AUTOMOTIVE MECHANICS

Level-I

Based on Curriculum March 2022, TTLM Version 1



Module Title: - Applying Automotive Mechanical System Fundamentals

Module code: EIS AUM1 M05 0322

Nominal duration: 80Hour

Prepared by: Ministry of Labor and Skill

September 2022

Addis Ababa, Ethiopia

Table of Content

Acknowledgment……...…3

Introduction to the Module 5

Unit one: Identify system fundamentals 6

1.1 Basic terminologies of automotive mechanical systems 7

1.2 Functions and principles of operation 8

1.3 Identifying sources of information for mechanical system 12

Self-Check -1 18

Unit Two: Identify operation of system/component 19

2.1 Automotive mechanical systems and components 20

2.2 Identifying safety hazards 32

Self-Check -2 35

Operation sheet 2.1 37

Operation sheet 2.2 38

Operation sheet 2.3 39

Operation sheet 2.4 40

Operation sheet 2.5 41

LAP test 1 42

Unit Three: Locate system or component on vehicle 43

3.1 Tracing suitable automotive systems and components 44

3.2 Confirming location of systems or components 46

Self-Check -3 47

Unit Four: Apply system fundamentals 48

4.1 Examining subassembly components 49

4.2 Identifying common faults 50

Self-Check -4 62

Operation sheet 4.1 64

LAP test 2 65

Reference 66

Acknowledgment

Ministry of Labor and Skills wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

Acronym

OS================== Occupational Standard

LAP test============== Learning Activity Performance test

RWD================ Rear Wheel Drive

CV joints=============Constant Velocity joint

ECU=================Electronic Control unit

IC==================Internal combustion

EC==================External Combustion

FFWD ===============Front engine, Front wheel drive

FRWD ===============Front engine, Rear wheel drive

RR WD===============Rear engine, Rear wheel drive

MR WD===============Mishap engine, Rear wheel drive

SST ================Special service tools

CGM=================Crank gear mechanism

VGM ================Valve gear mechanism

4WD ================four wheel drive

Introduction to the Module

In Automotive Mechanic filed; the knowledge, skill and attitude required to demonstrate basic knowledge and awareness of automotive terminology, terms and principles as they apply to vehicle systems, components and technologies found in modern motor vehicles and also remove and re-install non difficult system components.

This module is designed to meet the industry requirement under the Automotive Mechanic occupational standard, particularly for the unit of competency: Apply Automotive Mechanical System Fundamentals.

This module covers the units:

- Identifying system fundamentals
- Identifying operation of system or component
- Locate system or component on vehicle
- Apply system fundamentals

Learning Objective of the Module

- Identify system fundamentals
- Identify operation of system or component
- Locate system or component on vehicle
- Apply system fundamentals

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: Identify system fundamentals

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Basic terminologies of automotive mechanical systems
- Identifying Functions and principles of operation
- Identifying sources of information for mechanical system

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify Basic terminologies of automotive mechanical systems
- Identify Functions and principles of operation
- Identify sources of information for mechanical system

1.1 Basic terminologies of automotive mechanical systems

IC Engine Terminologies

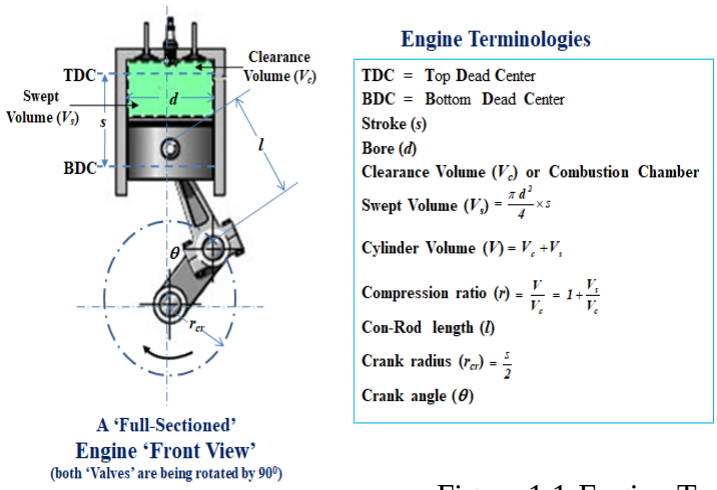


Figure 1.1 Engine Terminologies

Basic Definitions used in engine terminology:

Bore: The inner diameter of the cylinder is called a bore.

Stroke: Stroke is the length of the piston moves from the bottom of the cylinder to the top of the cylinder is known as a stroke.

Clearance Volume: The clearance volume is the space between the top of a cylinder and the top dead center.

Top Dead Centre: The top dead center point is the end point of the piston which moves in the cylinder at the time of combustion process.

Bottom Dead Centre: When the piston moves in down wards after the combustion process, bottom dead center is the bottom point that piston travels and raises again for combustion process.

Total volume of the cylinder: Total volume of the cylinder is calculated when the piston is at bottom dead center.

Swept Volume; This is the volume swept by the piston when reciprocating in between the top dead center and the bottom dead center.

Compression ratio: It is the ratio of total volume to the clearance volume.

Mean Effective Pressure: Mean effective pressure is the ratio of the engine work to the volume of the cylinder.

1.2Functions and principles of operation

A. Operate Engine systems

Introduction the engine is the vehicle's main source of power. The engine uses fuel and burns it to produce mechanical power. The heat produced by the combustion is used to create pressure which is then used to drive a mechanical device.

The engine is the heart of the automobile. It converts fuel into the energy that powers the automobile. To operate, it requires clean air for the fuel, water for cooling, electricity (which it generates) for igniting the fuel, and oil for lubrication. Engine system means the engine, the emission control system and the communication interface (hardware and messages) between the engine system electronic control unit(s) (ECU) and any other powertrain or vehicle control unit;

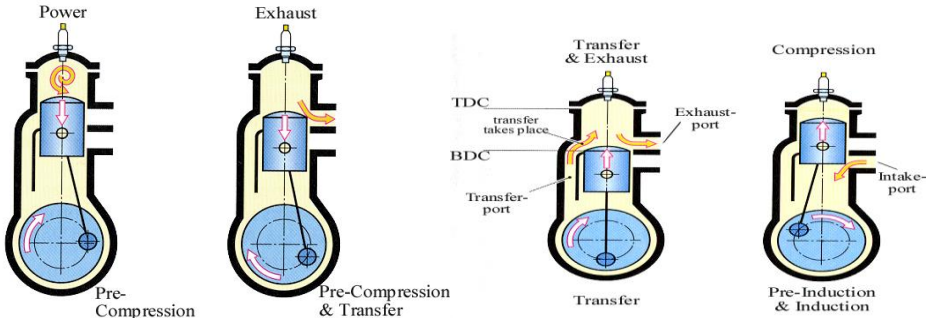
The engine consists fixed cylinder of and a moving piston. The expanding combustion gases push the piston, which in turn rotates the crankshaft. Ultimately, through a system of gears in the powertrain, this motion drives the vehicle's wheels

Principle of engine operation

1. Two-Stroke Cycle Engines – these are engine where the cycle is completed in two (2) strokes of the piston. This means that the piston has to move two

times to complete the cycle.

Figure 1.2 *Two-Stroke Cycle*



2. *Four-Stroke Engines* - these are engines where the cycle is completed in four (4) strokes of the piston. This means that the piston has to move four (4) times to complete the cycle.

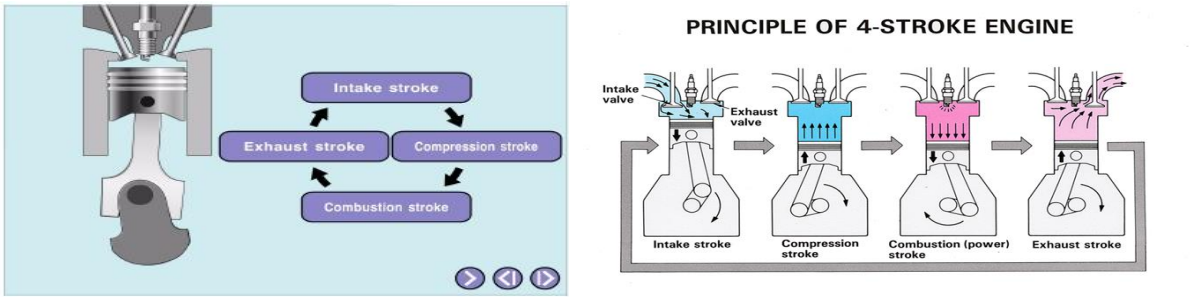


Figure 1.3 *Four-Stroke Engines*

Stroke	Movement of	Position of the Valve		Purpose
	the Piston	Intake Valve	Exhaust Valve	
Intake	Going Down	Open	Close	✓ Sucked air/fuel mixture into the cylinder
Compression	Going Up	Close	Close	✓ Compressed the air/fuel mixture to increase its temperature
Power	Going Down	Close	Close	✓ Combustion takes place
Exhaust	Going Up	Close	Open	✓ Burned gases pushed out from the engine cylinder

B. **Operate Transmissions and drive trains systems**

Definition Of Transmission System :- The mechanism that transmits the power developed by the engine of automobile to the engine to the driving wheels is called the Transmission system (or power train).It is composed of Clutch , The gear box, Propeller shaft ,Universal joints ,Rear axle Wheel Tires Requirements Of Transmission System Provide means of connection and disconnection of engine with rest of Clutch, The gear box ,Propeller shaft, Universal joints , Rear axle Wheel ,Tires.

There are two types of transmissions in use—

- **Manual transmission**
- **Automatic transmission**

Manual transmission, the driver selects all gears manually using both a movable gear selector and a driver-operated clutch. This type of transmission is also known as a "stick shift" or a "standard" transmission.

Automatic transmission that uses a torque converter, planetary gear set and clutches or bands to shift through a vehicle's forward gears automatically. Some automatics allow the driver a limited amount of manual control over the vehicle (aside from choosing a forward, reverse or neutral mode) -- for example allowing the driver to control upshifts and downshifts by utilizing buttons or paddles on the steering wheel or the gear selector. Common names for such transmissions are "shift able automatic," "Tiptronic" and "autostick."

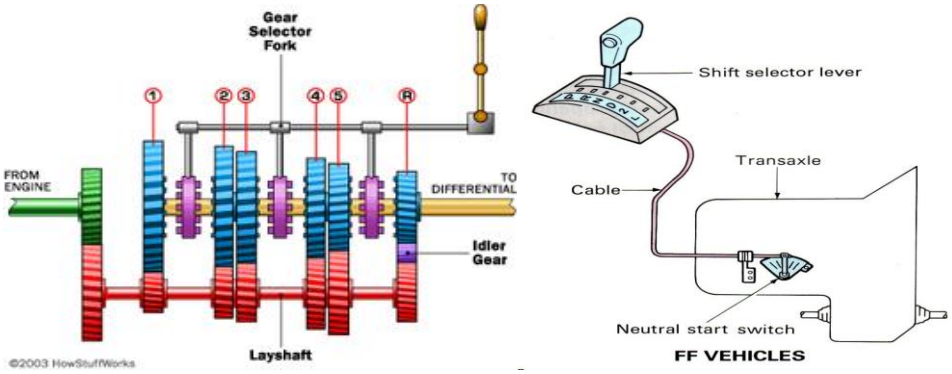


Figure 1.4 Manual and Automatic transition

Drive trains

The drivetrain (also called driveline) is the sum of components which are delivering the engine power to the wheels. For example, on a rear-wheel drive (RWD) vehicle, the drivetrain consists of: clutch (or torque converter), gearbox (manual or automatic), propeller shaft, differential and drive shafts.

The efficiency of the drivetrain has a significant impact on the overall efficiency of the vehicle. The higher the efficiency of the drivetrain, the lower the fuel consumption of the vehicle (also lower CO2).

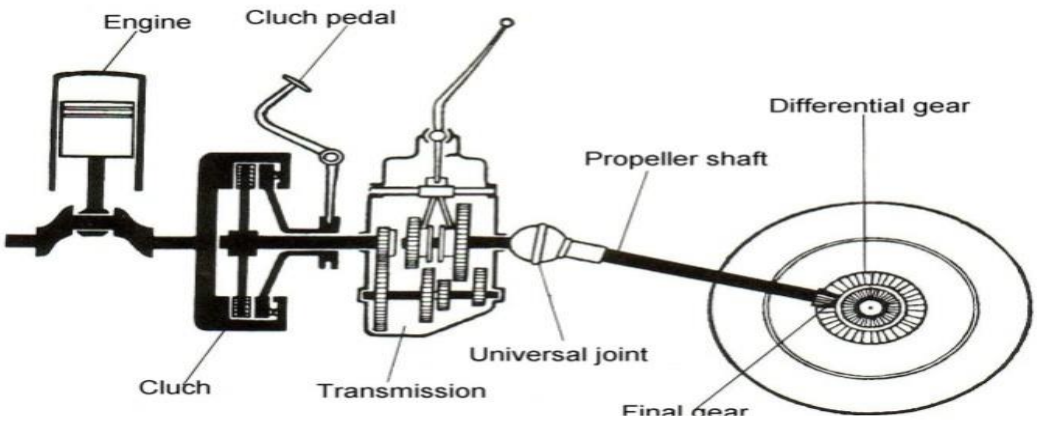


Figure 1.5 Transmissions and drive trains systems

C. Steering system

To improve driving comfort, most modern automobiles have wide low pressure tires which increase the tire to road contact area. As a result of this, more steering efforts is required. Steering effort can be decreased by increasing the gear ratio of steering gear. However, this will cause a larger rotary motion of the steering wheel when the vehicle is turning, making sharp turns impossible.

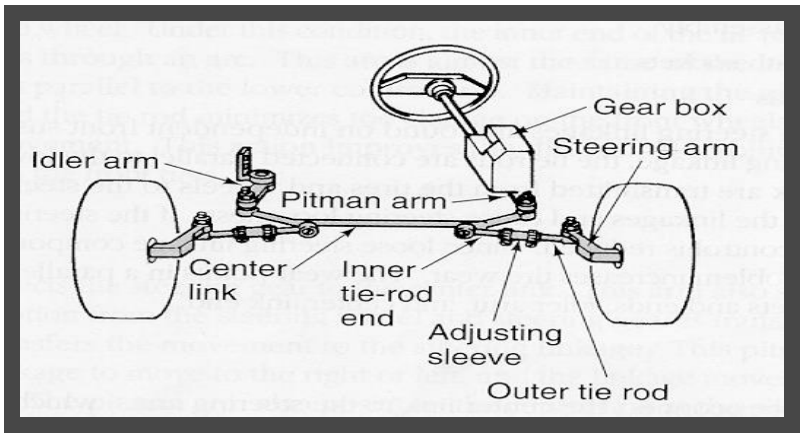


Figure1.6 steering system operation

In all power steering systems hydraulic pressure is provided by a pump mounted near the front of the engine. It is driven by a v-belt from the camshaft pulley. The pump is connected to the control valve by means of two hoses. One hose delivers the hydraulic fluid to the control valve. The second hose returns the fluid to the reservoir.

D. Suspension system

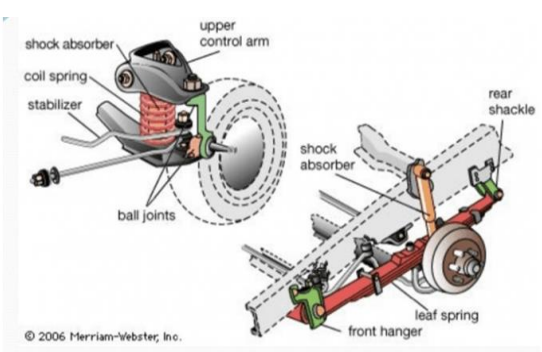
Function of suspension system

The suspension system on a vehicle is between the frame and the road. The suspension system's primary function is to maximize the overall performance of a vehicle as it cruises down the road. The suspension system also helps to absorb bumps in the road and provide a safe and comfortable ride

Principles of Suspension System

The principles of the suspension system are due to springing action of motor vehicles.

1. Supporting the weight of vehicle.
2. Absorbing satisfactorily larger and smaller road impacts with the help of a single springing device.
3. The reduction of rolling or pitching of the body to a minimum design and attachment of springs.



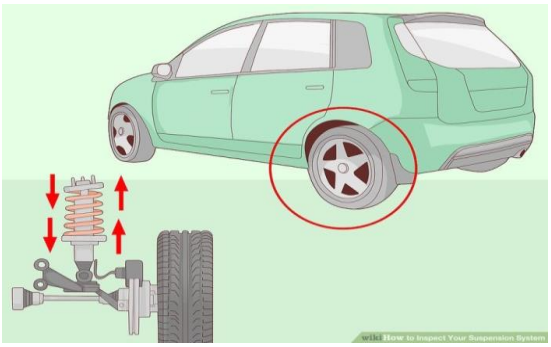


Figure 1.7 Principles of Suspension System

E. **Brake system**

The function Break system

Brake system is to stop or slow down the moving motor vehicle or prevent it from moving when in stationary position. All the braking systems use the force of friction for their operation. Friction opposes the relative motion of the bodies that are in contact with each other is to stop the vehicle within the smallest possible distance and hence this is done by converting the kinetic energy of the vehicle into the heat energy which is dissipated into the atmosphere.

Enabled the vehicle to stop

Brake system enables the vehicle to stop and lowdown.

Braking force takes place when the driver applies pressure and continuous application to the brakes will enable the vehicle to stop.

The following are the methods of stopping the rotational movement of the tires :

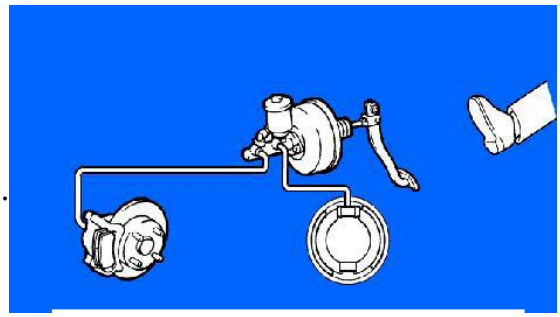


Figure 1.8 Foot brakes

(a) Foot brakes

Foot brakes are used to control the speed and stop the vehicle. Generally, disc brakes are used in the front wheels and disc or drum brakes are used in the rear wheels.

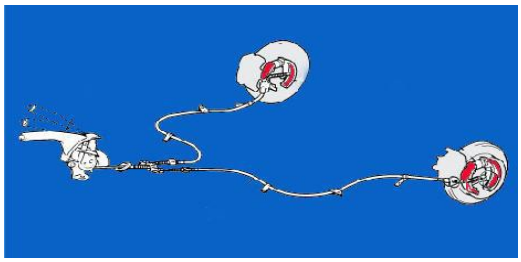


Figure 1.9 Parking brakes

(b) Parking brakes

Parking brakes or handbrakes are mainly used when the car is parked. The mechanical brake system locks the rear wheels.

(c) Engine brake

Engine brake used the retarding effect of engine when the vehicle is in gear and throttle Valve is closed.

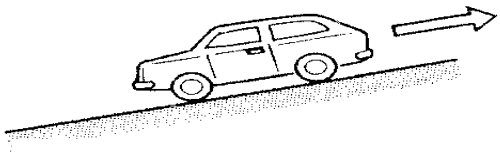


Figure 1.10 engine brakes

Figure 1.11 Engine brake

1.3 Identifying sources of information for mechanic

Sources of information

Information can come from virtually anywhere; personal experiences, books, articles, expert opinions, encyclopedias, the web. The type of information needed will change depending on its application .individuals generate information on daily basis as they go about their work. In academic institution, staff and students consult various source of information. The choice of the source to consult is usually determined by the type of information sought.

In general there are three types of sources of information; primary, secondary and tertiary.it is important to understand these types and to know what type is appropriate for your coursework prior to searching for information.

Primary sources

They are the original documents of an event or discovery such as results of research, experiments or surveys, interviews, letters, diaries, legal documents, and scientific journals articles. Primary sources are also records of events as they are first described.

Primary source are the first formal appearance of results in print or electronic formats example of primary source are: eyewitness account, journalistic report, financial report, government document, archeological and biological evidence, court records, ephemerals (posters, handbills), literary manuscript and minutes of meetings etc.

Secondary sources

Are offer an analysis or is statement of an event or discovery described in primary sources. They interrupt, explain or summarize primary sources. Some secondary sources are used to persuade the reader. Secondary sources may be considered less objectives .Example of secondary source include dictionaries, encyclopedias, textbooks, articles and editorials

Tertiary sources

Definition: tertiary sources consist of information which is a distillation and collection of primary and secondary source generally, tertiary sources are not considered to be acceptable material on which to base academic research. Tertiary sources are usually not credited to a particular author. They are intended only to provide an overview of what the topic includes its basic terminology, and often references for further reading. Some reference materials and textbooks are considered tertiary sources when their chief purpose is to list, summarized or simply repackage ideas or other information. Tertiary source include

Work which list primary and secondary resources in a specific subject area

Work which index, organized and compile citations to, and show secondary and sometimes primary source can be used

Material in which the information from secondary sources has been “digested” reformatted and condensed, to put into a convenient, easy to read form

Source which are once removed in time from secondary sources

Difference between primary, secondary and tertiary sources of information

Timing of the event recorded Rhetorical aim of the written item

Primary sources	Secondary sources	Tertiary sources
• Autobiographies • Correspondence: email, letters • Descriptions of travel • Diaries, • Eyewitnesses • Oral histories • Literary works • Interviews • Personal narratives • First-hand newspaper and magazine accounts of events • Legal cases, treaties • Statistics, surveys, opinion polls, • scientific data, transcripts • Journal articles • Records of organizations and government agencies • Original works of literature, art or music • Cartoons, postcards, posters Map, paintings, photographs, films	• Biographies, Encyclopedias, dictionaries, handbooks • Textbooks & monographs on a topic • literary criticism & interpretation • history & historical criticism • political analyses • reviews of law and legislation • essays on morals and ethics • analyses of social policy • study and teaching material • Articles, such as literature reviews, • Commentaries, research articles in all subject disciplines • Criticism of works of literature, art and music	• Chronologies • Classifications • Dictionaries • Encyclopedias • Directories • Guidebooks and manuals • Population registers statistics • Fact books • Abstracts • Indexes • Bibliographies • Manuals/Guide books

1.3.1 Vehicle workshop manuals

Every technician knows the appropriate type of manuals and their uses as per job requirements. There are different types of manuals according to their use as job requirements. These are

Manufacturer's specification manual

Manufacturer's service manual or sometimes it's called a shop manuals, are written by the automotive manufacturer for the technicians in their dealership. A shop manual covers one model and one year of a vehicle in great detail, sometimes it is printed in a number of volumes. Shop manuals are the best source of detailed service information for specific car.

Shop manuals / service manuals are necessary to obtain the desired specification for specific job. It also provides drawings and photograph to show where and how to perform a certain procedure in a particular car you are working on. Special tools or instrument are listed and shown when they are required. Precautions were given to prevent injury and damage to the parts.



Fig1.12 Typical Cover of a Service Manual

The shop manuals contain three basic types of information. First, there is diagnostic or troubleshooting information. Second, they contain a step-by-step repair procedure. Third, there a specification charts.

Diagnosing or troubleshooting information

Probably the most valuable type of service information comes from the troubleshooting or diagnosing guides. These are designed to help the technician save time in identifying and solving problems.

PROCEDURE INFROMATION

Procedure information gives the steps to follow in doing a repair job. The procedures are usually numbered in a step-by-step order.

SPEFICIFICATION

Specifications are included as part of the service manual. Specifications are technical data, numbers, clearances and measurements used to diagnose and adjust automobile components. Specifications can be referred to as specs. They are usually considered precise measurements under standard conditions. Examples of specifications include valve clearances, spark plug gaps, tire pressure, number of quarts of oil, ignition timing and size of engine.

Owner's manual

An owner’s manual or an operator’s manual is a booklet that comes with a new car. This manual usually explains how to operate the automobile’s control and accessories. In addition the owner’s manual provides a great deal of technical information that can be useful to the technician.

An owner's manual (also called an instruction manual or a user guide) is an instructional book that is supplied with almost all technologically advanced consumer products such as vehicles, home appliances and computer peripherals. Information contained in the owner's manual typically includes:

Repair Manual

A repair manual is most often used by the technician at independent repair shops. This manual is called an aftermarket because it is published by independent publisher and not by the car manufacturer. Like the shop manual. This contains information on troubleshooting, specifications and step-by-step repair procedures. The main difference is that they cover many different car models and years instead of just one. Because they are covering more models and years, they typically cover topics in less detail.

Maintenance Procedure Manual

Procedure information gives the step by step to follow in doing a repair job. The procedures are usually numbered in a step-by-step order.

Periodic maintenance Manual

Performing inspection

Block diagrams, flow charts , maintenance schedules Changing brake parts, Set back maintenance indicator, changing drive belt, Oil and Filter changes, Battery maintenance, wheels Tires, windshield wipers

Structure manual

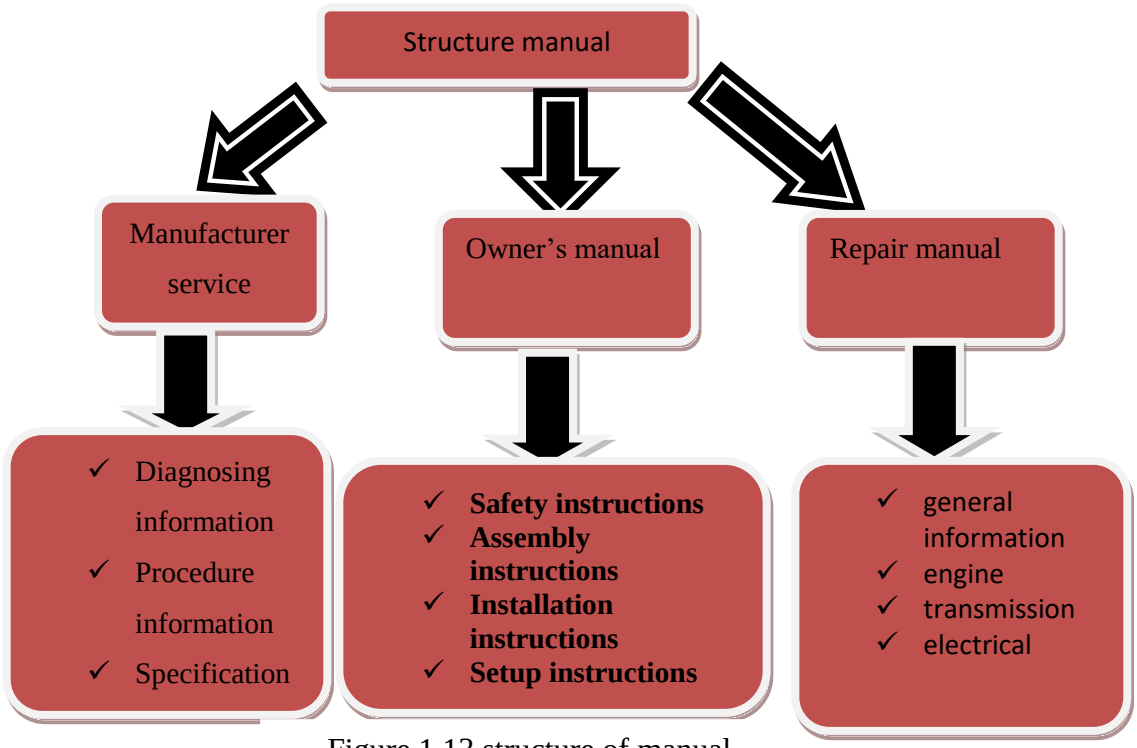


Figure 1.13 structure of manual

1.3.2 Automotive texts and technical articles

We have been providing translations to clients in the automotive industry since 1983. Currently, we translate around 9 million words of automotive copy a year. We offer you high quality, flexible delivery and a virtually 100% deadline guarantee. We can help you with:

- Service manuals
- Handbooks
- Software translation
- Technology marketing

- Technical documents
- Magazine technical articles

The objective for CODE Magazine's technical articles ("How-To Articles") is to teach the reader how to use a certain technology, product, or technique. The author first sets the stage by introducing the scenario to make sure the reader understands what the article is all about and what the pre-conditions are. The author then methodically walks the reader through using the technology, technique, or product. The article focuses on how to do certain things. Articles do not focus on things that do not work. It may at times be beneficial to warn the reader of certain pitfalls and explain how to avoid them, but overall, CODE articles take a positive approach and focus on how to make things happen.

1.3.3 Written instructions automotive

Document workplace procedures

All workplaces use documents to record their business activities. Some documents need to be completed as part of government acts or regulations, while others are developed to ensure the efficient delivery of services and products to customers.

It is important to know which workplace documents, records and forms you will be expected to complete as part of your job.

Click on these headings to learn more about different kinds of workplace documents, forms and procedures, logs, diaries and basic hand-written or typed reports. It may also include entry of information into computer-based documents and forms.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

1. - What is meant by TDC
   A. The extreme top position up
   B. Bottom dead center
   C. The extreme Bottom position
   D. A &C
2. One of the following statement is true about Classification of modern automobiles
   A. Source of energy
   B. Engine construction
   C. Application
   D. All
3. Which vehicle has no propeller shaft that pro vides spacious interiors and comfortable ride
   A. Front engine, Front wheel drive (FF)
   B. Front engine, Rear wheel drive (FR)
   C. Rear engine, Rear wheel drive (RR)
   D. Mishap engine, Rear wheel drive (MR)
4. _____ Is the vehicle's main source of power?
   A. Transmission
   B. Engine
   C. steering system
   D. suspension system
5. Which of the following is primarily needed to perform vehicle maintenance
   a. Manual
   b. Procedure
   c. Safety
   d. Specification

Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. What are primary, secondary and tertiary source of information?
2. List 4 primary, secondary and tertiary sources of information?
3. Write the main Functions of mechanical systems?

Score = _____

Rating: _____

Answer Sheet

Name: _____ Date: _____

1. _____
2. _____
3. _____

Unit Two: Identify operation of system/component

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying Automotive mechanical systems and components
- Identifying safety hazards

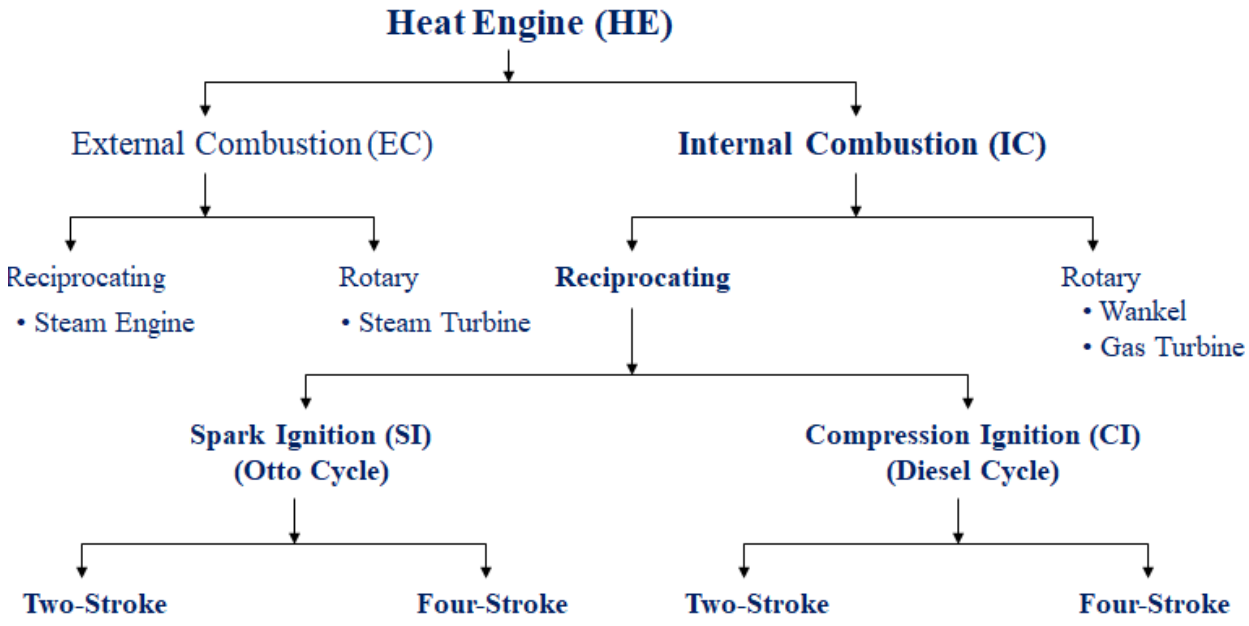
This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify Automotive mechanical systems and components
- Identify safety hazards

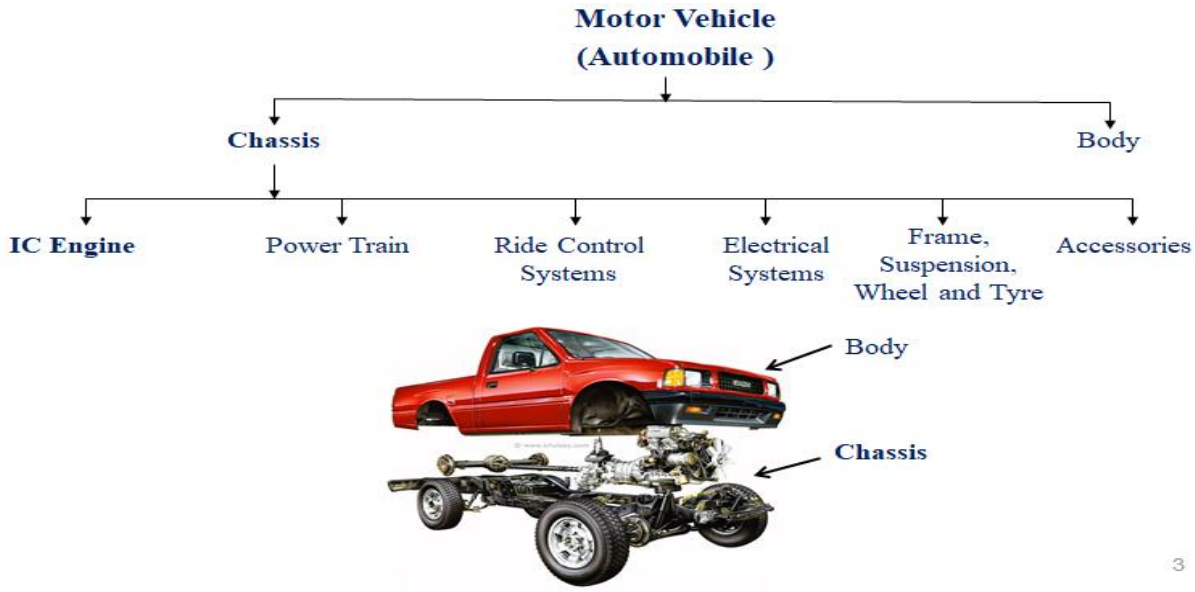
2.1 Automotive mechanical systems and components

2.1.1 Engine systems

A **Heat Engine (HE)** is a **work developing** machine which converts **Thermal (Heat) Energy** into **Mechanical Energy (Work or Power)**.



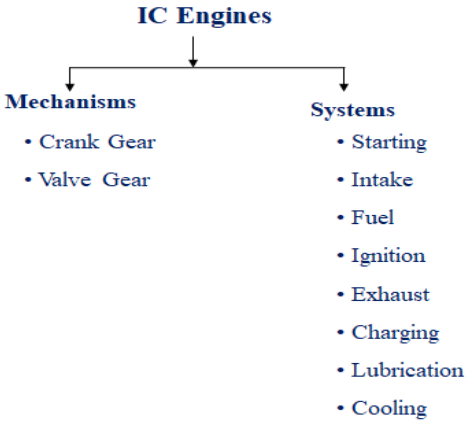
Note: In this course, only '**Reciprocating**' type '**IC Engines (SI 'Otto' and CI 'Diesel')**' will be discussed ! 2



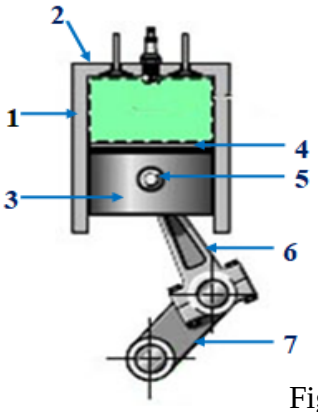
3

Figure 2.1 IC engine

Main Components of IC Engines



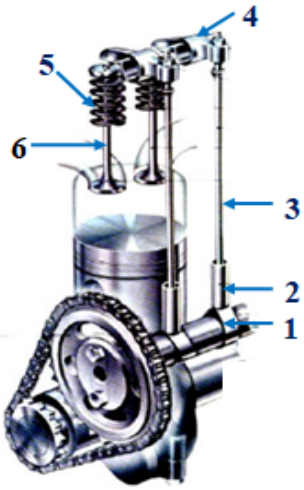
Main component parts (elements) of the **Crank Gear Mechanism (CGM)**



1. Cylinder
2. Cylinder Head
3. Piston
4. Piston Rings
5. Piston Pin
6. Connecting Rod
7. Crankshaft

Figure 2.2 crank gear mechanism

Main components parts (elements) of the **Valve Gear Mechanism (VGM)**



1. Camshaft (Cam)
2. Follower
3. Push Rod
4. Rocker Arm
5. Valve Spring

Figure 2.3 valve gear mechanism

a. Intake system

The intake system is responsible for delivering oxygen, which is necessary for combustion. An intake system generally comprises an air filter, a throttle, and passageways for air to reach the cylinders themselves. There are several main types of intake systems.

Air cleaner: -Which cleans & filters the air before interring the combustion chamber of an engine

Superchargers: -it increases the air pressure into the engine so that more fuel can be burnt & the engine output increases

Intake manifold: -is required to deliver into the cylinder either a mixture of fuel & air From the carburetor or only from the air Cleaner.

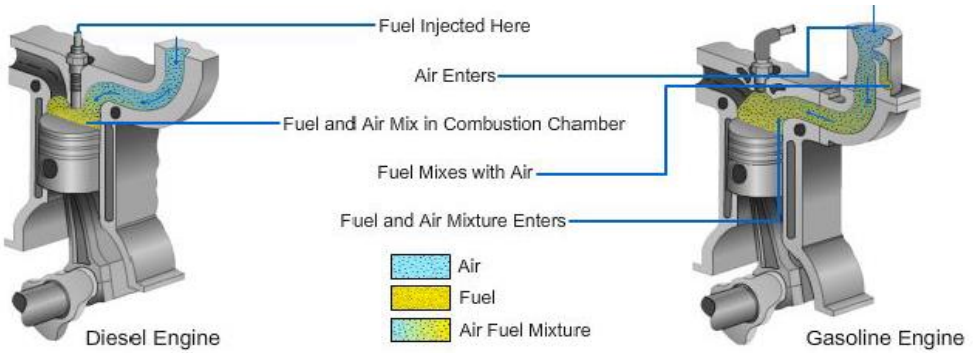


Figure 2.4 Intake system

b. Fuel system compon

The purpose of the fuel supply system for a petrol engine is to store, transfer and filter the petrol required by the float chamber of a carburetor

Fuel system: -which includes the fuel tank, fuel line, fuel filter, fuel pump, carburetor and combustion chamber**.**

Carburetor: - it is a device to mix air with fuel in the proper ratio for the purpose of combustion Petrol is the fuel used in the gasoline engine.

Fuel tank is used as a reservoir & for the reason of safety it is placed at the rear of the car, to prevent it from fire hazards. There is a small filter which is placed in the tank at the end of the line. (Two filter is called strainer)

Which is used to filtered out large particle out of the fuel

The fuel line which allow fuel to reach to the pump & to the carburetor

The full filter is used to filtered out dust particle out of the fuel generally it is located b/n the pump & carburetor, in some model it may be b/n the fuel tank & fuel pump.

Fuel pump: - Which feeds the fuel from the tank to the carburetor through the filter.

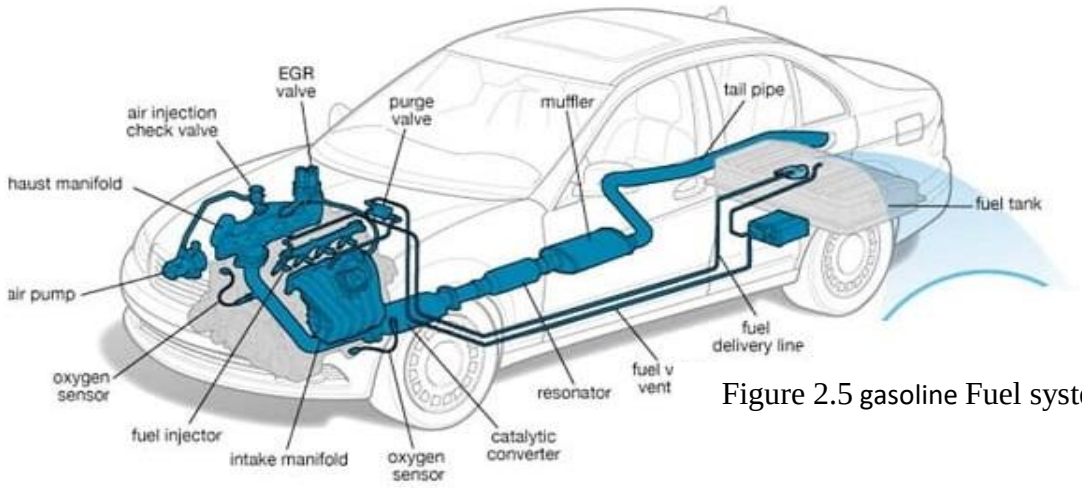
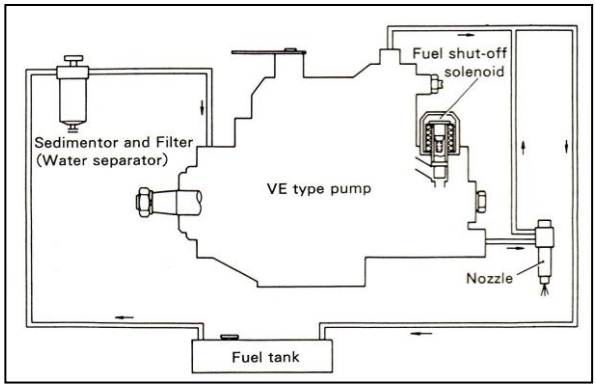


Figure 2.5 gasoline Fuel system components

Diesel Fuel System

Diesel fuel is drawn from the fuel tank through the sedimentor/ water separator and fuel filter by the feed pump, which is incorporated in the front of the injection pump. The feed pump not only supplies fuel to the injection pump, but also circulates fuel to lubricate the moving parts of the pump. The single pump plunger meters and distributes the fuel (under pressure) through the nozzle to the combustion chamber, and does so in the correct combustion order.



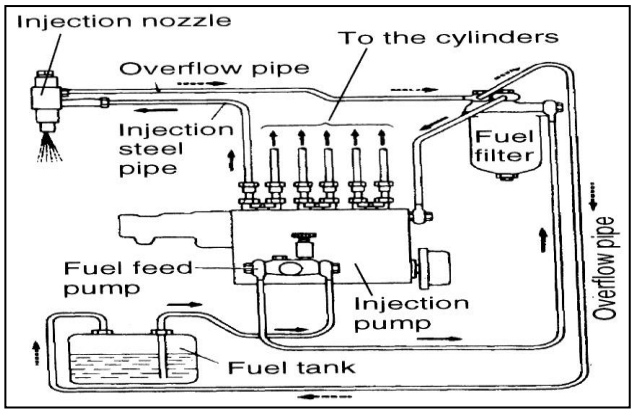


Figure 2.6 diesel Fuel system components

Fuel tank: - It is a reservoir of fuel which is made of sheet metal of sufficient capacity

Fuel Line: - which allow fuel to reach to the pump & to the injector nozzle

Fuel Filter Feed pump It maintains the fuel pressure in the system at a sufficient high level to circulate the fuel

Injection Pump the pump supplies fuel to the injectors according to the firing order at the constant stroke correct time in the cycle.

Nozzle: - A single unit used to meter, atomize & inject the required amount of fuel into the combustion chamber of the cylinder

c. Ignition system

The purpose of the ignition system

The purpose of the ignition system is to produce the high voltage surges required to ignite the compressed air fuel mixture in the engine combustion chamber at the proper instant under all speed and load conditions. The ignition system is supplied a 12 volt or less battery voltage or charging system voltage and increases to 50,000 to 30000 volts required to create a spark across the spark plug electrodes in the combustion chamber.

Operation of the contact point ignition system

When the ignition key is turned on, the primary circuit is completed and current flows through the coil causing magnetic field collapses creating a short pulse of high voltage in the secondary coil the high voltage flows through the distributor cap and rotor to the spark plug in the cylinders that is ready to fire.

Ignition coil: -is used to step up the battery voltage to 20000 & above

High tension cable: - It connect the secondary voltage the step up voltage to the distributor & spark plug

Distributor: --It distributed the high voltage to each spark plug & time the spark

Spark plug: -Convert the electrical volt/current to spark by making the high voltage jumped between to gap

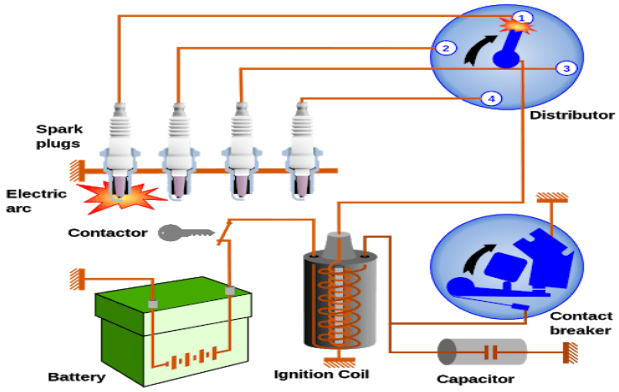


Figure 2.7 ignition system components

d. Cooling system

The engine cooling system keeps the engine maintains its normal operating temperature.

Types of Cooling System

The engine cooling system keeps the engine maintains its normal operating temperature. *Direct Cooling System* – engines with this type of cooling system are also called air-cold engines. During operation, air is drawn by a blower leading to air metal fins or shrouds are the cylinders through air ducts.

Indirect Cooling System– engines with this type of cooling system are also called water-cooled engines.

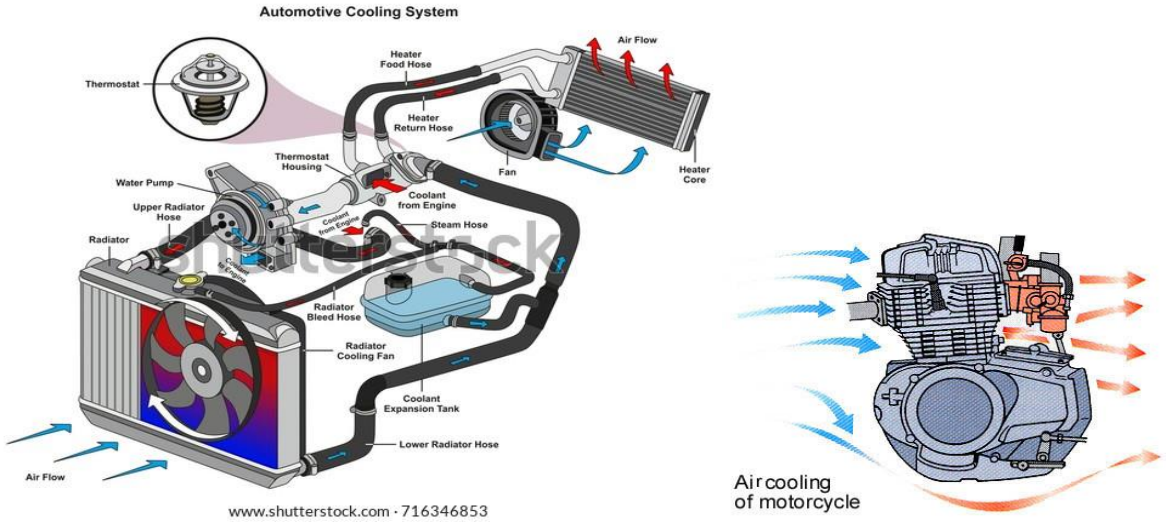


Figure 2.8 cooling system components

Which include the radiator, lower house; water pump, water jacket, thermostat, upper hose and radiator also fan.

Water Pump: -Is a centrifugal type pump, it increases the flow rate of the water

Fan It draws fresh air through the radiator and thus increases the efficiency of the radiator in cooling hot water

Radiator: -The purpose of the radiator is to cool down the water received from the engine, it has three main parts: - upper tank, Lower tank and Tubes

Thermostat:-It is a kind of check valve which opens & closes with the effect of temperature The normal operating temperature of an engine is 80-900c.

Water Jacket: -It provided a way for the coolant to circulate & take off the heat from the engine component.

e. Lubrication System

The engine uses a combination pressure/splash lubrication system, delivering oil under pressure to crankshaft, connecting rod and main bearing surfaces. Other component areas are splash lubricated. A high-efficiency greater oil pump maintains high oil flow and oil pressure, even at low speeds and high operating temperatures. A pressure relief valve limits maximum pressure of system. Oil pan must be removed to service oil\ pickup and oil pump.

Components of Engine Lubrication System:

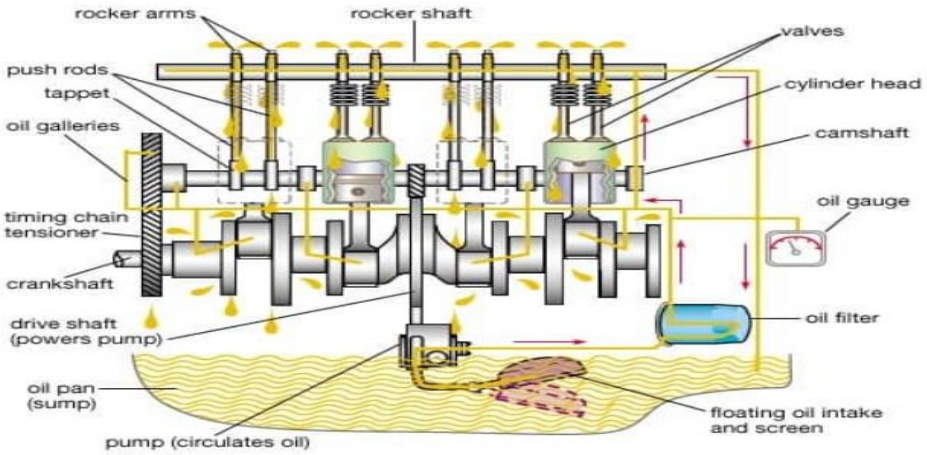


Figure 2.9 lubrication system components

f. Starting system

The purpose of the cranking system

The automotive cranking motor circuit includes the storage battery, the starter switch, the cables to connect the motors and switch, to the battery, and the ground return circuit. The starter motor is a low voltage direct current motor, which converts electrical energy from the storage battery in to mechanical energy. When circuit between the starting motor and the battery is completed by the cranking switch it cranks the engine at speed sufficient to cause the starting of the engine at speeds sufficient to cause starting of the engine.

Battery: -provide electrical power to the starter motor

Switch: -it controls the starter circuit

Starter Motor: -It converts the electrical energy to mechanical energy & rotates the crank shaft with a minimum cranking speed

Ring gear at fly wheel: -it takes the starter motor torque to the engine crank shaft

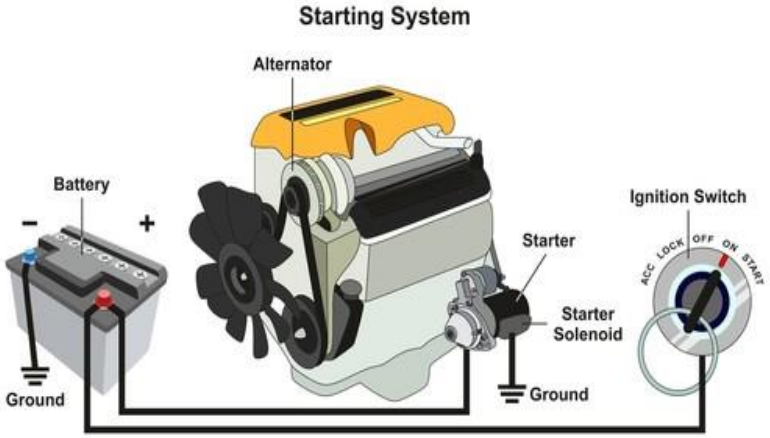


Figure 2.10 starting system components

g. Charging system

This includes the battery, ignition switch and alternator (generator) regulator. It is the system which supply electricity to the electrical load & charge the battery after the engine is started

Battery: -It is the primary sources of electricity to the vehicle

Switch: -Which operate the circuit of the charging system

Alternator: - Which convert the mechanical energy of the engine to electrical energy

Regulator: - It makes the output of the alternator not mover than 12v.

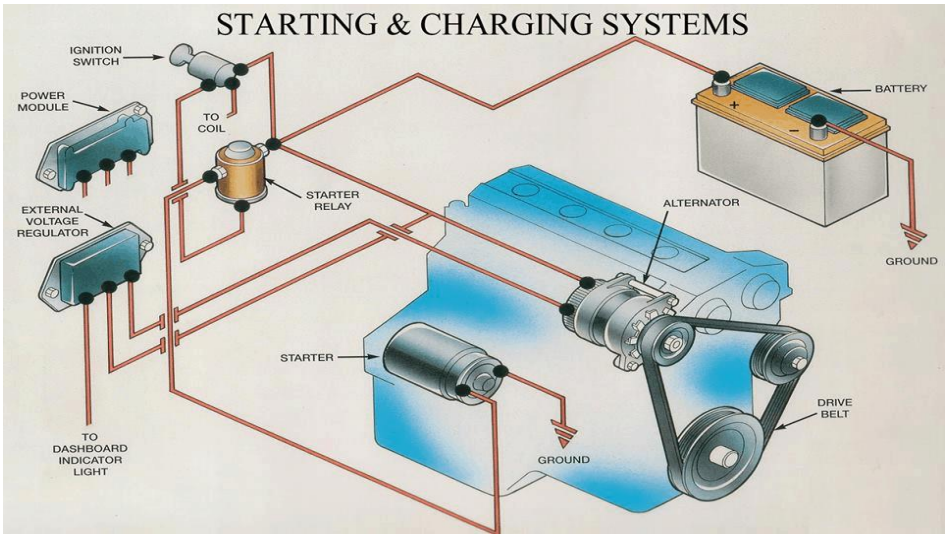


Figure 2.11charging system components

h. Exhaust system

Exhaust system: - The exhaust system collects exhaust gases from the engine & expels them out. It consists of: -

Exhaust Manifold The exhaust manifold is made of cast iron and is bolted over the exhaust ports of the engine, usually alongside the intake manifold pipe. It provides heat to the intake manifold. This heat further vaporizes the fuel in the intake manifold.

Exhaust Pipe The exhaust pipe is a long pipe leading from the exhaust manifold to the muffler.

Catalytic converter It is discussed under exhaust gas treatment.

Muffler The exhaust gas emerges in a pulsating flow and therefore causes marked vibration in the exhaust pipes and mufflers (silencers).

Resonator It is used to further muffle the noise of the exhaust gases. It is also called secondary muffler.

Tail Pipe The tail pipe is a pipe that carries the exhaust gases from the muffler to the rear of the vehicle. This pipe may be a separate unit or an integral part of the muffler when the muffler is located near the rear of the vehicle.

Turbo Charger: - Is an exhaust gas driven turbine which drives a centrifugal compressor wheel

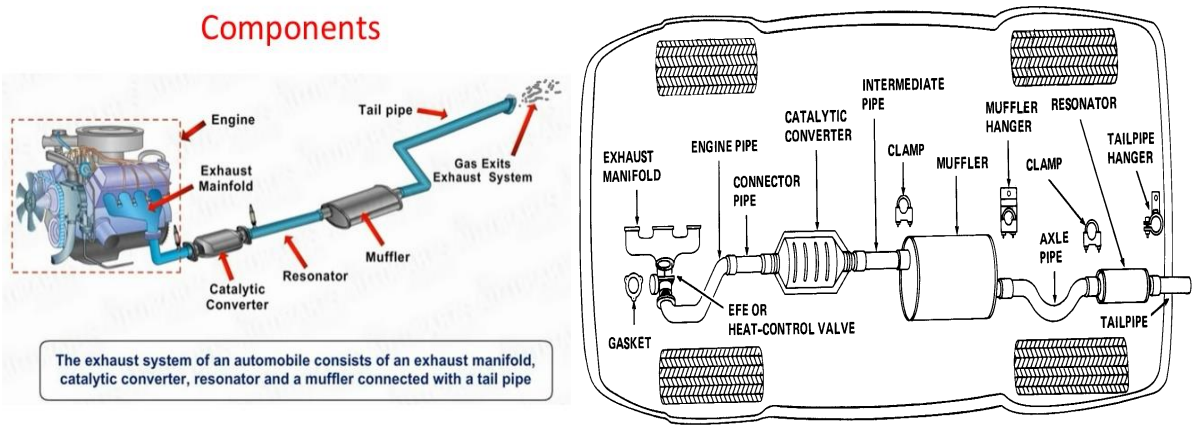


Figure 2.12 exhaust system components

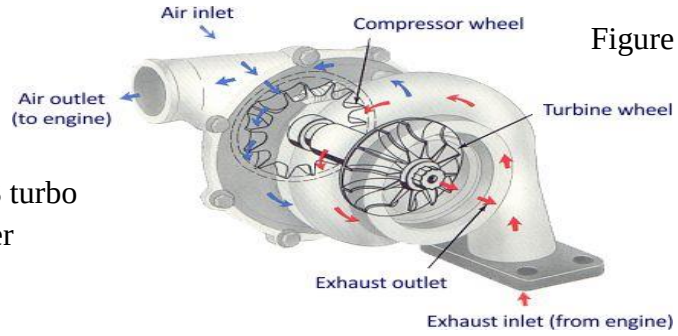


Figure 2.13 turbo charger

2.2.2 Transmissions and drive trains

The drivetrain includes the transmission, the driveshaft, the axles, and the wheels. Simply put, it works in conjunction with the engine to move the wheels. The drivetrain system is an essential component of a vehicle and the transmission is an integral part of the drivetrain.

There are four different types of drivetrains:

- All-wheel drive
- Four-wheel drive
- Front-wheel drive
- Rear-wheel drive.

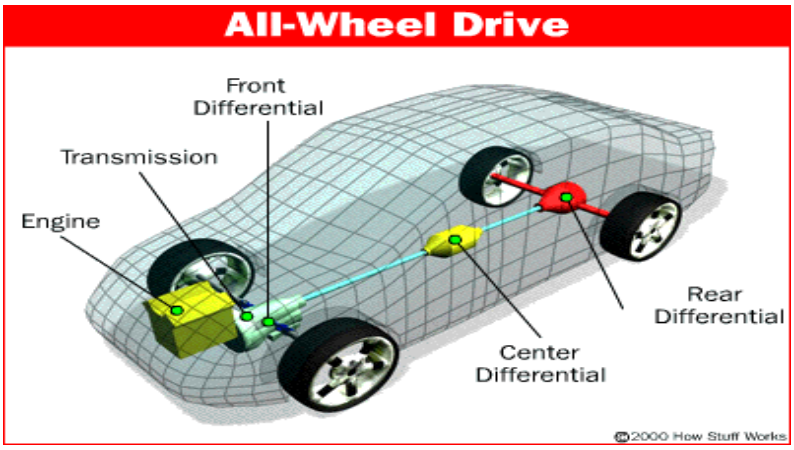
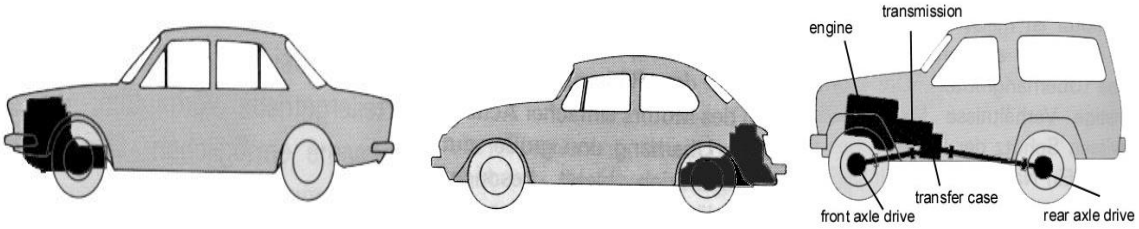
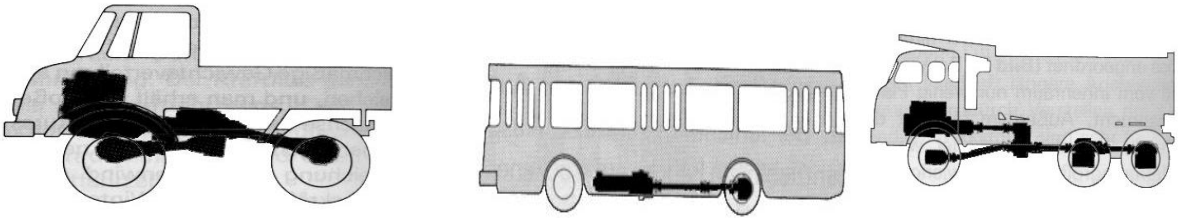


Figure 2.14 All-wheel drive



FFWD **RRWD** **4WD (four wheel drive),**



4WD truck **under floor engine, bus** **6WD, truck**

Figure 2.15 different drive line operation

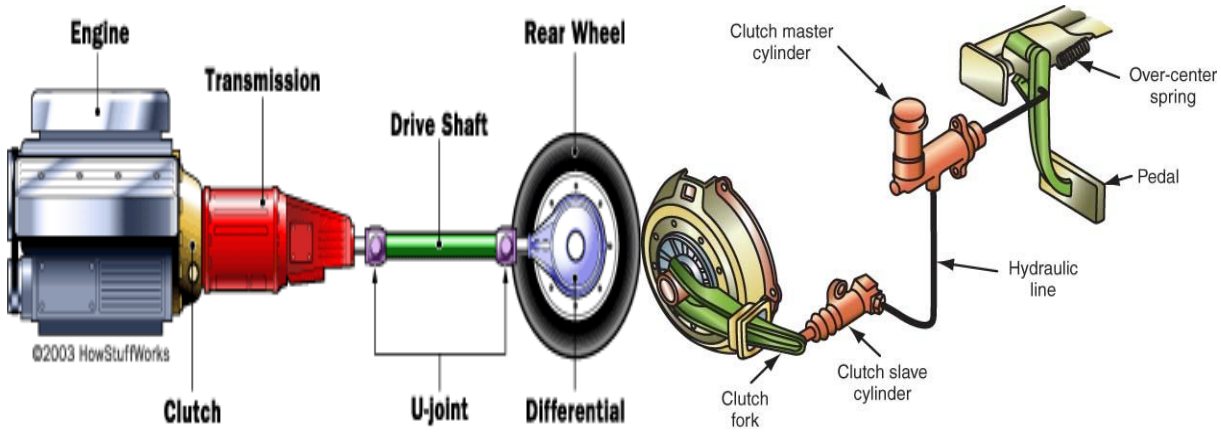
Parts and Components of drivetrains

The driveshaft also referred to as the drive shaft, propeller shaft, or prop shaft—is the first driveline component.

Differential(s). The differential is the driveline component that transmits torque to the wheels.

- Axle shafts.
- U-joints.
- CV joints.

Figure 2.16 Drive trains



2.2.3 Steering system

Types of a steering system

There are two main types of steering gears used for most modern vehicles:

1. The rack and pinion steering gear and

2. The recirculating ball steering gear.

Rack and pinion steering:- uses a gear-set to convert the circular motion of the steering wheel into the linear motion required to turn the wheels. It also provides a gear reduction, so turning the wheels is easier.

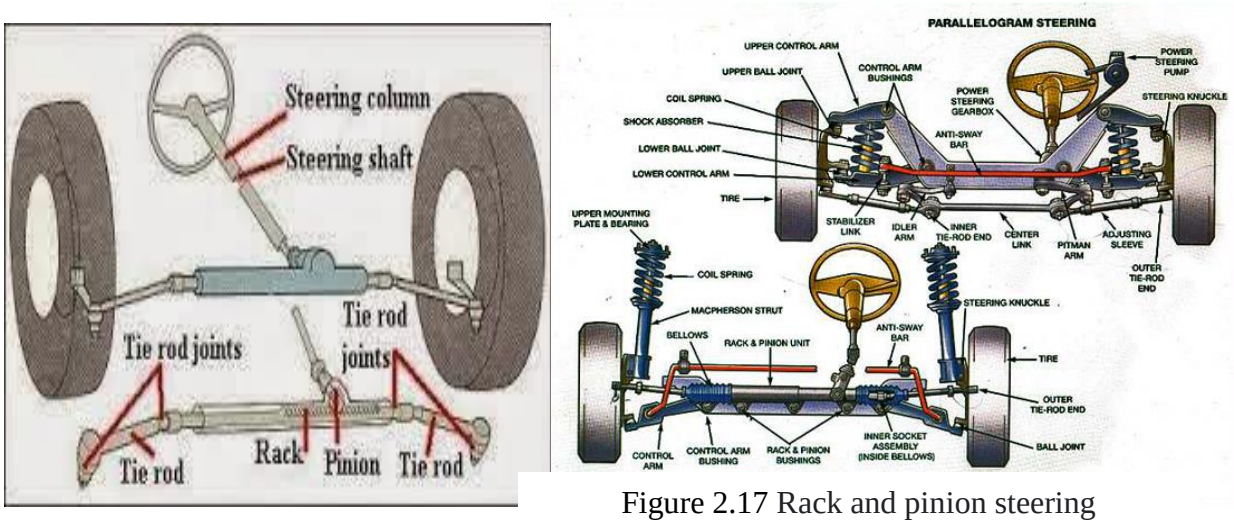


Figure 2.17 Rack and pinion steering

2.2.4 Suspension system

The primary functions of the suspension system include maximizing the contact between the tires and the road surface, providing steering stability and good handling, evenly supporting the weight of the vehicle (including the frame, engine, and body), and ensuring the comfort of passengers by absorbing and dampening

Components of Suspension System

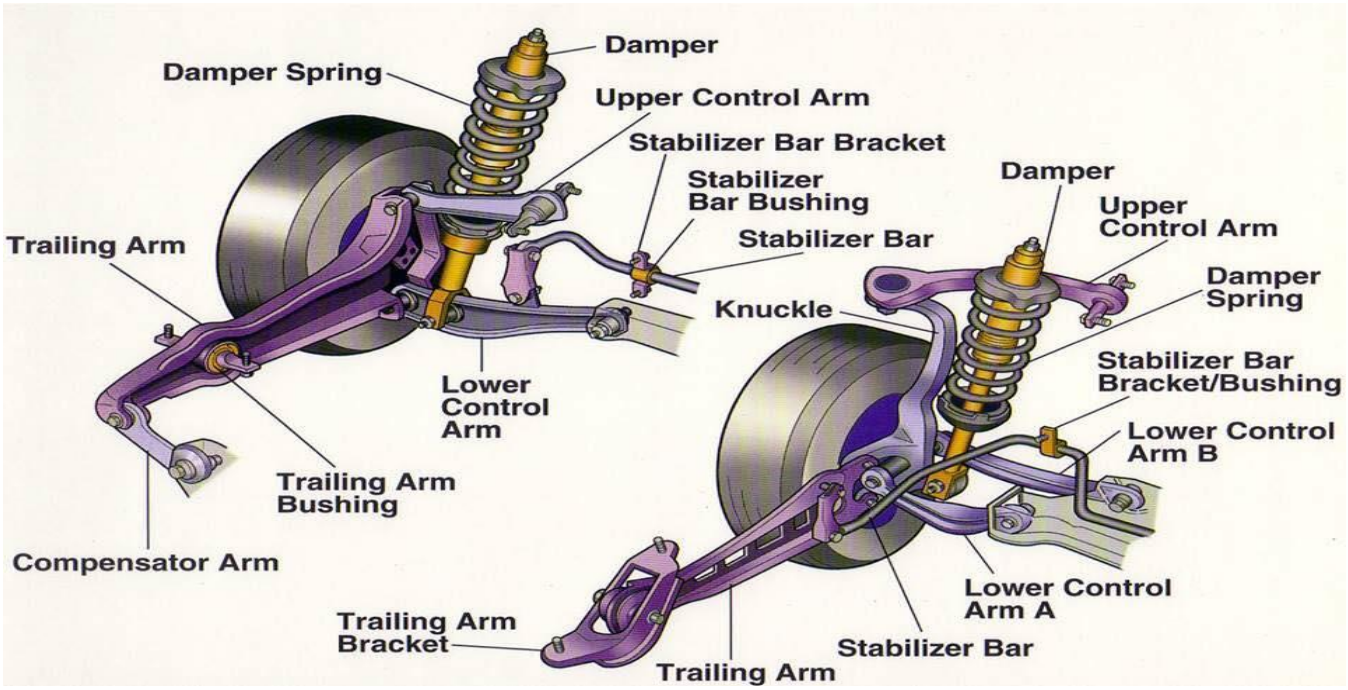


Figure 2. 18 Suspension system

2.2.5 Brake system

Types of Break system

- The drum brake
- Disc brakes

Advantages of drum brakes over disc brakes

- Since the force is applied to the brake shoe at one end and the shoe is pivoted at the other, the resulting high leverage represents an internal increase in application force. Further more
- Lining friction generates a torque, which presses the leading brake shoe more firmly against the drum wall and therefore boosts, the braking action. On the trailing shoe however, the friction created at the rotating drum has the opposite effect, that is to say it reduces shoe contact pressure.
- It is protected against dirt to a large extent since the drum brake is housed inside the dished area of the road wheel
- It is an easy matter to install a mechanically operated parking brake

Disadvantage

- Relining work takes longer than on the disc brake
- It is more difficult to provide any form of automatic compensation
- There is a problem of in the disposal of lining dust
- There is heat dissipation problem. Drum brakes suffer badly from fading, that is to say a drop in braking effect when the brake overheats, for instance during a long period of continuous braking. At the same time, the drum expands much more rapidly than the brake shoe with its lining, so that the lining curvature is too severe to make full contact with the drum surface.

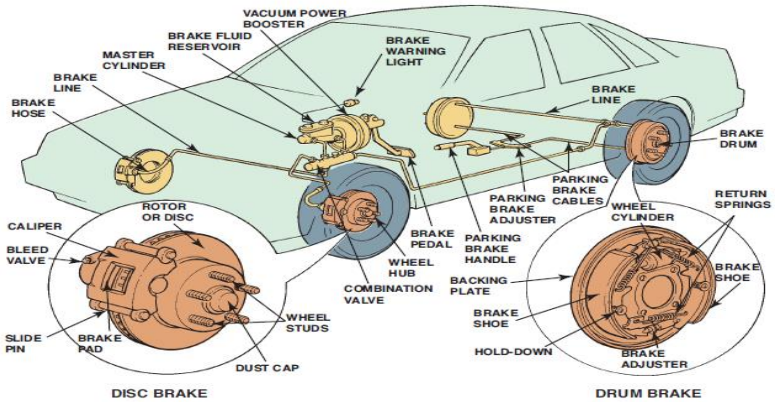


Figure 2.19 Types of Break system

2.2 Identifying safety hazards

2.2.1 Electricity and water

Electrical safety is a system of organizational measures and technical means to prevent harmful and dangerous effects on workers from electric current, electric arc, electromagnetic field and static electricity Avoid water at all times when working with electricity. Never touch or try repairing any electrical equipment or circuits with wet hands. It increases the conductivity of the electric current.

Electric shock safety

- Turn off power at the main breaker.
- Call an ambulance.
- Don't touch the victim until you are certain there is no live electricity. (Never move someone if they are touching a power line or other high-voltage current.)
- If the victim is not breathing, begin mouth-to-mouth.
- If the victim has no pulse, begin CPR

Electrical Tool Safety

1. Do not use power equipment or tools on which you have not been trained.
2. Keep power cords away from the path of vacuum cleaners, floor polishers and grinders.
3. Do not carry plugged in equipment or tools with your finger on the switch.
4. Do not carry equipment or tools by the cord.
5. Disconnect the tool from the outlet by pulling on the plug, not the cord.
6. Turn the tool off before plugging or unplugging it.
7. Do not leave tools that are "On" unattended.
8. Do not handle or operate electrical tools when your hands are wet or when you are standing on wet floors.
9. Turn off electrical tools and disconnect the power source from the outlet before attempting repairs or service work. Tag the tool "Out of Service".
10. Do not drive over, drag, step on or place objects on a cord

Electricity and Water: A Dangerous Combination

Electricity would travel through the water and through you to the ground. This is why it's so important to keep all electrical appliances away from water, and to make sure your hands are dry and you are not standing in water when you touch anything electrical

Depending on the job task to be performed, PPE for the electric power industry generally includes safety glasses, face shields, hard hats, safety shoes, insulating (rubber) gloves with leather protectors, insulating sleeves, and flame-resistant (FR) clothing.

10 Tips – How to avoid getting shocked when working with electricity at home?

1. Never mix water and electricity. ...
2. Pay attention to what your appliances are telling you. ...
3. Install Ground Fault Circuit Interrupters (GFCI). ...
4. Make sure you're using the right size circuit breakers and fuses. ...
5. Protect kids with outlet covers

2.2.2 Toxic substances

There are generally four types of toxic entities; chemical, biological, physical and radiation.

Scale is the main scale used to measure toxicity

Here are some examples of natural toxic chemicals:

- Mercury.
- Snake venom.
- Caffeine in coffee, tea, kola and cocoa.
- Arsenic.
- Ricin from castor beans.
- Petroleum.
- Hydrogen sulfide.
- Chlorine gas.

2.2.3 Spillages or damaged equipment.

A manufacturing or design defect in the equipment can increase the risk of an accident. Workers who have been injured by a piece of defective equipment may have another source of compensation. They may be able to name the manufacturer or distributor of the equipment in a third party lawsuit.

Faulty equipment is any type of mechanical or electronic equipment that is dangerous or unsafe to use. This usually refers to equipment used in the workforce for producing or manufacturing products. Faulty equipment is responsible for several types of on the job injuries each year

Identifying faulty portable electrical tools and equipment

- a competent person regularly electrically testing and inspecting tools, extension leads and portable electrical equipment — inspection tags should be fitted;
- recording inspection details in an equipment register;
- tagging out and removing all faulty equipment for repair or disposal; and

Faulty equipment Harm can be caused when exposed to 'live parts' or through conducting objects or materials. Faulty or overloaded equipment can lead to fires which can cause damage, injuries and loss of life.

2.2.4 Flammable materials and fire hazards

Flammable liquids and fire risk. Petrol and other fuels, as well as many common products like solvents, thinners, cleaners, adhesives, paints, waxes and polishes, are highly flammable and there's a high risk of fire and/or explosion if there is a source of ignition nearby.

Flammable and combustible liquids are liquids that can burn Under the Workplace Hazardous Materials Information System (WHMIS) 1988, flammable liquids have a flashpoint below 37.8°C (100°F)

Keep in mind:

- Do not attempt to lift by bending forward. Bend your hips and knees to squat down to your load, keep it close to your body, and straighten your legs to lift.
- Never lift a heavy object above shoulder level.
- Avoid turning or twisting your body while lifting or holding a heavy object

Check out these safe lifting and handling tips, recommended by the Health and Safety Executive.

- Think before you lift
- Keep the load close to the waist
- Adopt a stable position
- Ensure a good hold on the load
- Don't bend your back when lifting
- Don't bend the back any further while lifting
- Don't twist when you lift.

Spillages

In industrial production, spillages is a loss of production output due to production of series defective or an acceptable product which must be rejected

The following steps should be taken during spill cleanup.

- Prevent the spread of dusts and vapors. ...
- Neutralize acids and bases, if possible. ...
- Control the spread of the liquid. ...
- Absorb the liquid. ...
- Collect and contain the cleanup residues. ...
- Dispose of the wastes. ...
- Decontaminate the area and affected equipment

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Instruction I choose the correct Answer Questions

1. Mechanic A says that "Adding a turbocharger is one way to increase output power of diesel engines."

   Mechanic B says that "Adding a turbocharger is one way to decries output power of diesel engines." which mechanic is correct?

   A. Mechanic A only
   B. Mechanic B only
   C. Mechanic A nor Mechanic B
   D. All

2. Measures the amount of oil in the engine sump by what.

   A, Dipstick B, Oil Gallery C, Pressure Gauge D, oil filter

3. Viscosity of oil is expressed by

   A, engine oil B, viscosity C, number D, all

4. Witch statement is true about air cleaner?

   a. To reduce noise c. it captures moisture
   b. To control the flow of fuel d. it act as a flame arrestor

5. Witch statement is <u>false</u> about cooling system?

   a. To reduce engine temperature c. to prevent engine overheating
   b. To control the flow of oil d. effective combustion

6. _____ it increases the air pressure into the engine so that more fuel can be burnt & the engine output increases

   A. Supercharger B .Turbocharger C. Air cleaner D. None

7. One of the following components <u>is not</u> Flammable liquids and fire risk

   A. Petrol B. solvents C. paints D. All E. none

8. Which type of toxic entities

   A. Chemical B. biological C. Physical D. Radiation E. All

9. Which system is maximizing the contact between the tires and the road surface, providing steering stability and good handling other

   a. Brake system B. steering system C. Suspension system D. Engine system

10. Which part is exhaust gas treatment?

a. Catalytic converter B. Turbo Charger C. Exhaust Manifold D. All

11. It converts the electrical energy to mechanical energy & rotates the crank shaft with a minimum cranking speed

A. Starter Motor B. Battery C. Alternator D. Turbo Charger D. All

12. What is the possible fault of Brake Warning Light On

B. A It could also be a faulty sensor or electrical fault

B. Fill up the brake fluid reservoir,

C. check for leaks, normal brake pedal operation

D.ALL

Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Write mechanical systems /component?
2. What are Toxic substances?
3. List Flammable materials and fire hazards?

Operation sheet 2.1

Operation title: check Engine operation systems

Instruction:

- ✓ make Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Purpose: Ensure a correct inspection to operate the condition of engine.
Required tools and equipment: Work area, wrench, hammer, screw driver
Consumable Materials: Safety poster, first aid kit, waste bin, engine fluid kerosene
Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Procedures:

1. Before road-testing the car, check the tires for specified inflation pressure and for abnormal wear.
2. Check for proper operation of the instruments-panel warning lights, gauges, and information displays.
3. Note any unusual noise, vibrations or hardness heard or felt during the road test.
4. Check the headlights and horns to make sure they work. Check all other lights. Replace burned-out bulbs. Check headlights aim, if necessary.
5. Visual inspection should always be your first step in checking the charging system. Check for proper electrolyte level and state of charge. When fully charged,
6. Check the battery terminals and cables. The terminals should be free of corrosion and the cable connections tight.
7. Check the Fuses and Fusible Link • Check the Fuses for Continuity.
8. Check Engine Coolant Level At Radiator Reservoir
9. Check Engine Coolant Quality
10. Check Engine Oil Quality
11. Check Engine Oil Level
12. Check Oil Pressure
13. Start Engine And Check For Oil Leaks
14. Check for belt separation, cracks, fraying, or glazing. If necessary, replace the drive belt.
15. Check the drive belt tension using the proper tension gauge, Nippondenso BTG-20
16. Check the wiring and connections. Replace any damaged wires, tighten any loose connections.
17. Check for abnormal noises. Squealing may indicate drive belt or bearing problems. Defective diodes can produce a whine or hissing noise because of a pulsating magnetic field and vibration.
18. CHECK THE WARNING LAMP CIRCUIT • with the engine warm and all accessories off, turn the ignition to ON. The warning lamp should light.
19. With the engine started and the ignition in RUN, the warning lamp should be off.
20. If the lamp does not operate as specified, check the bulb and check the lamp circuit.

Quality criteria: operate all activates without any damage and according to specifications

Operation sheet 2.2

Operation title: check Transmissions and drive trains operation systems

Instruction:

- ✓ make Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Purpose: Ensure a correct inspection to operate the condition of transmission and drive trans.

Required tools and equipment: Work area, wrench, hammer, screw driver

Consumable Materials: Safety poster, first aid kit, waste bin, brake and steering fluid kerosene

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Procedures:

1. Before road-testing the car, check the tires for specified inflation pressure and for abnormal wear.
2. Check for proper operation of the instruments-panel warning lights, gauges, and information displays.
3. Check the CV joints for noise and smooth operation. If a CV-joint boot is torn, check for grit in the grease and for joint wear.
4. Check the operation of the clutch and manual transmission or transaxle. Note the shift timing and shift quality in a vehicle with an automatic transmission or transaxle.
   Note any unusual noise, vibrations or hardness heard or felt during the road test.
5. Check lever Hard to shift or will not shift
6. Check clutch pedal height
7. Check Clutch pedal free play
8. Check For air in clutch line
9. Check clutch line
10. Check clutch Master cylinder
11. Check **TRANSMISSION OIL there is linkage or not**
12. Check the oil level. Automatic transmission oil has large thermal expansion characteristic
13. Check **differential OIL there is linkage or not**
14. Check whether each actual gear conditions are synchronized with each shift positions on the shift lever, or not. (To prevent miss shift, needs to refer manual.)
15. Check the engine to starts only with the shift position “P” and “N”, or not

Quality criteria: operate all activates without any damage and according to specifications

Operation sheet 2.3

Operation title: check Steering operation systems

Instruction:

- ✓ make Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Purpose: Ensure a correct inspection to operate the condition of steering systems.

Required tools and equipment: Work area, wrench, hammer, screw driver

Consumable Materials: Safety poster, first aid kit, waste bin, steering fluid kerosene

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Procedures:

1. Check the steering system for ease and smoothness of operation.
2. Check for excessive play in the steering system.
3. Note any unusual noise, vibrations or hardness heard or felt during the road test.
4. Check the power steering fluid level.
5. Check the hoses and lines around the power steering pump for possible leaks.
6. Lift the front end of the car with a jack. Check the seals of the rack and pinion for leaks. If you have an older car, you may have a recirculating ball unit to check instead.
7. Check for loose belts.

ROAD TEST

After adjusting the front axle, suspension, steering and/or front wheel alignment, carry out the following road test to check the result of the adjustment.

1. STRAIGHT- AHEAD DRIVING

- The steering wheel must be at the correct position during straight- ahead driving
- When driving on a flat road, the vehicle should run straight ahead without pulling to the left or right.
- Excessive steering shimmy or flutter should occur.

2. TURNING

- The steering wheel should turn easily in either direction, and should return quickly and smoothly to the neutral position when released.

3. BRAKING

- The steering wheel should not pull to either side when the vehicle is braked on a flat, smooth road.

4. CHECKING FOR ABNORMAL NOISE

- No abnormal noise must be heard during test. Also the steering and suspension components must not come into contact with chassis or body when the steering wheel is fully rotated.

Quality criteria: operate all activates without any damage and according to specifications

Operation sheet 2.4

Operation title: check Suspension **operation systems**

Instruction:

- ✓ make Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Purpose: Ensure a correct inspection to operate the condition of suspension systems.

Required tools and equipment: Work area, wrench, hammer, screw driver

Consumable Materials: Safety poster, first aid kit, waste bin, kerosene

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Procedures:

1. Before road-testing the car, check the tires for specified inflation pressure and for abnormal wear. Abnormal wear would mean suspension trouble and the need for wheel alignment.
2. Check for proper operation of the instruments-panel warning lights, gauges, and information displays.
3. Check the suspension system for looseness, excessive play and wear.
4. Check the front-suspension ball joints for excessive wear.
5. Check for loose wheel bearings at the non-driving wheels. Adjust the wheel bearings if necessary.
6. Note any unusual noise, vibrations or hardness heard or felt during the road test.
7. Inspecting your shocks for leaks, cracks or other damage;
8. Looking for vehicle bounce, nose dives, squats or rolls;
9. Spinning the tires manually to see if there is any wobble, imbalance or uneven tire wear;
10. Checking for leakage from any of the steering components;
11. Ensuring the tension in the power steering pump belt is correct;
12. Bouncing the car to see if your shocks or struts are functioning correctly.

Quality criteria: operate all activates without any damage and according to specifications

Operation sheet 2.5

Operation title: check Brake **operation systems**

Instruction:

- ✓ make Safe working area
- ✓ Properly operated tools and equipment
- ✓ Appropriate working cloths fit with the body

Purpose: Ensure a correct inspection to operate the condition of brake systems.

Required tools and equipment: Work area, wrench, hammer, screw driver

Consumable Materials: Safety poster, first aid kit, waste bin, brake fluid kerosene

Precautions:

- ✓ Wearing proper clothes, eye glass, glove
- ✓ Make working area hazard free
- ✓ Read and interpret manual which guide you how to use tools and equipment

Procedures:

1. Check for Proper Operation of the Instruments-Panel Warning Lights, Gauges, and Information Displays.
2. Check The Brakes For Even And Adequate Braking.
3. Note Any Unusual Noise, Vibrations Or Hardness Heard Or Felt During The Road Test.
4. Check Brake Fluid
5. Brake Noise.
6. Vibration
7. Abnormal Pad Wear.
8. Check Pedal Height
9. If Necessary, Adjust Pedal Height
10. Check Pedal Free play
11. Check That Parking Brake Lever Travel
12. If Necessary, Adjust Parking Brake Lever Travel

Quality criteria: operate all activates without any damage and according to specifications

LAP test 1	Performance test

Name…… ID…… Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **6** hour. The project is expected from each student to do it.

Task 1: Trace suitable automotive systems and components

Task 2: Identify automotive systems and components

Task 3: Identify principles of operation

Unit Three: Locate system or component on vehicle

This unit to provide you the necessary information regarding the following content coverage and topics:

- Tracing suitable automotive systems and components
- Confirming location of systems or components

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Trace suitable automotive systems and components
- Confirm location of systems or components

3.1Tracing suitable automotive systems and components

a. Engine system

An Engine is a mechanical device used to convert heat energy into mechanical energy. And is usually called a Heat Engine.

1 - Distributor
2 - Valve cover
3 - High tension cables
4 - Tappet
5 - Air cleaner
6 - Timing pulley
7 - Camshaft
8 - Water pump
9 - Timing belt
10 - Connecting rod
11 Crankshaft pulley
12 - Oil sump 13 - Strainer
14 – Crankshaft 15 - Engine block
16 – piston 17 - exhaust manifold
18– Valve 19 - Cylinder head

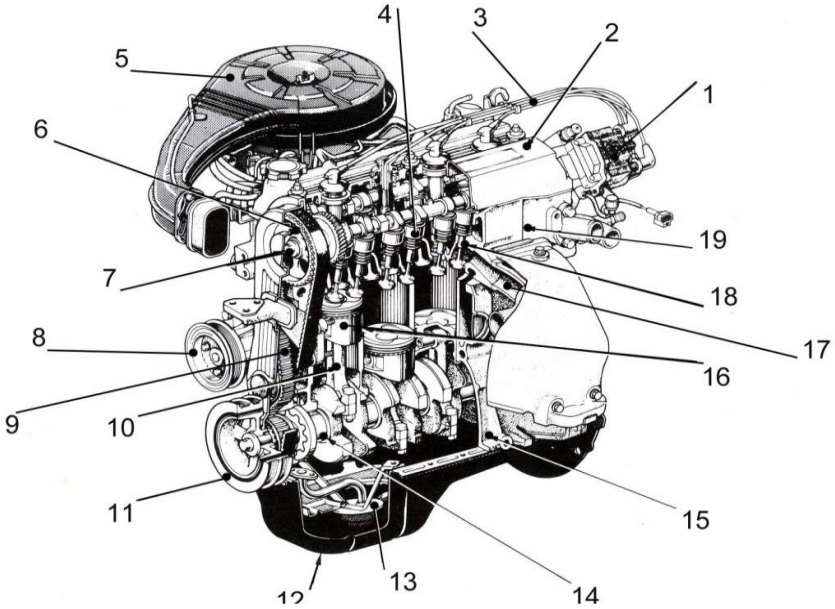


Figure 3.1 location of engine components

b. The Drivetrain and the Transmission

The drivetrain and the transmission are actually two very different concepts. The main function of the transmission is similar to the chain on a bicycle: it keeps the engine turning in time with the wheels, regardless of what gear the vehicle is in. The drivetrain represents everything that is behind the transmission involved in propelling the vehicle. The main function of the drivetrain is basically to convey power from the vehicle's engine, through the transmission to the drive wheels on the vehicle to control the amount of torque. "Torque" is turning or twisting force.

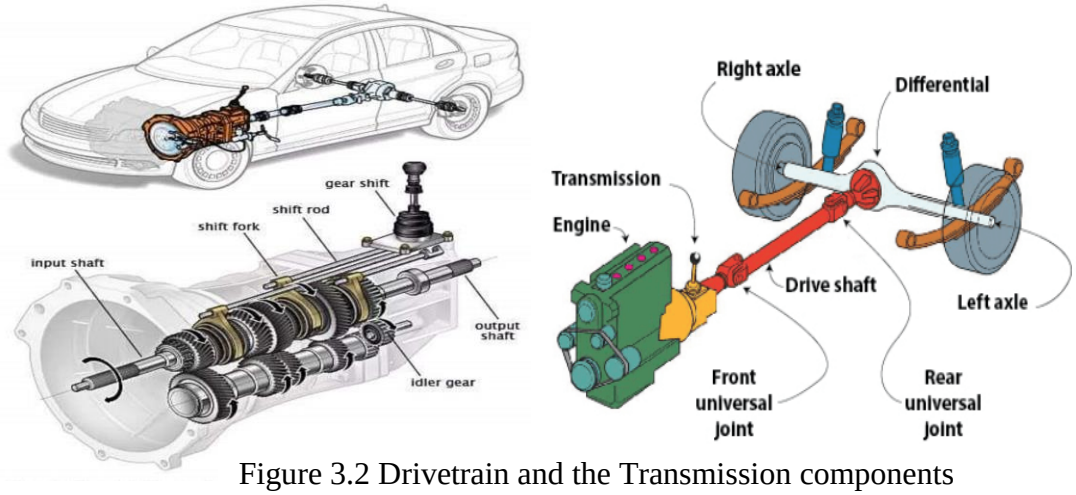
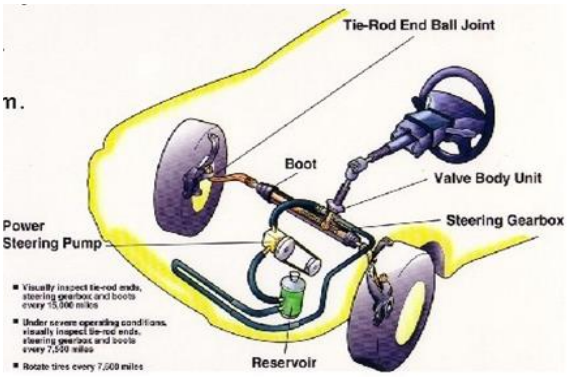


Figure 3.2 Drivetrain and the Transmission components

c. Steering System

In front wheels can be turned to left and right by steering system so that the vehicle can be steered. The steering wheel is placed in front of driver. It is mechanically linked to the wheels to provide the steering control. The primary function of the steering system is to provide angular motion to front wheels so that vehicle can negotiate a turn. It also provides directional stability to vehicle when the vehicle moves ahead in straight line.



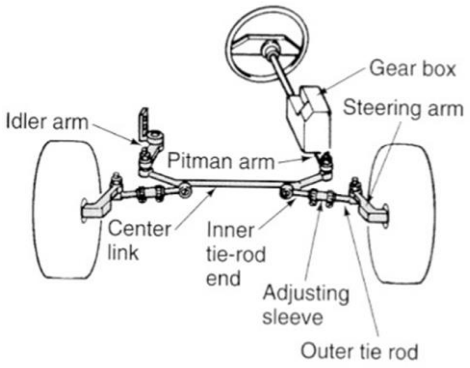


Figure 3.3 location of steering system components

d. Suspension System

A suspension system also maintains the stability of the vehicle in pitching or rolling when vehicle is in motion. It supports the body on the axles and maintains the proper geometrical relationship between the body and wheels.

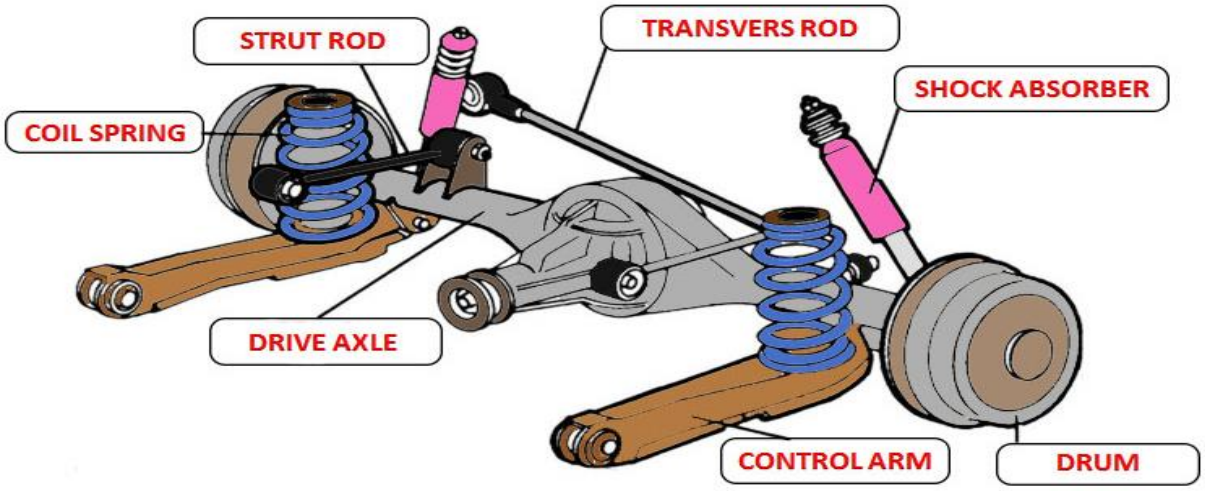


Figure 3.4 location of Suspension System components

e. Brake system

Brakes are used to slow down or stop the vehicle. Hydraulic brakes are generally used in automobiles, where brakes are applied by pressure on a fluid. Mechanical brakes are also used in some vehicles. These brakes are operated by means of leavers, linkages, pedals, cams, etc. Hand brake or parking brake is known usually mechanical brake. These are used for parking the vehicles on sloppy surfaces and also in case of emergency.

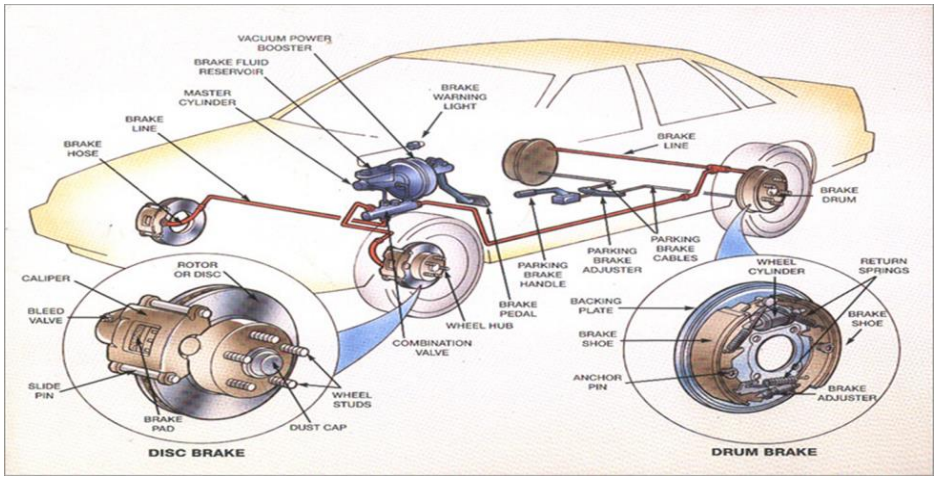
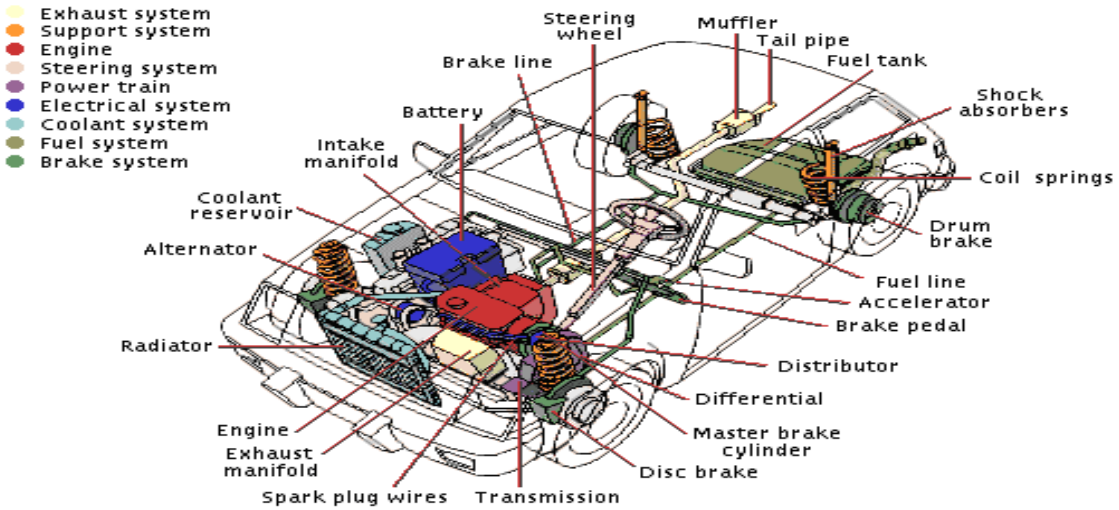


Figure 3.5 location of brake System components

3.2 Confirming location of systems or components



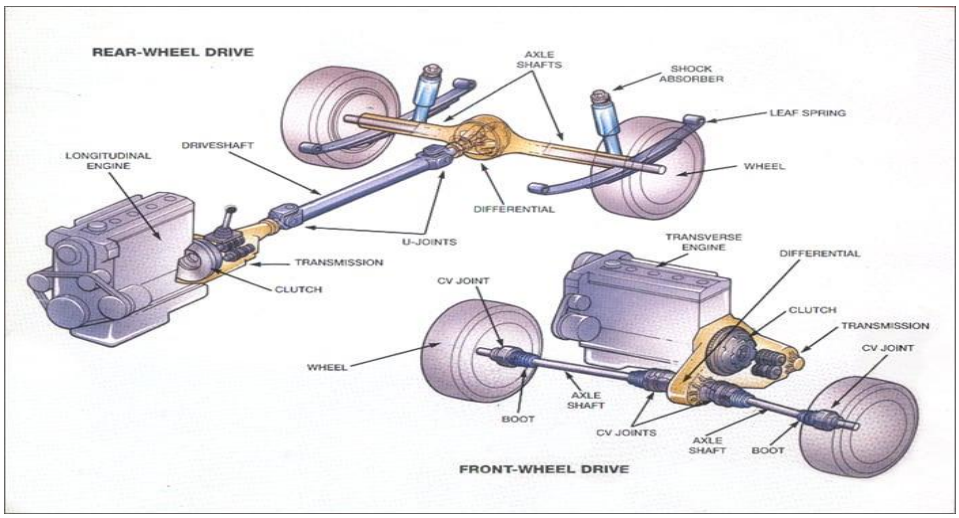


Figure 3.6 location of mechanical System components

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. How to Locate mechanical system or component on vehicle

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1. _____
   _____
2. _____
   _____

_____
_____
_____

Unit Four: Apply system fundamentals

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Examining subassembly components
- Identifying common faults

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Examine subassembly components
- Identify common faults

4.1 Examining subassembly components

a. Air conditioning

Air conditioning is divided into industrial air-conditioning and comfort air-conditioning. The controlled atmosphere, which gives maximum comfort to the human beings, is known as comfort air-conditioning.

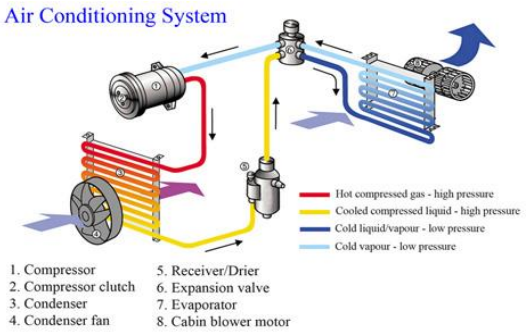


Figure 4.1 Air conditioning System componen

b. Airbag

The goal of an airbag is to slow the passenger's forward motion fraction of a second.



Figure 4.2 Air bag System

Turbocharger and Supercharger

The turbocharger and supercharger are devices that force air into the cylinders creating a pressure that is greater than the atmospheric pressure in order to increase engine output.

Generally, the engine output is determined by the amount of the air-fuel mixture, burned over a specified period of time, and becomes greater as the amount of the air-fuel mixture increases.

That means in order to increase the engine output, either the engine displacement or engine speed must be increased.

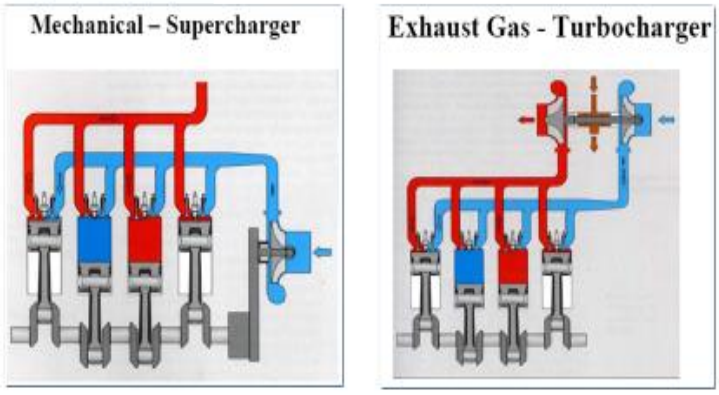


Figure 4.3 turbocharger and supercharger

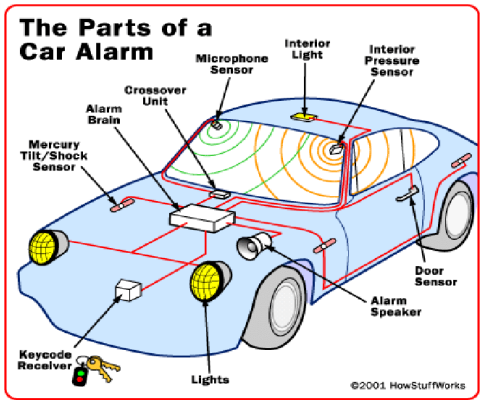


Figure 4.4 Alarm system

c. Audio system

Sound systems are available in a wide variety of models. The complexity of the system varies significantly from the basic AM radio to more complex stereo systems that include an AM/FM radio receiver, a stereo amplifier, compact disc (CD) player, cassette player, equalizer, several speakers, and a power antenna system.

d. Radio

High frequency, electromagnetic radio waves propagate through the air at the speed of light.

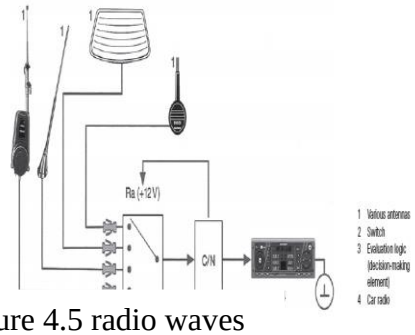


Figure 4.5 radio waves

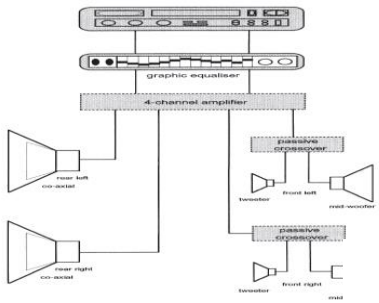


Figure 4.6 *Speakers*



Figure 4.7 *'Active' type*

e. Speakers

The low-frequency AC signals generated by the output stage of the entertainment system must be converted into acoustic sound-waves at frequencies appropriate for the human ear (in the 20 Hz to 20 kHz range). This task is performed by the speaker system.

f. Mobile telephone

Phone integration in the vehicle many vehicles are now offered with phone hands-free operation built in (via Bluetooth). The driver can easily answer and end mobile phone calls as they drive. It is not necessary to touch the handheld mobile phone once it is paired with the car. As a phone call is answered, the system conveniently mutes the car's audio system.

4.2Identifying common faults

4.2.1 Failure to achieve ignition and power

The ignition relay is one of the most important electronic relays found on modern vehicles. It is usually located in the fuse and relay panel beneath the hood, and is responsible for providing power to the vehicle's ignition system, and some of the fuel system's components. When the key is turned to the on position the relay is switched on and power is directed to the vehicle's ignition and fuel system components, notably the fuel pump and ignition coils. When the relay fails or has an issue it can cause major problems with the operation of the vehicle. Usually a bad or failing ignition relay will produce a few symptoms that can notify the driver of a potential issue.

- **Car suddenly stalls while operating**

One of the most common symptoms of a failed ignition relay is a car that suddenly stalls while operating. If the ignition relay shorts, burns out, or otherwise fails while the engine is operating it will cut off power to the fuel pump and ignition system. This will cause the vehicle to immediately stall due to fuel and spark being cut off. In some instances of a faulty relay the vehicle will be able to restart once the relay cools off, only to stall out once again after the relay overheats.

- **Car not starting**

Another symptom of a faulty ignition relay is a no power condition. If the relay fails it will cut off power to fuel pump and ignition system, which will result in a no power, and therefore no start condition. You may find that turning the key may power on the accessories, and may even crank the engine, however the vehicle will not start due to there not being any power directed to the fuel and ignition system. Similar symptoms can also be caused by a wide variety of other issues, so a proper diagnosis is recommended in order to make certain what the issue is.

- **Dead battery**

A dead battery is another symptom of a faulty ignition relay. If the relay has an internal short it may keep power fed to the ignition and fuel system, even when ignition cylinder is in another position, or the key is removed. This will cause the fuel pump and ignition components to remain powered on, drawing current, at all times, which will eventually lead to a dead battery. Aside from draining the battery this may also cause accelerated wear on the components, notably the fuel pump, due to having them powered on, but not operating.

- **Burned relay**

In certain instances it may be possible for the relay to overheat to the point of burning up and melting. Apart from cutting off power to the vehicle's ignition relay and causing performance issues, a burned relay may melt onto the fuse panel. This may make it difficult to remove, and in some instances can even lead to the replacement of the entire fuse box.

While servicing the ignition relay is not generally considered routine maintenance, it can sometimes fail and cause major issues for the vehicle. If you suspect that your ignition relay may be having an issue, have the vehicle inspected by a professional technician, such as one from Your Mechanic, to determine if the relay should be replaced.

4.2.2 Failure to achieve fuel flow

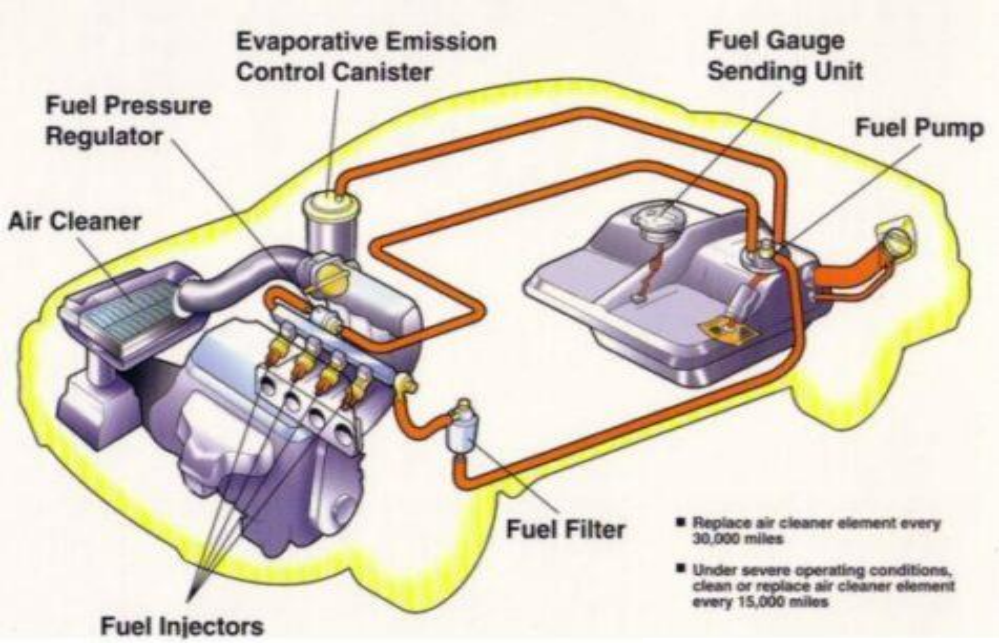


Figure 4.8 Failure of fuel flow

Fuel system related problems, can be difficult to solve.

Consequently, anything that might affect the flow and pressure of the fuel system; is going to result in poorer performance.

Above all, the biggest cause of any fuel system problems is dirt.

So, the weak link in the fuel system is usually, the fuel filter. In other words, the very purpose of this usually small part is to; prevent any contaminants from getting into the fuel.

The big thing to note is that most of the failure warning signs; are the same for most fuel system problems:

- Hesitating Engine
- Stalling
- Not Starting
- Hard Starting
- Different Performance at Different Speeds
- Engine Misfiring
- Engine Sputters at High Speeds
- Loss of Power When the Vehicle Is Under Load
- Surging

The three most common causes of fuel pump failure include:

Fuel contamination: Fuel is jeopardized from corrosion, debris and moisture, which can all bring visible contaminants into the tank.

Clogged strainers/filters: The aforementioned contaminants eventually clog critical components including strainers, filters and the fuel pump itself. This blockage ultimately impairs the flow of fuel, which may affect the vehicle during acceleration, among other long-term impairments.

Electrical issues: Electrical faults are also significant contributors to fuel pump failures. The most common electrical issues are rusted connectors, loose connectors, or melted wiring and connectors. To help identify issues of poor electrical connections, a high quality digital volt/ohm/meter should be used to test for voltage drops and continuity.

4.2.3 Excessive exhaust smoke or noise

What does excessive exhaust smoke mean?

If your car is emitting a lot of exhaust smoke there's a solid chance that the vehicle has suffered some sort of engine issue. If a vehicle's engine is not properly cared for, meaning it is denied scheduled maintenance such as oil changes and cooling system flushes, it will eventually bite the dust earlier than one that does have these services completed. Depending on the color of the smoke coming out of the tailpipe you can generally tell what kind of problem the motor is suffering from. It is necessary to have your car looked at by an auto mechanic as when you first notice an increase in the amount of colored exhaust in order to avoid more extensive engine trouble. These are the most common colors of exhaust smoke and the trouble that they may be a sign of.



Figure 4.9 Excessive exhaust smoke or noise

- **Blue Exhaust**

An oil leak that causes oil to be burnt up in the combustion chamber will result in blue exhaust smoke. This needs to be taken care of immediately because if the motor becomes starved of oil it will not be lubricated properly and it will likely result in massive engine damage.

- **White Exhaust**

If your car is creating white clouds of exhaust smoke there is likely cooling system trouble. The white smoke is produced by coolant burning up in the engine. This can occur if there's an internal coolant leak within the motor. Cooling system problems may cause additional problems for the motor, including blown head gaskets or burnt piston rings. If the issue is not dealt with in a quick manner you may find your car in need of extensive and expensive engine repair on your hands.

- **Black Exhaust**

A vehicle that produces excessive black smoke is likely burning too much gasoline. There are a number of issues that can cause this, which include:

Leaking fuel injector(s) - Leaking fuel injectors can drip extra fuel into the combustion chamber.

Stuck fuel pump relay - This is a rare problem but if the relay for the fuel pump is stuck in the "on" position it may feed extra amounts of gas to the engine.

Clogged air filter - Another less common problem is a clogged air filter. If the air filter is clogged the engine will not be able to produce the right air/fuel mixture and the car's computer system will compensate by burning extra gas.

4.2.4 Unusual engine noises or vibrations

There are several common causes of engine vibration in a car, and they all result in shaking and noises that can be quite alarming and sometimes scary. However, if you know what some of the most frequent caused of engine vibration are, you can not only avoid too much stress and worry, you can know how to explain the problem and symptoms to a car mechanic when the time comes to correct the problem. So, here is a list of some of the most common reasons your car's engine might shake or vibrate.

- **Worn Out Spark Plugs**

In many vehicles a common cause of engine vibration is worn out or faulty sparkplugs. Worn out or dirty sparkplugs will cause the car's engine to misfire or not properly fire on each and every cylinder. When this occurs, it is commonly referred to as the engine missing or not firing on all

cylinders. This can usually be corrected by installing new sparkplugs or correcting other spark or compression-related issues.

- **Loose or Disconnected Hoses**

Loose or disconnected hoses can also be a common cause of many types of engine vibration. A loose or disconnected air hose or vacuum hose can cause quite a bit of violent shaking and vibration in your car's engine. To correct the problem, simply look for any loose or disconnected hoses and reattach them and replace them as needed.

- **Broken Motor Mounts**

If the vehicle shakes violently or the engine vibrates excessively when stopped at a red light or when parked with the engine on, this may be a good indicator that the motor mounts or transmission mounts on the vehicle are damaged or broken. A good way to tell if this is the problem is to simply put the car in neutral and see if the vibration or shaking decreases a bit.

- **Faulty or Poorly Adjusted Fuel Intake System**

Another common problem that causes engine vibration and nasty shaking is a poorly adjusted fuel intake system. Sometimes, idling problems that cause engine vibration may be as simple as adjusting the idle on a carburetor or cleaning components in the fuel intake system so that fuel passes through the engine more easily creating cleaner and more efficient combustion your car's engine.

- **Faulty Timing Belt**

Problems with your vehicle's timing belt, or other belt driven accessories, are another common cause of engine vibrations in vehicles. Timing belts and other belts that are loose or damaged will cause components controlled by belts such as fans and other parts to not rotate or turn a consistent speeds which will result in strange sounds and vibrations from your car's engine. To avoid these types of problems, you should frequently inspect all of the belts in your vehicle to make sure that they are free from cracks and ribbing and also make sure that the belts are tight and operating as they should.

4.2.5 Excessive play or vibration through steering

- **Free play in the tie rods**:

Tie rod ends, as the name suggests, are found on the ends of the steering rack and 'tie' the rack to the steering knuckle or hub carrier. Any free play in these affects the tracking and is generally displayed as uneven wear on the outside edge of the tyres. Poor tracking will also cause the vehicle to wander/drift to one side while driving or braking.

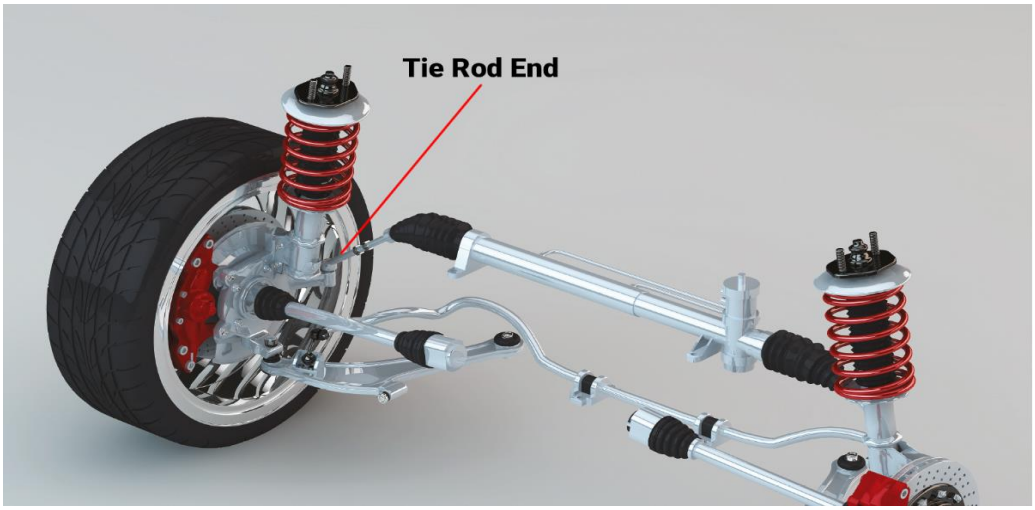


Figure 4.10 *Free play in the tie rods*

- **Free play in the steering rack**:

The majority of light vehicles use rack and pinion steering. The steering rack is essentially a straight bar with splines at the ends. These splines engage with similar splines on the pinion and allow the steering to function when the wheel is turned. Steering racks are fairly tough and generally little goes wrong with them. If anything the bushings on either side of the rack tend to fail and it is these that allow for play in the steering.

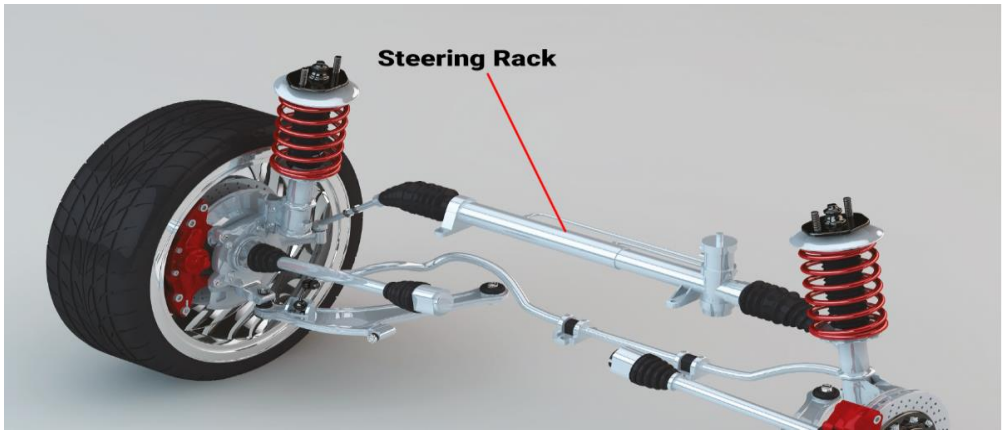


Figure 4.11 *Free play in the steering rack:*

- **Free play in the ball joints:**

To respond to driver inputs and turn the wheels, ball joints allow the suspension to move up and down while allowing the steering knuckle to pivot. Worn out ball joints affect the camber of the wheels and result in the poor response to driver input as well as a tendency for the car to pull to one side.

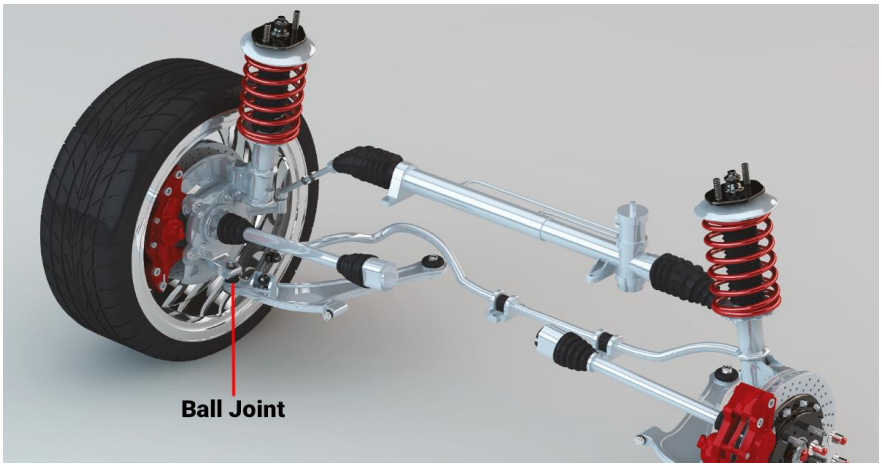


Figure 4.12*: Free play in the ball joints*

- **Wheels that are Unbalanced**

Even if the wheels are just minimally unbalanced, they will cause your steering wheel to excessively vibrate, and even on your entire vehicle. If you have a new car with a lightweight suspension system, your vehicle might be susceptible to this problem.

- **Bearings that are Not in Good Condition**

The hub bearings are essential in letting your wheels rotate correctly. Moreover, they are important in supporting the car's weight. When they are not lubricated properly, they eventually become damaged or broken. Weak bearings cause the steering wheel to shake when you turn the car to any direction. Typically, bad bearings trigger a noise coming from your wheels. You can remove them to check for damage. In most cases, you only must clean and properly lubricate them to fix the issue. On the other hand, when they are badly worn or broken, you'd have to replace them.

- **Your Wheels are Misaligned**

One of the most common reasons why your steering wheel is shaking is because of misaligned wheels. Over time, when you drive on roads with bad conditions, your wheels get misaligned. You can easily determine if this is the cause of your shaky steering wheel. Simply check the tread on the tires and look for uneven wear. If the inside has completely worn down while the outside has almost full tread, then it is likely that your wheels are misaligned. Also, if you notice that your car guides itself to the sides even when your steering wheel is centered and straight, it means that you have misaligned wheels. Make sure you consult a professional mechanic to get this fixed right away.

- **Problems with your Brakes**

When your steering wheel vibrates whenever you slow down, then it is possible that the problem lies with your brakes. Shaky steering wheels are caused by loose connections, bad brake discs,

worn brake pads, or worn shocks. In most cases, you will notice vibration on your steering wheel when you turn, accelerate, or maintain a particular speed. Brake issues are easier to identify because even before you start to notice your steering wheel shaking, you will feel that there's something wrong when you apply pressure to your brakes.

4.2.6 Loss of coolant

Coolant loss can be hard to diagnose sometimes

Coolant loss may indicate a poorly maintained cooling system, a system fault, or even a change in driving patterns. For example, a coolant leak could have any of these causes:

1. Overfilling the cooling system
2. A faulty radiator cap
3. A worn-out radiator hose
4. A leak that only occurs under certain operating conditions
5. An undiagnosed cracked engine block or cylinder head, or a blown gasket
6. Towing heavy loads

- **Bad Radiator Cap**



Figure 4.13: Bad Radiator Cap

A bad radiator cap may not seal properly, which could lead to coolant leaking past the seals and evaporating. Look for steam near the radiator cap, and also check the overflow reservoir if your overflow reservoir is pressurized.

- **Blown Head Gasket**

The head gasket sits between the cylinder head and the engine block. Its job is to keep combustion gases in the combustion chamber and coolant in the water jackets.

When a leak forms in the head gasket, it is possible for coolant to leak into the combustion chamber and burn off, exiting the exhaust. When you have an internal head gasket leak, you are

unlikely to notice any coolant leaking onto the ground. Common symptoms are overheating and white smoke coming from the exhaust.

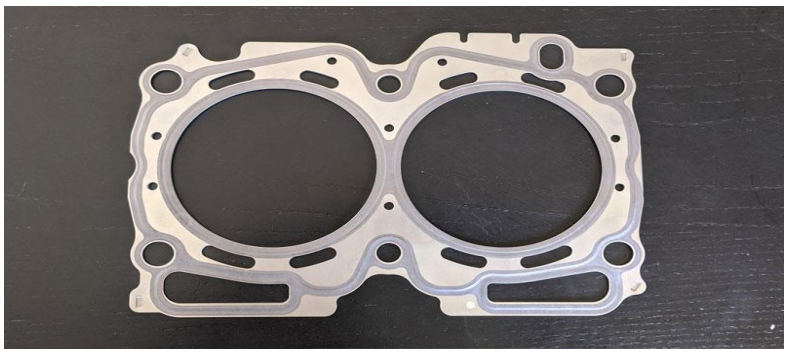


Figure 4.14: Blown Head Gasket

- **Blown Intake Manifold Gasket**



Figure 4.15: Blown Intake Manifold Gasket

Some intake manifolds have water jackets. If these intake manifold water jackets were to leak into the intake, coolant would be sucked into the combustion chamber. The resulting symptoms would resemble a blown head gasket.

- **Leaking Turbo Seal**

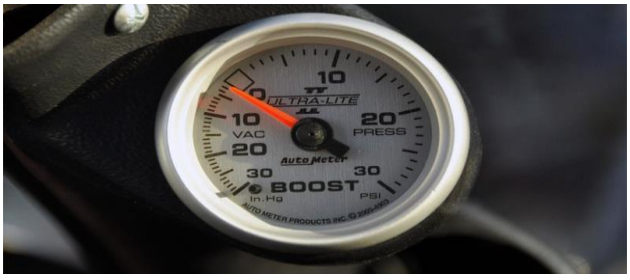


Figure 4.16: Leaking Seal

Most turbos are cooled using engine coolant. If a turbo seal allows coolant to leak into the turbo, you will lose this coolant out the exhaust.

- **Evaporation**

Why Is My Coolant Evaporating?

The water in your coolant can only evaporate when the system isn't perfectly sealed. The source of the leak can be tricky to find since it happens so slowly.

As long as the coolant loss is very slow (a few drops every month), this is often no immediate cause for concern. Keep an eye on things to make sure the leak doesn't get worse. If you start to see coolant on the ground, it's time for a proper repair.



Figure 4.17: Coolant Evaporating

4.2.7 Slow response or excessive pedal travel when braking System or component fluid or gas leakage

Acceleration tends to get the most attention when it comes to cars, but great performance is about more than going fast. It's also about stopping quickly.

When you have a brake problem, bringing your car to a full stop can take more effort than it should. Spongy brakes—also described as squishy or mushy brakes—can cause big trouble if not addressed right away with a brake inspection and service. Find out what could be causing such a change in braking performance and how we can help solve it.

- **Air in the Brake Lines**

Air in the brake lines is one of the most common causes of spongy brakes. Braking systems rely on evenly distributed hydraulic pressure to bring vehicles to a halt. Air in any of these lines can throw off this balance of pressure. Poor pressure can result in more time, distance, and/or effort to stop. In other words: a soft brake pedal. Air in the brake lines could be due to a leak or low brake fluid.

- **Brake Line Damage**

What can damage a brake line and cause a leak? Rust, for one. Rust from road salt and moisture can cause brake lines to become brittle, leak, and break. Damage from a car crash can also cause brake lines to bend and collapse, weakening them and making them more susceptible to problems down the road.

- **Old or Low Brake Fluid**

And how about low brake fluid? Time might be the key suspect here. Brake fluid converts the energy you apply to the brake pedal into the force required to bring your car to a stop. Just as your brake pads wear thin over time, so can your brake fluid. If you can't remember when you last had a brake service, then you might have low brake fluid simply because it's being used by your braking system. Or, the low fluid could be due to a leak. Either way, it's time to schedule a brake inspection!

- **Cylinder Wear**

The master cylinder plays an important role in distributing the hydraulic pressure mentioned in #1. It pushes the brake fluid where it needs to be to help bring your car to a stop. Over time, seals within the cylinder can break or leak. If you have to press the brake pedal all the way to the floor to bring your vehicle to a stop, this might be why. The braking system simply isn't working as efficiently as it used to.

- **Damaged Disc Brake Caliper**

Braking creates a great deal of heat. That heat can damage your car's disc brake calipers over time. How can you spot disc brake caliper damage? On top of spongy brakes, you may notice that your car pulls to one side or the other when stopping. You might also hear a squeaky or squealing sound when braking.

Self-Check -4	Written Test

Name…… ID…… Date…….

Test I say true or false

1._____ mechanical faults are bearing fault, rotor damage, air gap eccentricity and shaft bending.

2._____ Suspension issues can be difficult to diagnose

Test II Choose the best alternative

1. What is the possible fault Hard Pedal

   A. Servo inoperative B. Seized calliper pistons C. Faulty Master Cylinder D.ALL

2. Black exhaust gas released from diesel engine is the indication of
   a. Lean mixture
   b. Oil inter in the composition chamber
   c. Over rich mixture
   d. Worn piston ring
3. Why failures of Slow response or excessive pedal travel when braking System or component fluid or gas leakage
   a. Air in the Brake Lines
   b. plugged canister purge vacuum hose
   c. Brake Line Damage
   d. Old or Low Brake Fluid
   e. All
4. Which statement is false about failures of Loss of coolant
   a. Overfilling the cooling system
   b. A faulty radiator cap
   c. A worn-out radiator hose
   d. All
   e. none
5. White Exhaust gas released from engine is the indication of
   a. coolant burning up in the engine
   b. Oil inter in the composition chamber
   c. Over rich mixture
   d. All

6. The Unusual engine noises or vibrations is
   a. Worn Out Spark Plugs
   b. Loose or Disconnected Hoses
   c. Broken Motor Mounts
   d. All
   e. none
7. Blue Exhaust gas released from engine is the indication of
   a. coolant burning up in the engine
   b. Oil inter in the composition chamber
   c. Over rich mixture
   d. All
8. common Failure to achieve ignition and power is called
   a. ignition relay
   b. dead battery
   c. ignition coils
   d. All

Test III Directions: Answer all the questions listed below. Examples may be necessary to aid some explanations/answers.

1. Write mechanical systems common faults?

2. Write at list 5 subassembly components?

Answer Sheet

Score = _____

Rating: _____

Name: _____ Date: _____

1._____

_____

_____

_____

Operation sheet 4.1

Operation title: check mechanical systems common faults

Engine Testing Instruments (sample)

The most common instruments used for engine diagnosis and tune-up are: -

- Test lump (bulb): - to adjust ignition timing statically.
- Tachometer: - to indicates the engine speed in revolutions per minute (rpm).
- Cylinder compression tester: - to measure the compression pressure.
- Cylinder leakage tester: - to find places of compression pressure leakage.
- Dwell angle tester: - to measure and correct the dwell angle.
- Ignition timing light: - to adjust ignition timing dynamically.
- Oscilloscope: - to examine the condition of the primary and secondary ignition circuits.
- Exhaust-gas analyzer: - to measure the concentration of exhaust gases (CO, HC,).
- Vacuum gauge: - to check manifold vacuum.
- Engine analyzer: - to measure various engine parameters on a single unit.

Tune-up procedures

Step I

1. Know the system.
2. Ask the driver or the owner of the car for the problem.
3. Get hold of the Repair Manual.
4. Inspect the Engine (fuel, engine oil, coolant, battery, wirings, drive belts, valve clearance, etc.).
5. Run the Engine.
6. List the possible causes or troubles.

Common engine troubles

- Engine does not crank.
- Engine cranks but does not start.
- Engine runs but misses.
- Engine Lacks power, acceleration,…
- Engine consumes more fuel.
- Engine consumes more oil.
- Engine overheats.
- Engine backfires.
- Engine emission high.

Step II

Inspect the starting system
Inspect the intake system
Inspect the fuel system
Inspect the ignition system
Inspect the lubrication system
Inspect the cooling system
Inspect the exhaust system
Inspect the charging system
Check cylinder compression
Check cylinder leakage
Check engine balance
Check manifold vacuum

Quality criteria: operate all activates without any damage and according to specifications

LAP test 2	Performance test

Name…… ID…… Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 6 hour. The project is expected from each student to do it.

Task 1: Locate of mechanic systems or components

Task 2: Identify mechanical systems common faults

Reference

1. Introduction to Automotive Technology Third Edition 7/2010

Vehicle Service Manual Third Edition 7/2010

2. https://www.autoandbrakerepair.com/blog/fuel-system-common-problems.php
3. 2.https://www.uesystems.com/5-ways-poor-lubrication-can-cause-problems/
4. https://www.yourmechanic.com/article/how-to-diagnose-a-cooling-system-problem-by-tyler-kirkland
5. https://www.teamryanautomotive.com/strategy-based-diagnostics
6. https://www.autoandbrakerepair.com/blog/fuel-system-common-problems.php
7. https://www.uesystems.com/5-ways-poor-lubrication-can-cause-problems/
8. https://www.yourmechanic.com/article/how-to-diagnose-a-cooling-system-problem-by-tyler-kirkland
9. https://www.autotrader.co.uk/content/advice/what-is-a-pre-delivery-inspection

Participants of this Module (training material) preparation

No	Name	Qualification (Level)	Field of Study	Organization/ Institution	Mobile number	E-mail
1	Fasil Ebabu	A	Automotive Technology	Debark/PTC	0918209786	fasilebabu@gmail.com
2	Abebe Mola	A	Automotive Technology	Hawassa P/ T/ College	0913160533	abebemola0533@gmail.com
3	Biniyam bayeh	B	Motor vehicle engineering	Major Meneral Mulugeta Buli/ PTC	0922258639	Hailebin7@gmail.com
4	Zeyneba mengistu	A	Automotive Technology	w/ro sheen /PTC	0912891142	zeynebame@gmail.com
5	Seid denbi	B	Automotive Technology	Assosa/PTC	0915890277	Seiddenbiali25@gmail