EXCITING WORLD OF

AUTOMOBILES

STUDENT WORKBOOK

Automobile Technology

Level – 4, Class XII

Vocational Learning Material for Schools

PSSCIVE, Bhopal

PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION

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PREFACE

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

The present material contains activity unit related to Level L-4 for the Automobile service sector. This will fulfill the needs of the students willing to learn activities relating to the Automobile Service Sector. Any student/ entrepreneur willing to start an Automobile Service Sector can acquire the desired competencies with the help of this book.

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

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

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

Prof. R.B. Shivagunde
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January, 2016

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

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

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Vocational Learning Material for Schools

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Bhopal

Introduction

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 service center for repairs for critical defect, a mechanic refers to the service manual of a model. This service manual is made available to the service center by respective manufacturer of a vehicle. As we know that now a days, a new models of vehicles keep coming regularly in the market and all technical information is to be made available to the service mechanic/technician/service advisor. Service manual gives detail information about technical details of a particular vehicle.

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

In this Unit, you will develop an understanding of the service manual.

Session 1: Reading of Service manual

Relevant Knowledge

Automobile is a complex unit of machinery. This requires regular services to maintain in originality in performance, appearance, control, and safety efficiency. The Research and Development in auto manufacturers facilitates all the comforts with efficiency so it is the duty of service workshop to maintain originality in performance of vehicle. The manufacturers develops service manual which gives clear cut ideas of their product, like material used specification, service limit, span life of component, storage life and sequences to overhaul etc. Figure of service manual are given here with. The service manual helps to teach the technicians to work on the vehicle systematically to solve the problems as well as to provide service to maintain originality.

The service manual takes cover of the following areas:

1. Expanded view of an 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.

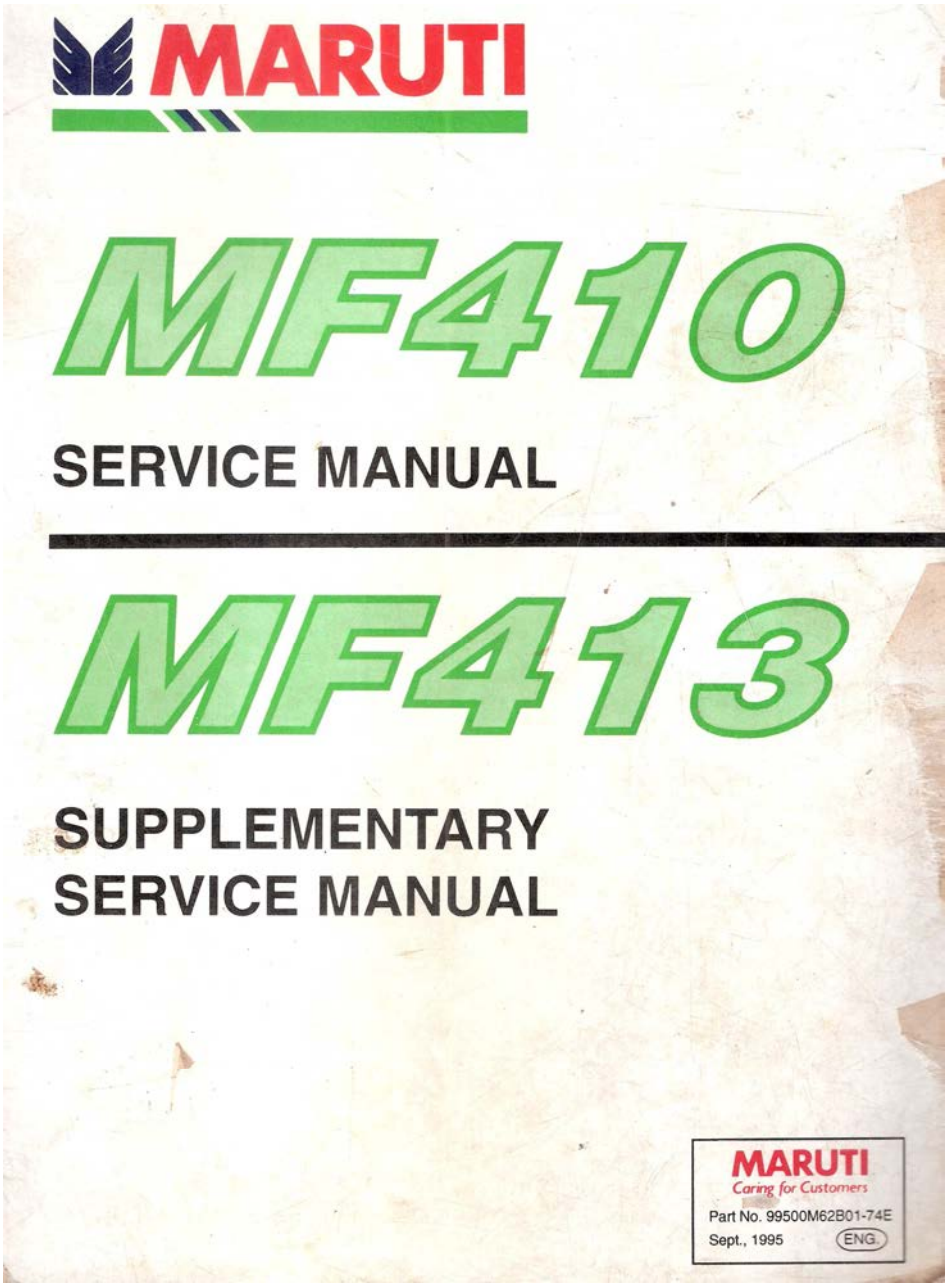

Fig1: Service manual

Fig 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.

- Index
- Page number
- 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 technician/mechanic must use the service manual regularity to check the serviceability of component. This helps the technician 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.

Service manual should be kept in handy place for ready reference for the service work. Strict observation of the so specified item will enable one to obtain the full performance of the vehicle.

The automobile today has many electrical, electronic gadgets which operate only at specialized voltages, amperage and resistance. The service manual gives range of voltage, amperage and resistance in variation of speed. This helps technician to take appropriate decision to solve the problem. The service manual also gives circuit diagram with colour code. This assists the mechanic to trace the connectivity and continuity in supply of current to senses and other units also. Technician should use service manual as per make of the vehicle.

Assessment

Session : Reading of Service manual

Exercise: Assignment

1. List the content of vehicle service manual seen.

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

2. Writ the part number of following components
   a. Clutch disc
   b. Diskpad
   c. Headlight
   d. Backlight
   e. Piston

Session: Reading of Service manual

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

1. Why service manual is used?
2. Who develops the Service manual?

Fill in the blanks

1. Service manual are important for _____ .
2. Service manual is used for_____,
3. Service manual is available with a _____.
4. Mechanic use_____ for any defect in a vehicle.

Session : Reading of Service manual

Checklist for Assessment Activity

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

Part A

- Able to read and understand the vehicle service manual.

Part B

Discussed in class the following:

- Importance of service manual.
- What are advantages of using service manual?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to use service manual		
Able to identify the number of item in service manual.		

STUDENT WORKBOOK

Curriculum :AUTO-SRV *L4-NQ*^{2016}

Unit :AUTO-SRV *L4U2*

Fasteners

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Introduction

Fasteners

An automobile vehicle is an assembly of a large number of sub-assemblies and components. The assemblies such as engine-clutch-gearbox-differential-wheels-brakes etc. together may form a vehicle. Each of these assemblies is formed by joining many components. Some of the components or sub-assemblies can move with respect to each other, others are physically fixed together, with no relative motion possible. The first type of connection is called a ***kinematic joint***, and the second type is called a ***rigid joint*** (or a ***structure***). Both types of joints are important in manufacturing a vehicle, and there are many ways of achieving such joints. The process and methods used for joining depend on the type of joint, the required strength, the materials of the components being joined, the geometry of the components, and cost issues. There are five most common methods of joining:

1. Mechanical fasteners
   - Screws
   - Bolts
   - Nuts and
   - Rivets
2. Welding
3. Brazing
4. Soldering
5. Adhesive bonding

In this we will study about the fasteners used in automobiles.

Mechanical Fasteners

A fastener is a hardware device that mechanically joins or affixes two or more objects together. A fastener can be a button or a zipper as well as a bolt or a screw. Varieties of fasteners are available in the market as shown in Fig-1 and can be selected according to need or requirement.

Automotive fasteners are the mechanical devices or components like bolts, nuts, screw, stud, rivets, shims, pin, tie rods etc used for holding or connecting two or more objects together in a structure.

Fasteners are widely used in number of industries such as aerospace, defense, automotive, petrochemical, waste processing, marine and pharmaceutical sectors. Automotive fasteners are made up of variety of metals such as stainless steel, iron, brass, aluminum, nickel etc.

Fig-1 Fasteners

The parts or components, which need to be dismantled for repair and replacement, are joined by mechanical fasteners. For example the main components of engine such as cylinder block, cylinder head, cylinder head cover, crank case etc; are joined by fasteners. Similarly there are many other sub-assemblies which are joined by fasteners to make an engine. If the parts or sub-assemblies malfunction, can be repaired or replaced by opening the fasteners.

Session-1: Automotive bolts/machine screws

Relevant Information

Automotive bolts often known as threaded fasteners is one of the types of auto fasteners that comprises of either a threaded pin or rod having a head at one end. The bolts are inserted through holes in assembled parts and fastened by a mated nut with a help of torque. Therefore a bolt is an externally threaded headed fastener, which is used in conjunction with a nut. To obtain reliable and repeatable fastener torque the bolt / nut combination should always be tightened by holding the bolt head stationary and turning the nut. The machine screw is an externally threaded headed fastener, which is tightened by applying torque to the head, causing it to be threaded into the material it will hold. Nearly any bolt with a common head can be used as a screw by tightening it by the head into a tapped hole (Fig-2). The head of machine screw does not necessirily be hex can be of different shapes. Usually the machine screws are fully threaded.

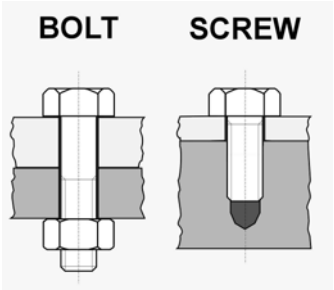


Fig-2 Bolt and screw

A wide variety of automotive bolts are available in the market such as connecting rod bolts, wheel bolts, hub bolts, U-bolts, J-bolts, engine mounting bolts, suspension links and bolts, lug bolts, radiator bolts, motor mount bolts and all mounting plates bolts etc. The parts of a standard bolt are shown in Fig-3. A bolt is defined either in Inch or Metric. The machine screw or bolt is described by length, the type of head and the thread.

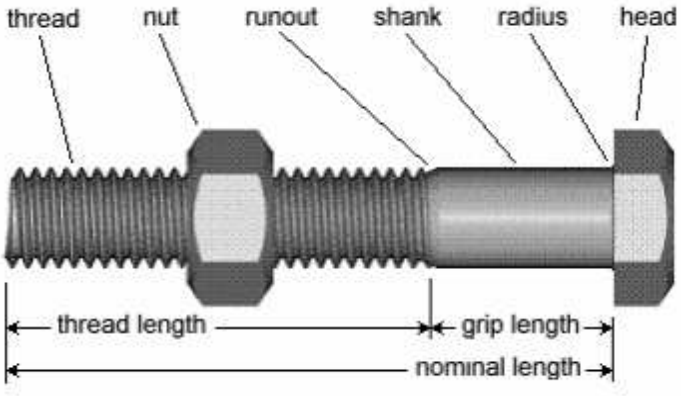


Fig-3 Parts of standard bolt

Thread on the bolt: A thread is a ridge of uniform section in the form of a helix on the internal or external surface of a cylinder or it could be described as a sloping plane curled around a cylinder.

External threads are on the bolts or screws and internal threads are on the nuts. There are two types or directions of the thread helix, left hand and right hand threads. Most Common threads are right hand threads. Always be sure to check if the lead screw is right hand or left hand threads before purchasing. Right hand threads are denoted (RH) and (LH) for left hand threads. The saying “righty tighty lefty loosey”

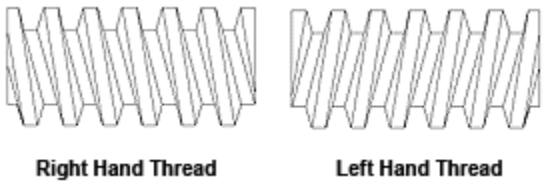


Fig-4

describes a right hand thread and nut, where turning the nut clockwise or right moves the nut further along the lead screw. Left hand screws are opposite. The Fig-4 shows how to identify left and right hand threads.

The number of starts on most threads is one (single start). However, number screw threads may have from 2 to 20 starts or more. As illustrated in Fig-5, if the end view is an offset circle, the screw is single start. A two start thread will have roughly a football shape, a three start thread will have a tri-oval shape and a four start thread will be noticeably four cornered. Usually, five starts and up can simply be counted in the transverse section.

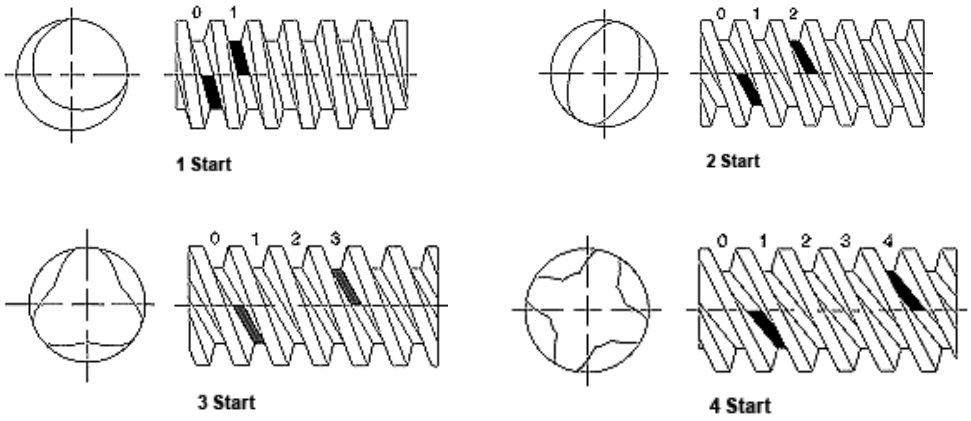


Fig-5 Number of starts

Basic thread terms

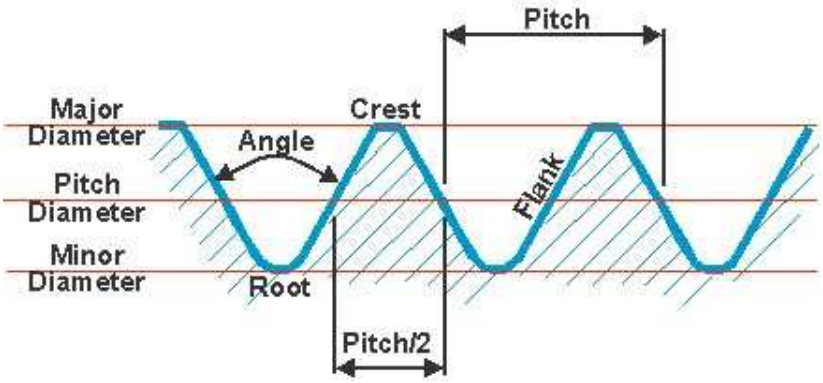


Fig-6 Basic thread terms

The basic terms of thread are shown in Fig-6 and described below:

Pitch diameter: The pitch diameter (often called the effective diameter) of a parallel thread is the diameter of the imaginary co-axial cylinder which intersects the surface of the thread in such a manner that the intercept on a generator of the cylinder, between the points where it meets the opposite flanks of a thread groove, is equal to half the nominal pitch of the thread.

Major diameter: The major diameter of a thread is the diameter of the imaginary co-axial cylinder that just touches the crest of an external thread or the root of an internal thread.

Minor diameter: The minor diameter is the diameter of an imaginary cylinder that just touches the roots of an external thread and (or) the crests of an internal thread.

Crest: The crest of a thread is the prominent part of a thread, whether internal or external.
Root: The root is the bottom of the groove between the two flanking surfaces of the thread whether internal or external.
Flank: The flanks of a thread are the straight sides that connect the crest and the root.
Thread angle: The angle of a thread is the angle between the flanks, measured in an axial plane section.
Pitch: The pitch of a thread is the distance, measured parallel to its axis, between corresponding points on adjacent surfaces, in the same axial plane.

Basic profile of metric thread

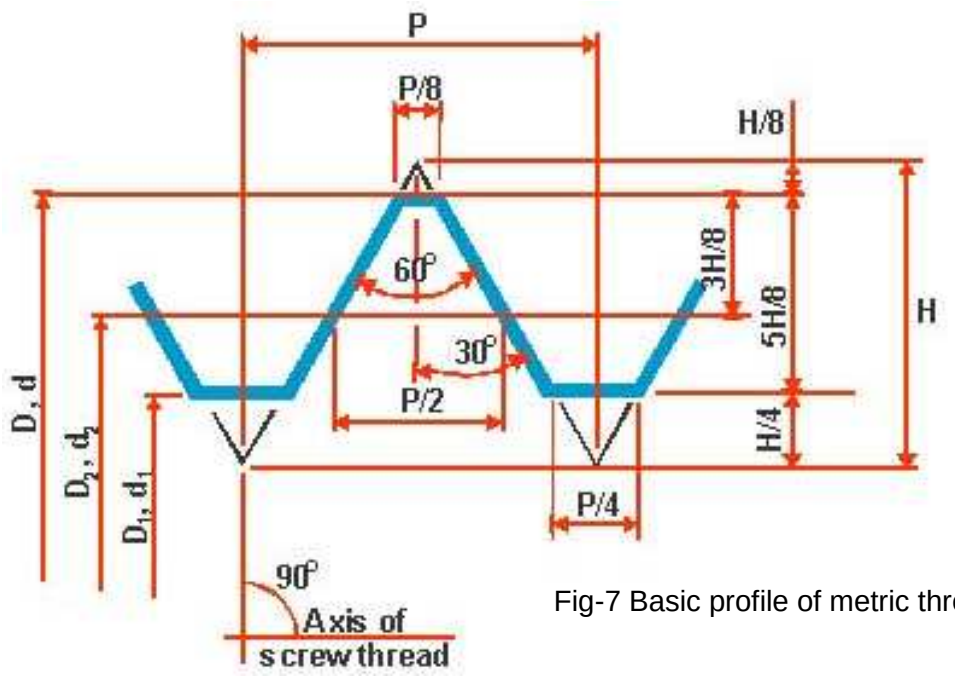


Fig-7 Basic profile of metric thread

In the country we use ISO metric thread and the basic profile is shown in Fig-7, where
D= Major diameter of internal thread (Nut)
d= Major diameter of external thread (bolt)
D_2= Pitch diameter of internal thread
d_2= Pitch diameter of external thread
D_1= Minor diameter of internal thread
d_1= Minor diameter of external thread
P= Pitch
H= Height of fundamental triangle

d = D = nominal diameter	d2 = D2 = d - 0.6495 P	H = 0.866 P
d1 = D1 = d - 1.0825 P	P = Pitch	r = 0.1443 P

Bolt head dimensions

Bolt head dimensions are related to their diameter as follows (Fig-8):
Structural bolts: A large, heavy-duty hex bolt used for structural applications in buildings and bridges, ships, aeroplane and vehicles. Heavy hex structural bolts are designed for steel-to-steel structural connections. Consequently, they are typically very short.

Nonstructural bolts: These are general duty hex bolts used in sheet metal works and for fixing trims in vehicles.

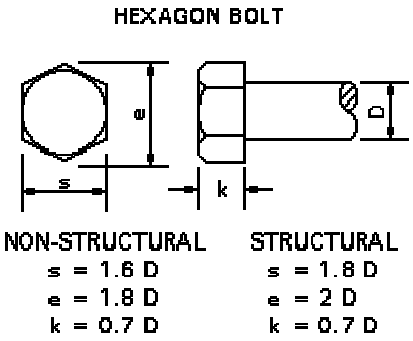
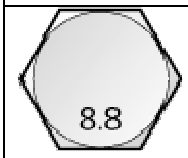
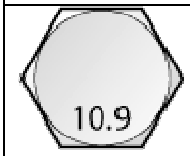


Fig-8 Bolt head dimensions

Bolt head marking

Bolt head marking for metric bolts is shown in the table below:

Head Marking	Class and Material	Nominal Size Range (mm)	Mechanical Properties		
			Proof Load (MPa)	Min. Yield Strength (MPa)	Min. Tensile Strength (MPa)
 8.8	**Class 8.8** Medium Carbon Steel, Quenched and Tempered	All Sizes below 16mm	580	640	800
		16mm - 72mm	600	660	830
 10.9	**Class 10.9** Alloy Steel, Quenched and Tempered	5mm - 100mm	830	940	1040
 12.9	**Class 12.9** Alloy Steel, Quenched and Tempered	1.6mm - 100mm	970	1100	1220
Stainless markings vary. Most stainless is non-magnetic. Usually stamped A-2	**A-2 Stainless** Steel alloy with 17-19% Chromium and 8-13% Nickel	All Sizes thru 20mm		210 Min. 450 Typical	500 Min. 700 Typical

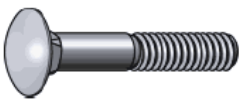
Tensile Strength: The maximum load in tension (pulling apart) which a material can withstand before breaking or fracturing.
Yield Strength: The load at which a material exhibits a specific permanent deformation.
Proof Load: An axial tensile load which the product must withstand without evidence of any permanent set.
1MPa = 1N/mm^2 = 145 pounds/inch^2

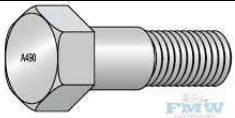
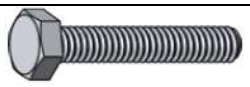
Bolt/machine screw material

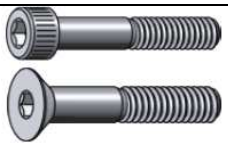
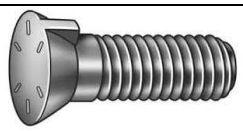
Bolt and machine screws are made of the following materials.

Material	Features
Aluminum	These are light, resistant to oxidation, thermal and electrical conducive, and easy to manufacture.
Brass	These are strong, conductive, and corrosion resistant, with low magnetic permeability
Copper alloy	They have good load capacity, wear resistance, and are suitable for use near magnets.
Plastic	These are inexpensive and corrosion resistant for light loads. They are common for applications near water, such as pools.
Steel	These are produced of strong, carbonated iron. Uncoated steel is vulnerable to corrosion.
Hardened steel	These are stronger than steel screws, but more brittle. They are made of steel treated by tempering and quenching methods.
Stainless steel	These are chemical and corrosion resistant with an appealing finish. They cannot be hardened like carbon steel.
Super alloys	They exhibit good mechanical strength, surface stability, corrosion resistance, and resistant to creep at high temperatures.
Titanium	These screws are hard and strong, light, and corrosion resistant. When alloyed with other metals, it increases strength and durability.

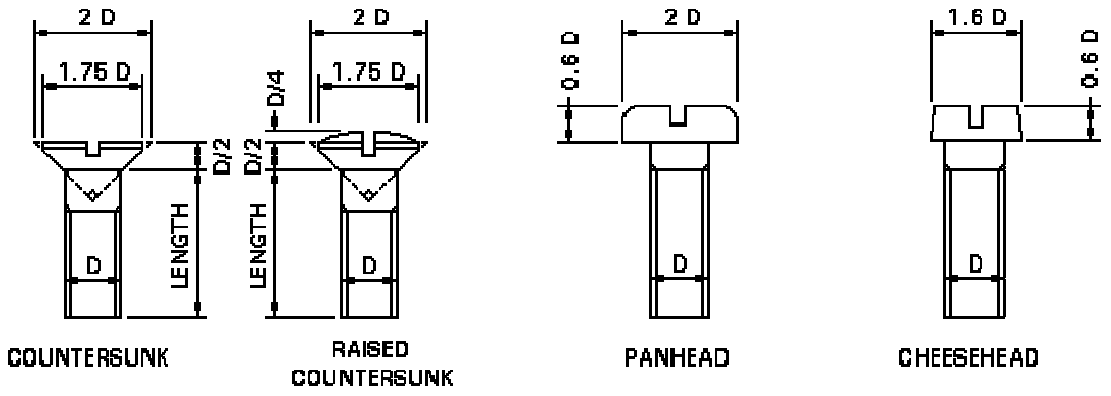
Types of bolts: The table below shows the different types of bolts available and can be used according to job and requirements.

Type	Shape	Features
Anchor bolt		Available in roll thread as well as cut thread and "J" shaped Anchor bolts: Available in roll thread as well as cut thread. Threaded studs: Available in roll thread and cut thread.
Carriage bolt		A type of threaded fastener designed to be used with wood, although specialized versions can be used to fasten metal components. Carriage Bolts come in an assortment of lengths, diameters, and thread pitches.

Elevator bolt		A type of threaded fastener designed to be used with wood, although specialized versions can be used to fasten metal components.
Eye bolts		An Eye Bolt is a screw with a loop on one end and threads on the other end. Eye bolts are commonly used to attach cables to objects, for instance attaching a string to the back of a painting to allow the painting to hang from a nail on a wall.
Flange bolt		Flange Bolts are also known as Frame Bolts, Hex Frame Flange Bolts and Hex Flange Screws. The large bearing surface distributes clamping force over a large area, allowing them to be used with irregular and over sized holes.
Frame bolt		A bolt that is used in truck frames. A one-piece Hex-Washer head bolt with a flat bearing surface made of high alloy steel. The flange eliminates washers and helps compensate for a misaligned hole.
Hanger bolt		Hanger Bolts are threaded at both ends. One end is a lag screw thread for wood; the other end has a bolt thread. Standard hanger bolts are designed for insertion into a predrilled pilot hole.
Heavy hex bolt		A low carbon steel Hex Head Bolt with a wider head than that of a standard Hex bolt. It offers greater wrenching area than standard Hex Machine bolts for use in heavy duty industrial work.
Hex bolt		Hex bolts have a head style shaped in a hexagon shape which are common throughout the industry. They are available in different grades of steel, stainless, brass, silicon bronze and other types of material.
Hex machine bolt		Hex bolts are bolts with a hexagonal head on one end, with no washer face on the bearing surface, and a threaded shaft on the other end; hex bolts are tightened with a wrench, they are used to connect metal parts.
Socket shoulder bolt		A Hex Socket Head Screw with an enlarged, unthreaded, cylindrical shoulder under the head. For rotation or sliding applications such as pulley shafts in punch and die works or for use as a bearing pin.
Lag bolt		A Lag Bolt or screw is a full bodied bolt with a hex head, spaced threads and a gimlet point. For use in wood

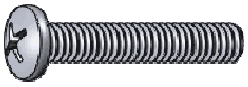
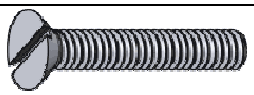
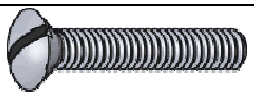
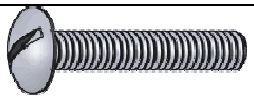
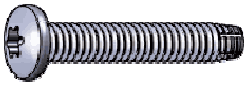
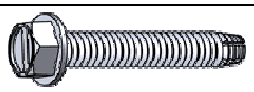
		applications such as fences, patio covers etc.
Socket screws		A Hex Socket Head Screw with an enlarged, unthreaded, cylindrical shoulder under the head. For rotation or sliding applications such as pulley shafts in punch and die works or for use as a bearing pin. Allen head wrench is used for tightening the screw.
Square head bolt		Square headed bolts are the same basic size and shape as the Hex Cap screw except the head is square instead of hexagonal. They have the Roll thread and also come in the Lag screw thread as well.
U-Bolt		A U-Bolt is a U shaped bolt with two threaded arms protruding from a curved base. U-bolts are used as framing fasteners and anchors for foundations and roofs, pipe and conduit holders and bolts for motor and engine shaft components.
Knurled bolts		This is a special bolt that is used in Electrical Switchboards and or Panel Boards.
Plough bolt		A type of fastener that is used for making mechanical connections that require a smooth, or flush, surface at the location where the bolt head protrudes. Today plough bolts are used on many types of heavy construction equipment, such as snowplows, road graders, and scoop shovels.
T-head bolt		A type of bolt with a T-shaped head that matches T-slots in a machine table. T-head bolts are used for holding parts on a machine table.

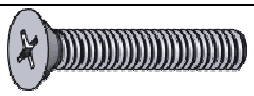
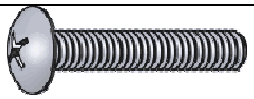
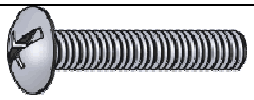
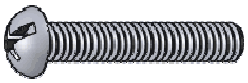
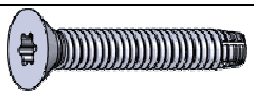
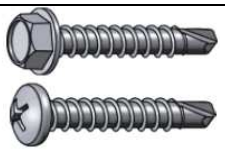
Machine screws: Machine screws have machine threads for use with a nut or in a tapped hole. Also referred to as a stove bolt. The dimensions of metric machine screws are shown below:



ISO METRIC MACHINE SCREWS

Different types of machine screws categorized on the bases head shape and features are shown in the table below:

Type	Shape	Features
Phillips pan head		Pan heads are slightly rounded with short vertical sides. Phillips drives are X shaped for a Phillips screw driver.
Slotted flat head		Flat heads are countersunk (cone shaped under the head) with a flat top. Slotted drives are simple slots for a flat bladed screw driver.
Slotted oval head		Oval heads are countersunk (cone shaped under the head) with a rounded top. Slotted drives are simple slots for a flat bladed screw driver.
Slotted truss head		Truss heads are wide with a low profile rounded top. Slotted drives are simple slots for a flat bladed screw driver.
Slotted round head		Round heads are domed and look like half of a sphere. Slotted drives are simple slots for a flat bladed screw driver.
Torx pan head type F		Type F screws have a thread cutting tip. Pan heads are slightly rounded with short vertical sides. Torx drives are six pointed recesses designed for maximum installation torque.
Slotted hex washer head type F		Type F screws have a thread cutting tip. Slotted hex washer heads are six sided for use with a wrench, have a slot for use with a flat

		bladed screw driver and have a built in washer.
Phillips flat head		Flat heads are countersunk (cone shaped under the head) with a flat top. Phillips drives are X shaped for a Phillips screw driver.
Phillips oval head		Oval heads are countersunk (cone shaped under the head) with a rounded top. Phillips drives are X shaped for a Phillips screw driver.
Phillips truss head		Truss heads are wide with a low profile rounded top. Phillips drives are X shaped for a Phillips screw driver.
Combo truss head		Truss heads are wide with a low profile rounded top. Combination drives have both a slot and an X shaped recess for use with either a flat bladed or Phillips screw driver.
Combo round head		Round heads are domed and look like half of a sphere. Combination drives have both a slot and an X shaped recess for use with either a flat bladed or Phillips screw driver.
Torx flat head type F		Type F screws have a thread cutting tip. Flat heads are countersunk (cone shaped under the head) with a flat top. Torx drives are six pointed recesses designed for maximum installation torque.
Set screw		Machine screws with no head for screwing all the way into threaded holes.
Sheet metal screw		A sheet metal screw with a self drilling point.

Session-1: Automotive bolts/machine screws

A. Exercise: Assignment

1. List the types of bolt used in a vehicle and state their features

Sr.No.	Type of bolt	Features
1		
2		
3		
4		

2. List the types of machine screws used in a vehicle and state their features

Sr.No.	Type of bolt	Features
1		
2		
3		
4		

1. Make a poster showing basic profile of metric thread

Session-1: Automotive bolts/machine screws
Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

3. A fastener is a hardware -------- that mechanically joins or ---------- two or more objects together.
4. Automotive fasteners are made up of variety of ----------.
3. A bolt is an externally threaded --------fastener, which is used in conjunction with a ----------.
4. External threads are on the ---------- or screws and internal threads are on the ----------.

5. In the country we use ISO ---------- thread.
6. Machine screws have machine --------- for use with a nut or in a ---------- hole.

Session-1: Automotive bolts/machine screws

Use the following checklist to see if you've met all the requirements for automotive bolts/machine screws.

Part A

- Able to identify and understand the use of automotive bolts/machine screws used in vehicle.

Part B

Discussed in class the following:

- Describe the importance of bolts.
- Describe the importance of machine screws.
- What is importance of threads on bolt and machine screws and why threads are important?
- Differentiate between bolt and screw.
- What you understand by metric thread? Make a profile of metric thread and state all the terminologies.
- Name different types of bolts.
- Name different types of machine screws.

Performance standards/criteria covered by this assessment

Performance standards	**Yes**	**No**
Able to understand importance of bolts and machine screws as fasteners		
Able to identify different types of bolts		
Able to identify different types of machine screws		
Able to loosen and tighten different types of bolts and screws using hand tools		

Session-2: Automotive Nuts

Relevant Information

Fig-9 Different types of nuts

A nut is a type of fastener with a threaded hole. Nuts are almost always used opposite a mating bolt to fasten a stack of parts together. The two partners are kept together by a combination of their threads' friction, a slight stretch of the bolt, and compression of the parts. In applications where vibration or rotation may work a nut loose, various locking mechanisms may be employed. Automotive nuts, one of the important types of auto fasteners are usually square or hexagonal shaped metal having a threaded hole which is used for screwing a bolt that hold together temporary or permanent structures through which bolt passes. Automotive nuts can be of different types such as simple nuts, collar nuts, locking nuts, t-nuts, hex nuts, jam nuts, lug nuts, plate nuts, self locking nuts, stainless steel nuts etc. Different types of nuts are shown in Fig-9.

Thread profile in nut

For joining two metal part the nut is screwed on the bolt. Therefore the thread profile of bolt and nut must match. Since in the country we use metric threads, the nut being used in conjuction with bolt have metric threads as well. The pitch of the bolt and nut must be same else the nut can not be screwed on the bolt. Mismatching of the profile and forcible screwing will damage the thread profiles of nut and bolt and nut will be loose on the bolt. The nut can have left hand or right hand internal threads.

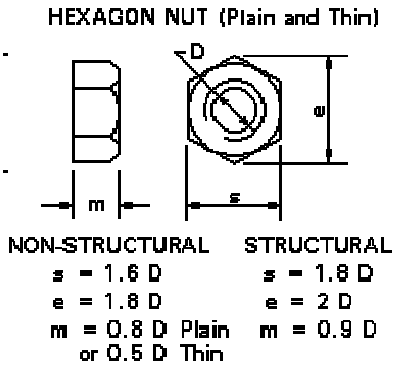


Fig-10 ISO metric nut

Dimensions of nut

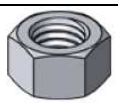
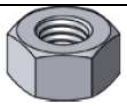
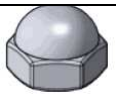
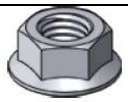
The dimensions of ISO metric nut are shown in Fig-10. All the dimensions are related to the internal diameter of the nut.

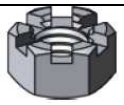
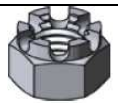
Material of nuts

The nuts are made of the same material as bolts which can be aluminium, brass, copper alloy, plastic, steel, hardened steel, stainless steel, super alloys, titanium etc.

Types of nuts

Different types of nuts are shown in the table below:

Type	Shape	Features
Hex		A hexagonal nut is a type of metal fastener that has six sides. Most nuts are cut in a hexagonal shape, since it seems to be the easiest shape to grasp. Nuts, in any form, are almost exclusively used to fasten a bolt to another object.
Heavy hex		Heavy hex nuts are slightly larger and thicker than standard (finished) hex nuts. Because of their secure hold and durability they are usually used for large diameter and high strength bolt applications.
Nylon insert lock		A torque prevailing nut that uses nylon patented insert to provide a locking feature. The nylon insert, it is claimed, helps to seal the bolt thread against seepage of water, oil, petrol, paraffin and other liquids.
Jam		The term is sometimes used for thin (or jam) nuts used to lock a thicker nut. When used in this way the thin nut should be adjacent to the joint surface and tightened against the thick nut. If placed on top of the thick nut the thin nut would sustain loads it was not designed to sustain.
Nylon insert jam lock		Threads are molded into the nylon insert locking the bolt into place. Nylon Insert Jam Lock Nuts typically have a cased metal outside formed into a hex pattern easily torqued by a wrench or socket. Jam nylon locknuts are thin pattern hex jam nuts with a nylon insert inside the nut that tightens to restrict loosing of the nut.
Wing		A wingnut or wing nut is a type of nut with two large metal "wings", one on each side, so it can be easily tightened and loosened by hand without tools.
Cap		Cap Nuts are used to cover exposed threaded stud, rod and bolt ends with a dome-like cap. This provides safety and a finished look to the exposed threaded end.
Acorn		A nut (so-called because of its shape) that has a domed top so that it prevents contact with the external thread.
Flange		Enlarged circular base distributes heavy pressures equally in order to assure a secure hold. Large base requires a greater amount of torque to loosen and will cover an oversized or poorly aligned hole.

Tee		Tee Nuts are Internally threaded fasteners used to fasten to wood, particle board or plastic, leaving a flush surface. They have a long, thin body with a flange at one end that often have prongs or serrations. Available in 3-prong and 4-prong styles.
Square		A square nut is a four-sided nut. Compared to standard hex nuts, square nuts have a greater surface in contact with the part being fastened, and therefore provide greater resistance to loosening (though also greater resistance to tightening). Square nuts are typically mated with square-headed bolts.
Prevailing torque lock		A type of lock nut which has a prevailing torque to assist in preventing self loosening. There are two main categories of prevailing torque nuts, all metal and nylon insert. All metal torque prevailing nuts generally gain a prevailing torque by distorting the threads at the top of the nut by some means. Nylon insert torque prevailing nuts utilizes a nylon (or other polymer) insert to achieve a prevailing torque.
K-lock or Kep		A Keps nut, also called a K-nut or washer nut, is a nut with an attached, free-spinning washer. It is used to make assembly more convenient. Common washer types are star-type lock washers, conical, and flat washers.
Coupling		Designed to join two externally threaded objects, usually threaded rod, together. Reducing Coupling Nuts are available.
Slotted		Slotted Hex Nuts are hex nuts with opposed slots cut into the top of the nut. Typically the slots are cut through the center of the flats. These slots are for the insertion of a cotter type pin. Used in many applications but used specifically in automotive bearing/wheel hub to spindle assemblies.
Castle		A castellated nut, also called a castle nut , is a nut with slots (notches) cut into one end. The bolt or axle has one or two holes drilled through its threaded end. The nut is torqued properly and then, if the slot is not aligned with the hole in the fastener, the nut is rotated forward to the nearest slot. The nut is then secured with a split pin or safety wire .It is a positive locking device. Castellated nuts are used in low-torque applications, such as holding a wheel bearing in place.

Session-2: Automotive nuts

A. Exercise: Assignment

1. List the types of nuts used in a vehicle and state their features

Sr. No.	Type of bolt	Features
1		
2		
3		
4		

2. Make a poster showing profile of ISO metric nut

Session-2: Automotive nuts
Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. A nut is a type of fastener with a ---------- hole.
2. For joining two metal part the nut is screwed on the ----------.
3. The ---------- of the bolt and nut must be same else the nut can not be ---------- on the bolt.
4. The nut can have left hand or right hand ---------- threads.
5. A hexagonal nut is a type of metal fastener that has ---------- sides.

Session-2: Automotive nuts

Use the following checklist to see if you've met all the requirements for automotive nuts.

Part A

- Able to identify and understand the use of automotive nuts used in vehicle.

Part B

Discussed in class the following:

- Describe the importance of nuts.
- Why the nuts are made of four or six faces?
- What is importance of threads in a nut and why threads are important?
- Differentiate between bolt and nut.
- What you understand by ISO metric thread?
- Name different types of nuts.
- Name different types of machine screws.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand importance of bolts as fasteners		
Able to identify different types of nuts		
Able to loosen and tighten different types of nuts using hand tools		

Session-3: Automotive Studs

Relevant Information

Studs are mechanical fasteners which are threaded on one or both ends. One end is secured to an object. The other end is used typically with a nut. Automotive studs are commonly referred to as a double ended automobile fastener. Automotive studs are fastened at both the ends with the help of an unthreaded shank. With the growing automotive parts industry, various automotive fasteners manufacturers & suppliers are coming up with new materials to manufacture a variety of auto studs.

Studs, Fig-11 are used for joining of parts to cast iron components. The tensile strength of cast iron is very low, and excessive tightening of a set screw into a cast iron thread may cause the thread to crumble, thus permanently damaging the casting. The studs are first screwed into the casting, and the tightening done by using mild steel nuts. Any damage done by excessive tightening will be to the stud or the nut, and not to the casting. Studs are used to ensure gas-tight and water-tight joints in applications where heavy pressures are encountered. In automobile studs are used for holding down cylinder head on a cylinder block of motor car engine. The joint between the cylinder and the head must be a temporary one, because it is necessary to remove the head when engine needs reconditioning.

Fig-11 Different types of studs

On the basis of their usage, automotive studs can be categorized as- engine studs, wheel studs and stainless steel studs.

On the basis of material, automobile studs are of many types such as brass studs, copper studs, plastic studs, nylon studs, aluminium studs, bronze studs and titanium studs.

Wheel Studs

Wheel studs are the threaded fasteners that hold on the wheels of many automobiles. They are semi-permanently mounted directly to the vehicle hub, usually through the brake drum or brake disk. Lug nuts are fastened over to the wheel stud, Fig-12 to secure the wheel. When a wheel is removed for tire changes etc., the stud remains in the hub. Many automobiles instead use bolts to do this, where removable bolts screw into the wheel hub. The primary advantage of wheel studs over wheel bolts is greater ease for tire changes by creating the ability to lift both the wheel and tire onto the studs creating the ability to hold and locate the assembly during tire changes rather than trying to hold up the wheel and tire while lining up the holes to insert a bolt.

Fig-12 Wheel stud

The primary advantage of wheel studs over wheel bolts is greater ease for tire changes by creating the ability to lift both the wheel and tire onto the studs creating the ability to hold

and locate the assembly during tire changes rather than trying to hold up the wheel and tire while lining up the holes to insert a bolt. Many wheels that use bolts also have one or more small locator pins to assist this: the wheel is lifted onto the pins, and then the bolts inserted. Once the bolts are tightened and the wheel is fully installed, the pins have no further function whilst the vehicle is being driven.

Types of wheel studs

Wheel studs are replaceable and come in two basic kinds: press-in and screw-in. Welded-in studs are possible but unlikely to be encountered.

Screw-in

Screw-in studs, Fig-13 simply screw into the existing threaded bolt hole in the hub. The end that screws into the hub is usually either threaded with a higher tolerance fit or installed with a chemical thread-locking fluid to keep it from backing out from the hub when the lug nut is removed.

Fig-131 screw-in type stud

Press-in

Press-in studs, Fig-14 are installed from the back side of the disk or drum hub and may require removal of the hub from the vehicle for installation or removal. They consist of a threaded portion and a larger diameter section, called the knurl, which is splined to prevent rotation. The diameter of the knurl is larger than the hole in the hub requiring a press fit to seat the stud. The stud is prevented from being pulled through the hub by a larger diameter stop on the end.

Fig-14 press-in type stud

Most press-in studs are designed and recommended to be installed with a mechanical or hydraulic press to ensure proper seating without damage. It is possible, though not advised, to install a press-in by using a washer and nut to "draw" it into the hub. In doing so, the installer must ensure that the stud is fully seated and that no damage is done to the threaded portion of the stud. While a common installation method by many garage mechanics, this method puts excessive strain on the stud, and can cause it to stretch and fatigue, which could lead to premature failure.

Engine studs

Main studs

For a performance or heavy-duty application, the use of studs, Fig-15 is preferred whenever possible instead of main cap bolts, in those instances where a choice is available. Studs provide the ability to obtain much more accurate torque values because the studs don't twist during tightening as do bolts. Because the studs remain stationary during nut tightening, the studs stretch in one axis alone, providing much more even and accurate clamping forces. Also, because the use of studs results in less wear applied to the block's threads, this extends the life of the threaded holes in the block over periods of servicing/rebuilding. This is especially important

Fig-15 Main studs in engine block

when dealing with alloy blocks. The use of studs also eases main cap installation, and contributes to main cap alignment. There is less chance of main cap walking because the studs remain stationary during cap clamping.

Cylinder head studs

The use of head studs, Fig-16 will aid in cylinder head installation, simply from a standpoint of gasket and head alignment. This is especially helpful in an application where frequent head removal will occur.

Fig-16 Cylinder head studs

In terms of function, the use of studs provides much more accurate and consistent torque loading. When a bolt is installed, the act of tightening results in both twisting (torsional load) and stretching (vertical or axial load). This results in the bolt being exposed to two forces at the same time, as well as experiencing frictional loads at the thread engagement. When the nut is tightened on a stud, the stud stretches on its vertical axis only. The exposed end (top) of the stud features “fine” threads, which allow more precise and therefore accurate, torque readings when the nut is torqued (or torque/angle tightened) to specifications.

Session-3: Automotive Studs

A. Exercise: Assignment

1. List the types of studs used in a vehicle

Sr.No.	Type of stud
1	
2	
3	
4	

2. Make a poster showing different types of studs used in automobile

Session-3: Automotive Studs
Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. Studs are mechanical ---------- which are ---------- on one or both ends.
2. Automotive studs are ---------- at both the ends with the help of an unthreaded ----------.
3. Wheel studs are the threaded fasteners that hold on the ---------- of many automobiles.
4. Press-in studs are installed from the back side of the --------- or ----------.
5. For a performance or ------- application, the use of ---------- is preferred whenever possible instead of main cap bolts.

Session-3: Automotive Studs

Use the following checklist to see if you've met all the requirements for automotive studs.

Part A

- Able to identify and understand the use of automotive studs used in vehicle.

Part B

Discussed in class the following:

- Describe the importance of studs.
- What are the advantages of studs over bolts?
- In what conditions the studs should be used in place of bolts?
- Differentiate between bolt and stud.
- Name different types of studs.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand importance of studs as fasteners		
Able to identify different types of studs		
Able to loosen and tighten different types of studs using hand tools		

Session 4 : Automotive Washers and Rivets

Relevant Information

A washer is a thin plate (typically disk-shaped) with a hole (typically in the middle) that is normally used to distribute the load of a threaded fastener, such as a screw or nut. Other uses are as a spacer, spring, wear pad, preload indicating device, locking device, and to reduce vibration. Washers usually have an outer diameter (OD) about twice the width of their inner diameter (ID).

Washers, Fig-17 are usually metal or plastic. High quality bolted joints require hardened steel washers to prevent the loss of pre-load due to strain hardening after the torque is applied.

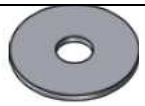
Fig-17 Different types of washers

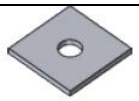
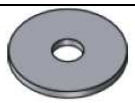
Automotive washers are the small flat dishes having a hole in the center. These essential auto fasteners are generally made of metal, leather, plastic, and rubber. The main function of the automotive washers is to hold or bear the load of a threaded fastener or bolt. Washers are just put below a nut, axle bearing or joint with the main purpose of preventing leakage and distributing pressure. The automotive washers include bolt lock washers, cylinder head washers, lug nut washers, radiator washers and hardened washers.

Washers can be categorized into three types;

1. 'plain washers', which spread a load, and prevent damage to the surface being fixed, or provide some sort of insulation such as electrical;
2. 'spring washers', which have axial flexibility and are used to prevent fastening loosening due to vibrations; and
3. 'locking washers' which prevent fastening loosening by preventing unscrewing rotation of the fastening device; locking washers are usually also spring washers.

Different types are washers are shown below in the table:

Type	Shape	Features
Flat		Intended for the general use under the head of a bolt or nut in order to provide a smooth bearing surface and distribute the fastener load over a wider surface area.
Fender		A fender washer is a flat washer with a particularly large outer diameter in proportion to its central hole. They are commonly used to spread the load on thin sheet metal, and are named after their use on automobile fenders. They can also be used to make a connection to a hole that has been enlarged by rust or wear.

Finishing		Designed to accommodate the heads of a countersunk screw in order to provide a finished appearance.
Split lock		A split type of spring washer whose purpose is to prevent self loosening of the nut or the bolt. The idea or principle behind the helical spring washer is for one end of the tang of the washer to indent into the fastener (the nut or bolt head) and the other into the joint surface so that any loosening rotation is prevented.
External tooth lock		A toothed lock washer, also known as a serrated washer or star washer, has serrations that extend radially inward and/or outward to bite into the bearing surface. These acts lock washer when used with a soft substrate, such as aluminum or plastic, and resist rotation more than a plain washer on hard surfaces. The external style has the serrations around the outer edge, which provides better holding power, because of the greater circumference
Internal tooth lock		The internal style has the serrations along the inner edge of the washer, which makes them more aesthetically pleasing
Square		Square plate washers are made from low carbon steel and have a larger surface area than round washers. Since they develop more friction when tightened against wood, this type of washer is specified for seismic applications. They are often found in timber construction.
Dock		Similar to a fender washer, but larger; with up to a 100mm outside diameter, this thick flat washer is ideal for heavy duty load bearing applications.
Ogee		Ogee refers to the curved shape of this large, cast iron washer which is typically used in dock and wood construction. These oversized washers have a large bearing surface designed to prevent bolt heads and nuts from pulling into the wood.
Sealing		Sealing washers are vibration-resistant, each having a silicone rubber section, molded and bonded to a stainless steel formed washer. These sealing washers are designed for use with regular screws, bolts or studs for sealing panels and enclosures having large or irregular clearance holes or slots, and can also be used to seal openings of protruded mounting holes. Upon tightening, a seal is formed within the shank and threaded surface of the fastener as well as around the periphery of the washer face.

Rivets

Rivets often regarded as a semi-permanent mechanical fastener having a cylindrical shaft with head on one hand and the end opposite the head is called buck-tail. Rivets are the oldest forms of automotive fasteners used in building traditional wooden boat. But now rivets are used as automobile fasteners in a wide number of applications like vehicle bodies, aircraft, bridges, cranes, building frames etc. Riveting is one of the earliest developed joining methods for metals and involves a malleable rivet being placed through pre-drilled holes in the mating parts while the end of the rivet is upset or deformed so that it expands to about 1.5 times the original shaft diameter of rivet. Like this the rivet is held in place and the metal parts are joined. The joint can be opened by removing the deformed end of the rivet by chisel or grinding. Because there is effectively a head on each end of an installed rivet, it can support tension loads (loads parallel to the axis of the shaft); however, it is much more capable of supporting shear loads (loads perpendicular to the axis of the shaft). Bolts and screws are better suited for tension applications. Rivets and riveted joint are shown in Fig-18.

Fig-18 Different types of rivets and rivet joint

Types of rivets

Rivets are usually categorized on the basis of their heads as shown in Fig-19. The material of the rivets must be tough and ductile. They are usually made of steel (low carbon steel or nickel steel), brass, aluminium or copper, but when strength and a fluid tight joint is the main consideration, then the steel rivets are used.

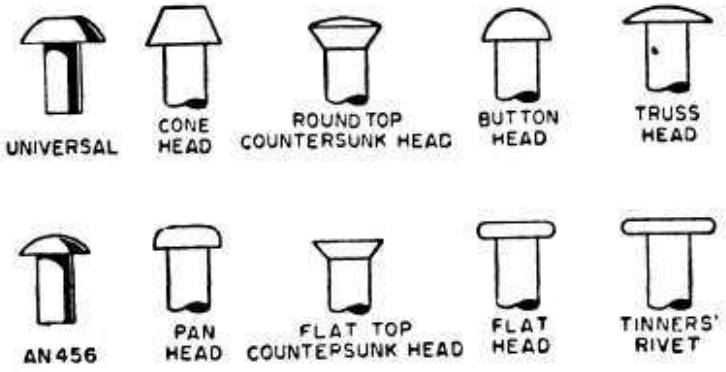


Fig-19 common types of rivets

Forming Rivet Heads by hand rivet set

To form the rivet head on the rivet is made by using a hand rivet set as shown in Fig-20. The sheet metal to be joined by riveting is drilled according to size of rivet shank. The holes are aligned and rivet is inserted in the holes. The deep hole of the rivet set is used to draw the sheets and rivet together and also to draw the rivet directly through thin sheeting. The rivet set selected should have a hole, slightly larger than the diameter of the rivet. The rivet shank is hammered by the hammer and finally keeping the shallow cone hole of the rivet set on the protruding end of the rivet. A good job of riveting can be done with not more than six normal blows of the hammer and after a little practice this number can be cut by half.

A skilled sheet metal worker will perform the operation in sequence by striking a blow on the rivet set, one blow to flatten the rivet down and another blow on the rivet set to form the head.

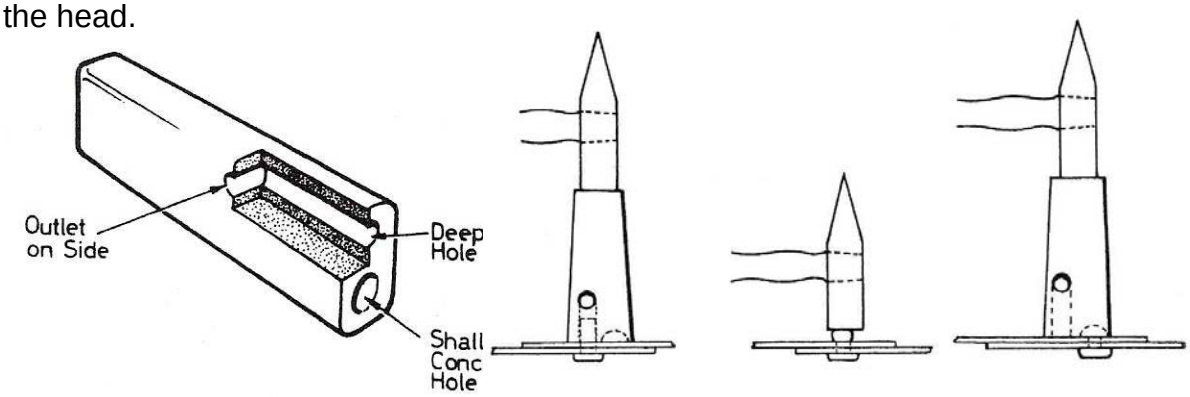


Fig-20 Forming rivets head

Other important fasteners

The other important fasteners used in the automobiles are as below:

Circlip

A circlip, is a type of fastener or retaining ring consisting of a semi-flexible metal ring with open ends which can be snapped into place, into a machined groove on a dowel pin or other part to permit rotation but to prevent lateral movement. There are two basic types: internal and external, referring to whether they are fitted into a bore or over a shaft. Circlips are often used to secure pinned connections. These are used to retain piston wrist pins / gudgeon pins, the clips are known as *wrist* pin clips or wrist pin retainers or gudgeon pin clips. The most commonly used circlip for this application is a simple spring steel circlip (snap ring), or plain wire ring. A circlip and circlip plier are shown in Fig-21.

Fig-21 Circlip and circlip plier

Since circlips are stamped out of sheetmetal there is a smooth side and a rough side. To prevent potential damage, circlips are installed with the smooth side facing the part and the rough side facing out. Circlips are designed to be removed with special circlip pliers (snap ring tool) which can be reassembled for internal or external clips, but in field expedient situations, a pair of needle-nose pliers (for internal clips) or leverage with a flat-headed screwdriver (internal or external) are sometimes used.

Split pin

A split pin, also known as a cotter pin or cotter key, is a metal fastener with two tines that are bent during installation, similar to a staple or rivet. Typically made of thick wire with a half-circular cross section, split pins come in multiple sizes and types.

A new split pin (see Fig- 22 A) has its flat inner surfaces touching for most of its length so that it appears to be a split cylinder (Fig-22 D). Once inserted, the two ends of the pin are bent apart, locking it in place (Fig-22 B). When they are removed they are supposed to be discarded and replaced, because of fatigue from bending.

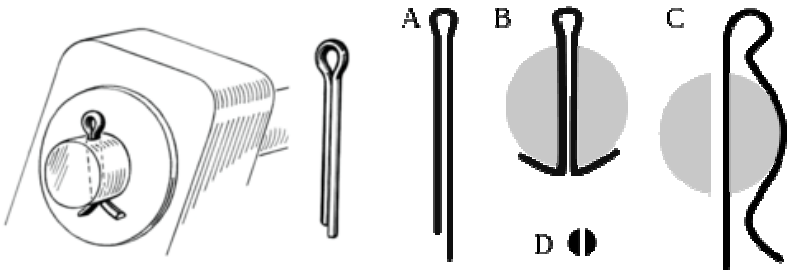


Fig-22 Split pin in shaft. A-new, B-installed, C-spring type, D-cross-section

Split pins are typically made of soft metal, making them easy to install and remove, but also making it inadvisable to use them to resist strong shear forces. Common materials include mild steel, brass, bronze, stainless steel, and aluminium.

Spring pin

A spring pin, Fig-23 (also called tension pin or roll pin) is a mechanical fastener that secures the position of two or more parts of a machine relative to each other. Spring pins have a body diameter which is larger than the hole diameter, and a chamfer on either one or both ends to facilitate starting the pin into the hole. The spring action of the pin allows it to compress as it assumes the diameter of the hole. The radial force exerted by the pin against the hole wall retains it in the hole, therefore a spring pin is considered a self retaining fastener.

Fig-23 slotted spring pin (1) and washer (2) used to secure a shaft (3)

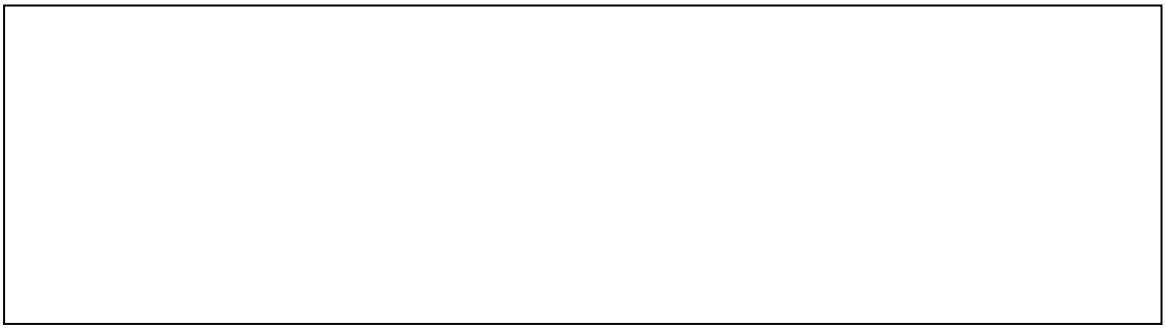
Session-4: Automotive Washers and Rivets

B. Exercise: Assignment

1. List the types of washers used in a vehicle and state their features also

Sr.No.	Type of washer	Features
1		
2		
3		
4		

2. Make a poster showing different types of rivets used in automobile



Session-4: Automotive Washers and Rivets
Answer the following questions
(Use additional sheets of paper if necessary)

A. Fill in the blanks

1. A washer is a thin -------- with a hole that is normally used to ---------- the load of a threaded ----------.
2. Automotive washers are the small flat ---------- having a ---------- in the center.
3. Rivets are the oldest forms of automotive --------- used in ---------- traditional wooden boat.
4. Rivets are usually ---------- on the basis of their heads.
5. Circlips are often used to ---------- pinned connections.
6. Split pins are typically made of -------- metal, making them easy to --------- and remove.
7. Spring pins have a body diameter which is larger than the ---------- diameter, and a ---------- on either one or both ends to facilitate ---------- the pin into the hole.

Session-4: Automotive Washers and Rivets
Use the following checklist to see if you've met all the requirements for automotive washers and rivets.

Part A

- Able to identify and understand the use of automotive washers and rivets used in vehicle.

Part B

Discussed in class the following:

- Describe the importance of washers.
- Describe the importance of rivets.
- What are the advantages of using washers as fasteners?
- In what conditions the rivets should be used as fasteners?
- What are the advantages of using split pin as fastener?
- What are the advantages of using spring pin as fastener?
- Name different types of washers.
- Name different types of rivets.
- What are uses of circlip.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand importance of washers as fasteners		
Able to understand importance of rivets as fasteners		
Able to identify different types of washers		
Able to identify different types of rivets		
Able to make rivet head using hand rivet set		
Able to remove and fix the split pin using hand tools		
Able to remove and fix the spring pin using hand tools		
Able to remove and fix the circlip using hand tools		

Session-5: Removal of Damaged Fasteners and Replacement

Relevant Information

Removal of broken/spoiled headed screw

In automobile, due to jerk, vibration and corrosion screws get broken. It ultimate it leads to dislocate the assembly. It is necessary that it should be removed and replaced. Similarly improper uses of screw drivers with its snap head, screw head get spoiled. It becomes difficult to tight, loosen and removal of screw from the assembly. The broken and spoiled screws are shown in Fig-24.

Fig- 24 Broken and spoiled screw

Method of removal of damaged screw

Case 1: Removal of spoiled headed screw

If the screw driver slips, due to widening of groove/screw way

- Use hacksaw blade and dress the groove
- Now use screw driver of thick snap and turn anticlockwise
- This removes the screw, if it is not responded
- Take a prick punch and hammer. Give light blow in anti clock wise direction. This loosen the screw
- If it does not work then use drill machine of drill bit smaller than size of screw
- Now drill it at the centre of screw, now 100% screw will be removed

Case 2: Removal of unheaded screw

- If the screw is broken at the top of the assembly
- Remove the other screw and separate the assembly
- Hold the jaws of the cripper on broken screw
- Lock the cripper and turn anti clock wise
- Screw may come out

Case 3: Removal of unheaded (Fig-25) screw broken in the assembly

- Use drill machine of drill bit smaller than size of screw
- Now drill it at the centre of screw, now 100% screw will be removed
- Now dress the threads before fixing new screw

Fig- 25 Unheaded screw

Broken nut/bolts

In automobile, due to jerk movement and vibration, nuts and bolt get loosened and may causes spoiling of internal/external threads in nut and bolt respectively. This slackens the assembly unit and changes the alignment with other unit. Improper use of spanners/socket may leads to spoiling of edges of nut/bolt. It is necessary that it should be removed and replaced. It becomes difficult to tight, loosen and removal of nut/bolt from the assembly. The broken bolt is shown in Fig-26.

Fig-26 Broken bolt

Method of removal of spoiled headed nut/bolts (Fig-27)

Case 1: Removal of nut/bolts

- Use spanner of smaller size, fix it on the nut/bolt and turn anticlock wise
- It will come out
- If it does not come out, use prick punch.
- Take a prick punch and hammer at the face of nut/bolt. Give light blow in anti clock wise direction. This loosen the nut/bolt.
- If it does not work then use drill machine of drill bit smaller than size of nut/bolt
- Now drill it at the centre of nut/bolt an remove the edges of nut, in case of bolt remove the bolt head by using cripper, remove the remaining part of the bolt from the assembly.

Case 2: Dress the internal threads of the bolts by using tap of appropriate size

- In case of nut, use die to rethread stud threaded portion and use new nut

Fig-27 Broken thread

Broken / spoiled threaded studs (Fig-28)

A stud is stronger than a bolt, with correct stud installation; the stud is screwed into the threaded hole without applying pressure to the threads and without galling the threads. After stud installation, the parts are slipped over the stud, then install the correct washer, and then tighten the nut.

Fig- 28 Removal of thread

The stud is stronger because thread contact at the stud and at the threaded hole will be stationary at the time pressure is applied (when tightening the fastener). But when a bolt is used to mount a part, the bolt is rotated in the threaded hole during tightening, which can tear out weak threads.

No doubt there will be times when clearance problems will make it impossible to use a stud, rather than a bolt. Sometimes there is not room to slip a large part over a stud, but rather the part has to be slipped into place from the side. But when a stud can be used rather than a bolt, the stud will result with greater fastener strength than the bolt.

Method of removal of Broken/ spoiled threaded studs

Case 1: Removal of spoiled threaded studs

- To remove spoiled threaded stud, give gentle pressure on assembly by using screw driver, this will lift the spoiled portion of the stud threads upward.
- Turn the nut in anticlockwise, turn the stud assembly and gentle press the screw driver inside so that stud will come out
- In case, if the nut threads internal threads of the nut/external threads of the studs are spoiled, then give welding spot to nut and stud. Now turn assembly anti clockwise. Now stud will come out

Case 2: Removal of broken studs above the casing

- If the stud is broken above the assembly unit,
- Separate the assembly by removing other nuts
- Fix stud extractor on the broken stud and lock it
- Now turn stud extractor slowly, the stud will be driven out

Case 3: Removal of broken studs inside the casing

- Take a prick punch and hammer at the face of broken stud. Give light blow in anti clock wise direction. This will loosen the remaining portion of the stud.
- If it does not work then use drill machine of drill bit smaller than size of stud
- Now drill it at the centre of stud, Remove the burr from the casing
- Use appropriate tap and redress the internal thread
- Fix the new stud by using stud extractor

Use of anti rust solution

Anti rust solution are used for dissolving the dust, rust from the fastener area. Use of this solution will make fasteners comfortable during removal/changing process. Now days indian as well as imported antirust solution/spray are available in the market. The antirust can is shown in Fig-29.

Fig-29 Antirust solution or spray can

Session-5: Removal of Damaged Fasteners and Replacement

A. Exercise: Assignment

1. Write the procedure for removal of damaged screw

Session-5: Removal of Damaged Fasteners and Replacement
Answer the following questions
(Use additional sheets of paper if necessary)

B. Fill in the blanks

1. In automobile, due to ----------, vibration and ---------- screws get broken.
2. Use hacksaw --------- and dress the ----------.
3. In automobile, due to ---------- movement and vibration, nuts and bolt get ----------.
4. A stud is stronger than a ----------, with correct stud installation; the stud is screwed into the ---------- hole without applying pressure.
5. Anti rust solution are used for dissolving the --------, rust from the ---------- area.

Session-5: Removal of Damaged Fasteners and Replacement

Use the following checklist to see if you've met all the requirements for removal of damaged fasteners and replacement.

Part A

Able to identify and understand the removal of damaged fasteners and replacement in vehicle.

Part B

Discussed in class the following:

- Method to remove screw with spoiled head.
- Method to remove screw without head/unheaded.
- Method for removal of unheaded screw broken in the assembly.
- Method of removal of spoiled headed nut/bolts.
- Method of removal of broken/ spoiled threaded studs.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to remove screw with spoiled head with the use of hand tools		
Able to remove screw without head/unheaded with the use of hand tools		
Able to remove unheaded screw broken in the assembly with the use of hand tools		
Able to remove spoiled headed nut/bolts with the use of hand tools		
Able to remove broken/ spoiled threaded studs with the use of hand tools		

STUDENT WORKBOOK

Curriculum : AUTO-SRV *L4-NQ*^{2016}

Unit :AUTO-SRV *L4U3*

Measuring Equipments

Vocational Learning Material for Schools

PSS Central Institute of Vocational Education
Bhopal

Introduction

Measurement and Measuring Instruments

All of us are totally surrounded by measurements, no matter what we may be doing. A measurement is assigning a value to length, mass and time. The importance of measurements in science is the exactness. You can not verify laws, properties or science experiments without having exact measurements. If measurements are not given, and you try and recreate a project someone else did, you will not come up with the same result they did.

Accurate measurement is important because it helps in quality assurance and giving of accurate calculations in almost every field. Lack of accurate measurement causes errors which may be quite costly and dangerous. Instruments used for measuring basic units such as mass, length and time or derived units such as speed, acceleration, pressure etc; are called measuring instruments or equipment.

An automobile require regular care and maintenance so that its working life and efficiency can be increased, and the cost of operation, which includes unnecessary breakdowns and spares, can be reduced. An automobile technician must know the measuring instruments and techniques, which is a basis for repair & maintenance and inspection of parts and require different measuring tools, instruments and gauges.

Session-1: Handling and Usage of Direct and Indirect measuring instruments

Relevant Knowledge

You must have heard and seen important measuring instrument used in our daily life. Similarly measuring instruments are also used in automobile serviceability. These instruments help in measurement of important dimensions of components. Important measuring instruments used are Dial gauge, Bore Gauge, Vernier caliper, Depth Gauge, Micrometer, Hydrometer and Multi meter etc. We will try to understand the handling and usage of these measuring equipments.

Measuring Instruments

Measuring instruments used in automotive can be classified as below:

1. Linear measurement
   - Direct measuring instruments
   - Indirect / instruments for transferring measurements
2. Angular measurement
3. Plane surface measurement

Direct measuring instruments

The measuring instruments, which do not require the help of other instruments for measuring are called direct measuring instruments. Usually these instruments have a line, which is divided in equal parts, called graduated scale. commonly used direct measuring instruments are:

Steel scale/rule: It is a line measuring device. It is the simplest and most common measuring instrument used in inspection. It works on the basic measuring technique of comparing an unknown length to the one previously calibrated. It consists of a strip of hardened steel having line graduations etched or engraved at interval of fraction of a standard unit of length. The scale can be either 150 mm long or 300 mm or 600 mm or 1000 mm long. The scale need not be graduated uniformly throughout its length. In some part e.g. it may have 10 divisions of centimetre, in some portion 20 divisions, so that it can be used for all types of work and the particular range chosen depending upon the accuracy required. The use of scale is shown in Fig-1.

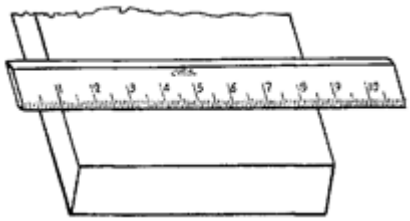


Fig-1 Recommended method of using scale.

Steel tape: A measuring tape is a flexible form of ruler. It consists of a ribbon of cloth, plastic, fiber glass, or metal strip with linear-measurement markings. It is a common measuring tool. Its flexibility allows for a measure of great length to be easily carried

Fig-2 Steel tape

in pocket or toolkit and permits one to measure around curves or corners. For workshop a 3m length tape can be used. The steel tape is shown in Fig-2.

Vernier caliper: The meter scale enables us to measure the length to the nearest millimeter only. Automobile technicians need to measure much smaller distances accurately. For this a special type of scale called Vernier scale is used. The Vernier Caliper is a precision instrument that can be used to measure internal and external distances extremely accurately. The vernier caliper is usually a manual caliper. Measurements are interpreted from the scale by the user. The vernier caliper is shown in Fig-3.

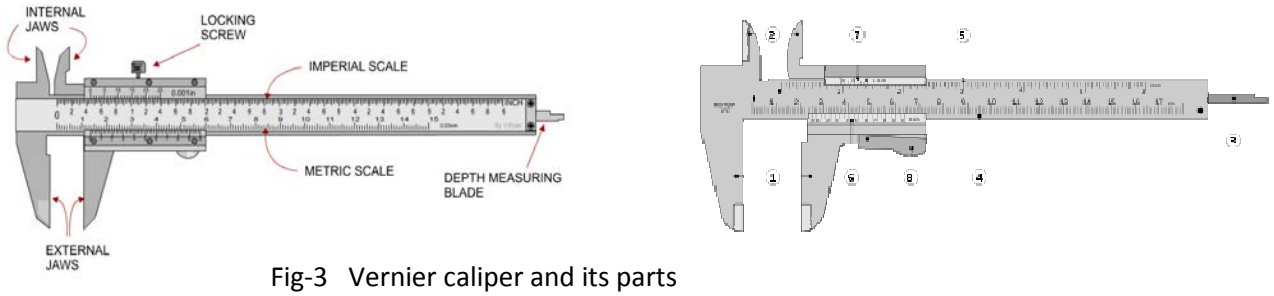


Fig-3 Vernier caliper and its parts

Parts of a vernier caliper:
Outside jaws: used for measuring external diameter or width of an object
Inside jaws: used to measure internal diameter of an object
Depth probe: used to measure depths of an object or a hole
Main scale: scale marked every mm
Main scale: scale marked in inches and fractions
Vernier scale gives interpolated measurements to 0.1 mm or better
Vernier scale gives interpolated measurements in fractions of an inch
Retainer: used to block movable part to allow the easy transferring of a measurement

In the vernier calliper sliding jaw containing the vernier scale, moves over the main scale. When the two jaws are in contact, the zero of the main scale and the zero of the vernier scale should coincide. If both the zeros do not coincide, there will be a positive or negative zero error

The Vernier scale consists of a main scale graduated in centimeters and millimeters (in inches if there is imperial scale). On the vernier scale 0.9 cm is divided into ten equal parts. The least count or the smallest reading which you can get with the instrument can be calculated as under:
Least count = one main scale (MS) division - one vernier scale (VS) division.
Suppose 10 division of vernier scale = 9 division of main scale. Therefore one division of vernier scale = 9/10 = 0.9 mm of main scale division (one division of main scale = 1 mm). Therefore the least count will be

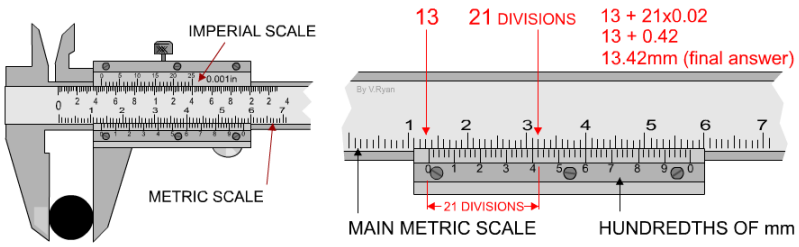
= 1 mm - 0.9 mm
= 0.1 mm
= 0.01 cm

Reading of vernier caliper and measuring diameter of the cylinder

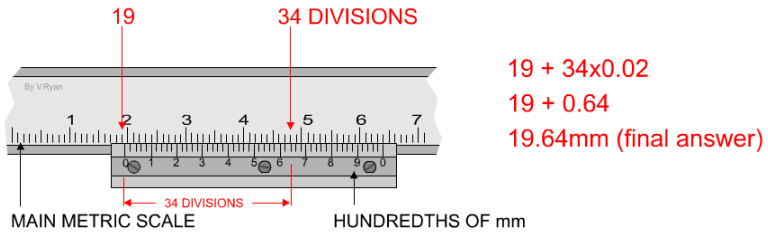
1. The sliding jaw is moved along the beam until it contacts the cylinder kept against the fixed jaw. In this way the cylinder is held between the fixed and sliding jaw.
2. Clamp the sliding jaw assembly to the main beam with the help of fine adjustment screw
3. The knife edges of two jaws are now in contact with the cylinder
4. The main slide assembly is then locked to the beam with the help of retainer.
5. Remove the cylinder held in the jaws for reading the measurement or read the caliper when the cylinder is held in the jaws.
6. Read the main scale left to the zero of vernier scale.
7. Read the vernier scale division which coincide with the main scale division.
8. Multiply the reading of vernier scale with the least count and add to the main scale reading to arrive at the final reading.

   In the following example 50 divisions on the vernier scale = 49 division on main scale. The value of one division on main scale is 1mm. Therefore the least count = 1-49/50 = 0.02 mm

Example-1



EXAMPLE 2:



Dial caliper: Instead of using a vernier mechanism, which requires some practice to use, the dial caliper (Fig-4) reads the final fraction of a millimeter on a simple dial.

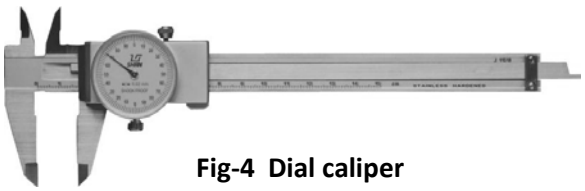


Fig-4 Dial caliper

In this instrument, a small, precise gear rack drives a pointer on a circular dial, allowing direct reading without the need to read a vernier scale. Typically, the pointer rotates once every 1 millimeter. This measurement must be added to the whole centimeters read from the slide. The dial is usually arranged to be rotatable beneath the pointer, allowing for "differential" measurements (the measuring of the difference in size between two objects, or the setting of the dial using a master object and subsequently being able to read directly the plus-or-minus variance in size of subsequent objects relative to the master object).

The slide of a dial caliper can usually be locked at a setting using a small lever or screw; this allows simple go/no-go checks of part sizes.

Digital caliper: It is refinement or replacement of the analog dial with an electronic digital display on which the reading is displayed as a single value. Some digital calipers can be switched between centimeters or millimeters. All provide for zeroing the display at any point along the slide, allowing the same sort of differential measurements as with the dial caliper. Digital calipers may contain some sort of "reading hold" feature, allowing the reading of dimensions even in awkward locations where the display cannot be seen.

Fig-5 Digital caliper

Ordinary 150-mm digital calipers are made of stainless steel, have a rated accuracy of 0.02mm and resolution of 0.01mm. The digital caliper is shown in Fig-5.

Vernier depth gauge: For measuring the depth of holes, recesses and distances from a plane surface to a projection, the vernier depth gauge is employed. In vernier depth gauge, the graduated scale can slide through the base and vernier scale remains fixed. For use of vernier depth gauge, its base or anvil is rested on or against a reference surface and the scaled beam or tongue is pushed beyond the base to contact the measured point. It must be ensured that the reference surface on which the depth gauge base is rested is satisfactorily true, flat and square. The gauge, though true and square, can be imperceptibly tipped or canted. The gauge is shown in Fig-6.

Fig-6 Vernier depth gauge

Micrometer: The micrometer is a precision measuring instrument, used by engineers and technicians for inspection and measuring the distance between

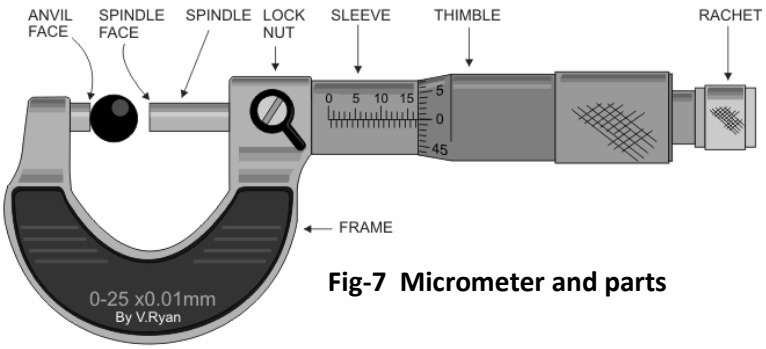
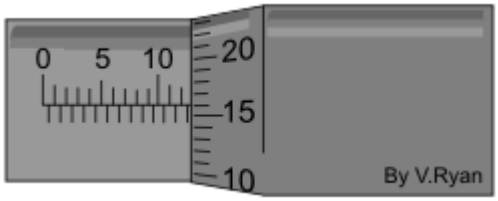


Fig-7 Micrometer and parts

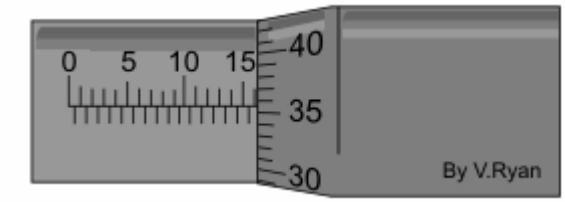
two faces. Each revolution of the ratchet moves the spindle face 0.5mm towards the anvil face. The 0.5 mm is the pitch of the screw to which spindle is attached. The object to be measured is placed between the anvil face and the spindle face. The ratchet is turned clockwise until the object is 'trapped' between these two surfaces and the ratchet makes a 'clicking' noise. This means that the rachet cannot be tightened any more and the measurement can be read. The micrometer and its parts has been shown in Fig-7.
Calculation of least count of a micrometer. Use the given formula:

Least Count (L. C) = Pitch/No. of divisions on micrometer barrel (thimble) where, Pitch = distance travelled by thimble on linear scale in one rotation, which is usually 0.5 mm unless stated.

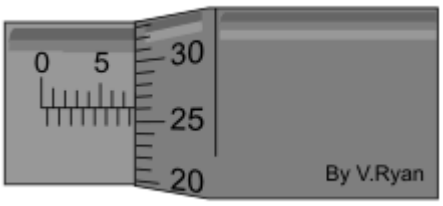
In the examples below, the number of division on the barrel are 50. Therefore the least count of the micrometer will be 0.5/50 = 0.01
1. Read the scale on the sleeve. The example clearly shows12 mm divisions.
2. Still reading the scale on the sleeve, a further ½ mm (0.5) measurement can be seen on the bottom half of the scale. The measurement now reads 12.5mm.
3. Finally, the thimble scale shows 16 full divisions (16 x 0.01 = 0.16 mm).
The final measurement is 12.5mm + 0.16mm = 12.66



SLEEVE READS FULL mm = 12.00
SLEEVE READS ½ mm = 0.50
THIMBLE READS = 0.16
TOTAL MEASUREMENT = 12.66mm



SLEEVE READS FULL mm = 16.00
SLEEVE READS ½ mm = 0
THIMBLE READS = 0.355
TOTAL MEASUREMENT = 16.355mm



SLEEVE READS FULL mm = 7.00
SLEEVE READS ½ mm = 0.50
THIMBLE READS = 0.26
TOTAL MEASUREMENT = 7.76mm

Digital Micrometer: The digital micrometer is shown is the figure and display the final reading. There are many types of micrometers which depend on the type of anvil and spindle faces such as gear tooth micrometer, sheet metal micrometer etc.

Fig-8 Digital micrometer

Micrometer head can be part of any measuring instrument which makes the instrument known with prefix as micrometer such as micrometer depth gauge, micrometer bore gauge etc. The digital micrometer is shown in Fig-8.

Indirect measuring instruments

There are situations where direct measuring instruments cannot be used. The simple calipers can be used in these situations. For measuring, the object is held between the ends, object removed and the ends are placed on steel scale to determine the distance. These calipers can be used to measure the length, outside and inside diameters. Some of the calipers are as below:

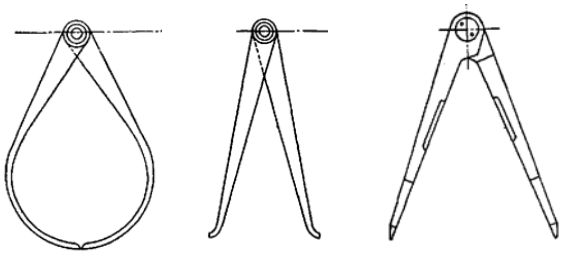


Fig- 9 Firm joint calipers: outside, inside and divider

Firm Joint Calipers: These are the devices for comparing measurements against known dimensions. The firm joint caliper has two legs and working ends are suitably hardened and tempered, the legs are joined together by a rivet. The legs are set correctly so that the working ends meet evenly and closely when brought together. The capacity of the caliper is the maximum dimension which can be measured by it. The nominal size of 100,150, 200 and 300 mm are commonly used. Different calipers are shown in figure. The firm joint calipers are shown in Fig-9.

Measuring outside dimension.

Checking inside groove.

Spring joint calipers: The spring joint calipers are shown in the figure. The functions these calipers are similar to firm joint calipers. The legs of caliper can be opened and closed with the help of screwing the nut in and out on the bolt. The spring joint calipers are shown in Fig-10.

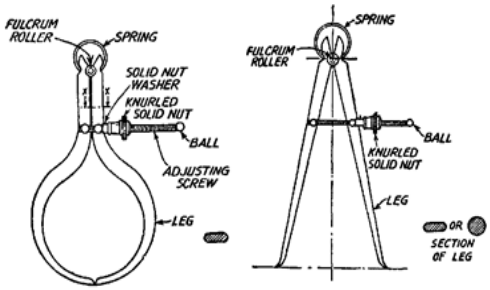


Fig-10 Spring joint calipers: Outside and Inside

Session-1: Handling and Usage of Direct and Indirect measuring instruments

Exercise: Assignment

1. Make a list of direct and indirect measuring instruments

S.No.	Name of instrument

2. Make two posters in which draw the line diagram of vernier caliper an micrometer, label the parts.

Session-1: Handling and Usage of Direct and Indirect measuring instruments

Answer the following questions

(Use additional sheets of paper if necessary)

Fill in the blanks

1. A ---------- is assigning a value to length, mass and time.
2. The measuring instruments, which do not require the help of other ----------for measuring are called ---------- measuring instruments.
3. Steel scale/rule is a ---------- measuring device.
4. The Vernier Caliper is a ---------- instrument that can be used to measure ---------- and external distances extremely accurately.
5. In the vernier calliper sliding jaw containing the ---------- scale, moves over the main scale.
6. For measuring the depth of ----------, recesses and ---------- from a plane surface to a projection, the vernier depth gauge is employed.
7. The micrometer is a precision measuring instrument, used by engineers and technicians for ---------- and measuring the distance between two ----------.
8. The digital micrometer display the ---------- reading.

Session-1: Handling and Usage of Direct and Indirect measuring instruments
Checklist for Assessment Activity
Use the following checklist to see if you've met all the requirements for handling and usage of direct and indirect measuring instruments.

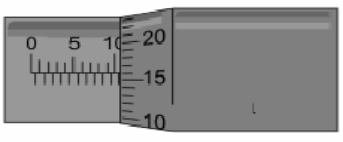
Part A
Share importance of use of handling and usage of direct and indirect measuring instruments in repair and maintenance of automobiles.

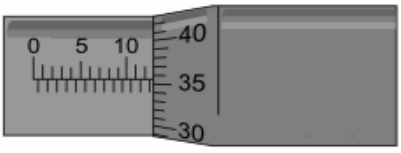
Part B
Discussed in class the following:

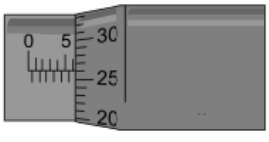
- Importance of measuring instruments.
- What is difference between direct and indirect measuring instruments?
- Describe the procedure for determining the least count of vernier caliper.
- Describe the procedure for determining the least count of micrometer.
- Describe the process for measurement with indirect measuring instruments.
- Differentiate between vernier and digital caliper.
- Describe the parameters which can be measured with vernier depth gauge.
- What are the various alerts sign found in a dashboard of a vehicle?
- Take any object round or square. Measure and write the reading with the help of vernier caliper in the table given below:

Sr. No	Main Scale Reading(A)	Vernier Scale Reading(B)	Least Count (C)	Least count x Vernier Scale (BxC=D)	Actual Reading (A+D)

- Readings of the sleeves and thimbles are shown in the following pictures. Calculate the total measurement.







Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance direct and indirect measuring instruments		
Able to identify direct and indirect measuring instruments		
Able to use steel rule and steel tape		
Able to use vernier caliper, micrometer and vernier depth gauge		
Able to use indirect measuring instruments		
Able to use digital measuring instruments		

Session-2: Angular Measuring Instruments

Relevant Knowledge

Instruments used for measuring the angle are called angular measuring instruments. Angle is formed by two intersecting lines at the point of intersection. The instruments used for measurement of the angle are:

Protractor: A protractor (Fig-11) is a device for measuring the angle between two intersecting lines. The angle is measured in degrees, and a circle is defined as having 360 degrees of identical size.

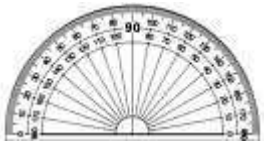


Fig-11 Protractor

Blade protractor:

This is a highly useful and accurate tool for setting bevels, transferring angles, small squaring tasks, and many other applications. Double graduations from 0 - 180° in opposite directions permitting the direct reading of angles and supplementary angles. The blade protractor is shown in Fig-12.

Fig- 12 Blade protractor

Bevel / Combination gauge:

A **bevel gauge** is an adjustable gauge for setting and transferring angles. The handle is usually made of wood or plastic or steel and is connected to a metal blade with a thumb screw or wing nut. The blade pivots and can be locked at any angle by loosening or tightening the thumb screw. The bevel gauge and its applications is shown in Fig-13.

Fig- 13 Bevel gauge and its use

Gauge is mainly used to measure of angle of valve face, valve seat. The straight edge is used to check the distortion of plain surfaces like cylinder head, cylinder block

Universal Protractor: The universal bevel protractor picks up where the blade protractor leaves off. The universal bevel protractor (Fig-14) is designed for precision measuring and layout of angles. The universal bevel protractor is capable of measuring obtuse angles as well as acute angles when accompanied with the correct attachments. Look at Figure below to give you an idea as to the uses of the universal bevel protractor.

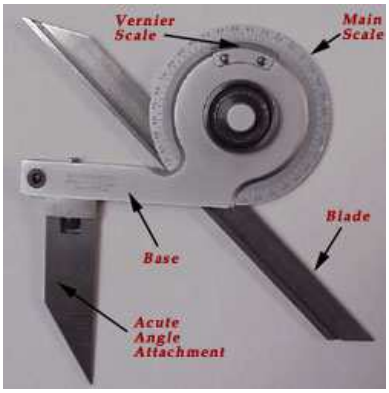


Fig-14 The universal bevel protractor is capable of measuring to within 5 minutes or 1/12 of a degree.


Measuring acute angles


Measuring obtuse angles


Using a protractor with a vernier height gauge

The main component of the bevel protractor is the main scale. The main scale is graduated into four 90-degree components. The main scale is numbered to read from 0 to 90 degrees and then back from 90 degrees to 0 (Figure).

As with other vernier measuring devices, the vernier scale of the bevel protractor allows the tool to divide each degree into smaller increments. The vernier scale is divided into 24 spaces, 12 spaces on either side of the zero.

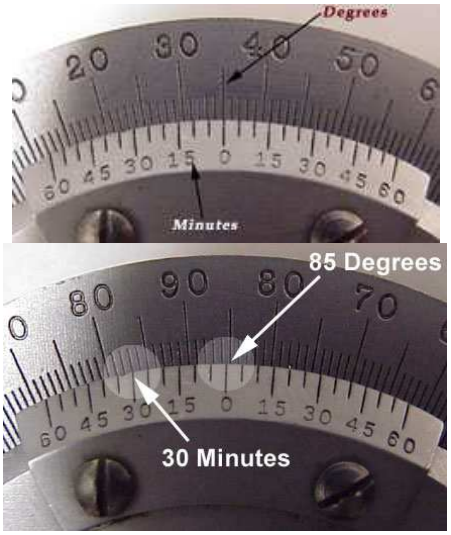


Fig-16 Always read the vernier in the same direction that you read the dial

Each space on the vernier scale is, therefore, one-twelfth of a degree. One-twelfth of a degree is equal to 5 minutes. To read the protractor, note where the zero on the vernier scale lines up with the degrees on the dial in Fig-15. The degrees are read directly from the main scale. The zero on the vernier scale is just pass the 85 degree mark. Now, *reading in the same direction (counter-clockwise)*, count, by five, from zero on the vernier scale to the lines that match up on the dial (Fig-16).

Add this number of minutes to the number of whole degrees. The total number of degrees and minutes in Fig-16 would equal 85 degrees and 30 minutes. Look at the measurements in Figure to get you more accustomed to vernier bevel protractor reading.

Session-2: Angular Measuring Instruments

Exercise: Assignment

1. Make a list of angular measuring instruments

S.No.	Name of instrument

2. Make a poster in which draw the line diagrams of angular measuring instruments and label the parts.

Session-2: Angular Measuring Instruments
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. Instruments used for measuring the angle are called ---------- measuring instruments.
2. A protractor is a device for measuring the angle between two ----------lines.
3. The blade protractor has double graduations from 0 - 180° in -------directions permitting the direct reading of angles and ---------- angles.
4. A bevel gauge is an ---------- gauge for setting and ---------- angles.
5. The universal bevel protractor is designed for ---------- measuring and ---------- of angles.

Session-2: Angular Measuring Instruments
Checklist for Assessment Activity
Use the following checklist to see if you've met all the requirements for angular measuring instruments.

Part A
Share importance of use of handling and usage of angular measuring instruments in repair and maintenance of automobiles.

Part B
Discussed in class the following:

- Importance of angular measurement and measuring instruments.
- What is difference between protractor and blade protractor?
- Describe the procedure for using the bevel gauge.
- Describe the procedure for determining the least count of universal bevel protractor.

Performance standards/criteria covered by this assessment

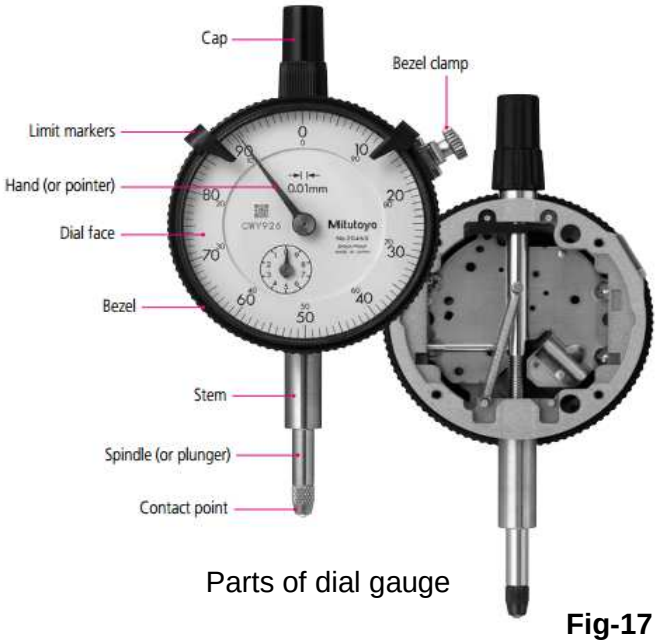
Performance standards	Yes	No
Able to explain importance angular measurement and measuring instruments		
Able to identify angular measuring instruments		
Able to use angular measuring instruments		

Session-3: Dial Indicator/Gauge and other Gauges

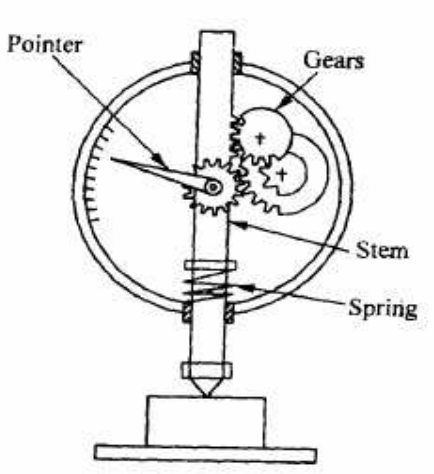
Relevant Knowledge

It is used as a measuring device to measure the accuracies in alignment, eccentricity of the parts/components. Dial indicators are also great for checking crankshaft runout, crank end play, shaft thrust, gear backlash, flywheel face runout, flywheel housing concentricity, valve seat concentricity or piston deck clearance.

A dial gauge is like a fine watch. It consists of a graduated dial, pointer, plunger and a clamp. It measures the displacement of its plunger on a circular dial by means of a rotating pointer. The dial gauge is shown in Fig-17.



Parts of dial gauge



Mechanism of dial gauge

Fig-17 Dial gauge

It works on the rack and pinion principle. The stem/plunger has rack teeth. A set of gears engage with the rack. The pointer is connected to a small pinion. The small pinion is independently hinged. i.e. it is not connected to the stem. The vertical movement of the stem is transmitted to the pointer through a set of gears. A spring gives a constant downward pressure to the stem.

Fig-18 Dial

Thus any movement of the plunger causes a corresponding movement of the main pointer on a graduated dial. In addition to the main pointer the dial gauge has a secondary scale and a small pointer for indicating the number of revolutions made by the main pointer. Zero setting of the main pointer of the dial gauge can be done by rotating the dial face until '0' line coincides with the pointer. For use dial gauge is attached to the magnetic mounting stand (Fig-18) and the base of the stand is held on flat surface. The contact point of the stem is brought into the contact with the part to be inspected. The part is rotated or

translated and deviations in readings are observed on the dial face by the movement of pointer.

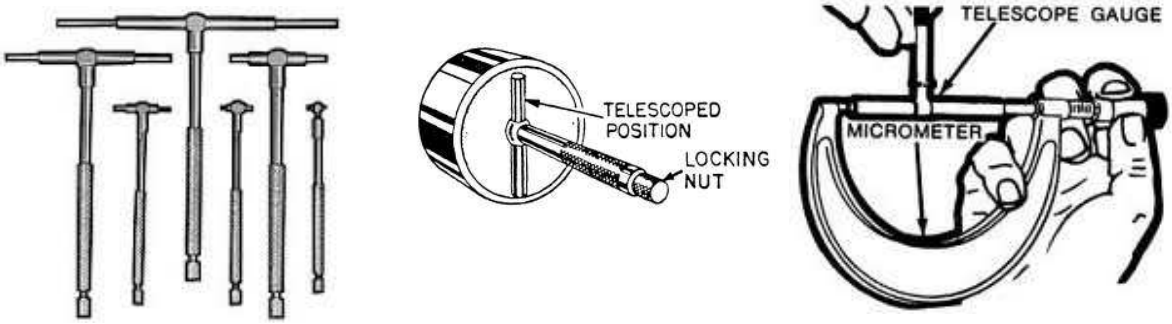
Fig-19 Digital dial gauge

Digital dial indicator/gauge

Its use is similar to the dial indicator/gauge and uses inductive measuring system and has LCD display. It has on/off function, zero setting at any position, hold function and plus-minus preset function. It is also used in conjunction with magnetic base stand. The reading is displayed on the dial. The digital dial gauge is shown in Fig-19.

Telescopic Gauge

There are a range of gauges that are used to measure a bore's size, by transferring the internal dimension to a remote measuring tool. They are a direct equivalent of inside calipers and require the user to develop the correct feel to obtain repeatable results. A telescoping gauge is a measuring tool with spring-loaded plungers used together with a micrometer to measure the inside of holes or bores. Telescopic gauge is used to find out the internal diameter of pipe, cylinder bore and slots. This gauge has ratchet locking at top, handle, body and telescopic operated plungers. A telescoping gauge is an indirect measuring device, the head of which can be positioned inside holes or openings and then extended to touch the walls. Telescoping gauges are made insets to measure from small to very large bores. Telescopic gauges and its application is shown in Fig-20.



Telescopic gauges | Using telescopic gauge | Measuring telescopic gauge with micrometer

Fig- 20 Telescopic gauge and

Measuring diameter of bore with telescopic gauge

- Select appropriate size of telescopic gauge according to bore
- Press the plungers in the barrel and lock the ratchet
- Place the gauge in cylinder bore to check internal diameter
- Turn the ratchet, the spring loaded plungers will come out and touch the side of the bore and exert equal pressure on both side of the cylinder wall. Make sure, however, that the gauge is held with the telescoping end at right angles to the axis of the hole to measure the true, maximum diameter.

- Rock the gauge back and forth to be sure it is square in the bore and gauge parallel to the ground
- Lock the telescopic gauge, plunger remains open and occupied the internal diameter
- Slowly remove the telescopic gauge from the bore and measure across the two ends of the plungers with an outside micrometer
- This gives main reading of cylinder bore

Bore gauge

A dial or vernier bore gauge measures a bore directly. The gauge has three symmetrical anvils that protrude from the gauge body that are connected to the dial or micrometer mechanism. As the knob is rotated it moves the anvils in or out with respect to the measurements. The knob usually has a slipping mechanism to take the feel out of the device and increase reliability between measurements. The measurement given is the mean diameter of the three anvils, and is usually good to 0.001 mm..

Dial bore gauge: A dial bore gauge (Fig-21) is a special tool, which is used to accurately measure the inside diameter of a hole, cylinder or pipe and will also detect ovality and tapers in bores. Dial-bore gauges are useful in checking for taper or out-of-round conditions in a cylinder bore as well as many other inside machinists measurements. In conjunction with a micrometer, a bore gauge will give the exact reading of a bore size. A typical bore gauge is comprised of a shaft with a dial indicator at the top and a measuring sled at the base. The measuring sled consists of three guides and an actuating plunger. Dial bore gauges give quick and accurate readings on the size, less than perfect roundness or wear.

Fig.21 Dial bore gauge

Fig.22 Using bore gauge showing measuring sled

Fig.23 Micrometer bore gauge

Measuring the bore size with Dial Bore Gauge

1. Zero the dial bore gauge against a calibrated ring of the same relative size as the bore being measured.

2. Insert the head of the gauge into the bore following the tool's operating instructions. Rock the tool back and forth gently in the bore once the gauge is inserted and standing upright.
3. Watch the readout on the dial face as you rock the gauge back and forth. Record the value of the largest deviation away from "0" on the dial face. Record the deviation as a positive number if it falls to the right of "0," and a negative number if it falls to the left of "0."
4. Look at the reading. This is the lowest reading, which is taken when the gauge is square on the bore, and the indicator needle reverses its direction. It can be either more or less than the zero mark, and will indicate an oversize or undersize bore
5. Add or subtract the value of the largest deviation from the calibrated value of the bore gauge. If the gauge was zeroed at 100 mm, and the largest deviation was 0.5 mm to the right of the "0" on the dial face, then the final measurement of the bore is 100.5 mm. Alternatively, if the largest deviation was 0.5 mm to the left of the "0" on the dial face of a gauge calibrated to 100 mm, then the final measurement of the bore is 99.5 mm. The use of dial bore gauge is shown in Fig-22 and 23.

Precautions:

- Clean the hole to be measured and ensure that it is free of oil, grease or particles before introducing a precision measuring tool into the hole.

Never force precision measuring tools. Permanent and expensive damage may result and the tool will likely be ruined. Avoid shocks to the tool such as dropping it or hitting it.

Screw Pitch Gauges:

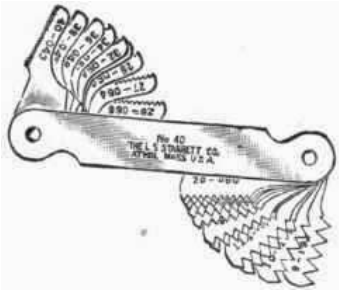


Fig-24 Screw pitch gauge

Screw pitch gauges are used to check the pitch of the thread immediately. It is very much in everyday tool used to pick out a required screw. The number of flat blades with different pitches is pivoted in a holder. The pitch value is marked on each blade. To know the pitch of any thread (nut, bolt etc.), by visual inspection the leaf is selected and placed on the profile of the thread. If the profile of screw pitch gauge leaf matches with the profile of the thread being inspected, the value of pitch is read from the leaf. If the profile does not match, another leaf is selected and process repeated till the profiles matches. It must be ensured that during matching air or light should not pass through the profiles. The screw pitch gauge is shown in Fig-24.

Feeler Gauges:

Fig-25 Feeler gauge

Feeler gauges are used for checking the clearance between mating surfaces. They are mainly used in adjusting the valve clearance and setting of spark plug gaps in automobiles. They are made from 0.03to 1.0mm thick of 100mm long leaves. The blades are pivoted in a holder. The value of thickness of the leaf is marked/engraved on it.

To know or adjust the clearance/ gap, the leaf of the feeler gauge is selected and inserted in the gap, the leaf should not be loose or inserted with force. The leaf should go in the

gap with slight drag/resistance. The value of the clearance/gap is read from the leaf of feeler gauge. The feeler gauge is shown in Fig-25.

Session-3: Dial Indicator/Gauge and other Gauges
Exercise: Assignment

1. Various types of gauges are used for checking components of automobile. Make a list of these gauges

S.No.	Name of gauge

2. Make a poster showing working principle of dial gauge and label the parts.

Session-3: Dial Indicator/Gauge and other Gauges
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. Dial gauge is used as a measuring device to measure the accuracies in ----------, ---------- of the parts/components.
2. Dial gauge works on the ---------- and ---------- principal.
3. A telescoping gauge is a measuring tool with spring-loaded ---------- used together with a ---------- to measure the inside of holes or bores.
4. A vernier bore gauge measures a bore ----------.
5. A dial bore gauge is a special tool, which is used to accurately measure the inside ---------- of a hole, cylinder or pipe and will also detect -------- and tapers in bores.
6. Screw pitch gauges are used to check the ---------- of the thread immediately.
7. Feeler gauges are used for checking the clearance between --------surfaces.

Session-3: Dial Indicator/Gauge and other Gauges
Checklist for Assessment Activity
Use the following checklist to see if you've met all the requirements for dial indicator/gauge and other gauges

Part A
Share importance of use of dial indicator/gauge and other gauges in repair and maintenance of automobiles.

Part B

Discussed in class the following:

- Importance of dial indicator/gauge and other gauges.
- Describe the working principle of dial gauge.
- Describe feeler gauge and its application.
- Describe the steps required the measure the bore of the object with the help of dial bore gauge.
- Describe screw pitch gauge and its application.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance dial and other gauges in inspection of automobile components		
Able to describe the working principle of dial gauge		
Able to identify dial and other gauges		
Able to use dial and other gauges		

Session- 4: Instruments on the Dash Board of a Vehicle

Relevant Knowledge

Whenever we enter a vehicle and sit on driver's seat, we find many instrument or indicators on a dashboard. A dashboard can be considered as a control panel placed in front of the driver on which he keeps an eye for proper functioning of the vehicle. The dashboard has cluster of instruments and gauges which convey the health of vehicle to the driver. The instrument cluster contains gauges and indicators such as speedometer, tachometer, odometer and fuel gauge, and indicators such as gearshift position, seat belt warning light, parking-brake-engagement warning light and an engine-malfunction light. There may also be indicators for low fuel, low oil pressure, low tire pressure and faults in the airbag (SRS) system. Heating and ventilation controls and vents, lighting controls, audio equipment and automotive navigation systems are also mounted on the dashboard. The top of a dashboard may contain vents for the heating and air conditioning system and speakers for an audio system. A glove compartment is

Fig:-26 Dash board and instrument panel of a vehicle

commonly located on the passenger's side. There may also be an ashtray and a cigarette lighter which can provide a power outlet for other low-voltage appliances.

Important Components of Dashboard

- Speedometer,
- Tachometer,
- Odometer and
- Fuel gauge, and
- Indicators such as gearshift position,
- Seat belt warning light,
- Parking-brake-engagement warning light and an
- Engine-malfunction light.
- Low fuel, low oil pressure,
- Low tire pressure and
- Faults in the airbag (srs) system.
- Heating and ventilation controls and vents,
- Lighting controls,

- Audio equipment and
- Automotive navigation systems

Every component fitted in dashboard indicates working of particular section. Some of the important instruments are:

Fig-27Speedometer

Speedometer: The speedometer tells the driver the speed of a vehicle whether he is driving fast or slow or within specified speed limit. Speed is measured in kilometers per hour. The control of vehicle rests with the driver therefore the speedometer helps the driver to keep the speed in safe limit depending on the situations for his own and passenger's safety. The speedometer is shown in Fig-27.

Tachometer: Tachometer (Fig-28) tells how fast engine is turning in revolutions per minute (rpm). Driver should avoid running engine so hard that it surges up into the "danger zone" as indicated on the tachometer. If the driver notice that tachometer is reading abnormally high on accelerating, it indicates problems and it is a time to get the vehicle checked in service station.

Fig-28 Techometer

Odometer:

An odometer (Fig-29) is an instrument that indicates distance traveled by a vehicle, such as a bicycle or automobile. The device may be electronic, mechanical, or a combination of the both. The device is helpful to know the distance covered between two destination.

Fig-29 Odometer

Fuel Gauge:

The fuel gauge (Fig-30) informs abut status of the amount of fuel in the tank of vehicle. If you don't keep an eye on your fuel gauge, you could run out of fuel. We should regularly check the fuel gauge so that we are not stranded at road due to absence of fuel.

Fig-30 Fuel gauge

Temperature Gauge:

The temperature gauge (Fig-31) doesn't actually measure the temperature of your engine. Instead, it measures the temperature of engine's coolant. Most gauges have ranges for cold, normal, and hot. If vehicle's temperature gauge gets into the hot range, it needs to be moved to a safe place and stop driving immediately. Ignoring this it may cause a lot of expensive damage in a fairly short amount of time.

Fig-31 Temperature gauge

It's important to get an idea of how hot car typically runs. While outside temperatures will affect the reading somewhat, temperatures that are consistently above vehicle's normal range could indicate problems with the cooling system.

Malfunction Indicator Lamp

A malfunction indicator lamp (MIL), also known as a check engine light, is a tell-tale to indicate malfunction of a computerized engine management system. It is found on the instrument panel of most automobiles. When illuminated, it is typically either an amber or red colour. On vehicles equipped with OBD-II, the light has two stages: steady (indicating a minor fault such as a loose gas cap or failing oxygen sensor) and flashing (indicating a severe fault that could potentially damage the catalytic converter if left uncorrected for an extended period). When the MIL is lit, the engine control unit stores a fault code related to the malfunction, which can be retrieved with a scan tool and used for further diagnosis. The malfunction indicator lamp usually bears the legend CHECK ENGINE, SERVICE ENGINE SOON, or a pictogram of an engine.

Fig-32MIL-Service Engine Soon

Fig-33MIL-Check Engine

In most cases, the light isn't a sign of anything serious. For that reason, a lot of people ignore it. The problem there is that one could end up driving around with a very serious issue and causing even more damage to the vehicle. The MIL warning display is shown in Fig-32, and 33.

Automotive navigation system

An automotive navigation system is a satellite navigation system designed for use in automobiles. It typically uses a GPS navigation device (Fig-34) to acquire position data to locate the user on a road in the unit's map database. Using the road database, the unit can give directions to other locations along roads also in its database. Various companies manufacture this unit and same can be fitted in dashboard of vehicle.


Fig-34 Navigator

Driver Information System (DIS):

Now days most of the vehicles are fitted with DIS System. This system enables driver about various information such as spontaneous fuel consumption, range of travel, available quantity of fuel in terms of kilometer, digital watch with atmospheric temperature.

Session- 4: Instruments on the Dash Board of a Vehicle

Exercise: Assignment

Answer the following questions

(Use additional sheets of paper if necessary)

1. List the important instruments which are fitted on a dashboard of a vehicle.

S.No.	Name of instrument

2. Draw a diagram of a dashboard with different instruments and components fitted on it and also label them.

Session- 4: Instruments on the Dash Board of a Vehicle

Answer the following questions

(Use additional sheets of paper if necessary)

Fill in the blanks

1. The speedometer tells the driver the ---------- of a vehicle.
2. Tachometer tells how fast engine is turning in ---------- (rpm).
3. An odometer is an instrument that indicates ---------- traveled by a vehicle.
4. The fuel gauge informs abut status of the ---------- of fuel in the tank of vehicle.
5. The temperature gauge doesn't actually measure the temperature of your engine; instead, it measures the temperature of engine's ----------.
6. An automotive navigation system is a ---------- system designed for use in automobiles.

Session- 4: Instruments on the Dash Board of a Vehicle
Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for instrument for dash board of a vehicle.

Part A

Share importance of dash board of a vehicle.

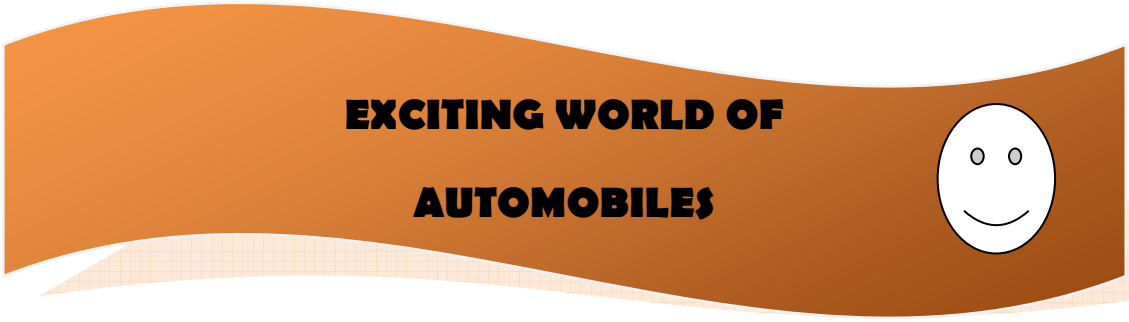
Part B

Discussed in class the following:

- Importance of instruments on the dash board.
- What information is given by the speedometer?
- What information is given by the odometer?
- What is the use of navigation system in automotive vehicles?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain importance of instruments used on the dash board of vehicle		
Able to identify the instruments used on the dash board of the vehicle		
Able to read instruments used on the dash board of the vehicle		
Able to interpret the reading of the instruments used on the dash board of the vehicle		



STUDENT WORKBOOK

Curriculum :AUTO-SRV *L4-NQ*^{2016}

Unit :AUTO-SRV *L4U4*

Serviceability, Replacement or Repair of Engine Components

Vocational Learning Material for Schools

PSS Central Institute of Vocational Education
Bhopal

Introduction

Engine is 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, cooling system. MPFI, CRDI and non CRDI are very important systems of a vehicle. Valve mechanism and its adjustment are important. Repair, servicing and replacement of defective component are necessary for smooth running of an engine.

In this Unit, you will develop an understanding of the reconditioning of valve mechanism, inspection and replacement of piston rings, inspection and replacement of connecting rod and engine bearing, testing of cooling system and replacement of defective component, regular servicing of MPFI system, Servicing of CRDI / non CRDI system vehicle so that engine's efficiency improves.

Session 1: Reconditioning of Valve Mechanism

Relevant Knowledge

In earlier unit, you were exposed about the role of valve. Valve is usually known as poppet valve. A poppet valve 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 guide the plug portion by sliding through a valve guide**.**

Fig 1: Valve

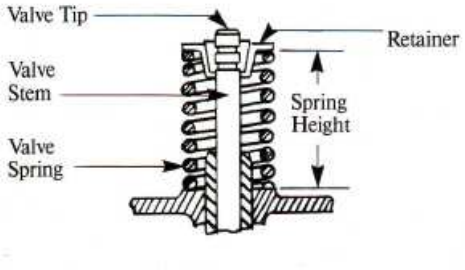


Fig 2 : Installed Valve Spring

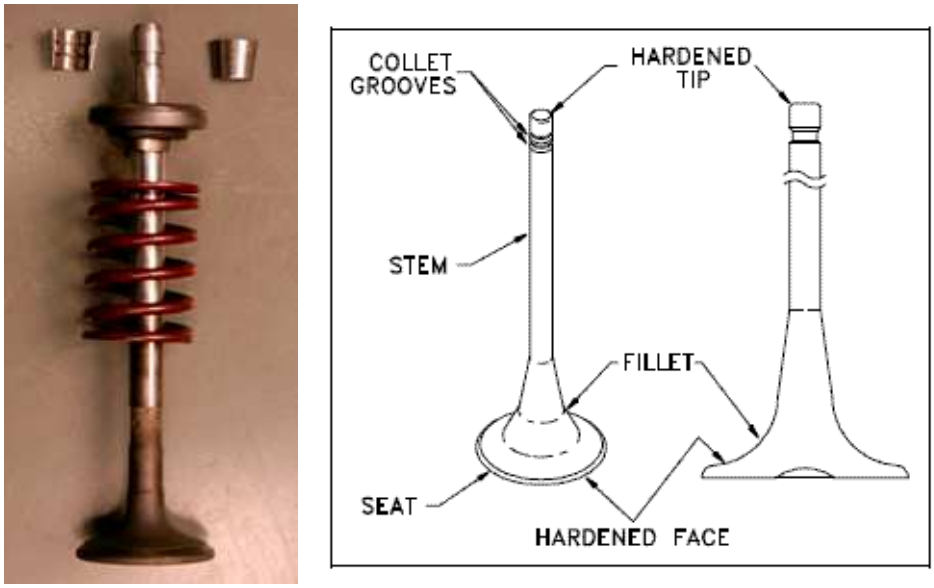


Fig 3: Engine Valve

Valve mechanism: It controls submission of inlet gases and emission of exhaust gases at right time in relation with rotation of cam shaft. Valve mechanism are classified as given below

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

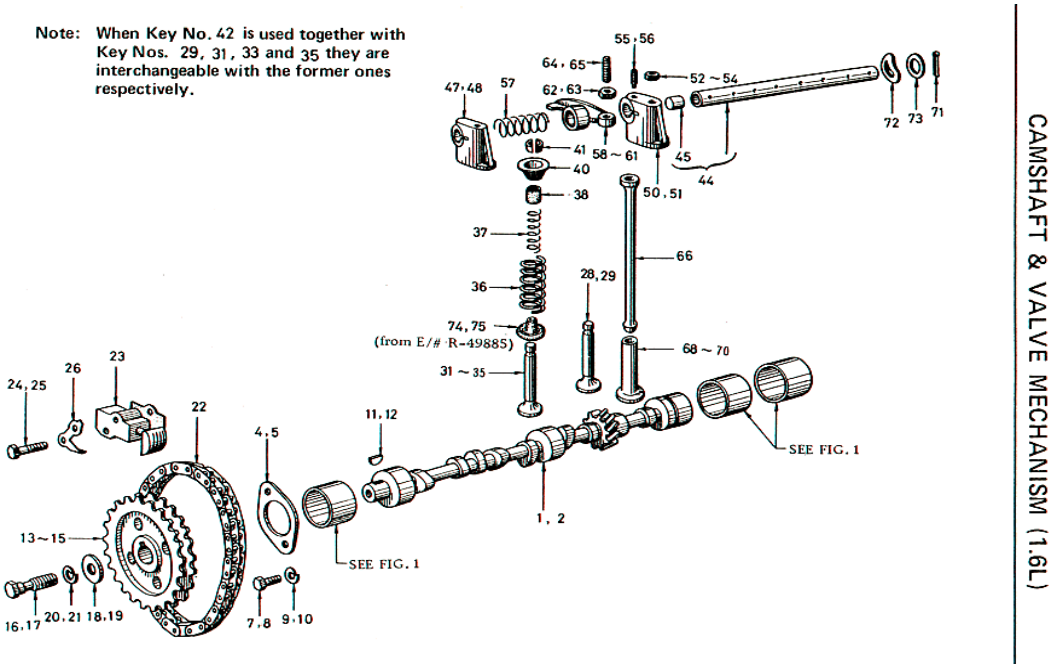


Fig 4 : Overhead Valve Mechanism

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 5 : Overhead mechanism

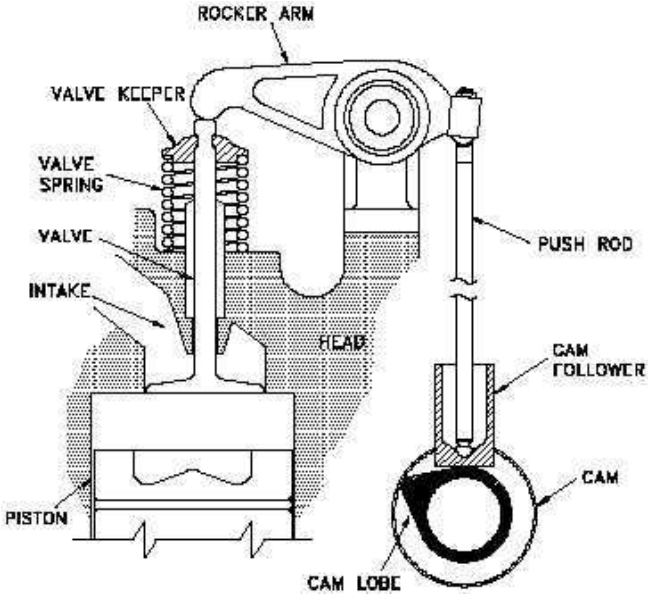


Fig 6: Valve cam mechanism

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 camshaft is fixed in the cylinder head. It consumes less engine power for operation of valve mechanism. In advance mechanism, supply of fuel increases the engine efficiency at high speed.

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 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 , valve timing. Together, these operations constitute the valve service necessary for smooth engine performance and maximum power output.

Procedure for reconditioning

- Dismantle the cylinder head from the engine.
- Remove the carbon from the 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 precision blue in petrol and with the help of dropper, put the mixture on the valve face.
- Remove the valves using a valve spring compressor, observe the valve leakage.
- Blue colour shows leakage area.
- Clean the valves with a wire brush

- Be careful not to interchange the valves. After reconditioning each valve must be placed in the same valve port from which it was removed.

The most common way to place them on a piece of board with holes drilled and numbered to correspond with respect to the cylinder number as each valve removed from.

Resurface the Valve

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

- 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

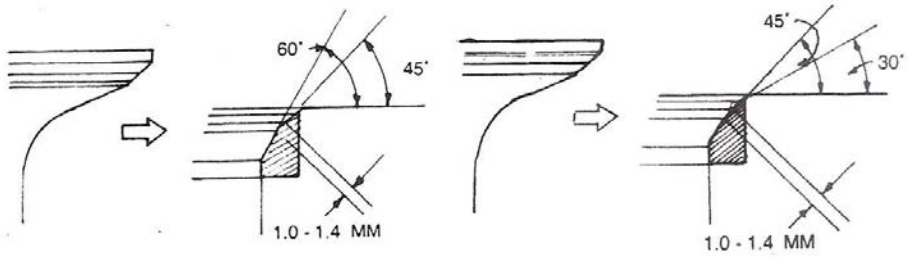


Fig 7 : Changing of Valve angle

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 2mm then it is suggested to carryout valve seat grinding operation,
- Select grinder/ cutter of appropriate size and angl,
- 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.

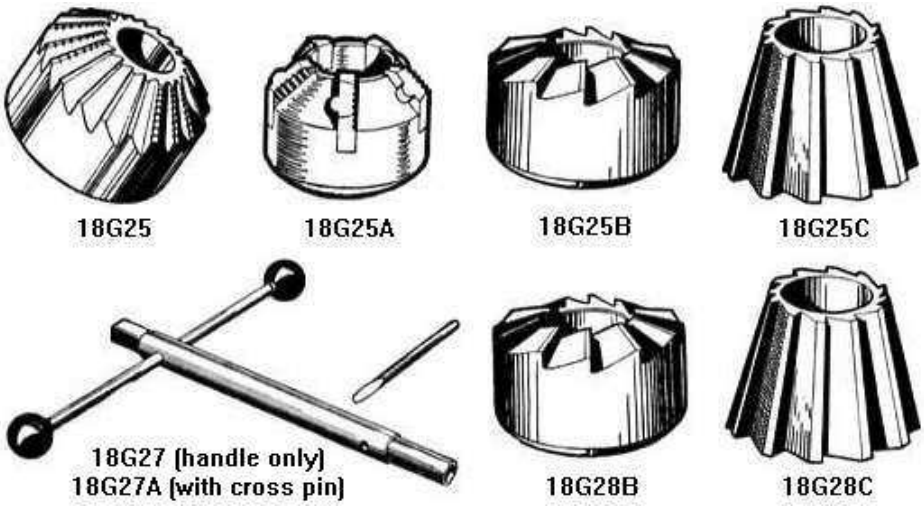


Fig 8: Seat angle cutting tools

Fig 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 operation to check the leakage

If leakages are noticed then use fine emery paste and continue the operation to solve the leakage problem

Fig 10 : Valve Lapping process

Session- 1: Reconditioning of Valve mechanism
Exercise: Assignment

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- 1: Reconditioning of Valve mechanism

Answer the following questions

(Use additional sheets of paper if necessary)

Fill in the blanks

1. A poppet valve is a --------- typically used to control the timing and ---------- of gas or vapour flow into an engine.
2. In overhead valve mechanism (OHV) the camshaft is fixed in the ----------.
3. In overhead cam mechanism (OHC) the camshaft is fixed in the ----------.
4. To overcome leakages of combustion gases, valve ---------- is required.
5. Remove the valves using a valve ----------, observe the valve leakage.
6. Measure the ---------- of valve seat with help of bevel protractor.

Session- 1: Reconditioning of Valve mechanism

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for reconditioning of valve mechanism of a vehicle.

Part A

Share importance of reconditioning of valve mechanism of a vehicle.

Part B

Discussed in class the following:

- What is poppet valve?
- How many kinds of valve used in IC Engine?
- What are the purpose of a valve?
- Briefly describe a function of a valve & draw its line diagrams with details?
- What are the seat angles & why it is required?
- Which part control opening & closing of a valve?
- Write the name of the tools required for valve seat grinding?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and explain the procedure for reconditioning of valves		
Able to understand and explain the procedure for resurfacing of valves		
Able to understand the procedure for cutting /grinding of valve seat and carry out the operation		
Able to understand the procedure for valve lapping and carry out the operation		

Session 2: Replacement of Piston Rings

Relevant Knowledge

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 piston has 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 to Bottom Dead Centre. The piston ring normally wears due to following reasons;

Compression ring withstands for more pressure and temperature. Piston ring expands and contract during compression and exhaust stroke. This movement of ring reduces width of 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.

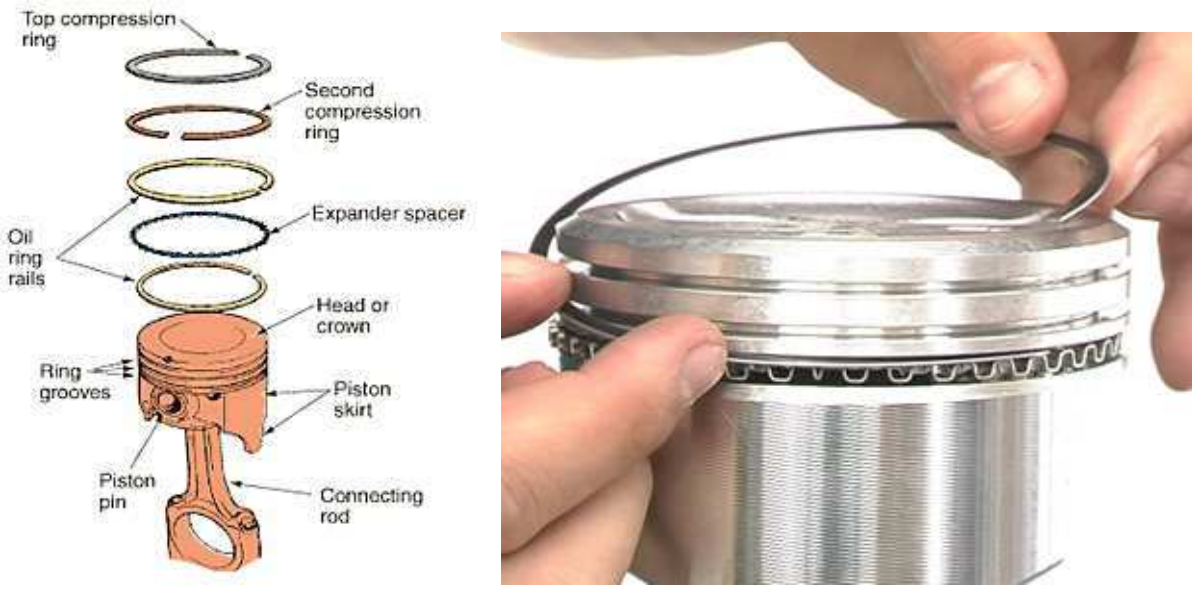


Fig 11: Inspection of Piston clearance in cylinder bore

Aim: To inspect the piston clearance, end gap, and side gap, piston clearance from the multi cylinder engine.

Tools required: Spanners, Micrometer and feeler gauge.

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 aside.
- The alternator, starter motor is not necessary to remove out, keep it 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 fuel line pipe and keep aside.
- Then remove the engine heater connection and lose the heaters.

- Take the 23-27 ring spanners, remove the injector, and 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.
- Also remove the cylinder head gasket.
- Then 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 reconditioning of valves if necessary.
- Clean and inspect the components.
- Set the valve timing, FIP and tapped cover setter.

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 feeler gauge.
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. Then take the micrometer and measure the feeler gauge.
4. Note down the reading.

C) Piston Clearance:

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

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

Session- 2: Replacement of Piston Rings
Exercise: Assignment

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- 2: Replacement of Piston Rings
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. A piston ring is a split ring which fits into a ---------- of an internal combustion engine or steam engine piston.
2. Most automobile engine piston has ---------- rings.
3. Compression ring withstands for more ---------- and ----------.
4. Piston ring ---------- and ---------- during compression and exhaust stroke.

5. Two compression rings are used in most of the ---------- combustion engine.
6. Piston rings transfer heat from the ---------- to the cylinder wall.
7. Oil ring is also ---------- when oil enters in combustion chamber and there is ---------- in the consumption of oil.

Session- 2: Replacement of Piston Rings

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for replacement of piston rings in a vehicle.

Part A

Share importance of replacement of piston rings in a vehicle.

Part B

Discussed in class the following:

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and explain the functions of piston rings		
Able to understand and explain gap between the ends of piston ring, side gap and piston clearance		
Able to measure gap between the ends of piston ring, side gap and piston clearance		

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

Relevant Knowledge

- 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 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 on the press.
- Apply pressure of 0.2 to 0.5 tone 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 becomes 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 pressure of 0.1 to 0.3 tone 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 for all sleeves.

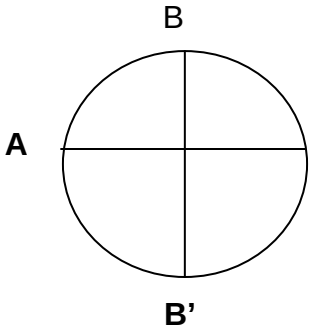
Replacement of Wet Liner / Bore Sleeve

- 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 on the press.

- Apply pressure of 0.1 to 0.3 tone 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 tone, take care that 'O' rings will 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 apply lubricating oil and with help of ring compressor place the piston in engine block with connecting rod.

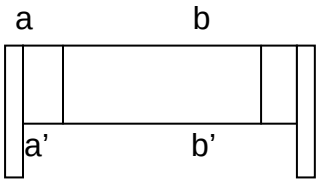
Inspection of Crank Shaft and Main Bearing

- 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 need to regrind the crank shaft.
- Inspect he big end journal/main journal for ovality and tapernes.
- Use micrometer and take reading at position A A' (Horizontal) and



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 tapernes take the reading at two end of the pin of main journal /connecting journal.
- Use micrometer and take reading at position a a' and then at position b b'. This shows tapernes.



- The permissible value of tapernes 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 upto 0.15 mm.
- To repair/ undersize the crank shaft special grinding machine is used.
- Undersize the crank shaft maximum upto 0.15 mm only.
- To accommodate the gap / clearance change 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 play 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 thrust pad of over size and if less reduce thickness of 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.

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

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

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

Fill in the blanks

1. Always replace the bend or ---------- connecting rod.
2. Turn the crank shaft, if run out is noticed more than ----------, then it is need to regrind the crank shaft.
3. The permissible value of ovality is ---------- mm to ---------- mm.
4. The permissible value of tapernes is ---------- mm to ---------- mm.

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

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for inspection and replacement of cylinder liner/ bore sleeve, connecting rod and engine bearing in a vehicle.

Part A

Share importance of inspection and replacement of cylinder liner/ bore sleeve, connecting rod and engine bearing in a vehicle.

Part B

Discussed in class the following:

- What is the function of connecting rod?
- Why do some connecting rod have hole drilled from small end to the big end bearing?
- Which part are connected to the small end of the connecting rod?
- Which part of connecting rod is connected with crankshaft?
- How to check bend in connecting rod?
- How to check clearance between connecting rod and crankshaft?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and explain the procedure for inspection and replacement of cylinder liner/ bore sleeve		
Able to understand the procedure and carryout inspection of crankshaft and main bearings		
Able to understand the procedure for replacement of wet liner and carry out the replacement.		
Able to understand the procedure for replacement of dry liner and carry out the replacement.		

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

Relevant Knowledge

In I.C. engine during power stroke, the engine temperature reaches between 700 – 900 ^{o}C. The 30% heat is released during exhaust stroke. The cooling system removes approximately 30% of heat.

(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 keep 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 lubricants. The cooling system protects the engine components by circulating coolant through the passages provided in cylinder block, cylinder head. The heat is collected by the coolant and the coolant will be sent to radiator. The radiator radiates the heat and cools down the coolant temperature. The air circulated around the engine also dispers the heat and allows the engine to maintain optimum temperature.

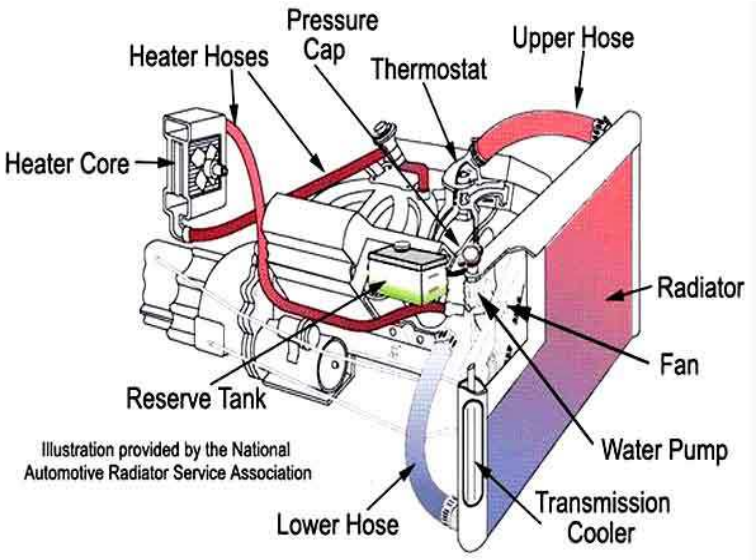


Fig : Automobile Cooling

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

Causes and remedy for Cooling System

Reasons	Remedy
Loose or broken water pump pulley belt	Adjust / replace
Low level of coolant	Check coolant level and add as necessary
Faulty thermostat	Replace
Faulty water pump	Replace
Dirty or bend radiator fins	Clean or remedy
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 Service manual.

Session 4 : Testing of cooling system and replacement of defective components
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-4: Testing of cooling system and replacement of defective components
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. In I.C. engine during power stroke, the engine temperature reaches between ---------- to ---------- ^{o}C.
2. In a vehicle, most of the energy of fuel (approx. 70%) is converted into ----------, and it is the job of the ---------- to take care of that heat.
3. The primary job of the cooling system is to keep the engine from overheating by ---------- this heat to the air.

Session-4: Testing of cooling system and replacement of defective components
Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for testing of cooling system and replacement of defective components in a vehicle.

Part A

Share importance of testing of cooling system and replacement of defective components in a vehicle.

Part B

Discussed in class the following:

- Why the cooling system is important in I C Engine?
- Name the different component of cooling system
- Name the different methods of engine cooling.
- Difference between oil cooling system and water cooling system.
- What is the function of radiator in cooling system?
- Why coolant is added in the radiator?
- What is the function of thermostats?
- What is the function of water pump and cooling fan?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and explain the working of cooling system in the engine		
Able to understand and identify common faults in cooling system		
Able to identify cause of faults and suggest remedies		
Able to identify components of cooling system		

Session 5: Regular Servicing of MPFI system

Relevant Knowledge

Multi Point Fuel Injection system (MPFI): Due to legislative requirement to reduce exhaust gas emissions (air pollution) and to increase demands in term of performance of engine, driving comfort and control and safety, MPFI system has been introduced. 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 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: Sensing 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 (lymda) sensor etc.

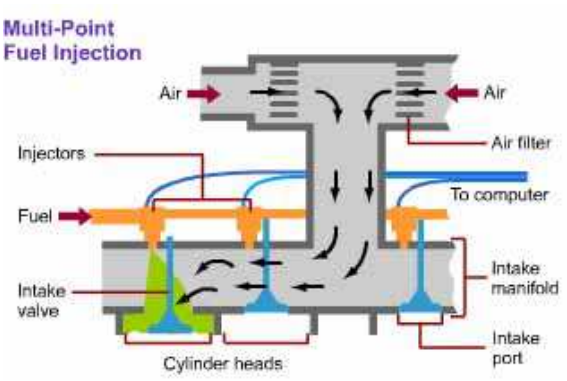
Actuators: Receives control signal from ECM and does function accordingly. (ISCA, PCSV, Injectors and Power Transistor etc.) Important actuators are fuel injector, immobilizer unit, body control module, motorised headlight, fuel pump etc.

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 which can be recovered or read by diagnostic equipment.

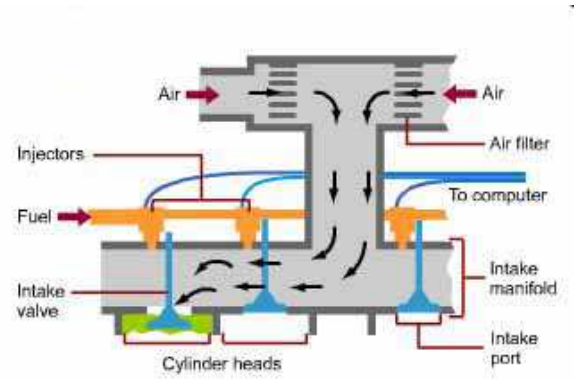
Case I: If ECM fails to send control signal to all actuators then the engine won't get started.

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

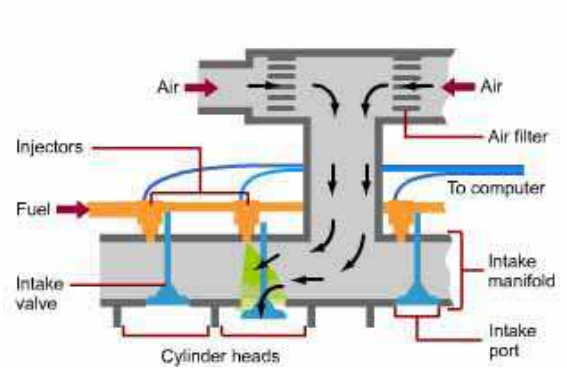
Figure given below shows different stages from 1 to 4 of multipoint injection fuel as per valve timing.



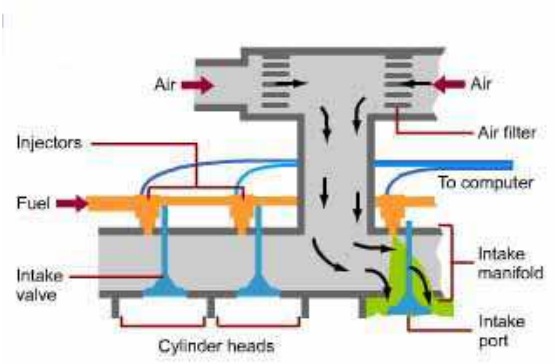
Stage(1)



Stage(2)



Stage(3)



Stage(4)

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. Due to short circuit and poor battery voltage, leads to failure of sensor.
3. Sledge formation can be seen in battery terminal and will 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. Due to carbon deposit inside the throttle valve and backfire. Throttle body (Butter fly) can be cleaned by carbo cleaner.

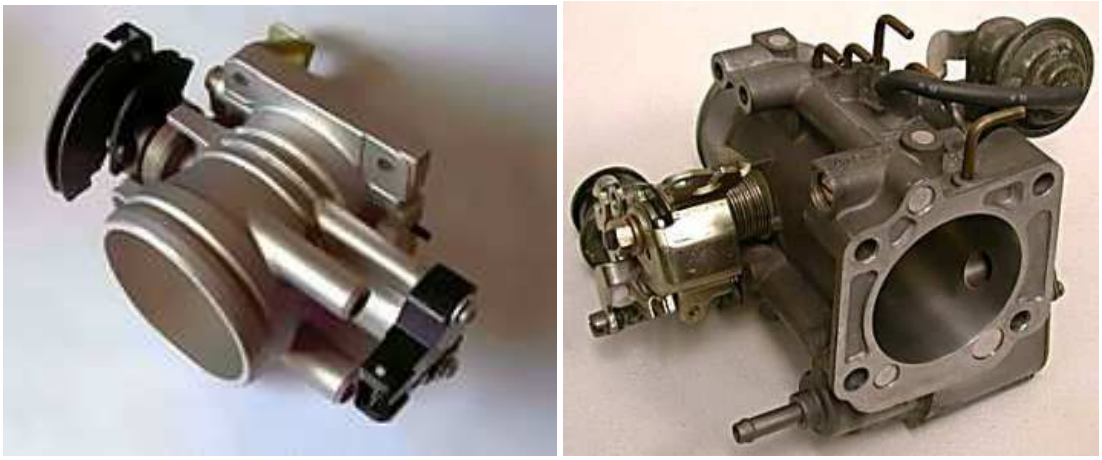


Fig13 : Throttle body

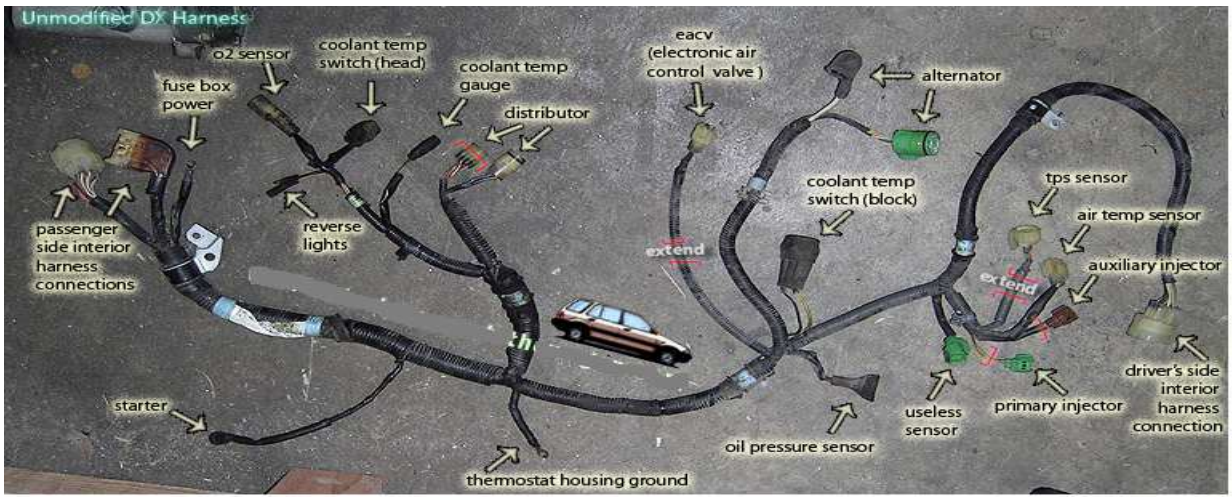


Fig 14 : Sensor representation at MPFI Circuit

Session-5: Regular Servicing of MPFI system

Exercise: Assignment

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-5: Regular Servicing of MPFI system

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

Fill in the blanks

1. Sensors sense different ---------- of the engine and send ---------- to ECM.
2. Actuators receives control signal from -------- and does --------- accordingly.
3. Processor collects all the data from -------- and --------, takes appropriate decision.
4. The function of ECM is to receive signal from various ----------, manipulate the signals and send control signals to the ----------.
5. MPFI system is also called ---------- engine management system.

Session-5: Regular Servicing of MPFI system
Checklist for Assessment Activity
Use the following checklist to see if you've met all the requirements for regular servicing of MPFI system in a vehicle.

Part A
Share importance of regular servicing of MPFI system in a vehicle.

Part B
Discussed in class the following:
- What is the full form of MPFI?
- What are main components of MPFI?
- What are the advantages of MPFI over Conventional System?
- What are the disadvantages of MPFI over Conventional System?
- What precaution to be taken while working on MPFI system?
- What is Sensor?
- What is Actuator?
- What is ECM?
- Write the two name of sensor used in MPFI?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and explain the working of MPFI		
Able to understand the advantages of MPFI over conventional system		
Able to understand and explain working of sensor		
Able to understand and explain working of actuator		
Able to understand and explain working of ECM		

Session 6 : CRDI and Non CRDI system

Relevant Knowledge

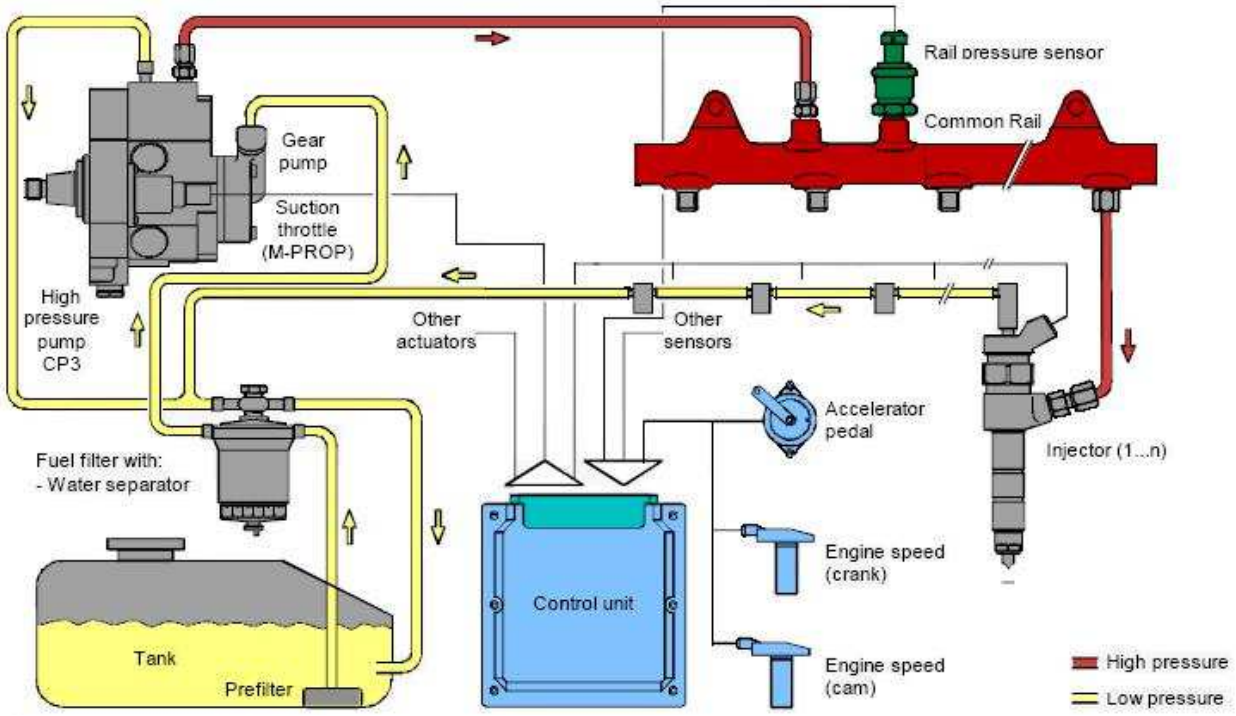


Fig 15 : CRDI System

CRDI (Common Rail Direct Injection);It is a modern technique of fuel supply system used in new generation of diesel engine.

Main component of fuel supply system are

- 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 16 : Cut section view of high pressure pump

Fig 17 : Internal component 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 & springs similar to engine valves.

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

Individual Pump Fuel Injection system: In this system 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 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 18 : Individual Inline injection pump

Fuel Injector Nozzel:

To inject the fuel in the cylinder in properly,automized form and in proper quantity, fuel injector nozzel is 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 19: Nozzel

Fig 20 : Different type of nozzel

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 charger**s are popularly used with Petrol and Diesel internal combustion engines.

Fig 21: Cut portion of Turbo charger

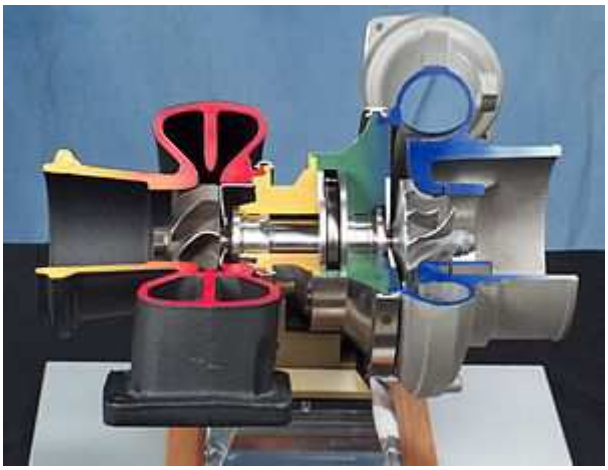


Fig 22 : Turbo Charger

Servicing of Turbocharger:

Normally turbochargers are working at 150000 rpm. Servicing of turbocharger is not recommended by the manufacture but if the oil seal failure occurs than complete turbocharger assembly is replaced. Precaution to be taken not came across dust entry while disassembly of turbocharger.

Session-6: CRDI and Non CRDI system
Exercise: Assignment

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

Session-6: CRDI and Non CRDI system

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

Fill in the blanks

1. In common rail fuel injection system a ------- injection pump with injector called as unit ---------- is employed on each ----------.
2. In individual pump fuel injection system fuel is drawn from the --------- by means of fuel feed ---------- which is operated from the injection pump ----------.
3. To inject the fuel in the ---------- in properly,automized form and in proper quantity, fuel injector ---------- is used.
4. Nozzel consist of small ---------- which helps in ---------- of the fuel.
5. A turbo charger or turbo is a forced ---------- device used to allow more power to be produced by an ---------- of a given size.
6. Turbo chargers are popularly used with petrol and diesel ---------- combustion engines.

Session-6: CRDI and Non CRDI system

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for CRDI and Non CRDI system in a vehicle.

Part A

Share importance of CRDI and Non CRDI system in a vehicle.

Part B

Discussed in class the following:

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and explain the working of CRDI		
Able to understand the advantages of CRDI over conventional system		
Able to understand and explain working of main components of CRDI system		
Able to understand and explain working of turbo-charger		
Able to understand and explain working of non CRDI system		
Able to understand explain the working on common rail and individual pump injection system		

EXCITING WORLD OF AUTOMOBILES

STUDENT WORKBOOK

Curriculum :AUTO-SRV *L4-NQ*^{2016}

Unit :AUTO-SRV *L4U5*

Transmission System

Vocational Learning Material for Schools

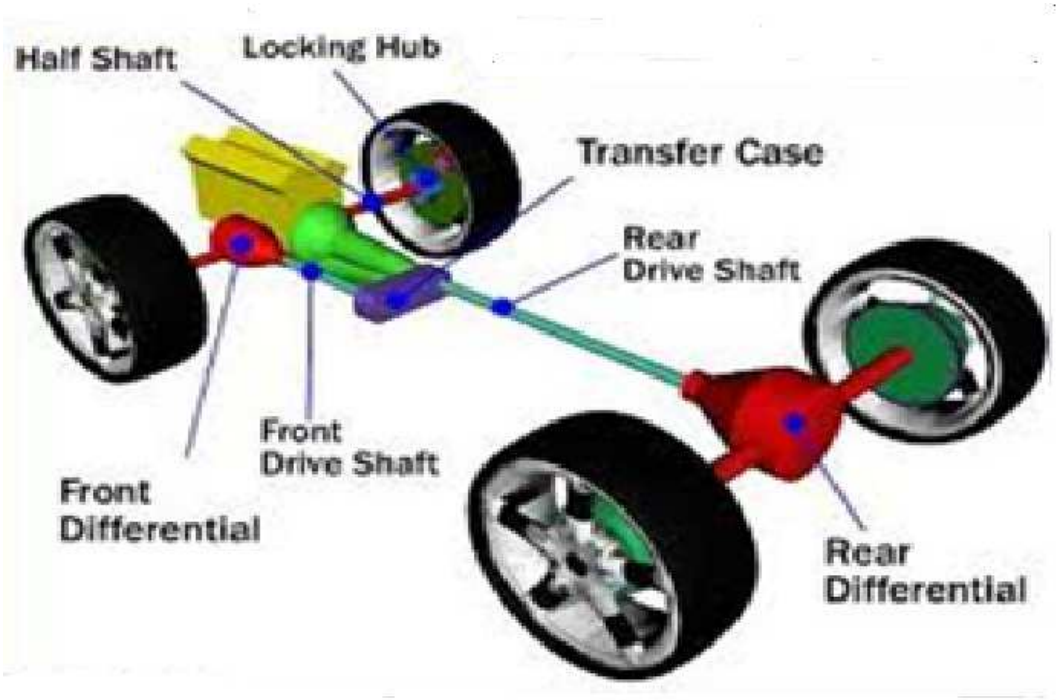
PSS Central Institute of Vocational Education Bhopal

Introduction

The oldest variant of the transmission system in India is the manual transmission that has undergone various modifications and alterations to form the present day automatic transmission.

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

In this Unit, you will develop an understanding of the transmission system.



Session 1: Overhauling of clutch

Relevant Knowledge

In unit 3 we have discussed about maintenance and regular adjustments in clutch for efficient power transmission. When clutch runs nosily and clutch slips, do not engage and disengage properly, gives jerking 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 vero drive.

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 compare to spring clutch and it transmits more torque as diaphragm exerts more pressure as compare to springs. 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 compare to other types of clutches.

Fig 1: Diaphagram Clutch

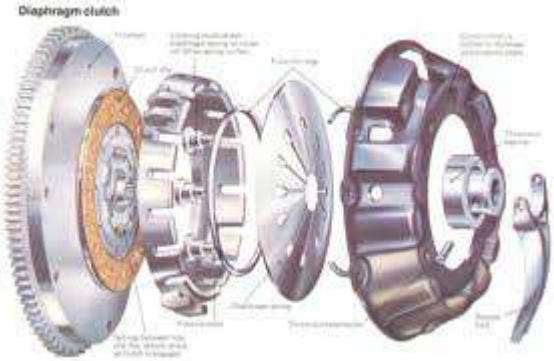


Fig 2: Exploded View of clutch

Activity 1: To overhaul the clutch used in vehicles

Tools required: Open, ring and box spanner, special tools etc.

Procedure for removing clutch assembly from the engine:

1. Place the vehicle on the level 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 the replace it.
3. Check the cover assembly of clutch, if there is oil leakage then replaces 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 2.0mm then replace the clutch plate.
7. Inspect for the bend of the clutch shaft and also check the spline condition of the clutch.
8. Inspect the torsion springs for breakage or slackness.
9. Check the gap between internal spline of clutch hub and clutch shaft external spline and it should not exceed the gap of 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
5. 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 torn finger and if it has cracks on it.
2. Check the tension of the spring.
3. Check the release bearing for wear, 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 clutch pedal is released for the engagement of the clutch, vehicle starts moving with jerks. This phenomena 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

Session- 1: Overhauling of clutch
Exercise: Assignment

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

S.No.	Steps
1	
2	
3	
4	

2. In a vehicle the clutch judder, make a list of causes and remedies.

S.No	Causes	Remedies
1		
2		
3		
4		

Session- 1: Overhauling of clutch
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. In diaphragm clutch, ---------- is used in place of coil spring.
2. Diaphragm acts as both ---------- spring and release ----------.
3. Diaphragm clutch requires less -------- compare to other types of clutches.
4. The frictional surface of the pressure plate has ---------- lines/scratches.
5. Diaphragm clutch is small in ------ as compare to spring clutch and it transmits more ----------.

Session- 1: Overhauling of clutch
Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for overhauling of clutch of a vehicle.

Part A

Share importance of reconditioning of overhauling of clutch of a vehicle.

Part B

Discussed in class the following:

- What is function of clutch in vehicle?
- When the clutch plate is changed in vehicle?
- What are the components of clutch system?
- What parts are connected to the gear input shaft?
- Why the clutch springs used in clutch plate?

Performance standards/criteria covered by this assessment

Performance standards	**Yes**	**No**
Able to understand and explain the procedure for overhauling of diaphragm clutch		
Able to check the friction surfaces of clutch, pressure plate and flywheel for oil leakage		
Able to carry out overhauling of diaphragm clutch		

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

Related Knowledge

Propeller shaft :

When the engine and axles are separated from each other on four-wheel-and rear-wheel-drive vehicles, propeller shaft is used to transmit engine power to the rear drive axles. The propeller shaft is mounted between the gearbox and differential and thus the engine power is transmitted to the driving wheels.

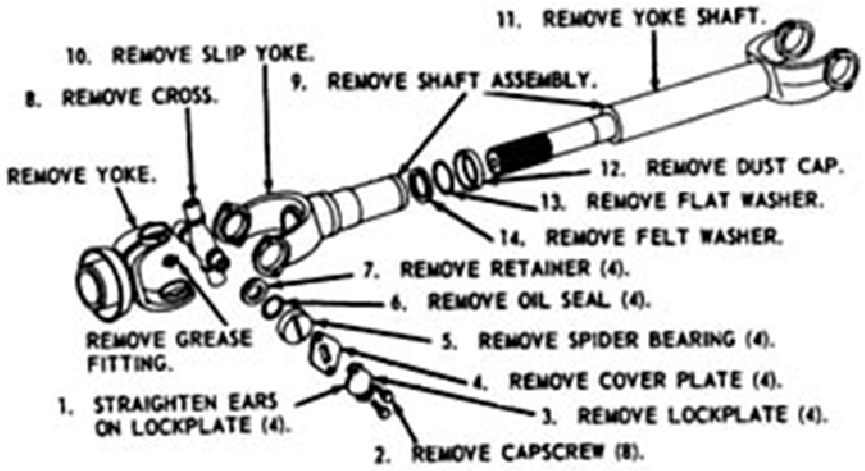


Fig 5: Propeller shaft

Inspection of propeller shaft, universal joint and sleep 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 deflection of 2 mm then it indicates the propeller shaft is bent.

The bent propeller shaft 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.

Now 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. Sleep joint internal splines

If the readings or not found in permissible values replace the universal joint with sleep 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 6: Drive shaft) is solid circular shaped shaft usually made of steel this transmits power from engine to gear and then to the wheels of a vehicle.

Fig :6 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 snapping fitting of joint so as to release snap ring fitting of joints spline at differential side.
5. Disconnect stabilizer joint form 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 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 tool to fix/remove cage.
16. Draw away 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 for breakage or deformation.
3. Check that there is no play in the out board joint.
4. Check and see the inboard joint, slides smoothly in thrust direction.
5. Check the play in redial direction of in board joint, it should not be there.

Assembly of Drive shaft

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

Session- 2: Servicing of propeller shaft, universal and slip joints

Exercise: Assignment

1. Make a list of steps for inspection of propeller shaft, universal joint and sleep 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- 2: Servicing of propeller shaft, universal and slip joints

Answer the following questions

(Use additional sheets of paper if necessary)

Fill in the blanks

1. The propeller shaft is mounted between the ---------- and ----------.
2. The propeller shaft is used to transmit ---------- power to the rear driving ----------.
3. A drive shaft is solid ---------- shaped shaft.
4. The drive shaft transmits power from engine to -------- and then to the -------- of a vehicle.

Session- 2: Servicing of propeller shaft, universal and slip joints

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for servicing of propeller shaft, universal and slip joints of a vehicle.

Part A

Share importance of servicing of propeller shaft, universal and slip joints of a vehicle.

Part B

Discussed in class the following:

- 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 to be changed?
- Describe the functions of drive shaft.

Performance standards/criteria covered by this assessment

Performance standards	**Yes**	**No**
Able to understand and explain the procedure for servicing of propeller shaft, universal and slip joints		
Able to understand and explain the procedure for servicing, inspection and adjustment of drive shaft		
Able to find causes of faults in propeller shaft and suggest suitable remedies		

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 consist crown gear, sun gear and star gear.

Importance of Differential

A vehicle wheel rotates at different speeds, especially when turning. Each wheel travels a different distance through the turn, and that the inside wheels travel a shorter distance than the outside wheels. Since speed is equal to 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.

(New picture need to be inserted)

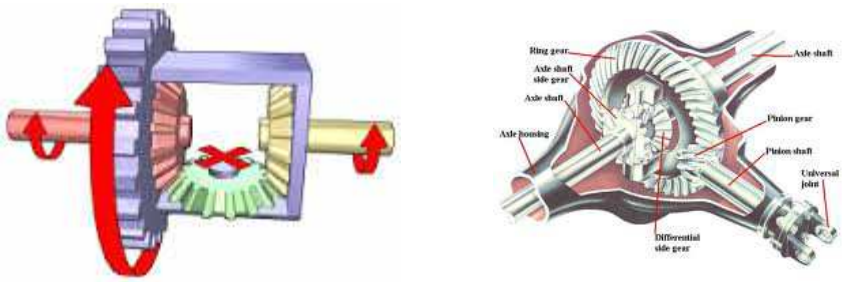


Fig 9: Differential unit

Fig 10: Differential view

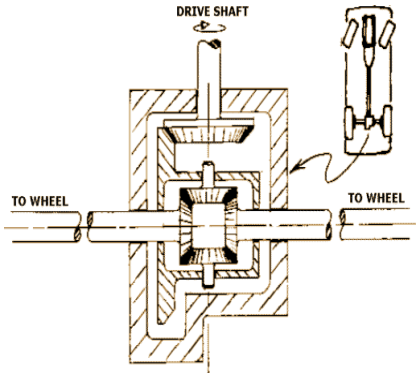


Fig 11: Differential section

Differential

The differential has three jobs:

- To transfer the engine power through gearbox and propeller shaft to wheels.
- To act as the final gear reduction in the vehicle, slowing the rotational speed of the transmission one final time before it hits the wheels
- To transmit the power to the wheels while allowing them to rotate at different speeds while taking a turn.

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, the planet gear does not rotate, and both wheels turn at the same rate.

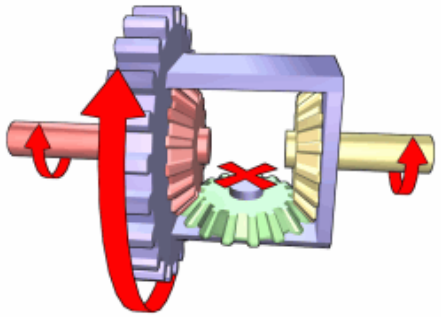


Fig12: Differential at work

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

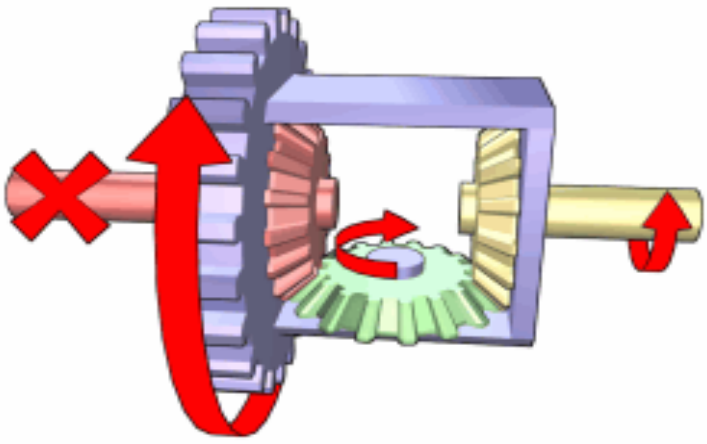


Fig13: Differential at left not working

Servicing of Differential

Servicing of differential means regular interval of oil has to be changed with proper grade as per service manual. Replace the broken gear and brass washer or damaged portion if required

Adjustment of differential

Adjustment of differential can be done by various thickness of shim. Adjusting bolt is provided at outer side of cage assembly to adjust 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 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 side of side caps and remove the crown star gear and sun gears.
6. Mark the position of all parts carefully for their easy reassembly in their original position.
7. Check crown wheel, sun gears, star gears teeth if it is broken replace the gears. Change all the brass washers.
8. Keep the caps and shims carefully as the 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 bearing.
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.
2. Inspect the condition of all the gears teeth's for roughness, chipping, cracking.
3. Put the 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 the above mentions pastes to the crown wheel teeth's.
   - Apply the grease on both the side of the teeth equally.
   - And then rotate the pinion check the tooth contact.
   - If the tooth contact is improper the 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 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 also provided to support crown and final drive.

Assembly

1. Fix the thrust washers, shims and distance rings properly in correct position and reassemble the differential unit.
2. Check the end play of pinion shaft moved up and down.
3. Adjust the clearance to the proper value by means of shims and adjusting nut.
4. Check all the clearance of the tooth contact between the crown wheel & pinion.
5. While doing the adjustment you have to take care of backlash .
6. Backlash is gap between two meshing teeth of bevel pinion and crown wheel

Check the backlash in final drive

After assembly the differential unit,

- Place the telescopic end of dial gauge on the crown wheel teeth, set dial gauge to zero
- Now without turning the pinion shaft, move the crown wheel backlash will be noted on the dial gauge
- The Backlash of pinion & crown wheel should not exceed 0.15 to 1.18mm.
- To adjust the backlash, tighten the side check nuts in 4:1 ratio
- Backlash between sun gear and star pinion
- Place the dial gauge telescopic end on 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 0.20mm.
- If there is more backlash, change the thrust pad with 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 0.0025mm.

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

Drive is not is not transmitted

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

Session- 3: Servicing of differential unit and adjustments

Exercise: Assignment

1. Make a list of functions of differential in a vehicle

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- 3: Servicing of differential unit and adjustments
Answer the following questions
(Use additional sheets of paper if necessary)
Fill in the blanks

1. A differential is a device employing ----------, capable of transmitting -------and rotation through three shafts**.**
2. A vehicle wheel rotates at ---------- speeds, especially when turning.
3. Each wheel travels a different distance through the ---------, and that the inside wheels travel a ---------- distance than the outside wheels.
4. Servicing of differential means regular interval of oil has to be -------- with proper ---------- as per service manual.
5. The Backlash of pinion & crown wheel should not exceed ------- to --------mm.
6. The backlash of sun gears & planetary gears should not exceed -------- to ---------- mm.

Session- 3: Servicing of differential unit and adjustments
Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for servicing of differential unit and adjustments of a vehicle.

Part A

Share importance of servicing of differential unit and adjustments of a vehicle.

Part B

Discussed in class the following:

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and explain the procedure for servicing and adjustment of differential unit		
Able to carry out adjustments in differential unit		
Able to find causes of faults in differential unit and suggest suitable remedies		

Session 4: 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 having to shift 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 takes the place of a 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 14: 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 of 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).

Session- 4: Introduction to the Automatic Transmission System Exercise: Assignment

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

Fill in the blanks

1. Automatic transmission is an ---------- gearbox that can change gear ratios automatically.
2. An automatic transmission incorporates a torque converter, which takes the place of a ----------.

Session- 4: Introduction to the Automatic Transmission System Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for introduction to the automatic transmission system of a vehicle.

Part A
Share importance of introduction to the automatic transmission system of a vehicle.

Part B

Discussed in class the following:

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand the importance of automatic transmission in a vehicle		
Able to understand the working principle of automatic transmission		

EXCITING WORLD OF AUTOMOBILES

STUDENT WORKBOOK

Curriculum :AUTO-SRV *L4-NQ*^{2016}

Unit :AUTO-SRV *L4U6*

Suspension system

Vocational Learning Material for Schools

PSS Central Institute of Vocational Education
Bhopal

Introduction

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 movement. Similarly whenever a vehicle moves on smooth or rough roads, more jerk takes place. To reduce the jerk in a vehicle, a suspension system is provided.

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

In this Unit, you will develop an understanding of the suspension system used in a vehicle, Maintenance of suspension system, Service and repair of leaf spring set etc., Manual and power steering system, Steering system adjustment adjustments of a vehicle so that vehicle's efficiency increases.

Session- 1: Maintenance of suspension system

Relevant Knowledge

Importance of vehicle's suspension

Vehicle's 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 performing the function of keeping the tyres evenly connected with the road and maintaining a vertical load on 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 support the weight of vehicle act as a flexible link that allows the body and frame to ride with minimal disturbance, while the tyres and suspension follow the road.

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

- 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 checkups

Suspension is very important to the safety and performance of vehicle. As the part of vehicle that puts tyres in contact with the road, the suspension plays a critical role. 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 suspension system. Checkup should 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 vehicle.
- Avoid sudden acceleration and breaking.

Session- 1: Maintenance of suspension system
Exercise: Assignment
Answer the following questions
(Use additional sheets of paper if necessary)

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

S.No.	Function
1	
2	
3	
4	

Session- 1: Maintenance of suspension system
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. The shock absorbers on a vehicle go through as many as ---------- movements per kilometer.
2. The springs support the ---------- of vehicle act as a flexible link that allows the body and frame to ride with minimal disturbance.
3. Suspension keeps the vehicles tyres in contact with the ----------.
4. Suspension is very important to the ---------- and ---------- of vehicle.
5. Most of the suspension parts are made of ------- material to minimize ----------.

Session- 1: Maintenance of suspension system
Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for maintenance of suspension system of a vehicle.

Part A
Share importance of maintenance of suspension system of a vehicle.
Part B
Discussed in class the following:

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain the importance of suspension system in a vehicle		
Able to identify major components of suspension system		
Able to understand and describe the functions of suspension system in a vehicle		

Session 2: Service and replacement of leafs, cambering of leaf springs, shackle, shackle pin and centre bolt

Relevant Knowledge

Leafs 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.

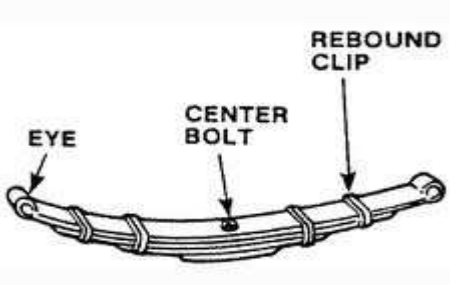


Fig1: Leaf spring

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, while tie holes are provided at either end for attaching 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 can serve locating and to some extent damping as well as springing functions. While the interleaf friction provides a damping action, it is not well controlled and results in static friction in the motion of the suspension.

Fig 2: Leaf spring fitted in a vehicle

Fig 3: 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 takes up the tendency of the leaf spring to elongate when compressed and thus makes for softer springiness.

Role of leaf spring

- 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.
- As the positioning of the axle is carried out by the leaf springs so it makes it disadvantageous to use soft springs i.e. a spring with low spring constant.
- 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 end. This process is called Cambering process. It helps to reduce the flexibility of spring. It helps to overcome the problem of lowering of fender.

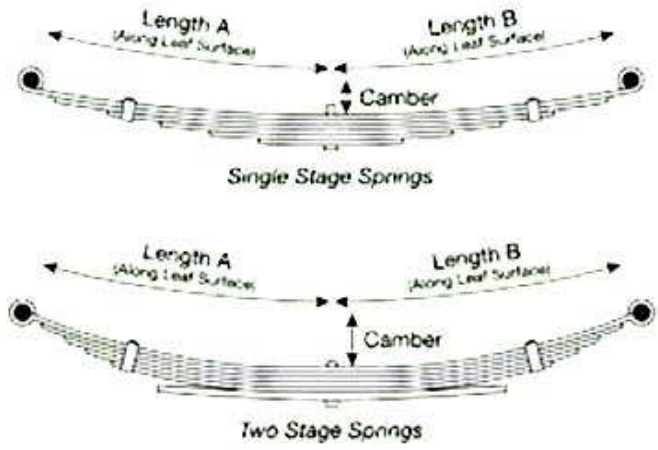


Fig 4: Cambering of leaf spring

Fig 5: 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 tire on the road. Without a shackle, the spring would not be able to move and the tire would be pulled off of the road's surface when a bump or obstacle was encountered. 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 leads 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 spanner 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 leaves, 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 the every nut/bolts 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.

Session- 2: Service and replacement of leafs, cambering of leaf springs, shackle, shackle pin and centre bolt

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

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- 2: Service and replacement of leafs, cambering of leaf springs, shackle, shackle pin and centre bolt

Answer the following questions

(Use additional sheets of paper if necessary)

Fill in the blanks

1. A leaf spring is a simple form of ---------- commonly used for the suspension in ---------- vehicles.
2. A leaf spring takes the --------- of a slender arc-shaped length of ------ steel of rectangular cross-section.
3. Leaf springs can serve -------- and to some extent ---------- as well as springing functions.
4. The leaf spring acts as a linkage for holding the --------- in position and thus separate ---------- are not necessary.
5. Cambering helps to reduce the ---------- of spring.
6. A spring shackle is a device found on leaf-spring ----------vehicles.
7. Centre bolt holds the ---------- of leaf together to bear the ----------.

Session- 2: Service and replacement of leafs, cambering of leaf springs, shackle, shackle pin and centre bolt

Use the following checklist to see if you've met all the requirements for service and replacement of leafs, cambering of leaf springs, shackle, shackle pin and centre bolt of a vehicle.

Part A

Share importance of service and replacement of leafs, cambering of leaf springs, shackle, shackle pin and centre bolt of a vehicle.

Part B

Discussed in class the following:

- Why leaf springs are provided in vehicle, state its functions?
- Sate the role of leaf spring in a vehicle?
- Describe the functions of shackle.
- Describe the functions of centre bolt
- What tools and equipment are required for servicing of leaf spring system.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain the role of leaf spring in a vehicle		
Able to understand the procedure for servicing, repair and replacement of leaf springs		
Able to use the tools and equipment used in servicing, repair and replacement of leaf springs		
Able to carry out servicing, repair and replacement of leaf springs		

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

Relevant Knowledge

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 shock up/suspension has its own life. Suspension system has damper with spring. This works as shock absorber/strut.

Fig 6: Shock absorber

ADD figure Exploded view of strut

Life of shock absorber is affected due to 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 example)

- 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 shockup 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 the certain height to make the wheel free to rotate
3. Loosen the wheel nut and remove out 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.

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

Exercise: Assignment

Answer the following questions

(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- 3: Replacement of strut/shock absorbers, inspection of steering linkages
Answer the following questions
(Use additional sheets of paper if necessary)
Fill in the blanks

1. A shock absorber is a mechanical device designed to smooth out or damp ---------- and dissipate ----------.
2. Suspension system has damper with ----------.
3. Every shock up/---------- has its own life.

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

Use the following checklist to see if you've met all the requirements for replacement of strut/shock absorbers, inspection of steering linkages of a vehicle.

Part A

Share importance of replacement of strut/shock absorbers, inspection of steering linkages of a vehicle.

Part B

Discussed in class the following :

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

Performance standards/criteria covered by this assessment

Performance standards	**Yes**	**No**
Able to explain the role of shock absorber in a vehicle		
Able to understand the procedure for servicing, repair and replacement of shock absorber		
Able to use the tools and equipment used in servicing, repair and replacement of shock absorber		
Able to carry out servicing, repair and replacement of shock absorber		

Session 4: Inspection of steering linkage

Relevant Information

Steering Linkage

A steering linkage 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.

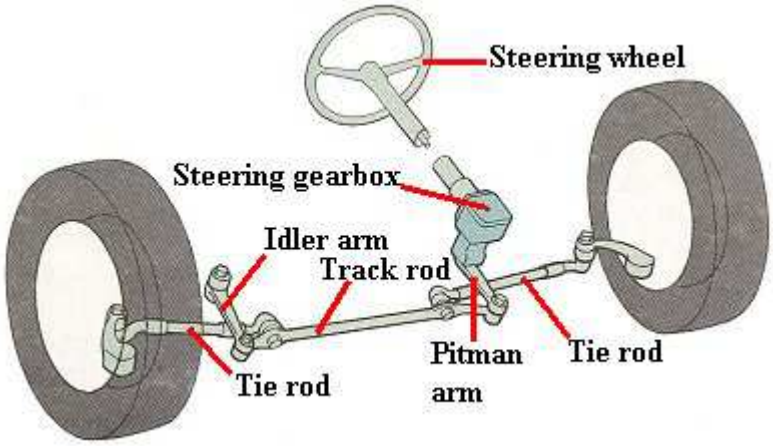


Fig 7: Steering Linkage

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 its 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.

Precaution

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

Session- 4: Inspection of steering linkage
Exercise: Assignment
Answer the following questions
(Use additional sheets of paper if necessary)

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- 4: Inspection of steering linkage

Answer the following questions

(Use additional sheets of paper if necessary)

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.

Session- 4: Inspection of steering linkage

Use the following checklist to see if you've met all the requirements for inspection of steering linkages of a vehicle.

Part A

Share importance of inspection of steering linkages of a vehicle.

Part B

Discussed in class the following:

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain the role of steering linkages in a vehicle		
Able to understand the procedure for inspection, repair and replacement of steering linkages		
Able to carry out servicing, repair and replacement of shock absorber		

Session 5: Manual and Power steering System

Relevant Knowledge

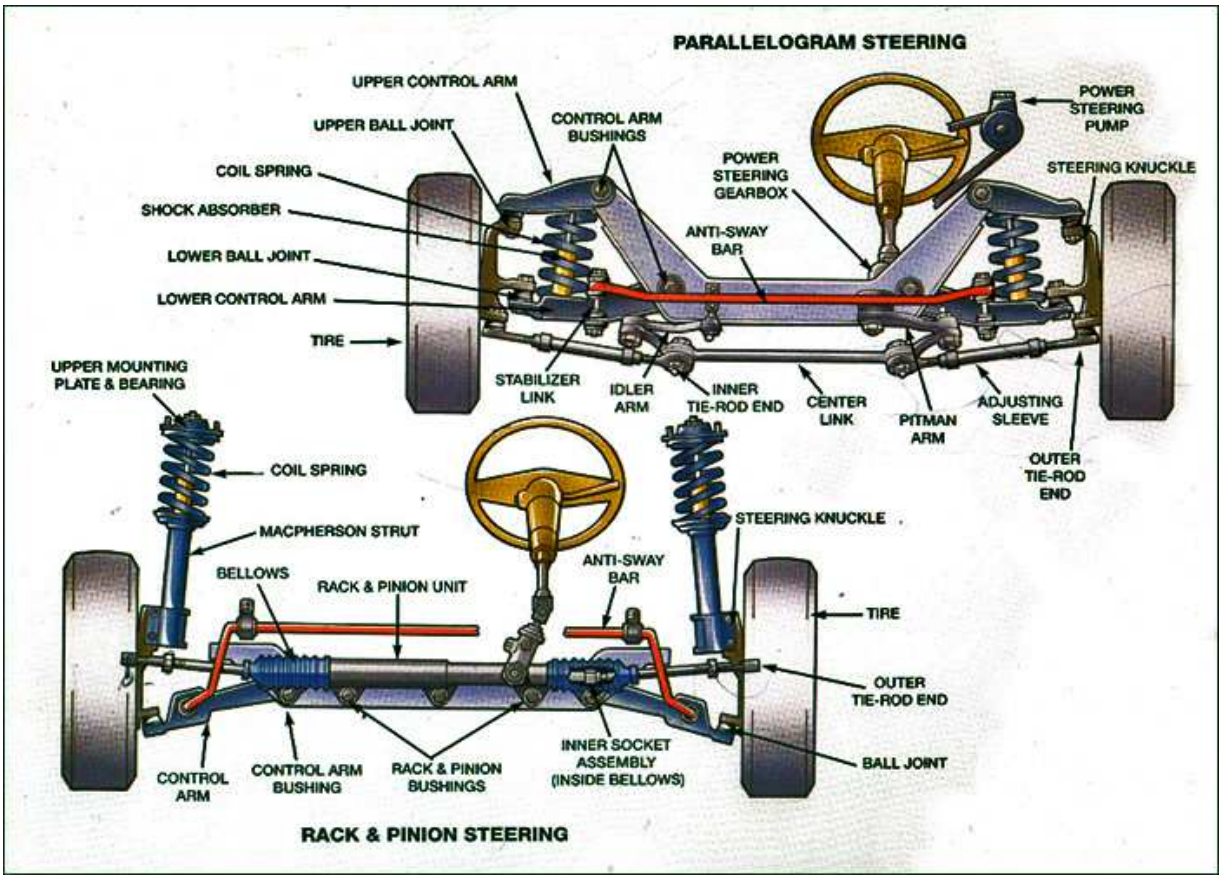


Fig 8: Steering System

Manual Steering

Vehicle is steered with mechanical efforts and maintains and control road stability. Different types of steering box are used in automobile vehicle.

- Worm and roller shaft
- 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/Manual operated steering

Procedure for servicing of the manual steering system (Worm and roller shaft**)**
To check the working of mechanically/manually operated steering system, following steps are followed.

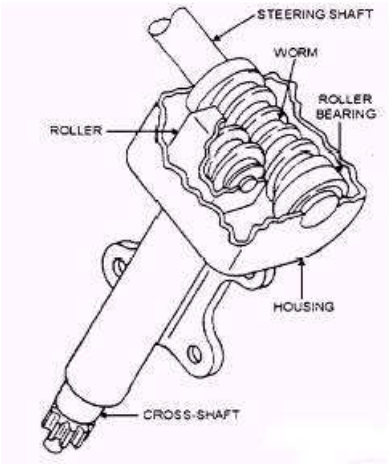


Fig 9: Worm and roller steering gear

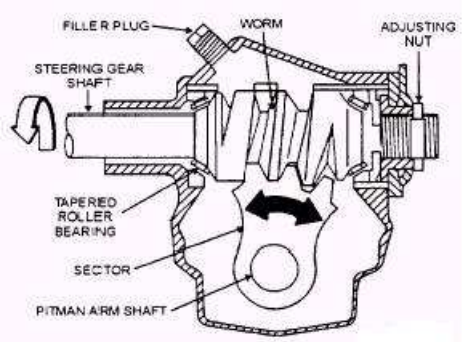


Fig 10: Worm and sector steering gear

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 compare to worm and wheel type of steering gear.

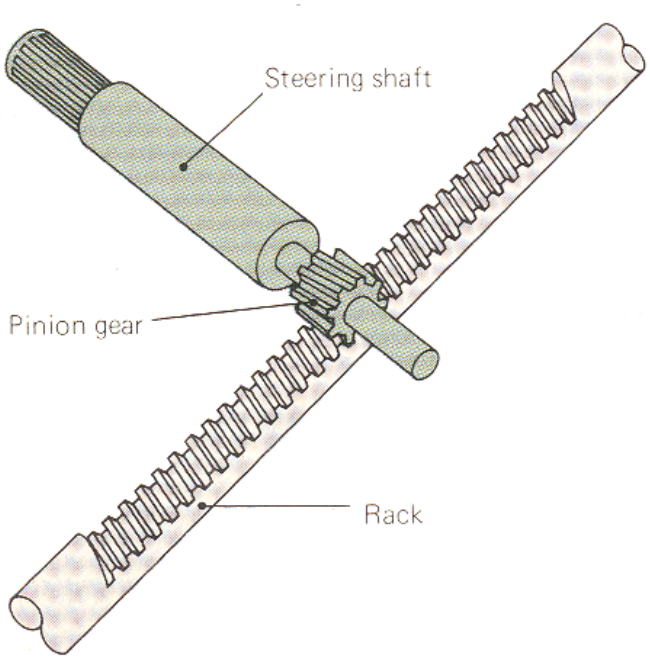


Fig 11: Rack and pinion steering system

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 02mm
  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 power is applied mainly hydraulic and electronically operated motor.

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 v belt. Hydraulic system consist 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, when 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

2nd type of Electronic power assisted steering system EPS

EPS uses as 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 connect to either steering gear or steering column. This mechanism is fitted at steering shaft/ worn shaft. It helps in assisting in steering of vehicle. In this system electrical motor operated

Advantage of this system is in fuel efficiency because there is no belt driven hydraulic pump constantly running by the 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 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 days gas filled shock absorber are being used for more comfort.

Fig12: Air Suspension System

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

Session- 5: Manual and power steering system
Exercise: Assignment
Answer the following questions
(Use additional sheets of paper if necessary)

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- 5: Manual and power steering system
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. Rack and pinion type of steering gear is used for --------- vehicles and in ---------- steering.
2. In hydraulic operated power steering, fluid is ---------- through a centrifugal pump.
3. The centrifugal pump is driven by the engine ----------through v belt.
4. EPS uses as electric ---------- to assist the driver of the vehicle.
5. Air suspension is a type of vehicle suspension -------- by an electric or engine driven ------ or compressor.
7. The purpose of air suspension is to --------- a smooth, --------- ride quality and in some cases it is self-leveling.

Session- 5: Manual and power steering system
Use the following checklist to see if you've met all the requirements for manual and power steering system of a vehicle.

Part A
Share importance of manual and power steering system of a vehicle.

Part B

Discussed in class the following:

- Describe the procedure for servicing of the manual steering system.
- Describe the procedure for servicing of rack and pinion type of steering.
- State types of powers used in operation of power steering.
- Describe the procedure for inspection of power steering.
- Describe principle of working of air suspension system.
- What is function of steering in vehicle?
- Write the name of components of steering system.
- In modern vehicle which types of steering are used.
- What are limitations of manual steering?
- What are advantages of power steering over manual steering.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain the role of manual and power steering in a vehicle		
Able to understand the procedure for inspection, repair and maintenance of manual steering		
Able to understand the procedure for inspection, repair and maintenance of rack and pinion type steering box		
Able to understand the procedure for inspection and servicing of power steering		

Session 6: Steering System Adjustments

Relevant Knowledge

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 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 13: Wheel Balancing Machine

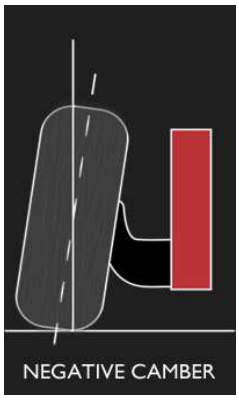
Wheel Alignment:

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 loose 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

1. When the wheels tilt out ward at top the camber is positive
2. When the wheels tilt inward ward at 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 replace

The real advantages to negative camber are seen in the handling characteristics. An aggressive driver will enjoy the benefits of increased grip during heavy cornering with negative camber. During straight acceleration however, negative camber will reduce the contact surface between the tires and road surface. The real advantages to negative camber are seen in the handling characteristics. An aggressive driver will enjoy the benefits of increased grip during heavy cornering with negative camber. During straight acceleration however, negative camber will reduce the contact surface between the tyres and road surface.

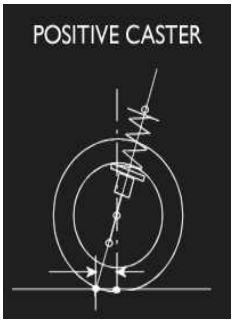
Toe–in

In other 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 forwardThe difference between the readings at backward end and forward end of the road wheels. 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.

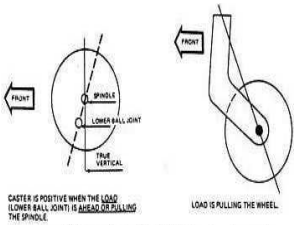
Toe–in adjustment

1. The difference between the readings at backward end and forward end of the road wheels.
2. The purpose of the toe in, toe out is to ensure parallel rolling of the front wheel and maintains directional stability
3. Toe is adjusted by changing the tie rod length
4. Toe in adjustment maintains the normal wear of the tyre

Castor angle



1. 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.
2. Typically, positive caster will make the vehicle more stable at high speeds, and will increase tire lean when cornering. This can also increase steering effort as well.
3. Caster influences directional control of the steering but does not affect the tire wear and is not adjustable on this vehicle. Caster is 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. When the rear of the vehicle is lower than its designated trim height,



From the side, caster is the tilt of the steering axis. When the wheel is in front of the load, the caster is positive.

Toe out on turn

Is a the difference in angles between the front two wheels during a turn, steering system is designed to turn the inner wheel at more angle then the outer wheel. 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 wandering of the vehicle

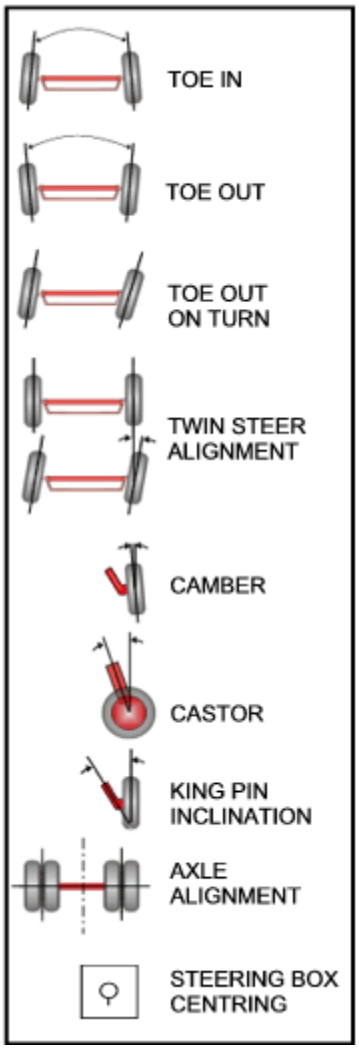


Fig14: Steering Angles

Procedure for checking and adjustment of wheel alignment

1. Made ON the red color switch on the back side of machine.
2. Parked the vehicle with its front wheels on turntables.
3. Fitted both heads (of machines) to both rims.
4. Tied the vehicle with string, from one front wheel to other through both rear wheels.
5. Switched “ON” the monitor. It showed “MENU” on the screen.

6. There were five details in the menu.
   - Measurement
   - Front self calibration.
   - Rear self calibration.
   - Records of new models.
   - Service.
7. There were some figures and numbers on the keys of keyboard Pressed number (1) and then (Enter).We got the next step. There was (selection 1 to 5) below menu. Pressed the desired job (select 1 to 5). Press “Enter” after it.
8. Fed the vehicle details/code using key board. After entering the data pressed “Enter”.
9. We got the “Date and specification chart” on screen. Fed the vehicle details to the blank space in this chart. Pressed “Enter”.
10. We got “selection (1 to 4)”. Details of operation 1 to 4 were given below the selection.
11. We were to do alignment of front wheels so we pressed “2” and then “Enter”. As soon as we pressed the “enter”, we got the Toe-in, Camber Angle, Caster Angle, King Pin Set Back Max and Steering Angle on screen.

Wheel Steering Adjustment

Steering Adjustments

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 10-12mm
- 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
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 may causes due to the following resons

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 toe 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 sides 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 is 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 returnablity

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

Session- 6: Steering System Adjustments
Exercise: Assignment
Answer the following questions
(Use additional sheets of paper if necessary)

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	

Session- 6: Steering System Adjustments
Answer the following questions
(Use additional sheets of paper if necessary)

Fill in the blanks

1. Wheels which are out of balance generally produce a ---------- that makes ---------- to drive a vehicle.
2. The first sign that wheels may be out of balance is when steering wheel starts to ---------- at certain speed.
3. Wheel alignment consists of adjusting the -------- of the wheels so that they are set to the manufacturer's ----------.
4. When the wheels tilt out ward at top the camber is ----------.
5. Toe-in is a measurement of how much the front and/or rear wheels are turned ------ or ---------- from a straight-ahead position.
6. Toe in adjustment maintains the normal ---------- of the tyre.
7. Defined as the angle, created by the steering pivot point from the front to back of the --------- is called ---------- angle.
8. The distance between the centre of the front axle and the rear axle is called the wheel ----------.
9. The improper wheel base causes ---------- tyre wear.
10. When the vehicle is steered the inner wheel turns an angle of -------degrees the outer wheel turns an angle of --------- degrees.

Session- 6: Steering System Adjustments

Use the following checklist to see if you've met all the requirements for steering system adjustments of a vehicle.

Part A

Share importance of steering system adjustments of a vehicle.

Part B

Discussed in class the following:

- What is the use of castor plate?
- Write the turning radius of two small cars?
- Wheel Balancing/Wheel alignments
- Why wheel balancing is required in a vehicle?
- How dynamic balancing of wheel is carried out with the help of balancing machine?
- Write the symptoms of imbalanced wheel in the vehicle?
- What are the ill-effects, if wheels are not properly balanced in a car?
- What do you understand by toe-in and toe-out?
- What is castor angle and how does it affects steering system?
- What is camber angle and how does it affects steering system?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to explain the role of steering system adjustments in a vehicle		
Able to understand the procedure for inspection and adjustment of wheel alignment		
Able to carry inspection and adjustment of wheel alignment		
Able to carry toe-in adjustment		
Able to locate the different types of troubles occurring in steering system, find their causes and suggest suitable remedies		

STUDENT WORKBOOK

Curriculum :AUTO-SRV *L4-NQ*^{2016}

Unit :AUTO-SRV *L4U7*

Auto Electrical

Vocational Learning Material for Schools

PSS Central Institute of Vocational Education
Bhopal

Introduction

With the development of new technology in the field of Automobile, comfort level of the passenger have increased. One of the most important component in automobile technology is use of appropriate technology. These technology are driven by appropriate signals. Automobile Electrical is one of the most appropriate technology used now a days. It is necessary that proper maintenance, repair and maintenance of auto electrical items in a vehicle are done by trained authorised mechanic. In this unit important components of auto electrical has been discussed.

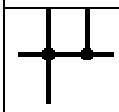
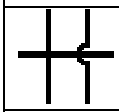
These are automotive electrical and electronics symbol, reading of circuit diagrame, cables specification and colour code, wiring harness, Electrical test equipments, Battery and its maintenance, Checking of electrical connections of lighting system in a vehicle, Application and replacement of fuses, Circuit diagrame of charging system of automobile and checking of charging system, Circuit diagram of starting system of automobile and checking of starter circuit, Circuit diagram of ignition system and checking of ignition circuit, Maintenance and servicing of major electrical accessories and Introduction to climate control system heating ventilation and air conditioning in a vehicle.

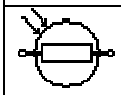
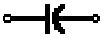
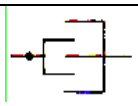
In this Unit, you will develop an understanding of the Auto Electrical System.

Session 1 : Automotive Electrical and Electronics Symbol, Reading of Circuit Diagramme, Cables Specification and Colour Code, Wiring Harness

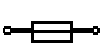
Relevant Knowledge

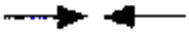
The Automotive Electrical and Electronics Symbols with their name and descriptions are given below :

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	Relay open / closed connection by an electromagnet
	SPDT Relay	

	Jumper	Close connection by jumper insertion on pins
SYMBOLS	**COMPONENT NAME**	**DESCRIPTION**
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 / soienoid that generates magnetic field
	Iron Core Inductor	Includes iron
	Variable Inductor	
SYMBOLS	**COMPONENT NAME**	**DESCRIPTION**
	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	
	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.
SYMBOLS	**COMPONENT NAME**	**DESCRIPTION**
	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.

	Fuse	Used to protect circuit from high currents.
	Spark Gap	Spark gap is given to the spark plug.

Automobile Cables and their specification

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

It may be mentioned that these days 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 0.875mm 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 the 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, 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.

It may be mentioned that whenever long cables are used producing voltage drop greater than 10%, 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 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 V. 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 was affected by heat, oil and petrol. This resulted 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 7mm. 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 Colours 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 circuit. 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 and so on.

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.

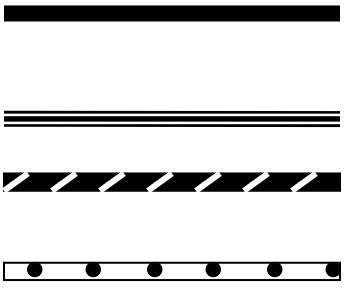
Blue Cables

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	WH	VT	VIOLET	WH

	GREEN				
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

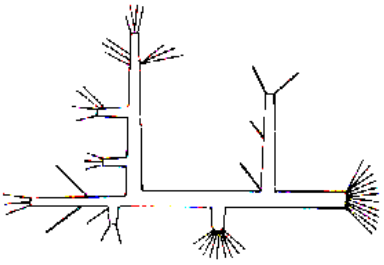
MAIN CIRCUIT IDENTIFICATION CODES (CHRYSLER)

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 Illumination Circuits
F Radio Speakers and Power Seat Circuits.
G Gauges and Warning Lamp Circuits
H Horn Circuit.
J Ignition System Run Circuit.
J1 Ignition Switch Feed Circuit.
J3 Ignition Switch Start Circuit.
K Tralier Tow.
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 Voltage Regulator (Field).
R6 Alternator Circuit to Ammeter (Feed)
S Starter Motor and Starter Relay Circuit
T Trunk Lamp Circuit.
V Windshield Wiper and Washer Circuit.
W Power Window Circuit
X Radio, Cigar Lighter, Lamp Grounds, Clock, Speed Control, Power Antenna, 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. 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.



It may be noted that there is a typical drawback to this system. It 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. If at all it happens, it is advisable to fit a new cable externally to the harness instead of cutting the same and then binding it to the harness.

Session-1 : Automotive Electrical and Electronics Symbol, Reading of Circuit Diagram, Cables Specification and Colour Code, Wiring Harness
Exercise: Assignment

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

S.No.	Name of the component	Description
1		
2		

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

Session 1: Automotive Electrical and Electronics Symbol, Reading of Circuit Diagram, Cables Specification and Colour Code, Wiring Harness
Answer the following questions
(Use additional sheets of paper, if necessary)

Fill in the blanks

1. While selecting the cable size, the ---------- is kept in mind.
2. When the cranking motor is switched on, it draws ---------- current in the beginning of its operation.
3. 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 ----------.
4. The harness consists of -------- of cables leading to the various --------- to be connected.
5. ---------- cables are used for the battery circuit.
6. Yellow cables are used for the ---------- circuit.
7. White cables are used for the ---------- circuit.
8. Blue cables are used for the ---------- circuit.
9. Black cables are used for the ---------- circuit.

Session 1: Automotive Electrical and Electronics Symbol, Reading of Circuit Diagram, Cables Specification and Colour Code, Wiring Harness

Checklist for Assessment Activity

Use the following checklist to see if you've met all the requirements for Automotive Electrical and Electronics Symbol, Reading of Circuit Diagram, Cables Specification and Colour Code, Wiring Harness

Part A

Share importance of electricity and electronics in the automobile.

Part B

Discuss in class the following:

1. Show following items in symbolic form.
   - Fuse
   - Relay
   - Transistor
   - LED
   - Ground
2. Write various specification of Automobile cables.
3. What do you understand by cable color codes? Classify the Automobile cables.
4. What is Wiring Harness? How does it effect the electrical connections in Automobile?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to identify electrical and electronics symbols used in automotive electricity		
Able to read electrical and electronics circuits used in automobiles		
Able to understand and identify cable specifications and colour codes used in automotive electrical		

Session 2: Electrical Test Equipments

Relevant Knowledge

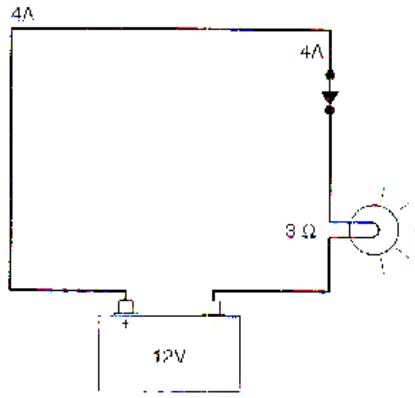
Since electricity is an invisible force, the proper use of test tools will permit the technician to "See" the flow of electrons. Knowing what is being looked at and being able to interpret various meter types will assist in electrical system diagnosis. To diagnose and repair electrical circuits correctly,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

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 bypassing switches, conductors, and connections in the circuit. Jumper wires can also be used to provide the ground to test that portion of the circuit. Jumper wires can never be used to ump the load 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 technician 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. 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.

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 technician 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 (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 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.

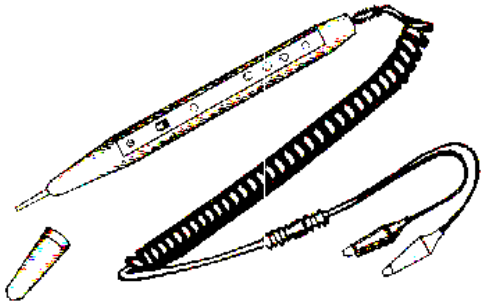


Fig.: Typical Logic Probe

Multimeter

A multimeter is an electrical test meter capable of measuring

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

Fig. : 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. This also eliminates the almost certain error caused by viewing an analog meter at an angle.

Fig. : Digital Multimeter

All meter have 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 leads 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 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.

- There are three general rules about the readings the technician 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.

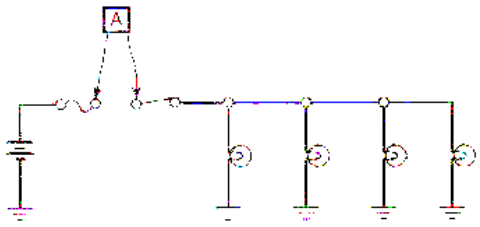


Fig. : Measuring Current Flow with an Ammeter (or Multimeter). The meter must be connected in series with the circuit

Voltmeter Test (available voltage)

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

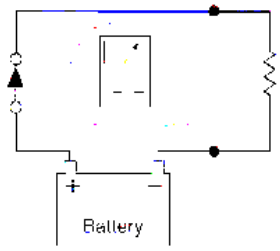


Fig.: Connecting a Voltmeter in parallel to the Circuit

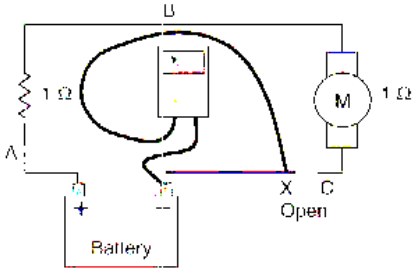


Fig. : Checking Voltage in an open circuit

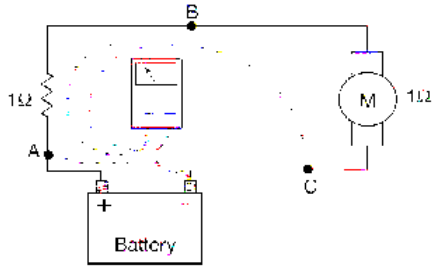


Fig. : Checking Voltage in a closed Circuit

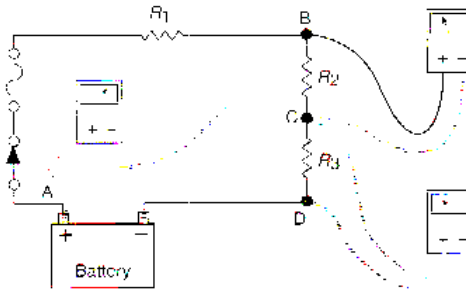


Fig. : Measuring the Voltage Drop

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 devices 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 Voltmeter Tests

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 if:

- 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 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 in a component that requires resistance. For example, a coil winding should have a high resistance value, a zero ohms reading would indicate the clil 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.

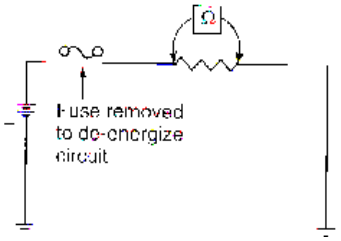


Fig. : Measuring resistance with an ohmmeter.

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 technician 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), 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. : 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.

Session- 2: Electrical Test Equipments
Exercise: Assignment

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

S.No.	Name of the electrical testing equipment	Applications
1		
2		

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

Session- 2: Electrical Test Equipments
Answer the following questions
(Use additional sheets of paper, if necessary)
Fill in the blanks

1. One of the simplest types of test equipment is the ---------- wire.
2. A ---------- light is used when the technician needs to look for ---------- power in the circuit.
3. A multimeter is an electrical test meter capable of measuring ----------, resistance and ----------.
4. Digital meters rely on ---------- circuitry to measure electrical values.
5. If the multimeter shows no current, the ---------- is open some point.
6. In a multimeter AC and DC ---------- can be checked with the proper selection of the switch.
7. The sum (total) of the voltage drops around a circuit equals the ------- voltage.
8. An Ohmmeter will measure resistance and ----------.
9. The Oscilloscope is very useful in diagnosing many electrical ---------- quickly and accurately.

Session- 2: Electrical Test Equipments

Use the following checklist to see if you've met all the requirements for electrical test equipments

Part A

Share importance of electrical test equipments in the testing of automobile electrical circuits.

Part B

1. Name various electrical test equipments used in automobile.
2. With the help of multi-meter what are the parameters can be tested?
3. Explain how to test following parameters with the help of multi-meters?

a. Voltage
b. Current
c. Resistance

4. Explain regarding the Oscilloscope. What are the parameters can be checked with the help of Oscilloscope?

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to identify electrical test equipments		
Able to use electrical test equipments		
Able to measure different electrical parameters by using electrical test equipments		

Session 3: Battery and Its Maintenance

Relevant Knowledge

The Battery is the Heart of the Automotive Electrical System. The battery must be in good usuable 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 technician 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 when charging s 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, shorting 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.

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.

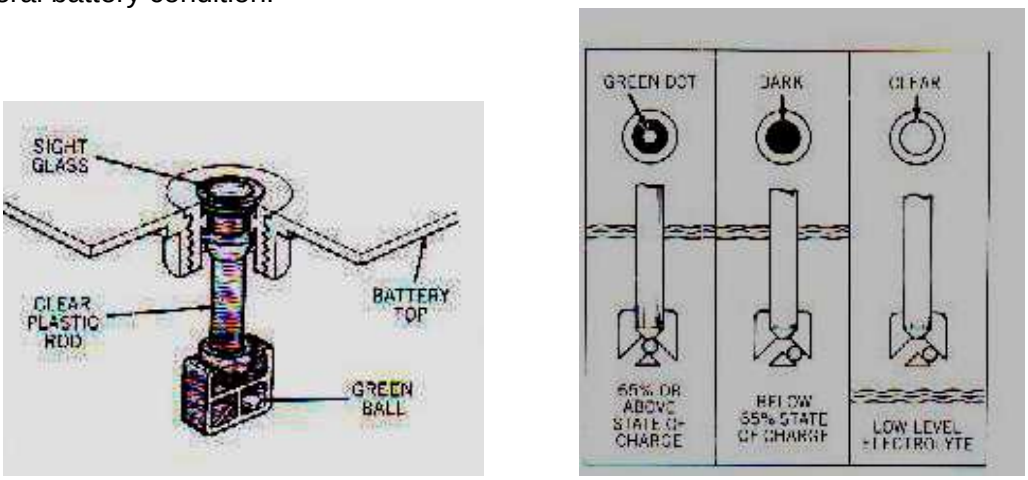


Fig.: The colour of a built-in hydrometer indicates the general state of charge. (Chrysler, Delco-Remy)

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, too 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

Caution. Do not let baking soda or ammonia enter the battery cells. These solutions will neutralize the acid in electrolyte and destroy a battery.
Keep dissolved corrosion and cleaning solutions of painted surfaces and rubber parts. Dissolved acid will harm paint and rubber.

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.
   - In a side-terminal battery, use a wrench to remove the capscrews that sevure 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.

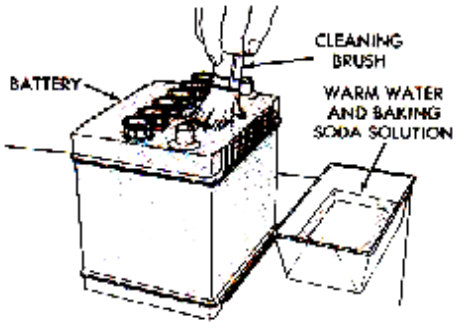


Fig.: Cleaning of Battery with the help of Baking Soda and water or ammonia, will neutralize and remove corrosion.

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.

- 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 volt, 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.

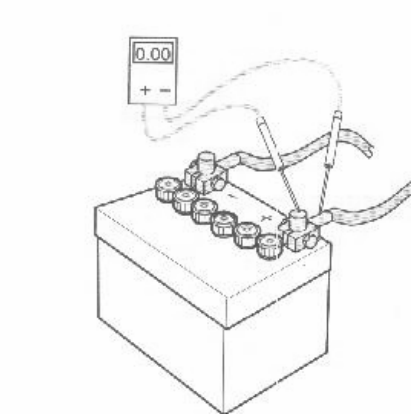


Fig : Tests Connections for Battery terminal test

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 250V 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 a battery becomes discharged, its electrolyte has a larger percentage of water. Thus, a discharged battery's electrolyte 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 5^0 C 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

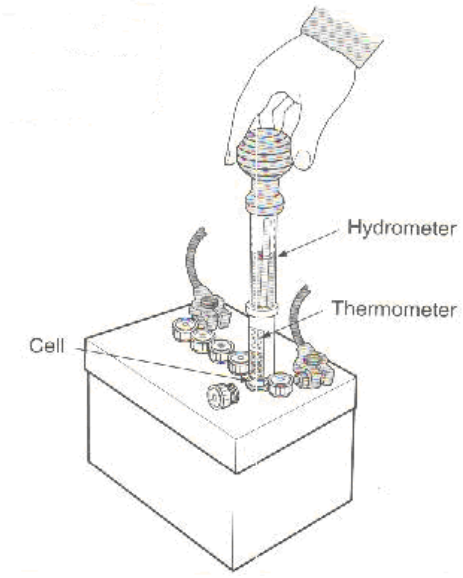


Fig.: Checking the Specific Gravity of Electrolyte with the help of Hydrometer.

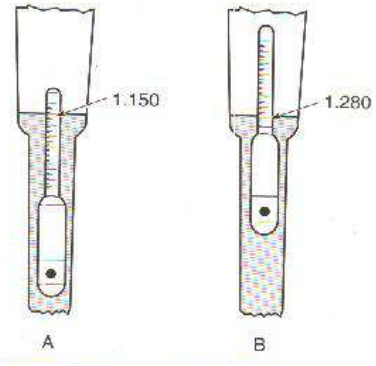


Fig.: The Specific Gravity of the electrolyte is read at the point where The electrolyte intersects the float.
(A) shows a low reading
(B) shows a high reading.

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. 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.

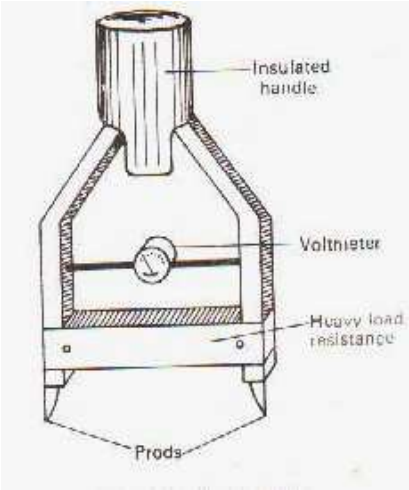


Fig.: High Rate Discharged Tester

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
- Zero the ammeter.
- Connect the amps inductive pickup around one of the tester 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

- 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
- When ever 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 sometime must be fully charged and stored in a cool dry place. They should be topped up and charged at frequent intervals to prevent sulphation.

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	i. Check both ii. Check iii. Reduce load iv. Battery may not be allowed to remain idle, recharge it periodically

	iv. High self-discharge v. Old or defective battery	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 over charging; plates short-circuited due to displaced active material.	i. Rebuild or replace battery as required.

Session- 3: Battery and Its Maintenance
Exercise: Assignment

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	

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

Session- 3: Battery and Its Maintenance
Answer the following questions
(Use additional sheets of paper, if necessary)

Fill in the blanks

1. The battery is the ---------- of the automotive electrical system.
2. Battery acid is very ----------. Do not allow it to come in contact with ---------, eyes, or ----------.
3. When disconnecting battery cables, always disconnect the --------- cable first.
4. Wear safety ---------- or face --------- when servicing the battery.
5. Wash the battery terminals and cable connectors with a ---------- solution or ---------- to remove all corrosion.
6. Measuring the state of charge is a check of the battery's ---------- and ----------.
7. As a battery becomes discharged, its ---------- has a larger percentage of water.
8. The open circuit Voltage test is used to determine the battery's state of ----------.
9. In the capacity test, a specified ---------- is placed on the battery while the terminal voltage is observed.
10. Always keep the battery ------- and clean and apply -------- to all metal parts.

Session- 3: Battery and Its Maintenance

Use the following checklist to see if you've met all the requirements for battery and Its maintenance

Part A

Share importance of battery and its maintenance in automobile

Part B

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and carry out different tests on lead acid battery		
Able to identify different faults in lead acid battery, their causes and suggest appropriate remedies		
Able to check and clean the battery		
Able to use tools and equipment used for checking and cleaning of the battery		

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

Relevant Knowledge

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, lavps, 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 technician 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 be 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. You can't figure out why a circuit doesn't work unless you understand how it 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. 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.

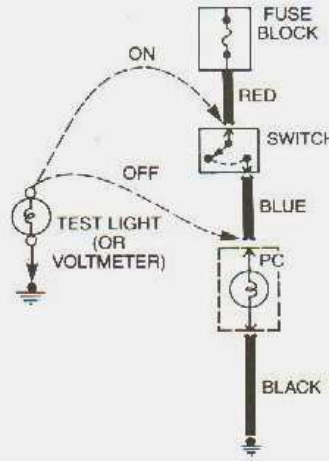


Fig. : Testing for Voltage

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 approximately 6-inch interval. 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. When the lamp lights or the ohmmeter registers, you have pinpointed the area in which the short to ground is located.

If the short to ground is between the power source and the load, it will be blow 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.

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.

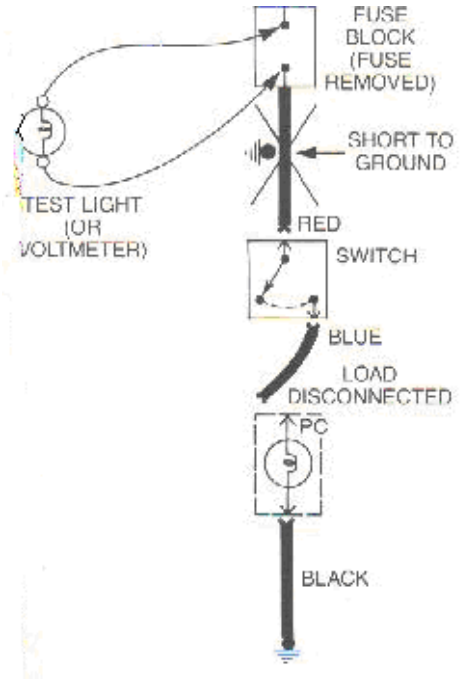


Fig.: Checking for Short

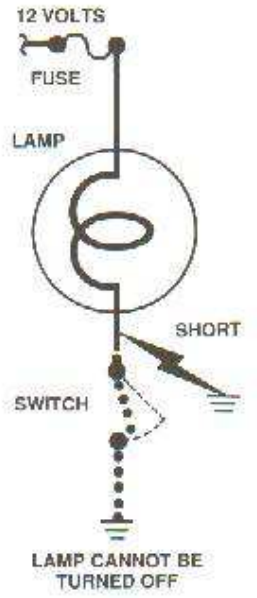


Fig.: A short between the load and Switch will keep the load on indefinitely

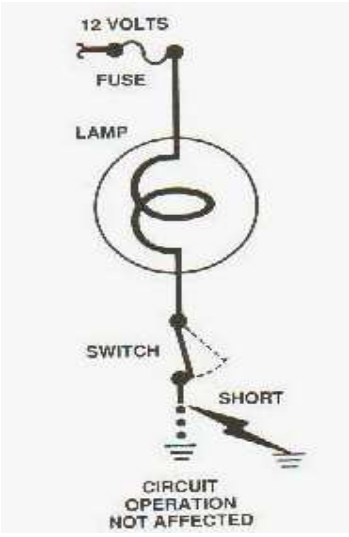


Fig.: A short between the switch and ground provides an alternative ground and will not affect circuit operation

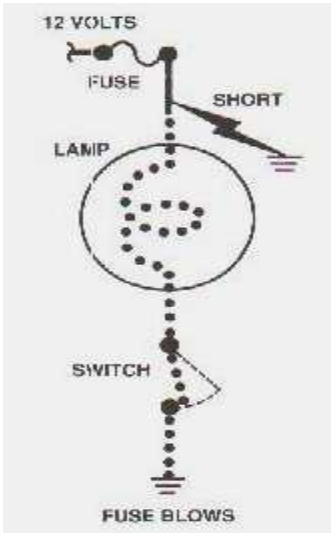
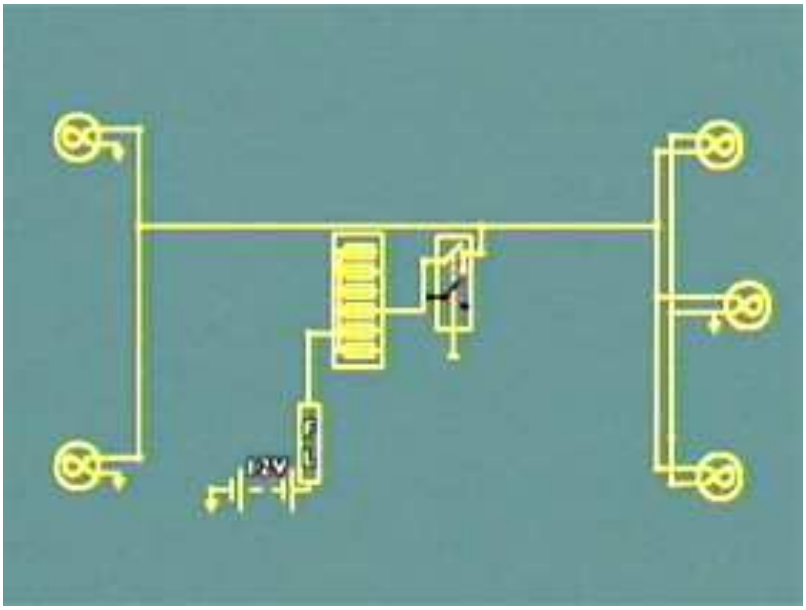


Fig.: A short between load and power source will blow the fuse

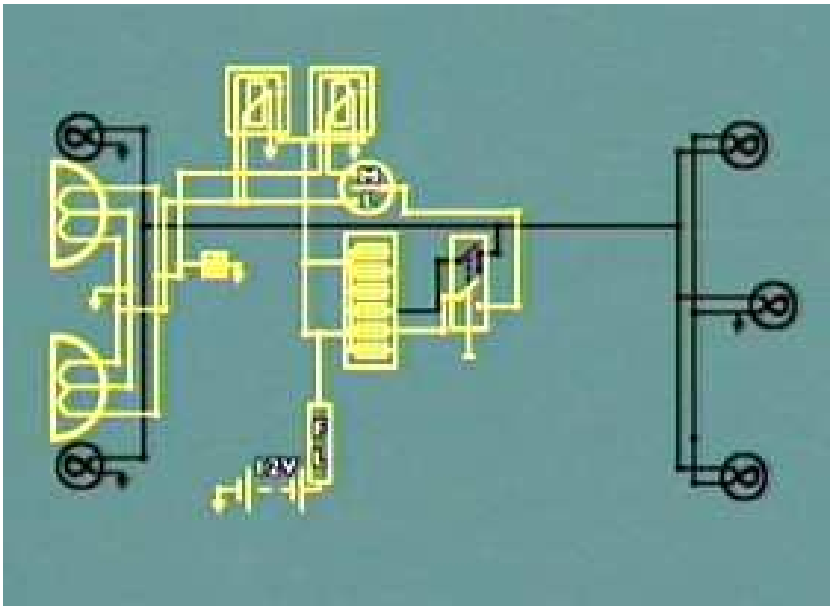
Testing for Continuity

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.

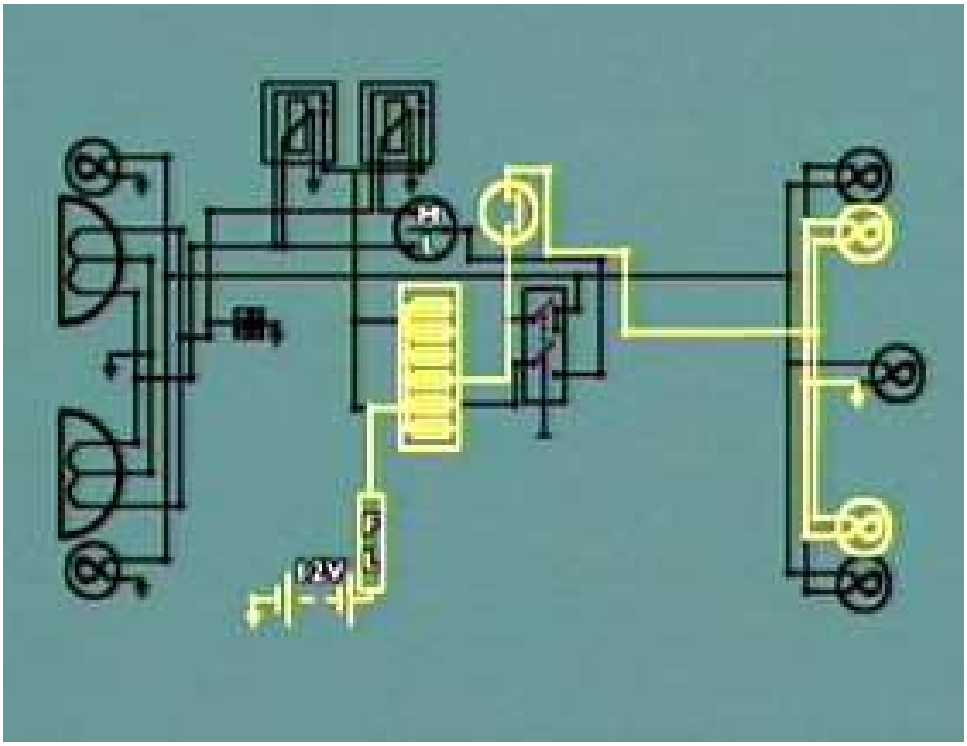
TYPICAL LIGHTING CIRCUITS OF A CAR



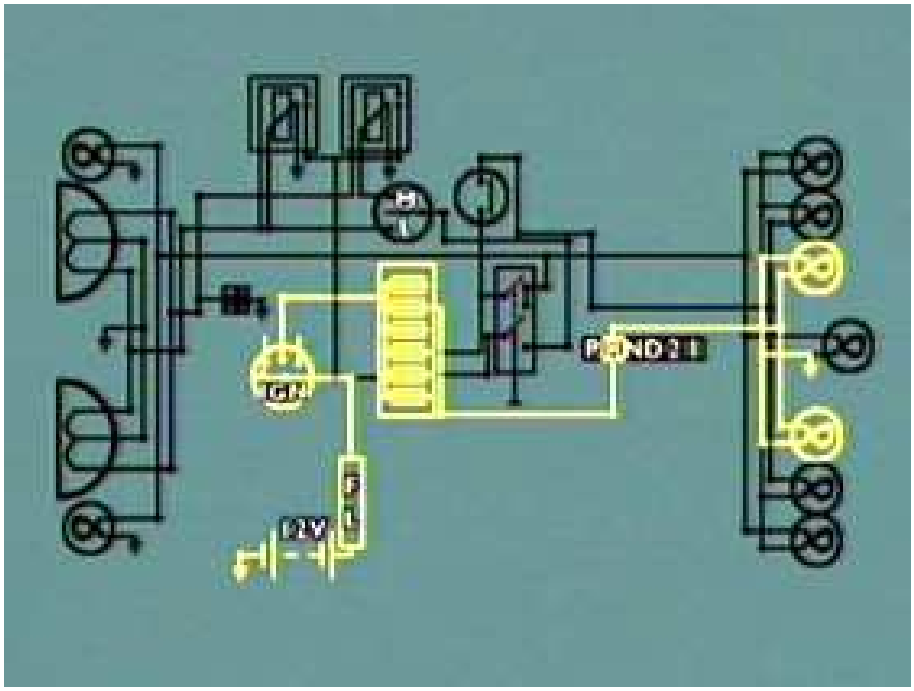
1. This is the park and tail light circuit.



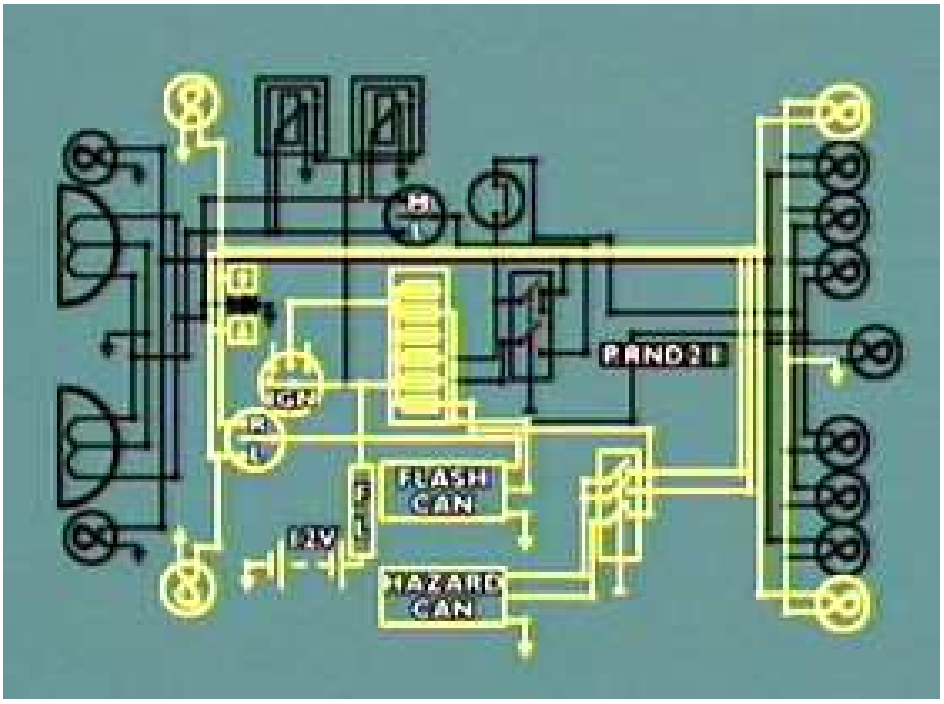
2. To this circuit we add the circuit for the headlights and dipped lights.



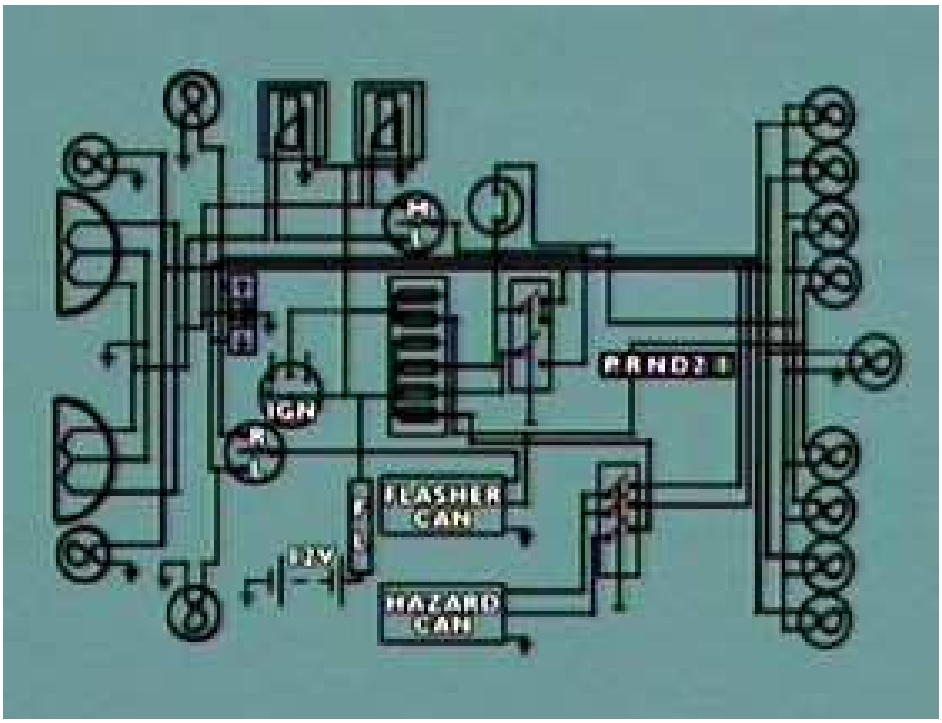
3. Now we include the stop light circuit.



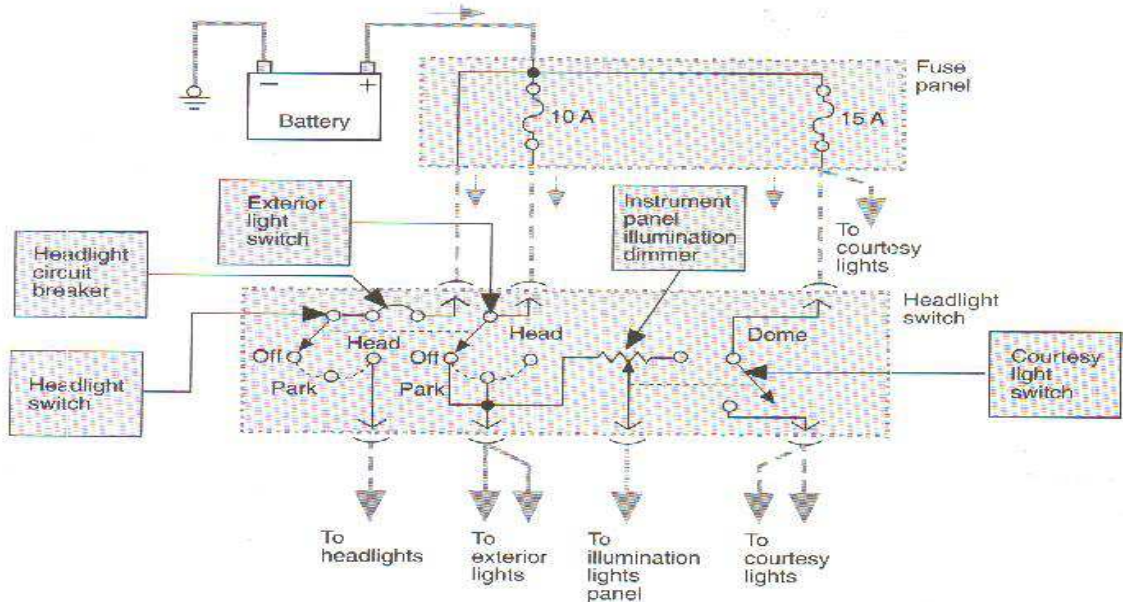
4. Then we add the reversing light circuit.



5. And the indicator or turn signal circuits.



6. The completed circuit diagram represents all the wiring for the external lighting of a motor vehicle. Other circuits such as ignition, charging & starting circuits can be constructed in a similar way and added to provide a complete vehicle wiring system.



Headlight Circuit Component (Ford Car)

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 discoloured 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.

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

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	
22.	

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

Session- 4: Checking of Electrical Connections of Lighting System in a Vehicle
Answer the following questions
(Use additional sheets of paper, if necessary)

Fill in the blanks

1. If a lighting circuit is not operating --------- there is a --------- danger to the driver and other people.
2. A ----------volt test lamp or ---------- is used to check for voltage.
3. A voltmeter is a better ---------- in many cases because it will tell you how much ---------- is present.
4. To check for a short to ground, remove the --------- and disconnect the ----------.
5. You can check a circuit for continuity by disconnecting power from the circuit and connecting a self-powered ---------- or ---------- between parts of the circuit you want to test.

Session- 4: Checking of Electrical Connections of Lighting System in a Vehicle
Use the following checklist to see if you've met all the requirements for checking of electrical connections of lighting system in a vehicle.

Part A
Share importance of checking of electrical connections of lighting system in a vehicle.

Part B

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

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand and carry out different tests on lighting system of vehicle		
Able to identify different faults in lighting system, their causes and suggest appropriate remedies		

Session: 5 Applications and Replacement of Fuses

Relevant Knowledge

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, more 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 35A. 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 more 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

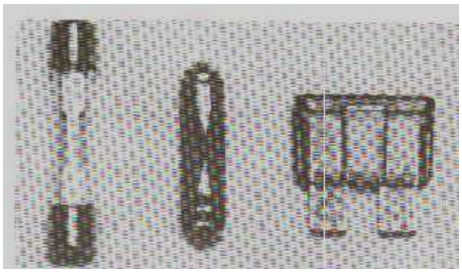
There are three basic types of fuses:

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

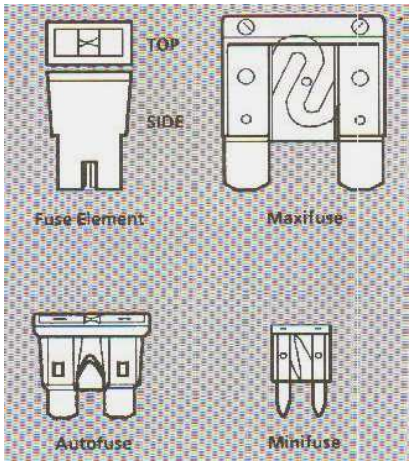


Fig.: Common blade type fuses

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.

Session- 5: Applications and Replacement of Fuses

Exercise: Assignment

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- 5: Applications and Replacement of Fuses
Answer the following questions
(Use additional sheets of paper, if necessary)

Fill in the blanks

1. Fuses are used for protecting the electrical ---------- and ---------- against the effects of excessive currents.
2. The fuses are generally installed in a central ----------.
3. Glass and ceramic fuses are found mostly on ---------- vehicles.
4. Cartridge-type fuses are used in many older ---------- vehicles.
5. When it is diagnosed that in particular circuit the fuse either have been ---------- off or ----------, it is to be replaced with correct size and --------- of fuse.

Session- 5: Applications and Replacement of Fuses

Use the following checklist to see if you've met all the requirements for applications and replacement of fuses in a vehicle.

Part A

Share importance of applications and replacement of fuses in a vehicle.

Part B

1. Name different types of fuses and explain.
2. Write the values of fuses used in different electrical system of automobile.
3. Explain colour coding of different fuses.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to identify different types of fuses used in electrical system of vehicle		
Able to replace the fuse		

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

Relevant Knowledge

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 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.

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 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.

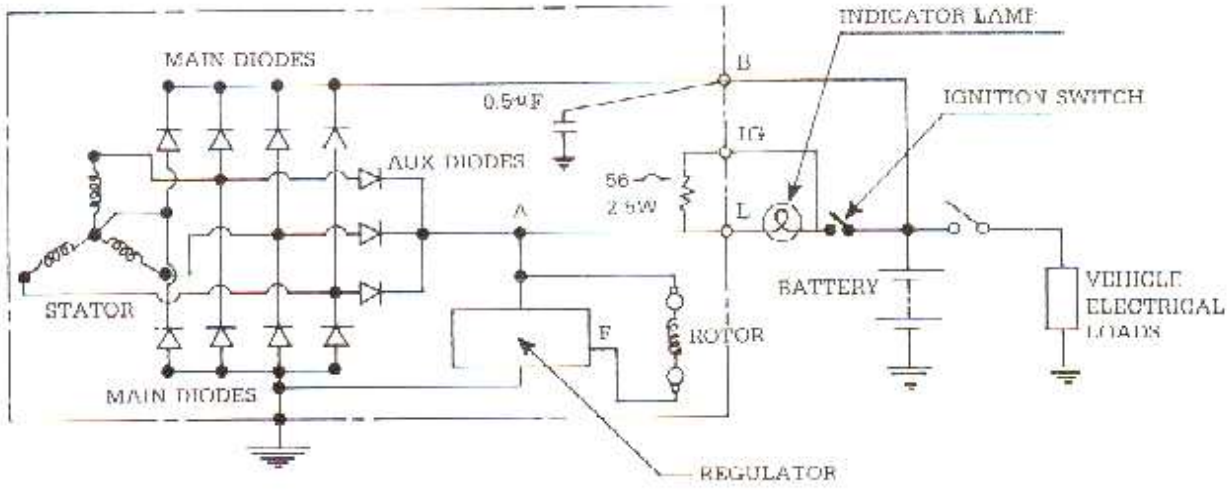


Fig.: Charging Circuit

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

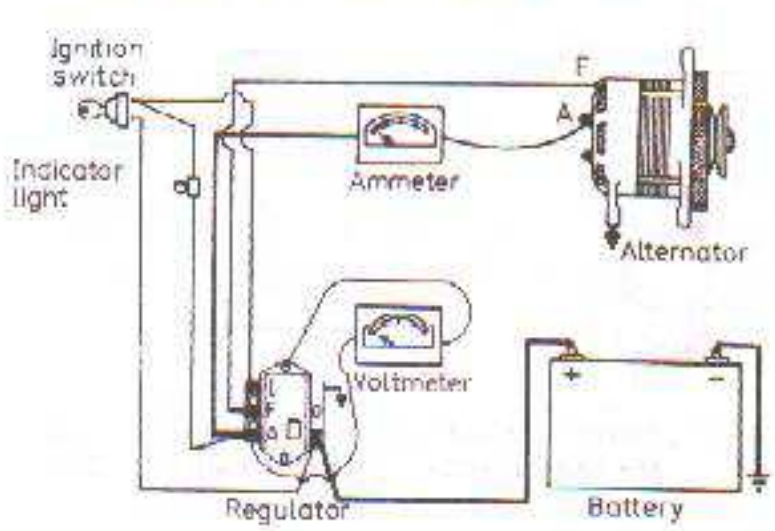


Fig.: Wiring Diagram for Testing Alternator and Regulator on the Vehicle

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.
- 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 does not charged 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 Alternator 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, 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 of 12 – 15 A should lie between 13.5 and 14.4 V.
  When the ammeter shows only 3 – 5 A at the above speed (with lights etc. off), the voltage should be between 14.2 and 14.9 V. The voltage should never exceed 14.9 V.
  The voltage adjustment, if necessary, is done by adjusting the tension of the armature spring, by bending the hooked end where the spring rests. Increase tension for increasing the voltage and vice versa. If unable to set correctly in this manner, remove regulator for bench tests.

Checking of Stator

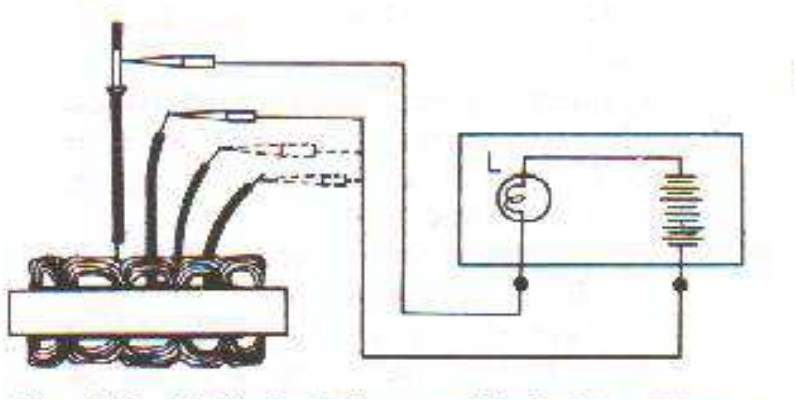


Fig.: A Winding Insulation Test With the Help of Battery and Lamp.

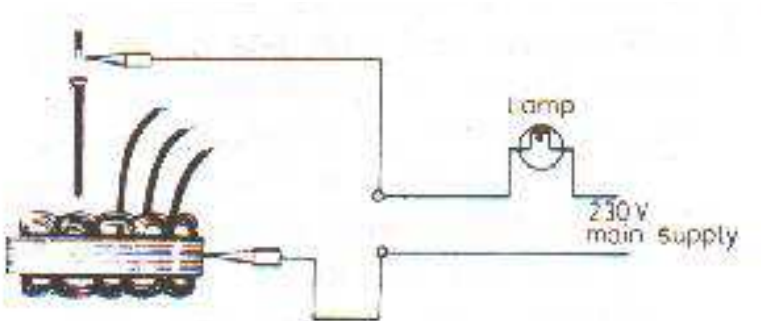


Fig. B: Winding Insulation Test on Mains

Above figure A shows the circuit diagram for carrying the insulation test of windings with the help of a lamp and a battery. Above figure 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 discolouration of varnish. A resistance test with an ohmmeter between the neutral and each of the phase leads should give similar readings.

Rotor Testing

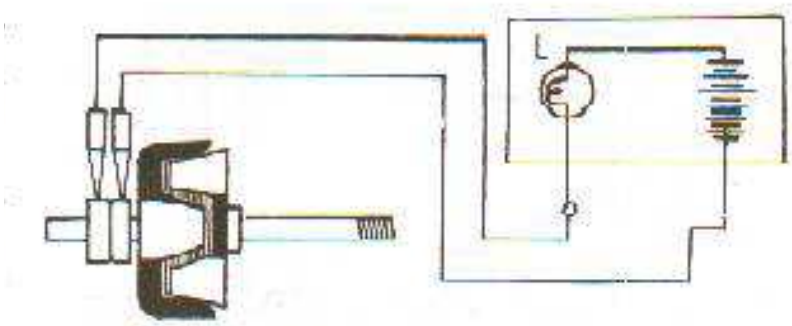


Fig. C: Circuit Diagram of Rotor Insulation Test With the help of Battery and Lamp

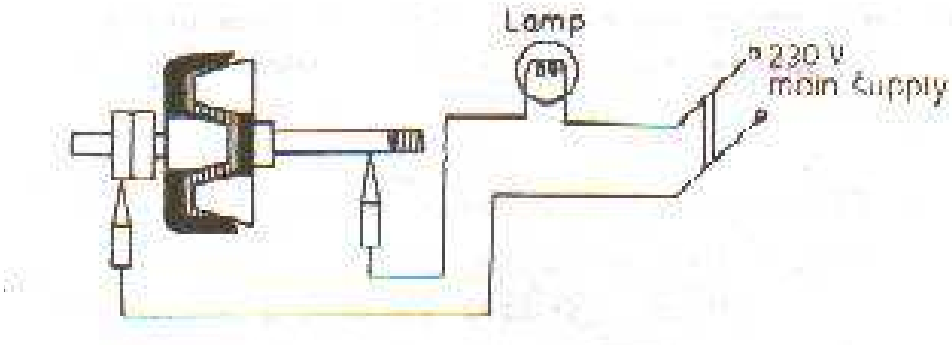


Fig. D: Circuit Diagram of Rotor Insulation test on Main Supply

The above figure C shows the circuit diagram for carrying out insulation test of rotors with the help of a lamp and battery. Above figure 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 Testing

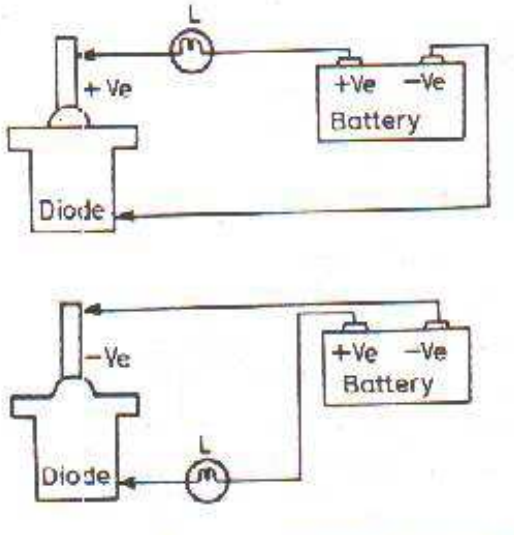


Fig. E: Circuit Diagram of Testing diode with the help of Lamp and Battery

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 with test prods of 12 V and 2.2 W respectively. Figure E shows the circuit diagram for performing this test. Make connections as shown. 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 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.

Defects of Charging System, Causes and their Remedies :

DEFECTS	CAUSES	REMEDIES
1. Ignition warning lamp fails to illuminate when ignition is switched 'on'	• Defective bulb • Fuse blown. • Alternator or battery connections loose or oxidized poor earth connection. Open circuit in regulator, rotor or brush circuits. • Ignition switch defective.	• Fit new bulb. • Fit new fuse. • 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'	• Drive belt slack. Fuse blown. • Alternator connections loose	• Adjust drive belt. Refer to Service Manual. Fit new fuse

when engine is running.	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.	• 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.

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

Exercise: Assignment

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

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

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

Answer the following questions

(Use additional sheets of paper, if necessary)

Fill in the blanks

1. A properly operating ---------- is necessary for the ---------- operation of an automobile's entire electrical system.
2. Check the battery ---------- for correctness of specific gravity of ----------.
3. If the alternator is okay and still the charging is not proper, the ---------- needs checking.
4. The diodes are checked with the help of a ---------- tester.
5. The windings are checked for continuity with the help of a ----------.

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

Use the following checklist to see if you've met all the requirements for circuit diagram of charging system of automobile and checking of charging system 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 charging circuit of a modern car.
2. Explain the procedure of testing the charging circuit step by step.
3. Explain the procedure of testing the following:
   a. Alternator Stator
   b. Alternator Rotor
   c. Rectifier
4. Write different faults may occur in the charging circuit, their causes and remedies.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand charging system of vehicle		
Able to identify faults in charging system of vehicle		
Able to carry out testing of rotor, stator and regulator of alternator		

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

Relevant Knowledge

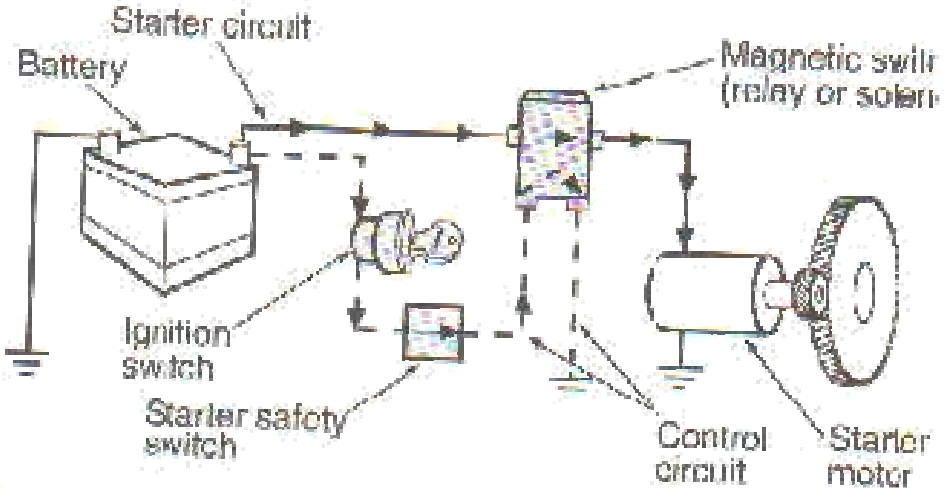


Fig.: Major Components of the starting system. The solid line represents the starting circuit. The dashed line indicates the starter control circuit

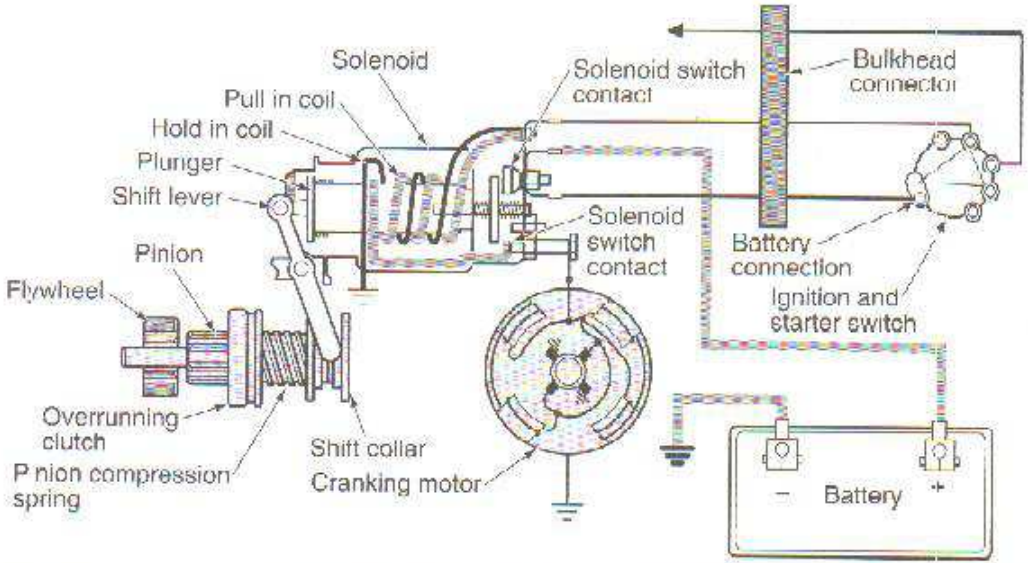


Fig.: Excessive wear, loose electrical connections, or excessive voltage drop in any of these areas can cause a slow crank or no-crank condition

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	• Solenoid hold in winding open. • High setting of solenoid relay with low battery.	• Replace solenoid. • Recharge battery, reset relay.
DEFECTS	**CAUSES**	**REMEDIES**
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.	• Recharge battery, replace if defective • Clean terminates and other connections, apply petroleum jelly, tighten all connections. • Locate fault and rectify it

	• Burnt commutator worn-out brushes • Defective solenoid switch • Armature/field coils defective • Excessive drop in voltage	• 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 fails to engage.	• Pinion sticks • Burr on pinion or ring gear. • Wornout one or both ends bushes • Defective auxiliary coil • Mounting loose	• Clean splines • Duburr by filing • Replace defective bush • 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

Exercise: Assignment

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

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

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

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

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

Part A

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

Part B

Draw the circuit diagram of starting system of an Indian car.
Explain the procedure of checking the starting circuit.
Write different faults may occur in the starting circuit, their causes and remedies

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand starting system of vehicle		
Able to identify faults in starting system of vehicle		
Able to carry out testing of starting motor of vehicle		

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

Relevant Knowledge

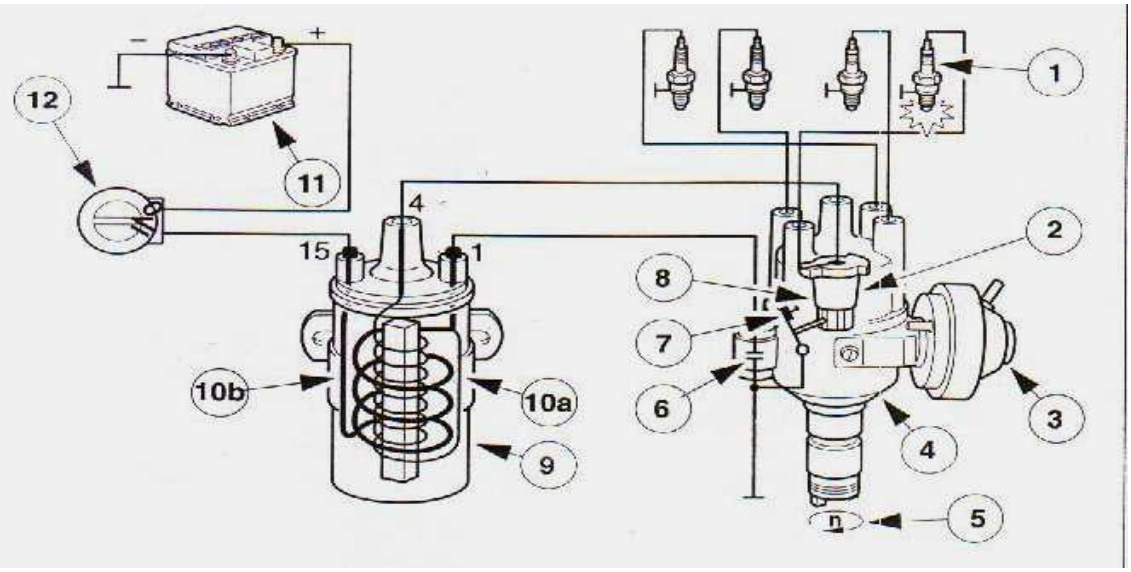


Fig.: Coil Ignition System

List of Components

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

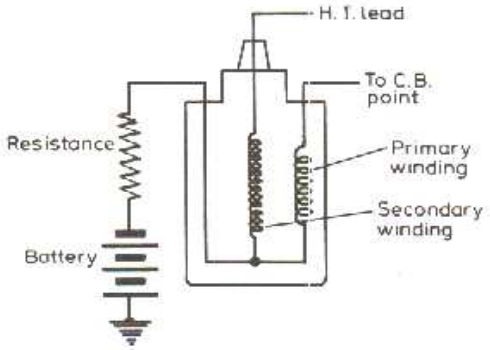
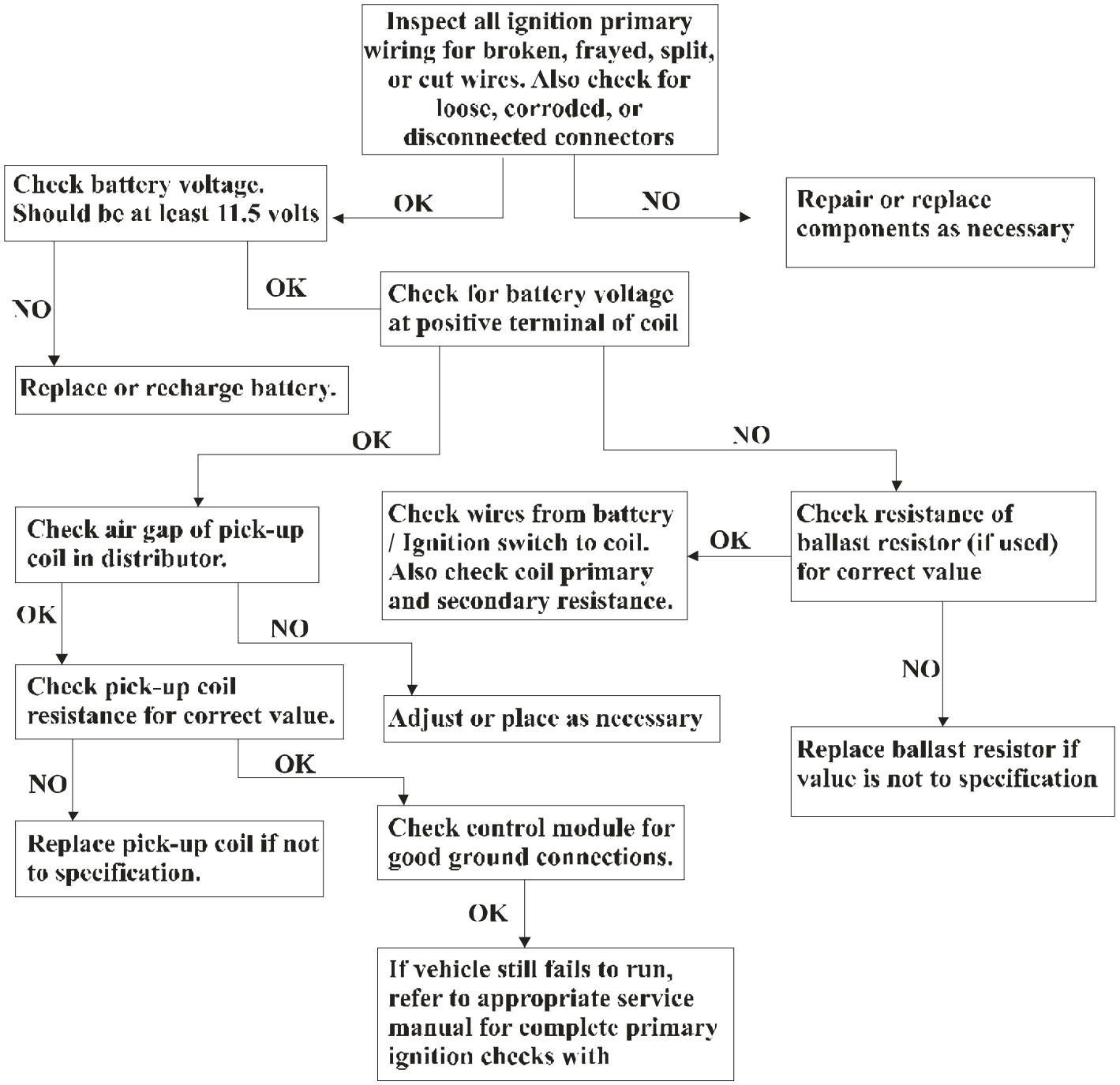
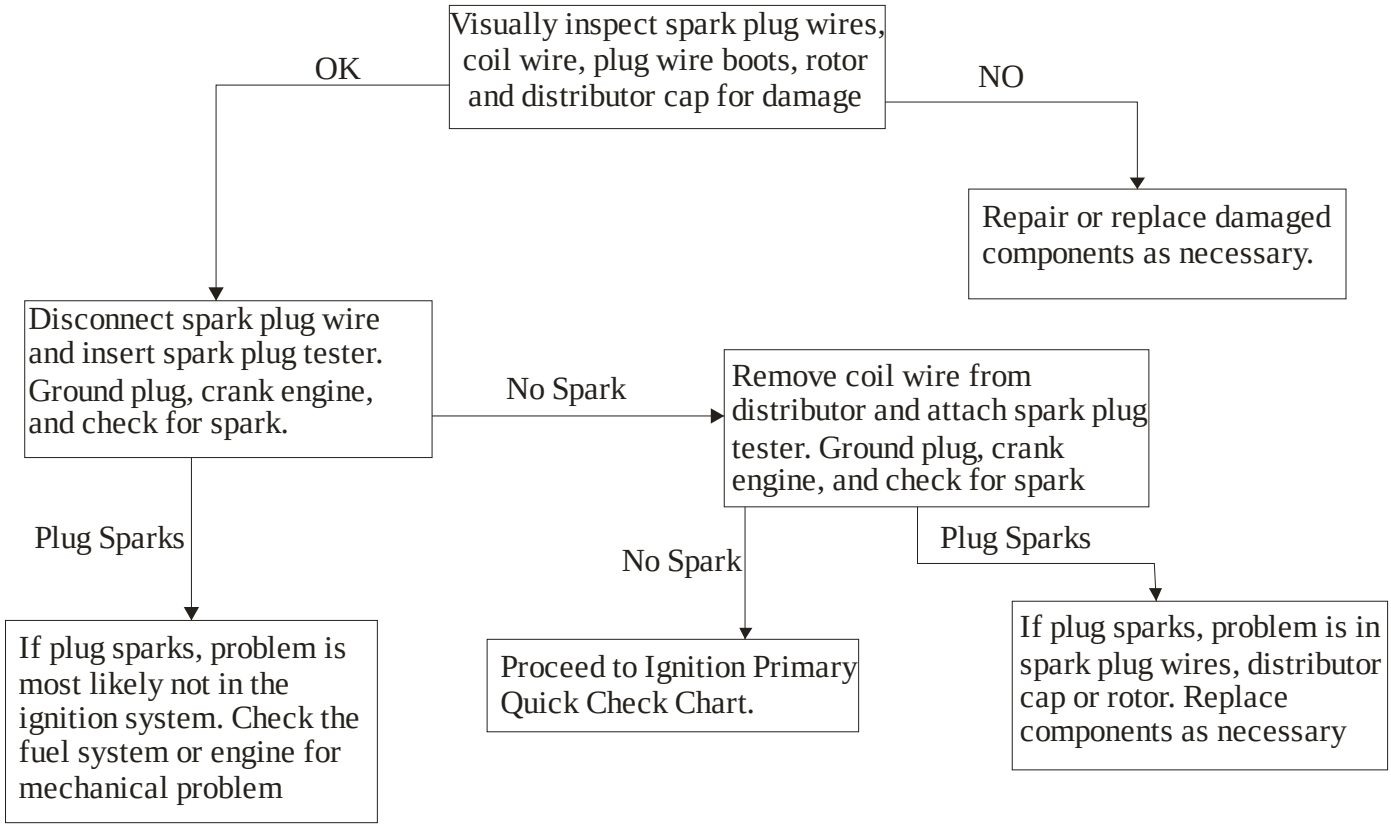


Fig.: Ballast Resistance Connected in-series with the Primary Coil

QUICK CHECK CHART OF IGNITION PRIMARY CIRCUIT



QUICK CHECK CHART OF IGNITION SECONDARY CIRCUIT



Distributor with Magnetic Pick-up

This type of distributor looks like a distributor with contact points when the cap is on.

Bottom figure shows the simple wiring diagram of the ignition system using the magnetic pulse distributor and the transistor control unit. The pulse amplifier unit is connected between the primary winding and the battery. It permits the current of the battery to flow to the primary winding and interrupt the same on a signal from the distributor. This action is similar to that of the opening and closing of the points in the case of a distributor with contact points.

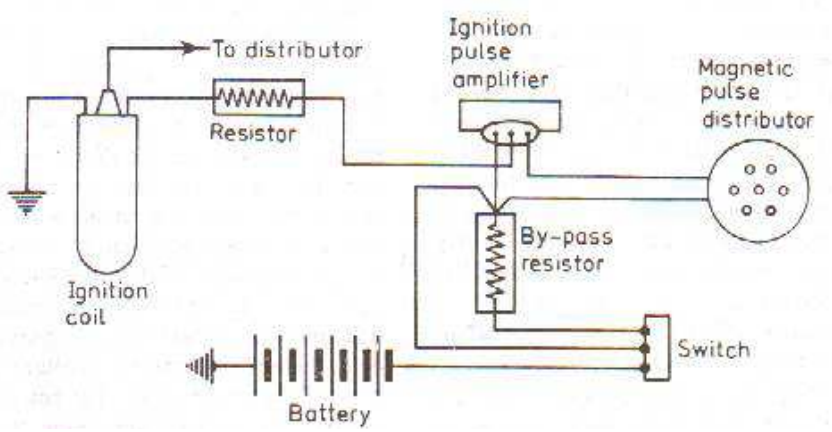


Fig.: A simple Wiring Diagram of an Ignition System using magnetic pulse distributor and transistor control unit

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.

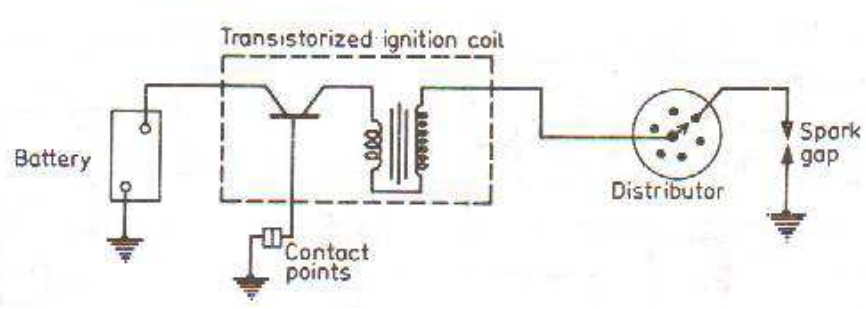


Fig.: Simple Wiring Diagram of distributor with contact points and Transistorized Ignition Coil

Piezoelectric Ignition

The operation of this system depends on the piezoelectric property of certain crystals which when subjected to compression generate an electric charge. This type of ignition system does not use the usual items like contact points, battery, ignition coil, or condenser. These properties are utilized widely in pick-up units used on gramophones and microphones.

Bottom figure shows a simplified diagram of this type of an ignition system for a single cylinder engine. This type of a system is likely to be developed for use in multi-cylinder engines in the near future.

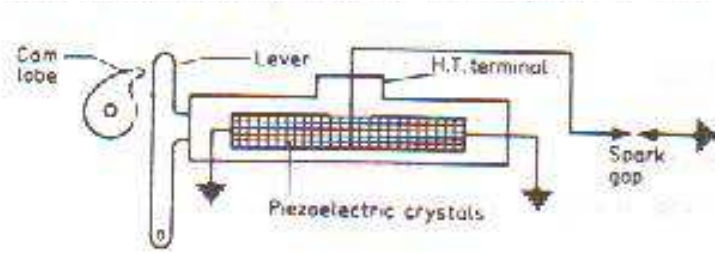


Fig.: Simplified Diagram of Piezoelectric Ignition system for a single cylinder engine

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.

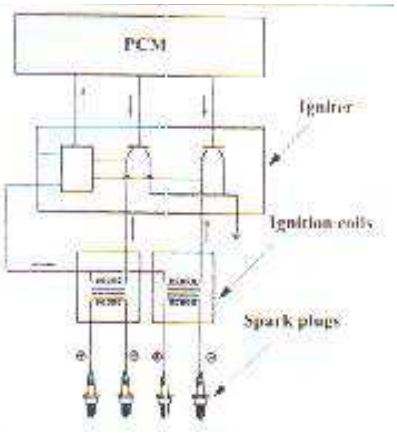


Fig.: Distributor less Ignition Control Circuit (computerized ignition system)

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 plug 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 leads. Locate fault and rectify • Replace / clean.
4. Engine develops less power.	• Timing out.	• Check and adjust timing.
5. Overheating of engine.	• Ignition riming are.	• 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.	• Check and adjust timing • Repair or replace distributor. • Re-adjust them. • Replace bearing • Rebuild or replace it • Replace them with correct spark

	• Bent distributor shaft • Incorrect heat range of spark plugs	plugs
8. Contact points pitted.	• Incorrect capacity of condenser • Improperly arranged leads	• Replace it with correct capacity • Re-arrange them.
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.

Session- 8: Circuit Diagram of Ignition System and Checking of Ignition Circuit
Exercise: Assignment

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.

Session- 8: Circuit Diagram of Ignition System and Checking of Ignition Circuit
Answer the following questions
(Use additional sheets of paper, if necessary)

Fill in the blanks

1. A transistor is an electronic device that works like a ----------.
2. A transistor has three terminals; a base, a ---------- and an emitter.
3. Transistor terminals the transistor that turns the ignition coil on and off is called the ---------- transistor.
4. Modern ignition systems are fully ----------.

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

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. Computerised 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

Relevant Knowledge

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.

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. 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.

Horn does not Sound (Single-horn System)

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

Electromagnetic System with 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.

Electromagnetic System without Relay

1. Check the condition of the circuit fuse or fusible link. Correct if necessary.
2. Clean and tighten the horn ground connection.
3. Depress the horn button to close the horn switch and check for voltage at the horn terminal, with a voltmeter

- If battery is shown, the horn is defective.
- If battery voltage is not shown, continue testing.

4. Check for voltage at the horn side of the horn switch:

- If battery voltage is shown, locate and correct the problem in the wiring between the orn and the switch.
- If battery voltage is not shown, continue testing.

5. Check for voltage at the power side of the horn switch:

- If battery voltage is shown, the horn is defective.
- If battery voltage is not shown, locate and repair the problem in the wiring between the switch and the battery.

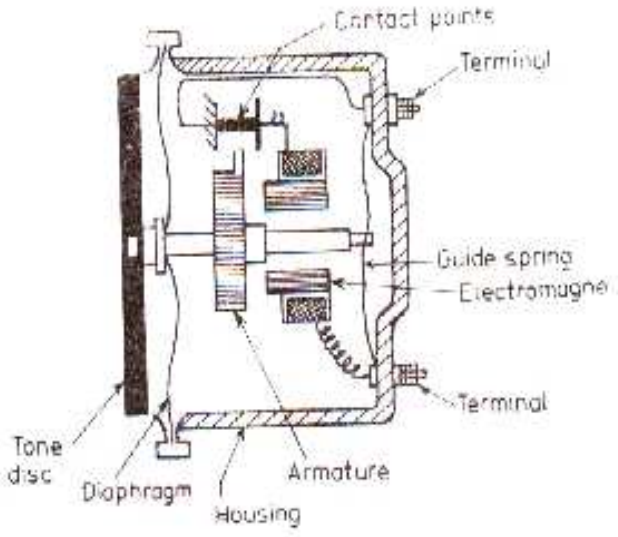


Fig.: Horn assembly without Relay

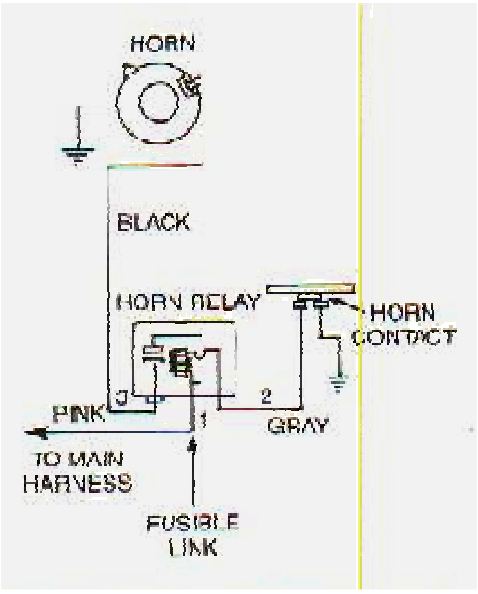


Fig.: Single Horn Circuit with Relay

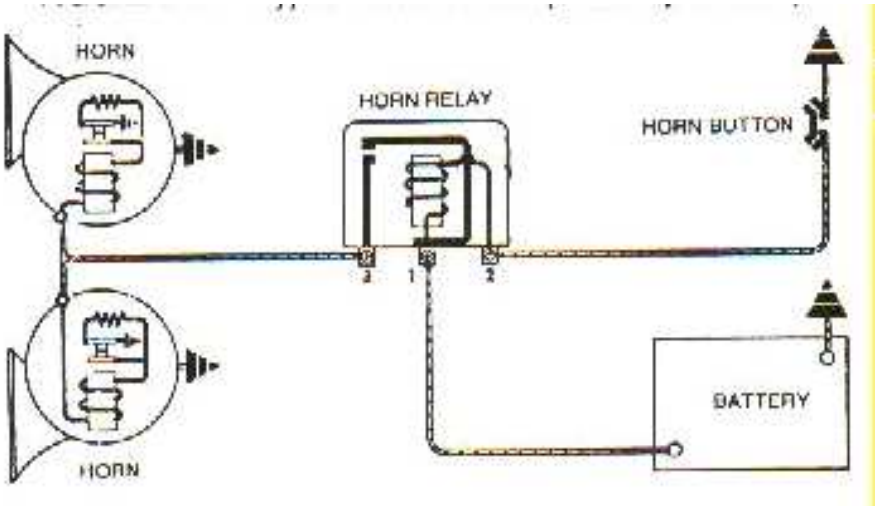


Fig.: A Dual Horn Circuit with Relay

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

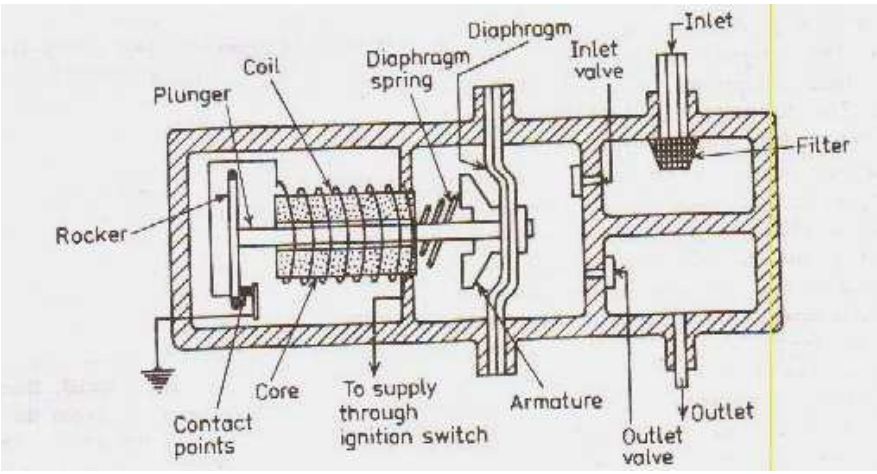


Fig.: Electric Fuel Pump (Diaphragm type)

The Electric fuel pump is an alternative to the mechanical pump driven by the engine. 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

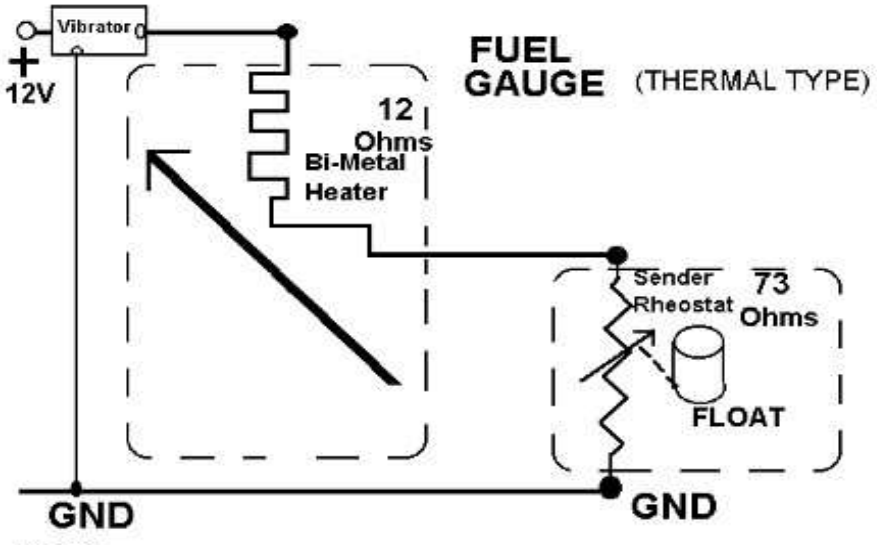
The sulfur contaminants found in some of today's gasoline can have corrosive effects on the fuel system sending unit, disrupting electrical continuity and leading to erratic or false fuel gauge readings.

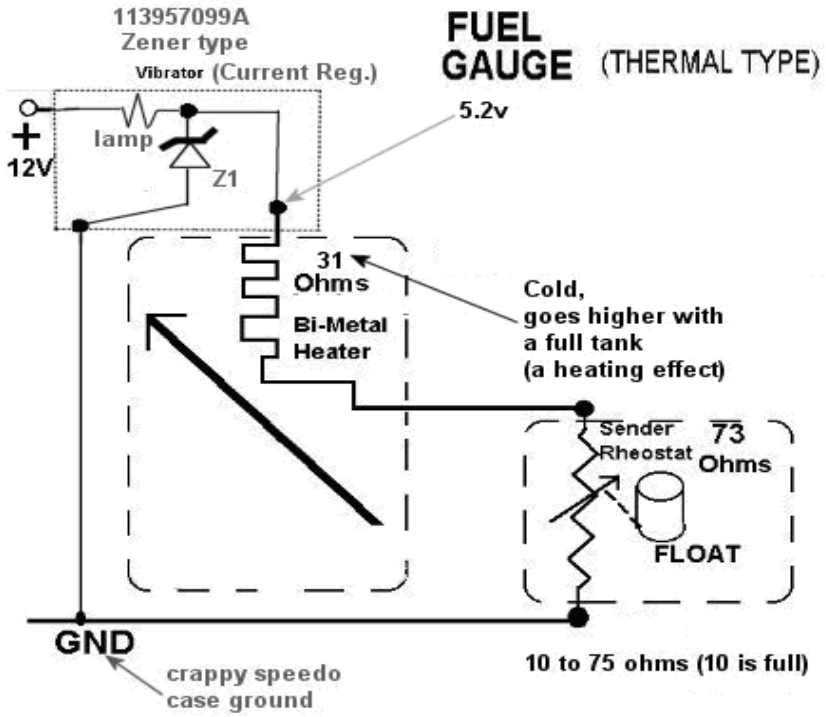
Fuel Pump Control Module

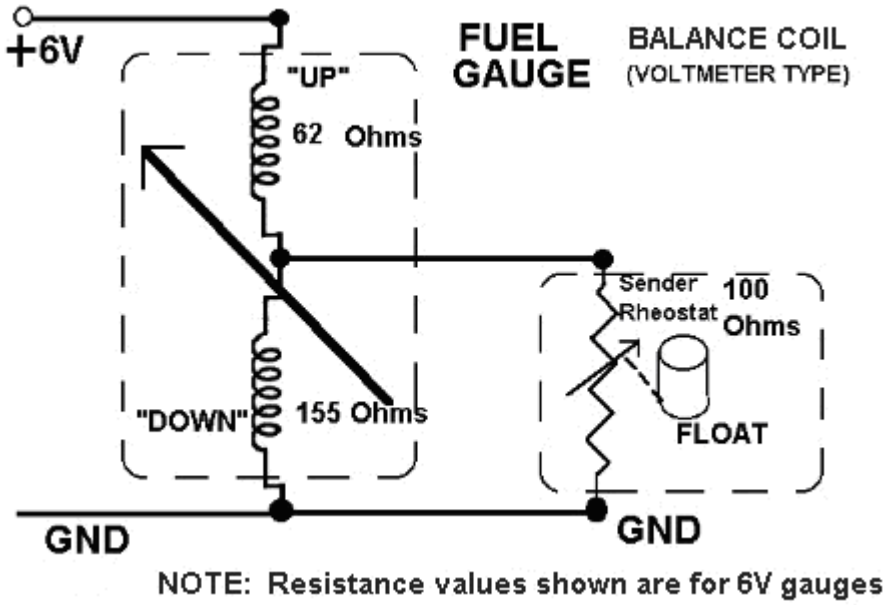
With electronic return less fuel systems, the Fuel Pump Control Module (FPCM) controls the voltage supplied to the fuel pump (located within the fuel tank) to achieve the desired fuel pressure requested by the Engine Control Module (ECM). There is also a fuel line pressure sensor, which sends a feedback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


Vibrator
+
12V
FUEL
GAUGE (THERMAL TYPE)
12
Ohms
Bi-Metal
Heater
Sender
Rheostat
73
Ohms
FLOAT
GND
GND


113957099A
Zener type
Vibrator (Current Reg.)
FUEL
GAUGE (THERMAL TYPE)
+
12V
lamp
Z1
5.2v
31
Ohms
Bi-Metal
Heater
Cold,
goes higher with
a full tank
(a heating effect)
Sender
Rheostat
73
Ohms
FLOAT
GND
crappy speedo
case ground
10 to 75 ohms (10 is full)

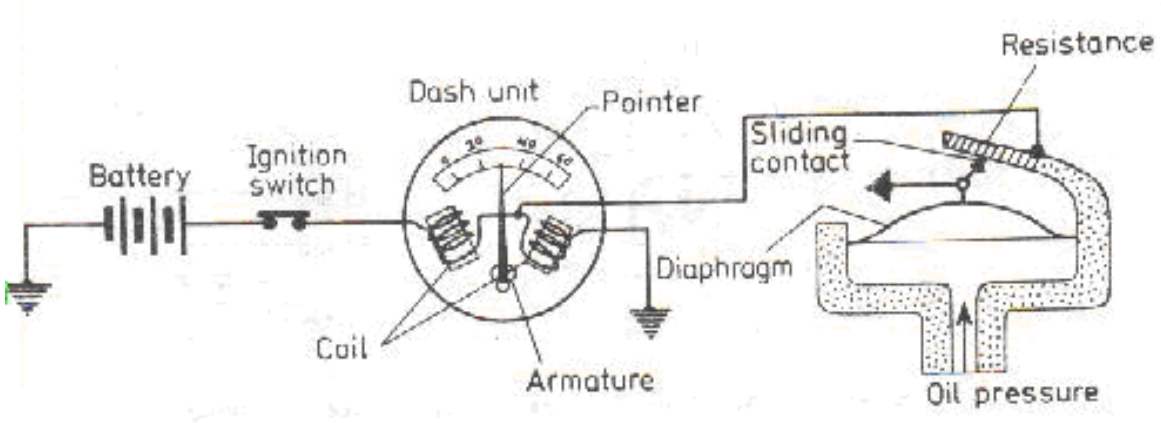


Above figures shows different types of fuel gauges (**thermal type and balancing coil type**) used in automobile.

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 • Float arm sticking • Defective gauge	• Earth it properly • Rectify • Insulate it • 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

.: Balancing Coil Type Oil Pressure 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
iii. Gauge reads minimum under all conditions	• Wire disconnected from ignition switch to gauge • Engine unit not earthed • Diaphragm punctured • Defective gauge	• Locate fault and rectify • Earth it • Replace it • Replace it
iv. Gauge register inaccurately.	• Faulty earth connection.	• Rectify the connections

Temperature Gauge

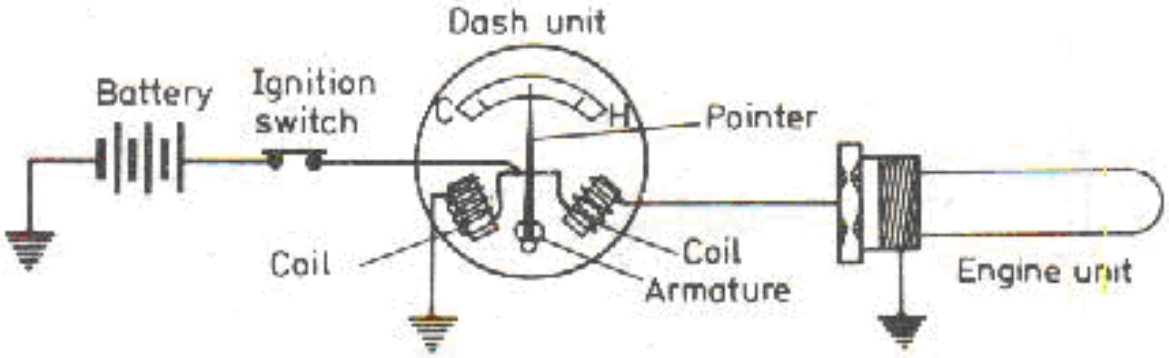


Fig.: Circuit of a Balancing Coil Type Temperature Gauge

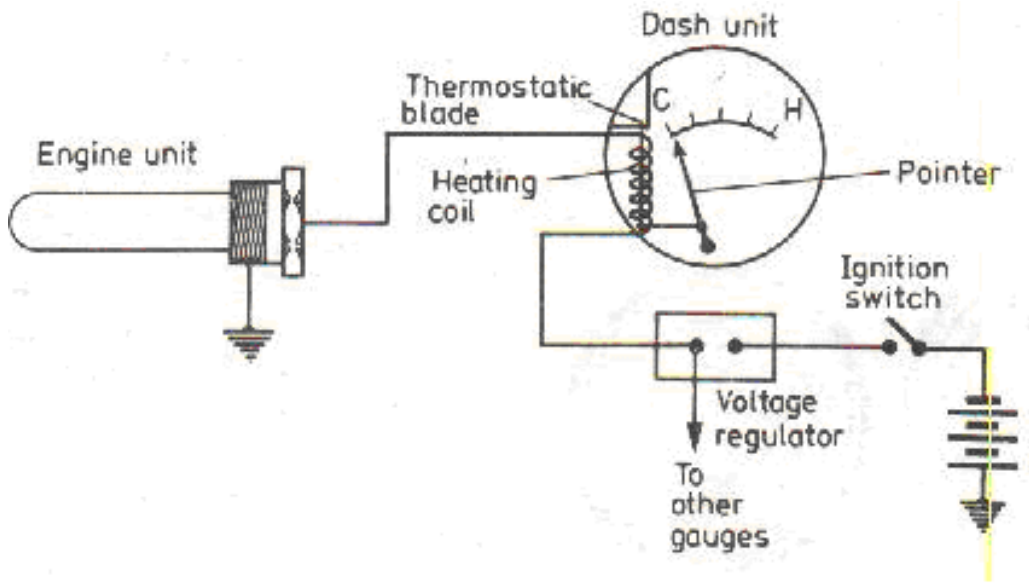


Fig.: Circuit of a Thermostatic Type Temperature Gauge

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

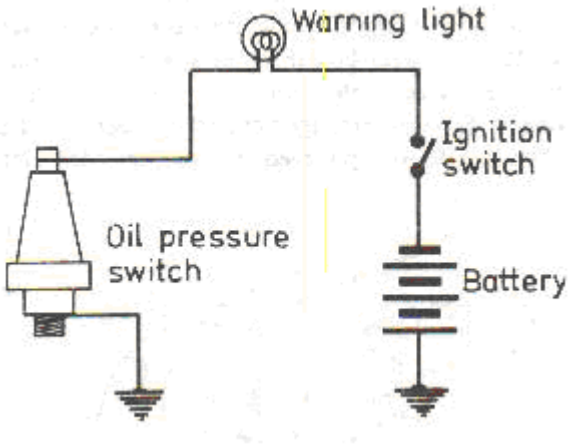


Fig.: Oil Pressure Warning Light

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 switch • Wire earthed between pressure switch 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

Electrical Speedometer

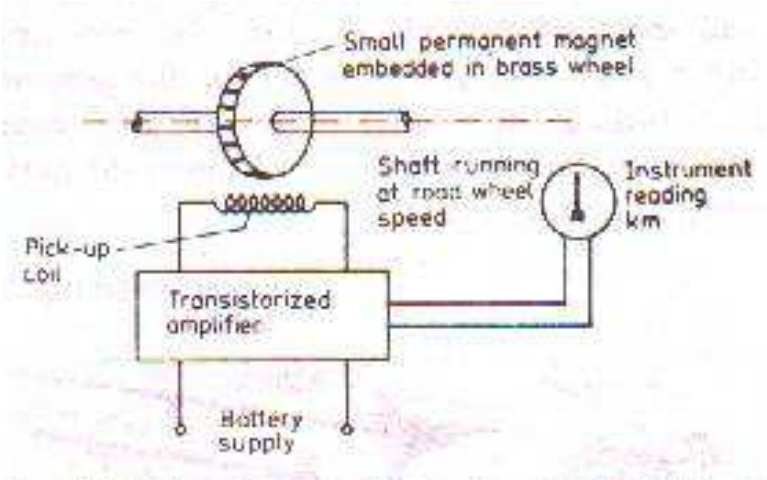


Fig.: Circuit Diagram shows the Principles of Electrical Speedometer

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

Fault	Causes	Remedies
1. Needle remains at zero	• Incorrectly engaged shaft with spindle of speedometer • Worn or sheared driving key at the gear-box end of the shaft • Driving gear stripped • Worn mating surfaces of shaft and spindle • Speedometer cable broken • Undue friction between casing and speedometer cable • Speedometer defective	• Rectify • Replace • Replace • Replace • Replace • Lubricate • Rectify or replace
2. Readings wavering and erratic	• Sharp bends in cable casing • Speedometer cable worn or stretched • Defective speedometer	• Replace • Replace • Rectify replace
3. Gives steady but inaccurate readings	• Defective speedometer • Wrong size tyres fitted on rear wheels • Rear axle ratio altered from standard	• Rectify or Replace • Replace with correct size • Recalibrate speedometer

Windscreen / Windshield Wiper

All present day 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:

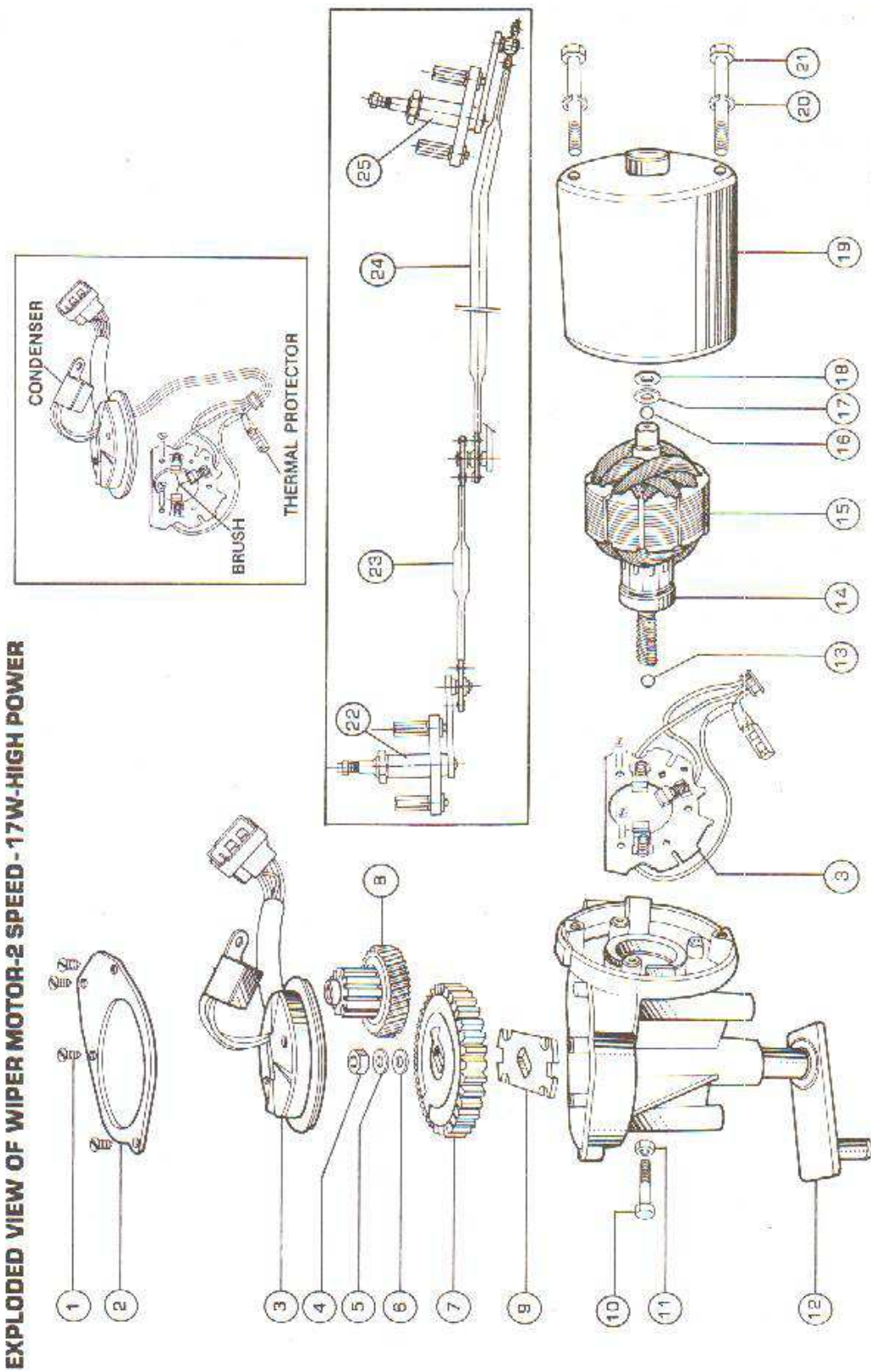
- Standard motor - 50 cm Arm, 50 cm Blade
- High power motor - 50 cm Arm, 65 cm Blade

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.

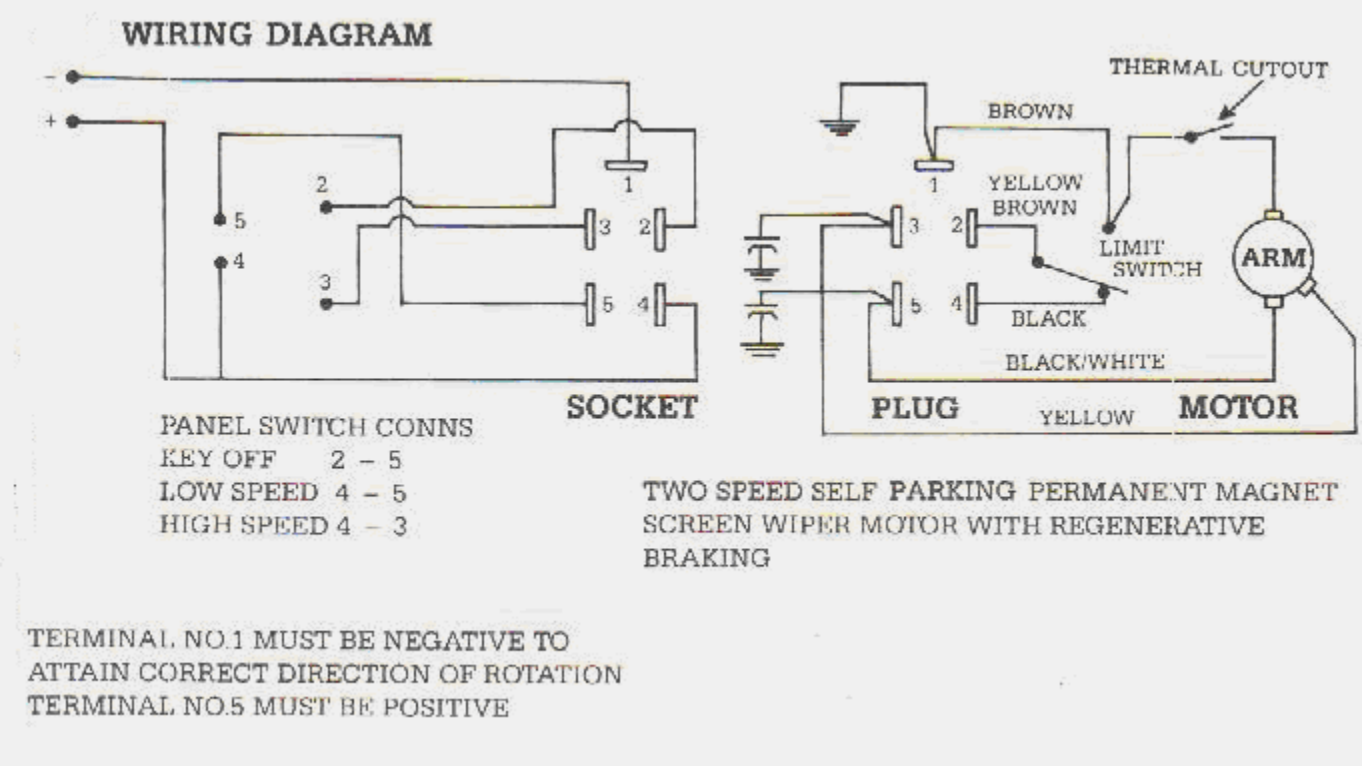
Electrical connections are made to the motor via a non reversible in line plug and socket assembly. This type of connection ensures the maintenance of correct motor polarity during the course of motor connecting to vehicle wiring.

SPARE PARTS LIST OF BOTTOM FIGURE

1. SCREWS
2. COVER PLATE
3. BRUSH PLATE & SWITCH ASSY
4. ROTARY LINK LOCKING NUT
5. SPRING WASHER
6. PLAIN WASHER
7. FINAL GEAR ASSY
8. WORM WHEEL & PINION MOULDING
9. GEAR LOCATION PLATE
10. THRUST SCREW
11. THRUST SCREW NUT
12. ROTARY LINK ASSY
13. BALL – WORM END
14. BALL BEARING
15. ARMATURE
16. BALL – YOKE END
17. FELT WASHER
18. THRUST DISK
19. YOKE POLE AND BEARING ASSY
20. SPRING WASHER
21. THROUGH BOLT
22. SPINDLE UNIT ASSY I
23. TUBULAR LINK ASSY I
24. TUBULAR LINK ASSY II
25. SPINDLE UNIT ASSY II



EXPLODED VIEW OF WIPER MOTOR-2 SPEED-17W-HIGH POWER



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.

- 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

Session-9: Maintenance and Servicing of Major Electrical Accessories

Exercise: Assignment

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-9: Maintenance and Servicing of Major Electrical Accessories
Answer the following questions
(Use additional sheets of paper, if necessary)
Fill in the blanks

1. Switches and relays are circuit --------- devices which are to be tested for their ---------.
2. Check the circuit's ---------- if the horn is not working at all.
3. The Electric fuel pump is an ---------- to the mechanical pump driven by the engine.
4 All present day automobiles are equipped with ---------- operated windshield wipers.
5. Do not use ---------- or wax polishes on wind screen.
6. Low fuel ---------- in the fuel tank can ---------- fuel pump life.

Session-9: Maintenance and Servicing of Major Electrical Accessories

Use the following checklist to see if you've met all the requirements for maintenance and servicing of major electrical accessories in a vehicle.

Part A

Share importance of maintenance and servicing of major electrical accessories in a vehicle.

Part B

1. 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 wiper.
2. 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.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand importance of maintenance and servicing of major electrical accessories in a vehicle		
Able to describe the working of major electrical accessories used in electrical system of vehicle		
Able to find faults in major electrical accessories used in electrical system of vehicle, their causes and possible remedies		

Session 10: Introduction to Climate Control System Heating Ventilation and Air Conditioning in a Vehicle

Relevant Knowledge

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.

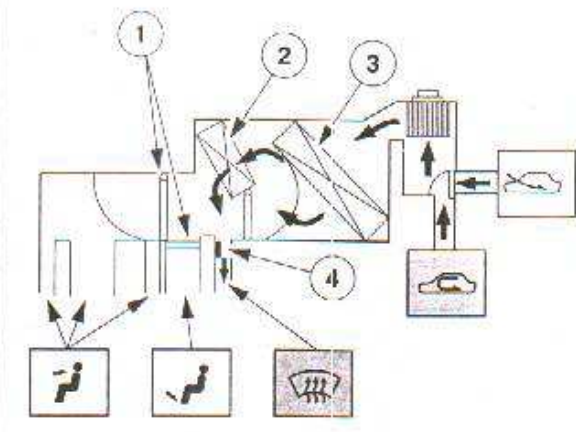
The air conditioning (A/C) system and the heating system are known together as heating, ventilation and air conditioning (HVAC) system. The HVAC system controls heat and the removal of humidity. The HVAC system uses an air distribution system of ducts, vents and doors to direct outside air or climate 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

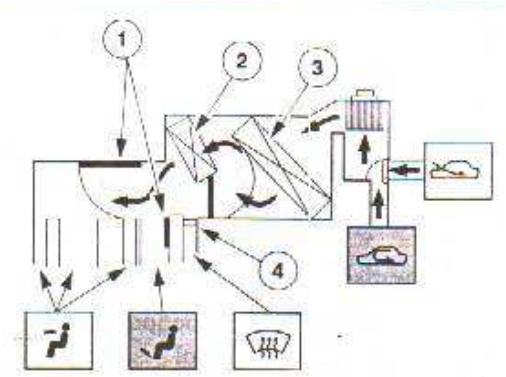
The present-day automobiles, specially cars, are provided with heaters and defrosters. The heater system of a car uses a motor to drive the fan. The fan forces fresh air through the heater element into the interior of the car. The heater element is kept hot by means of hot water of the radiator. The 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.

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.



Defroster door operation

1. Vent doors closed
2. Heater core
3. Evaporator
4. Defroster door



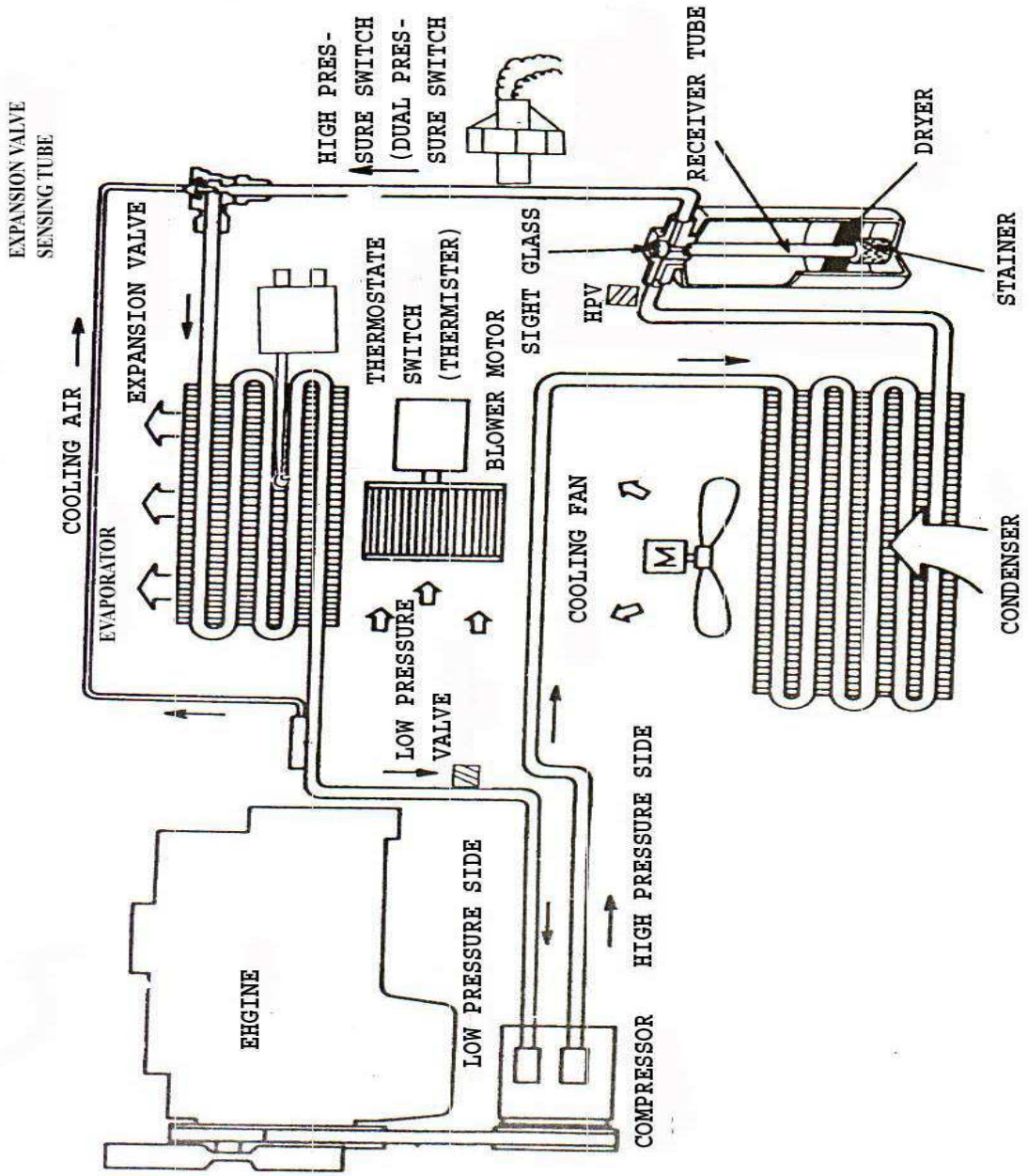
Vent / face heater door operation

1. Vent doors
2. Heater core
3. Evaporator
4. Defroster door.

Air Conditioning System

Following figure 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.



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.

3. 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.

4. 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.

5. 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.

6. 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.

7. 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^{0}C (68 – 95^{0}F)
- 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.

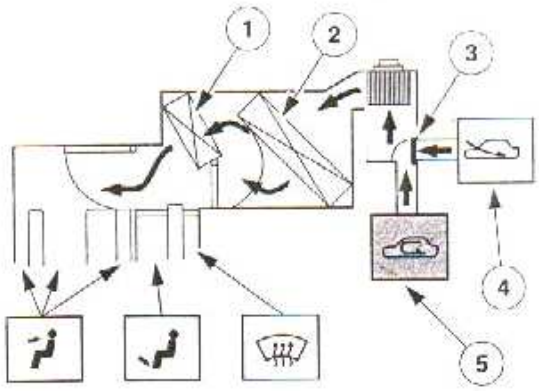
Use the following table when checking charged state of refrigerant and correct it as necessary

Symptom	Charge of refrigerant	Remedy
1. Bubbles observed in sight glass	Insufficient charge of refrigerant in system	Check system for leaks with a leak test
2. No bubbles observed in sight glass	No or insufficient charge of refrigerant in 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 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 system	Recover refrigerant, evacuate and charge proper amount of refrigerant.
5. When A/C is turned OFF, refrigerant in sight glass clears immediately and remains clear.	Too much charge of refrigerant in system.	Recover refrigerant, evacuate and charge proper amount of refrigerant.
6. When A/C is turned OFF, refrigerant in sight glass once produces bubbles and then clears.	Proper charge of refrigerant rant in system	NO CORRECTION NEEDED BECAUSE CHARGE OF REFRIGERANT IS NORMAL

TROUBLE DIAGNOSIS

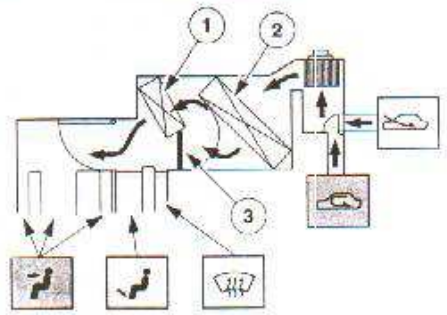
DEFECTS	CAUSES	REMEDIES
1. No cooling or warm air.	**Magnetic clutch does not engage properly** • Fuse blown • Magnetic clutch faulty • A/C switch faulty • Thermal switch faulty • Duel pressure switch faulty • Wiring or grounding faulty • No refrigerant	Replace fuse and check for short Check clutch. Check switch Check thermal switch. Check switch. Repair as necessary. Check A/C circuit

	• 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 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 • Expansion valve faulty • Thermister 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 condenser. Check or replace drive belt. Check magnetic clutch. Check compressor. Check expansion valve. Check thermister. 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



Temperature Blend door operation

1. Heater core
2. Evaporator
3. Temperature blend door

Session-10: Introduction to Climate Control System Heating Ventilation and Air Conditioning in a Vehicle

Exercise: Assignment

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.

Session-10: Introduction to Climate Control System Heating Ventilation and Air Conditioning in a Vehicle

Answer the following questions

(Use additional sheets of paper, if necessary)

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 system of a car uses a ---------- to drive the fan.
4 The heater element is kept hot by means of ---------- of the radiator.
5. The defroster operates like the ----------.
6. The defroster directs the --------- air against the windshield to avoid -------- or freezing of the moisture.
7. The compressor of the refrigerator is driven by a belt and pulley from the engine ---------- pulley.
8. If a V-belt is too loose, it will be ---------- off because of slippage.
9. When many air bubbles are seen through the sight glass, it indicates a ---------- of refrigerant.

Session-10: Introduction to Climate Control System Heating Ventilation and Air Conditioning in a Vehicle

Use the following checklist to see if you've met all the requirements for introduction to climate control system heating ventilation and air conditioning in a vehicle.

Part A

Share importance of climate control system heating ventilation and air conditioning in a vehicle.

Part B

Discussed the following in the class

1. What do you mean by climate control in an automobile?
2. Write the functions of Heater and Defroster in automobile.
3. Draw the operational circuit of an automobile air conditioning system and label different components.
4. Explain different fault of automobile air conditioning system, their causes and remedies.

Performance standards/criteria covered by this assessment

Performance standards	Yes	No
Able to understand importance of air conditioning system in a vehicle		
Able to describe the working of air conditioning system in a vehicle		
Able to find faults in air conditioning system of vehicle, their causes and possible remedies		

Suggested Reading

Books

Title	Author	Publisher
Service Manual	Maruti suzuki	Maruti Suzuki
Service Manual	Tata Nano	Tata Nano
Text Book of Automobile Engineering	R K Rajput	Laxmi Publications

Websites

www.marutisuzuki.com/owner-manual.aspx

auto.indiamart.com/auto-technology

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www.wikipedia.com

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