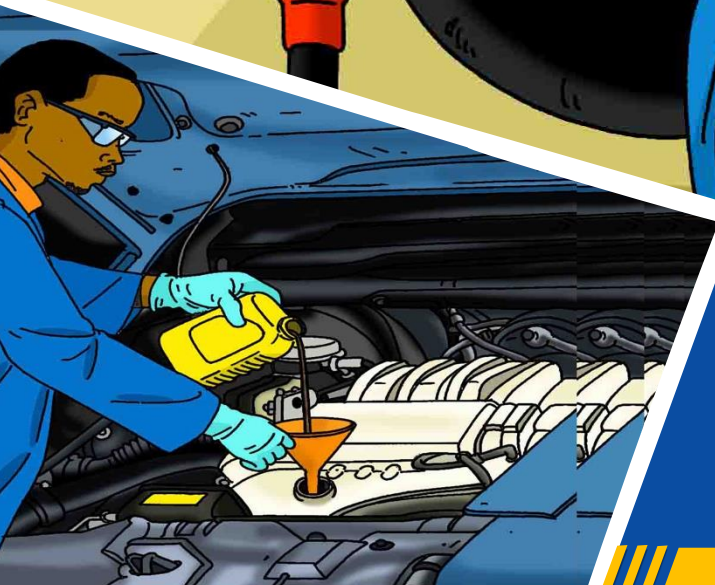




RQF LEVEL 3



AUTER301 AUTOMOBILE TECHNOLOGY

Automotive Engine Repairing

TRAINEE'S MANUAL

December 2023



AUTOMOTIVE ENGINE REPAIRING



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LIST OF ABBREVIATIONS AND ACRONYMS

%	: Percentages
A/F	: Air and Fuel Mixture
A/C	: Air condition
CBET	: Competency-Based Education and Training
DOHC	: Double overhead camshaft
IBC	: In-Block Camshaft
Km/h	: Kilometer per hour
mph	: miles per hour
OHC	: Overhead camshaft
PPE	: Personal protective equipment
RQF	: Rwanda Qualification Framework
RTB	: Rwanda TVET Board
SOHC	: Single overhead camshaft
TVET	: Technical and Vocational Education and Training
VTC	: Vocational Training Center

INTRODUCTION

This trainee manual encompasses all necessary skills, knowledge and attitudes required to repair engine cooling system. Students undertaking this module shall be exposed with practical activities that will develop and nurture their competences. The writing process of this training manual embraced competency-based education and training (CBT) philosophy by providing enough practical opportunities reflecting real life situations.

The trainee manual is subdivided into units, each unit has various topics, trainee will start with a self-assessment exercise to help trainee rate him/herself on the level of skills, knowledge and attitudes about the unit.

A discovery activity is followed to help trainee discover what he/she already know about the unit.

After these activities trainee will learn more about the topics by doing different activities, reading the required knowledge, techniques, steps, procedures and other requirements under the key facts section, trainee may also get assistance from the trainer. The activities in this training manual are prepared such that they give opportunities to students to work individually and in groups.

After going through all activities, trainee shall undertake progressive assessments known as formative and finally conclude with his/her own self-reflection to identify his/her strengths, weaknesses and areas for improvements.

Do not forget to read the point to remember section which provides the overall key points and takeaways of the unit.

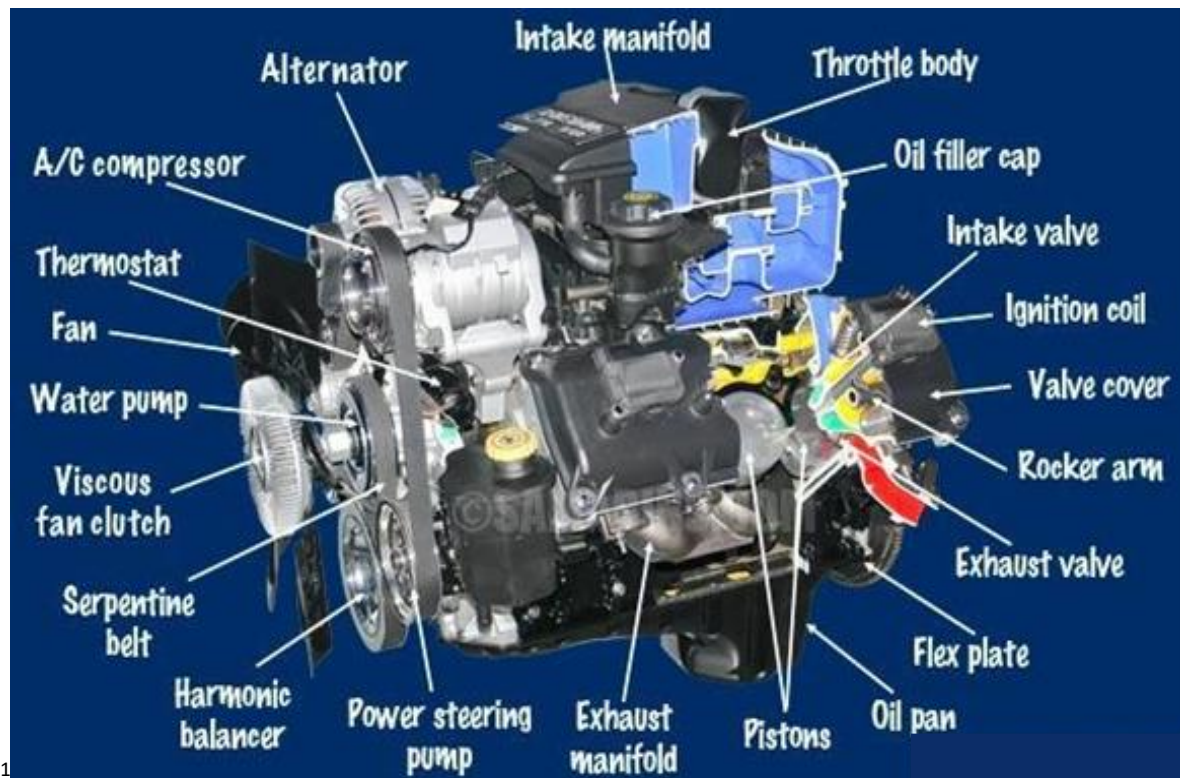
Module Units:

Unit 1: Describe automotive engine

Unit 2: Prepare workplace and apply safety

Unit 3: Overhaul engine

UNIT 1: DESCRIBE AUTOMOTIVE ENGINE



Unit summary:

This unit provides you with the knowledge, skills and attitudes to describe the automotive engine system. It covers the classification of internal combustion engines, the identification of engine systems as well as the description of engine mechanical components.

¹https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.samarins.com%2Fglossary%2F&psig=AOvVaw3X_xx2ntTCx1Hdu-otgc69&ust=1694929738456000&source=images&cd=vfe&opi=89978449&ved=0CBAQjRxqFwoTCNjlsby3roEDFQAAAAAdAAAAABAE

Self-Assessment: Unit 1

1. Referring to the unit illustration above discuss the following:
 - a. What does the illustration show?
 - b. What do you think this unit is about?
2. Fill in and complete the self-assessment table below.
 - a. There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
 - b. Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?
 - c. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.
 - d. At the end of this unit, you will assess yourself again.

My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
Classify the internal combustion engines.					
Identify the engine systems					
Identify the engine's mechanical components					
Define the functions of engine mechanical components.					
Describe materials made of the engine's					

My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
mechanical components					
Assess the stresses subjected to the engine's mechanical components					
Pay attention to details while describing the engine					
Demonstrate team spirit while working with others					



Key Competencies:

Knowledge	Skills	Attitudes
1. Identify engine types	1. Classify the internal combustion engines	1. Pay attention to details while describing the engine
2. Identify the engine systems	2. Describe the engine's mechanical components	2. Demonstrate team spirit while working with others
3. Describe the functions of engine mechanical components.	3. Describe materials made of the engine's mechanical components	
	4. Assess the stresses subjected to the engine's mechanical components	

Discovery activity



Task 1

Answer the Following questions:

1. What is an automotive engine?
2. What is the function of an automotive engine?
3. How many classes of internal combustion engines?
4. Do you know auxiliary engine systems? What are they?
5. Describe one mechanical component of one of the automotive engines you know.

 Share your responses with the rest of the class.

Topic 1.1: Classification of Internal Combustion Engines



Activity 1: Problem Solving



Task 2:

Read the following scenario and answer the related questions below.

Mrs. Rachel is a designer in the Automotive design industry, she has to demonstrate all classes of internal combustion engines to facilitate Mr. Dominic to choose a suitable vehicle.

1. What are the features of the automotive engine which Mrs. Rachel should base on to help Mr. Dominic?
2. Describe the differences between the various classes of internal combustion engines.

🗉 Share your results with the rest of the class.

🗉 Refer to Key facts 1.1 a for further information and clarifications.

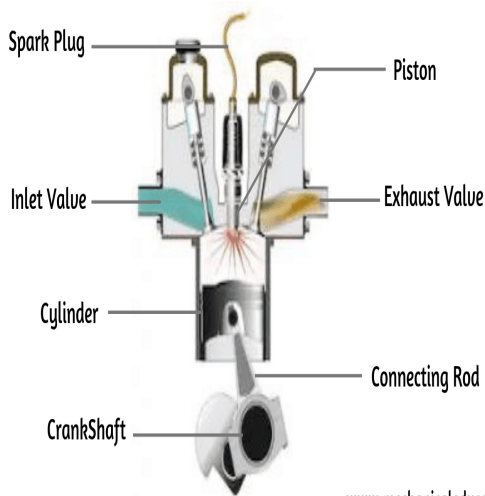
Key Facts 1.1 a: Classification of internal combustion engines

Introduction

An automotive engine is a complex machine built to convert heat from burning gas into the force that turns the road wheels.

There are different types of car engines: internal combustion engines; hybrid engines (Internal combustion engine + electric engine); electric engines and V type engines usually boast of high-quality engines.

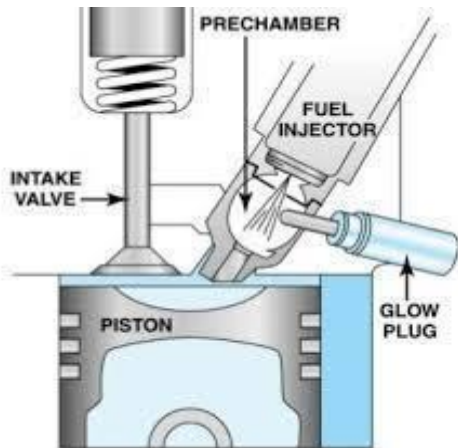
Automotive engines can be classified based on the following design features:

Mixture formation and ignition	
✓ Spark ignition engine  2	Spark ignition engine A spark ignition engine, also known as a gasoline engine or petrol engine, is a type of internal combustion engine that uses a spark plug to ignite the air-fuel mixture within the combustion chamber. It is the most common type of engine used in automobiles and many other applications.
 www.mechanicaleducation.com 3	Diesel engine It is a type of internal combustion engine that uses the heat of compression to ignite the fuel-air mixture. Unlike spark ignition engines, which rely on a spark plug for ignition, diesel engines compress the air within the cylinder to high pressure and temperature, causing the fuel injected into the cylinder to ignite spontaneously.

²<https://www.google.com/search?q=spark+ignition+engine&tbm=isch&hl=en&bih=619&biw=1349&sa=X&ved=2ahUKEwjGpumkwa6BAxVnmCcCHWqHCMMQ3VYoAHoECAEQNA>

³ <https://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.mechanicaleducation.com%2Fwp-content%2Fuploads%2F2019%2F03%2FSpark-Ignition-Engine.png&tbid=w86lcjplR-8aNM&vet=12ahUKEwjGpumkwa6BAxVnmCcCHWqHCMMQMygAegQIARBV..i&imgrefurl=https%3A%2F%2Fwww.mechanicaleducation.com%2Fspark-ignition-engine-working%2F&docid=JmAnLiDH7NrMUM&w=1600&h=850&q=spark%20ignition%20engine&hl=en&ved=2ahUKEwjGpumkwa6BAxVnmCcCHWqHCMMQMygAegQIARBV>

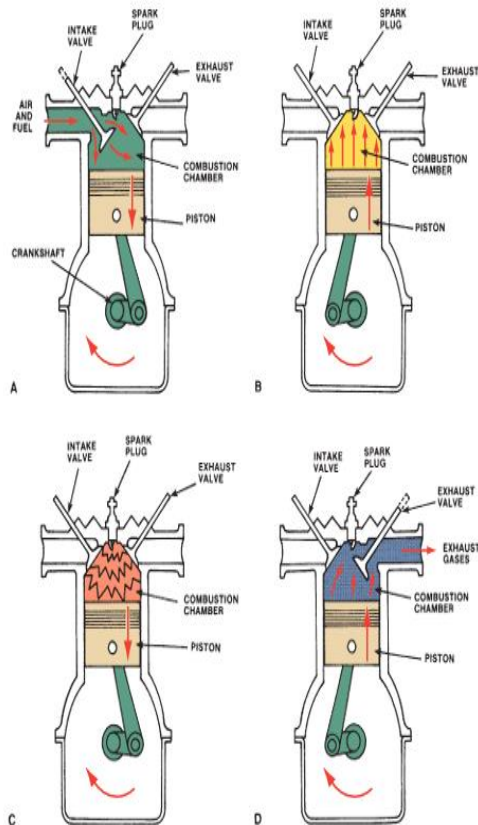
✓ Diesel engine



Diesel engines are commonly used in vehicles, heavy machinery and power generators due to their high efficiency and ability to deliver strong torque.

• Operating principles

✓ Four-stroke engines



Four-stroke engines

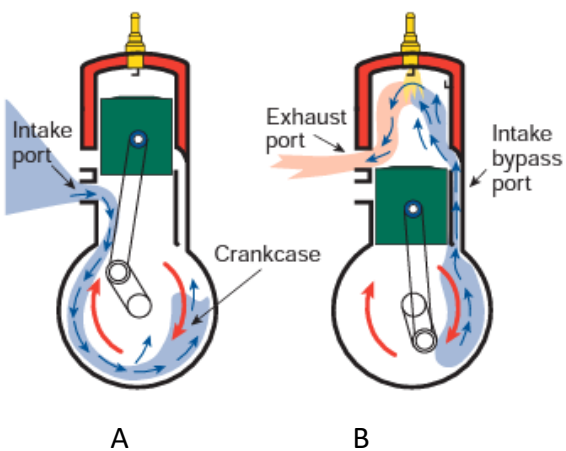
This is also known as a four-stroke cycle engine; it is a type of internal combustion engine that completes four distinct strokes or movements within each cycle to convert fuel into mechanical energy.

The four strokes are intake, compression, combustion and exhaust and they occur in a specific sequence.

a. Induction Stroke

The piston moves downward, creating a vacuum within the cylinder. The intake valve opens, allowing a mixture of air and fuel to enter the combustion chamber.

⁴ <https://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.dieselhub.com%2Fimg%2Ffigures%2Fdi%2Fdi-vs-di.jpg&tbid=aKo16GWoqr-TVM&vet=12ahUKewiw2cy1wq6BAxVomScChcOOA8IQMygCegQIARBT..i&imgrefurl=https%3A%2F%2Fwww.dieselhub.com%2Ftech%2Fdi-vs-di.html&docid=zN4Hz1LNQ0PbnM&w=609&h=300&q=diesel%20engine%20prechamber&ved=2ahUKewiw2cy1wq6BAxVomScChcOOA8IQMygCegQIARBT>

	b. Compression Stroke: The piston moves upward, compressing the air-fuel mixture. Both the intake and exhaust valves are closed during this stroke. c. Combustion Stroke: When the piston reaches the top of the compression stroke, a spark plug ignites the highly compressed air-fuel mixture. This ignition causes a rapid combustion, resulting in an explosion that forces the piston downward. d. Exhaust Stroke: As the piston moves upward again, the exhaust valve opens and the burned gases are expelled from the cylinder to the exhaust system. This process prepares the cylinder for the next intake stroke.
✓ Two-stroke engines  A B In the past, several imported vehicles have used two-stroke engines. As the name implies, this	Two-stroke engines A two-stroke engine is a type of internal combustion engine that completes the entire combustion process in just two strokes or movements of the piston within each cycle. The two strokes are the compression stroke and the power stroke and unlike the four-stroke engine, the two-stroke

engine requires only two strokes of the piston to complete all four operations: intake, compression, power and exhaust. This is accomplished as follows:

1. Movement of the piston from BDC to TDC completes both intake and compression.
2. When the piston nears TDC, the compressed air-fuel mixture is ignited, causing an expansion of the gases. During this time, the intake and exhaust ports are closed.
3. Expanding gases in the cylinder forces the piston down, rotating the crankshaft.
4. With the piston at BDC, the intake and exhaust ports are both open, allowing exhaust gases to leave the cylinder and the air-fuel mixture to enter.

Although the two-stroke-cycle engine is simple in design and lightweight because it lacks a valve train, it has not been widely used in automobiles. It tends to be less fuel efficient and releases more pollutants into the atmosphere than four-stroke engines.

Oil is often in the exhaust stream because these engines require constant oil delivery to the cylinders to keep the piston lubricated. Some of these engines require a certain amount of oil to be mixed with the fuel.

engine does not have separate intake and exhaust strokes.

Here is a simplified explanation of the two-stroke engine cycle:

a. Compression/Combustion Stroke:

As the piston moves upward, it compresses the fuel-air mixture that has entered the combustion chamber through the intake port. Near the top of the stroke, the spark plug ignites the mixture, causing combustion.

The rapid expansion of the ignited mixture creates pressure, which drives the piston downward.

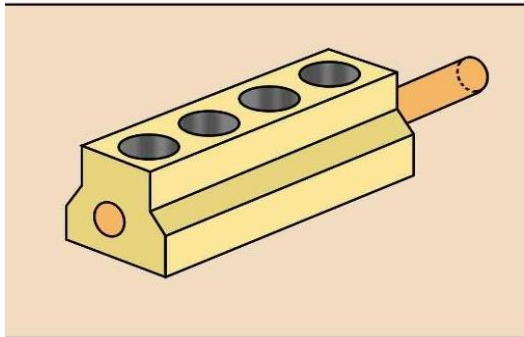
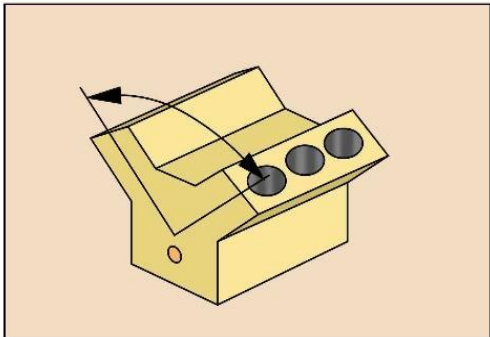
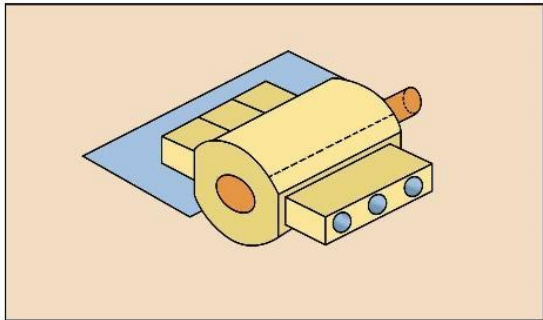
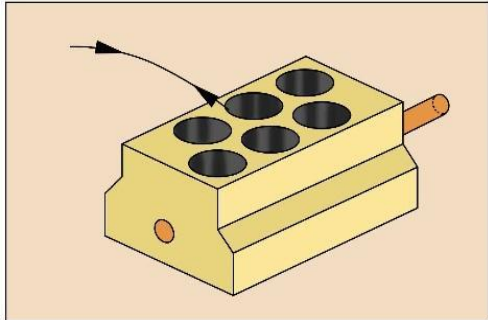
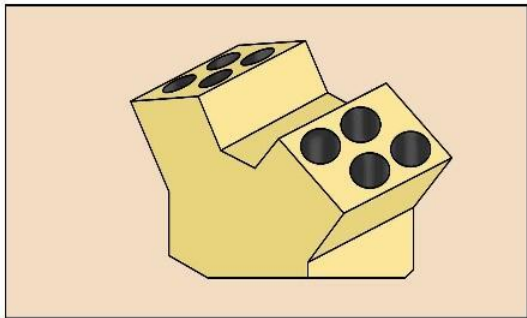
b. Power/Exhaust Stroke:

As the piston moves downward, it uncovers the exhaust port, allowing the burned gasses to escape.

Simultaneously, the intake port is uncovered, allowing a fresh mixture of fuel and air to enter the combustion chamber.

At the end of the stroke, the piston covers the exhaust port and begins to move upward again, compressing the new mixture.

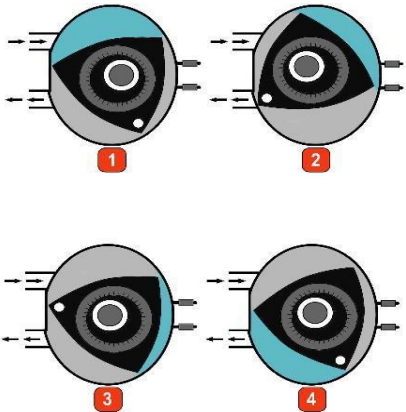
- **Cylinders arrangement**

✓ In-line engines	✓ V-Engine
	
✓ Opposed -cylinders engine	✓ VR-engine
	
✓ W-Type	
	

Engine firing order according to the number of cylinders and their arrangement styles:

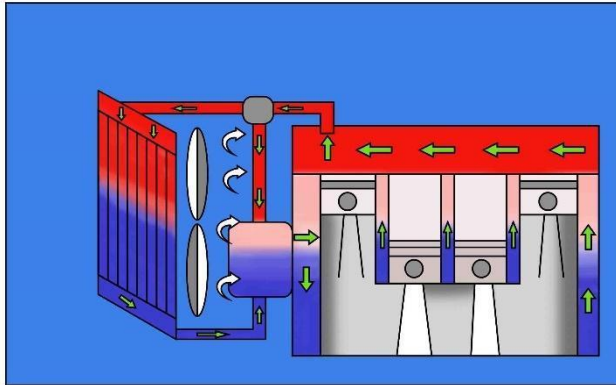
Generally, the more cylinders your engine has, the more power is produced. Most cars have a 4-, 6- or 8-cylinder engine. The numbers indicate the number of cylinders and they will either be laid out in a straight line, V-shaped or in a flat arrangement.

Number of cylinders and firing order.	
Type	Firing order
4-cylinder in-line	1-3-4-2 or 1-2-4-3
6-cylinder in-line	1-5-3-6-2-4
8-cylinder V-type (CW)	1R-4L-2R-3L-4R-1L-3R-2L
12-cylinder V-type (CW)	1L-2R-5L-4R-3L-1R-6L-5R-2L-3R-4L-6R
4-cylinder opposed	1-3-2-4 or 1-4-2-3
6-cylinder opposed	1-4-5-2-3-6
8-cylinder opposed	1-5-8-3-2-6-7-4
9-cylinder radial	1-3-5-7-9-2-4-6-8
14-cylinder radial	1-10-5-14-9-4-13-8-3-12-7-2-11-6
18-radial	1-12-5-16-9-2-13-6-17-10-3-14-7-18-11-4-15-8
Piston stroke	
✓ Reciprocating engine 	Reciprocating engine A reciprocating engine, also known as a piston engine, is a type of internal combustion engine that converts the pressure created by the combustion of fuel into mechanical work through the reciprocating motion of pistons within cylinders. In a reciprocating engine, the cylinders are cylindrical chambers within which pistons move back and forth. The engine's operation typically follows a four-stroke cycle (intake, compression, combustion and exhaust) or a two-stroke cycle (compression/ power and

	exhaust/intake), as explained earlier. The pistons are connected to a crankshaft through connecting rods and as the pistons move up and down, they transfer the linear motion into rotary motion via the crankshaft.
✓ Rotary engines 	Rotary engines A rotary engine, also known as a Wankel engine, is a type of internal combustion engine that utilizes a unique rotary design to convert fuel combustion into mechanical power. It differs from reciprocating engines, such as piston engines, in its internal structure and operation. In a rotary engine, the core component is a rotor that rotates within an oval-shaped housing. The rotor has a unique shape resembling a triangle with curved sides. The housing contains three separate chambers, known as the intake, compression and combustion/ exhaust chambers. As the rotor rotates, it moves through these chambers, completing the engine's four-stroke cycle.

- **Cooling types**

✓ **Liquid-cooled engines**



Liquid-cooled engine

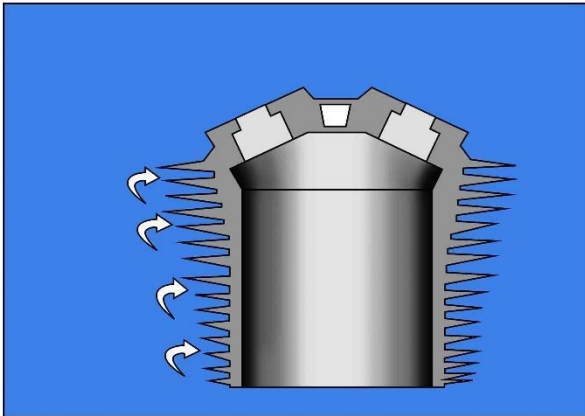
A liquid-cooled engine, also known as a water-cooled engine, is an internal combustion engine that uses a liquid, typically coolant or a mixture of water and coolant, to transfer and dissipate heat generated during engine operation.

This cooling system is designed to maintain the engine's operating temperature within optimal limits for performance, efficiency and durability.

In a liquid-cooled engine, the coolant circulates through passages and channels within the engine block and cylinder head, absorbing heat from the combustion process and various engine components.

The heated coolant is then directed to a radiator, where it exchanges heat with the outside air, typically facilitated by a fan, before being circulated back into the engine to repeat the cooling process.

✓ **Air-cooled type engines**



Air-cooled type engine

An air-cooled engine is an internal combustion engine that relies on the circulation of air to dissipate heat generated during operation. Instead of using a liquid coolant like in liquid-cooled engines, air-cooled engines have fins and other cooling structures that facilitate the exchange of heat between the engine and the surrounding air.

In an air-cooled engine, the fins are typically attached to the outer surface of the engine block, cylinder heads and sometimes the cylinders themselves. These fins increase the surface area available for heat transfer and promote airflow around the engine. As the engine runs, air naturally flows over the fins, carrying away the heat and keeping the engine within an acceptable temperature range.

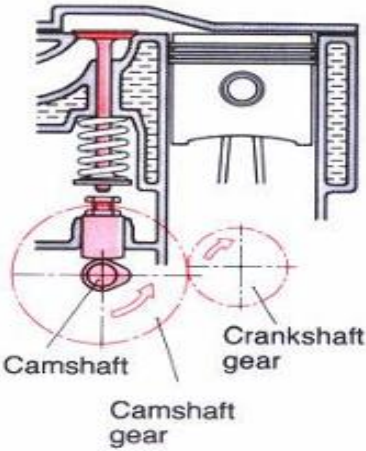
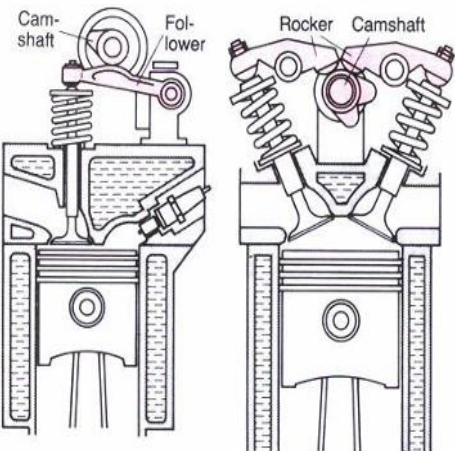
• **Camshaft location and valve arrangement**

The different camshaft location configurations in engines determine the placement of the camshaft(s) in relation to the cylinder head and engine block. Here's a breakdown of each configuration:

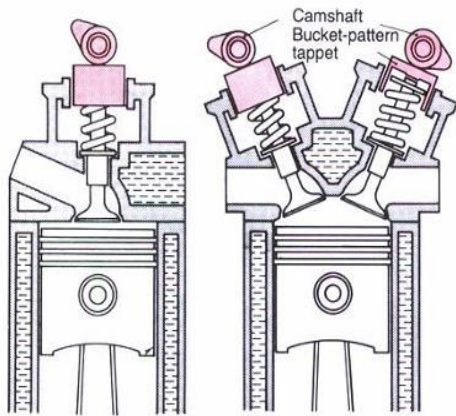
- ✓ **A side valve engine**
- ✓ **OHC** (Overhead camshaft)
- ✓ **SOHC** (Single overhead camshaft)

A side valve engine:

This is also known as a flathead or L-head engine, is a type of internal combustion engine that has its valves located on the side of the engine cylinder block. In a side valve configuration, the intake and exhaust valves are positioned adjacent to the

✓ DOHC (Double Overhead Camshaft) IBC (In-Block Camshaft)  The diagram shows a cross-section of an engine cylinder head with two camshafts. The top camshaft is connected to the intake valve, and the bottom camshaft is connected to the exhaust valve. The camshafts are driven by a crankshaft gear. Labels include: Camshaft, Crankshaft gear, Camshaft gear, Rocker, Valve spring, Valve, Pushrod, Tappet, Timing chain, Crankshaft gear, and Camshaft gear. 5  The diagram shows a cross-section of an engine cylinder head with two camshafts. The top camshaft is connected to the intake valve, and the bottom camshaft is connected to the exhaust valve. The camshafts are driven by a crankshaft gear. Labels include: Cam-shaft, Fol-lower, Rocker, and Camshaft.	combustion chamber and are operated by a camshaft located in the engine block. OHC (Overhead Camshaft): In an OHC configuration, the camshaft is located above the cylinder head, typically housed in the cylinder head itself. The camshaft operates the engine's valves directly through lifters, rocker arms or other mechanisms. This design allows for more precise valve control and improved engine performance compared to older designs where the camshaft was located within the engine block. SOHC (Single Overhead Camshaft): SOHC refers to an engine configuration that has a single camshaft located above the cylinder head. This camshaft operates both the intake and exhaust valves for each cylinder. SOHC engines are simpler and generally less expensive to manufacture compared to DOHC engines, but they may have limitations in terms of maximum RPM and valve control compared to DOHC designs. DOHC (Double Overhead Camshaft): DOHC engines feature two camshafts, one for the intake valves and one for
--	--

⁵ Modern Automotive technology volume 2



Overhead-valve engines with single or double overhead camshafts and bucket-pattern tappets

6

the exhaust valves, positioned above the cylinder head. Each camshaft is dedicated to its respective set of valves, allowing for more precise control over valve timing and lift. DOHC configurations often result in improved engine performance, especially at higher RPMs, but they can be more complex and expensive to produce compared to SOHC or OHC designs.

IBC (In-Block Camshaft):

IBC refers to an engine design where the camshaft(s) is located within the engine block itself. In this configuration, the camshaft operates the valves directly through mechanisms such as pushrods and lifters. IBC engines are generally older designs and are less common in modern engines. They can have certain advantages, such as compactness and simplified valvetrain, but they may have limitations in terms of maximum RPM and valve control compared to OHC or DOHC designs.

⁶ Modern Automotive technology volume 2



Activity 2: Guided Practice



Task 3

Read the scenario below and perform the tasks related

Assume that you are requested by your supervisor to assist the marketing department in the automotive engine design industry to know more about the car engine designs that exist in order to prepare a customer information sheet about engine classes.

1. In a complete description differentiate them by:
 - a. Mixture formation and ignition
 - b. Operating principles
 - c. Cylinders arrangement
 - d. Piston stroke
 - e. Cooling type
 - f. Number of cylinders
 - g. Camshaft location
2. Classify different types of engines in the automotive industry.

 Present your observation/results to the rest of the class.

Key Facts 1.1 b: Classification of automotive engines

When classifying automotive engines, several factors should be carefully considered:

- **Engine design:** Analyze the overall design of the engine, including the arrangement of cylinders, valve configuration, cooling system and other key components. Understanding these design aspects helps in determining the engine's performance characteristics and suitability for specific applications.
- **Power output and torque:** Assess the power output and torque characteristics of the engine. Consider factors such as horsepower, torque curves and specific power output to determine the engine's performance capabilities.
- **Fuel type and efficiency:** Examine the type of fuel the engine utilizes, such as gasoline, diesel, hybrid or electric power. Evaluate the engine's efficiency, fuel consumption and emissions to understand its environmental impact and operational costs.
- **Application and intended use:** Consider the intended application of the engine, whether it is for passenger vehicles, motorcycles, trucks, marine vessels or industrial machinery. Different applications may require specific engine characteristics such as power delivery, durability and operational conditions.
- **Technology and innovations:** Stay updated on the latest engine technologies and innovations, such as direct injection, variable valve timing, turbocharging or hybrid powertrains. These advancements can significantly impact the engine's performance, efficiency and environmental footprint.
- **Displacement and configuration:** Evaluate the engine's displacement, usually measured in liters or cubic centimeters and the configuration of cylinders, whether it is in-line, V-shaped, flat or radial. These factors influence the engine's size, power output and smoothness of operation.
- **Historical and comparative analysis:** Consider the historical context of the engine type and compare it with other engines within the same category or segment. Understanding the engine's track record, reliability and industry reputation can provide valuable insights.

- **Regulations and standards:** Take into account applicable emissions regulations and standards that impact the engine's compliance, such as Euro emission standards or local environmental regulations.

By paying attention to these factors, one can accurately classify automotive engines and gain a comprehensive understanding of their performance, efficiency and suitability for specific applications.

🔧 Ask for more clarification from your trainer.

🔧 Refer to the following key facts 1.1 b for further information and clarifications.



Activity 3: Application



Task 4

Read the following scenario and answer the questions

Visit the neighbouring automotive repair shops, check the different vehicles under repair and describe each engine.

Make a report on the classification of internal combustion engines, by focusing on the following:

1. Factors you based on while classifying them
2. Description of the difference between the ignition and diesel engine
3. The two main types of internal combustion engines based on fuel type
4. The functioning of an internal combustion engine that relies on spark plugs to ignite the air-fuel mixture.
5. By using a sketch, show how the cylinders are arranged in a V-shaped engine.

Topic 1.2: Identification of Engine Systems



Activity 1: Problem Solving



Task 5

Analyse the illustrations below and answer the questions that follow.

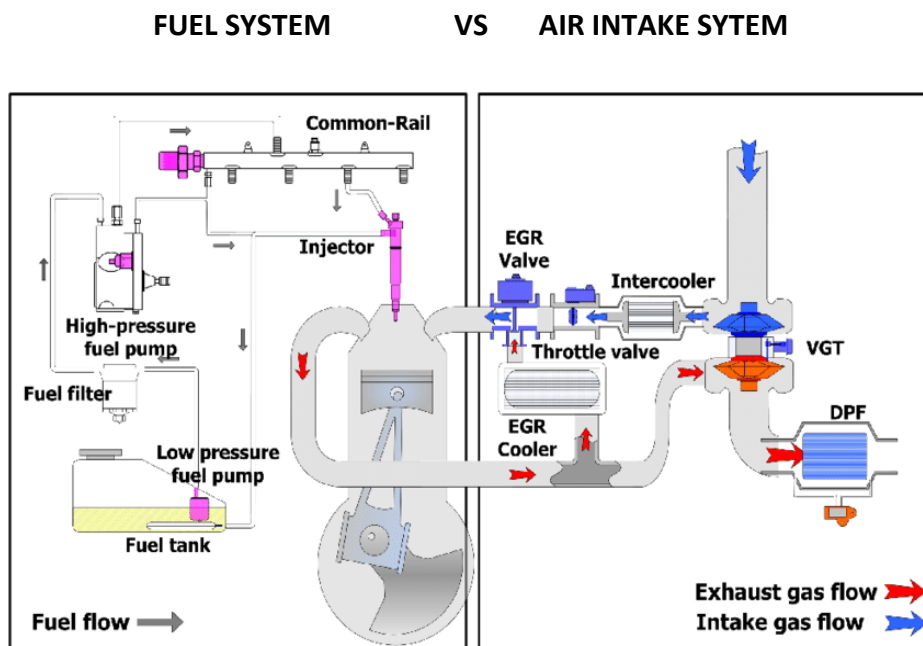


Figure 1: Comparison between fuel system and Air intake system

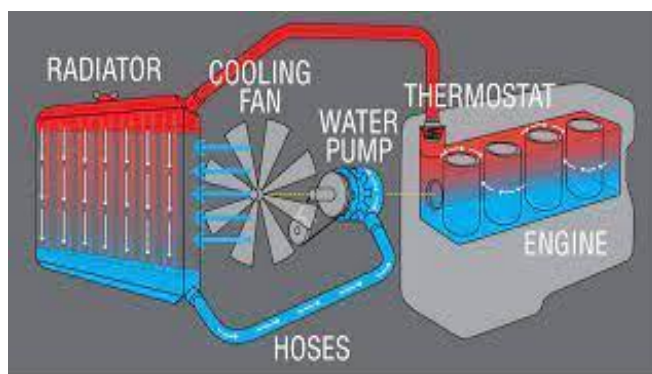


Figure 2: Engine Cooling system⁷

⁷ <https://www.google.com/url?sa=i&url=https%3A%2F%2Fbgfindashop.com%2Farticles%2Fhow-automotive-cooling-systems->

1. What is the difference among the above systems?
2. What are their functions?
3. What are the advantages and disadvantages liquid cooling system?
4. What are the advantages and disadvantages air cooling system?

Refer to the following key facts 1.2 for further information and clarifications.

Key Facts 1.2: Automotive Engine Systems

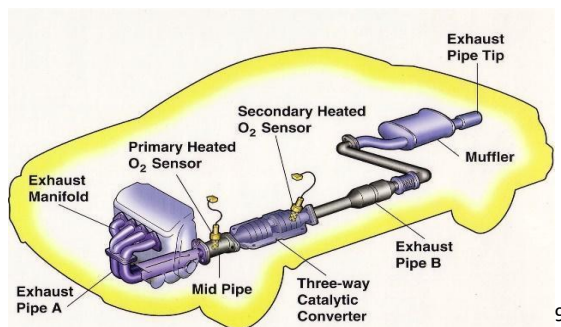
These engine systems play crucial roles in the overall operation, performance and efficiency of the engine. Each system performs specific functions that contribute to the engine's power generation, air intake, cooling, lubrication, fuel delivery, starting and electrical systems.

• Air intake system



Air Intake System: The air intake system is responsible for bringing air into the engine for combustion. It includes components such as the air filter, intake manifold, throttle body and mass airflow sensor (MAF).

• Exhaust system

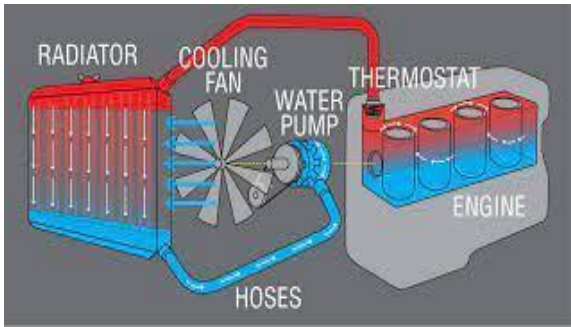
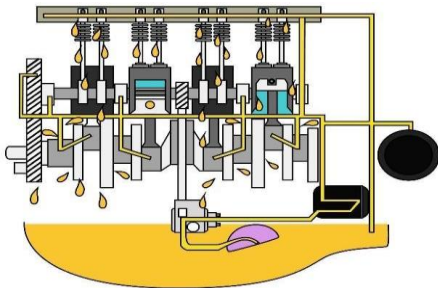
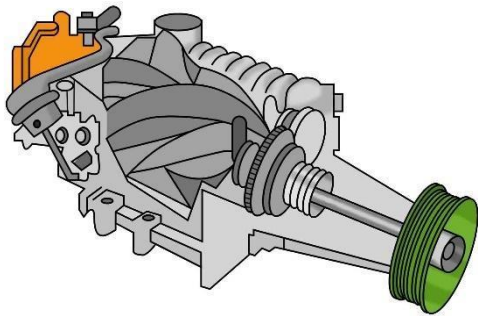


Exhaust System: The exhaust system is responsible for removing exhaust gasses from the engine after combustion. It includes components such as the exhaust manifold, catalytic converter, muffler and tailpipe.

work%2F&psig=AOvVaw3YdzkObV9fGrkiYFrzguGJ&ust=1694935515885000&source=images&cd=vfe&ved=OCBAQjRxqFwoTCOD7gf7MroEDFQAAAAAAdAAAAABAD

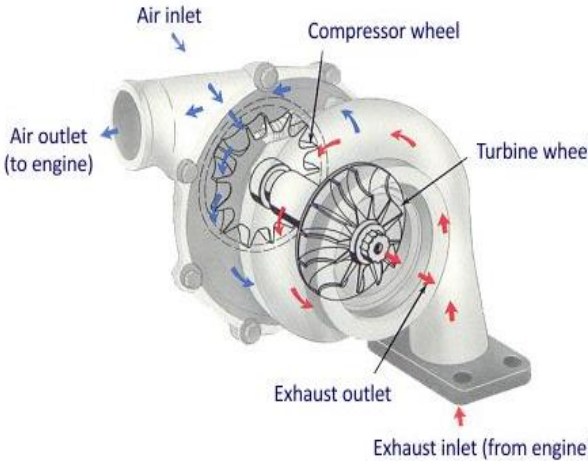
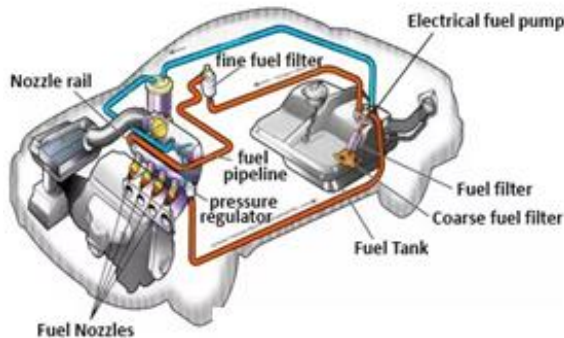
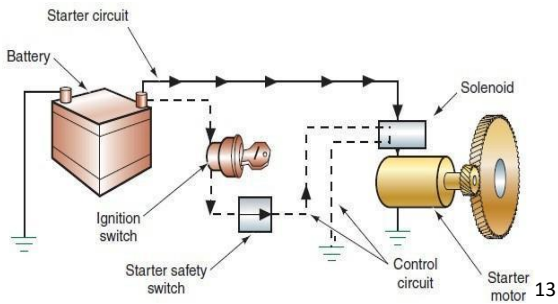
⁸ Book automotive technology, 5th Edition by Jack Erjavec

⁹ <https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.trufitexhaust.com.au%2Ffunctional-differences-mufflers-exhaust-systems%2F&psig=AOvVaw2OQnwShi->

● Cooling system  10	Cooling System: The cooling system helps regulate the engine temperature and prevent overheating. It includes components such as the radiator, water pump, thermostat, cooling fan and coolant.
● Lubrication system 	Lubrication System: The lubrication system ensures proper lubrication of engine components to reduce friction and wear. It includes components such as the oil pump, oil filter, oil pan and various oil passages.
● Supercharging system 	Supercharging System: The supercharging system increases the air intake pressure to provide more oxygen to the engine, resulting in increased power output. It includes components such as a supercharger or turbocharger, intercooler and associated piping.

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AAAAAABAD

¹⁰ <https://www.google.com/imgres?imgurl=https%3A%2F%2Fwww.bgprod.com%2Fbg-master%2Fuploads%2FCooling-System-diagram-600x300-01.jpg&tbnid=mDpOT6TegEDz6M&vet=12ahUKEwigncyA6q6BAxUzpkwKHQLEAhgQMygEegQIARB8..i&imgrefurl=https%3A%2F%2Fbgfindashop.com%2Farticles%2Fhow-automotive-cooling-systems-work%2F&docid=WLgzUT587Lu4LM&w=1251&h=626&q=Cooling%20System&ved=2ahUKEwigncyA6q6BAxUzpkwKHQLEAhgQMygEegQIARB8>

● Turbocharging system  11	Turbocharging system The turbocharging system is another method of forced induction used in engines to increase their power output. It involves the use of a turbocharger, which is a device that utilizes exhaust gasses to drive a turbine and compress the incoming air before it enters the engine's combustion chamber.
● Fuel supply system  12	Fuel Supply System: The fuel supply system delivers fuel to the engine for combustion. It includes components such as the fuel tank, fuel pump, fuel injectors or carburetors and fuel lines.
● Starting system  13	Starting System: The starting system initiates the engine's operation. It includes components such as the starter motor, ignition switch, ignition key and associated wiring.

¹¹https://dieselnet.com/tech/air_turbocharger.php

¹² <https://www.newkidscar.com/fuel-system/>

¹³ <https://www.google.com/url?sa=i&url=https%3A%2F%2Flearnmech.com%2Fstarting-system-components-and-working-of-starting->

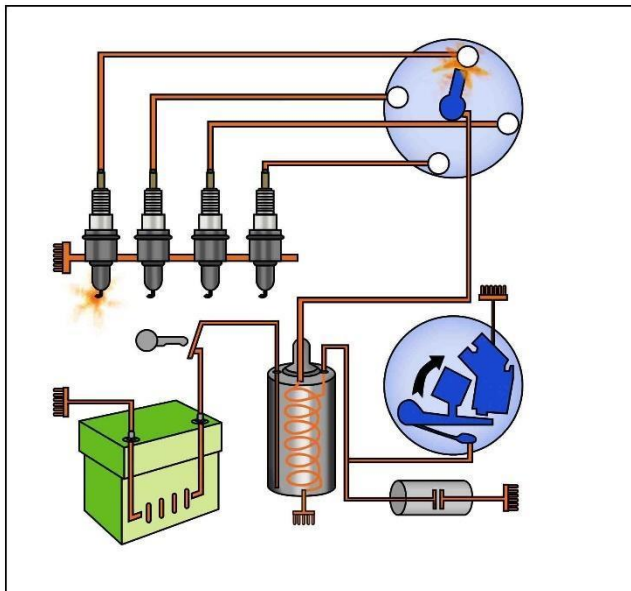
- **Charging system**



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Charging System: The charging system ensures the battery remains charged while the engine is running. It includes components such as the alternator or generator, voltage regulator and battery.

- **Ignition System**



Ignition System: The ignition system provides the spark required to ignite the air-fuel mixture in the combustion chamber. It includes components such as the ignition coil, distributor (in older systems), spark plugs, ignition control module and associated wiring.

system%2F&psig=AOvVaw2sliviwVgFUaSr2zSNQPcA&ust=1694945699544000&source=images&cd=vfe&opi=89978449&ved=0CBAQjRxqFwoTCOi21fnroEDFQAAAAAdAAAAABAR

¹⁴ <https://www.google.com/url?sa=i&url=https%3A%2F%2Fproformance-diesel-auto.com%2Fstarting-charging-system->

diagnostics%2F&psig=AOvVaw1un9MsEal2lh6DdARNUw6n&ust=1694946075137000&source=images&cd=vfe&opi=89978449&ved=0CBAQjRxqFwoTCliW_qf0roEDFQAAAAAdAAAAABAE



Activity 2: Guided Practice



Task 6

Read the following engine systems components and answer the questions that follow:

Air filter/cleaner, air pressure regulator, spark plug, air cleaner, starter motor, oil dipstick, radiator, alternator, fuel pump, water pump, turbine, intake manifold, exhaust manifold, oil galleries, injector, throttle body, impeller, oil filter, ignition coil, voltage regulator, thermostat, oil pressure relief valve, tailpipe, fuel tank, contact breaker.

1. Record each one to its corresponding system and give the function for each

Engine systems	Corresponding components from the list	Functions
● Air intake system		
● Exhaust system		
● Cooling system		
● Lubrication system		
● Supercharging system and Turbocharger system		
● Fuel supply system		
● Starting system		
● Charging system		
● Ignition system		

2. Present your observation/ results to the rest of the class and ask for more clarification from your trainer.



Activity 3: Application



Task 7

Answer the following questions:

Visit one of the garages in your neighbourhood and describe the different engine systems of one of the vehicles in place.

Make a report that includes:

1. The primary function of the engine cooling system
2. The engine system responsible for mixing air and fuel in the correct ratio for combustion
3. The purpose of the exhaust system in an internal combustion engine
4. The role of the engine lubrication system
5. The system used to ignite the air-fuel mixture in a diesel engine without the use of spark plugs.
6. Engine system responsible for reducing harmful emissions produced during combustion.

 Share your results with the rest of the class

Topic 1.3: Description of Engine Mechanical Components



Activity 1: Problem Solving



Task 8

Read the following scenario and answer the questions:

You are a technician at an automotive repair shop. A customer brings a vehicle which has complaints about the engine which has the following performance issues: uneven power reduction, irregular idling, oil leaks, backfiring and a noticeable knocking noise. Your task is as follow:

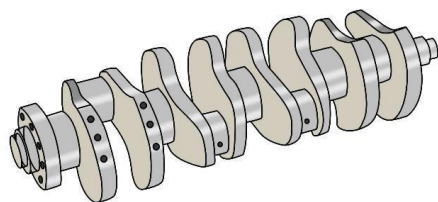
1. Analyze and describe the engine mechanical components involved in the scenario and
2. Propose potential causes for the observed issues.

Refer to the following key facts 1.3 a for further information and clarifications.

Key Facts 1.3 a: Engine mechanical components

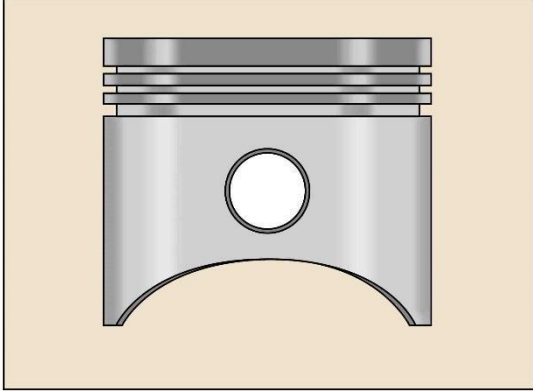
The engine's mechanical components work together to facilitate the proper functioning of the engine. Each component has a specific role and contributes to the overall power generation, combustion process, timing and mechanical operation of the engine.

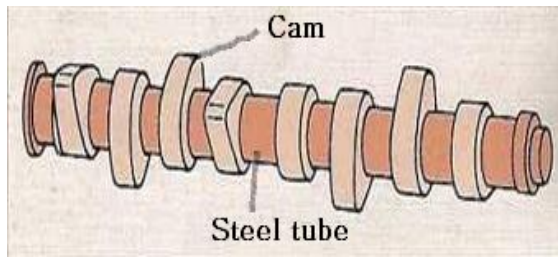
- **Crankshaft:** The crankshaft is a vital engine component responsible for converting the reciprocating motion of the pistons into rotational motion. It transfers the power generated by the combustion process to the drivetrain.



The following are commonly used materials for engine crankshaft designing: steel, cast iron, ductile iron, forged steel and billet steel.

Engine crankshafts are typically made from high-strength materials that can

	withstand the following mechanical stresses: tensile stress, compressive stress, bending stress, shear stress, torsional stress, fatigue stress and bearing stress.
● Pistons: Pistons move up and down within the engine cylinders, driven by the expanding gases produced during combustion. They compress the air-fuel mixture, transmit force to the crankshaft and aid in the expulsion of exhaust gases.	
	Engine pistons are critical components that experience high temperatures, pressures and mechanical stresses during engine operation. To withstand these conditions, pistons are typically made from materials that offer high strength, heat resistance, durability and low friction. The following are commonly used materials for engine piston designing: aluminum alloy, cast iron, steel, hypereutectic aluminum alloy, composite materials.
● Camshaft: The camshaft controls the opening and closing of the intake and exhaust valves in coordination with the engine's rotation. It ensures precise timing and synchronization of the valve operation, allowing for efficient intake and exhaust processes.	
	The material used to manufacture camshafts must possess high strength, wear resistance, bending stresses, torsional stresses, fatigue stresses, contact stresses and durability to withstand these

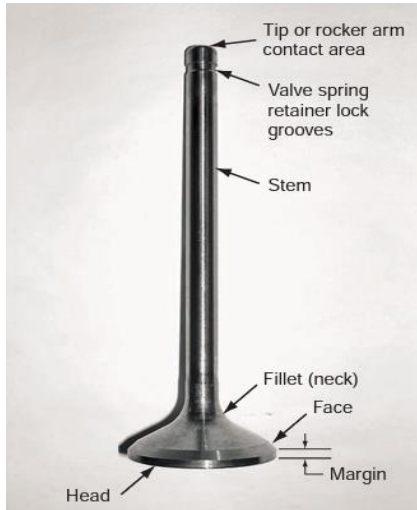


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stresses. The following are commonly used materials for camshaft construction: cast iron, steel alloys, ductile iron and billet steel.

- **Valves:** Valves regulate the flow of air and fuel into the combustion chambers (intake valves) and the expulsion of exhaust gases out of the cylinders (exhaust valves). They open and close at specific times, driven by the camshaft, to optimize the engine's performance.

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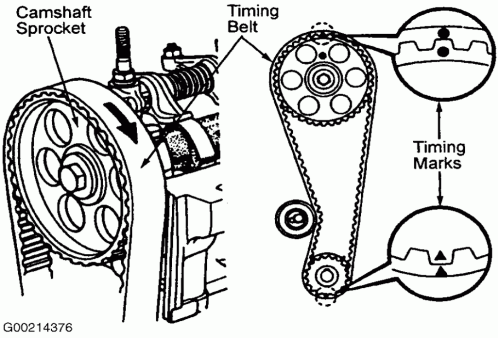


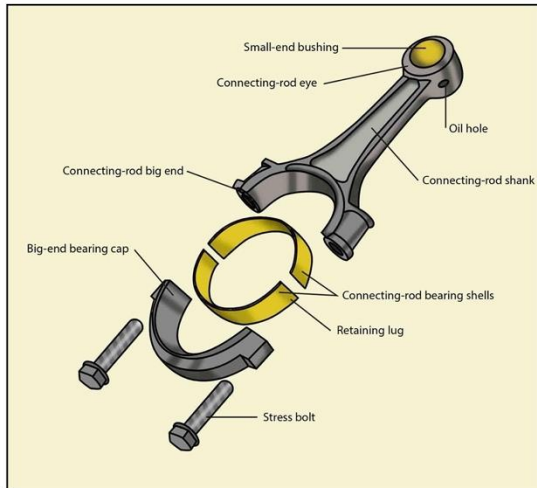
The materials used for engine valves must possess high strength, wear resistance, heat resistance and durability. The following are commonly used materials for engine valve construction: stainless steel, martensitic steel, titanium alloy and nickel-based alloys.

- **Timing Belt/Chain:** The timing belt or chain ensures accurate synchronization between the camshaft and crankshaft. It ensures that the valves open and close at the correct time in relation to the position of the pistons. This precise timing is crucial for the engine's proper functioning.

¹⁵ Modern automotive technology

¹⁶ Modern automotive technology

	They are subjected to various stresses during engine operation. The materials used for engine timing belts/chains must possess high tensile strength, wear resistance and durability. The following are commonly used materials for engine timing belts: rubber, fiber reinforcement and tooth coating.
Cylinder Head: The cylinder head is positioned at the top of the engine block and contains the combustion chambers, valves and associated components. It provides a sealing surface for the cylinders, facilitates proper airflow and houses the valves and valve train mechanisms.	
	They are subjected to various stresses and operating conditions during engine operation such as combustion pressure, thermal stresses, mechanical stresses and sealing stresses. The materials used for engine cylinder heads must possess high strength, heat resistance and durability. The following are commonly used materials for engine cylinder head construction: aluminium alloy, cast iron and aluminium-silicon alloy.
Connecting rods with bearing shells: connecting rods connect the pistons to the crankshaft. They transmit the reciprocating motion of the pistons to the rotational motion of the crankshaft, enabling the conversion of linear motion into rotary motion. The bearing shells facilitate the connecting rod to be cramped to the crankshaft and it provides a smooth surface for the rotating crankshaft to ride on.	
	They are subjected to various stresses and operating conditions during engine operation. The materials used for



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connecting rods and bearing shells must possess high strength, fatigue resistance, wear resistance and durability. The following are commonly used materials for connecting rods and bearing shells:

steel alloys, aluminium alloy, titanium alloy.

Bearing shells are made in babbitt metal, aluminium alloy and steel-backed bearings.

- **Flywheel:** The flywheel is attached to the rear of the crankshaft and helps store rotational energy. It provides inertia for starting the engine and assists in maintaining smooth power delivery.



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Flywheels are subjected to various stresses and operating conditions during engine operation. The materials used for engine flywheels must possess high strength, durability and heat resistance. The following are commonly used materials for engine flywheel construction:

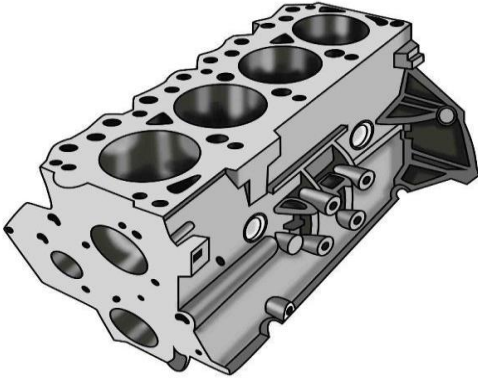
cast iron, steel and aluminium alloy.

The stresses subjected to flywheels are tensile and compressive stresses, centrifugal stresses, shear stresses and fatigue stresses.

- **Engine Block:** it is also known as cylinder block and it is the main structure of the engine. It houses the cylinders, pistons, crankshaft and other key components. The engine block provides rigidity, acts as a support structure and contains coolant passages to manage engine temperature.

¹⁷ Modern automotive technology

¹⁸ <https://www.iemotorsport.com/product/lightened-steel-flywheel-215mm-228mm/>

	It is subjected to various stresses and operating conditions during engine operation. The materials used for engine blocks must possess high strength, rigidity, heat resistance and durability. The following are commonly used materials for engine block construction: cast iron, aluminium alloy, aluminium-silicon alloy and magnesium alloy
---	---



Activity 2: Guided Practice



Task 9

Read the following scenario and answer the questions

Mr Dominic is going to manufacture the engine's mechanical components and he is asking for advice on how these components can be strong and have much ability to withstand the engine's operational conditions and stresses. He gives you a task to

1. Thoroughly describe and explain the function and location of each component within the engine and
2. Describe the materials which are recommended to use for each engine's mechanical component.

 Refer to the following key facts 1.3 b for further information and clarifications.

Key Facts 1.3 b: Maintenance, repair and care for engine's mechanical components

Maintenance, repair and care for engine mechanical components are crucial for ensuring optimal performance, longevity and reliability of the engine. Here are some key practices and considerations:

- **Regular Inspection:** Perform regular visual inspections of engine mechanical components to check for any signs of wear, damage or leaks. Look for cracks, loose connections, oil leaks or excessive play in moving parts.
- **Scheduled Maintenance:** Follow the manufacturer's recommended maintenance schedule for servicing engine mechanical components. This includes tasks such as oil changes, filter replacements and inspections of specific components at designated intervals.
- **Proper Lubrication:** Ensure that all moving parts, such as the crankshaft, pistons and camshaft, are properly lubricated. Use high-quality engine oil recommended by the manufacturer and maintain the appropriate oil levels.
- **Coolant System Maintenance:** The cooling system plays a critical role in preventing overheating of the engine. Regularly check coolant levels, inspect hoses for leaks or cracks and flush and replace coolant as recommended by the manufacturer.
- **Timing Belt/Chain Replacement:** Timing belts or chains should be replaced according to the manufacturer's recommended intervals to prevent potential failures that can cause severe engine damage. Follow proper tensioning and alignment procedures during replacement.
- **Valve Clearance Adjustment:** Some engines require periodic valve clearance adjustments to maintain optimal performance and prevent valve-related issues. Refer to the manufacturer's specifications and perform adjustments as necessary.

- **Cylinder Head Maintenance:** Inspect the cylinder head for signs of leaks, warpage or damage. Ensure proper torque of cylinder head bolts and periodically check valve seals, guides and springs for wear or damage.
- **Bearing Inspection and Replacement:** Regularly inspect bearings, including main bearings and connecting rod bearings, for wear or damage. Replace worn bearings promptly to prevent engine damage.
- **Gasket Replacement:** As part of regular maintenance or during repairs, replace gaskets, such as head gaskets and oil pan gaskets, to prevent leaks and maintain proper sealing.
- **Professional Repairs:** For complex repairs or major component replacements, it is recommended to seek the assistance of a qualified mechanic or automotive technician with expertise in engine mechanical systems.
- **Proper Storage:** If the engine will be out of service for an extended period, follow proper storage procedures, including applying rust inhibitors, protecting open ports and maintaining proper lubrication.
- **Clean Environment:** Keep the engine compartment clean and free from debris, dirt and contaminants that can affect component performance and contribute to premature wear.

Remember to refer to the specific maintenance instructions and recommendations provided by the engine manufacturer in the owner's manual or technical documentation.

Following these maintenance practices and caring for engine mechanical components will help ensure optimal engine performance, prevent premature failures and extend the overall lifespan of the engine.

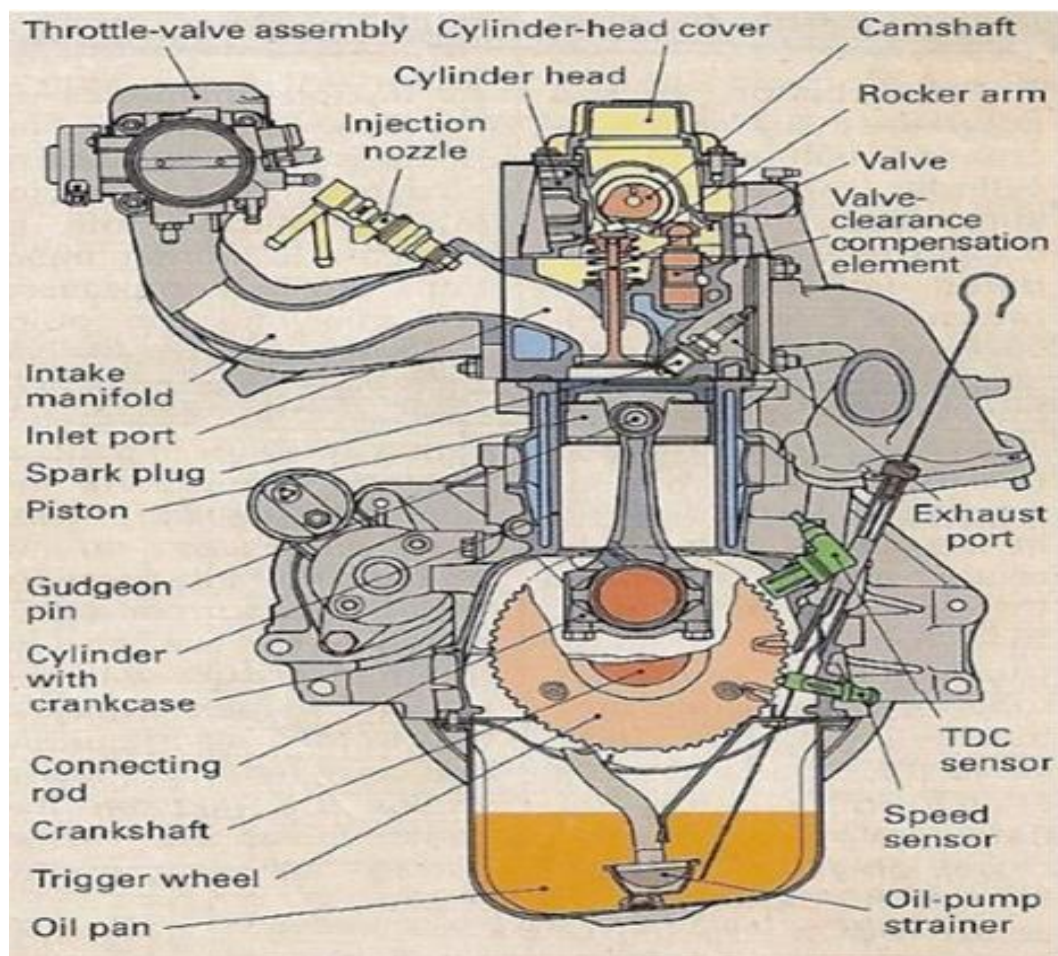


Figure 3: Parts of Engine¹⁹



Activity 3: Application



Task 10

Read the following scenario and answer the questions

Mrs Domina is a technician at SAWA TECHNOLOGY Garage and she is tasked to do an overhauling of a failed engine;

¹⁹ Modern automotive technology

1. Suggest to Mrs Domina the mechanical components which she should basically repair.
2. Tell her the stresses which might lead them to fail.
3. Suggest also the preferred materials for each component so that in case there is one which should be replaced. She can take the reference to what you have suggested.



Formative Assessment

Instructions: The following formative assessment is designed to evaluate your understanding of the classification of internal combustion engines, identification of engine systems and description of engine mechanical components. Please answer the questions to the best of your knowledge. There are multiple-choice questions and short answer questions.

1. Classification of internal combustion engines:
 - a. Which type of internal combustion engine uses a spark plug to ignite the air-fuel mixture?
 - i. Diesel engine
 - ii. Gasoline engine
 - iii. Rotary engine
 - iv. None of the above
 - b. A two-stroke engine completes one power stroke in every two strokes of the piston.
 - i. True
 - ii. False
 - c. Which type of engine classification refers to the arrangement of cylinders in a line?
 - i. In-line engine
 - ii. V-engine
 - iii. Flat engine
 - iv. W-engine

2. Identification of engine systems:
 - a. What is the function of the intake system in an internal combustion engine?
 - b. The exhaust system in an engine is responsible for expelling combustion gases from the cylinders.
 - i. True
 - ii. False
 - c. The cooling system in an engine is responsible for
 - i. Regulating the engine temperature and preventing overheating
 - ii. Controlling the air-fuel mixture
 - iii. Reducing friction between moving parts
 - iv. Igniting the air-fuel mixture
3. Description of engine mechanical components:
 - a. Describe the function of the crankshaft in an internal combustion engine.
 - b. Where is the camshaft located in an engine and what is its role?
 - c. Briefly explain the purpose of the flywheel in an engine.
 - d. Name two materials commonly used for engine pistons.
 - e. What are the primary stresses experienced by engine connecting rods?
4. Bonus Question: Describe the key difference between an overhead camshaft (OHC) and a single overhead camshaft (SOHC).



Points to Remember

- Internal combustion engines can be classified based on their fuel type (gasoline, diesel, natural gas, etc.) and their working cycles (two-stroke, four-stroke).
- Gasoline engines use spark plugs to ignite the air-fuel mixture, while diesel engines use compression to ignite fuel.
- Two-stroke engines complete one power stroke in every two strokes of the piston, while four-stroke engines complete one power stroke in every four strokes of the piston.
- Engines can also be classified based on the arrangement of their cylinders, such as in-line engines, V-engines, flat engines or W-engines.
- Engine systems include the intake system, exhaust system, cooling system, lubrication system, supercharging system, fuel supply system, starting system, charging system and ignition system.
- The intake system is responsible for delivering air and fuel into the engine cylinders.
- The exhaust system expels combustion gases from the cylinders after the combustion process.
- Engine mechanical components include the crankshaft, pistons, camshaft, valves, timing belt/chain, cylinder head, connecting rods, timing belt/chain tensioner, flywheel and engine block.
- Engine components experience various stresses, including tensile, compressive, bending and fatigue stresses, depending on their specific functions and operating conditions.



Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.

There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

1. Think about yourself:
 - a) Do you think you have the knowledge, skills or attitudes to do the task?
 - b) How well?
2. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
Classify the internal combustion engines.					
Identify the engine systems					
Describe the engine's mechanical components					
Define the functions of engine mechanical components.					
Describe materials made of the engine's mechanical components					

My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
Assess the stresses subjected to the engine's mechanical components					
Pay attention to details while describing the engine					
Demonstrate team spirit while working with others					

3. Fill in the table below and share the results with the trainer for further guidance.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	1.	1.
2.	2.	2.
3.	3.	3.

UNIT 2: PREPARE WORKPLACE AND APPLY SAFETY

BE CAREFUL SAFETY FIRST

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Unit summary:

This This unit provides you with the knowledge, skills and attitudes to prepare for the workplace. It covers the safety precautions at workplace, selection of PPEs as well as the cleaning and arrangement of the workplace.

²⁰ <https://www.accuform.com/safety-sign/be-careful-safety-first-MGNF971>

Self-Assessment: Unit 2

1. Study the unit illustration above and answer the following questions:

- a. What is the mostly displayed information?
- b. What do you think this learning outcome will be about?

2. Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.

- a. There are no right or wrong ways to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
- b. Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?
- c. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.
- d. At the end of this unit, you will assess yourself again.

My experience	I don't	I know	I have	I have a	I am
Knowledge, skills and attitudes	have any experience doing this.	a little about this.	some experience doing this.	lot of experience with this.	confident in my ability to do this.
What is the mostly displayed information?					
What do you think this learning outcome will be about?					
What is the mostly displayed information?					
What do you think this learning outcome will be about?					

My experience	I don't	I know	I have	I have a	I am
Knowledge, skills and attitudes	have any experience doing this.	a little about this.	some experience doing this.	lot of experience with this.	confident in my ability to do this.
What is the mostly displayed information?					
What do you think this learning outcome will be about?					
What is the mostly displayed information?					
What do you think this learning outcome will be about?					



Key Competencies:

Knowledge	Skills	Attitudes
1. Automotive Systems	1. Diagnostic Skills	1. Safety Consciousness
2. Engine Types	2. Application of safety while working on engine	2. Continuous Learning
3. Safety Regulations	3. Precision and Attention to Delta Application of safety regulations.	3. Organization and Cleanliness
4. Tools and Equipment	4. Problem-Solving	4. Time Management
5. Service Manuals	5. Using service manuals	5. Good communication attitude

Discovery activity



Task 11:

Read the following scenario and answer the questions that follow

Mrs Angelique is an ordinary level graduate and she is about to join Technical Secondary school in Automobile technology.

1. Advise her the personal protective equipment she can buy
2. Explain to her the safety precautions which should be taken into account at the workplace.

Topic 2.1: Application of Safety Precautions at Workplace



Activity 1: Problem Solving



Task 12

Read the following questions and give their answers

1. Observe the following pictures and give their name with respect to their numbers of the label: 1, 2, 3, 4, 5 and 6



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2. What do you understand about the term PPE?
3. Give the difference between working area and working place
4. What do you understand by the term safety?

Refer to the following key facts 2.1 a for further information and clarifications.

● Introduction

To protect yourself from injuries, you must take precautions. This includes wearing protective equipment, dressing appropriately, working professionally and correctly handling tools and equipment.

²¹ <https://www.screwfix.com/c/safety-workwear/safety-boots/cat850524>

- **Personal safety**

Personal safety is a fundamental aspect of leading a healthy and secure life and it empowers individuals to make informed decisions to protect themselves from potential risks and dangers. To achieve this person should use appropriate Personal protective equipment (PPE).

- **Personal Protective Equipment (PPE)**

Name	Image	Function
Overall	 22	Overalls, also known as coveralls, are one-piece garments designed to protect the wearer's clothing and body from dirt, dust, chemicals and other potential hazards present in the work environment.
Gloves		Shield the hands from cuts, abrasions, chemicals, heat and electrical hazards in construction, manufacturing, healthcare and laboratory work.
Safety boots	 23	Protect the feet from impact, compression, falling objects and punctures in construction, manufacturing and heavy industries.

²² <https://www.screwfix.com/c/safety-workwear/safety-boots/cat850524>

²³ <https://www.screwfix.com/c/safety-workwear/safety-boots/cat850524>

Helmet	 24	Protect the head from falling objects, impact and electrical hazards in construction, manufacturing and industrial environments.
Goggles/Safety Glasses		Shield the eyes from flying debris, chemicals, splashes and other eye hazards in laboratories, construction and industrial settings.
Face Shields		Provide full-face protection against chemical splashes, heat, sparks and impact in welding, metalworking and chemical handling tasks.
Ear defender		Reduce noise exposure and protect the ears from hearing damage in noisy environments, such as construction sites and factories.
Respirators	 25	Filter out airborne contaminants and protect the respiratory system from dust, fumes, chemicals and infectious agents in various industries.

²⁴ <https://www.screwfix.com/c/safety-workwear/safety-boots/cat850524>

²⁵ <https://www.screwfix.com/c/safety-workwear/safety-boots/cat850524>



Activity 2: Guided Practice



Task 13

Read the following questions and answer

1. Give five (5) PPEs and their functions.
2. What do you understand by the term safety?
3. Match the items in column A to their correspondences in column B.

Refer to the following key facts 2.1 b for further information and clarifications.

Answers	Column A	Column B
1	1. Safety Signage and Labels	A. Regular cleaning and maintenance of the work area. Are essential to keep it free from clutter, spills, debris and other hazards.
2	2. Fire Safety	B. Regular assessments of the work area. Are conducted to identify potential hazards, such as slippery floors, exposed wires, uneven surfaces or poorly stored materials.
3	3. Personal Protective Equipment (PPE)	C. Clear and visible safety signs and labels. Are posted to indicate potential hazards, emergency exits, fire extinguishers and other safety information.
4	4. Workplace Ergonomics	D. Fire prevention measures, including fire alarms, smoke detectors, fire drills and designated assembly points. Are implemented to ensure quick response in case of a fire.

5	5. Hazard Identification and Assessment	E. This includes safety goggles, gloves, helmets and ear protection. Is enforced when necessary to protect workers from specific hazards.
6	6. Housekeeping	F. Workstations and equipment. Are arranged ergonomically to minimize physical strain and reduce the risk of repetitive stress injuries.

Key Facts 2.1 b: Work area and Tool and equipment safety

- **Work area safety**

Work area safety refers to the implementation of measures and practices to create a safe and secure environment for employees, visitors and anyone present in a workplace. It involves identifying potential hazards, mitigating risks and promoting a safety-first culture. Ensuring work area safety is essential to prevent accidents, injuries and illnesses, as well as to maintain productivity and employee well-being. Here are key aspects of work area safety:

- ✓ **Hazard Identification and Assessment:**

Regular assessments of the work area are conducted to identify potential hazards, such as slippery floors, exposed wires, uneven surfaces or poorly stored materials.

- ✓ **Safety Signage and Labels:**

Clear and visible safety signs and labels are posted to indicate potential hazards, emergency exits, fire extinguishers and other safety information.

- ✓ **Housekeeping:**

Regular cleaning and maintenance of the work area are essential to keep it free from clutter, spills, debris and other hazards.

- ✓ **Proper Lighting:**

Sufficient and appropriate lighting is provided to ensure visibility and prevent accidents, especially in areas with low natural light.

- ✓ **Emergency Equipment and Exits:**

Emergency equipment, such as fire extinguishers, first aid kits and emergency exits, should be easily accessible and clearly marked.

✓ **Fire Safety:**

Fire prevention measures, including fire alarms, smoke detectors, fire drills and designated assembly points, are implemented to ensure quick response in case of a fire.

✓ **Electrical Safety:**

Electrical equipment is regularly inspected and maintained and electrical hazards are properly addressed to reduce the risk of shocks and fires.

✓ **Machinery and Equipment Safety:**

Machinery and equipment are equipped with appropriate guards and employees are trained on their safe operation and maintenance.

✓ **Personal Protective Equipment (PPE):**

The use of PPE, such as safety goggles, gloves, helmets and ear protection, is enforced when necessary to protect workers from specific hazards.

✓ **Safe Material Handling:**

Proper procedures for lifting, moving and storing materials are implemented to prevent strains, sprains and falling objects.

✓ **Workplace Ergonomics:**

Workstations and equipment are arranged ergonomically to minimize physical strain and reduce the risk of repetitive stress injuries.

✓ **Policies and Procedures:**

Workplace safety policies and procedures are established, communicated to all employees and regularly reviewed and updated as needed.

● **Tool and equipment safety**

An automotive technician must adhere to the following shop safety guidelines when using all tools and equipment

✓ **Hand tool safety:**

Preventing shop accidents involves proper use and care of hand tools.

- ✚ Keep tools grease-free to avoid slipping accidents and inspect them for damage before use.
- ✚ Always use the right tool for the job, ensuring professional-quality equipment and avoiding broken or damaged tools.
- ✚ Follow proper techniques when using wrenches and hammers and wear safety glasses. Never misuse tools, use wrenches as hammers or strike two hammer heads together. Exercise caution with sharp tools and avoid placing them in pockets.
- ✚ Keep tools sharp for safer use and handle pointed tools carefully when handing them to others.

✓ **Power tool safety:**

Power tools, operated by external power sources, require utmost respect and caution.

- ✚ Always wear safety glasses and use tools within their stated capacity. Before using a power tool, ensure proper knowledge of its operation. Carelessness can lead to severe injuries, so handle power tools with care and follow safety guidelines.
- ✚ Tool and equipment safety is a crucial aspect of workplace safety, as improper use or maintenance of tools and equipment can lead to serious injuries and accidents.
- ✚ Proper training, inspection and safe handling practices are essential to ensure the well-being of workers and prevent incidents.

● **Safety tips every employee should know at work area** (esafety.com, 2023)

- ✓ Be aware of your surroundings
- ✓ Keep correct posture
- ✓ Take regular breaks
- ✓ Never take shortcuts on procedures
- ✓ Be aware of new safety procedures
- ✓ Keep emergency exits clear
- ✓ Report unsafe conditions
- ✓ Always wear personal protective equipment



Activity 3: Application



Task 14

Read the following questions and give the answers:

1. What does PPE stand for?
 - a. Public Protection Equipment
 - b. Personal Protective Equipment
 - c. Primary Prevention Equipment
 - d. Protective Procedure Equipment
2. When should you wear PPE?
 - a. Only when there's a safety inspection
 - b. Only in high-risk areas
 - c. Only during emergencies
 - d. Whenever there is a potential hazard that PPE can protect against
3. Which of the following is an example of PPE?
 - a. Mobile phone
 - b. Safety boots
 - c. Pen
 - d. Office chair
4. PPE is only necessary for certain job roles or departments, not for everyone in the workplace.
 - a. True
 - b. False
5. It is okay to remove your PPE while still in a hazardous area if you feel uncomfortable wearing it.
 - a. True
 - b. False
6. Give three examples of potential hazards which can be identified during working area assessment.
7. Give the safety tips every employee should know at work area

Topic 2.2: Cleaning and Arrangement of the Workplace



Activity 1: Problem Solving



Task 15

Observe the following pictures and answer the questions that follow:



26



A

B

C

1. What is the person in the picture A doing?
2. What specific workshop is the person cleaning?
3. Observe the picture B and C and compare them and give comments
4. What are the materials which can be used while cleaning the workplace?
5. What are the tools which can be used while cleaning the workplace?
6. Define the following terms:
 - a. Regular cleaning
 - b. Cleaning agents
 - c. Waste disposal
 - d. Tool organization
 - e. Clear pathways
 - f. Equipment grouping

Refer to the following key facts 2.2 a for further information and clarifications.

²⁶ <https://www.kaercher.com/int/professional/know-how/workshop-cleaning.html>

Key Facts 2.2 a: Cleaning and arranging a workshop

- **Key points to consider during the cleaning and arranging workshop:**

Cleaning and arranging a workshop are essential for maintaining a safe and productive working environment. Here are some key points to consider:

- ✓ **Cleaning:**

- ✚ Regular cleaning: Regularly cleaning the workshop helps remove dirt, dust and debris, creating a cleaner and healthier workspace.
- ✚ Use appropriate cleaning agents: Selecting suitable cleaning agents ensures effective cleaning without damaging tools, equipment or surfaces.
- ✚ Safety first: Prioritize safety while cleaning, especially when dealing with hazardous materials or chemicals.
- ✚ Organized storage: Ensure tools and materials have designated storage spaces, reduced clutter and make cleaning more manageable.
- ✚ Machinery maintenance: Regularly clean and maintain machinery to prevent dirt buildup and ensure optimal functionality.
- ✚ Waste disposal: Properly dispose of waste and hazardous materials according to regulations to maintain a safe and environmentally friendly workspace.

- ✓ **Arrangement:**

- ✚ Workstation layout: Plan the layout to maximize efficiency, placing frequently used tools and equipment within easy reach.
- ✚ Clear pathways: Keep walkways and work areas free from obstructions to prevent accidents and promote smooth workflow.
- ✚ Tool organization: Implement a system for organizing tools, such as using pegboards, toolboxes or wall-mounted racks.
- ✚ Equipment grouping: Group similar equipment together to streamline work processes and minimize unnecessary movement.
- ✚ Safety zones: Designate specific areas for hazardous or potentially dangerous tasks, ensuring they are well-marked and isolated.
- ✚ Utilize vertical space: Install shelves and racks to optimize storage and keep the floor area tidy.

- ✚ Labels and signage: Use clear labels and signs to identify tools, equipment and designated areas for specific tasks.
- ✚ Regular maintenance: Conduct routine checks and maintenance of workstations and equipment to prevent wear and tear.
- ✚ Employee involvement: Encourage employees to take ownership of their work areas and participate in the workshop's organization.

Overall, a well-maintained and organized workshop promotes productivity, reduces accidents and enhances the overall efficiency of daily operations.

- **Key activities involved in cleaning and arranging the workplace**

Cleaning and arranging an automobile workshop is essential for maintaining a safe and efficient working environment. Below are the typical activities involved in the process:

- ✓ **Initial assessment:** Start by evaluating the current condition of the workshop. Take note of the clutter, dirt and disorganization in the workspace.
- ✓ **Clearing the workspace:** Remove any vehicles, tools and equipment from the workshop area. This will provide a clear workspace to clean and rearrange effectively.
- ✓ **Dispose of waste:** Properly dispose of any waste materials, such as used parts, packaging and other rubbish. Consider recycling where possible to minimize environmental impact.
- ✓ **Sweep and dust:** Begin by sweeping the floors thoroughly to remove loose debris and dust. Pay attention to corners and under workbenches where dirt often accumulates.
- ✓ **Washing workbenches and tools:** clean workbenches, tool chests and other work surfaces. Use a suitable cleaning solution to remove grease, oil and other stains. Also, clean the tools and equipment to ensure they are in good working condition.
- ✓ **Organizing tools and equipment:** Sort all the tools and equipment into categories. Place frequently used tools within easy reach and those used less often can be stored in designated cabinets or shelves.

- ✓ **Inspect and maintain equipment:** Check all the workshop equipment, such as lifts, compressors and power tools, for any signs of damage or wear. Perform routine maintenance to keep them in optimal condition.
- ✓ **Workbench setup:** Organize the workbenches in a way that promotes efficiency. Arrange tools logically and use tool organizers to keep everything tidy.
- ✓ **Storage optimization:** Utilize wall-mounted racks, pegboards and cabinets for efficient storage of tools and parts. Keep frequently used items easily accessible.
- ✓ **Floor marking:** Consider using floor markings to designate specific areas for different purposes, such as parking spaces for vehicles, tool storage and walkways. This enhances safety and organization.
- ✓ **Proper disposal of hazardous materials:** If there are any hazardous materials or waste, ensure they are correctly stored and disposed of following local regulations.
- ✓ **Labeling:** Label shelves, bins and cabinets to identify the contents clearly. This helps everyone locate items easily and maintain organization.
- ✓ **Emergency exits and safety equipment:** Ensure that emergency exits are clear and accessible. Check the functionality of fire extinguishers and other safety equipment.
- ✓ **Workshop layout optimization:** Reevaluate the workshop layout to ensure an efficient flow of work. Place tools and equipment based on the frequency of use and the natural progression of tasks.
- ✓ **Cleaning tools and area:** Once everything is arranged, give the workshop a final cleaning. Sweep the floors again, dust off surfaces and make sure everything is in its designated place.
- ✓ **Establish maintenance routines:** Set up regular maintenance schedules for cleaning and organizing the workshop. Encourage everyone in the workshop to maintain cleanliness and orderliness on a daily basis.
- ✓ **Safety guidelines:** Communicate and post safety guidelines throughout the workshop to remind everyone of best practices for a safe working environment.



Activity 2: Guided Practice



Task 16

Read the following questions and give their answers.

1. Match the item in column A to the correspondence meaning in column B

Answers	Column A	Column B
1	1. Dispose of waste	A. Remove any vehicles, tools and equipment from the workshop area. This will provide a clear workspace to clean and rearrange effectively.
2	2. Initial assessment	B. Properly dispose of any waste materials, such as used parts, packaging and other rubbish. Consider recycling where possible to minimize environmental impact.
3	3. Sweep and dust	C. Sort all the tools and equipment into categories. Place frequently used tools within easy reach and those used less often can be stored in designated cabinets or shelves.
4	4. Inspect and maintain equipment	D. Start by evaluating the current condition of the workshop. Take note of the clutter, dirt and disorganization in the workspace.
5	5. Clearing the workspace	E. Begin by sweeping the floors thoroughly to remove loose debris and dust. Pay attention to corners and under workbenches where dirt often accumulates.
6	6. Organizing tools and equipment	F. Check all the workshop equipment, such as lifts, compressors and power tools, for any signs of damage or wear. Perform routine maintenance to keep them in optimal condition.

2. Give the tools, equipment and materials used while cleaning workplace

 Refer to the following key facts 2.2 b for further information and clarifications.

Key Facts 2.2 b: Tools, equipment and materials for cleaning workplace

- **Brooms and dustpans:**
For sweeping and collecting debris from floors.
- **Mops and mop buckets:**
Used for cleaning hard floors, such as tiles and concrete.
- **Vacuum cleaners:**
For cleaning carpets, upholstery and hard-to-reach areas.
- **Cleaning cloths and rags:**
Used for wiping surfaces, cleaning windows and dusting.
- **Cleaning brushes:**
For scrubbing surfaces and removing stubborn dirt and stains.
- **Sponges and scrub pads:**
Useful for cleaning dishes, sinks and other surfaces.
- **Buckets:**
Used for carrying water and cleaning solutions.
- **Cleaning solutions:**
Various types of cleaning agents, including all-purpose cleaners, degreasers, glass cleaners and disinfectants.
- **Trash bags:**
For collecting and disposing of waste.
- **Gloves:**
To protect hands from chemicals and potentially harmful substances.
- **Dusters or microfiber cloths:**
For dusting surfaces and electronics.
- **Pressure washer:**
Ideal for cleaning outdoor areas, such as sidewalks and exteriors.
- **Scrapers:**
For removing stubborn residues from surfaces like paint, stickers or gum.
- **Safety signs:**
To indicate wet floors, ongoing cleaning or hazardous areas.
- **Labels and markers:**

For proper labelling of cleaning solutions and storage containers.

- **Dust masks:**

To protect against dust and airborne particles.

- **Step stools or ladders:**

For reaching high shelves and areas that are not easily accessible.

- **Disinfecting wipes:**

Convenient for quick disinfection of frequently touched surfaces.

- **Air fresheners:**

To maintain a pleasant environment after cleaning.

- **First-aid kit:**

For any minor injuries that may occur during the cleaning process.



Activity 3: Application



Task 17

Read the following questions and provide answers:

1. Why do we need to clean and arrange the workplace?
2. Give the functions of the following tools:
 - a. Vacuum cleaners
 - b. Cleaning cloths and rags
 - c. Vacuum cleaners



Formative Assessment

1. What is the primary reason for maintaining a clean and organized engine repair workshop?
 - a) Aesthetic purposes
 - b) Compliance with regulations
 - c) Improved safety and efficiency
 - d) Saving time on cleaning
2. Which of the following should be included in the regular cleaning routine of an engine repair workshop?
 - a) Cleaning the tools and equipment only
 - b) Sweeping the floor once a week
 - c) Wiping down workbenches, tools and equipment
 - d) Cleaning the office area
3. Why is it essential to clean the workbenches and equipment after each use?
 - a) To make the workshop look tidy
 - b) To impress clients who visit the workshop
 - c) To prevent the buildup of dirt and debris
 - d) To have a designated break time for the technicians
4. What should be the ideal storage method for engine repair tools?
 - a) Scatter them on the workbench for easy access
 - b) Hang them on walls using hooks
 - c) Keep them in a large bin, all mixed together
 - d) Sort and store them in designated tool cabinets or drawers
5. Which of the following best describes the "first in, first out" (FIFO) principle in inventory management?
 - a) Using the newest tools first
 - b) Using the oldest tools first
 - c) Storing tools randomly for easy access
 - d) Cleaning tools in the order of their size

6. Why should hazardous materials be stored in a separate, designated area?
 - a) To avoid wasting time searching for them when needed
 - b) To show that the workshop is environmentally responsible
 - c) To keep them away from flammable materials and reduce the risk of accidents
 - d) To impress potential customers during inspections
7. What is the purpose of marking pathways and emergency exits in the workshop?
 - a) To adhere to government regulations
 - b) To impress visiting clients
 - c) To make the workshop look more professional
 - d) To ensure a safe and easy evacuation during emergencies
8. How can the workshop team contribute to maintaining cleanliness and arrangement in the workspace?
 - a) By leaving all cleaning tasks to the designated janitorial staff
 - b) By reporting any safety hazards or cleanliness issues to the supervisor
 - c) By ignoring minor spills and messes to avoid



Points to Remember

Cleaning and arranging an engine repair workshop are essential for maintaining a safe, efficient and productive working environment. Here are the key points to remember during the process:

- **Safety first:**
Prioritize safety by ensuring all employees wear appropriate personal protective equipment (PPE) like gloves and goggles when handling chemicals or engine components.
- **Regular cleaning:**
Schedule regular cleaning sessions to keep the workshop clean, including workbenches, floors, storage areas and tools.
- **Proper waste disposal:**
Dispose of used engine oil, fluids and other waste materials following environmental regulations to prevent pollution.
- **Engine components organization:**

Store engine components and parts in an organized manner. Label containers based on engine type and size to facilitate easy access and prevent mixing of parts.

- **Tool organization:**

Keep tools well-organized and easily accessible. Implement a system for storing and tracking tools to minimize loss and improve efficiency.

- **Efficient layout:**

Arrange workstations and equipment to promote a smooth workflow during engine repair. Ensure easy access to different sides of the engine.

- **Cleaning solutions and materials:**

Use appropriate cleaning solutions, degreasers and materials for engine components. Avoid using harsh chemicals that may damage sensitive parts.

- **Regular maintenance:**

Conduct routine maintenance of tools and equipment to ensure they are in good working condition, reducing downtime and increasing efficiency.

- **Engine washing area:**

Designate a specific area for engine washing and use proper equipment, like pressure washers, to clean engine components thoroughly.

- **Cleaning spills promptly:**

Address oil spills and other accidents immediately to prevent slips and falls and maintain a clean workspace.

- **Safety signage:**

Display safety signs and reminders throughout the workshop to promote a culture of safety and prevent accidents.

- **Employee training:**

Train all workshop personnel on proper cleaning procedures, waste disposal and the importance of maintaining a clean and organized workspace.

- **Continuous improvement:**

Encourage employees to provide feedback and suggestions for further improving the cleaning and arrangement processes in the



Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.

There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

1. Think about yourself:
 - a) Do you think you have the knowledge, skills or attitudes to do the task?
 - b) How well?
2. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

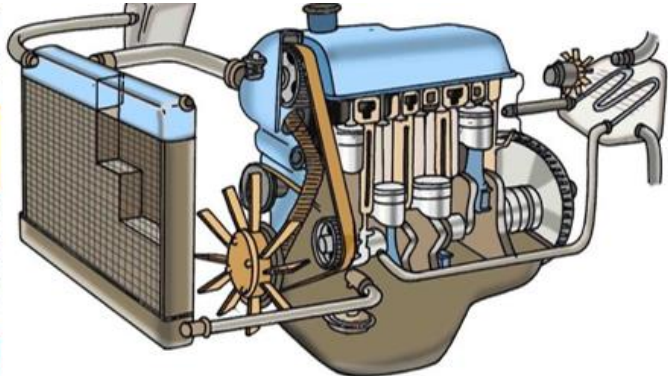
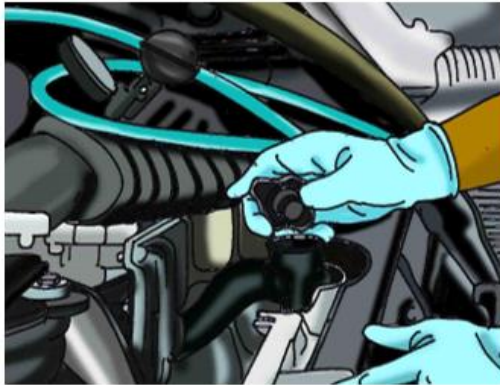
My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
Understanding the importance of safety and accident prevention in an automotive shop					
Aware of basic principles of personal safety, including protective eyewear, clothing, gloves, shoes and hearing protection					
Explain the procedures and precautions for safely using tools and equipment					
Explain the precautions that need to be followed to					

My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
safely raise a vehicle on a lift.					
Explain what should be done to maintain a safe working area in a shop.					
Describe the unique safety considerations that must be adhered to when working on hybrid vehicles.					
Describe the purpose of the laws concerning hazardous wastes and materials, including the Right-To-Know laws					
Describe your rights, as an employee and/or student, to have a safe place to work.					

Fill in the below table

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	1.	1.
2.	2.	2.

UNIT 3: OVERHAUL ENGINE



Unit summary:

This unit provides you with the knowledge, skills and attitudes to overhaul the automotive engine. It covers the selection of tools, materials and equipment, servicing of engine, removal of engine from the vehicle, correction of damaged engine mechanical components as well as remounting of the engine to the vehicle.

Self-Assessment: Unit 3

1. Referring to the unit illustration above discuss the following:

- What does the illustrations show?
- What is happening?
- What do you think this unit is about based on the illustration?

2. Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.

- There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.
- Think about yourself: do you think you have the knowledge, skills or attitudes to do the task? How well?
- Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.
- At the end of this unit, you will assess yourself again.

My experience	I don't	I know	I have	I have a	I am
Knowledge, skills and attitudes	have any experience doing this.	a little about this.	some experience doing this.	lot of experience with this.	confident in my ability to do this.
Comprehend the mechanical principles of engine					
Identify the process of troubleshooting the engine components					
Identify diagnosis techniques					

My experience	I don't	I know	I have	I have a	I am
Knowledge, skills and attitudes	have any experience doing this.	a little about this.	some experience doing this.	lot of experience with this.	confident in my ability to do this.
Identify troubleshooting techniques					
Follow the mechanical principles of engine while diagnosing					
Apply the process of troubleshooting the engine components					
Perform diagnosis					
Perform troubleshooting					
Follow safety precautions and regulations while overhauling engine					
Follow environmental regulations while overhauling engine					
Pay attention to details while describing the engine					
Demonstrate team spirit while working with others					



Key Competencies:

Knowledge	Skills	Attitudes
1. Comprehend the mechanical principles of engine	1. Follow the mechanical principles of engine while diagnosing	1. Follow safety precautions and regulations while overhauling engine
2. Identify the process of troubleshooting the engine components	2. Apply the process of troubleshooting the engine components	2. Follow environmental regulations while overhauling engine
3. Identify diagnosis techniques	3. Perform diagnosis	3. Pay attention to details while describing the engine
4. Identify troubleshooting techniques	4. Perform troubleshooting	4. Demonstrate team spirit while working with others



Discovery Activity



Task 18:

Read and answer the following questions:

1. What is engine overhauling?
2. What are the tools and equipment used to overhaul the engine?
3. List the different engine mechanical components that can be inspected during engine overhauling
4. Give the steps of removing the engine from the vehicle
5. Name the steps of remounting the engine on the vehicle

Topic 3.1: Selection of Tools, Materials and Equipment



Activity 1: Problem Solving



Task 19

Read the following questions and give their answers:

1. What type of tool is commonly used to measure the thickness of the gap between engine components, such as valve clearances?
2. During an engine overhaul, what is the purpose of using gasket sets?
3. Which piece of equipment is essential for securely holding and rotating the engine during the overhaul process?
4. Name a consumable material that is often used to ensure proper lubrication during engine assembly.
5. What is the function of a valve spring compressor in an engine overhaul?
6. When overhauling an engine, why is it important to use torque wrenches?
7. Which specialized machine is used for precision honing of cylinder walls during an engine overhaul?
8. What role do piston rings play in the engine overhaul process?
9. Explain the purpose of using thread locker on threaded fasteners during an engine overhaul.
10. Why is it crucial to wear appropriate safety equipment, such as gloves and safety glasses, when working on an engine overhaul?

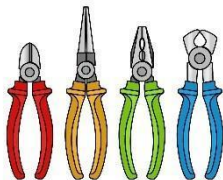
Refer to the Key facts 3.1 a, b & c for further information and clarifications.

Key Facts 3.1 a: Selection of tools, materials and equipment

Overhauling an engine is a complex process that involves disassembling, inspecting, repairing and reassembling the engine components to restore its functionality and performance. The tools, materials and equipment used for an engine overhaul can vary depending on the type of engine and the specific tasks involved.

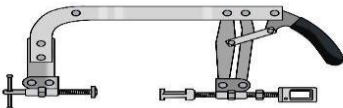
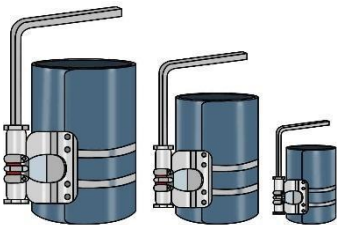
Below is a general list of tools, materials and equipment commonly used in an engine overhaul:

- Types of tools

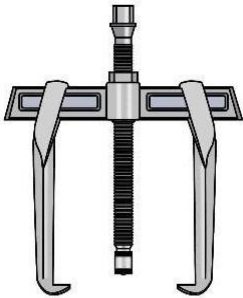
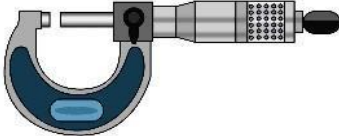
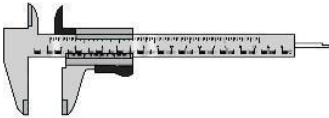
Name	Image	Functions
Wrenches and socket sets (metric and standard)	 27	Socket wrenches are widely used hand tools for easy tightening and loosening of common fasteners, typically nuts and bolts
Screwdrivers (various types and sizes)		A screwdriver is a simple and common tool used to install or remove screws.
Pliers (needle-nose, locking, etc.)		A plier is a hand-operated tool for holding and gripping small articles or for bending and cutting wire.

²⁷ <https://www.amazon.com/Standard-Extension-Sockets-72Tooth-Motorcycle/dp/B08SQ6NQ49>

Torque wrenches (various ranges)		A torque wrench is a tool used to tighten nuts and bolts to a predetermined torque value. This instrument allows fasteners to be tightened to the proper tension, helping avoid damage from over tightening or joints coming apart from under tightening.
Ratchets and extension bars		Attaches between a socket and ratchet to increase the reach of the socket and turn recessed fasteners. Available in various lengths. Locking extensions prevent the socket from dropping off or sticking on the fastener.
Oil filter wrench		An oil-filter wrench is a tool for removing spin-on type oil filters.
Pry bars and soft mallets		Pry bars, also known as crowbars or pinch bars, are hand tools used to pull two objects apart. Their angled, flattened end acts as a lever, allowing you to apply a significant amount of force between objects.

Bearing pullers and installers		A bearing puller is a tool which is used to remove components such as bearings, gears and pulleys from a shaft or a recess.
Feeler gauges	 28	A feeler gauge is used to measure or set very small gaps, normally under 1 mm. When the blades are folded back into the handle, the thin, delicate blades are protected. The thickest possible blade that can be inserted into a gap or crack shows its width. Note: normally the blades are not hardened.
Valve spring compressor		This tool is used to attach and detach valve springs and features a self-locking lever and quickly-adjustable fittings to allow it to be used with all kinds of engines.
Piston ring compressor		The piston ring compressor is a special tool that is specifically designed for compressing the piston rings when a piston is re-installed.

²⁸ <https://shopgraytools.com/products/25-blade-full-range-feeler-gauge>

Cylinder honing tool		The purpose of the hone tool is to transmit the power generated by the machine to the work piece. Honing will correct the bore for taper, size, finish and straightness, but cannot normally correct axial alignment or location.
Micrometer		Micrometer, in full micrometer caliper, instrument for making precise linear measurements of dimensions such as diameters, thicknesses and lengths of solid bodies
Vernier caliper		Vernier calipers are an important device in the steel industry. It is used to measure the inner and outer dimensions of objects that are made up of steel
Dial indicator and magnetic base		Dial Indicators are measuring devices used in mechanical and industrial applications. They are designed to measure in vertical or horizontal positions and typically used to measure clearances, tolerance and variation in tolerance of

29

²⁹ <https://www.amazon.com/Dial-Indicator-Magnetic-Base/s?k=Dial+Indicator+with+Magnetic+Base>

		machined parts to ensure accuracy. A magnetic base is essentially a holder with a magnet that can be switched “on” and “off” It functions as a stand for items (commonly dial indicators) and can be fixed to magnetic surfaces.
Timing light		The timing light is connected to the ignition circuit and used to illuminate the timing marks on the engine's crankshaft pulley or flywheel, with the engine running.
Compression tester		A compression test is to determine how much pressure the engine makes and a leak-down test measures its ability to hold pressure.
Leak-down tester		A leak-down test can tell you if the loss of compression is due to things like worn rings, burned or stuck open valves (intake or exhaust) or a leaking head gasket.

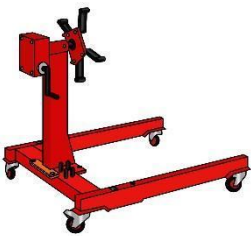
³⁰ <https://www.gunson.co.uk/product/G4101/Hi-Gauge-Compression-Tester>

³¹ <https://premium-diagnostics.com.au/products/cylinder-leak-down-tester-compression-leak-detector-petrol-engines>

Engine cleaning brushes	 32	These are used for removing the dust and other unwanted metal particles.
Gasket scrapers and sealant applicators		A gasket scraper is a carbon steel used to remove pieces of old gasket, sealant and hardened oil or carbon deposits from engine parts.

³² <https://www.ebay.co.uk/itm/202219112651>

Key Facts 3.1 b: Types of equipment used to overhaul engine

Name	Image	Function
Engine hoist or crane	 33	An engine crane (also referred as engine hoist) is a common repair equipment used in vehicle repair shops to remove or install gasoline or diesel engines in small and crowded vehicle engine compartments.
Engine stand		An engine stand is a mechanical tool that allows you to securely hold an engine in place, providing you with the ability to safely and conveniently work on your equipment.
Cylinder honing machine.	 34	The honing machine can be used directly on liners, outside the engine. Honing rectifies the shape of the liner, removes scuffing and restores surface cross pattern.

33

https://www.google.com/search?sca_esv=566055515&sxsrf=AM9HkKmt05C1yO8OVW2GU8vub9IhmuQWNw:1694948178065&q=Engine+hoist+or+crane&tbm=isch&source=lnms&sa=X&ved=2ahUKEwicpMOAvrGBAxW7gf0HHU7yC4oQ0pQJegQIDBAB&biw=1366&bih=619&dpr=1#imgsrc=6t3v1os4U47cvM

³⁴ <https://chris-marine.com/products/grinding-machining/cylinder-liner-honing-and-deglazing-machine-hon-2a/>

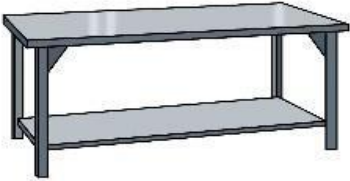
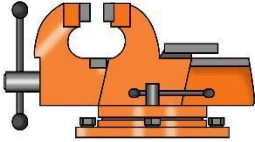
Valve seat cutting machine	 35	A valve seat cutting machine can also accurately measure the concentricity of the valve seat surface using a gauge, providing complete accuracy so the valve seat and valve can have the contact needed for the engine to run safely and efficiently.
Valve grinder	 36	This is used for smoothing out the engine valves so that they are effectively able to seal in the valve seat in the cylinder head to completely seal the engine's combustion chamber.
Torque wrench calibration tools	 37	This is Mainly used to detect a variety of fixed-type torque wrench, digital torque wrench, preset torque wrench, torque The screwdriver, screwdriver and other equipment involved in tightening force and products.
Air compressor	 38	An air compressor's main function is to convert electric power into pressurized air. When air is compressed, it becomes stronger, making it useful for different workshop applications or to power tools. In an air compressor, air is stored under pressure.

³⁵ <https://theultimatetooling.com/en/product/peg-fm1-valve-seat-manual-cutting-machine/>

³⁶ <https://www.comecpn.com/en/engine-line/rv516-valve-grinding-machine>

³⁷ <https://larsonsystems.com/product/torque-wrench-calibration/>

³⁸ <https://www.peerlessproducts.com.au/collections/single-phase-air-compressors>

Oil changer		This used for engine oil draining
Bench grinder	 39	A bench grinder is an appliance that is used to sharpen other tools. It is a must-have for your home workshop. Bench grinder has wheels that you can use for grinding, sharpening tools or shaping some objects.
Bench table		This is used as a working area station, where someone can lay an object.
Bench vice		A bench vise is an essential and integral tool used in metalworking, woodworking and some other manufacturing applications. It is mounted on workbenches and its main function is to hold the workpiece safely and securely.

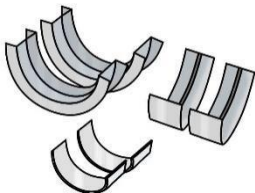
³⁹ <https://www.bosch-professional.com/lb/en/products/gbg-60-20-060127A400>

Key Facts 3.1 c: Types of materials

Name	Image	Functions
Engine oil	 40	Engine oil flows through an engine, lubricating every part. The three major functions that lubricants perform are: reducing friction, cooling and cleaning.
Oil filters		The role of the oil filter is to remove impurities such as carbon residue and metal particles from engine oil. If you continue to use an oil filter after the recommended replacement time, the engine oil will become more viscous and the filter will become clogged.
Coolant		Coolant helps reduce corrosion and engine rust. Coolant also provides resistance to freezing.
Antifreeze	 41	Anti-freeze is a colored liquid that stops the water in your engine's cooling system from freezing during the winter months.

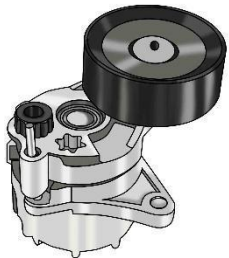
⁴⁰ <https://gomechanic.in/blog/engine-oil-guide/>

⁴¹ <https://www.edentyres.com/why-antifreeze-is-so-important-for-your-vehicle-this-winter/>

Engine assembly lubricant		Its primary function is to protect newly machined or replaced parts from wear at start-up.
Engine degreaser and Cleaning solutions		Engine degreaser is used to remove oil, dirt and grease from engines. It is an essential part of engine maintenance to keep it clean and running smoothly.
Gasket sets (head gasket, valve cover gasket, etc.)	 42	The main function of a car gasket is to act as an insulator between the cylinder block and the cylinder head. The purpose of the insulation is to prevent oil leakage so that oil will not enter the radiator channel or vice versa.
Piston rings	 43	The main functions of piston rings in engines are: Sealing the combustion chamber so that there is minimal loss of gases to the crankcase.
Bearings (main bearings, rod bearings, cam bearings)		Bearing is a device that is used to reduce friction between moving parts of machine elements to provide movement in a desired way with minimum power losses.

⁴² <https://mycarmakesnoise.com/engine/faulty-valve-cover-gasket-symptoms/>

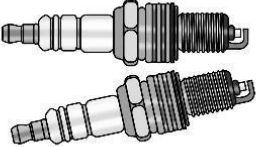
⁴³ <https://savree.com/en/encyclopedia/engine-piston-rings>

Timing chain	 44	A timing chain is an internal engine component that's fitted to synchronize the rotation of the camshaft and the crankshaft
Timing belt	 45	The timing belt is the belt that controls the camshafts in your engine, opening and closing valves at just the right time for smooth operation.
Tensioner		Tensioners apply the correct amount of tension to the timing belt to ensure a synchronous drive.
Valve seals		Essentially, valve stem seals prevent oil from entering the combustion chamber from the cylinder head.
Cylinder head dowel pins	 46	These are the Dowel Pins that fit into the deck and align the cylinder heads during assembly.

⁴⁴ <https://partshawk.com/acdelco-12637743-engine-timing-chain.html>

⁴⁵ <https://uk.rs-online.com/web/content/discovery/ideas-and-advice/timing-belts-guide>

⁴⁶ <https://store.440source.com/Cylinder-Head-Dowel-Pins-Package-of-4-New/productinfo/101-1016/>

Thread locker and sealants (e.g., Loctite)		Loctite thread lockers are primarily designed to prevent fasteners from leaking or loosening from vibration.
Fuel		Fuel is there for making mixture formation with air
Air filters	 ⁴⁷	An engine air filter prevents your engine from being damaged with dirt, dust, sand and other contaminants.
Spark plugs		A spark plug is an important component of internal combustion engines, typically in automotive applications, to ignite the fuel and air mixture by providing a spark.



Activity 2: Guided Practice

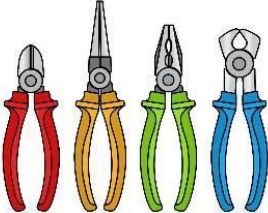


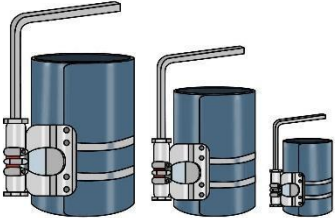
Task 20:

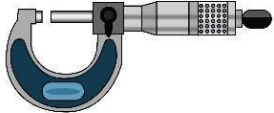
Read the following scenario and answer the questions:

There are interns from VTC Cyasha that visited your school workshop. You have been designated to take them around and explain the tools by emphasizing on the indicated ones below and their functions.

⁴⁷ <https://wuling.id/en/blog/autotips/facts-about-a-car-air-filters>

Image	Name and functions
	Tool Name: Function:
	Tool Name: Function:
	Tool Name: Function:
	Tool Name: Function:
	Tool Name: Function:

	Tool Name: Function:
	Tool Name: Function:
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Task 21:

Read the following scenario and answer the questions:

Still with the interns from VTC Cyasha in school workshop, explain them the equipment by emphasizing on the equipment in column A and match them to their corresponding function in column B.

Answers	Column A	Column B
1	1. Engine hoist or crane	A. is a mechanical tool that allows you to securely hold an engine in place, providing you with the ability to safely and conveniently work on your equipment
2	2. Bench grinder	B. This is used as a working area station, where someone can lay an object.
3	3. Bench table	C. is a common repair equipment used in vehicle repair shops to remove or install gasoline or diesel engines in small and crowded vehicle engine compartments
4	4. Engine stand	D. is an appliance that is used to sharpen other tools. It is a must-have for your home workshop.



Task 22:

Read the following scenario and answer the questions:

Help the interns from VTC Cyasha that visited your school workshop, to understand the materials used to overhaul engine by answering the following questions:

1. What is the material which performs friction reduction, cooling and cleaning at the same time?
2. What components perform its role as insulator between cylinder block and cylinder head?
3. What can happen if you continue to use an oil filter after the recommended replacement time?
4. Give the names of the following materials used in engine:

No	Image	Name
1		
2		
3		

☞ Present your results to the rest of the class.

☞ Refer to the Key facts 3.1 a, b & c for further information.

☞ Ask for more clarification from your trainer.



Activity 3: Application



Task 23

Read the following scenario and answer the questions:

Visit a repair shop in the neighbourhood, select the tools, materials and equipment then answer:

1. What is the purpose of a valve spring compressor in an engine overhaul?
 - a. Measuring cylinder bore diameter
 - b. Cleaning engine components
 - c. Compressing valve springs for removal and installation
 - d. Checking engine oil viscosity
2. Which of the following is a consumable material used during an engine overhaul?
 - a. Torque wrench
 - b. Feeler gauge

- c. Engine oil
 - d. Engine hoist
3. What equipment is commonly used to securely hold and rotate the engine during assembly?
- a. Pliers
 - b. Screwdriver
 - c. Engine hoist
 - d. Engine stand
4. Which tool is used to measure the thickness of the gap between engine components, such as valve clearances?
- a. Torque wrench
 - b. Dial indicator
 - c. Micrometer
 - d. Feeler gauge
5. What is the purpose of a piston ring compressor?
- a. Measuring piston diameter
 - b. Cleaning piston rings
 - c. Compressing piston rings during installation
 - d. Measuring valve stem clearance
6. Which of the following is NOT a consumable material used in an engine overhaul?
- a. Engine oil filter
 - b. Main bearings
 - c. Valve spring compressor
 - d. Gasket set
7. What equipment is commonly used for precision honing of cylinder walls?
- a. Engine stand
 - b. Cylinder honing machine
 - c. Torque wrench
 - d. Valve grinder
8. Which tool is used to measure the depth of valve recession in the cylinder head?
- a. Piston ring compressor

- b. Micrometre
 - c. Dial indicator
 - d. Thread locker
9. What is the purpose of using thread locker during an engine overhaul?
- a. Cleaning threads
 - b. Measuring torque
 - c. Securing threaded fasteners from loosening
 - d. Checking cylinder pressure
10. Make a report on the tools, materials and equipment used to overhaul engines available at the repair shop, their functions and how to handle them.

Topic 3.2: Maintaining and Servicing the Engine systems



Activity 1: Problem Solving



Task 24

Read and answer the questions below

1. Give the steps to be followed when changing engine oil and filter
2. Give the steps to be followed when changing coolant
3. Give the steps to be followed when replacing the air filter
4. Give the steps to be followed when replacing the fuel filter
5. Give the steps to be followed when replacing the spark plugs
6. Give the steps to be followed when replacing the timing belt or chain
7. Give the steps to be followed for the throttle body cleaning
8. Give the steps to be followed for the engine compression test
9. Give the steps to be followed for the engine tune-up
10. Give the steps to be followed for the gasket replacement
11. Give the steps to be followed for the engine mounting replacement
12. Give the steps to be followed for the testing of engine performance
13. Give the safety precautions while servicing engine

 Refer to the Key facts 3.2 for further information and clarifications.

Key Facts 3.2: Engine systems maintenance and servicing

The following are the steps and procedures needed for engine servicing:

- **Changing engine oil and filter**

Engine oil is a clean or refined form of crude oil. Crude oil, when taken out of the ground, is dirty and does not work well as a lubricant for engines. Crude oil must be refined to meet

industry standards. Engine oil (often called motor oil) is just one of the many products that come from crude oil.

The following are the steps needed to be passed through while changing the engine oil and filter.

Step 1: Always make sure the vehicle is positioned safely on a lift or supported by jack stands before working under it. Before raising the vehicle, allow the engine to run a while. After it is warm, turn off the engine



Figure 5: First step of Changing engine oil and filter⁴⁸

Step 2: The tools and other items needed to change the engine's oil and oil filter are rags, a funnel, an oil filter wrench, safety glasses and a wrench for the drain plug.



Figure 6: Second step of Changing engine oil and filter⁴⁹



Figure 7: Third step of Changing engine oil and filter

Step 3: Place the oil drain pan under the drain plug before beginning to drain the oil

⁴⁸ Modern automotive technology

⁴⁹ Modern automotive technology

Step 4: Loosen the drain plug with the appropriate wrench. After the drain plug is loosened, quickly remove it so the oil can freely drain from the oil pan.	 Figure 8: Fourth step of Changing engine oil and filter
Step 5: Make sure the drain pan is positioned so it can catch all of the oil.	 Figure 9: Fifth step of Changing engine oil and filter
Step 6: While the oil is draining, use an oil filter wrench to loosen and remove the oil filter.	 Figure 11: Sixth step of Changing engine oil and filter
Step 7: Make sure the oil filter seal comes off with the filter. Then place the filter into the drain pan so it can drain. After it has completely drained, discard the filter according to local regulations.	 Figure 12: Seventh step of Changing engine oil and filter

Step 8: Wipe off the oil filter sealing area on the engine block. Then apply a coat of clean engine oil onto the new filter's seal.



Figure 13: Eighth step of Changing engine oil and filter

Step 9: Install the new filter and hand tighten it. Oil filters should be tightened according to the directions given on the filter

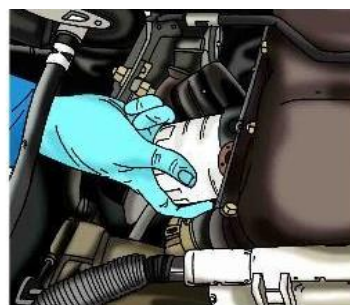


Figure 14: Ninth step of Changing engine oil and filter

Step 10: Prior to installing the drain plug, wipe off its threads and sealing surface with a clean rag.

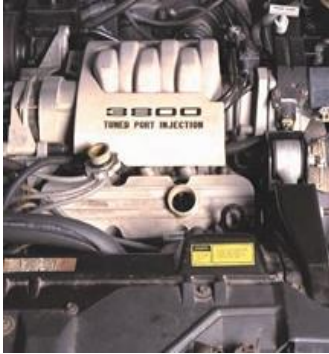


Figure 15: Tenth step of Changing engine oil and filter

Step 11: Tighten the drain plug according to the manufacturer's recommendations. Overtightening can cause thread damage, whereas under tightening can cause an oil leak.



Figure 16: Eleventh step of Changing engine oil and filter

Step 12: With the oil filter and drain plug installed, lower the vehicle and remove the oil filler cap.	 Figure 17: Twelfth step of Changing engine oil and filter⁵⁰
Step 13: Carefully pour the oil into the engine. The use of a funnel usually keeps oil from spilling on the engine.	 Figure 18: Thirteenth step of Changing engine oil and filter
Step 14: After the recommended amount of oil has been put in the engine, check the oil level.	 Figure 19: Fourteenth step of Changing engine oil and filter⁵¹

⁵⁰ Modern automotive technology

⁵¹ Modern automotive technology

Step 15: Start the engine and allow it to reach normal operating temperature. While the engine is running, check the engine for oil leaks, especially around the oil filter and drain plug. If there is a leak, shut down the engine and correct the problem.



Figure 20: Fifteenth step of Changing engine oil and filter

Step 16: After the engine has been turned off, recheck the oil level and correct it as necessary.

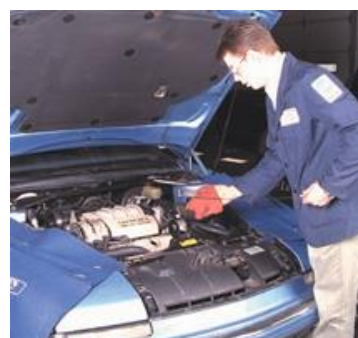


Figure 21: Sixteenth step of Changing engine oil and filter⁵²

- **Changing coolant**

Whenever you change an engine's oil, you should also do a visual inspection of the different systems under the hood, including the cooling system. Inspect all cooling system hoses for signs of leakage and/or damage. Replace all hoses that are swollen, cracked or show signs of leakage.

The radiator should also be checked for signs of leaks; if any are evident the radiator should be repaired or replaced. Also, check the front of the radiator for any buildup of dirt and bugs. This can restrict airflow through the radiator and should be removed by thorough cleaning.

- **Caution:**

- A. Never remove the radiator cap when the coolant is hot. Because the system is pressurized, the coolant can be hotter than boiling water and will cause severe

⁵² Modern automotive technology

burns. Wait until the top radiator hose is not too hot to touch. Then press down on the cap and slowly turn it until it hits the first stop. Now slowly let go of the cap. If there is any built-up pressure in the system, it will be released when the cap is let up. After all pressure has been exhausted, turn the radiator cap to remove it.

- B. Never leave ethylene glycol or propylene glycol coolant out and lying around. Both children and animals will drink it because of its sweet taste. The coolant is poisonous and can cause death.

Changing the coolant in a vehicle's cooling system is an important maintenance task that helps ensure the engine operates at the proper temperature and remains protected from overheating. Here are the general steps to follow when changing the coolant:

1. Preparation:

- i. Park the vehicle on a flat surface and engage the parking brake.
- ii. Open the hood and locate the radiator and coolant reservoir.

2. Draining the Old Coolant:

- i. Place a drain pan beneath the radiator drain plug (located at the bottom of the radiator) to catch the old coolant.
- ii. Use a screwdriver or wrench to loosen and remove the radiator drain plug. Allow the coolant to drain completely into the drain pan.

3. Flushing the System (Optional):

Some manufacturers recommend flushing the cooling system with distilled water to remove any residual contaminants. This step may involve running water through the system until it runs clear. Check your vehicle's manual for specific instructions.

4. Closing the Drain Plug:

Once the old coolant has drained, carefully tighten the radiator drain plug back in place.

5. Refilling with New Coolant:

- i. Use a funnel to pour the new coolant into the radiator or the coolant reservoir, depending on your vehicle's design.
- ii. Follow the manufacturer's instructions regarding the coolant-to-water ratio, if applicable.
- iii. Be sure to use the correct type of coolant as recommended by the vehicle manufacturer.

6. Bleeding Air from the System:

Some cooling systems may require bleeding to remove air pockets. Consult your owner's manual for the correct procedure, which may involve squeezing a coolant hose or using a bleeder valve.

7. Checking Coolant Level:

- i. Start the engine and let it run for a few minutes to allow the coolant to circulate.
- ii. Check the coolant level in the reservoir and top it up if necessary.

8. Final Checks:

- i. Check for any leaks around the drain plug, radiator and hoses.
- ii. Dispose of the old coolant properly at a recycling center or service station that accepts used coolant.



- **Air filter replacement**⁵³

The steps followed while replacing the air filter:

1. Park the vehicle on a level surface and engage the parking brake.
2. Open the hood and locate the air filter housing.
3. Remove the clips, screws or clamps securing the housing cover.
4. Lift off the housing cover and remove the old air filter.
5. Clean any debris from inside the housing.
6. Insert the new air filter in the same orientation as the old one.
7. Replace the housing cover and secure it with clips, screws or clamps.
8. Close the hood.
9. Start the engine and ensure proper operation.

- **Fuel filter replacement**⁵⁴

The steps followed while replacing the fuel filter:

1. Locate the fuel filter.
2. Depressurize the fuel system by relieving pressure from the fuel lines.
3. Disconnect the negative battery terminal.
4. Position a container beneath the filter to catch any fuel that may leak.
5. Disconnect the fuel lines from the filter using appropriate tools.
6. Remove any mounting brackets or clamps securing the filter.
7. Install the new filter and secure it with mounting brackets.
8. Reconnect the fuel lines.
9. Reconnect the negative battery terminal.
10. Start the engine and check for leaks.



⁵³ <https://www.cornerstoneplymouth.com/change-engine-air-filter-frequency/>

⁵⁴ <https://www.waynesautocenter.com/blog/how-often-should-i-change-my-diesel-fuel-filter/>

- **Spark plugs replacement** ⁵⁵

The steps followed while replacing the spark plug:

1. Locate the spark plugs on the engine.
2. Disconnect the negative battery terminal.
3. Remove any components obstructing access to the spark plugs (e.g., engine covers, wires).
4. Use a spark plug socket to remove the old spark plugs.
5. Check the gap on the new spark plugs to ensure they match manufacturer specifications.
6. Install the new spark plugs by hand, then tighten them using a torque wrench.
7. Reattach any components that were removed.
8. Reconnect the negative battery terminal.



- **Timing belt or chain replacement**



The steps followed while replacing the Timing belt or chain:

1. Consult the vehicle's manual for specific instructions and precautions.
2. Remove any components obstructing access to the timing belt/chain.
3. Rotate the engine to the specified position to align timing marks.
4. Remove the old timing belt/chain and associated components (tensioners, guides).
5. Install the new timing belt/chain and components, ensuring proper alignment of timing marks.
6. Tension the timing belt/chain according to manufacturer guidelines.
7. Rotate the engine manually to check for proper alignment and tension.

⁵⁵ <https://leahysauto.com/how-to-replace-your-spark-plugs-yourself/>

8. Reassemble any removed components.
9. Reconnect the negative battery terminal.

- **Throttle body cleaning**

The steps followed while cleaning the throttle body:



1. Locate the throttle body.
2. Disconnect the negative battery terminal.
3. Remove any air intake components obstructing access to the throttle body.
4. Use a throttle body cleaner and a soft brush to clean the throttle body's interior.
5. Clean the throttle plate carefully, avoiding damage.
6. Reassemble any removed components.
7. Reconnect the negative battery terminal.
8. Start the engine and allow it to idle, then rev it a few times to ensure proper operation.

- **Engine compression test** ⁵⁶

The steps followed while performing engine compression test:



1. Disable the ignition system to prevent the engine from starting.
2. Remove the spark plugs from all cylinders.
3. Screw a compression gauge into one of the spark plug holes.
4. Have an assistant crank the engine while you monitor the compression gauge.
5. Record the compression reading for each cylinder.
6. Compare the readings to the manufacturer's specifications.
7. Repeat the process for all cylinders.

⁵⁶ <https://blog.amsoil.com/how-to-test-engine-compression/>

8. If compression is significantly low in one or more cylinders, further diagnostics may be needed.

- **Engine tune-up⁵⁷**

Activities carried out while performing Engine tune-up:

1. Replace spark plugs if necessary.
2. Check and replace the air filter if dirty.
3. Check and replace the fuel filter if needed.
4. Inspect ignition wires or coils for damage.
5. Check and adjust ignition timing if applicable.
6. Check and adjust idle speed if applicable.
7. Check and adjust valve clearance if applicable.
8. Check and top up engine fluids (oil, coolant, etc.).
9. Inspect and tighten belts and hoses.
10. Perform a test drive to ensure proper engine performance.



- **Gasket replacement⁵⁸**

The steps followed while replacing the gasket:

1. Identify the gasket that needs replacement.
2. Disconnect any components or parts blocking access to the gasket.
3. Remove the old gasket carefully to avoid damaging the mating surfaces.
4. Clean the mating surfaces thoroughly.
5. Apply a thin layer of gasket sealant if required.
6. Install the new gasket onto the mating surfaces.
7. Reassemble any components that were removed.



⁵⁷ <https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.kbb.ca%2Fnews-details%2F--what-s-involved-in-a-vehicle-tune-up---%2F%3Fid%3D82&psig=AOvVaw0GTmvAavyOnjJuHHDkNkwr&ust=1695054180614000&source=images&cd=vfe&opi=89978449&ved=0CBAQjRxqFwoTCJDq1oWHsoEDFQAAAAAdAAAAABAE>

⁵⁸ <https://www.thedrive.com/maintenance-repair/36754/head-gasket-repair>

8. Ensure proper torque settings when tightening bolts or fasteners.
9. Test for leaks and proper sealing.

- **Engine mounting replacement**

The steps followed while replacing engine mountings:

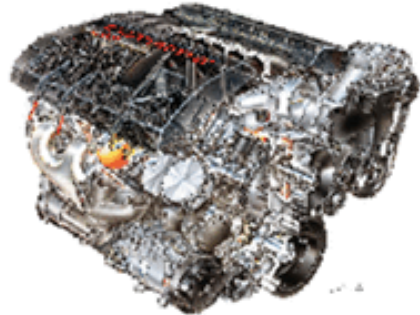
1. Safely raise and support the vehicle.
2. Identify the engine mount that needs replacement.
3. Support the engine from below using a jack or engine hoist.
4. Remove any components obstructing access to the engine mount.
5. Remove the bolts securing the old mount to the engine and frame.
6. Install the new mount and secure it with bolts.
7. Lower the engine onto the new mount.
8. Reassemble any components that were removed.
9. Lower the vehicle and remove the support.



- **Testing of engine performance**

The activities carried out while testing engine performance:

1. Use a diagnostic scanner to check for any stored trouble codes.
2. Check engine fluid levels (oil, coolant, transmission fluid, etc.).
3. Perform a visual inspection for leaks, damaged wires or components.
4. Start the engine and listen for unusual noises.
5. Observe the exhaust for excessive smoke or unusual odors.
6. Perform a test drive to evaluate acceleration, braking and overall engine performance.



7. Use performance testing equipment to assess power output, acceleration times, etc.
8. Compare results to manufacturer specifications.

Safety precautions while servicing engine

⁵⁹The following are the safety precautions to be applied while servicing the engine:



1. Always work in a well-ventilated area to avoid exposure to fumes.
2. Wear appropriate personal protective equipment (PPE) such as gloves, safety goggles and a dust mask.
3. Disconnect the negative battery terminal to prevent accidental electrical contact.
4. Use proper tools and equipment for the task at hand.
5. Support the vehicle securely on jack stands when working underneath it.
6. Follow proper lifting procedures if the engine needs to be lifted.
7. Let the engine cool down before starting work to avoid burns.
8. Use caution around moving parts and hot components.
9. Consult the vehicle's manual for specific safety precautions related to your make and model.
10. If you're unsure about any step, seek guidance from a professional mechanic.

⁵⁹ <https://www.idoinspire.com/blog/create-a-positive-safety-culture>



Activity 2: Guided Practice



Task 25:

Read the following scenario and provide answer to the questions:

Assume in the school workshop, there are vehicles from different TVET schools in your District. Each of your class member is going to service one vehicle, by performing the following tasks:

1. Explain the importance of safety and proper workspace setup when performing engine service.
2. Oil change.
3. Demonstrate locating the oil drain plug and positioning the oil drain pan.
4. Removing the plug, draining the oil and replacing the plug.
5. Oil filter replacement
6. Assess the condition of the air filter.
7. Cleaning or replacement spark plugs



Activity 3: Application



Task 26:

Read the following scenario and answer the questions that follow:

In one of the repair shops in your neighbourhood, there is a sedan experiencing a sluggish performance and reduced fuel efficiency. Upon initial inspection, you find that the engine oil is dark and dirty, the air filter is clogged and the spark plugs appear worn. You decide that a basic engine servicing is necessary to address the issues and restore the car's performance.

1. Identify the potential causes of sluggish performance and reduced fuel efficiency.
2. Make a list of the several issues indicated in the scenario.
3. Write down specific recommendations for each issue, explaining the importance of addressing each one.
4. Create a step-by-step outline of the engine servicing procedure based on your recommendations.
5. Compile a report.

Topic 3.3: Dismount engine from the vehicle



Activity 1: Problem Solving



Task 27

Read the following questions and select the correct answers:

1. What is the primary reason for removing an engine from a vehicle?
 - a) To increase the vehicle's weight
 - b) To access the air conditioning system
 - c) To perform maintenance or repair work
 - d) To change the vehicle's tires
2. Which safety measure should be taken before beginning the engine removal process?
 - a) Disconnecting the battery
 - b) Increasing the engine's RPM
 - c) Removing safety goggles
 - d) Wearing sandals
3. What role does the leader in a team play during the engine removal process?
 - a) They operate the tools
 - b) They support the vehicle on jack stands
 - c) They oversee the process and coordinate team members
 - d) They dismantle the engine components
4. Why is it important to disconnect the battery before starting the engine removal?
 - a) To prevent air pollution
 - b) To conserve battery power
 - c) To ensure engine stability
 - d) To prevent electrical accidents

5. Which component is commonly removed to access the engine and perform maintenance?
 - a) Radiator
 - b) Transmission
 - c) Exhaust pipe
 - d) Fuel tank
6. Which step comes first in the engine removal process?
 - a) Disconnecting electrical connections
 - a) Lifting the engine
 - b) Removing the engine covers
 - c) Draining fluids from the engine
7. What should you use to support the vehicle securely during the engine removal process?
 - a) Wooden blocks
 - b) Jack stands
 - c) Concrete bricks
 - d) Air cushions
8. Why is it important to drain fluids from the engine before removal?
 - a) To make the engine lighter
 - b) To clean the engine compartment
 - c) To recycle the fluids
 - d) To prevent spills and contamination
9. What tool might be used to lift the engine during removal?
 - a) Screwdriver
 - b) Pliers
 - c) Toy crane
 - d) Wrench
10. Which aspect of engine removal emphasizes teamwork and coordination?
 - a) Removing the battery
 - b) Draining fluids
 - c) Lifting the engine

d) Removing the exhaust pipe

🗉 Share your results with the rest of the class.

🗉 Refer to Key facts 3.3 for further information and clarifications.

Key Facts 3.3: Removal of engine from the vehicle

- **Removal steps**

Certainly, here are the key steps to follow when removing an engine from a vehicle, along with general safety precautions:

- ✓ **Disconnection of the starter battery:**

- 🔧 Locate the vehicle's battery.
- 🔧 Use the appropriate tools to disconnect the negative (black) terminal first, then the positive (red) terminal.
- 🔧 Safely secure the disconnected battery cables to prevent accidental reconnection.

- ✓ **Draining Fluids:**

- 🔧 Place a drain pan under the engine.
- 🔧 Drain engine oil, coolant and any other fluids as required by removing drain plugs or using drain valves.
- 🔧 Dispose of drained fluids properly according to regulations.

- ✓ **Removal of Auxiliary Components:**

- 🔧 Remove engine covers, air intake and other components obstructing access to the engine.
- 🔧 Label and disconnect hoses, belts and connectors attached to the auxiliary components.

- ✓ **Disconnection of Wiring and Hoses:**

- 🔧 Carefully disconnect electrical connectors and wiring from the engine.
- 🔧 Label and disconnect hoses connected to the engine and related components.

- ✓ **Removal of Exhaust System:**

-  Unbolt and remove the exhaust components, including pipes, mufflers and catalytic converters.
- ✓ **Disconnection of transmission:**
 -  If necessary, disconnect the transmission from the engine by removing bolts and linkages.
 -  Support the transmission to prevent strain on other components.
- ✓ **Supporting the vehicle:**
 -  Lift the vehicle using a proper lifting device, such as a hydraulic lift or jack stands.
 -  Ensure the vehicle is securely and evenly supported to prevent accidents.
- ✓ **Unbolting the engine mountings:**
 -  Locate the engine mountings and support brackets.
 -  Carefully unbolt the engine mountings from the vehicle frame.
- ✓ **Lift of engine:**
 -  Attach a suitable lifting device, such as an engine hoist, to the engine lifting points.
 -  Gradually lift the engine while ensuring it's clear of all components and connections.
- ✓ **Clear the engine bay:**
 -  Carefully guide the engine out of the vehicle, ensuring it is clear of obstructions.
- ✓ **Inspect and Store:**
 -  Inspect the engine and related components for damage or wear.
 -  Store the removed engine in a safe and clean area, if needed.
- **General Safety Precautions:**
 - ✓ **Safety Gear:**

Wear appropriate personal protective equipment (PPE), including gloves, safety goggles and protective clothing.
 - ✓ **Disconnect Battery:**

Always disconnect the battery to prevent electrical accidents during engine removal.

✓ **Secure Tools:**

Use proper tools and keep them organized to prevent accidents and confusion.

✓ **Label Components:**

Label wires, hoses and connectors to ensure correct reconnection.

✓ **Work Area:**

Keep the work area clean and well-lit and ensure proper ventilation when working with fluids.

✓ **Proper Lifting:**

Use proper lifting devices and techniques to avoid strain or injury.

✓ **Team Communication:**

Communicate clearly and effectively with team members during the process.

✓ **Double-Check:**

Before lifting the engine, double-check all connections and components to ensure they are properly disconnected.

Always consult the vehicle's manual or seek professional assistance if you're unsure about any step or aspect of the process. Safety is paramount when working on vehicles.



Activity 2: Guided Practice



Task 28:

Read the following scenario and perform the tasks related:

You are a part of a team of mechanics tasked with removing the engine from a vehicle for a major overhaul in your school workshop. You have access to the necessary tools and safety equipment. Follow the correct steps and procedures to safely and efficiently service the engine.

Support your actions by answering the below questions:

1. What is the main objective of removing the engine from the vehicle?
 - a) To clean the engine compartment
 - b) To improve the vehicle's fuel efficiency
 - c) To perform maintenance, repairs or upgrades
 - d) To repaint the engine parts
2. Before starting any work, what should you do to ensure your safety?
 - a) Disconnect the transmission
 - b) Wear appropriate personal protective equipment (PPE)
 - c) Drain the fuel tank
 - d) Unbolt the engine mountings
3. Why is it important to disconnect the starter battery before removing the engine?
 - a) To save battery power
 - b) To reduce engine weight
 - c) To prevent electrical accidents
 - d) To cool down the battery
4. Which component should you remove first during the "Removal of Auxiliary Components" step?
 - a) Air intake and engine covers
 - b) Engine oil drain plug
 - c) Fuel injectors
 - d) Radiator cap
5. What precaution should you take while disconnecting wiring and hoses?
 - a) Disconnect them without labeling
 - b) Use any tools available
 - c) Label them for proper reconnection
 - d) Leave them connected for safety reasons
6. Why is the removal of the exhaust system necessary during engine removal?
 - a) To make the engine sound louder
 - b) To reduce the vehicle's weight
 - c) To access and disconnect the transmission

- d) To improve the vehicle's aerodynamics
7. What precaution should be followed when disconnecting the transmission?
- a) Disconnect the transmission while the vehicle is in gear
 - b) Support the transmission to avoid strain on other components
 - c) Disconnect the exhaust system last
 - d) Drain the transmission fluid after disconnection
8. Why is it essential to support the vehicle securely during engine removal?
- a) To make the engine removal process faster
 - b) To increase the vehicle's height
 - c) To improve visibility during the process
 - d) To prevent accidents and ensure safety
9. What is the primary purpose of unbolting the engine mountings?
- a) To remove the tires
 - b) To clear the engine bay
 - c) To disconnect the battery
 - d) To separate the engine from the vehicle frame
10. After lifting the engine, what should you do next?
- a) Drain the engine oil
 - b) Inspect the exhaust system
 - c) Inspect the vehicle's tires
 - d) Clear the engine bay and guide the engine out



Activity 3: Application



Task 29:

Read the scenario and perform the tasks related:

1. Visit the neighboring automotive repair shops, service two different engines for the vehicles brought yesterday for the service.
2. Make a report on the service to be provided, by focusing on the following:
 - a) Disconnecting the starter battery
 - b) Draining fluids
 - c) Removal of the auxiliary components
 - d) Disconnecting wiring and hoses
 - e) Removal of exhaust system
 - f) Disconnecting of transmission
 - g) Supporting the vehicle
 - h) Unbolting the engine mountings
 - i) Lift of engine
 - j) Clear the engine body
 - k) Inspect and store and
 - l) The general safety precautions needed while removing the engine from vehicle

Topic 3.4: Correction of Damaged Engine Mechanical Components



Activity 1: Problem Solving



Task 30:

Read and answer the questions below

Section 1: Disassembling of engine mechanical components

1. What is the purpose of disassembling the cylinder head in an engine?
 - a) To clean the exterior of the head
 - b) To access and service valves, springs and other components
 - c) To improve exhaust sound
 - d) To replace the engine case
2. Engine cases are disassembled primarily to:
 - a) Adjust the engine timing
 - b) Inspect the condition of the cylinder head gasket
 - c) Access and work on internal components
 - d) Replace the fuel injectors
3. Engine timing involves the synchronization of:
 - a) Engine cooling system with the exhaust system
 - b) Camshaft and crankshaft positions
 - c) Piston and cylinder positions
 - d) Turbocharger and supercharger operation
4. The crankshaft drive is responsible for:
 - a) Adjusting the engine's fuel mixture
 - b) Distributing electrical power to various components
 - c) Converting reciprocating motion to rotational motion
 - d) Controlling the transmission shifting

Section 2: Inspection of engine mechanical components status

1. During the inspection of the cylinder head, what components might you examine for wear or damage?
 - a) Tires and suspension system
 - b) Valves, valve springs and valve seats
 - c) Air conditioning compressor
 - d) Exterior paint condition
2. What might you assess when inspecting the engine case?
 - a) Brake pad thickness
 - b) Oil filter condition
 - c) Presence of coolant leaks
 - d) Cracks, warping or signs of stress
3. Engine timing inspection involves checking:
 - a) Ignition coil resistance
 - b) Camshaft and crankshaft alignment
 - c) Alternator belt tension
 - d) Airbag deployment mechanism
4. When inspecting the crankshaft drive, you're primarily looking for:
 - a) Radio volume control functionality
 - b) Crankshaft material composition
 - c) Worn bearings and misalignment
 - d) Tire pressure sensor readings

Section 3: Repair and Replacement

What is the purpose of repair and replacement in engine maintenance?

- a) Enhancing the vehicle's top speed
- b) Reducing the engine's overall weight
- c) Restoring proper functioning and extending lifespan
- d) Increasing fuel consumption

Section 4: Re-assembling Engine Mechanical Components

1. After repairing engine components, what's the next step in the maintenance process?
 - a) Disposing of old engine parts
 - b) Replacing the entire engine assembly
 - c) Re-assembling the components in the reverse order
 - d) Changing the vehicle's paint color
2. What's the significance of properly torquing bolts during reassembly?
 - a) It prevents engine overheating
 - b) It ensures consistent exhaust tone
 - c) It prevents oil leaks and maintains component integrity
 - d) It improves fuel efficiency
3. Why is following the manufacturer's specifications important when re-assembling engine components?
 - a) It impresses your friends with your mechanical skills
 - b) It makes the engine louder and more powerful
 - c) It maintains warranty coverage and proper functionality
 - d) It helps reduce engine vibrations

🔧 Present your observation/results to the rest of the class and

🔧 Refer to the Key facts 3.4 a for more clarifications

Key Facts 3.4 a: Disassembling of engine mechanical components

Engine disassembly involves carefully dismantling an internal combustion engine into its individual components. This process requires proper tools, safety equipment and a methodical approach. Key steps include removing the intake and exhaust manifolds, disconnecting electrical and fuel system components, detaching the cylinder head and disassembling the rotating assembly, which includes the crankshaft, pistons and connecting rods. Careful documentation and organization of parts are crucial for successful reassembly.

Raise the engine and position it next to an engine stand. Mount the engine to the engine stand with bolts. Most stands use a plate with several holes or adjustable arms. The engine must be supported by at least four bolts that fit solidly into it. The engine should be positioned so that its center is in the middle of the engine stand's adapter plate. This will ensure that the engine is not too heavy when rotated on the engine stand.



Figure 22: Engine on stand

In most cases, the flywheel or flex plate must be removed to mount the engine on its stand. Mark the position of the flywheel on the crankshaft. This aids the reassembly of the engine. To do this, loosen—but do not remove—the attaching bolts in a “star” pattern to reduce the chance of distorting the flywheel.

Cylinder Head Removal

The first step in disassembly of an engine is usually the removal of the intake and exhaust manifolds. On some inline engines, the intake and exhaust manifolds are often removed as an assembly.

And remember to drain oil and coolant.

⁶⁰ <https://www.knockoutengine.com/what-is-engine-stand-and-from-what-parts-it-consists/>

Remove the valve cover

During valve cover inspection, the condition of the gasket and seals is checked for leaks and the overall cleanliness of the internal components, such as the camshafts, valves and lifters, is assessed to ensure proper lubrication and functioning. Additionally, any signs of sludge buildup or unusual wear patterns are noted for maintenance or repair considerations.



⁶¹ Figure 23: Valve cover

Removing the oil pan and pickup tube:

- 1) Inspect oil pan for cracks or damage.
- 2) Clean oil pans thoroughly to remove debris and sludge.
- 3) Check the pickup tube for damage and proper alignment.

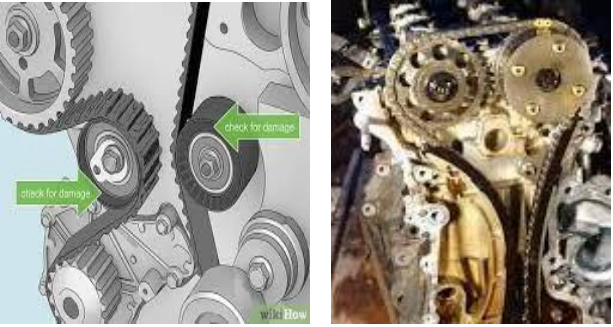


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Figure 24: Oil Pan and Pickup Tube

⁶¹ <https://www.mobil.com/en/lubricants/for-personal-vehicles/auto-care/vehicle-maintenance/how-to-replace-a-valve-cover-gasket>

⁶² <https://209yota1.com/5vz-fe-oil-pan-info/>

Removing the timing components: 1) Inspect timing chain/belt for wear and tension. 2) Check timing gear teeth for signs of wear or damage. 3) Measure timing chain/belt deflection or stretch.	63  Figure 25: Timing Components
Disassemble the rocker arm components. Check the rocker area for sludge. Keep the rocker arms or rocker arm assemblies in the order they were installed. Rocker arm components undergo inspections for wear, alignment and lubrication. Wear patterns, pivot points and bearing surfaces are checked to ensure smooth movement and proper contact with the camshaft and valve stems. Additionally, proper alignment with related components and adequate lubrication are crucial for optimal performance and longevity of the rocker arm system.	64  Figure 26: rocker arm components

⁶³ <https://www.wikihow.com/Change-a-Timing-Belt>

⁶⁴ https://en.wikipedia.org/wiki/Rocker_arm

N.B: If the engine uses the camshaft.

At this step, remove the camshaft:

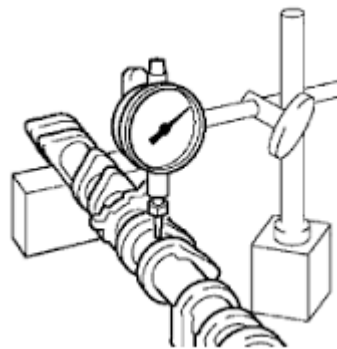
After removing the camshaft, conduct the following practices:

- 1) Measure camshaft lobes for wear and profile accuracy.
- 2) Inspect camshaft journals for scoring or damage.
- 3) Check camshaft endplay and thrust clearance.



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Figure 27: Camshaft



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Figure 28: Measuring the camshaft lobes for wear and profile accuracy

Loosening the cylinder head bolts

When loosening cylinder head bolts; follow the sequence given by the manufacturer.

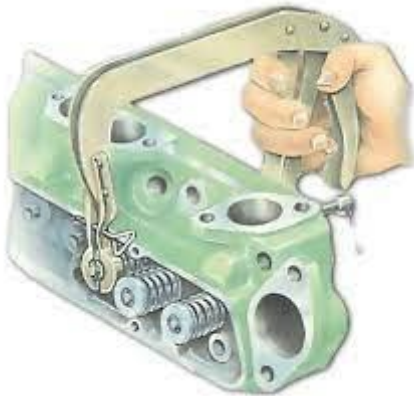


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⁶⁵ <https://club.autodoc.co.uk/magazin/camshaft-engine-functions-problems-and-inspection>

⁶⁶ http://skcmspvtltd.org/agh/m/toyota/hilux/repair2/html/frame_rm000000ymj000x.html

⁶⁷ <https://www.motortrend.com/how-to/do-you-need-to-retorque-head-bolts-after-break-in/>

Remove the cylinder head After removing the cylinder head conduct the following practice: 1) Inspect valve seats and guides for wear or damage. 2) Check camshaft lobes for wear and pitting. 3) Measure valve spring height and tension. 4) Check for cracks in the cylinder head.	68  
Remove the valves and springs: 1) Inspect valve faces and stems for wear or pitting. 2) Measure valve stem diameter. 3) Check valve spring free length and tension. 4) Inspect valve seals for damage or wear.	 69

⁶⁸ <https://www.youtube.com/watch?v=7KXliwFjdVk>

⁶⁹ <https://www.howacarworks.com/engine/removing-and-grinding-valves>

Removing the pistons and rings:

After removing the pistons and rings conduct the following practices:

- 1) Inspect piston skirts for scuffing or wear.
- 2) Measure piston ring end gap and side clearance.
- 3) Check for signs of the piston ring sticking.
- 4) Inspect piston pins for wear and scoring.



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Removing the crankshaft:

After removing the crankshaft conduct the following practices:

- 1) Measure main and rod journal diameters.
- 2) Inspect crankshaft for signs of scoring or wear.
- 3) Check for straightness using precision tools.
- 4) Inspect keyways and gear teeth for damage.



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⁷⁰ <https://www.ms-motorservice.com/en/technipedia/post/mounting-and-disassembling-piston-rings/>

⁷¹ <http://blog.ecklerscorvette.com/crankshaft-bearing-removal/>

⁷² <https://www.k1technologies.com/k1-blog/how-to-check-bearing-clearances/>

Removing the connecting rods: After removing the connecting rods and bearing conduct the following practices: 1) Measure big end and small end bore diameters. 2) Inspect rod bolts and nuts for wear. 3) Check for signs of rod bearing wear or damage.	 73 74
Removing the main and rod bearings: 1) Inspect bearing surfaces for wear, scoring or pitting. 2) Measure bearing clearances using plastigauge or precision tools. 3) Check bearing material for signs of fatigue or overheating.	 75 big end for 1 rod cap
Inspection for the gaskets and seals: 1) Inspect cylinder head gasket for leaks or damage. 2) Check valve cover gaskets for proper sealing. 3) Inspect rear main seal for leaks or wear.	 76

⁷³ <https://fdautoparts.com/post/5842>

⁷⁴ <https://fdautoparts.com/post/5842>

⁷⁵ <http://marinersrepository.blogspot.com/p/engine-bearing-failures.html>

⁷⁶ <https://inspecvision.com/applications/gasket-and-seal-inspection/>

Inspection for the accessories and pulleys: 1) Inspect accessory pulleys for wear or wobble. 2) Check A/C compressor, power steering pump, etc., for damage.	
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Activity 2: Guided Practice



Task 31:

Read the scenario below and perform the tasks related

Among the vehicles from different TVET schools in the school workshop, some vehicles require correction/replacement of damaged engine mechanical components, you are tasked to carry out the repair, by performing the following tasks:

1. Re-assembling engine mechanical components
 2. Consideration of torque specifications when tightening bolts during reassembly.
 3. Application of engine assembly lube during the re-assembly process
 4. Installation of pistons and connecting rods.
 5. Prime the oil pump before starting the engine after reassembly
 6. Following the recommended torque sequence when installing the cylinder head?
 7. Compress valve springs during the valve train component installation.
 8. Double-checking every component after reassembly
 9. Refer to the manufacturer's service manual for your specific engine during the re-assembly process
- ☞ Present your observation/results to the rest of the class
 - ☞ Ask for more clarification from your trainer.
 - ☞ Refer to the key facts 3.4 b for further information and more clarification

Key Facts 3.4 b: Re-assembling engine mechanical components⁷⁷

Step 1: Prepare Your Workspace and Tools

- **Safety Precautions:** Wear appropriate personal protective equipment (PPE) such as gloves, safety glasses and hearing protection. Ensure the workspace is well-ventilated and free from any flammable materials.



- **Tools Needed:** Socket and wrench set, torque wrench, pliers, screwdrivers, gasket scraper, engine assembly lube and shop towels.

Step 2: Clean and Inspect Components

- **Safety Precautions:** Handle components with care to avoid damage or injury. Clean parts in a well-ventilated area and use appropriate cleaning solvents.
- **Tools Needed:** Cleaning solvent, wire brush and inspection tools (magnifying glass, calipers).

Step 3: Lubricate Components

- **Safety Precautions:** Use proper lubricants and assembly lubes recommended for your engine type.
- **Tools Needed:** Engine assembly lube.

Step 4: Install Pistons and Connecting Rods

- **Safety Precautions:** Ensure proper alignment of connecting rod bearings and pistons. Follow torque specifications for rod bolts.
- **Tools Needed:** Torque wrench, piston ring compressor.

⁷⁷

<https://www.google.com/search?q=disassembled+engine&oq=disa&aqs=chrome.0.69i59l2j69i64j69i57j0i512j69i60l3.4494j0j7&sourceid=chrome&ie=UTF-8#vhid=bQotXszNn58SBM&vssid=l>

Step 5: Install Crankshaft and Main Bearings

- **Safety Precautions:** Carefully lower the crankshaft into position to prevent damage.
- **Tools Needed:** Torque wrench, main bearing cap bolts.

Step 6: Install Camshaft and Cam Bearings

- **Safety Precautions:** Handle the camshaft gently to avoid damaging lobes.
- **Tools Needed:** Torque wrench, camshaft installation tool (if applicable).

Step 7: Install Timing Components

- **Safety Precautions:** Ensure proper timing alignment.
- **Tools Needed:** Timing chain or belt, timing chain tensioner tool, crankshaft pulley holding tool.

Step 8: Install Cylinder Head

- **Safety Precautions:** Follow torque specifications in a proper sequence to prevent warping.
- **Tools Needed:** Torque wrench, torque angle meter.

Step 9: Install Valve Train Components

- **Safety Precautions:** Ensure proper valve lash and proper seating of valve springs.
- **Tools Needed:** Valve spring compressor, feeler gauges.

Step 10: Install Oil Pump and Oil Pan

- **Safety Precautions:** Prime the oil pump before starting the engine.
- **Tools Needed:** Torque wrench, gasket sealant.

Step 11: Install Intake and Exhaust Manifolds

- **Safety Precautions:** Properly torque fasteners to prevent leaks.
- **Tools Needed:** Torque wrench, gasket sealant.

Step 12: Install Accessories

- **Safety Precautions:** Follow proper routing of belts and hoses.
- **Tools Needed:** Socket and wrench set.

Step 13: Double-Check Everything

- **Safety Precautions:** Carefully inspect all components for proper installation.
- **Tools Needed:** Inspection tools (magnifying glass, flashlight).

Step 14: Reconnect Electrical and Fuel Systems

- **Safety Precautions:** Ensure proper connection and routing of wires and hoses.
- **Tools Needed:** Wrench set, pliers.

Step 15: Fill Fluids and Start the Engine

- **Safety Precautions:** Double-check that all connections are secure.
- **Tools Needed:** Funnel, engine oil, coolant, starter key.



Activity 3: Application



Task 32:

Read the scenario and perform the tasks related:

Visit the neighbouring automotive repair shops, correct/replace damaged components of two different engines for the vehicles brought for the repair.

Make a report on the repair to be provided, by focusing on the following:

1. Disassembling Engine Mechanical Components:
 - a) Which major engine component involves removing components like valves, valve springs and camshafts during disassembly?
 - b) What is the purpose of disassembling the engine case during an engine overhaul?

- c) Engine timing disassembly involves the removal of components like the timing belt or chain, as well as the _____.
 - d) When disassembling the crankshaft drive, you may need to remove parts such as pulleys, belts and _____.
2. Inspecting Engine Mechanical Components Status:
- a) During the inspection of the cylinder head, what should you look for in the valves and valve seats?
 - b) What are some common signs of wear or damage that you might find when inspecting the engine case?
 - c) When inspecting engine timing components, what is a critical aspect to check to ensure proper synchronization?
 - d) During the inspection of the crankshaft drive, what should you examine in terms of bearings and journal surfaces?
3. Repair and Replacement:
- a) If you discover a cracked cylinder head during inspection, what might be a recommended course of action?
 - b) When replacing engine timing components, why is it often advised to replace the timing belt or chain at the same time?
 - c) What is a common repair approach for a worn or damaged crankshaft journal?
4. Re-assembling Engine Mechanical Components:
- a) What safety precautions should you keep in mind while re-assembling engine mechanical components?
 - b) Which tool is commonly used to ensure proper torque on fasteners during reassembly?
 - c) Why is it important to follow the recommended torque sequence during the re-assembly of the cylinder head?
 - d) Why is applying engine assembly lube a crucial step when re-assembling engine components?

Topic 3.5: Remounting the Engine to the Vehicle



Activity 1: Problem Solving



Task 33

Read the following questions and give their answers:

1. What is the first step before remounting an engine into a vehicle?
2. What equipment is typically used to lift the engine and place it into the engine bay?
3. Why is it important to clean the engine mounts before aligning and bolting the engine?
4. What is the purpose of aligning the engine properly before securing it with bolts?
5. List two types of components that need to be reconnected after the engine is mounted.
6. Why is it crucial to check fluid levels after remounting the engine?
7. What might happen if engine accessories or the starter battery are not connected properly?
8. After remounting the engine, why is it necessary to test the engine for both running and driving?
9. Mention two safety precautions that should be observed during the engine remounting process.

 Refer to the Key facts 3.5 a for further information

Key Facts 3.5 a: Remounting the Engine to the Vehicle



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1. Preparing the Engine Bay:

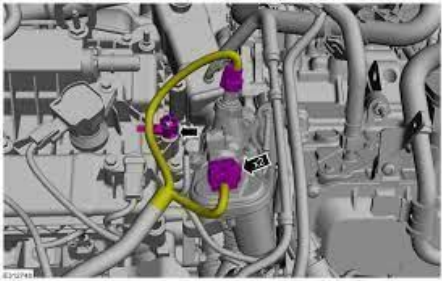
- a) Clear the engine bay of any obstacles, components or debris that could hinder the installation.
- b) Ensure proper lighting and ventilation in the work area.

⁷⁸ <https://www.onallcylinders.com/2018/04/03/paint-engine-bay-learn-pro-tips-paint-master-kevin-tetz/>

	c) Have all necessary tools and equipment ready.
 ⁷⁹Figure 29: Lifting the Engine	2. Lifting the Engine: - Attach an engine hoist or crane to the lifting points on the engine. - Carefully lift the engine, ensuring it's balanced and stable. - Position the engine hoist over the engine bay, aligning it with the mounting points.
 Figure 30: Cleaning the Engine Mounts⁸⁰	3. Cleaning the Engine Mounts: - Clean the engine mounts on the vehicle's frame to ensure a solid and secure connection. - Remove any rust, dirt or debris that could affect the alignment.
 Figure 31: Aligning and Bolting the Engine	4. Aligning and Bolting the Engine: - Slowly lower the engine into the engine bay, aligning the engine mounts with the mounting points on the vehicle. - Make sure the transmission input shaft aligns with the clutch or torque converter. - Insert the mounting bolts through the engine mounts and into the

⁷⁹https://www.google.com/search?sca_esv=566104123&sxsrf=AM9HkKnBSJqogICPsC7_lj_loalXYbneKQ:1694972009311&q=%E2%80%A2+Attach+an+engine+hoist+or+crane+to+the+lifting+points+on+the+engine&tbm=isch&source=lnms&sa=X&ved=2ahUKEwirnZPklrKBAXWvhv0HHbIKC4wQOpQJegQIChAB&biw=1366&bih=619&pr=1#imgsrc=SCEfpTmnh5zovM&imgdii=RzmS8X0F71IGIM

⁸⁰ <https://www.firestonecompleteautocare.com/blog/maintenance/bad-motor-mounts/>

	corresponding holes in the vehicle's frame. d) Hand-tighten the bolts initially to allow for adjustments.
 Figure 32: Reconnecting the Components	5. Reconnecting the Components: a) Reconnect all wiring harnesses, hoses and connectors that were disconnected during the removal process. b) Attach the exhaust system, cooling system hoses and any other components that were removed.
 Figure 33: Adding the oil in engine  Figure 34: Checking the engine oil level	6. Checking for the Fluids: a) Check fluid levels, including engine oil, coolant, transmission fluid and brake fluid. b) Top off the fluids as needed to ensure proper levels.

⁸¹ <https://www.google.com/url?sa=i&url=https%3A%2F%2Fclunkbucket.com%2Fcheck-your-oil%2F&psig=AOvVaw2RXF9q6YkPvFMwL0IEqGJs&ust=1695064807679000&source=images&cd=vfe&opi=89978449&ved=0CBAQjRxqFwoTCMjd9c-usoEDFQAAAAAdAAAAABAE>



Figure 35: Connection of Engine Accessories and Starter Battery

7. Connection of Engine Accessories and Starter Battery:

- a) Reconnect all engine accessories such as alternator, power steering pump and air conditioning compressor.
- b) Ensure that the starter battery is connected and properly secured.



Figure 36: Testing the Engine for Run and Drive

8. Testing the Engine for Run and Drive:

- a) Turn the ignition key to start the engine and listen for proper cranking.
- b) Check for any abnormal noises, leaks or warning lights on the dashboard.
- c) Allow the engine to idle and warm up while monitoring temperature and fluid levels.
- d) Engage the clutch (if manual transmission) or shift gears (if automatic) to test the drivetrain.



⁸³Figure 37: Final engine Adjustments and Inspection

9. Final Adjustments and Inspection:

- a) Double-check all connections, hoses and bolts to ensure they are secure.
- b) Test the throttle response, brakes and steering to confirm proper functionality.
- c) Make any necessary adjustments to components or settings.



Activity 2: Guided Practice



Task 34:

Referring to the scenario of the vehicles from different TVET schools that you have done correction/replacement of damaged engine mechanical components, you are tasked to carry out the remounting of the engine, by following the safety precautions when remounting an engine:

1. The engine hoist or crane before lifting the engine
2. Clear the engine bay of debris and obstacles before remounting the engine
3. When reconnecting electrical components
4. Safety equipment to be kept nearby during the engine remounting process
5. Two safety concerns associated with working around fluids during engine remounting
6. Proper ventilation in the workspace during engine remounting
7. Securing the starter battery properly during engine remounting

⁸³ Modern automotive technology

8. Precaution to take to avoid accidental engagement of the transmission while remounting the engine
9. Recommended way to test the engine after remounting it onto the vehicle

🔧 Present your observation/results to the rest of the class.

🔧 Ask for more clarification from your trainer.

🔧 Refer to the Key facts 3.5b for more information.

Key Facts 3.5 b: Safety precautions to consider when remounting an engine

Always bear in mind the safety of yourself and those surrounding your work environment.

1. Personal Protective Equipment (PPE):

Wear appropriate PPE, including gloves, safety glasses and suitable clothing to protect against cuts, burns and chemical exposure.

2. Lifting equipment:

- a) Ensure the engine hoist or crane is in good condition and capable of handling the engine's weight.
- b) Check for any signs of wear, damage or corrosion on lifting equipment.

3. Workspace preparation:

- a) Clear the work area of debris, tools and obstacles to prevent tripping hazards.
- b) Ensure proper lighting and ventilation for a safe working environment.

4. Electrical precautions:

- a) Disconnect the vehicle's battery before starting any work on electrical components.
- b) Ground electrical components properly to prevent electrical shocks.

5. Fire safety:

- a) Have a fire extinguisher nearby, rated for fuel and electrical fires.
- b) Keep the work area free of flammable materials and ensure proper fuel containment.

6. Fluid handling:

- a) Wear gloves and eye protection when handling fluids to prevent skin contact and splashes.

- b) Be cautious with fuel, oil, coolant and other fluids, as they are flammable and can cause environmental harm.

7. Ventilation:

- a) Work in a well-ventilated area or use exhaust extraction equipment to prevent inhalation of harmful fumes.
- b) Avoid working in enclosed spaces where fumes can accumulate.

8. Starter battery safety:

Ensure the starter battery is disconnected or properly secured to prevent electrical hazards or shifting during lifting.

9. Transmission safety:

Disconnect the transmission shift linkage or engage the parking brake to prevent accidental engagement of the transmission.

10. Testing and inspection:

- a) After installation, perform a thorough inspection of all components and connections before starting the engine.
- b) Test the engine for proper operation, checking for leaks, abnormal noises and warning lights.

11. Double-check:

- a) Double-check all bolts, connections and components before testing or driving the vehicle.
- b) Verify that no tools or equipment are left in the engine bay.

12. Emergency plan:

- a) Familiarize yourself with emergency shutdown procedures in case of unexpected issues.
- b) Have a communication plan to alert others in case of emergencies.



Activity 3: Application



Task 35:

Read the following scenario and perform the tasks that follow and then produce a report:

You have visited and worked the whole day in one of the busy auto repair shops in your neighbourhood. A customer's vehicle, a sedan, has undergone an extensive engine overhaul and it is now time to remount the engine back into the vehicle. The engine bay is prepared and you have all the necessary tools and equipment at your disposal. Follow the proper procedures to ensure a successful and secure engine re-installation on the vehicle.

Make a report on the activities undertaken to remount the engine on the vehicle, by focusing on the following:

1. Equipment to safely lift the engine and position it into the engine bay
2. The engine mounts are clean and ready for the new engine
3. Hand-tighten the mounting bolts initially during the engine remounting process
4. Reconnecting wiring harnesses and hoses,
5. Safety precaution should to prevent electrical hazards
6. Fluids to be checked after the engine is remounted and its importance
7. Securing the starter battery to prevent electrical hazards while remounting the engine
8. Testing the engine for both running and driving after it is remounted.
9. Factors to consider before engaging the transmission during the engine remounting process



Formative Assessment

Read the following questions and choose the best option for multiple-choice questions and provide a brief answer for short answer questions.

1. Why is selecting the appropriate tools, materials and equipment crucial for an engine overhaul?
 - a. To increase project cost

- b. To show off tool collection
 - c. To ensure efficient and safe work
 - d. To impress colleagues
2. Which of the following falls under the "materials" category when overhauling an engine?
- a. Wrench
 - b. Gloves
 - c. Engine oil
 - d. Engine hoist
3. What is the purpose of changing the oil and oil filter during engine servicing?
- a. To make the engine heavier
 - b. To save money on parts
 - c. To clean the engine bay
 - d. To remove contaminants and improve lubrication
4. Which component is commonly replaced during spark plug servicing in an engine overhaul?
- a. Throttle body
 - b. Alternator
 - c. Radiator
 - d. Ignition coil
5. What precaution should you take before removing the engine from a vehicle?
- a. Wash the engine bay
 - b. Disconnect the battery
 - c. Remove the engine
 - d. Fill the gas tank
6. Which tool or equipment is used to safely lift the engine out of the vehicle?
- a. Screwdriver
 - b. Jack stands
 - c. Engine hoist
 - d. Hammer
7. What does it mean to "correct" damaged engine mechanical components during an overhaul?
- a. Replace everything with new parts
 - b. Repair or replace only the damaged components
 - c. Paint over the damage
 - d. Remove all components

8. Which of the following might need correction if found damaged during an engine overhaul?
 - a. Tires
 - b. Radio
 - c. Cylinder head
 - d. Trunk latch
9. Why is it important to align the engine mounts properly before securing the engine?
 - a) To impress the customer
 - a. To improve fuel efficiency
 - b. To prevent overheating
 - c. To ensure stability and proper fit
10. What is the purpose of checking fluid levels after the engine is remounted?
 - a. To impress colleagues
 - b. To make the vehicle look good
 - c. To prevent rust
 - d. To ensure proper engine function and prevent damage
11. How do appropriate tools and equipment enhance safety during an engine overhaul?
12. Briefly explain the purpose of servicing an engine as part of the overhaul process.
13. List two safety precautions that should be taken before removing an engine from a vehicle.
14. Provide an example of a damaged engine mechanical component that might need correction during an overhaul.
15. Outline three key steps involved in safely remounting an engine back into a vehicle after an overhaul.
16. Why is it crucial to double-check all connections and components after remounting the engine?
17. What safety considerations are important when working around fluids during an engine overhaul?
18. Why should you ensure proper ventilation in the workspace during engine overhauling?
19. Describe the role of a fire extinguisher in maintaining safety during engine overhauls.
20. Why should you disconnect the starter battery or properly secure it during the remounting of the engine?



Points to remember

Certainly, here are the key points to remember when overhauling an engine:

- **Plan and Preparation:** gather all necessary tools, materials and equipment before starting the overhaul and review the manufacturer's service manual for your specific engine model.
- **Safety First:** prioritize safety by wearing appropriate personal protective equipment (PPE). Besides, keep a fire extinguisher and first aid kit nearby.
- **Workspace organization:** set up a clean, well-lit and properly ventilated workspace and organize tools and components to avoid confusion.
- **Engine Servicing:** change engine oil, filters and other fluids according to recommended intervals. Remember to inspect and replace worn or damaged components.
- **Inspection:** thoroughly inspect the engine for visible signs of wear, leaks and damage while verifying the components that require repair or replacement.
- **Engine removal:** disconnect the battery to prevent electrical hazards and safely remove the engine from the vehicle using appropriate lifting equipment.
- **Correcting damaged components:** repair or replace only the damaged components identified during inspection. Then, follow proper repair techniques and use quality replacement parts.
- **Precision and detail:** document and label components to ensure correct reassembly and pay attention to torque specifications and proper assembly order.
- **Cleaning and preparing:** thoroughly clean all engine parts, ensuring surfaces are free from dirt and debris and prepare engine surfaces for new gaskets and seals.
- **Reassembly:** assemble components with care, following the manufacturer's guidelines and use proper torque settings and sequences for bolts.
- **Fluid Check:** check and top up fluid levels, including engine oil, coolant and transmission fluid and ensure proper fluid levels for optimal engine performance.
- **Safety during reassembly:** double-check all connections, hoses and bolts before starting the engine and ensure no tools or equipment are left in the engine bay.

- **Engine mounting:** Align the engine mounts properly before securing the engine.
- Engage the parking brake or disconnect the shift linkage to prevent accidental transmission engagement.
- **Testing:** start the engine and listen for abnormal noises, leaks or warning lights. And test the engine for run and drive, checking throttle response, brakes and drivetrain function.
- **Final inspection:** Inspect the entire engine bay and vehicle for any overlooked issues as well as ensure that everything is secure, properly connected and functioning as intended.
- **Maintenance records:** Keep detailed records of the overhaul, including parts replaced, maintenance performed and any adjustments made.
- **Professional Help:** if unsure about any step, seek guidance from experienced professionals or mechanics; remember, the engine overhaul process requires attention to detail, careful execution and adherence to safety protocols. Always refer to the manufacturer's service manual for specific instructions related to your engine model and regenerate.



Self-Reflection

Fill in and complete the self-assessment table below to assess your level of knowledge, skills and attitudes under this unit.

There is no right or wrong way to answer this assessment. It is for your own reference and self-reflection on the knowledge, skills and attitudes acquisition during the learning process.

1. Think about yourself:
 - a) Do you think you have the knowledge, skills or attitudes to do the task?
 - b) How well?
2. Read the statements across the top. Put a check in a column that best represents your level of knowledge, skills and attitudes.

My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
Comprehend the mechanical principles of engine					
Identify the process of troubleshooting the engine components					
Identify diagnosis techniques					
Identify troubleshooting techniques					
Follow the mechanical principles of engine while diagnosing					
Apply the process of troubleshooting the engine components					
Perform diagnosis					
Perform troubleshooting					
Follow safety precautions and regulations while overhauling engine					
Follow environmental regulations while overhauling engine					
Pay attention to details while describing the engine					

My experience	I don't have any experience doing this.	I know a little about this.	I have some experience doing this.	I have a lot of experience with this.	I am confident in my ability to do this.
Knowledge, skills and attitudes					
Demonstrate team spirit while working with others					

Fill in the table below and share the results with the trainer for further guidance.

Areas of strength	Areas for improvement	Actions to be taken to improve
1.	1.	1.
2.	2.	2.



Summative assessment (Integrated situation)

Integrated/Summative assessment

Integrated situation

DOMINIQUE is a driver at RUKOZO Health Center, he brought the car Toyota RAV4 with electronic petrol fuel injection system at SAWA TECHNOLOGY GERAGE located in RULINDO District, BASE sector for intervention. He told a receptionist that the car has the following problem: The lack of engine power, blue smoke and consumption of engine oil. As an automotive engine mechanic, the head of garage is requesting you to solve the above-mentioned problems within 8 hours.

Tools	Spanners, Screw drivers, Tire lever, Chisels, Scriber, Ruler, Hammer, Vernier caliper, Micrometer, Torque wrench, Cylinder bore gauge, Dial gauge, Straightedge, Piston ring compressor, Piston ring expander, Valve spring compressor, Circlips plier, Punches, Core plugs remover, Valve grinder, Oil gun, Blow gun, Puller, Filler gauge.
Equipment	Personal protective equipment (PPE), Multimeter, Valve grinding machine, Hydraulic press, Oil pan, connecting rod aligner, Engine hoist, Air compressor, Timing light, Engine compression tester, Spark plugs cleaner and tester, Injector cleaner and tester, Engine stand, Table.
Materials/ Consumables	Exhaust gaskets, Bolts and nuts, Rags, Wire brushes, cleaning brush, Solvents, Grinding paste, Sanding paper, Silicon, Gasket kit, Piston rings, Con bearing, Main bearing, Trust washer, Piston pin bushing, Camshaft bushing, Cylinder liner, Air filter, Oil filter, Fuel filter, Engine oil, Air hose, Crankshaft oil seals, Timing belt, Spark plugs, Injectors nozzle, injectors, Glow plugs, Anti-rust.

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