(Draft Study Material)

Four-Wheeler Service Technician

(Job Role)

Qualification Pack: Ref. Id. ASC/Q1402

Sector: Automotive

(Grade XII)

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION,
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Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilise in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

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Date: 20 June 2024

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Module Overview

Maintenance is the key to any successful maintenance program for motor vehicles. Through preventive maintenance, vehicles are inspected, repaired, and kept in such a way that defects are prevented from surfacing before a violation or accident can occur.

When vehicles are brought to a service centre for repair of critical defects, a mechanic refers to the service manual of a model. This service manual is made available to the service center by the respective manufacturer of a vehicle. As we know that now a days, a new model of vehicle is introduced on a regular basis in the market and all technical information is to be made available to the service mechanic/Assistant/service advisor. Service manual gives detailed information about the technical details of a particular vehicle.

Service manual helps the mechanic to learn new developments, new changes, technique to disassemble, assembly procedure, testing etc.

Learning Outcomes

After completing this module, you will be able to:

1. Identify and explain the different sections of a service manual, including general information, safety precautions, specifications, and procedures.

Module Structure

Session 1: Reading of Service Manual

Session 1: Reading of Service Manual

An automobile is a complex unit of machinery. This requires regular services to maintain its originality in performance, appearance, control, and safety. Research and Development (R&D) departments in auto manufacturers play a crucial role in developing new technologies and innovations that enhance the comfort, efficiency, and overall performance of vehicles. These innovations can

include improvements in engine efficiency, safety features, connectivity options, fuel economy, and more. However, it's important to clarify the roles and responsibilities of R&D and service workshops in maintaining the originality and performance of vehicles. Automotive manufacturers provide detailed service manuals for automobiles. These service manuals are essential resources for service technicians and mechanics working in service workshops to properly maintain, repair, and overhaul the vehicles. Sample service manuals can be seen from Fig 1.1 and Fig 1.2. Service manuals are invaluable tools that help service technicians, including assistants, to work on vehicles systematically and effectively to address problems and provide maintenance services while maintaining the originality and performance of the vehicle.

The service manuals for vehicles typically cover a wide range of areas and topics to provide comprehensive guidance to service technicians and assistants. These areas include:

1. Expanded view of a unit/assembly
2. Name of parts with part number
3. The specification of each part and their tolerances in assembly
4. Sequencing of disassembly and precaution
5. Sequencing of assembly with tolerance, play adjustment etc.
6. Testing procedures and workability
7. Maintenance schedule
8. Replacement limit of components
9. Trouble shooting chart
10. Use of special tools and their part number
11. Correct quantity and accurate grade of lubricants used in different assemblies.

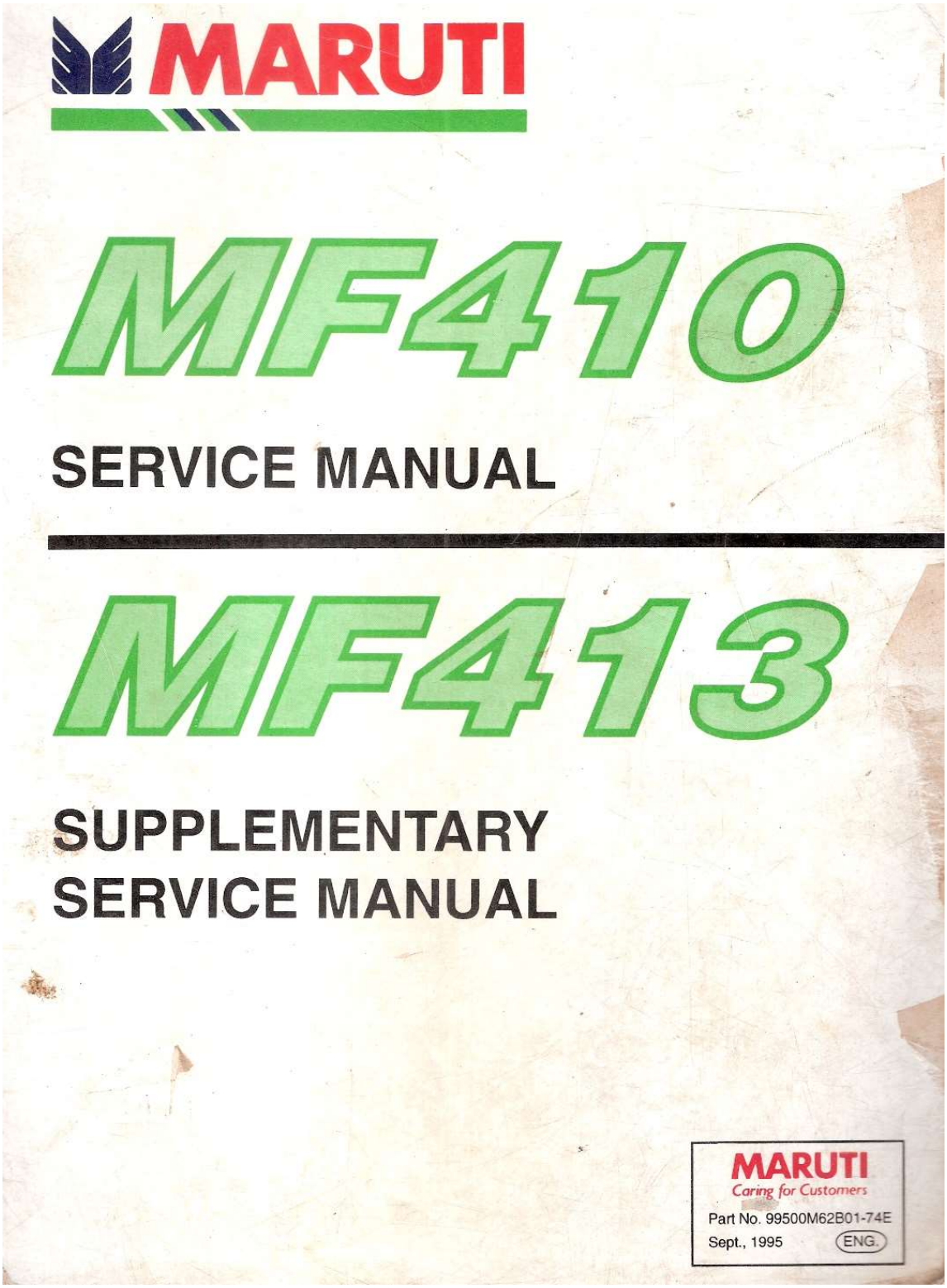


Fig. 1.1: Service manual

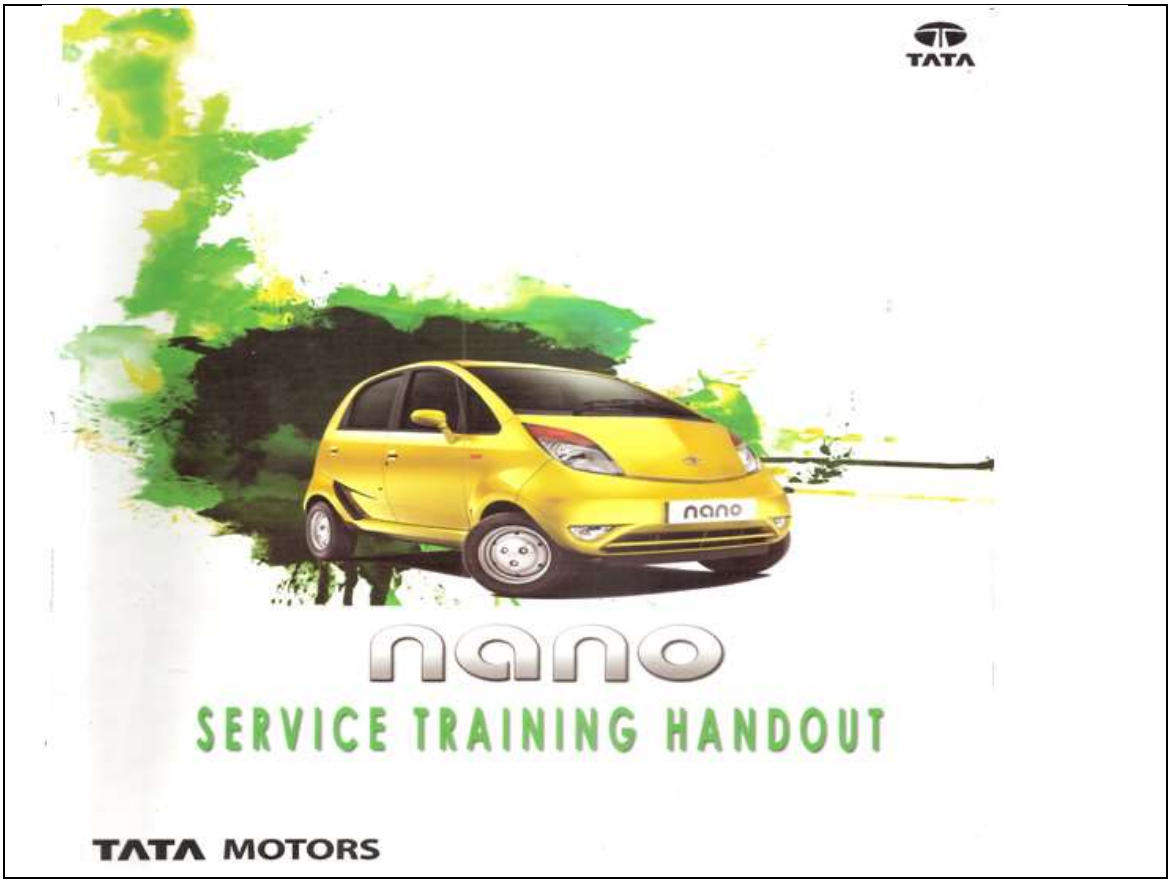


Fig. 1.2: Service Training handout

Content of Manual

Manual consists of the following contents which may be followed while using service manual in a workshop or home.

- Expanded view of assembly
- Disassembly sequence
- Tolerances, gazes, sizes of components
- Serviceability
- Life span
- Decision for Repair or Replacement
- Assembly procedure and
- Working test procedure

The Assistant/mechanic must use the service manual regularity to check the serviceability of component. This helps the Assistant to decide about replacement of component. The modern automobile requires attention to maintain its working while assembly. Reading helps in maintaining the tolerances, play for smooth working of components or assembly.

The service manual should be kept in a handy place for ready reference. The Service manuals are typically detailed documents that provide information on how to repair, maintain, and troubleshoot a particular device. This helps the Assistants to make appropriate decision to solve the problem. The service manual also gives a circuit diagram with colour code. This assists the mechanic in tracing the connectivity and continuity in supply of current to sensors and other units. Assistants should refer to the service manual as per the 0make of the vehicle.

Know Your Progress

Answer the following questions

Q1. Why service manual is used?

Q2. Who develops the Service manual?

Q3. What are advantages of using service manual?

Fill in the blanks

1. The service manual provides a _____ chart.
2. The service manual gives range of voltage, amperage and _____ in a variation of speed.
3. Mechanic use_____ for any defect in a vehicle.

Multiple Choice Question

Question 1: What is the primary purpose of a service manual for motor vehicles?

a) To determine the vehicle's resale value
b) To provide entertainment for mechanics
c) To help mechanics perform repairs and maintenance
d) To showcase the latest vehicle models

Question 2: What does the service manual help mechanics learn about a vehicle?

a) Marketing strategies
b) Historical data
c) Techniques for component manufacturing
d) Technical details and assembly procedures

Question 3: Which of the following is NOT covered by the service manual?

a) Maintenance schedule
b) Vehicle's color options
c) Replacement limit of components
d) Testing procedures and workability

Question 4: What information does the service manual provide about electrical components in modern automobiles?
a) Historical anecdotes
b) Cooking recipes
c) Voltage, amperage, and resistance ranges
d) Fashion trends

Activity

1. List the content of vehicle service manual seen.

S.No.	Name of Content
1.	
2.	
3.	
4.	
5.	

2. Write the part number of following components
   a. Clutch disc
   b. Disk pad
   c. Headlight
   d. Backlight
   e. Piston

Unit 2	SERVICEABILITY, REPLACEMENT OR REPAIR OF ENGINE COMPONENTS

Module Overview

The engine is the heart of the vehicle. Proper maintenance, care and servicing at regular interval keep the engine free from trouble. Important components of engine are valve, piston rings, connecting rod, camshaft, engine bearing, and cooling system. Multi-Point Fuel Injection (MPFI), Common Rail Direct Injection (CRDI), and non-CRDI (often referred to as traditional or indirect injection) are important fuel injection systems used in vehicles. These systems play a significant role in how an engine operates and its overall efficiency. The valve mechanisms and their adjustment are crucial components of an internal combustion engine. Properly functioning valves and their precise adjustment are vital for the engine's performance, efficiency, and longevity. Repair, servicing and replacement of defective components are necessary for an engine's smooth running.

Learning Outcomes

After completing this module, you will be able to:

1. understanding of the valve mechanism.
2. Understanding the process of inspection and replacement of piston rings, and of connecting rod and engine bearing.
3. Understand the procedure of testing of cooling system and replacement of defective components of an engine.
4. Demonstrate the Regular servicing of Multi-Point Fuel Injection (MPFI) systems and the servicing of Common Rail Direct Injection (CRDI).

Module Structure

Session 1: Reconditioning of Valve Mechanism
Session 2: Inspection and replacement of piston rings
Session 3: Inspection and replacement of sleeves, connecting rod and Engine bearing
Session 4: Testing of cooling system and replacement of defective Component
Session 5: Regular servicing of MPFI system
Session 6: Servicing of CRDI and Non CRDI system

Session 1: Reconditioning of Valve Mechanism

The valves used in internal combustion engines are usually known as poppet valve. A poppet valve (Fig. 2.1, Fig. 2.2 and Fig. 2.3) is a valve typically used to control the timing and quantity of gas or vapour flow into an engine. It consists

of a hole, usually round or oval, and a tapered plug, usually a disk shape on the end of a shaft also called a valve stem. The shaft guides the plug portion by sliding through a valve guide.

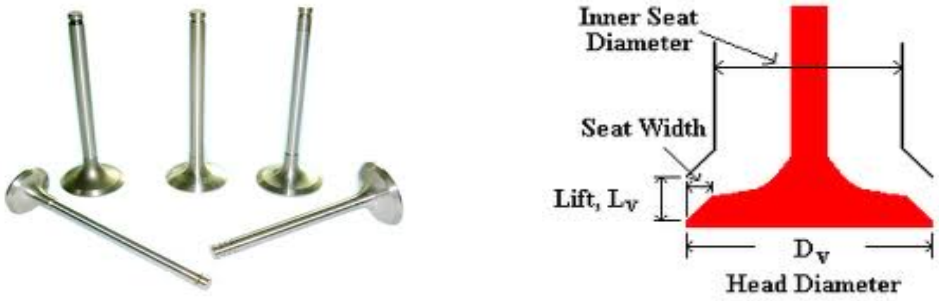


Fig. 2.1: Valve

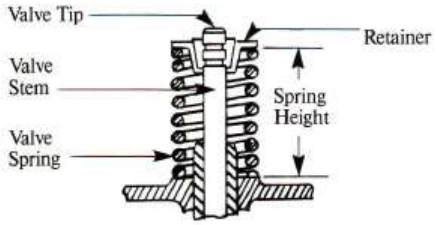


Fig. 2.2: Installed Valve Spring

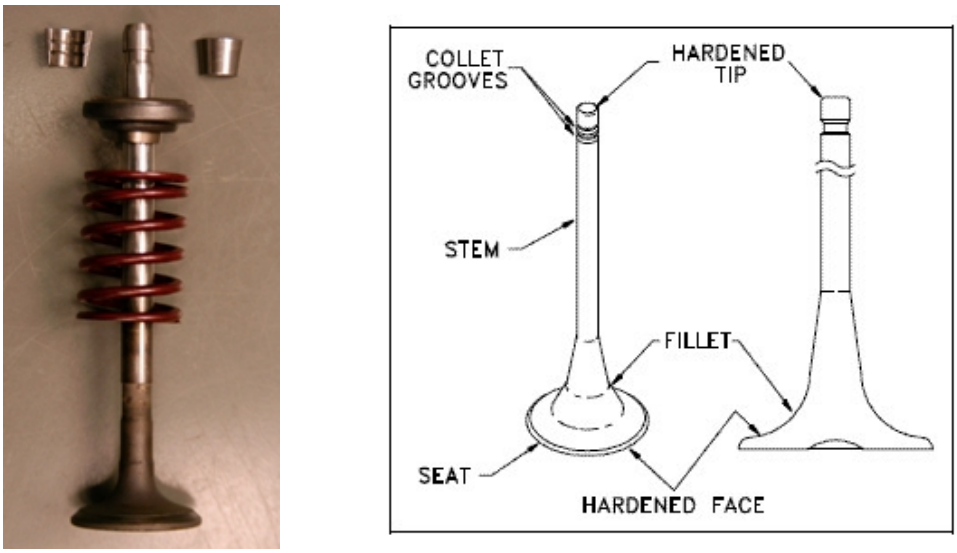


Fig. 2.3: Engine Valve

Valve mechanism: It controls the submission of inlet gases and emission of exhaust gases at right time in relation with the rotation of the cam shaft. Valve mechanism are classified as given below :-(Fig. 2.4, Fig. 2.5, Fig. 2.6)

1. Overhead valve mechanism (OHV)
2. Overhead Cam mechanism (OHC)

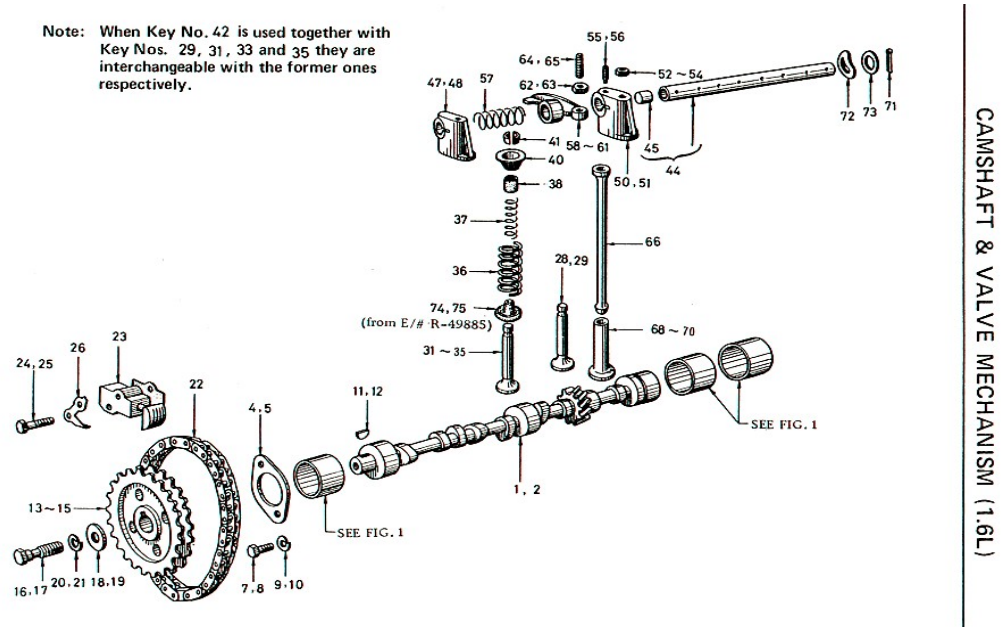


Fig. 2.4: Overhead Valve Mechanism

Overhead valve mechanism (OHV): It consist of inlet valve, exhaust valve, valve guide, valve spring lock, valve seat, valve spring, push rod, rocker arm and rocker shaft. In this case camshaft is fixed in the crankcase.

Fig .2.5: Overhead mechanism

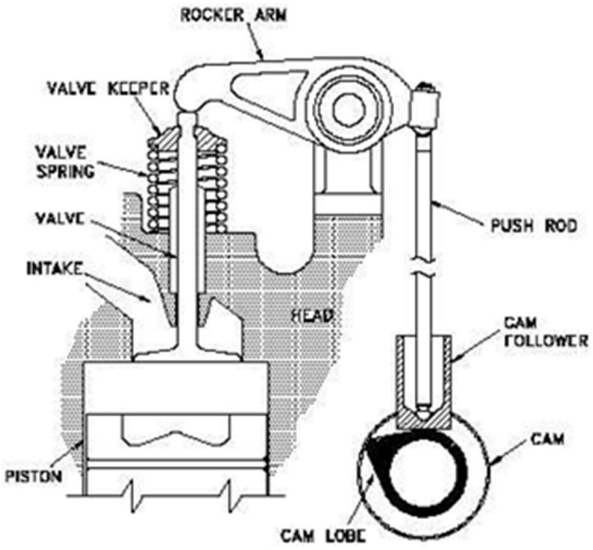


Fig. 2.6: Valve cam mechanism

Overhead Cam mechanism (OHC): It consist of inlet valve, exhaust valve, valve guide, valve spring lock, valve seat, valve spring, rocker arm, and rocker shaft. In this case, the camshaft is fixed in the cylinder head. It consumes less engine power for operation of valve mechanism. The valve advance mechanism controls the supply of fuel and increases the engine efficiency at high speeds.

Reasons for Valve Leakage

If the combustion gases leaks from valve, then it may cause

- Excessive fuel consumption
- No pickup
- Engine do not take load
- Hard starting
- Valve sticks
- Engine overheats

It is necessary to conduct compression test of an engine to find out leakage from the valve mechanism.

Reconditioning of valves

To overcome leakages of combustion gases, valve reconditioning is required. Valve reconditioning operation includes installation of new valve seat, valve guide, and operations like valve seat grinding, valve refacing, valve lapping, valve tappet clearance adjustment, valve timing. Together, these operations constitute

the valve servicing necessary for smooth engine performance and maximum power output.

Procedure for valve reconditioning

- Dismantle the cylinder head from the engine.
- Remove the carbon from the cylinder head and piston head.
- Clean the piston head. Care should be taken to prevent gouging and scratching, as rough spots collect carbon readily and lead to pre-ignition and detonation during operation.
- Add little quantity of prussian blue in petrol and with the help of dropper, put the mixture on the valve face.
- Remove the valves using a valve spring compressor, and observe for the valve leakage, if any.
- Blue colour shows leakage area.
- Clean the valves with a wire brush.
- After reconditioning each valve must be placed in the same valve port from which it was removed.
- Be careful while fitting the valve as interchange of the valves may lead to engine stall during starting.

The most common way is to place them on a piece of board with holes drilled and numbered to match the respective cylinder number from which the valve was originally removed.

Resurface the Valve

The next step is to resurface the valve face. This is done by using a valve grinding or refacing machine. The procedure is as follows:

- Inspect the valve run out if it is more than 2 degree.
- Inspect the valve margin if it is less than 2 mm then it is necessary to replace the valve.
- Place the valve on valve refacing machine.
- Set the machine at the angle between 35 to 45 degree.
- Start the machine.
- Open the coolant supply and start refacing operation slowly (Fig. 2.7).

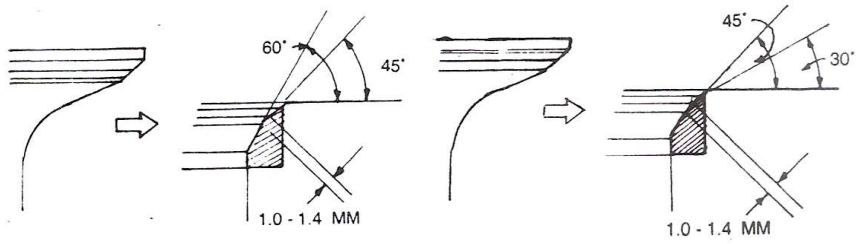


Fig. 2.7: Changing of valve angle

Valve Seat Cutting/Grinding Operation

- Measure the angle of valve seat with help of bevel protractor.
- Check the margin of valve seat; if it is less than 2 mm replace the valve seat.
- If it is more than 2 mm, then it is suggested to carryout valve seat grinding operation.
- Select grinder/ cutter of appropriate size and angle.
- Fix the holder and pilot to the grinding stone/cutter.
- Now grind the valve seat with machine or manually and cut the valve seat to get required angle (Fig. 2.8, Fig. 2.9).

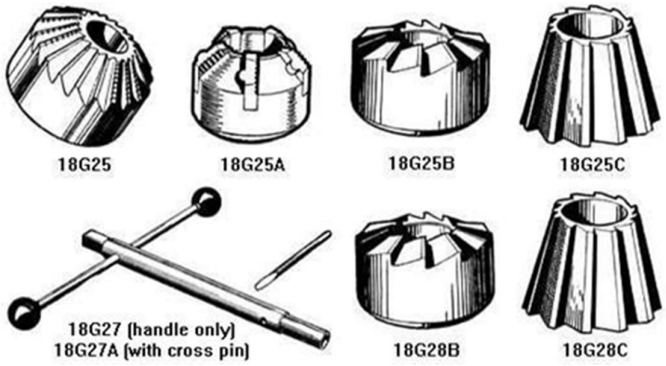


Fig. 2.8: Seat angle cutting tools

Fig. 2.9: Seat Cutting operation

Valve Lapping Operation

- Select the valve lapping stick of proper size.
- Place its rubber hide on the valve face.
- Apply abrasive/emery coarse paste on the valve face.
- Now turn the lapping stick in to clockwise and anticlockwise direction, this will lap valve with valve seat. Again, repeat the same operation to check the leakage.

If leakages are noticed then use fine emery paste and continue the operation to solve the leakage problem (Fig. 2.10).

Fig. 2.10: Valve lapping process

Know Your Progress

Fill in the blanks

1. The valve mechanism controls the submission of inlet gases and emission of exhaust gases in relation to the rotation of the _____.
2. Valve _____ is necessary to diagnose leakages of combustion gases and improve engine performance.
3. During the valve lapping operation, abrasive/emery paste is applied on the valve face, and the lapping stick is turned in both clockwise and anticlockwise directions to ensure proper sealing between the valve and _____.
4. The Overhead Cam (OHC) mechanism consumes less engine power for valve operation and is located at the _____.

Multiple Choice Questions

1. Which of the following components controls the timing and quantity of gas or vapor flow into an engine?
a) Piston rings
b) Rocker arm
c) Valve
d) Camshaft

2. What is the primary reason for conducting a compression test of an engine's valve mechanism?
a) To measure fuel efficiency
b) To check for coolant leaks
c) To assess valve leakage
d) To evaluate oil pressure

3. In an Overhead Cam (OHC) mechanism, where is the camshaft fixed.
a) In the crankcase
b) In the cylinder head
c) On the rocker arm
d) In the valve guide

4. What is the purpose of the valve lapping operation during reconditioning?
a) To measure valve leakage
b) To replace damaged valves
c) To adjust valve tappet clearance
d) To ensure proper sealing between the valve and valve seat

Answer the following questions

Q1. What is poppet valve?
Q2. How many kinds of valve used in IC Engine?
Q3. What are the purposes of a valve?
Q4. Briefly describe a function of a valve & draw its line diagrams with details.
Q5. What are the seat angles & why it is required?
Q6. Which part control opening & closing of a valve?
Q7. Write the name of the tools required for valve seat grinding.

Activity

1. Make a list of reasons for valve leakage in a vehicle.

Sr. No.	Reason
1	
2	
3	
4	

2. Make a poster showing engine valve and label its parts.

Session 2: Replacement of Piston Rings

Piston Ring

A piston ring is a split ring which fits into a groove of an internal combustion engine or steam engine.

The main functions of piston rings in internal combustion engine are:

1. To seal the combustion chamber so that there is no transfer of combustion gases from the chamber to the crankcase.
2. Supporting heat transfer from the piston to the cylinder wall.
3. Regulates engine oil consumption and avoids oil leakage.
4. To withstand compression pressure during compression and power stroke.

Most automobile engine's pistons have three rings: The top two rings are compression rings and lower one is oil ring. The lower ring is used for controlling the supply of oil to the liner, which lubricates the piston skirt and the

compression rings. Two compression rings are used in most of the internal combustion engine.

Importance of replacement of ring

Piston rings are subject to wear as they move up and down the cylinder bore as per the movement of piston from Top Dead Centre (TDC) to Bottom Dead Centre (BDC). The piston ring normally wears due to following reasons:

Compression rings are designed to withstand more pressure and temperature. Piston ring expands and contract during compression and exhaust stroke. This movement of ring reduces width of the ring and increases end gap. Further it reduces elasticity/tension causing piston ring wear. Oil ring is also replaced when oil enters in combustion chamber and there is increase in the consumption of oil (Fig. 2.11).

In this session, our focus is on examining the spaces within a multi-cylinder engine's piston. This involves checking the clearance around the piston, both at its ends, and along the sides. To accomplish this, we'll need a set of tools on hand. Specifically, we'll be using spanners, a micrometer, and a feeler gauge. These tools will allow us to ensure the proper functioning of the engine by maintaining the correct gaps and clearances.

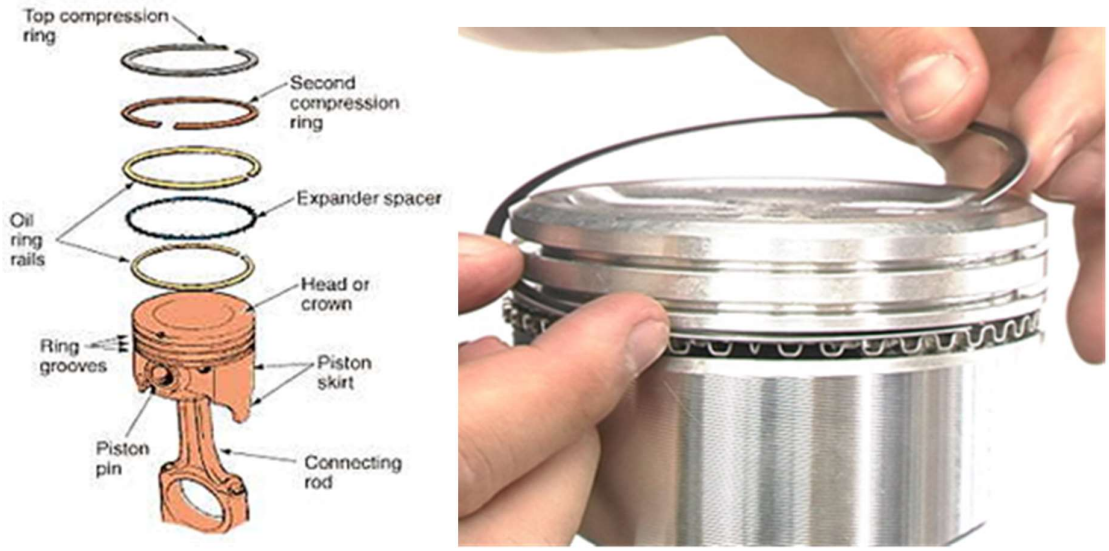


Fig. 2.11: Inspection of piston clearance in cylinder bore

Procedure:

- Place the vehicle on level ground.
- Remove the negative terminal of the battery.
- Keep a tray below the engine.

- Take the spanner and remove the drain plug.
- Allow all the oil to flow out of the engine into the tray and keep the tray aside.
- Remove the connection of radiator hoses, pipe from water pump also.
- Take out the radiator by unscrewing the nuts/bolts.
- Take out the fan, and then remove the belt from pulley. Dismantle the water pump and keep it aside.
- It is not necessary to remove the alternator and the starter motor. These may be kept aside on the chassis.
- Then from underneath, remove the nut of the sump using ring spanner.
- Remove the oil sump.
- Then remove the tapped cover.
- Now remove the induction manifold.
- Using 14-15 ring spanner remove the connection of the fuel line pipe and keep it aside.
- Then remove the engine heater connection and loose the heaters.
- Take 23-27 ring spanner, remove the injector, and then put a mark as per the cylinder number.
- Loosen the bolts of rocker arm, remove the rocker arm shaft, and slowly lift the push rods.
- While removing push rods first slowly pull the push rods little up and tap it so that tapped may not fall.
- Then slowly loosen the bolts of the cylinder head and remove the head.
- Remove the cylinder head gasket.
- Thereafter using 14-15 ring spanners loosen the nuts of the big end of the connecting rod of piston no. 1.
- Push and remove the pistons 2, 3 and 4 respectively and keep them aside properly.
- Clean the ring grooves of all the pistons thoroughly.
- Then clean the cylinder bore and inspect for wear.
- Check the spring for bend, length, valve bend and do the reconditioning of valves, if necessary.
- Clean and inspect the components.
- Set the valve timing as per the recommendations of manufacturer.

A) End Gap:

1. Take the piston ring and place it in cylinder bore at TDC.
2. Align and level the piston ring with the help of piston.
3. Take the feeler gauge and slide it in place between the end gap of the ring.
4. Take the micrometer and measure the thickness of the feeler gauge strip.
5. Note the reading.

B) Side Gap:

1. Take the piston and piston ring.
2. Take any one piston ring on the ring groove with feeler gauge.
3. Take the micrometer and measure the thickness of the feeler gauge strip.
4. Note down the reading.

C) Piston Clearance:

1. Take the piston out from the respective cylinder.
2. Place the piston in the respective cylinder bore with feeler gauge.
3. Use micrometer to measure the feeler gauge thickness.
4. The measured thickness is known as piston clearance.

Piston No. →	1	2	3	4
Piston Clearance				
Piston Ring End Gap				
Piston Ring Side Gap				

Check Your Progress

Fill in the blanks

1. The primary functions of piston rings in an internal combustion engine are to seal the _____ so that there is no transfer of combustion gases from the chamber to the crankcase.
2. The top two rings in most automobile engines are known as _____, while the lower ring is an oil ring responsible for controlling oil supply.
3. Piston rings are subjected to wear due to movement within the cylinder bore as the piston moves from _____ to Bottom Dead Centre.
4. During the inspection of piston clearance in a multi-cylinder engine, a set of tools including spanners, a micrometer, and a _____ gauge is used to ensure correct gaps and clearances.

Multiple Choice Question

1. What is the main function of piston rings in an internal combustion engine?

A) To increase fuel efficiency

B) To regulate exhaust emissions
C) To cool down the engine components
D) To seal the combustion chamber and prevent gas leakage

2. Which type of piston ring is responsible for controlling the supply of oil to the cylinder liner?
A) Compression ring
B) Exhaust ring
C) Oil ring
D) Power ring
Answer: C) Oil ring

3. What is the primary reason for the wear of piston rings in an engine?
A) Movement within the cylinder bore during engine cycles
B) Inadequate cooling
C) Excessive lubrication
D) Irregular combustion

4. What is the purpose of inspecting the end gap of a piston ring?
A) To measure the thickness of the ring
B) To check for wear on the cylinder bore
C) To ensure proper alignment of the piston ring
D) To determine the oil consumption rate of the engine

Answer the following questions

- How many types of rings used in piston?
- How much the clearance provided in the cylinder bore?
- What are the functions of compression rings?
- What are the functions of oil control ring?
- What is the position of the ring in the piston?

Activity

1. Make a list of steps required to measure the clearance between piston and cylinder wall.

S.No.	Steps
1	
2	
3	
4	

2. Make a poster showing piston and piston rings and label parts.

Session-3: Inspection and replacement of cylinder liner/ Bore sleeve, connecting rod and engine bearing

As engines power our vehicles with their intricate workings, it's important to understand some key components that keep them running smoothly. In this discussion, we'll enter into the world of engines and learn about the inspection and replacement of three vital parts of the engine: the cylinder liner or bore sleeve, the connecting rod, and engine bearings. These components play crucial roles in the engine's performance, and knowing how they work and how to maintain them can provide valuable insights into the heart of automotive engineering. So, let's embark on a journey to uncover the working of these fascinating pieces that drive our vehicles forward.

1. Cylinder Liner/Bore Sleeve:

In a car's engine, there are cylinders where the fuel burns to create power. The cylinder liner, also known as a bore sleeve, is like a protective tube that lines the inside of the cylinder. It's usually made of a tough material like cast iron. Over time, the cylinder liner can wear out due to the constant movement of the piston inside it. When this happens, it can affect the engine's performance.

Inspection: Mechanics check the condition of the cylinder liner by looking inside the cylinder with special tools or cameras. They look for signs of wear, scratches, or damage. If the liner is damaged too much, it might need to be replaced.

Replacement: If the cylinder liner is too worn or damaged, mechanics will carefully remove the old one and put in a new one. This is a complex process that requires special tools to ensure the new liner fits perfectly and is sealed correctly.

2. Connecting Rod:

The connecting rod is an important part of the engine that connects the piston to the crankshaft. It helps transfer the up-and-down motion of the piston into the rotational motion of the crankshaft.

Inspection: Mechanics inspect the connecting rod for any signs of cracks, bending, or wear. They also check whether the connecting rod is still straight and strong. It must not be in bent condition due to repeated loading conditions.

Replacement: If the connecting rod is damaged beyond repair, mechanics will replace it with a new one. This involves taking the engine apart to access the connecting rod and carefully fitting the new rod.

3. Engine Bearings:

Engine bearings are like small cushions that help reduce friction between moving parts in the engine, like the crankshaft and connecting rod. They're usually made of metal and help keep the engine running smoothly.

Inspection: Mechanics check engine bearings for signs of wear, scoring, or damage. They also look for any metal particles in the oil, which could indicate that the bearings are wearing out or already worn.

Replacement: If the engine bearings are worn out, mechanics will replace them. This involves carefully removing the old bearings and fitting new ones. It's important to make sure the new bearings are properly lubricated to prevent friction and damage.

Inspection of Cylinder Liner/Bore Sleeve:

- Check the upper side of the bore sleeve. If it is worn out, replace the sleeve.
- Check the swept volume / or ring travel area especially at TDC for the wear with the help of dial bore gauge.
- If the piston ring is stuck in the ring groove the scratches will be noticed on the bore sleeve.
- Due to engine overheating the piston seizes in the bore sleeve.

Replacement of Dry liner/bore sleeve

- Place the engine block on the press.
- Use special tool as per the size of cylinder bore.
- Support the engine block properly and rigidly fix it on the press.
- Apply pressure in the range of 0.2 to 0.5 Tonne for dry liner of B.D.C, where sleeve ends from the crank case side of engine block. The old sleeve will come out from engine block.
- Select new standard size bore sleeve with standard piston and rings.

- Place the sleeve in liquid hydrogen where it will become easy to place in the engine block bore.
- Place the sleeve on the engine block from the cylinder head side.
- Operate the press slowly with a pressure of 0.1 to 0.3 Tonne. The sleeve will easily enter in the engine block.
- Inspect the height of the sleeve in engine block with machinist edge and feeler gauge.
- Maintain equal height for all cylinders.
- Clean and lubricate the bore.
- Check piston clearance with the help of feeler gauge.
- Use piston ring compressor and place the piston with connecting rod in the engine block.
- Repeat the same process for all sleeves.

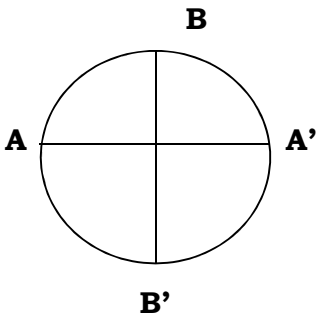
Replacement of Wet Liner / Bore Sleeve

- Place the engine block on the press.
- Use special tool as per the size of cylinder bore.
- Support the engine block properly and rigidly fix it on the press.
- Apply pressure of 0.1 to 0.3 tonnes for wet liner from the crank case side of engine block where sleeve ends at B.D.C. The old sleeve will come out from engine block.
- Select new standard size bore sleeve with standard piston and rings.
- Apply soap water on the sleeve and fit the 'O' ring to avoid leakage of water in the crank case.
- Place the sleeves on the cylinder block from the cylinder head side.
- Operate the press slowly with pressure of 0.1 to 0.3 tonne, take care that 'O' rings must not twist. Slide the liner in engine block.
- Inspect height of sleeve with machinist edge and feeler gauge.
- Clean and lubricate the bore.
- Place the rings in ring grooves and apply lubricating oil. With the help of ring compressor, place the piston in engine block along with connecting rod.

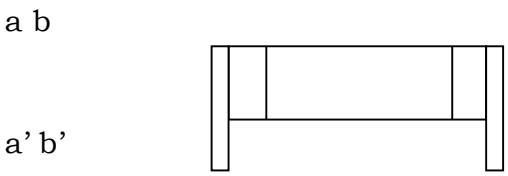
Inspection of Crank Shaft and Main Bearing

- Inspect crank shaft for alignment.
- Inspect the main bearing.
- Remove the crank shaft from the crank case.
- Place the crank shaft on the lathe machine.
- Use dial gauge to check the run out /bend.
- Place the dial gauge at both ends and at centre.
- Turn the crank shaft, if run out is noticed more than 0.06 mm, then it is necessary to regrind the crank shaft.

- Inspect the big end journal/main journal for ovality and taperness. Use micrometer and take reading at position A A' (Horizontal) and position B B' (vertical). The difference between he reading gives ovality.



- The permissible value of ovality is 0.01 mm to 0.015 mm.
- To check the taperness, take the reading at two ends of the pin of the main journal /connecting journal.
- Use micrometer and take reading at position a a' and then at position b b'. This shows taperness.



- The permissible value of taperness is 0.01 mm to 0.015 mm.
- Check the collars at journal ends.
- Check the edge of oil hole and clear the hole.
- If the alignment /ovality/taperness of crank shaft is more than that of permissible values then undersize the crank shaft up to 0.15 mm.
- To repair/ undersize the crank shaft special grinding machine is used.
- Undersize the crank shaft maximum up to 0.15 mm only.
- To accommodate the gap / clearance change the engine bearings.
- Also inspect oil clearance / bearing clearance by using plastic gauge or micrometer. The permissible value is 0.05 mm.
- Always replace the bend or twisted connecting rod.
- Fit the crank shaft in engine crank case and check the end play.
- To check end place dial gauge at one end of crank shaft, pull / push the crank shaft. The dial gauge shows deflection.
- If the play is more add oversized thrust pad and if less reduce the thickness of the thrust pad.

- Change all oil seals, 'O' ring, packing kit, etc.
- Assemble engine in proper order as prescribed in service manual.
- Fill the engine oil and attach other engine accessories.
- Run the engine at ideal speed up to 2 hours and check the leakage.
- After 2 hours, conduct the test.

Check Your Progress

Fill in the blanks

1. In an engine, the cylinder liner, also known as a _____, lines the inside of the cylinder to protect it from wear and damage.
2. If a connecting rod is damaged beyond repair, it needs to be _____ with a new one.
3. One of the indicators of worn-out engine bearings is the presence of _____ in the oil.
4. Inspecting the _____ of the crankshaft is done using a dial gauge to check for runout or bending.

Multiple Choice Questions

1.What is the purpose of a cylinder liner or bore sleeve in an engine?
A) To hold the spark plugs
B) To line the inside of the cylinder and protect it
C) To connect the piston to the crankshaft
D) To control the flow of coolant

2. What is the primary reason for inspecting the cylinder liner?
A) To check the color of the liner
B) To ensure proper coolant flow
C) To measure the piston size
D) To identify wear, scratches, or damage

3.What could cause scratches on a cylinder liner?
A) Excessive coolant flow
B) Incorrect piston size
C) Piston ring sticking
D) Too much engine oil

4. The connecting rod in an engine serves to:
A) Direct the flow of air
B) Convert rotational motion to up-and-down motion
C) Hold the fuel injectors

D) Control exhaust gas emissions

Answer the following questions

1. What is the function of connecting rod?
2. Why do some connecting rod have hole drilled from small end to the big end bearing?
3. Which parts are connected to the small end of the connecting rod?
4. Which part of connecting rod is connected with crankshaft?
5. How to check bend in connecting rod?
6. How to check clearance between connecting rod and crankshaft?

Activity

1. Make a list of steps required for inspection and replacement of cylinder liner/ bore sleeve

S.No.	Steps
1	
2	
3	
4	

2. Make a poster showing ovality and taperness.

Session 4: Testing of cooling system and replacement of defective components

In I.C. engines, during power stroke, the engine temperature reaches between 700-900°C. About 30% heat is released during exhaust stroke. The cooling system removes approximately 30% of the heat (Fig. 2.12). In a vehicle, most of the energy of fuel (approx. 70%) is converted into heat, and it is the job of the cooling system to take care of that heat. The primary job of the cooling system is to prevent the engine from overheating by transferring this heat to the air.

Cooling is necessary because high temperature damages engine components and changes the viscosity of the lubricants. The cooling system protects the engine components by circulating coolant through the passages provided in

cylinder block and cylinder head. The heat is collected by the coolant and the coolant is passed through the radiator. The radiator radiates the heat and cools the coolant. The air circulated around the engine also disperse the heat and allows the engine to maintain optimum temperature.

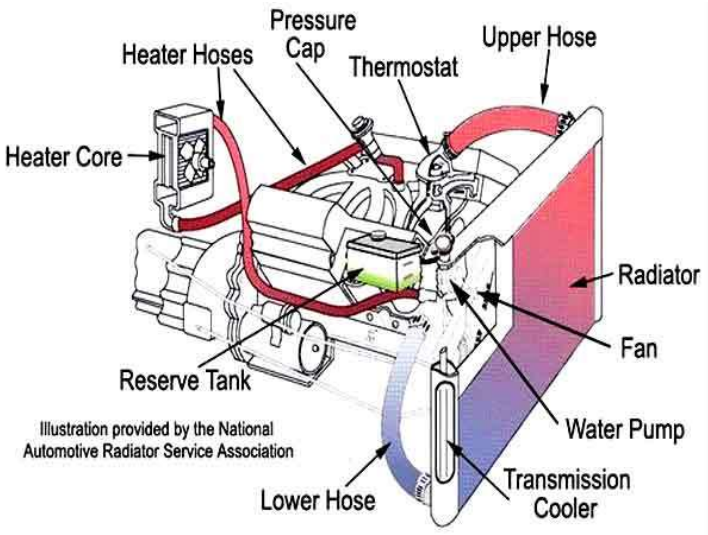


Fig. 2.12: components Automobile Cooling

Common faults in cooling system

- Loose or broken water pump pulley belt
- Low level of coolant
- Faulty thermostat
- Faulty water pump
- Dirty or bend radiator fins
- Broken water pump fan
- Coolant leakage on cooling system
- Defective cooling fan motor
- Plugged radiator
- Faulty radiator cap
- Improper ignition timing

Inspection of Coolant Temperature Sensor

Temperature (°C)	Resistance (ohms)	Voltage
0	6000	4.5
20	2500	3.2
30	1400	3.1
60	800	2.4
80	280	1.2

Fig. 2.13: Automobile Cooling System temperature sesnor

Causes and remedies for Cooling System

Reasons	Remedy
Loose or broken water pump pulley belt	Adjust / replace
Low level of coolant	Check coolant level and add if necessary
Faulty thermostat	Replace
Faulty water pump	Replace
Dirty or bend radiator fins	Clean or replace
Broken water pump fan	Replace
Coolant leakage on cooling system	Repair
Defective cooling fan motor	Check and replace
Plugged radiator and defective rubber hoses	Check and replace radiator
Faulty radiator cap	Check the upper hole on the radiator cap and also check rubber sealing and replace it if found defective
Faulty thermostatic switch	Replace switch
Improper ignition timing	Adjust

With the help of appropriate tools, defective component may be replaced with the help of Standard Operating Procedure (SOP) given in the service manual.

Check Your Progress

Fill in the blanks

1. The primary purpose of the cooling system in an internal combustion engine is to prevent _____.
2. The cooling system is responsible for removing approximately _____% of the heat generated during the engine's power stroke.

3. The radiator is responsible for dissipating heat and cooling down the _____.
4. The component responsible for regulating coolant flow based on engine temperature is called the _____.

Multiple Choice Questions

1. What is the primary function of the cooling system in an internal combustion engine?
A) Increase engine efficiency
B) Enhance fuel combustion
C) Prevent overheating
D) Improve exhaust emissions

2. During which stroke of the internal combustion engine, the highest temperature typically occurs?
A) Power stroke
B) Compression stroke
C) Exhaust stroke
D) Intake stroke

3. What is one of the potential consequences of high engine temperatures?
A) Improved fuel efficiency
B) Reduced exhaust emissions
C) Increased lubricant viscosity
D) Enhanced engine performance

4.What is the purpose of the cooling fan in the cooling system?
A) Increase engine power
B) Enhance exhaust flow
C) Improve fuel combustion
D) Disperse heat and maintain engine temperature

Answer the following questions

Q1. Why the cooling system is important in I C Engine?
Q2. Name the different component of cooling system.
Q3. Name the different methods of engine cooling.
Q4. Difference between oil cooling system and water-cooling system.
Q5. What is the function of radiator in cooling system?
Q6. Why coolant is added in the radiator?
Q7. What is the function of thermostats?

Q8. What is the function of water pump and cooling fan?

Activity

Exercise: Assignment

1. Make a list of common faults in cooling system

S. No.	Fault
1	
2	
3	
4	

2. Make a poster showing water/fluid cooling system of any vehicle and label all the components.

Session 5: Regular Servicing of MPFI system

Multi Point Fuel Injection system (MPFI): The introduction of Multi-Point Fuel Injection (MPFI) systems in vehicles plays a crucial role in addressing legislative requirements related to reducing exhaust gas emissions, improving engine performance, enhancing driving comfort and control, and ensuring safety. This system is also called Motronic engine management system.

In this system, each cylinder has number of injectors to supply/spray fuel in the cylinders as compared to one injector located centrally to supply/spray fuel in case of single point injection system.

Advantage of M.P.F.I.

1. More uniform Air-Fuel ratio will be supplied to each cylinder, hence the difference in power developed in each cylinder is minimum. Vibration from the engine equipped with this system is less. Due to this, the the life of engine components is improved.
2. No need to crank the engine twice or thrice in case of cold starting as happens in the carburetor system.
3. Immediate response, in case of sudden acceleration / deceleration.
4. Since the engine is controlled by ECM (Engine Control Module), more accurate amount of A/F mixture will be supplied and as a result complete

combustion will take place. This leads to effective utilization of fuel supplied and hence low emission level. ECM is also known as computer of the vehicle.

5. The mileage of the vehicle will be improved.

ECM (Engine Control Module) component and its function: The function of ECM is to receive signal from various sensors, manipulate the signals, and send control signals to the actuators.

Sensors: Senses different parameters (Temperature, Pressure, Engine Speed etc.) of the engine and send signal to ECM. Some of the important sensor are crank angle sensor (CKP), cam sensor, throttle position sensor, AMF (Air mass flow) sensor, coolant temperature sensor, oxygen (lambda) sensor etc.

Actuators: Receives control signal from ECM and performs its function accordingly. Important actuators are fuel injectors, immobilizer unit, body control module, motorised headlight, fuel pump etc.

Processor: ECM is also called processor because it collects all the data from sensor and process, take appropriate decision. Any sensor or actuator faults are stored in ECM memory (Fig. 2.14) which can be recovered or read by diagnostic equipment.

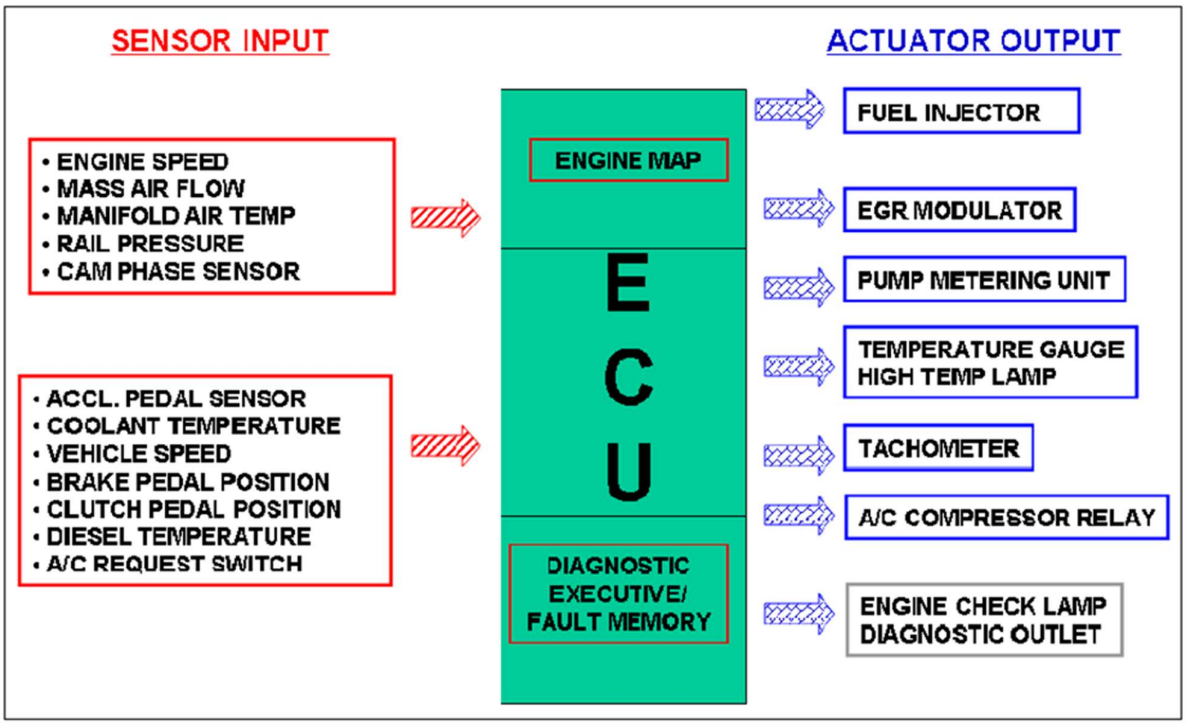
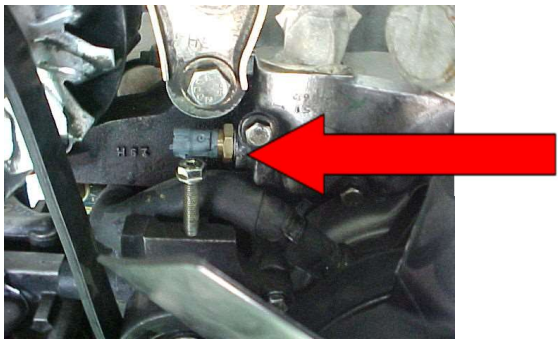


Fig. 2.14: ECU of an automobile

COOLANT TEMPRATURE SENSOR:

Most coolant sensors are "thermistors" that change resistance as the temperature of the coolant changes. Most are the "NTC" (Negative Temperature Coefficient) type where resistance drops as the temperature goes up. With this type of sensor, resistance is high when the engine is cold. As the engine warms up, the internal resistance of the sensor drops until it attains the desired temperature (Fig. 2.15).



Coolant Temperature Sensor (CTS)
Location - On the Water Outlet Box, Near Thermostat
Type - 2 Wires, Resistor with Negative Temperature Coefficient
Function - Monitors the Coolant Temperature
Purpose – To Determine The Temperature of The Engine

Fig. 2.15: Coolant temperature sensor

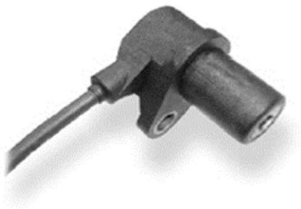


Fig. 2.16: Automobile Cooling System

THROTTLE POSITION SENSOR.

Mounted on the throttle shaft of the carburetor or throttle body, the throttle position Sensor (TPS) changes resistance as the throttle opens and closes. The computer uses this information to monitor engine load, acceleration, deceleration and when the engine is at idle or wide-open throttle. The sensor's signal is used by the ECM to enrich the fuel mixture during acceleration, and to retard and advance ignition timing.

CRANK POSITION SENSOR

A crankshaft position sensor is the magnetic type or OVER Hall Effect switch; most problems can be traced to faults in the wiring harness. (Fig. 2.16) A disruption of the sensor supply voltage, ground or return circuits can cause a loss of the important timing signal resulting in an engine that cranks but won't start.

Fig. 2.16: Crankshaft Position Sensor

MASS AIRFLOW SENSOR

Location - On the Intake Hose

Type - 3(5) Wire, Hot Film Mass Flow Sensor

Function - Monitors the Air Flow (Fig. 2.17)

Purpose – To correct Air Flow Map and Regulate EGR Flow

Intake Air Temperature

Location - Integrated with MAF Sensor

Type - 2(5) Wire, Resistor with negative Temperature Coefficient

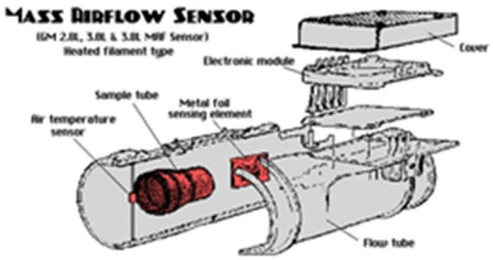


Fig. 2.17: Mass flow sensor

Function - Monitors the Intake Air Temperature

Purpose – Measures Air Temperature for Density Correction & Maintaining Temperature of Hot Film

OXYGEN (O_2) /LAMBDA SENSOR

Mounted in the exhaust manifold, the O_2 sensor monitors the amount of unburned oxygen in the exhaust. The O_2 sensor generates a voltage signal that is inversely-proportional to the amount of unburned oxygen in the exhaust. When the fuel mixture is rich, most of the oxygen is consumed during combustion so there is little unburned oxygen in the exhaust (Fig. 2.18 and Fig. 2.19). The difference in oxygen levels between the exhaust inside the manifold and the air outside creates an electrical potential across the sensor's platinum and zirconium tip. This causes the sensor to generate a voltage signal. The sensor's output is high (up to 0.9 V) when the fuel mixture is rich (low oxygen), and low (down to 0.1 V) when the mixture is lean (high oxygen).

Fig. 2.18: A type of oxygen sensor

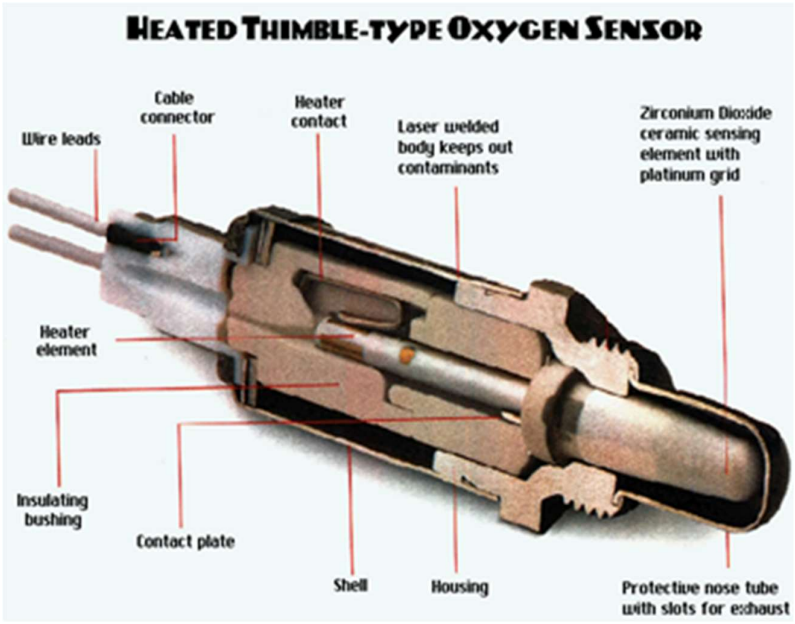


Fig. 2.19: Oxygen sensors components

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR

The MAP sensor is mounted on or connected to the intake manifold to monitor intake vacuum. It changes voltage or frequency as manifold pressure changes. The computer uses this information to measure engine load so ignition timing can be advanced and retarded as needed. It performs essentially the same job as the vacuum advance diaphragm on an old-fashioned mechanical distributor.

RAIL PRESSURE SENSOR (RPS)

LOCATION - On the Fuel Common Rail

FUNCTION - MONITORS RAIL PRESSURE

PURPOSE – To Decide on Injector Energising Time

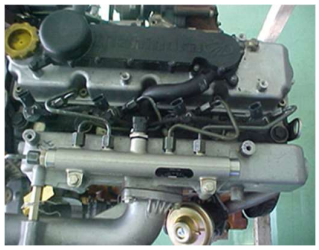


Fig 2.20: Automobile Cooling System

FUEL INJECTOR

Location – On The Cylinder Head

Type – 2 Wire, Solenoidoperated, Electro-Hydraulic Injector

Function – Solenoid Valve Opens, On Recept Of Signal From Ecu.The Amount Of Time The Injector Open Determines Amount Of Fuel Flow, As The Rail Pressure Is Monitored.

Purpose – To Inject Fuel In A Fine Mist Inside The Cylinder

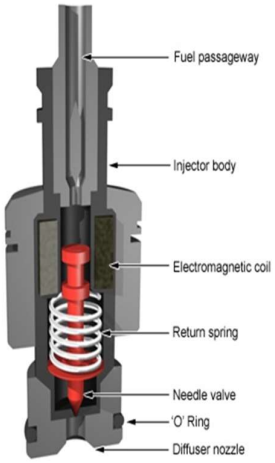


Fig. 2.21: Fuel injector assembly

ECU (Electronic Control Unit)

Fig. 2.22: Automobile Cooling System

A modern ECU might contain a 32-bit, 40-MHz processor. This may not sound fast compared to the 500- to 1,000-MHz processor you probably have in your PC, but remember that the processor in your car is running much more efficient code than the one in your PC. The code in an average ECU takes up less than 1 megabyte (MB) of memory. By comparison, you probably have at least 2 gigabytes (GB) of programs on your computer -- that's 2,000 times the amount in an ECU.

EGR VACUUM MODULATOR

Location – On The Firewall

Type – Solenoid Controlled Vacuum Modulator

Function - To Supply Desired Level Of Vacuum To Egr Valve

Purpose – To Control Egr Flow

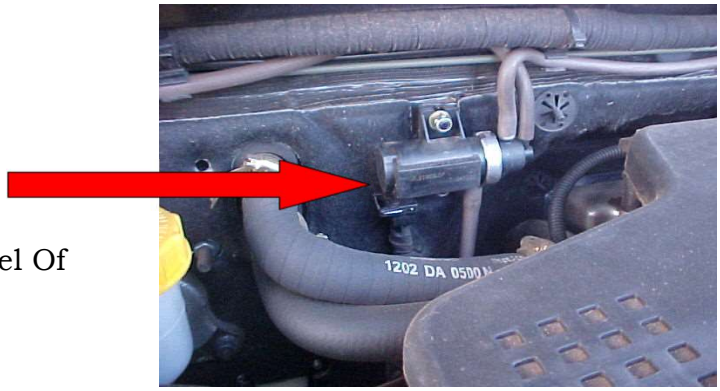


Fig. 2.23: Automobile Cooling System

Method of detection of fault in MPFI

1. A major fault comes with faulty sensor, poor voltage received in ECM due to improper connection.
2. Short circuit and poor battery voltage may result into sensor failure.
3. Sledge formation can be seen in battery terminal which may lead to voltage drop due to high resistance. It is suggested that petroleum jelly should be applied on battery terminals.
4. Check all connector for looseness and use electric contact cleaner if required.
5. Check with service manual for specific trouble.

Throttle Body

Throttle body is very important part of air supply system to the engine. It should be regularly cleaned (Fig 2.24). The throttle body (Butter fly) can be cleaned by carbo cleaner.

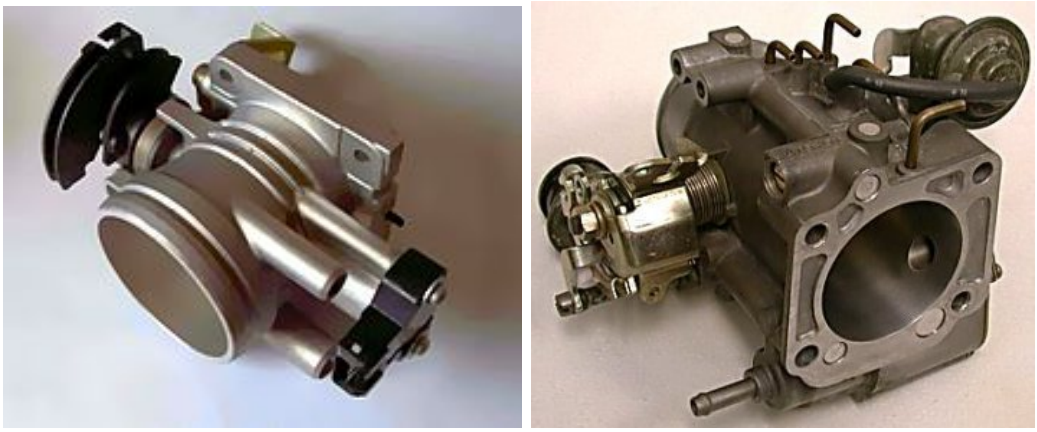


Fig. 2.24: Throttle body

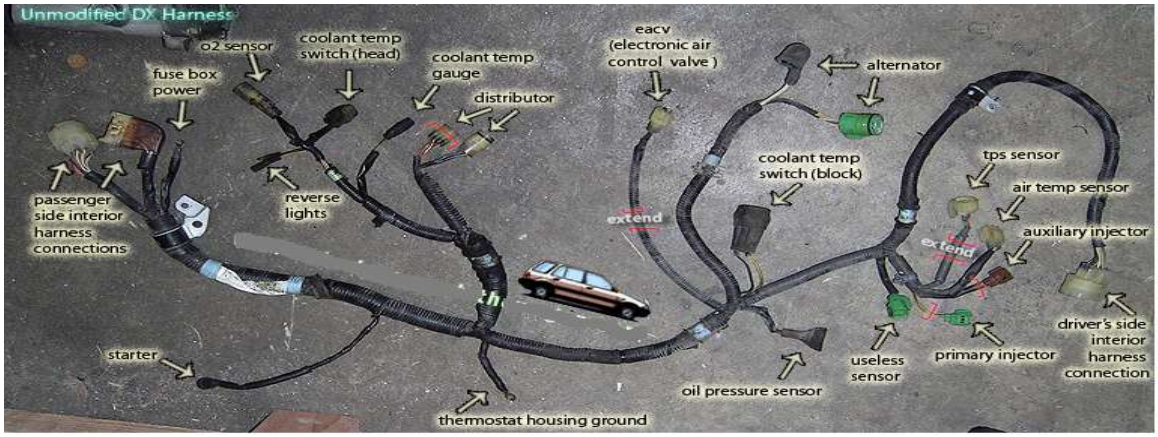


Fig. 2.25: Sensor representation at MPFI Circuit

Case I: If ECM fails to send control signal to all actuators then the engine won't get started.

Case II: If ECM fails to service from all sensors then also the engine won't get started

Case III: If any sensor is either disconnected or faulty, it should be replaced after performing proper inspection referring to service manual.

Check Your Progress
Fill in the blanks 1. The Multi Point Fuel Injection (MPFI) system is advantageous because it provides a more uniform _____ to each cylinder, resulting in minimized power differences between cylinders.

2. The Mass Air Flow (MAF) sensor is responsible for monitoring the intake air flow, which is crucial for correcting the Air Flow Map and regulating _____.
3. The Coolant Temperature Sensor (CTS) is a type of _____ that changes resistance as the engine's temperature changes, helping determine the engine's temperature.
4. The Rail Pressure Sensor (RPS) is located on the fuel common rail and its primary function is to monitor and decide the _____ of the fuel injector.

Multiple Question Answer

1. What is the primary advantage of the Multi Point Fuel Injection (MPFI) system over a single-point injection system?

A) Improved engine vibration
B) Lower fuel consumption
C) Increased exhaust emissions
D) Enhanced cold start performance

2. Which component of the MPFI system is responsible for receiving signals from various sensors and sending control signals to actuators?

A) Throttle Position Sensor (TPS)
B) Crankshaft Position Sensor
C) Oxygen (O2) Sensor
D) Engine Control Module (ECM)

3. Which sensor changes resistance based on the temperature of the coolant and helps in regulating engine performance?

A) Throttle Position Sensor (TPS)
B) Crankshaft Position Sensor
C) Coolant Temperature Sensor (CTS)
D) Mass Air Flow (MAF) Sensor

4. What is the main function of the EGR Vacuum Modulator in the MPFI system?

A) To control exhaust emissions
B) To monitor intake vacuum
C) To regulate fuel pressure
D) To control EGR flow

Answer the following questions

Q1. What is the full form of MPFI?

Q2. What are main components of MPFI?
Q3. What are the advantages of MPFI over Conventional System?
Q4. What are the disadvantages of MPFI over Conventional System?
Q5. What precaution to be taken while working on MPFI system?
Q6. What is Sensor?
Q7. What is Actuator?
Q8. What is ECM?
Q9. Write the two names of sensor used in MPFI.

Activity

1. Make a list of advantages of MPFI system

S.No.	Advantage
1	
2	
3	
4	

2. Make a poster showing different stages from 1 to 4 of multipoint injection fuel as per valve timing.

Session 6: CRDI and Non CRDI system

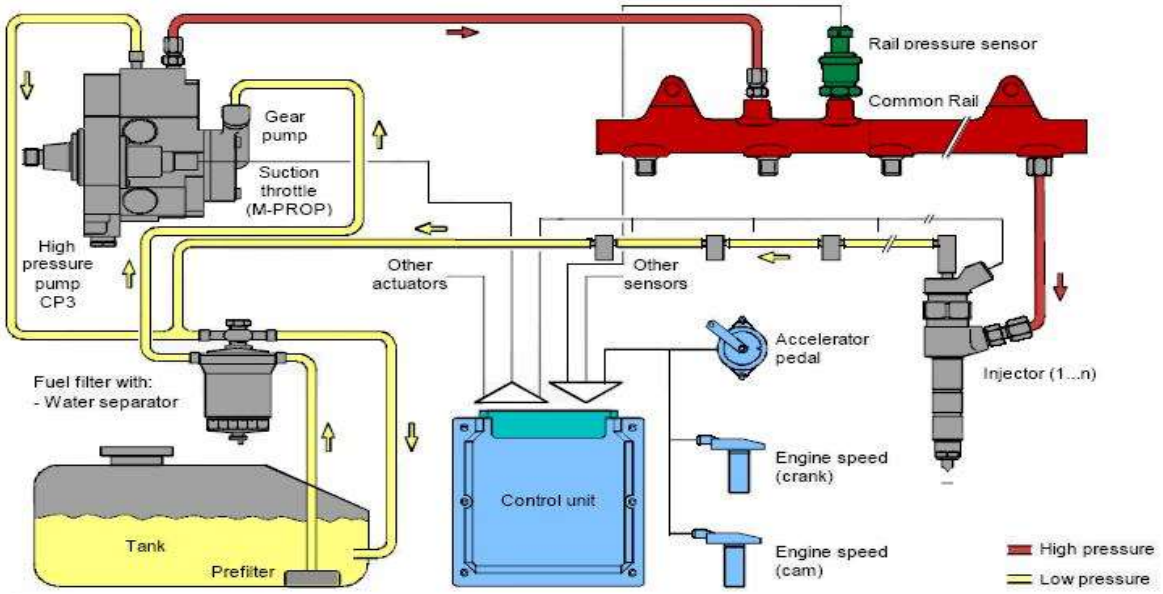


Fig. 2.26: CRDI System

CRDI (Common Rail Direct Injection); It is a modern technique of fuel supply system used in new generation of diesel engine (Fig. 2.26). The main component of fuel supply system are shown in Fig. 2.27 and Fig. 2.28.

- Storage of fuel (Fuel tank)
- Filtering of fuel (Fuel filter, sedi meter)
- Delivery of fuel to injection pump (Primary pump)
- Injecting the fuel into engine cylinder (rail assembly, unit injector, high pressure pump)
- Controlling the engine speed (ECM operated)

Fig. 2.27: Cut section view of high-pressure pump

Fig. 2.28: Internal components of ECM

Types of solid injection systems:

There are two types of solid injection systems.

Common Rail Fuel Injection system: In this type of system, a single injection pump with injector, called as unit injector, is employed on each cylinder. These unit injectors are operated by rocker arms and springs similar to engine valves.

The fuel is taken from the fuel tank by the feed pump and is supplied at low pressure through a filter to the low-pressure common rail and therefore, to all the unit injectors.

Individual Pump Fuel Injection system: In this system, the fuel is drawn from the fuel tank by means of fuel feed pump which is operated from the injection pump cam shaft. The fuel injection pump (Fig. 2.29) then injects definite quantity of fuel into individual cylinders according to firing order through injectors fitted on them. It is also known Non-CRDI system.

Fig. 2.29 : Individual Inline injection pump

Fuel Injector Nozzel:

To inject the fuel in the cylinder in properly, automized form and in proper quantity, fuel injector nozzels are used. Nozzel consist of small holes which helps in spray of the fuel. A good nozzel should automize fuel uniformly so as to maintain proper injection angle and direction (Fig. 2.30 and Fig. 2.31).

Fig. 2.30: Nozzle

Fig. 2.31: Different types of nozzles

Turbo Charger: A turbo charger or turbo is a forced induction device used to allow more power to be produced by an engine of a given size. A turbocharged engine can be more powerful and efficient than a naturally aspirated engine because the turbine forces more air (oxygen), and proportionately more fuel, into the combustion chamber than atmospheric pressure alone.

Turbo charger is commonly used on truck, car, and bus. Turbo chargers are popularly used with Petrol and Diesel internal combustion engines (Fig. 2.32 and Fig. 2.33).

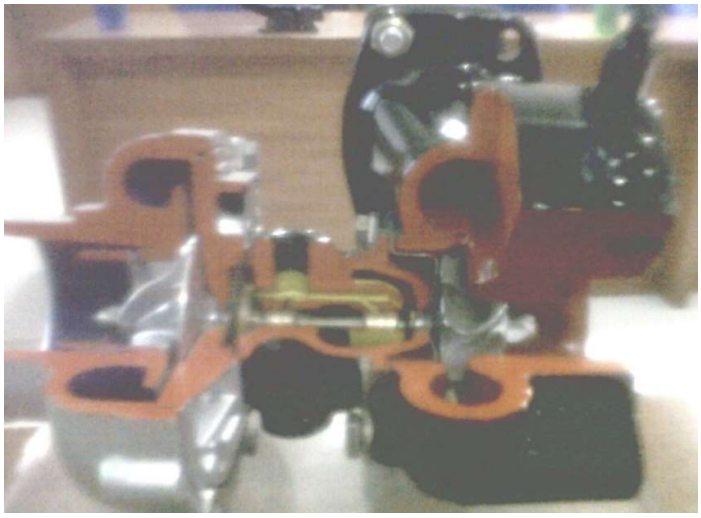


Fig. 2.32: Cut section of Turbo charger

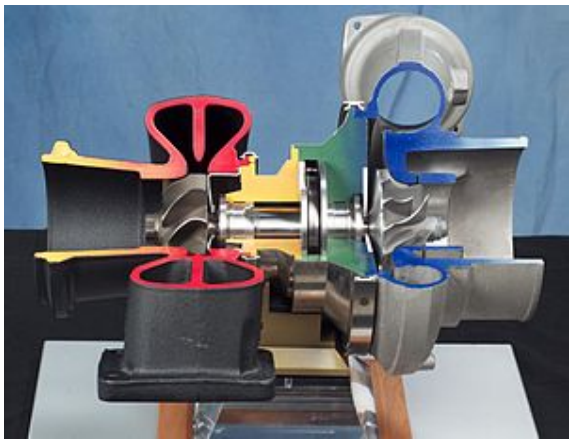


Fig. 2.33: Turbo Charger

Servicing of Turbocharger:

Normally turbochargers work at 150000 rpm. Servicing of turbocharger is not recommended by the manufacture, but, if the oil seal failure is detected, then the complete turbocharger assembly is replaced. Precautions must be taken to avoid the exposure of dust that me come across while disassembly.

Check your Progress

Fill in the blanks

1. The main purpose of a Common Rail Direct Injection (CRDI) system is to inject fuel directly into the _____.
2. A turbocharger increases engine power by forcing more _____ into the combustion chamber.
3. The Electronic Control Module (ECM) is responsible for controlling the _____ of the diesel engine.
4. The role of a fuel injector nozzle is to spray fuel into the cylinder in _____ form for proper combustion.

Multiple Choice Question

1. What is the main function of a Common Rail Direct Injection (CRDI) system in a diesel engine?
a) Controlling the engine speed
b) Storing fuel
c) Filtering air for combustion
d) Injecting fuel into the cylinder

2. What is the purpose of a turbocharger in an engine?
a) Increase the size of the engine

b) Improve fuel efficiency
c) Generate electricity
d) Force more air into the combustion chamber

3. What is the role of the Electronic Control Module (ECM) in a diesel engine's fuel supply system?
a) Filtering the fuel
b) Storing excess fuel
c) Controlling the engine speed
d) Injecting fuel into the cylinder

4. What is the purpose of a fuel injector nozzle in a diesel engine?
a) Storing excess fuel
b) Controlling the engine speed
c) Filtering the fuel
d) Spraying fuel into the cylinder in an atomized form

Answer the following questions

1. What is the full form of CRDI?
2. What are the main components of CRDI?
3. What are the Advantages of CRDI over Conventional Diesel system?
4. What are the disadvantages of CRDI over Conventional Diesel system?
5. What precaution to be taken while working on CRDI system?
6. Explain the use of turbo charger.

Activity

1. Make a list of components of CRDI system

S. No.	Advantage
1	
2	
3	
4	

2. Make a poster showing CRDI system and its components

Module 3	TRANSMISSION SYSTEM

Module Overview

A vehicle's Transmission system helps transmit mechanical power from the engine to the wheels. It is an interconnected system that consists of a clutch, gearbox, and propeller shaft/drive shaft (in front wheel and 4X4 wheel drive vehicles). The complete set-up of the system (Fig. 3.1) helps maintain the vehicle's cruising speed without any disturbance to the car's performance.

This module covers critical elements such as the clutch, propeller shaft, universal and slip joints, differential unit, and automatic transmission systems. Through this module, students will gain the necessary skills to effectively overhaul, service, and adjust these components, ensuring optimal vehicle performance.

Learning Outcomes

After completing this module, you will be able to:

- Understand the function and importance of the clutch system, including the pressure plate, clutch disc, release bearing, and flywheel in the transmission system.
- Identify and explain the various components of a clutch system, including the pressure plate, clutch disc, release bearing, and flywheel.
- Demonstrate the step-by-step procedure to dismantle, inspect, and reassemble a clutch system.
- Conduct a detailed inspection and servicing of the differential unit, including cleaning, lubrication, and replacement of worn parts.
- Perform basic servicing and maintenance tasks for an automatic transmission system.
- Troubleshoot and diagnose common issues in automatic transmissions and recommend appropriate repair procedures.

Module Structure

Session 1: Overhauling of clutch
Session 2: Servicing of propeller shaft, universal and slip joints
Session 3: Servicing of Differential unit and adjustment
Session 4: Automatic transmission system

Session 1: Overhauling of clutch

In module 3, we have discussed about maintenance and regular adjustments in clutch for efficient power transmission. When the clutch runs with noise and clutch slips and it does not engage and disengage properly, it may result into jerky movement in engagement and as well as disengagement. Then it is necessary to overhaul the clutch assembly**.** Mostly different types of clutches are used in today's automobile like diaphragm clutch, multi plate clutch and centrifugal clutch with zero drive.

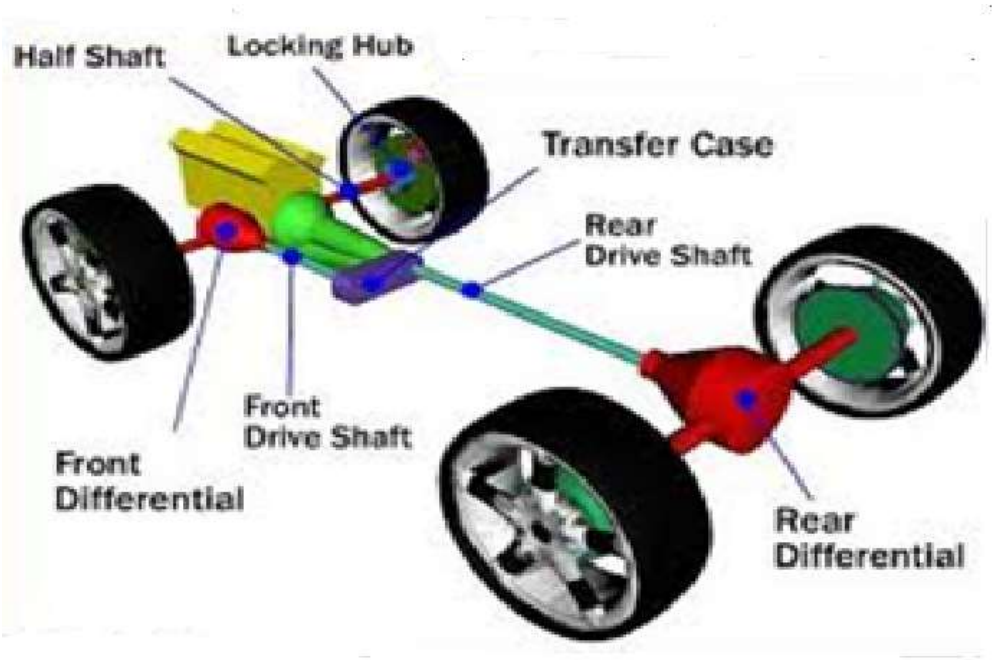


Fig. 3.1: Transmission system

Diaphragm clutch: In this type of clutch, diaphragm spring is used in place of coil spring. This type of clutch is called as diaphragm clutch. Diaphragm clutch is small in size as compared to the spring clutch and it transmits more torque as diaphragm exerts more pressure (Fig. 3.2 and Fig. 3.3). Therefore, it is advantageous to use diaphragm clutch instead of spring clutch. It is more compact means of storing energy, thus compact design results in smaller clutch housing. It is less affected by centrifugal force and it can withstand higher rotational speeds. Diaphragm acts as both clamping spring and release levers. This clutch requires less maintenance compared to other types of clutches.

Fig. 3.2: Diaphagram Clutch

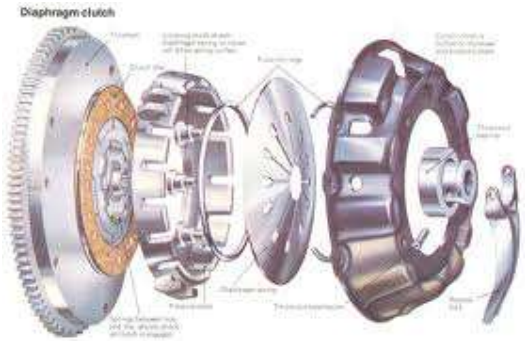


Fig. 3.3: Exploded View of clutch

Activity 1: To overhaul the clutch used in vehicles

Tools required: Open ring and box spanner, Screw Drivers, etc.

Procedure for removing clutch assembly from the engine:

1. Place the vehicle on a plain ground.
2. Raise the vehicle at a specific height.
3. Remove the clutch linkage connection from the bell housing.
4. Remove propeller shaft from companion flange of the gear box.
5. Loose and remove nut/bolt of clutch housing and gearbox housing.
6. Mark the position of cover on the flywheel.
7. Remove all the bolts of pressure assembly from the fly wheel.
8. Remove the clutch plate, pressure plate, release bearing and keep it on the work bench for inspection.

Inspection of Clutch plate for oil leakage

1. Check for the oil leakage on the clutch plate.
2. Check the thickness of clutch plate with Vernier depth gauge, if it is out of permissible limit then replace it.
3. Check the cover assembly of clutch, if there is oil leakage then replace the oil seal on gear box or from crankshaft.
4. Place the clutch plate on clutch shaft/input shaft.
5. Place the dial gauge on clutch plate and rotate the clutch shaft for checking the distortion of the clutch plate.
6. Allow the pointer to rest perpendicular to clutch plate, rotate the clutch plate and check radial run out, if it is more than 2.0 mm, then replace the clutch plate.
7. Inspect for the bend of the clutch shaft and also check the conditions of the splines.
8. Inspect the torsion springs for breakage or slackness.
9. Check the gap between internal spline of clutch hub and clutch shaft external spline. Please ensure that the gap should not exceed beyond 0.05 mm.

Inspection of Flywheel frictional surface

1. Visual inspect the frictional surface of flywheel, if the circular lines or wear is found then remove the fly wheel from the crankshaft.
2. Skim the frictional surface of the flywheel on lathe machine.
3. Inspect the pivot bearing for wear
4. Check the ring gear teeth wear of flywheel, if found damage replace the ring.

Pressure plate

1. The frictional surface of the pressure plate has circular lines/scratches.
2. If the pressure plate is distorted then do the skimming process.
3. In case, the thickness of friction lining is increased then maintain the clearance between clutch plate and pressure plate.

Diaphragm spring

1. Inspect the diaphragm spring for any sort of torn using finger and if it has cracks on it.
2. Check the tension of the spring.
3. Check the release bearings for wear, and replace if it is worn out.
4. Inspect release bearing supporting, furculum and shaft.

Precautions

1. Do not misplace the parts.
2. Keep the removed nuts/bolts properly in the tray.
3. Do not misplace the parts.
4. Keep the removed nuts and bolts properly in the tray.

Trouble shooting process in clutch.

Clutch slip: If power transmission is not transmitted to gear box after releasing the clutch plate. This indicates that there is clutch slip.

CAUSES	**REMEDIES**
Improper clutch pedal free play	Adjust the setting of the clutch pedal
Oil on the clutch plate lining	Replace the lining/ replace the clutch plate
Weakened diaphragm spring	Replace it
Wrapped disc, pressure plate, flywheel surface	Replace
Noisy clutch	Replace worn out clutch release bearing or replace crack clutch disc/hub.

Clutch Judder: When the clutch pedal is released for the engagement of the clutch, the vehicle starts moving with jerks. This phenomenon is known as Clutch judder.

Cause	**Remedy**
Weakened diaphragm	Replace
Spoiled input/clutch shaft spline	Replace
Rusted clutch plate	Replace cable
Broken clutch disc	Replace clutch disc
Glazed clutch facing	Replace disc

Check Your Progress

Fill in the blanks

1. Diaphragm clutch is advantageous over spring clutch as it transmits more torque due to the use of a diaphragm _____.
2. During the process of overhauling a clutch assembly, it is important to inspect the clutch plate for _____ and check its thickness.
3. Clutch slip occurs when power transmission is not properly _____ to the gearbox even after releasing the clutch plate.
4. A weakened diaphragm spring can be one of the causes of_____.

Multiple Choice Question

Question 1: What type of clutch uses a diaphragm spring instead of a coil spring?
a) Spring clutch
b) Multi-plate clutch
c) Centrifugal clutch
d) Diaphragm clutch

Question 2: Why is a diaphragm clutch advantageous over a spring clutch?
a) It has larger size
b) It requires more maintenance
c) It transmits more torque
d) It is less affected by centrifugal force

Question 3: What is the primary purpose of overhauling a clutch assembly?
a) To increase rotational speed
b) To replace the engine

c) To improve fuel efficiency
d) To restore proper functioning and efficiency

Question 4: Clutch slip occurs when:
a) The clutch pedal is released slowly
b) Power transmission is not transmitted to the gearbox after releasing the clutch plate
c) The engine stalls
d) The clutch pedal is pushed all the way to the floor

Answer the following questions

1. What is the importance of reconditioning and overhauling the clutch of a vehicle?
2. What are the functions of clutch in vehicle?
3. When is the clutch plate changed in a vehicle?
4. Enlist the components of clutch system?
5. What components are linked to the gear input shaft?
6. Why the clutch springs are used in clutch plate?

Activity

1. Make a list of steps for removing clutch assembly from the engine

S.No.	Steps
1	
2	
3	
4	

2. Prepare a list for the causes and remedies of clutch judder.

S. No.	Causes	Remedies
1		
2		
3		
4		

Session 2: Servicing of Propeller Shaft, Universal and Slip Joints

Propeller shaft:

When the engine and axles are separated from each other on four-wheel (4W) rear-wheel-drive (RWD) vehicles, propeller shaft is used to transmit engine power to the rear drive axles. The propeller shaft, as shown in Fig. 3.4, is mounted between the gearbox and differential and thus the engine power is transmitted to the driving wheels.

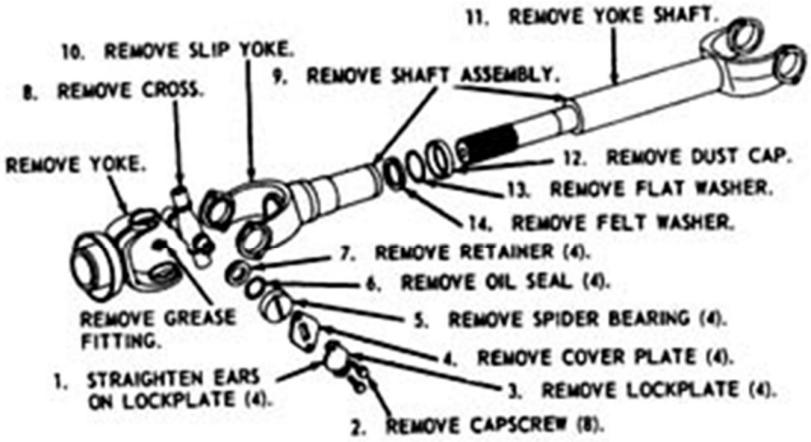


Fig. 3.4: Propeller shaft

Inspection of propeller shaft, universal joint and slip joint

Procedure:

- Remove nut bolts from the companion flange of the propeller shaft from the gear box end as well as from the differential.
- Place the propeller shaft on the lathe machine and turn the propeller shaft.
- Place the dial gauge at one end of the propeller shaft.
- If the dial gauge shows a deflection of more than 2 mm then it indicates the propeller shaft is bent.
- The bent propeller shafts always run noisy.

To clean and replace the universal joint.

- Clean and check universal joint, if it worn out.

- Remove the snap rings / lock from yoke.
- Place the universal joint on arbour press and give gentle pressure. The bearing cup of cross will come out from opposite end. Likewise separate the cross from the yoke.

Inspect the condition of the following

i. Bearing

ii. Cross

iii. Dust covers

iv. Yoke

v. Slip joint internal spines

If the readings or not found in permissible values replace the universal joint and slip joint.

Trouble Shooting

Noisy running of propeller shaft

Causes	Remedies
Bent propeller shaft	Straighten the shaft or replace
Squeaking noise	Lubricate the universal joints and propeller shaft
Enlarged hole of the yokes	Replace yokes
Worn out Universal Joint cross	Replace universal joint cross
More play in the slip joint splines	Replace slip joint
Worn out centre bearing and rubber cushion	Replace bearing and rubber cushion

Drive shaft

A drive shaft (Fig. 3.5) is solid circular shaped shaft usually made of steel which transmits power from engine to gear and then to the wheels of a vehicle.

Fig. 3.5: Drive Shaft

Servicing of the drive shaft

1. Remove the engine cover.
2. Use appropriate spanner and remove the drive shaft nut and washer.
3. Drain the transmission oil from engine/gear box.

4. Using large screw drivers, pullout the driving shaft joint, so as to release the snap ring fitting of joints spline at differential side.
5. Disconnect stabilizer joint from suspension arm.
6. Remove cotter pin and nut from the steering knuckle.
7. Disconnect tie rod ends from steering knuckle.
8. Disconnect the lower arm from the steering knuckle.
9. By using a plastic hammer, drive out the drive shaft joint so as to release snap ring fitting of joints spline at centre shaft.
10. Cover the drive shaft boot with cloth to protect it from dust and damage.
11. To remove drive shaft assembly, pullout inboard joint from centre shaft, wheel side joint and from steering knuckle.
12. Loosen centre bearing support bolt and remove centre shaft from differential side gear.
13. Remove the boot clamp from differential side.
14. Slide boot towards the centre of shaft and remove snap ring from outer race.
15. Clean the drive shaft and use special tools to fix/remove the cage.
16. Draw the cage and boot form the shaft.

Inspection of Drive Shaft

1. Check boots for breakage or deterioration and replace the boots.
2. Replace the broken circlip, snapping and rubber boot bands if broken or damaged.
3. Check that there is no play in the out board joint.
4. Check if the inboard joint is sliding smoothly in the thrust direction or not.
5. Check the play in radial direction of in board joint. Ensure that there is no play.

Assembly of Drive shaft

1. Clean boots with cloth (do not wash boot in diesel or kerosene).
2. Fix the boot on drive shaft. The small diameter side fits to the shaft groove and fixed with boot band.
3. Install cage to the shaft and place the circlip by using special tool (nose plier).
4. Apply grease to entire surface of the cage and CV joint.
5. Insert the cage into outer race and fit the snap ring into the groove of outer race.
6. After fitting boot insert screw driver and allow air to enter in the boot to maintain 1 atmospheric pressure.

Check Your Progress

Fill in the blanks

1. If the dial gauge shows a deflection of 2 mm, it indicates that the propeller shaft is _____.
2. The drive shaft is responsible for transmitting power from the _____ to the _____.
3. To prevent squeaking noise, it's recommended to lubricate the _____ joints and propeller shaft.
4. The drive shaft assembly consists of inboard joint, wheel side joint, and _____ joint.

Multiple Choice Questions (MCQs):

1. What is the purpose of a propeller shaft in a vehicle?
A) To clean the engine
B) To transmit power between the gearbox and differential
C) To steer the vehicle
D) To control suspension

2. Which component connects the engine to the wheels and is usually made of steel?
A) Steering wheel
B) Drive shaft
C) Universal joint
D) Differential gear

3. What is the consequence of a bent propeller shaft?
A) Improved fuel efficiency
B) Reduced noise
C) No effect on performance
D) Noisy operation

4. What should be done if the universal joint cross is worn out?
A) Replace the propeller shaft
B) Clean the joint with solvent
C) Replace the universal joint cross
D) Lubricate the differential

Answer the following questions

- What is the purpose of using propeller shaft/driveshaft in the vehicle?

- Explain the various parts of the propeller shaft/driveshaft.
- When universal joint & slip joint need replacement?
- Describe the functions of a drive shaft.

Activity

1. Make a list of steps that are adopted for inspection of propeller shaft, universal joint and slip joint of a vehicle

S.No.	Steps
1	
2	
3	
4	

2. In a vehicle, the propeller shaft is running noisy; make a list of causes and remedies.

S. No.	Causes	Remedies
1		
2		
3		
4		

Session 3: Servicing of differential unit and adjustments

Differential unit

A differential is a device employing gears, capable of transmitting torque and rotation through three shafts**.** It transfers the power while in turning to the respective wheels. It consists crown gear, sun gear and star gear.

Importance of Differential

A vehicle wheel rotates at different speeds, especially while turning. Each wheel has to travel different distance while turning. In addition, the inner wheel has to travel a shorter distance than the outer wheel. Since speed is equal to (Fig. 3.6, Fig. 3.7, Fig. 3.8 and Fig. 3.9) the distance travelled divided by the time it takes to go that distance, the wheels that travel a shorter distance travel at a lower speed. Also note that the front wheels travel a different distance than the rear wheels.

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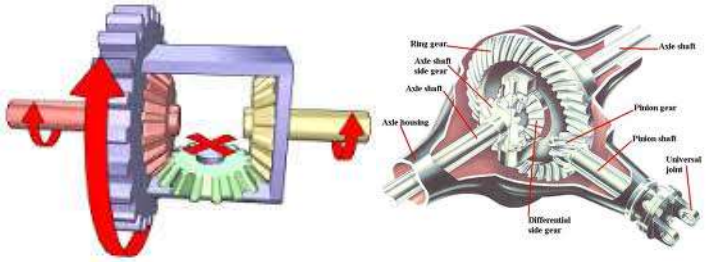


Fig. 3.6: Differential unit

Fig. 3.7: Differential view

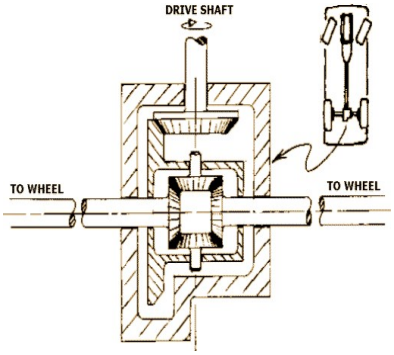


Fig. 3.8: Differential section

Differential

The differential has to perform three jobs:

- Transfers the engine power through gearbox and propeller shaft to wheels.
- The final gear reduction in the vehicle is responsible for slowing the rotational speed of the transmission before it reaches the wheels.
- The wheels are able to rotate at different speeds when taking a turn thanks to the power being transmitted to them.

Working of Differential:

Input torque is applied to the ring gear, which turns the entire carrier, providing torque to both side gears, which in turn may drive the left and right wheels. If the resistance at both wheels is equal, (Fig. 3.9 and Fig. 3.10) the planet gear does not rotate, and both wheels turn at the same speed.

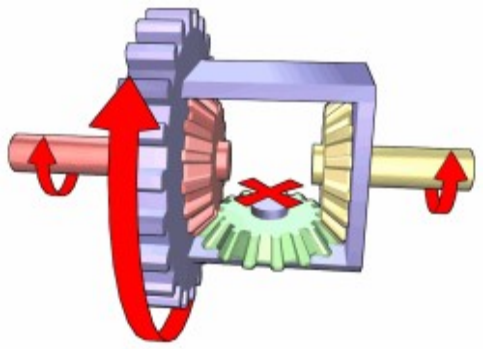


Fig. 3.9: Differential at work

- If the left side gear encounters resistance, the planet gear rotates about the left side gear, which in turn, applies extra rotation to the right-side gear.

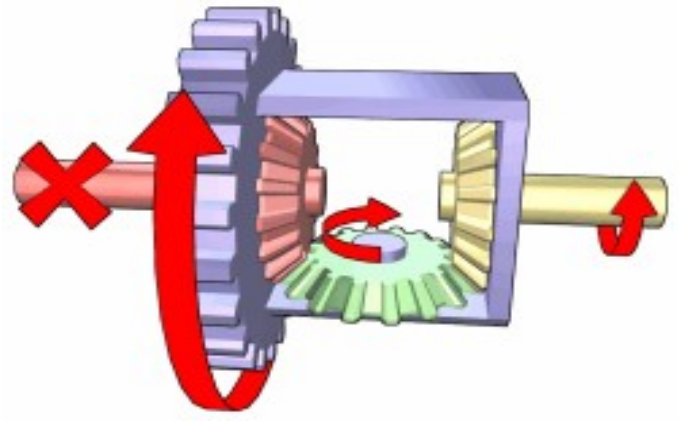


Fig. 3.10: Differential at left not working

Servicing of Differential

Servicing differentials means changing the oil regularly with the proper grade as per the service manual. Replace the broken gear and brass washer or damaged portion if required.

Adjustment of differential

Adjustment of differential, for any backlash, can be done using shims of different thickness. Adjusting bolt is provided at outer side of cage assembly to adjust the crown gear.

Activity 1: To overhaul the differential unit and carry out the necessary adjustments.

Material required: Cotton cloth, oil, kerosene, cleaning brush, metal tray.

Procedure:

1. Drain off the oil from the differential unit & open the cover.
2. Disconnect the propeller shaft from the companion flange of pinion drive.
3. Disconnect the half axle shaft from the differential housing.
4. Open the complete cage assembly.
5. Open both sides of side caps and remove the crown star gear and sun gears.
6. Mark the position and location of all parts carefully for their easy reassembly in their original position.
7. Check the teeth of crown wheel, sun gears, and star gears for any breakage. If found broken, replace the gears. Change all the brass washers.
8. Keep the caps and shims carefully as they control clearance between two moving parts.
9. Pull out the companion flange from pinion drive.
10. Now slowly tap the pinion shaft from outside the casing, the pinion will come out with spacer and two bearings.
11. Mark the position of pinion and no. of shims.

Inspection

1. Inspect the bearing, if they are badly worn out /do not run freely, replace them, if required.
2. Inspect the condition of all the gears teeth for roughness, chipping, and cracking.
3. Fit new oil seals/gaskets, brass washer.
4. To check the tooth contact
   - To check the tooth contacts, apply the precision blue or red oxide paste.
   - Apply above mentioned pastes to the crown wheel teeth.
   - Apply the grease on both the sides of the teeth equally.
   - Rotate the pinion and check the tooth contact.
   - If the tooth contact is improper then do the following adjustments.

Adjustments in Differential unit

1. If there is heavy face contact then remove the shims from the bevel Pinion and move the pinion towards crown wheel.
2. If there is heavy flank contact, then add the shims in the pinion and pullout the pinion away from the crown wheel.
3. If there is heavy toe contact then remove the shims from right hand side and add shims towards left hand side of the crown wheel.
4. If there is heavy heel contact, add the shims towards right hand side of crown wheel.

5. In some cases, outer adjustments bolt with chuck nut is also provided to support the crown and final drive.

Assembly

1. Fix the thrust washers, shims and distance rings properly. Then position and reassemble the differential unit.
2. Check the end play of pinion shaft by moving up and down.
3. Adjust appropriate clearance using shims and adjusting nut.
4. Check the clearances of the tooth and the contact between the crown wheel & pinion.
5. While doing the adjustment, do take care of the backlash (i.e., the gap between two meshing teeth of bevel pinion and crown wheel).

Check the backlash in the final drive

After assembling the differential unit,

- Place the telescopic end of dial gauge on the crown wheel teeth, and set dial gauge to zero.
- Now without turning the pinion shaft, move the crown wheel. The backlash will be displayed on the dial gauge.
- The Backlash of pinion & crown wheel should not exceed 0.15 to 1.18 mm.
- To adjust the backlash, tighten the side check nuts in 4:1 ratio.
- Check the backlash between sun gear and star pinion.
- Place the dial gauge telescopic end on the sun gear tooth.
- Rotate the sun gear without turning star pinion and take down the reading from dial gauge.

Important points

- The backlash of sun gears & planetary gears should not exceed 0.10 to 0.20 mm.
- If there is more backlash, change the thrust pad by adding more thickness.
- If there is less backlash, change the thrust pad with less thickness.
- Also check the radial run out of crown wheel, it should not exceed more than 0.0025 mm.
- Check the internal splines of sun gear and external spline of half axle shaft for stripping.
- Check the gears at the other end of the half axle shaft.

TROUBLE SHOOTING

Noisy running of Differential

Causes	**Remedies**
Improper backlash adjustment in	Adjust the backlash

final drive	
Improper tooth contact in final drive	Adjust the final drive accordingly
Worn out bearing of bevel pinion	Replace
Worn out crown wheel cage bearing	Replace
Worn out thrust, washer of star and sun gear	Replace
Worn out splines of half axle shaft	Replace

Drive is not is not transmitted

Causes	**Remedies**
Broken teeth of bevel pinion and crown wheel	Replace
Broken teeth of sun gear	Replace
Broken cross	Replace
Broken half axle shaft	Replace
Stripped splines of axle shaft and hub	Replace

Check Your Progress

Fill in the blanks

1. The differential allows wheels to rotate at _____ speeds when a vehicle turns.
2. The primary function of the differential is to transfer engine power to the _____.
3. Proper adjustment of backlash ensures correct tooth _____ between gears.
4. In the differential, the components responsible for transmitting torque to the wheels are the half axle _____.

Multiple-Choice Questions (MCQs):

1. What is the main purpose of a differential in a vehicle?
A) To increase engine power
B) To reduce fuel consumption
C) To allow wheels to rotate at different speeds during turns
D) To control steering alignment

2. Which of the following gears is NOT a part of a differential?
A) Crown gear

B) Sun gear
C) Star gear
D) Drive gear

3. The differential's job includes:
A) Increasing transmission speed
B) Slowing down engine power
C) Transferring power to the wheels and allowing speed variation during turns
D) Providing suspension support

4. When a vehicle turns, which wheels travel a shorter distance?
A) Front wheels
B) Rear wheels
C) Left wheels
D) Outside wheels

Answer the following questions

- What is the function of differential unit?
- What is the importance and working of differential?
- What are the main parts of differential?
- Write the steps to adjust crown wheel and pinion clearance.
- What rotates the differential pinion shafts?
- To which gear half shaft splines are connected?
- What kind of joint is used to link differential with shaft & why?
- What lubricants are commonly used in differential?

Activity

1. Make a list of the functions performed by a differential.

S.No.	Functions
1	
2	
3	
4	

2. In a vehicle, to overhaul the differential unit and carry out the necessary adjustments, make a list of necessary steps.

S. No.	Steps
1	
2	
3	
4	

Session 4: A: Transmission System (Gearbox)

The transmission system (gearbox) is positioned between the engine and the propeller shaft or differential in a vehicle's drivetrain. Its primary purpose is to amplify the effective power generated by the engine in order to conquer various forms of resistance. These resistances encompass countering air resistance, surmounting gradient-related resistance, surpassing load-induced resistance, and prevailing over road resistance. The gearbox plays a crucial role in enhancing the engine's capacity to overcome these impediments and ensure efficient vehicle movement.

In summary, we can say that the gear box is used to increase the attractive efforts of an engine power to overcome the following resistances:

- To overcome the air resistance.
- To overcome the gradient resistance.
- To overcome the load resistance.
- To overcome the road resistance.

Shift the gear gently to reduce friction and power loss. Inspect the components of the gear selective mechanism and provide necessary adjustments. If the transmission is not sending drive through respective gear follow the gear box overhauling procedure. During the maintenance of the gearbox, carry out oil change at regular intervals.

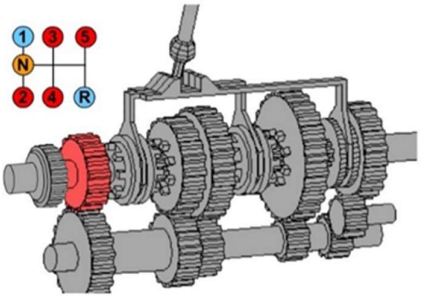


Fig. 3.11: Transmission in Neutral

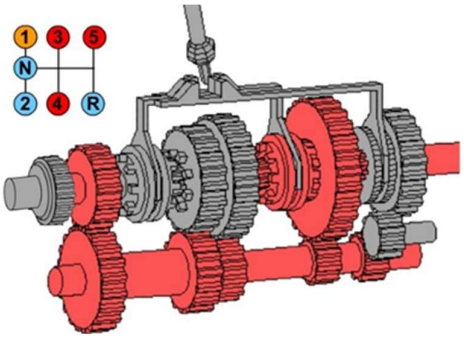


Fig. 3.12: Transmission in 1st Gear

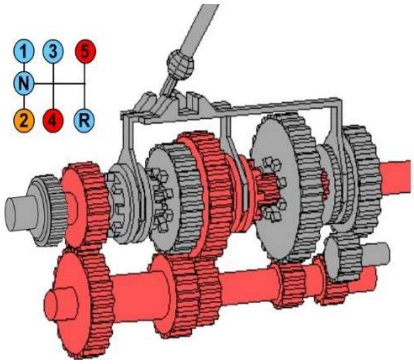


Fig. 3.13: Transmission in 2nd Gear

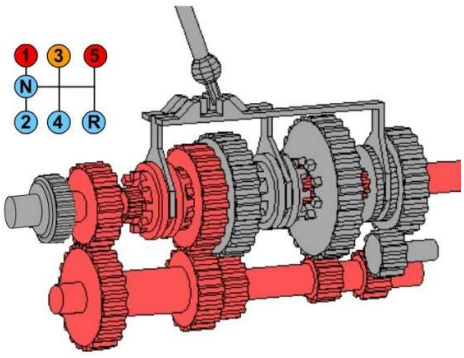


Fig. 3.14: Transmission in 3rd Gear

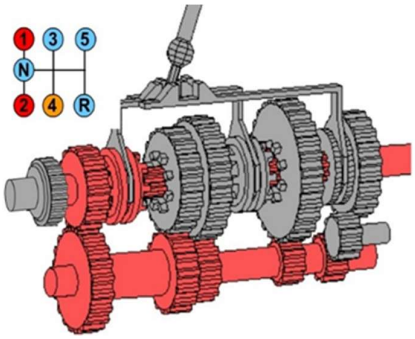


Fig. 3.15: Transmission in Top Gear

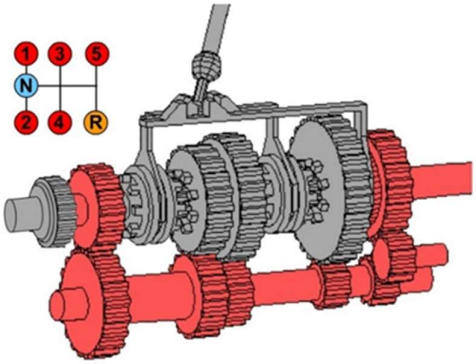


Fig. 3.16: Transmission in Reverse Gear

Figures 3.11 to 3.16 shows the working of gear box during neutral, 1st, 2nd, 3rd, 4th and reverse gears respectively. The constant gear mesh gearbox, in which the gears are rigidly fixed in the lay shaft, uses helical gears for power transmission. The gears in output shaft rotates freely without engaging with shaft, thus not transmitting power. The gears in both shafts are always meshed together. The gears on the main shaft, which is splined, are free to rotate. The dog clutches are provided which are free to slide on the main shaft. The drive is transmitted by shifting the fork lever towards the desired gear position.

First (low) gear: The Dog clutch moves towards by means of gear shift lever, its teeth are engaged with teeth on low gear.

Second gear: Similarly, when dog clutch is moved right & mesh with teeth on next gear, a second gear is obtained.

Reverse gear: When dog clutch, is moved right & mesh with teeth on gear, a reverse gear is obtained. The direction of rotation is change using idler gear.

Gear Box Overhauling Procedure -

1. Dismount the self-starter by unthreading the two bolts on which it is tightened.
2. Unscrewed clamps of inlet hose pipe and separate them from the engine and gear box.

3. Unthread all bolts of gear box assembly and separate it from engine and vehicle body.
4. Unthread drain plugs with Allen key and drain out the gear oil in a tray.
5. Dismount the rear foundation bracket and gear box from it.
6. Unlock the clutch fork using screwdriver.
7. Unscrew all four Philips head screw of oil retainer.
8. Unthread all bolts joining upper and lower housing of the gear box.
10. Separate the differential housing from the gear box housing.
11. Remove main shaft assembly from housing along with all gears and bearings.
12. Unlock main shaft's rear nut lock with the help of chiesel and ball peen hammer.
14. Unthread main shaft's nut and dismantle the main shaft.
15. Clean and check all the components of the gearbox. Check the width of slot of all three synchronizing rings using Vernier caliper, as 8 mm, 10 mm, 9.6 mm respectively.
16. Assemble main shaft and tighten the nut with a torque of 750 kg-cm.
17. Fit counter gear along with bearing at lower housing and mesh main shaft with it.
18. Mount differential assembly along with lock and bearing in housing.
19. Match upper and lower housing and slightly tighten bolts.
20. Mount oil retainer over input shaft and tighten it, using Philips screwdriver.
21. Tighten all screws and bolts.
22. Fit and locked thrust bearing with clutch fork.
23. Fill gear oil (SAE 90) up to max. level marked on dipstick.
24. Connect the gear box with engine.
25. Mount the self-starter and tighten both bolts.
26. Fit the clutch housing's dust shield with it.
27. Connect hose pipes with water pipe line and engine.
28. Properly tighten the gear foundation.

Procedure to service the constant mesh gear box

1. Arrange a constant mesh gear box of any vehicle (for e.g., Ashok Leyland).
2. Unthread the drain plugs and drain out the gear oil in a tray.
3. Dismantle the gear shifting lever.
4. Disconnect speedometer cable, clutch linkage, and propeller shaft etc.
5. Unthread the mounting bolts and place a jack below the gear box and lower down the gear box.

Dismantling -

1. Clean the gear box housing and place it on work bench.
2. Dismount selector tower by unscrewing it's all four screws.

3. Dismount the top cover.
4. Dismount the gear plate from clutch housing's rear end side.
5. Engage first gear by shifting the selector fork.
6. Serrate selector carriage after unthreading its bolts.
7. Dismount clutch withdrawal bearing, operating lever and lubrication pipe.
8. Dismount clutch housing after unthreading its nuts.
9. Serrate clutch shaft bracket from clutch housing.
10. Take out clutch shaft and ball bearing by removing the circlip and washer fitted over ball bearing.
11. Open counter shaft's front cover
12. Lock main shaft by engaging any of two dogs.
13. Dismount flange and took out oil seal.
14. Dismount speedometer drive wheel and spindle.
15. Dismount speedometer drive housing.
16. Take out main shaft from rear end and serrate gear fixing dogs, clutch sliding dogs, clutch bushes and thrust washer.
17. Take out split pin from reverse selector spindle bush's rear end.
18. Remove ball pin from reverse selector fork.
19. Dismount reverse shaft's keep plate.
20. Dismantle reverse shaft and pinion.
21. Take out counter shaft along with rear roller bearing with the help of drift.

Inspection -

1. Dismantle and wash all components using kerosene oil.
2. Check clutch shaft's helical gears and dog teeth.
3. Check bore of spigot bearing.
4. Check clutch plate splines.

Main Shaft-

1. Check threads and splines made over main shaft.
2. Check surface of front and rear bearing seats.
3. Check worn out of floating bushes.
4. Check worn out of thrust washer.
5. Check teeth of fixed and sliding dogs.
6. Check play of main shaft bearing.

Counter Shaft –

1. Check worn - out of teeth.
2. Check seat and outer race of front and rear ball bearing.
3. Check reverse gear teeth, there worn out and worn out of shaft.

Note: Counter shaft gears are mounted and dismounted only on hydraulic presses.

Assembling of Gear Box –

1. Place the gear carriage over stand.
2. Mount the clutch housing and tightens its nuts.
3. Place the counter shaft.
4. Slide the forward permanent wheel with the help of distance washer and fitted roller bearing.
5. Check the nip clearance without fittings counter shaft's front bearing (0.25mm – 0.33mm).
6. Fit the front bearing of counter shaft.
7. Fit the reverse pinion and cover plate.
8. Assemble the main shaft and temporarily tighten nut without fitting spigot bearing.
9. Fit the main shaft to rear end side of gear carriage.
10. Check the nip clearance of shaft (0.38mm – 0.43mm) fitted thrust washer over stepped face of rear ball bearing.
11. Unthread the main shaft's nut. Fit spigot bearing and again tighten the nut with a torque of 35 kgm (250 lbft).

B: Introduction to the Automatic Transmission System

Automatic Transmission System

An automatic transmission (also called automatic gearbox) is a type of motor vehicle transmission that can automatically change gear ratios as the vehicle moves, freeing the driver from shifting the gears manually. An automatic transmission uses a number of components to get the optimum amount of power from the engine to the wheels.

An automatic transmission incorporates a torque converter, which replaces the clutch; a complex planetary gearing system that provides all the different ratios, and a hydraulic system of valves that regulate how the gears interact with each other. The fluid inside an automatic transmission system (known as automatic transmission fluid or ATF) is used not only for the hydraulics, but also as a lubricant and to prevent corrosion of the parts (Fig. 3.17)

Fig.3.17: Automatic transmission

We can say that an automatic transmission is an automobile gearbox that can change gear ratios automatically as the vehicle moves under varying conditions, thus freeing the driver from shifting the gears manually.

Main components of an automatic transmission are converter housing case, oil pan, and extension housing.

There are two types of Automatic transmission namely automated manual transmission (AMT) and continuously variable transmission (CVT).

Check Your Progress

Fill in the blanks

1. The gearbox is positioned between the engine and _____ or differential in a vehicle's drivetrain to overcome various forms of resistance and enhance engine power.
2. In maintenance of the gearbox, it's important to carry out oil changes at regular intervals to ensure proper _____.
3. The _____ of the gear selective mechanism should be inspected periodically, and necessary adjustments should be provided.
4. An automatic transmission system can change gear ratios automatically using a torque converter and a complex _____ system.

Multiple Choice Questions (MCQs):

1. What is the primary purpose of a gearbox in a vehicle's drivetrain?
   a) To amplify the engine's noise
   b) To reduce engine power
   c) To overcome various resistances and enhance engine power
   d) To decrease the vehicle's efficiency
2. Which of the following is NOT a resistance that a gearbox helps to overcome?
   a) Air resistance

b) Gradient resistance
c) Load resistance
d) Fuel resistance

3. Which component is responsible for changing gear ratios automatically in an automatic transmission?
a) Clutch plate
b) Torque converter
c) Synchronizer ring
d) Differential gear

4. What does ATF stands for in the context of an automatic transmission system?
a) Advanced Transmission Fluid
b) Automatic Torque Factor
c) Automatic Transmission Fluid
d) Automated Transmission Feature

5. Which part of the automatic transmission system replaces the clutch of manual transmissions?
a) Torque converter
b) Gear shifter
c) Synchronizer
d) Planetary gear

6. What is the function of the planetary gearing system in an automatic transmission?
a) To regulate engine power
b) To change tyre pressure
c) To provide different gear ratios
d) To control air conditioning

Answer the following questions

1. What are main components of automatic transmission?
2. How many types of automatic transmission are used in a vehicle?
3. State the working principle of automatic transmission.

Activity

1. Demonstrate the different types of Gear Box and find the difference between them by identifying their features.

Module 4	Suspension System

Module Overview

When you walk on smooth road, you don't feel any jerk or jerking movement due to body structure. In case of rough road, we feel more jerk and strain on our body. Similarly, whenever a vehicle moves on rough terrain, it encounters jerk. To reduce the jerk, a suspension system is provided in the vehicles.

This suspension system safeguards vehicle chassis and carriage carried by the vehicle. It also helps smooth rolling of the wheels. This maintains stability in control of vehicle. Suspension system consists of leaf spring set, damper, shock absorber, strut, and inflated tyre.

The "Suspension System" module is designed to provide students with an in-depth understanding of the various components and operations involved in vehicle suspension systems. This module covers a wide range of topics, from the maintenance and repair of suspension components to the inspection and adjustment of steering systems. Through a combination of theoretical knowledge and practical sessions, students will gain the skills necessary to maintain, service, and adjust suspension and steering systems, ensuring safe and smooth vehicle operation.

Learning Outcomes

After completing this module, you will be able to:

- Understand the function and importance of the suspension system, shock absorber, steering linkage, and steering systems in a vehicle.
- Identify the different types of suspension systems, shock absorber, steering linkage, and steering systems including independent and dependent systems.
- Perform routine maintenance tasks on suspension components, including inspection for wear and tear, lubrication, and replacement of worn parts.
- Demonstrate the process of adjusting steering components, such as tie rods and steering gearboxes, to ensure proper alignment and handling.

Module Structure

Session 1: Maintenance of suspension system
Session 2: Service and repair of leaf spring set
Session 3: Replacement of strut/shock absorber, steering linkage
Session 4: Inspection of the steering linkage
Session 5: Manual and power steering system
Session 6: Steering system adjustment

Session-1: Maintenance of suspension system

Importance of vehicle's suspension

Automotive suspension system is made up of four basic components namely the struts, shock absorbers, springs and tyres. Shock absorbers and struts are important for on road safety. They ensure that the tyres evenly connected with the road and a vertical load is applied over the tyres.

The shock absorbers on a vehicle go through as many as one thousand movements per kilometre so it is not surprising that they wear out quite quickly and should be checked every 20,000 kilometres during major servicing. The springs supports the weight of vehicle and act as a flexible link that allows the body and frame to ride with minimal disturbance, while the tyres and suspension follow the road pattern.

The suspension of the vehicle has a number of functions for safety and optimum performance. The important functions are:

- Maintaining the correct vehicle ride height.
- Reducing the effect of shock forces to the vehicle.
- Maintaining the correct wheel alignment.
- Supporting the vehicles driving stability.
- Keeping the vehicles tyres in contact with the road.
- Control of vehicle's direction of travel.
- Maintain the centre of gravity, when vehicle is moving.

Maintenance of vehicle suspension system is very important. One must observe that how vehicle behaves on the road. Making sure it is working properly and will not only make your vehicle safer but will also help to reduce unnecessary wear and tear.

Suspension check-ups

Suspension system is extremely important for the safety and performance of vehicle. As the part of vehicle, the suspension system keeps the tyres in contact with the road. Badly maintained suspension results in faster and more uneven tyre wear, which further compromises safety. If you don't have a well-maintained suspension system, you are not as safe as you should be and are putting yourself and others at risk. Most of the suspension parts are made of rubber material to minimize shocks, therefore it is necessary that rubber parts should be regularly checked for wear, tear and torn. We should always maintain the suspension system and check-ups must be conducted at regular intervals.

Maintenance Tips for Suspension system

- Thoroughly clean the leaf spring set and its fittings.

- With the help of grease or pneumatic grease gun, lubricate all shackle pins, swing arm of the leaf spring set.
- Lubricate each leaf with graphite grease.
- Tighten the u clamp bolts /nuts with specified torque.
- Check the centre bolt.
- Tighten the clamp nut bolt with specified torque.
- Check the slackness of shackle and tighten the set if needed.
- In case of shock absorber/stud, tighten the holding nuts and bolts at both ends.
- In case of two-wheeler, tighten the swinging of nuts/bolts of front and rear wheels.
- Avoid overloading the vehicle.
- Avoid sudden acceleration and breaking.

Check Your Progress

Fill in the blanks

1. Maintenance of the vehicle's suspension system is crucial for both safety and _____ performance.
2. Suspension check-ups are important as they ensure the proper _____ of tyres with the road surface.
3. Suspension parts are often made of rubber to minimize shocks, hence regular checks for wear and _____ are necessary.
4. One of the functions of the suspension system is to maintain the correct vehicle _____ height.

Multiple Choice Questions (MCQs):

1. What are the basic components of a vehicle's suspension system?
A) Steering wheel and brakes
B) Engine and transmission
C) Struts, shock absorbers, springs, and tyres
D) Exhaust system and radiator

2. What is the primary function of shock absorbers and struts in a vehicle's suspension system?
A) Generating power for the engine
B) Maintaining tyre pressure
C) Ensuring smooth rolling of wheels
D) Keeping the tyres evenly connected with the road

3. Which of the following is NOT a function of a vehicle's suspension system?
A) Maintaining correct wheel alignment

B) Supporting the vehicle's driving stability
C) Adjusting the vehicle's audio system
D) Keeping the vehicle's tyres in contact with the road

4. What should be regularly checked for wear, tear, and torn in a suspension system?
A) Engine oil level
B) Rubber parts
C) Brake fluid quality
D) Exhaust emissions
Answer: B) Rubber parts

Answer the following questions

1. Why is suspension system required in a vehicle?
2. Name different components of a suspension system?
3. Make a list of maintenance tips for suspension system.

Activity

1. Make a list of important functions of suspension system of a vehicle.

S.No.	Function
1	
2	
3	
4	

Session 2: Service and replacement of leaf spring set

Leaf spring: A leaf spring is a simple form of spring commonly used for the suspension in wheeled vehicles, sometimes referred to as a semi-elliptical spring or cart spring. It is one of the oldest forms of springing, dating back to medieval times.

A leaf spring takes the form of a slender arc-shaped length of spring steel of rectangular cross-section. The centre of the arc provides location for the axle, (Fig. 4.1 and Fig. 4.2) while tie holes are provided at either end for attaching it to the vehicle body.

For very heavy vehicles, a leaf spring can be made from several leaves stacked on top of each other in several layers, often with progressively shorter leaves. Leaf springs are a type of suspension system commonly used in vehicles,

especially in heavy-duty applications like trucks and trailers. They serve several functions, including locating, damping, and springing. While interleaf friction within leaf springs can provide some damping action, it is not a well-controlled or adjustable form of damping, and it can lead to certain limitations and issues in the motion of the suspension.

Fig. 4.1: Leaf spring fitted in a vehicle

Fig. 4.2: Shackle

A leaf spring can either be attached directly to the frame at both ends or attached directly at one end, usually the front, with the other end attached through a shackle, a short swinging arm. The shackle in a leaf spring suspension system plays a crucial role in compensating for the tendency of the leaf spring to elongate when compressed. This elongation, often referred to as "arching" or "buckling," occurs when the leaf spring flattens out as it absorbs a load or encounters bumps and uneven road surfaces. The shackle helps make the suspension "softer" or more compliant in response to these forces. Role of leaf spring are as follows.

- The leaf spring acts as a linkage for holding the axle in position and thus separate linkage are not necessary. It makes the construction of the suspension simple and strong.
- The positioning of the axle in a vehicle's suspension system is influenced by the leaf springs. Consequently, there are considerations to keep in mind when using soft springs (springs with low spring constants) in such a setup.
- The inter-leaf friction between the leaf springs affects the riding comfort.

Cambering of leaf springs

The process of hammering leaf throughout the length so that it will achieve desired angle to maintain the height from the center to eye holes at both ends.

This process is called cambering. It helps to reduce the flexibility of spring. It helps to overcome the problem of lowering of fender (Fig. 4.3 and Fig. 4.4).

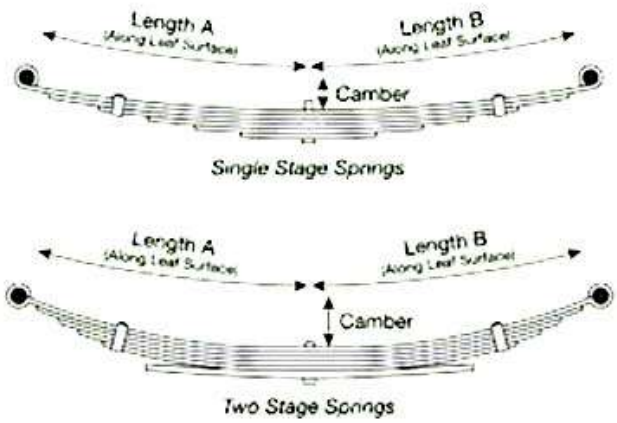


Fig. 4. 3: Cambering of leaf spring

Fig. 4.4: Shackle Pin

Shackle: A spring shackle is a device found on leaf-spring equipped vehicles. The spring shackle mounts to one end of the leaf spring and allows it to flex and move while keeping the tyre on the road. Without a shackle, the spring would not be able to move and the tyre would be pulled off of the road's surface when a bump or obstacle encounters. The spring shackle can also be lengthened and give lift or a greater amount of ground clearance to the vehicle.

The leaf spring is attached at the front and rear by a shackle pin passing through the spring's eyehole as well as a mounting bracket. One end of the spring is held closely to the vehicle's chassis and cannot move, the other end of the spring has a spring shackle mounted between the chassis mount and the spring's eye. This spring shackle is nothing more than two flat pieces of steel with several holes drilled through to allow different mounting heights. The shackles allow for movement of the suspension by pulling in or pushing out as the suspension travels through its up and down cycle.

Centre Bolt: It holds the bunch of leaf together to bear the shocks. If it is broken, it will lead to vehicle pull to one side, it is necessary to replace immediately.

Service Procedure

Tools Required: Chassis jack/hydraulic jack, screw jack, supporting stands, Socket spanner set, Open end spanner, DE ring spanner, spring clamp, anvil, hammer.

Activity: To carry out the servicing, maintenance and repair of leaf spring.

Procedure

1) Keep the vehicle on plane hard surface.
2) Disconnect the negative terminal from the battery.
3) Take the stand and support the chassis at appropriate height.
4) Take the stand and support the axle/axle beam.
5) Using appropriate spanners loosen the nuts and remove the 'U' clamp bolts.
6) Remove the shackle pin from the chassis fixed end.
7) Slowly dismount the spring assembly set from the chassis.
8) Take the leaf spring set and place it on the workbench.
9) With proper precaution, place the leaf spring in the spring vice and remove the centre bolt.
10) Separate the spring leaves and place it in proper order.
11) Clean the leaves thoroughly.
12) Inspect the angle of each leaf and check if necessary to replace any broken leaf.
13) If the spring is too flexible, or angle is improper, we have to carry out the cambering process.
14) First take the master leaf and place it on the anvil and hammer it throughout the length as the leaf spring gets desired angle.
15) Arrange the leaves in proper order apply graphite grease to each leaf, place the set on spring vice.
16) Place the centre bolt and tighten the same to the specified torque.
17) Repeat the same to all leaves as per their size.
18) If the leaf is broken, we have to do the same process with the new spring leaf.
19) Apply the graphite grease between each leaf.
20) Check the opening of the eyehole of the master leaf, if it is widened it will make the chattering noise, hold the same end on the perk of the anvil and repair the eyehole.
21) Replace the eye bush of the shackle.
22) Inspect the shackle pin for the wear and replace the same, if necessary.
23) Mount the leaf spring set on the axle and fix the shackle pin to the chassis.
24) Check the shackle pin. If worn out, replace it.
25) Fix the 'U' clamp bolt to the spring set and tighten the same to the specified torque.
26) Fix and tighten the clamp nuts at specified torque only.

Precaution

1) Fix the spanners properly.
2) Use special jack and the stand to support the spring.

3) While disassembling the leaf spring, fix it on the vice and disassemble it.
4) Place every nut/bolt properly in the tray.
5) Support the chassis and axle with stand before removing it from the chassis.
6) Tighten the nut/bolts to the specified torque.

Check Your Progress

Fill in the blanks:

1. The leaf spring acts as a linkage for holding the _____ in position and thus separate linkages are not necessary.
2. The process of hammering the leaf throughout its length to achieve a desired angle is known as _____.
3. The spring shackle allows for movement of the suspension by pulling in or pushing out as the suspension travels through its up and down _____.
4. The shackle takes up the tendency of the leaf spring to elongate when compressed, making the suspension's springiness _____.

Multiple Choice Questions:

1. What is the purpose of a leaf spring in wheeled vehicles?
a) To provide steering control
b) To hold the chassis together
c) To absorb engine vibrations
d) To support the suspension

2. In leaf springs, what is the primary function of interleaf friction?
a) Enhancing steering responsiveness
b) Providing damping action
c) Reducing tyre wear
d) Increasing ground clearance

3. What is the purpose of a shackle in a leaf spring suspension?
a) To provide additional ground clearance
b) To connect the axle to the chassis
c) To improve engine performance
d) To enhance braking efficiency

4. The device that allows a leaf spring to flex and move while keeping the tyre on the road is called:
a) Axle pin
b) Leaf holder
c) Spring lock

d) Spring shackle

Answer the following question

1. Why leaf springs are provided in vehicle? State the functions of leaf springs.
2. Sate the role of leaf spring in a vehicle?
3. Describe the functions of shackle.
4. Describe the functions of centre bolt
5. What tools and equipment are required for servicing of leaf spring system?

Activity

1. Make a list of steps to carry out the servicing, maintenance and repair of leaf spring.

S.No.	Step
1	
2	
3	
4	

2. Make a poster showing cambering of leaf spring.

Session 3: Replacement of strut/shock absorbers, Inspection of steering linkages

Replacement of strut/shock absorbers:

A shock absorber is a mechanical device designed to smooth out or damp shock and dissipate energy. In a vehicle, shock absorbers reduce the effect of traveling over rough ground, leading to improved ride quality and vehicle handling. Every shocker/suspension has its own life. Suspension system has damper with spring. This works as shock absorber/strut.

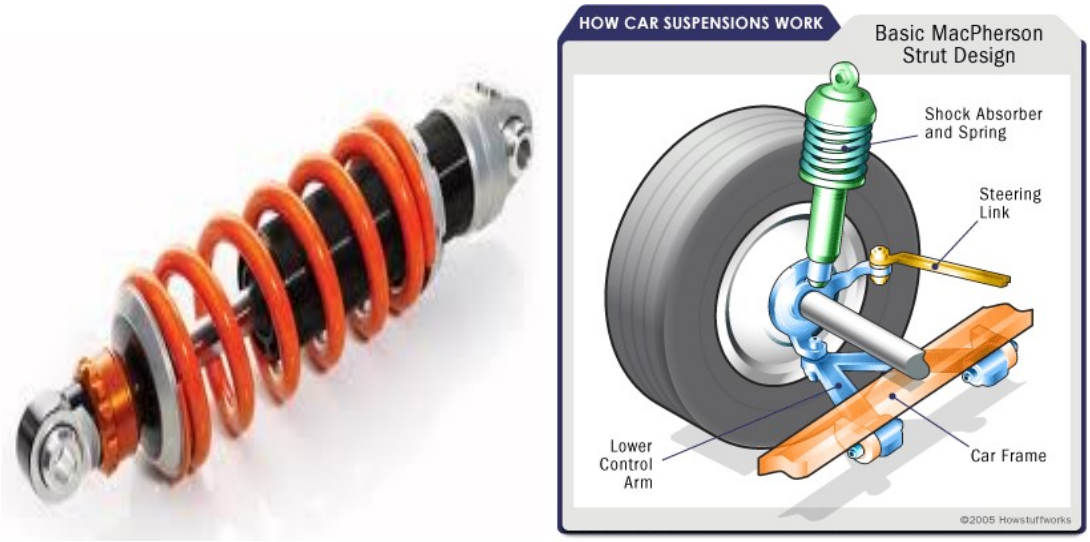


Fig. 4.5: Shock absorber

Life of shock absorber is affected due to the following reasons:

- Overloading
- Road conditions
- Worn-out Linkage/bushes
- Leakage of fluid/gas
- Broken casing
- Deterioration of Bump stopper
- Rubber bellows
- Improper handling in service

Testing of shock absorber on the vehicle

Following procedure should be adopted for testing the shock absorber.

- Keep the vehicle on the level ground
- Press the front portion of the car with gentle pressure
- Now feel resistance in the up and down movement of front portion
- If notice any jerking movement, indicates defect in shock absorber
- Release the pressure and experience, upward movement with same resistance
- If it feels hard, noisy and stucked /binding at any movement indicate faulty shock up
- Visually inspect the shocker for fluid leakage if found, replace it

Testing of shock absorber off the vehicle

Activity: To overhaul suspension system used in the car

Tools and Equipment

Open end spanners, ring spanner, tubular spanner, locking clamps, screw drivers etc.

Material required

Oil, grease, metal tray, bolts waste, equivalent parts etc.

Sequence of operation

1. Keep the vehicle on level ground
2. Jack up the vehicle at certain height to make the wheel free to rotate
3. Loosen the wheel nut and remove the front wheel
4. Remove brake drum with bearing from stub axle by using hub puller
5. Remove the brakes pins/ bolts from strut bracket
6. Remove the strut bracket bolts
7. Remove support nuts by supporting the strut properly
8. Dismount the strut assembly from the vehicle
9. Use a spring compressor to remove the strut spring
10. Fix the spring compressor on the strut and compress the spring
11. To remove the spring support unit, loosen the nut slowly and release the spring compressor
12. Remove the spring from the strut

Testing of shock absorber/struts of the vehicle

- Visually inspect strut for fluid leakage
- Inspect the piston rods/strut rod for bend, scratches etc.
- Press the rod inside with pressure and release the same, it should move in and out with resistance
- If it does not work, replace the strut/shock absorber as it is not repairable.

Check Your Progress

Fill in the blanks

1. The shock absorber is a mechanical device designed to dampen shocks and dissipate energy, contributing to improved _____ and vehicle handling.

2. During the testing of a shock absorber on a vehicle, if a jerking movement is noticed, it indicates a _____ in the shock absorber.

3. When overhauling a _____, tools such as open-end spanners, ring spanners, tubular spanners, locking clamps, and screwdrivers are commonly used.

4. To remove a strut spring, a _____ is used to compress the spring before loosening the nut and releasing the spring compressor.

Multiple Choice Questions (MCQs):

1. What is the main purpose of a shock absorber in a vehicle?
a) Increase road noise
b) Enhance fuel efficiency
c) Smooth out shocks and vibrations
d) Improve tyre grip

2. What component is often paired with a shock absorber to provide suspension in a vehicle?
a) Battery
b) Radiator
c) Spring
d) Exhaust pipe

3. Which of the following factors can affect the life of a shock absorber?
a) Road conditions
b) Brand of the vehicle
c) Frequent car washing
d) Color of the vehicle

4. What does a jerking movement during the testing of a shock absorber indicate?
a) Proper functioning
b) Defect in the shock absorber
c) Need for a car wash
d) Low tyre pressure

Answer the following question

1. Describe the uses and applications of shock absorbers.
2. Sate the reasons which affect life span of shock absorbers?
3. Describe the procedure for testing of shock absorber after removing it from the vehicle.
4. Describe the procedure for testing of shock absorber when it is on the vehicle.
5. What tools and equipment are required for servicing of shock absorber.

Activity

(Use additional sheets of paper if necessary)

1. Make a list of steps to carry out the testing of shock absorber on the vehicle

S.No.	Step
1	
2	
3	
4	

2. Make a list of steps to carry out the testing of shock absorber off the vehicle

S.No.	Step
1	
2	
3	
4	

Session 4: Inspection of steering linkage

Steering Linkage

A steering linkage, as shown in Fig. 4.6, is the part of an automotive steering system that connects to the front wheels. Steering linkages consist of drag link (pitman arm), tie rod, ball joint, end joint, arm assembly, torsion bar, and steering shock absorber, bushes of steering axis, steering arm and stub axle.

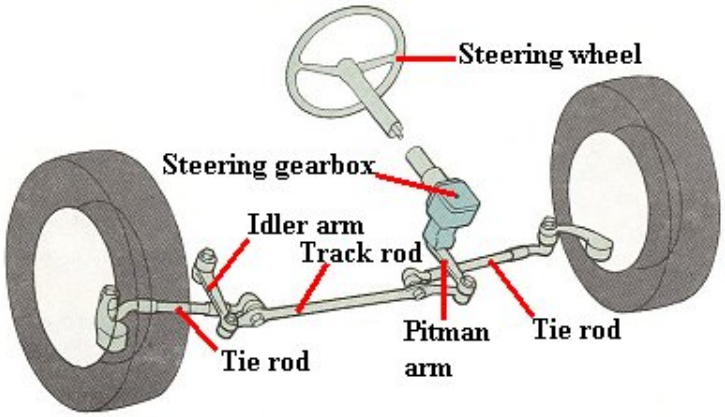


Fig. 4.6: Steering Linkage

Regular Inspection of steering linkage is necessity to maintain safety and control of the vehicle. If it is ignored, it may cause fatal accident.

Inspection of steering linkages

Following procedure should be adopted for inspection of steering linkages

- Lift the front portion of the car/vehicle
- Turn the steering wheel from one lock end to another lock end
- Check for noise and binding in-steer
- If the binding is traced, remove the drag link connection from steering gearbox
- Now rotate the steering wheel in both the direction and trace for the binding. If the binding is noticed then it probably lies in the steering gear box
- If the binding is not traced in steering gear box then problem is in steering linkage
- Check the ball joint/bushes for free movement with thumb pressure and replace the same if necessary
- Inspect the ball joint if it is worn out or bellow torned then replace it.
- Inspect the bushes of the torsion bar and replace it
- Inspect the draglink, tie rod for straightens
- Remove the bush by using special tool and replace the same
- Inspect damper/strut for any crack, rust and also check its length if it is not with a specified value then replaces it
- Check the bushes for wear
- Check the coil spring for its length, height and tension

Precautions

1. Fix the spanner properly
2. Keep the removed nut bolts properly
3. Handle the pots carefully
4. Support the chassis properly with stand

Check Your Progress

Fill in the blanks

1. A steering linkage is the part of an automotive steering system that connects to the ---------- wheels.

2. Regular Inspection of steering linkage is necessity to maintain --------- and ---------- of the vehicle.

Multiple Choice Question

1. What is the purpose of a steering linkage in an automotive steering system?

A) To connect the front wheels to the engine.
B) To provide cushioning for a smoother ride.
C) To maintain safety and control by connecting the front wheels.
D) To adjust the vehicle's suspension height.

2. Which component of the steering linkage is responsible for connecting the steering gearbox to the wheels?

A) Tie rod
B) Drag link
C) Ball joint
D) Torsion bar

3. Why is regular inspection of the steering linkage necessary for vehicle maintenance?

A) To improve fuel efficiency.
B) To enhance engine performance.
C) To prevent fatal accidents and ensure safety.
D) To increase top speed capabilities.

4. What is the purpose of using a special tool to remove and replace bushes during steering linkage inspection?

A) To make the process more complicated.
B) To increase the cost of maintenance.
C) To improve the appearance of the vehicle.
D) To ensure proper and efficient bush replacement.

Answer the following question

1. Describe the procedure for inspection of steering linkages of a vehicle.
2. What are functions of steering linkages?

Activity

1. Make a list of steps to carry out the inspection of steering linkages

S.No.	Step
1	
2	
3	
4	

2. Make a list of precautions to be taken while inspection of steering linkages

S.No.	Precaution
1	
2	
3	
4	

Session 5: Manual and Power steering System

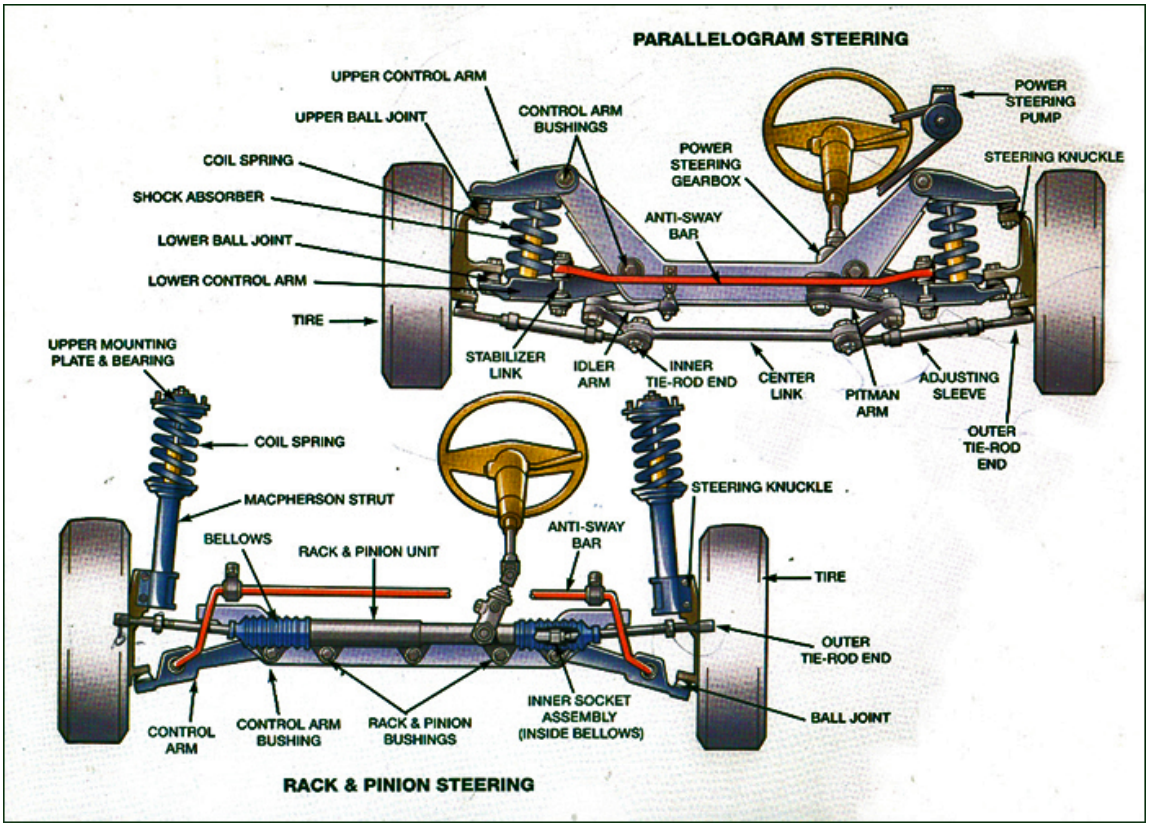


Fig. 4.7: Steering System

Manual Steering

Vehicle is steered with mechanical effort and maintains and control road stability. Fig. 4.7 shows the detailed parts of the steering system used in

automobiles. Different types of steering boxes that are used in automobile vehicle are:

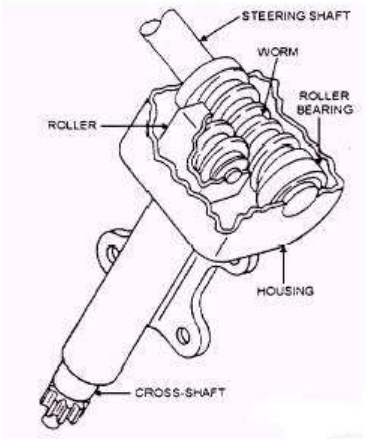
- Worm and roller
- Worm and nuts
- Rack and pinion
- Worm and sector

These all gearboxes are supported with power steering, which helps the driver to increase his efforts in steering of vehicle.

Manual Steering: Mechanically/Manually operated steering

Procedure for servicing of the manual steering system (Worm and roller shaft)

To check the working of mechanically/manually operated steering system, as shown in Fig. 4.8 and Fig. 4.9, following steps are followed:



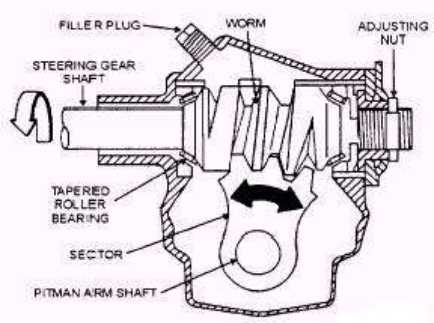


Fig. 4.8: Worm and roller steering gear Fig. 4.9: Worm and sector steering gear

1. Conduct the road test and mark the central or the mid position of the road wheels and the steering gear box,
2. Raise the front portion of a car and turn the steering wheel,
3. To check for the binding in the steering,
4. If binding is traced then disconnect the drop arm from the cross shaft of the steering gear box,
5. Now again turn the steering and inspect for the binding,
6. If the binding is traced then the fault is in the steering gear box, and need to service the steering gear box,
7. Disconnect the electric connections from the steering wheel,
8. Using specified spanner remove the steering wheel nut from the steering shaft,

9. Use special tool to remove the steering wheel,
10. Remove the steering gear mounting bolts and dismount the steering gear box from the chassis,
11. Clean the external portion of the steering box,
12. Remove the side cover from the steering gear box,
13. Remove the cross shaft from the steering gear box casing,
14. Loosen the steering column bolts and remove it out,
15. Slowly remove the steering shaft from the casing,
16. Wash the components check their wear also check their alignment
17. Replace the worn-out components,
18. Assemble the worm shaft and then the cross shaft with their bearing(s).
19. Conduct the road test and assure proper steering alignment

Rack and pinion type steering gear box:

This type of steering gear is used for light vehicles and in power steering. It occupies very small space and uses lesser number of linkage components as compared to worm and wheel type of steering gear (Fig. 4.10).

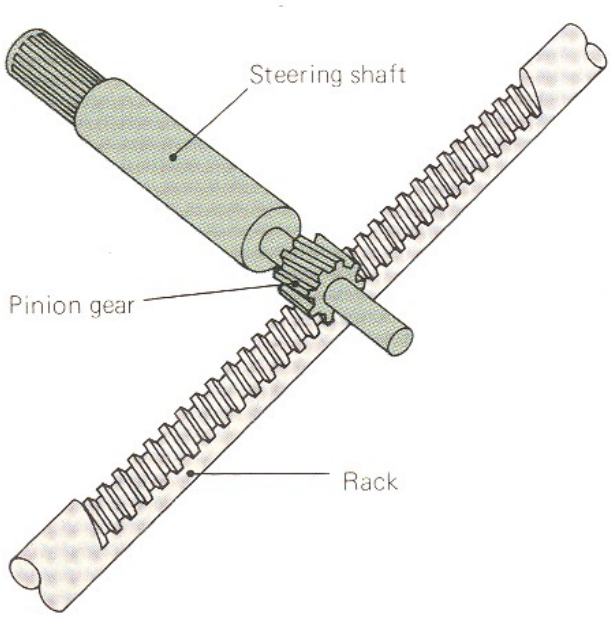


Fig. 4.10: Rack and pinion steering system

Procedure for servicing of Rack and pinion type of steering

(i) Slide driver seat as back as possible.
(ii) Put off the front part of floor mat on the driver side and remove steering shaft joint cover.

(iii) Remove the steering shaft lower joint bolt and disconnect lower joint bolt form pinion.
(iv) Hoist car at appropriate height and remove both wheels.
(v) Remove quarter pin/split pins and tie rod castle nuts from both knuckles.
(vi) Disconnect both tie rod ends from knuckle using special tool.
(vii) Remove steering gear cage mount bolts gear cage brackets and then gear case.
(viii) Remove the rubber boot wire clip and remove the rubber boot from the tie rod.
(ix) Unbend parts of tie rod lock washer and remove tie rod from rack.
(x) Remove the rack damper screw cap, damper screw and remove the plunger from steering rack.
(xi) Use special tool to remove pinion bearing.
(xii) Slowly tap with nylon hammer and remove pinion assembly.
(xiii) Clean and inspect the components.

Inspection

- Inspect the rack for the following
  Run out /deflection should not exceed more than 2 mm
  Teeth wear/damaged
  Back surface of rack for wear or damaged
- Inspect the ball joint with thumb pressure, if loose replace ball joint
- Check angular movement of ball joint, if binding noticed replace ball joint
- Replace the bushes at regular intervals
- Change the rubber boots at every service

Assemble the rack and pinion in reverse order of disassembly

Carry out following steering gear adjustment

- Central or mid position
- Back lash in rack and pinion gear
- Adjust toe in and toe out
- Check the bushes and pivots of steering axes
- Check the bushes of pull and push rod

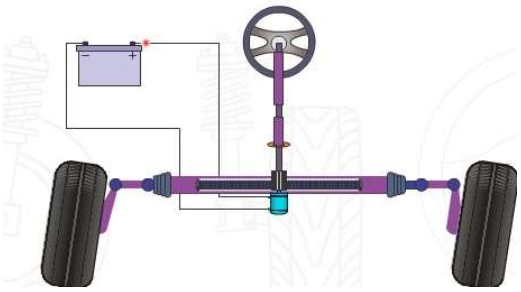
Power Steering

To reduce the steering effort at steering wheel turning, two types of powers are applied i.e., hydraulically and electronically operated motors.

Hydraulic operated power steering: In this type of power steering, fluid is pressurized through a centrifugal pump. This centrifugal pump is driven by the engine crankshaft through a V belt. Hydraulic system consists of pump, fluid

container, hoses and steering mechanism having in and out valve connected through pipes and hoses. When the vehicle is moving in straight ahead direction, pump rotates and does not actuate the steering effort, while the vehicle takes turn at low speed or in standing condition or parking condition. Pressurized Fluid is forced through the steering worm and rack piston through inlet valve. It helps to steer vehicle easily by reducing steering efforts.

Inspect the power steering



- Park the vehicle on the level ground
- Switch off the engine and check the oil level in power steering container
- It should be between minimum and maximum level
- Type of fluid is known as power steering fluid
- Check power steering hose connections for leakage/damages/cracks
- Check and replace fluid filter at regular interval as per service manual
- Inspect the functioning of centrifugal pump in turning of vehicle, if faulty replace the pump
- Carry out bleeding operation after each service

Electronic power assisted steering system (EPS)

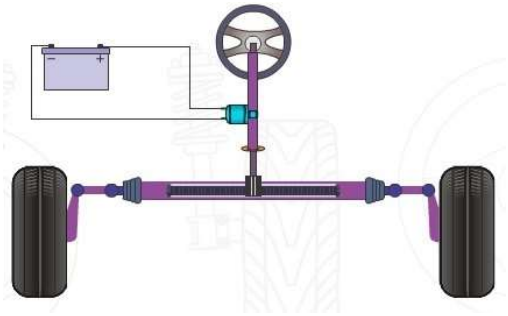


Fig. 4.11: Electronic power assisted steering system

EPS uses an electric motor to assist the driver of the vehicle. Steering sensors detect the position and torque of the steering column and ECU applies assistive torque via the motor which connects to either steering gear or steering column. This mechanism is fitted at steering shaft/worn shaft. It helps in assisting the steering of the vehicle. This system is operated using electrical motors. There are two types of EPS: Column assisted and pinion assisted as shown in Fig. Fig.4.11. Advantage of this system is in its fuel efficiency because there is no belt driven hydraulic pump that requires constant power from engine.

Air Suspension System

Air suspension is a type of vehicle suspension powered by an electric or engine driven air pump or compressor. This pump compresses the air using compressor. Compressed air is sent to the balloon. Air suspension, as shown in Fig. 4.12, is used in place of conventional steel springs and in heavy vehicle applications such as buses and trucks. If the engine is left off for an extended period, the vehicle will gradually settle to the ground. The purpose of air suspension is to provide a smooth, constant ride quality and in some cases, it is self-leveling. Now a days, gas filled shock absorbers are being used for more comfort.

Fig. 4.12: Air Suspension System

Over the last decade, air suspension has become extremely popular in the automobile.

Check Your Progress

Fill in the blanks

1. In the _____ type of steering gear, a worm and roller shaft mechanism is used for manual steering.
2. Rack and pinion type steering gear occupies less space and uses fewer _____ components.
3. Hydraulic operated power steering uses a centrifugal pump driven by the engine's _____.
4. Air suspension is often used in heavy vehicles such as _____ and trucks.

Multiple Choice Questions

1. What is the purpose of power steering in a vehicle?

a) Decrease road stability
b) Reduce steering efforts for the driver
c) Increase mechanical efforts
d) Improve fuel efficiency

2. In the Rack and Pinion type steering gear, what is used to connect the steering wheel to the steering rack?

a) Worm shaft
b) Pinion bearing
c) Cross shaft
d) Tie rod ends

3. Which type of power steering operates by pressurizing fluid through a centrifugal pump?
a) Electronic power assisted steering
b) Hydraulic operated power steering
c) Manual steering
d) Worm and roller shaft steering

4. Which component of the EPS system detects the position and torque of the steering column?
a) Worm shaft
b) Steering wheel
c) Electronic Control Unit (ECU)
d) Pinion bearing

Answer the following question

1. Describe the procedure for servicing of the manual steering system.
2. Describe the procedure for servicing of rack and pinion type of steering.
3. State the types of powers used in operation of power steering.
4. Describe the procedure for inspection of power steering.
5. Describe principle of working of air suspension system.
6. What is function of steering in vehicle?
7. Write the name of components of steering system.
8. In modern vehicle which types of steering systems are used?
9. What are limitations of manual steering?
10. What are advantages of power steering over manual steering?

Activity

1. In automobile different types of steering are used. Make a list of types of steering.

S.No.	Type of steering
1	
2	
3	
4	

2. Make a list of steps followed for servicing of rack and pinion type of steering

S.No.	Step
1	
2	
3	
4	

Session 6: Steering System Adjustments

Steering system adjustments consist of wheel balancing, wheel alignment and checking of steering adjustment. We will concentrate on these topics.

Wheel balancing

Wheels which are out of balance generally produce a vibration that makes uncomfortable to drive a vehicle. It results in premature wearing of suspension parts, steering components, rotating parts and tyres.

Correctly balanced wheels help to eliminate vibration and avoid premature wear caused by an imbalance in the rotating wheel and tyre assembly.

The first sign that wheels may be out of balance is when steering wheel starts to wobble at certain speed. The light weight of modern cars means (Fig. 4.13) that they don't dampen down the vibrations caused by spinning wheels in the way that older, heavier vehicles could.

A driver may not always sense an imbalance at the steering wheel. It could be present with but dampened by the vehicle weight. This is why balancing is equally important for both front and rear wheels.

Wheels are balanced on a wheel balancing machine. The machine rotates the wheel assembly and automatically calculates the weight and location of the balance counter, as a result of wheel balancing, one will feel a smoother ride and low wear from tyres.

Fig. 4.13: Wheel Balancing Machine

Wheel alignment:

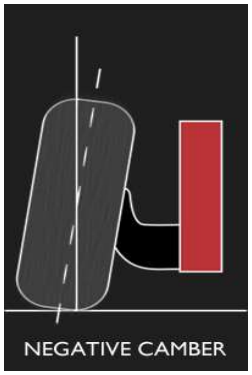
It consists of adjusting the angles of the wheels so that they are set to the manufacturer's specification. The purpose of these adjustments is to reduce tyre wear, and to ensure that vehicle travel is straight and true (without "pulling" to one side). Angles of wheels are of two types, Primary and Secondary type.

Preliminary procedure for wheel alignment

1. Check all tyres for the proper inflation pressure and also same tread wear
2. Check for the run out of the tyre and wheel
3. Check for the looseness of the ball joint
4. Adjust the braking system
5. Check and adjust the slackness of the suspension system
6. Check for the looseness of suspension arm
7. Check for loose or missing stabilizer bar attachment
8. Test for the binding in the steering gear
9. Lubricate the ball joints and tighten the joints with specified torque

10. Tighten the U clamp bolts at regular intervals.

Camber angle



Camber is the tilting of the front wheels from the vertical as shown in Fig. 4.14.

1. When the wheels tilt out ward at top the camber is positive
2. When the wheels tilt inward as seen from the top, the camber is negative
3. Camber maintains the directional stability

The change in the camber causes due to damaged, loose, bend, dented or worn out suspension parts and they should be replaced

The real advantages to negative camber are seen in the handling characteristics. During straight acceleration however, negative camber will reduce the contact surface between the tyres and road surface.

Fig. 4.14: Camber angle

Toe–in

Toe-in is a measurement of how much the front and/or rear wheels are turned in or out from a straight-ahead position. When the wheels are turned in, toe is positive (+). When the wheels are turned out, toe is negative (-). The actual amount of toe is normally only a fraction of a degree. The purpose of toe is to ensure that the wheels roll parallel. Toe also serves to offset the small deflections of the wheel support system that occur when the vehicle is rolling forward.

Castor angle

Defined as the angle, created by the steering pivot point from the front to back of the vehicle. Caster is positive if the line is angled forward, and negative if backward. Typically, positive caster will make the vehicle more stable at high speeds, and will increase tyre lean when cornering. This can also increase steering effort as well. Caster influences directional control of the steering but does not affect the tyre wear and is not adjustable on this vehicle. Caster is (Fig. 4.15: **castor angle)** affected by the vehicle height, therefore it is important to keep the body at its designed height. Overloading the vehicle or a weak or sagging rear spring will affect caster.

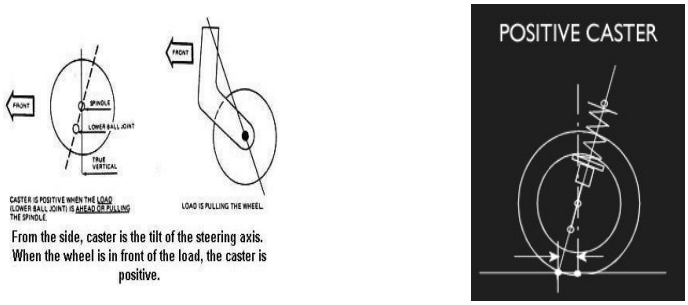


Fig. 4.15: Castor angle

Toe-out on turn

Toe-out is the difference in angles between the front two wheels during a turn, steering system is designed to turn the inner wheel at more (Fig. 4.16). When the vehicle is steered the inner wheel turns an angle of 23 degrees the outer wheel turns an angle of 20 degrees. The following components are needed to be inspected and adjusted accordingly

1. Tie rod end ball joints for the slackness
2. Improper toe in adjustment
3. Bend steering arm/ knuckle
4. Bend stub axle
5. Improper king pin settings

Wheel base

The distance between the centre of the front axle and the rear axle is called the wheel base. The improper wheel base causes abnormal tyre wear, vehicle pulls to one side and causes wandering of the vehicle.

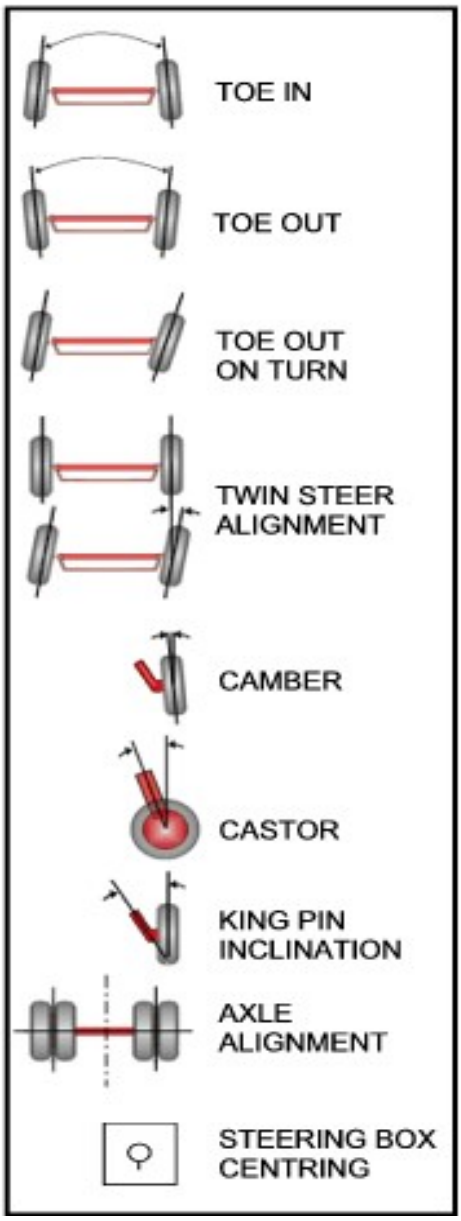


Fig. 4.16: Steering Angles

Procedure for checking and adjustment of wheel alignment

1. Switch on the red color switch on the back side of the machine.
2. Park the vehicle with its front wheels on turntables.
3. Fit both heads (of machines) to both rims.
4. Tie the vehicle with string, from one front wheel to other through both rear wheels.
5. Switch “ON” the monitor. It shows “MENU” on the screen.
6. There are five details in the menu.
   - Measurement
   - Front self-calibration.

- Rear self-calibration.
- Records of new models.
- Service.

7. There are some figures and numbers on the keys of the keyboard. Press number (1) and then (Enter). We move to the next step. Press the desired job (select 1 to 5). Press "Enter" after it.

8. Feed the vehicle details/code using key board. After entering the data press "Enter".

9. We will get the "Date and specification chart" on screen. Feed the vehicle details to the blank space in this chart. Press "Enter".

10. We will get "selection (1 to 4)". Details of operation 1 to 4 were given below the selection.

11. To align the front wheels press "2" and then "Enter". We will see the Toe-in, Camber Angle, Caster Angle, King Pin Set Back Max and Steering Angle on screen.

Wheel Steering Adjustment: Adjustments in steering gear

a. Worm shaft and play adjustments

- Hold the steering wheel by the right hand and with a left hand hold the steering column
- Now pull and push the steering shaft /worm shaft in and out
- If excessive play is noticed check the condition of the worm shaft bearings or add the shims again check the end play.

b. Cross shaft end play adjustments

- Loosen the adjusting nut of the cross shaft
- Now pull and push the cross shaft in and out
- If excessive play is noticed then tighten the stud and reduce the play
- After setting the play tighten the nut

c. Central or mid-position adjustment

- Turn the steering wheel from one lock position to other lock position
- Mark the position and count the number of turns of the steering wheel from lock to lock position
- Divide the number of turns by 2 and set the center position of the steering gear box
- Now assemble steering gear box on the marked position and fix the drop arm without shifting the position of the draglink and center position of the road wheels

d. Wheel lash adjustments

- Now turn the steering wheel without movement of the road wheels is called wheel lash, it should not exceed the value 10-12 mm
- If it is excessive inspect the steering linkage for wear and replace the worn-out components

Trouble shooting in steering system.

HARD STEERING

CAUSES	*REMEDIES*
In operative power steering	Attend the trouble as per the service manual
Low or un even tyre pressure	Inflate the tyre to the correct pressure
Friction in the steering linkage	Lubricate, readjust, replace the worn parts
Friction in the steering gear	Lubricate, readjust, replace the worn parts
Friction in the ball joints	Lubricate, and inspect the ball joint for free movement/ replace the ball joint
Improper steering gear adjustment	Readjust the steering gear adjustment
Binding in the steering column	Inspect the steering shaft and the steering column
Incorrect alignment (camber, castor and toe- in adjustment	Check the wheel alignment adjust as per the specification
Weak spring	Camber the leaf spring set as per specifications
Weak damper spring/ damper	Replace the strut/ damper/spring
Sagging of the spring set	Carry out cambering process/ and replace the weak spring
Broken or bend steering arm	Replace the steering arm

❖ **Wandering of the vehicle:** - The tendency of the vehicle to move one side when driver brings back to straight ahead position moves to the opposite side is called vehicle wandering it is caused due to the following reasons

CAUSES	***REMIDIES***
Low or un even tyre pressure	Inflate the tyre to the correct pressure
Friction in the steering linkage	Lubricate, readjust, replace the worn parts
Friction in the steering gear	Lubricate, readjust, replace the worn parts

Incorrect alignment (camber, castor and toe- in adjustment	Check the wheel alignment adjust as per the specification
Slackness in the steering linkage	Lubricate, Readjust and tighten the fasteners with specified torque replace the worn-out joints
Looseness in the steering gear	Adjust the steering gear (worm shaft end play, cross shaft end play adjustment)
Improper toe in adjustment	Set the ton-in
Loose suspension spring	Tighten the loose spring set/ U clamp bolts
Defective torsion bar	Replace the torsion bar
Improper steering gear adjustment	Carry out steering gear adjustments
Bend steering knuckle/ Loose king pin	Replace / and adjust the king pin

Vehicle pulls to one side: -When vehicle pulls to one side constantly the more force is applied to bring the vehicle to straight ahead position

Causes	***Remedies***
Poor performance of torque sensor	Check torque sensor and repair the same
Brake grabs	Readjust, replace brake lining
Uneven tyre inflation	Inflate to the correct pressure
Uneven camber	Reset the camber angle
Uneven castor	Reset the castor angle
Tight wheel bearing	Set the bearing play properly
Uneven springs (sagging, broken spring)	Camber the leaf spring set and replace the broken spring
Loose/broken centre bolt	Tighten/replace the bolt
Improper toe in adjustment	Adjust the tie rod ends and set the toe-in
Improper torsion bar adjustment	Adjust the torsion bar
Brake dragging	Adjust the brakes

Front wheel tramp: -This condition causes the movement of the front wheel up and down

- The major reasons for the wheel tramp are due to Unbalanced wheels

Causes	**remedies**
Wheels are out of balance	Rebalance the wheels
Too much run out of the wheel	Balance the run out tyre Straight or replace the wheel
Defective shock absorber	Replace
Uneven or more tyre pressure	Inflate to correct pressure

Slackness in the steering linkage	Lubricate, Readjust and tighten the fasteners with specified torque replace the worn-out joints
Looseness in the steering gear	Adjust the steering gear (worm shaft end play, cross shaft end play adjustment)
Front spring too flexible	Replace the components and tighten the spring components
Unequal the camber	Set the camber angle

❖ **Wheel wobble (low speed shimmy)**

❖ The oscillatory motion of the wheel in the sideway is called the wheel wobble

Causes	***remedies***
Uneven or low tyre pressure	Inflate to correct tyre pressure
Slackness in the steering linkage	Lubricate, Readjust and tighten the fasteners with specified torque replace the worn-out joints
Loose ball joint	Replace, the ball joint
Looseness in the steering gear	Adjust the steering gear (worm shaft end play, cross shaft end play adjustment)
Front spring too flexible	Replace the components and tighten the spring components
Unequal the camber	Set the camber angle
Improper steering gear adjustment	Adjust the steering gear
Irregular tyre treads	Replace the worn out tyre
Imbalanced wheel	Balance the wheel dynamically
LOOSEN/ worn out wheel bearing	Adjust/replace the worn-out bearing
Disturbed front end alignment	Check and adjust the front-end alignment
Sagging or broken leaf spring	Replace the spring
Worn lower ball joint	Replace

Poor returnability

Causes	***remedies***
Binding in tie rod end ball joint/ stud	Replace the tie rod ends
Binding in the steering column	Repair or replace
Poorly lubricated steering gear Poorly lubricated steering linkage	Lubricate the steering gear Grease the steering linkage
Uneven or more tyre pressure	Inflate to correct pressure
Improper toe in adjustment	Adjust the toe in

Improper camber angle	Adjust the camber angle
Improper centre or mid position adjustment	Adjust
Bend stub axle	Replace
Loose front wheel	Re-tighten the wheel
Too tight steering bushes	Replace

EXECESSIVE TYRE WEAR

CAUSES	REMEDIES
Over inflation of the tyre	Inflate the tyre at proper pressure
Under inflation of the tyre	Inflate the tyre at proper pressure
Improperly set camber angle	Set the angle as per the specification
Improper setting of the castor angle	Set the angle as per the specification
Sagging or the broken spring	Replace the spring
Tyre out of balance	Adjust balance or replace the tyre
Disturbed front and rear end alignment	Check and adjust front end alignment
Faulty shock absorber/ strut	Replace the strut/ shock absorber
Hard driving	Replace the tyre
Over loaded vehicle	Avoid over loading
Tyre are not rotated	Rotate tyre at regular intervals
Worn or loose road bearing	Replace the bearing
Wobbly wheel or tyre	Adjust the tyre and wheel

Erratic steering

CAUSES	REMEDIES
Worn out wheel bearing	Replace
Broken or sagging of the spring	Replace the coil spring or camber the leaf spring
Over inflation of the tyre	Inflate the tyre at proper pressure
Disturbed front end alignment	Check and adjust front end alignment
Brakes are not working / adjusted equally	Adjust the brakes avoid dragging of the brakes
Leaking of the wheel cylinder	Repair or replace the rubber kit or the wheel cylinder or the clipper pads
Improper alignment of the steering	Adjust the steering
Weak strut	Replace the strut
Binding in tie rod end ball joint/ stud	Replace the tie rod ends

Binding in the steering column	Repair or replace

Check Your Progress

Fill in the blanks

1) Wheel balancing helps to eliminate _____ and prevent premature wear of various vehicle components.
2) The first sign of possible wheel imbalance is when the steering wheel starts to _____ at certain speeds.
3) Wheel alignment consists of adjusting the angles of the wheels to reduce tyre wear and ensure _____ travel.
4) Caster angle influences vehicle stability at _____ speeds and affects tyre lean during cornering.

Multiple Choice Questions (MCQs):

1. What is the purpose of wheel balancing?
a) To increase tyre wear
b) To eliminate vibration and premature wear
c) To make steering harder
d) To increase vehicle weight

2. What is the primary purpose of adjusting wheel alignment?
a) Increase fuel efficiency
b) Improve suspension performance
c) Reduce tyre wear and ensure straight travel
d) Enhance engine power

3. Which type of wheel imbalance causes a vibration that can be felt at the steering wheel?
a) Rear wheel imbalance
b) Front wheel imbalance
c) Left wheel imbalance
d) Right wheel imbalance

4. Toe-in adjustment is responsible for ensuring:
a) Wheels roll parallel
b) Wheels rotate in opposite directions
c) Wheels tilt inward at the top
d) Wheels are balanced

Answer the following question

1. What is the use of castor plate?
2. Write the turning radius of two small cars?
3. Explain Wheel Balancing and Wheel alignment.
4. Why wheel balancing is required in a vehicle?
5. How dynamic balancing of wheel is carried out with the help of balancing machine?
6. Write the symptoms of imbalanced wheel in the vehicle?
7. What are the ill-effects, if wheels are not properly balanced in a car?
8. What do you understand by toe-in and toe-out?
9. What is castor angle and how does it affect steering system?
10. What is camber angle and how does it affect steering system?

Activity

1. Make a list of preliminary procedure for wheel alignment

S.No.	Procedure
1	
2	
3	
4	

2. Make a list of adjustments which can be done in steering gear

S.No.	Adjustment
1	
2	
3	
4	

Module 5	Auto Electrical System

Module Overview

This module is designed to provide students with a comprehensive understanding of automotive electrical and electronic systems, essential for anyone interested in the field of electric vehicle retrofitting and maintenance. The course covers a range of topics, from basic electrical symbols and circuit diagrams to more advanced systems such as the vehicle's starting, charging, and ignition circuits. Students will gain hands-on experience with electrical testing equipment, learn how to maintain batteries, and understand the intricacies of wiring harnesses and fuse applications. Additionally, the module will introduce students to the climate control systems within a vehicle, including heating, ventilation, and air conditioning (HVAC).

Learning Outcomes

After completing this module, you will be able to:

1. Understand and read various electrical and electronic symbols used in automotive circuit diagrams.
2. Accurately identify and interpret cable specifications, color codes, and wiring harnesses.
3. Confidently use electrical test equipment to diagnose and troubleshoot electrical issues in vehicles.
4. Understand the role of fuses in vehicle electrical systems.
5. Interpret the circuit diagram of an automobile's charging system.
6. Check and service the ignition circuit to maintain the proper functioning of the vehicle's ignition.
7. Perform maintenance and servicing of key electrical accessories within the vehicle.
8. Gain an introductory understanding of the vehicle's climate control systems, including heating, ventilation, and air conditioning (HVAC).
9. Understand basic maintenance and servicing techniques for HVAC systems.

Module Structure

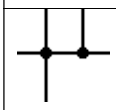
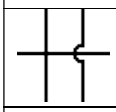
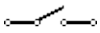
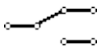
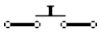
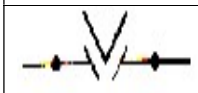
Session1: Automotive electrical and electronics symbol
Session 2: Electrical test equipment
Session 3: Battery and its maintenance
Session 4: Checking of electrical connections of the lighting system in a vehicle
Session 5: Application and replacement of fuses
Session 6: Circuit diagram of charging system of automobile and checking of charging system
Session 7: Circuit diagram of starting system of automobile and checking of starter circuit

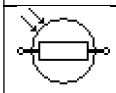
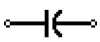
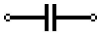
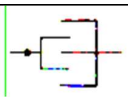
Session 8: Circuit diagram of ignition system and checking of ignition circuit
Session 9: Maintenance and servicing of major electrical accessories
Session 10: Introduction to climate control system heating ventilation and air conditioning in a vehicle

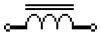
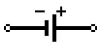
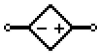
Session 1: Automotive Electrical and Electronics Symbol

Relevant Knowledge

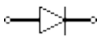
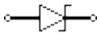
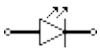
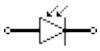
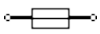
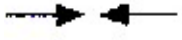
The Automotive Electrical and Electronics Symbols with their name and descriptions are given below:

SYMBOL	COMPONENT NAME	DESCRIPTION
Wire Symbols		
	Electrical wire	Symbol represents the electrical wire.
	Wire connected	Fig. represents the symbol for wires that crossed but are joined together. The dots at the intersection indicates the joining the wires.
	Wire not connected	Fig. represents the symbol for wires that crossed but are not joined.
Switch and Relay Symbols		
	SPST Toggle Switch	Disconnects current when open
	SPDT Toggle Switch	Selects between two connections
	Pushbutton Switch (N.O)	Momentary Switch – normally open
	Pushbutton Switch (N.C)	Momentary Switch – normally closed
	Heavy duty Switch	Used Many places in Automobile
	DIP Switch	DIP Switch is used for onboard configuration
	SPST Relay	

	SPDT Relay	Relay open / closed connection by an electromagnet
	Jumper	Close connection by jumper insertion on pins
Ground Symbols		
	Earth Ground	Used for zero potential reference and electrical shock protection
	Chassis Ground	Connected to the chassis of the circuit
	Digital / Common Ground	
Note: In automobiles, the circuits are generally completed through the chassis instead of through wires, which is called earth returned system of wiring.		
Resistor Symbols		
	Resistor	Resistor reduces the current flow
	Potentiometer	Adjustable resistor – has three terminals
	Variable Resistor / Rheostat	Adjustable resistor – has two terminals
	Thermistor	Thermal resistor – change resistance when temperature changes
	Trimmer Resistor	Preset resistor
	Photo resistor / Light dependent resistor (LDR)	Photo-resistor, change resistance with the change of intensity of light.
Capacitor / Condenser Symbols		
 	Capacitor or Radio condenser	Capacitors or radio condenser is used to store electric charge. It acts as short circuit with AC and open circuit with DC.
	Condenser	It is generally used to eliminate radio interference or to avoid arcing at the contact points. In an inductive circuit it is always used in parallel to contact points.

Inductor / Coil Symbols		
	Inductor	Coil / solenoid that generates magnetic field
	Iron Core Inductor	Includes iron
	Variable Inductor	
	Induction Coil	It has primary and secondary windings. The primary windings are shown thicker than the secondary windings and are connected to them. The lines in between the two windings indicate the magnetic core. The symbol may be even without the magnetic core.
Power Supply Symbols		
	Voltage Source	Generates constant voltage
	Current Source	Generates constant current
	AC Voltage Source	Indicates AC Voltage Source
	Generator / Alternator	Electric Voltage is generated by mechanical rotation of the generator / Alternator
	Battery Cell	Generates constant voltage. The long line indicates the positive terminal and short line indicates the negative terminal
	Battery	
	Controlled Voltage Source	Generates voltage as a function of voltage or current of other circuit element
	Controlled Current Source	Generates current as a function of voltage or current or other circuit element

Meter Symbols		
	Voltmeter	Measures voltage. Has very high resistance. Connected in parallel.

	Ammeter	Measures electric current. Has near zero resistance. Connected in series with the circuit
Lamp / Light bulb Symbols		
	Lamp / light bulb	Generates light when current flows through.
	Lamp / light bulb	
	Lamp / light bulb	
Diode / LED Symbols		
	Diode	Diode allows current flow in one direction only. In the figure the flow of current will be from left to right.
	Zener Diode	Allows current flow in one direction, but also can flow in the reverse direction when above breakdown voltage.
	Light Emitting Diode (LED)	LED emits light when current flows through
	Photodiode	It allows current flow when exposed to light.
Transistor Symbols		
	NPN Transistor	Allows current flow when high potential at base (middle) - B
	PNP Transistor	Allows current flow when low potential at base (middle) - B
Misc. Symbols		
	Motor	Electric motor
	Fuse	The fuse disconnects when current above threshold. Used to protect circuit from high currents.
	Fuse	
	Spark Gap	Spark gap is given to the spark plug.

Automobile Cables and their specification

Various kinds of cables are employed in the wiring system of present-day automobiles. While selecting the cable size, the voltage drop is kept in mind. Generally, the voltage drops permitted for a particular length of cable under its full current loading capacity is of the order of 10%.

The cables used in automobiles are of the stranded type instead of the single-conductor type. The stranded cables are more flexible than the single one but they are not easily soldered. The size of the cable is designated by the number of strands and the diameter of each wire used. For instance, a cable having 37 strands of wire, each of 0.875 mm diameter, is designated as a 37/0.875 cable.

Automobile cables can be classified into three main categories:

1. Starting system cables
2. General purpose cables
3. High-tension cables

Starting system cables

When the cranking motor is switched on, it draws heavy current in the beginning of its operation. Hence it is quite essential to employ this type of cable which is capable of conducting such heavy currents. Generally, three different cables are used for starters having insulation of either vulcanized rubber or of PVC (polyvinyl chloride). The cables of 37/0.900, 61/0.900 and 61/1.100 size are suitable for the starting system. PVC insulated cables have PVC insulation, that are braided and compounded, whereas, the rubber insulated cables are of the rubber-proofed, braided and compounded type.

General Purpose Cables

There are twelve different sizes of cables which are generally used for automobiles as the standard sizes. These sizes include cables of 9/035-120/0.350 for single conductor type and 9/0.350-35/0.350 for twin conductor cables. A three-conductor cable of 9/0.350 size is also used.

When long cables that produces voltage drop greater than 10% are used, it is advisable to use the next higher size of cable. Care is also to be taken to see that the insulation used is not affected by the action of water, oil, or fuel. Also, it should not deteriorate quickly under bonnet temperatures. Neoprene rubber is quite suitable for this purpose. The Society of Automotive Engineers (SAE) recommends the use of thermoplastic insulated braided cables in the case of LT currents as they are stronger and harder than rubber. They are also not affected by exposure to engine bonnet temperatures and also to oxygen or ozone of the atmosphere. One distinct advantage is that thermoplastics are easily extruded and can be made in a variety of colours.

High-Tension (HT) cables

The cables connecting the ignition coil to the central point of the distributor and from the distributor to the various spark plugs, fall under the category of HT cables. These cables are subjected to very high voltages such as those of the order of 6000-22,000 volts. They are exposed to engine bonnet temperature and also come in contact with oil, petrol and water. Due to this, it is essential that these cables must have a special kind of insulation. Earlier, these cables were having an insulation of natural rubber. The overall diameter of the cable is of the order of 7-12 mm. The conductor size was 35/0.350 – 44/0.350 of stranded type. It may be mentioned that these cables carry very small quantities of currents when compared to other cables. The natural rubber insulation is affected by heat, oil and petrol. This results in cracks in the cable after a certain service period, leading ultimately to short-circuiting.

These days, neoprene artificial rubber insulation is generally used, and it has practically replaced all other insulating rubbers. This insulation has a marked resistance to heat, ageing, oil, etc. Further, it has much less capacitance than other insulations of ordinary rubber.

The standard size of the conductor used is of the order of 7-19 strands of annealed tinned copper wire. The overall diameter of the cable is about 7 mm. The cable is subjected to various tests like water-proofing, life-cycle, temperature and hot oil. It may be mentioned that PVC insulated type cables are also used with plain annealed copper wires.

Cable colour code

In order to quickly identify and also to simplify the wiring system, the cables are coloured. In addition, colour lines or threads are also used around the cables, which provide a very wide choice of colour combinations. The seven colour code system is the general one and involves brown, yellow, red, white, green, blue and black colours.

Brown Cables

Brown cables are used for the battery circuit. It is used from the cranking motor switch to the ammeter, to the radio receiver, to the electric clock, to the inspection sockets and to the battery auxiliary fuse.

Yellow Cables

These are used for the generator circuits. The cable is used from the generator terminal to the corresponding control-box terminal and to the ignition warning light.

White Cables

These cables are used for the ignition circuits and also for other circuits which do not require fuses and are operated through the ignition switch, such as the electric fuel pump, motor starter, solenoid switch etc.

Green Cables

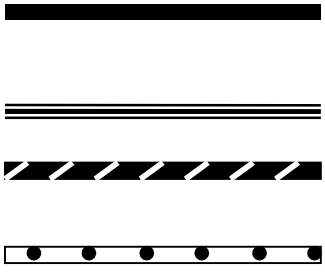
These cables are used for all the auxiliary circuits which are fed through the ignition switch but are protected by the fuses. Examples of these circuits are the brake stop lamps, the fuel gauge, the windscreen wipers, the direction indicators, etc.

Blue Cables

These cables are used for the headlamp circuits. These cables are used for the side and tail lamp circuits. It is also used for fog lamps, panel lights and other lamps which are only used when the side lamps are in operation.

Black Cables

These cables are used for the earth circuits. Following are the examples of a typical wire colour code tables (Ford and Chrysler):



WIRING COLOUR KEY (PRIMARY COLOURS)

BK	--	**BLACK**	**Y**	--	**YELLOW**
BR	--	**BROWN**	**DB**	--	**DARK BLUR**
GY	--	**GRAY**	**LB**	--	**LIGHT BLUE**
O	--	**ORANGE**	**DG**	--	**DARK GREEN**
P	--	**PURPLE**	**LG**	--	**LIGHT GREEN**
PK	--	**PINK**	**(D)**	--	**DOT**
R	--	**RED**	**(H)**	--	**HASH MARK**
T	--	**TAN**	**SRTIPE IS UNDERSTOOD**		
W	--	**WHITE**			

FORD COLOUR CODES

WIRING COLOUR CODE CHART					
COLOUR CODE	COLOUR	STANDARD TRACER COLOUR	COLOUR CODE	COLOUR	STANDARD TRACER CODE
BK	BLACK	WH	PK	PINK	BK OR WH
BR	BROWN	WH	RD	RED	WH
DB	DARK BLUE	WH	TN	TAN	BK
DG	DARK GREEN	WH	VT	VIOLET	WH
GY	GRAY	BK	WT	WHITE	BK
LB	LIGHT BLUE	BK	YL	YELLOW	BK
LG	LIGHT GREEN	BK	●	WITH TRACER	
OR	ORANGE	BK			

CHRYSLER COLOUR CODES

MAIN CIRCUIT IDENTIFICATION CODES (CHRYSLER)

A1 Battery Circuit to Ammeter.
A2 Battery Circuit to Ammeter.
B Back Up Lamp Circuit.
C Air Conditioning and Heater Circuits.
D Emergency, Stop Lamp and Turn Signal Circuits.
E Instrument Panel Cluster, Switches and Voltage
Illumination Circuits
F Radio Speakers and Power Seat Circuits. (Feed)
G Gauges and Warning Lamp Circuits Circuit
H Horn Circuit.
J Ignition System Run Circuit. Circuit.
J1 Ignition Switch Feed Circuit.
J3 Ignition Switch Start Circuit. Grounds,
K Tralier Tow. Antenna,
L Lighting Circuit (Exterior Lights)
M Lighting Circuit (Interior Lights).
P Brake Checking Circuit.
Q2 Accessory Buss Bar Feed (Fuse Block).
Q3 Battery Buss Bar Feed (Feed)
R3 Alternator Circuit to Electronic Regulator (Field).
R6 Alternator Circuit to Ammeter
S Starter Motor and Starter Relay
T Trunk Lamp Circuit.
V Windshield Wiper and Washer Circuit.
W Power Window Circuit
X Radio, Cigar Lighter, Lamp Clock, Speed Control, Power Deck Lid and Door Locks

Wiring Harness

The electrical system of present-day cars is quite complex. Connecting each electrical component individually is a tedious and costly affair. With the adoption of wiring harness method, it has become quite simple to connect the various electrical components. It has also resulted in space saving and safeguarding of the individual cables from metal objects.

The harness shown in following (Fig. 5.1) is simplified one. The harness consists of bunches of cables leading to the various components to be connected. Each bunch is bound together with a PVC tape, leaving sufficient lengths of individual cables protruding at each end for making the necessary electrical connections easily.

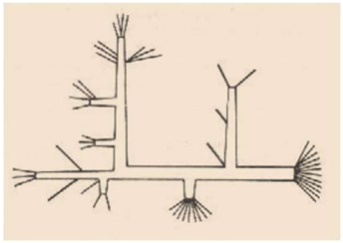


Fig. 5.1: Basic electrical system

It may be noted that there is a typical drawback to this system. If one of the cables fails, it necessitates the harness to be cut for rectification. However, the present- day cables have got good mechanical strength as well as insulation properties.

Check Your Progress

Fill in the blanks

1. The symbol for an electrical wire represents the _____.
2. Resistor reduces the flow of _____ in an electrical circuit.
3. Neoprene rubber is often used as insulation for cables due to its resistance to _____, oil, and heat.
4. High-tension (HT) cables are used to connect the _____ to the spark plugs.
5. The purpose of a wiring harness is to simplify connections and prevent damage from _____ objects.

Multiple Choice Questions:

1. What is the purpose of using automotive electrical symbols?

a) To confuse mechanics

b) To simplify circuit diagrams
c) To increase voltage
d) To generate light

2. Which type of switch disconnects the current when open?
a) SPST Toggle Switch
b) Pushbutton Switch (N.O)
c) SPDT Relay
d) Jumper

3.What does a resistor do in an electrical circuit?
a) Increases voltage
b) Reduces current flow
c) Acts as a switch
d) Generates light

4. Which cable is used for the battery circuit?
a) Black
b) Green
c) Yellow
d) Brown

5. What is the primary purpose of a wiring harness in automobiles?
a) To confuse mechanics
b) To increase voltage
c) To simplify connections
d) To generate heat

6. Which cable is used for the headlamp circuits?
a) White
b) Blue
c) Red
d) Black

Answer the following questions

1. Draw a neat diagram of following items in symbolic form.
   a. Fuse
   b. Relay
   c. Transistor
   d. LED
   e. Ground

2. Write various specifications of Automobile cables.

3. What do you understand by cable color codes? Classify the Automobile cables.
4. What is Wiring Harness? How does it affect the electrical connections in Automobile?

Activity

1. Make a list of the auto electrical components and also write brief description

S.No.	Name of the component	Description

2. Prepare a poster showing symbols of auto electrical and electronic components and write also their names.

Session 2: Electrical Test Equipment's

Since electricity is an invisible force, the proper use of test tools will permit the Assistant to "See" the flow of electrons. Knowing what is being looked at and being able to interpret various meter types will assist in electrical system diagnosis. To diagnose and repair electrical circuits correctly, a number of common tools and instruments are used. The most common tools are jumper wires, test lights, voltmeters, ammeters, ohmmeters etc.

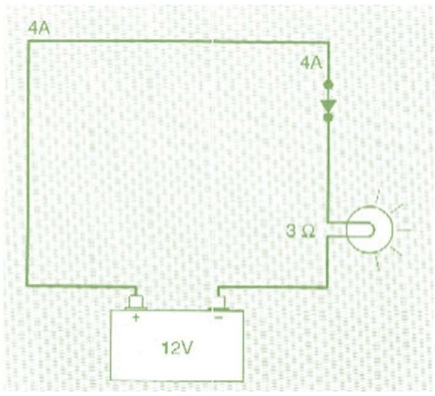
Jumper Wires

One of the simplest types of test equipment is the Jumper wire. A jumper wire is simply a wire with an alligator clop on each end. Connecting one end of the jumper wire to battery positive will provide an excellent 12-volt power supply for testing a component. Jumper wires can be used to check the load components by by-passing switches, conductors, and connections in the circuit.

Jumper wires can also be used to provide the ground to test that portion of the circuit.

Warning: Never connect a jumper wire across the terminals of the battery. The battery could explode, causing series injury.

Test Lights



A test light is used when the Assistant needs to "look" for electrical power in the circuit. The test light handle is transparent and contains a light bulb. A sharp probe extends from one end of the handle while a ground wire with a clamp extends from the other end (Fig. 5.2). If the circuit is operating properly, clamping the lead of the test light to ground and probing the insulated side of the circuit, the lamp should light.

Fig. 5.2: Test Lights

A test light is limited in that it does not display how much voltage is at the point of the circuit being tested. However, by understanding the effects of voltage drop, the Assistant will be able to interpret the brightness of the test light and relate the results to that which would be expected in a good circuit. If the lamp is connected after a voltage drop, the lamp will light dimly. Connecting the test lamp before the voltage drop should light the lamp brightly. The light should not illuminate at all if it is probing for voltage after the last resistance.

A typical test used to probe for voltage in a circuit

Warning 1: It is not recommended that a test light be used to probe for power in a computer-controlled circuit. The increased draw of the test light may damage the system components.

Warning 2: Do not connect a self-powered test light to a circuit that is powered. Doing so will damage the test light.

Logic Probes

Many computer-controlled system (Multi Point Fuel Injection (MPFI) Engines) use a pulsed voltage to transmit messages or to operate a component. A standard or self-powered test light should not be used to test these circuits

(Fig. 5.3) since they may damage the computer. However, a logic probe can be used. A logic probe looks something like a test light except it contains three different colored LEDs.

- The red LED will light - If there is high voltage at the point in the circuit.
- The green LED will light - If there is low voltage at the point in the circuit
- The yellow LED will light - If there is presents of voltage pulses.
- If the voltage is a pulsed voltage from a high level to low level, the yellow LED will be on and the red and green LEDs will cycle indicating the change in voltage.

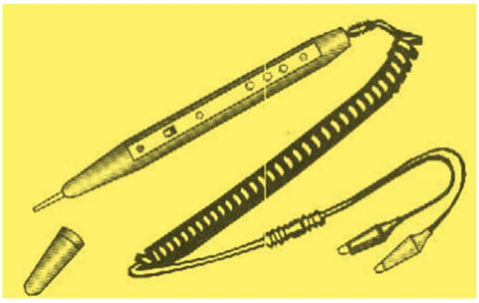


Fig. 5.3 Typical Logic Probe

Multimeter

A multimeter (fig.5.4) is an electrical test meter capable of measuring

- Voltage
- Resistance (in Ohms)
- Current Flow (in ampere)

Fig. 5.4 Analog Multimeter

In addition, some types of multimeters are designed to **test diodes, measure frequency, duty cycle, temperature, and rotation speed**. Multimeters are available in analog and digital display.

With modern vehicles incorporating computer-controlled system, the need for digital multimeters (DMM) is required. Computer systems have integrated circuits that operate on very low amounts of current. Analog meters will download computer circuits and burn out the IC chips since they allow a large amount of current to flow through the circuit. On the other hand, most digital multimeters have very high input resistance (**impedance**) which prevents the meter from drawing current when connected to a circuit. Most DMMs have at least 10 megohms (10 million ohms) of impedance. This reduces the risk of damaging computer circuits and components.

Digital Multimeter

Digital meters rely on electronic circuitry to measure electrical values. The measurements are displayed with LEDs or on a liquid crystal display (LCD). Digital meters tend to give more accurate readings and are certainly much easier to read. Rather than reading a scale at the point where the needle lines up, digital meters simply display the measurement in a numerical value (Fig. 5.5). This also eliminates the almost certain error caused by viewing an analog meter at an angle.

Fig. 5.5 Digital Multimeter

All meter has test leads to contact the circuit or part being tested. The leads may be permanently attached to the meter, or they may plug into various sockets for different uses. When you measure amperage or voltage in a circuit, you must be sure that the polarity of the meter and the lead matches the polarity of the circuit. One lead is usually red for positive (+) and is connected to the positive side of the circuit. The other lead is usually black for negative (-) and is connected to the negative side of the circuit.

Test Procedure with the help of Multimeter

Ammeter Test

- Before connecting multimeter prods into a circuit, set the range selector switch to the range above the maximum expected current draw (Fig. 5.6).
- There are three general rules about the readings the Assistant may get from an Ammeter in series with a circuit:

1. If the meter shows **no current**, the circuit is open some point. There is no circuit continuity.
2. If meter shows **low current**, the circuit is complete but has high resistance.
3. If meter shows **too high current,** some of the normal resistance has been bypassed to ground or through a short circuit.

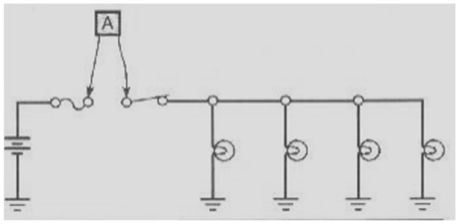


Fig. 5.6 Measuring current flow with an ammeter (or Multimeter). The meter must be connected in series with the circuit

Voltmeter Test (available voltage)

- In a multimeter AC and DC voltage can be checked with the proper selection of the switch (Fig. 5.7 and Fig. 5.8).
- Select the switch to DC for checking automobile circuit and set the range selector to the range above the maximum expected voltage (Fig. 5.9 and Fig. 5.10).

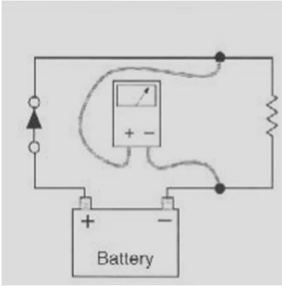


Fig. 5.7 Connecting a Voltmeter in Parallel to the Circuit

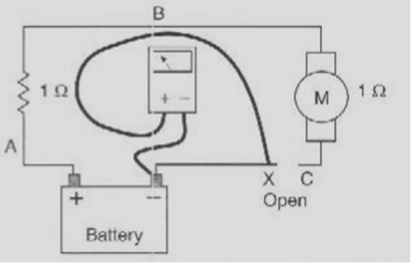


Fig. 5.8 Checking Voltage in an open circuit

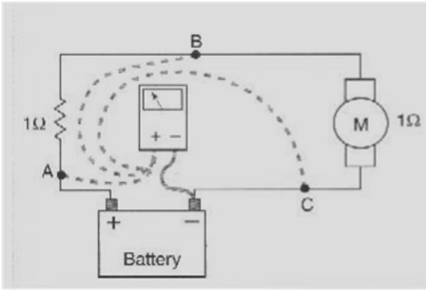


Fig. 5.9 Checking Voltage in a closed

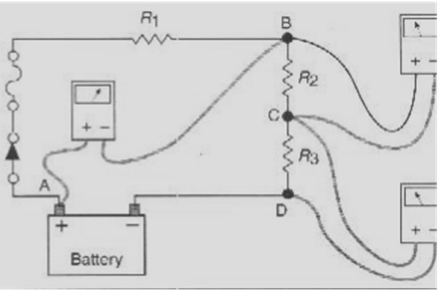


Fig. 5.10 Measuring the Voltage Drop

Circuit

You can measure voltage available in a circuit with or without current flowing. Voltage without current flow is open-circuit voltage and should equal battery, or source, voltage. When current flows through a circuit, the circuit device use, or drop, some voltage as they operate. Voltage on one side of a load will be different from the voltage on the other side when the circuit is closed and operating. Battery voltage also will drop when a circuit is operating and will continue to drop until recharged by an alternator or battery charger.

As an example, measure available source voltage at the battery by connecting your voltmeter + lead to the battery + terminal and the - lead to the - terminal. Be sure all electrical circuits are open (off). The meter reading should be about 12 to 12.6 volts. Now turn on the head-lamps to complete a circuit and read the meter again. The available voltage will be lower than open-circuit voltage, depending on the condition of the battery and the circuit current draw.

You also can use your voltmeter to locate high-resistance problems in a circuit with current flowing. Connect the voltmeter - lead to ground and use the + lead to test for available voltage at several points in the circuit. This drawing shows that poor motor operation has been caused by high resistance and an unwanted voltage drop at a corroded connection.

Voltage-Drop Test

When an electrical device operates, it uses, or drops, a specific amount of voltage that depends on the resistance of the device and the current in the circuit. Unwanted voltage drop can result from a high-resistance connection or a defective device. An important rule for voltage-drop testing is:

The sum (total) of the voltage drops around a circuit equals the source voltage.

A voltage-drop test can tell you:

- An electrical device is using too much voltage because of high resistance in the device.
- An electrical device is using too little voltage because of a short or grounded circuit in the device.
- High resistance from a loose or corroded connection is causing an un-wanted voltage drop.

A circuit must be closed and operating for voltage-drop testing. You can calculate voltage drop indirectly or measure it directly for any part of the circuit.

Ohmmeter Test (resistance in Ohms)

An Ohmmeter will measure resistance and continuity. The ohmmeter is powered by an internal battery, thus the power to the circuit being tested must be disconnected. By connecting the ohmmeter leads in parallel to the portion of

the circuit being tested, an open or excessive resistance can be detected. The meter sends a current through the component and determines the amount of resistance based (Fig. 5.11) on the voltage drop across the load. The meter reads from zero to infinity.

- A reading of zero means there is no resistance in the circuit. This may indicate the presence of a short circuit in a component that requires resistance. For example, a coil winding should have a high resistance value, zero ohms reading would indicate the clip windings are being by passed.
- If the meter indicates an infinity reading, this means the resistance is higher than the meter can read on the selected scale. If an infinity reading is obtained on the highest scale this usually indicates the circuit has an open.

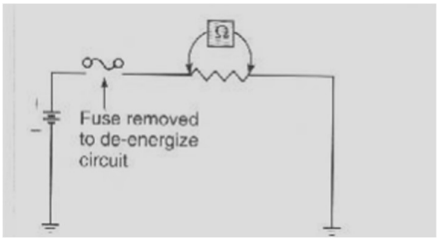


Fig. 5.11 Measuring resistance with an ohmmeter.

The meter is connected in parallel with component being tested after power is removed from the circuit

Most ohmmeters use a multiplier to figure higher resistances. The multi-position switch on the front of the meter indicates four ranges. These ranges are usually labeled R X 1, R X 10, R X 100, and R X 1K. The reading on the ohmmeter scale must be multiplied by the value indicated by the range to get the actual resistance.

Oscilloscope

The Oscilloscope is very useful in diagnosing many electrical problems quickly and accurately. Digital and analog voltmeters do not react fast enough to read systems that cycle quickly. The oscilloscope may be considered as a very fast reacting voltmeter that reads and displays voltages. The scope allows the Assistant to view voltage over time. These voltage readings appear as a voltage trace on the oscilloscope screen. Some smaller oscilloscopes use liquid crystal displays (LCD). However, most larger screens are cathode ray tube (CRT), (Fig. 5.12) which is very similar to the picture tube in a television set. High voltage from an internal source is supplied to an electron gun in the back of the CRT when the oscilloscope is turned on. This electron gun emits a continual beam of electrons against the front of the CRT. The external leads on the oscilloscope are connected to deflection plates above and below, and on each side of the electron beam. When a voltage signal is supplied from the external leads to the deflection

plates, the electron beam is distorted and strikes the front of the screen in different locations to indicate the voltage signal from the external leads.

Fig. 5.12 Oscilloscope

An upward movement of the voltage trace on an oscilloscope screen indicates an increase in voltage, and a downward movement of this trace represents a decrease in voltage. As the voltage trace moves across an oscilloscope screen, it represents a specific length of time. Most oscilloscopes of this type are referred to as analog scopes or real-time scopes. This means the voltage activity is displayed without any delay.

Check Your Progress

Fill in the blanks

1. One of the simplest types of test equipment is the _____ wire.
2. A test light is limited in that it does not display the _____ at the point of the circuit being tested.
3. Digital multimeters (DMMs) are preferred for testing computer circuits due to their high input resistance, which reduces the risk of _____ to components.
4. An oscilloscope displays voltage traces on a screen, representing voltage variations over _____.

Multiple Choice Questions:

1. What is the primary purpose of using jumper wires in electrical testing?
A) To measure resistance
B) To diagnose voltage drops
C) To provide a ground for testing
D) To bypass load components

2. Which tool is used to "look" for electrical power in a circuit?
A) Voltmeter
B) Ammeter
C) Logic probe

D) Ohmmeter

3. Which type of multimeter is recommended for testing computer-controlled circuits due to its high input resistance?
A) Analog multimeter
B) Digital multimeter (DMM)
C) Ohmmeter
D) Logic probe

4. What is the purpose of a logic probe in electrical testing?
A) Measure voltage drops
B) Test diodes
C) Measure frequency
D) Test computer-controlled circuits

5. In a circuit, the sum of voltage drops around the circuit is equal to:
A) Zero
B) The source voltage
C) Infinity
D) Half of the source voltage

Answer the following questions

1. Discuss the importance of electrical test equipment's in the testing of automobile electrical circuits.
2. Name various electrical test equipment's used in automobile.
3. With the help of multi-meter what are the parameters can be tested?
4. Explain how to test following parameters with the help of multi-meters?
   a. Voltage
   b. Current
   c. Resistance
5. Explain regarding the Oscilloscope. What are the parameters can be checked with the help of Oscilloscope?

Activity

1. Make a list of the auto electrical testing equipment and also state their applications.

S.No.	Name of the electrical testing equipment	Applications

2. Prepare a poster showing electrical test equipment used in testing of automobile electrical components and circuits.

Session 3: Battery and Its Maintenance

The Battery is the Heart of the Automotive Electrical System. The battery must be in good useable condition for the rest of the electrical system to function correctly. In this chapter we describe the battery service and testing methods necessary to assure proper battery operation.

General Precautions while Handling Battery

Before attempting to do any type of work on or around the battery, the Assistant must be aware of certain precautions. To avoid personal injury or property damage, take the following precautions:

1. Battery acid is very corrosive. Do not allow it to come in contact with skin, eyes, or clothing. If battery acid gets into your eyes, rinse them thoroughly with clean water and receive immediate medical attention. If battery acid comes in contact with skin, wash with clean water. Baking soda added to the water will help to neutralize the acid. If the acid is swallowed, drink large quantities of water or milk followed by milk of magnesia and a beaten egg or vegetable oil.
2. When making connections to a battery, be careful to observe polarity (positive to positive and negative to negative).
3. When disconnecting battery cables, always disconnect the negative (ground) cable first.
4. When connecting battery cables, always connect the negative cable last.
5. Avoid any arcing or open flames near battery. The vapors produced by the battery cycling are very explosive. Do not smoke around a battery.
6. Follow manufacturer's instructions while charging the battery. Charge the battery in a well-ventilated area. Do not connect or disconnect the charger leads while the charger is turned on.
7. Do not add additional electrolyte to the battery if it is low. Add only distilled water.

8. Do not wear any jewelry or watches while servicing the battery. These items are excellent conductors of electricity. They can cause severe burns if current flows through them by accidental contact with the battery positive terminal and ground.
9. Never lay tools across the battery. They may come into contact with terminals, sorting out the battery and causing it to explode.
10. Wear safety glasses or face shield when servicing the battery.
11. If the battery's electrolyte is frozen, allow it to defrost before doing any service or testing of the battery. While it is defrosting, look for leaks in the case. Leakage means the battery is cracked and should be replaced.

Battery Inspection and Cleaning

Even maintenance-free batteries need periodic inspection and cleaning to ensure that they are in good working order. If a vehicle charging system is working properly and electrical loads are not excessive, inspection and cleaning may be the only services any battery needs. To do these jobs, you will need the following equipment and tools.

- A cleaning solution of baking soda and water, or ammonia
- Stiff bristled cleaning brushes
- Terminal pliers and wrenches and perhaps a terminal spreader and puller.
- Terminal and connector scraping and cleaning tools.
- A battery carrier or lifting strap.
- Protective coating for the battery terminals (jelly or spray).

Battery Inspection

Complete battery inspections consist of the following eight steps but takes only a couple of minutes to do (Fig.5.13).

1. If the battery has removable cell caps, check the electrolyte level. It should be above the tops of the plates or at the split-ring indicator level in each cell. Add distilled water to raise the electrolyte level, if necessary. Do not overfill the battery.
2. Check for missing or damaged cell caps, replace as required.
3. Check battery terminals, cable connectors, and metal hold-down parts for acid corrosion. Clean as required.
4. Check the cables for broken or corroded wire strands, worn insulation, and defective connectors. Replace defective parts.
5. Check battery case and cover for dirt, grease, or electrolyte condensation that could cause voltage to leak to ground. Clean battery as necessary.
6. Inspect the battery for cracks, loose terminals, and other damage. Replace a damaged battery.

7. Check the battery carrier (tray) hold-down parts, and heat shields for looseness or improper installation. Tighten or replace loose or damaged parts.
8. If the battery has built-in hydrometer (state-of-charge indicator), check its colour indication for general battery condition.

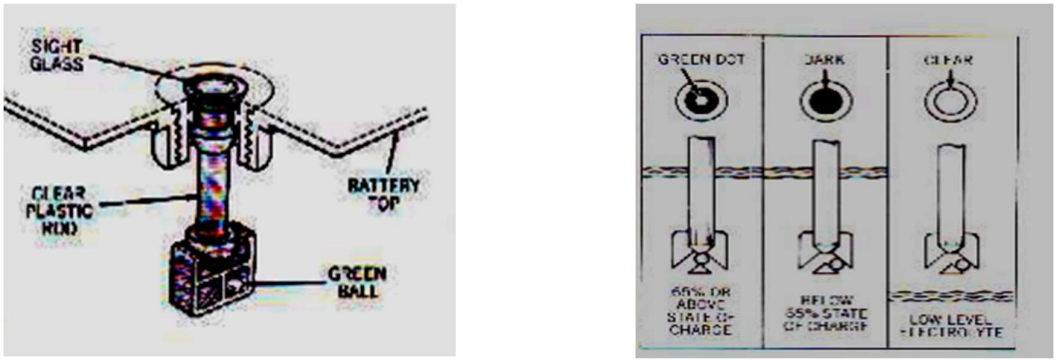


Fig. 5.13 the colour of a built-in hydrometer indicates the general state of charge.
(Chrysler, Delco-Remy)

Battery Cleaning

Some dirt and corrosion naturally collect on a battery from two general sources:

1. High temperature and air movement under the hood cause dirt and grease to collect on any flat surface.
2. Normal battery gassing (hydrogen release) and water evaporation carry electrolyte vapors out of the battery. The vapors condense on the battery top and contain a small amount of sulfuric acid. As acid vapors condense over a period of time. They corrode metal parts.

Dirt and corrosion cause two general problems:

- Dirt and grease form a conductive film that causes voltage to discharge slowly to ground or between the + and – battery terminals. Electrolyte condensation adds to this discharge action because it is conductive. The same electrochemical self-discharge that occurs inside a battery will occur outside when electrolyte condenses on a battery top.
- Electrolyte condensation contains corrosive H_2SO_4, which eats away the metal of battery terminals, cable connectors, and hold-down parts. Corrosion on battery terminals and cables adds resistance to the entire electrical system. In extreme cases, corrosion between battery terminals and cables can add enough circuit resistance to drop 12 volts across the cable connection and leave no voltage for the electrical system.

Periodic battery cleaning eliminates these two problems of voltage leakage (discharge) and circuit resistance. Through battery cleaning consists of the following steps

1. Wash the battery top, case, and hold-down parts with a mixture or baking soda and water or with house-hold ammonia. These solutions neutralize acid and dissolve corrosion.
2. Remove heavy corrosion with a stiff-bristled brush. Do not splash corrosion or the cleaning solution onto painted surfaces.
3. After neutralizing acid and corrosion with baking soda or ammonia, wash the battery with detergent and water to remove dirt. Rinse with clear water from a hose or bucket.
4. Dry the battery, the cables, the hold-down parts, and adjoining vehicle parts with a clean cloth or low pressure compressed air.
5. Cleaning the outside of battery terminals and cables often does not remove corrosion that forms between the cable connectors and terminals. Starting with the ground cable, remove the cable connectors from the terminals as follows (Fig. 5.14).
   - In a side-terminal battery, use a wrench to remove the cap screws that severe the cables to the terminals.
   - On a top-terminal battery, use a wrench or battery pliers to loosen the nut on the cable connector bolt, or use pliers to release spring-type connectors. Use a puller to remove a cable that is stuck to a post. Do not pry or hammer on a stuck cable connector.

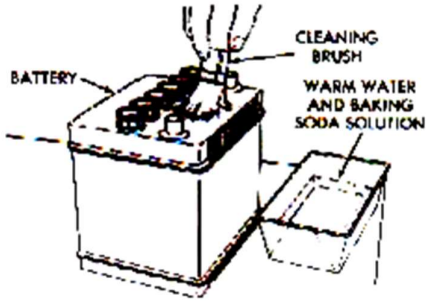


Fig. 5.14 Cleaning of battery with the help of baking soda and water or ammonia, will neutralize and remove corrosion.

6. Wash the battery terminals and cable connectors with a baking soda solution or ammonia to remove all corrosion. Use a spreading tool to open the connectors top terminal battery.
7. Scrape battery posts and the insides of cable connectors with wire brushes that have internal and external bristles. Remove corrosion from side-terminal connectors with a stiff-bristled brush.
8. After cleaning cable connectors and battery terminals, dry them with a clean cloth or low-pressure compressed air.

9. Remove and clean corroded hold-down part with the same methods used for battery cables and terminals.
10. Starting with insulated (positive or "hot" cable, reconnect the battery cables and reinstall hold-down parts securely.

Battery Testing

When the battery and cables have been completely inspected and any problems have been corrected, the battery is ready to be tested further. Before carrying out any tests on battery ensure that it is fully charged.

1. Battery terminal test: The battery terminal test checks for poor electrical connections between the battery cables and terminals. The procedure of tests is as follows (Fig. 5.15).

- Connect the negative voltmeter test lead to the cable clamp and connect the positive meter lead to the battery terminal.
- Disable the ignition system to prevent the vehicle from starting. This may be done by removing the ignition coil secondary wire from the distributor cap and putting it to ground.
- Crank the engine and observe the voltmeter reading. If the voltmeter shows over 0.3 volts, there is a high resistance at the cable connection.
- Remove the battery cable using the terminal puller. Clean the cable ends and battery terminals and refit the cables.

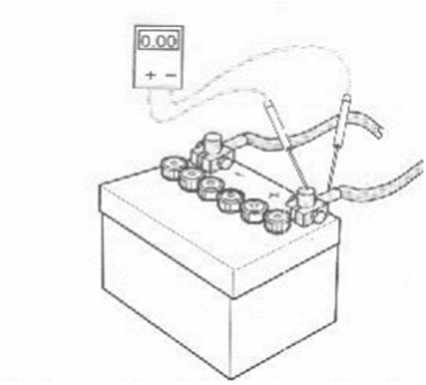


Fig. 5.15 Tests Connections for Battery terminal test

2. Leakage Test

If no apparent damage is visible the battery should be subjected to a leakage test using the battery leakage tester. Remove the vent stoppers from the battery and hold the test firmly in a vertical position over each vent in turn. Apply a pressure of 1 lb./sq. inch by means of the hand pump, this pressure must not fall off by more than 0.05 lb/sq. inch in 15 seconds. Any battery which fails this test should be rejected.

3. Insulation Tests

Before a battery is used from the charging room it should be tested for insulation resistance between the battery terminals and the metal case using a 250 V insulation tester (megger). The minimum permissible reading is 0.5 meg. Ohms.

4. State of Charge Test

A. Specific Gravity Test (Hydrometer Test)

Measuring the state of charge is a check of the battery's electrolyte and plates. It can be determined by testing the specific gravity of the electrolyte using a hydrometer.

Follow these steps to test the battery's state of charge:

- Remove all battery vent caps.
- Check the electrolyte level. It must be high enough to withdraw the correct amount of solution into the hydrometer.
- Squeeze the bulb and place the pickup tube into the electrolyte of a cell.
- Slowly release the bulb. Draw in enough solution until the float is freely suspended in the barrel. Hold the hydrometer in a vertical position.

The float rises and the specific gravity is read where the float scale intersects the top of the solution. The reading must also be compensated for temperatures.

Test Result

As the battery gets discharged, its electrolyte has a larger percentage of water. Thus, a discharged battery's electrolyte (Fig. 5.16 and Fig. 5.17) will have a lower specific gravity number than that of a fully charged battery.

A fully charged battery will have a hydrometer reading of 1.280 at 27^0 C. Remember, the specific gravity is also influenced by the temperature of the electrolyte and the readings must be corrected to the temperature. If the temperature is above or below the standard temperature 27^0 C than subtract or add 0.004 specific gravity for every 5^0C temperature rise or fall respectively.

Specific Gravity of Electrolyte in Batteries in Warm Climates

Sl. No	Approximate sp. gravity	State of charge of battery
1.	1.260 – 1.280	Fully charged
2.	1.230 – 1.260	¾ charged
3.	1.200 – 1.230	Half charged
4.	1.170 – 1.200	¼ charged
5.	1.140 – 1.170	About run down
6.	1.110 – 1.140	Discharged

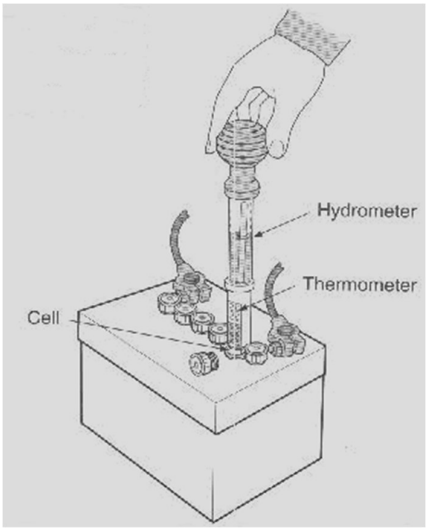


Fig. 5.16 Checking the Specific Gravity of Electrolyte with the help of Hydrometer. The electrolyte intersects the float.

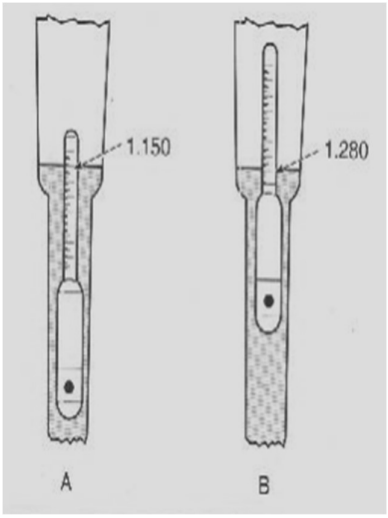


Fig. 5.17 The Specific Gravity of the Electrolyte is read at the point where (A) shows a low reading (B) shows a high reading.

B. Open Circuit Voltage Test

The open circuit Voltage test is used to determine the battery's state of charge. It is used when a hydrometer is not available or cannot be used. To obtain accurate test results, the battery must be stabilized (surface charge removed). If the battery has just been recharged, perform the capacity test, then wait at least 10 minutes to allow battery voltage to stabilize. Connect a voltmeter across the battery terminals, observing polarity. Measure the open circuit voltage. Take the reading to the 1/10 volt.

The results of the open circuit voltage test indicate the state of charge

Open Circuit Voltage	State of Charge
12.6 or greater	100%
12.4 to 12.6	70 – 100%
12.2 to 12.4	50 – 75%
12.0 to 12.2	25 – 50%
11.7 to 12.0	0 – 25%
11.7 Or less	0%

C. High Discharge Test

The state of charge of a battery can be measured with an instrument which inserts a resistance across the cell terminals and the cell voltage reading is obtained on the voltmeter. As the prods are placed on the cell terminals, the resistance places the cell under high discharge and at the same time the voltmeter indicates the cell voltage (Fig. 5.18). The duration of test should be very short because the current flow across the resistance is high – of the order of 100 to 200 A. For a 12-V battery, if each cell is fully charged, the test should show a battery voltage not below 10 V. Further, all cells of the battery should give the same reading. Lower voltage readings point towards faulty cells or cells not in a position to hold their full charge. The Exide Double-check tester which is used for carrying out state of battery charge, discharge and charging checks.

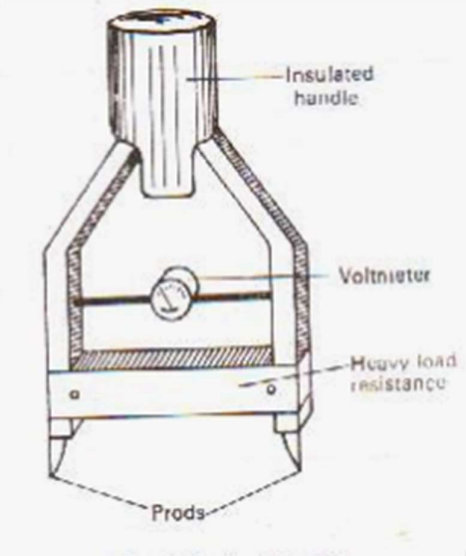


Fig. 5.18: High Rate Discharged Tester

D. Capacity Test

The capacity test provides a realistic determination of the battery's condition by checking its ability to perform when loaded. For this test to be accurate, the battery must pass the state of charge or open circuit voltage test. If it does not, recharge the battery and test it again

In the capacity test, a specified load is placed on the battery while the terminal voltage is observed. A good battery should produce current equal to 50% of its cold-cranking rating (or three times its ampere-hour rating) for 15 seconds and still provide 9.6 volts to start the engine.

To do this test using a battery tester with a carbon pile:

- Charge the battery, if necessary, to at least a specific gravity reading of 1.225 in all cells.
- Determine the load test specification. This specification is either 50% of the cold-cranking amperage rating, three times the amp-hour rating specified on the battery label, or provided by the vehicle manufacturer.
- Connect the large load leads across the battery terminals, observing polarity
- Set the ammeter to zero value.
- Connect the amps inductive pickup around one of the testers leads.
- Set the test selector to the starting position.

- Turn the load control knob slowly to apply the amount of load determined in step 2
- Read the voltmeter while applying the load for 15 seconds. Do not exceed the 15-second limit. Turn the carbon pile off and record the reading.
- Check voltage readings from the chart given below.

Electrolyte Temperature F^0	70+	60	50	40	30	20	10	0
C^0	21+	16	10	4	-1	-7	-12	-18
Minimum Voltage (12 Volt Battery)	9.6	9.5	9.4	9.3	9.1	8.9	8.7	8.5

If voltage level is below the specifications listed in the above table, observed the battery voltage for the next 10 minutes. If the voltage raises to 12.45 volts then it is OK.

If the voltage does not return to 12.4 volts, recharge the battery until the open circuit test indicates a voltage of 12.66 volts. Repeat the capacity test. If the battery fails again, replace the battery.

If the capacity test readings of a clean and fully charged battery are equal to or above specification, the battery is good. If the battery tests are border line, perform the three-minute charge test.

Important Maintenance Points for batteries

- Always top up with distilled water to keep the level.
- Do not allow to remain in the discharged, condition
- Always keep them dry and clean and apply grease to all metal parts (only mineral grease, PX – 7 should be used)
- Always give proper charging and do not overcharge them.
- Handle with care. Mishandling will cause shedding, breakage and shorting
- Whenever suspected, it should be leakage tested.
- Before battery is used from the charging room it should be tested for insulation resistance
- Once every three months all batteries in used to be tested for their capacity.

Storage: Accumulators which have been in use and are not required for some time must be fully charged and stored in a cool dry place. They should be topped up and charged at frequent intervals to prevent Sulphation.

Maintenance free Battery:

In present days maintenance free battery is used as per the requirement of car. Inspect the cable clamps/

Battery should not move in its mounting.
Inspect the battery health Indicator.
Conduct the load test as per the life of the battery and if necessary replace the battery.

Trouble-shooting chart for batteries

Defects	Causes	Remedies
1. Overcharging	i. High charging voltage ii. High temperature	i. Check generator –regulator system ii. Reduce setting of voltage regulator; also reduce specific gravity of electrolyte.
2. Use of excessive water	i. Overcharging ii. Cracked container iii. Leakage at cover seal	i. Check as in (1) ii. Replace battery or reseal as required iii. Replace battery or reseal as required
Defects	**Causes**	**Remedies**
3. Run down battery	i. Defective generator or regulator ii. Faulty wiring circuit iii. Excessive load demand iv. High self-discharge v. Old or defective battery	i. Check both ii. Check iii. Reduce load iv. Battery may not be allowed to remain idle, recharge it periodically v. Recharge, re-test, replace if necessary
4. Cracked container	i. Battery loose in bracket ii. Hold-down clamps too tight iii. Battery frozen iv. Battery hit by flying stones	i. Replace battery or container; tighten in bracket properly ii. Replace battery or container; tighten hold down clamps properly iii. Replace battery; keep it charged to avoid freezing iv. Ensure shield is in place.
5. Bulged case	i. Hot battery ii. Hold-down clamps too tight	i. If it is from overcharge, reduce regulator voltage ii. Tighten the clamps properly
6. Corroded battery bracket	i. Overfilling ii. Overcharging	i. Avoid overfilling; clean bracket and paint it ii. Adjust regulator voltage

7. Sulphated plates	i. Undercharging ii. Battery left in discharged condition without attention; low electrolyte level; excessive gassing due to overcharging	i. Adjust charging rate; rectify defects of generator and charging circuit if any ii. Battery may be charged at low charging rate; renew plates if required
8. Wide variation of readings of different cells when checked with hydrometer	i. Cells with low reading may be short circuited partially; acid lost due to leakage from low-reading cells; excessive water evaporation from high reading cells	i. Replace plates or battery as required
9. Voltage readings differ on individual cells	i. Plates defective because of loss of active material due to shedding or sulphation; short-circuiting of cells; open circuit in cells	i. Defective cell may be opened and rectified; if battery in poor state, may be replaced
10. Battery cells short-circuited	i. Plates get buckled, separators charged due to overcharging; plates short-circuited due to displaced active material.	i. Rebuild or replace battery as required.

Check Your Progress

Fill in the blanks

1. Battery acid is very _____. If it comes in contact with skin, wash with clean water.
2. When connecting battery cables, always connect the _____ cable last.
3. Avoid any _____ or open flames near a battery, as the vapors produced can be explosive.
4. To clean a battery, you can use a solution of baking soda and water or _____.
5. Battery's state of charge can be determined by testing the specific gravity of the _____ using a hydrometer.
6. The open circuit voltage test is used to determine the battery's _____, and it is performed when a hydrometer is not available.

Multiple Choice Questions:

1. What is the purpose of battery inspection and cleaning in the automotive electrical system?
a) To increase battery capacity
b) To reduce battery voltage
c) To prevent dirt and corrosion buildup
d) To enhance engine performance

2. When making connections to a battery, which of the following should you observe?
a) Connect positive to negative
b) Connect negative to positive
c) Observe no specific polarity
d) Connect positive to positive and negative to negative

3. What is the purpose of adding baking soda to water when cleaning a battery?
a) To make the water conductive
b) To neutralize battery acid
c) To increase the battery's capacity
d) To remove rust from terminals

4. Why should you avoid laying tools across a battery?
a) It might discharge the battery
b) It could damage the tools
c) It might cause a short circuit
d) It could lead to battery freezing

5. Which type of cable should you disconnect first when working on a battery?
a) Positive (hot) cable
b) Negative (ground) cable
c) Both cables simultaneously
d) It doesn't matter which one you disconnect first

6. What should you wear to protect your eyes while servicing a battery?
a) Gloves
b) Earplugs
c) Safety glasses or a face shield
d) A hard hat

Answer the following questions
1.Explain the importance of battery and its maintenance in automobile

2. Write various precautions to be observed while handling the lead acid battery.
3. Write the procedure of inspection and cleaning of a battery.
4. Name various tests carried out on a lead acid battery and explain each one of those tests.
5. Write different faults occur in lead acid battery, their causes and remedies.

Activity

1. Make a list of the tools and equipment required for checking and cleaning of automotive battery

S.No.	Name of the tool/ equipment
1.	
2.	
3.	
4.	

2. Prepare a poster showing cutout of the battery and label all the components.

Session: 4 Checking of Electrical Connections of Lighting System in a Vehicle

The lighting system of the vehicle is becoming very complex. There may be over 50 light bulbs and hundreds of feet of wiring in the lighting circuits. The circuits include circuit protectors, switches, laps, and connectors. Any failure requires a systematic approach to diagnose, locate, and correct the fault in the minimum amount of time.

The lighting system should be checked whenever the vehicle is brought into the shop for repairs. Often a customer may not be aware of a light failure. If a lighting circuit is not operating properly there is a potential danger to the driver and other people. When today's Assistant performs repairs on the lighting systems, the repairs must assure vehicle safety and meet all applicable laws. Be sure to use the correct lamp type and size for the application.

Before performing any lighting system tests, check the battery for state of charge. Also, be sure all cable connections are clean and tight. Visually check the wires for damaged insulation, loose connections, and improper routing.

After studying this chapter students should be able to understand the following jobs.

1. **Select the proper replacement bulb and install it in the following**
   - Head lamp
   - Parking lamp
   - Turn signal lamp
   - Side marker lamp
   - Backup lamp
   - Instrument cluster
   - Interior lamp

2. **Use a test lamp or voltmeter and demonstrate the proper method of testing for:**
   - Voltage
   - Ground
   - A short to ground
   - Circuit continuity

3. Select the proper equipment to locate a problem in any of the exterior or interior lighting circuits. Check the connector for signs of corrosion. When testing the circuit with a voltmeter, ohmmeter, or test light, check those components that can be easily accessed first.

GENERAL PROCEDURE OF TESTING THE CIRCUITS

Circuit testing is a systematic approach to dealing with known facts in an effort to locate the cause of a problem. To do this efficiently, you must understand how the circuit works and know how to test for voltage, ground, shorts, and current continuity.

Unless you are completely familiar with the circuit and how it works, take the time to locate the correct electrical schematic and use it. (Fig. 5.19) You can't figure out why a circuit doesn't work unless you understand how it

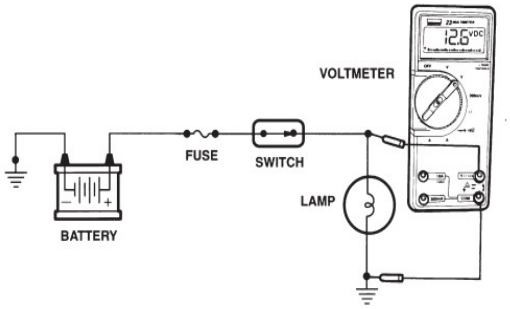


Fig. 5.19: TESTING THE CIRCUITS

should work. By tracing circuit operation on the electrical

Schematic, you can do some of the diagnosis mentally without help of test equipment. Problems can take place in four areas of a circuit:

1. At the load.
2. At some point between the load and the power source.
3. At some point between the load and the ground.
4. At the power source

Testing for Voltage

A 12-volt test lamp or voltmeter is used to check for voltage. The test lamp is a yes-no device that simply indicates the presence of voltage. (Fig 5.20)

Remember that a test lamp should not be used in a circuit containing solid-state components, because it may damage the circuit or components.

A voltmeter is a better choice in many cases because it will tell you how much voltage is present. Also remember that circuits using solid-state components should be checked only with a 10-megohm or higher impedance digital voltmeter or multimeter to prevent circuit or component damage.

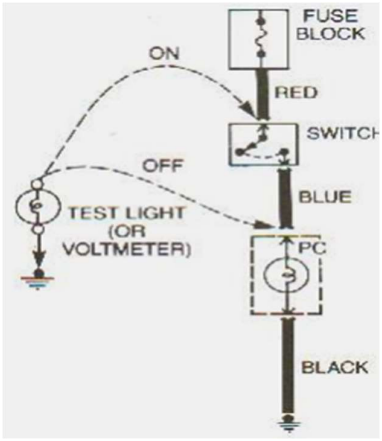


Fig.5.20: Testing for Voltage

To use either tool, ground the negative (-) lead and momentarily touch the positive (+) lead to various points in the circuit where voltage should be present. If there is voltage, the test lamp will light or the voltmeter needle will indicate the amount of voltage present. The voltmeter reading should be with one volt of battery voltage. If it is not, a problem is indicated. Perform basic voltage-drop test on circuit components.

Testing for Ground

Checking for ground is similar to checking for voltage, except that you should clean and tighten the ground connection before connecting the test instrument between the circuit ground and component. Again, basic voltage drop tests will help you isolate a problem.

Testing for Shorts

To check for a short to ground, remove the fuse and disconnect the load. Connect a 12-volt test lamp or voltmeter across the fuse terminals with the circuit. Start at the fuse block and wiggle the circuit wiring from side to side. Move down the wiring away from the fuse block to a convenient point and wiggle

the wiring again. Repeat this again. When the test lamp lights or the voltmeter registers, there is a short to ground in the wiring close to the last point where you wiggled the wiring.

A self-powered test lamp or an ohmmeter also can be used for this procedure providing that power is disconnected from the circuit (Fig. 5.21 and Fig. 5.22).

If the short to ground is between the power source and the load, it will be blowing the fuse. In an unfused circuit, the conductor will overheat and probably burn in half.

A short to ground between the load and the switch will cause the load to remain ON constantly (Fig 5.23 and Fig 5.24).

A short between the last component in the circuit and ground will have no effect on circuit operation, because it is providing an alternative ground.

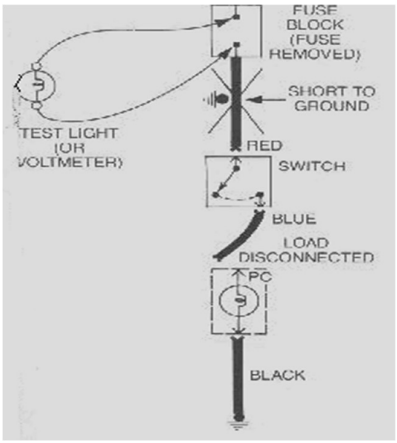


Fig. 5.21 Checking for short

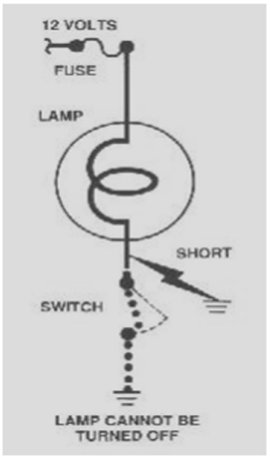


Fig. 5.22 A short between the load and switch will keep the load on indefinitely

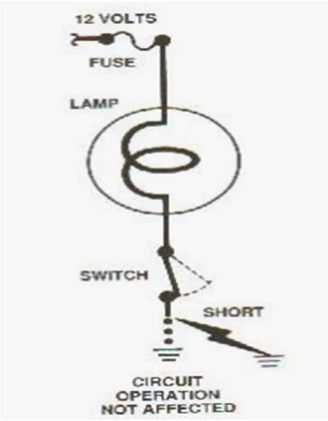


Fig. 5.23 A short between the switch and power Ground provides an alternative ground And will not affect circuit operation

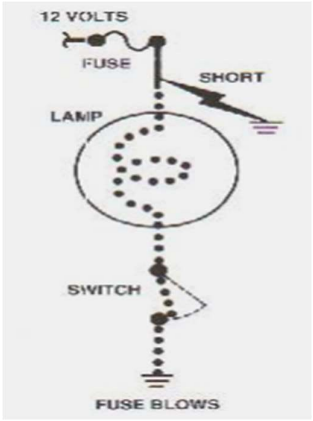


Fig. 5.24 A short between load and source will blow the fuse

Testing for Continuity

You can check a circuit for continuity by disconnecting power from the circuit and connecting a self-powered test lamp or ohmmeter between parts of the circuit you want to test. If the test lamp lights or the ohmmeter shows little or no resistance, there is continuity in the circuit or component being checked.

Note: For all kind of lighting circuits please refer to the shop manual for respective make and model and follow the testing procedures as the circuit diagram with appropriate color code, units & relays and switches. For example, one circuit diagram is placed for reference (Fig. 5.25),

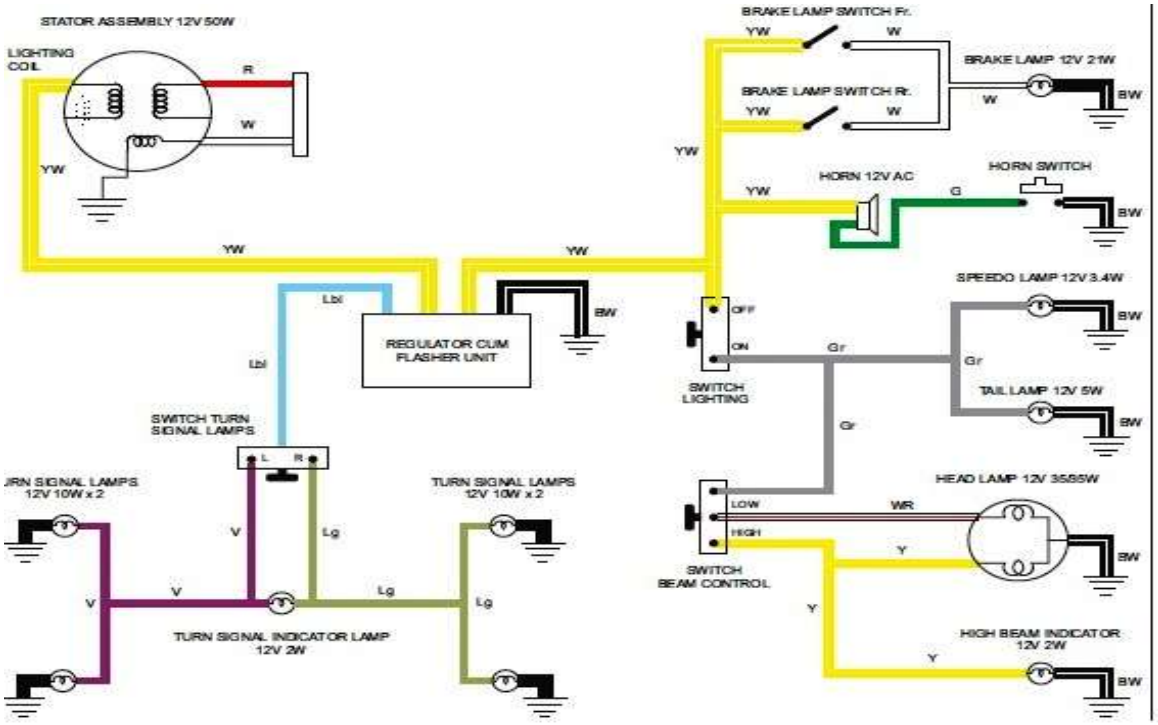


Fig. 5.25 **Testing for Continuity**

Lighting System Trouble-shooting Chart

Following table gives the general defects which are likely to occur in the lighting system of an automobile, and their causes and remedies.

Defects	Causes	Remedies
A. Lighting System		
1. Lamps do not give sufficient illumination	i. Battery discharged / defective ii. Bulbs out-of-focus iii. Reflector dirty/ bulbs discolored due to long use iv. Improperly earthed reflector, lamp body or mounting	i. Charge or replace battery as required. ii. Focus the bulbs. iii. Clean reflectors; replace bulbs. iv. Check earthing connections and rectify.

2. Lamps do light when switched on but they gradually dim out	i. Discharged/defective battery	i. Recharge or replace battery as required.
3. Brightness varies with vehicle speed	i. Discharged battery ii. Excessive resistance in circuit	i. Recharge it. ii. Tighten connections; replace defective cables.
4. Lights flicker	i. Loose connections	i. Locate faulty connections and tighten them.
5. Lights fail	i. Blown fuse	i. Check the circuit and replace fuse.

Check Your Progress

Fill in the blanks

1. Circuit testing is a _____ approach to locating the cause of a problem in a vehicle's lighting system.
2. To effectively diagnose a circuit problem, it's important to understand how the circuit should _____.
3. Checking for _____ involves cleaning and tightening the ground connection before testing.
4. A short to ground can be located by using a self-powered test lamp or _____, with power disconnected from the circuit.
5. When using a voltmeter to check for voltage, the reading should be within _____ of battery voltage.
6. In an unfused circuit, if there is a short to ground, the conductor may _____ and possibly burn.

Multiple Choice Questions:

1. What is the purpose of checking the lighting system in a vehicle?
a) To save fuel
b) To reduce emissions
c) To ensure vehicle safety and compliance with laws
d) To increase engine performance

2. Which of the following is NOT a component of a lighting circuit in a vehicle?
a) Circuit protector
b) Engine block
c) Switch
d) Connector

3. What is the potential danger if a lighting circuit in a vehicle is not operating properly?
a) Increased fuel efficiency
b) Enhanced driving experience
c) Risk to driver and other people
d) Improved audio system performance

4. Which tool is used to check for voltage in a lighting circuit?
a) Hammer
b) Screwdriver
c) Test lamp or voltmeter
d) Pliers

5. Why should a test lamp not be used in circuits containing solid-state components?
a) It can improve circuit performance
b) It may damage the circuit or components
c) It can increase circuit resistance
d) It may cause overheating of wires

6. How can you locate a short to ground in a wiring circuit?
a) By disconnecting the load and fuse, then wiggling the wiring
b) By increasing the circuit voltage
c) By using a test lamp only
d) By disconnecting the battery

Answer the following questions

1. Discuss the importance of checking of electrical connections of lighting system in a vehicle.
2. Write the general procedure of testing the automobile lighting circuit for following parameters
   a. Voltage
   b. Ground
   c. Shorting
   d. Continuity
3. Draw a circuit diagram of Lighting system of any Indian car.
4. Write different fault of lighting system of a car, their causes and remedies.

Activity

1. Make a list of the problems which can take place in four areas of a lighting circuit:

S.No.	Name of the area
1	
2	
3	
3.	

2. Prepare a poster showing head light circuit diagram and label all the components.

Session: 5 Applications and Replacement of Fuses

Fuses are used for protecting the electrical equipment and circuits against the effects of excessive currents. Two different ways can be deployed for protecting electrical circuits and accessories. Firstly, a greater number of fuses can be used for protecting the circuits. Secondly, only a few fuses can be employed in such a manner that each fuse has to protect a group of electrical items. One fuse may be used to protect the circuits controlled by the ignition switch and it has a value of about 35 A. The second fuse of 35-50 A is used to protect all circuits which are operative whether the ignition switch is in the ON or OFF position.
In the case of a greater number of fuses, the following table gives the value and the equipment for which they are used. This practice is more prevalent in American cars.

• Heater and air conditioner	25 A
• Interior lamps	7.5 A
• Cigar lighter	15 A
• Radio	7.5 A
• Radio antenna	14.0 A
• Reversing lights	7.5 A
• Direction indicator lights	7.5 A
• Over drive	15 A
• Battery-generator circuit	40 A
• Windscreen wiper, clock, Interior lights, etc.	25 A

The fuses are generally installed in a central **Fuse Box**. Fuse box is the term used to identify the central location of the fuses contained within a single holding fixture. The most common location of the fuse box is under the instrument panel. However, it can be located in the glove box, and electrical junction box on the fender well. Fuse identification and specifications are usually labeled on the fuse box or on the fuse box cover. Of course, this information can also be found in the vehicle's owner's manual and the service manual.

Types of Fuse

There are three basic types of fuses:

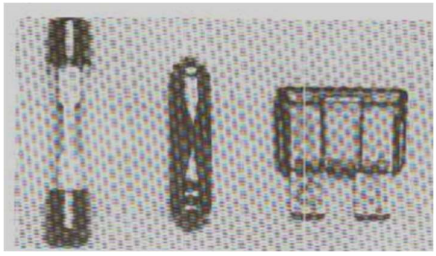
- Glass or ceramic fuses
- Blade-type fuses
- Bullet or cartridge fuses

Glass and ceramic fuses are found mostly on older vehicles. Sometimes, however, you can find them in a special holder connected in series with a circuit.

Glass fuses are small glass cylinders with metal caps. The metal strip connects the two caps. The rating of the fuse is normally marked on one of the caps.

Blade-type fuses are flat plastic units and are available in three different physical sizes: mini, standard, and maxi. (Fig. 5.26 and Fig. 5.27) The plastic housing is formed around two male blade-type connectors. The metal strip connects these connectors inside the plastic housing. The plastic is colour coded.

Cartridge-type fuses are used in many older European vehicles. These fuses are made of plastic or a ceramic material. They have pointed ends and the metal strip rounds from end to end. This type of fuse is much like a glass fuse except the metal strip is not enclosed.



A B C

Fig. 5.26 three types of commonly used fuses
(A) Glass cartridge, (B) Ceramic, and (C) Blade (or mini-fuse)

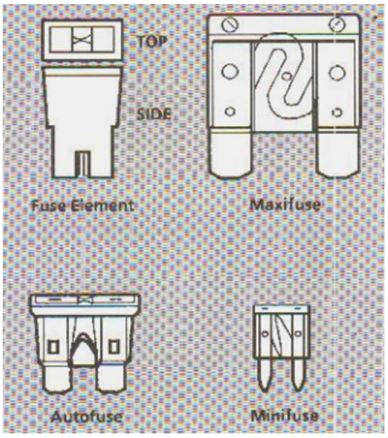


Fig. 5.27: Common blade type fuses

AUTOFUSE

CURRENT RATING IN AMPS.	COLOUR
3	VIOLET
5	TAN
7.5	BROWN
10	RED
15	BLUE
20	YELLOW

25	NATURAL
30	GREEN

MAXIFUSE

CURRENT RATING IN AMPS.	COLOUR
20	YELLOW
30	GREEN
40	AMBER
50	RED
60	BLUE
70	BROWN
80	NATURAL

MINIFUSE

CURRENT RATING IN AMPS.	COLOUR
5	TAN
7.5	BROWN
10	RED
15	BLUE
20	YELLOW
25	WHITE
30	GREEN

Replacement of Fuses

When it is diagnosed that in particular circuit the fuse either have been blown off or damaged. It is to be replaced with correct size and type of fuse. While replacing a fuse following points to be kept in mind.

- First recognize the fuse which is to be replaced for its **value and type**.
- Identify the system for which the fuse is to replace and the colour of the fuse to be replaced.
- Remove old fuse and ensure that the old fuse is blown off or unserviceable.
- Fit the new fuse in proper position.
- Switch on the system and check the serviceability of the system.

Check Your Progress

Fill in the blanks

1. The primary purpose of fuses is to protect electrical circuits from the detrimental effects of _____.
2. Blade-type fuses are characterized by flat plastic units with _____ male blade-type connectors.

3. Cartridge-type fuses, commonly used in older European vehicles, have pointed ends and a metal strip that extends from _____ to _____.
4. Fuse identification and specifications can usually be found on the _____ or the cover of the fuse box.
5. When replacing a fuse, it's important to ensure that the new fuse has the correct _____ and _____.

Multiple Choice Questions:

1. Fuses are used for protecting electrical circuits and equipment against the effects of:
   A) Voltage spikes
   B) Excessive currents
   C) Magnetic fields
   D) Static electricity

2. In the case of a greater number of fuses, each fuse might protect:
   A) A single electrical item
   B) A specific type of circuit
   C) A group of electrical items
   D) All lighting circuits

3. Which fuse is commonly used to protect circuits controlled by the ignition switch?

   A) 15 A
   B) 25 A
   C) 35 A
   D) 50 A

4. The three basic types of fuses include glass or ceramic fuses, blade-type fuses, and:
   A) Bullet or cartridge fuses
   B) Wire fuses
   C) Fiber fuses
   D) Magnetic fuses

Answer the following questions

1. Discuss the importance of applications and replacement of fuses in a vehicle.
2. Name different types of fuses and explain.
3. Write the values of fuses used in different electrical system of automobile.
4. Explain colour coding of different fuses.

Activity

1. Make a list of equipment used in automobile which uses fuses for their protection and also write the value of fuse.

S.No.	Name of the equipment	Value of fuse in ampere
1		
2		
3		
4		

2. Prepare a poster showing three types of fuses used in automobile electrical system and write their names also.

Session: 6 Circuit Diagram of Charging System of Automobile and Checking of Charging System

With the increase in installation of electrical equipment in present day vehicles, the demand on direct current generator has increased. This can only be met by increasing the size and weight of the generator and also by running it at higher speeds. But, it should be noted that the speed of the direct current generator cannot be increased (Fig. 5.28) beyond a certain limit because of brush and commutation limitations. Hence, it has become necessary to employ alternators in almost all modern vehicles in place of dynamo.

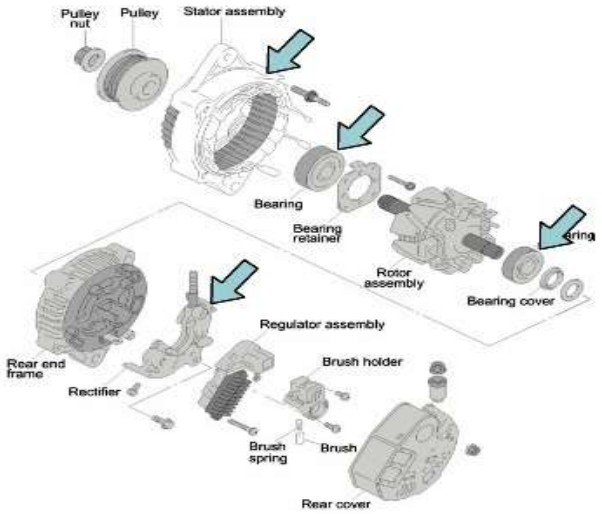


Fig. 5.28 Components of Direct Current Generator

A properly operating charging circuit is necessary for the correct operation of an automobile's entire electrical system. After the battery has been tested and known to be capable of supplying its rated capacity, and (Fig. 5.29) has been tested to be at least 75% charged, the charging system can be tested in a sequence designed to pinpoint exact problems or faults in the charging system.

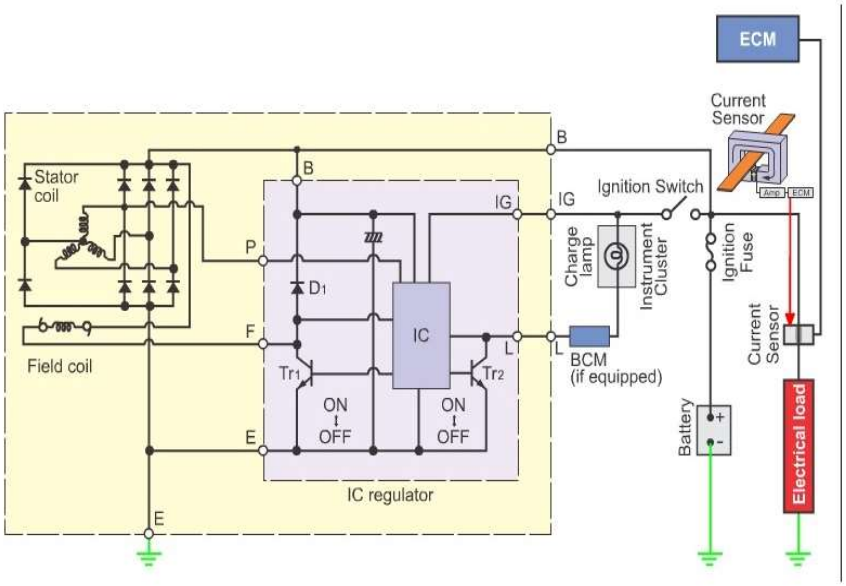


Fig. 5.29 Charging Circuit

Testing of Charging System

Precautions:

- Ensure all connections are secure and clean.
- Ensure that no connection in the charging unit, including the battery, is broken while the engine is running.
- Observe correct polarity when refitting the vehicle battery or when using a slave battery to start the engine.
- Do not flash the alternator output leads to check the working of the alternator.

Routine Maintenance:

- Keep alternator clean. Check for tightness of connecting bolts.
- Ensure that the Driving Belt is in good condition i.e. neither too slack not too tight. If found slack, adjust the belt deflection to be 10 – 15mm when pressed at mid-way between pulleys.
- Check the battery cells for correctness of specific gravity of electrolyte. Check for tightness of terminals.
- Check Brushes once every 20,000 Kms. Adhere to Specifications as given in the Technical Data.
- Check Bearings once every 50,000Kms. Renew if worn.
- Slip Ring surfaces should be clean and smooth. If unclean, use very fine emery paper and smoothen the surfaces.

Alternator Checking on the Vehicle

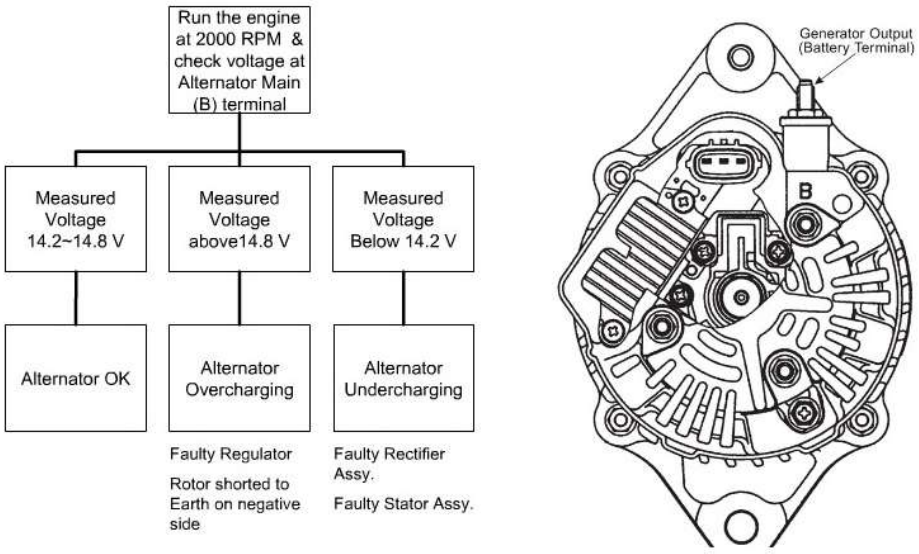


Fig. 5.30 Wiring Diagram for Testing Alternator and Regulator on the Vehicle

a) Turn the Ignition Switch 'ON'.

Warning Lamp must glow. If it does not Glow:

- Check ignition switch, Warning Lamp, Warning Lamp cable and holder for open circuit – replace if faulty (Fig. 5.30).
- If not, remove alternator for inspection.

b) Start the engine.

Warning Lamp must go off. If it continues to glow: -

- Check belt tension. If found slack tighten properly. If not remove alternator for inspection.

Testing Alternator

After routine checkup if the alternator or the regulator still do not charge, the following procedure may be adapted in order to locate the defect in the regulator or alternator

- Disconnect the battery earth cable.
- Insert the ammeter in series and the voltmeter across the alternator terminal and earth as shown in the above figure.
- Connect a jumper wire across the field and output terminals in the alternator. The ammeter should indicate a reading of 2 A approximately representing the field current drawn if the battery is connected and the ignition switch put on. Disconnect F lead from the regulator and insulate the wire end to avoid accidental earthing.
- Reconnect the battery earth wire and start the engine. Run the engine at half throttle and switch on the lights etc. to obtain a voltage reading of 14.2 V. The alternator should now charge at or near its maximum rate. If the ammeter does not record the highest rated current, the alternator should be removed from the vehicle for overhaul. If the alternator is okay and still the charging is not proper, the regulator needs checking.

Checking of Regulator System

- After disconnecting the battery insert an ammeter in series by disconnecting it between Alternators A terminal and the disconnected wire from the terminal. Connect a voltmeter across Alternator A terminal and ground. The other wiring connecting leads are as per normal; wiring harness.
- Reconnect the battery, and start and run the engine, at first in idle speed to obtain a reading of 10 A in the ammeter, if necessary by switching on the light and other accessories. Run the engine for 10/15 min in this condition, (Fig. 5.31) then cycle the system by starting and stopping the engine.
- The voltage at an engine speed corresponding to 50 km per hour speed of vehicle reading should lie between 13.5 and 14.4 V.

Checking of Stator

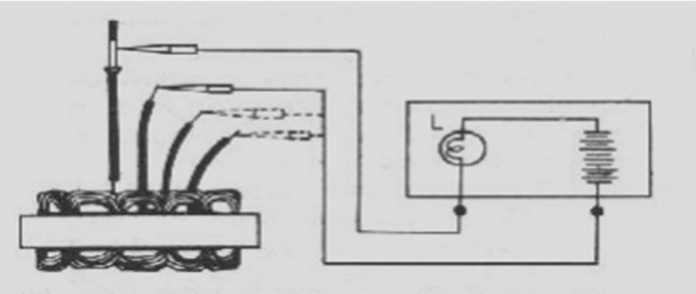


Fig. 5.31 A Winding Insulation Test with the Help of Battery and Lamp.

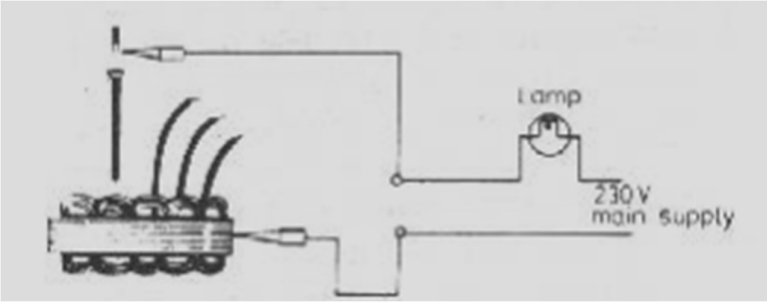


Fig. 5.32 (b) Winding Insulation Test on Mains

Figure 5.32 A shows the circuit diagram for carrying the insulation test of windings with the help of a lamp and a battery. Figure 5.32 B shows the circuit diagram for similar test on main supply. In case of any shorted phase, bulb will light brighter compared to other phases.

A shorted phase or rectifier will be shown by discoloration of varnish. A resistance test with an ohmmeter between the neutral and each of the phase leads should give similar readings.

Rotor Testing

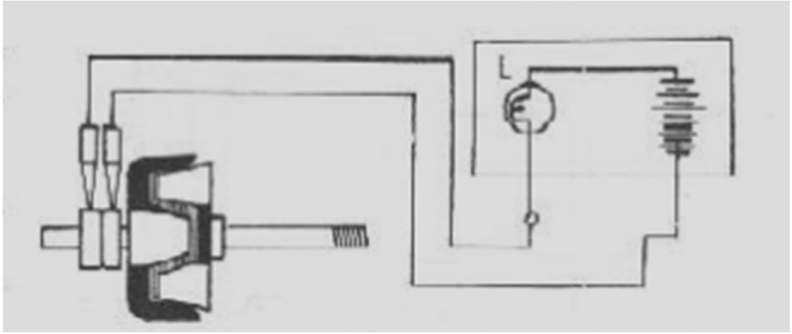


Fig. 5.33 Circuit Diagram of Rotor Insulation Test With the help of Battery and Lamp ©

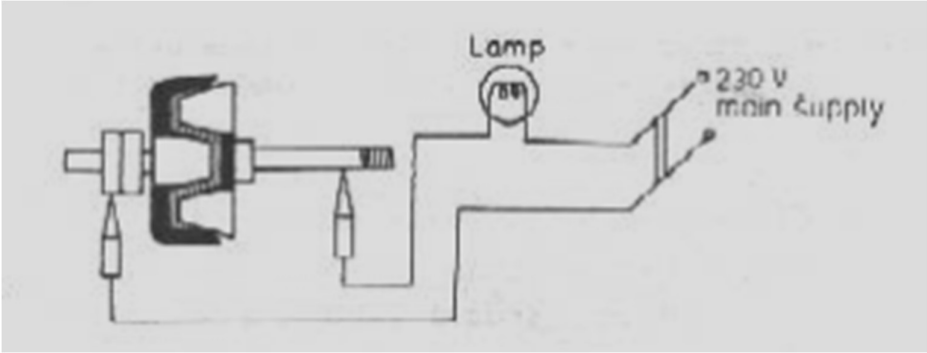
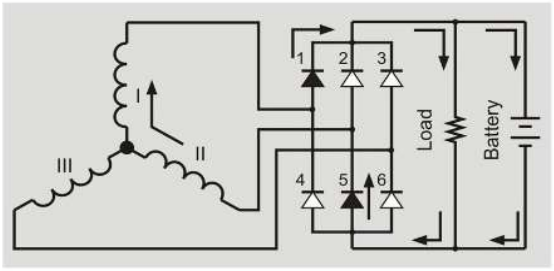
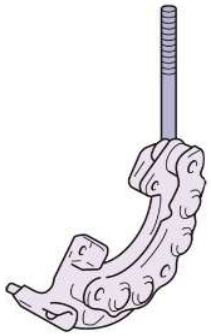


Fig. 5.34 Circuit Diagram of Rotor Insulation test on Main Supply (D)

The Fig. 5.33 C shows the circuit diagram for carrying out insulation test of rotors with the help of a lamp and battery. Above figure (Fig. 5.33 and Fig. 5.34) D shows the circuit diagram for a similar test on main supply. The windings are checked for continuity with the help of a lamp. The check is carried from slip ring to slip ring. This test can also be performed with the help of an ohmmeter.

Rectifier





- The rectifier used in alternator rectifies the 3-phase alternating current into direct current by using a 3-phase bridge having 6 diodes.

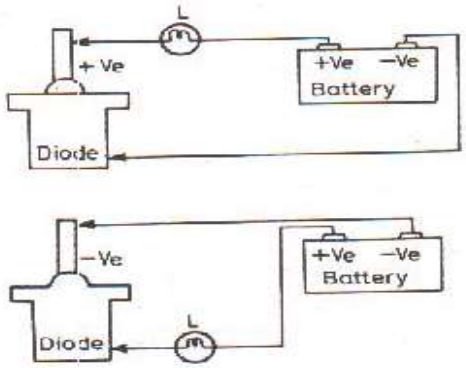


Fig. 5.35 Circuit Diagram of testing diode with the help of Lamp and Battery (E)

The diodes are checked with the help of a diode tester. They can also be tested individually with the help of a 12 V battery and a warning lamp made up of test prods of 12 V and 2.2 W respectively. Figure 5.35 E shows the circuit diagram for performing this test. Make connections as shown in the same figure. Touch one prod to the bracket or casing and the second to the rectifier lead. Check light and reverse prod position. For a good rectifier, the bulb should light for one position only. No light for both positions indicates an open circuit. Light ON for both positions indicates short circuit. The needs replacement of diode. All rectifiers should be checked in turn and a faulty rectifier may be changed with the new one.

With the increase in engine speed, alternator output also increases. At high engine speeds, the high alternator output could cause damage to electrical system components.

Function of regulator is to control the output voltage of the alternator. The regulator controls the output by turning the field current ON and OFF very rapidly.

This controls the strength of the magnetic field. The strength of the magnetic field determines the alternator output.

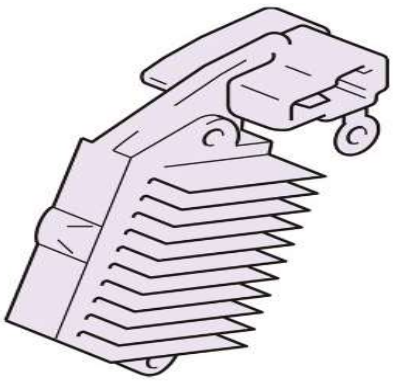


Fig. 5.36 : Diode Tester

Defects of Charging System, Causes and their Remedies:

DEFECTS	CAUSES	REMEDIES
1. Ignition warning lamp fails to illuminate	• Defective bulb • Fuse blown.	• Fit new bulb. • Fit new fuse.

when ignition is switched 'on'	• Alternator or battery connections loose or oxidized poor earth connection. Open circuit in regulator, rotor or brush circuits. • Ignition switches defective.	• Clean and tighten battery or alternator cables, applying acid resistant grease. Check earth connections, clean and tighten as necessary. • Eliminate open circuit. Fit new ignition.
2. Ignition warning lamp remains 'ON' when engine is running.	• Drive belt slack. Fuse blown. • Alternator connections loose or oxidized, poor earth connection. • Brushes do not contact slip rings, are jammed in their guides, are worn, broken, oily or dirty. Worn bearings, slip rings, defective regulator or rectifier assembly.	• Adjust drive belt. Refer to Service Manual. • Fit new fuse • Clean & tighten connections as necessary. • Fit new alternator.
3. Battery is serviceable but is being undercharged	• Drive belt slack. • Defective soldered connections in alternator. • Poor earth Connection between regulator and alternator body.	• Adjust drive belt. Refer to service manual • Fit new regulator or replace as necessary. Clean and tighten connection.
4. Battery is serviceable but is being overcharged.	• Faulty regulator	• Fit new regulator.
5. Noisy operation.	• Belt worn. • Loose pulley. • Worn bearings.	• Fit new belt. • Re-tighten pulley to specified torque. If shaft has been damaged replace alternator. • Fit new bearings.

Check Your Progress

Fill in the blanks

Routine maintenance of the alternator involves checking the _____ and ensuring the tightness of connecting bolts.

During the alternator testing on the vehicle, if the ignition warning lamp remains illuminated while the engine is running, it could be due to a _____.

Diodes can be tested individually using a 12-V battery and a warning lamp with test prods of _____ V and _____ W respectively.

If the ignition warning lamp fails to illuminate when the ignition is switched on, a possible cause could be a _____ or _____ connection.

Multiple Choice Questions (MCQs):

1. What is the purpose of using alternators in modern vehicles instead of dynamos?
a) To increase generator speed
b) To decrease generator size
c) To overcome brush and commutation limitations
d) To reduce electrical load

2. What precaution should be taken before checking the charging system?
a) Disconnect the battery
b) Flash the alternator output leads
c) Use a slave battery to start the engine
d) Ensure all connections are secure and clean

3. What should be the belt deflection when checking the driving belt's condition?
a) 5 - 10mm
b) 10 - 15mm
c) 15 - 20mm
d) 20 - 25mm

4. In the alternator checking procedure, if the warning lamp does not go off when the engine starts, what could be the issue?
a) Loose belt
b) Faulty ignition switch
c) Defective alternator
d) Disconnected battery

5. What is the purpose of inserting an ammeter and a voltmeter during alternator testing?
a) To measure engine speed
b) To measure battery voltage
c) To measure field current and alternator voltage
d) To measure fuel consumption

If the voltage during engine speed of 50 km/h falls below 13.5V or above 14.4V, what might be the issue?
a) Faulty regulator
b) Loose battery terminal
c) Worn bearings
d) Shorted phase in the stator

Answer the following questions

1. Name the importance of circuit diagram of charging system of automobile and checking of charging system in a vehicle.
2. Draw the charging circuit of a modern car.
3. Explain the procedure of testing the charging circuit step by step.
4. Explain the procedure of testing the following:
    a. Alternator Stator
    b. Alternator Rotor
    c. Rectifier
5. Write different faults may occur in the charging circuit, their causes and remedies.

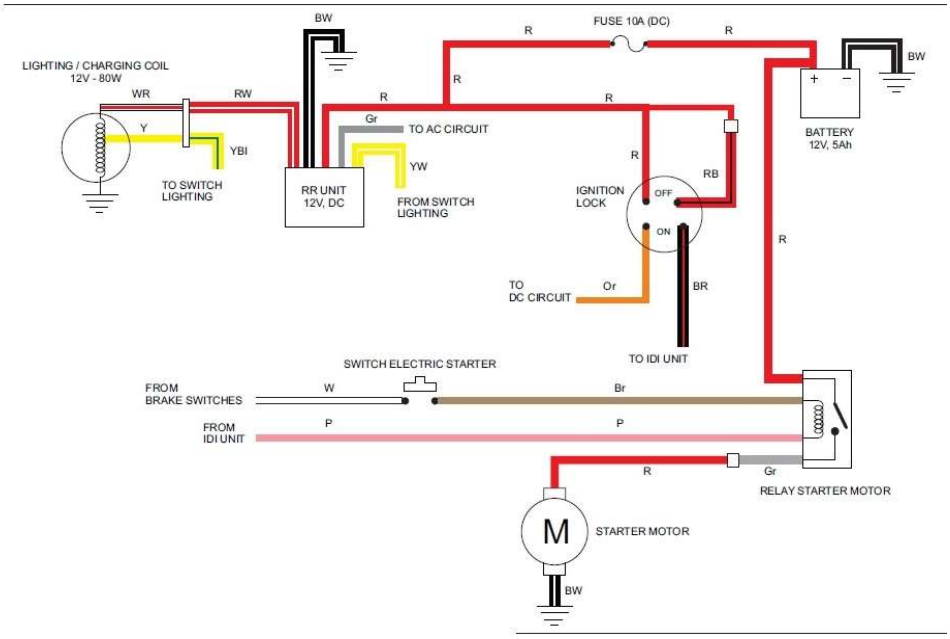
Activity

1. Prepare a poster showing charging system of any vehicle.

2. Prepare a poster showing testing of alternator and regulator of vehicle.

Session 7: Circuit Diagram of Starting System of Automobile and Checking of Starter Circuit

Electric starter system consists of battery, ignition lock, starter motor, relay starter motor, switch electric starter (starter switch) and IDI shown in (Fig. 5.37)



Circuit Diagram of Starter Motor

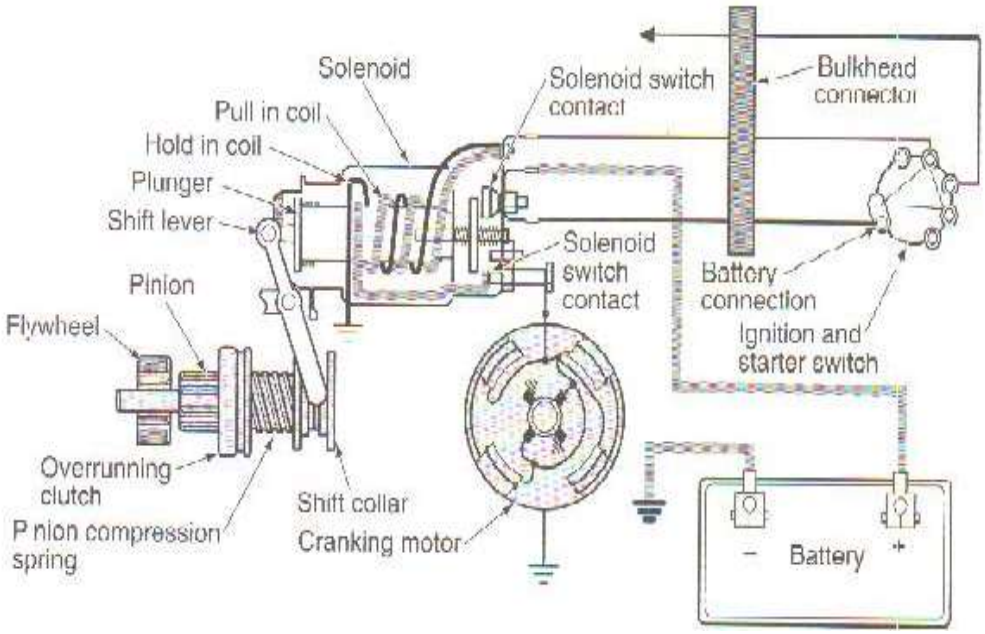


Fig. 5.37 Excessive voltage drop can cause a slow crank or no-crank condition

Here are the steps to disassembling each part of circuit diagram

1. Disconnect negative terminal from battery.
2. Disconnect starter motor connection
3. Loosen and dismantle the starter motor assembly from the engine.
4. Disconnect electromagnetic switch wiring.
5. Remove magnetic switch assembly from the bracket
6. Disengage the ring from the pinion stopper ring gauge with appropriate method.
7. Remove circlip, pinion stopper, pinion and pinion spring form pinion shaft
8. Remove the yoke assembly from the front bracket by losing its attaching bolt.
9. Remove the rear bracket from yoke assembly by losing it mounting bolt.
10. Remove the armature from the yoke assembly
11. The armature is merely inserted into the yoke assembly brush holder so be sure not to drop the brushes.
12. Open up the brush towards the outside of brush holder and remove the brush.
13. Remove the packing
14. Dislocate the lock plate
15. Remove lock plate spring
16. Remove the gear shaft assembly over running clutch lever at a time.

Inspection

1. Place the armature on the growler tester hold piece of iron parallel to the armature and slowly turn the alternator by hand.
2. If iron piece is attracting or vibrates, it means there is short circuit, replace armature.
3. Check the continuity across the commutator and shaft.
4. If there is a continuity, indicating that the coil is grounded replace the armature.
5. Rotate connecter by hand and inspect for deflection if it is higher than limit correct the same.
6. If the commutator is rough, or has step wear rub it with polish paper by #300 or #500
7. If commutator is warm out replace armature.
8. Measure the depth of mica between two segments if below 0.5mm, replace armature.
9. Check continuity test between the terminal lead and the brush, it shows continuity the coil is open then replace yoke assembly.
10. If the continuity is noticed between yoke and the brush this indicates, the coil is shorted to grounded.
11. Repair the faulty insulator or replace the yoke assembly.

12. Inspect the brush for wear if it warm, unevenly replace the brush replace brush spring.
13. Inspect the brush holder assembly far no continuity between +ve and –ve.
14. If continuity is noticed replace the brush assembly.
15. Inspect the over running clutch for smarter rotation of pinion and shaft also inspect Bendix drive and warm gear with spring.
16. Inspect armature bearings or replace if worm out.
17. Verify the continuity test between ground terminal and S & M terminal if continuity is not shown replace the switch.
18. Inspect the axial play of pinion shaft and adjust by addition or reduction of shinning assembly.
19 Assemble the starter motor in reverse order of disassembly and test its washing.

Starting Motor Trouble-shooting

DEFECTS	CAUSES	REMEDIES
1. No cranking of engine, no lights	• Dead battery • Open circuit	• Recharge or replace battery. • Clean and tighten connections, replace wiring if necessary.
2. No cranking of engine, lights go out.	• Poor connections, most probably at battery	• Clean terminals and cable clamps, also tighten clamps.
3. No cranking of engine, lights dim slightly.	• Bendix pinion not engaging. • Excessive resistance or open circuit in cranking motor	• Clean pinion and sleeve, replace damaged parts if any. • Clean commutator, replace brushes and repair poor connections.
4. No cranking of engine, lights dim heavily	• Trouble in engine • Low battery • Bendix pinion jammed • Direct short in cranking motor, shaft bearing seized	• Check engine to find trouble • Check, recharge, or replace battery as required • Free Bendix pinion • Repair cranking motor
5. No cranking of engine, lights remain bright.	• Open circuit in switch • Open circuit in cranking motor • Open in control circuit	• Check switch connections and contacts • Check connections, brushes and the commutator.

		• Check connections, relay and solenoid and switch (vacuum)
6. The engine cranks slowly but does not start.	• Run down battery. • Defective cranking motor. • Undersized battery cables. • Mechanical trouble in engine.	• Check, recharge or replace battery. • Check and repair cranking motor. • Renew cables of adequate size. • Check engine.
7. Engine cranks at normal speed but does not start.	• Defective ignition system • Defective fuel system • Air leakage in intake manifold system or carburetor • Defective engine	• Perform spark test, check timing and ignition system • Check fuel pump, fuel line and carburetor. • Tighten mountings, replace gasket if needed. • Check compression, valve timing etc.
8. Solenoid plunger chatters	• Solenoids hold in winding open. • High setting of solenoid relay with low battery.	• Replace solenoid. • Recharge battery, reset relay.
9. Armature fails to rotate or rotates slowly	• Discharged or defective battery. • Loose or oxidized battery terminals, corroded or loose connectors, defective earth connections. • Motor terminals or brushes earthed / short-circuited. • Burnt commutator worn-out brushes • Defective solenoid switch • Armature/field coils defective • Excessive drop in voltage	• Recharge battery, replace if defective • Clean terminates and other connections, apply petroleum jelly, tighten all connections. • Locate fault and rectify it • Clean commutator or turn down as required, replace brushes • Replace switch or clean contacts • Replace armature/field coils as require. • Check and rectify starter circuit.
10. Armature rotates but	• Pinion sticks • Burr on pinion or ring gear.	• Clean splines • Duburr by filing • Replace defective bush

pinion fails to engage.	• Wornout one or both ends bushes • Defective auxiliary coil • Mounting loose	• Replace auxiliary coil • Tighten mounting
11. Cranking motor continues running after release of starting switch.	• Starting switch sticks • Solenoid switch contacts stick • Short in wiring harness • Pinion bush seized on shaft • Pinion flywheel gear fouled or damaged.	• Repair or replace switch. • Check and rectify. • Repair fault after locating it. • Replace bush • Clean thoroughly, deburr gear and pinion.
12. Pinion engages but engine does not crank	• Corroded terminals, low battery • Clutch slip • Defective brushes springs or wornout brushes • Shorted armature • Partially shorted field coil • Solenoid second contacts not contacting	• Clean terminal, recharge battery. • Replace clutch. • Replace springs or brushes as required • Replace armature. • Replace field coil. • Re-set solenoid and replace spring
13. Pinion disengages slowly after engine has started.	• Solenoid plunger sticky • Over-running clutch sticks on shaft • Defective over-running clutch • Weak shift lever return spring • Defective vacuum switch	• Clean and free plunger. • Clean shaft and sleeve of clutch • Replace clutch • Replace spring • Replace switch

Session- 7: Circuit Diagram of Starting System of Automobile and Checking of Starter Circuit

Check Your Progress

Fill in the blanks

1. The starter motor converts electrical energy into _____ motion to crank the engine.
2. To check the continuity between the terminal lead and the brush, a continuity test is performed using a _____.

3. If the commutator is rough or worn, it can be smoothed using _____ paper.
4. In the event of no cranking and dim lights, a possible cause could be an _____ circuit in the switch.
5. A weak shift lever return _____ can lead to the pinion disengaging slowly after the engine has started.

Multiple Choice Questions (MCQs):

1. The electric starter system of an automobile includes which of the following components?
a) Alternator, carburetor, spark plugs
b) Battery, ignition lock, starter motor
c) Radiator, transmission, throttle body
d) Exhaust pipe, fuel pump, brake pads

2. What is the purpose of the Bendix pinion in the starter system?
a) To generate electricity
b) To engage the gears in the transmission
c) To rotate the crankshaft
d) To engage the starter motor with the engine's flywheel

3. The armature in the starter motor is primarily responsible for:
a) Controlling the ignition timing
b) Holding the brushes in place
c) Converting electrical energy into mechanical motion
d) Regulating fuel flow to the engine

4. Excessive resistance in the cranking motor circuit can result in:
a) Bright lights
b) Faster engine cranking
c) Slow engine cranking
d) Overheating of the starter motor

5. In a starter system, the solenoid plunger chattering is often caused by:
a) Low battery voltage
b) A defective ignition system
c) A short circuit in the control circuit
d) Overheating of the starter motor

6. What is the purpose of the over-running clutch in the starter system?
a) To engage the Bendix pinion

b) To regulate fuel flow to the engine
c) To prevent the starter motor from overheating
d) To allow the engine to start even after the starter motor disengages

Answer the following questions

1. Share importance of circuit diagram of starting system of automobile and checking of starter circuit in a vehicle.
2. Draw the circuit diagram of starting system of an Indian car.
3. Explain the procedure of checking the starting circuit.
4. Write different faults may occur in the starting circuit, their causes and remedies

Activity

1. Make a list of faults in starting system of a vehicle, their causes and remedies

S.No.	Fault	Causes	Remedies
1			
2			
3			
4			
5			

1. Prepare a poster showing main component of starting system of a vehicle.

Session 8: Circuit Diagram of Ignition System and Checking of Ignition Circuit

- A spark is needed to burn air-fuel mixture in a petrol engine. Spark plug needs a very high voltage electricity to create that spark. This high voltage needed by spark plug is not supplied by battery directly.
- Function of ignition system is to generate the high voltage electricity needed to create spark and distribute the same to each of the spark plug at appropriate time.

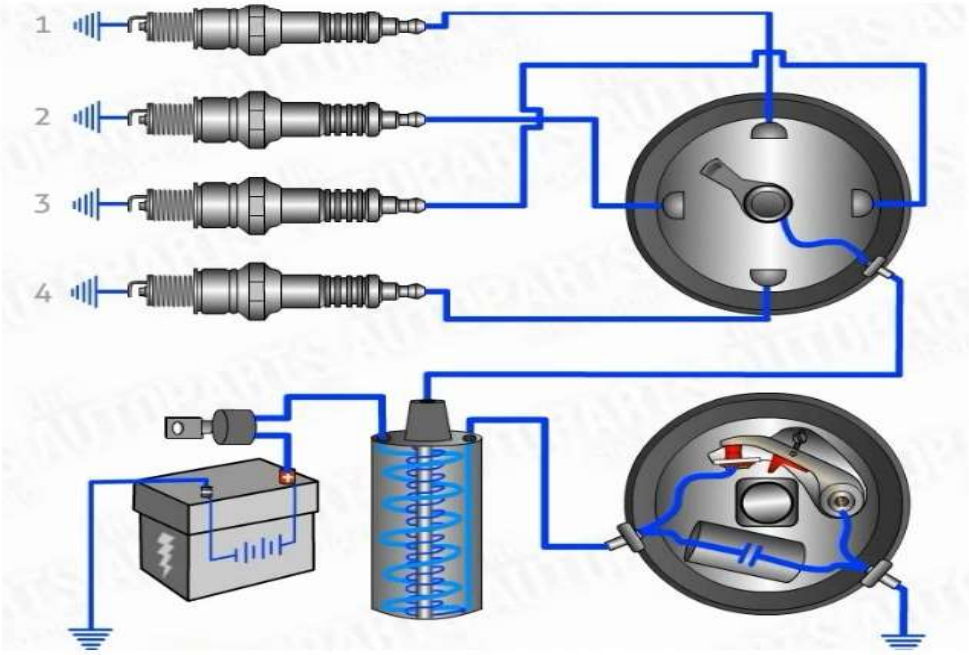


Fig. 5.38: **Coil Ignition System with CB Point**

The details of the components shown in Fig. 5.38 are as follows:

1. Spark Plug
2. Rotor
3. Vacuum advance assembly
4. Distributor
5. Camshaft
6. Ignition capacitor
7. Contact breaker point
8. Cam
9. Ignition coil
10. (a) Primary winding
    (b) Secondary winding
11. Battery
12. Ignition

Electronic Ignition System shown in (fig5.39).

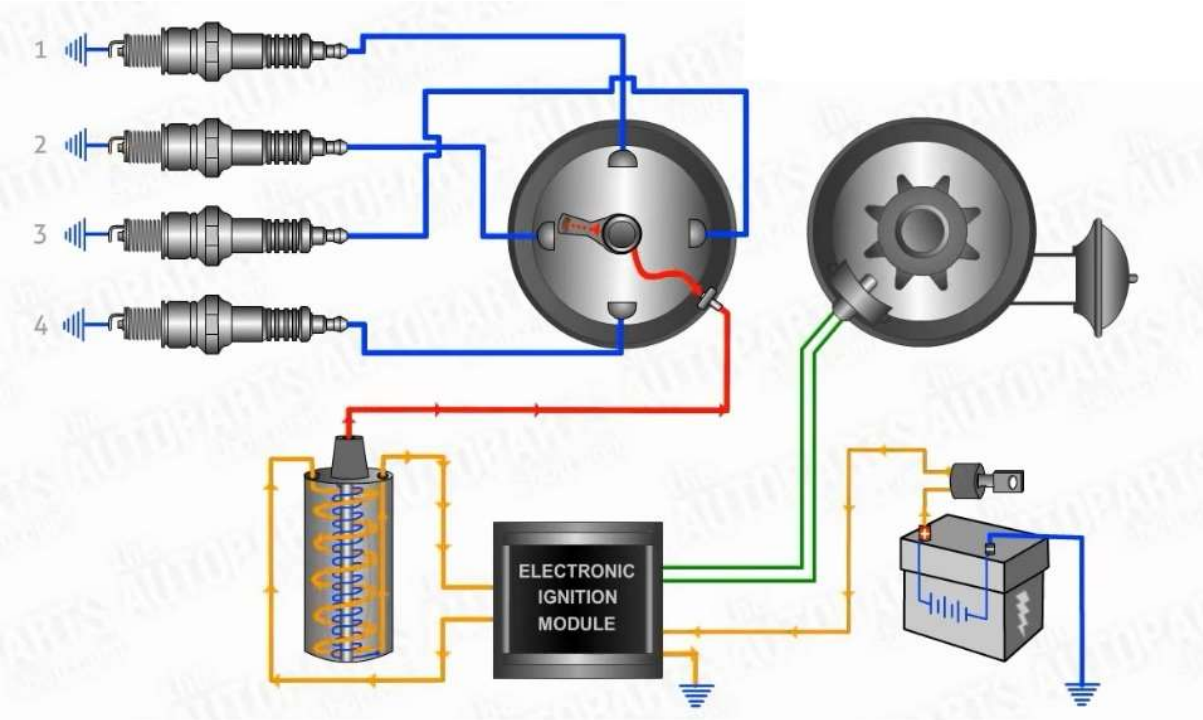


Fig. 5.39 **Electronic Ignition Systems**

Transistorized Ignition System

- A transistor is an electronic device that works like a relay. However, a transistor has no moving parts. This means that ignition system components last longer and need less maintenance.
- A transistor has three terminals; a base, a collector and an emitter.
- Transistor terminals the transistor that turns the ignition coil on and off is called the primary transistor. It is located in the ignition module.
- The current for the ignition coil's primary winding flows from the emitter to the collector.
- The relatively high current flow in the ignition coil's primary windings can be started and stopped by changing the voltage that reaches the base of the transistor.
- As in a breaker point ignition system, it is this on – Off cycle that causes the induction of voltage into the secondary winding of the coil(fig.40).

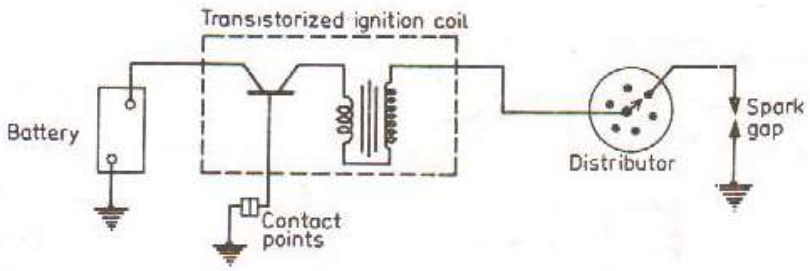


Fig. 5.40 Simple Wiring Diagram of distributor with contact points and Transistorized Ignition Coil

Distributor less ignition system shown in (fig. 5.41)

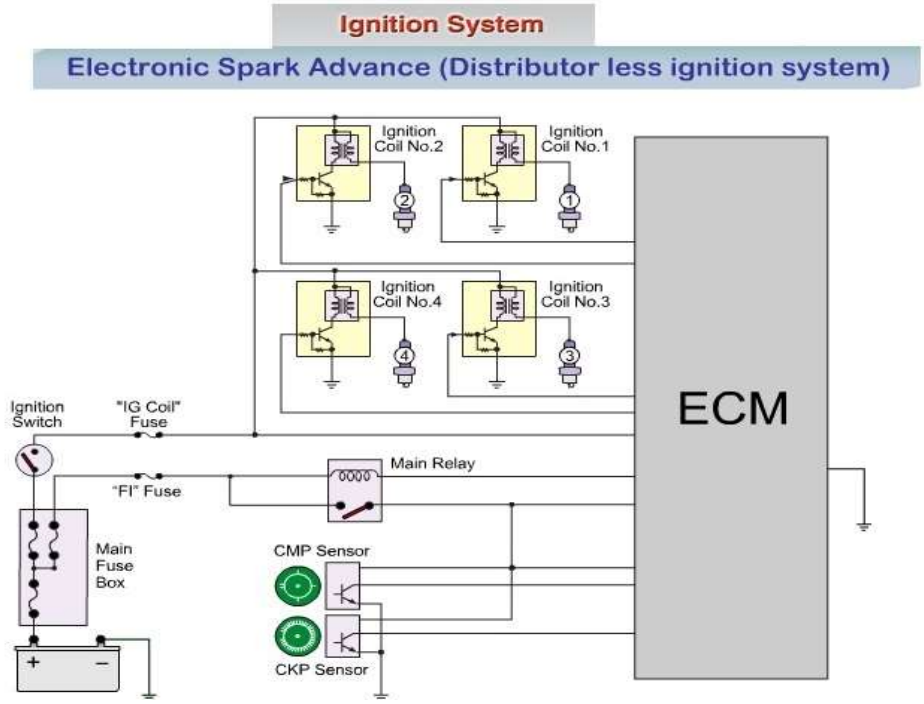


Fig. 5.41 Distributor less ignition system

Computerized Ignition System

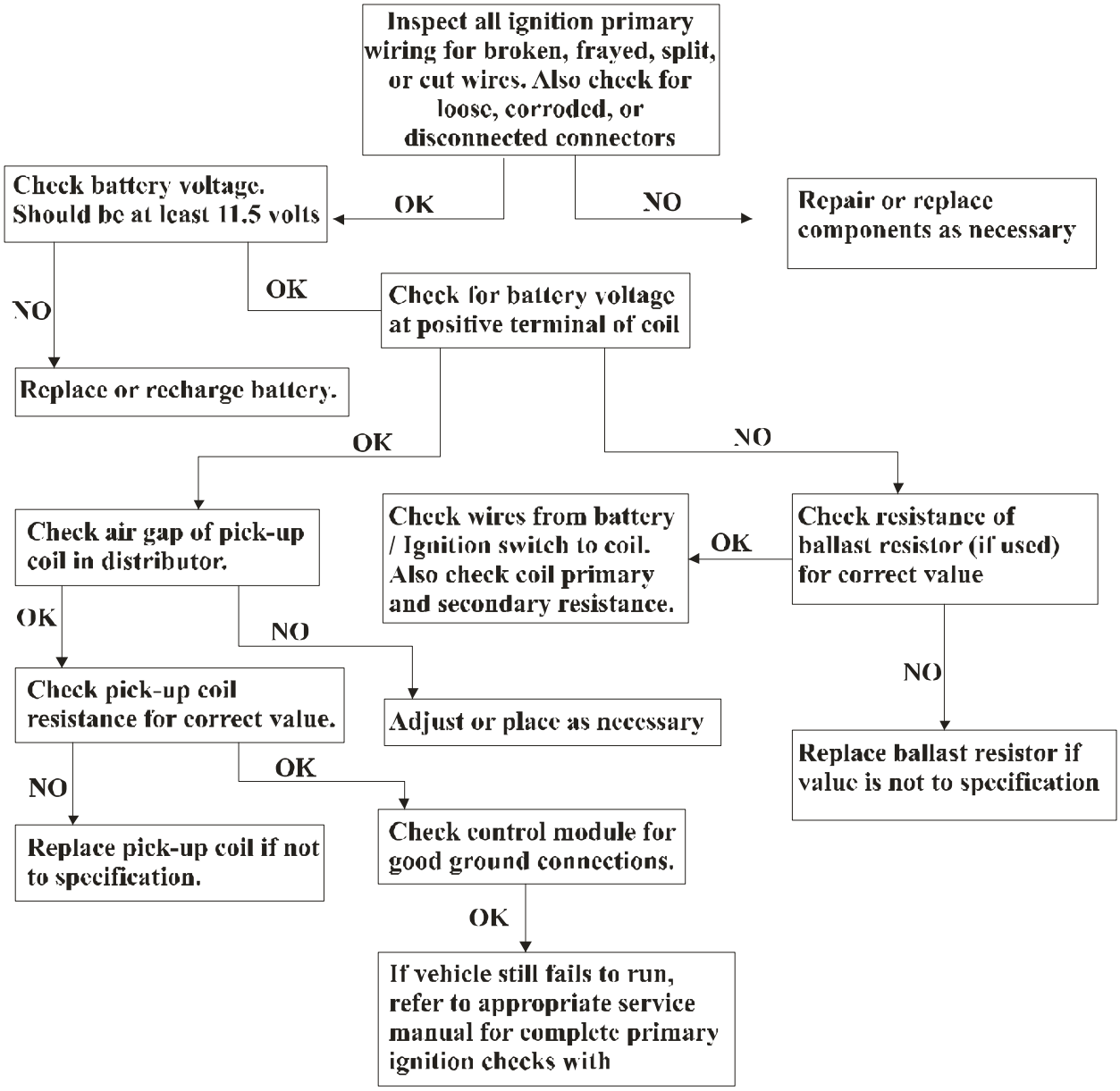
Modern ignition systems are fully computerized. The spark that ignites the air/fuel mixture is completely controlled by a computer that uses sensors to determine the optimum ignition timing.

The **distributor less ignition** type of system works the same way as the larger, centrally-located coils. The engine control unit controls the transistors that break the ground side of the circuit, which generates the spark. This gives the ECU total control over spark timing.

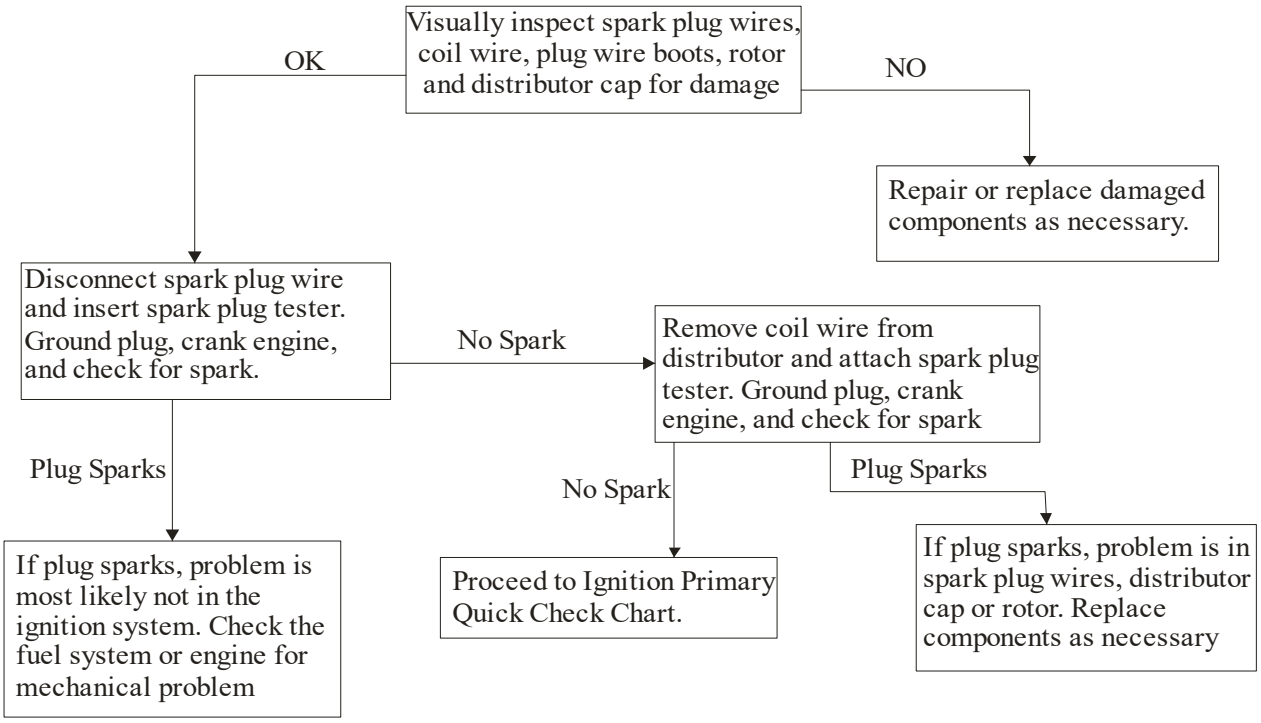
Systems like these have some substantial advantages. First, there is no distributor, which is an item that eventually wears out. Also, there are no high-voltage spark-plug wires, which also wear out. And finally, they allow for more

precise control of the spark timing, which can improve efficiency, and emissions and increase the overall power of a car.

QUICK CHECK CHART OF IGNITION PRIMARY CIRCUIT



QUICK CHECK CHART OF IGNITION SECONDARY CIRCUIT



DEFECTS	CAUSES	REMEDIES
1. There is normal cranking of engine but it does not start.	• Primary circuit open • Primary of the Ignition coil earthed • Contact points not opening • Burnt contact points • Timing out • Defective condenser • Secondary of the ignition coil open or earthed • Leakage in high tension circuit • Fouled spark plugs	• Check connections, coil, points and ignition switch for open circuit and rectify. • Replace coil; repair if possible • Adjust points • Clean or replace them as required • Check it and adjust • Replace it • Repair or replace ignition coil as required. Check ignition coil head, distributor cap, rotor and HT (high tension) leads. Locate the fault and rectify. • Clean and adjust gap; replace if necessary.

2. Engine running but one cylinder is missing.	• Spark plugs defective • Defective HT lead or distributor cap	• Clean or replace it • Replace it.
3. Engine running but missing different cylinders	• Dirty/worn-out points or parts out of adjustment • Defective condenser • Defective spark advance mechanism • HT leads defective • Defective/weak ignition coil • Corroded connections • High-tension leakage • Spark plugs defective	• Clean, replace and adjust them as required • Replace it. • Repair or replace distributor as required. Replace them. • Replace it. • Clean and tighten connections • Check ignition coil head, distributor cap rotor and HT lead. Locate fault and rectify • Replace / clean.
4. Engine develops less power.	• Timing out.	• Check and adjust timing.
5. Overheating of engine.	• Ignition riming is.	• Check and adjust timing.
6. Engine backfires	• Timing out • Cross firing of ignition Incorrect heat range of spark plugs	• Check and adjust timing • Check for leakage, HT leads, distributor cap and rotor • Replace them with correct spark plugs
7. Engine knocks	• Incorrect timing • Faulty spark advance mechanism • Contact points out of adjustment • Worn-out distributor hearing. • Bent distributor shaft • Incorrect heat range of spark plugs	• Check and adjust timing • Repair or replace distributor. • Re-adjust them. • Replace bearing • Rebuild or replace it • Replace them with correct spark plugs
8. Contact points pitted.	• Incorrect capacity of condenser	• Replace it with correct capacity • Re-arrange them.

	• Improperly arranged leads	
9. Contact points burnt	• Condenser circuit containing excessive resistance • High voltage • Contact angle excessive • Spring tension weak	• Tighten connections and mounting of condenser, replace condenser if required. • Readjust voltage regulator • Reset them • Adjust it or replace spring
10. Defective spark plugs	• Insulator cracked • Sooty plugs • White or gray plug with blistered insulator	• Careless handling; replace it. • Replace with hotter plugs. • Replace with cooler plugs.

Check Your Progress

Fill in the blanks

1. In a distributor less ignition system, the Engine Control Unit (ECU) controls the transistors that break the _____ side of the circuit to generate the spark.
2. A transistorized ignition system uses a _____ to control the on-off cycle of the ignition coil's primary winding.
3. One advantage of a computerized ignition system is its ability to precisely control the ignition _____, leading to improved efficiency and emissions.
4. In a coil ignition system with CB point, the component responsible for opening and closing the circuit is the _____.
5. The secondary winding of an ignition coil induces voltage into the _____ circuit.
6. One of the benefits of a transistorized ignition system is that it has no moving parts, which contributes to longer component _____ and reduced maintenance.

Multiple Choice Questions:

1. In a coil ignition system with CB point, which component is responsible for opening and closing the circuit to generate the spark?

A) Spark Plug
B) Rotor
C) Contact Breaker Point
D) Ignition Coil

2. Which electronic component in a transistorized ignition system is responsible for controlling the ignition coil's primary winding?

A) Spark Plug
B) Camshaft
C) Distributor Cap
D) Primary Transistor

3. What advantage does a computerized ignition system offer over traditional systems?

A) Longer spark plug lifespan
B) Elimination of the battery
C) Improved control of ignition timing
D) Higher fuel consumption

4. In a distributor less ignition system, what component controls the transistors to generate the spark?

A) Camshaft
B) Distributor Cap
C) Engine Control Unit (ECU)
D) Contact Breaker Point

5. What does a transistor in an ignition system function as?

A) Relay
B) Switch
C) Battery
D) Spark Plug

6. What does the secondary winding of an ignition coil induce voltage into?

A) Battery
B) Camshaft
C) Primary Transistor
D) Secondary Circuit

Activity

1. Make a list of components of coil ignition system of a vehicle.

S.No.	Component
1	
2	
3	
4	

2. Prepare a poster showing coil ignition system of a vehicle.

Use the following checklist to see if you've met all the requirements for circuit diagram of ignition system and checking of ignition circuit in a vehicle.

Part A

Share importance of circuit diagram of charging system of automobile and checking of charging system in a vehicle.

Part B

1. Draw the Circuit diagram of Coil Ignition system and label different components.
2. What is ballast resistance? Explain the function of ballast resistance.
3. Draw the Quick check chart of ignition primary and secondary circuit.
4. Draw the Circuit diagram of following:
   a. Distributor with magnetic pick-up
   b. Transistorized Ignition circuit.
   c. Piezoelectric Ignition Circuit
   d. Computerized Ignition circuit.

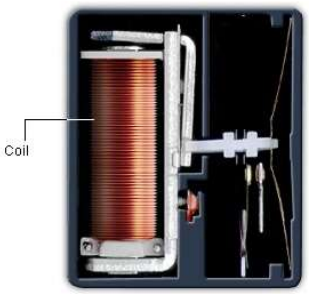
Performance standards/criteria covered by this assessment

Performance standards	**Yes**	**No**
Able to understand coil ignition system of vehicle		
Able to describe different types of ignition systems used in vehicle		
Able to find faults in ignition system of vehicle		

Session 9: Maintenance and Servicing of Major Electrical Accessories

Testing Switches and Relays

Switches and relays are circuit control devices which are to be tested for their serviceability. A switch can be diagnosed with a continuity test once it has been disconnected from the circuit. A relay must be checked to determine if the coil is being energized and if current is flowing through the power circuit. (fig5.42) This involves quick voltmeter checks for power output, control, and power input voltage and ground. Relay operation also can be checked with an ohmmeter and 12-volt battery.



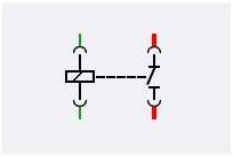


Fig. 5.42 Testing Switches and Relays

Horn system service

The tone of and electromagnetic horn can be adjusted. An adjustment will clear up the quality of the sound but it will not change the horn frequency. If the horn will not sound or if it sounds continuously, the circuit must be checked.

Horn does not Sound (Single-horn System)

The procedures are divided into those for electromagnetic systems with and without a horn relay.

a. Check the condition of the circuit fuse or fusible link. Correct if necessary.
b. Clean and tighten the horn ground connection.
c. Depress the horn button to close the horn switch and check for voltage at the horn terminal, with a voltmeter:
   - If battery voltage is shown, the horn is defective.
   - If battery voltage is not shown, continue testing.
d. Check for voltage at the armature terminal on the horn side of the horn relay.
   - If battery voltage is shown, locate and correct the problem in the wiring between the horn and the relay
   - If battery voltage is not shown, continue testing.
e. Check for voltage at the power feed terminal of the horn relay.
   - If battery voltage is shown, continue testing.

- If battery voltage is not shown, locate and correct the problem in the wiring between the relay and the battery

f. Check for voltage at the horn switch terminal of the horn relay.
- If battery voltage is shown, continue testing.
- If battery voltage is not shown, the horn relay is defective.

g. Check for voltage on the battery side of the horn switch:
- If battery voltage is shown, continue testing.
- If battery voltage is not shown, locate and correct the problem in the wiring between the horn switch and the relay

h. Check for voltage on the ground side of the horn switch:
- If battery voltage is shown, continue testing.
- If battery voltage is not shown, the horn switch is defective.

i. Clean and tighten the horn switch ground connection. If the horn still will not sound, replace the horn switch. shown in (fig5.43)

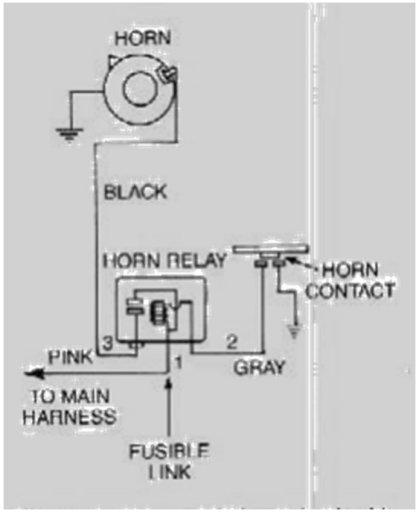


Fig. 5.43 a) Single Horn Circuit with Relay

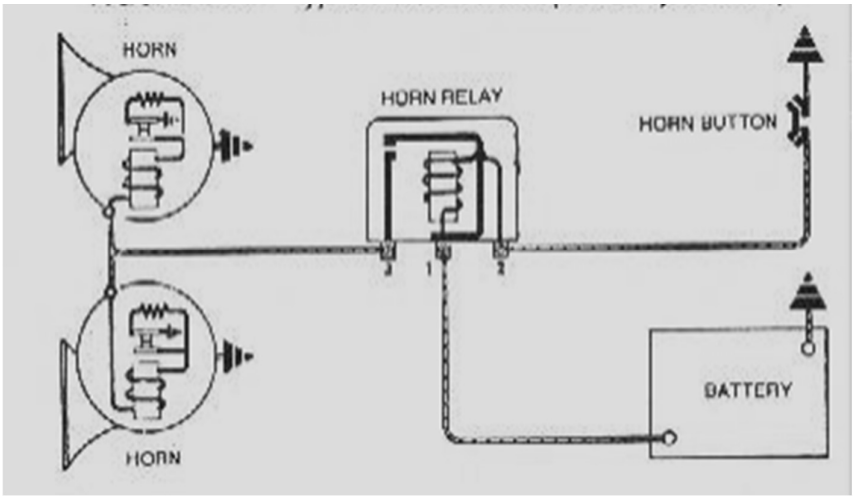


Fig. 5.43 b) A **Dual Horn Circuit with Relay**

How to troubleshoot the Horn assembly of a car

Required tools:

- Screw driver (ordinary or Phillips)
- Two Jumper Wire of one-meter length
- Voltmeter

Procedure

- Check the circuit's fuse if the horn is not working at all. If the fuse is blown, replace it and test the horn again. If the fuse is OK, go to the next step.
- Open the bonnet of your vehicle, and ask an assistant to press the horn button on the steering wheel while you listen for a possible weak sound coming from the horn. Sometimes, the sound is so weak you won't be able to hear it. Touch the horn with your hand, and try to feel a vibration while the horn is activated. If you hear sound, go to the next step. If not, go to Step 4.
- Locate the adjustment screw on the horn and adjust it using a standard or Phillips screwdriver. If the horn still does not work, go to the next step.
- Connect a jumper wire to a good ground on the vehicle, and ask an assistant to press the horn button while you bring the other end of the jumper wire in contact with the horn. If the horn works, fix its ground connection, making sure the horn makes good contact with the vehicle's chassis.
- Detach the horn from the vehicle, and connect it directly to battery power using jumper wires. If the horn fails to work, replace it. If it does work there, go to the next step.
- Reinstall the horn to its circuit, and check for voltage at the horn with a voltmeter, connecting the red probe to the horn's terminal and the black one to the horn's body. Ask an assistant to depress the horn button at the steering wheel. If the horn is receiving voltage, replace the horn. If there is no voltage, go to the next step.
- Check for continuity at the wire running from the horn to its relay. If there is no continuity, the wire has an open. Fix it, and test again. If there is continuity, go to the next step.
- Check the horn relay, and make sure it is working properly. Test for voltage at the relay's power-and-control circuit with a voltmeter while an assistant operates the horn button at the steering wheel. If the relay is not working properly, replace it and test it again. If there is no voltage reaching the relay, go to the next step.

- Inspect the wire going from the horn relay to the fuse panel. If you find an open or short, fix it and test again. If the wiring is OK, go to the next step.
- Ask an assistant to press the horn button at the steering wheel while you check for continuity at the wire running from the relay to the horn button and ground. If there is an open in the wire, fix it and test it again. If you don't find the open in the wiring, replace the horn button.

Electric Fuel Pump

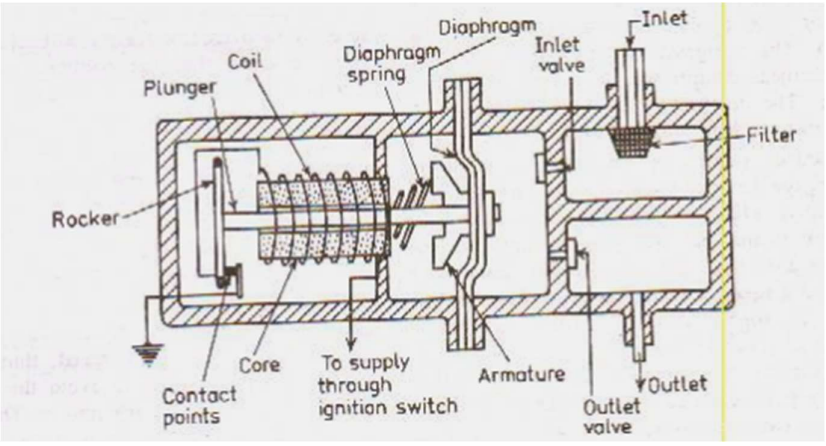


Fig. 5.44 Electric Fuel Pump (Diaphragm type)

The Electric fuel pump is an alternative to the mechanical pump driven by the shown in (Fig. 5.44). It has got the following advantages:

1. It can be located away from the engine. In this way, it can be fitted directly above or below the fuel tank, thus reducing the length of the suction pipe to the minimum.
2. It does not depend upon the engine drive and can be operated even when the engine is at rest.
3. It is easily accessible for inspection or maintenance. Hence in the event of failure it can be replaced quickly.
4. It is not affected by the under-bonnet temperatures.
5. It is self-priming.

Electric fuel pumps can be of two types, viz. the flexible diaphragm type and the motor-driven centrifugal type or impeller type.

Diagnosis of defects

During fuel pump diagnosis, keep in mind these key items:

• Start with the basics

– Is fuel pressure within specifications? (check the Service Information)

– Does the fuel pressure hold with the key off? (if applicable)

– On return systems with a vacuum operated regulator, does the fuel pressure increase during acceleration?
– Has the in-line fuel filter been changed? (if applicable)

- Measure amperage
  - If amperage is low, it may be due to bad connections
  - If amperage is high, check for possible restrictions or a bad fuel pump
- If a burned, loose terminal is connected to a new fuel pump connector, the new fuel pump will be ruined
- Low fuel level in the fuel tank can shorten fuel pump life. Inform the customer that fuel level affects the life of the fuel pump (gasoline is used for both cooling and lubrication), and fuel with an octane rating specified in the vehicle owner manual should be used.
- Check for fuel contamination. It's the number one reason for fuel pump failure. Dirty fuel, additive breakdown, rust and fuel tank delamination all work to clog the fuel pump strainer and cause premature pump failure.

Pump Replacement

When proper diagnosis leads to the need to replace the fuel pump, be sure to follow these guidelines:

- Check for contamination and flush the fuel tank
  - Clean the top of the fuel tank before removing the fuel pump
  - Use hot water
  - Install a new in-line filter and sock filter
- Always install a new strainer (never re-use)
- Replace the fuel tank O-ring when installing a new fuel pump
- Always follow the directions provided with the new fuel pump

Treatment Plus. Remember that any additive that is put into the fuel tank, such as to clean the fuel injectors must first go through the fuel pump.

Corrosion and Contamination

The sulfur contaminants found in some of today's gasoline can have corrosive effects on the fuel system sending unit, disrupting electrical continuity and leading to erratic or false fuel gauge readings.

Fuel Pump Control Module

With electronic return less fuel systems, the Fuel Pump Control Module (FPCM) controls the voltage supplied to the fuel pump (located within the fuel tank) to achieve the desired fuel pressure requested by the Engine Control Module (ECM). There is also a fuel line pressure sensor, which sends a feedback

signal to the FPCM, so the FPCM can determine whether the desired pressure is being achieved.

Check the serviceability of Fuel Pump control module (FPCM) and Fuel line pressure sensor by prescribed method.

Fuel Gauge

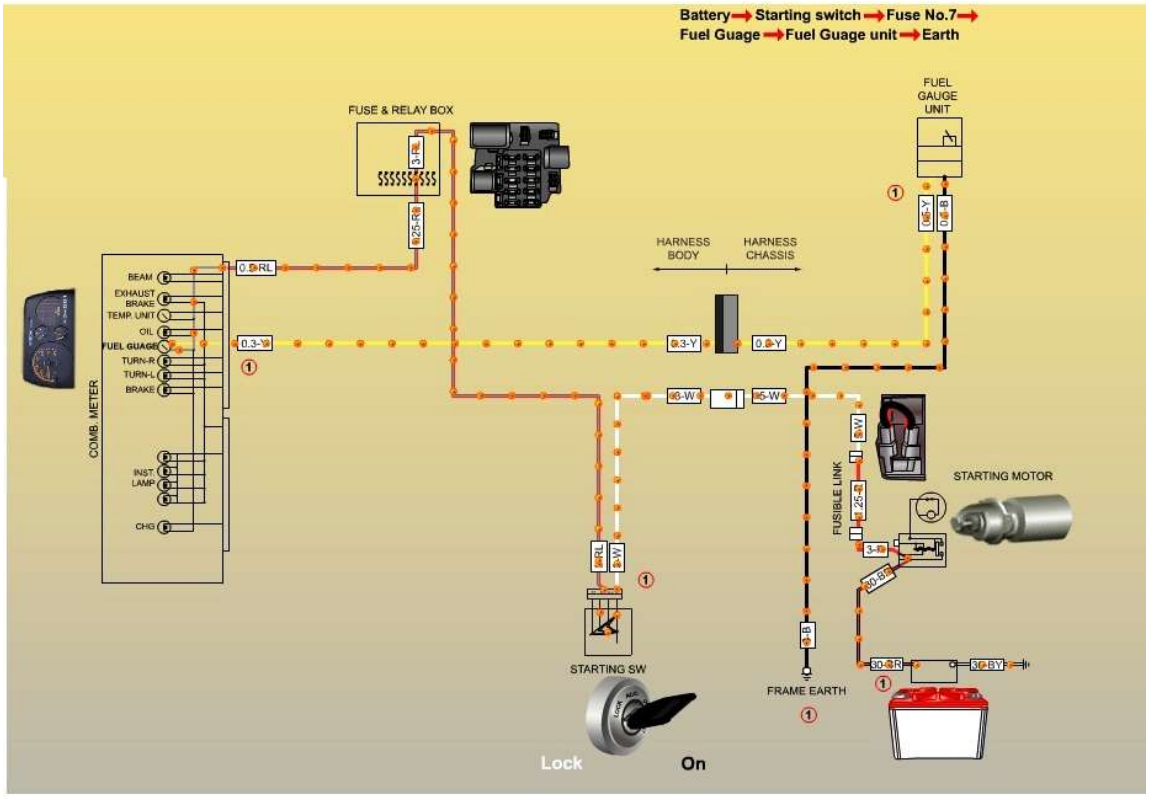


Fig. 5.45: Above figures shows different types of fuel gauges (**thermal type and balancing coil type**) used in automobile.

The following table gives some of the common faults and their causes.

Fault	Causes	Remedies
i. Pointer does not move when ignition switch is put it.	▪ Fuse blown. • Broken connection between ignition switch and the gauge	▪ Replace Fuse ▪ Connect the broken connection.
ii. Gauge reads full under all conditions.	• Casing of gauge not earthed • Wire earthed between gauge and tank unit. • Tank unit terminal earthed	• Earth it properly • Rectify • Insulate it

	• Float arm sticking • Defective gauge	• Find the cause and rectify. • Replace
iii. Gauge reads empty under all conditions	• Wire disconnected from ignition switch to gauge • Tank unit not earthed • Float punctured • Float arm sticking • Defective gauge	• Locate fault and rectify • Earth it • Replace it • Find cause and rectify • Replace it
iv. Gauge register inaccurately.	• Faulty earth connection.	• Rectify the connections

Oil Pressure Gauge

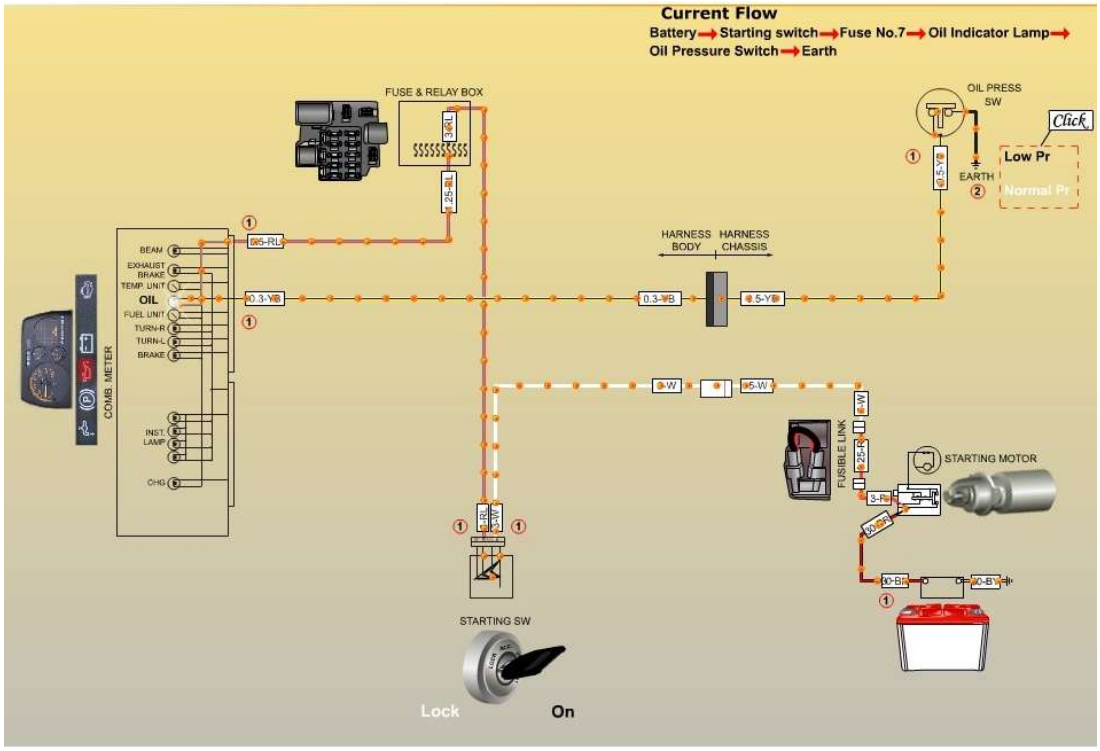
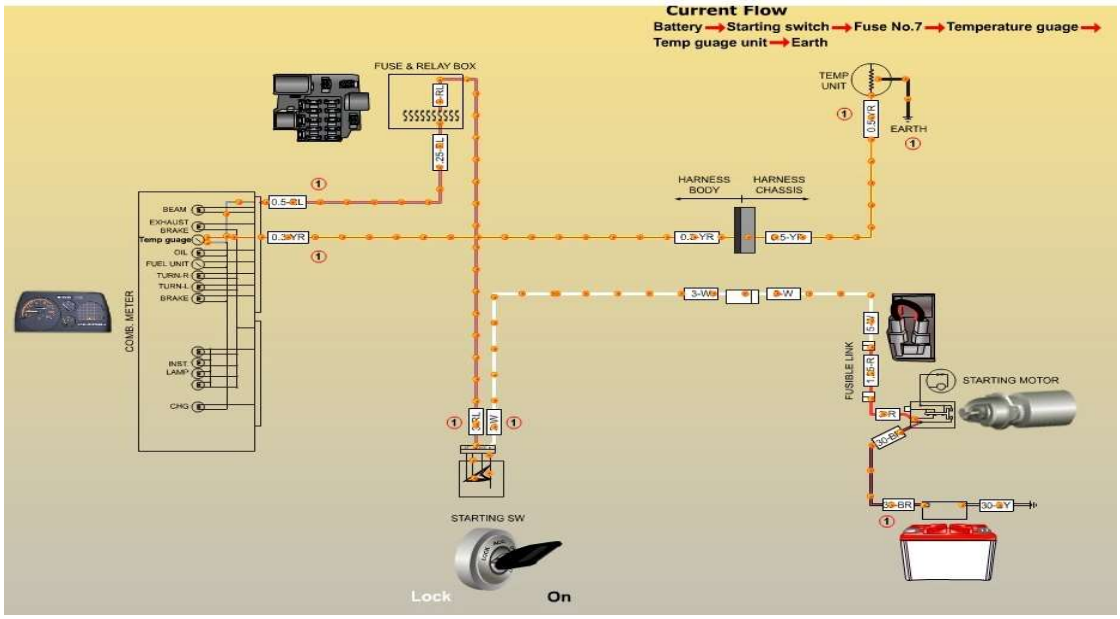


Fig. 5.46: Oil Pressure Gauge used in automobile.

Fault	Causes	Remedies
I Oil Pressure indicator lamp does not glow.	▪ Fuse blown. • Broken connection between ignition switch and the sensor valve and relay.	▪ Replace Fuse ▪ Connect the broken connection.

ii. Low Oil Pressure	• Oil Pressure Switch is not earth. • Wire earthed between sensor and engine unit. • Engine unit terminal is not earthed.	• Earth it properly • Rectify • Insulate it • Replace

Temperature Gauge



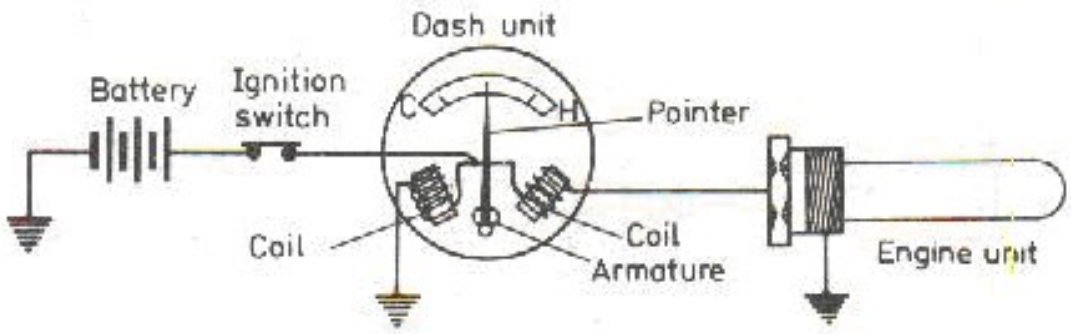


Fig.: 5.47 Circuit of a Balancing Coil Type Temperature Gauge

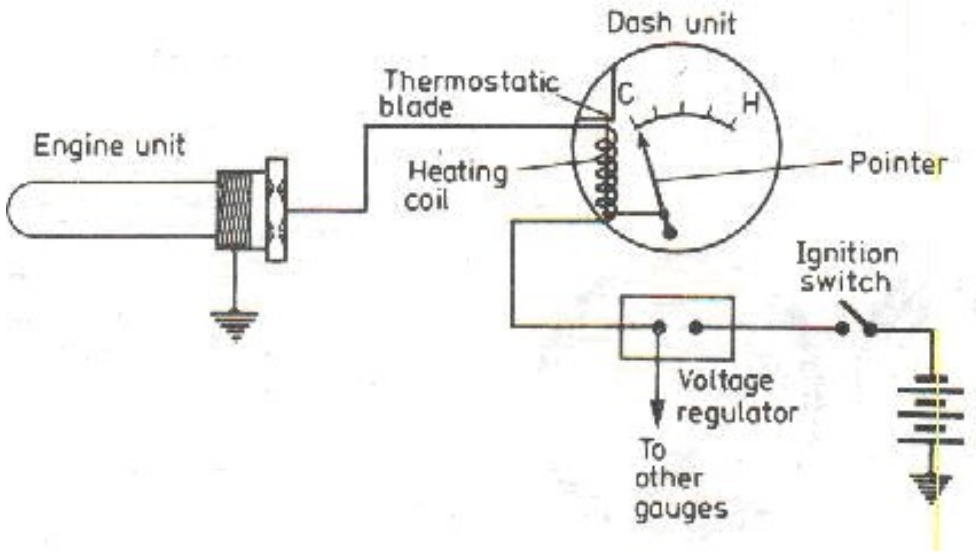


Fig.:5.48 Circuit of a Thermostatic Type Temperature Gauge

The following table gives some of the common faults and their causes.

Fault	Causes	Remedies
i. Pointer does not move when ignition switch is put it.	▪ Fuse blown. • Broken connection between ignition switch and the gauge	▪ Replace Fuse ▪ Connect the broken connection.
ii. Gauge reads maximum under all conditions.	• Casing of gauge not earthed • Wire earthed between gauge and engine unit. • Engine unit terminal earthed • Defective gauge	• Earth it properly • Rectify • Insulate it • Replace
Fault	**Causes**	**Remedies**
iii. Gauge reads minimum under all conditions	• Wire disconnected from ignition switch to gauge • Engine unit not earthed • Float punctured • Defective gauge	• Locate fault and rectify • Earth it • Replace it • Replace it
iv. Gauge register inaccurately.	• Faulty earth connection.	• Rectify the connections

Oil Pressure Warning Light

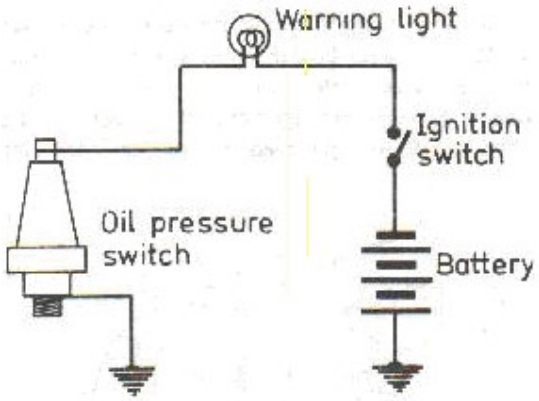


Fig.: 5.49 Oil Pressure Warning Light

The following table gives some of the common faults and their causes.

Fault	Causes	Remedies
1. Light continues to glow when oil pressure is adequate	• Defective pressure sensor • Wire earthed between pressure switch/sensor and light	• Replace • Rectify
2. Light does not glow when ignition switch is switched on	• Defective pressure switch • Wire disconnected between ignition switch and warning light or between light and pressure switch.	• Replace • Locate the spot and rectify

Windscreen / Windshield Wiper

Automobiles are equipped with electrically operated windshield wipers. Following figure shows an exploded view of 17 W wiper motor manufactured by Lucas – TVS. It is a single speed unit designed to operate a link type wiper installation. The unit is manufactured both in 12 V and 24 V. The following are the maximum arm and blade sizes recommended to be used:

- Standard motor - 50 cm Arm, 50 cm Blade
- High power motor - 50 cm Arm, 65 cm Blade

The motor is of a self-switching, two pole design, having a permanent magnet field system provided by high energy magnets, together with a gear box housing a two-stage reduction gear. The power from the motor is transmitted by a three start worm gear provided on the extension of the armature shaft through a low stage reduction gear system. The drive to the blades is transmitted via a shaft and rotary link assembly. It is incorporated with a special limit switch

which ensures application of regenerative braking to the armature on completion of wiping cycle during which the control switch is turned to OFF position. It thus ensures consistent parking of the wiper arms and blades in the correct position.

Electrical connections are made to the motor via a non-reversible in line plug and socket assembly. This type of connection ensures the maintenance of correct motor polarity during the course of motor connecting to vehicle wiring.

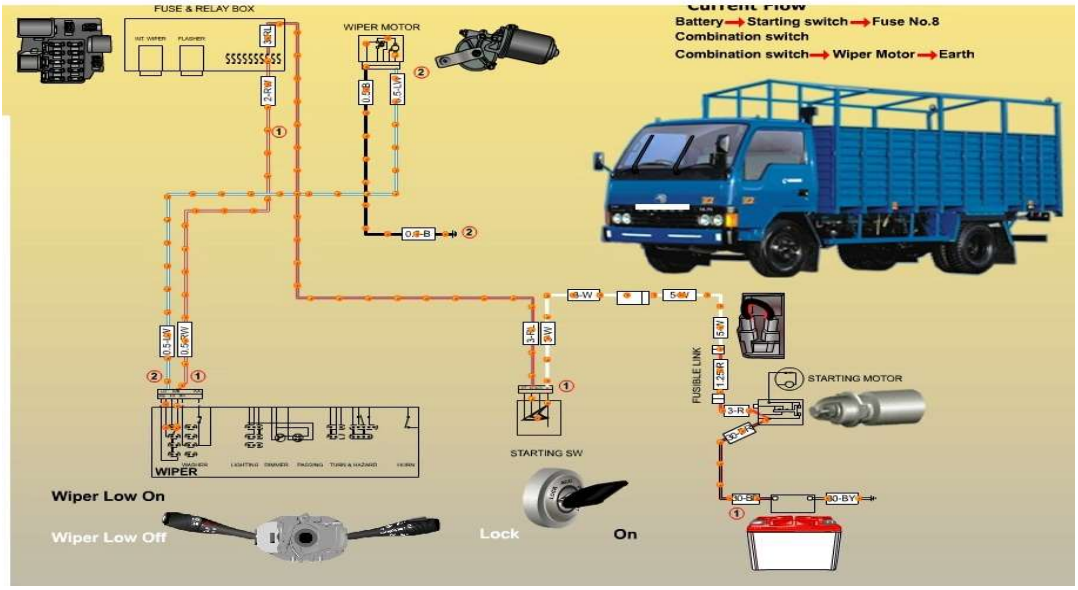


Fig.: 5.50 Electrical connections in vehicle

Precautions

While installing wiper motor in the vehicle the following precautions should be observed:

- Do not rotate motor crank by hand. Ensure links of correct lengths are used
- For centre mounting arrangement the link ends at both the spindle boxes should be inside.
- Circuit cable resistance must be such that the voltage drop does not exceed 1.0 volt with motor current of 5.0 amperes.
- Use 5 amperes fuse in the circuit to protect the motor.
- Observe correct polarity while connecting motor.
- For adjusting the parking position, the limit switch cover should be turned in a direction opposite to that of motor crank rotation, if required.
- When the motor is in parking position assemble the arms with blades to the spindles so that blades are in horizontal position ensuring 2 inches gap between the blades and the rubber beading. Ensure blades do not slap beading on wet screen operation.

- Ensure that the links do not foul with the cross members or brackets on body of the vehicle.
- Ensure recommended arm/blade sizes are used.
- Circuit cable resistance drop does not exceed 1.0 volt with motor current 5.0 Amps.
- Observe correct polarity while connecting motor.
- Ensure recommended Arm/Blade sizes are used.

Routine Maintenance

- Remove oil, tars-pots or similar deposits from the wind screen with methylated spirits (denatured alcohol)
- Do not use silicone or wax polishes on wind screen.
- Ensure all electrical connections are in good condition.
- Keep wiping blades in good condition. Otherwise, or will make screeches to the wind shield
- Worn or perished blades should be replaced.

Wiper Motor Check

Unsatisfactory operation may be due to electrical or Mechanical faults. Before dismantling the unit, consideration should be given to the nature of fault.

Fault Diagnosis and Check List

DEFECT	REMEDY
1. Motor not working when switched 'ON'	• Check fuse • Check connections at both socket at and plug. • Disconnect socket at motor end and connect a voltmeter between No.5 or No.1 pin is defective or loose connection / open circuit. • If above three points are satisfactory, check motor side.
2. Motor continues to run even after switching 'OFF'.	Limit switch defective – change limit switch.
3. Jerky movement of the motor while running.	- do -
4. Fuse blows 'OFF' when motor switched 'ON'	Limit switch defective (Terminal No.! and 4 permanently shorting) Or Armature light

Check Your Progress

Fill in the blanks

1. During the troubleshooting of a horn assembly, if the fuse is blown, it should be _____ and the horn should be tested again.
2. Electric fuel pumps can be of two types: the flexible diaphragm type and the motor-driven _____ type.
3. To adjust the parking position of windshield wipers, the limit switch cover should be turned in the direction _____ to the motor crank rotation.
4. If the oil pressure indicator lamp continues to glow even when oil pressure is adequate, the most likely cause is a _____ pressure sensor.
5. The purpose of cleaning the top of the fuel tank before removing the fuel pump is to ensure a clean _____ for the pump.
6. In an electronic return-less fuel system, the Fuel Pump Control Module (FPCM) controls the voltage supplied to the fuel pump to achieve the desired fuel _____ requested by the Engine Control Module (ECM).

Multiple Choice Questions:

1. What is the purpose of testing switches and relays in a vehicle's electrical system?

a) To adjust the sound quality of the horn
b) To determine the horn frequency
c) To check for voltage at the power feed terminal
d) To diagnose their serviceability

2. What should you do if a horn in a single-horn system does not sound when the horn button is pressed?

a) Replace the horn relay
b) Clean and tighten the horn switch ground connection
c) Check the circuit fuse
d) Replace the horn switch

3. What is the advantage of an electric fuel pump over a mechanical pump in a vehicle's fuel system?

a) It depends on the engine drive
b) It requires less maintenance
c) It is affected by under-bonnet temperatures
d) It can be located away from the engine

4. What is a key factor that can cause fuel pump failure?

a) Low fuel level in the tank

b) Excessive fuel pressure
c) Use of high-octane fuel
d) Frequent use of additives

Answer the following questions

1. Discuss the importance of maintenance and servicing of major electrical accessories in a vehicle.
2. Draw the circuit diagram of following:
    a. Dual Horn assembly
    b. Electrical fuel pump
    c. Electrical fuel gauges (balancing coil type and thermostatic type)
    d. Oil pressure gauge (balancing coil type)
    e. Temperature gauge.
    f. Electric Speedo meter
    g. Two speed windscreen wipers.
3. Explain different fault, causes and remedies of following automobile accessories.
    a. Dual Horn assembly
    b. Electrical fuel pump
    c. Electrical fuel gauges (balancing coil type and thermostatic type)
    d. Oil pressure gauge (balancing coil type)
    e. Temperature gauge.
    f. Electric Speedo meter
    g. Two speed windscreen wiper.

Activity

1. Make a list of major electrical accessories of a vehicle.

S.No.	Electrical accessory
1	
2	
3	
4	

2. Prepare a poster showing circuit diagram of electrical speedometer, oil pressure warning light, electrical fuel gauge (balanced coil type and thermostatic type) of a vehicle.

Session 10: Introduction to Climate Control System Heating Ventilation and Air Conditioning in a Vehicle

Climate Control System

The climate control system is designed to provide comfort for the driver and passengers. The climate control system maintains in-car air temperature and humidity within a range that is comfortable for the people inside and provides fresh clean air for ventilation. A comfortable temperature inside the vehicle helps keep the driver alert and attentive.

The air conditioning (A/C) system and the heating system are known together as heating, ventilation and air conditioning (HVAC) system. The HVAC system controls heat and the removal of humidity. The HVAC system uses an air distribution system of ducts, vents and doors to direct outside air or climate-controlled air into the vehicle passenger compartment. An electrical system provides the operator control of the HVAC system. The HVAC system in a vehicle is divided into four closely related subsystems:

- Heating and defrosting system
- Air conditioning system
- Air distribution and ventilation system
- Electrical system

Heaters and Defrosters

The present-day automobiles, specially cars, are provided with heaters and defrosters. The heater system of a car uses a motor to drive the fan. The fan forces fresh air through the heater element into the interior of the car. The heater element is kept hot by means of hot water of the radiator. The motor gets its supply through the ignition switch. During hot weather conditions, the motor – driven fan can be used to provide cool air from outside the car. Under these circumstances, the heater element is bypassed by means of a duct system controlled by the dampers show in (Fig. 5.51 and Fig. 5.52).

The defroster operates like the heater. It also derives heat from the same beater element. The defroster directs the hot air against the windshield to avoid

condensation or freezing of the moisture. The motor used for the heater and defroster consumes about 2.5 – 5.0 A at 12 V.

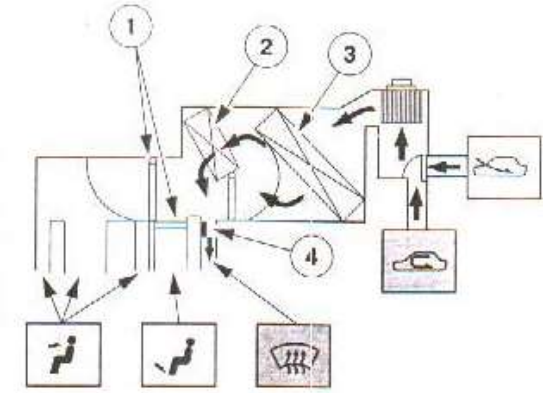


Fig. 5.51 Defroster door operations

Defroster door operation

1. Vent doors closed
2. Heater core
3. Evaporator
4. Defroster door

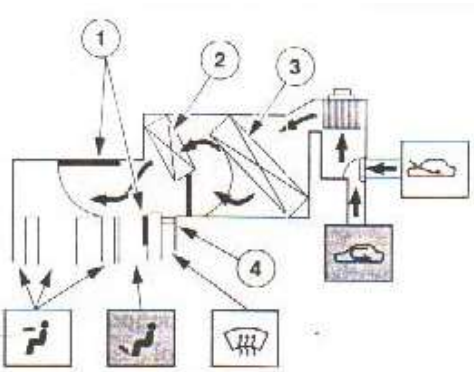


Fig. 5.52 Vent / face heater door

Vent/face heater door operation

1. Vent doors
2. Heater core
3. Evaporator
4. Defroster door.

Air Conditioning System

Figure 5.53 shows the details of air conditioning system (also shows the refrigerant flow) used in modern automobiles.

The present-day cars of the more expensive variety are provided with air conditioning system which serves to keep the car interior cool under hot weather conditions. It is done with the help of a refrigerating system. In this case, a larger blower motor is used to supply the required volume of air. In a typical car, the motor of the blower consumes about 15 – 18 A at 12 V. The refrigerator employed may be of the mechanical compressor or the gas absorption type. The compressor of the refrigerator is driven by a belt and pulley from the engine crankshaft pulley. A provision is made to disengage the drive by mechanical or solenoid operated clutch when the air conditioning system is not in use. The absorption type refrigerator has got no moving parts, but instead it needs a heater element. The element gets its supply from the battery and has a rating of about 25 W shown in (Fig. 5.53).

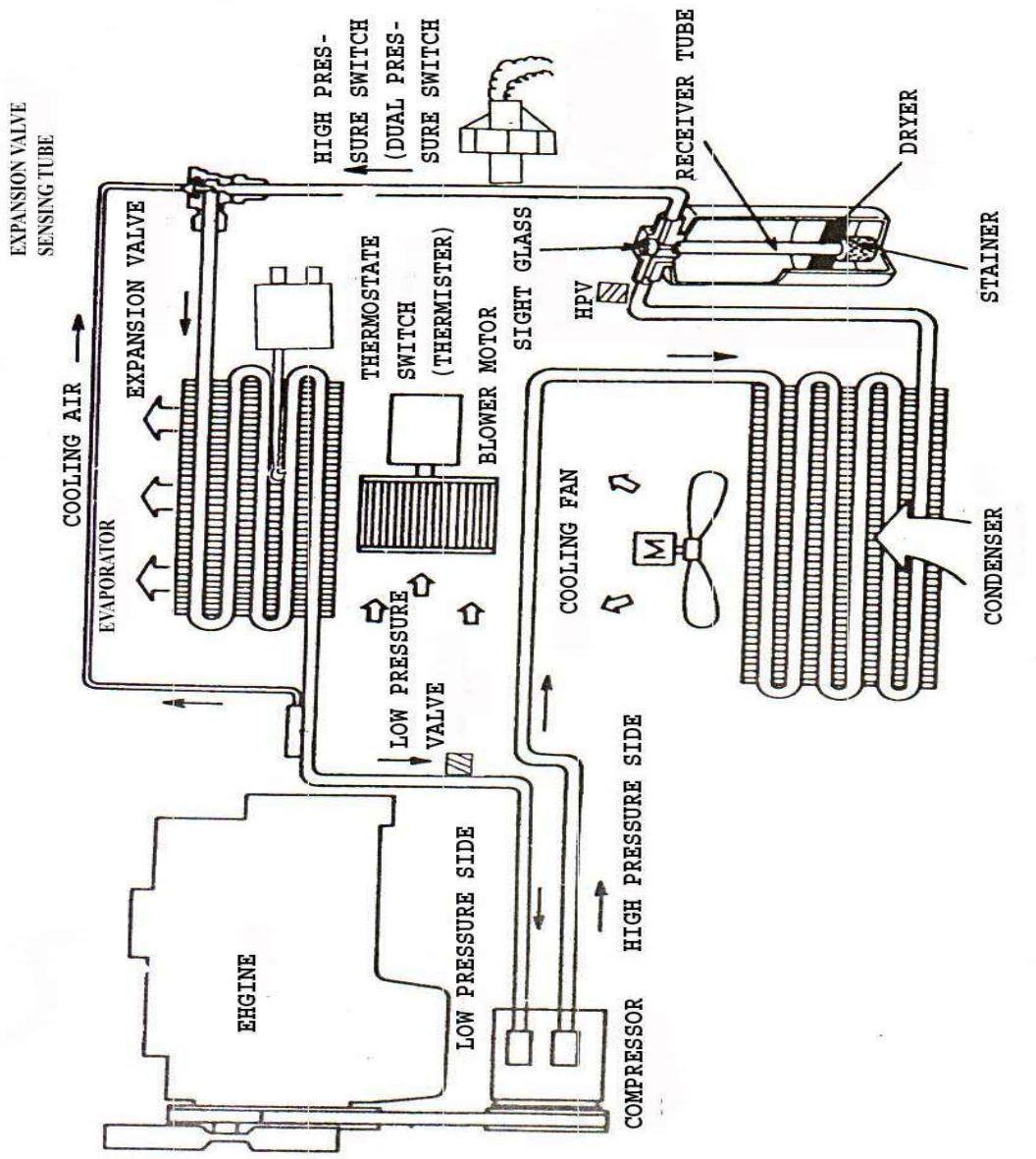


Fig. 5.53:Air Conditioning System

Air conditioning Inspection

1. **Is V-belt too loose?**
   If a V-belt is too loose, it will be torn off because of slippage. To prevent such trouble, keep the belt tight. Replace a torn belt with a new one.

2. **Noise around the compressor.** Check the compressor mounting bolt and the bracket mounting bolts for looseness and tighten if necessary.

1. **Noise from inside the compressor.**
   This may indicate the either a delivery or suction valve has been damaged or that the connecting rod has become loose.

2. **Mud and dirt on the condenser and fins.**
   If the condenser and fins are fouled with mud or dust, the cooling effect of the condenser will decline to a marked degree and the room cooling capacity to the air conditioner will also be reduced. BE sure to wash the mud and dust off the condenser. If the condenser fins are washed with hard hair brush, they will be scratched or bent. Therefore, clean them very carefully.

3. **Dirty connection and portions with oil.**
   The presence of oil indicates that the refrigerant is leaking.
   The compressor oil contained in the refrigerating gas escapes from the cycle together with the leaking refrigerant. Consequently, the gas leaking portions get fouled with oil. If any place has become dirty with oil, retighten the fastener or replace the related parts to prevent gas leakage. Oil stains are frequently found in the compressor gaskets and piping connections, so check these portions carefully.

4. **Noise around the blower.**
   Run the blower at low (Lo), Medium (Med), and High (Hi) speeds. If you notice any abnormal operating noise or unsatisfactory rotation, replace the blower motor. But before replacing the blower motor, see if the noise is caused by foreign matter stuck in the motor or if the motor is running unsatisfactorily because of loose parts.

5. **Checking the quantity of refrigerant through the sight glass.**
   When many air bubbles are seen through the sight glass, it indicates a lack of refrigerant. In this case, see if there are any oil stains and confirm that the refrigerant is not leaking from any point. If no air bubbles are seen through the sight glass even when the condenser is cooled with water, it indicates that too much refrigerant has been charged into the condenser.

Performance Test

- Warm up engine to normal operating temperature
- Check that ambient Temp. is 20 – 35^0C (68 – 95^0F)
- Operate air conditioning, and set blower switch at “HI”, temp, lever at “COOL”, Fresh / Recirculation control lever at “Recirculation”.
- Keep all windows and doors open.
- Insert at dry bulb thermometers in center duct air outlet and evaporator inlet port, and measure each temperature.

- Check inlet port temp. to-outlet port temp.
- If cooling is not efficient enough, check charged state of refrigerant through sight glass of receiver dryer and perform pressure test using manifold gauge.

Checking charged state of refrigerant

The following procedure can be used for quickly checking whether the A/C system has a proper charge of refrigerant or not.

Run engine at fast idle, and operate A/C at its max. Cooling capacity for a few minutes. Then, look at the sight glass on receiver / dryer to check of refrigerant.

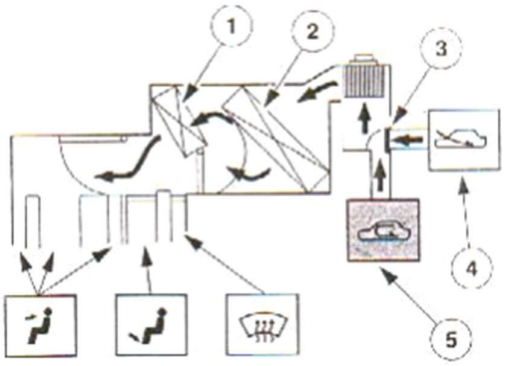
Use the following table when checking the charged state of the refrigerant and correct it as necessary

Symptom	Charge of refrigerant	Remedy
1. Bubbles observed in the sight glass	Insufficient charge of refrigerant in the system	Check the system for leaks with a leak test
2. No bubbles observed in the sight glass	No or insufficient charge of refrigerant in the system	Refer to the items 3 and 4
3. No temperature difference between compressor inlet and outlet	Empty or nearly empty system	Evacuate and charge the system and then check it for leaks with a leak tester
4. Noticeable temperature difference between compressor inlet and outlet	Proper or too much charge of refrigerant in the system	Recover refrigerant, evacuate and charge the proper amount of refrigerant.
5. When A/C is turned OFF, the refrigerant in sight glass clears immediately and remains clear.	Too much charge of refrigerant in the system.	Recover refrigerant, evacuate and charge the proper amount of refrigerant.
6. When A/C is turned OFF, the refrigerant in sight glass once produces bubbles and then clears.	Proper charge of refrigerant rant in the system	NO CORRECTION NEEDED BECAUSE CHARGE OF REFRIGERANT IS NORMAL

TROUBLE DIAGNOSIS

DEFECTS	CAUSES	REMEDIES
1. No cooling or warm air.	**Magnetic clutch does not engage properly** • Fuse blown • Magnetic clutch faulty • A/C switch faulty • Thermal switch faulty • Duel pressure switch faulty • Wiring or grounding faulty • No refrigerant • A/C relay faulty **Compressor is not rotating properly** • Drive belt loose or broken • Compressor faulty **Blower inoperative** **Expansion valve faulty** **Leak in system** **Receiver/dryer having blown fusible plug or clogged screw**	Replace fuse and check for short Check clutch. Check switch Check thermal switch. Check switch. Repair as necessary. Check A/C circuit Replace A/C relay Tighten or replace drive belt. Check compressor. Check blower. Check expansion valve. Check system for leaks. Check receiver / dryer
2. Cool air comes out only intermittently	• Magnetic clutch slipping • A/C relay faulty • Expansion valve faulty • Wiring connection faulty • Excessive moisture in system	Check magnetic clutch. Replace A/C relay Check expansion valve. Repair as necessary. Evacuate and charge system
3. Cool air comes out only at high	• Condenser clogged • Drive belt slipping • Compressor faulty • Insufficient or excessive charge of refrigerant • Air in system	Check condenser Check or replace drive belt. Check compressor. Check charge of refrigerant Evacuate and charge system
4. Insufficient cooling	• Condenser clogged • Drive belt slipping • Magnetic clutch faulty • Compressor faulty	Check condenser. Check or replace drive belt.

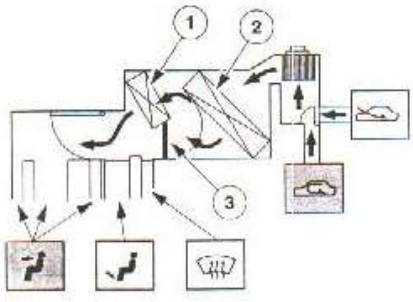
	• Expansion valve faulty • Thermistor faulty • Insufficient or excessive charge of refrigerant • Air or excessive compressor oil existing in system • Receiver / dryer clogged • Evaporator clogged or frosted • Air leaking from cooling unit or air duct • Air inlet blocked • Blower motor faulty	Check magnetic clutch. Check compressor. Check expansion valve. Check thermistor. Check charge of refrigerant. Evacuate and charge system Check receiver / dryer. Check evaporator. Repair as necessary Repair as necessary Replace blower motor.



Air Distribution and Ventilation Door Control Components

1. Heater core
2. Evaporator.
3. Fresh / re-circulated air door.
4. Fresh air door.
5. Re-circulated air control

Fig. 5.54: Air Distribution and Ventilation Door Control Components



Temperature Blend door operation

1. Heater core
2. Evaporator
3. Temperature blend door

Fig. 5.55: Temperature Blend door operation

Know Your Progress

Fill in the blanks

1. The climate control system is designed to provide comfort for the _____ and _____.
2. The HVAC system controls _____ and the removal of _____.
3. The heater element is kept hot by means of _____ of the radiator.
4. The _____ operates similarly to the heater, using heat from the same heater element. It directs hot air against the windshield to prevent condensation or freezing.
5. The purpose of the _____ is to check whether the A/C system has the proper charge of refrigerant. It involves operating the A/C at maximum cooling capacity and observing the sight glass on the receiver/dryer.

Multiple Choice Questions:

1. The purpose of the climate control system in a vehicle is to:
a) Improve fuel efficiency
b) Enhance vehicle speed
c) Provide comfort for occupants
d) Increase engine performance

2. Which of the following is NOT a subsystem of the HVAC system?
a) Cooling system
b) Heating and defrosting system
c) Air distribution and ventilation system
d) Air conditioning system

3. The component that directs hot air against the windshield to prevent condensation or freezing is called the:
a) Vent door
b) Evaporator
c) Defroster
d) Compressor

4. What is the purpose of the blower motor in a vehicle's HVAC system?
a) To control fuel injection
b) To drive the vehicle
c) To provide fresh air for ventilation
d) To charge the battery

5. In an air conditioning system, the compressor is driven by a belt and pulley from the:

a) Radiator fan
b) Engine crankshaft pulley
c) Transmission
d) Alternator

6. What does the sight glass on the receiver/dryer of an A/C system indicate?
a) Oil level
b) Engine temperature
c) Refrigerant charge state
d) Battery voltage
Answer: c) Refrigerant charge state

Answer the following questions

1. Discuss the importance of climate control system heating ventilation and air conditioning in a vehicle.
2. What do you mean by climate control in an automobile?
3. Write the functions of Heater and Defroster in automobile.
4. Draw the operational circuit of an automobile air conditioning system and label
5. different components.
6. Explain different fault of automobile air conditioning system, their causes and remedies.

Activity

1. Make a list of components of air conditioning system of a vehicle.

S.No.	Component
1	
2	
3	
4	

2. Prepare a poster showing circuit diagram of air conditioning system of a vehicle.

ANSWER KEY

Unit – 1: Service Manual

Session 1: Service Manual of Respective Vehicle		
Fill in The Blanks	1. Troubleshooting	2. Resistance
	3. Service Manual	
Multiple Choice Question	1. C	2. D
	3. B	4. C

Unit – 2: Serviceability, Replacement or Repair of Engine Components

Session 1: Reconditioning of Valve Mechanism		
Fill in The Blanks	1. Camshaft	2. Reconditioning
	3. Valve Seat	4. Cylinder Head
Multiple Choice Questions	1. C	2. C
	3. B	4. D
Session 2: Inspection and Replacement of Piston Rings		
Fill in The Blanks	1. Combustion Chamber	2. Compression Rings
	3. Top Dead Centre	4. Feeler
Multiple Choice Questions	1. D	2. C
	3. A	4. C
Session 3: Inspection and Replacement of Sleeves, Connecting Rod And Engine Bearing		
Fill in The Blanks	1. Bore Sleeve	2. Replaced
	3. Metal Particles	4. Alignment
Multiple Choice Questions	1. B	2. D
	3. C	4. B
Session 4: Testing of Cooling System and Replacement of Defective Component		
Fill in The Blanks	1. Overheating	2. 30
	3. Coolant	4. Thermostat
Multiple Choice Questions	1. C	2. A
	3. C	4. D
Session 5: Regular Servicing of MPFI System		
Fill in The Blanks	1. Air-Fuel Ratio	2. EGR (Exhaust Gas Recirculation) Flow
	3. Thermistor	4. Injector Energizing Time
Multiple Choice Questions	1. A	2. D
	3. C	4. D
Session 6: Servicing of CRDI And Non CRDI System		
	1. Cylinder	2. Air

Fill in The Blanks	3. Engine Speed	4. Atomized
Multiple Choice Questions	1. D	2. D
	3. C	4. D

Unit – 3: Transmission System

Session 1: Overhauling of Clutch

Fill in The Blanks	1. Spring.	2. Oil Leakage
	3. Transmitted	4. Clutch Judder.
Multiple Choice Questions	1. D	2. C
	3. D	4. B

Session 2: Servicing of Propeller Shaft, Universal and Slip Joints

Fill in The Blanks	1. Bent	2. Engine, Wheels
	3. Universal	4. Steering Knuckle
Multiple Choice Questions	1. B	2. B
	3. D	4. C

Session 3: Servicing of Differential Unit and Adjustment

Fill in The Blanks	1. Different	2. Wheels
	3. Contact	4. Shaft
Multiple Choice Questions	1. C	2. D
	3. C	4. A

Session 4: Automatics Transmission System

Fill in The Blanks	1. the propeller shaft	2. lubrication
	3. components	4. planetary gearing
Multiple Choice Questions	1. C	2. D
	3. B	4. C
	5. A	6. C

Unit – 4: Suspension System

Session 1: Maintenance of Suspension System

Fill in The Blanks	1. Optimum	2. Contact
	3. Tear	4. Ride
Multiple Choice Questions	1. C	2. D
	3. C	4. B

Session 2: Service and Repair of Leaf Spring Set

Fill in The Blanks	1. Axle	2. Cambering
	3. Cycle	4. Softer
Multiple Choice Questions	1. D	2. B
	3. B	4. D

Session 3: Replacement of Strut/Shock Absorber, Steering Linkage		
Fill in The Blanks	1. Ride Quality	2. Defect
	3. Suspension System	4. Spring Compressor
Multiple Choice Questions	1. C	2. C
	3. A	4. B
Session 4: Inspection of Steering Linkage		
Fill in The Blanks	1. Front	2. Safety, Control
Multiple Choice Questions	1. C	2. B
	3. C	4. D
Session 5: Manual and Power Steering System		
Fill in The Blanks	1. Worm and roller shaft	2. Linkage
	3. Crankshaft	4. Buses
Multiple Choice Questions	1. B	2. D
	3. B	4. C
Session 6: Steering System Adjustment		
Fill in The Blanks	1. Vibration	2. Wobble
	3. Straight	4. High
Multiple Choice Questions	1.B	2. C
	3. B	4. A

Unit – 5: Auto Electrical

Session1: Automotive Electrical and Electronics Symbol, Reading of Circuit Diagram, Cables Specification and Colour Code, Wiring Harness		
Fill in The Blanks	1. Electrical wire	2. Current
	3. Heat	4. Ignition coil
	5. Metal	
Multiple Choice Questions	1. B	2. A
	3. B	4. D
	5. C	6. B
Session 2: Electrical Test Equipment's		
Fill in The Blanks	1. Jumper	2. Voltage
	3. Damage	4. Time
Multiple Choice Questions	1. D	2. C
	3. B	4. D
	5. B	
Session 3: Battery and Its Maintenance		
Fill in The Blanks	1. Corrosive	2. Negative
	3. Arcing	4. Ammonia
	5. Electrolyte	6. State of charge
	1. C	2. D

Multiple Choice Questions	3. B	4.C
	5. B	6. A
Session 4: Checking of Electrical Connections of Lighting System in A Vehicle		
Fill in The Blanks	1. systematic	2. work
	3. Ground	4. ohmmeter
	5. one volt	6. Overheat
Multiple Choice Questions	1. C	2. B
	3. C	4. C
	5. B	6. A
Session 5: Application and Replacement of Fuses		
Fill in The Blanks	1. Excessive currents	2. Two
	3. End, End	4. Fuse Box
	5. Size, Type	
Multiple Choice Questions	1. B	2. C
	3. C	4. A
Session 6: Circuit Diagram of Charging System of Automobile and Checking of Charging System		
Fill in The Blanks	1. Alternator Clean	2. Drive belt slack
	3. 12, 2.2	4. Defective bulb, fuse blown
Multiple Choice Questions	1. C	2. D
	3. B	4. A
	5. C	6. A
Session 7: Circuit Diagram of Starting System of Automobile and Checking of Starter Circuit		
Fill in The Blanks	1. Mechanical	2. Multimeter
	3. Polish	4. Open
	5. Spring	
Multiple Choice Questions	1. B	2. D
	3. C	4. C
	5. A	6. D
Session 8: Circuit Diagram of Ignition System and Checking of Ignition Circuit		
Fill in The Blanks	1. Ground	2. Transistor
	3. Timing	4. Contact Breaker Point
	5. secondary	6. Lifespan
Multiple Choice Questions	1. C	2. D
	3. C	4. C

	5. B	6. D
Session 9: Maintenance and Servicing of Major Electrical Accessories		
Fill in The Blanks	1. Replaced	2. Centrifugal
	3. Opposite	4. Defective
	5. Surface	6. Pressure
Multiple Choice Questions	1. D	2. C
	3. D	4.A
Session 10: Introduction to Climate Control System Heating Ventilation and Air Conditioning in A Vehicle		
Fill in The Blanks	1. Driver, Passengers	2. Heat, Humidity
	3. Hot Water	4. Defroster
	5. Sight Glass	
Multiple Choice Questions	1. C	2. A
	3. C	4. C
	5. B	6. C

Glossary

Alternator:	**A component that generates electrical power for the vehicle's electrical system and charges the battery while the engine is running.**
Battery:	An energy storage device that provides electrical power to start the engine and power various electrical components in the vehicle.
Brake System:	A collection of components that work together to slow down or stop the vehicle, including brake pads, rotors, calipers, and brake fluid.
CV Joint (Constant Velocity Joint):	A joint that allows power to be transmitted from the engine to the wheels at varying angles, ensuring smooth power delivery even during turns.
Fuel Injection:	The process of delivering fuel into the engine cylinders in a precise and controlled manner for optimal combustion.
Gearbox/Transmission:	A mechanical system that transfers power from the engine to the wheels by selecting and changing gears according to the vehicle's speed and load.
Ignition System:	A system that generates the spark needed to ignite the air-fuel mixture in the engine cylinders, enabling combustion.
Oil Change:	The process of draining and replacing the engine oil to ensure proper lubrication and cooling of the engine components.
Radiator:	A heat exchanger that helps regulate the engine's temperature by dissipating heat from the engine coolant.
Timing Belt/Chain:	A component that synchronizes the movement of the engine's crankshaft and camshaft, ensuring proper engine performance.
Tyre Rotation:	The practice of moving tyres from one-wheel position to another to promote even tyre wear and extend tyre life.
Wheel Alignment:	The adjustment of the angles of the wheels to ensure they are parallel to each other and perpendicular to the road, improving steering stability and tyre wear.
Wheel Balancing:	The process of equalizing the weight distribution of a tyre and wheel assembly to prevent vibrations and uneven tyre wear.

Catalytic Converter:	A component that reduces harmful emissions by converting pollutants in the exhaust gases into less harmful substances.
Differential:	A gearbox that distributes power from the transmission to the wheels while allowing them to rotate at different speeds, crucial for turning.
Spark Plug:	A device that produces an electric spark to ignite the air-fuel mixture in the engine's cylinders.
Power Steering System:	A system that assists the driver in turning the steering wheel by using hydraulic or electric power to reduce steering effort.
Suspension Bushings:	Rubber or polyurethane components that connect various suspension parts, allowing movement while maintaining stability.
Shock Absorbers:	Dampers that absorb and dissipate energy from road irregularities, providing a smoother ride and better vehicle control.
Transmission Fluid:	A lubricating fluid that cools and facilitates smooth gear shifting within the transmission.
Differential Fluid:	Fluid that lubricates and cools the gears and bearings within the differential, ensuring smooth power distribution.
Transfer Case:	A gearbox that divides engine power between the front and rear axles in all-wheel-drive and four-wheel-drive vehicles.
Emission Control System:	Components that reduce harmful exhaust emissions to comply with environmental regulations.
Drive Belt:	A belt that transfers power from the engine to various components such as the alternator, water pump, and air conditioning compressor.
Drive Shaft:	A rotating shaft that transfers power from the transmission to the differential in rear-wheel-drive and four-wheel-drive vehicles.
ABS (Anti-lock Braking System):	A safety system that prevents the wheels from locking up during braking, allowing the driver to maintain steering control.
HVAC (Heating, Ventilation, and Air Conditioning) System:	A system that controls the interior temperature and air quality within the vehicle.
EGR (Exhaust Gas Recirculation) Valve:	A valve that recirculates a portion of exhaust gases back into the engine cylinders to reduce emissions.

Knock Sensor:	A device that detects abnormal vibrations or knocking in the engine and sends signals to the ECU to prevent engine damage.
Timing Chain:	A metal chain that connects the crankshaft to the camshaft, synchronizing their movements.
Exhaust Manifold:	A component that collects exhaust gases from the engine cylinders and directs them into the exhaust system.
Differential Lock:	A mechanism that locks the differential to ensure equal power distribution to both wheels, improving traction in off-road conditions.
Propeller Shaft:	A shaft that transmits power from the transmission to the differential in rear-wheel-drive and four-wheel-drive vehicles.
Water Pump:	A component that circulates coolant through the engine to prevent overheating.
Idler Arm:	A pivoting component that supports the steering linkage and helps maintain proper alignment.
Pitman Arm:	A steering component that connects the steering box to the steering linkage.
Drag Link:	A steering component that connects the pitman arm to the steering knuckle, transmitting steering input.
Fuel Pressure Regulator:	A device that maintains a consistent pressure in the fuel system for proper fuel delivery.
Transmission Shift Solenoid:	An electromagnetic device that controls the engagement of gears in an automatic transmission.
Fuel Injector:	A component that sprays fuel into the engine cylinders in a controlled manner for combustion.
Compression Ratio:	The ratio of the volume in a cylinder when the piston is at the bottom of its stroke to the volume when the piston is at the top of its stroke, affecting engine efficiency and power.
Torsion Bar Suspension:	A suspension system that uses torsion bars to support the vehicle's weight and absorb shocks.
Variable Valve Timing (VVT):	A technology that adjusts the timing of the engine's valves to optimize performance, efficiency, and emissions.
Camber Angle:	The vertical tilt of the wheels relative to the road surface, affecting tyre wear and handling.

Caster Angle:	The angle between the steering axis and the vertical axis when viewed from the side, influencing steering stability.
Toe Angle:	The angle formed by the longitudinal axis of the wheels in relation to each other, affecting tyre wear and handling.
Driveline:	The components that transmit power from the engine to the wheels, including the transmission, driveshaft, and differential.
Distributor Cap:	A protective cover on the distributor that directs the high-voltage current to the correct spark plug.
Evaporative Emission Control System (EVAP):	A system that captures and stores fuel vapors from the fuel tank to prevent them from entering the atmosphere.
Curb Weight:	The weight of a vehicle with all fluids and a full tank of gas, but without passengers or cargo.
Power Steering Fluid:	Fluid that provides hydraulic assistance to the power steering system for easier steering.
Transmission Fluid Cooler:	A device that cools transmission fluid to prevent overheating during heavy use.
Heat Exchanger:	A device that transfers heat from one fluid to another, such as a radiator or oil cooler.
Active Suspension:	A suspension system that uses sensors and electronic controls to adjust suspension settings in real-time for optimal performance.
Engine Knock:	The metallic pinging or knocking noise produced when the air-fuel mixture detonates prematurely in the engine.
Clutch Judder:	A vibration or shuddering felt during clutch engagement, often due to worn clutch components.
Rack and Pinion Steering:	A steering system that uses a gear mechanism (rack) and a toothed bar (pinion) to convert rotational motion into linear motion for steering.
Treadwear Rating:	A standardized measurement indicating a tire's expected lifespan based on its wear performance in comparison to a reference tyre.
Camber Wear:	Uneven tyre wear caused by improper camber alignment, typically appearing as excessive wear on one side of the tyre tread.
Brake Fade:	A decrease in braking effectiveness due to overheating of the brake components, resulting in reduced stopping power.

Four-Wheel Steering:	A system that allows the rear wheels to turn in coordination with the front wheels to improve maneuverability and stability.
Manifold:	A component that collects and directs fluids or gases, such as the intake manifold and exhaust manifold.