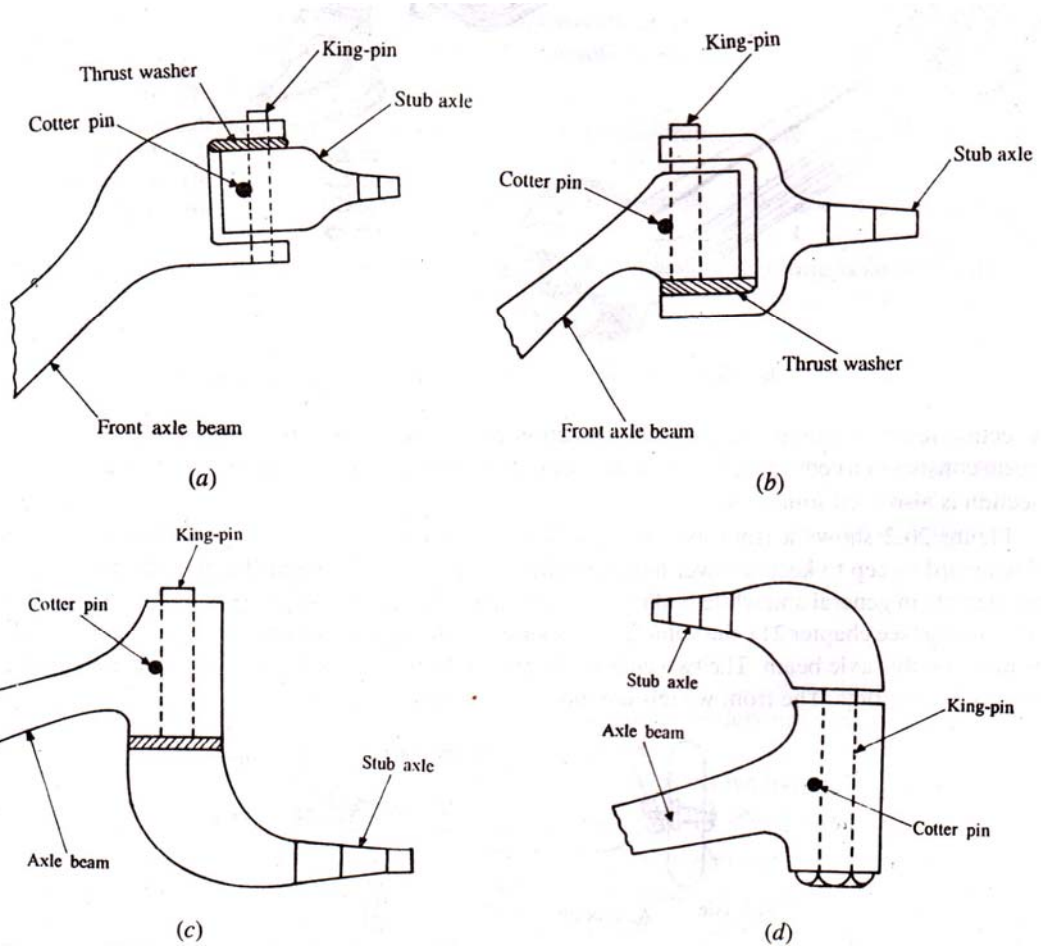


Fig : Different types of stub axles (a) Elliot Type, (b) reverse Elliot type, (c) lamoine type, and (d) reverse lamoine type

Types of Front Axle

- **Live front axle** (used for front wheel drive and 4X4 type of drive).
- **Dead front axle** (used for 4X2 type of drive).

Types of Arrangement of Front Axle

There are two types of Front Axle arrangements employed on automobiles which, are as follows:

1. **Stub-axle with rigid axle beam type:** This type was used earlier on all types of vehicles, but now it finds use on medium and heavy commercial vehicles only, such as trucks and buses.

2. **Stub-axle without rigid axle beam type**: It is widely used on cars and light commercial vehicles.

Rigid Axle Beam:

The rigid axle beam is a stationary structural member used to sustain bending and torsional loads and to connect the stub axles. The bending is induced in its central region and due to the vehicle's weight the torsional loads are caused near its ends due to the wheel's braking. Since the I-section resists bending and the circular section can resists torsion more efficiently, the axle beam consists of a central region made of I-section and the ends of circular section. An elliptical section is also used sometimes.

Stub Axle:

A stub axle is an inter-mediatory small shaft between the road wheel and the front (dead) axle. On one end it remains connected to the axle beam by means of a king pin or a ball joint, while the other end, the front wheel is mounted on it. The stub axles are available in different shapes and they are connected to the axle beam in different styles. Depending upon the shapes, and styles of connection, the stub axles can be one of the following types.

1. Elliot types
2. Reversed Elliot type as used on Eicher 10.90, Ashok Leyland Vicking, Tata 407 etc.
3. Lamoine type generally used on front axle of tractors.
4. Reversed lamoine type

Session 8: Front Axle

Exercise: Assignment

1. List the functions of the front axle

S.No.	Functions of front axle

2. Prepare a poster showing parts of axle used in automobiles.

Session 8: Front Axle

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Axle is used for_____.
2. A stub axle is an inter-mediatory _____ between the road wheel and the front (dead) axle.
3. Rigid axle beam is a stationary _____ member.
4. In a four wheel drive, the front axle transmits _____ to road wheels.

Tick the correct answer

1. Front axle is made of.
   A. Iron
   B. Wood
   C. Steel
   D. Aluminum

2. A stub axle is used for
   A. tightening the bolt
   B. opening the nut
   C. rotating wheel
   D. folding the nut

Session 8: Front Axle

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for front axle.

Part A

- Share importance of front axle of a vehicle.

Part B

- Discussed in class the following:
  - What is meaning of front axle?
  - What are the different types of axles used in automobile?
  - Differentiate between Stub-axle with rigid axle beam type and Stub-axle without rigid axle beam type?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of front axle		
Able to identify front axle		

Session 9: Steering System

Related Information

In the previous level you studied the functions of the steering system and its layout. In this level, you will learn more about the steering system.

Requirements of Steering System

For smooth performance of the system, the steering system of any vehicle should fulfill the following requirements:

- It should multiply the turning effort applied on the steering wheel by the driver.
- It should be to a certain degree irreversible so that the shocks of the road surface encountered by the wheels are not transmitted to the driver's hands.
- The mechanism should have self-rightening effect so that when the driver releases the steering wheel after negotiating the turn, the wheel should try to achieve straight ahead position.

The readers may bear in mind that the requirements of any system may vary, but, they should have some kind of average compromise.

Types of Steering System

On the basis of mode of effort application the steering system is divided into two categories

- Mechanical Linkage Type Steering System
- Power Steering System: In this type hydraulic fluid with some mechanism is used for the operation.

Steering Gears

To accomplish the turning of road wheels by few degrees, it rotates the steering wheel many times. All these are possible only by use of a steering gear. A steering gear serves two main functions.

- It transforms rotary motion of the steering wheel into the reciprocating motion of the drag link.
- It assists in multiplying a small effort applied at the steering wheel into a much greater force on the drag link.

Types of Steering gear

To perform the above two jobs, several types of steering gear systems are employed on automobiles. Important and commonly used systems among them are the following :

- Worm and worm-wheel type steering gear.
- Worm and worm-sector type steering gear as in earlier Austin small cars.
- Worm and nut type steering gear as in Swaraj Mazda.
- Worm and roller type steering gear as tn Premier Padmini SI and Diesel cars, DJ series jeeps
- Re-circulating steel balls type steering gear as in Tata 1210, Dodge/Fargo 89 M4, Omni, Eicher 10.70, Tata 407, Tempo Excel-4 pick up truck.
- Worm and peg (or cam) type steering gear as in Ford FS 16C truck, Morgan Plus 8.
- Rack and pinion type steering gear as in Maruti 800 Ambassador Diesel, Standard Herald Mark III, Chrysler Alpine cars (UK), A.C. sports cars (UK), Cielo, Fiat Uno, Zen, Terios.

In most of the above types a worm is the basic component which is used in conjunction with wheel, wheel sector, or nut etc.

Session 9: Steering System

Exercise: Assignment

1. List the functions of steering

S.No.	Functions of steering

2. Prepare a poster showing parts of steering used in automobiles.

Session 9: Steering System

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Steering is used for_____.
2. A steering gear serves____ main functions.
3. Steering gear transforms _____ of the steering wheel into the _____ of the drag link.
4. Several types of steering _____ systems are employed on automobiles.

Session 9: Steering System

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for pollution control.

Part A

- Share the importance of steering system of a vehicle.

Part B

Discussed in class the following:

- What is use of steering?
- What are the different types of steering gear used in automobiles?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of steering		
Able to identify steering system		

Session 10: Rear Axle
Related Information
Final Drive

The functions of the final drive are to provide a permanent speed reduction and also to turn the drive round through 90^0. The reduction provided is about 4:1 in cars and 10:1 in heavier vehicles. This is done either in one or two stages. For lesser reduction, say unto about 7:1, single reduction is used, while higher reductions are achieved in two steps. The double reduction has to be resorted to, because, otherwise the size of the larger gear becomes too much.

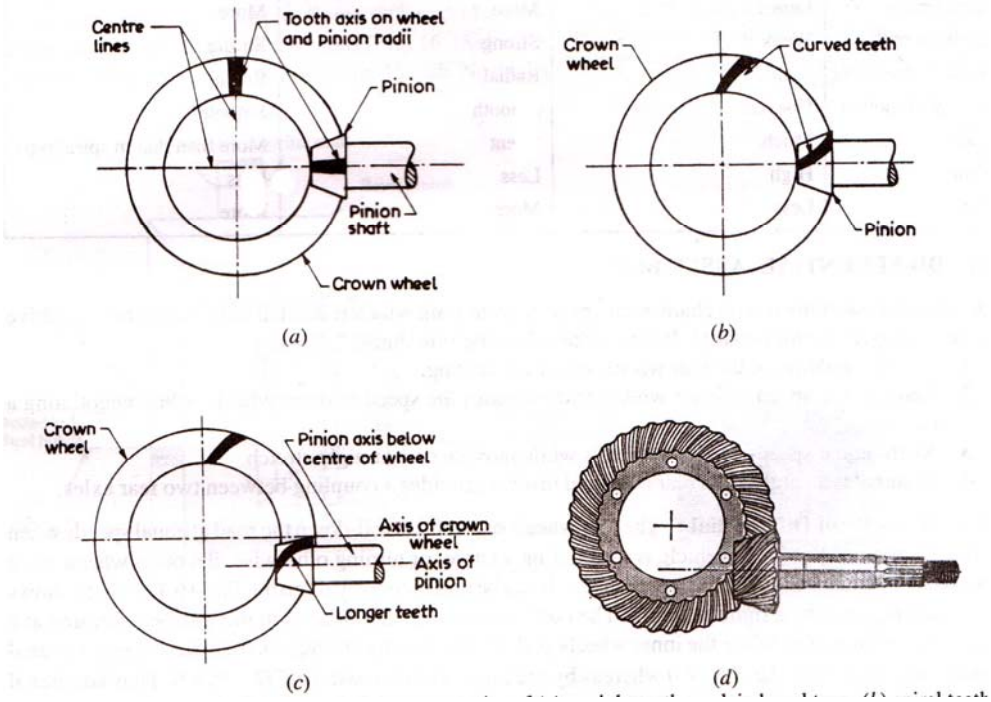


Fig : Crown wheel and bevel pinion geometries of (a) straight teeth or plain bevel type, (b) spiral teed bevel type, (c) hypoid seeth bevel type, and (d) off-centre hypoid-bevel type.

The final drive, in practice, consists of a bevel pinion and a crown wheel. The bevel pinion mounted on a shaft which is connected to the propeller shaft generally through a universal joint. From the crown wheel the drive goes to the differential. Three types of gears are used for the final drive gearing:

- **Straight Bevel Gears:** These contain the straight teeth. They are therefore simplest and thus the cheapest of all types.
- **Spiral Bevel Gears:** The spiral bevel gears have curved teeth which result in greater contact of the teeth. Because of this the spiral bevel gears are silent running and stronger than the straight bevel gears.
- **Hypoid Gears:** These types of gears are widely used for final drive these days. As is clear from the case of hypoid gears, the pinion shaft is placed below the axis of the crown wheel. This permits a lower position of the propeller shaft, thus allowing a low chassis height. The obvious disadvantage is less ground clearance. Further, these are comparatively expensive, difficult to assemble and need special high pressure lubricant because of greater sliding action present in this case.

Session 10: Rear Axle

Exercise: Assignment

1. List the functions of rear axle

S.No.	List of functions

2. Prepare a poster showing tools used in automobiles.

Session 10: Rear Axle

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Real axle is used for_____.
2. From the crown wheel the drive _____ to the differential.
3. Hypoid Gears are widely _____ for final drive these days.
4. The functions of the final drive are to _____ a permanent speed _____and also to turn the drive _____ through 90^0.

Session 10: Rear Axle

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for pollution control.

Part A

- Share the importance of the steering wheel.

Part B

Discussed in class the following:

- What is meaning of steering?
- Types of gear used in steering.
- Straight Bevel Gears and Spiral Bevel Gears

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of steering in a vehicle		
Able to identify general steering of a vehicle		

Session 11: Suspension System

Relevant Knowledge

In the first level you learnt about objects and functions of suspension system and various components and types of suspension system. In this level you will learn more about the same.

Suspension System

After the engine of a vehicle it is the suspension system that holds prime importance because it is the harbinger of a comfortable ride. The suspension system minimizes the impact of a particular road condition providing a safe drive to the occupants of the vehicle. This might sound pretty simple but when you come to think of it seriously it is not as simple. When acceleration comes into force and force translates into raw energy, this energy travels through the frame of the vehicle .without coils and springs, To absorb this, the vertical energy would cause the vehicle to jump up off the road, reducing tyre friction and control, which would result in a heavy bounce back downwards by the car with even greater force, which could be very dangerous. Coil spring and leaf springs absorb all forces and keep the tyres firmly planted to the ground so that the tyre always remains in contact with the ground.

The term suspension is given to the springs, shock absorbers and linkages that connect a vehicle to its wheels. The suspension system mainly serves the purpose of providing safety to the car by minimizing jerks and provides comfort to the occupants of the vehicle.

Principle of the Suspension System

- To restrict road vibrations from being transmitted to the various components of the vehicle
- To protect the passengers from road shocks
- To maintain the stability of the vehicle in pitching and rolling

Components of the Suspension System

- **Control Arm:** A movable lever, that fastens the steering knuckle to the frame of the vehicle.

- **Control Arm Busing:** This is a sleeve which allows the control arm to move up and down on the frame.
- **Strut Rod:** Prevents the control arm from swinging forward and backwards.
  Ball Joints: A joint that allows the control arm and steering knuckle to move up and down and sideways as well
- **Shock absorbers or Struts:** prevents the suspension from bounce after spring compression and extension
- **Stabilizer Bar:** Limits body roll of the vehicle during cornering
- **Spring:** Supports the weight of the vehicle

Common problems of the suspension system

- **Shocks and Struts:** Shocks and Struts are located behind the wheels of a vehicle. They are subject to wear and tear just like other vehicle parts. The signs of a shock wear out are, the car bouncing excessively, leanings hard in corners and jerking at brakes. The sign indicates thatn the shocks and struts are definitely calling for a change.
- **Ball joints:** The wearing out of ball joints can get dangerous because if they separate they cause you to lose control over the vehicle which could also be a life risk

Preventive Measures

The shocks and struts should be checked frequently for leakages Ball joints should be checked immediately, incase the motion of the car is not right. Make sure to lubricate the ball joints of your car frequently.

Terminologies Related with Suspension System

For a better understanding of this chapter, some terms related to suspension system are explained below:

- **Pitching, Rolling and Bouncing:** When a moving vehicle comes across a road pit or a bump, it experiences a jolt. Consequently, the vehicle stars vibrating and exhibits tendencies of undesired motions. When the tendency of motion is along the length, it is called pitching. If these tendencies are widthwise and along the height of the vehicle, they are termed as rolling and bouncing respectively.

- **Spring Camber:** The initial curvature provided in a leaf spring is called camber of the spring. The leaf of the spring possesses some radius of curvature due to the camber. The provision of camber is essentially required in them, so that the curved springs may change to a flattened shape on loading.

- **Yawing:** A phenomenon in which the highly cambered leaf springs exhibit movement about the vertical axis is known as yawing. Tendency of yawing is less in flat springs than in cambered springs.

- **Dipping:** Tendency of a vehicle to dive in its front on application of brake is called dipping. This is due to the effect of weight transfer during which extra weight is added on the front wheels. Consequently the front wheel suspension is overloaded. This is not a desired condition.

- **Bottoming:** When a vehicle is overloaded, it causes greater deflection in the springs than their normal specified values. The result is lowering down of the whole vehicle. This is called bottoming. It causes overburdening of the springs and a reduction in the ground clearance.

- **Sprung Weight:** The weight of the vehicle frame, body, engine, transmission and any other load on these components are supported over the suspension system, therefore, such weights are called as sprung weight. A vehicle should have greater sprung weight for a better suspension. Generally its share is about 65-80% of the whole vehicle weight.

- **Un-sprung Weight**: Some parts of an auto-vehicle, which are fitted between suspension system and the road surface, are not supported by the suspension system. Weights of these parts are known as un-sprung weight. Examples of such weights are the rear axle assembly, wheels, tyres, brakes and the steering knuckle etc. The fraction of un-sprung weight should be a minimum possible for comfortable ride.

- **Soft Suspension:** A suspension is said be ‘soft’ when the road wheels bounce too much even for smaller road shocks. A soft suspension is

desired on vehicles, since, it provides greater comfort to the passengers. However, too soft a suspension is not desirable as it results in poorer contact between the wheels and the road. It also results in reduced driving and braking efforts.

- **Hard Suspension:** It is just opposite to the soft suspension in the sense that, the road wheels do not experience sufficient bounce even for larger road shocks. It, therefore, results in reduced comfort to the occupants of the vehicle. Although, the driving and braking efforts are satisfactory in this case, even though it is not desirable. A good suspension system should be such that it is neither too soft nor too hard.

- **Spring Stiffness:** The spring is specified by a parameter called 'spring stiffness' (rate of constant). The spring stiffness S is defined as the load P required to deflect it by unit length. It is expressed in N/mm or kgf/cm. Thus

- $$s = \frac{P}{\delta}$$

Where δ is deflection of the spring, which can be either compression or an extension depending upon the type of spring and its behaviour. A spring of about 15N/mm stiffness is most suitable for soft springing. Different types of automotive springs have the values for their stiffness.

Session 11: Suspension System

Exercise: Assignment

1. List the components of suspension system

S.No.	Name of components

2. Prepare a poster showing suspension system used in automobiles.

Session 11: Suspension System

Answer the following questions

(Use additional sheets of paper if necessary)

Fill in the blanks

1. The suspension system _____ of a particular road condition providing a _____drive to the occupants of the vehicle..
2. Tendency of a vehicle to dive in its front on application of brake is called _____.
3. Tendency of a vehicle to dive in its _____ on application of brake is called dipping.
4. The term suspension is given to the _____, shock absorbers and _____ that connect a vehicle to its wheels.
5. Shocks and Struts are located _____ the wheels of a vehicle.

Session 11: Suspension System

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for under standing the Suspension system.

Part A

- Share the importance of suspension system in a vehicle.

Part B

Discussed in class the following:

- What is meaning of suspension system?
- What are the different components of suspension system?
- List the components of suspension system
- Differentiate between sprung weight and non-sprung weight.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of suspension system		
Able to identify component of suspension system		

Session 12: Wheels and Tyres

Relevant Knowledge

Wheels

The wheel is an important component of a vehicle. Wheel is assembly of hub, disc or spokes, rim, tyre and tube. The wheels not only support the weight of the vehicle, but also protect it from road shocks.

Tyre

The tyre is mounted on the wheel rim. It has to carry the vehicle load and provide a cushioning effect

Fig : Tyre

Types of Tyres

Tyres may be of the following types:

1. **Tube tyre:** Tube tyre is the traditional tyre. It encloses a tube in which air is forced to a high pressure as a cushioning medium. The outer position of the tyre which rolls on the road is made of synthetic rubber and is called *tread*. On the inner edges, beads are formed by reinforcing with steel wires. The beads act as strong shoulders, for bearing against the wheel rim. Rayon cords are formed into a number of piles. Where the beads and cords give strength to the tyre, the threads provide resistance against slipping and thicker surface at the outer periphery.
2. **Tubeless Tyre:** Tubeless tyre does not enclose the tube. The air under pressure is filled in the tyre itself. The inner construction of this tyre is almost the same as that of the tube tyre. A non-return valve is fitted to the rim through which the air is forced inside the tyre.

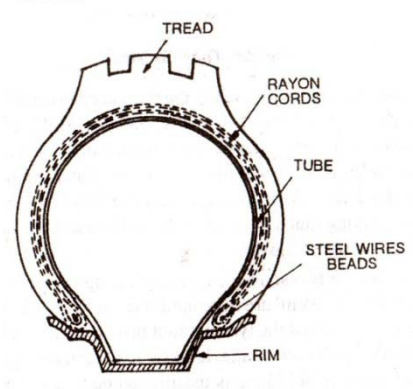


Fig : Traditional Tube Tyre

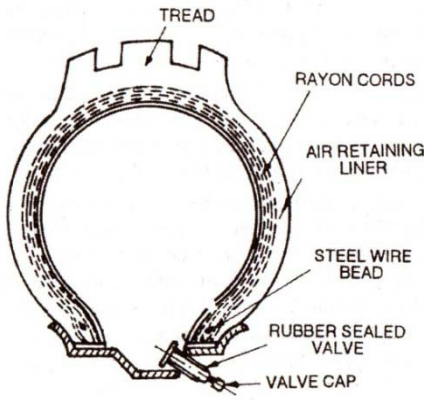


Fig : Tubeless Tyre

Advantages of Tubeless Tyre

- The tubeless tyres are lighter and run cooler than tube tyre.
- The main advantage of a tubeless tyre is that it retains air for a long period even after being punctured by nail, provided the nail remains in the tyre. But, the tube tyre releases the air almost immediately after being punctured.
- Any hole in the tubeless tyre can be repaired simply by rubber plugging.
- Ordinary punctures can be repaired with removing the tyre from the wheel.
- It can be retreated in the same manner as the tube tyre.

The tubeless and tube tyres are called pneumatic tyres, in which the air is forced inside the tube itself or in a tube which is fitted in the tyre. In both the cases, air is the cushioning medium. But in solid tube, it is not so. Neither the air is forced inside the tyre nor the tube is enclosed inside it. The tyre is completely solid and is mounted on the wheel rim. It runs for a life long time. Because, it is a heavy tyre and there is no chance of being punctured. Once it is heavy and does not provide cushioning effect, it is not used on automobiles. Its use is limited to children's tricycles.

Session 12: Wheels and Tyres

Exercise: Assignment

1. List the type of tyres

S.No.	Name of tyres

2. Prepare a poster showing wheel and tyre used in automobiles.

Session 12: Wheels and Tyres

Answer the following questions

(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Tube tyre is _____ tyre.
2. The tyre is _____on the wheel rim.
3. The tubeless and tube tyres are called _____ tyres.
4. Pliers is used to _____ small objects and either_____ or loosen parts.

Session 12: Wheels and Tyres

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for understanding about Wheels and Tyresl.

Part A

- Share importance of wheels and tyres used in a vehicle.

Part B

Discussed in class the following:

- What is meaning of wheels and tyres?
- What are the different types of tyres used in vehicles?
- Differentiate between tyres and tubes?
- Advantage of tubeless tyres.

.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of tyres and wheel		
Able to identify different type of tyres.		

Session 13: Brakes

Relevant Knowledge

Principle of Braking

The brake is a friction creating device which causes speed reduction of the vehicle at a faster rate than the speed reduction obtained by changing the gears and closing-down the accelerator. However, this rate cannot be high enough to stop the vehicle instantaneously. It is because a vehicle of weight W moving at a speed V possesses kinetic energy whose value is given by

$$K.E. = \frac{1}{2}\frac{W}{g}V^2$$

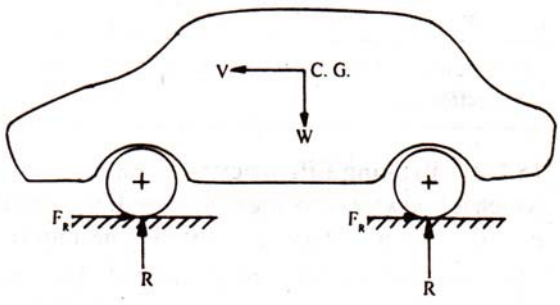


Fig. The work done on the brakes should be equal to the kinetic energy of moving vehicle, to stop it.

In order to bring the vehicle to rest (K.E.= 0), some work has to be done on the wheels. The work (or braking work) is the product of average frictional resistance F_R at the road-wheel junction and the distance d moved by the vehicle before halting. Thus from work-energy relation of vehicle's dynamics.

Braking work done = K.E.

$$F_R \cdot d = \frac{1}{2}\frac{W}{g}V^2$$

Here, d is known as stopping distance or braking distance

Requirements of a good breaking system

- The brakes should stop the vehicle in shortest possible distance and time.
- The brakes should work equally well on fair or bad roads.
- Pedal effort applied by the driver should not be more so as not to strain the driver.
- Brakes should work equally well in all weathers.
- It should have very few wearing parts.
- It should require little maintenance.

- Brakes, when applied should not disturb steering geometry.
- There should be minimum sound when brakes are applied.

Session 13: Brake

Exercise: Assignment

1. List the different types of brakes used in automobiles.

S.No.	Types
1	
2.	
3.	
4	
5	

2. Draw the photograph of brake of a vehicle.

Session 13: Brake

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Brakes are used for _____ component of a vehicle
2. Brakes are used for _____.
3. Functions of a brake is _____ or _____ vehicle .
4. Brake should work in _____or _____ roads.

Session 13: Brake

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for Assessment Activity.

Part A

- Role of brake

Part B

Discussed in class the following:

- Importance of brakes in an automobile
- Principle of brakes for the automobiles
- Properties of good brakes.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to draw the brake		
Able to identify the components of wheel and rim.		

Session 14: Electrical and Electronics System

Relevant Knowledge

In the previous level you studied the name of various electrical and electronic systems and their components. In this level you will learn the functions of those components and the details about the lead acid battery, which is generally used for almost all types of vehicles. Before starting the above topics let us learn about some fundamentals of electrical and electronic system, which shall be more useful to you.

Fundamentals

- **Amperage (Amps or A)**
  The Amp is the unit of electron flow, or how many electrons are passing along a conductor in a second.
  Amps (A) = I or 'Intensity' of the current flow.

- **Voltage (Volts or V)**
  It is the measurement of electric potential or the attracting / repelling force causing electrons to flow through the circuit.
  Volts (V) = E or 'EMF' (Electromotive Force).

- **Resistance (Ohms or Ω)**
  An ohm is the unit of resistance or how hard a conductor resists the flow of electrical current.
  Ohms (Ω) = R or 'Resistance' to electron flow.

- **Ohm's Law**
  The flow of current in a circuit is directly proportional to the applied voltage and inversely proportional to the resistance.
  Ohm's Law is expressed as an equation that shows the relationship between voltage (E for EMF), current flow (I) and resistance (R).

E = I x R or Voltage = Amps x Resistance

- **Power**

  Many electrical devices are rated by how much power they consume, rather than by how much they produce. Power consumption is expressed in watts. It is denote by the letter W.

  The relationships among power, voltage, and current are expressed by the Power Formula:

$$W = E \times I$$

$$W = V \times I$$

As per Ohm's Law $V = I \times R$

Therefore, $W = \frac{V^2}{R}$

Or $W = I^2 \times R$

Functions of major components of Auto electrical system

- **Battery**

An automotive battery is an **electrochemical** device capable of producing electrical energy. It has several important functions which are as follows:

- It operates the starting motor, ignition system, electronic fuel injection, and other electrical devices for the engine during cranking and starting.
- It supplies all the electrical power for the vehicle accessories whenever the engine is not running or when the vehicle's charging system is not working.
- It acts as a stabilizer of voltage for the entire automotive electrical system.
- It stores energy for extended periods of time.

- **Starting Motor (Cranking Motor)**

The function of starting motor is to start the engine by drawing direct current (dc) from the battery. While cranking the engine with the help of

the starting motor, it draws around 250 Amps of current from the battery for few seconds (4-5 sec.).

- **Alternator**

  The functions of alternator are as follows:

  - It produces alternating current when the engine is running (the alternator is run by a V-belt connected with engine crank shaft pulley).
  - It also converts the alternating current into direct current with the help of rectifier fitted along with it.
  - It is the source of electricity in automobile when the engine is running.
  - When the engine is running the alternator charges the battery by supplying the current to the battery through the charging circuit.

- **Cut Out Unit**

  This is fitted into the charging circuit. It is a safety device for the battery in automobile. When the alternator / dynamo voltage is more than the battery voltage it helps to flow the current from alternator / dynamo to battery. But when the alternator / dynamo voltage is less than the battery voltage it avoids to flow the current from battery to the alternator / dynamo by cutting out the contact breaker points.

- **Voltage and Current Regulator**

  The function of voltage regulator is to regulate the voltage (12 volts to 14.2 volts) in the circuit.

  The function of current regulator is to regulate the current flow in the circuit as per the demand of various electrical and electronic components.

- **Ignition Coil**
- It is fitted in the ignition system of engine. It is just like a step up transformer. The function of ignition coil is to convert 12volt dc to around 22000 volts dc (low tension current in to high tension current) and supply to the spark plugs.

- **Distributor**

The function of distributor is to distribute the high tension current to the spark plug according to the firing order.

- **Spark Plug**
  The function of spark plug is to create the spark in the combustion chamber according to the firing order to ignite the air and fuel mixture.

- **Lighting System**

- Head Light helps the driver to drive the vehicle at night. The functions of head lights are
  1. It increases visibility at night
  2. It helps to over take the other vehicle
  3. By using dipper switch it helps the opposite drivers to drive safely.
- Side Lights are used for parking purpose.
- Rear Light is for giving indication to the road users behind it.
- Break Light : It operates when the driver applies the break which indicates the other road users behind it.
- Reverse Light: This light glows when drivers engage the reverse gear of the vehicle, which, warns other road users behind the vehicle.
- Fog Lamps **:** The colour of fog lemp is amber (yellow). The amber colour light rays have the quality to penetrate into fog. So, during foggy climate this light helps the driver and other road users use the road safely.
- **Left and Right Indicator lamps** help to take turn to left or right.
- **Interior Lights:** There are two types of interior lights.
  1. Dash board panel lights which helps the driver to read all the meters such as Speedo meter, oil pressure gauge, etc.
  2. Cabin lights helps the occupants' of the vehicle.

Other Important Accessories

- **Horns:** The function of horn is to warn other road users to clear the road for the safe movement of the vehicle.

- **Wind Screen wiper:** The function of wind screen wiper is to clean the wind screen while raining to have a clear view in front of the vehicle.
- **Electric fuel pump:** The function of fuel pump is to supply the fuel to the curburettor or injectors from the fuel tank.
- **Fuel gauge:** The function of fuel gauge is to indicate level of fuel or quantity of fuel in the fuel tank.
- **Sensors and actuators**
- In the modern vehicles sensors and actuators are fitted in various system of engine along with computer control system. The function of all those sensors and actuators shall be discussed in the next level.
- **Battery and its Importance**

  The battery is the main power source for the entire vehicle. It supplies electrical energy when starting the vehicle and when accessories are operating with the engine off or at low idle. The battery will also compensate for any shortage of power from the alternator when the electrical load is especially heavy. For this reason the battery should always be checked first whenever a vehicle is brought in with an electrical problem.

  The storage battery is an electrochemical device that converts electrical energy into chemical energy and stores this energy until electrical energy is once again needed. Electrical energy is produced by a chemical reaction between two dissimilar conductors (plates) that are immersed in an electrolyte. The amount of electrical energy a battery can produce depends upon the size, weight and active area of the materials in the plates and the quantity of sulfuric acid in the electrolyte. When all the active materials on the plates have reacted with the electrolyte, the battery is said to be in a discharged state.

Design of Conventional Battery

A lead-acid storage battery consists of seven basic components:

- Positive Plates
- Negative Plates
- Separators
- Electrolyte
- Container (or case) and cover
- Inter cell connectors
- Terminals

Positive and Negative Plates

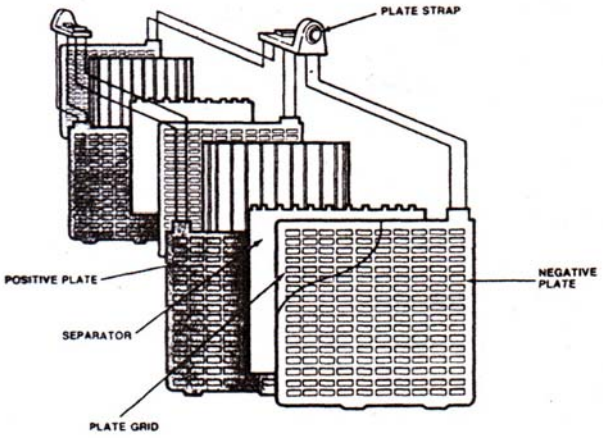


Fig : Elements Constructions

The "framework" of the battery plates is the grid, which is made primarily of lead for low electrical resistance and high conductivity. The grid conducts current to and from the active materials on the positive and negative plates. In a conventional battery, the grid is made from an alloy of lead and antimony.

When the grid is "pasted" with active materials it becomes either a negative or positive plate. The active material that forms a positive plate is a **lead oxide paste** which is applied evenly to the **grid.**

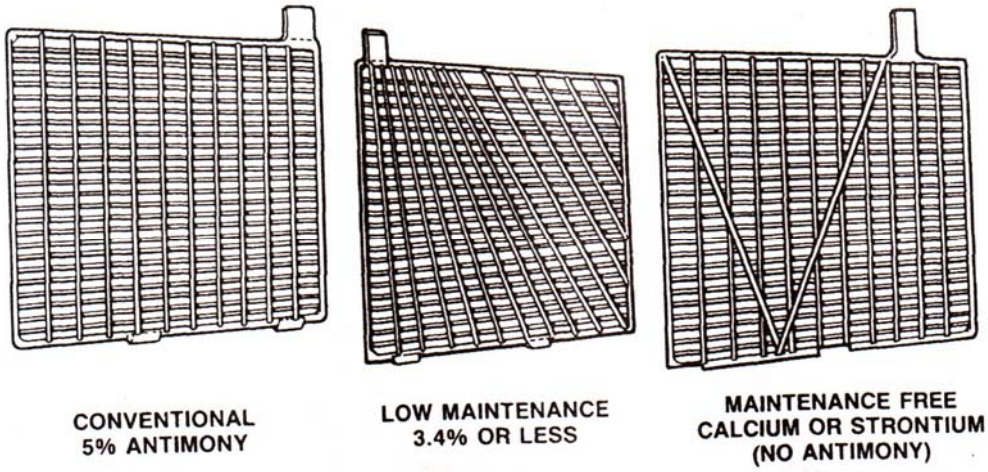


Fig : Battery Plate Grids

The plate is then given a “forming” charge which electrochemically converts the paste material into lead peroxide. The lead peroxide is composed of very small grains or particles which provide a high degree of porosity. This allows the electrolyte to penetrate the plate. A negative plate is formed when the grid is pasted and formed into sponge lead.

Separators

If positive and negative plates, is allowed to touch each other, they will quickly short out and lose their potential energy. To prevent this contact, thin sheets of non-conducting, micro porous material called separators are placed between each pair of plate.

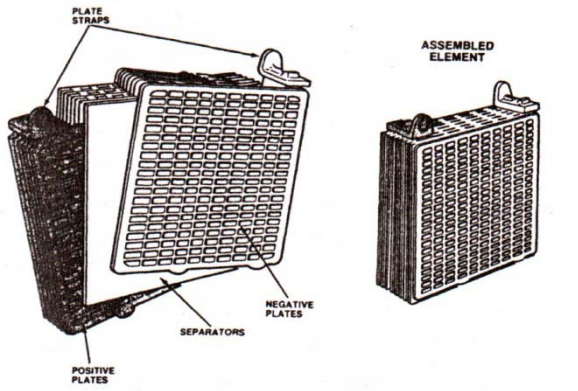


Fig : Element Construction

The assembly resulting from combining one positive plate group and one negative plate group together, with separators, is known as an element. A plate strap connects the lugs at the top of all the positive plates. A second plate strap connects the negative plates.

Battery Case

The battery case contains the plate and separator assemblies, or cell elements, and the electrolyte. The case is made of polypropylene, hard rubber or other plastic-like material. It is designed to :

- Withstand temperature extremes of hot and cold
- Resist vibration caused by mechanical shock.
- Resist acid absorption.

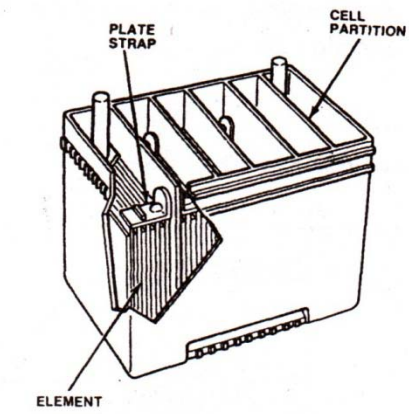


Fig : Battery Case

The case has partitions that separate the individual cell elements. Since each cell produces slightly over two volts, a twelve – volt battery requires six cells. Three cells make up a six-volt battery.

Inter-cell connectors

Inter cell connectors are used to connect the cell elements in series that is, the positive strap of one cell in connected to the negative strap of the adjacent cell. Connections between the cells are either through the cell partitions in the case or over the top of the partition.

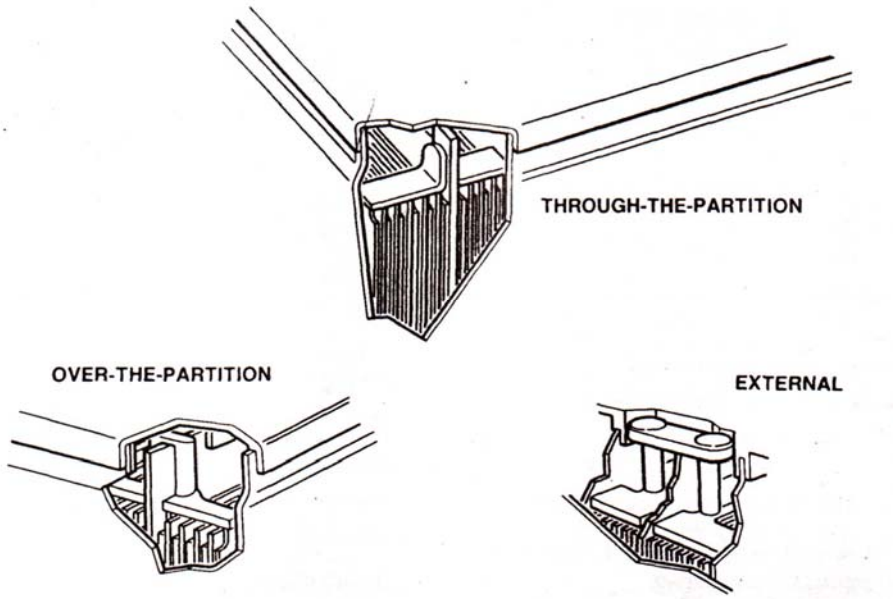


Fig : Cell Connectors

The connections are made before the cover is placed on the battery. This type of construction not only provides an acid-tight seal between the cells, but, also assures minimum voltage loss from cell to cell.

Of the three types of connections, the through the partition type, provides the shortest path between the cells, hence the lowest electrical resistance. The over the partition connector is slightly longer and thus offers more resistance. External connectors are the longest and offer the greatest resistance.

Electrolyte

The one essential ingredient needed to complete the battery is the electrolyte. The electrolyte consists of sulfuric acid (H_2SO_4) diluted with water (H_2O); the ratio is about 35% acid to 65% water by weight. When an electrical load is connected to the terminals of a charged battery, the acid in the electrolyte reacts with the active materials on the plates and electricity is produced.

Battery Cover

The battery cover is permanently bonded to the case. One piece covers are used with both through the partition and over the partition cell connectors.

Battery Terminals

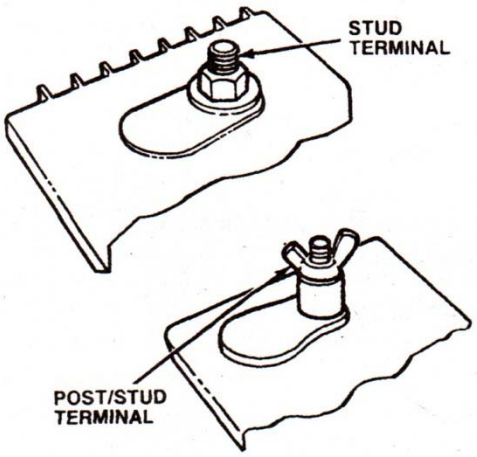


Fig : Heavy Duty Commercial Terminals

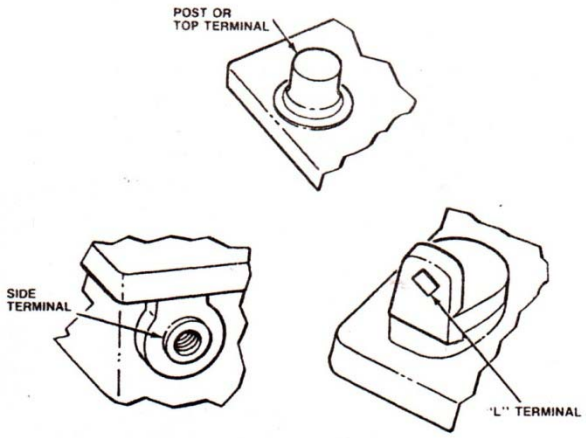


Fig : Common Terminals

The connecting terminals for the vehicle's electrical system are, with one exception, located on the cover. The following are the most common types of terminals :

- *Post or top terminals,* used on most car and truck batteries.
- *Side terminals,* which are positioned in the sidewall of the container near the top edge. These terminals are threaded and require a special bolt to attach the cables.
- *L terminals,* widely used on specialty batteries and on some import car batteries.
- Many heavy duty commercial applications use the familiar post terminals plus two additional types:
- *Stud terminals,* used frequently on heavy truck batteries.
- *Combination post / stud terminals* used on marine, golf cart and industrial motive power batteries.

Battery Operation

- **When a battery is being discharged,** current flow from the negative pole to the positive pole. The hydrogen ions (H) of electrolyte (diluted H_2SO_4) move to the positive plate and combine with oxygen (O) to form water. The sulphate ions (SO_4) combine with lead to form lead sulphate ($PbSO_4$). When the battery is fully discharged the specific gravity of electrolyte reaches to 1.160.

- **When a battery is being charged**, the current flows from the positive pole to the negative pole. The oxygen ions move to the positive plate where they displace the sulphate ions (SO_4) simultaneously move back from the negative plates into the electrolyte. This turns the negative plates back into lead (Pb).

- **Charge / discharge cycle**
  In a fully charged cell, the active material of the positive plate is lead peroxide (PbO_2). The negative plate contains pure lead (Pb) and the electrolyte is dilute sulphuric acid (H_2SO_4).

  When the cell discharges current, the electro chemical reaction changes the material of both plates to lead sulphate and weakens the electrolyte.

To recharge a cell, current is passed through it in the opposite direction to the discharge current. The chemical reaction described above is reversed, the positive and negative plates being reconverted to lead peroxide and lead respectively, and the electrolyte regaining strength as sulphate are given of from the recharged plates (See figure given below).

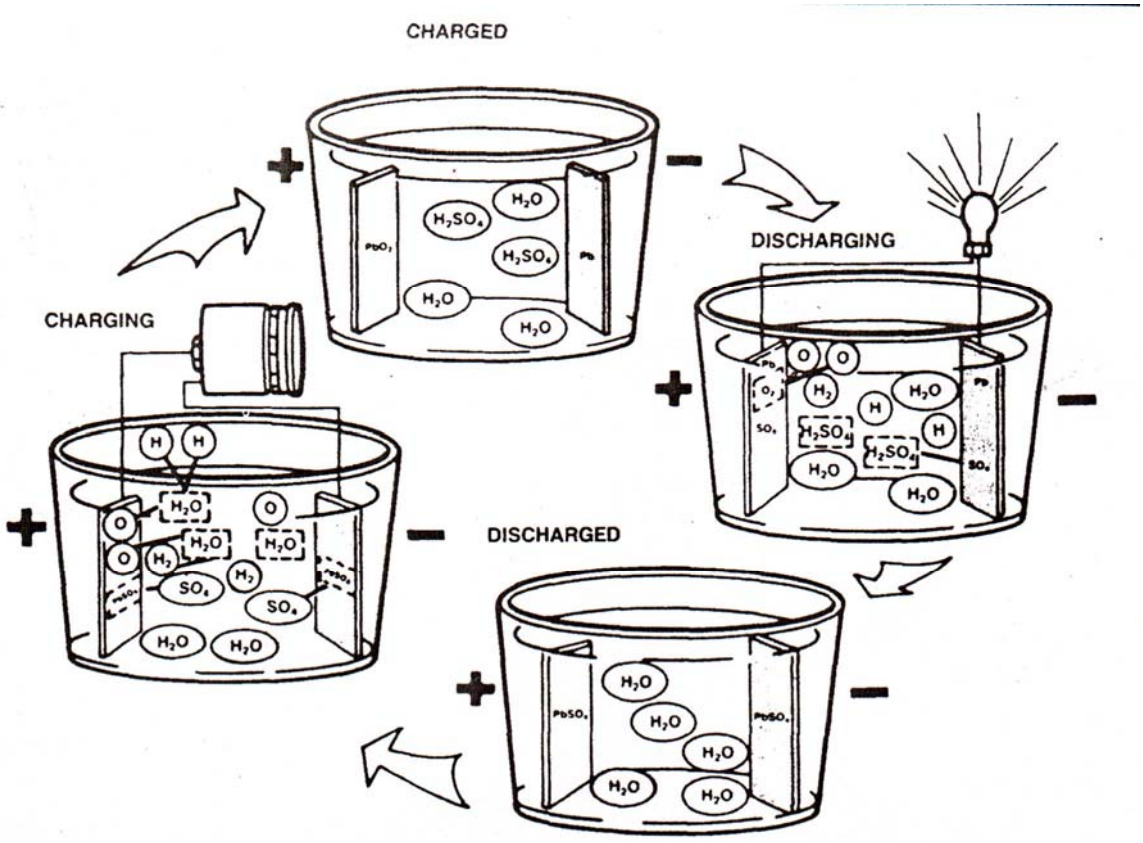


Fig : Battery Charge and Discharge Cycles – Conventional Battery

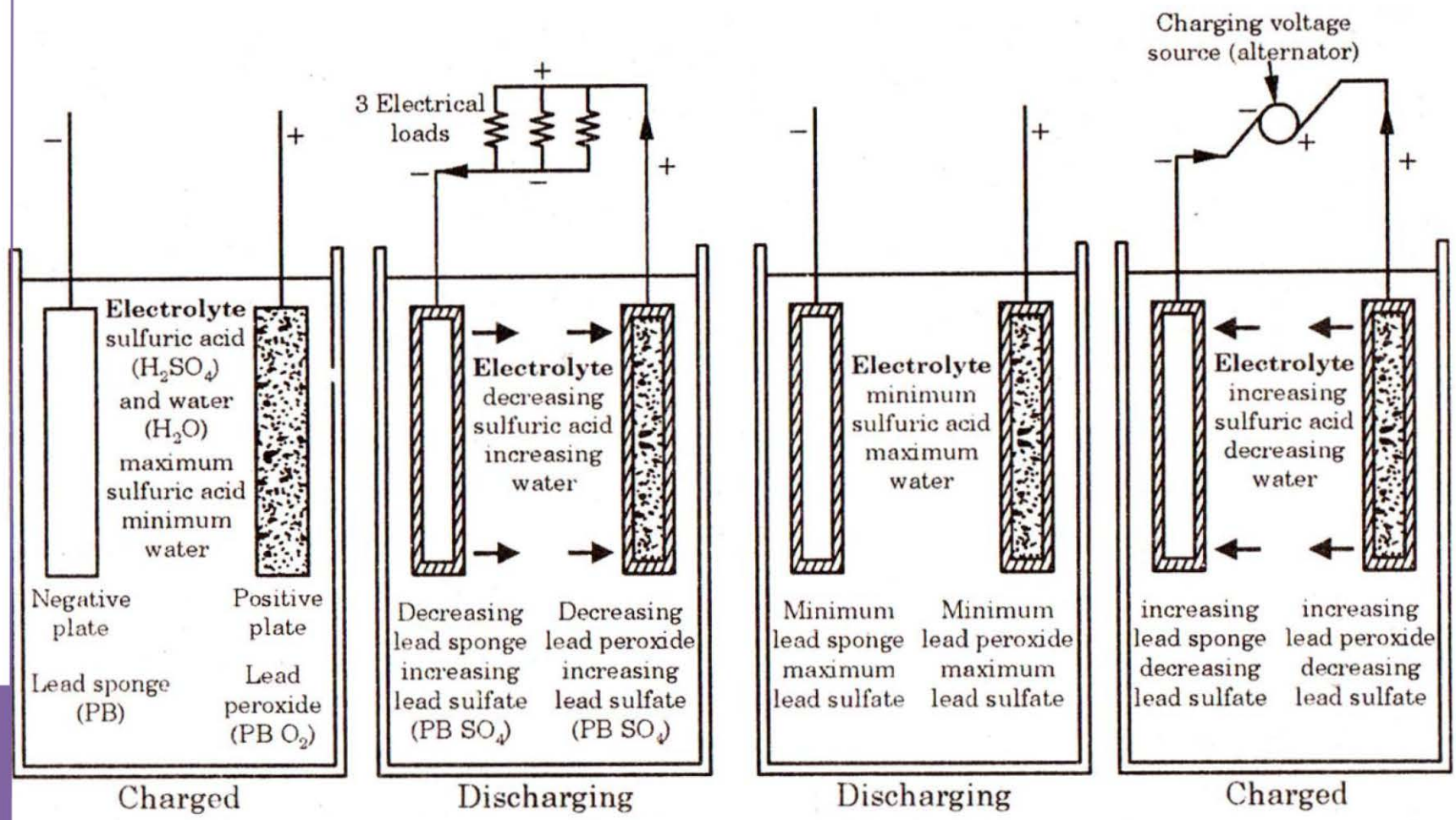


Fig. Battery electrochemical action from charged to discharged, and back to charged

Session 14: Electrical and Electronics systems

Exercise: Assignment

1. List the different components of Electrical system in a vehicle.

S.No.	Components
1	
2.	
3.	
4	
5	

2. Draw the photograph of battery and its components used in a vehicle.

Session 14: Electrical and Electronics System

Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Battery is used for _____ a vehicle
2. Electrical lights are used for _____.
3. An automotive battery is an _____ device capable of producing electrical energy.
4. Electrical energy is _____ by a chemical reaction between two _____ conductors (plates) that are immersed in an _____.
5. The function of wind screen wiper is to _____ the wind screen

Session 14: Electrical and Electronics System

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for assessment activity.

Part A

- Role of electrical and electronic system in a vehicle.

Part B

Discussed in class the following:

- Importance of electrical and electronics system in automobiles
- Use of battery in automobiles
- Properties of a good battery.
- Care and maintenance of battery

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to identify electrical and electronic system of the vehicle.		
Able to identify and handle battery of a vehicle.		

Suggested Reading
Books

Title	Author	Publisher
Automobile Engineering Vol I	Kirpal Singh	Standard Publishers
Automobile Engineering, Vol II	Kirpal Singh	Standard Publishers
Text Book of Automobile Engineering	R K Rajput	Laxmi Publications
Automobile Engineering by	R K Singal	S. K. Kataria and Sons
Automobile Engineering Theory	Kapil Dev	Computech Publications
Automobile Engineering,	K. M. Moeed	S. K. Kataria and Sons

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