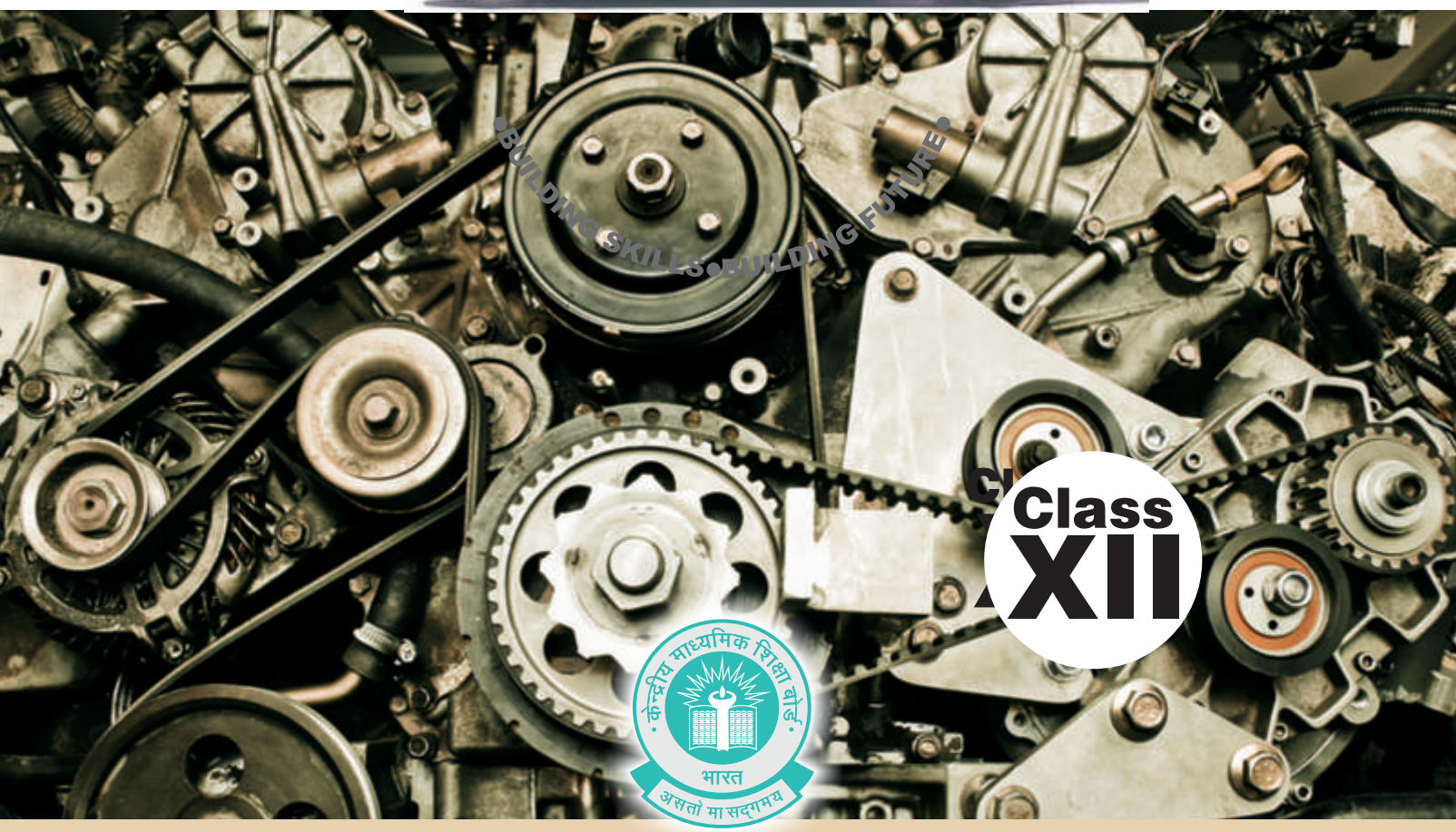
# Auto Shop Repair and Practice

## Student Handbook

## Study Material




CENTRAL BOARD OF SECONDARY EDUCATION

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# Auto Shop Repair & Practice

Students Handbook, Class XII

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# भारत का संविधान

## उद्देशिका

**हम, भारत के लोग, भारत को एक सम्पूर्ण 'प्रभुत्व-सम्पन्न समाजवादी पंथनिरपेक्ष लोकतंत्रात्मक गणराज्य बनाने के लिए, तथा उसके समस्त नागरिकों को**

**समाजिक, आर्थिक और राजनैतिक न्याय,**
**विचार, अभिव्यक्ति, विश्वास, धर्म**
**और उपासना की स्वतंत्रता,**
**प्रतिष्ठा और अवसर की समता**
**प्राप्त कराने के लिए**
**तथा उन सब में व्यक्ति की गरिमा**
**और राष्ट्र की एकता और अखण्ड**
**निश्चित करने वाली बंधुता बढ़ने के लिए**

**दृढ़संकल्प होकर अपनी इस संविधान सभा में आज तारीख 26 नवम्बर, 1949 ई० को एतद्द्वारा इस संविधान को अंगीकृत, अधिनियमित और आत्मार्पित करते हैं।**

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1. संविधान (बयालिस संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "प्रभुत्व-संपन्न लोकतंत्रात्मक गणराज्य" के स्थान पर प्रतिस्थापित।
2. संविधान (बयालिस संशोधन) अधिनियम, 1976 की धारा 2 द्वारा (3.1.1977) से "राष्ट्र की एकता" के स्थान पर प्रतिस्थापित।

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## भाग 4 क

## मूल कर्त्तव्य

**51 क. मूल कर्त्तव्य** – भारत क प्रत्येक नागरिक का यह कर्त्तव्य होग कि वह –

(क) संविधान का पालन करें और उसके आदर्शों, संस्थाओं, राष्ट्रध्वज और राष्ट्रगान का आदर करें,

(ख) स्वतन्त्रता के लिए हमारा राष्ट्रीय आंदोलन को प्रेरित करने वाले उच्च आदर्शों को हृदय में संजोए रखे और उनका पालन करें,

(ग) भारत की प्रभुता, एकता और अखण्डता की रक्षा करें और उसे अक्षुण्ण रखे,

(घ) देश की रक्षा करें और आह्वान किए जाने पर राष्ट्र की सेवा करें,

(ड) भारत के सभी लोगों में समरसता और समान भातृत्व की भावना का निर्माण करें जो धर्म भाषा और प्रदेश या वर्ग पर आधारित सभी भेदभाव से परे हों, ऐसी प्रधाओं का त्याग करे जो स्त्रियों के सम्मान के विरुद्ध है;

(च) हमारी सामासिक संस्कृति की गौरवशाली परपंरा का महत्त्व समझे और इसका परिक्षण करे;

(छ) प्राकृतिक पर्यावरण की जिसके अंतर्गत वन, झील, नदी, और वन्य जीव है, रक्षा करे और उसका संवर्धन करे तथा प्राणी मात्र के प्रति दयाभाव रखे;

(ज) वैज्ञानिक दृष्टिकोण, मानववाद और ज्ञानार्जन तथा सुधार की भावना का विकास करे;

(झ) सार्वजनिक संपत्ति को सुरक्षित रखे और हिंसा से दूर रहे;

(ञ) व्यक्तिगत और सामूहिक गतिविधियों के सभी क्षेत्रों की और बढ़ाने का सतत प्रयास करे जिससे राष्ट्र निरंतर बढ़ते हुए प्रयत्न और उपलब्धि की नई उचाईयों को छू ले;

(ट) यदि माता-पिता या संरक्षक है, छह वर्ष से चौदह वर्ष तक की आयु वाले अपने, यथास्थिति, बालक या प्रतिपाल्य के लिये शिक्षा के अवसर प्रदान करें।

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1. संविधान (छयासीव संशोधन) अधिनियम, 2002 की धारा 4 द्वारा प्रतिस्थापित।

# THE CONSTITUTION OF INDIA

## PREAMBLE

**WE, THE PEOPLE OF INDIA,** having solemnly resolved to constitute India into a **SOVEREIGN SOCIALIST SECULAR DEMOCRATIC REPUBLIC** and to secure to all its citizens :

**JUSTICE,** social, economic and political;
**LIBERTY** of thought, expression, belief, faith and worship;
**EQUALITY** of status and of opportunity; and to promote among them all
**FRATERNITY** assuring the dignity of the individual and the unity and integrity of the Nation;

**IN OUR CONSTITUENT ASSEMBLY** this twenty-sixth day of November, 1949, do **HEREBY ADOPT, ENACT AND GIVE TO OURSELVES THIS CONSTITUTION.**

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1. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "Sovereign Democratic Republic" (w.e.f. 3.1.1977)
2. Subs, by the Constitution (Forty-Second Amendment) Act. 1976, sec. 2, for "unity of the Nation" (w.e.f. 3.1.1977)

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# THE CONSTITUTION OF INDIA

## Chapter IV A

## FUNDAMENTAL DUTIES

### ARTICLE 51A

**Fundamental Duties - It shall be the duty of every citizen of India-**

(a) to abide by the Constitution and respect its ideals and institutions, the National Flag and the National Anthem;
(b) to cherish and follow the noble ideals which inspired our national struggle for freedom;
(c) to uphold and protect the sovereignty, unity and integrity of India;
(d) to defend the country and render national service when called upon to do so;
(e) to promote harmony and the spirit of common brotherhood amongst all the people of India transcending religious, linguistic and regional or sectional diversities; to renounce practices derogatory to the dignity of women;
(f) to value and preserve the rich heritage of our composite culture;
(g) to protect and improve the natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures;
(h) to develop the scientific temper, humanism and the spirit of inquiry and reform;
(i) to safeguard public property and to abjure violence;
(j) to strive towards excellence in all spheres of individual and collective activity so that the nation constantly rises to higher levels of endeavour and achievement;
(k) to provide opportunities for education to his/her child or, as the case may be, ward between age of 6 and 14 years.

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1. Subs. by the Constitution (Eighty - Sixth Amendment) Act, 2002

# Preface

CBSE has introduced Automobile Technology as vocational course at Secondary and Senior Secondary level from class-IX (Level-1) to class-XII (Level-4). People globally, are truly living in the era of wheels. Millions of people depend on their vehicles as their primary means of transportation. Therefore, experts predict a strong demand for skilled automobile technicians and related professionals for the foreseeable future.

In an attempt to equip the students with this skill, this Student Handbook titled “Autoshop Repair and Practice” for classXI & XII was prepared. PSSCIVE Bhopal prepared the Handbook for the benefit of the students who opt for the course.

Ample care has been taken to align the subject with National Occupation Standards (NOS) which are competency based standards identified by the Automobile industry to train students in knowledge and skills that equip students to perform effectively with confidence.

The language used in this book is simple and easily understandable to the students at class IX level. Relevant pictorial illustrations, tables, examples and simplified concepts provided in this book help the students to learn with ease and comfort.

This book is authored by competent educationists in the field of Automobile Technology under the supervision of PSSCIVE with focus on helping the students to learn without any difficulty and use this book as a tool for easy learning.

I complement everyone who is associated in developing this book which is a very useful resource for the benefit of the students.

Comments and suggestions are welcome for further improvement of the Book.

**Chairman, CBSE**

# Acknowledgements


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**Sh. K.K Choudhary, Controller of Examinations**

## Connent Developed by

**PSSCIVE,** Bhopal

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# Contents

## Introduction

# Contents

## Introduction

## Unit Description

This unit provides introductory knowledge & related skills covering the service manual of a vehicle.

## Resource Required

Notebooks, Pen, Pencil, Eraser, Computer, Open Source Software for making digital presentation, LCD projector. Pictures, sketches, Drawings & posters for building awareness about various types of vehicle. Operator manual and Service manual of a vehicle.

## Elements and Performance Criteria

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

| Element of an Knowledge | Performance Criteria |
|---|---|
| Reading of service manual | • Able to identify service manuals of respective vehicles.<br>• Able to read and use the service manuals for specification, sequences in repair work. |

## Relevant Knowledge and Skills

**1. Relevant Knowledge**

- Importance of Service manual.

**2. Skills**

- Able to identify service manuals of different vehicles.
- Able to read and use the service manual

## Assessment Plan

| Session No. | Assessment Method | Due Date | Completion Date |
|---|---|---|---|
| 1. | Fill in the Blanks | | |
| 2. | Fill in the Blanks | | |
| 3. | Fill in the Blanks | | |

# Unit - 1

## 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 day, a new model of vehicle keep coming regularly in the market and all technical information is to be made available to the service mechanic. Service manual keeps informed mechanic about technical detail of a 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 service 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. Grade of lubricants used in different areas of assemblies and their correct quantity


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 regularly 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

## Exercise : Assignment

1. List the content of vehicle service manual seen.
2. Writ the part number of following components

a. Clutch disc
b. Diskpad
c. Headlight
d. Backlight
e. Piston

## 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 | | |

## 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
- www.automobileindia.com/consumer-guide/automobile-technology
- auto.indiamart.com/auto-technology
- books.google.com/books/about/Automobile_Engineering.html
- www.bikeadvice.org
- www.wikipedia.com

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## Unit Description

This unit provides introductory knowledge & skills covering importance, regular inspection and repair of fasteners used in automobile. Students will be given a broad view of identification, selection, changing of fasteners used in automobile.

## Resource Required

- Notebooks, Pen, Pencil, Eraser.
- Computer, Open Source Software for making digital presentation, LCD projector.
- Sketches, pictures, animation and videos of fasteners, special tools.
- Various types of fasteners and tools etc.
- Posters for building awareness about these topics.

**Nominal Hours**: 10 Periods

## Elements and Performance Criteria

- Elements define the critical learning outcomes of a unit of competency.

| Element of Knowledge | Performance Criteria |
|---|---|
| Fasteners and its type used in automobile | • Able to identify fasteners in a vehicle |
| Various procedure used for removal of fasteners in a vehicle | • Able to handle rusty, broken, spoiled threaded fasteners<br>• Able to use special tools for removal of defected/ affected fasteners<br>• Able to select appropriate fasteners and tightening at appropriate torque. |

## Relevant Knowledge and Skills

**1. Relevant Knowledge**

- Fasteners and their type and uses
- Various procedure and tools used for removal of fasteners in a vehicle
- Importance of specified torque values for tightening the fastener

**2. Skills**

- Able to identify various fasteners used in a vehicle
- Able to handle rusty, broken, spoiled threaded fasteners
- Able to use special tools for removal of defected/ affected fasteners
- Able to select appropriate fasteners and tightening at appropriate torque.

## Assessment Plan

| Session No. | Assessment Method | Due Date | Completion Date |
|---|---|---|---|
| 1. | Fill in the Blanks | | |
| 2. | Fill in the Blanks | | |
| 3. | Fill in the Blanks | | |

## Introduction

Automobile vehicle consist of different assemblies as per its working system. These assemblies are needed to tightly link with each other for proper working of vehicle. Each component is assembled with other with the help of screws, nuts, bolts and studs etc., to make a unit. The units such as engine-clutch gearbox-differential-wheels-brakes etc. together may form a vehicle. These nut, bolt, screw, studs are called fastener. Fastener is an important device to keep the assembly together for smooth running of a vehicle.

These fasteners are assembled with the help of specified tools such as torque wrench etc. It is necessary to tighten the fasteners with specified torque. Fasteners get slackened due to vibration. Therefore, it is necessary to tight the fasteners at regular service intervals. If it is ignored, fasteners get loosened and results in spoiling of thread. This will lead to major problem in a vehicle and in the overhauling work of respective unit.

For smooth handling of the fasteners, it is necessary to use specified tools of appropriate size. Fasteners must be tightened with specified torques. If this is ignored, it may cause damaged to fastener. Over tightening of fastener causes damage to the fasteners as well as to the assembled units.

In this Unit, you will develop an understanding of the different types of fasteners and its handling so that no damage takes place.

## Session - 1: Fasteners and its Type used in Automobile

### Relevant Knowledge

### Fasteners

A fastener is a unit that mechanically joins or affixes two or more parts together. Fasteners are very important as each component or machinery or vehicle needs these to hold it together.

Fasteners come in thousands of varieties, each with specific purpose, made in different metals, ferrous and non-ferrous, and now even of engineering plastics. Screws, nuts, bolts, rivets, retaining rings, pipe plugs, pins, panel fasteners, clinch studs, bolts, bits and anchors are some of the common fasteners used in industry.

Fig -1: A view of fasteners

**Types of Fasteners:** Screws, nuts, bolts, rivets, retaining rings, pipe plugs, pins, panel fasteners, clinch studs, bolts, bits and anchors are some of the common fasteners used in industry. We will be discussing some of these fasteners here.

**Screws:** A screw is threaded device made of steel which has different types of head. It is used to assemble smaller units which bare small torque. Size of screw varies up to 10 mm diameter and length up to 50 mm. A screw will always have a head, which is a specially formed section on one end of the screw that allows it to be turned or driven.

Common tools for driving screws include screwdrivers and wrenches. The head is usually larger than the body of the screw, which keeps the screw from being driven deeper than the length of the screw and to provide a bearing surface.

Fig -2: Phillips screw and hexagonal screw

**Nuts and Bolts:** A nuts 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 lead to loosening of bolt/nut. Washers are used to prevent from loosening of nut and bolts. It also acts as locking device. Bolts and nuts are used for heavier application which bears good torque in conjunction with each other. Bolts are either fully threaded or part of length is threaded. Threaded portion of the bolt usually equal to two times of threaded diameter. Allen Key bolts are also used in automobile, which has a square or hexagonal head will be operated by specific size of keys.

Fig- 3: Allen key bolt with nut

Fig- 4: Nut and Bolt

**Stud:** A stud is a round metal bar screwed at both ends or fully screwed. It is used to assemble housings cylinder head, wheel drum, and block etc. Where the more jerking movements and vibration occurs, stud help to hold firmly.

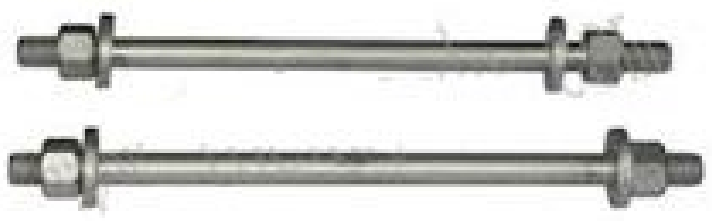

Fig- 5: Stud used in Automobile

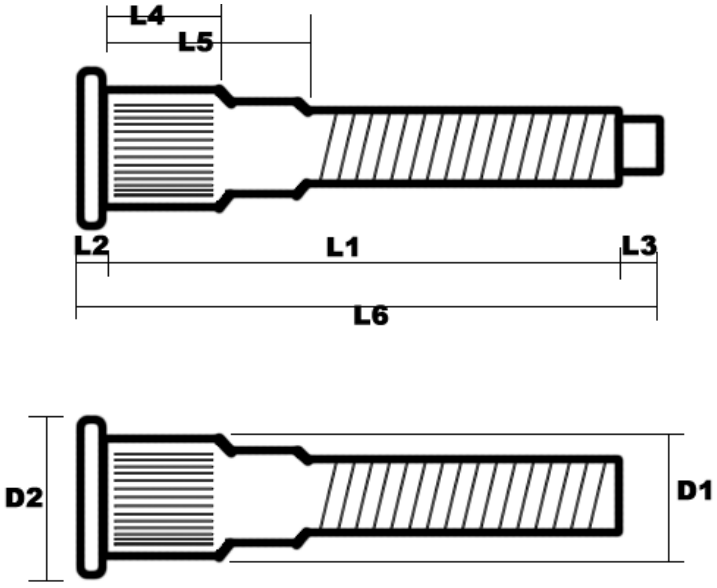


Fig- 6: Stud Drawing

Fig- 7: Stud

**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 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.

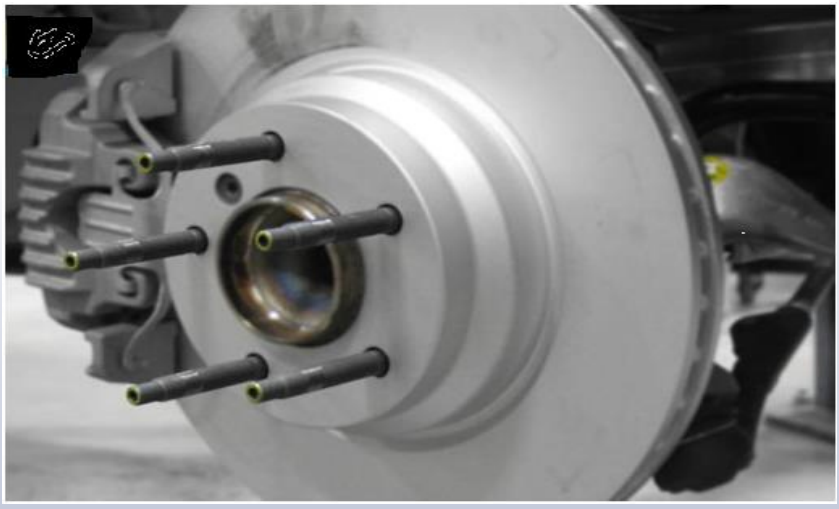

Fig- 8: Wheel Stud

Some of various types of fasteners used in automobile assembled units are given below in table.

### Table 1: Fastener used in assembled unit of automobile

| Sr. No. | Name of the assembled unit | Type of fastner used |
|---|---|---|
| 1 | Cylinder head and block | Stud with nut |
| 2 | Connecting rod with crankshaft | Nut and bolt |
| 3 | Oil sump and crankcase | Bolts |
| 4 | Silencer Cover | Boltsm Allen Key Bolt |

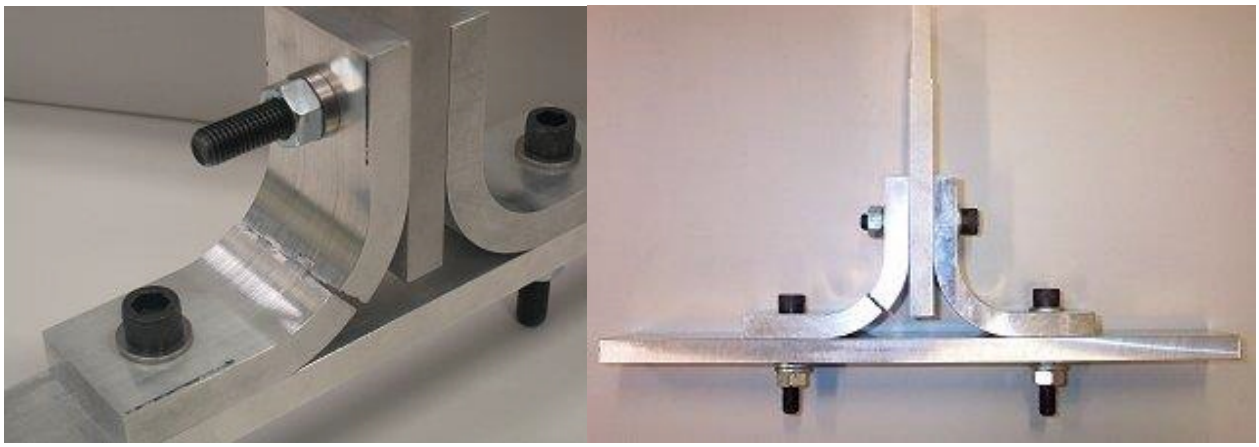

Fig- 9: Application of fastener

## Session - 2: Broken/Spoiled Headed Screw

## Related Knowledge

## 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

screw head get spoiled. It becomes difficult to tight, loosen and removal of screw from the assembly.

Fig- 10: 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 anticlock 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 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- 11: Unheaded Screw

## Session - 3 : Broken Nut/Bolts

## Related Knowledge

## 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.

Fig- 12: Broken Bolt

## Method of removal of spoiled headed nut/bolts

## 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, incase 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-13: Broken Thread

## Session - 4: Broken /Spoiled Threaded Studs

## Related Knowledge

## Broken / spoiled threaded studs

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.

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.

Fig-14: Removal of Thread

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 anticlock 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

## Session - 5: Use of Anti Rust Solution

### Related Knowledge

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.


Fig-5: Antirust solution/spray can

## Assessment: Inspection and Repair of Fasteners

### A. Exercise: Assignment

1. List the types of nut, bolt and screw used in a vehicle

| Sr.No. | Name of vehicle | Type of Fastener |
|---|---|---|
| | | |
| | | |
| | | |

2. Prepare a poster showing nut, bolt, stud and screw.

3. Name the assembly unit where fasteners are used.

### B. Answer the following questions

(Use additional sheets of paper if necessary)

1. Why we use fasteners?
2. Name the material used in fasteners.
3. Draw the figure of stud and label it.

### C. Fill in the blanks

1. Important fastener used in automobile are_____,_____ and _____
2. For tightening the screw_____is used.
3. Wheel stud helps in _____ of_____.
4. Mechanic use_____ for tightening stud a vehicle.

### D. Checklist for Assessment Activity

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

**Part A**

- Able to identify and understand the use of fasteners.

**Part B**

Discussed in class the following:

- Importance of fasteners.
- What are different types of fasteners used in automobile?

## E. 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 | | |

## Suggested Reading

## Books

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

## Websites

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- www.bikeadvice.org
- www.wikipedia.com

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## Unit Description

This unit provides introductory knowledge & related skills covering measuring equipments used during vehicle servicing. Students will be given a broad view of these important issues.

## Resource Required

- Notebooks, Pen, Pencil, Eraser.
- Computer, Open Source Software for making digital presentation, LCD projector.
- Sketches, pictures, animation and videos of measuring instruments and its components used in automobiles.
- Measuring equipments
- Posters for building awareness about these topics.

**Nominal Hours:** 30 Periods

## Elements and Performance Criteria

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

| Element of Knowledge | Performance Criteria |
|---|---|
| Dial Gauges and its application | • Able to use dial gauge for measurement of dimensions |
| Vernier Caliper and its application | • Able to use vernier caliper for easurement of dimensions. |
| Micrometer and its application | • Able to use micrometer for measurement of dimensions |
| Bore Gauge and its application | • Able to use bore gauge for measurement of dimensions |
| Depth Gauge and its application | • Able to use depth gauge for measurement of dimensions |
| Dash board and its importance | • Able to identify the components of dash board in a vehicle and their uses |

## Relevant Knowledge and Skills

### 1. Relevant Knowledge

- Dial Gauges and its application
- Vernier Caliper and its application
- Micrometer and its application
- Bore Gauge and its application
- Depth Gauge and its application
- Dash board and its importance

### 2. Skills

Able to do the following tasks in a vehicle

- Able to use dial gauge for measurement of dimensions
- Able to use vernier caliper for measurement of dimensions
- Able to use micrometer for measurement of dimensions

- Able to use bore gauge for measurement of dimensions
- Able to use depth gauge for measurement of dimensions
- Able to identify the components of dash board in a vehicle and their uses

## Assessment Plan

| Session No. | Assessment Method | Due Date | Completion Date |
|---|---|---|---|
| 1. | Fill in the Blanks | | |
| 2. | Fill in the Blanks | | |
| 3. | Fill in the Blanks | | |

## Introduction

Whenever you are driving a vehicle, you are supposed to see the gauges fitted at dashboard of your vehicle. We should not overlook it as gauges fitted in the vehicle tell various position of your car. We know the status of fuel through fuel gauge, speed of vehicle through speedometer, engine speed through tachometer gauge, temperature gauges for informing temperature of coolant. Gauges tell about brake, battery, oil status in the vehicle. Similarly various types of gauges are fitted in vehicle as per model. As a driver it is necessary to keep monitoring the reading of these gauges. If you find some issue/odd situation, immediately visit to the service station. Similarly we use various types of measuring equipment for measuring various parameters, which help the service mechanic to find fault. These instruments may be Dial Gauges, Vernier Caliper, Micrometer Bore Gauge, Depth Gauge etc. In this unit we will go through different types of gauges used for measurement in a vehicle.

## Session - 1 : Handling and Usage of Dial Gauge, Telescopic Gauge and Bore Gauge

### 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.

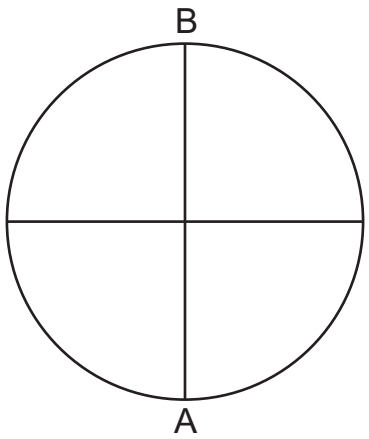
### Dial Gauge

It is used as a measuring device to measure the accuracies in alignment, eccentricity of the parts/components.

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 point.


Fig- 1: Dial Gauge

It works on the rack and pinion principal. The plunger has gear teeth cut on it and when it reciprocates it actuates a pinion attached to the pointer shaft. 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 coincide with the pointer.




| Sr. No. | Reading | Position at A | Position at B | Ovality (A-B) | Taperness |
|---|---|---|---|---|---|
| 01 | Aa | | | | |
| | Bb | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Dial Gauges are one of the most commonly used instruments in all types of automobile related industry.

## Telescopic Gauge

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.

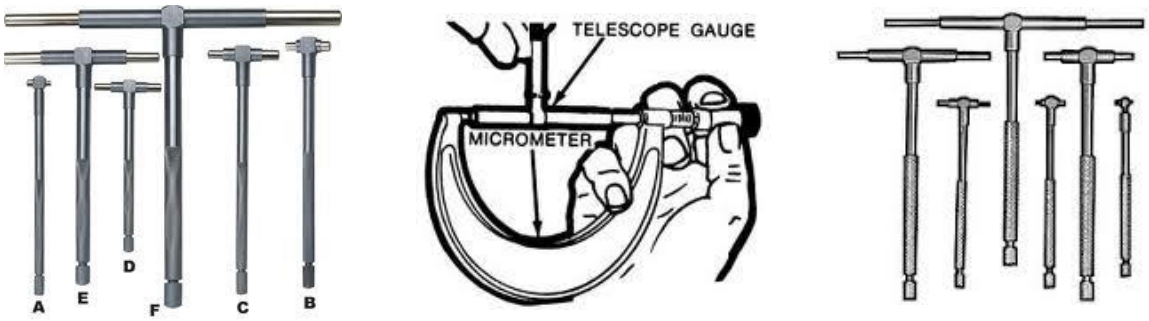



Fig- 2: Telescopic gauge and its uses

Mechanics most often use telescoping gauges, though anybody working with machinery needing to measure the interior radius or calculate the circumference of a hole or pipe can use them to the same effect. They are typically used to measure the interior radius of the bore or cylinder of a crank case in which the cylinder's pistons would extend and retract. For both internal combustion and diesel engines to work properly, absolutely no air can pass out of the cylinder when the piston extends, compressing the combustible gases within. This means that the circumference and radius of the piston head must match the circumference and radius of the cylinder as closely as possible. This means that precision indirect measuring tools such as telescoping gauges are an absolute necessity.

## Sequences of operation

- Select appropriate size of telescopic gauge
- Press the plunger in the barrel and lock the ratchet
- Place the gauge in cylinder bore to check internal diameter
- Turn the ratchet, plungers will exert equal pressure on both side of the cylinder wall.

- Hold the telescopic gauge parallel to the ground
- Lock the telescopic gauge, plunger remains open and occupied the internal diameter
- Slowly remove the telescopic gauge and read the dimension in external micrometer
- This gives main reading of cylinder bore
- See the figure given below for more clarity.

## Bore Gauge/Cylinder Gauge

Bore gauge or cylinder gauge is used to measure hole diameter or internal diameter or bore, ovality and taperness in the IC Engine cylinder.

Fig-3: Bore Gauge

The bore/cylinder gauge has a dial indicator mounted on a sledge which acts or a guide when the instrument is in use. There are two contact points and a extension roads of varying length as per requirement.

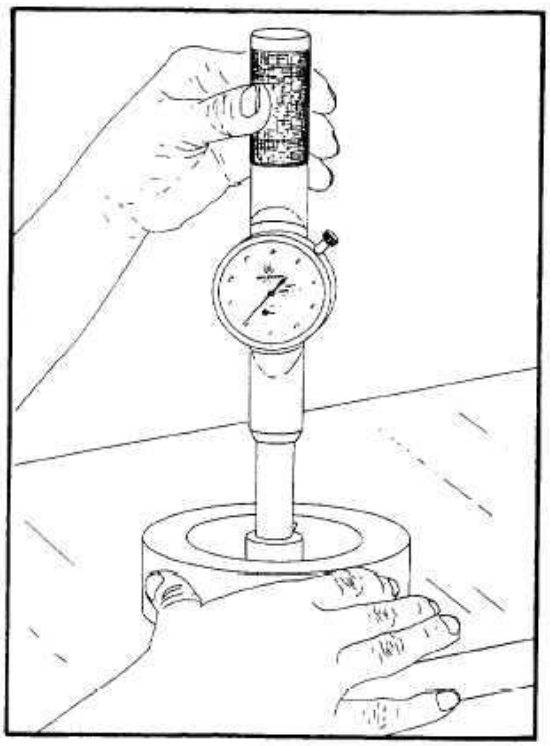


Fig -4: Use of Bore Gauge

To make a measurement a suitable length rod is fitted and the gauge is inserted in the cylinder where it is carefully traversed up and down in several positions while the movement of dial gauge pointer is observed. In this way we can detect the variations along the bore/internal diameter of engine cylinder. Dial gauge gives fractional reading in 0.001 mm.

## Session - 2 : Handing and Usage of Vernier Caliper and Depth Gauge.

### Relevant Knowledge

The name 'vernier' as applied to several precision tools is derived from the name of a French Scientist and mathematician, 'Pierre vernier'.

A vernier is a graduated short scale that is mounted on the measuring instrument that its graduations subdivided the divisions on the main scale of the instrument.

A vernier calliper is used to make both inside and outside measurement with the help of its specially designed jaws.

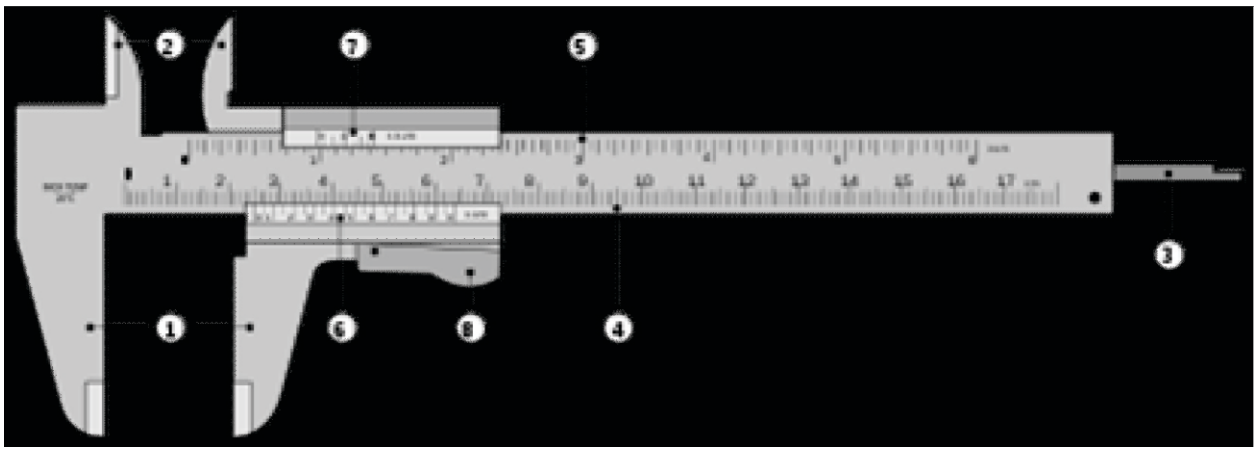



Fig- 5: Vernier caliper

Parts of a vernier caliper:

1. **Outside jaws:** used to measure external diameter or width of an object
2. **Inside jaws:** used to measure internal diameter of an object
3. **Depth probe:** used to measure depths of an object or a hole
4. **Main scale:** scale marked every mm
5. **Main scale:** scale marked in inches and fractions
6. **Vernier scale:** gives interpolated measurements to 0.1 mm or better
7. **Vernier scale:** gives interpolated measurements in fractions of an inch
8. **Retainer:** used to block movable part to allow the easy transferring of a measurement

The vernier, dial, and digital calipers give a direct reading of the distance measured to high accuracy. They are functionally identical, with different ways of reading the result. These calipers comprise a calibrated scale with a fixed jaw, and another jaw, with a pointer, that slides along the scale. The distance between the jaws is then read in different ways for the three types.

The simplest method is to read the position of the pointer directly on the scale. When the pointer is between two markings, the user can mentally interpolate to improve the precision of the reading. This would be a simple calibrated caliper; but the addition of a vernier scale allows more accurate interpolation, and is the universal practice; this is the vernier caliper.

Vernier, dial, and digital calipers can measure internal dimensions (using the uppermost jaws in the picture at right), external dimensions using the pictured lower jaws, and in many cases depth by the use of a probe that is attached to the movable head and slides along the centre of the body. This probe is slender and can get into deep grooves that may prove difficult for other measuring tools. The vernier scales may include metric measurements on the lower part of the scale and inch measurements on the upper, or vice versa, in countries that use inches. Vernier calipers commonly used in industry provide a precision to 0.01 mm (10 micrometres), or one thousandth of an inch. They are available in sizes that can measure up to 1,829 mm (72 inches).

## Procedure of taking measurement with a vernier calliper

If we want to measure an outside diameter of cylinder:

1. The sliding jaw is moved along the beam until the sliding jaw almost contact the cylinder kept against the fixed jaw. In this way the cylinder is held between the fixed jaw and sliding jaw.
2. Then the sliding jaw assembly that carries the fine adjustment screw should be clamped to the beam with the help of fine adjustment clamp.
3. The two jaws are now brought into contact with the work piece by moving the sliding jaw with the help of fine adjustment screw.
4. The jaws should make definite contact with the surface of the cylinder but should not be tight.
5. The main slide assembly is then locked to the beam with the help of clamp.
6. The calliper is carefully removed from the work piece to prevent springing of the jaws.

## The reading is then take as the procedure described below :

Least count is the minimum possible measurement which can be measured by the measuring instruments.

Least count = Main scale reading / Vernier scale reading

(1) Take that least main scale reading just ahead of which zero of the vernier scale takes place. Assume that the zero of vernier scale is just ahead of 32mm reading of main scale. So take note of 32 mm.

(A) Main scale reading = 32mm

(2) Now note the least count (L.C) of the vernier calliper. Least count is the minimum possible measurement which can be measured by the measuring instruments. Assume in this case L.C is .02 mm

(B) Least count = 0.02 mm

(3) Now look for the graduation mark of the vernier scale that coincides with any graduation mark of the main scale.

Assume in this case the 11th graduation of vernier scale coincides with any graduation of the main scale. So note it down as C=11

Now calculate the reading as follows

Actual measurement = A + (BX C)
= 32 + (0.02 X 11)
= 32 + 0.02
= 32.22 mm.

## Exercise

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) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

## Tyre Depth Gauge

Tyre depth gauge is measuring instrument to measure depth of a cylindrical part/surface. It works on the same principal on which vernier caliper works. Depth gauge is used for measuring tyre tread gap.

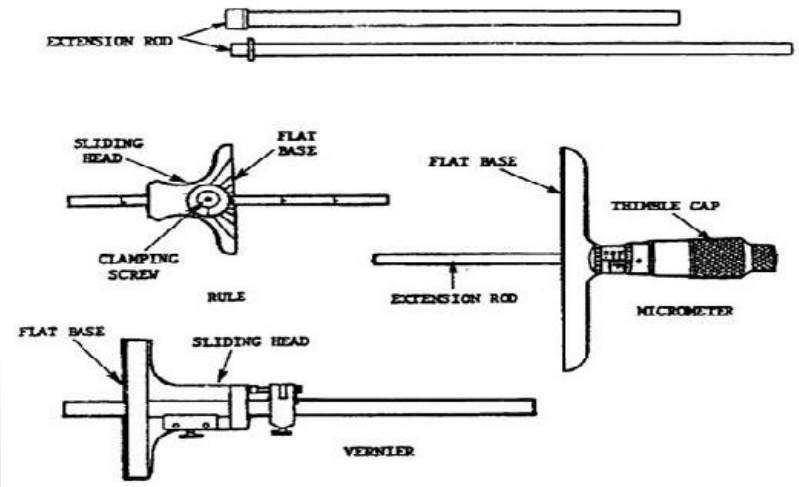



Fig- 6: Tyre Depth Gauge

## Session - 3: Micrometer (Screw Gauge)

### Relevant Knowledge

Micrometer is a measuring instrument used to measure very fine and precise dimensions of length, width, thickness, diameter etc. Micrometer measure the cylindrical component like shaft, bolt, coin, boll etc. This is more accurate and precise than a vernier calliper.

Fig- 7: Micrometer

It consists of a rigid frame which carries a hardened and optically flat anvil face at one end. At the other hand the micrometer head is attached which a spindle of accurate flat face. The micrometer head consists of thimble which can be rotated with the thumb and finger. The rotating thimble gives rotating movement to the simple.

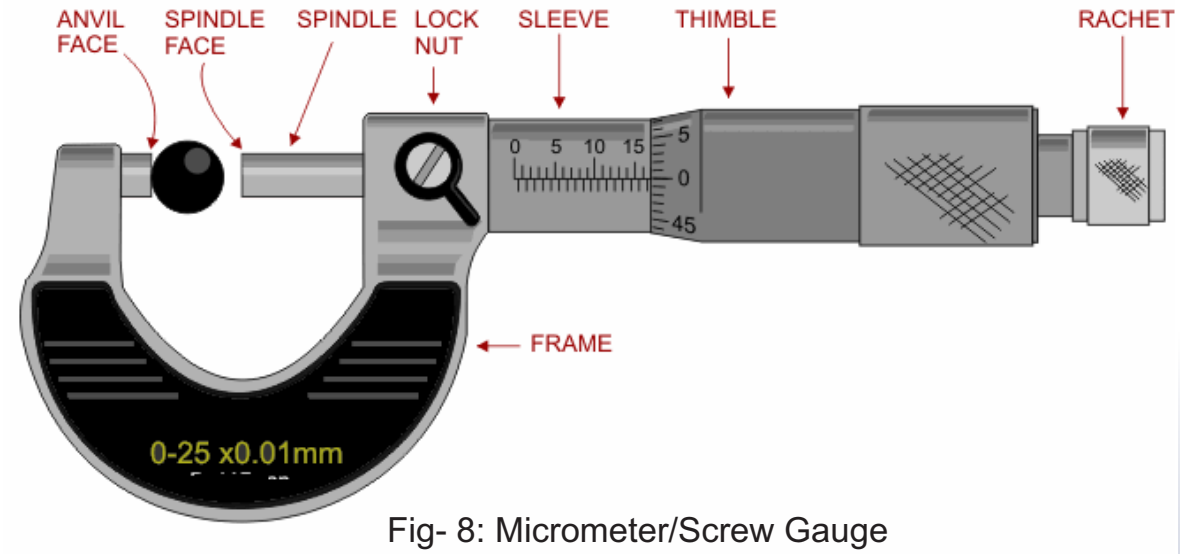



Fig- 8: Micrometer/Screw Gauge

A micrometer sometimes known as a micrometer screw gauge is a device having a calibrated screw used widely for precise measurement of small distances in mechanical engineering and machining as well as most mechanical trades, along with other metrological instruments such as dial, vernier, and digital calipers.

A micrometer is composed of:

**Frame :** The C-shaped body that holds the anvil and barrel in constant relation to each other. It is thick because it needs to minimize flexion, expansion, and contraction, which would distort the measurement. The frame is heavy and consequently has a high thermal mass, to prevent substantial heating up by the holding hand/fingers. It is often covered by insulating plastic plates which further reduce heat transference.

**Anvil :** The shiny part that the spindle moves toward, and that the sample rests against.

**Sleeve / barrel / stock :** The stationary round part with the linear scale on it. Sometimes vernier markings.

**Lock nut / lock-ring / thimble lock :** The knurled part (or lever) that one can tighten to hold the spindle stationary, such as when momentarily holding a measurement.

**Screw :** The heart of the micrometer is inside the barrel. The shiny cylindrical part that the thimble causes to move toward the anvil.

**Thimble :** The part that one's thumb turns. Graduated markings.

**Ratchet stop :** Device on end of handle that limits applied pressure by slipping at a calibrated torque.

For taking measurements the work piece should be held between the anvil face and the spindle face. The rotating spindle should not be tightened hardly. For this purpose the ratchet is used to give proper pressing of the spindle against the work piece. Now locked the micrometer with the help of lock nut and removed from the work piece very precisely.

Least Count = Pitch / Number of divisions on circular scale (thimble)

Where pitch is distance travelled by thimble on a linear scale in one rotation.

Now take readings as follows-

1. Take note of the least count (L.C) of micrometer. In this case L.C = 0.01mm
2. Take note of Major division on barrel 'A'
3. Take note of Minor division on barrel 'B'
4. Take note of thimble division 'C' X L.C =D
5. Now to read the micrometer, a circular scale on the sleeve is provided.

The circular scale has each graduation represent 0.002 mm and each graduation is marked with a number 0,2,4,6,8 etc to help in the reading. Now look for which no. of division of circular scale is coincides with the division of vernier scale coincides with the any division of thimble then vernier division on barrel = 3 X .002 = .006 mm =E

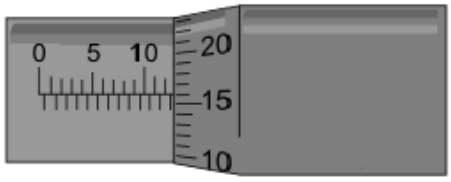
Total reading = A+B+D+E

## Example Measure Readings

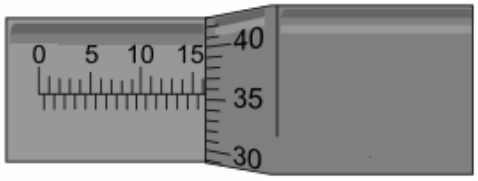
Using the first example seen below:

1. Read the scale on the sleeve. The example clearly shows 12 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 (these are hundredths of a mm).

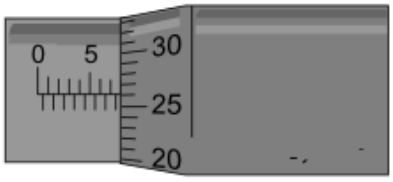
The final measurement is 12.5mm + 0.16mm = 12.66



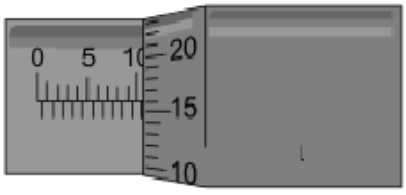

SELEEVE READS FULL MM = 12.00
SELEEVE READS ½ MM = 0.50
THIMBLE READS = 0.16



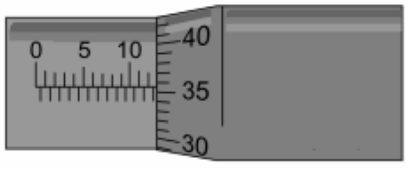

SELEEVE READS FULL MM = 16.00
SELEEVE READS ½ MM = 0
THIMBLE READS = 0.355



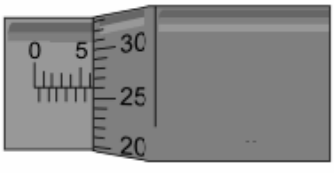

SELEEVE READS FULL MM = 7.00
SELEEVE READS ½ MM = 0.50
THIMBLE READS = 0.26




ANSWER:




ANSWER:




ANSWER:

## Session - 4: Handling and use of Hydrometer and Bevel Gauge

### Relevant Knowledge

Hydrometer is used to measure specific gravity of the electrolyte of the battery. It consists of a glass tubular body with a rubber bulb at the top and a sampler tube at the bottom. There is a glass float inside the glass body. There is a mark inside the glass (red & green).

Fig- 9: Hydrometer

Fig- 10 : Use of Hydrometer

This glass float has a vertical density scale. To test the specific gravity of the electrolyte :

1. Immerse the sample tube in the cell containing electrolyte. (Mixture of water and sulphuric acid)

2. Squeeze the rubber bulb and release the same which would cause a sample of the electrolyte to be drawn inside the glass body. Let the float inside rise and then read off the scale drawn at the surface of the sampler tube. The specific gravity of a fully charged battery is 1.280. If the specific gravity is less than 1.200 then it should be charged.

## 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.

Fig-11; Bevel Gauge

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

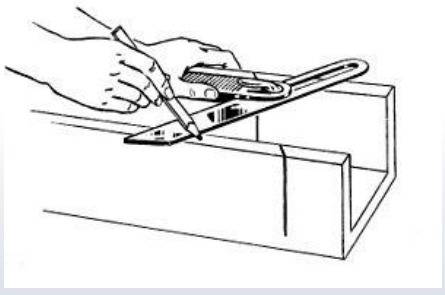


Fig-12: Application of Bevel Gauge

## Session - 5: Handling and Uses of Torque Wrench and Filler Gauge

A **torque wrench** is a tool used to precisely apply a specific torque to a fastener such as a nut or bolt. It is usually in the form of a socket wrench with special internal mechanisms. It was invented by Conrad Bahr in 1918. It was designed to prevent over tightening nuts and bolts. A torque wrench is used where the tightness of nut and bolts is crucial. It allows the operator to measure the torque applied to the fastener so it can be matched to the specifications for a particular application. Torque wrenches are of various types such as digital wrench, angular wrench etc.

Fig-13 : Torque Wrench


Fig-14: Torque Wrench Angular Type


Fig-15: Torque Wrench Gun Type

Torque wrenches are often considered and used as “tools” rather than true measuring “instruments”. They provide a “visible” measure of torque (dial indicating, flat beam TW). They are used to control torque in assembly and fastening operations.

## Filler Gauge

A filler gauge is a tool used to measure gap widths. Filler gauges are mostly used in engineering to measure the clearance between two parts or surfaces.

Fig- 16 : Filler Gauge

They consist of a number of small lengths of steel of different thicknesses with measurements marked on each piece. They are flexible enough that, even if they are all on the same hinge, several can be stacked together to gauge intermediate values. It is common to have two sets for imperial units (typically measured in thousandths of an inch) and metric (typically measured in hundredths of a millimetre) measurements.

A similar device with wires of specific diameter instead of flat blades is used to set the gap in spark plugs to the correct size; this is done by increasing or decreasing the gap until the gauge of the correct size just fits inside the gap. The lengths of steel are sometimes called leaves or blades, although they have no sharp edge.

## Session - 6: Inspection of Dashboard of a Vehicle

### Relevant Knowledge

Whenever we enter a vehicle and sit in place of driver, we find that there is many instrument or indicators placed in a dashboard. We may say that a dashboard is a control panel placed in front of the driver of an automobile, housing instrumentation and controls for operation of the vehicle. Items located on the dashboard at first included the steering wheel and the instrument cluster. The instrument cluster pictured to the right contains gauges such as a 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 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.

Fig- 17: Dashboard of a Vehicle

## Important Components of Dashboard

- Speedometer,
- Tachometer,
- Odometer
- Fuel gauge,
- 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


Fig -18: Speedometer

Every component fitted in dashboard indicates working of particular section. We will now discuss the role of some of the very important instruments.

**Speedometer**: The speedometer keep informs us accurate reading on speed of a vehicle. Speed may be miles per hour or kilometers per hour. If we don't see the speed in speedometer, vehicle will run higher speed and it may not be under control of driver.

**Tachometer:** Tachometer tells you how fast your engine is turning in revolutions per minute. You should avoid working your engine so hard that it surges up into the “danger zone” as indicated on the tachometer. If you notice that your tachometer is reading abnormally high when you accelerate, that could indicate problems and you should see a mechanic.


Fig -19:Tachometer

**Odometer:** An odometer is an instrument that indicates distance travelled by a vehicle, such as a bicycle or automobile. The device may be electronic, mechanical, or a combination of the two. The word derives from the Greek words hodós ("path" or "gateway") and métron ("measure").


Fig -20: Odometer

**Fuel Gauge**: The fuel gauge 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- 21: Fue Gauge

**Temperature Gauge:** The temperature gauge doesn't actually measure the temperature of your engine. Instead, it measures the temperature of your engine's coolant. Most gauges have ranges for cold, normal, and hot. If your vehicle's temperature gauge gets into the hot range, you need to move to a safe place and stop driving immediately. Ignoring this one can cause a lot of expensive damage in a fairly short amount of time.

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


Fig-22:Temperature Gauge

## 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. In the United States, specific functions are required of the MIL by EPA regulations.

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 you could end up driving around with a very serious issue and causing even more damage to your car.


A Malfunction Indicator Lamp, this one labeled "Service Engine Soon".


A MIL "Check Engine" light on a Volkswagen Bora indicating a fault in the Engine Management System.

Fig- 23: Malfunction Indicator Lamp

## Automotive Navigation System

An **automotive navigation system** is a satellite navigation system designed for use in automobiles. It typically uses a GPS navigation device 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 -24: Navigator

Some sorts can be taken out of the car and used hand-held while walking.

## 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.

## Assessment

### Exercise: Assignment

### (Use additional sheets of paper if necessary)

1. List the important component shown in a dashboard of a vehicle.

2. Draw a diagram of a dashboard with its component.

## Answer the following questions

**(Use additional sheets of paper if necessary)**

## Fill in the blanks

1. The speedometer keep informs us _____ reading on speed of a vehicle.
2. The temperature gauge doesn't actually _____ the temperature of your engine. Instead, it measures the temperature of your engine's _____.
3. A malfunction indicator lamp (MIL), also known as a _____ is a tell-tale to indicate malfunction of a computerized _____ management system.
4. An _____ is a satellite navigation system designed for use in automobiles.

## Checklist for Assessment Activity

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

### Part A

Share importance of Use of dial gauge, vernier caliper and micrometer Share importance of dashboard of a vehicle.

### Part B

Discussed in class the following:

- Why Use of dial gauge,vernier caliper and micrometer is necessary?
- What are the steps to be followed while adjusting these dial gauge, vernier caliper and micrometer?
- Why dashboard should be regularly checked?
- What are the various alerts sign found in a dashboard of a vehicle?

## Performance standards/criteria covered by this assessment

| Performance standards | Yes | No |
|---|---|---|
| Able to explain importance of Use of dial gauge, vernier caliper and micrometer | | |
| Able to list general steps during Use of dial gauge, vernier caliper and micrometer | | |
| Able to explain importance of dashboard of a vehicle | | |
| Able to list components of dashboard of a vehicle | | |

## Suggested Reading

### Books

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

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- www.shell.com/home/content/ind/products_services/on_the_road
- http://www.saasblg.com/index_files/dialgauge.htm -Dial gauge
- http://www.measurecontrol.com/english/how-does-a-dial-indicator-work/

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## Unit Description

This unit provides introductory knowledge and skills covering periodic maintenance of suspension system, servicing or overhauling while the general servicing of the vehicle. Students will be given a broad view of these important issues.

## Resource Required

- Notebooks, Pen, Pencil, Eraser.
- Computer, Open Source Software for making digital presentation, LCD projector.
- Sketches, pictures, animation and videos of wheels stud and its components.
- Posters for building awareness about these topics.

**Nominal Hours:** 40 Periods

## Elements and Performance Criteria

- Elements define the critical learning outcomes of a unit of competency.

| Element of Knowledge | Performance Criteria |
|---|---|
| • Importance of maintenance of suspension system. | •Maintenance tips of suspension system |
| • Importance of servicing and repair of leaf spring set etc. | • Service and repair of leaf spring set etc |
| • Procedure of replacement of strut/shock absorber | •Replacement of strut/shock absorber |
| • Manual and power steering system | •Adjustment of manual and power steering system |
| • Steering system adjustment | • Adjustment Steering system |

## Relevant Knowledge and Skills

### 1. Relevant Knowledge

- Maintenance of suspension system
- Service and repair of leaf spring set etc
- Replacement of strut/shock absorber
- Manual and power steering system
- Steering system adjustment

### 2. Skills

- Able to do maintenance of suspension system
- Able to do service and repair of leaf spring set etc
- Able to do replacement of strut/shock absorber
- Able to do adjustment of manual and power steering system
- Able to do adjustment of steering system

## Assessment Plan

| Session No. | Assessment Method | Due Date | Completion Date |
|---|---|---|---|
| 1. | Fill in the Blanks | | |
| 2. | Fill in the Blanks | | |
| 3. | Fill in the Blanks | | |

## Introduction

When you walk on smooth road, you don't feel any jurk or jurking 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

### Why vehicles'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 vital 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 vital to safety and optimum performance. They include:

- 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

Clearly the maintenance of vehicle suspension system will be of vital 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.

### Why get regular suspension checkups?

The simple answer is that suspension is vital 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 in how your car handles. 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 and regular checkup should be conducted.

## 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 - 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.

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 stiction (static friction) in the motion of the suspension.

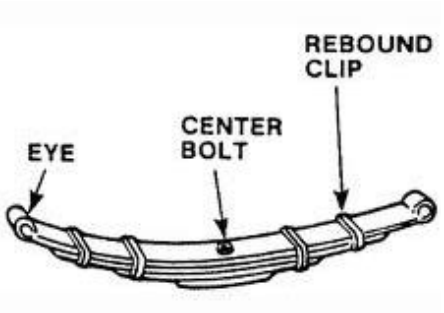

Fig-1: Leaf Spring

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.


Fig- 2: Leaf Spring Fitted in a Vehicle

### 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.


Fig 3: Shackle

## Cambering of leaf springs

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.

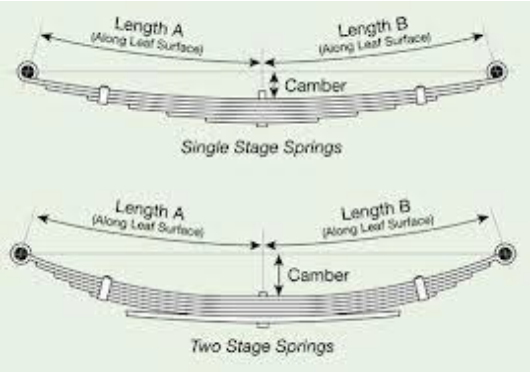


Fig- 4: Cambering of Leaf Spring

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 long bolt passing through the spring's eyelet 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) Then take the stand and support the chassis at appropriate height.
4) Then take the stand and support the axle/axle beam.
5) Now by using appropriate spanner loosen the nuts and remove the 'U' clamp bolts.
6) Then remove the shackle pin from the chassis fixed end.
7) Now slowly dismount the spring assembly set from the chassis.
8) Then 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) Now clean the leaves thoroughly.
12) Then 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) Then 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) Now 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) Now 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) Now replace the eye bush of the shackle.
22) Inspect the shackle pin for the wear and replace the same, if necessary.
23) Now 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 - 3: Replacement of strut/shock absorbers, inspection of steering linkages

## Relevant Knowledge

## Replacement of strut/shock absorbers:

Why we do it?

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 travelling 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

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

Opened end spanners, ring spanner, tube spanner, locking clumps, 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. Extract brake drum with bearing from stub axle by using 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 - 4: Inspection of steering linkage

### Relevant Information

### Inspection of 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, steering shock absorber, bushes of steering axis, steering arm and stub axle.

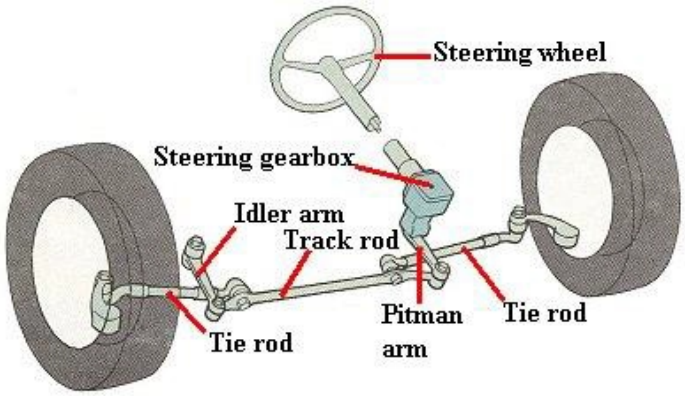


Fig- 7: Steering Linkage

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 from one end to another end,
- Check for noise and binding in-steer,
- If the binding is traced,
- Remove the drag link connection from steering gear box,
- Now rotate the steering gear box 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 bushing by using special tools 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 replace 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 - 5 : Manual and Power Steering System

## Relevant Knowledge

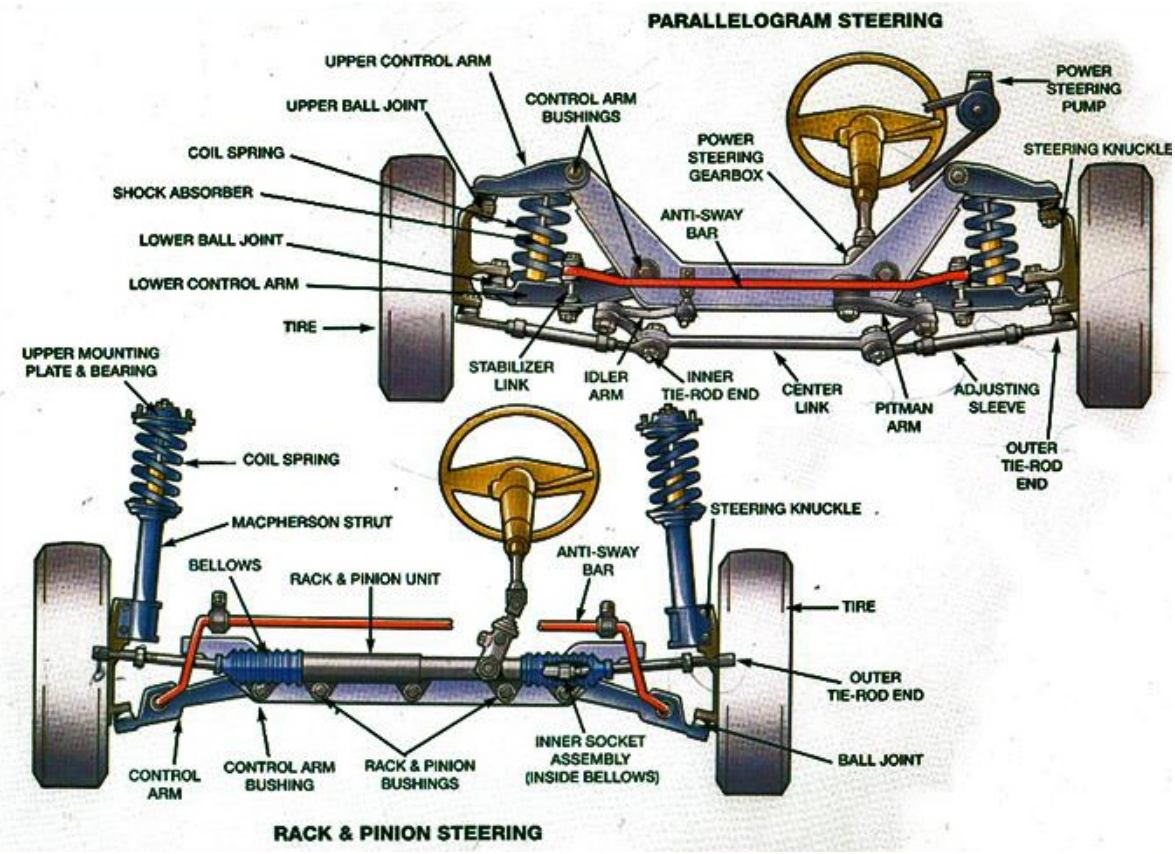


Fig- 8: Steering System

### 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 gear boxes 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.

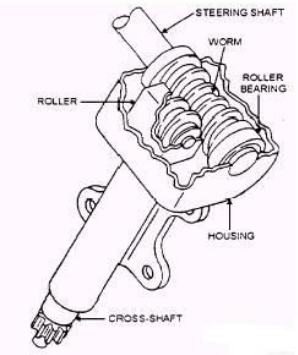


Fig- 9: Worm and roller steering gear

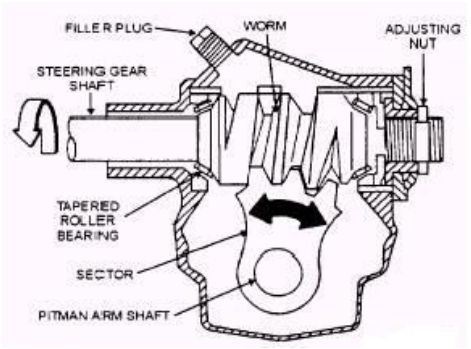


Fig -10: Worm and sector steering gear

1. Conduct the road test and mark the central or the mid position of the road wheels and the steering gearbox.
2. Now 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 gearbox.
5. Now again turn the steering and inspect for the binding.
6. If the binding is traced then the fault is in the steering gearbox, and need to service the steering gear box.
7. Disconnect the electric connections from the steering wheel.
8. Now 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. Now 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.

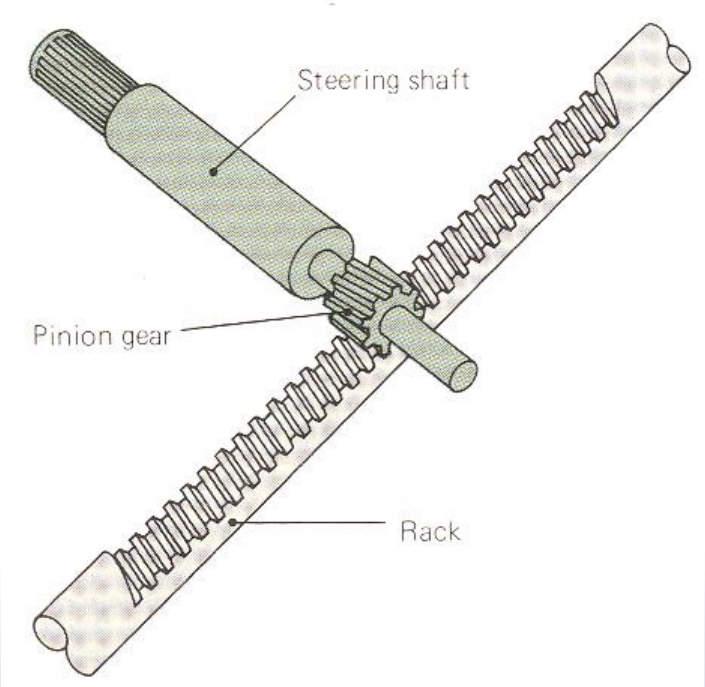


Fig- 11: Rack and Pinion Steering System

## Procedure for servicing of the rack and pinion type steering gear box

1. Unthreaded the steering wheel nut using socket, ratchet. Separate the wheel from steering shaft.
2. Unthreaded the steering rod's guide nut.
3. Using screwdriver, the screw of gear lever bracket was unscrewed and separates the gear lever bracket.
4. Separate the guide nut support plate and gear lever bracket.
5. To separate the steering shaft and gear shaft from steering column both nuts of bracket were loosened.
6. Steering shaft's lock nut and both was opened with the help of ring spanner and double ended spanner. Separate pinion from steering shaft.
7. By removing the lock nut of gear rod from support plate, the rod was taken out.
8. Support plate was separated from gear box housing and end plate, using ring spanner (9/16")
9. End plate was taken out from steering gear box housing.
10. Loosened the wheel nuts and jacking up the vehicles. Take the front wheels out.
11. Unthreaded the tie rod end nut from both the sides and take out the rubber boots from steering gear box housing.
12. Using pipe wrench, both the ball joints were taken out from steering rack.
13. Remove the U clamp bolt form the steering column by using socket spanner and take out the steering assembly.
14. Using socket plier to remove the pinion assembly from the housing.
15. Now slowly push out the rack from the column.
16. Inspect the rack for bend and teeth's for the wear; also inspect the pinion assembly for wear.
17. Also check the pinion bearings, splines for the wear.
18. Thoroughly clean the components of steering.
19. Place the rack in the column and place the pinion in housing.
20. Lubricate rack and pinion with silicon grease.
21. Now assemble the rack and pinion assembly on the vehicle with help of supporting bolts, tighten the same to specified torque.
22. Check the rack play adjustment and adjust the rack with the help of shims/nut.

23. Check the pinion play adjustment if noticed more/less adjust the spacer with more/less length.
24. Place these.
25. Now slowly turn the pinion and check it for the free movement.
26. Fix the steering wheel as per the aligning mark and tight the nut.
27. Connect the lower and upper steering shaft and fasten it with the pinion coupling.
28. Carry out central or mid position adjustment and connect the ball joint with steering shaft.
29. Fix both dust boots over the ball joints and lock it.
30. Tighten the ball joint with specified torque with steering shaft.
31. Conduct the road test and adjust the steering accordingly.

## 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

## Following step are to be taken

- 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/ worm 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 pressurizes the air, using compressed air as a spring. 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.

Fig-12: Air Suspension System

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

## 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 that are not balanced or are out of balance generally produce a vibration that is uncomfortable to drive in and results in premature wearing of suspension and 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 above a 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 tyre and 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: Wheeel 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 tire 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.

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.

The primary angles are the basic angle alignment of the wheels relative to each other and to the car body. These adjustments are the camber, caster and toe.

- Front: Caster (left & right)
- Front: Camber (left & right)
- Front: Toe (left, right & total)
- Rear: Camber (left & right)
- Rear: Toe (left, right & total)

## Secondary Angles:

The secondary angles include numerous other adjustments, such as:

- SAI (Steering Axis Inclination) (left & right)
- Included angle (left & right)
- Toe out on turns (left & right)
- Maximum turns (left & right)
- Toe curve change (left & right)
- Track width difference
- Wheel base difference
- Front ride height (left & right)
- Rear ride height (left & right)
- Frame angle
- Setback (front & rear)

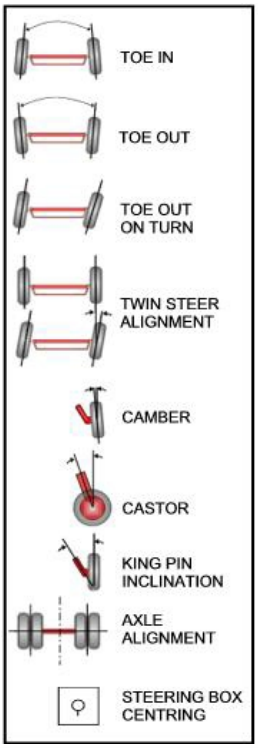


Fig-14: Steering Angles

## Procedure for checking and adjustment of wheel alignment

1. We were given car to do its wheel alignment
2. Made ON the red color switch on the back side of machine.
3. Parked the vehicle with its front wheels on turntables.
4. Fitted both heads (of machines) to both rims.
5. Tied the vehicle with string, from one front wheel to other through both rear wheels.
6. Switched “ON” the monitor. It showed “MENU” on the screen.
7. There were five details in the menu.

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

8. 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.
9. Fed the vehicle details/code using key board. After entering the data pressed "Enter".
10. We got the "Date and specification chart" on screen. Fed the vehicle details to the blank space in this chart. Pressed "Enter".
11. We got "selection (1 to 4)". Details of operation 1 to 4 were given below the selection.
12. We have to do alignment of front wheels so we pressed "2" and then "Enter". As soon as we pressed the "enter", we got the Toein, 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 two 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.

## Assessment

### Answer the following?

- What is the need of suspension system in vehicle?
- Write the name of main components of suspension system?
- What is the use of shock absorber?
- Why leaf springs are used in the vehicle & its function?
- What is the use of castor plate?
- What is the use of steering in the vehicle?
- Write the components of steering system?
- Write the types of steering used in modern vehicle?
- What are the limitations of manual steering?
- What is advantage of power steering over manual steering?
- 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?

## Suggested Reading

### Books

| Title | Author | Publisher |
|---|---|---|
| Automobile Engineering Vol I | Kirpal Singh | Standard Publishers |
| Automobile Engineering,Vol II | Kirpal Singh | Standard Publishers |
| Text Book of Automobile Engineering | Rajput R K, Laxmi | Laxmi Publications |
| Automobile Engineering | R. K. Singal | S. K. Kataria and Sons |
| Automobile Engineering Theory | Kapil Dev | Computech Publications |
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# Unit - 5

## SERVICEABILITY, REPLACEMENT OR REPAIR OF ENGINE COMPONENTS

### Unit Description

This unit provides introductory knowledge and skills covering vehicle servicing specially about the servicing of the wheels. Students will be given a broad view of these important issues.

### Resource Required

- Notebooks, Pen, Pencil, Eraser,
- Computer, Open Source Software for making digital presentation, LCD projector.
- Sketches, pictures, animation and videos of engine parts and its components.
- Engine parts
- Posters for building awareness about these topics.

**Nominal Hours:** 90 Periods

### Elements and Performance Criteria

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

| Element of Knowledge | Performance Criteria |
|---|---|
| • Reconditioning of valve mechanism | • Able to identify different types of valve |
| • Inspection and replacement of piston rings | • Able to recondition of valve |
| • Inspection and replacement of connecting rod and engine bearing | • Able to inspect the piston<br>• Able to replace piston |
| • Testing of cooling system and replacement of defective component | • Able to replace connecting rod<br>• Able to replace engine bearing |
| • Regular servicing of MPFI system | • Able to identify cooling system<br>• Able to check defective part<br>• Able to replace defective part |
| • Servicing of CRDI / non CRDI system | • Able to identify MPFI system<br>• Able to do servicing of MPFI system |

## Relevant Knowledge and Skills

### 1. Relevant Knowledge

- 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

## 2. Skills

- Able to identify different types of valve
- Able to recondition of valve
- Able to inspect the piston
- Able to replace piston
- Able to replace connecting rod
- Able to replace engine bearing
- Able to identify cooling system
- Able to check defective part
- Able to replace defective part
- Able to identify MPFI system
- Able to do servicing of MPFI system
- Able to identify CRDI / non CRDI system
- Able to do servicing of CRDI and non CRDI system

## Assessment Plan

| Session No. | Assessment Method | Due Date | Completion Date |
|---|---|---|---|
| 1. | Fill in the Blanks | | |
| 2. | Fill in the Blanks | | |
| 3. | Fill in the Blanks | | |

## Introduction

Engine is heart of the vehicle. Proper maintenance, care and servicing at regular interval keeps the vehicle 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 components of a vehicle. Valve and its adjustment, valve mechanism and much adjustment are important component. Repair, servicing and replacement of defective component is necessary for smooth running of a vehicle.

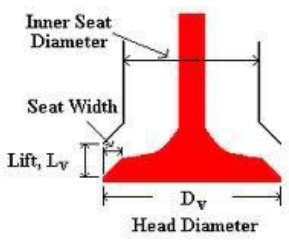
In this Unit, you will develop an understanding of the reconditioning of valve mechanism, inspection and replacement of piston rings, inspection and replacement of connecting rod and engine bearing, testing of cooling system and replacement of defective component, regular servicing of MPFI system, Servicing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

## 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 guides the plug portion by sliding through a valve guide.

Fig- 1: Valve



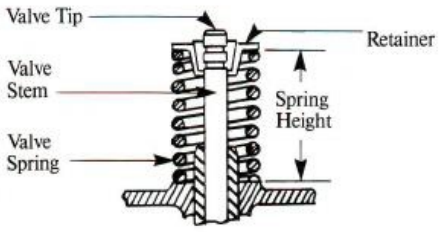




Fig- 2 : Installed Valve Spring

**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)

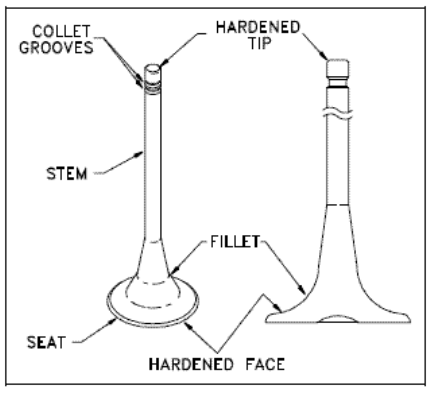



Fig- 3 : Engine Valve

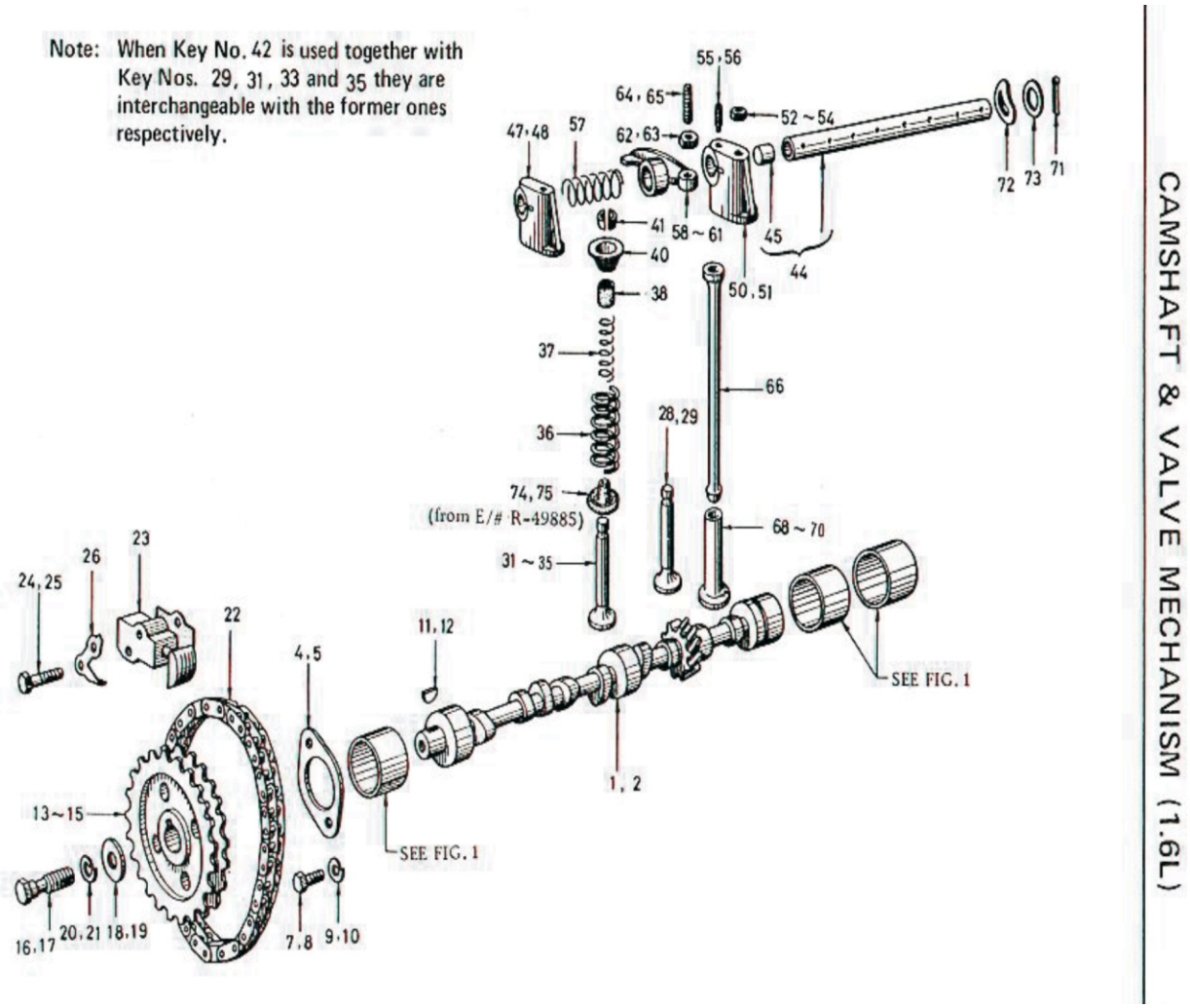



Fig- 4 : Overhead Valve Mechanism

**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

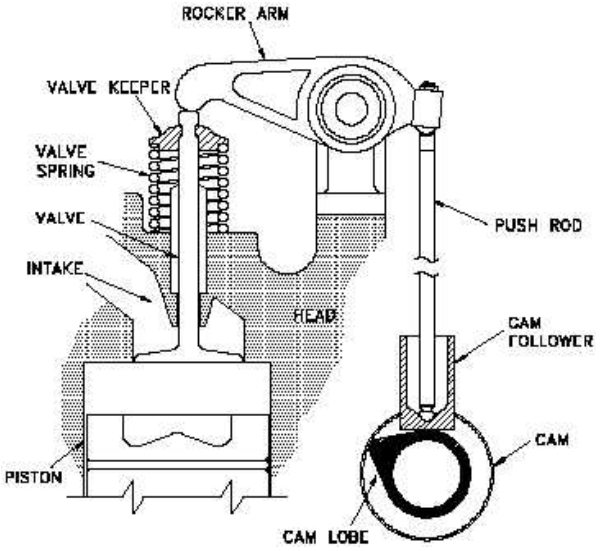



Fig- 6: Valve Cam Mechanism

**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 over head. It consumes less engine power for operation of valve mechanism. In advance mechanism, supply of fuel increases the engine efficiency at high speeds.

**Reasons for Valve Leakage**

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

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

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

## Reconditioning Valves

Due to leakages of gases, valve reconditioning is required. Valve reconditioning operation includes installing new valve seat inserts, valve seat grinding, valve refacing, valve lapping, valve tappet clearances and timing the valves. Together, these operations constitute the valve service necessary for smooth engine performance and maximum power output.

## Procedure for reconditioning

- First remove the cylinder head from the engine.
- Once the cylinder head is off, remove the carbon from the head, the cylinder block, and the pistons.
- In cleaning the top of the piston, you must exercise care 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, place the liquid on the valve face.
- Remove the valves using a valve spring compressor, observe the valve for the leakage.
- Blue colour indicates leakage area.
- Next, clean the valves with a wire brush.
- Be careful not to interchange the valves.
- Each valve must be replaced in the same valve port from which it was removed.
- The valve stem moving up and down in the valve guide develops a wear pattern. If the valves are interchanged, a new wear pattern is developed.
- This causes excessive wear on the valve stem and guide.
- To eliminate confusion, you should devise a system to identify a valve with the cylinder from which it was taken.
- The most common way to identify valves is to place them on a piece of board with holes drilled and numbered to correspond with the cylinder each valve came 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 radial run out by more than 2 degree and margin of the valve 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.

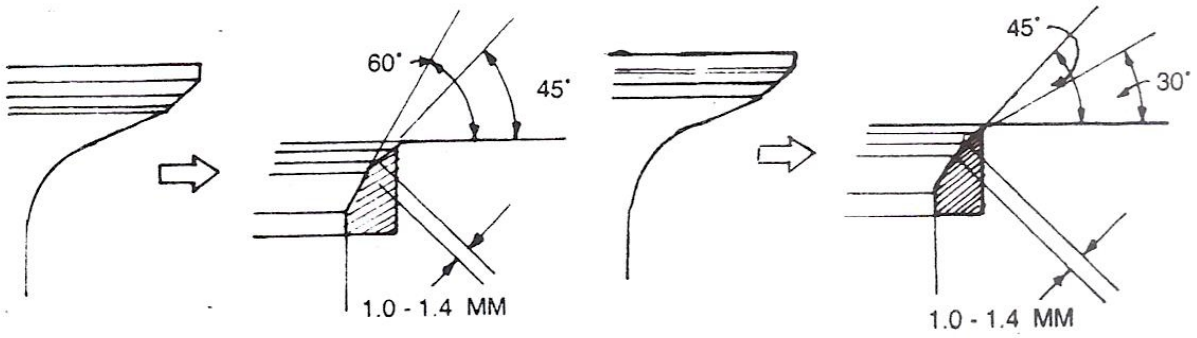



Fig- 7 : Changing of Valve Angle

## Valve Seat Cutting/Grinding Operation

- Measure the angle of valve seat.
- Check the margin of valve seat, if it is less than 2 mm replace the valve seat then replace it, if it is more than 2mm then it is suggested to carryout valve seat operation.
- Select grinder/ cutter of appropriate size.
- 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 desired angle.

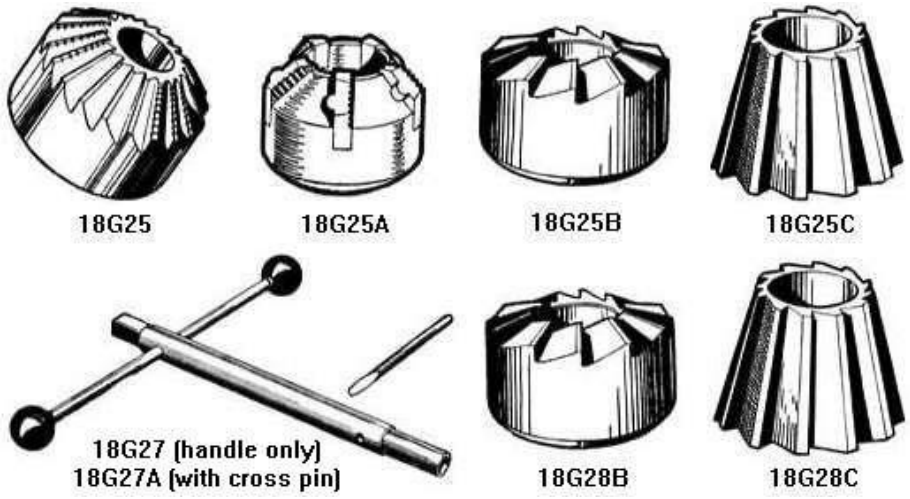



Fig- 8: Seat Angle Cutting Tools

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.
- Continue operation until, leakages are not found with fine emery paste.

Fig- 10 : Valve Lapping Process

## Session - 2: Replacement of Piston Rings

## Relevant Knowledge

## Piston Ring

A piston ring is a split ring that fits into a groove on the outer diameter of a piston in a reciprocating engine such as an internal combustion engine or steam engine.

## The three main functions of piston rings in reciprocating engines are:

1. Sealing the combustion chamber so that there is no transfer of gases from the combustion chamber to the crank.
2. Supporting heat transfer from the piston to the cylinder wall.

The gap in the piston ring compresses to a few thousandths of an inch when it is inside the cylinder bore.

Most automotive pistons have three rings: The top two are compression rings controlling oil; the lower ring is for controlling the supply of oil to the liner which lubricates the piston skirt and the compression rings (oil control rings). At least two piston rings are found on most piston and cylinder combination. Oil control rings typically are of three types:

1. Single piece cast iron
2. Helical spring backed cast iron or steel
3. Multipiece steel

## Why we replace ring ?

Piston rings are subject to wear as they move up and down the cylinder bore due to their own inherent load and due to the gas load acting on the ring. It will be better if a new piston ring should be used and groove of the piston ring should not be aligned.

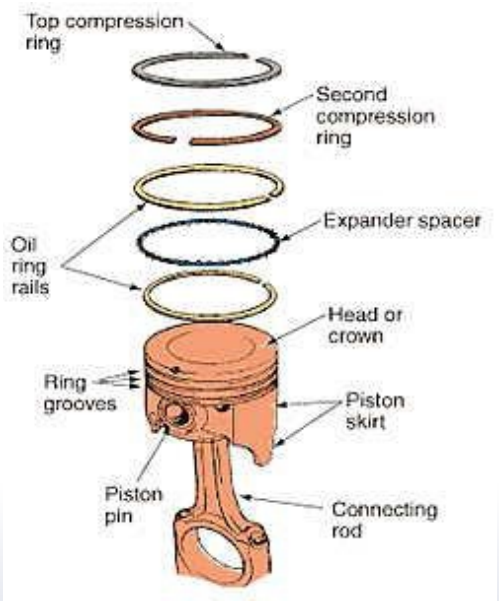



Fig 1-1: Inspection of Piston clearance in cylinder bore

## Session - 3: Replacement of Sleeve, Connecting Rod and Engine Bearing

### Relevant Knowledge

**Activity:** To inspect the Connecting rod (CR) bush, engine bearing, and to inspect the crank assembly.

**Tools :** Tube spanners, dial bore gauge, v block, screw driver, hammer, magneto puller, dial indicator stand, circlip plier, ring catcher.

### Procedure:

- Place the vehicle on level ground.
- Now drain the oil from engine.
- Remove the bonnet of the vehicle.
- Remove all the control cable connection like clutch, gears and throttle.
- Remove all electrical connector related with the engine.
- Use appropriate spanner and remove the spark plug or injector.
- Remove the fuel line connections.
- Loosen the foundation bolt & remove the engine from chassis.
- Take the engine on work bench.
- Remove the tappet cover from the cylinder head and then remove the cylinder head from the engine block.
- Open the oil sump and remove the strainer assembly.
- Rotate the crankshaft and visual inspect the rotation of crank bearing.
- Remove the oil pump from the engine block and visually check the functioning of oil pump.
- Open the nuts and bolt of connecting rod and remove the piston along with connecting rod from the engine block. Mark pistons and cylinder with matching numbers from crank driven pulley.
- Remove the piston ring from the piston and remove the side lock of the piston pin and remove the piston pin from piston end and connecting rod.
- Remove the engine bearing from the connecting rod.

### Inspection of Crank shaft and Main bearing

- Crank shaft should be inspected for alignment and wear for engine main bearing.

- Take the crank shaft which is supported at its end journal on v –block. Check the alignment by means of dial gauge whose base is fixed at magnet stand.
- The permissible limit of bending as specified by service manual.
- In case excessive bend is found, crank shaft can be straightened in power press.
- Wear of journal and crank pin can be determined by measuring diameter at different points with a micrometer.
- Check the ovality and taperness, whether they are within permissible limit as specified by service manufacturer.
- Oil passage in the crank shaft should also be inspected, if it is block then clean it. Lubricate the passage immediately after cleaning.
- Check the side play of journals with filler gauge.
- Check the wear pattern of main bearing.
- Bearing clearance can be checked by using inside/outside micrometer or filler gauge/plastic gauge.
- If the clearance exceeds the specified limit or scoring mark or polish is removed the then bearing has to be replaced.

Note: Assembly of engine should be done in reverse process.

## Session - 4: Testing of Cooling System and Replacement of Defective Components

### Relevant Knowledge

In a vehicle, most of the energy of fuel (perhaps 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 the heat to the air.

Cooling is needed because high temperatures damage the engine materials and lubricants. Internal - combustion engines burn the fuel hotter than the melting temperature of engine materials and make it hot enough to set fire to lubricants. Engine cooling removes energy fast enough to keep temperatures low so the engine can survive.

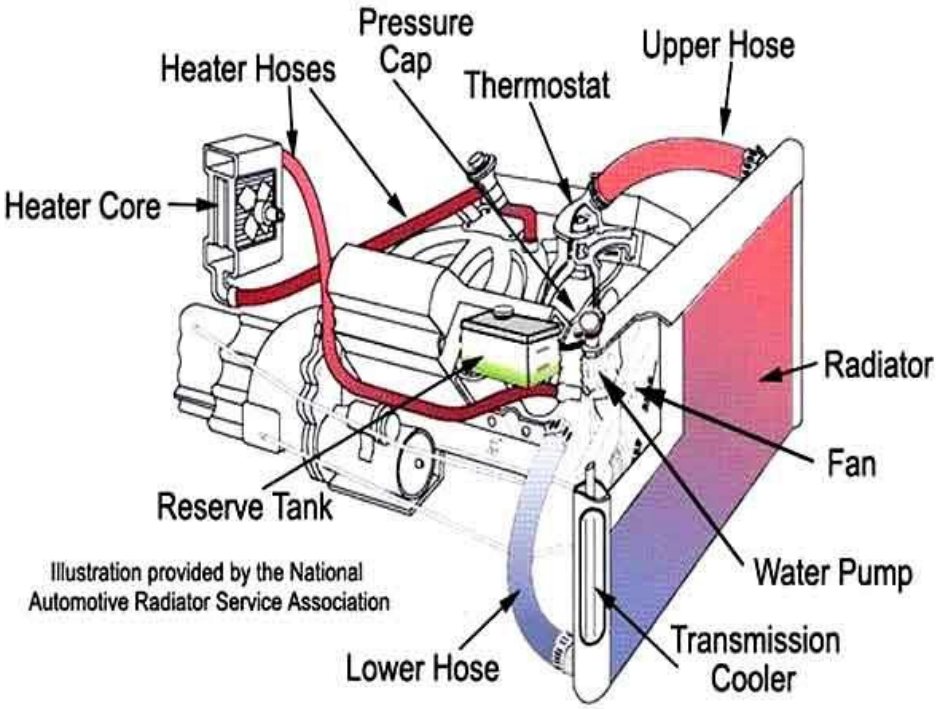



Fig.- 12 : Automobile Cooling System

## Common faults in cooling system

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

## Causes and remedy for Cooling System

| Causes | Remedy |
|---|---|
| • Loose or broken water pump belt | Adjust or replace |
| • Low level of coolant | Check coolant level and add as necessary |
| • Faulty thermostat | Replace |
| • Faulty water pump | Replace |
| • Dirty or bent radiator fins | Clean or remedy |
| • 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. |
| • 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 - 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.

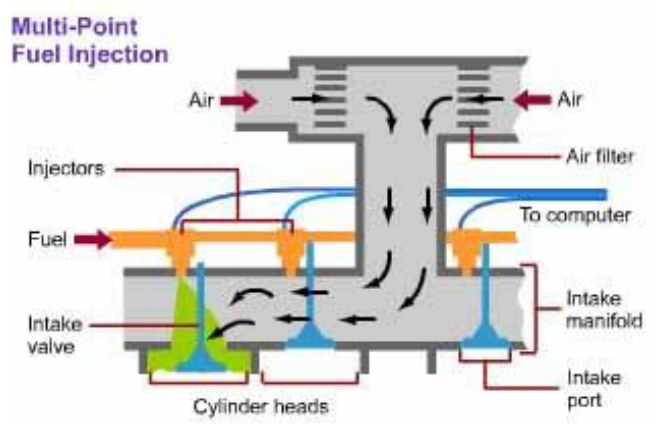
**Sensors:** Sensing different parameters (Temperature, Pressure, Engine Speed etc.) of the engine and send signal to ECM. Some of the important sensor are crank angle sensor (CKP), cam shaft sensor, throttle position sensor, AMF (Air mass flow) sensor, coolant temperature sensor, oxygen (lymda) sensor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

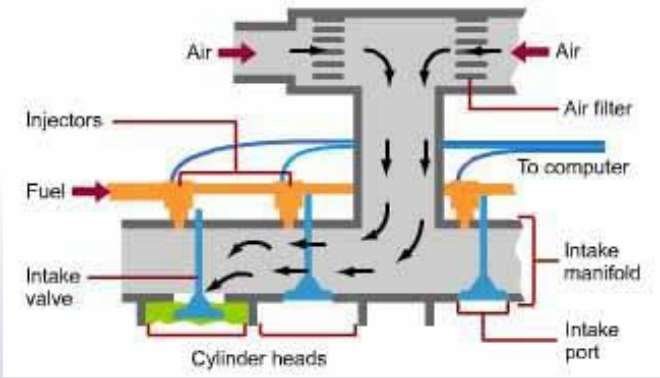
**Processor:** ECM is also called processor because it collects all the data from sensor and process, take appropriate decision. Any sensor or actuator faults are stored in ECM memory which can be recovered or read by diagnostic equipment.

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

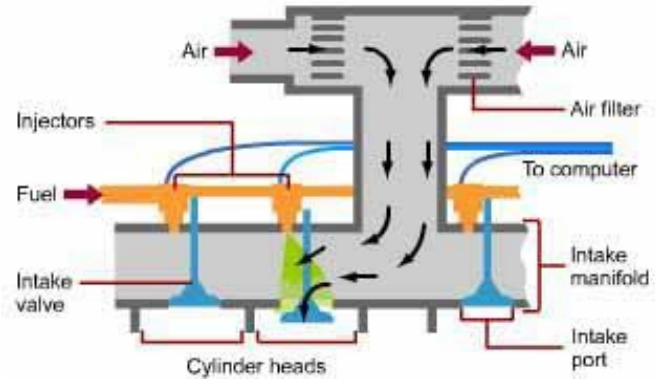
**Case - II:** If ECM fails to service from all sensors then also the engine won't get started. Figure given below shows different stages from 1 to 4 of multipoint injection fuel as per valve timing.



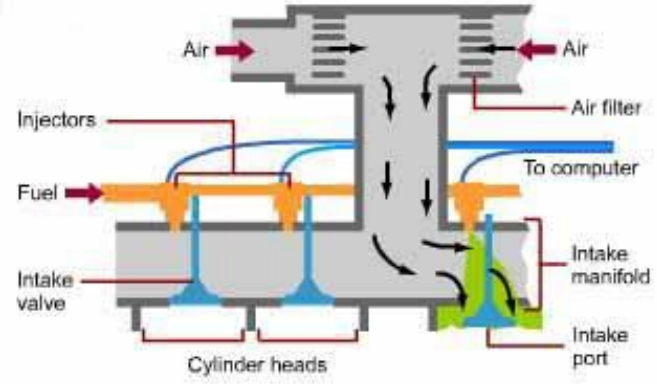

**Stage (1)**




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 deposition inside the throttle valve and it backfires. Throttle body (Butter fly) can be cleaned by carbo cleaner.

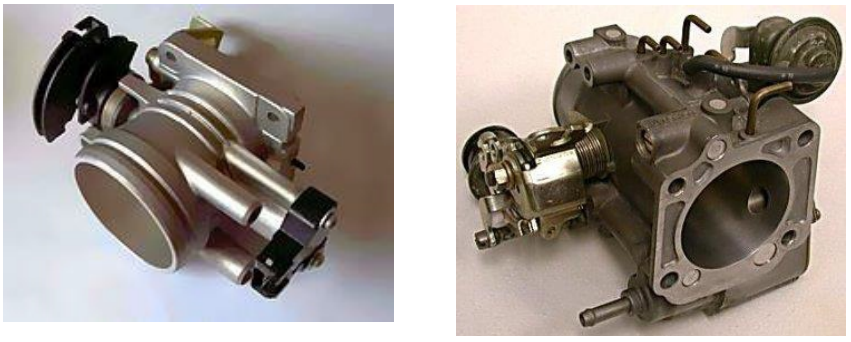


Fig.-13 : Throttle Body

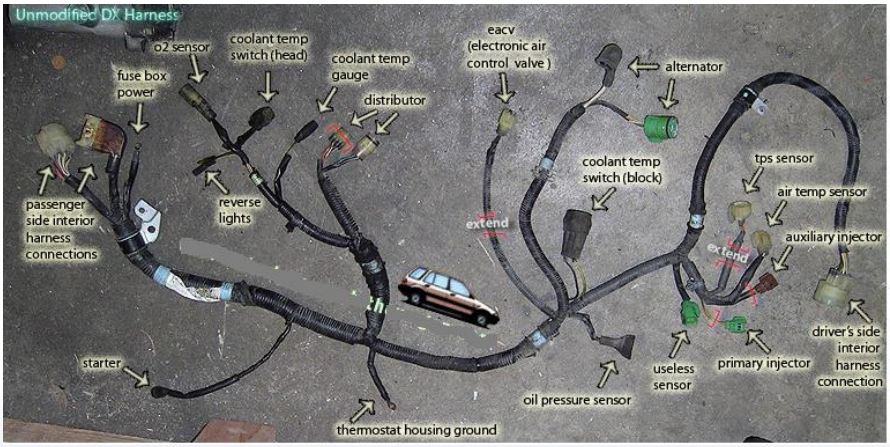



Fig. -14 : Sensor Representation at MPFI Circuit

## Session - 6 : CRDI and Non CRDI System

## Relevant Knowledge

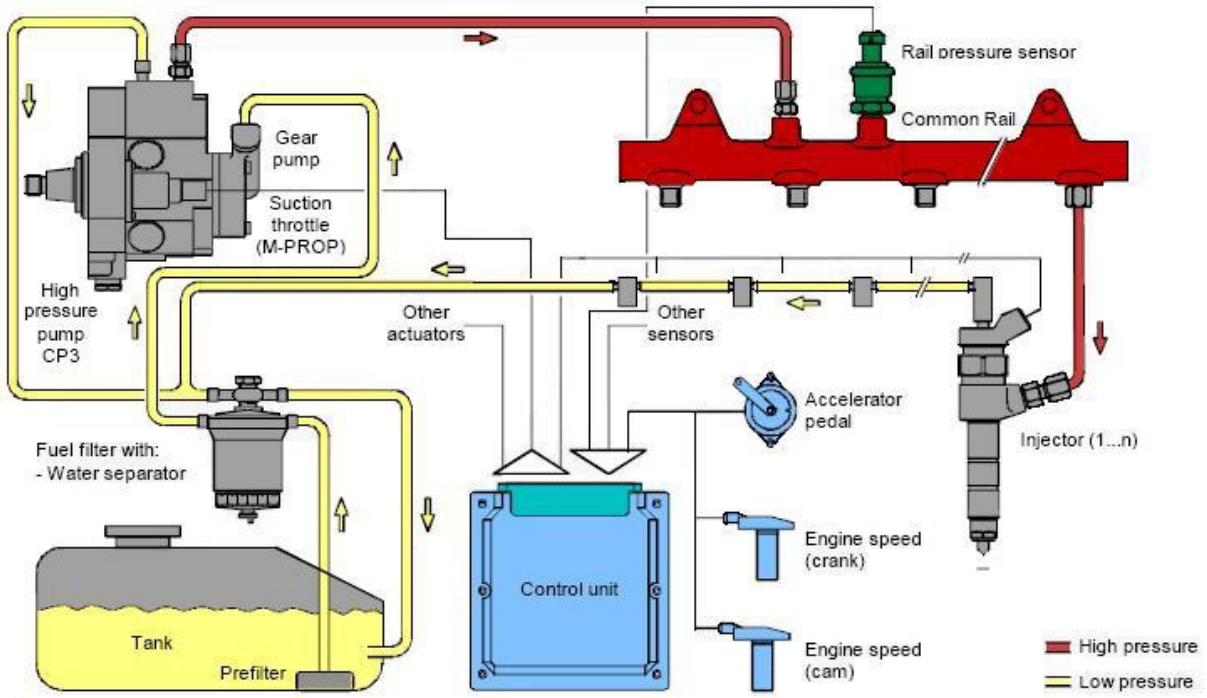



Fig. -15 : CRDI System

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, sedimeter)
- 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)

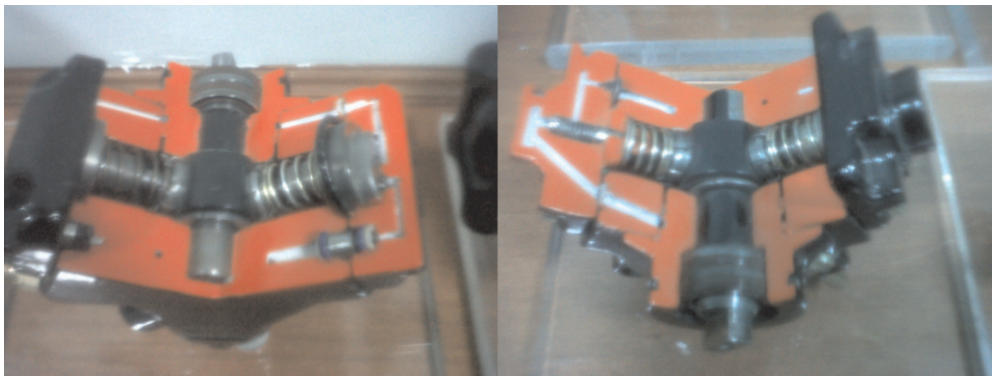


Fig. -16 : Cut section view of high pressure pump

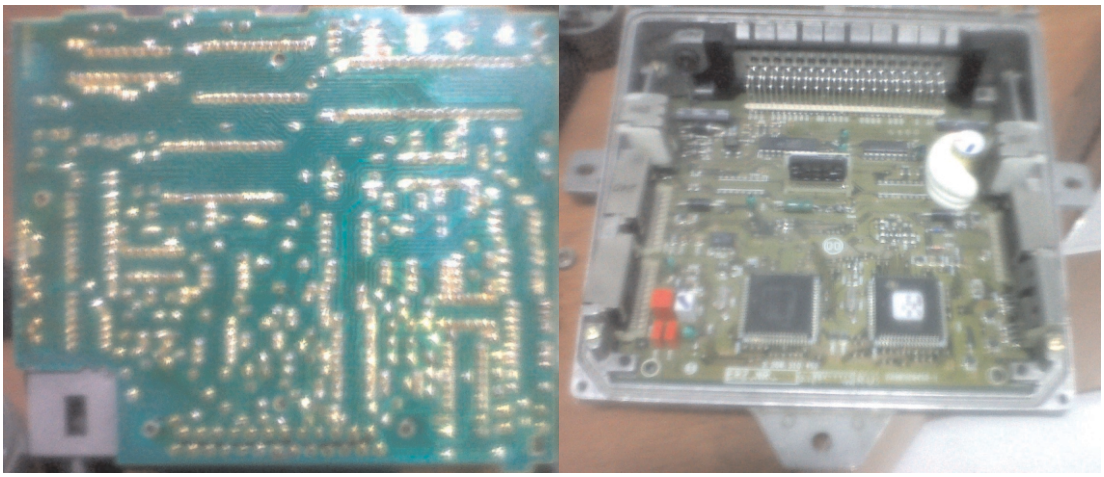


Fig. -17 : Internal component of ECM

## 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 and 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 as 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 turbo charged engine can be more powerful and efficient than a naturally aspirated engine because the turbine forces more air (oxygen), and proportionately more fuel, into the combustion chamber than atmospheric pressure alone.

**Turbo charger** is commonly used on truck, car, and bus. Turbo chargers are popularly used with petrol and diesel internal combustion engines.

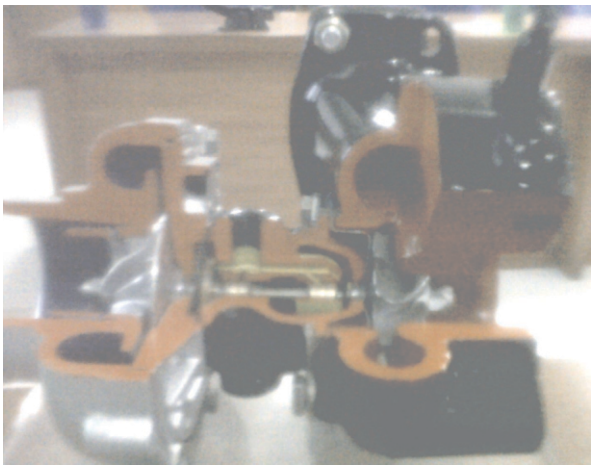


Fig. -21: Cut Portion of Turbo Charger

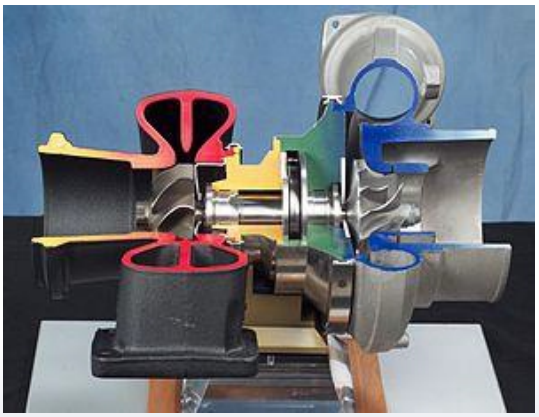


Fig. -22 : Turbo Charger

## Servicing of Turbo Charger

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

## Assessment

## Exercise: Assignment

Answer the following question.

1 What is poppet valve?
2 How many kinds of valve used in IC Engine?
3 What are the purpose of a valve?
4 Briefly describe a function of a valve & draw its line diagrams with details?
5 What are the seat angles & why it is required?
6 Which part controls opening & closing of a valve?
7 Write the name of the tools required for valve seat grinding?
8 How many types of rings used in piston?
9 How much the clearance provided in the cylinder bore?
10 What are the function of compression rings?
11 What are the function of oil control ring?
12 What is the position of the ring in the piston?
13 What is the function of connecting rod?
14 Why do some connecting rod have hole drilled from small end to the big end bearing?
15 Which part are connected to the small end of the connecting rod?
16 Which part of connecting rod is connected with crank shaft?
17 How to check bend in connecting rod?
18 How to check clearance between connecting rod and crankshaft.
19 Why the cooling system is important in I C Engine?
20 Name the different component of cooling system.
21 Name the different methods of engine cooling.
22 Difference between oil cooling system and water cooling system.
23 What is the function of radiator in cooling system?
24 Why coolant is added in the radiator?
25 What is the function of thermostats?

26 What is the function of water pump and cooling fan?
27 What is the full form of MPFI & CRDI?
28 What are main components of MPFI?
29 What are the main components of CRDI?
30 What are the advantages of MPFI over Conventional System?
31 What are the advantages of CRDI over Conventional Diesel system?
32 What are the disadvantages of CRDI over Conventional Diesel system?
33 What are the advantages of MPFI over Conventional System?
34 What precaution to be taken while working on MPFI/CRDI system?
35 Explain the use of turbo charger?
36 What is Sensor?
37 What is Actuator?
38 What is ECM?
39 Write the two name of sensor used in MPFI.
40 Transmission System
41 What is the use of clutch in the vehicle?
42 When the clutch plate will be replaced?
43 What are components of clutch system?
44 Which part connect with input shaft of gearbox?
45 Why clutch springs are fixed in clutch plate?
46 What is the purpose of using propeller shaft/drive shaft in the vehicle?
47 Explain the various parts of the propeller shaft/drive shaft?
48 When universal joint & slip joint to be changed?
49 What is the function of differential?
50 What is the importance and working of differential ?
51 What are the main parts of differential ?
52 How to adjust crown wheel and pinion clearance ?
53 What rotates the differential pinion shafts ?
54 To which gear half shaft splines connects?
55 What kind of joint is used to link differential with shaft & why ?
56 What are the lubricants commonly used in differential ?

## Suggested Reading

### Books

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

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- www.wikipedia.com
- www.shell.com/home/content/ind/products_services/on_the_road
- http://www.saasblg.com/index_files/dialgauge.htm -Dial gauge
- http://www.measurecontrol.com/english/how-does-a-dial-indicator-work/

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## Unit Description

This unit provides introductory knowledge and skills covering vehicle servicing specially with regard to regular maintenance and adjustment of transmission system used in vehicle.

## Resource Required

- Notebooks, Pen, Pencil, Eraser.
- Computer, Open Source Software for making digital presentation, LCD projector.
- Sketches, pictures, animation and videos of engine parts and its components.
- Engine parts
- Posters for building awareness about these topics.

**Nominal Hours:** 20 Periods

## Transmission System

1. Servicing of propeller/drive Shaft, Universal and slip joints.
2. Servicing of differential unit and adjustment .
3. Introduction to automatic transmission system.

## Propeller shaft

Propeller shaft is a part of ever transmission system. It is a long hollow shaft together with short sheding shaft together with dust cover protecting the joint between two. It transmit the power from gear box to rear axle. It carry power in terms of rotational motion. It transmit power between two part of varying vertical and horizontal distance from each other.

Two make provision of changing the angle of the propeller shaft of each end universal joints are fitted. Universal joints providing for variation
in angle of drive. It

act as universal hinges, slight variation of length is provided at one end of shaft free to side on splines or it is done so by providing slip joint.

Thus we can say that propeller shaft basically consist of three parts
1) Shaft
2) Universal joint at the end for variation in position of rear axle and
3) Slip joint to provide for its length variation.

There are generally two type of propeller shape used
1) Solid Shaft
2) Hollow Shaft protected by inner tube

These shapes are also known as
1) open type
2) enclose type

**Open Type Shaft :** This type shaft is mostly used in heavy commercial vehicles. Various types of cars and even light vehicle use open type of propeller shaft. It is tubler in cross section. One end is attached to gear box other end to driving axle pinion shaft.

**Enclosed Type** - It is of solid cross section. It is enclosed in tublar structure called torque tube regidly connected to gear box casing by a ball joint.

When the brakes are applied the torque the twisting motion of rear axle casing are resisted by this tube. Torque tube is the name given to the reaction of drive. Torque tube is rigid extension of axle housing and prevent the twisting of axle. This type of propeller shaft has smaller diameter.

## Universal Joint-:

To provide flexible connection between two rigid shaft at some angle with each other constantly varying universal joints are used.

In other way we can say that for connecting two shafts inclined with on another at some angle as well as for transmitting rotary motion from engine to road wheel universal joints are used. Transmission of power under this variable condition is impossible without using universal joints. universal joint consists of two yokes. A central piece join the two yokes.

Different types of joint are used in motor vehicles:
1) Flexible coupling joints
2) Hooks or ring type of universal joints
3) Multi coupling U joints
4) Yoke type U Joints

## Servicing of Propellor Shaft

1. After removal from the vehicle it is to be inuspected for bent and twist.
2. If so bent can be removed by cold press method.
3. If it is twisted then to be replaced by new one.
4. Finally the propeller shaft to be checked for dynamically balance in the balancing machine (which can be done in ordinary work shop as it is a special balancing machine).
5. If imbalance found at any point of the propeller shaft, required size of sheet metal to be welded at particular place and again recheck the balancing (Greasing should be done after every 11000 km.)

## Servicing of Universal Joint

1. The Universal joint should be lubricated after specified interval of time recommended by manufacturer with proper grade of grease.
2. For greasing, grease nipples are provided at the cross of universal joint.
3. While greasing ensured that the old grease is completely replaced by new grease.
4. If any noise comes from the universal joint dismantle the joint, remove the needle roller bearings (four numbers) from the yokes of the universal joint.
5. After cleaning inspect all the needles, if require replace needles and reassemble and check for serviceability.

## Slip Joint Servicing

1. A grease nipple is provided on the slip joint for lubricating (greasing)
2. According to recommended interval by the manufacturer it should be lubricated (10000 km of run or yearly or once in a year)

## Servicing of Differential Unit and Adjustment Servicing

Tools and materials required : Technician's Tool Box,
Differential Oil, Flushing Oil, Cotton Waste etc.

Note : Checking the Serviceability of differential and replacement of differential oilcomes under the heading of servicing.

## Checking the Serviceability

1. Park the vehicle on hard level ground and lift the front wheel.
2. Jack rear wheels from the ground (M case of rear live axle).
3. Start the engine and engage first gear, observe any unusual noise coming from the differential. If any noise observed than differential has to be dismantled and overhauling is to be done.
4. If there is no any noise found, remove the jack after stopping the engine and go for replacement of differential oil.

## Replacement of Lubricating Oil

1. In the jack in position run the differential approximately for half an hour to warm up the differential oil.
2. Place a tray under the differential .
3. Remove the drain plug and drain the oil completely .
4. Fit-back the drain cock and till is obtained flushing oil of required quantity.
5. Start the engine and engage first gear and run it for one minute only.
6. Remove the drain plug and drain out flushing oil and leave it for half an hour so that flushing oil is completely drained out from the differential assembly.
7. Replace the drain cock and tighten.
8. Fill the differential case with lubricating oil of required quantity and grade.

## Adjustment of differential (Adjustment of crown wheel and pinion)

A noise spiral level drive indicate that the gear teeth of the crown wheel and pinion are incorrect meshed or badly worn. The correct meshing of the crown wheel and pinion is effected by two adjustments.

1. End play adjustments (Fore-and off adjustment)
2. Backless adjustment

## End Play Adjustment

Then end play of level pinon is correct out by removal or insertion of shims placed between the pinion and casing.

## Backless Adjustment

This adjustment side of the differential assembly by adjusting nuts or by the removal or insertion of shims.

## Over hauling of propeller shaft and universal joint

- First of all disassemble the parts of propeller shaft and universal joints by using appropriate tools.
- Make it free from dust.
- The bearing from joint.
- Check all th parts properly and clean them.

If anyone part has warn outer cracked or get damaged and become out of order it should be replaced by new one. After cleaning and drying fit them properly between the gear box and driven axle sliding parts. Joint parts showed be properly lubricated with appropriate lubricant of specified quality.

## Over hauling may be of two types

i) Miner Over hauling
ii) Major Over hauling

## Servicing of Differential System

Differential is an important mechanical system of four wheeler vehicle . It plays important role for smooth driving of vehicle specially on curved path while vehicles is taking turn on curved path with respect to inner wheels outer wheel should have to travel comparatively more distance within same interval of time. To take smooth turn on curved path without skidding specific characteristic system is used. This could be achieved by using differential which vary speed of two wheels. With respect to inner wheel out wheel should have more speed and the outer wheel travel more distance than inner wheel.

Differential is used in rear axle of rear wheel drive vehicles. Differential is also used in trans axles in front engine front wheel drive vehicles. In four wheeler four wheel drive vehicles have differential is at both front and rear axle. In some four wheel drive vehicle have a third differential in transfer case. But in most of the vehicle are front engine rear wheel drive. In this vehicle differential is attached between the real axle of two rear wheels. This drive of vehicle power produced in
engine is transmitted through transmission system to differential.

In this drive two solid shaft part is attached one end is attached with rear wheel and other and with differential. Both shafts one end is attached with differential and other part with wheels.

Inner end of each axle is a small bevel gear called differential side gear when two bevel gears are put together their teeth mesh driving and driven shaft are attached at 90° angle.

## Operation of differential

While vehicle is moving on straight ahead path ring gear, differential case, differential, pinion gear and two differential side gears all turn as one unit. Two differential pinion gears do not rotate on pinion shaft. Due to which they exert equal force on two differential side gears. As a result of which side gears turn at same speed as ring gear. Which causes both the driving wheels to turn at same speed.

When the car began to move on curved road path the differential pinion gears rotate on pinion shaft. This permits outer wheel to run faster than inner wheel. Suppose that one wheel turns slower than the other as car move on curve path. As the differential case rotates pinion gears must rotate on their shaft. This occurs because pinion gear must walk round slower turning differential side gear. So pinion gear carry additional rotatory motion to faster turning outer wheel on turn. If differential case speed is considered to be 100%. The rotation action of pinion gear carry 90% of this speed to slower rotating inner wheel. It sends 110% of speed faster rotating wheel.

In this way differential allows one drive wheel to turn faster than the other. Thus when-ever vehicle goes round a turn outer wheel travel greater distance than the inner drive wheel. Two pinion gears rotating on their shaft it send more rotating motion to the outer wheel. While vehicle is moving on straight road pinion gears do not rotate on their shaft. It will apply equal torque to the differential side gear. Therefore both drive wheels rotate at same speed.

Differential for front wheel driver and rear wheel drive are similar in construction and working .

## Servicing

Differential is mechanical system which is assembly of various type of gear pinions shafts attached according to their design and construction made by the manufacturer. There gear pinion size number of teeth may be different but working principle are same.

The best servicing is proper and regular maintenance. For this we should have to use the lubricating oil of specific viscosity and grade which is recommended by the manufacturer prescribed in car manual. It is essential to check the life of lubricating oil after running of vehicle prescribed by manufacturer.

It is best to adopt the principle that is prevention is better than cure.

We should always try to prevent the failure of components by regular checking and maintenance.

## Trouble of Differential

First sign of trouble in differential will be able system is noise. By hearing the sound produced in differential technician to determine the cause of trouble. Provided the hearing noise should be coming from differential. Some times we get illution by hearing noise produced by some where else like universal joint wheel bearing, type etc.

## Humming Sound

Some time specific noise is heard from differential that is produced due to in correct internal adjustment of driving pinion or ring gear. Incorrect adjustment prevent the normal meshing of teeth of two gear or a gear and pinion. It may cause rapid wear and tear of teeth of the differential. This humming sound produced due to faulty adjustment may go on increasing progressively and wear and tear progresses. So its best servicing is to disassemble the differential system and reset with compact adjustment and should be properly lubricated with quality lubricating oil for getting good performance. Some times it has been found that there is louder sound produced while vehicle is accelerated. There may be heavy contact on the heal end of the gear teeth.

Noise may be louder when there is heavy toe contact. As we know that differential action become active while vehicle is steered with the help of

steering system. So it

is very essential that both type of trouble could be corrected according to manufacturer's service manual for servicing procedure.

If the noise provided from differential is hard while vehicle is moving on curved path. This trouble is from inside the differential casing. It may be due to tight feeling of pinion gear on pinion shaft, it may be due to damage of gear or pinion, worn on differential casing worn bearing or defective axle bearing or defective axle setting, defective alignment. All these may because of hard sound.

There may be chattering sound during turn which may be caused due to the use of wrong lubricating oil. This can be removed by draining out the old lubricant and using recommended lubricating oil.

- Proper lubrication is essential to whole differential and bearing of the driving shaft and even driving wheel bearing.
- For getting good performance of differential it is essential that limited slip should be used.
- Same type of tyres should be used on both rear wheels.
- If one tyre is more worn out than that other it may cause trouble in differential. It may also shorten the life of differential. For smooth operation of differential it is essential that its fault should be detected as early as possible and removed so that less finantial load come for its maintenance.
- It's Proper and systematic maintenance is desirable.
- Any defective or cracked part should be removed by new one.
- Bearing should be replace by new on of both side of rear axle.
- Parts which are required to replace should be replaced with same dimension and quality.
- Bevel pinion and crown wheel should be replaced only in set.
- Backlash should be as per manufacturer instruction.
- Fastening devices used should be properly dismantled. If it has lost its life or got damage should be replaced by new one of same dimension and quality.

- Those tools and equipment should be used during dismantling which is suitable to fit.
- SAE 120-140 should be used for differential.
- Technitians should also pay attention one their own safety. So we should use to safe guard our body during working.

## Automatic Transmission System

Automatic transmission system is an important one used in modern vehicle and heavy vehicle for the transmission of turning force (torque) from its power unit (engine) to the driving axle. Automatic transmission system is used for both front wheel and rear wheel drive vehicles. Although automotive transmission system varry in detail from one model to another model but all of them work on same basic principle.

It is hydraulically operated system, all the system have torque converter and planetary gear systems with clutch and band controlled by hydraulic system. Almost all modern automatic transmission system have three or four forward speed and a reverse one. In four forward speed automatic transmissions provide over drive in fourth.

In most of the automatic transmission for front drive vehicles are called automatic transmission axle.

## Function of Automotic Transmission

In this transmission systems gear shift without the assistance of driver. Driver start the car and move in first gear then shift into second, third and fourth as car speed increases and load on engine decreases. Shift at various speed are provided by hydraulic pressure acting through automatic transmission fulid or oil used in transmission. Transmission oil should have specific characteristic. That is incompressible, non viscous, non reactive, high boiling point and low freezing point.

There are three basic parts in automatic transmission system

i) Torque Converter
ii) Gear System
iii) Hydraulic Control System

Torque Converter transmit the torque produced by power unit (engine) to the gear system.Hydraulic pressure act on gear system to produce the shifts. Motor vehicles equipped with hydraulic drive not provided with clutch pedals but accelerator and brake entirely accomplish the purpose of control while driving the vehicle.

Automatic Transmission consists of two half dough nut shaped shells equipped with interior fins that radiate from hubs. This unit are mounted very close with their oval ends facing each other, so that they can turned independently.

Housing surrounds both units make a complete assembly. About 80% of interior is filled with oil. Driving unit called empeller is linked with engine crank shaft which sets the oil into motion when its throttle is opened. Force of rotation trapped oil impinges on the fins of driven unit (runner) cause it to move. In this way liquid transmits the engine power to the clutch driving plate without any metal to metal contact.

In case of ideal liquid coupling driven unit (runner) would attain the same speed as empller (driving unit). In commercial design runner speed become almost equal to impeller under best operating condition & when efficiency of coupling is highest. The lag of runner behind impeller is known as slip which varies due to many faults like engine speed, car speed, vehicle road. This types of transmission system is even used in heavy vehicle used in mines like dumper.

## Assesment

## Exercise : Assignment

Answer the following question.

1. How would transmision system be maintained to get good performance ?
2. Write the name of important systems used in transmission system for the transmission of poer from engine to drive wheel in sequence.
3. Write down the step of overhauling of the universal Joints.
4. Explain the major overhauling and miner overhauling.
5. Define overhauling - why it is essential of the system of automobile?
6. How would servicing of differntail system be done so that it gives good performance?
7. How automobile transmission is better than mechanical transmission system?

## Unit Description

This unit provides introductory knowledge and skills covering vehicle servicing specially with regular to regular maintenance and adjustments of electrical system.

Knowledge of electrical symbol colour code and wiring diagram on vehicle.

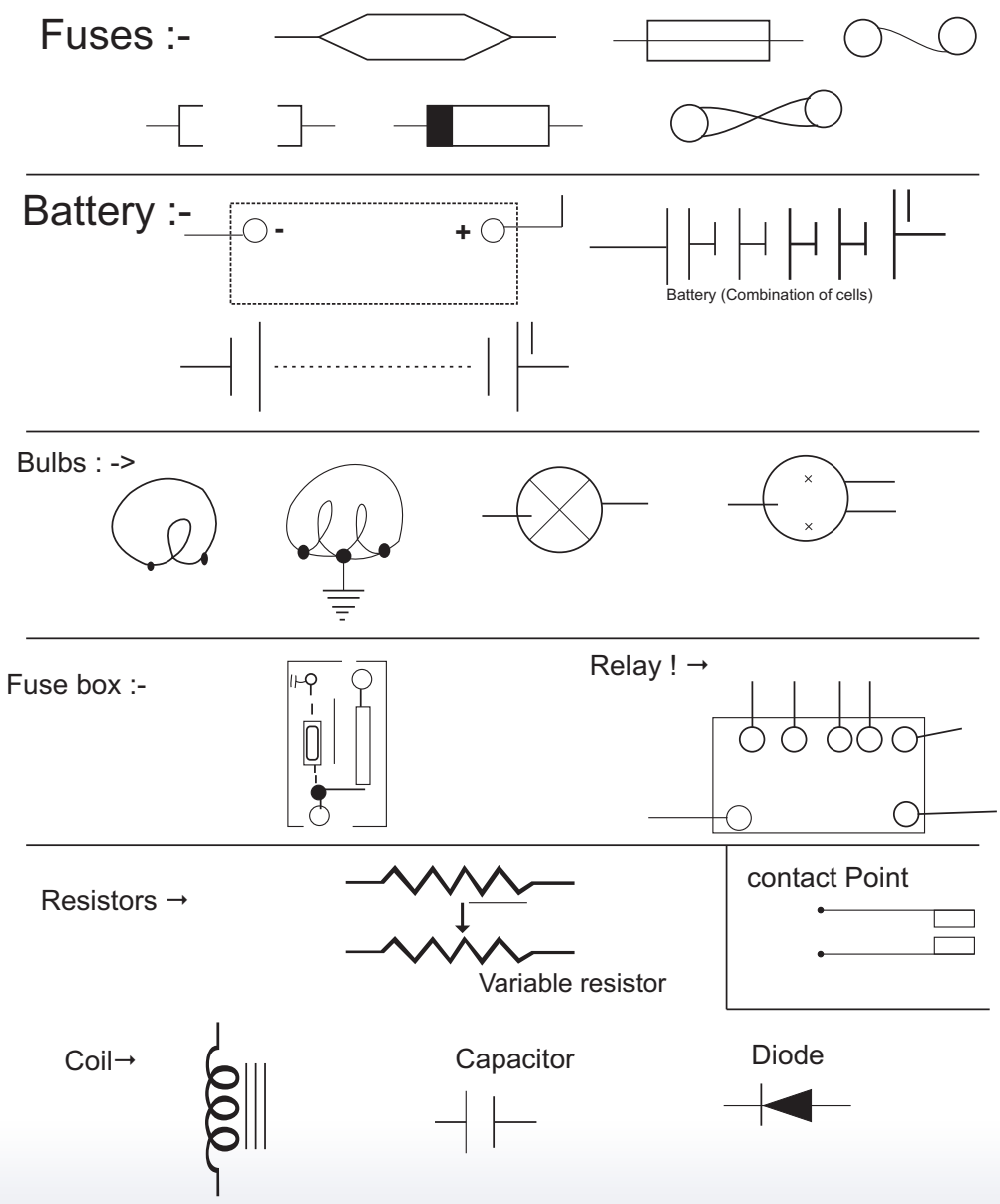
Student will be given a board view of these important issues.

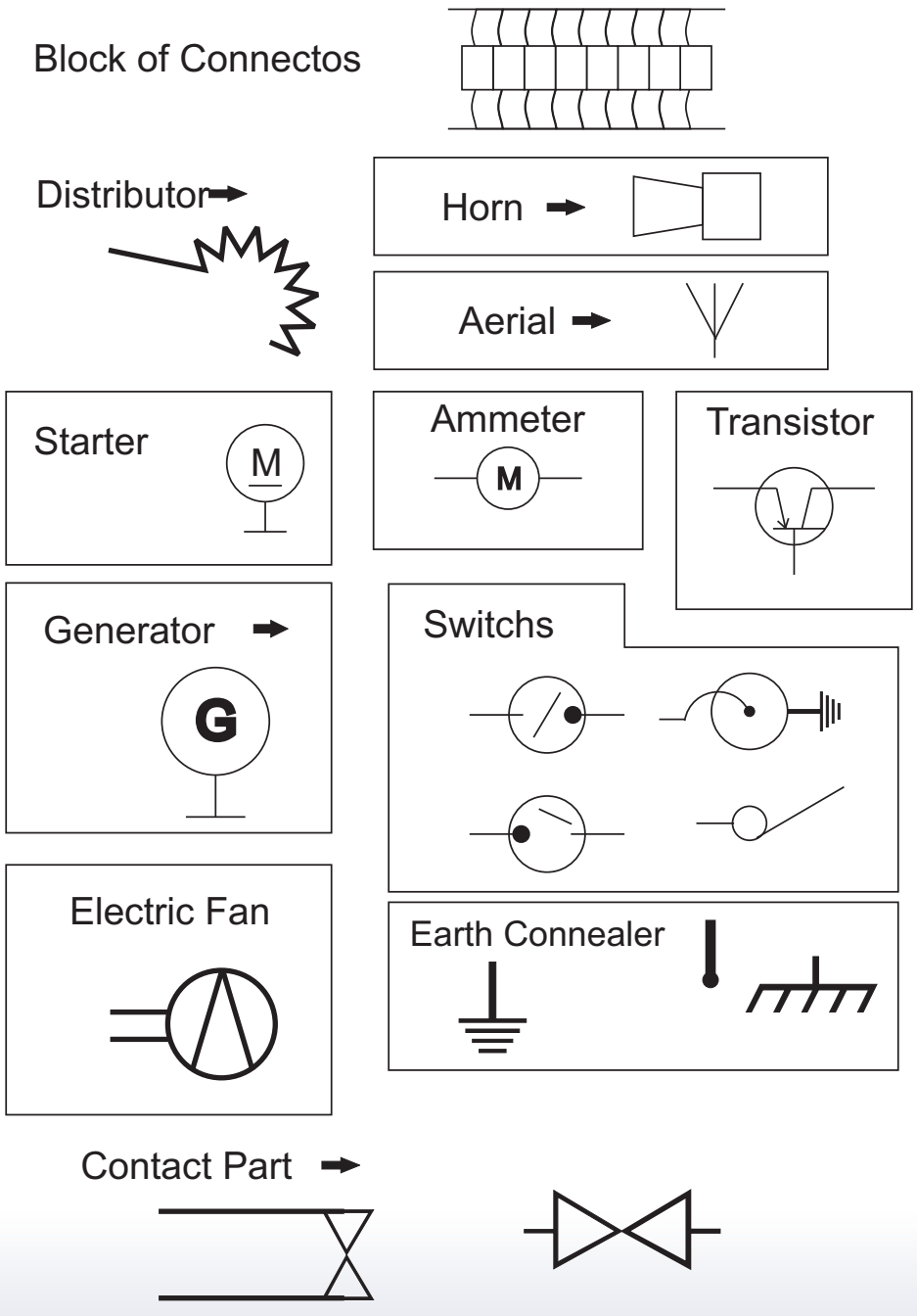
## Resource Required

- Notebooks, Pen, Pencil, Eraser,
- Computer, Open Source Software for making digital presentation, LCD projector.
- Sketches, pictures, animation and videos of wheels stud and its components.
- Posters for building awareness about these topics.

**Nominal Hours:** 20 Periods

## Electrical Symbols used in wiring diagrams




Block of Connectos
Distributor
Horn
Aerial
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Transistor
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Switchs
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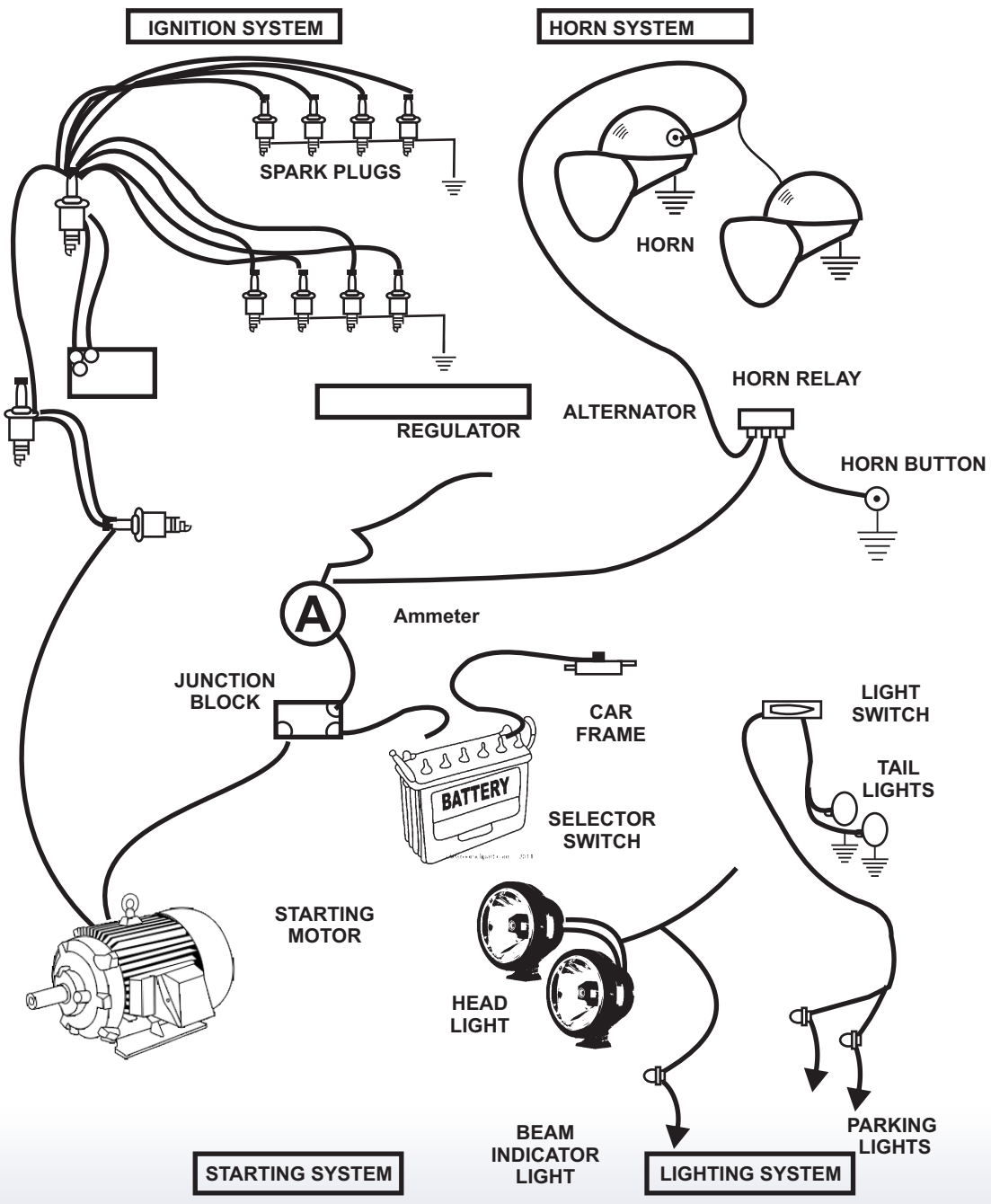
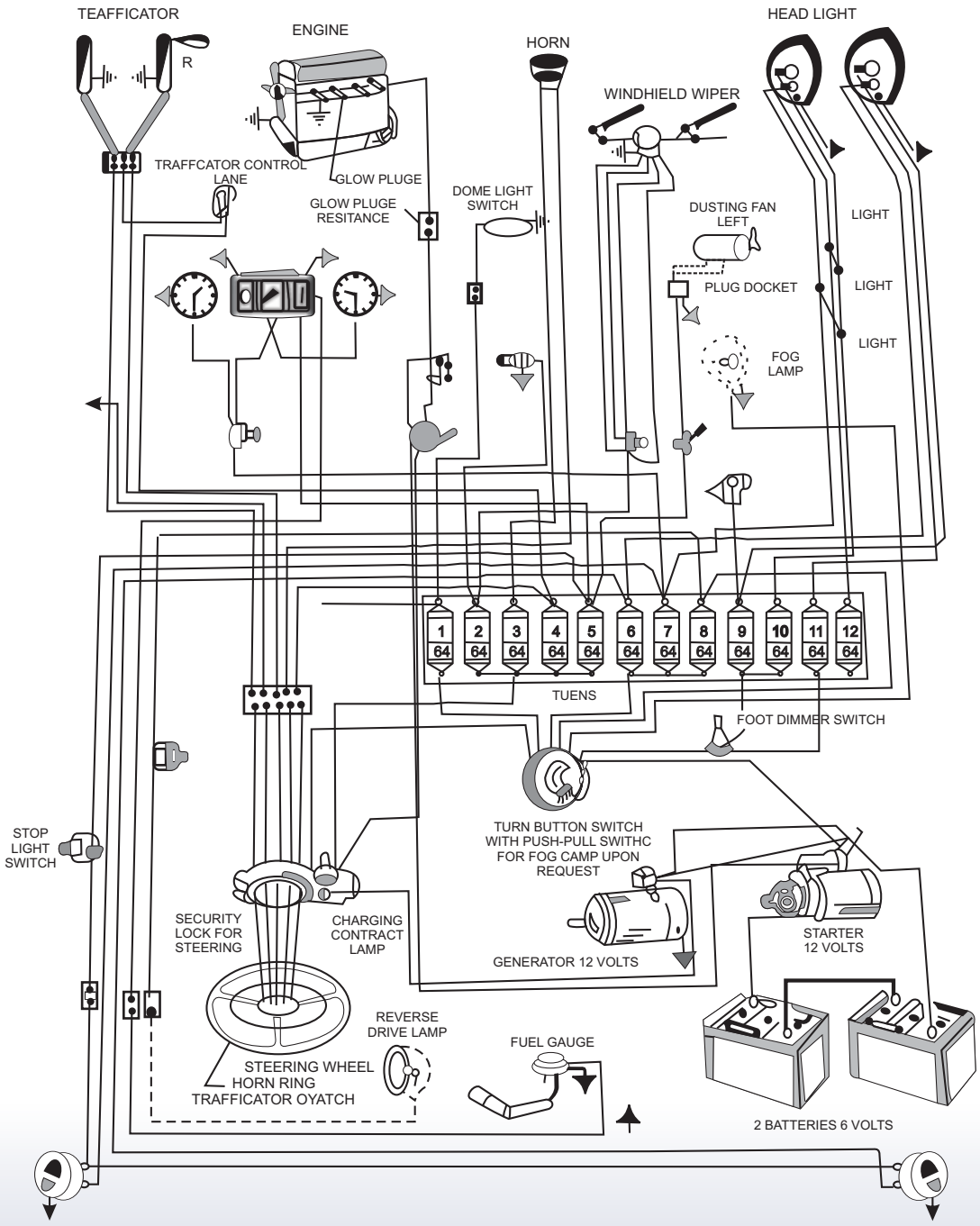
Earth Connealer
Contact Part


IGNITION SYSTEM
HORN SYSTEM
SPARK PLUGS
HORN
REGULATOR
ALTERNATOR
HORN RELAY
HORN BUTTON
A
Ammeter
JUNCTION BLOCK
CAR FRAME
LIGHT SWITCH
TAIL LIGHTS
BATTERY
SELECTOR SWITCH
STARTING MOTOR
HEAD LIGHT
BEAM INDICATOR LIGHT
PARKING LIGHTS
STARTING SYSTEM
LIGHTING SYSTEM


TEAFFICATOR
R
ENGINE
HORN
HEAD LIGHT
WINDHIELD WIPER
TRAFFCATOR CONTROL LANE
GLOW PLUGE
GLOW PLUGE RESITANCE
DOME LIGHT SWITCH
DUSTING FAN LEFT
PLUG DOCKET
FOG LAMP
LIGHT
LIGHT
LIGHT
1 64
2 64
3 64
4 64
5 64
6 64
7 64
8 64
9 64
10 64
11 64
12 64
TUENS
FOOT DIMMER SWITCH
TURN BUTTON SWITCH WITH PUSH-PULL SWITHC FOR FOG CAMP UPON REQUEST
STOP LIGHT SWITCH
SECURITY LOCK FOR STEERING
CHARGING CONTRACT LAMP
GENERATOR 12 VOLTS
STARTER 12 VOLTS
REVERSE DRIVE LAMP
FUEL GAUGE
STEERING WHEEL
HORN RING
TRAFFICATOR OYATCH
2 BATTERIES 6 VOLTS

## Session - 1 : Motor Vehicle Wiring

### Relevant Knowledge

Electrical Systems is an important one for smoothing operation. Wiring system is one important and complicated system. Wiring should be branded with subsidiary hardness cable sets for particular and unit wise construction. Vehicle manufacturers strictly adopt to fulfil their requirement on vehicle.

Electrical circuits are furnished by connecting the main and sub-hardness cable together by mean of plug or snap connector at the junction boxes or junction terminal. Wiring system is most difficult systems of electrical equipment to analyse and trace the fault.

Electrical system of vehicle has number of circuits each of which contain electrical unit, control switch, and three electrical conductors

- Feed Wire
- Switch Wire
- Return Wire

### Colour Coding

Colour coding for electrical system is provided in automobile to facilate the electrician for tracing the electrical circuit. In most of the vehicle colour coding is standard but in some vehicle it may vary from model to model.

### Standard Colour Coding

It is better to use standarded colour coding for motor vehicle wiring. In each electric unit three wire (conductors) are used to complete the circuit :

i) Feed Wire
ii) Switch Wire
iii) Return Wire

In vehicles metal chassis (body) is used as return wire (ground return) in some cases switch is connected in unit side and in some cases switch is attached in return side.

## Main Feed Colour

There are seven main feed colours allocated to a particular circuit. Feed wire are allocated added with main circuit colour switch wire are branded with main clolour but coloured tracer is made spirally, return wire (grounded) are with black colour insulation :

1) Brown Colour : Battery circuit, interior light, ignition switch, control box, horn etc.
2) White Colour : Ignition circuit, electric control pump, solenoid switch.
3) Yellow Colour : Generator circuit, control box, warning light
4) Green Colour : Stop light, Fuse Gange, Direction, Indicator, Wind Shield Wiper, Fused Auxillary Circuit which are fed through indicator switch.
5) Light Green : Flash unit Flash Indicator Waving Light
6) Blue Colour : Head Lamp Circuit
7) Red Colour : All tail Lamp circuit fed from lighting switch. Fog Lamp, Door Light Panel Light
8) Black Colour : It is used for all ground wire. If unit is not eternally grounded.

## Automobile Cables

Various kinds of cables are employed in the wiring of present day automobile. While selecting the cable size, the voltage drop is kept in mind.

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 an insulation of either vulcanized rubber 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 cable of 9/0.350-120/0.350 for single conductor type and 9/0.350 -35/0.350 for twin conductor cable. A three conductor of 9/0.50 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 voltage such as those of the order of 6000-22,000 vott. 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 7-12mm. 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 rubber. 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.

## 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 ha also resulted in space saving and safegaurding of the individual cables form metal objects.

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 connection easily.

It may be noted that there is a typical drawback to this system. If one of the cables fails, it necessitates the harness to be cut for rectification. However, the present-day cables have got good mechanical strength as well as insulation properties. If at all it happens, it is advisable to fit a new cable externally to the harness instead fo cutting the same and then binding it to the harness.

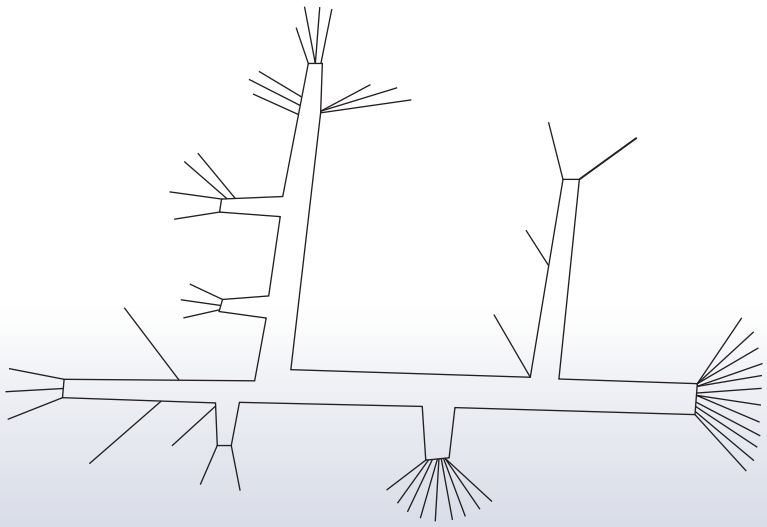


Fig. 23 : The harness method of wiring a typical car.

## Electrical Symbols

In order to simplify the depiction of automobile circuits, various standard symbols are used to represent the components of the electrical system.

(a) **Ground :** In automobile, the circuits are generally completed through the chassis instead of through wires.

(b) **Battery :** The long line generally indicates the positive make marked otherwise.

(c) **Non-Inductive :** Such type of resistance is used in proper alignment primary circuits in order to reduce the amount of current flowing through the circuit.

(d) **Fuse :** It is used to protect circuits like light, transistor, cigar lighter,etc.

(e) **Simple Switch :** It can be compared with a gate.

(f) **Spring Switch :** Such type of switches are used for horns, stop light circuits, etc. This symbol can be compared to the letter X with both ends closed.

(h) **Induction Coil :** It has primary and secondary windings. The primary windings are shown thicker than the secondary windings and are connected to them two indicate the magnetic core. The symbol may be even without magnetic core.

(i) **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.

(j) **Wire Crossed :** Represents the symbol for wires that cross but are not joined. It is the usual practice to represent crossing wires in automotive practice.

(k) **Light Bulbs :** In the case of a double-contact light bulb, both ends of the filament will be connected to wires instead of one end shown grounded.

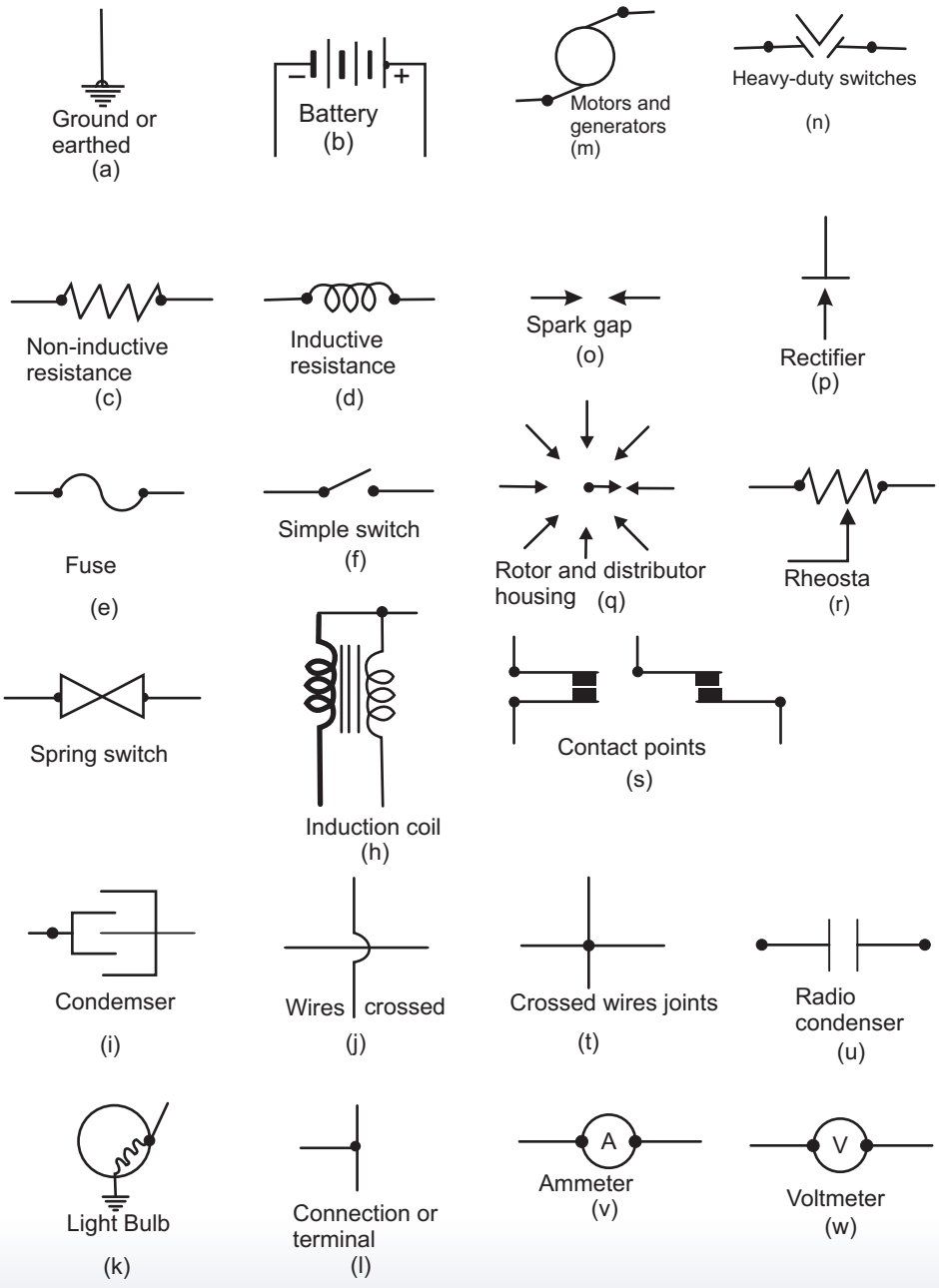
(l) **Connection or Terminal :** The symbol of a dot is used to show an electrical connection or terminal.

(m) **Motor and Generators :** It may be mentioned that this symbol is incomplete. Hence, it is more desirable to use a combination of other standard symbols exactly to indicate the desired unit.

(n) **Rheostat :** It is a variable non-indctive resistance used to control the amount of current in the circuit.

(o) **Ammeter :** The symbol for an ammeter. The letter 'A' in the circle indicates the ammeter. It is used for measuring current.

(q) **Voltmeter :** The letter 'V' indicates the voltmeter.




Electrical symbols.

## Session - 2 : Multi Meter

### Relevant Knowledge

Multi meter is also known as volt-ohm meter or volt-ohm millimeter. It is an electronic instrument which is combination of several measurement function in one unit. It has ability to measure voltage, current and resistance.

Its pointer move over a scale calibrated for all the different measurements that can be made.

Digital multi-meter display the measured value in numericals. It may also display in bar of length proportional to the quantity being measured.

Digital multi-meter is now more common but analog meter are still preferred for monitering those which varry rapidly.

A multi-meter can be hand-held device useful for basic fault finding and in field service work. Bench instrument which can measure to a very high degree of accuracy. These are used to trouble shoot electrical problems wide area of industrial and house hold devices such as electronic equipments motor controls, domestic appliance, power supplies etc.

### Application of multi meter

There are different application of the muti meter for the measurements:

1) Temperature and environment application low cost weather station

2) Voltage measurement like high and low value DC measurement .
   Peak to peak voltage measurement D.C average measurement

3) Current Measurement
   a. Current measurement
   b. True RMS Ac current measurement
   c. Resistance measurement with constant voltage
   d. Measuring resistance with constant current

4) Time and frequency measurement (Fast frequency measurement)

**Stroboscope :** It is such an instrument used to make a cyclically moving object appear to be slow moving or stationary.

- It consists of either a rotating disk with slots or a holes or a lamp such as a flash tube.
- It produces repeating flash of light the rate of stroboscopes is adjustable at different frequencies.
- If we observe an object with stroboscope at its vibration frequency it appears to be stationary
- Stroboscope is also used to measure frequency.
- It is used for studying of rotating, reciprocating oscillating or vibrating objects.
- A stroboscope is used set the ignition timing of internal combustion engine called timing light.

## Application of Stroboscopes

It plays an important role in studying of stress on machinery while it is in motion and even other forms of research work. Bright stroboscopes are able to over power ambient lighting and make the stop motion more effective. It is also used as measuring instruments for determining cyclic speed. For example- Timing light are used to set the ignition timing of external combustion engines. In medicine stroboscopes are used to view the vocal cords for diagnosis of conditions.

**Ocilloscope :** Initially it was called as oscillograph. CRO (Cathode Ray Oscilloscope) or DSO (For modern digital storage oscilloscope). It is a type of electronic testing instrument. It is used for observation of contantly varying signal voltage.It is a two dimensional plot of one on more signals as a function of time. Other signals such as sound or vibration can be converted into voltage display.

Oscilloscopes as mainly used to observe the change of an electrical signal over time such that voltage and time describe a shape which is a graphed against a Calibrated scale.

Observed wave form can be analyzed for properties like amplitude, frequency rise in temperature, time interval, distortion etc. Modern digital instruments may calculate and display above properties directly. Oscilloscope can be adjusted so that repetitive signal can be observed as a continuous shape on screen.

Oscilloscopes are used in science, medicine, engineering and to telecommunication industries. General purpose instruments one use for maintenance of electronic instrument and laboratory work.

Special purpose oscilloscopes may be used for the purpose of analyzing an automatic ignition system.

It is also used to display in wave form of heat beat as in electrocardiogram.

Now a days digital electronic oscilloscopes are used before this cathode ray tubes oscilloscope.

It is also used as :

i) Power analysis
ii) Serial data analysis
iii) Data storage device testing
iv) Fame domain reflectometry

## Session- 3 & 4 : Battery and its Maintainace and Circuit Diagram for Battery Charging

### Relevant Knowledge

### Battery

Battery is a combination of number of cells. They are connected in series arrangements. Cell used in battery are electrochemical cell.

To make it commercial it should have following requirements:

1) It should have compactness, lightness, and ruggedness for portability.
2) Its voltage should not drop much during use. Drop in voltage should be negligible over small interval of time during which it is being used.

Cells are mainly classified into following types

I) Primary cells
ii) Secondary cells

**Primary cells :** This type of cell is used in torch. Toy, remote, calculator, radio. Primary cells are those in which redox reaction (Reduction & Oxidation occur). Primary cell becomes dead after sometime. It can not be used again.

**Dry Cell:** It is compact form of leclanche cell. It consists of a cylindrical zinc container which act as anode. A graphite rod is put centrally but should not touch zinc container. It act as cathode. Between road and container past e of NH4cl and $znCl_2$ is put but around rod $MnO_2$ powder is filled. Graphite rod caped with metal cylinder is sealed from top with pitch. Zinc container is covered with card board to protect it from atmospheric effect. Bottom surface is kept open.

## Anode

$Zn\,(s) \rightarrow Zn^{2}\,(as) + 2e$

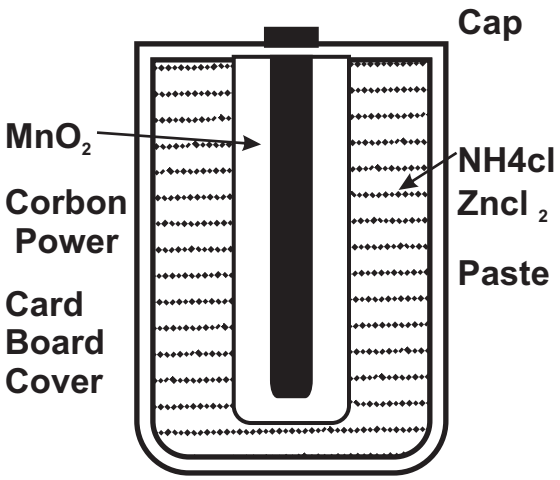
$2MnO_2 + 2NH4 + aq \rightarrow 2e^{-}$

$\rightarrow Mn_2O_3(S) + 2NH_3\,(Z) + H_2o$

$NH_3$ gas formed Is liberated is gas

$2NH_3 + 2cl \rightarrow [Zn\,(NH_3)_2\,cl_2]$

This type of cells have voltage 1.25 to 1.5 volt.




Mercury cell is new type of dry cell. It is used in small devices like hearing aids and watches. This type of cell give constant voltage of 1.35 volt through out its life.

It consist of Zinc as anode and Mercury (M) (Hgo) as Cathode. As electrolyte paste of KoH and ZnO. is used.

Reaction occurred in cell as follows:

$$Zn + 2\,OH \rightarrow ZnO\,(S) + H_2O + 2e$$

$$HgO + H_2O + 2e \rightarrow Hg(l) + 2H$$

$$Zn + Hgo(S) \rightarrow Zn\,(S) + Hg(l)$$

In this cell reaction does not involve in any ionic solution whose concentration could change. Therefore it has advantage that its potential remain almost constant through out its life. Where as potential of ordinary dry cell decreases slowly. But voltage of this cell is 1.35 volt through out its life.

**Ordinary Cells:** Ordinary cells are not rechargeable. It is just like use and throw. However there are some cells which are rechargeable. This type of cells are called accumulator or storage type cells. These cells are rechargeable and so can be used again and again as a source of electrical energy. Most popular secondary cells are lead storage cell. Number of cells are connected in series to make a battery. This battery is most commonly used in automobile like car, bus, truck, jeep as a source of electrical energy. Battery supply direct current to fulfill the requirement in vehicle.

**Lead storage battery:** This storage battery most commonly used in vehicle and even at home at the time of power failure. It is combination of number of cells. Each cells give 2 volt supply. If we require 12 volt regular supply 6 cells are connected in series.

In each cell anode is a grid of lead packed with finely divided spongy lead, whereas cathode is a grid of lead packed with $pbO_2$. As electrolyte is a aqueous solution of sulphuric acid containing 38% by mass having density 1.30 gm/milliliters is used .

Lead plate is kept for sometime to deposite lead sulphate on it. Thus at anode, lead is oxidized to pb2+ ion insoluble $PhSo_4$. At cathode $PbSo_2$ is reduced to $Pb^{2+}$ ions and $PhSo_4$ is formed.

To Increase the current out put of each cell, the cathode plates are joined together and anode plates are also joined together by keeping them in alternate position. Cell are connected anode to anode and cathode to cathode. To get voltage of 18 volt nine cells are connected in series. Electrode reactions that occur during discharging (when current is drawn from battery).

At anode: - $Pb\,(s) \rightarrow Pb^{2} + (2q) + Ze^{-}$
$Pb + So_4^{2-} \rightarrow PbSo_4\,(s) + 2e^{-}$ (overall anode reaction)

At cathode
$PbO_2\,(s)$ is reduced
$PbO_2\,(s) + 4H^{+} + 2e^{-} \rightarrow Pb^{2+}\,(aq) + 2H_2o$
$Pb^{2+}\,(aq) + So_4^{2-}\,(aq) \rightarrow PbSo_4\,(s)$

Overall cathode reaction
$PbO_2 + 4H^{+} + So_4^{2-} \rightarrow Pbso_4 + 2H_2o$
Complete electrode reaction
Anode $\quad Pb(s) + So_4^{2-}\,(aq) \;\text{®}\; PbSo_4\,(s) + 2e$
Cathode $\quad PbO_2\,(s) + 4H^{+} + So_4^{2-} \;\text{®}\; PbSo_4(s) + 2H_2o$

$$Pb(s) + PbO_2\,(s) + 2HrSo_4(aq) \;\text{®}\; 2PbSo_4\,(s) + 2H_2o$$

From above reactions we conclude that during working cell $PbSo_4$ is formed at each electrode and sulphuric acid is consumed. As a result of which concentration of $H_2SO_4$ decreases and density of solution also decreases .

When density of electrolyte aqueous $H_2SO_4$ solution decreases to 1.2 to 1.1 gm/m battery is discharged. It need recharging.

**Recharging of Battery :** The lead acid battery can be recharged by passing electric current of suitable voltage in opposite direction. Electrode reaction reversed. During charging flow of electrons in reverse direction takes place and lead is deposited on anode and $PbO_2$ on cathode. Density of $H_2SO_4$ also increases and become 1.3 gm/ml to 1.35 gm/ml

Reacting during charging

$$2PbSO_4 + 2H_2O \rightarrow (\text{Charging}) PbO_2 (s) + 2H_2OSO_4$$

Lead storage battery acts as voltage cell as well as electrolyte cell. When battery is used to start the engine it act as voltaic cell and produce electrical energy. During charging it act as an electrolyte cell.

**Electrolyte cell work on electrolysis process :** When electric current is drawn from cell chemical energy is converted into electrical energy during charging electrical energy is converted into chemical energy.

**Electrolysis :** The phenomenon of chemical change take place by passing electrical energy form external source main supply is called electrolysis. The device used to carry out electrolysis are called electrolyte cells.

Battery container should be and of into single piece, made of hard rubber insulating properties, acid proof and of greater mechanical strength. It is divided into number of compartments or cells.

**Cells are connected by lead bars :** It consists of the sets of plates called electrodes. On set of plate is made of spongy lead. Another set of plate is made of lead dioxide. As function of cell, acid start reacting with $PbO_2$ plate to convert chemical energy into electrical energy.

Negative charge built on spongy lead plate and positive charge on lead peroxide plate $PbO_2$. To escape gases produced during chemical reaction (charging) vent holes are provided in plug. Storage capacity of battery depend upon the effective area submerged in electrolyte.

**Operator:** In order to avoid the damage of all due to short circuiting, the cell sheet of non-conducting porous material is interposed between them. Material used as separator are : wood, treated wood, porous rubber, ebonite glass wood, plastic PVC.

**Electrolyte :** Sulphuric acid having specific gravity 1.84 and distilled water 38 % $H_2So_4$ and 62% $H_2O$ is used.

**Battery Charging :** In normal a generator is provided in a motor vehicle to keep the battery in charged condition. In special circumstance or unusual running condition like frequent use of starter for long period of vehicle parking with parking light, frequent or regular use of accessories like radio, heater air conditioner may get discharged. In such circumstances external recharging from main supply at service station or garage is required where apparatus for this purpose is available.

Before going to start charging it is desirable to notice its specific gravity by hydrometer as well as electrolyte level should be checked. If the electrolyte level is below the top edge of plate more electrolyte should be added up to correct level.

## Charging circuit consists dynamo control box and battery

- For charging the battery the negative terminal should be connected to relevant terminal fo the battery charging or DC main value of charging current should be kept half in number of amperes to that of number of plates in cell. The temperature of electrolyte during charging should not go beyond 45°C .

If the battery temparature increase it should be disconnected and allowed to cool. Due to the over charging of battery its positive plates get damaged. For charging more number of battery at a time they should be connected in series.

- Depending upon the battery condition and charging rate usually 13 to 24 hours is required to charge the battery.
- There are three method of recharging a battery

  i. Slow rate charging battery is charged by passing low ampere current and more hours of charging.
  ii. In quick rate of charging method battery is supplied with high charging current such as 100 ampere 6 volt and 50 ampere 12 volt type current is supplied for lesser time in hours.
  iii. It the battery is not in good condition it should not be charged by this method.

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- Non-uniform specific gravity reading
  Discoloured electrolyte
  Bad Suphated battery plate
  Badly over charged battery
  Their such reaction quick rare charging showed be avoided

  Third method of charging is tickle charging. This method is used in case batteries are left in storage for longer periods. Battery has got self discharged or vehicle have not used for long period

  In this method of charging battery is charged at very low rate by keeping one ampere current. It should be connected in day and disconnected at night

- For proper working maintenance of battery is necessary . It could be done by keeping battery clean, fully charged, full of water at its level so that plates should be dipped and well supported in battery carrier. If it fail to start the engine it should be checked for detecting the defect.

  For this there are four important tests :
  (i) Specific gravity test
  (ii) Voltage test
  (iii) High discharge test
  (iv) Cadmium test

Hydrometer is used to check specific gravity. Thermometer to measure temperature. For open volt test is performed in a battery to measure specific gravity of electrolyte. With the help of voltmeter open circuit voltage of battery is measured.

## For Over Hauling of battery

Before over hauling the battery it is essential that we should go through two basic tests that is to test the basic condition of the battery:

1. We should check the specific gravity of the electrolyte.
2. Charging capacity test.

To over haul the battery it is very essential to known in detail about its construction working principle, how it should be charged and how it get discharged.
By checking the gravity of electrolyte we know the condition of electrolyte. We should know that dilute sulphuric acid react with battery plates when it discharges.

We know the specific gravity of electrolyte by hydromenter. It work on floating principle. Floating lever give the idea about the state of charge. We should add distilled water up to the level so that plates are just covered without over flowing. By measuring the capacity of battery we know that how much current and for how much hour it would supply electrical energy and its voltage can be measured by voltmeter.

## Battery Charging

If battery is fully discharged, it is unable to deliver any current. This means it require charging. Charging of battery is done by supplying electric current from external source, it may be generator or main AC supply. For this electric current flow through battery in reverse direction to that of while current is drawing. During charging battery plates get restored to their original composition

## Chemical used in battery:

1) Spongy lead (Solid)
2) Lead Oxide (Paste)
3) Sulphuric acid (Liquid)

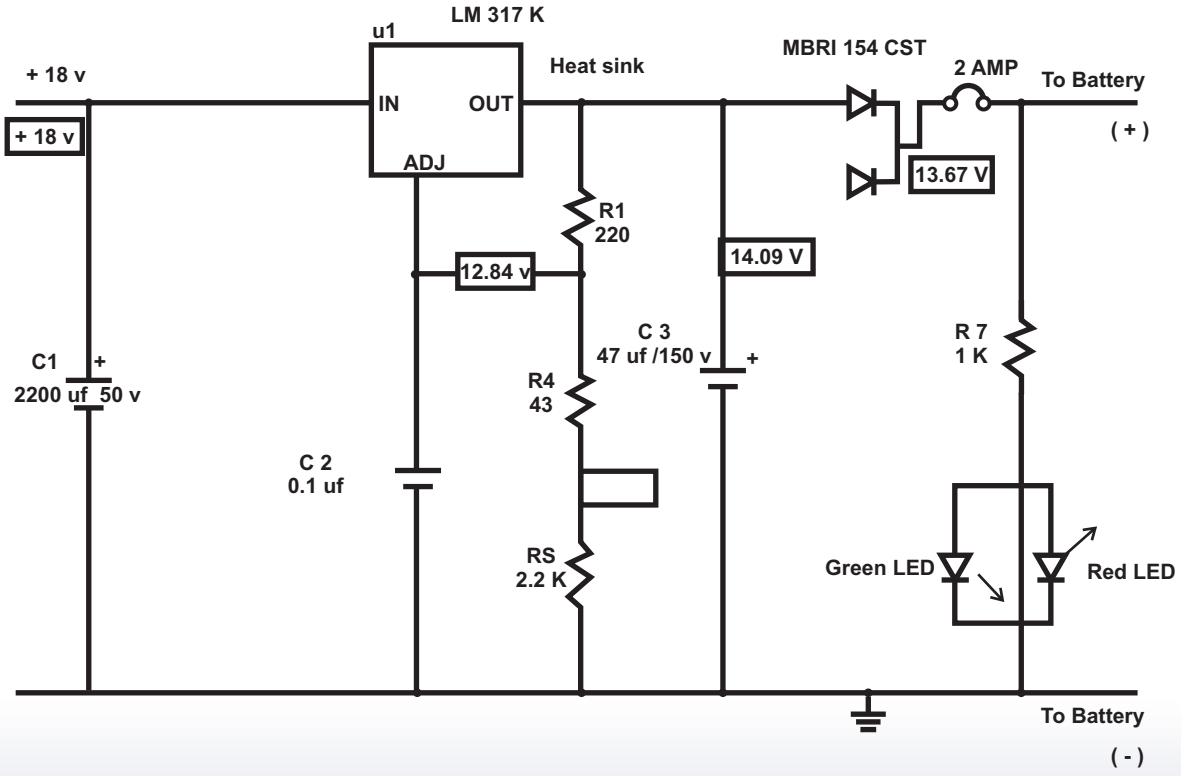
Spongy leady and lead peroxide are held in plate grids to form negative and positive plate respectively

Plate grid is a frame of antimony lead alloy with interlocking horizontal and vertical bars. Which held the plates in place.

**Battery capacity:** The capacity of battery is defined as the amount of current it can deliver. Amount of current depends upon following factors:

1) Number of plates
2) Area of Plates
3) Temperaline
4) Quantity of electrolyte

Note: There is always one more negative plate than positive plate. Between two negative plate there is one positive plate.



## Charging procedure:

- First of all before charging we should see the level of electrolyte in the battery. Electrolyte level should always be at least 10 mm above the top edge of the plates submerged in electrolyte.
- We should note down the specific gravity and temperature of the electrolyte.
- Battery charger is source of direct current. This should be usually kept in a cell. If there are 10 plates keep 5 ampere.
- We should continue charging till the charging current decreases. We should continue till increase of specific gravity continue.
- We should observe the temperature of electrolyte during charging it should not increase more than 45° C. If it increases discontinue to allow the electrolyte to cool down which will ultimately lower the temperature. Now we can continue charging.
- We should check the specific gravity of the electrolyte hourly till it become 1.22.
- We should avoid over charging it may damage plates specially positive plates.
- Specific gravity checking of the electrolyte is the most common method of checking for the state of battery charging.
- Fully charged value of specific gravity is 1.220 half charge value of specific gravity is 1.175
- Fully discharged value of specific gravity is 1.1.

## Rate of charging battery

It is two types:
1) Slow rate charging
2) Quick rate charging

Out of above said two method of charging a battery. Slow rate of charging is most common and better. During this method of charging low ampere direct current is passed to charge. It may take 12-20 hours. In ordinary battery this very method is used. Even it is safer for charging the old battery.

Quick rate charging of battery should be done for good quality battery. In this method of charging high ampere of direct current is passed for charging up to 80% charging level after that charging current is lower down. In this method of charging it will take half to one hour to fully charge the battery.

## Session - 5 : Checking of Electrical Connection and Light in a Vehicle

### Relevant Knowledge

If there is trouble without any obvious cause in any electrical components we should have to test the circuit find the cause. For this we require a circuit tester.

A current tester is useful tool for making electrical test to detect the fault. Lighting circuit are simpler one but electrical wiring in a car contain many interlinking and branching circuits which bring complications. All car wiring has colour code. There is no national or international standards for colours.

Generally colour code of every car are given in the wiring diagrams in car handbook or in the service manual provided by manufacturer. We should have to study wiring diagram so that we can find out the short circuit. For this we have to check the entire circuit. If we know that the power in the circuit is coming from ignition switch and item are red from that very switch there can be no fault between the battery and ignition. So we should start checking from ignition switch.

**Charging of battery :** We connect the current tester up to the negative terminal of the battery and touch the probe to the positive one. If tester lamp does not light the battery is dead. (or even bulb of the tester has blown)

But if it give light we should try again with clip earthed to the car body. If the lamp fails to light the battery it is possible that negative terminal is not earthed properly. Now earth the clip near the switch of the circuit which has to test and now launch

the probe to the live side of the switch. If the lamp does not light up the wiring is faulty
between battery and switch or a fuse has blown.

- Whenever we are checking the component operated by the ignition switch we should assure ignition switch is on.

  If the lamp light up turn the switch on and probe to other. If the lamp does not light the switch is faulty. If the switch is working we leave it on, earth the clip near the component and probe to the lamp side of the component. If the lamp does

not light up, wiring from switch to component is faulty, or fuse has been blown out. All are found satisfactory transfer the clip to the live side of the battery. Now touch the probe to the earth side of the component (if it is earthed by its metal body which fixed to the car body). If the lamp does not light up that means the component is badly earthed or faulty.

## Session - 6 : Lighting System, Application and Replacement of Fues

### Relevant Knowledge

### Lighting System Application

### Introduction

Lighting system is an important for smooth and convenient driving of vehicle in case of both day and night time. All modern vehicles have well organized lighting system. Head light is provided for illumination for night driving on the high way.

It is provided with two beams one for maximum illuminate at night drive whereas other is provided deflection towards ground side to minimum glare while other cars or vehicle is passing. It avoid high intensity of light and facilitate to cross another without any problems. In some vehicle third beam is also provided, which is of low intensity. It is usually used for driving in cities. Low intensity parking light are usually provided in-front of the vehicle. Parking light is kept on during night when vehicle is parked. It provide signal for other traffic user and avoid the accident.

Direction signal light are used to give indication about the direction in which vehicle is going to take turn. Besides this some special signal lights are also used like this may be of red signal light. Which is operated by brake. When brake are applied red light on rear side lit to give indication of other vehicle coming from back side. Back up light is also provided in vehicle this light come into action when driver shift into reverse. This connect a switch linked to the selector lever and connect the back-up light with battery.

## Blinker light

It is provided in the vehicle which provide a means of signaling when the car is stalled on road/highway side. The blinking light is much more noticeable than a steady light to provide warning or indication for the approaching vehicle. Tail light is provided in the back portion of the car to illuminate the car at the night so that other traffic user are able to come into notice for rear vehicle. Tail light are kept on all the time when car is moving in night . Stop light are also attached in the rear portion. It become effective when brake is applied it is usually operative all time driving whether day or night.

Interior lights are also used in vehicle at various panels. They are like:

i) Compartment light
ii) Key hole
iii) Instrument panel light
iv) Various warning indicator light
v) Clock light radio, music system dial light
vi) Map light etc

In this way we realize that all above said lighting system provided in vehicle play important role for smooth and safe drive of vehicle and provide all sorts of indication required to the other traffic users.

**Fuse :** In vehicle lighting system is categories into various type like :

i) Heat light
ii) Parking light
iii) Direction signal lights
iv) Blinker lights
v) Stop light
vi) Back up light
vii) Tail light
viii) Interior light

All these lighting system get power from battery. All these are of great importance in driving of vehicle So each branch of lighting system is protected by in individual fuse

and also by main fuse. The wire of different circuit are also marked by means of special colums in insulation. The green dark green, blue, black, red etc colours provided in the vehicle give indication to user of different circuit.

## Replacement of Fuse/ Changing of a fuse

Fuse seems to break all the time. This happen due to flow of much electricity flowing though it. It may cause serious damage and even fire. Fuse are expensive but easy to replace. We can store extra fuses in our vehicle fuse panel. We can also store it in glove compartment or in our tool box.

## How to change the fuse

1) Local the fuse panel

Owner of vehicle the will tell where is the fuse panel. in most of model of vehicle fuse panel are kept on driver's side of desk board or under the steering wheel or in engine compartment but location vary from vehicle to vehicle. In some cases it is in glove box. We remove the fuse panel's cover. If will remove the fuse panel's cover. We can see diffrent colour could fuses plugged in. These colors along with numbers stamped on fuses, indicate different ampearage ratings. Turn the fuse panel cover over to see a helpful fuse diagram. This diagram will show which fuse work with which electrical component.

## Remove the blown fuse

Before we can change a fuse, we must find out the faulty one. It will have broken filament or will be black inside. Some vehicles come with special puller to remove fuse. Remove the faulty fuse with care and replace it. Note down the vehicles electrical problems whether fuse look blown or not.

**Replace the fuse:** Replace the blown fuse with a new fuse of same amperage .
Use fuse panel diagram given in the vehicle's owner's manual and the number color coded fuse to determining the correct ampearage. If we use wrong amperage it will cause much worse damage to the vehicle than just a blown fuse. Once we have located the fuse of the right amperage place it into the correct slot. Push it down with your finger to ensure it completely installed and then replace the fuse panel's cover.

**Check the Current :** Once the fuse is replaced and panel is covered, turn over vehicle damaged ignition and check to see if the damged circuit is working properly or not. If it is working correctly it is O.K. If not than check again and replace with correct one.

## Session - 7 : Horn Assembly, Electrical Fuel Gauge and Fuel Pump their Application and Maintenance

### Relevant Knowledge

**Electric Horn :** Electric horn is used as a alarming device for other traffic and road users. One vehicle driver send massage to other vehicle driver which are travelling very near to first vehicle. It send massage about their presence and intension what he want. The horn blown or emitted by horn system should neither be too much musical or two hoarse or irritating. It should not be to hard and irritating but should be of normal noise. It is a simple device. It require electrical energy to blow. Being a simple device it require little maintenance. It requires miner maintenance. A double diaphragm electric horn is usually used in vehicle. Inside its casing there is an electromagnet in which there is and diaphragm. Its diaphragm attached with low frequency (300 vibration/sec.) diaphragm. Its diaphragm is fixed around its edges with casing. Armative road is fixed to the metal. Tone disc is designed to produce frequency of approximately 200-250 vibration/sed. Contact breaker is sets with armature into vibration as horn switch is pressed. When the armature move circuit breaker is struck by armature and electric circuit breaks. Guide springs push the armature again and cycle restarts. When magnet system is struck by armature at the end of each stroke, tone disc produce over tone. Its design is such that frequency of tone disc is exact multiple of low frequency diapharm. Tone disc give out resonant high frequency vibrations. The resultant of combining high and low frequency is not of good penetration one. Generally two types of problems arises in horns:

i) Horn is not providing sound
ii) Horn is producing poor quality sound
a) Blown off fuse.
b) Broken Circuit wire
c) Defect in horn circuit

1. Poor quality of sound may be due to incomplete contacting action inside the horn.
2. Improper point gas burnt out horn point cracked diaphragm.

In these cases if possible should be repaired otherwise replaced with new one.

**Fuel Gauge :** It is an instrument used to indicate the level of fuel available in the fuel tank. This instrument is used in most of the motor vehicle. This instrument is used in any tank to see the level of fuel available in the tank even in under ground storage tank like petrol pump:

1) Sensing Unit
2) Indicator

The sensing unit is usually uses a float which is connected with a potentiometer ink printing design. It is used in modern automobile vehicle. As the tank is empty, the float drops and slides a moving along the resistor. When the resistance is at a certain point it will also turn on a low fuel light on some vehicles indicator unit is a measuring one and displaying amount of electric current flowing through sending unit. When tank is at high level maximum current is flowing and the needle points to "F" indicating tank is full. When the tank is empty least current is flowing. Needle points to "E" indicating tank is empty. The system can be fail if an electrical fault open. Electrical circuit causes the indicator to show the tank to be empty. Which indicate and provoking the driver to refill the tank. Though it is full.

Corrosion or wear of potentiometer will provide incorrect reading of fuel level. In most of automotive vehicle fuel gauges resistor are on the inward side of the gauge. That means inside the fuel tank. Sending current thought such resistor has a fire hazard and an explosion risk associated with it . These resistance sensors are showing an increase failure rate due to increase in addition of alcohol in automotive gasoline fuel. Alcohol increases the corrosion rate of potentiometer.

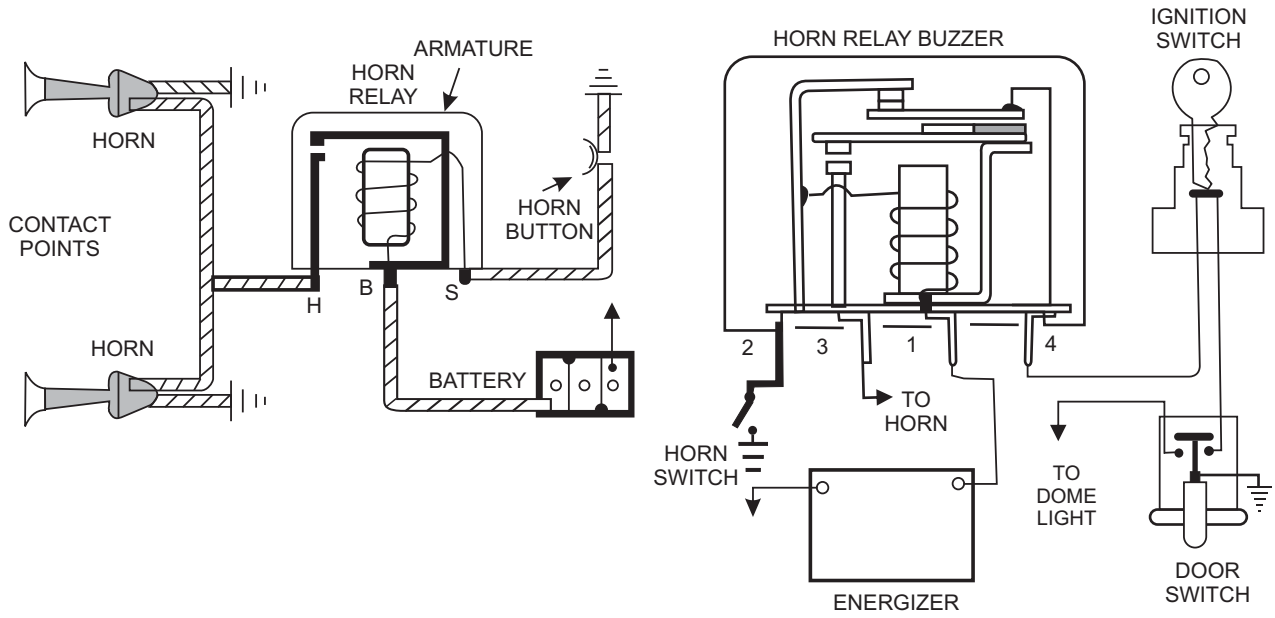
Magneto resistance type fuel level sensor have become common in small air craft applications which offer potential alternative for automotive use.

**Fuel System:** To run an internal combustion engine fuel should have to supply from fuel tank to engine cylinder. In diesel engine fuel is injected into cylinder by injector. injector. Where as in petrol engine fuel is injected by carburetor.

Fuel system should have following characteristics:

1. Metering (measure)
2. Timing

3. Pressurize
4. Atomization
5. Distribution
6. Control




Horn Circuit

**1. Metering (measure) :** Fuel injection system must measure the fuel supplied into the engine cylinder in accurate amount. It varry from low to high engine speed. Fuel is measured within the injection pump. It has pumping inlet metering and pumping outlet metering chamber, which supply measured quantity of fuel.

**2. Timing :** Timing of fuel injection inside the combustion chamber has great importance during starting the engine. Timing of fuel injection vary from low speed to high speed engine. In case of diesel engine fuel should be injected at very close to TDC position of piston but before reaching here because at this moment air is the hottest. If the engine has started running at high speed injection time may be advanced to compensate injection lag, ignition lag etc. In most of the modern luxurious vehicle injection pump have an automatic time device built into them so that timing automatically change as engine speed changes. Their main purpose is to vary fuel injection timing to produce powerful and efficient engine.

**3. Pressurize :** Fuel system must have the quality so that it pressurize the fuel to open the injection nozzle. It requires high pressure to inject the fuel into combustion chamber so that it over come the pressure of compression which developed during compression stroke. Pressure of injection nozzle (injector tip) is directly related to the degree of atomization. Fuel is pumped through multi hole type nozzle or pentle type nozzle at high pressure that may be 1050 to 2850 $N/cm^2$

**4. Atomization :** Fuel Supplied inside the combustion chamber should be injected into fine atomized form. Atomized fuel would burn smoothly and easily and produce very high pressure suddenly. The degree of atomization vary from engine to engine the piston depending upon design of combustion chamber. High degree of atomization require for direct injection engine. Designed so that fuel completely mixed with compressed air and become homogeneous mixture. In this type of engine multi hole type nozzle tip is used.

**5. Distribution :** Distribution of pressurized and atomized fuel is directly related with timing and firing order and engine. Distributor pump deliver fuel to each pump outlet in succession of firing order in side, the combustion chamber (cylinder). In-line pumps contain camshaft, to permit pump outlet to fire fuel at right time in required firing order. Fuel must be ejected in such a way so that all compressed air must be utilized for the combustion of fuel.

**6. Control :** Injection of fuel must start quickly and also and end quickly. Any delay in beginning will alter the pump timing causing difficulty in starting and poor engine running. It may also cause smoky exhaust gas and irregular exhaust gas out put sound. In camshaft designed pump sharp drop is provided so that injection stop rapidly.

## Method of fuel injection

There are two method used for injection of fuel in compression ignition engines

1) Air blast injection
2) Airless injection

**1) Air blast injection :** In this method of injection first of all air is compressed to very high pressure. Blast of this air is injected carrying together fuel into the cylinder. In this method of fuel injection rate of fuel injection is controlled by varying the pressure of air. For high pressure multistage compressor is required.

Fuel get ignited by high temperature of air due to having high compression ratio of engine “compressor consume about 10 % of the power developed by the engine. So net output of engine decrease. This method of fuel injection was used in large stationary compression ignition engine and even in marine engine. Being quite expensive and complicated has become obsolete.

**2) Airless injection method :** This method of injection is very much popular in modern vehicle. In this method fuel is injected inside the cylinder at very high pressure directly. Temperature of air become very high due to very high pressure obtained by high compression ratio. In this method we require a fuel pump at his pressure 3000 $N/m^2$. This pressure should be much more higher than internal pressure of cylinder.

This method is used for all small and big diesel engines.

**It is two type**

a) Individual pump system
b) Common rail system

**a) Individual pump system :** In this method of fuel injection each cylinder has individual high pressure pump together with metering device. It is compact but more costly.

**b) Common rail system :** In this method of fuel injection system fuel is pumped by multi cylinder pump attached on common rail. Pressure of this system is control by using relief valve. Fuel is supplied to every cylinder in measured quantity at right moment from rail supply system. This method of fuel injection system is simple in construction so light in weight. It is also cheaper. It is very much popular in multi cylinder compression ignition engine. This system automize the fuel intovery fine droplet form. But it require high accuracy in manufacturing of the pump barrel and fuel injection plunger.

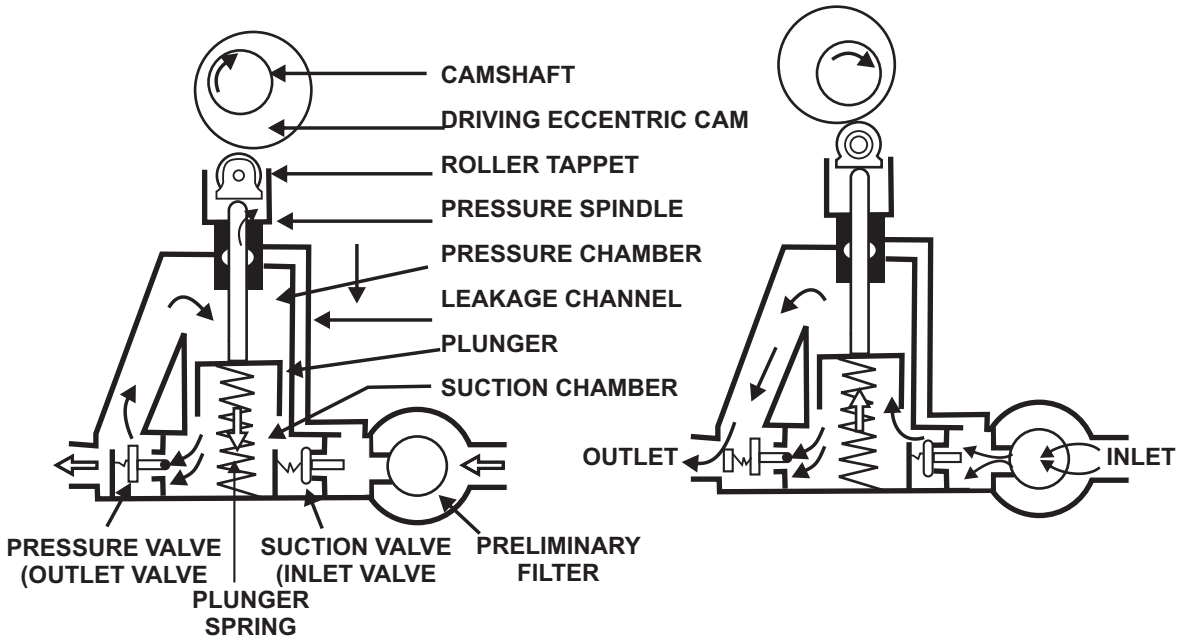
Set engine fuel system consist of following components:

1) Fuel tank
2) Fuel filter
3) Air cleaner
4) Injection pump
5) Fuel guage
6) Injector

7) Fuel line pipe
8) Feed pump

In diesel engine during suction stroke only air is sucked and compressed inside the cylinder. At the end of compression stroke or we can say just before the completion of the compression stroke diesel fuel injected at right time in automized form by an injector in the compressed air. This diesel fuel get ignited due to the heat of compression and develop very high pressure on the face of piston.

Fuel pump delivers fuel at comparatively low pressure to injector filled individually for every cylinder quantity of fuel to be injected inside the cylinder by injector. If less fuel is injected inside the cylinder less power would be developed and engine will run slow. If more fuel is injected inside, more power would be developed. Thus we can say that it is heart of the vehicle.



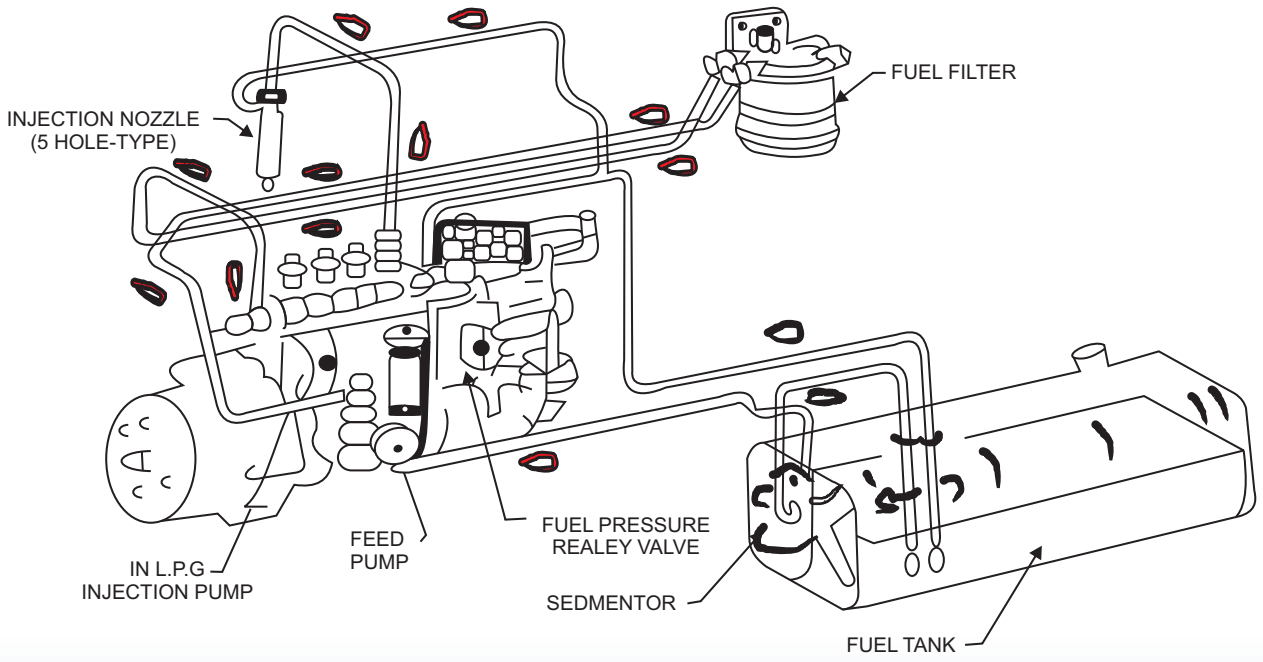

**WORNING OF FUEL PUMP**

**Fuel pump :** Fuel pump is a simple device used in fuel supply system. Its may function is to deliver fuel from fuel tank to the carburetor or fuel supply injector system.
Generally two type of fuel pump is used in vehicles:

1) Mechanical fuel pump : Mechanical fuel pump is run by getting power from eccentric engine camshaft. It is mounted on the side of cylinder block

2) Electrical fuel pump : This type of pump is mounted in the fuel tank. It contain an impeller which is driven by an electric motor. It pressurize fuel form reservoir and send to carburetor. Some electric fuel pump is also mounted in engine compartment.

Performance of fuel pump is tested by vacuum pressure and volume




Fuel system of direct injection SL engine for Swaraj Mazda refciles

Fuel Pump

## Session - 8 & 9 : Circuit Diagram for Starter Circuit and Ignition Circuit

### Relevant Knowledge

**Starter System :** Internal combustion engine is capable of self-starting. Some bigger engines used in truck, tractor, off- road industrial equipment are required for cranking to start the engine. For this a small starter engine is required. Automotive engine both for spark ignition engine and diesel engine also required to crank by a small but powerful electric motor. This motor is called cranking motor, starter or starter motor. For this direct current motor is used. D.C. current is supplied from battery to the starter motor. When the driver turn ignition switch to start, a pinion gear in starter motor mesh with the teeth on ring gear around the engine fly wheel starter motor rotates the engine crank shaft for starting the engine.

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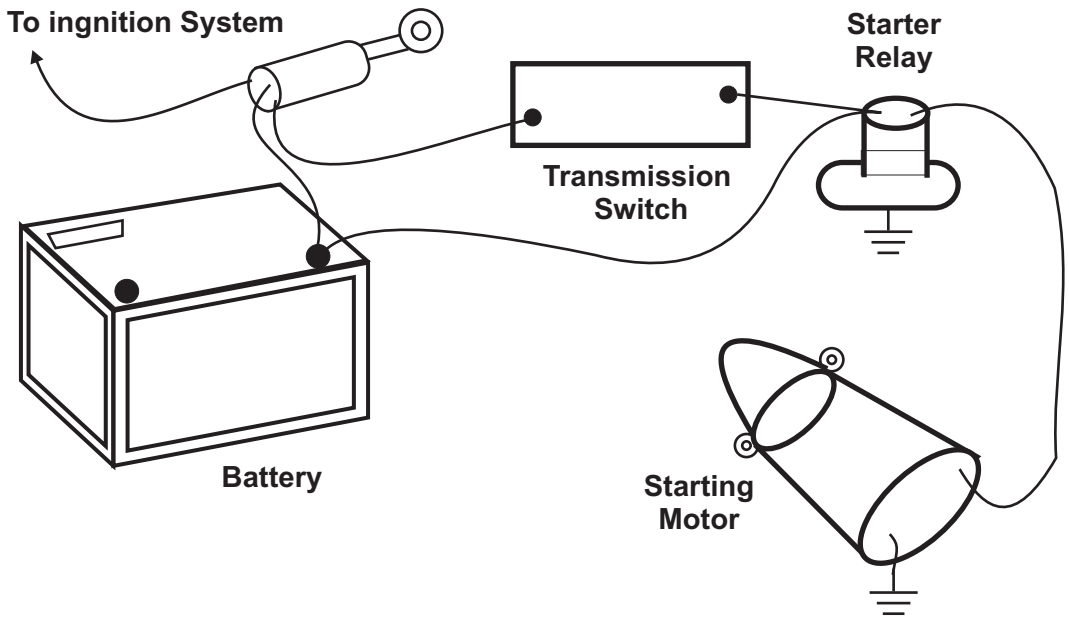
### This starter system requires following components:

1) Ignition switch, battery, starter motor, drive mechanism starter relay, solenoid, neutral safety switch, wire for connection.
2) Starting motor : For this loop of heavy wire are placed between the magnetic poles. When the current drawn from the battery flows through loop a strong magnetic field is produced around the loop. This magnetic field produced in loop opposes the magnetic field of the stationary magnet.

This opposition cause the loop to rotate. In motor there are many loops assembled in roter called armature. Where as stationary magnetic field is produced by field winding in field frame. When motor is connected to the battery, the opposing magnetic fields of the armature and the field windings causes armature to spin. Then starter motor drive unit to rotate the crank shaft so that the engine could start with completion of four stroke and getting expansion stroke to rotate the crank.

Starter motor require high magnetic strength to crank the engine. To obtain strong magnetic field high current should flow through starter motor. Some starter motor are series wound motor. Their field windings are connected in series. Some starting motor has four field winding and four bushes.

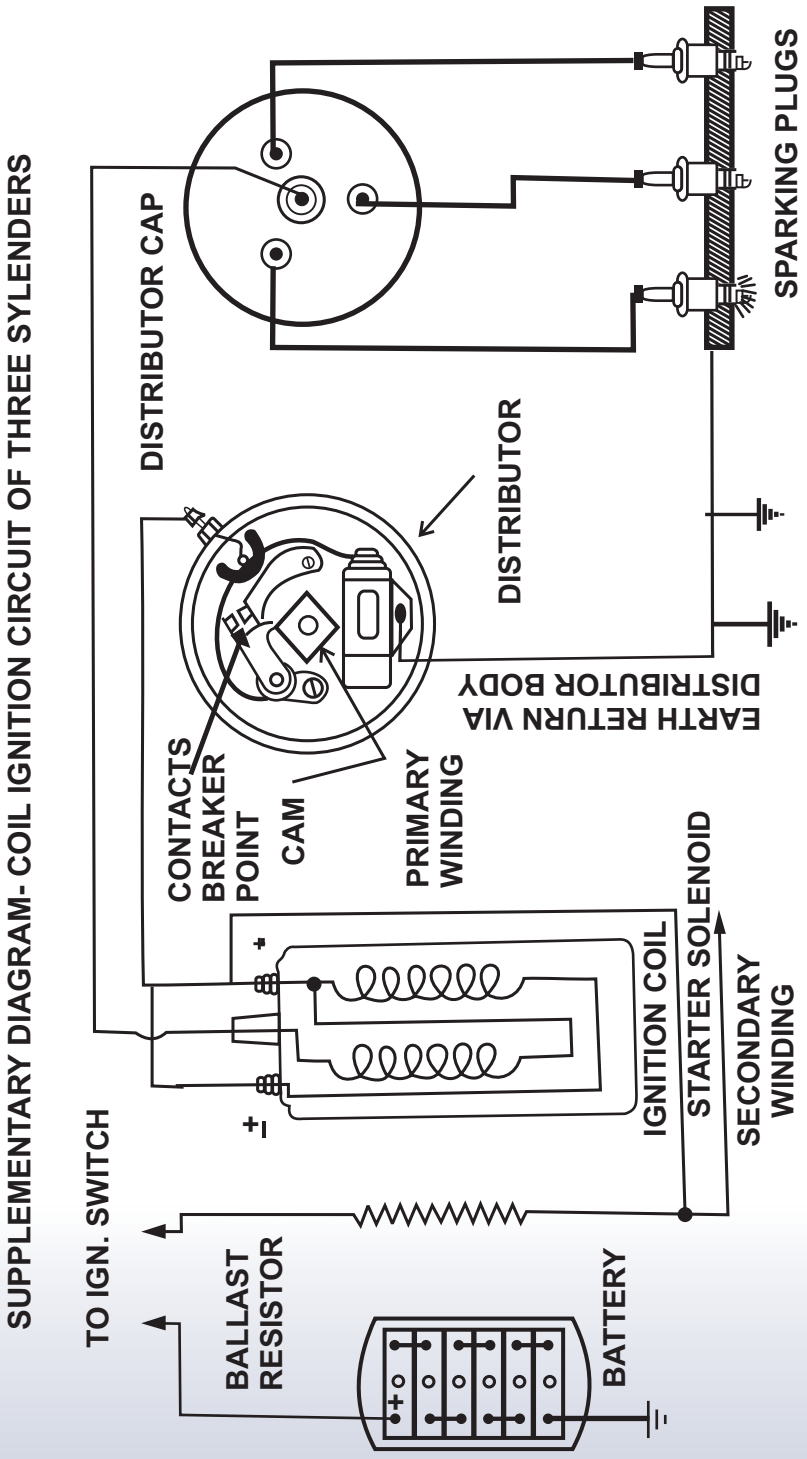



**Ignition System :** Ignition system is an important device used for igniting fuel air mixture to provide high pressure for the production of power in a vehicle. It is used to burn petrol (gasoline) air mixture in most of the petrol running motor vehicle. It is also used in oil fired and gas fired boilers and rocket engine. Ignition system used as electric spark ignition system. For ignition of air fuel mixture electrical system get energy from lead acid battery which is charged by car's electrical system by using dynamo or alternator . Engine operates contact break point, which interrupt the current at high voltage

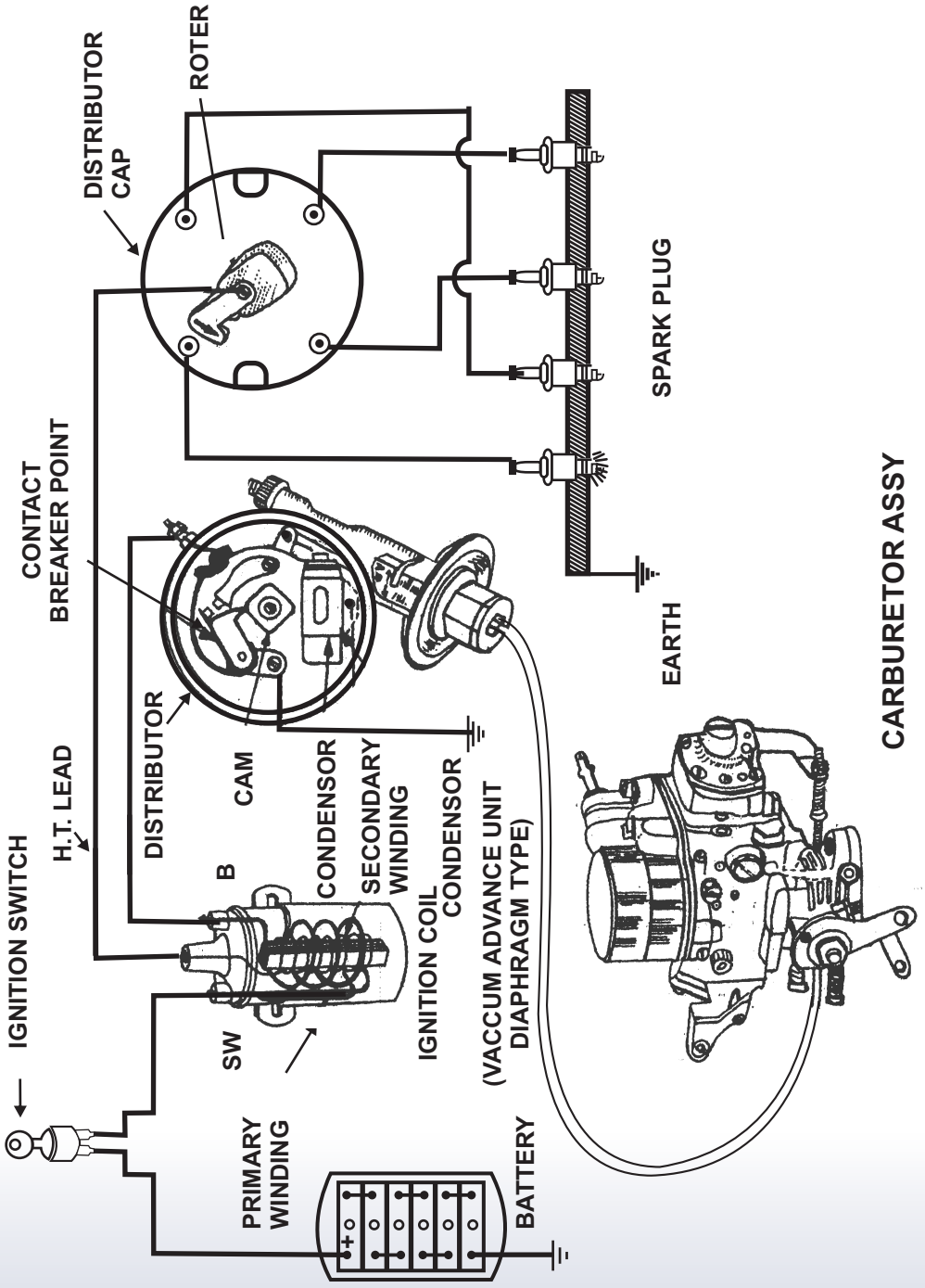
through induction cool (ignition cool) ignition cool consists if two transformer winding:

1) Primary winding
2) Secondary winding

These winding share a common magnetic core. Primary winding, secondary winding is connected with induction coil. It work as step up transformer which produce voltage current for induction coil.

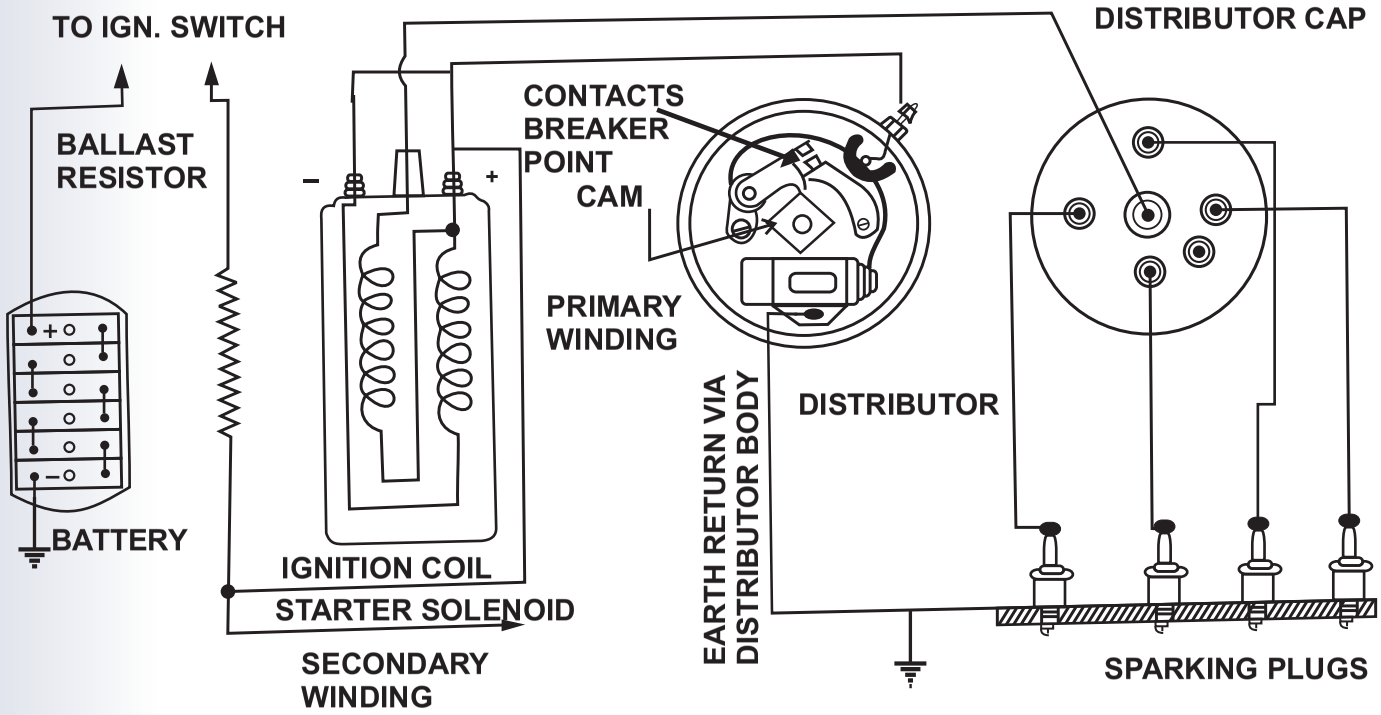



Coil Ignition Circuit of Three Cylinders



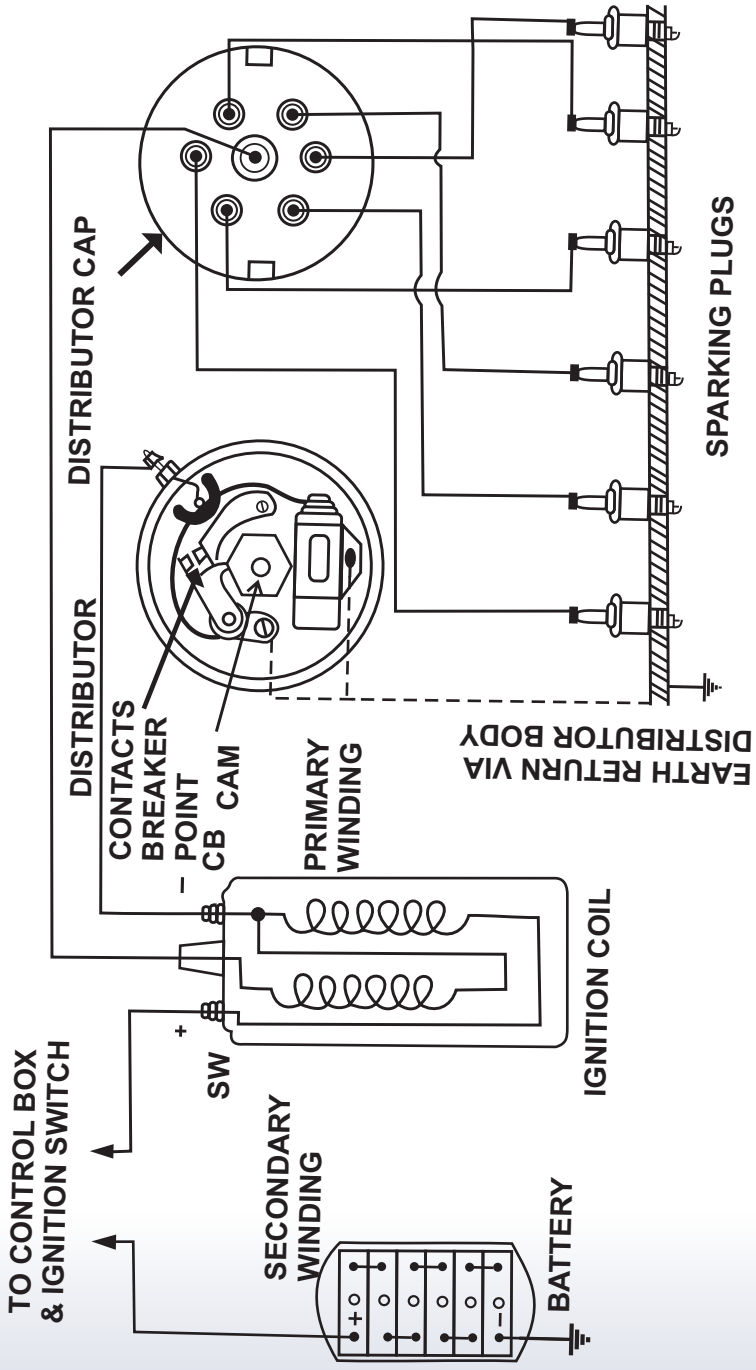

INTERNAL VIEW OF
IGNNITION CIRCUIT OF FOUR CYLINDER

SUPPLEMENTARY DIAGRAM- COIL IGNITION CIRCUIT OF FOUR SYLENDERS

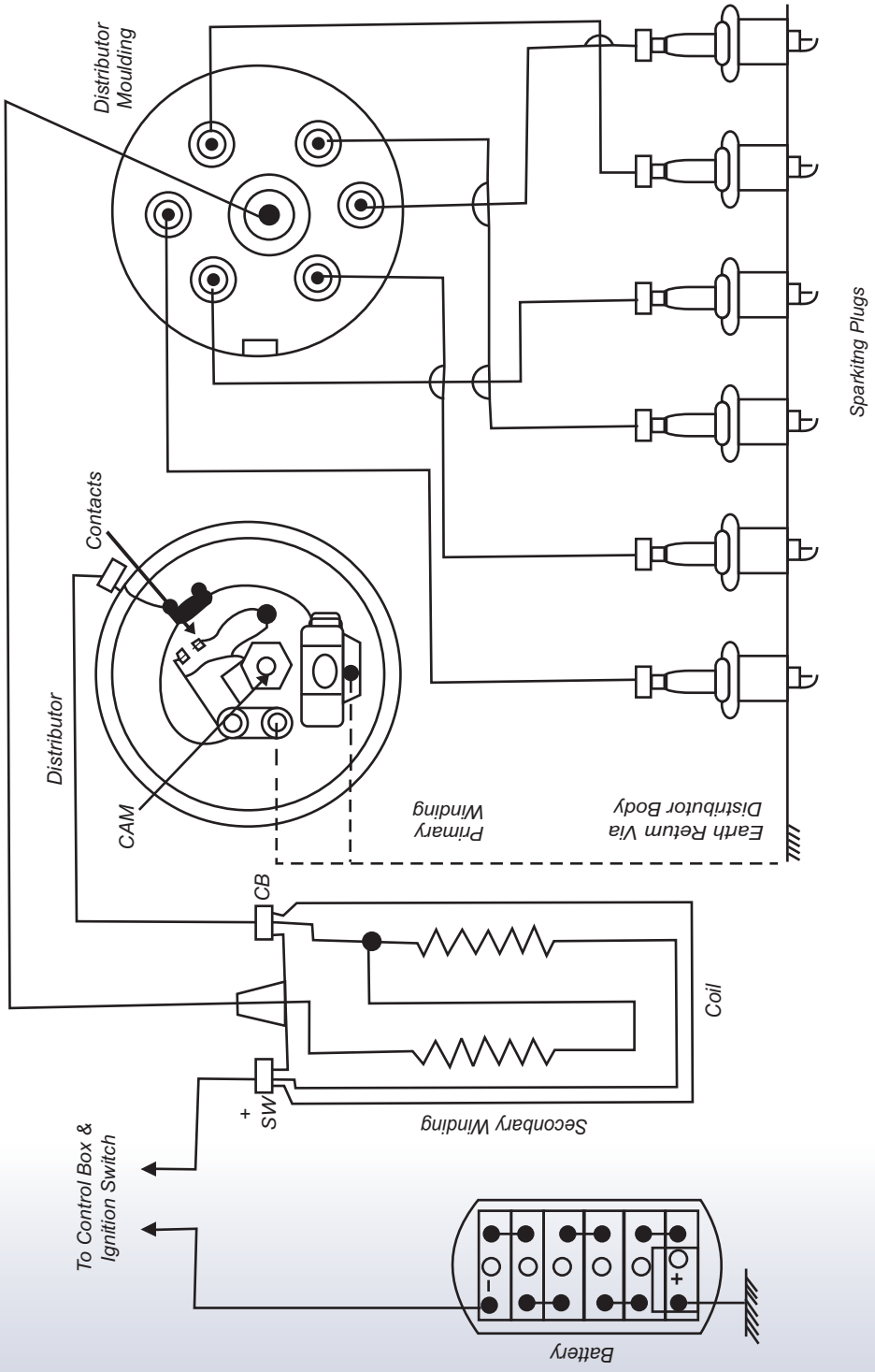



Coil Ignition Circuit of Four Cylinders

SUPPLEMENTARY DIAGRAM- COIL IGNITION CIRCUIT OF FOUR CYLINDERS




Coil Ignition Circuit of Six Cylinders




Supplementary Diagram - Ignition Circuit of Six - Cylinder Old CNG Model Commercial Vehicle (TATA Bus - LPO 1510)

## Session - 10 & 11 : Servicing of Wiper System & Introduction HVAC System in Vehicle

### Relevant Knowledge

**Servicing of wiper system:** Wind shield wiper is an essentials system. Its main function is to remove water from the front screen glass for clear vision on road for driver. It also remove humidity form front glass. The blades of wind shield wipers are actuate at very slow speed. To move and provide reciprocating motion to the blades. Small electric motor is used.

Two types of motor are used to run the blade of wind shielding wiper system.

1) Reciprocating wiper systems
2) Rotating wind motor.

**1) Reciprocating wiper motor :** In this type of motor the rotary motion of motor shaft is converted in the reciprocation motion of one blade by means of gear system with crank. Second blade is made to move through suitable linkage.

**2) Rotating wiper motor :** In this type of motor driving shaft rotates and this rotating motion is converted into reciprocating motors out side the motor. This reciprocating motor is transmitted to the blade of wind shield motors. Most of the motion are of full cycle cut out type. This type of motor stop only when blades reach their end positions.

**Servicing of wiper system :** Wind shield wiper is very essential while vehicle driven during rainy season. So it is essential that is should be always in good working conditions. So it require maintenance from time to time. It may become out of order even due to miner falult. Generally problems come in to knowledge that wiper is not running. This problem arises due to the following reason :

Cause :

1) Fuse of motor may become loose or blown off.
2) Brushes may be worn out or (floating ).
3) Loose terminal connection on wiper switch.
4) In complete metal to metal connection.
5) Dirty commutator or burnt out.

Remedy :

1) It require to light or replace by new one.
2) If worn out replace with new one and if floating it require repair.
3) It require repair.
4) It require repair if it is completely out of order should be replace.

Power wiping action regson :

1) This problem arises due to in sufficient pressure of wiper arm
2) Blade may be improperly set
3) Blade may get hardened
4) Wind shield may become disturb with oil
5) Wiper stop at wiping position

Remedies

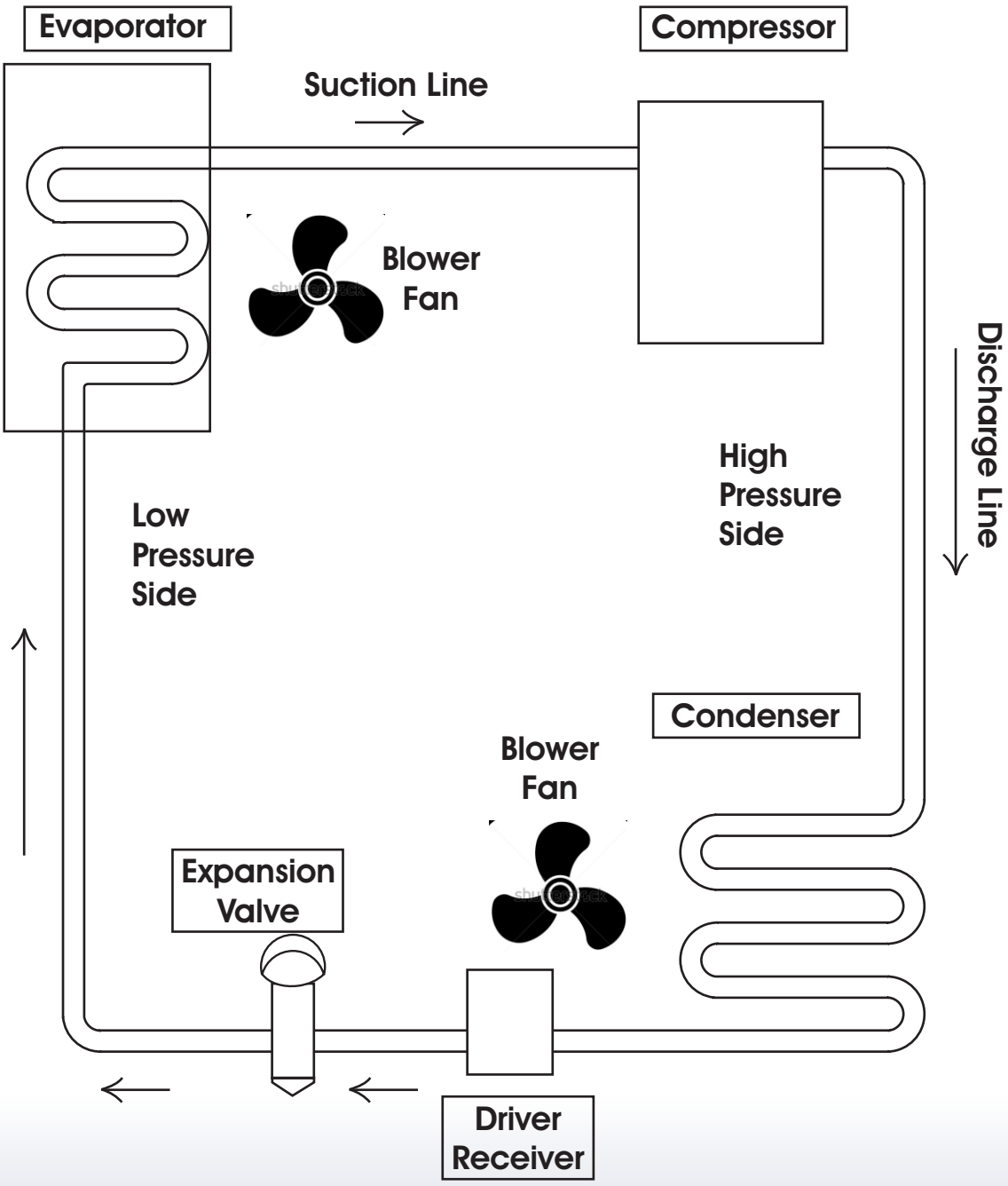
1) If there is minor problems it should be repaired. If not so it should be replaced with new one.
2) It may be repaired.

## Introduction of HVAC System in Vehicle

## HVAC system

Heating ventilation and air conditioning. It is the technology for indoor and automotive ambient comfort. It facilitates in managing pleasant climate inside the cabin by controlling the degree of hotness coolness. HVAC system was introduced into automobiles in the early of 1960 and is available in most if the high quality vehicles. It is a complex system consisting of mechanical and electronic switches or knobs in the front end of the vehicle. Back end of the vehicle comprises one or more blower motors actualators for fresh air circulation flow control and flow control and temperature control.

Refrigeration unit is coupled with many conduit through which cool air is transferred into the cabin. The basic principle behind the operation of HVAC unit is conduction and convection heat energy is transferred from low temperature region to a high loop region in the vehicle due to pressure difference . This process of transfer of heat energy is called refrigeration.




Refrigeration Cycle Diagram
of Air Conditionery

Air conditioning system comprises fire major components.

1) Evaporator
2) Compressor
3) Condenser
4) Receiver / Driver
5) Expansion device

The five major components are divide into two pressure regions. The high pressure side is condenser and receiver/drier unit and this is condenser and law pressure is air high and low pressure cut through the compressor and the expension valve.

**Evaporator :** An evaporator is a heat exchanger device in the refrigeration cycle. The liquid refrigerant coming out of expansion valve and entericing into the evaporator is at lower temperature and lower pressure. On passing through the evaporator cool refrigerant absorbs heat from air and is blown through the coil and get converted to low leap low pressure vapour. Liquid refrigerant is made to flow from bottom to top of the evaporator coil so that liquid refrigerant boil before it leave the evaporator coil.

**Compressor :** Compressor is know as the heart of central air conditioning unit. Compressor absorbs vapour refrigerant from suction line and compresses vapour to high super heat vapour. Temprature of vapour is two and half time higher than out side temperature. As heat always flows from hot to cold refrigerant must be much hotter than outside air so hot air could move heat out of the system. As refrigerant flows across the compressor it also remove heat of compression, compressor create the flow of refrigerant on the system compressor superheat and remove latent heat and generate flow of refrigerant.

**Condenser :** Condenser is hot high pressure vapour working unit to stop at it. Condenser is just like the evaporator. It is a heat exchanger. Refrigerant flows from top to bottom of the coil inside the condensing unit. Refrigerant is a much higher temperature than ambient temperature. It cool down as it passes through the coil. By this time superheat refrigerant reaches the third coil. It cool down enough to change back into liquid state to the refrigerant this process is known as super cooling. Placement of condenser is important for better efficiency.

As it is very hot, So maximum surface area needed to exposed to ensure cooling as faster rate.

## Drier / Receiver

Drier/ receiver are located at high pressure side of the system. If installed between condenser out let and expansion valve inlet.

It serves three important functions

1) Act as storage condenser for extra refrigerant during low cooling demand.
2) If filter and trap the contaminants in side A/c system. It absorb moisture (water) that may get inside A/c system.

## Expansion device

Expansion device is required to generate the pressure difference for liquid refrigerant to boil off into gas. Expansion device create pressure drop by restricting the flow of refrigerant around the system.

## Assessment

## Exercise: Assignment

Answer th following question.

1. Write the name of important electrical symbol with simple figure used in vehicle.
2. What are the different colours used in automobile wiring?
3. What are various specification of cables used for wiring in automobile for various electrical system?
4. What are the function of multi meter?
5. Write the note on stroboscope.
6. How battery plays an important role for smooth operation of vehical?
7. How should be bettery be maintained so that it gives good performance?
8. Draw the circuit diagram of battery charging.
9. How would you detect the fuel pump?
11. How would you overhaul the fuel pump?
12. Draw the starter circuit diagram.
13 Draw the ingnition circuit diagram of
   a) Four Wheeler vehicle (Car)
   b) Three Wheeler Vehicle
14. Write down the important steps of servicing of wiper systems.
15. Write note on HVAC systems used in vehicle.