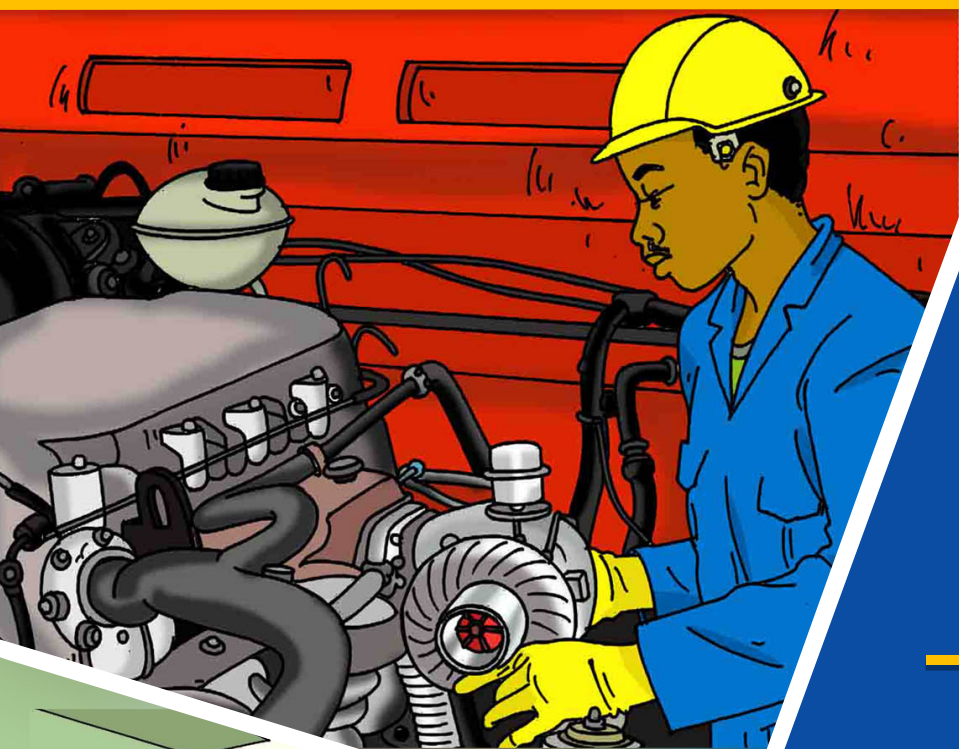




RQF LEVEL 3



AUTSR301

AUTOMOBILE TECHNOLOGY

Engine Supercharging System Repairing

TRAINEE'S MANUAL

December 2023



ENGINE SUPERCHARGING SYSTEM REPAIRING



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LIST OF ABBREVIATIONS AND ACRONYMS

RQF: Rwanda Qualification Framework

RTB: Rwanda TVET Board

TVET: Technical and Vocational Education and Training

%: Percentages

CBET: Competency Based Education and Training

MPH: Miles Per Hour

KM/H: Kilometer Per Hour

A/C: Air Conditioning

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INTRODUCTION

This trainee manual encompasses all necessary skills, knowledge and attitudes required to repair engine supercharging. 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 (CBET) philosophy by providing enough practical opportunities reflecting real life situations.

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

A discovery activity is followed to help you discover what you already know about the unit.

After these activities you will learn more about the topics by doing different activities by reading the required knowledge, techniques, steps, procedures, and other requirements under key facts section; you 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, you shall undertake progressive assessments known as formative and finally conclude with your own self-reflection to identify your strength, weaknesses, and areas for improvements.

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

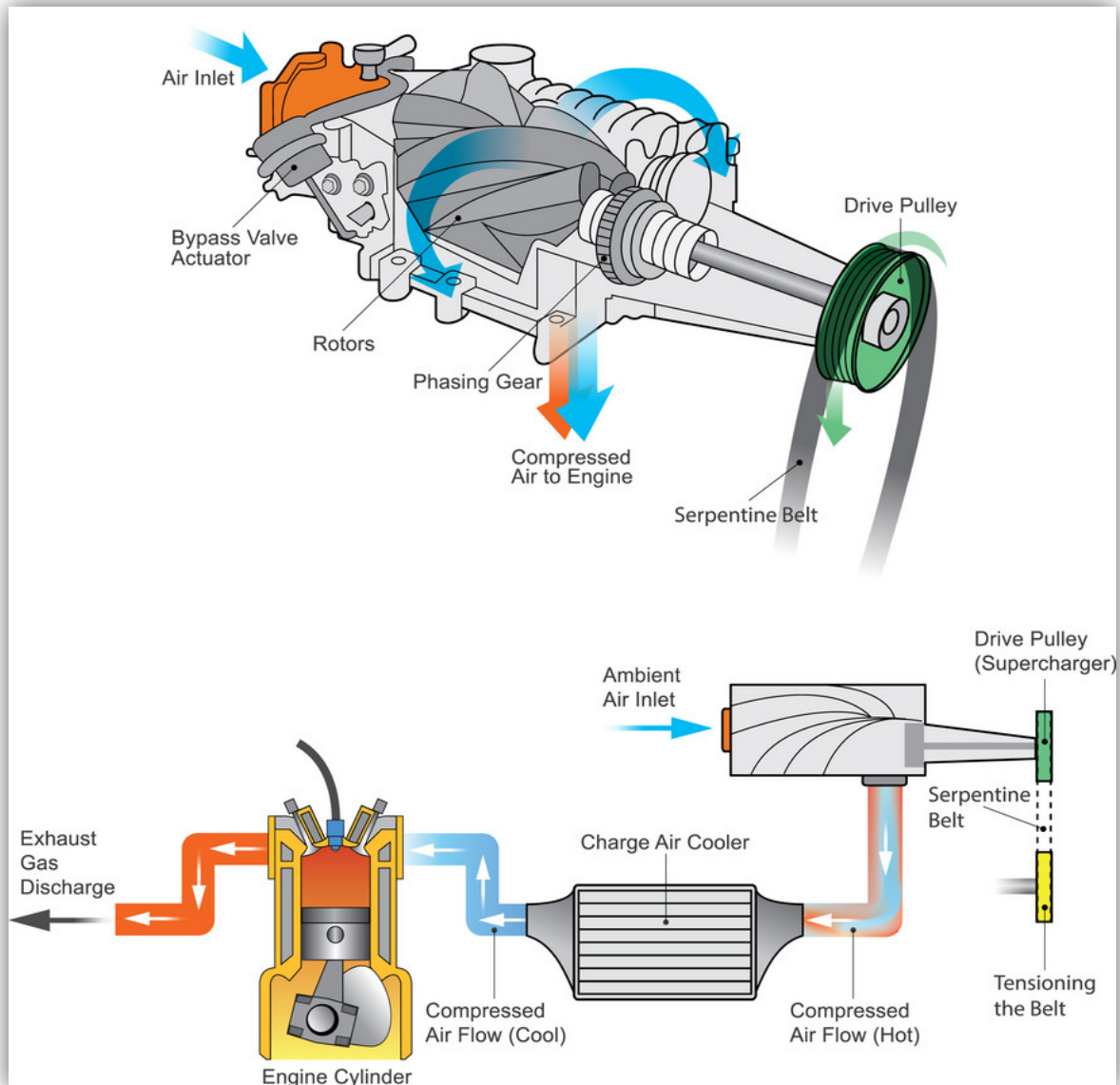
Module Units:

Unit 1: Describe supercharging system

Unit 2: Prepare workplace

Unit 3: Repair supercharging system

UNIT 1: DESCRIBE SUPERCHARGING SYSTEM



Units summary:

This unit explores the fundamental concepts and components of engine supercharging systems, their purpose, and the benefits they offer to automotive and industrial applications.

Self-Assessment:

1. Study the unit illustration above and answer the following questions.
 - a. What do you see in the illustration?
 - b. What topics do you think will be covered under this unit 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.
 - 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 this? How well?
 - c. Read the statements across the top. Put a check in column that best represents your level of knowledge, skills or 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					
Identify the function of supercharging system					
Identify types of supercharging system					
Identify Charger with and without mechanical drive components					
Differentiate Charger with and without mechanical drive based on their 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					
Identify Pressure-wave charger components					



Key Competencies:

Knowledge	Skills	Attitudes
1. List types of supercharging system	1. Differentiate supercharger types based on their construction	1. Commitment
2. Describe dynamic supercharger	2. Identify dynamic supercharger components	2. Have attention to detail
3. Describe independent supercharger	3. Identify independent supercharger components	3. Time management



Discovery Activity



Task 1:

1. What do you understand by supercharging system?
2. Enumerate the functions of supercharging system.
3. State the types of supercharging system.

Topic 1.1: Description of Supercharging System



Activity 1: Problem Solving



Task 2:

Read carefully and answer the following questions:

- a. Define supercharging system.
- b. Identify types of supercharging.
- c. Differentiate types of supercharging system basing on their operation and construction.

Key Facts 1.1. Description of supercharging system

- **Types and Function of Supercharging Systems**

The process of forcing more charge into the engine cylinder that can be drawn by naturally aspirated piston action to get more power is called Supercharger.

- ✓ **Function of Supercharging System**

A supercharger is a driven air pump, which compresses and packs air into an engine. This aids in higher power output as the engine gets more oxygen in each of its intake cycles and helps it to burn more fuel.

There are two types of supercharging system:



- **Dynamic Supercharging System Types:**

- **Ram Effect Supercharging Type**

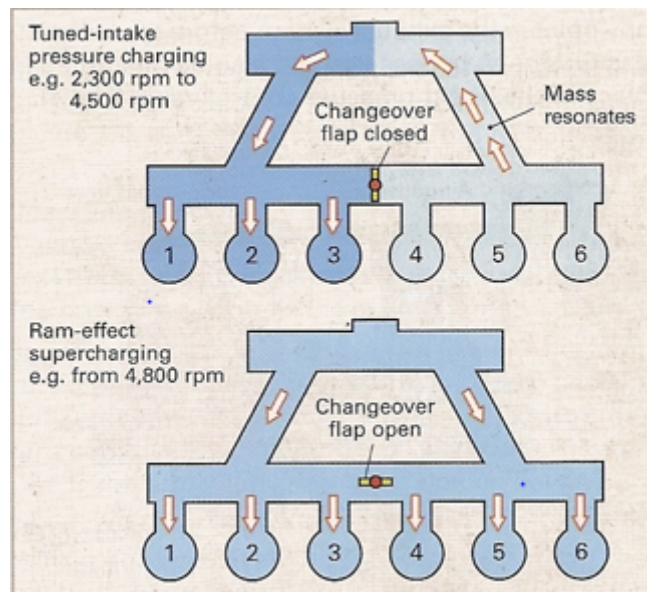
This method of supercharging includes the inlet manifold which is designed in such a way that the air automatically gets pushed inside the cylinder. This air continuously to get into the cylinder but the intake valves open and close various times in a second.

Whenever the valve gets closed, the air which is present just gets into it and generates a pressure wave that travels in the opposite direction until it hits the plenum and gets reflected back again.

- **Tuned Intake Pressure Type**

Tuned-intake pressure and ram-tube systems are combined with each other so that the supercharging effects of the individual systems can be exploited. An improved charge is achieved, for example, in the lower to middle-speed range by tuned-intake pressure charging and in the upper-speed range by ram-effect supercharging (figure.1). for this purpose, a flap is electrically or electro pneumatically opened or closed depending on the speed.

Here below is a tuned-intake pressure charging in the lower to middle-speed range, changeover flap closed. When, for example, cylinder no.2 draws in air, the chamber of cylinder bank 4,5,6 acts as an additional resonance chamber. In this way, the frequency of the vibrating mass is reduced and the valve opening frequency is adapted.



✓ **Independent Supercharging System Types:**

- ✚ **Charger Without Mechanical Drive Type**

Exhaust gas turbochargers are used to increase engine power by compressing intake air before it enters the engine. Turbochargers are air pumps driven by the engine's exhaust stream.

The heat and pressure of the exhaust gases spin the turbine blades (hence the name turbocharger) of the pump. The turbine wheel is connected to a compressor wheel.

As the turbine spins, so does the compressor wheel. The compressor wheel spins at very high speeds and compresses the intake air.

The compressed air is then sent to the cylinders. Turbochargers are used on both diesel and gasoline engines. The main advantage of their use is that they allow for an increase of power without a substantial decrease in fuel economy. This is because they boost the engine's power output only when extra power is needed. A small engine, in most cases, can be used to provide low fuel consumption and emissions levels.

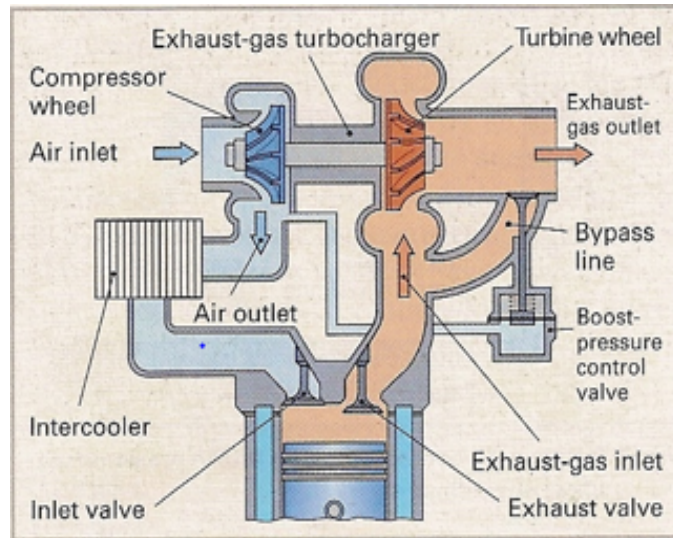


Figure 1: Diagram of an engine with exhaust gas turbocharger

Operating Principle

The exhaust gas from the engine drives the turbine wheel in the turbine, which drives the compressor wheel via the shaft.

The compressor draws in the fresh gases and supplies the engine with a pre-compressed fresh gas charge. The charge air is heated by the pre-compression by up to 180°C.

- **Charge Air Cooling and Boost Pressures:** The heated air pre-compressed by the charger can be cooled by means of charge air cooling before entering the cylinders. This increases the air density of the fresh gas charge. The boost pressure with and without charge air cooling are set out in the table below.

Supercharged engines	Overpressure in bar
Without charge air cooling	0.2 to 1.18
With charge air cooling	0.5 to 2.2

The boost pressures of an engine supercharged by an exhaust gas turbocharger must not exceed the boost pressures stipulated by the manufacturer as this would destroy the engine.

Boost Pressure Control: In addition to the danger of the engine being destroyed by excessively high boost pressures. The boost pressure must therefore be regulated. The following different types of boost pressure control may be used:

- **Mechanical-Pneumatic Boost-Pressure Control:** Here a diaphragm pre-tensioned with a helical spring is pressurized with the boost pressure in a boost pressure control valve. The valve opens as soon as the boost pressure overcomes the initial spring tension. The exhaust gases flow in the bypass line past the turbine into the exhaust pipe.

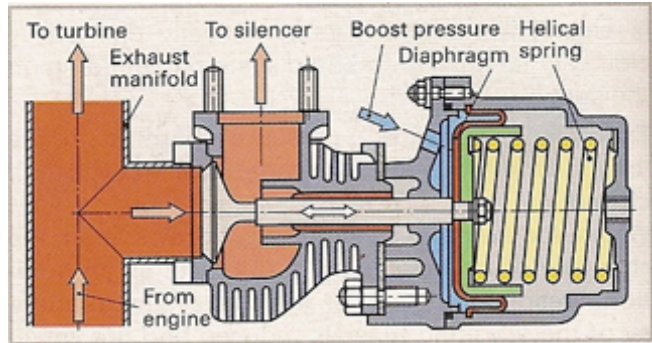


Figure 2: Boost-pressure control valve

Inside the turbocharger, the turbine wheel (hot wheel) and the compressor wheel (cold wheel) are mounted on the same shaft. The Central Housing Rotating Assembly (CHRA) houses the shaft, shaft bearings, turbine seal assembly, and compressor seal assembly. A turbocharger is equipped with a waste-gate valve to control the pressure of the air delivered to the cylinders.

The turbocharger typically begins to compress the intake air when the engine's speed is above 2,000 rpm. The force of the exhaust flow is directed against the side of the turbine wheel. As the hot gases hit the turbine wheel, causing it to spin, the specially curved turbine fins direct the exhaust gases toward the center of the housing where they exit.

➤ **Wastegate Valve:** If the pressure of the air from a turbocharger becomes too high, knocking occurs, engine output decreases, and the pressure created by the combustion of the air-fuel mixture can become so great that the engine may self-destruct.

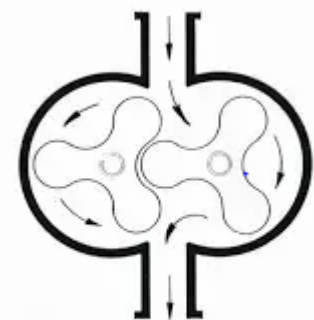
To prevent this, turbochargers have a waste-gate valve. The waste-gate valve is part of the turbine housing. It allows a certain amount of exhaust gas to bypass the turbine when the boost pressure exceeds a certain value.

✓ **Charger with Mechanical Drive Type**

Screw-Type Supercharger (Root Blower)

In mechanically driven superchargers, the compressor is driven directly by the engine. This means that the compressor is mechanically connected to the crankshaft, through a gear or belt, and takes power from the engine in order to compress the intake air.

To work is the rotating meshing lobes spin in different direction right side lobe in clock wise and left one in anti-clock wise. Air comes from outside through the inlet fill side, the two rotors can trap the air by these lobes and actually pushes the air down towards the discharge outlet. Each time it compresses the fixed amount of air at outlet during each rotation. Air gets compressed below the rotary lobes while inlet only sucks the air. Eventually pushing it more pressurized air at the inlet manifold.



Passage of Air Through a Roots Supercharger

Depending on the method of air compression, mechanically driven superchargers are split into two main categories:

Centrifugal Superchargers

The mechanical centrifugal supercharger uses the flow principle and the principle of momentum in order to compress the intake air. It basically consists of a compressor wheel (impeller) which is mounted on a shaft and driven by the engine through a gear set or a belt drive.

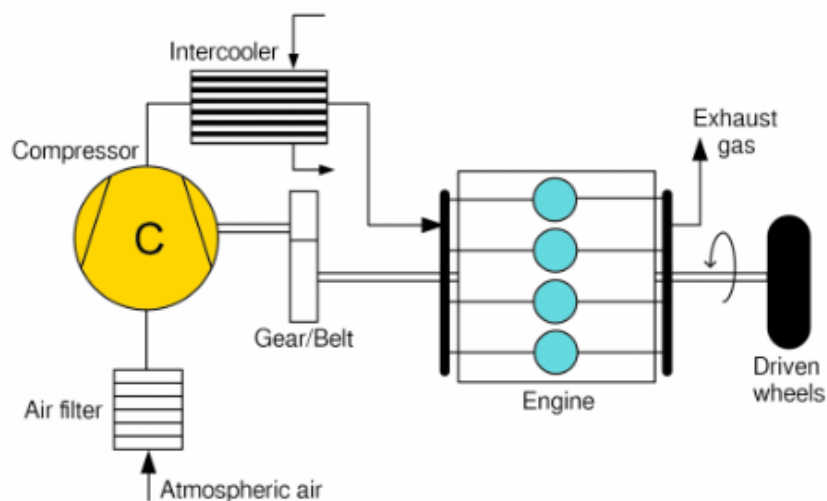


Figure 3: Mechanical centrifugal supercharging schematic

The atmospheric air is drawn by the impeller (compressor) through the filter and compressed to a higher pressure. Before entering the engine (cylinders) the intake air is cooled, to further increase its density. Cool dense air means more fuel can be injected into the engine, which generates more torque (power) at the crankshaft. The boost pressure depends on the engine speed, the higher the speed of the impeller (engine), the higher the pressure of the compressed air.

Since the power required by the compressor to rotate is taken directly from the engine and not from the exhaust gases, as in the turbocharger case, the disadvantage is that the supercharger increases the parasitic loads on the engine. The advantage is that there is no temperature transfer from the exhaust gases to the compressed air, which translate into higher intake air density, compared to turbocharging.

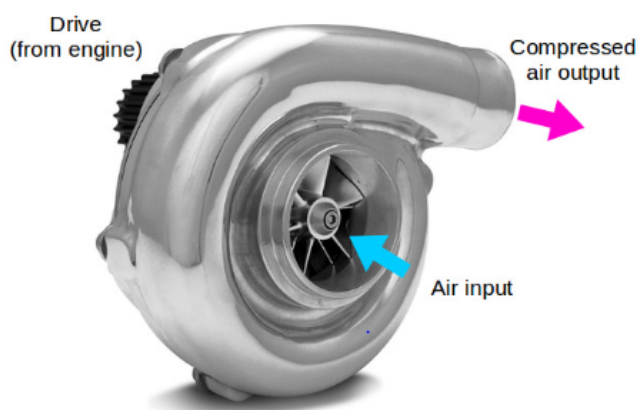


Figure 4: Centrifugal supercharger working principle

The simplest drive gear for the centrifugal supercharger is using a belt, connected to the crankshaft through two pulleys. This method gives a better control of the boost pressure function of the engine operating point (speed and torque).

Positive-Displacement Superchargers

Positive-displacement superchargers are those that spin a pair of multi-lobe rotors that mesh tightly to squeeze air through an outlet under high pressure. The displacement is derived from the amount of air delivered with each revolution of the supercharger. Typically, the larger the rotors, the more air the supercharger displaces.

✓ **Pressure Wave Supercharger**

A pressure wave supercharger (also known as a wave rotor) is a type of supercharger technology that harnesses the pressure waves produced by an internal combustion engine exhaust gas pulses to compress the intake air.

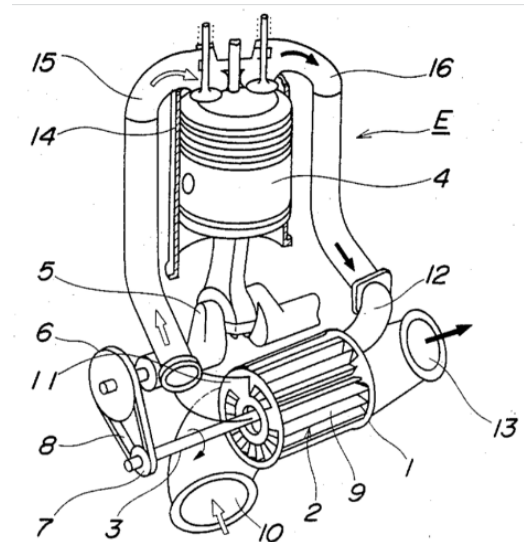


Figure 5: Pressure-wave charger components

1. Rotor Housing	2. Rotor
3. Rotary Shaft	4. Piston of Engine
5. Crankshaft	6. Crankshaft Pulley
7. Rotary Shaft Pulley	8. Belt
9. Rotor Cells	10. Air Inlet
11. Air Outlet	12. Exhaust Gas Inlet
13. Exhaust Gas Outlet	14. Cylinder of Engine
15. Intake Passage	E. Piston Engine

✓ **Pressure-Wave Charger Operation**

The process is controlled by a cylindrical cell rotor driven by the engine crankshaft via a belt or chain. Individual cells alternately open and close the exhaust gas and fresh air apertures. When the aperture on the exhaust gas side is reached, pressurized exhaust gas flows into the cell and compresses the fresh air.

As the cell rotor continues to rotate and reaches the aperture on the inlet side, the compressed air flows to the engine. Before the exhaust gas can flow, the aperture is closed again and the exhaust gas column is reflected before entering the engine. The exhaust gas exits at high speed, sucking further intake air into the cell behind it, repeating the process.

- **Advantages and Disadvantages of Supercharging Systems**

- **Advantages**

✓ Higher power output	✓ Greater induction of charge mass
✓ Better atomization of fuel	✓ Better mixing of fuel and air
✓ Better scavenging products	✓ Better torque characteristics over whole range
✓ Quick acceleration of vehicle	✓ Complete and smooth combustion
✓ Even fuel with poor ignition quality can be used	✓ Improved cold starting
✓ Reduced exhaust smoke	✓ Reduced specific fuel consumption

- **Disadvantages**

✓ Increased detonation tendency in SI engines	✓ Increased thermal stress
✓ Increased heat loss due to increased turbulence	✓ Increased gas loading
✓ Increased cooling requirements of the engine	



Activity 2: Guided Practice



Task 3:

With the guidance of your trainer, answer the following questions:

1. Explain the operation of mechanical-pneumatic boost-pressure control.
2. Identify types of supercharging.
3. Differentiate types of supercharging system basing on their operation and construction.



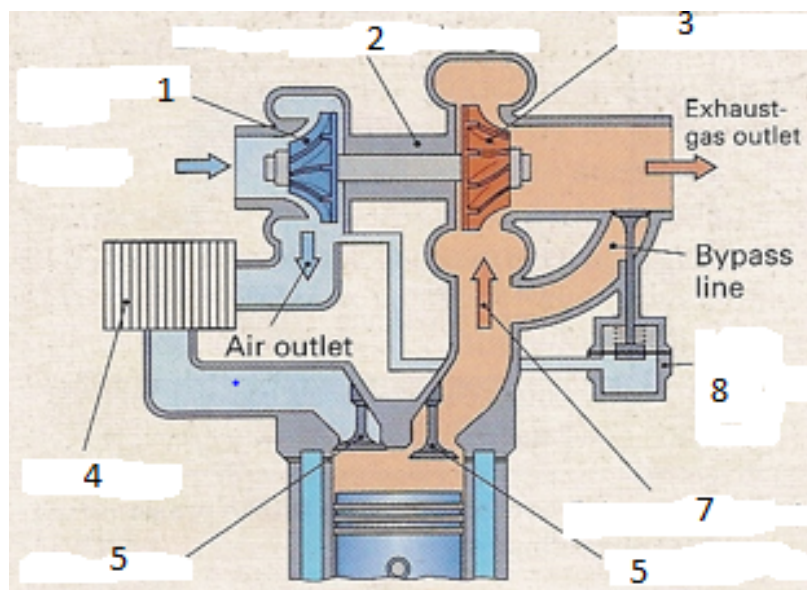
Activity 3: Application



Task 4:

Observe the figure given below carefully and answer the questions that follow:

1. Label from 1 to 8.
2. What is the operation of part 8?





Points to Remember

The compressor draws in the fresh gases and supplies the engine with a pre-compressed fresh gas charge. The charge air is heated by the pre-compression by up to 180°C.

Pressure Wave Supercharger

A pressure wave supercharger (also known as a wave rotor) is a type of supercharger technology that harnesses the pressure waves produced by an internal combustion engine exhaust gas pulses to compress the intake air.



Self-Reflection

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



Formative Assessment

- Q1. What is a supercharging system in an internal combustion engine?
- Q2. How does a supercharger work?
- Q3. List down the main components of a supercharging system?
- Q4. Differentiate supercharger from turbocharger?
- Q5. Enumerate 3 advantages and disadvantages of engine supercharging system?
- Q6. What is the role of an intercooler in a supercharging system?

UNIT 2: PREPARE WORKPLACE



Unit summary:

This unit describes the workplace accidents, action needed and state of the workshop to apply safety precautions, select PPE, clean and arrange the workplace. Accidents should be reduced as much as possible so that the workplace workers stay safe. This will also have a positive effect on your work ethic, as being prepared makes the job easier.

Self-Assessment:

1. Look at the illustration above and answer the following questions
 - a. What is happening?
 - b. What do you think this unit will be about?
2. Fill in the self-assessment below.
 - a. There are no right or wrong ways to answer this survey. It is for your own use during this course.
 - b. Think about yourself: do you think you can do this? How well? Read the statements across the top.
 - c. Put a check in a column that best represents your situation.
 - d. At the end of this learning outcome, we'll take this survey 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					
Identify precautions at workplace					
Classify and use PPE					
Identify cleaning types					
Apply Tool and equipment safety precautions					
Apply cleaning techniques					



Key Competencies:

Knowledge	Skills	Attitude
1. Identify Personal safety precautions	1. Select and wear PPE	1. Have attention to details when selecting and wearing PPEs
2. Explain work area safety precautions	2. Perform work area cleaning	2. Being rapid
3. Identify safety tools and equipment	3. Apply Tool and equipment safety precautions	3. Be efficient during selection of cleaning medium
4. Identify cleaning types	4. Arrange workplace	4. Be efficient during selection of cleaning medium



Discovery Activity



Task 5:

Carefully read and answer the following questions:

1. Who is responsible for safety at the workplace?
2. How do you classify PPE?
3. Discuss about the rules for workplace safety.
4. Identify equipment for safety precautions
5. Why is arrangement in the workshop necessary?

Topic 2.1: Safety Precautions at Workplace



Activity 1: Problem Solving



Task 6:



Look at the picture above and answer the following questions:

1. What do you see in the picture?
2. Do you think what you see in the picture is useful? Explain.
3. Where is the activity above taking place?
4. Apart from what you are seeing in the picture, suggest other related activities that can be carried out.

Key Facts 2.1.1.

- **Personal Safety**

- ✓ **Point to Practice for Ensuring Personal Safety**

- ✚ Develop and implement safe systems of work
- ✚ Meet your workplace health and safety training obligations
- ✚ Provide adequate supervision
- ✚ Manage workplace incidents

-  Develop a risk management plan

-  Develop a response plan

- ✓ **Develop and Implement Safe Systems of Work**

-  Have safe work systems in your workplace (e.g. procedures for reporting workplace incidents)

-  Ensure you understand these procedures and know what to do when a workplace incident happens.

-  Meet your workplace health and safety training obligations

-  Provide adequate supervision

-  Manage workplace incidents

-  Report incidents

- The death of a person
 - Serious work-related injury or illness
 - Dangerous incidents that expose people to serious risk.

-  Develop a risk management plan

- **Work Area Safety**

- ✓ **Safety Suggestion for The Workplace**

These are ten of the most important safety tips for the workplace to create a safe environment:

- **Understand Risks**

Every work environment is different and these will vary from industry to industry and from job site to job site. It's critical that employees understand the inherent risks that come with a particular job so they can take the proper steps necessary to avoid injury. Particularly if working with dangerous equipment or in a hazardous environment.

Be Aware of Your Surroundings at All Time

This builds on the previous point of understanding risks – but requires employees to always be aware of what is going on around them and to look for hazards constantly.

Know Where the First Aid Kit/Officer Are

If someone requires first aid, do your employees know how to access it in the workplace? Ensure your staff know where the first aid kit is and if you have a designated first aid officer, ensure they know who that person is so they can get assistance should they need it.

Taking Regular Breaks

Many workplace injuries happen as a result of an employee being tired or burned out. By taking regular breaks, employees can stay fresh on the job.

Always Using Equipment Properly

When machines and tools are used in the workplace, employees should always take proper precautions, never take shortcuts and never use the equipment for purposes other than what is intended. By doing so, the risk of workplace injury is greatly reduced.

Pay Attention to Signage

Signage is placed to indicate that there could be a potential hazard in the area and includes important information about maintaining a safe work environment.

Know Where Emergency Exits Are

All employees should understand where they should safely exit the workplace in the event of an evacuation.

Keep Emergency Exist Accessible

Because employees need to access exits quickly in the event of an emergency, it is imperative that these be kept clear. Nothing should be placed in front of the exits that would block them or impede them from opening.

Reporting Unsafe Conditions

Employees should know how to report unsafe conditions so management can quickly address any safety risks or hazards.

Wear Correct Safety Equipment

Every employee has a responsibility to ensure they are wearing proper protective equipment that will enable them to safely carry out their job.

- **Tool and Equipment Safety Precautions**

- ✓ **Tool Safety**

- **Hand Tools Safety Precaution:**

- Inspection should be done before use.
 - Always keep clean.
 - Always keep tools in a box.
 - Use proper tools for the job.
 - Use a bucket and leather bed to shift the tools at height.
 - Follow color coding.
 - Awareness among the workers for the safe use.

- **Carrying or Transporting Tools**

- Use a tool box, tool-holder, belt or pouch, this will protect the person and the tool
 - Carry pointed or sharp tools with the point or cutting edge away from the body
 - Do not carry tools by hand up ladders
 - Do not lay tools down where people can trip on them or they can fall on someone

- ✓ **Equipment Safety Precautions**

- **Best Practices for Equipment Maintenance**

In addition to keeping your equipment operating smoothly and efficiently, a good maintenance program will help your equipment hold its value longer.

Here below are some best practices and considerations for equipment maintenance, no matter the type of equipment:

- **Check Your Warranty Guidelines**

Does your equipment warranty contain specifics about how to keep your warranty intact? Some warranty guidelines could include clauses that state you must use certified equipment maintenance and repair providers or parts in order to keep the warranty intact.

- **Keep Detailed Records**

Paper records can work, as long as the documentation is complete, accurate and accessible. If you only have a few pieces of equipment, this can be a very good option.

- ✓ **Adhere to Manufacturer's Recommended Equipment Maintenance Schedules**

Equipment manufacturers publish planned maintenance schedules that detail the service operations that need to be performed, the intervals in which they need to be performed and the parts necessary to perform the maintenance tasks. These schedules are designed to keep the equipment in peak operating condition, not only for performance reasons, but also for safety reasons.

- ✓ **Inspect the equipment on a regular basis**

Despite adherence to the regularly scheduled maintenance, wearable parts can become worn or damaged, simply through use, especially heavy use or adverse conditions. Inspecting belts, hoses, tires and other parts on a regular basis can identify signs of wear and tear holes, fraying, leaks enabling you to replace them before they break or fail.

- ✓ **Involve the Operators or Drivers in The Equipment Maintenance Program**

The people who operate or drive the equipment on a regular basis tend to be the closest to the equipment.

They know how each individual machine runs and can often tell when the machine is “Acting Up”. Inspections by the operators before and after each shift are perfect opportunities to find and identify issues before they become big problems.

✓ **Inspect the Space Around the Equipment**

Oftentimes a mere inspection of the equipment itself won’t turn up a problem. Think of a slow fluid leak. Merely looking at the inside of the machine, or the fluid tank itself, may not identify a leak.

But if you look at the floor underneath the machine, you may see a wet spot where fluid has been leaking. (How many times have you discovered an oil leak in a car because the driveway or garage had an oil stain on it?) This is really important if the piece of equipment remains in one spot (think of a machine tool) because a wet spot on the floor may not be readily noticed.

✓ **Keep a Stock of Often-Replaced Parts On-Hand**

Having a few of the often-replaced parts on-hand means you don’t have to wait for your supplier to get parts to you. Especially if you are conducting regular inspections of the equipment, having spare parts on hand enables you to replace them as needed, rather than having to wait for a delivery.

Yes, waiting a day or two for a delivery is not a problem if you’ve discovered the need for replacement before a breakdown. But if the machine has broken down, that one or two days could have a severe negative impact on your bottom line.

✓ **Understand the Costs of Your Equipment Maintenance Program**

At some point, the cost of maintenance and repair for equipment will surpass that of the value or debt service of the equipment. Understanding the costs of maintenance will help you determine when it’s time to replace a piece of equipment.



Activity 2: Guided Practice



Task 7:

You are assigned to work in the school workshop to provide technical support to customers from different areas. As part of your duties, the trainer will guide you to:

1. Apply personal safety precautions.
2. Practice workplace safety precautions.
3. Practice workplace equipment safety precautions.
4. Perform Tools and equipment safety precautions.



Activity 3: Application



Task 8:

In your school workshop, you are asked to perform safety measures for the tools and equipment that have been used.

Topic 2.2: Selection of PPE



Activity 1: Problem Solving



Task 9:

Read carefully and answer the following questions:

1. Write PPE in full word.
2. Classify types of PPE.
3. What are the conditions to consider when choosing PPE?

Key Facts 2.1. Selection of PPE

- **Classification of PPE**

- ✓ **Definition of Personal Protective Equipment (PPE)**

“Any equipment to be worn or carried by the worker to protect him from one or more risks that may pose a threat to his health or safety in the workplace, as well as any complement or accessory with such a purpose”

Depending on its protective effects, PPE may be classified as:

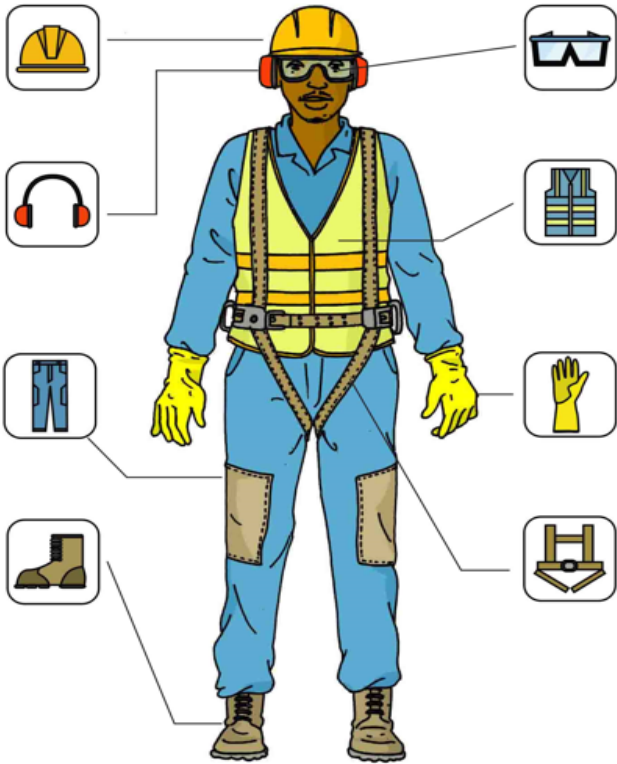
- ✓ **Partial:** aimed at protecting against hazards that are localized in specific areas or parts of the body (e.g. helmets, boots, gloves, etc.).
 - ✓ **Complete:** which protects against hazards whose scope of action does not have a specific area of localization (e.g. fireproof clothing, safety belts, etc.).

The following table shows the different types of PPE and their classification:

Types of PPE	Area of protection	Protection tool
PPE Offering Partial Protection	Head Protective	Helmet
	Ear Protection	Earplugs, Earmuffs
	Protection for the eyes and Face	Goggles, Visors
	Protection for the Respiratory Tract	Masks
	Arm and Hand Protection	Gloves
	Foot and Leg Protection	Safety shoes
	Trunk and Abdomen Protection	Back belts, Aprons
PPE Offering Complete Protection	Barrier Protection	Creams
	Fall-arrest Protection	Belts, Harnesses
	Specific Protective Equipment	Fireproof clothing

- ✓ **Proper Selection of PPE**

PPEs are identified depending on the hazards in the workplace and is worn to protect the eyes, face, head, body, arms, legs and feet from hazards

	✓ Head Protection Examples: Head covers, cask ✚ Face Protection Examples: Face shields ✚ Hand Protection Examples: Gloves ✚ Body Protection Examples: High visibility hat, vest, pants, overall, overcoat ✚ Feet Protection Examples: Safety boot ✚ Respiratory Protection Examples: Mask ✚ Hearing Protection Examples: Eye Protector
--	--

- **Use of PPE**

- ✓ **Conditions that PPE Must Fulfill**

PPE must provide effective protection against the hazards that prompt its use and also:

- ✚ Not supposed to be a hazard in itself.
- ✚ Not be the cause of additional hazards.
- ✚ Not produce unnecessary inconveniences.

- ✓ **Use and Maintenance of PPE**

The use, storage, cleaning, disinfection (when applicable) and repair of PPE should be carried out in accordance with the manufacturer's instructions. Before using any kind of PPE, it is therefore essential to carefully read said instructions and in no case whatsoever modify or alter the original PPE.

In principle, all PPE is for personal use and may only be employed for its specified uses, except in exceptional particular cases. The conditions in which PPE is to be used are determined by:

-  The seriousness of the hazard.
-  The time or frequency of exposure to the hazard.
-  The conditions of the job.
-  The equipment's features.
-  Additional hazards derived from the actual use of the equipment that could not be avoided.



Activity 2: Guided Practice



Task 10:

Visit the school workshop with your trainer and perform the following activities:

1. Select and use appropriately personal protective equipment



Activity 3: Application



Task 11:

In collaboration with your school administration, arrange a tour visit in another technical school for practical skills. After reaching in the workshop, you are requested to select PPE to use when working on the supercharger.

Topic 2.3: Cleaning and Arrangement of the Workplace



Activity 1: Problem Solving



Task 12:

Carefully read and answer the following questions:

1. Define cleaning.
2. Identify cleaning types.
3. Describe the Procedures for workplace, tools and equipment cleaning.

Key Facts 2.3. Cleaning and Arrangement of the Workplace

- **Identification Types of Cleaning**

- ✓ **Types of Cleaning**

- 📌 **Regular cleaning:** weekly or bi-weekly cleaning sessions that usually involve hoovering, mopping, dusting, and dishwashing.
- 📌 **Deep cleaning:** full deep clean of a home or office that targets important areas of the home such as the kitchen and bathroom.
- 📌 **End of Tenancy cleaning:** similar to a deep clean but follows a strict checklist approved by a landlord.
- 📌 **General cleaning:** basic tasks that are necessary to keep a home clean and tidy regularly.
- 📌 **Spring cleaning:** a cleaning that is often done once a year, typically in the spring.

- **Procedures for Workplace, Tools and Equipment Cleaning**

- ✓ **Stages of Cleaning**

- 📌 **Pre-Clean:** The first stage of cleaning is to remove loose debris and substances from the contaminated surface you're cleaning.

You can do this by wiping with a disposable towel, sweeping, or rinsing. The aim is to remove as much loose debris as possible to prepare the area for the next stage of cleaning.

 **Main Clean:** The second stage of cleaning is to loosen any substances, dirt, grease, and debris that you were unable to remove during the pre-clean stage. This involves using hot water and a detergent. You may be able to wipe away the loosened substances right away with something suitable, such as a cloth or mop, or you may have to allow the disinfectant to do its work for a certain amount of contact time before doing so.

 **Rinse:** The third stage of cleaning is to remove all the loosened substances, dirt, and debris as well as the detergent that was present in the second stage. You can do so using clean, hot water with a cloth, mop, squeegee, etc.

 **Disinfection:** The fourth stage of cleaning is to disinfect the surface, which will destroy bacteria and other microorganisms. For example, by using heat or a chemical disinfectant for an adequate contact time. Follow the instructions for any products or equipment you use.

 **Final Rinse:** The fifth stage of cleaning is to remove any disinfectants from the previous stage using clean, hot water. This step may not always be carried out however, depending on the disinfectant and surface you're cleaning. As stated in the previous stage, follow the manufacturer's guidance and seek further advice if needed.

 **Drying:** The sixth and final stage of cleaning is to dry the surface, and it's recommended that you air dry where possible. You can use drying cloths if needed, but they should be single use if so, especially in a commercial setting. You must not air dry any drying cloths that are damp from use and reuse them, as bacteria could grow on the cloths and pose a contamination risk.

✓ **Cleaning Methods**



Simple Cleaning Method: With a simple cleaner like Klein's Multi-Purpose Cleaner-Degreaser it's easy to clean your tools after every use. The specially formulated solvent is intended for maintenance cleaning on grime, grease, lubrication fluids, silicone, tars, adhesives, and fluxes.

As it's harmless to most plastics, it's a great solvent to use on tools that utilize plastic grips, such as the pliers. Here's what you'll need:

- Multi-Purpose Cleaner-Degreaser
- Cloth rag

With the cloth rag, spray a small amount of the multi-purpose cleaner onto the tool and rub excess dirt and grime off. Not a lot is needed for effective results. Klein's Multi-Purpose Cleaner evaporates without leaving residue and is essentially nonconductive, non-corrosive, and non-staining, which means you don't have to worry about hurting your tools when cleaning.



Advanced Cleaning Method: If you clean your tools after every use with Klein's Multi-Purpose Cleaner, you should never have to worry about a bigger, more drastic cleaning process as the second method entails. However, if you have older tools that you haven't touched in years, ones you inherited, or tools you found at garage sales or flea markets that you just couldn't pass up, you may need a more drastic wash.

To clean really dirty and rusty tools, here is what you will need:

- Wire scrub brush
- Steel wool
- Klein Multi-Purpose Cleaner-Degreaser
- Commercial Cleaner (Ajax, Pinesol)
- Bucket
- Hot water
- Cloth rags

✓ **Procedures for Cleaning Dirty Tools**

- ✚ Start by filling the bucket with hot water and a small amount of commercial cleaner.
- ✚ Soak your tools in the bucket for 30 seconds to a minute.
- ✚ With your wire brush, scrub the tools to remove dirt and grime.
- ✚ Rinse and repeat until all dirt has been cleared from the tool.
- ✚ Let dry atop a cloth rag. For older tools with a considerable amount of rust, you will want to take the steel wool and scrub the rust off.
- ✚ Allow time for everything to dry. It's important to make sure all of the tools are absent of moisture to prevent future rusting.
- ✚ Use your dry cloth rag and wipe down as much as possible to ensure that all water is gone.
- ✚ As a final cleaning, use a small amount of Klein's Multi-Purpose Cleaner and wipe down each tool.
- ✚ Although most new tools are rust resistant, if it's older tools you're cleaning, you may want to add a small amount of household oil (i.e. WD-40). By applying some to a small rag and wiping your older tools down, you will help prevent them from rusting.
- ✚ Effective cleaning after every use is the best way to ensure you'll get the best results from the tools you depend on. With proper care of your Klein tools, you can guarantee they'll last a lifetime.

✓ **Equipment Cleaning Procedures**

- ✚ Dismantle all the removable parts of the equipment to be cleaned.
- ✚ Adhere "To be cleaned" sticker on the equipment and transfer the removable parts to the designated washing area.
- ✚ Clean the immobile part of the equipment according to the manufacturer's suggested cleaning procedure then fill-out the Equipment Log Book after completion.
- ✚ Reassemble all the cleaned removable parts to the cleaned equipment after assuring that every part is dried.

-  Affix the signed and dated “Cleaned” sticker on the reassembled cleaned equipment. The “Cleaned” sticker must identify previous batches being processed by the equipment.
-  Use the cleaned equipment within 72 hours from the date of cleaning. Wipe all product contact parts with clean lint-free cloth prior to next use.
-  If the equipment is not used within 72 hours after the date of cleaning, adhere a “To be cleaned” sticker on the equipment and perform the cleaning procedure again before use.

- **Arrangement of Workplace**

- ✓ **Tips to Arrange the Workplace**

Organizing the workplace can help reduce the frustration of having to search for items that should be readily available. Taking the time to organize your space according to company/school activities not only improves workflow by saving steps, it also forces you to think through the different aspects of your operation, and how to approach them efficiently and systematically.

 **Sharing Work, Sharing Space:** You may have an impeccable memory that can help you locate every piece of paper on every pile, but one of your coworkers may need to find those same papers without the benefit of having handled them. Unless you work in a one-person office, you'll most likely be looking for items your coworkers have put away and they'll similarly be looking for things you have moved. Organizing the workplace can help reduce the frustration of having to search for items that should be readily available.

Designate specific places for different types of papers and tools.

Work with your coworkers to create a workplace culture in which items are placed where they belong right away, rather than pushed aside to be organized later. Label your bins, trays and file folders, and train new employees to follow your system so they'll be on board with your organizational systems from the start. Remove things you don't use regularly to keep them from tying up space and making it difficult to find items that you actually need.

✚ **Efficiency and Time:** Aside from the minutes and hours you'll save by not having to search for indispensable items, an organized workplace can improve efficiency by aligning your space with operational processes.

✚ **Workplace Organization as a State of Mind:** Keeping your workplace organized isn't just a matter of finding permanent places for essential items and instructing employees to replace them there.

Workplace organization is a state of mind that takes ongoing work and thought. Create a culture of keeping your space clean and organized by taking pride in efficient physical systems and praising and rewarding workers who take these systems to heart.

✓ **How to Apply 5S Methodology**

Sort, Set in Order, Shine, Standardize and Sustain, these principles are more commonly summarized as the 5S methodology.

✚ **Sort:** Begin the first step of the 5S methodology by sorting through all the items in the workplace. Identify the items that are no longer needed and can be thrown away. Tag these items as you sort them so you can easily move the tagged items to a central location once you have completed the sorting process. Ask the entire team to review the tagged items together and make the final decision on whether to keep, discard, recycle or relocate each of the items.

✚ **Set in order:** Sometimes referred to as "straighten," this step involves organizing the entire workspace. Decide on a place for each item.

✚ **Shine:** Clean the workplace once the clutter has been sorted and organized. If necessary, demonstrate to workers how the items must be cleaned. Assign each employee an area of responsibility, and direct staff to clean their area on a daily basis.

✚ **Standardize:** Develop and enforce a consistent routine to implement the sorting, straightening and shining procedures. For example, set an expectation that each machine will be cleaned and free of clutter at the end of the work day. Employees can easily tell if the standards are lacking just by looking at the machine.

 **Sustain:** Embed the 5S methodology in company culture so the behavior becomes a habit. Remind staff of your expectations with posters, emails and regular staff meetings. Provide training to reinforce the methods, and reward those who follow the methodology.

✓ **Organizing Your Automotive Workshop**

Here are three ways you can make everything easier and more efficient in your auto shop:

 Clear up floor space

Floor space is extremely valuable in an auto shop. The more floor space you can clear up, the better! You'll then find operations will naturally start to flow more efficiently in your workshop. You need to provide enough space to manage large vehicles, store equipment and leave room for your employees to navigate around each other.

One of the best ways you can optimize floor space is by making use of wasted air space. Long span Shelving is ideal for long, awkward shaped and oversized car parts. It's also easily accessible and comes in various heights and depths, to suit the size of your workshop.

 Store your Tools Away

It's easy in a fast-paced environment like an auto shop for items to be misplaced from time to time. This especially applies to small tools which are used interchangeably during car repair operations. If your tools are going missing or turning up in the wrong area on a regular basis, this can slow down outputs in your workshop, and negatively impact your business.

One of the simplest ways to manage your automotive tools is by investing in small parts storage systems. Small storage systems can help you find your tools much quicker and protect them from wear and tear. Many tools can be expensive but when they are cared for properly, they can last a lifetime which can keep costs down. You can store tools based on size or how frequently they are used. Check out the 5 Best Warehouse Storage Solutions for Small Items and see what would work best for your business.

Create Designated Areas

Establishing designated areas in your workshop can help improve your work turnarounds and impress customers. You need to create areas which efficiently facilitate all facets of your business. It should include areas for:

- Short-term and long-term vehicle repairs;
- Spare parts and tires storage;
- A fitted customer service waiting room;
- A back of house office for administrative tasks;
- A break area and changing room for your employees.

Your workshop needs to be designed to benefit both your staff and customers. Keeping these areas separate can help you compartmentalize and organize all aspects of your business more efficiently. It can assist with tracking staff productivity as well as inventory, which working together assures that high-quality standards of services are being met.



Activity 2: Guided Practice



Task 13:

In your school workshop and with the guidance from your trainer, apply the procedures for:

1. Workplace cleaning.
2. Tools cleaning.
3. Equipment cleaning.



Activity 3: Application



Task 14:

After long time working in workshop on repairing engine supercharging system, use appropriate cleaning techniques to perform the following activities:

1. Clean the used tools

2. Clean the used equipment
3. Arrange the workplace



Points to Remember

- For personal safety or workplace user's safety, Safe work systems in the workplace should exist and supervised.
- For the workplace Safety, the safety measures should be taken into consideration.
- Remember that at the end of the day, tools and equipment should be cleaned and arranged for safety and next day easy work.
- PPEs must be selected, worn and used before each activity and accordingly.
- The workplace should be cleaned and arranged according to appropriate cleaning and arranging methods.



Self-Reflection

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



Formative Assessment

Q1. Choose the correct answer among the following:

An incident is notifiable if it involves:

- a. The death of a person
- b. Dangerous incidents that expose people to serious risk.

- c. No one of the above
- d. All the above

Q2. Answer by true if the statement is correct and false if the statement is incorrect

A. The following indicate the Safety measures at the Workplace:

- a. No need to report Unsafe Conditions.
- b. Keep a clean workstation.
- c. Wear non-suitable protective equipment.
- d. Work the whole day without breaks to save time
- e. Don't skip steps.
- f. Stay up to date with new procedures or protocols.
- g. Maintain proper posture.
- h. Offer guidance to new employees.

B. The following are the types of PPE according to its function

- a. For head protection we use gloves
- b. For eyes protection safety boots are used
- c. For respiratory protection, eye protector may be used
- d. Hands protection we use face shield

Q3. Depending on its protective effects, classified PPE

Q4. Enumerate the procedures to follow for Cleaning Dirty Tools

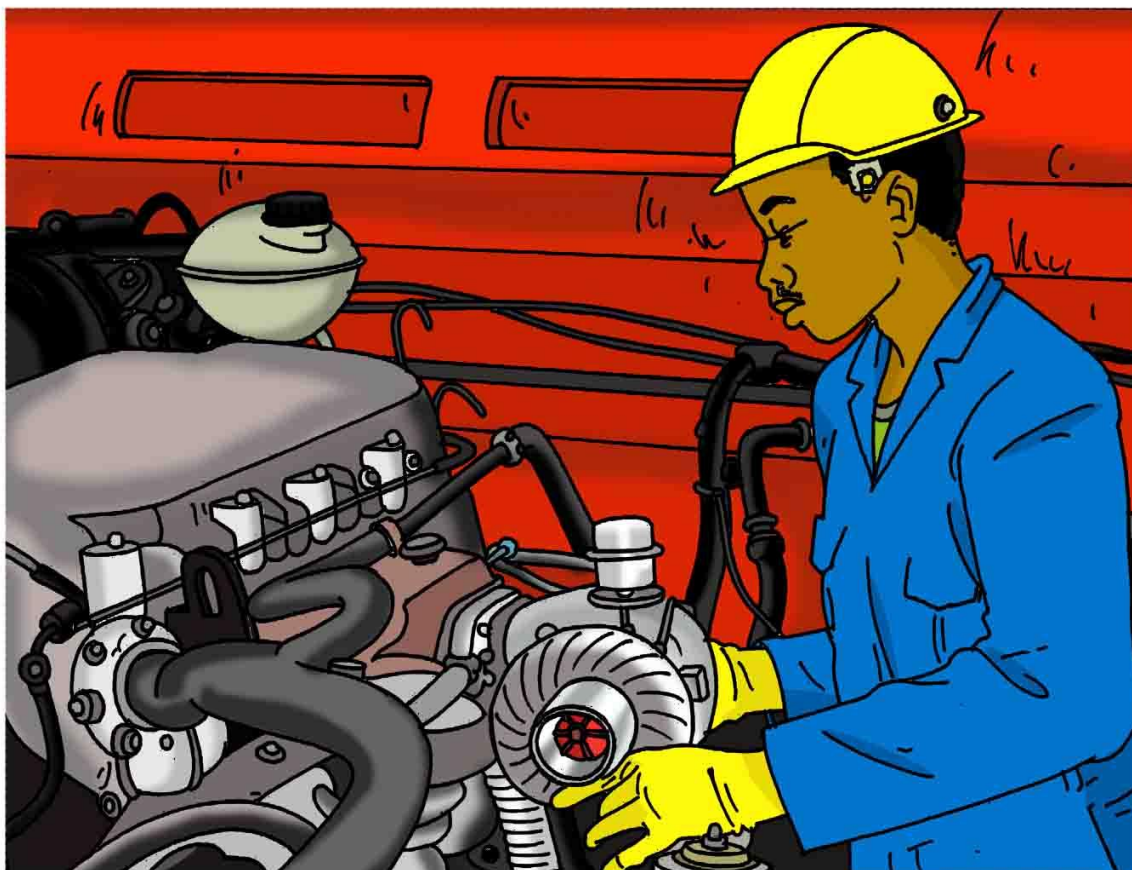
Q5. List any five (5) PPEs to be selected while working on supercharging system

Q6. What are the Conditions that must be fulfilled by PPE?

Q7. Enumerate the procedures to follow for Cleaning Dirty equipment

Q8. List any five (5) general safety precautions to be observed in any work area.

UNIT 3: REPAIR SUPERCHARGING SYSTEM



Unit summary:

This unit helps you to gain knowledge, skills and attitude to Select materials, tools and equipment, Diagnose, Correct and Test engine supercharging systems.

Self-Assessment:

1. Look at the illustration above.
 - a. What do you see in the illustration?
 - b. What is happening?
 - c. What do you think this learning outcome will be about?
2. Fill in the self-assessment below.
 - a. There are no right or wrong ways to answer this survey. It is for your own use during this course.
 - b. Think about yourself: do you think you can do this? How well?
 - c. Read the statements across the top. Put a check in the column that best represents your situation.
 - d. At the end of this learning outcome, we'll take this survey 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					
Identify materials					
Identify tools and Equipment					
Inspect supercharging system					
Dismount engine supercharging system from the engine					
Disassemble engine supercharging system components					
Solve supercharging system faults					
Reassemble engine supercharging system 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					
Remount engine supercharging system					
Test engine supercharging system					



Key Competencies:

Knowledge	Skills	Attitudes
1. Identify materials, tools and equipment used for engine supercharging system repairing	1. Perform engine supercharging system dismount from the engine	1. Being organized to achieve the required result
2. Identification of engine supercharging system	2. Perform engine supercharging system disassembling	2. Be patient
3. Describe procedures to dismount, disassemble, reassemble and remount of engine supercharging systems	3. Perform engine supercharging system Reassembling	3. Be precise
4. Differentiating different methods used to solve engine supercharging system faults	4. Perform engine supercharging system remounting to the engine	4. Have attention to detail
5. Outline and differentiating methods used to test engine supercharging system	5. Perform engine supercharging system testing	5. Be responsible

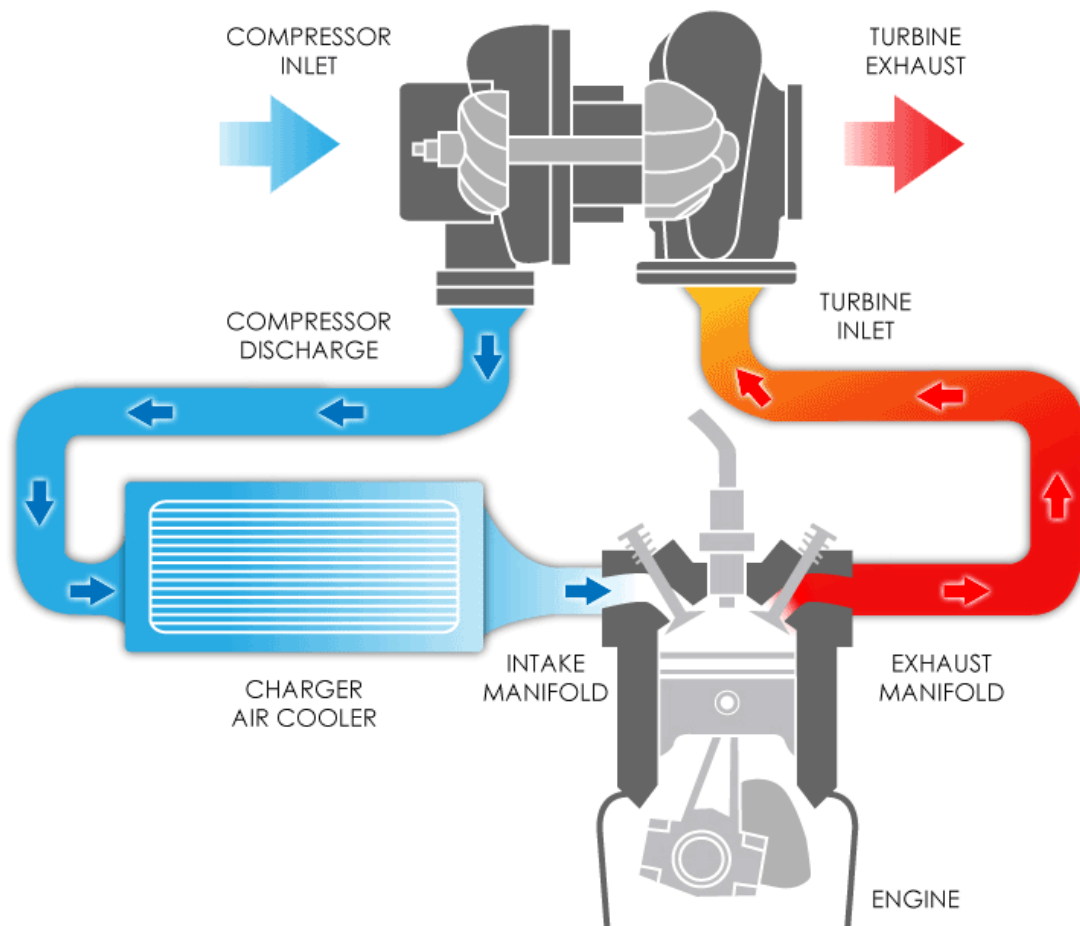


Discovery activity



Task 15:

Carefully, observe and read the image below and answer the following questions:



1. What is the engine system that the image above represents?
2. What is the function of the system represented by the image above?
3. Give the function of each stated part of the system.
4. List faults that can occur on the system represented by the image above.

Topic 3.1: Selection of Materials, Tools and Equipment



Activity 1: Problem Solving



Task 16:

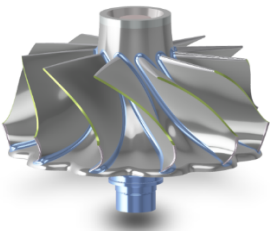
Read carefully and answer the following questions:

1. What are the material used in supercharging system?
2. Give a list of tools used in supercharging system.
3. List 5 equipment used in supercharging system and describe their functions

Key Facts 3.1. Selection of Materials, Tools and Equipment

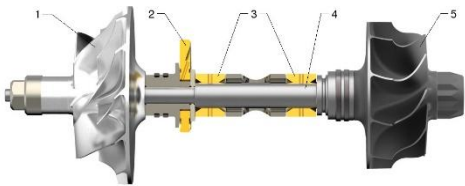
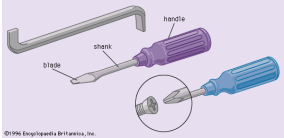
• Identification of Materials

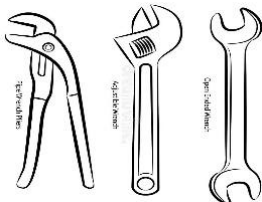
Item	Picture	Function
Air Cleaner		Filters are used to remove foreign particles like dirt, dust and grit or filters are used to remove dust and particles out of the air
Roots Blower		Roots blowers are typically used in applications where a large volume of air must be moved across a relatively small pressure differential.
Exhaust Manifold		As the first component in the exhaust system, the exhaust manifold collects the exhaust fumes released from the engine cylinders and directs them to the catalytic converter. In turbocharged engines, the turbocharger is situated

		downstream of the exhaust manifold.
Exhaust Gasket		An exhaust manifold gasket seals the connection between the manifold and cylinder head and also ensures that all exhaust gas will flow through the catalytic converter for treatment.
Air Clean Housing		Air purifiers are also known as room air cleaners and residential air cleaners. They are usually portable units whose purpose is to provide for clean air in residential environments to include particulate and odor removal. They are used to cover the air filter element
Impeller		The compressor / impeller draws in the fresh gasses and supplies the engine with a pre-compressed fresh gas charge.
Workshop Rags		workshop rags absorb oil, grease and fuels and are used for general-purpose workshop cleaning tasks such as cleaning hands, tools and equipment.
Turbine		The turbine consists of a turbine wheel and the turbine housing whose purpose is to guide the exhaust gasses into the turbine wheel.

		The turbine uses a series of blades to convert kinetic energy from the flow of exhaust gasses to mechanical energy of a rotating shaft
Sand Paper		Sandpaper is a special thick paper with a rough, abrasive surface. sandpaper is also useful for removing loose paint, grit, or dirt when you're painting or refinishing something
Diffuser		The function of the diffuser is to turn the rapidly compressed and high-speed air leaving the compressor wheel into static pressure as it fills the volute.
Intake Manifold		Featuring a series of tubes, the intake manifold ensures that the air coming into the engine is evenly distributed to all the cylinders. This air is used during the first stroke of the combustion process. The intake manifold also helps cool down the cylinders to prevent the engine from overheating.
Nozzle Ring		Nozzle rings are critical. In your turbochargers, they directly convert exhaust gas energy into kinetic energy and therefore power. Dirty, they reduce fuel and emissions efficiency and demand regular cleaning.

Cleaning Soap		Soap solubilizes particles and grime. It also kills microorganisms by disorganizing their membrane lipid bilayer and denaturing their proteins.
Cleaning Water		water is used for fabricating, processing, washing, diluting, cooling, or transporting a product.
Exhaust Gas Intercooler		The intercooler's task is to reduce the temperature of the inlet gas and thus densify the air required which optimizes the combustion. The intercooler lowers the temperature of the inlet gas from 130° C to 60° C, removes the negative effects of the turbo and increases the power by around 20%.
Cleaning Fuel		It helps in Fuel system cleaning to inhibit performance problems and mechanical damage in the engine while keeping it running for a long time.
Wire/Metal Brush		Wire brush is primarily an abrasive implement, used for cleaning rust and removing paint. It is also used to clean surfaces and to create a better conductive area for attaching electrical connections
Grease Oil		Because of its consistency, grease acts as a sealant to prevent lubricant leakage and also to prevent entrance of

		corrosive contaminants and foreign materials. It also acts to keep deteriorated seals effective.
Intermediate Shaft		An intermediate shaft simply transmits torque from one place to another, supported by bearings. It connects the turbine wheel to a compressor wheel.
• Identification of Tools and Equipment		
Item	Picture	Function
Torque Wrench		Torque wrench applies specific amount of torque to a fastener, such as a nut or bolt. It is usually used by mechanics to ensure that bolts are properly tightened.
Socket & Ratchet Set		A socket set is a collection of sockets that fit onto a ratchet, which is a hand-held tool that can be turned in either direction to loosen or tighten bolts and nuts
Breaker Bar		A breaker bar is a long, solid metal rod that is used to provide extra leverage when loosening or tightening bolts and nuts
Screwdrivers		As the name suggests, screwdrivers are used to tighten or loosen screws

Wrench Set		Wrenches are made in various shapes and sizes and are used for gripping, fastening, turning, tightening and loosening things like pipes, pipe fittings, nuts and bolts
Pliers		Pliers are hand engine tools that you use to grip and hold objects. The most common type of pliers is the adjustable pliers, which can be used to grip and hold objects of various shapes and sizes.
Hammers		A hammer is used to hit or tap objects. Some tasks to install components will also require the gentle tap of a hammer.
Impact Wrench		Impact wrenches powered, automotive engine repair tools used to loosen or tighten bolts and nuts. It works by using a hammering action to generate high levels of torque
Funnels		These are cone-shaped tools that are used to pour liquids such as oil or coolant. These car engine tools come in various sizes, depending on the size of the container they are being used for
Jack stands		A jack stand is a metal height-adjustable mechanical device that is used to support the weight of a lifted vehicle. Most commonly, they are placed underneath the car as a safety net to protect against a vehicle falling on a body part

Jack		These car engine tools repairs help you to lift your vehicle so that you can work on it more easily
Engine Stand		An engine stand is a tool commonly used to repair large heavy gasoline or diesel engines. It uses a heavy cantilevered support structure to hold the engine in midair so that the mechanic has access to any exposed surface of the engine.
Car lifter		Commonly car lifts are used in garages for increasing the parking space and for easily performing car maintenance and servicing
Engine Crane		An engine crane (also referred to as engine hoist) is a common repair tool used in vehicle repair shops to remove or install gasoline or diesel engines in small and crowded vehicle engine compartments
PPEs		Personal Protective Equipment (PPE) refers to specialized clothing, equipment, or gear designed to protect individuals from various workplace or environmental hazards There are PPE for Head protection, Feet protection, Body protection, Face protection and Hand protection.



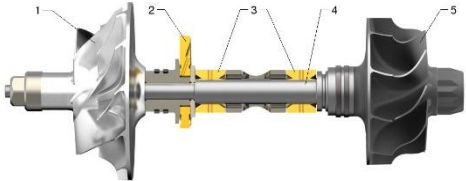
Activity 2: Guided Practice



Task 17:

Under guidance with your trainer, perform the following activities:

1. Describe the function of below tools and equipment
 - a. Engine Stand
 - b. Impact Wrench
 - c. Sockets & Ratchet Set
2. Give the name for the material, tools and equipment below:



Activity 3: Application



Task 18:

1. As a learner who has knowledge and skills about selecting materials, tools and equipment to be used for engine supercharging system, you are requested to go in school workshop and do the following activities:
 - a. Make a list of PPEs found in the school workshop to be worn when working on supercharging system
 - b. Identify materials to be used in repairing of the supercharging system.
 - c. What equipment that exist in the workshop for the use when repairing supercharging system?

Topic 3.2: Diagnosis of Engine Supercharging System



Activity 1: Problem Solving



Task 19:

Read carefully and answer the following questions:

1. How do we identify faults in supercharging system?
2. What are the causes of those faults?
3. What are the main components to diagnose when suspecting the supercharging system defaults?

Key Facts 3.2. Diagnosis of Engine Supercharging System

- **Inspection of supercharging system**



- ✓ **Faults identification**

The engine supercharging faults includes: air filter blockage, compressor fouled, cooler tube and air side fouled, turbine fouled

- ✓ **Air Filter Related Faults**

The blockage of the air filter is one of the most common faults associated with engine turbocharger systems. Fouling of the air filter and air flow ducts will significantly affect the quality of energy conversion and also it could cause an increase in fuel consumption. During operation, the air filter will eventually get contaminated and display the following inefficiencies:

- ✚ Increase in the flow resistance
- ✚ Loss of filtering properties
- ✚ Loss of tightness
- ✚ Increase in the flow resistance

-  Loss of filtering properties
-  Loss of tightness
-  Increase in the flow resistance
-  Loss of filtering properties
-  Loss of tightness
-  Increase in the flow resistance
-  Loss of filtering properties
-  Loss of tightness

✓ **Air Cooler Related Faults**

Turbochargers increase the temperature of the air in intake manifold, so it is important to reduce these excessive temperatures to achieve an efficient combustion process and lower exhaust emissions. For this purpose, engines are equipped with a scavenge air cooler which is usually constructed of bronze alloy tubes for cooling water circulation and aluminum fins for necessary air flow

✓ **Compressor Related Wheel Fault**

The purpose of the turbocharger compressor is to draw air from the engine room in an axial direction and then expel it in a radial direction with high velocity. Three essential components of the compressor that ensure high performance are: compressor wheel, casing and diffuser

✓ **Turbine Blades Related Fault**

The turbocharger turbine side, which consists of a turbine casing and turbine wheel, is a crucial part for converting exhaust gas energy into mechanical energy (shaft power) to drive the compressor.

Because the high-velocity and high-temperature exhaust gas is directed onto the turbine blades, without preventive maintenance, the exhaust side of the turbocharger can easily get contaminated with carbon deposits and soot from the combustion process.

Fouled turbine blades cause an increase in the exhaust gas flow resistance, which leads to a reduction in turbine efficiency and an increase in the specific fuel consumption.

✓ **Supercharger failure chart**

Here below is a table that shows noise, its cause and how to solve it.

Noise	Cause & Cure
Growling	Debris in the rotor or slight rotor to cause contact. It will never be a burden. Rebuild supercharger if case and rotor are useable
Clacking	Coupler metal. Coupler worn. If clicking at idle, rev. engine. if noise goes away, it's a rough engine idle from cam or poor tune if the supercharger isn't using oil. Front seals are Ok. New couplers can be installed with a supercharger on a car. A melted coupler creates debris that usually damages front seals.
Whistling	Normal air flow through the supercharger and inlet tract can make a slight whistling noise. That is normal. The rotors and bearings are silent since there is no rotor to cause contact and the bearings ride on oil. Whistling may also be from a vacuum leak.
Gear Whine	Worn gears. Rare, regardless of the mileage, unless run low on the oil or out of oil. The Supercharger must be rebuilt. Gear shavings will damage seals.
Noise increase/Smaller Pulley	Air flow is noisy. Can't be avoided. Smaller pulley. more boost. Greater air flow (noise) more noise
Just Noisy	Remove the belt and rotate the supercharger. If free and quiet, check the alternator, water pump, idler pulley etc. supercharger often get blamed for other engine parts
Vibration	The Supercharger is balanced. Vibration is from engine or drive



Activity 2: Guided Practice



Task 20:

Under the guidance of your trainer, in school workshop do the following activities:

1. Observe the engine supercharging system.
2. List and describe the components of supercharging system.
3. Detect the defections of supercharging system and locate them.

- **Key area to inspect on engine supercharging system**

- ✓ **Main components and areas to inspect**

🔧 **Supercharger Unit:** Examine the supercharger unit itself for any signs of damage, leaks, or abnormal wear. Check the housing, rotors (if it's a positive displacement supercharger), impeller (if it's a centrifugal supercharger), and bearings for proper functioning.



🔧 **Drive System:** Inspect the drive system components, such as belts, pulleys, tensioners, and gears. Ensure that they are properly aligned, tightened, and free from excessive wear. Look for any signs of belt slippage or damage.

 **Intercooler:** If the supercharged system includes an intercooler, inspect it for leaks, damage, or clogged passages. Ensure that the intercooler is clean and functioning effectively to cool the compressed air.

 **Air Filters:** Check the air filters for cleanliness and clogs. Dirty or clogged air filters can restrict airflow and affect the performance of the supercharging system. Clean or replace the filters as necessary.

 **Boost Pressure Control:** Inspect the boost pressure control components, such as waste gates, blow-off valves, or bypass valves. Ensure that they are functioning correctly and not stuck open or closed.

 **Vacuum and Boost Lines:** Check all vacuum lines, boost lines, and fittings for any cracks, leaks, or loose connections. A boost leak can result in reduced performance and potential damage to the engine.

 **Throttle Body and Intake Manifold:** Inspect the throttle body and intake manifold for any signs of leaks or damage. Ensure that the gaskets are in good condition and that all connections are secure.

 **Electrical Connections:** Check all electrical connections related to the supercharging system, such as sensors, solenoids, and relays. Ensure that the wiring is intact, connectors are clean, and there are no loose connections.

 **Fluids and Lubrication:** If the supercharger is oil-lubricated, check the oil level, quality, and condition. Ensure that the lubrication system is functioning properly and there are no oil leaks.

 **General Visual Inspection:** Perform a general visual inspection of the entire supercharging system, looking for any signs of damage, loose components, or abnormal wear.



Activity 3: Application



Task 21:

As a learner who has knowledge and skills to diagnose engine supercharging system, you are requested to go in school workshop and perform the following activities:

1. Diagnose the supercharging system.
2. Observe the causes of diagnosed faults.
3. List areas associated with the identified or detected faults
4. Make a short report to submit to the trainer

Topic 3.3: Correction of Engine Supercharging System



Activity 1: Problem Solving



Task 22:

Read and answer the following questions:

1. What are the steps to correct the engine supercharging system faults?
2. What are the methods used to solve supercharging system?
3. Describe the Reassemble process for Engine Supercharging System Components.

Key Facts 3.3. Correction of Engine Supercharging System

- **Dismount of Engine Supercharging System from Engine**

Steps:

- ✓ Prepare Workplace
- ✓ Select materials, tools and equipment
- ✓ Park the vehicle on a flat, level surface.
- ✓ Turn off the engine and allow it to cool down completely.

- ✓ Review the service manual
- ✓ Disconnect the vehicle's battery to prevent accidental electrical issues.
- ✓ Remove the air intake ducts and hoses connected to the supercharger.
- ✓ Release tension on the drive belts by adjusting or removing any belt tensioners.
- ✓ Slip the belts off the pulleys and remove them.
- ✓ If the supercharging system includes an intercooler, disconnect it from the supercharger and the intake manifold.
- ✓ Locate the mounting bracket that holds the supercharger to the engine block or intake manifold.
- ✓ Unbolt the supercharger from the mounting bracket using the appropriate tools.
- ✓ Remove the supercharger unit from the vehicle

- **Disassemble Engine Supercharging System Components**

Steps:

- ✓ Prepare Workplace
- ✓ Select materials, tools and equipment
- ✓ Review the service manual
- ✓ Remove waste gate turbocharger by unscrewing nuts on hot and cold sides of turbocharger
- ✓ Remove V-band clamp
- ✓ Separate Cartridge from exhaust side of turbocharger (If stuck, carefully use penetrating fluid and hammer for separation)
- ✓ Separate Cartridge from cold side of turbocharger (If stuck, carefully use penetrating fluid and hammer for separation)
- ✓ Take out compressor wheel from the casing
- ✓ Take out turbine wheel and intermediate shaft from the casing
- ✓ Separate turbine wheel from intermediate shaft
- ✓ Take off the seal plate assembly

- ✓ Use 2 screwdrivers to equally pry the center's trust surface out
- ✓ Peel O-rings off
- ✓ Take out thrust washers
- ✓ Take back plate off from the casing



Figure 6: Here below are pictures to understand the process



Figure 7: Some disassembled engine supercharging components

• **Methods for Solving Supercharging System Faults**

Here are some important points to consider regarding the maintenance, repair, and replacement of an engine supercharging system:

✓ **Maintenance**

✚ **Regular Inspection:** It is essential to perform regular inspections of the supercharging system to check for any signs of wear, damage, or leaks. This includes inspecting the belts, hoses, intercooler, and other related components.

✚ **Cleanliness:** Keeping the supercharger and intercooler clean from debris, dirt, and oil build up is crucial to maintain efficient airflow and prevent any potential issues.

✚ **Lubrication:** Some superchargers require regular lubrication to ensure smooth operation. It is important to follow the manufacturer's recommendations regarding lubrication intervals and the type of lubricant to be used.

✓ **Repair**

✚ **Identifying Issues:** If you notice any decrease in power, strange noises, or poor performance, it may indicate a problem with the supercharging system. Promptly addressing these issues can prevent further damage to the engine and other components.

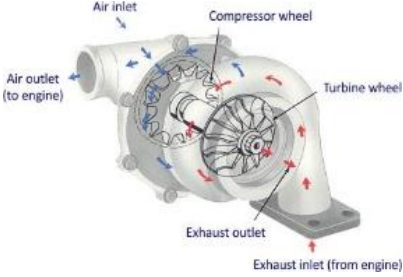
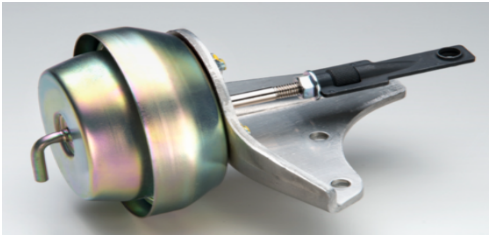
✚ **Component Replacement:** Faulty or damaged components within the supercharging system, such as the supercharger itself, intercooler, or belts, may need to be replaced to restore proper function. It is essential to use quality replacement parts to ensure compatibility and longevity.

✓ **Replacement**

✚ **Lifespan:** The lifespan of an engine supercharging system can vary depending on various factors, such as the quality of components, driving conditions, and maintenance. However, superchargers typically have a lifespan of around 100,000 to 150,000 miles, after which replacement may be necessary.

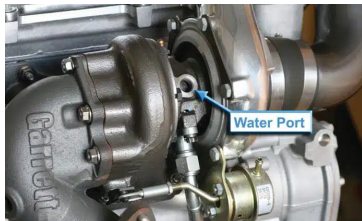
✚ **Upgrading:** Some vehicle owners may opt to upgrade their supercharging system to improve performance. This could involve replacing the existing supercharger with a more powerful or efficient model, or switching to a different type of forced induction system, such as a turbocharger.

Supercharger Unit	It should be inspected regularly for any signs of damage, such as worn-out bearings or damaged impellers.
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	Cleaning the impeller blades and ensuring proper lubrication is also important.
Intercooler 	It should be checked for leaks, dirt, or debris that can obstruct airflow. Cleaning the intercooler fins and ensuring proper coolant levels is essential for efficient cooling.
Air Filters 	Regularly inspecting and cleaning or replacing the air filters is crucial to maintain proper airflow and prevent damage to the supercharging system.
Belts and Pulleys 	It is important to inspect them for wear, cracks, or misalignment. Proper tensioning and lubrication of belts are necessary to prevent slippage and ensure smooth operation.
Boost Pressure Control System 	Components such as waste gates, blow-off valves, or pressure relief valves should be inspected for proper functioning and adjusted if necessary.
Intake Manifold and Piping	It is important to check for leaks, loose connections, or cracks that can cause loss of boost pressure. Cleaning the intake manifold and removing carbon deposits is also recommended.



Oil and Coolant System



Regularly checking and changing the oil and coolant levels, as well as ensuring proper circulation, is essential for maintaining optimal performance and preventing overheating or component failure.



Figure 8: Steps to assembling and remount engine supercharging system

• Reassemble Engine Supercharging System Components

Steps:

- ✓ Prepare Workplace
- ✓ Gather all necessary materials, tools and equipment
- ✓ Review the service manual

- ✓ Put back plate into the casing
- ✓ Put in thrust washers into their place
- ✓ Install O-Rings
- ✓ Put in Thrust surface
- ✓ Put in place all seal plate assembly
- ✓ Connect turbine wheel to the intermediate shaft
- ✓ Slide turbine wheel and intermediate shaft into the casing
- ✓ Connect compressor wheel to the intermediate shaft
- ✓ Connect cartridge to the cold side of turbocharger
- ✓ Connect cartridge to the hot side of turbocharger
- ✓ Place and Tight the V-band clamp in position
- ✓ Connect waste gate valve to the turbocharger

- **Remount Engine Supercharging System on Engine**

Steps:

- ✓ Prepare Workplace
- ✓ Gather all necessary materials, tools and equipment
- ✓ Park and secure the vehicle on a flat, level surface.
- ✓ Turn off the engine and allow it to cool down completely.
- ✓ Review the service manual
- ✓ Bolt the supercharger unit in the mounting bracket
- ✓ If the supercharging system includes an intercooler, connect it to the supercharger and the intake manifold.
- ✓ Slip the belt in the pulley
- ✓ Connect belt tensioners and tension the drive belts

- ✓ Connect air ducts and hoses to the supercharger
- ✓ Connect the vehicle's battery
- ✓ Perform throughout inspection for tightness of mounted components
- ✓ Fill in and verify the fluid level

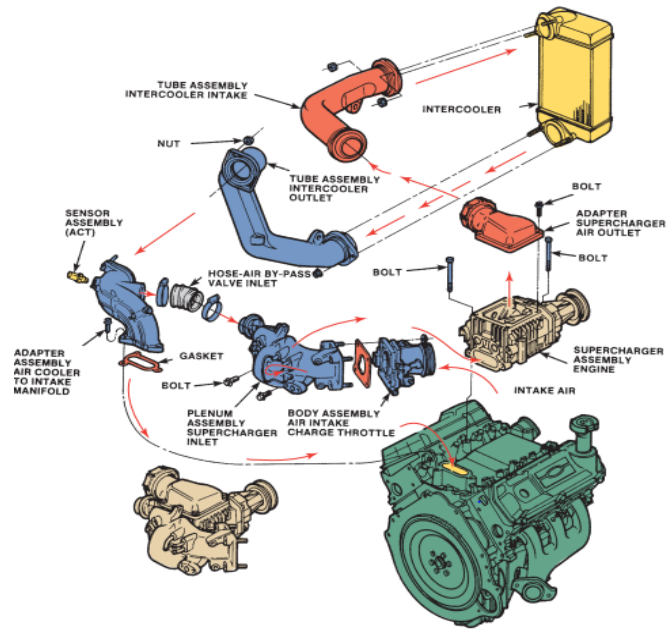


Figure 9: Extruded View of an engine supercharger assembly



Activity 2: Guided Practice



Task 23:

A customer brings a car with a supercharged engine that is experiencing the lack of power and unusual noise from the supercharger. Upon the inspection, you noticed the oil leakage around the supercharger housing. With the help of a repair manual and guidance from your trainer, you are supposed to solve problems following the recommended procedures for dismounting, disassembling, correcting, assembling and remounting the engine supercharging system.



Activity 3: Application



Task 24:

Go and drive a car of Mr. KALISA which is parked near the school main gate in the workshop. It has a supercharged engine and he suspects there is an issue with the supercharging system. The car seems to lack power and has unusual noises coming from the engine compartment during acceleration. You are required to diagnose and repair the engine supercharging system using the correct procedures.

Topic 3.4: Test Engine Supercharging System



Activity 1: Problem Solving



Task 25:

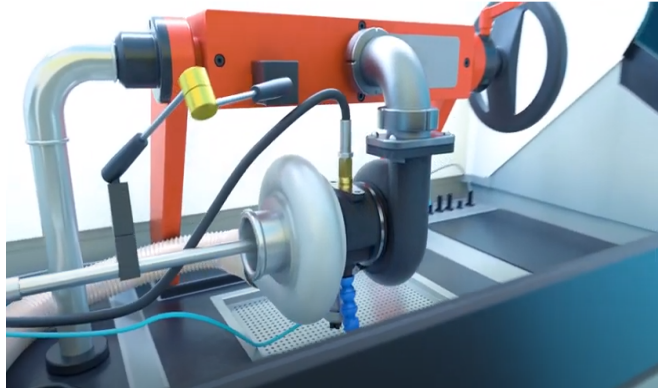
Look carefully at the picture below and answer the following questions:

1. What does the picture represent?
2. What are the testing methods of engine supercharging?
3. Describe the process to perform static testing of engine supercharging system.
4. Describe the process to perform dynamic testing of engine supercharging system.

Key Facts 3.4.1

- **Performing a Static Engine Supercharging Test**

Performing a static engine supercharging test involves measuring the engine's performance under boosted conditions without the vehicle moving. This test is typically conducted in a controlled environment like a test cell or dynamometer facility.



Here is a general outline of the steps to perform a static engine-supercharging test. It is important to follow safety protocols and manufacturer guidelines during all stages of the test.

- ✓ **Preparation:** Make sure the engine is in good working condition and properly maintained.

Check and calibrate all instruments and sensors to ensure accurate data acquisition.

Verify that the supercharger system is properly installed and functioning correctly.
- ✓ **Data Acquisition:** Set up data acquisition systems to record relevant parameters such as RPM, boost pressure, intake air temperature, exhaust gas temperature, fuel flow rate, and any other critical engine parameters. Ensure that all sensors are connected correctly and their readings are displayed in real-time.
- ✓ **Engine Warm-up:** Start the engine and let it warm up to its normal operating temperature. This helps stabilize the engine performance during the test.
- ✓ **Baseline Measurement:** Conduct a baseline measurement without supercharging to establish the engine's performance under normal conditions.
- ✓ **Supercharger Setup:** Activate the supercharger system and set it to provide the desired boost pressure. The boost pressure can be adjusted based on the engine's specifications and test objectives.



- ✓ **Test Procedure:** Gradually increase the engine RPM while monitoring the boost pressure and other relevant parameters.

Record data at various RPM points to create a performance map.

Repeat the test for different boost pressure settings to understand how the engine responds to various levels of supercharging.

- ✓ **Data Analysis:** After completing the test, analyze the recorded data to evaluate the engine's performance under different supercharging conditions.

Look for changes in power output, torque, and other relevant parameters as the boost pressure varies.

- ✓ **Validation:** Compare the results with the engine manufacturer's specifications and performance charts to ensure everything is within the acceptable range.

Verify that the supercharger system is operating efficiently and effectively.

- ✓ **Post-Test Procedures:** Shut down the engine and supercharger system following the manufacturer's guidelines.

Review the data and documentation to ensure accuracy and completeness.

It's worth mentioning that static engine tests provide valuable data, but the engine's performance might differ when installed in a moving vehicle due to factors like airflow and cooling.

- **Performing a Dynamic Engine Supercharging Test**

Performing a dynamic engine supercharging system test involves evaluating the performance and efficiency of a supercharger while the engine is running. Superchargers are used to increase the amount of air and fuel mixture delivered to the engine, resulting in improved power output.

To perform this test, you will need appropriate safety precautions, tools, and access to a test track or a dyno facility. Here's a general outline of the procedure:

- ✓ **Safety Precautions:** Ensure that the vehicle is in good working condition, and all safety features are operational.

Wear appropriate personal protective equipment (PPE), including safety glasses and ear protection.

Make sure the test area is clear of obstacles, and bystanders are at a safe distance.
- ✓ **Pre-Test Preparation:** Confirm that the supercharging system is correctly installed and connected to the engine. Check the supercharger for any leaks, damages, or loose fittings and Verify that the engine is in proper working condition with all maintenance up to date.
- ✓ **Instrumentation Setup:** Connect data logging equipment to monitor critical engine parameters such as RPM, boost pressure, air-fuel ratio, temperature, etc. Attach pressure sensors to measure the supercharger boost pressure accurately. Set up a means of monitoring engine performance in real-time.
- ✓ **Warm-Up the Engine:** Start the engine and let it warm up to its operating temperature.
- ✓ **Baseline Run:** Conduct a baseline run without engaging the supercharger. This run will serve as a reference for later comparisons.
- ✓ **Supercharger Engagement:** Engage the supercharger system according to the manufacturer's recommendations. Gradually increase the engine RPM while monitoring the boost pressure and other relevant parameters.
- ✓ **Data Collection:** Log and record all data during the dynamic test, including RPM, boost pressure, air-fuel ratio, temperature, and any other relevant parameters.

- ✓ **Performance Evaluation:** Analyze the data to assess the performance of the supercharger system. Look for changes in power output, boost efficiency, and any issues that may have arisen during the test.
- ✓ **Cool Down:** After completing the test, allow the engine to cool down before performing any further inspections or adjustments.
- ✓ **Post-Test Analysis:** Review the data collected during the test to understand the supercharger system's behavior and performance.

Compare the results with the baseline run to gauge the effectiveness of the supercharging system.
- ✓ **Address Issues:** If any problems or anomalies are identified during the test, address them accordingly. This may involve adjusting the supercharger system or performing maintenance on the engine.



Activity 2: Guided Practice



Task 26:

Mr. Kalisa brought his vehicle at ABIZERWA Garage to be repaired as its supercharging system was not working properly causing the engine power loss. As technician, under your trainer guidance you are requested to perform the static testing of the turbocharging system used in Kalisa's car.



Activity 3: Application



Task 27:

Mr. Kalisa brought his vehicle at ABIZERWA Garage to be repaired as its supercharging system was not working properly causing the engine power loss and blue smoke whereby he requested to make both static and dynamic testing of his car's supercharging system. Follow

all procedures to perform those requested tests and make a report after completing all activities.



Points to Remember

- Disassembling an engine supercharging system requires careful attention to detail and adherence to safety procedures. Please note that working on a supercharging system can be complex and may require knowledge, skills and attitude. It is recommended to use a repair/service manual.
- The engine supercharging system is a critical component in many modern vehicles, as it helps to increase engine power and performance. Like any other system in a vehicle, it requires regular maintenance, repair, and eventual replacement to ensure optimal functionality.



Formative Assessment

1. Give three name and function of tools used in supercharging system
2. List 5 equipment used in supercharging system and describes their function
3. Name the following figures

4. What are the common faults of engine supercharging system?
5. Explain the following terms
 - a. Gear Whine
 - b. Growling
6. What is the process to disassemble the engine supercharging system components?
7. List the process to perform static and dynamic testing and of engine supercharging system.

Self-Assessment

My experience	I don't have any	I know	I have some	I have a lot of	I am confident
Knowledge, skills and attitudes	experience doing this.	a little about this.	experience doing this.	experience with this.	in my ability to do this.
Identify materials					
Identify tools and Equipment					
Inspect supercharging system					

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					
Dismount engine supercharging system from the engine					
Disassemble engine supercharging system components					
Solve supercharging system faults					
Reassemble engine supercharging system components					
Remount engine supercharging system					
Test engine supercharging system					



Self-Reflection

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



Summative Assessment

Read the integrated situation here below and perform the stated related activities:

Mr. KAREKEZI is a driver of RUHENGERRI referral hospital located in Musanze District. He brought the car Toyota LANDCRUISER (TXL) with Turbocharger at UMUKOZI Garage located in MUSANZE District MUHOZA sector for repairing. He told to the head of garage that the car has the following problem: The lack of engine power, blue smoke, consumption of turbocharger oil, and abnormal noise. As an automotive engine mechanic, the head of garage requested you to solve the above-mentioned problems within 6 hours.

Here below is a list of materials, tools and equipment available in the garage. You are allowed to request any other materials, tools and equipment you may need.

Tools	Wrenches and Sockets, Torque Wrench, Screwdrivers, Pliers, Allen Wrenches/Hex Keys, Socket Set, Belt Tension Gauge, Diagnostic Tools, Multi-Meter, Hoist or Jack Stands, Lamp Tester, Electric Blower, Scriber.
Equipment	Maintenance and Repair Manuals, Vehicle with Supercharger, Simulator, Personal Protective Equipment (PPE), Curriculum, Books, White Board, Black Board, Projector, Personal Computer, Air Compressor.
Materials/ Consumables	Gaskets, Seals, Bearings, Belts, And Other Supercharging System Components, Bolts and Nuts, Rags, Wire Brushes, Chalks, Papers, Solvent, Wires, Soap, Water, Bucket, Jerry Cans, Mop, Spray Bottle, Soft Brushes, Scrubber Sponge, Broom, Marker Pen, Cleaning Drill Brush, Cleaners' Corner & Edge Brush, Notebook, Dustbin.

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